Adopted by Council at its meeting held September 17, 2012 [M428-2012]
/RB
Windsor, Ontario September 17, 2012

REPORT NO. 77 of the
ENVIRONMENT & TRANSPORTATION STANDING COMMITTEE
of its meeting held August 29, 2012

Present: **Councillor Hatfield, Chair**
Councillor Halberstadt
Councillor Payne
Councillor Sleiman
Councillor Valentinis

That the following recommendations of the Environment and Transportation Standing Committee **BE APPROVED:**

Moved by Councillor Sleiman, seconded by Councillor Payne,

THAT the draft Climate Change Adaptation Plan attached to this report **BE TABLED** for 30 days for public comment, and further;

THAT the Author of the report **BE DIRECTED** to consult with City Administration including members of the Environment & Transportation Standing Committee and **REPORT BACK** up to six identified climate change adaption options as outlined in the "Draft Climate Change Adaptation Plan" that City Council may consider implementing when devising 2013 Budgets.

Carried.

Clerk's Note: The administrative report authored by the City Engineer dated July 4, 2012 entitled "Draft Climate Change Adaptation Plan" is ***attached*** as background information.

LIVELINK 16035, EI/10822

CHAIRPERSON

DEPUTY CLERK

NOTIFICATION:				
Name	Address	Email Address	Telephone	FAX

Item No. 1

THE CORPORATION OF THE CITY OF WINDSOR
Environment & Transportation Standing Committee - Administrative Report

MISSION STATEMENT:
"The City of Windsor, with the involvement of its citizens, will deliver effective and responsive municipal services, and will mobilize innovative community partnerships".

LiveLink REPORT #: 16035 EI/10822	**Report Date: July 4, 2012**
Author's Name: Karina Richters	**Date to Standing Committee: Aug. 29, 2012**
Author's Phone: 519 253 7111 ext. 226	**Classification #:**
Author's E-mail: krichters@city.windsor.on.ca	#3381 - jc

To: **Environment & Transportation Standing Committee**

Subject: **Draft Climate Change Adaptation Plan**

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1. RECOMMENDATION: City Wide: X Ward(s): _____

That the draft Climate Change Adaptation Plan attached to this report be TABLED for 30 days for public comment.

EXECUTIVE SUMMARY:

N/A

2. BACKGROUND:

In November 2010, City Council approved the participation in the ICLEI ("Local Governments for Sustainability", formerly International Council for Local Environmental Initiatives) Canada Adaptation Initiative. The development of the ICLEI initiative was sponsored by National Resources Canada's Climate Change Impacts and Adaptation Division.

National Resources Canada's explanation of what is adaptation is as follows:
"Adaptation to climate change can include any activity that reduces the negative impacts of climate change and/or takes advantage of new opportunities that may be presented. This includes activities that are taken before impacts are observed (anticipatory) and after impacts have been felt (reactive). Both anticipatory and reactive adaptation can be planned (i.e. the result of deliberate policy decisions), and reactive adaptation can also occur spontaneously. In most circumstances, anticipatory adaptations will incur lower long-term costs and be more effective than reactive adaptations. Successful adaptation does not mean that negative impacts will not occur, only that they will be less severe than would be experienced had no adaptation occurred."

This initiative provides a straightforward methodology to adaptation planning using a five milestone approach. The five milestones are as follows; Milestone One – Initiate, Milestone

Two – Research, Milestone Three – Plan, Milestone Four – Implement, and Milestone Five – Monitor.

Milestones One and Two were completed with updates to the Environment & Transportation Standing Committees in June 2011 (Livelink Report # 15308) and in November 2011 (Livelink Report # 15549), respectively.

3. DISCUSSION:

Upon completion of Milestone Two (Research) a comprehensive understanding of climate change and potential impacts for the community had been developed. The use of vulnerability and risk assessment tools were used to prioritize the list of potential impacts. The development of the draft plan focused on those impacts rated medium-high and above, but also includes consideration for other impacts identified where co-benefits (mitigation and adaptation) exist or for impacts that are easily addressed.

The draft plan includes a summary of anticipated climate change predictions, current and future climate change impacts, initiatives already underway as well as proposed adaptation options. This draft plan is the City of Windsor's first look at how the changing climate may impact the City of Windsor and how to minimize those negative impacts while taking advantage of any positive impacts that may occur.

The adaptation options identified are considered feasible and in some cases necessary to address many of the current climate change impacts that departments are already facing such as increased flooding and heat alerts. The City of Windsor is currently one of a few municipalities across Canada that is looking at a coordinated approach to adapt to the potential impacts facing the municipality in the short and the long-term. To continue being a leader it is important to develop a long-term, on-going adaptation strategy. In this draft plan, some long-term or continuing work is identified including;

1. Incorporating climate change adaptation into city policies and high level plans;
2. Creating internal mechanisms to 'ask the climate question' for all new major infrastructure projects;
3. Monitoring climate change impacts and evaluating the effectiveness of adaptation strategies and adjusting them as needed;
4. Using the best available science to analyze how the climate is changing locally and how this may impact the community;
5. Reviewing the City of Windsor's vulnerability to climate change;
6. Continuously conduct risk assessments to identify priority impacts requiring adaptation actions; and
7. Engaging the public, business and other stakeholder groups.

As mentioned above, the draft plan was developed with extensive departmental and, where necessary, external agency input. However, there has currently been no consultation with the public at large. It is recommended that the draft report be opened for comment from the public.

As explained in the ICLEI's *Having the Climate Conversation, Strategies for Local Government* "municipalities are well-positioned to inspire individuals and organizations to take action on climate change and play a crucial role in educating the community and building support for local action". Several of the proposed adaptation actions will require support from the general public and business community. It is important to engage the community at this point for several reasons: 1) to show that the City of Windsor is acting on possible climate change impacts, 2) to

increase the awareness of how climate change will impact our region, and 3) to allow the public to provide input into the draft plan.

A couple of events are being planned to allow the public to comment on the plan. The first event will include a presentation from a guest speaker at the Ojibway Nature Centre on August 16th. Dr. McBean currently teaches at of the University of Western Ontario and is a lead author of the recently released "*Telling the Weather Story*" prepared by the Institute for Catastrophic Loss Reduction for the Insurance Bureau of Canada. Dr. McBean is one of Canada's leading researchers on climate change and will be able to bring the climate change discussion to a regional level.

A booth will also be set up to allow for public comment at Devonshire Mall the weekend of August 18 and 19th.

The draft plan will be posted to the City of Windsor's website and social media pages for comment.

A copy of the poster advertisement for the public comment events is attached for reference.

Following the public comment period, the final report will be brought back to the Environment and Transportation Standing Committee and to City Council for approval.

4. RISK ANALYSIS:

The Devonshire mall requires a Temporary Occupancy Agreement be signed and liability insurance certificate with at least $ 2 million in coverage.

5. FINANCIAL MATTERS:

The Environmental Master Plan budget currently has $9,500 reserved for the finalization of the Climate Change Adaptation Plan. A portion of this funding will be used to support the public comment period. An estimated break-down of expense are as follows:

Guest Speaker and Public Comment night:

- Guest Speaker Dr. Gordon McBean
  - No speaker fee required
  - Travel and Hotel Expenses approximately $ 500.00
- Ojibway Nature Centre room rental - $ 288.00

Additional costs may be occurred for printing of posters, copying of the plan and advertising.

6. CONSULTATIONS:

Office of Continuous Improvement, Planning, Engineering, Pollution Control, Parks & Forestry, Finance, Purchasing & Risk Management, Operations, Essex Region Conservation Authority

7. CONCLUSION:

As the level of government closest to residents, municipalities have the unique ability to connect the big picture to the real, local picture and can emphasize the connection between the community and the effects of climate change. As a municipality, several departments have already noted the impacts of climate change on the day to day operations. It is expected that residents and local businesses may also be experiencing some of these impacts. Prior to finalizing the plan, it would be beneficial to receive input from the public.

Karina Richters
Environmental Coordinator

Mike Palanacki
Executive Director - Operations

Onorio Colucci
City Treasurer and Chief Financial Officer

Mario Sonego
City Engineer and Corporate Leader – Environmental Protection and Transportation

KR/jc

APPENDICES:
Draft Climate Change Adaptation Plan

DEPARTMENTS/OTHERS CONSULTED:
Name:
Phone #: 519 ext.

NOTIFICATION :

Name	Address	Email Address	Telephone	FAX

Why is Adaptation Required?

> 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*

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.

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_2) than it had before the beginning of the industrial era.

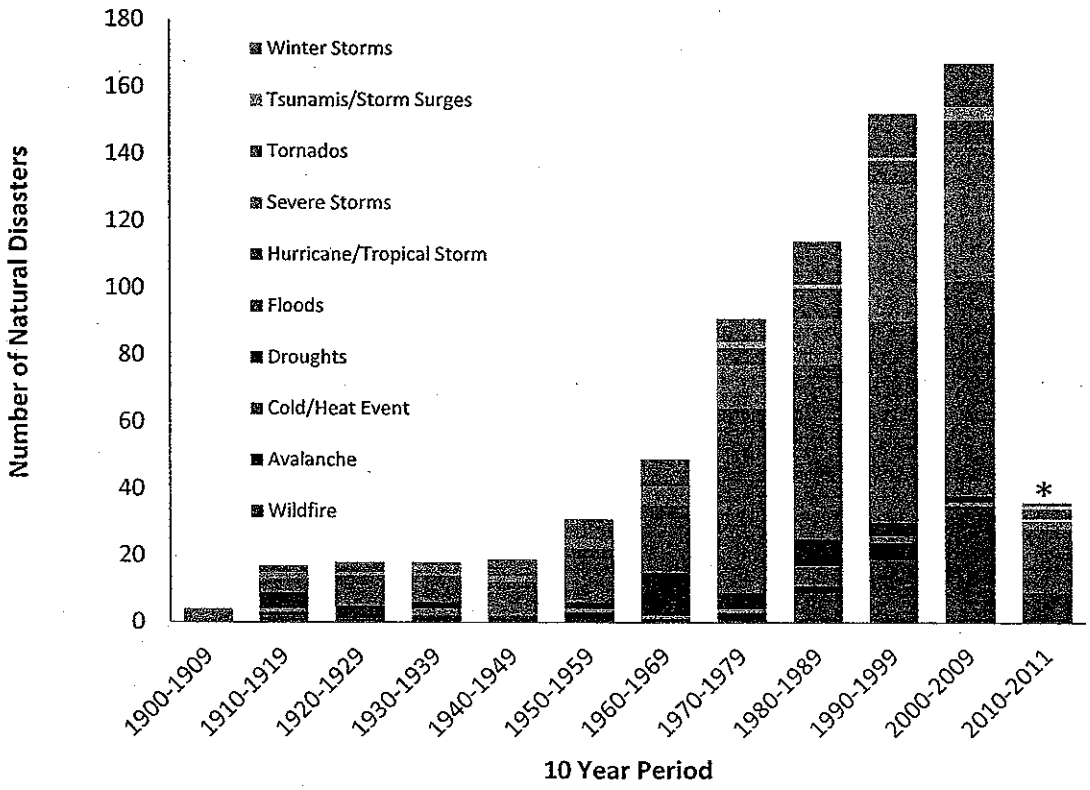
GHGs released decades ago are a main contributor to the change in our climate today. That means that even if globally, greenhouse gases were eliminated, changes will continue due to what was released in the past.

> "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.*

Public Safety Canada has been documenting "significant natural disasters" for over a decade in the Canadian Disasters Database. The following figure clearly shows the increase in "significant natural disasters" occurring across Canada. 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.

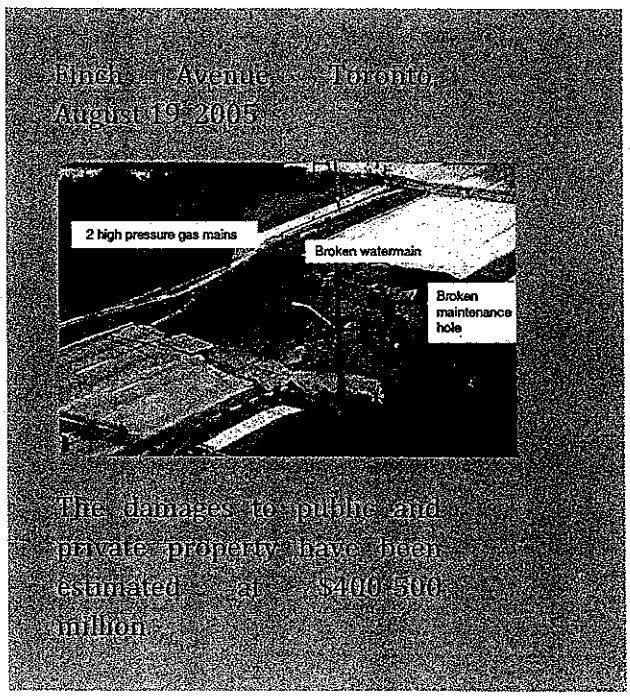
Frequency of Natural Disasters in Canada (1900-2011)



Note *: The final bar in the graph only covers the first 2 years of the decade.

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.[i] 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.[ii] 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[ii].

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.

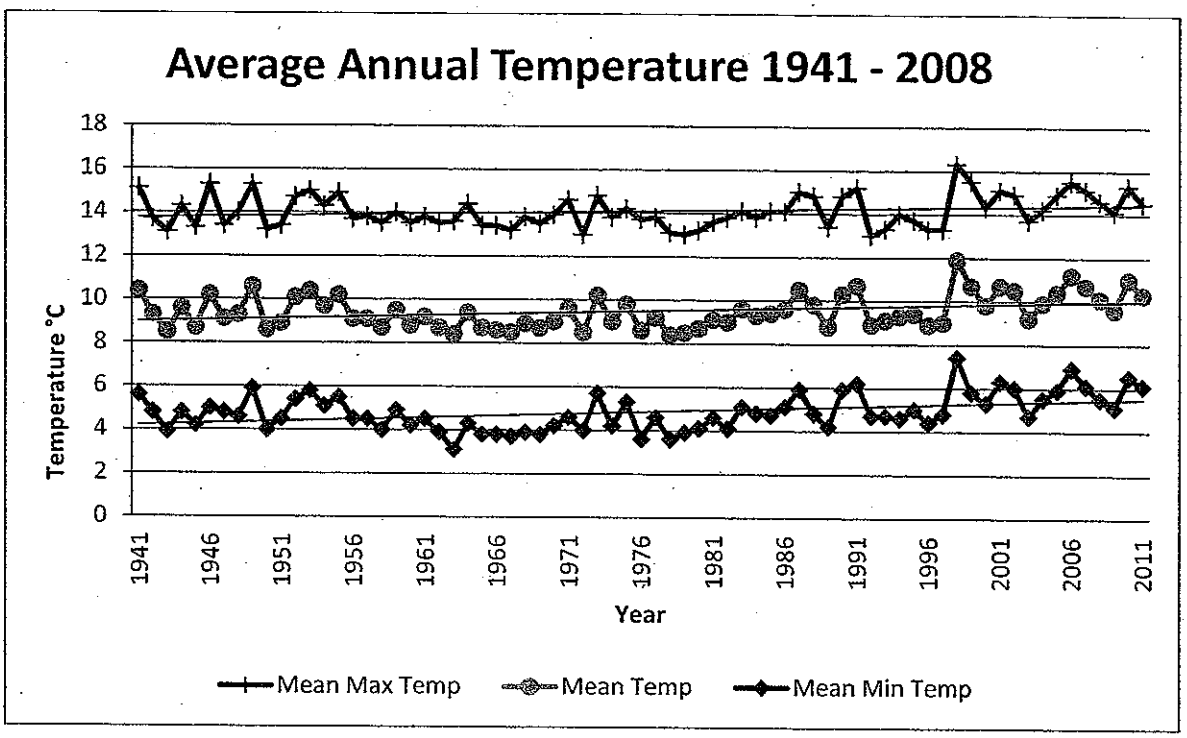
The actions taken today by the City of Windsor will enhance community resilience to climate change with the objective to reduce the human and economic costs of climate-related impacts.

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 baseline average 1961-1990[i].

Annual Average Temperature

The Environment Canada weather station located at Windsor Airport has been monitoring and recording weather data since 1940. Since this time, the average annual temperature has increased by almost 1 °C.



Note: The 1940 data was not used as monitoring was started in that year and missing data was estimated.

The Canadian 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.

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.

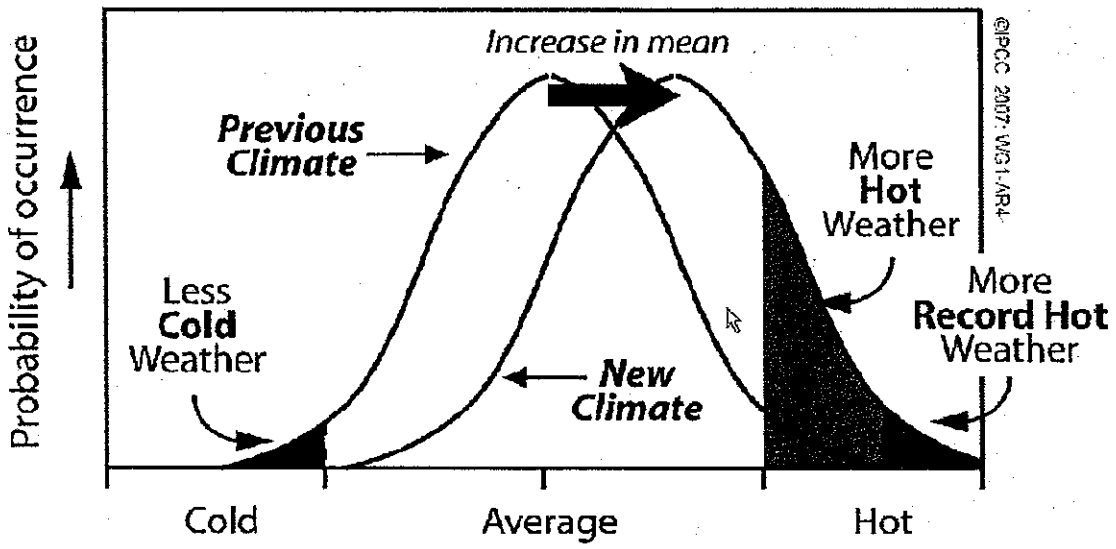
The following table shows the average annual temperature projections above the baseline period (1971-2000) based on the two scenarios.

Average Annual Temperature Projections:

	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

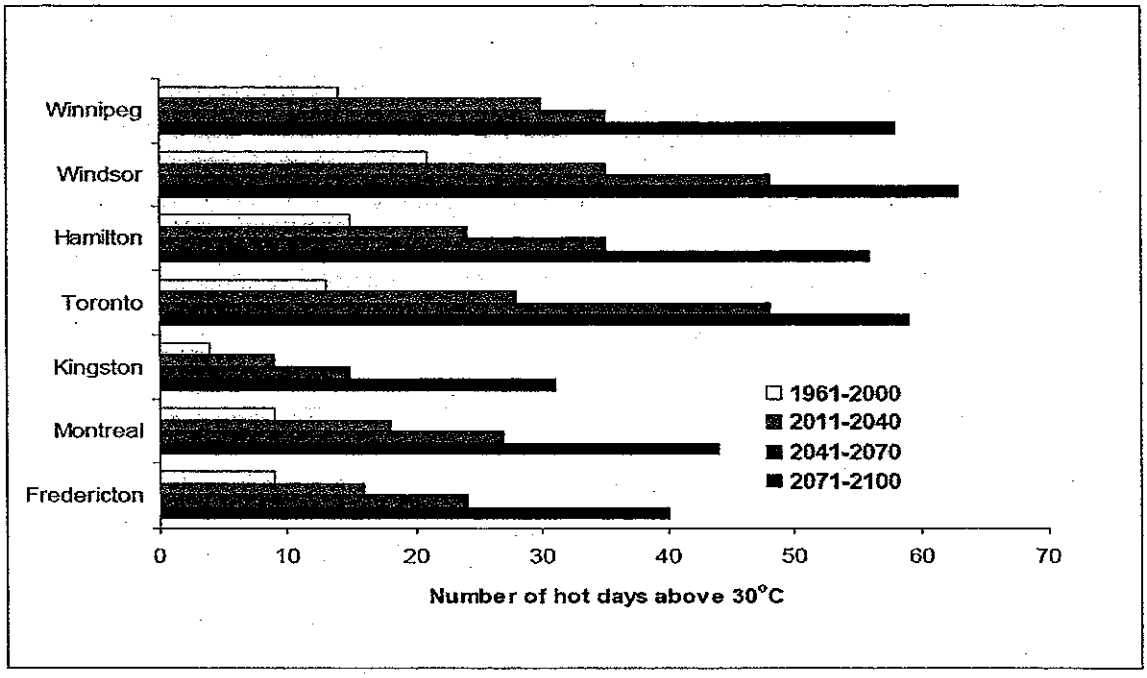
Note: Projections to 2050 are often most reliable as model results are not very divergent out to 2050.

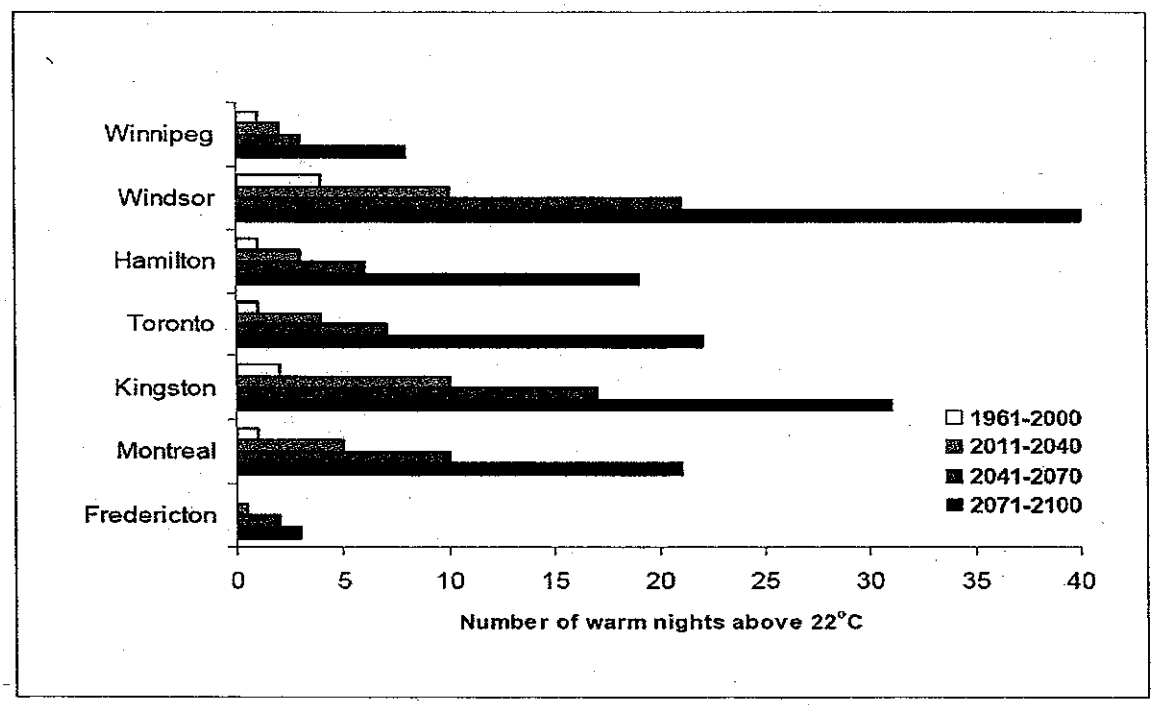
Though the average projection increase may be perceived as a minor change, it actually can have a significant impact on the region. As the figure below indicates a slight increase in the mean average temperatures will lead to more 'hot' and more record 'hot' weather with less cold weather. This shift 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.



Source: IPCC, 2007b[iii]

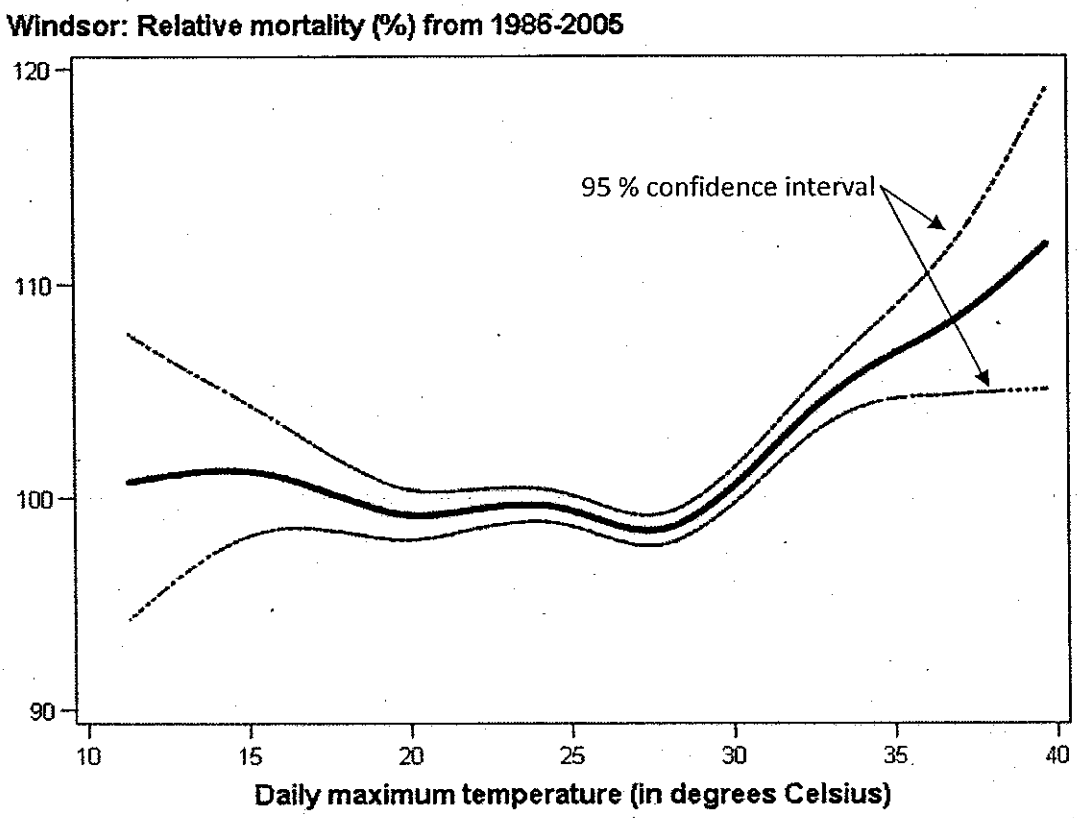
The City of Windsor was one of a few communities that were selected for analysis of extreme temperature. The temperature projections were completed by the Canadian Regional Climate Model (CRCM) developed by the Ouranos Consortium on Regional Climatology and Adaptation to Climate Change. The conclusions 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.[iv]





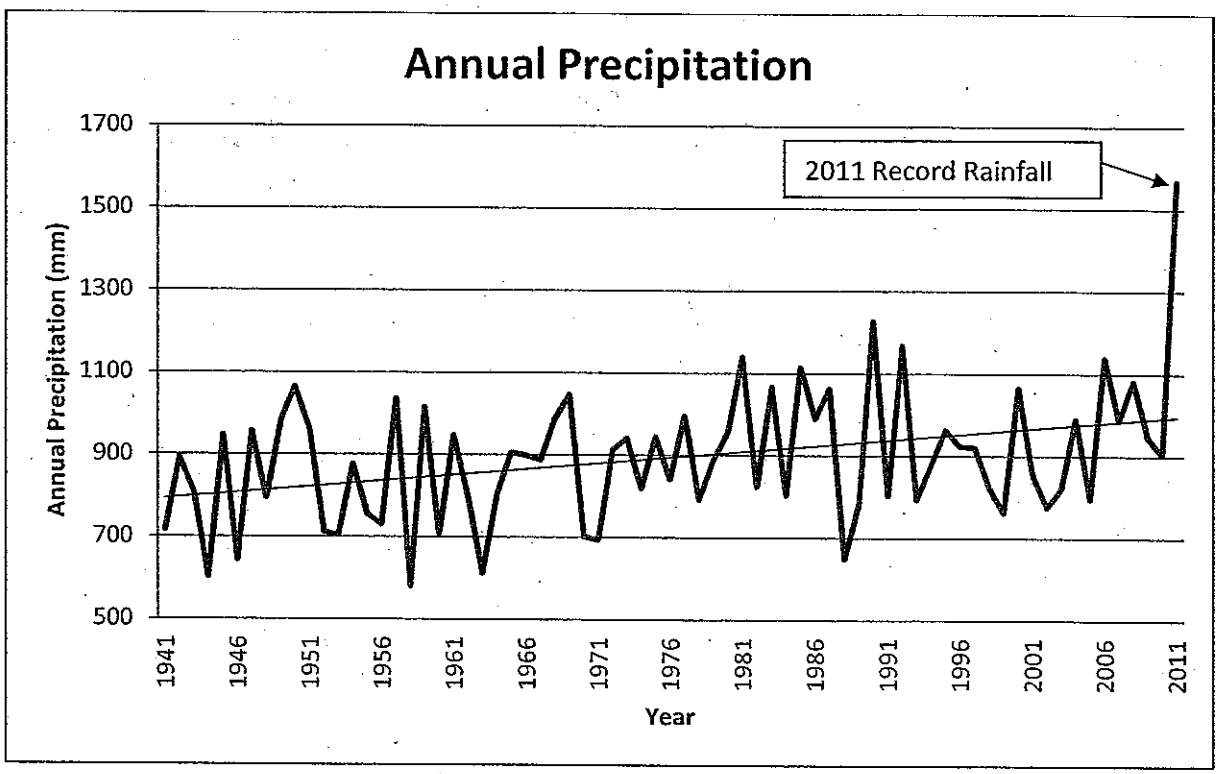
Source: Casati, B. and Yagouti, A

The following figure 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.[v]



Annual Precipitation

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



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

Precipitation Projection increases above the baseline period (1971-2000):

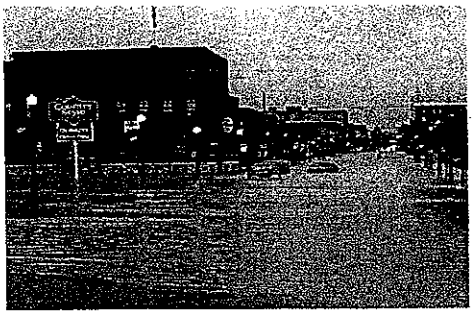
Year	B1 Scenario (Low Emissions)	A2 Scenario (High Emissions)
2020	2.2 %	2.2 %
2050	4 %	5.6 %
2080	5.7 %	8.3 %

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.

RAINFALL TRENDS **Summary of results**		
	Observed trends 1970 – 2000	Projected trends to 2050
30 minute extremes	5 % per decade (Adamowski) 4.5 % per decade to 1996 (Soil and Water Conservation Society)	5 % per decade
Daily extremes	7 % per decade (May, June, July) (Stone)	3 % per decade over the year (20 year return period)

	5% per decade (over the year) to 1996 (Soil and Water Conservation Society)	2.5 to 6 % per decade (rainfall with probability <5 %)
Annual rainfall	1 % to 3 % per decade	1 % per decade

Source: Bruce, J.P., Egener, M. And Noble, D. (2006)[vi]



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.

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

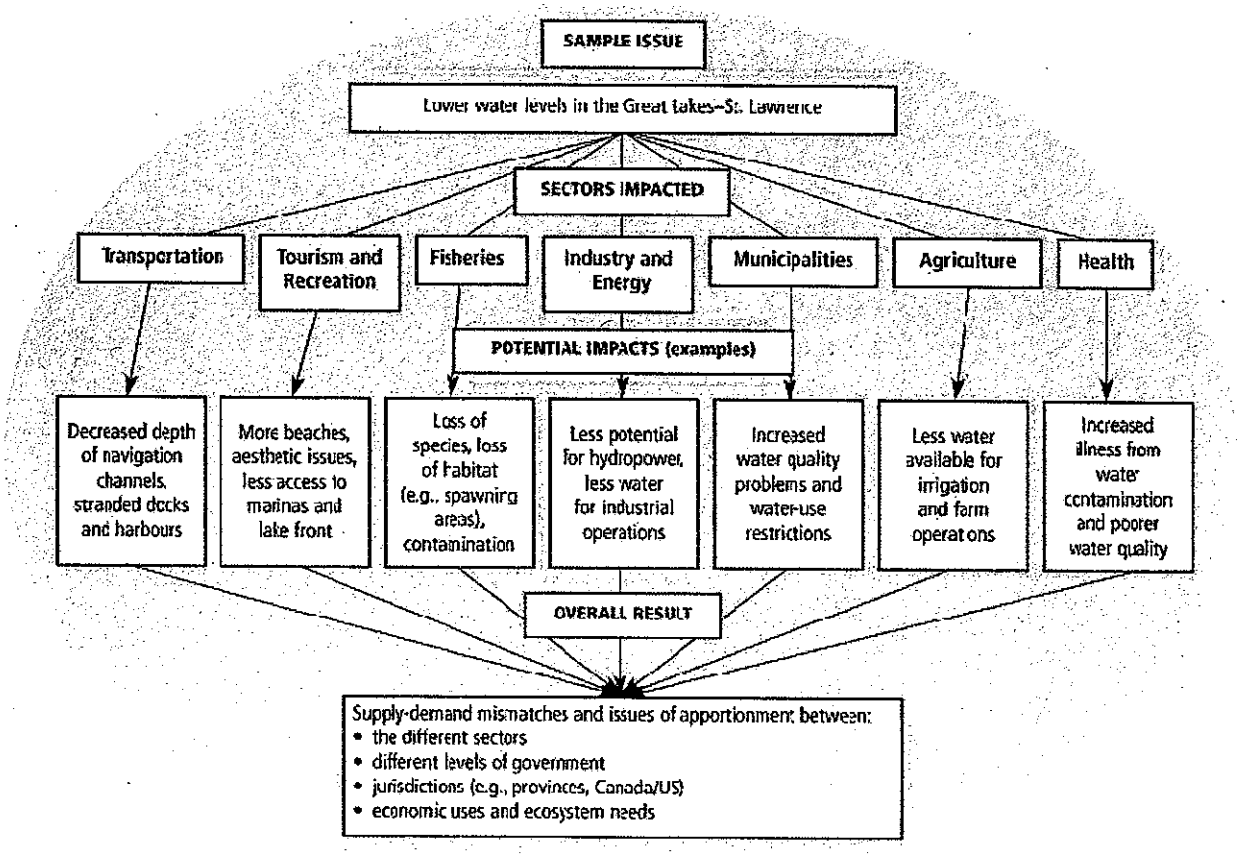
- Intense rainfalls estimated at or above the 1:50 year climate normal return frequency
  - Westside flooding in 2007. Anecdotal evidence and numerous reports estimated that 100 mm of rain fell in less than an hour.
  - June 5 & 6 2010 flooding. Approximately 90 mm of rain fell in 4 hours
- 2011: Windsor's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

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



Source: Lemmen and Warren, 2004[ix]

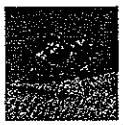
Some economic losses associated with a decrease in lake levels are easily calculated. For a 2.5 cm lowering of Lakes Michigan-Huron, cargo ships must reduce loads by 90 to 115 tonnes worth approximately $25,000 US per trip[vi]. Based on historical water level changes, it is known that hydroelectricity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

Climate Change Impacts

Current Impacts

2002

- Emerald Ash Borer is first discovered in Windsor
- More than 6,500 street trees were affected with thousands more in parks and on private property
- $4.1 million in costs to remove and replace the trees.



2002

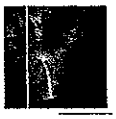
- West Nile Virus
- 38 human cases of West Nile virus detected in Windsor-Essex.

2004 - 2005

- Windsor - Ontario's New Snowbelt
- From November 2004 thru April 2005, Windsor received 225.5 cm of record breaking snow - about 100 cm more than normal.

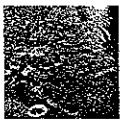
2005

- Summer 2005 - Hottest summer on record
- 47 days over 30 C
- 39 days under a smog advisory



2006, 2007, 2010

- Intense rain fall events
- 2006, 2007, 2010 and 2011 all experienced extreme rainfall events exceeding the historic 1:50 year storm return rates



2011

- Wettest year on record
- Windsor received 1568.2 mm of rain in 2011 compared to the average 844 mm.

Potential Impacts

Through consultation with all City departments and some City agencies, a list of over 250 potential impacts were realized. To focus the efforts, each department was asked to look at all of their potential impacts and determine which two to four potential impacts would present the most significant challenges. 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.

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. The ICLEI initiative interprets 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.

On January 23, 2012, City Council approved the development of a corporate wide Climate Change Action Plan with a focus on impacts with a medium-high risk or above. Therefore, the focus of this adaptation plan is on the following five potential climate change 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.

Though the focus of this plan is to minimize these five potential impacts, it is important to be aware of the other potential impacts discussed at the meetings. Having an understanding of all the potential impacts will ensure that an adaptation measure for one potential impact does not negatively affect another potential impact. At the same time, some adaptation measures may provide resiliency for more than one potential impact. Though the majority of the potential impacts discussed were negative, it is important to consider the possible advantages that may occur under a changing climate.

Additional Potential Impacts of Climate Change in Windsor: At a Glance

Projected Climate	Potential Negative Impacts
Increase in Average Temperature	• Increased opportunity for invasive species • More opportunity for vector borne diseases (West Nile, Lyme disease) • Increased demand for active transportation options
Increase in Winter Temperatures	• Increase in freeze/thaw cycles damaging roads, increasing winter control • Reduced ability to maintain outdoor ice rinks
Increase in Summer Temperatures	• A shift in physical activities to indoor venues • Decrease in air quality/increase in the number of smog days • Increased demand for electricity • Increase risk of brown/blackouts due to the demand for electricity • More rapid deterioration of infrastructure • More premature equipment failure • Increase chance of food-borne illnesses
Increase in Annual Precipitation	• Increase in plant growth • Increase risk of flooding to basements, roads and other infrastructure • Increased risk of erosion of stream banks, drains • Increase costs for storm water management
Increase in Winter Precipitation	• Increase risk of ice damage to urban forest • Increase in winter control costs • Increased risk of winter flooding/ice jam related flooding
Decrease in Summer Precipitation	• More stress/failures among tree plantings • Increased need for irrigation • Decrease in aquatic habitat
Increase in Frequency of Extreme Weather	• Increase risk of flooding (basement, road, stream) • Increase flooding of sport fields requiring closure • Damage to existing tree cover • Increase demand for emergency services to respond to extreme events • Increase in combined sewer overflows or waste water bypasses
Increase in Surface Water Temperatures	• Increased opportunities for invasive aquatic species • Decrease in surface water quality (more algae, e-coli) • Increase in shoreline erosion
Decrease in Great Lakes Levels	• Possible loss of access to marinas • Increased erosion • Undermining of shoreline protection structures, exposure of outlets

Projected Climate	Potential Positive Impacts
Increase in Average Temperature	• More opportunities to participate in active transportation or outside recreational activities
Increase in Winter Temperatures	• Reduced heating costs • More moderate winters, more attractive for retirement
Decrease in Summer Precipitation	• Increased opportunities for use of solar power technologies (streetlights, parking meters)
Increase in Surface water temperatures	• Increase in water recreational opportunities

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.

Downpout Disconnection

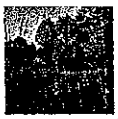
- Disconnecting downspouts reduces the amount of stormwater entering the sewer system reducing the risk of combined sewer overflows and basement flooding.

Basement Flooding Protection 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_2 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.

Proposed Adaptation Options

The anticipated changes in climate that garnered the most concern to the City of Windsor were: increase in precipitation (especially the increase in frequency of extreme precipitation events), and the increase in extreme summer heat events. The table below summarizes the proposed short-term adaptation actions. 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.

Adaptation Actions	Anticipated Benefit	Co-Benefits
Mandatory Downspout Disconnection	Reduce flooding, and pressure on storm water and sanitary sewer systems, reduces number of treatment plant overflows	Improved storm water quality
Mandatory Backwater valves	Reduce the risk of basement flooding to individual homes	
Development of a Green Roof Policy	Reduction in storm-water runoff, improved stormwater quality	Mitigation of the Urban Heat Island Effect and reduces summer air conditioning demand (Climate Change Mitigation)
Develop pilot projects for the use of Porous Pavement on City properties and develop guidelines for use in development	Reduction in storm water runoff and flows to the waste water treatment plant	Improved storm water quality
Installation of Rain Gardens as a pilot project to determine effectiveness	Reduction of storm water runoff and temporary storage for larger events	Improved storm water quality
Enhance Sewer Maintenance & CCTV Program (camera inspections of sewers)	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
Consideration of additional Off-Line Storage for Stormwater	Reduce the risk of basement flooding	Reduce the amount of combined sewer overflows
Increase the Use Flow Restrictors on Catch basins	Reduce the risk of basement flooding	
Seal Manhole Covers	Reduce the risk of basement flooding	
Update of the rainfall intensity duration (IDF) Curves	Improves ability to design storm drainage infrastructure for extreme runoff events, reduces future City maintenance costs	
Initiate flow monitoring of priority sewers	Enhance the resiliency of the sewer system and improve	

	assessment of risk to flooding	
Improvement and Enhancement of Green Space to improve rain water retention	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
Undertake Public Education on Sewer Use, Waste Water Treatment	Enhance the resiliency of the sewer system as the public understands their impact on the system	
Targeted Education towards homeowners with suspected cross-connections to sanitary sewer	Direct engagement with the public to increase individual resiliency to basement flooding	
Use Social Media and other Communication tools to warn public of Risk of Basement Flooding	Direct engagement with the public to increase individual resiliency to basement flooding	
Increase Tree Planting	Reduced Urban Heat Island Effect	Reduce storm water runoff, improved quality of life for the residents of the City
Increase Capital for Shade Structures	Decreased risk of heat illness in Windsorites and visitors	
Increase in Heat Education at Community Centres and Pools	Increased awareness of heat-health risks which increases the resiliency of individuals	
Complete an Urban Heat Island Study	Identification of Windsor's 'Hot Spots' and their causes as well as the prioritization of actions to reduce them	Reduced heat-health vulnerability
Develop Clear Policies for Weather Response	Increase resiliency of departments to respond to major events	
Creation of an Extreme Weather Fund Reserve	Minimize the impact to annual operating budgets	
Enhanced Maintenance & Inspection of roads and sidewalks during snow or extreme weather events	Reduced liability	

Note: Each of these adaptation options are outlined in more detail in Appendix A ***(Not included as part of draft plan)***.

Proposed On-going Climate Change Adaptation Strategy

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. 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.

Conclusions

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 required to minimize the extent of future climate change impacts.

[i] Climate Ready Ontario's Adaptation Strategy and Action Plan, 2011 - 2014

[ii] Canada. National Round Table on the Environment and the Economy. (2011). Paying the Price: The Economic Impacts of Climate Change for Canada

[iii] Intergovernmental Panel on Climate Change, (2007b). Summary for policymakers. In S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, et al. (Eds.). *Climate change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 1–18). Cambridge, : Cambridge University Press.

[iv] 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

[v] Berry, P, et al. (2011) "Assessment of Vulnerability to the Health Impacts of Extreme Heat in the City of Windsor".

[vi] 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.

[vii] 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 21st Century", November 2006.

[viii] 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.

[ix] Lemmen, D.L. and Warren, F.J. (2004): Climate Change impacts and adaptation: A Canadian Perspective; Government of Canada.

ENCLOSURE
ITEM NO. 1

WINDSOR

THE CORPORATION OF THE CITY OF WINDSOR

Public Works – Pollution Control

AUG 29 2012

Memo

CITY OF WINDSOR
COUNCIL SERVICES

AUG 23 2012

RECEIVED

To: Environment and Transportation Standing Committee

From: Environmental Coordinator

Date: August 20, 2012

Subject: Supplemental Information on Draft Climate Change Adaptation Plan

In mid July, the Draft Climate Change Adaptation Plan was circulated and posted to the City of Windsor website to allow for public comment on the draft plan.

As outlined in the report to the Environment and Transportation Standing Committee (LiveLink # 16035), the draft plan was posted under both the Standing Committee and Environmental sections of the City's website. Public notice in the Windsor Star was also completed by Council Services.

As outlined in the report, Dr. Gordon McBean attended the first public event on August 16th at the Ojibway Nature Centre. This event was well attended with approximately 45 people in attendance. Dr. Mc Bean provided a 45 minute presentation and remained at the centre for over an hour addressing the comments and questions posed by the audience. The level of interaction and interest from this group was excellent.

On the weekend of August 18th and 19th, a booth display was exhibited at the Devonshire Mall which attracted interest and questions from visitors at the mall.

To encourage review of the draft plan, posters of the public events were distributed at community centres, libraries and other facilities across the City. A YouTube video was also completed and posted to the City of Windsor's Facebook page. The media also assist with getting the message out about the draft plan, with coverage provided by AM800, CBC radio, CTV, Windsor Star and OurWindsor.ca.

Attached to this memo are the comments received as of August 20. Some of the comments received will be addressed through the incorporation of the detailed appendices. An example of an appendix is included in this memo (Porous Pavement).

In addition to the comments, the public was encouraged to contribute suggestions to the naming of the plan. The following is a list of the suggestions to date;

- Thriving and Surviving: Windsor's Climate Change Adaptation Strategy

- Ours to Preserve & Protect
- Circumventing the Future
- Conquering the Climate
- Weathering the Weather
- Triumph over Climate
- Surviving the Forecast
- Weathering the Storm
- Rough (Sweetwater) Seas Ahead
- Sweating the Details: Windsor Change Adaptation Strategy
- Windsor Green Climate Plan
- The Windsor Climate Sustainability Plan
- Windsor Weather Fix

It is recommended that the finalized version of the climate change adaptation plan will include some of the comments and recommendations received during the comment period and that the final report will come back to the committee for endorsement and adoption by city council.

Karina Richters
Environmental Coordinator

Mike Palanacki
Executive Director - Operations

Mario Sonego
City Engineer and Corporate Leader –
Environmental Protection and
Transportation

Attachments: Public comments
Pilot project for the use of porous pavement

KR/jc

To: Karina Richters
From: [redacted]
Date: July 23, 2012
Re: **Comments on Windsor's Draft Climate Change Adaptation Plan & Suggested Name for the Plan**

Suggested name for the plan: ***Ours to Preserve & Protect***

SUGGESTED REVISIONS FOR CONSIDERATION

A. ADDITION -- ***Foreword by Mayor Francis*** to communicate to the people of Windsor, in his own words, the significance that he personally attaches to climate change adaptation. The Mayor should be out front and centre to this initiative.

B. ADDITION -- ***Executive summary*** – for readers who don't have the time or interest to read the entire report, at least give them a summary of the core ideas. Who knows, they may be hooked to read selectively if not the complete report

C. ADDITION -- ***Table of contents*** – to powerfully communicate in one page the main headings, subheadings and logical structure of the plan. Effective ToC's have the power to hook readers.

D. ADDITION -- ***Context and Purpose*** – A brief section of no more than 500-600 words.

The Context part should be no more than 300 words including, for example:

- emphasis on the man-made origins of climate change;
- the irreversible impacts even with emission reductions;
- the need for us to come to grips with the reality of the threat;
- why we have to pursue both mitigation ***and*** adaptation;
- reference to conclusions drawn from of one of two major authoritative reports on the environmental and economic risks to society if we fail to address the problem;
- a couple of sentences to explain in very general terms why Windsor is developing this climate adaptation plan; and
- the period of time during which the plan will be relevant to the risks we face, emphasizing the cost-effectiveness of the actions that will be taken to minimize risks and maximize opportunities.

The Purpose part should also be no more than about 250 words, including, for example –

- the overall aim of Windsor's adaptation strategy
- the aim might be described generally as "climate-proofing" the city and defined specifically in terms of the roles the city would play in doing this; e.g., research and monitoring to help in the formulation of climate change policies and actions; climate-proofing its policies, practices, assets, infrastructure; working in partnership with others to assist them in addressing climate change (e.g., City departments, utility and service providers, public sector bodies, businesses, residents, and so forth)

E. ADDITION – ***Vision*** – A succinct vision of what a well-adapting city looks like is essential because it will enable readers to see the logical connection among the component elements -- the problem, the strategy and goals, the plan, and the expected outcome or vision.

F. REVISION – Change the heading on page 2, "***Climate Change Impacts: Current Impacts***", to ***Summary of Expected Climate Changes in Windsor*** and revise and shorten the content. As it is now, the content of pages 2 through 11, takes up half of the 19-page report. Much of it is not directly specific to Windsor, and many of the graphs and tables, if needed, could be moved to the Appendices.

Under the revised title, "***Summary of Expected Climate Changes in Windsor***", summarize Windsor's expected climate changes along the lines of the following. The brevity is intended to reflect that the focus of this report is not about climate change per se, rather it is about Windsor's planned ***adaptation*** to

climate change. (Note: the following summary is provided solely as an example and does not necessarily reflect Windsor's situation).

- hotter, drier summers
- milder, wetter winters
- more frequent extreme high temperatures
- more frequent heavy rain downpours
- significant decreases in soil moisture content in summer
- possible higher wind speeds
- overall decrease in water levels in the Great Lakes

G. REVISION – Change the headings on page 12-14, ***Climate Change Impacts / Current Impacts /Potential Impacts***, to ***Summary of Associated Risks and Opportunities driven by Climate Change.*** As reflected by the revised title, instead of organizing the content on pages 12 through 14 under Climate Impacts, rearrange them under the identified associated Risks and Opportunities posed to the City. This has the advantage of *contextualizing* the impact of climate change by relating it to the kind of adaptation that will be required to address it. In this way the report places the focus squarely on ADAPTATION and not climate change. Here's an example drawn in large part from the current table on page 14:

- Managing health risks
- Managing biodiversity risks
- Managing transportation risks
- Managing parks and recreation risks
- Managing energy demand risks
- Managing flood risks
- Managing risks to regional plants and forests
- Managing risks to wildlife habitat
- Managing risks to potable water resources
- Managing heat and air pollution risks
- Managing ground conditions
- Managing river and lake risks
- Managing economic risks to city governance and local businesses
- Managing risks to residential and business buildings
- Equipment maintenance risks
- Cross-cutting issues – Why act now? What actions are already underway locally, regionally, provincially and nationally? What further actions are recommended?
- Opportunities (e.g. more moderate winters -- reduced heating costs, attractive to retirees)

H. OPTIONAL ADDITION (for body of report or Appendix) -- ***Overview of the City of Windsor*** – To provide readers with an appreciation of the size and scope of the City's responsibilities, present a broad overview (500 words maximum) of the major services, facilities, infrastructure provided and managed by the City, properties it owns and manages, city population, and the like. (Presuming that Windsor residents are among the report's target audience, a brief city overview would be highly relevant. If not included in the body of the report it could be made available in the Appendices).

I. OPTIONAL ADDITION (for body of report or Appendix) -- ***Adaptation Planning Model*** -- Clarify at the outset the primary adaptation planning model by which Windsor will Build Adaptive Capacity. Clearly identifying the components of an adaptive model will strengthen readers' confidence in the rigor of the planning process and the scholarship of the report. (Building Adaptive Capacity describes many of the adaptation responses that the central authority (i.e. Windsor City) and its local partners will undertake. New project management systems need to be put in place, data on future climate will need to be assembled and shared, research commissioned, training and member / staff development provided. All these activities can be seen as Building Adaptive Capacity).

Adaptation actions typically include --

- *Organizational change and leadership* -- One of the greatest challenges in preparing to adapt to climate change is building the organizational capacity to adapt to the impacts of climate change. When getting started local authorities need to engage others, identify resources and undertake a high level stock-taking of current policies and plans
- *Assessing current and future risks* -- Undertaking a risk-based assessment of significant climate change risks, vulnerabilities, impacts and opportunities is critical to identifying priorities for adaptation. Planners are initially expected to understand the current vulnerability to climate change; identify potential future impacts; ensure senior managers are prepared to address them; and prepare to develop and maintain a monitoring system. At a later stage, responsible agents should have undertaken a comprehensive assessment of climate threats and opportunities and identified priority risks.
- *Local Strategic Partnerships* (LSP) and community engagement – The city should start working early on with their Local Strategic Partners (LSP) to identify major weather and climate vulnerabilities. LSP partners should be encouraged to undertake risk-based assessments and ensure that partner organisations are managing climate change risks across the zone of responsibility. In addition, local authorities are likely to find that engaging with the local community and the LSP is critical to the process.
- *Early implementation of adaptation actions* – Some LSP's may begin to deliver some adaptation actions before they have developed an Adaptation Action Plan, even if these actions have not been formally identified as priorities. Eventually, partners will be expected to begin to implement some priority actions and move on to implement adaptation responses to priority issues.
- *Strategy and action plan development* -- Developing a comprehensive adaptation action plan is a key output of the process. Windsor needs to create an outline project plan, one that **expresses a vision for a well-adapting local community**, identify and prioritize adaptation actions, develop a comprehensive action plan and ensure that climate change impacts and risks are embedded into all decision-making. Local authorities and their partners are likely to be at different stages of the process, and to have approached strategy development in different ways.
- *Monitoring, review and ongoing evaluation* -- Continual monitoring and regular review are essential to any process. Arrangements for monitoring new risks and the effectiveness of adaptation levels are required, while robust systems for monitoring, reporting and review are essential. Central authorities typically use a range of tools to assess the risks to future plans and projects, such as their corporate risk registers and sustainability appraisal.

J. OPTIONAL ADDITION (for body of report or Appendix) -- ***Key ingredients for progress*** -- While the adaptation actions may vary considerably across communities, most share some common factors such as those listed below. These important ingredients should be made more explicit and given higher profile in the report

- *Leadership* -- Leadership at all levels is critical to building adaptive capacity
- *Raising awareness* -- One of the first steps for building adaptive capacity within local authorities, partnerships and individuals is to raise awareness of the impacts of climate change and the implications for local services and communities of the need to adapt to climate change.
- *Engaging and working in partnership* -- To build the adaptive capacity of the local area, local authorities cannot work alone; working in partnership with other organisations is critical. Early engagement of partners is essential to success.
- *Embedding climate change in decision-making* -- Embedding climate change in council and local area decision making is a sure way of creating the mandate for future action.
- *Resourcing action* -- Planning to adapt to climate change requires resources. Councils and LSPs that don't have the human resources to carry out an ambitious plan will either have to scale back or be creative in finding additional resources.
- *Delivering wider mitigation and sustainability benefits* – Ideally, climate change adaptation should take place within the context of sustainable development. Climate change adaptation can deliver wider benefits, including, for example: reducing health inequalities; greater public safety; reduced damage costs; new job opportunities; improved local business protection; enhanced protection of local inhabitants and biodiversity. Highlighting linkages between adaptation and mitigation can be particularly important. The two aspects of action on climate change can be mutually reinforcing: adaptation work raises people's awareness of the realities of climate

change, which can be a spur to action on mitigation; and mitigation actions are needed to give credibility to an area's commitment to acting on and preparing for climate change.

K. OPTIONAL ADDITION (for body of report or Appendix) -- ***Definitions of key terms***, especially – "adaptation", "mitigation", "sustainability" and "resiliency". Don't presume that readers know their meanings.

Richters, Karina

From: Richters, Karina
Sent: August 1, 2012 8:50 AM
To: EMP
Subject: FW: Comments on Draft Climate Change Adaptation Plan

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From: [redacted]
Sent: July 31, 2012 1:55 PM
To: Richters, Karina
Cc: Halberstadt, Alan; Dilkens, Drew
Subject: Comments on Draft Climate Change Adaptation Plan

Dear Karina:

Thank you for sharing your Draft Climate Change Adaptation Plan. Municipalities are in the front lines in experiencing, and in helping to mitigate, the worst effects of climate change. They can either play a passive role – responding only when confronted with a crisis situation – or they can prepare to minimize the harm to the community and its residents. Personally, I expect the latter.

As the past author of numerous publications for the Federal Government, I know how difficult it is to produce a clear, punchy, readable, and persuasive document. I am providing some thoughts on the format and content of your document, hoping that you may find them helpful.

1) **Title:** *You may consider using a title such as:* ***Thriving and Surviving: Windsor's Climate Change Adaptation Strategy****. Unless you are including the types of details that normally constitute a plan - such as clear goals and objectives; timeframes; assignment of responsibilities; indicators; and reporting mechanisms – you are probably producing a strategy at this point.*

2) **Executive Summary**: *You may consider starting with a one-page Executive Summary, which would help people to determine if they were sufficiently interested to continue reading the details. The Executive Summary should cover the key points in your document. At present, I would identify these as:*

   - Even if global Greenhouse gas emissions are reduced, those currently in the atmosphere will continue to produce changes in climate and weather patterns, posing risks to life, property and the natural world.
   - Because of Windsor's location and geography, Windsor is expected to experience more extreme heat, drought and severe storms than other major Ontario cities
   - Windsor is already experiencing an increase in extreme weather events: an increase in the number of hot days above 30 degrees C; intense, short duration rainfalls which resulted in flooding in 2007 and 2010; the wettest year ever on record in 2011; the hot, dry conditions of the summer of 2012.
   - These changes in climate and weather patterns pose risks to people, vegetation, infrastructure and the local economy. Consequences can include an increase in the number of heat-related deaths; new insect pests; new invasive species; new diseases; reduced crop yields; lower water levels in the Great Lakes, reducing cargo capacity and stranding docks; warmer water temperatures, threatening the commercial fishery; problems with water quality and availability for human and agricultural use; disruptions to the electrical grid; more flooding of basements, roads and other infrastructure; undermining of public and private infrastructure; a potential lessening of tree cover as current tree species struggle to adapt.
   - Climate change will add significant costs to services provided by the City of Windsor and its agencies. Merely responding to crises as they occur will be more expensive, and will place residents at greater risk, than taking immediate action to adapt to climate change.

- Windsor has instituted some programs that increase its resiliency to potential climate changes, such as the downspout disconnection program, the basement flooding protection subsidy program; the Heat Alert and Response Program; the phased implementation of the Bicycle Use Master Plan; a by-law to protect trees on City property and greater diversity of stock trees; and the availability of District Energy in the Downtown Core.
- However, these programs are not sufficient to meet the challenge of increased extreme summer heat and precipitation. This document proposes short-term and longer term adaptation actions by the City which build on current programs and suggests some new initiatives which will reduce flooding, reduce storm-water runoff; enhance the resiliency of the sewer system; reduce the Urban Heat island Effect; and decrease the risk of heat illnesses and death.
- The success of the proposed initiatives will depend on a comprehensive public education program to ensure residents' buy-in as well as buy-in by all levels of our municipal government and its agencies.

3) **Why is Adaptation Required**? *I would keep this section short, moving definitions (such as the one for "significant natural disaster") and most charts, graphs and explanations of studies to footnotes at the bottom of the page or into an appendix. Too much detail can obscure your main points, and interrupt the continuity of your ideas. The main points I would select from your text are the following:*

a) We cannot halt the progression of climate change and its destructive consequences. This is because the greenhouse gases released decades ago (especially carbon dioxide) which are warming the earth's atmosphere today, will take many years to leave the atmosphere. *[footnote]* So even if globally, greenhouse gases due to human activities could be eliminated, those currently in the atmosphere will continue to produce unwanted changes. *[footnote]* If the production of greenhouse gases is not curtailed dramatically, climate change will only accelerate and become ever more destructive. *[footnote]*

b) In Canada, climate change is responsible for an increase in the frequency of "significant natural disasters" since 1900. *[footnote]*

c) Quite apart from the human toll, it is very costly for governments to respond to extreme weather brought by climate change. For example, based on a 2006 study, Ontario can expect annual costs of about $5.66 billion dollars to respond to extreme weather brought about by climate change. *[footnote]* A 2011 report by the National Round Table on the Environment and the Economy expects the costs of climate change for Canada to escalate over time from an average of $5 billion/year in 2020 to $21 to $43 billion per year by 2050, depending on the level of Global emissions.*[footnote]*

d) Not only is it cost effective to take proactive measures now to reduce the impact of climate change, such measures can help our residents and communities to survive and thrive in these challenging times.

4) **Windsor's Changing Climate**:

This is where you sell your adaptation plan. People can easily tune out what is happening globally and nationally; it is what touches them personally that gets their attention. You must impress on your readers that Windsor is already experiencing significant impacts due to climate change and that these impacts will only get worse. Avoid technical jargon – e.g. "excess mortality; insect vectors – save it for the footnotes. Use language that is meaningful to people. Use a consistent format – e.g. what is happening; why should we be concerned. I have reworked some of your text to give you an idea of what I mean.

a) Windsor's Location

I would start this section with a short summary of why Windsor is at particular risk, compared to other Ontario cities. Here is an example of some points you could make, and a suggested reworking of some of your text:

As the southernmost city in Canada, Windsor is at greatest risk from increases in summer heat and humidity. Windsor is also in the direct path of dirty air from USA industries (e.g. Ohio) which, when combined with hot, stagnant air masses, results in smog advisories. To add to the mix, Windsor is at the tail end of "tornado alley" and, as the incidents of severe storms increase in the southern USA, Windsor can expect to experience ever-increasing, ever more intense storms. Windsor cannot change its location, but its municipal government and agencies can prepare to temper the worst effects of these life-threatening changes.

b) **Windsor's increasing temperature**:

Since 1940, Windsor's average annual temperature has increased by almost 1 degree C. Such a seemingly minor change has a significant impact, since it results in more "hot" and more record "hot" weather with less cold weather. A study conducted by the Canadian Regional Climate Model predicts that the number of days over 30 degrees C/86 degrees F in Windsor could increase to:

35 from 2011 - 2040

47 from 2041 – 2070

63 from 2071 to 2100 *[footnote]*

Of the seven Canadian cities analysed, Windsor was expected to show the greatest increase in the number of hot days above 30 degrees C and warm nights above 22 degrees C.

Why should we be concerned?

This increase in average temperatures allows for the survival of invasive species, the expansion or introduction of insects that carry disease (e.g. West Nile; Lyme disease); an increase in "heat alert" days and increased evaporation of surface waters. There is a strong association between temperature increases and deaths in vulnerable populations. At approximately 29 degrees C/84 degrees F, the number of such deaths begins to increase.*[footnote]*

c) **Windsor's increasing annual precipitation:**

As air temperature increases, so does the capacity of the air to hold more water, leading to more intense rainfalls. Since 1970, there have been increases in the number of heavier, short duration rainfalls (24 hours or less) in southern Ontario. *[footnote]* The Ontario Disaster Relief Assistance Program has provided over $60 million since 1998 for flood relief, due to an increase in the number of significant urban flooding events, including floods in Peterborough, Ottawa, Sudbury, Hamilton and Toronto.

In recent years, Windsor has experienced an increase in the number of intense rainfalls that are characterized to occur "once in fifty years". *(Statistics?)* Examples are: the Westside flooding in 2007, in which it is estimated that 100 mm of rain fell in less than an hour and the June 5-6 2010 flooding, in which approximately 90 mm of rain fell in 4 hours.

In addition to periods of intense rainfall, Windsor experienced its wettest year ever on record in 2011, with 1568.2 mm of rain compared to the average annual rainfall of 844 mm. *(What about snowfall – is this included; can it be separated?)* The spring of 2012 also broke rainfall records *(details?)*

Why should we be concerned?

Sudden, intense rainfalls increase the risk of flooding for basements, roads and other infrastructure; hasten the erosion of stream banks and drains; undermine municipal infrastructures; discharge untreated waste directly into the Detroit River, Lake St. Clair and Lake Erie due to combined sewer overflows or waste water bypasses; increase the costs of storm water management and the risk of water-borne diseases. In winter, an increase in precipitation can lead to ice damage to the electrical grid and to urban forests, add to the risk of winter flooding and increase the costs of winter control measures (salting, sanding, snow removal).

d) Rising surface water temperatures and Great Lakes Water Levels

(As per your text. To keep the same format, the section on page 11 could be entitled Why should we be concerned? Your verb, "may impacted" should be corrected to "may impact". You should delete the box, "Sample issue", since the specific issue you are dealing with is identified.)

5) **Climate Change Impacts:** *You could change the heading to "Examples of Climate Change Impacts" since you are only mentioning selected examples. They are not "Current impacts", as most of them are in the past.*

6) *The next section (pages 13-18) proved to be very confusing.*

The section about what Windsor is already doing is informative, but doesn't tie in to the above.

If I were writing this, I would reorganize as follows:

7) **Towards the development of a Climate Change Strategy (***Call it a Plan, if it truly is one....)*

a) What Windsor is already doing *(Your page 15)*

b) **City Council Direction** *(Details of the date and resolution.)(Did City Council identify the five "potential climate change impacts", or did these come out as a result of your consultation exercise? Depending on the answer, the 5 impacts will be listed here, or in the next section.*

c) **Internal consultations** *(Your first and last paragraphs on page 13, omitting the word "five" in the first line of the last paragraph; move the definition of risk to a footnote. Your page 14, or move it to an appendix.)*

8) **Proposed Climate Change Strategy:** *It's going to be tricky to organize this section because you are dealing with:*

a) Five potential climate change impacts that the Plan is designed to address;

b) Two priorities – increased precipitation and heat;

c) Short term and long term actions.

If it were my text, I would do the following:

- *Lead in by explaining that further to Council's direction to focus on impacts with a medium high risk, the focus of the adaptation strategy is to minimize the following five potential climate change impacts (list them).*

- *I would then explain that responding to the challenge of increased precipitation and heat was identified as the highest priority (your first sentence, page 16.) You could also mention that reducing the impact of these risks will also have the added benefit of reducing operating/maintenance demands, and other areas of Operations, as Windsor will be better positioned to withstand climate extremes. In the co-benefits section of your chart, you could integrate comments about curtailing costs.*

- *You will have to somehow integrate the Development policies impact – your section at page 18(items 1and 2) deal with this. Is this a long term objective? I hope not!*

- *I would group the proposed adaptation actions under the two priority risks: Reducing Risks associated with increased precipitation; Reducing risks associated with increased heat and, if possible, separate actions out as short-term; long- term or ongoing.*

9) **Continual improvement of the Climate Change Strategy** *I suggest you change your heading at page 18, as in this section you are dealing with continual updating as circumstances change.*

10) **Conclusions** *As per your text.*

Other suggested actions *Some actions you may want to consider adding to the strategy:*

Reducing Risks associated with increased heat:

- *Reserve a portion of each of the 18(?) parks identified for disposal and plant diverse tree species adapted to the new climate conditions to form an urban forest in these spaces – will reduce the "heat sink" effect; will not require maintenance, other than watering of trees until established.*

- *Identify a "cooling centre" in each Ward (e.g. the Community Centres) and stock these centres with basic materials (e.g. water bottles) for use during heat advisories; publicize the location of these centres on the City's website and in community notices. Offer free public transportation to these centres.*

- *Develop a comprehensive plan to deal with a longer term power outage (e.g. more than 2 days) during a heat advisory, storm aftermath or ice storm aftermath and publicize this plan widely.*

- *Ensure that the City's stock of public housing is adequately equipped for heat emergencies.*

- *Plant a demonstration xeriscaping landscape in a public park (e.g. Jackson Park; waterfront) and use drought-resistant, slow-growing grasses for over seeding public parks or when establishing new parkland. (Will reduce maintenance costs as well as the need for watering.*

- *Prepare a checklist for developers, indicating how to be sensitive to climate change in their site selectio and layout; use of building materials; design elements; landscaping; pavement choices; decisions re:*

heating and cooling; provision of public spaces, sidewalks and trails, etc., thereby reducing the "heat sink" effect of new housing developments, and lessening the risks of flooding during severe storms.

Long-term:

- *Offer incentives (e.g. reduced development fees) to a developer who is willing to build a demonstration model development that showcases many of the suggestions in the checklist for developers as per above.*

Richters, Karina

From: [redacted]
Sent: August 10, 2012 6:18 PM
To: EMP
Subject: re: Windsor Climate Plan

Hi,

I don't have a name for the plan, but I do have some suggestions:

1. Plant more trees. Compared to cities like Ottawa, Windsor is a barren cement pad.

2. Improve the bus system so people drive less, which will help cut down on our infamous smog.

3. Create a property owner garden incentive to encourage people to grow flowers and vegetables instead of grass, which will not only make properties look better, but will also increase the amount of oxygen in the air.

Thanks,

[redacted]

City of Windsor
Environmental Action Plan

- Create city jobs ~~that~~ with the purpose of determining the level of pollutants released by the city's industrial sector. Set limits on acceptable levels of pollutants. Set those limits and enforce them.

- Set limits on when + for how long people can water their lawns.

- Increase usage of rain barrels + encour gardeners + lawn-maintainers to water usin that

- Invest in solar power; car charging stati

- Allott funds for community-based solutio to community problems

"Green Roof Policy"?
"Rain Gardens"

- Increase green spaces

- Municipalities should consider an environmental cost when selling open fields for things like shopping malls, + charge MORE

Richters, Karina

From: [redacted]
Sent: August 20, 2012 8:35 PM
To: EMP
Subject: EMP

I just became aware of today's deadline for submissions. Here are some additional thoughts for adaptation measures:

Building code:
New residential and commercial/industrial buildings should have cisterns for rain water collection to be used for irrigation and uses like flushing toilets.
Much stricter insulation ratings to reduce the energy need for both heating and air conditioning. Mandatory wind turbines or solar panels for commercial/industrial buildings, as well as green roofs.

Drinking water: Lake Erie or Lake St. Clair may not be reliable sources for drinking water in the future (increased algae bloom with higher toxic contamination). Alternative sources may have to be found (i.e. aquifers).

Public awareness: i.e. the need to protect our lakes: Each storm sewer access point should have a little plaque next to it, reminding people that whatever goes into the storm sewer ends up in the lake.

[redacted]
Kingsville
[redacted]

Richters, Karina

From: [redacted]
Sent: August 20, 2012 11:20 PM
To: EMP
Subject: comments

Hi,
I-didn't-get-a-chance-to-read-the-plan,-but-did-attend-a-meeting-where-I-got-an-overview.-I-just-would-like-to-add-that-maybe-when-the-city-does-the-downspout-disconnection-programme-discounts-could-be-offered-to-those-that-would-like-to-install-a-rainbarrel-system,-as-this-would-be-an-opportune-time.
Green-spaces-should-be-preserved.-Alternatives-to-grass-could-be-introduced-to-cut-down-on-the-costs-and-emissions-of-mowing.-Eco-grass-would-be-once-such-possibiiity.
Thankyou.
[redacted]

Richters, Karina

From: [redacted]
Sent: August 20, 2012 11:23 PM
To: EMP
Subject: Climate Change Adaptation Plan Comments

Greetings:

Suggested name: The Windsor Weather Fix

The Climate Change Adaptation Plan that was presented at the Ojibway Nature Centre was very informative. I am pleased to see the City of Windsor taking the initiative to educate and provide solutions to it's citizens. Personally, I viewed the research data as very unsettling but found comfort in the fact that the City is taking steps to circumvent problems that may arise. Although, I believe it is important that additional measures be identified to mitigate risks based on unfavourable extreme weather data. Citizen awareness and climate change pro-activeness will largely depend on strong leadership and a clearly defined goal. And, each of us has the ability to do our share.

Take care,
[redacted]

DEVELOP PILOT PROJECTS FOR THE USE OF POROUS PAVEMENT ON CITY PROPERTIES AND DEVELOP GUIDELINES FOR THEIR USE IN DEVELOPMENT

DEPARTMENT	ADAPTATION TYPE	DRIVER	FUNDING SOURCE
☐ Engineering ☐ Planning ☒ Pollution Control	☐ Building Adaptive Capacity ☒ Delivery of Adaptation Options	☐ Reactive ☒ Anticipatory	☐ Municipal ☐ Provincial ☐ Federal ☐ Private

CONTEXT

Within the City of Windsor, climate change is expected to result in increased precipitation as well as the increased frequency of extreme weather. Due to these potential trends, the City's stormwater management approaches and infrastructure may not be sufficient to handle significantly greater quantities of stormwater. The City's current approach to stormwater management utilizes grey infrastructure. When using a grey infrastructure approach, stormwater is transported quickly and directly along hard surfaces into a municipality's storm sewer system. Furthermore, stormwater issues are typically addressed through hard infrastructure improvement projects such as sewer upgrades, or downspout disconnection programs. However, by utilizing green infrastructure techniques such as porous pavement, cities can address issues related to stormwater quantity and quality.

Porous (permeable, pervious) pavement contains void spaces that allow precipitation and stormwater runoff to infiltrate, become stored within subsurface layers, and exfiltrated beneath the earth's surface (Scholz & Grabowiecki, 2007). A variety of material options exist to construct permeable pavement surfaces including: porous asphalt, porous concrete, concrete interlocking grid pavers, and turf pavers. The use of porous pavement reduces rates of stormwater runoff and improves runoff quality, helping to alleviate stress on stormwater management systems (City of Calgary, 2007). To achieve these benefits, it is recommended that the City of Windsor undertakes porous pavement demonstration projects, and develops construction guidelines for the use of porous pavement.

ISSUE

Urban development in cities creates increased runoff rates through the replacement of natural landscapes with hard, impervious surfaces. This leads to stormwater issues such as: increased rates of runoff, increased peak flow of stormwater, higher pollutant concentrations, combined sewer overflows (CSOs), and flooding (LaPaix & Freedman, 2010).

By utilizing porous pavement, these issues will be addressed by capitalizing on opportunities to capture, store, and treat stormwater using green infrastructure. Permeable pavement allows for the infiltration of water that is collected, filtered, and transferred to the groundwater system. Through facilitating runoff infiltration, permeable pavements may help to reduce localized flooding, to recharge groundwater, to filter pollutants and debris, and to reduce the volume and costs of treating stormwater.

BENEFIT

This adaptation action will most significantly improve stormwater management by reducing the quantity of runoff entering wastewater

treatment plants. The use of porous pavement lps to reduce runoff rates by facilitating infiltration of stormwater below the pavement surface, and temporarily storing it in the subsurface layers. This reduces both the total volume and rate of runoff flow to wastewater treatment plants. Therefore, the risk of flooding, CSOs, and pollutant washout into nearby sewers and water bodies becomes decreased. This also helps to lessen the demand on Pollution Control facilities by reducing peak flow and the costs of treating stormwater (Ordonez & Duinker, 2012).

CO-BENEFITS

IMPROVED STORMWATER QUALITY Infiltration of stormwater through pavement also results in improved water quality. Improved stormwater quality occurs through the removal of pollutants of concern such as suspended solids, dissolved solids, nutrients, hydrocarbons, and heavy metals (Frazer, 2005).

A study completed by the City of Calgary found that the concentration of suspended solids in runoff from impervious pavement ranged between 30-300 mg/L, while their concentration in runoff from pervious surfaces ranged from 0-50 mg/L. Reductions in runoff pollutant concentrations result due to the presence of lower runoff volumes, as well as from the physical removal of contaminants within the structure of permeable pavement. Processes that result in pollutant removal include: runoff filtration, entrapment, sedimentation, and biodegradation as stormwater travels between the subsurface layers (City of Calgary, 2007).

BEST PRACTICES

e following initiatives are representative of best practices for undertaking porous pavement demonstration projects as well as for the development of municipal guidelines.

City of Chicago - Green Alley Project
The Green Alley Project was initiated in order to alleviate stormwater management challenges in Chicago. In the past, Chicago's extensive alley network has often experienced flooding due to poor grading and a lack of permeability. As an alternative to building expensive connections to Chicago's sewers, the utilization of permeable pavement was proposed. Originally beginning as a pilot project in 2006, the Green Alley Project has since evolved and resulted in the construction of approximately 200 permeable pavement alleys. The project sees that alleyways are retrofitted using permeable pavement as their scheduled maintenance is needed, rather than using traditional paving materials. The Green Alley Project also recognizes and encourages the adoption of other sustainable techniques such as using light-coloured materials to increase albedo, using recycled concrete, and planting rain gardens alongside alleyways (Daley & Bryne, 2010).

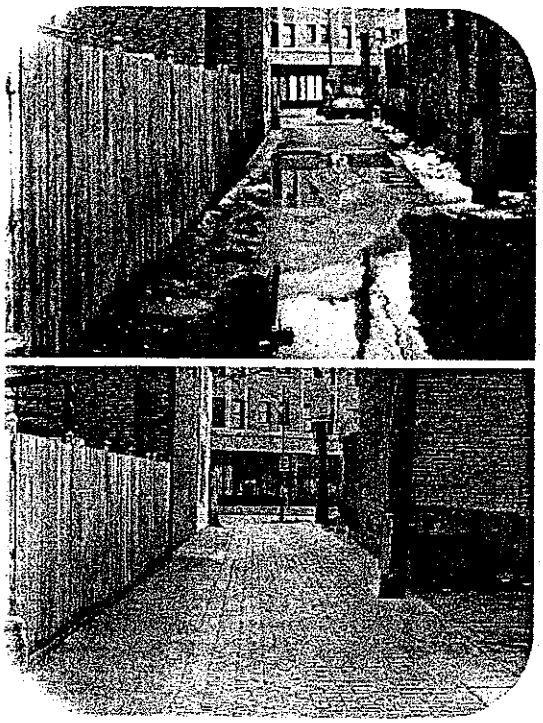

Figure 1: *Stormwater runoff before (above) and after (below) porous pavement alley construction (Daley & Bryne, 2010)*

City of Portland – Pervious Pavement Projects The City of Portland has conducted various types of pervious pavement projects across the city and for surfaces experiencing various levels of vehicular traffic. Some of these projects received partial funding from the U.S. Environmental Protection Agency (EPA) who administered grants from 2002-2003 to support alternative stormwater management projects.

The first project undertaken in Portland was the Westmoreland Permeable Pavement Project, which evolved based on recommendations from a report on alternative paving materials that was submitted to council by the Sustainable Infrastructure Committee. This pilot project tested various types of permeable paving materials along three blocks of streets in order to evaluate cost and performance. This is unique, as the majority of permeable pavements projects have been completed for lower intensity surfaces such as parking lots, driveways, and alleys. The approaches tested included a roadway with permeable concrete blocks, and a combination of standard asphalt in the center lanes and permeable pavement in the curb lanes.

Another pilot test called the North Gay Avenue Project resulted in the City paving four blocks using different paving strategies. These strategies include: porous concrete curb-to-curb, a combination of standard and porous concrete, porous asphalt curb-to-curb, and a combination of standard and porous asphalt. The project found that using porous pavement reduced the frequency of CSOs, reduced basement flooding, and increased groundwater recharge rates (City of Portland, 2012).

The City of Portland also completed a demonstration project for a 5225 ft^2 parking lot at East Holladay Park. The cost of completing the project was approximately \$10.00/ft^2 in comparison to conventional asphalt which typically costs \$3.50-4.00/ft^2. The project resulted in complete onsite stormwater treatment and runoff infiltration. This was achieved by covering 100% of the surface with permeable pavers, and by landscaping areas adjacent to the parking lot to capture runoff (City of Portland, 2007).

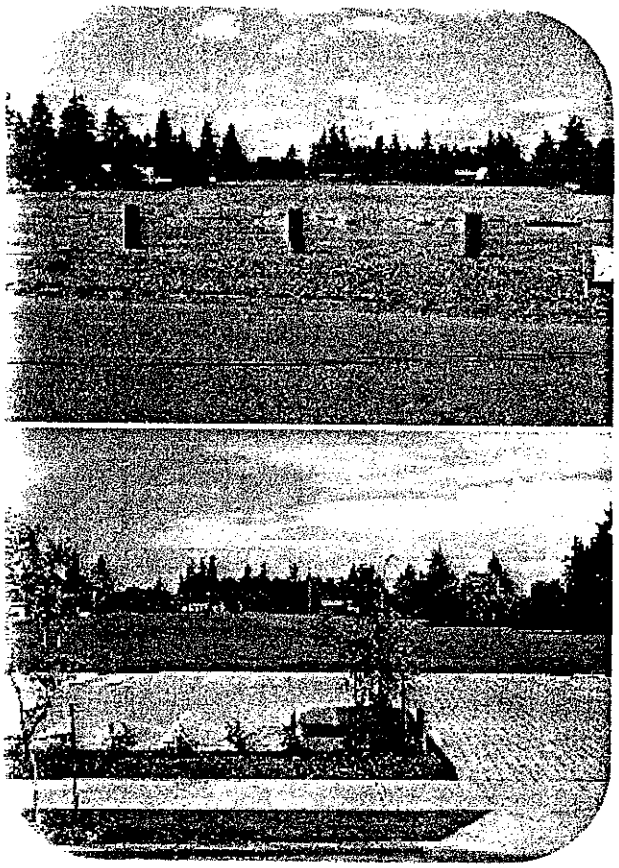

Figure 2: *Before (above) and after (below) East Holladay Park porous parking lot construction (City of Portland, 2007)*

Ravinia Festival Parking Lot – Highland Park, IL The Ravinia Festival South Parking Lot was rebuilt using permeable pavement in order to reduce severe surface flooding issues which had occurred approximately 25 days per year. The owners of the parking lot had previously received numerous complaints regarding the inability to access the parking lot, as well as flooding in nearby yards, basements, and homes. The frequency of such complaints was reduced to 0% upon completion of the project.

This project illustrates best practices for permeable pavement construction in areas with soils that have high clay contents. In most cases, the use of permeable pavement in areas with clay soils is discouraged. This is because soils with high clay content exhibit very low infiltration rates, minimizing the quantity and rate at which water can be absorbed into the ground. However, the builders of this project overcame this issue by constructing underground water detention areas beneath the permeable concrete block pavers. Up to 249,000 gallons of water can be stored in the detention area, and are then released slowly into the municipal storm sewer system (Landscape Architecture Foundation, 2011).

Ontario Ministry of Transportation – Pervious Concrete Pavement Standards In 2009, the MTO publication, *Road Talk,* reported positively on their first pervious concrete pavement project at a GO Transit commuter parking lot in Guelph, ON. In addition to the Guelph parking lot, two additional commuter lots have been paved with pervious concrete in Brampton and Barrie. In collaboration with the University of Waterloo and the University of Guelph, these lots were monitored to compare the rainfall quality to stormwater quality after filtration through the pavement.

As a result of these pilot projects, MTO developed the *Ontario Provincial Standard Specification* for pervious concrete construction. It is their hope that this specification will spur increases in the application of this technology across municipalities in Ontario. MTO recognizes that the use of pervious concrete has many environmental benefits such as: reducing runoff, minimizing the risk of flooding, increasing groundwater infiltration, and reducing the heat island effect (Ministry of Transportation, 2012).

Credit Valley Conservation Authority (CVC) – Elm Drive Green Street Pilot Project Elm Drive is located within the Cooksville Creek Watershed in Mississauga, ON. Due to significant development in the area, a number of issues have arisen with respect to stormwater management. The region has experienced flooding and erosion due to high stormwater runoff rates. This has led to infrastructure problems such as bridge collapse in the area. Concerns were also raised about the contamination of Cooksville Creek which intercepts water directly from storm sewers that contains pollutants.

To mitigate these issues, a Green Street Pilot Project was proposed to enhance the ability to manage stormwater using green infrastructure. This project was aided by a $1 million dollar grant provided by the Provincial government to the CVC. The two techniques used in the project include permeable pavement lay-bys that were installed adjacent to bioretention planters to replace the traditional concrete sidewalks, and permeable parking lanes (Credit Valley Conservation Authority, 2010).

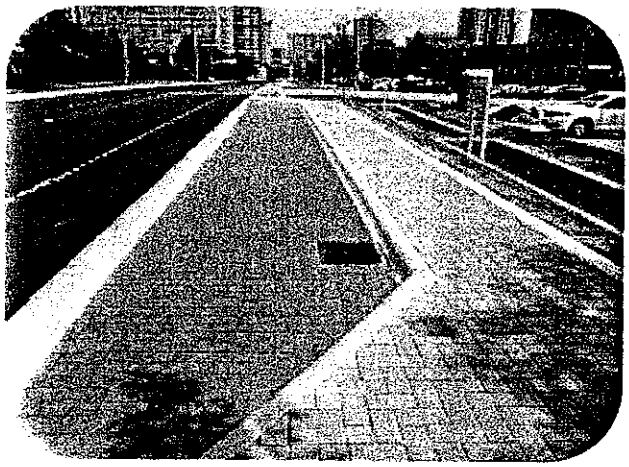

***Figure 3:** Elm Drive Green Street Pilot Project (Credit Valley Conservation Authority, 2010)*

City of Calgary – Porous Pavement Demonstration Projects and Development Guidelines Increasing rates of urbanization in communities such as Calgary increase the flow,

rate, volume, and amount of contamination in stormwater. Cities can mitigate these issues by fostering the development of demonstration projects that test sustainable and low impact technologies such as porous pavement (City of Calgary, 2009). The City has shown a commitment to developing these technical tools through projects such as the Water Centre, Currie Barracks, and Aurora Business Park's porous pavement parking lots.

Support for these projects was largely generated due to the City's creation of the Stormwater Source Control Practices Handbook in 2007. These practices are designed to encourage environmental stewardship with respect to stormwater management. Recommended practices include the development of: vegetated swales, absorbent landscapes, bioretention areas, rainwater harvesting, green roofs, and permeable pavement surfaces. The handbook serves as an aid for those designing and constructing permeable pavement systems by detailing the necessary technical specifics, design approaches, and construction guidelines (City of Calgary, 2007).

CHALLENGES

DURABILITY In comparison to impermeable pavement, porous pavements lacks durability as the void spaces may deteriorate due to air infiltration, oxidation, stripping, and shear stress. Concerns about the durability and longevity of porous pavement have rendered it suitable for only surfaces that receive light and infrequent usage. As a result, the use of porous pavement is commonly reserved for the following areas: driveways, road shoulders, parking lots, golf course paths, pedestrian paths, and bicycle trails (Scholz & Grabowiecki, 2007).

MAINTENANCE The presence of void space may also lead to clogging of porous pavement reducing the potential for water infiltration. This may result as sediments become trapped in the pores or as shear stress from vehicle weight causes the pores to collapse. If the void spaces become completely clogged, the pavement area would require complete replacement. To avoid this potentially costly issue, it is therefore necessary to develop maintenance regimes for street sweeping and pressure washing to clear debris from the void spaces (City of Calgary, 2007).

SITE APPLICABILITY The ability to successfully use permeable pavement is dependent on characteristics such as climate and soil conditions. Within Windsor, the cold winter climate and high clay content of soils may pose some challenges with respect to the development of porous pavement projects. Conflicting reports exist regarding the impact that freeze-thaw cycles can have on the lifespan of porous pavements. Therefore, it is important for pilot projects to be carried out in order to better understand how porous pavement will function in local climatic conditions.

Typically, permeable pavement systems are not suitable for sites with soils that have a clay content >30%. However, as noted for the Ravinia Festival parking lot construction case study, structural modifications may be made in order to facilitate water infiltration and exfiltration. In situations where the clay content of soil is high, cost-benefit analysis should be carried out in order to assess if the additional construction modifications result in substantial stormwater management benefits (City of Calgary, 2007).

REFERENCES

Beecham, S., Pessaniti, D., and Kandasamy, J. (2012). Stormwater treatment using permeable pavements. *Water Management, 165*(3), 161-170.

City of Calgary. (2007). *Stormwater Source Control Practices Handbook.* Retrieved August 10, 2012, from, http://www.calgary.ca/UEP/Water/Documents/WaterDocuments/Stormwater%20Source%20Control%20Practices%20Handbook%20-%20November%202007.pdf?noredirect=1.

City of Calgary. (2009). *Stormwater Management Report.* Retrieved August 9, 2012, from, http://www.calgary.ca/UEP/Water/Documents/WaterDocuments/stormwater_report.pdf?noredirect=1

City of Portland. (2007). *East Holladay Park Pervious Pavers.* Retrieved August 1, 2012, from, http://www.portlandonline.com/shared/cfm/image.cfm?id=161713.

City of Portland. (2012). *Pervious Pavement Projects – A New Approach to Stormwater Management.* Retrieved July 27, 2012, from, http://www.portlandonline.com/bes/index.cfm?a=77074&c=45435#benefits.

Credit Valley Conservation Authority. (2010). *Low Impact Development Conference – Elm Drive Retrofit.* Retrieved August 9, 2012, from, http://www.creditvalleyca.ca/wpcontent/uploads/2012/05/3Bprt1TWenzel-Elm DriveRetrofit.pdf.

Alley, R.M., and Bryne, T.G. (2010). *The Chicago Green Alley Handbook.* Retrieved July 27, 2012, from, http://www.cityofchicago.org/dam/city/depts/cdot/Green_Alley_Handbook_2010.pdf.

Frazer, L. (2005). Paving paradise: The peril of impervious surfaces. *Environmental Health Perspectives, 113*(7), 456-462.

Landscape Architecture Foundation. (2011). *Ravinia Festival South Parking Lot.* Retrieved August 10, 2012, from, http://lafoundation.org/research/landscape-performance-series/case-studies/casestudy/393/pdf.

LaPaix, R., and Freedman, B. (2010). Vegetation structure and composition within urban parks of Halifax Regional Municipality, Nova Scotia, Canada. *Landscape and Urban Planning, 98*(1), 124-135.

Ministry of Transportation. (2012). Pervious Concrete Pavements. *Road Talk, 17*(2). Retrieved August 1, 2012, from, http://www.mto.gov.on.ca/english/transtek/roadtalk/rt18-2/index.shtml#a2.

Ordonez, C., and Duinker, P.N. (2012). Ecological integrity in urban forests. *Urban Ecosystems, 10*(1), 1-15.

Scholz, M., and Grabowiecki, P. (2007). Review of permeable pavement systems. *Building and Environment, 42*(1), 3830-383