Towards Resilience

Durham Community Climate Adaptation Plan
2016

Text-only version

Terms and Acronyms

Adaptation	the process of adjusting our systems and infrastructure to climate change in order to improve our resilience
CO2	carbon dioxide
DRRCC	Durham Region Roundtable on Climate Change
Durham Region/Region	the Regional Municipality of Durham
Durham region/Durham	the geographic area
eCO2	equivalent carbon dioxide
EWAR	extreme weather alert and response
GHG	greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
LID	low impact development
LiDAR	Light Detection and Ranging remote sensing method
Mitigation	actions to decrease the emissions that cause climate change
OCRF	Ontario Climate Resilience Fund
ppm	parts per million
resilience	the ability to recover from or adjust easily to misfortune or change
SWM	storm water management
VPR	vulnerable person’s registry

Table of Contents

Message from the Regional Chair and Chief Executive Officer

In 2016, the globe set another record high average annual temperature. News coverage shows us that the frequency and intensity of extreme weather events, from flooding to drought driven wildfires, were also on the rise. Preparing our communities to cope with and respond to these occurrences thus is becoming increasingly important. This can include measures from increasing the span of bridges or the capacity of storm sewer systems, to planning emergency cooling centres and response plans.

The Durham community, including the Region, the eight area municipalities, and other partner organizations recognized the need to plan and prepare for the impact of extreme weather. Following the recommendation of the Durham Region Roundtable on Climate Change, more than 60 experts from organizations across the Region worked together to produce an adaptation plan for Durham.

This plan has received commendation from independent sources and positions Durham as a leader in adaptation planning in Canada. We can be proud of what we have accomplished as a community thus far. But now the true challenge begins: implementation. Executing the plan is complex, with several levels of government and many agencies with various programs to deliver and roles to play.

However, it will be worth the effort. When it comes to adjusting to climate change, an old saying is very applicable: an ounce of prevention is worth a pound of cure. The best way to protect our families and our property is to be prepared. By investing our time and resources in implementing adaptation programs now, benefits will accrue directly to Durham residents and businesses in the years to come.

Roger Anderson

Regional Chair and Chief Executive Officer

Message from the Chair of the Durham Region Roundtable on Climate Change

Our climate is changing. Each week we hear of another extreme weather event. Change is here and it's time for action.

In 2012, The Region of Durham published the Community Climate Change Local Action Plan. That document identified local actions to address the reality of climate change with a focus on reducing Durham region's carbon footprint.

Building upon that work, members from the Durham Region Roundtable on Climate Change formed a Climate Adaptation Subcommittee. Its mandate was to develop a plan for Durham region that would enable us to become more resilient to our future climate.

The process was innovative and unique. Climate modeling for the decade 2040-2049 for each municipality was conducted. Key experts, staff, and volunteers from all over the Region started to meet. Key questions such as 'Where are we the most at risk when it comes to extreme weather?', 'How can we ensure infrastructure is replaced with our future climate in mind?' and 'How can municipalities work together?' were asked.

This document is the result of those efforts and is the first step in a process that will continue long into the future.

As citizens we are responsible for reducing our carbon footprint. We now also need to be responsible for our own climate adaptation strategies. Working together, we can continue to learn and be models for others across the globe.

Richard Gauder

Chair of the Durham Region Roundtable on Climate Change

Executive Summary

This document constitutes Durham's Community Climate Adaptation Plan. It includes 18 proposed programs that have been approved in principle by Durham Regional Council on behalf of the Durham community on December 14, 2016. These program concepts have now been referred to a number of responsible agencies across Durham and beyond for further development, costing, approval and implementation. In addition to addressing its own responsibilities, the Regional government will monitor progress on behalf of the community.

We know that the climate is changing both globally and here in Durham and that we are locked-in to significant change before the middle of the century. The changes we face can be summarized as: "warmer, wetter and wilder". This Plan is the Durham community's response to the risks posed to our infrastructure, our health and welfare, and our economy. It is our attempt to prepare for a climate future that will be significantly different than when we constructed most of our roads, bridges, buildings, electricity grids and storm water systems, when we designed our public health systems and when we created our economy.

On behalf of the Durham community, the Region of Durham has coordinated key players across Durham over the last three years to consider the risks (and opportunities) to Durham from the changing climate and to prepare program proposals to proactively address this future and achieve the vision:

"In the face of a changing climate, Durham region remains a liveable, resilient and prosperous community through at least mid-century."

The process to produce this Plan has been:

- Scientifically-based – SENES Consultants was engaged to provide projections of the climate conditions in Durham in the 2040s. This work describes the mid-term future for which we need to plan.
- Consultative – The relevant stakeholders across the Durham community were consulted on the impacts and implications of these climate projections.
- Rigorous – Risk analyses were undertaken by expert stakeholders to identify the issues of greatest concern.
- Peer-based – Best practice analysis among other municipalities identified best practices elsewhere.

- Collaborative – Experts from the Region, local municipalities, electrical utilities, conservation authorities and the community were engaged to design the responsive programs needed in Durham.
- Comprehensive – This Plan addresses six sectors in a coordinated fashion that covers most of Durham's risk areas. Proposals for addressing remaining sectors (agriculture, telecommunications, provincial roads and other forms of transportation) are offered.

The 18 proposed programs in this Plan are:

Cross-Sectoral programs:

- Protect Our Outside Workers
- Social Infrastructure for Emergency Resilience

Building Sector programs:

- The Durham Climate Resilience Standard for New Buildings
- Building Retrofit for Climate Resilience

Electrical Sector programs:

- Asset Protection Against Flooding
- Vegetation Management
- Asset Design and Service Life Management program

Flooding Sector programs:

- Address Urban Flooding
- Redefine Flood Hazards Considering Climate Change
- Improve Flood Forecasting, Warning and Emergency Response
- Address Riverine Flooding

Human Health Sector programs:

- Extreme Weather Alert and Response (EWAR) System
- Property Standards By-laws for Maximum Temperature Allowed in Apartments

- “Cool Durham” Heat Reduction program

Roads Sector programs:

- Resilient Asphalt program
- Road Embankment program
- Adaptive Culverts and Bridges

Natural Environment Sector program:

- Achieving Climate Change Resilience in the Natural Environment

Responsibility for implementing these programs is a complex matter as legal responsibility and financial authority are distributed among:

- The Region of Durham,
- Local municipalities,
- Electrical utilities,
- Conservation authorities,
- Provincial agencies, and
- Federal agencies.

For each proposed program, the various implementation roles and responsibilities are identified in the Plan, as are next steps to further develop these programs towards costing, approval and implementation. It is expected that responsible agencies will respond to this Plan in a phased and measured manner consistent with their risk management policies and practices.

Ultimately, it will be the role of each responsible agency to make informed decisions within its legal obligations and financial resources on whether and how to implement the programs recommended in this Plan. Thus, it will be important for each responsible agency to report on its progress on a regular basis and for this Plan to be renewed at regular intervals.

Estimating the costs and benefits of these programs is difficult at this time. The costs of these programs will include substantial capital costs for infrastructure-type responses at high priority sites and more modest operating funding for new programs of analysis, emergency response, education and research. The benefits of these programs are the avoided future damage costs from climate change and extreme weather. Actual

experience from recent Canadian extreme weather events indicates that these costs are in the billions of dollars each year. In 2012, the National Roundtable on the Environment and the Economy estimated that every $1 spent now on adaptation will yield between $9 and $38 worth of avoided damages in the future.

Adequately addressing climate resilience needs in Durham will be a long-term process, one that will require extraordinary institutional memory, jurisdictional dedication and inter-agency collaboration. We will be at this task for the rest of our lives and that of our children.

Introduction

This document constitutes a Plan for climate adaptation in the community of Durham. It includes 18 proposed programs which have been approved in principle by the Council of the Regional Municipality of Durham on behalf of the Durham community on December 14, 2016. The Durham Region Roundtable on Climate Change (DRRCC) is the sponsor of the planning process that produced this plan and the Climate Adaptation Subcommittee of the DRRCC provided oversight and guidance to the process (See Appendix 1: Membership of the DRRCC and the Climate Adaptation Subcommittee).

Preparing the Durham community for the effects of a changing climate is an important and timely activity and one that requires the involvement and contributions of many stakeholders and agencies in the Durham community and beyond.

There have been a number of recent official reports on climate trends and adaptation which all point to the need for increased attention to climate adaptation, including:

- Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (reports of September 2013, March 2014 and April 2014)
- US National Climate Assessment (May 2014)
- Canada's Sixth National Report on Climate Change (June 2014)
- Climate Change: Implications for Cities, European Climate Foundation, International Council for Local Environmental Initiatives (ICLEI) and University of Cambridge (May 2014)
- Looking for Leadership, Environmental Commissioner of Ontario (July 2014)
- Paris Climate Accord, UNFCCC (December 2015)
- First Ministers' Vancouver Declaration on a Pan-Canadian Framework on Clean Growth and Climate Change and the creation of the Working Group on Climate Adaptation and Resiliency (March 2016)

For Durham, the implications of a changing climate include both local impacts which will directly affect us and national/international impacts which will affect us indirectly. The direct impacts will result from changes to Durham's climate and could include:

- Localized flooding,
- Violent storm damage,

- Various threats to human health and safety,
- Ecosystem changes,
- Loss of electricity supply,
- Loss of transportation and communication services, and
- Changes to agricultural conditions and production.

The indirect impacts will be more economic and social in character and will result from the changing climate nationally and internationally. Such impacts could include:

- Food shortages/higher prices due to crop and fisheries failures,
- Higher commodity and consumer product costs due to production and supply-chain disruption,
- Higher housing prices due to immigration and increased local housing demand,
- Higher taxes and insurance costs due to climate-related damages elsewhere (especially in Canada),
- Global economic disruption due to the costs of storm damage, rising sea levels, and the collapse of local economies around the world, and
- Population pressures due to migration and climate refugees.

This Plan addresses only the local adaptation measures for Durham Region. These are the measures we in Durham can take to protect ourselves and our infrastructure from the changing climate. Much of Durham's physical infrastructure (our roads and bridges, storm water systems, water supply and sewage treatment systems, buildings, energy supply systems, and communication networks) were built in the period 1950 to 2000. This infrastructure was designed and built to be resilient to the climate of this period. This is a climate that no longer exists, as recent extreme weather events in Ontario and across Canada have amply demonstrated. We not only need to upgrade our infrastructure to make it resilient to the climate of the present but to look ahead to the medium-term future (2040 to 2049) and anticipate the climate conditions that await us. On top of Canada's well-recognized "infrastructure deficit", we now have a "climate deficit" that needs to be addressed. This Plan is about addressing Durham's "climate deficit".

The goal of adaptation planning is to assess whether current programs and infrastructure design are sufficiently robust to continue to deliver desired results if subjected to the projected future climate conditions and extreme weather. By

recognizing the potential risks today, appropriate strategic decisions can be made to ensure continued effectiveness.

This Community Climate Adaptation Plan is the sister document to the Community Climate Change Local Action Plan (LAP) entitled “From Vision to Action” which was received by Durham Region Council on October 10, 2012 and published in December 2012. The LAP is our climate mitigation plan; it’s about reducing our GHG emissions in order to protect the global climate from us. This Community Climate Adaptation Plan is about protecting us from the changing global climate.

The Changing Climate

The Climate Record

Many of the observed changes to the climate have been unprecedented when compared to the 1950s. For example, the average annual temperature in Canada has risen 1.5°C between 1950 and 2010. Factors including the thermal inertia of oceans, natural feedback mechanisms (e.g., melting of permafrost resulting in the release of methane), and the long lifetimes of greenhouse gases in the atmosphere will continue to warm the Earth’s climate throughout the 21st century even if very significant reductions to carbon dioxide (CO_2) were made today.

The IPCC has concluded that “Each of the last three decades have been successively warmer at the Earth's surface than any preceding decade since 1850. In the northern hemisphere, 1983-2012 was likely the warmest 30 year period of the last 1400 years”. Further, the IPCC projects that the probability of more frequent hot days and nights is likely (66-100% certainty) in the early 21st century (2016-2035) and virtually certain (99-100% certainty) in the late 21st century (2081-2100). It also projects that an increase in frequency, intensity, and amount of heavy precipitation is likely in the early 21st century and very likely (90-100% certainty) in the late 21st century. The IPCC concluded in 2014 that climate change has already begun and that it is “severe, pervasive and irreversible”.

Climate Lock-In

Climate science has confirmed that we are facing a future of changed climate. The greenhouse gases (GHGs) emitted worldwide in the latter half of the 20th century are long-lived in the atmosphere and have “locked-in” a period of accelerating climate change until at least the middle of the 21st century.

Essentially, the global thermostat has been set and locked for 2050; there is very little that society can do to alter these trends. The various climate mitigation targets now being adopted around the globe (led by the Paris Climate Accord's goal of limiting the increase in global average temperatures to less than 2°C with an aim of limiting the increase to 1.5°C) are essentially targets for the second half of the 21st century. Climate science projects that warming beyond 2°C will lead to irreversible and catastrophic changes to global climate ("runaway climate change") that will threaten the future of human society. Thus climate change is regarded by many observers as the defining issue of the 21st century.

Such are the lead times and lag times in the global atmosphere that whatever we do in the next two decades to reduce GHG emissions (as necessary as this is) will not materially reduce the amount of global warming before mid-century.

This situation has been summarized as:

"Climate adaptation is necessary to manage the unavoidable and climate mitigation is necessary to avoid the unmanageable".

Figure 1 in the print version of this document shows that globally we are on track for CO_2 equivalent concentrations of as high as 1,000 ppm by the end of the century (we are currently at 404 ppm, up from 280 ppm in the mid-1800s). GHG concentrations above 750 ppm by the end of the century would lead to a global average temperature increase of 3.2°C to 5.4°C (relative to the temperatures in 1850 to 1900). This is clearly a disaster scenario. We have already experienced a global average increase of almost 1°C with more locked into the climate system by mid-century. Even the lowest emissions scenario in the preceding illustration, in which global emissions peak by 2020 and decline rapidly thereafter, results in a temperature increase of 0.9°C to 2.3°C by the end of the century. Clearly, even the most aggressive climate mitigation policies will not protect us from significant temperature increases in the medium-term. These are global trends. We know that temperature increases will be exaggerated as one moves towards the poles and that Canada's average temperature has already risen 1.5°C since 1950 (source: Environment Canada). Locations in the Canadian Arctic have already experienced increases in average annual temperature of 3°C to 4°C since the 1950s.

There will be local variations in annual temperatures caused by changes in the jet stream, the "arctic vortex", and by weather events like "El Nino" (which themselves are related to climate change). In Durham, the long-term trend is for rising temperatures. We know that, in general, rising temperatures due to global warming will tend to make the wet regions wetter and dry regions drier.

Figure 1: Historical global carbon dioxide emissions from human activity and four different IPCC future climate scenarios.

Figure 1 has been removed in the text-only document. Figure 1 is extracted from the Fuss *et al,* 2014 article titled “Betting on negative emissions” in Nature Climate Change and is available on page 13 of the print version of this plan. The full document can be accessed at the following webpage: http://www.nature.com/nclimate/journal/v4/n10/full/nclimate2392.html.

The figure shows emissions from fossil fuels and cement ($GtCO_2$/yr) on the primary y-axis and years from 1980 to 2100 on the x-axis. Plotted on the graph are historical emissions and five IPCC scenario categories, 430-480 ppm CO_2 equivalent, 480-580 ppm CO_2 equivalent, 580-720 ppm CO_2 equivalent, 720-1000 ppm CO_2 equivalent, and >1000 ppm CO_2 equivalent. The secondary y-axis shows four greenhouse gas concentration (not emissions) trajectories adopted by the IPCC for its fifth Assessment Report (AR5) in 2014, RCP8.5 (Representative Concentration Pathway), RCP6, RCP4.5, and RCP2.6. The figure shows that RCP8.5 results in increased global temperatures of 3.2-5.4 degrees Celsius relative to 1850-1900. RCP6 results in increased global temperatures of 2.0-3.7 degrees Celsius relative to 1850-1900, RCP4.5 results in increased global temperatures of 1.7-3.2 degrees Celsius relative to 1850-1900, and RCP 2.6 results in increased global temperatures of 0.9-2.3 degrees Celsius relative to 1850-1900.

Climate Changes in Durham

What does global climate change mean for Durham? What do the trends in temperature, precipitation, extreme weather and other climate factors mean for the Durham community? How can we plan if we don’t know the conditions for which we are planning? To answer these questions, the Region of Durham commissioned a projection of Durham Region’s Future Climate (2040 to 2049). This study was undertaken by SENES Consultants in December 2013 and was based on a similar projection commissioned by the City of Toronto in 2011.

The study was based on the IPCC’s most credible scenario of future global GHG emissions and linked three climate and weather models to provide detailed projections of average and extreme climate parameters for various sites in Durham. The projections cover the future period of 2040 to 2049 compared to the base period of 2000 to 2009. Whitby was selected as the proxy site for all of Durham, but data are provided for all eight local municipalities (in most cases the 1km by 1km cell over city hall).

Data for all eight municipalities are presented in Appendix 2: Durham Region’s Future Climate 2040-2049 (SENES Report Summary).

Future Period: 2040-2049 compared to 2000-2009

The following summarizes the projected climate changes for the proxy Whitby site for the future period compared to the base period:

- Less snow and more rain in winter,
- About 16% more precipitation (snow and rainfall) overall:
- ~50% increase in the one day maximum rainfall,
- ~40% decrease in the one day maximum snowfall,
- 100% increase in the number of days of rain greater than 25 mm,
- 80% reduction in the number of days with snow more than 5 cm,
- 146% more rain and 61% less snow in January, and
- 217% more rain and 75% less snow in February.
- Rainstorm events will be more extreme:
- 15% increase in the potential for violent storms,
- 53% increase in the potential for tornadoes,
- 74% more rain in July, and
- 79% more rain in August.
- Wind Chill is reduced by about 50% on average but is reduced 25-45% during the winter months.
- Average annual temperature increases by 4.0°C:
- Average winter temperatures increase by 5.8°C,
- Average summer temperatures increase by 2.6°C,
- Extreme daily minimum temperature "becomes less cold" by 12°C, and
- Extreme daily maximum temperature "becomes warmer" by 7.1°C.
- Average wind speed about the same:
- Maximum hourly winds reduced, and

- Maximum wind gusts reduced about 13%.
- "Comfort" remains similar but with some extreme events:
- Humidity and temperature taken together as the humidex remains similar (within 8% of present on average) for most of the year, but shows increases in November (up 30%) and in May through to September (up 15%) and pushes past the “dangerous” level (45°C equivalent) on several summer days, reaching a maximum of 51°C equivalent.

Overall, we need to prepare for a future in Durham where the climate in the 2040s is:

- Warmer: 4°C average temperature increase, with 5.8°C higher temperatures in winter and 2.6°C higher in summer compared to the 2000 to 2009 decade, heat wave temperatures 7.1°C higher than normal and humidex readings exceeding the “dangerous” level.
- Wetter: 50% increase in the one day maximum rainfall, 100% increase in days with more than 25 mm of rain, 72% more rain in July and 79% more in August, 217% more rain and 75% less snow in February.
- Wilder: More intense rainstorm events, including a 15% increase in the potential for violent storms and a 53% increase in the potential for tornadoes.

The Process of Plan Development

Work on Durham's Community Climate Adaptation Plan began in the fall of 2013 with the approval by the DRRCC of the process for plan development. This process was envisaged as a four phase process: assessment, program design, program approval and funding, and program implementation. Climate adaptation will be an ongoing effort for many years and the plan will need to be assessed and revised as climate change unfolds over many decades. This plan is just the beginning.

Figure 2: The process of plan development

Phase 1: Assessment (2014)

Phase 2: Program Design (2015/2016)

Phase 3: Program Approval and Funding (2017)

Phase 4: Program Implementation (2018 and beyond)

Phase 1: Assessment

Phase 1 consisted of three distinct steps:

Step 1: The SENES Study

The SENES study provided detailed projections on the future climate in Durham and the future conditions for which we need to prepare (2040-2049).

Step 2: Stakeholder Engagement

In 2014, this data was presented to a number of stakeholders such as local municipalities, electrical utilities, conservation authorities, the business community (through Boards of Trade and Chambers of Commerce), and others. There was considerable interest in this data because it was local, detailed, credible, and highly relevant data. It raised questions about the implications for the Durham community and the potential costs of both action and inaction.

Step 3: Expert Task Forces to Undertake Risk Analyses

To help interpret the implications of these projections, seven Expert Task Forces were created in the spring of 2014 to identify the impacts of the climate data and undertake a common risk assessment of the impacts. These Expert Task Forces were:

- Buildings Sector,
- Electrical Sector,
- Flooding Sector,
- Food Security Sector,
- Human Health Sector,
- Natural Environment Sector, and
- Roads Sector.

Note that the public water supply system and the sanitary sewerage system were not analysed at this time due to the fact that they are entirely owned and operated by the Regional Works Department and are already assessed and protected by the Region under its Corporate Climate Change Adaptation Program.

The members of the Expert Task Forces were drawn from Regional staff, local municipalities, conservation authorities, local electrical utilities, citizen groups, and post-secondary institutions. In total, 58 experts from across the Durham community were involved in this activity (See Appendix 3: Membership of the Expert Task Forces).

While largely self-governing, the Expert Task Forces were given a common mandate to:

- Define the scope of their assessments,
- Identify vulnerabilities and likely impacts resulting from the climate projections in the SENES report, and
- Undertake a risk analysis on each impact and classify it as high, medium, or low risk.

The Expert Task Forces were provided with the SENES data and a common risk assessment procedure. They were asked to identify potential impacts in Durham and, using their professional judgement, to rank the “Likelihood of an Impact” and the “Consequences of an Impact” to provide a semi-quantitative assessment of the “Risk” to the Durham community. This exercise produced so-called “heat maps” for each Task

Force where impacts that rated high likelihood and high consequence were clustered in the high risk area of the figure. The risk assessment of the Roads Expert Task Force is provided in Figure 3 on the print version for illustrative purposes (page 21).

The risk assessment work of each Task Force was brought to a Joint Task Force meeting on May 29, 2014, to compare their risk assessment results and discuss gaps, overlaps, and interdependencies.

This work resulted in the identification of 71 high risks and 68 medium risks across the seven Expert Task Forces as summarized in Table 1. The actual impacts and their associated risks as identified by each Expert Task Force is presented in Appendix 4: Results of the Risk Assessment Process

All of the work accomplished in Phase 1: Assessment was summarized into a progress report which was presented to Durham Regional Council on January 21, 2015, where it was endorsed and further work authorized towards preparation of this Durham Community Climate Adaptation Plan.

Table 1: Number of Risks Identified by the Expert Task Force (2014)

Task Force	High Risks	Medium Risks	Total
Flooding Sector	26	0	26
Natural Environment Sector	14	7	21
Buildings Sector	16	37	53
Electrical Sector	3	3	6
Human Health Sector	2	7	9
Roads Sector	6	5	11
Food Security	4	9	13

Phase 2: Program Design

The Expert Task Forces reconvened in spring of 2015 to begin designing programs to address the high and medium risks identified in Phase 1. In some cases, the membership of Task Forces was changed or supplemented slightly with representatives offering particular program development experience.

The Expert Task Forces undertook the following steps:

Step 1: Inventory Applicable Actions

Climate adaptation literature was reviewed and analysed to identify best practices to construct an inventory of applicable actions to prevent, reduce, or respond to each high and medium risk. The focus at this point was on identifying discrete actions (e.g., engineering designs for new infrastructure, backflow prevention valves, bio-swales, permeable pavement, white roofs, etc.) that can clearly result in adaptation or increased resilience.

Step 2: Classify Actions by Implementation Tools

The actions identified in Step 1 were then grouped by the policy or program tools that can be best used to implement the actions (e.g., regulations and plans, education and awareness, standards and codes, operational changes, and capital projects).

Step 3: Package Tools into Proposed Programs

The proposed actions and relevant tools were then combined into actionable program concepts, taking into account the often complex set of legal authorities and program responsibilities among various agencies. These program concepts addressed needs in the community such as flood prevention, flood adaptation, electricity reliability, resilient buildings, health protection, road resilience, environmental services, business continuity, and food security and supply. The Expert Task Forces produced a total of 28 sectoral program proposals.

Step 4: Participate in Design Charrette

Task Force members participated in a design charrette on February 29, 2016, to identify gaps, overlaps, conflicts, and improvements to the 28 program proposals. These proposed programs were reviewed by the DRRCC on June 10, 2016.

Step 5: Produce an Integrated Plan

Proposed sectoral programs were further reviewed to combine similar initiatives into an integrated and comprehensive Community Climate Adaptation Plan for presentation to Regional Council.

Figure 3: Risk Assessment process for the Roads Sector

Figure 3 in the print version of this document is a risk assessment. The header row depicts the likelihood of an impact whereby 1=low likelihood of impact and 5=high likelihood of impact

Column 1 depicts the severity of consequence whereby 1=low consequence and 5= high consequence

Therefore, an item falling under high likelihood and high consequence would be categorized as high risk. An item falling under low likelihood and low consequence is categorized as low risk.

The data has been sorted in the table below for the purposes of this print document.

High Risk	Moderate Risk	Low Risk
Storm structures/embankments (likelihood=5, consequence=5)	Pavement structure (storm) (likelihood=3, consequence=3)	Bridges (heat, less cold days) (likelihood=1, consequence=2)
Pavement softening (heat) (likelihood=5, consequence=4)	Buckling of concrete structures (heat) (likelihood=4, consequence=3)	Potholes (less cold days) (likelihood=2, consequence=2)
Pavement deterioration (less cold days) (likelihood=5, consequence=3)	Sanitary sewers (storm) (likelihood=4, consequence=2)	Signposts/trees (storm) (likelihood=4, consequence=1)
	Waterfront bluffs(likelihood=5, consequence=2)	
	Reduction in road salt (less cold days) (likelihood=5, consequence=1)	

Phase 3: Program Approval and Funding

The Durham Community Climate Adaptation Plan was approved in principle by the Council of the Regional Municipality of Durham on December 14, 2016.

This Plan will now be referred to a number of Regional departments, the eight local municipalities, five conservation authorities, four electrical utilities, and other responsible agencies indicated for each program. These partners will be requested to undertake further program development, costing, and incorporation into their business plans. They

will also be requested to report annually on their progress in implementing these programs.

Phase 4: Program Implementation

Implementation will include further development of the programs and decisions by the responsible agencies on whether and how to incorporate these programs into their annual business plans for the foreseeable future.

Annual reports will serve as a mechanism to monitor our efforts, assess our progress, and reflect on our successes and challenges as we build a resilient Durham.

Figure 4 in the print version of this document depicts the overall process for Phase 1: Assessment, Phase 2: Program Design, Phase 3: Program Approval and Funding, and Phase 4: Program Implementation. It is important to recognize the various program implementation roles and responsibilities in Phase 3 which belong to the Region of Durham, the eight local municipalities, the five conservation authorities, the four electrical utilities, and other agencies within Durham and beyond (e.g., provincial and federal departments and agencies).

Figure 4 – Schematic diagram of the process of plan development

In the print document Figure 4 shows a visual schematic of the four phases of the plan development. This figure is available on page 25 of the print version.

Vision, Goals, and Implementation Guidelines

Vision

“In the face of a changing climate, Durham region remains a liveable, resilient and prosperous community through at least mid-century.”

Goals

Further development and substantial implementation of this Plan will:

- Increase the resiliency of community infrastructure, programs and services to the changing climate in Durham;
- Promote and facilitate the incorporation of the proposed programs into the business planning of the responsible agencies;
- Improve emergency planning for weather extremes and in particular for vulnerable populations;
- Advance the infusion of climate change information into the business planning of both the public and private sectors;
- Improve the awareness, knowledge, skills and resources of government, citizens and business people regarding climate adaptation;
- Improve the sustainability of Durham region and its attraction as a place to invest, live, and play; and
- Lead to recognition of Durham region as a leader in climate adaptation planning and implementation.

Implementation guidelines

As this plan and the programs it recommends move towards funding and implementation, there are a number of guidelines that apply to these next steps. These include the following:

- Use the best climate science – Use the best climate science that is available at the time of planning and review and update this science regularly.
- “An ounce of prevention is worth a pound of cure” – Wise investments now in correcting our infrastructure deficit and building for future climate and weather

conditions should yield large benefits in the future (see section on Costs and Benefits of Climate Adaptation).

- Start with new infrastructure design – Investment in new buildings, roads, bridges, culverts, and other infrastructure should follow leading-edge codes, standards, and design criteria that account for future climate conditions, not last century's weather. Designing and building it right the first time is much more cost-effective than replacing or retrofitting it later.

- Prioritize our needs for retrofit – We need to inventory our current stock of infrastructure (roads, culverts, buildings, urban forests, vulnerable populations, etc.) and identify the most vulnerable sites for early investment.

- Follow the responsibility trail – There are many organizations in our community that are already responsible (i.e., legally and/or economically) for our protection from harm. These organizations have the risk management systems and business planning processes to respond to increased risks from climate change.

- Recognize the complexity – We have a complex web of government departments, organizations, and agencies and a patchwork of policy instruments and regulations that can affect climate adaptation (see Roles and Responsibilities). In some cases the responsibility and control are clear, while in others they are more difficult to identify.

- Look for the synergies – Interdependencies and common interests can define a "community of interest" that can make progress on adaptation (e.g., home builders, home owners, and the home insurance industry should all have a shared interest in improving the resilience of homes to extreme weather).

- Look for help – The Durham community is not alone in this challenge. Other communities, other levels of government, and private interests have experiences from which we can learn, and in some cases, financial resources to help.

- Emphasize the positive – We are building a community that is more resilient to the future. That is positive and hopeful. We have the land base, adequate fresh water, productive farmland, infrastructure, technical and management expertise, and wealth to make Durham a very attractive place to live, work, and play.

- Stick to the plan – Climate change is irreversible for the foreseeable future. Climate adaptation measures and programs will be needed for the long haul, beginning early and strategically. We need to sustain the effort for a long time and fully implement important programs. We will need to review and update this plan on a regular basis, probably every five years.

Objectives and Proposed Programs

Cross-Sectoral Objectives and Programs

Objective: Protect outside workers from increased exposure to extreme heat and vector borne diseases

CS1: Protect Our Outside Workers

Outdoor workers currently need to be protected from extreme heat, humidity, and infectious diseases. As summer temperatures and humidex readings rise further and vector-borne infectious diseases (e.g., West Nile virus, Lyme disease, etc.) spread, there will be a need for enhanced protective measures.

Such measures may include:

- Cancelling or rescheduling outdoor work to avoid extreme heat;
- Scheduling work for early morning or overnight to avoid daytime peaks;
- Provision of adequate breaks;
- Access to cooling and adequate hydration;
- Provision of protective clothing against heat, sun and insects; and
- Inoculations and other measures (when available) for vector-borne diseases (as recommended by Health Canada).

Affected sectors include:

- Utility outdoor workers;
- Roads and works crews;
- Waste collection crews;
- Conservation authority field staff;
- Summer camp, recreation and outdoor sports staff; and
- Emergency workers (where feasible).

Responsible agencies:

- Regional Health Department (for enforcement of legislation, disease surveillance, health promotion and communication of heat warnings);
- Regional and municipal works departments;
- Utilities;
- Conservation authorities;
- Municipal recreation departments;
- Sports clubs and associations; and
- Police, fire and emergency medical services.

Next steps:

- Set up a region-wide committee including municipal and Regional representatives and employers from responsible agencies to review current guidelines and programs and to benchmark against jurisdictions that currently experience the projected conditions; and
- Review Health Canada guidelines and current Ontario labour codes.

Objective: Increase our social resiliency against weather and climate emergencies

CS2: Social Infrastructure for Emergency Resilience

In the event of serious flooding, extreme heat, tornadoes, or power outages, our community's ability to cope and bounce back (and in particular the resilience of vulnerable people) will depend on social cohesion and the services of the voluntary sector. When electricity, clean water, food, fuel, transportation, and communication may not be readily available for extended periods of time, personal survival may depend on the response capacity of neighbours, volunteers and community services.

This program is designed to strengthen the fabric of our society in several ways:

- Public education and training:
- A training program for community volunteers and service club members to provide response and assistance to residents and businesses in times of weather emergency;

- Information on access to food and potable water and safe preparation and preservation of food during an extended power failure; and
- A special focus on vulnerable people (such as the elderly, isolated people and those with medical situations) and their support systems.
- Outreach and education for high-rise residential occupants:
- A specialized information package and training for property managers of apartment buildings and condominiums concerning the specialized needs of residents in such buildings (e.g., cooling and heating, access to potable water and food, mobility and medical services); and
- Decision guidance on evacuation versus shelter in place.
- Enhanced coordination among emergency responders, social service agencies and volunteer groups to service vulnerable populations.

Affected sectors include:

- General public, in particular, high-rise residents;
- Vulnerable populations;
- Volunteer organizations; and
- Emergency responders.

Responsible agencies:

- Durham Emergency Management Office (DEMO);
- Durham Region Social Services;
- Durham Region Health Department; and
- Emergency responders (police, fire and emergency medical services).

Next steps:

- Convene a community-wide coalition of emergency, social service, and health agencies to identify gaps and needs for improved emergency services; and
- Approach service clubs to provide needed support.

Building Sector Objectives and Programs

Objective: Improve the resilience of new buildings to future climate conditions

B1: The Durham Climate Resilience Standards for New Buildings

The Durham community is about to undergo a building boom. Between 2016 and 2025, there are projected to be 53,000 new housing units built in Durham, plus new industrial, commercial, and institutional buildings. It is projected that these homes and buildings will be subjected to extreme heat and rainfall, violent storms, high winds, and an increased chance of flooding. If new climate resilience standards are not instituted, most of these buildings will be designed and constructed for last century's climate conditions, not the climate that is projected to prevail during their lifespan. This would be a huge lost opportunity to increase the resilience of our buildings.

This program proposes to develop separate Durham Climate Resilience Standards for:

- Low-rise residential buildings (e.g., detached, semi-detached, town, and row houses); and
- High-rise residential buildings (apartments and condominiums), industrial, commercial, and institutional buildings.

These standards would prescribe climate resilience features for all new buildings in Durham constructed after 2020 with a phase-in period beginning in 2018.

Such local standards could be adopted through municipal by-laws and implemented through Official Plans, Plans of Subdivision, Site Plan approvals and (potentially) Building Permits.

A parallel-path strategy for implementation is recommended:

- Resolutions from Councils to the Province requesting the inclusion of climate resilience standards in the Ontario Building Code (OBC) as soon as possible (with monitoring of the Province's response); and
- Initiate development and implementation of the Durham Climate Resilience Standards in parallel and decide on full implementation as appropriate.

Example measures for low-rise houses are outlined in Appendix 5: Example Components of a Resilient House Standard. Such adaptation measures in new

buildings are low cost if incorporated at the time of design and construction. They are often impossible to install and much more costly if undertaken as retrofits at a later time.

Affected sectors include:

- Development and construction industry; and
- Municipal planning and building departments.

Responsible agencies:

- Municipal governments, Planning and Chief Building Officials;
- Ministry of Municipal Affairs, Building Code Division; and
- Regional Municipality of Durham.

Next steps:

- Prepare for consideration Council resolutions to the Province requesting inclusion of climate resilience measures in the OBC as soon as possible;
- Convene a committee of municipal officials to develop Resilience Standards for Durham (with consultant assistance as appropriate) and design a uniform by-law and program for all municipalities in Durham;
- Consult with the design and construction industry on these proposed standards and program;
- Seek clarification on delegated jurisdiction to municipalities for building standards referred to in the new Ontario Climate Change Action Plan; and
- Investigate the interest of the home insurance industry in supporting a Home Resilience Standard for purposes of identifying claims risk and setting incentive premiums.

Objective: Promote the resilience of existing buildings to future climate conditions through adaptation retrofit measures

B2: Building Retrofit for Climate Resilience

While it is more difficult and usually more costly to equip existing buildings for climate resilience, there is often a set of retrofit measures that can be undertaken cost-effectively on a site-specific basis. This is similar to building energy conservation measures, for which we have about 40 more years of technical and program

experience. Energy audits are regularly used to identify the specific set of energy measures that are appropriate and cost-effective for a given building. Similarly, ”resilience audits” are now being developed to advise homeowners and building managers of the specific measures they can take to protect their buildings against extreme weather.

On August 5, 2016, Burlington launched (with provincial assistance) a pilot Home Adaptation Assessment Program (HAAP) developed by the University of Waterloo’s Intact Centre for Climate Change. The program provides a site-specific set of recommendations for homeowners to protect their houses against flooding and may lead to a province-wide audit program. This program and other similar efforts should be tracked for possible adoption in Durham.

The Durham program would consist of several elements:

- Education concerning the need for home and building climate adaptation measures;
- Adoption of one of the emerging resilience assessment systems for use in Durham;
- Training for the home audit, renovation, and construction industry concerning adaptation assessment and retrofit measures;
- Possible provision of financial incentives or loans for the more costly measures identified by the audit (potentially through Local Improvement Charges and the recently-announced “Green Bank” in the Ontario Climate Change Action Plan); and
- Linkages to the building insurance industry for resilience certification and lower premiums.

Affected sectors include:

- Residential;
- Industrial;
- Commercial;
- Institutional; and
- Construction and renovation industry.

Responsible agencies:

- Regional Municipality of Durham,
- Local municipalities;
- Ministry of the Environment and Climate Change (MOECC); and
- Ministry of Municipal Affairs (MMA).

Next steps:

- Investigate the availability of the Home Adaptation Assessment Program developed by the Intact Centre on Climate Adaptation at the University of Waterloo;
- Assess availability and effectiveness of other audit programs with a wider scope (beyond just flooding); and
- Seek clarification on the scope and mandate of the “Green Bank” announced in the Ontario Climate Change Action Plan.

Electrical Sector Objectives and Programs

Objective: Prevent loss of electrical supply caused by flooding of electrical equipment

E1: Asset Protection Against Flooding

Extreme rainfall that results in overwhelmed drainage infrastructure poses the risk of overland flooding. Flooding of underground electrical vaults or surface-mounted electrical equipment can lead to failure and electrical outages. Electrical equipment that may be at risk of flooding should be reassessed for continuing adequacy. Consideration should also be given to projections of future extreme rainfall and the consequential changes to floodplain mapping.

There are two broad management approaches to safeguard equipment from flooding:

- Prevention:
- Locate or re-locate the equipment outside areas that are at risk of flooding; and
- Ensure flood control infrastructure (storm water drainage) is adequate.
- Protection:
- Ensure design of equipment is capable of withstanding submersion; and
- Ensure that barriers are in place to prevent overland floods from reaching equipment (e.g., diking, flood-proof vaults, etc.).

Actions to protect electrical equipment should include:

- Working with municipalities to build storm water infrastructure to avoid flooding;
- Overlaying revised floodplain maps (from conservation authorities) with electrical infrastructure maps;
- Flood-proofing equipment that is critical and vulnerable; and
- Revising practices to eliminate electrical equipment in high flood risk areas.

Affected sectors include:

- Electrical utilities and their customers; and
- Local municipalities.

Responsible agencies:

- Electrical distribution utilities;
- Conservation authorities; and
- Municipal works departments.

Next steps:

- Inventory all underground and surface electrical equipment and assess vulnerability to flooding;
- Overlay revised future floodplain maps with electrical infrastructure maps; and
- Identify priority equipment and develop a business case for prevention or protection.

Objective: Prevent electrical outages due to trees falling on electrical lines and equipment

E2: Vegetation Management

Ice and snow accumulation on vegetation coupled with high winds can lead to trees or limbs falling onto electrical lines (especially neighbourhood distribution lines) causing damage and electrical outage.

This is an existing problem that may be exaggerated by climate change due to:

- Warmer climate leading to longer growing season;
- Extreme heat and changes to precipitation may stress vegetation making it more susceptible to damage;
- Projected increase in the occurrence of wind storms; and
- Potential for more freezing rain (in the short-term).

Adaptation actions should include:

- Reviewing existing vegetation management strategies to ensure that they are aggressive enough for future tree canopy risk;
- Modifying future tree planting strategies in terms of location and species; and
- Considering the business case for burying wires.

Affected sectors include:

- Electrical distribution.

Responsible agencies:

- Electrical utilities;
- Municipalities foresters; and
- Regional foresters.

Next steps:

- Electrical utilities should review, modify and implement vegetation management programs as necessary;
- The electrical sector should consider the business case for burying local distribution lines; and
- Urban foresters should reconsider the location and species of future tree plantings.

Objective: Improve electrical reliability through equipment design and service life management

E3: Asset Design and Service Life Management Program

Extreme temperatures, high winds, lightning storms, snow and ice accretion, and vegetation can lead to either the accelerated aging of existing infrastructure or immediate damage. Either case results in a reduced infrastructure life expectancy. In order to maintain system reliability, additional maintenance and/or replacement before the expected end of service-life may be necessary. Examples include:

- Heat can cause sagging and annealing of overhead conductors;
- Lightning strikes can cause repeated tripping of protection which can reduce service life; and
- High winds from microbursts, tornadoes, and hurricanes can exceed the design criteria for overhead conductors and result in outages.

Adaptive actions should include such measures as:

- Reviewing existing protection design and operation (codes and practices) for continued adequacy against future climate conditions;
- Updating design codes and standards and building/maintaining to the new standard;
- Accelerated replacement of vulnerable electrical infrastructure; and
- Raising awareness with governing bodies that climate change and weather extremes will increase costs to maintain electrical reliability.

Affected sectors include:

- Electrical distribution.

Responsible agencies:

- Electrical utilities;
- Codes and standards agencies (e.g., CSA Group); and
- Ontario Energy Board.

Next steps:

- Review existing codes and practices against future conditions.

Flooding Sector Objectives and Programs

Objective: Reduce the severity and frequency of urban flooding

F1: Address Urban Flooding

Increasing rainfall intensities and violent storms will challenge existing infrastructure and potentially cause severe flooding in urban areas. These events could threaten the health and well-being of citizens and the community. By taking action to address flood hazards that include impacts of climate change, a proactive approach to community protection will be possible.

Durham's conservation authorities and municipalities should adopt new standards and codes, and take actions that protect the built environment from urban floods.

Adaptation actions covered by this program include the following:

- Implementing Low Impact Development (LID):
- Implement LID techniques;
- Implement site LIDs with green infrastructure; and
- Implement programs to help reduce the impervious surfaces of the lands.
- Addressing Infrastructure:
- Undertake monitoring and self-assessment and rehabilitation studies for existing storm water conveyance systems;
- Develop and implement Storm Water Management (SWM) Fee and Credit program in all municipalities;
- Address storm water discharge – define a climate change factor of safety when designing for storm water;
- Implement backflow preventer and sump pump programs;
- Install a 3rd pipe system when opportunity arises (a separate foundation drain collection system);
- Protect critical services from overland flow (e.g. waterproofing all critical underground services that could be affected, such as sanitary drains and electrical service);

- Ensure operation and maintenance of SWM infrastructure; and
- Implement major and minor system conveyance improvements.
- Addressing Existing Development:
- Acquire land in flood vulnerable areas;
- Retrofit buildings that are susceptible to flood damage;
- Flood-proof existing residential structures;
- Remove homes from the floodplain;
- Remove Combined Sewer Overflows (CSOs);
- Use parks and public lands for flood storage;
- Define and protect major overland flow routes; and
- Reduce flooding due to existing constrictions created by limited capacity of railway structures and Highway 401 structures.
- Addressing Future Development:
- Promote less land consumptive transportation infrastructure and parking areas;
- Increase the capacity of floodplain;
- Manage redevelopment in the floodplain;
- Update policies to further restrict development in the floodplain and other hazard lands;
- Provide floodplain freeboard/buffers (horizontal and vertical);
- Update planning policy and design standards; and
- Revise the current provincial SWM policies and Building Standards.
- Addressing Pollution that Results from Flooding:
- Inventory potential pollution hazards; and
- Reduce risks of pollution hazards.

Affected sectors include:

- Municipal planning and urban design;
- Conservation authorities;
- Provincial departments;
- Development industry;
- Railways.

Responsible agencies:

- Conservation authorities;
- Municipal planning and works departments;
- Ministry of the Environment and Climate Change (MOECC);
- Ministry of Natural Resources and Forestry (MNRF);
- Ministry of Transportation (MTO);
- Canadian Pacific Railway (CPR) and Canadian National Railway (CNR).

Next steps:

- Approach Metrolinx and railways to address issue of flooding “pinch-points” on the new GO train line to Bowmanville;
- The Region of Durham should support a new Durham Region Flood Hazard Standards Committee that would develop new standards for urban flooding and floodplain mapping as well as infrastructure and development design standards in consultation with stakeholders. These standards could be adopted by local municipalities and conservation authorities and cited in Official Plans, Site Plan requirements, and Building Permit requirements;
- The Region of Durham should support a committee of local municipalities that would consider the implementation of a consistent Storm Water Management Fee and Credit program in Durham Region;
- Municipalities and conservation authorities should adopt LID standards into any updates of applicable planning, development, and regulations documents; and
- As floodplain mapping is updated, conservation authorities should review existing and future flooding damage centres, and with municipalities, develop flood mitigation strategies that consider climate change impacts.

Figure 5: The Great Wall of Durham

Durham Region has a “Great Wall” somewhat like China’s, but in our case the wall consists of the railway and highway embankments that run along the lakeshore parallel to the highway 401 corridor. The largest wall includes the railway line that was built in the 1880s by the Grand Trunk Railway at a time when most of Durham was forest and farms and flood runoff was modest. Today the rail lines are owned by CNR and CPR and are used extensively by freight trains, GO trains, and VIA Rail. The embankments are of substantial height in many areas and are punctuated by bridges and culverts that are in some cases too small for the much greater runoff caused by modern development and hard surfaces to the north. There are several well-known “pinch-points” where already there is occasional flooding on the north side of the corridor.

A future extreme rain event in Durham could trigger large-scale urban flooding at these “pinch-points” and potentially flooding across the 401 in places as well as the washout of the main rail lines. One well known “pinch-point” is where the Oshawa Creek crosses under the rail lines and 401 in south Oshawa. While complicated by the ownership of CNR and CPR, early expansion of these bridges is considered a priority and could avoid major transportation disruptions. Further analysis and costing of this and other sites along the Great Wall of Durham, as well as pre-emptive investment are critical.

The print version of this document shows floodplain mapping conducted by Central Lake Ontario Conservation Authority (CLOCA) in two flood prone areas in Oshawa.

Objective: Reduce the risk of flood damages by updating floodplain maps and redefining future flood hazard areas

F2: Redefine Flood Hazards to Consider Climate Change

Durham conservation authorities and municipalities should adopt new standards and codes for defining floodplains which take into account the higher intensity and severity of storms to be encountered as a result of a changing climate. The newly defined flood hazard areas will require appropriate protection of health, property, and services against severe flooding events.

Adaptation actions covered by this program include the following:

- Changing Standards:
- Increase the standards for maximum precipitation/rainfall standard in one day and potential for violent storms;
- Change floodplain mapping standards to include more intense rainfall;

- Update floodplain modelling standards to account for climate change; and
- Undertake climate change sensitivity analysis for floodplain modelling.
- Improving Modelling:
- Use 2D modelling in urban areas where appropriate;
- Use Best Management Practices in modelling and mapping (e.g., LiDAR and real-time modelling);
- Model floodplain scenarios to define duration of flooding; and
- Maintain up-to-date floodplain models.
- Assessing Hazards:
- Update floodplain mapping with new standards;
- Identify flood vulnerable areas; and
- Undertake risk assessments.

Affected sectors include:

- Conservation authorities;
- Municipal planning and community design;
- Public works; and
- Development industry.

Responsible agencies:

- Conservation authorities;
- Municipal planning departments;
- Ministry of Natural Resources and Forestry (MNRF); and
- Ministry of the Environment and Climate Change (MOECC).

Next steps:

- The Region of Durham should support a new Durham Region Flood Hazard Standards Committee that would develop new standards for floodplain mapping as well as infrastructure and development design standards in consultation with

stakeholders. These standards could be adopted by local municipalities and conservation authorities and cited in Official Plans, Site Plan requirements, and Building Permit requirements; and

- Collaboration between municipalities and conservation authorities to use federal National Disaster Mitigation Program funding to undertake risk assessments and new floodplain mapping initiatives.

Objective: Reduce the impacts of flooding

F3: Improve Flood Forecasting, Warning and Emergency Response

The program addresses how to best forecast and warn communities of events that threaten the built environment (health, property, and services) from the magnitude of flood that may be experienced due to a changing climate. Additionally, the program looks to create emergency response that is more flexible, and therefore better responds to potential extreme flood events.

Adaptation actions covered by this program include the following:

- Improving monitoring:
- Evaluate monitoring networks;
- Improve event-based monitoring networks;
- Upgrade monitoring networks; and
- Leverage other monitoring networks and encourage multi-agency utilization.
- Improving forecast models:
- Develop predictive models tailored to more intense rainfall events;
- Improve integration of weather forecasts into predictive models; and
- Operate predictive flood model.
- Improving overall flood forecasting and warning systems:
- Address emergency communications;
- Improve public communication;
- Improve business communication;

- Ensure telecommunications back-up;
- Ensure communication plan addresses CC flooding;
- Create web based information tools;
- Inform political leaders; and
- Increase the public awareness on the subject matter.
- Protecting infrastructure critical for responding to flooding events
- Update Emergency Response Agreements;
- Ensure availability of appropriate vehicles and equipment;
- Protect operational centres;
- Protect evacuation centres; and
- Protect critical services.
- Addressing flood depth:
- Ensure access and egress;
- Employ access egress delineators;
- Develop depth of flooding mapping for flood stages; and
- Ensure access for emergency vehicles.
- Addressing flood event planning:
- Improve the quality and frequency of training;
- Include annual checklists;
- Update detailed Emergency Response Plans;
- Develop reporting metrics; and
- Improve emergency management planning.
- Addressing flood event cleanup:
- Coordinate clean-up support; and

- Address building integrity following flood event.

Affected sectors include:

- Municipal emergency planning organizations;
- Public works;
- Conservation authorities; and
- Provincial ministries and agencies.

Responsible agencies:

- Emergency management organizations;
- Conservation authorities;
- Local municipalities; and
- Provincial ministries and agencies.

Next steps:

- Conservation authorities should review monitoring networks and flood forecasting models to ensure climate change events are considered where possible. Ongoing review should be considered as monitoring and modelling technology improves;
- Updates of conservation authority flood contingency plans and municipal emergency management plans should include improvements in areas of public information and communication; and
- As part of future updates and as information becomes available, conservation authority flood contingency plans and municipal emergency management plans should be evaluated to ensure resources are available and able to address the potential extent of flooding present during climate change events. Where these plans are found deficient, strategies to address the deficiency should begin immediately.

Objective: Reduce the severity and frequency of riverine flooding

F4: Address Riverine Flooding

Large system flooding can be a result of the inappropriate development within the natural flood control elements of a watershed. These elements are natural attenuators of floods that for centuries have lessened the impact of floods on downstream developments. Examples include wetlands, floodplains (storage), forests, and areas of natural cover. Protection of these natural flood management elements is often the most cost-effective form of flood protection. This program will look to put in place proactive management of watershed resources to reduce flooding and protect communities.

The adaptation actions covered by this program include the following:

- Watershed Scale Considerations:
- Integrate planning process with watershed studies;
- Conserve headwaters, wetlands, forests, areas of natural cover (i.e., features and functions);
- Develop SWM criteria through watershed scale studies;
- Preserve major recharge areas;
- Consider cumulative impacts; and
- Restore natural heritage systems.
- Addressing Riverine Flooding:
- Improve riverine crossing – employ climate change factors of safety;
- Implement riverine conveyance improvements;
- Maintain stream geomorphology; and
- Manage floodplain infrastructure based on flood and erosion risk.

Affected sectors include:

- Local municipalities: planning and design;
- Conservation authorities; and
- Development industry.

Responsible agencies:

- Conservation authorities;
- Municipal planning departments; and
- Provincial ministries (MOECC and MNRF).

Next steps:

- Conservation authorities should review existing watershed plans to ensure climate change considerations are included. Where climate change considerations are lacking, conservation authorities should develop work plans to update watershed plans;
- Durham Region should develop (with provincial assistance) a funding program to ensure watershed plans are updated at a minimum of every five years and these updates should include consideration of climate change where older plans have not included this work;
- Conservation authorities should work with Durham Region and local municipalities to ensure that recommendations found within watershed plans are considered/reviewed by municipal councils and integrated into municipal planning documents; and
- Regional and local municipal works departments should include climate change considerations in all updates to infrastructure and asset management strategies.

Human Health Sector Objectives and Programs

Objective: Provide advanced warning of impending extreme weather

HH1: Extreme Weather Alert and Response (EWAR) System

This program is designed to create a mechanism to alert Durham residents (especially vulnerable populations and the agencies that serve them) about impending extreme weather events (e.g., high temperatures and humidex readings, ice storms, flooding, tornadoes, and poor air quality) and to provide, where possible, access to response systems to protect people. The responses could include opening of cooling/warming centres, free public swims, outreach to vulnerable people, checking on seniors and people with health issues, etc.

A more limited Heat Warning Information System (HWIS) employing harmonized heat criteria across southern Ontario was pilot tested by Durham Region Health Department in the summer of 2015 (as part of the Pan Am and Parapan Am Games). Environment Canada provided meteorological services and early notification of extreme heat events. Municipal and community partners were provided the opportunity to receive these early notifications through an email subscription service. Early notification allowed partners to prepare in advance for the extreme heat. The general public was alerted to extreme heat one day prior via media release and through the Durham Region Health Department website.

The full EWAR program should include a Vulnerable Persons Registry (VPR) which can be used to communicate with vulnerable persons and their caregivers proactively, to provide warning when extreme weather conditions are forecasted and to provide vital services during emergency situations, especially when extreme weather results in electricity outages. Currently, Durham Regional Police Service maintains a Vulnerable Persons Registry that is focused on people with cognitive challenges that may cause them to wander. This program could be expanded to cover all vulnerable populations and include health and social service agencies and community partners (e.g., Red Cross, Salvation Army, Central East-Community Care Access Centre, school boards, etc.). Community partners would be encouraged to develop strategies and to network together with other partners to identify gaps and ways to mitigate service disruption risks.

Affected sectors include:

- Health and social service sector;
- Community partners;

- Vulnerable groups; and
- General population.

Responsible agencies:

- Regional Municipality of Durham: Health Department, Social Services Department, Durham Emergency Management Office and Durham Regional Police Service;
- Local Municipalities: parks and recreation departments (for cooling/warming centres and evacuation centres), fire and rescue departments;
- Environment Canada (for extreme weather alerts);
- Health Canada;
- Public Health Ontario; and
- Local and regional community partner agencies.

Next steps:

- Undertake an inventory of municipal recreation centres, libraries and other facilities which could serve as cooling/warming centres and emergency evacuation centres, including the current and future availability of back-up power;
- Investigate existing VPR and the potential to integrate and maintain these systems to create a master VPR, including the use of cell phones and GPS to make the system more responsive; and
- Convene a meeting of all emergency responders and social service agencies to explore the potential for an EWAR system in Durham.

Objective: Protect tenants in multi-residential buildings from excessive heat in their units

HH2: Property Standards By-Laws for Maximum Temperature Allowed in Apartments

The purpose of these by-laws in each municipality is to reduce the health risk to tenants (and especially to vulnerable populations) in multi-residential buildings (mostly apartments) from exposure to extreme heat during heat waves. The populations that are

most vulnerable to extreme heat are young children, the elderly, those with pre-existing illnesses, low incomes, and those who are socially isolated.

Tenants in multi-residential buildings without air conditioning (or with minimal air conditioning) face a number of challenges in keeping their units cool, especially during extended heat waves. This is not simply an issue of comfort but can also be a matter of heat-related illness and death.

Most municipalities have by-laws that regulate landlords concerning how low the temperature in a rental unit is allowed to drop in winter but none in Durham regulate how hot apartments are allowed to be in the summer.

New property standards by-laws, together with tenant education efforts and assistance to landlords, could significantly reduce this problem.

Affected sectors include:

- Multi-unit residential buildings (apartments, rooming houses, condominiums).

Responsible agencies:

- Health Canada and Public Health Ontario for maximum indoor temperature criteria;
- Durham Region Health Department for communication and awareness; and
- Local municipalities for developing and adopting by-laws and enforcement.

Next steps:

- Set a uniform maximum allowable indoor temperature for rental units (or, where not readily feasible, require a cool common room where tenants can take reprieve from the heat);
- Prepare a common municipal property standards by-law and enforcement program for the approval of local councils across Durham; and
- Launch awareness programs for tenants and landlords.

Objective: Reduce ambient summer temperatures in urban areas in order to reduce heat stress

HH3: “Cool Durham” Heat Reduction Program

This program is intended to lower the ambient temperature in Durham region during future summer heat waves, especially in the more urbanized areas. This urban heat island effect exacerbates extreme temperatures and humidex levels and leads to health problems for outside workers, exposed populations, and especially vulnerable members of our community.

Durham municipalities should adopt planning, construction, and forestry practices to cool our summer micro-climates and reduce the local urban heat island effect by designing, building and converting our urban areas to reflect, not absorb, solar radiation and to use trees and other vegetation to provide cooling through shading and evapotranspiration.

Measures to cool Durham include:

- Reflective roofs (also called white roofs, cool roofs);
- “Green” or vegetated flat roofs;
- Increased urban tree cover on public and private land;
- Shading structures in parks and public spaces;
- Light coloured pavement and buildings;
- Improved thermal performance in buildings and passive cooling design; and
- Water features in landscaping (rain gardens, bio-swales).

Affected sectors include:

- Municipalities; and
- Construction industry.

Responsible agencies:

- Municipalities: Chief Building Officials, Planning Departments, Works and Urban Forestry.

Next steps:

- The Region of Durham could prepare a Durham Reflective Roof Standard that could serve as a common definition of what qualifies as a white/light/reflective roof for different types of buildings;
- Similar standards for pavement materials and landscaping could also be developed; and
- These standards could be adopted by local municipalities and cited in Official Plans, Site Plan requirements, building permit requirements and in procurement of buildings and roof repairs.

Roads Sector Objectives and Programs

Objective: Improve the performance of roads under extreme heat conditions

R1: Resilient Asphalt Program

Durham municipalities should adopt planning, design, construction, and maintenance practices to reduce the absorption of heat and/or increase tolerance to extreme heat in order to prevent softening of asphalt and subsequent deterioration of roads. Such a preventive measure would maintain the expected life of road pavement, thereby avoiding an increased maintenance cost. Major cities like Toronto have identified that the economic consequence of asphalt softening will severely impact the city's financial health, if not addressed in time.

Asphalt pavement is composed of aggregates and asphalt cement that are designed to perform over a range of temperatures. The asphalt cement binds the aggregates and it softens when subjected to temperatures higher than what it is designed for, making the asphalt more susceptible to rutting and the initiation of cracks.

Measures to address the extreme heat impact to asphalt pavement include the following:

- Using resilient asphalt that can tolerate extreme heat;
- Using alternative pavement surfaces such as concrete at critical locations like intersections and bus bays;
- Using light colored asphalt pavement to reduce heat absorption; and
- Increasing urban tree cover to reduce heat impact.

The Ministry of Transportation (MTO) has been experimenting with asphalt that is more heat-tolerant. Municipalities can benefit from this research when planning their programs related to road design, asphalt standards, maintenance, and replacement.

Affected sectors include:

- Public works; and
- Construction.

Responsible agencies:

- Regional and municipal works departments; and
- Ministry of Transportation, Provincial Design Standards Branch.

Next steps:

- Monitor ongoing impact of heat on existing pavement;
- Identify and prioritize emergency and economic routes that require early attention;
- Consider application of resilient pavement on priority routes including transit and truck routes emergency and evacuation routes; and
- Keep abreast of latest developments in resilient asphalt and modify specifications accordingly.

Objective: Improve the resilience of road systems to extreme rain storms.

R2: Road Embankment Program

This program is intended to address the detrimental impact of extreme storm events on road embankments and the subsequent economic and health consequences to Durham's community at large. Road embankments are often used in conjunction with storm sewers, culverts, and bridges to allow water courses, roads, trails, railways, and wildlife corridors to pass under the roadway without eroding the infrastructure.

Approaches to address the extreme storm impacts to road embankments include the following:

- Upgrading critical infrastructure to withstand extreme storm events;

- Using resilient erosion control treatments on shoulders and embankments;
- Improving drainage corridors; and
- Increased maintenance of embankments and shoulders.

Adaptation actions covered by this program include the following:

- Identification and inventory of critical infrastructure segments currently at risk for embankment or shoulder failure during storm events;
- Establish a monitoring program to inspect road segments that are susceptible to failures during extreme storm events;
- Upgrade of critical infrastructure segments currently at risk for embankment or shoulder failure during storm events;
- Schedule and implement routine inspection and maintenance programs for road embankments;
- Improve planning and engineering requirements for roads requiring embankments or granular shoulders (e.g., consider flatter slopes of 4:1, vegetated and reinforced slopes, or reinforced shoulders);
- Increase geotechnical requirements for embankments and shoulder designs to reduce failures;
- Research and incorporate the use of geo-synthetic reinforcement to reduce embankment failures;
- Research and incorporate the use of granular sealing on shoulders susceptible to erosion;
- Research and incorporate the installation of engineered drainage systems in areas prone to erosion;
- Avoid constructing new roads in areas vulnerable to extreme storm events;
- Provide emergency preparedness, response, and management training to field staff in case of embankment failures following extreme events;
- Provide field staff with training on safely dealing with catastrophic failures of road embankments following extreme storm events;
- Implement traffic management plans for areas susceptible to embankment or shoulder failures (e.g., load restrictions, road closures, or alternate routes);

- Consider paved shoulders in areas prone to erosion; and
- Improve storm water management and drainage practices in areas susceptible to embankment or shoulder failures.

Affected sectors include:

- Public works; and
- Conservation authorities.

Responsible agencies:

- Regional and municipal works departments;
- Conservation authorities; and
- Ministry of Transportation, Provincial Design Standards Branch.

Next steps:

- Initiate a program to identify and inventory critical segments currently at risk for embankment or shoulder failure during storm events;
- Review the existing construction design criteria for embankments to ensure ability to withstand extreme storm events;
- Consider pilot projects to test various geo-synthetic materials and other reinforcement products on embankments and shoulders; and
- Identify and prioritize routes used for transit, trucks, emergencies, and economic interest for early implementation.

Objective: Protect roads from washout at stream crossings

R3: Adaptive Culverts and Bridges

Durham municipalities should adopt planning, design, construction and maintenance practices to adapt its culverts and bridges to withstand newly projected extreme and frequent storm events. Such a preventive measure would make our transportation infrastructure more resilient and reduce the need for significant spending on restoration work after such extreme storm events.

Recent experiences in Canadian cities like Toronto and Calgary serve as a vivid demonstration of impacts from such extreme storm events and the very high social,

business, and restoration costs. Culverts and bridges (storm structures) maintain the continuity of water courses (both natural and manmade) under roads, trails and other transportation corridors. They were designed to perform satisfactorily over a range of storm averages and extremes and will fail if they are subjected to above-design storm events, resulting in potential road and embankment washouts.

This program recommends the following measures be taken to adapt the Region's culverts and bridges to face future extreme storm events:

- Inventory and assess storm structures to determine vulnerability and to improve their adaptive capacity;
- Modify inspection and maintenance practices to proactively accommodate future storm intensities;
- Implement rehabilitation and capital improvements/replacements where required;
- Initiate research and development to update the design criteria for future storms; and
- Train municipal operations and depot staff in emergency preparedness and response measures.

Affected sectors include:

- Public works;
- Conservation authorities; and
- Transit and rail authorities.

Responsible agencies:

- Regional and municipal works departments.
- Next steps:
- Conduct an inventory of all culverts and bridges to assess their capacity and current condition.

Natural Environment Sector Objectives and Programs

Objective: To enhance natural capital and build climate resilience in the natural environment.

NE1: Achieving Climate Change Resilience in the Natural Environment

One comprehensive program is recommended to address identified climate change risks to the natural environment across Durham. This program is adaptable at the local level and takes a “no-regrets” approach, in which any action undertaken is seen as positive in building resilience within the natural environment. The program builds upon work completed to date and current programs by recommending on-the-ground actions that will further build resilience within the natural environment and consider the urban/developed environment.

The recommended approaches and actions include:

Adaptive Management of our Plans and Policies

- Update policies, strategies, plans, studies, programs and reports that may have been developed without full consideration of climate change and may not adequately address anticipated changes in the natural environment or identify most vulnerable and highest risk functions and features;
- Implement applicable policies, strategies, plans, studies, programs and reports as they relate to the natural environment and climate change resiliency in the natural environment; and
- Evaluate and monitor the performance of the policies, strategies, plans, studies, programs and reports to better understand the effectiveness of actions in building resilience of the natural environment.

Collaboration

- Establish a working group that will oversee natural environment adaptation to climate change within the Durham Region; and
- Continue to define one connected natural heritage system that integrates targeted systems across Durham Region.

Stewardship, Education and Outreach

Use existing and develop new conservation programs to protect, enhance and restore the health and resiliency of the natural environment. Specific actions should include, but are not limited to:

- Tree and shrub planting within a natural heritage system context;
- Forest management;
- Sensitive habitat creation and restoration (e.g., tallgrass prairie, wetlands); and
- Riparian areas and in-stream habitat creation and enhancement.

Incorporate and support the concepts of green infrastructure to protect, enhance and restore the health and resiliency of the natural environment and communities. Specific actions and techniques should include:

- Backyard habitat creation;
- Green roof installation;
- Rain gardens;
- Soakaway pits;
- Permeable groundcovers; and
- Bioswales.

Develop new and promote existing education and outreach programs to increase understanding of:

- The natural environment;
- The impacts of climate change on the natural environment; and
- How the natural environment can help society adapt to climate change and the ecosystem services it provides.

Affected sectors include:

- All sectors are affected by and interact with the natural environment.

Responsible agencies:

- Conservation authorities; and
- Regional and local municipalities.

Next steps:

- Develop work plans to integrate anticipated climate change impacts to the natural environment into existing municipal and conservation authority policies, plans, programs, and activities;
- The Region of Durham should work with the five conservation authorities to develop funding for integration of climate change considerations into watershed plans;
- Establish a joint technical working group among the five conservation authorities and municipal staff to promote, guide, and provide expertise to support development and implementation of adaptation efforts; and
- Create a Durham Stewardship and Outreach working group involving the Region and the five conservation authorities to improve community understanding of the roles the natural environment and green infrastructure have in climate adaptation.

Food Security Sector Objectives and Programs

Objective: Develop subsequent programs to address climate adaptation in the commercial agriculture and food supply sectors

FS1: Convene Commercial Agriculture Task Force

During this phase of the Community Climate Adaptation Plan development, it was not possible to sufficiently engage the agriculture sector to develop specific program proposals for agriculture. This program is a “place-holder” for future development of such a program or programs.

Next Steps:

It is proposed to convene at an appropriate time of year representatives from the various agricultural commodity groups to develop programs to protect agricultural practices from the effects of changing climate and where possible to benefit from these changes (such as longer growing seasons).

Costs and Benefits of Climate Adaptation

Climate adaptation is an investment in the future of Durham – in the viability of our physical infrastructure, the protection of our health, personal security, environmental quality, and in the ability of our economy and our society to function in a climate that will be significantly different from today's.

We are asked to invest in measures to:

- Extend the lifespan of our roads, buildings, bridges and electrical transmission equipment;
- Prevent or reduce the impacts of floods, violent storms and wildfires;
- Protect human life against floods, extreme heat and violent storms;
- Maintain environmental quality and environmental services; and
- Manage weather emergencies when they do occur.

What are the costs and benefits of these investments? How do we estimate them and determine priorities among them?

In a purely economic sense, we are investing capital and operating funds now to avoid future damage costs from climate change and extreme weather events. However, avoided costs for infrastructure damage are only part of the benefit. Human health, human life, environmental quality, and the viability of local economies are all considerations which are difficult to monetize.

The National Roundtable on the Environment and the Economy (NRTEE) undertook a major study in 2012 of the economic costs of climate change entitled "Paying the Price: The Economic Impacts of Climate Change for Canada" which found that climate change impacts could have an economic cost to Canada of $5 billion annually by 2020 (this is likely an underestimate, given the recent $6 billion cost of flooding in southern Alberta in 2013, $1 billion in Toronto in 2013, and the $9 billion Fort McMurray wildfire in 2016). The report further projected longer-term costs in Canada of between $21 billion and $43 billion per year by 2050. The report concluded that ignoring climate change now will cost us more in the long run, and that adaptation is a cost-effective way to alleviate many of the impacts of climate change. It further estimated that every $1 spent now on adaptation will yield between $9 and $38 worth of avoided damages in the future (depending on the extent and rate of climate change).

Other studies from the University of Waterloo's Intact Centre on Climate Adaptation indicate that the cost to build a new house, bridge, or transmission line that is adapted to climate change for its lifecycle will only add 0% to 5% to the construction costs. This is significantly cheaper than retrofitting an existing building, restoring infrastructure post-damage, rebuilding, or the increased lifetime maintenance bill. The Intact Centre concludes that climate change adaptation is "simply good and smart business for Canada".

The current state of adaptation program development in the Durham Community Climate Adaptation Plan does not allow for detailed and specific estimation of costs, let alone the avoided damage costs or "benefits" of these programs. This sort of precision will only be possible as programs are further developed by the various responsible agencies in the context of their business planning processes. For example, it is only possible to accurately determine the cost of a culvert maintenance and replacement program in a given jurisdiction after an initial inventory of the flow capacity and current condition of all culverts to determine which ones require replacement (high cost) and which ones can be managed through improved maintenance (lower cost). Thus, program cost/benefit analyses will be staged over time and will be iterative. Moreover, they will be undertaken in the context of the business planning of the responsible agencies.

We know at this point that some programs will be low-cost and some will incur much more substantial costs. Generally, programs that are administrative or operational in nature, such as maintenance programs, research and monitoring, or emergency response activities will be low-cost and may be accommodated within existing budgets or with minor increases. On the other extreme, programs that call for capital improvements, upgrades, or replacement of inadequate infrastructure will be much more costly and likely will not be accommodated within existing budgets. In between these extremes of the cost spectrum are a large number of activities that relate to the adoption of increased standards for equipment procurement and maintenance, incremental improvements to construction practices and simple retrofit actions on homes and other buildings to increase resilience.

A local example of infrastructure replacement is the culvert under Brock Street in downtown Uxbridge. It has been known for some time that the old single culvert on the Uxbridge Creek from Centennial Drive to 100m north of Brock Street is inadequate to handle floods and poses a severe flood hazard. In the event of a rain event like Hurricane Hazel in 1954, large portions of downtown Uxbridge would be flooded up to the second storey of the commercial buildings along Brock Street. The cost of replacing and enlarging the culvert has been estimated at about $10 million. Fortunately, provincial funds have recently been made available to support this project which will be completed by 2019. In this example, the benefit of spending these funds is the

prevention or reduction of future flood damage in the commercial section of Uxbridge, which given the exposure of the businesses, would likely exceed $10 million for one event. Therefore, the investment is likely cost-effective; however, it is complicated by the fact that the cost is a public one but the benefit is largely private.

Roles and Responsibilities

Climate adaptation presents a complex set of roles and responsibilities in terms of which government organizations and agencies have jurisdiction and legal responsibility for implementation of various programs and measures. Table 2: Program Responsibilities Matrix summarizes the Responsible Agencies for each of the proposed programs in this Community Climate Adaptation Plan.

Most of the proposed programs fall into multiple jurisdictions and therefore require high degrees of collaboration to further develop and effectively implement. Such programs will require the breaking down of silos among our institutions, an unprecedented level of cooperation, as well as commitment and “institutional memory” over lengthy periods of time (in some cases decades).

Just within the structure of Durham region, there are multiple programs that require implementation by local municipalities which have the jurisdiction, for example, for areas such as:

- Storm water infrastructure;
- Development controls (e.g., flood zones);
- Site-plan controls (e.g., low impact development techniques);
- Enforcing building standards and codes;
- Culverts and bridges under local roads;
- Vegetation management; and
- Fire and emergency services.

At the Regional level, many of these responsibilities pertain to regional roads, water and sanitary sewer services, public health, policing, paramedic service, and broad-based land-use planning. The Region can also play a useful role in coordinating the establishment of standards and procedures for uniform application by local municipalities.

Local electrical utilities have almost exclusive jurisdiction for maintaining electrical services but they require complementary activities by local municipalities and conservation authorities.

Conservation authorities have legislated responsibilities for flood prediction and management, site-plan controls, ecosystem monitoring, protection and restoration. Conservation authorities rely on regional governments for much of their funding.

Provincial ministries and agencies (and in a few cases federal departments) play vital roles in conducting research, establishing new guidelines, standards and codes, improving their own infrastructure and regulating public and private sector activities.

Undertaking climate adaptation programs and improving the resilience of our Durham community will require extraordinary jurisdictional effort and inter-agency collaboration.

Table 2: Program Responsibilities Matrix

#	Sector/Program	Region	Municipalities	Electrical Utilities	Conservation Authorities	Provincial Agencies	Federal Agencies
	Cross-Sectoral Programs						
CS1	Protect Our Outside Workers	•	•	•	•		
CS2	Social Infrastructure for Emergency Resilience	•	•				
	Building Sector						
B1	Durham Climate Resilience Standard for Buildings	•	•			• 1	
B2	Building Retrofit for Climate Resilience	•	•			• 1,2	
	Electrical Sector						
E1	Asset Protection Against Flooding		•	•	•		
E2	Vegetation Management	•	•	•			
E3	Asset Design & Service Life Management			•		• 3	
	Flooding						
F1	Addressing Urban Flooding		•		•	• 2, 4, 5	• a
F2	Redefine Flood Hazards		•		•	• 2, 4	
F3	Improving Flood Forecasting, Warning & Emergency Response	•	•		•	• 4	
F4	Addressing Riverine Flooding		•		•	• 2, 4	
	Human Health						
HH1	Extreme Weather Alert and Response system	•	•			• 6	• b, c
HH2	Property Standards Bylaw for Maximum Heat Allowed in Apartments	•	•			• 6	• c
HH3	“Cool Durham” Heat Reduction Program	•	•		•		
	Roads						
R1	Resilient Asphalt Program	•	•			• 5	
R2	Road Embankment Program	•	•			• 5	
R3	Adaptive Culverts and Bridges	•	•		•		
	Natural Environment						
NE1	Achieving Climate Resilience in the Natural Environment	•	•		•		

Legend:

Provincial Agency codes:

1. Ministry of Municipal Affairs
2. Ministry of the Environment and Climate Change
3. Ontario Energy Board
4. Ministry of Natural Resources and Forestry
5. Ministry of Transportation
6. Ontario Ministry of Health and Long-Term Care

Federal Agency codes:

a. Transport Canada
b. Environment and Climate Change Canada
c. Health Canada

Next Steps

Implementation by Responsible Agencies

The purpose of this document is to present a set of proposed programs that constitute a comprehensive Community Climate Adaptation Plan for Durham and to seek Regional Council “approval in principle” on behalf of the Durham community. However, as outlined in the previous chapter, the Regional Municipality of Durham does not have jurisdictional authority or responsibility for most of the measures in this Plan; responsibility is distributed among a number of levels of government and agencies. Therefore, the next steps after “approval in principle” will involve referral from Regional Council to the responsible agencies for their consideration, approval, funding, and implementation within the context of their business plans.

Following “approval in principle” by Durham Regional Council, this Plan will be officially transmitted to all responsible agencies with explicit identification of the programs and activities that fall within the agency’s areas of jurisdiction and responsibility. Furthermore, a process will be suggested for:

- Further development of the programs and activities;
- Estimation of program costs and benefits;
- Integration of agencies’ efforts on each program;
- Consideration of adaptation programs in the context of multi-year business plans;
- Funding of program activities;
- Implementation of activities;
- Regular reporting on progress; and
- Review and renewal of the programs.

In the case of each program, Region of Durham staff will:

- Undertake a similar process for its areas of responsibility;
- Attempt to assist other agencies and coordinate activities; and
- Promote a uniform approach across the region, where appropriate.

It is expected that responsible agencies will respond to this Plan in a phased and measured manner consistent with their risk management policies and practices.

Ultimately, it will be the role of each responsible agency to make informed decisions within its legal obligations and financial resources on whether and how to implement the programs recommended in this Plan.

Securing Funding

Some of the activities identified in this Plan are low-cost or even no cost and it is expected that many of these can be accommodated within the existing budgets and business plans of the responsible agencies. In other cases, the costs for capital programs in particular, may be beyond the capability of the agency (and its taxpayers/ratepayers) to fund on its own. This is where outside funding, particularly from senior levels of government, will be needed to assist municipalities and their agencies to undertake critical adaptation investments.

The Region of Durham has proposed the creation of an Ontario Climate Resilience Fund (OCRF) to address this need. This proposal was approved by Regional Council on December 16, 2015 (Report 2015-J-56) and forwarded to the Premier of Ontario and the Prime Minister. The concept calls for significant amounts of dedicated funding to be committed by the federal, provincial, and municipal levels of government and the property insurance industry to a joint fund to provide support for high-priority infrastructure investments by municipalities in Ontario. At maturity the OCRF would provide about $4 billion per year in financial support to Ontario municipalities. For more information, see the original outline of the OCRF in Appendix 6.

Reporting and Renewal

Given the diverse nature of the programs in this plan and in particular the complex set of responsible agencies, it will be important for there to be full and regular reporting to the Region and to the community at large on progress in implementing approved programs. Moreover, it will be important to monitor progress and renew the Durham Community Climate Adaptation Plan based on changing climate, extreme weather experiences, and lessons learned in program implementation.

It is proposed that responsible agencies be requested to report annually to the Region concerning their progress in implementing the proposed programs in this Plan. These reports should be consolidated by the Region and released to elected officials and the public.

Furthermore, it is proposed that this Durham Community Climate Adaptation Plan be renewed every five years to keep pace with changing climate, program experience in Durham and elsewhere, and new developments in adaptation technologies and techniques.

After the initial five year period, it may be possible to relax the initial reporting and renewal frequency.

Addressing Gaps in Sectoral Coverage

As outlined in the previous section on Objectives and Proposed Programs, the work of the Expert Task Forces was not able to adequately address the agriculture and food security areas and to propose specific programs for these sectors. Given the importance of agriculture to Durham's economy, it is recommended that representatives of the agricultural sector in and beyond Durham be re-approached to work on proposed programs to address risks and opportunities for the food security sector.

It was also not possible to organize Expert Task Forces for the following important sectors:

- Telecommunications;
- Provincial roads; and
- Other forms of transportation (rail, air, and ship).

Working with these sectors requires a provincial or national approach since the decision-makers, regulators, and the industry associations are not in Durham and the infrastructure is widespread. It is recommended that Durham Region work in concert with other municipalities and other levels of government to engage these sectors on climate adaptation and resilience. The objective should be to include these sectors in the next Durham Community Climate Adaptation Plan in five years.

Appendices

Appendix 1: Membership of the DRRCC and the Climate Adaptation Subcommittee (2016)

Anderson, Roger
Regional Chair and CEO

Bridgeman, Brian
Commissioner of Planning and Economic Development (Alternate)

Caneo, Cesar
Citizen Member, Local Food Sector

Cubitt, Garry
Chief Administrative Officer

Gauder, Richard* (Chair)
Citizen Member, Small Business Sector

Gilbert, Dayna
Citizen Member, Housing Sector

Hall, Todd*
Citizen Member, Energy Sector

Hoornweg, Daniel*
Citizen Member, Education Sector

Lacina, Eric
Citizen Member, Student

Manns, Hida
Citizen member, Agriculture Sector

Moore, Samantha
Citizen Member, Student

Neil, Barry
Citizen Member, Health Sector

Solly, Jeff
Citizen Member, Land Development Sector

Vroegh, Martin (Vice-Chair)
Citizen member, Large Industry Sector

Councillor Kevin Ashe

Councillor Jack Ballinger*

Councillor Adrian Foster (Alternate)

Councillor Derrick Gleed

Councillor John Grant (Alternate)

Councillor Don Mitchell

Councillor Steve Parish (Alternate)

Councillor David Pickles (Alternate)

*Designates members of the Climate Adaptation Subcommittee

Appendix 2: Durham Region's Future Climate 2040-2049 (SENES Report Summary)

What Is this Document?

This document provides a summary of a comprehensive study prepared by SENES Consultants for the Durham Region Roundtable on Climate Change (DRRCC) entitled Durham Region's Future Climate (2040-2049). The SENES study constitutes a key starting point in the creation of a Community Climate Adaptation Plan.

The SENES study is based on a similar study undertaken by SENES for the City of Toronto in 2011 that covered the GTA and beyond. City of Toronto officials graciously provided access to the data compiled for Toronto's study which included certain sites in Durham Region. This has allowed the DRRCC to undertake this study focused on eight locations in Durham at significantly lower cost than the Toronto study and to complete a number of special detailed analyses (combinations of parameters) of particular interest to stakeholders.

The study provides projections of the climate that Durham Region will experience in the decade 2040 to 2049 compared the past decade (2000 to 2009). It does not forecast or predict daily weather for the future period; rather it provides projections of both climate averages and weather extremes for the future period and it does so at a high level of geographic resolution (cells of 1 km X 1km). In determining the likely impacts of changing climate in Durham, it is essential to take into account both climate averages and the extremes of temperature, precipitation, wind etc. Society must generally adapt to the changing averages, and the extremes that may pose the greatest risk to infrastructure and processes.

Why Was the Study Undertaken?

The study was undertaken as the first step of a 3-phase process to produce a proposed Durham Community Climate Adaptation Plan. The purpose of the study is to provide a state-of-the-science projection of key climate parameters for a relevant future period for purposes of planning:

- Infrastructure upgrades and new design criteria;
- Extreme weather and emergency response programs;
- Business continuity programs;
- Improved urban and rural design for resilience; and

- Programs and measures to protect human health and property.

What Locations Does It Cover?

The report provides detailed climate projections for all eight local municipalities in the Region of Durham:

- Ajax,
- Brock (Beaverton),
- Clarington (Bowmanville),
- Oshawa,
- Pickering,
- Scugog (Port Perry),
- Uxbridge (Town of Uxbridge), and
- Whitby.

Whitby was selected as the proxy site for Durham Region for purposes of general data presentation of the SENES report; however, full data sets for all sites are summarized in table A2.1.

How Were the Projections Made?

SENES Consultants is a highly specialized consulting firm based in Richmond Hill, Ontario that was selected by the City of Toronto in 2011 to prepare an extensive study on Toronto's future weather and climate drivers. The Region of Durham benefitted from this earlier ground-breaking work by selecting the same consultant. For the Toronto and Durham studies, SENES selected the most credible scenario of future global GHG emissions (the A1B scenario from the IPCC) to drive a global climate circulation model (HadCM3) and a regional climate model (PRECIS) connected to the FReSH weather forecasting system to project relevant climate parameters for the 2040 to 2049 period. These combined models also project the climate parameters for the recent base period 2000 to 2009 which are checked for accuracy against actual historical observations to ensure confidence in the future projections. A separate "backcast" to a specific historical weather event in Durham (the July 11, 2009 microburst in Oshawa) was used to further confirm accuracy of the combined models.

Large portions of the SENES report are dedicated to describing the methodology used in the study and demonstrating the relevance and reliability of the climate projections.

Figure A2.1: Schematic of how future weather and climate is determined utilizing the FReSH Weather Forecasting System

Figure A2.1 is a visual diagram of the inputs and outputs of the FReSH Weather Forecasting System used by SENES to calculate future climate statistics and detailed local weather forecasts. This diagram is available on page 84 of the print version of this plan.

Overview of Results

Overall, Durham region's climate in the 2040 to 2049 period can be described as:

- Considerably warmer with higher humidity;
- Less snow, more rain in winter;
- More frequent and intense summer rain events;
- Lower winds generally; and
- More extreme weather events with high winds and heavy rain.

Future Period: 2040-2049 Compared to 2000-2009

The following summarizes the projected climate changes for the proxy Whitby site for the future period compared with the base period:

- Less snow and more rain in winter:
- About 16% more precipitation (snow and rainfall) overall,
- ~50% increase in the one day maximum rainfall,
- ~40% decrease in the one day maximum snowfall,
- 100% increase in the number of days of rain greater than 25 mm,
- 80% reduction in the number of days with snow more than 5 cm,
- 146% more rain and 61% less snow in January, and
- 217% more rain and 75% less snow in February.

- Rainstorm events will be more extreme:
- 15% increase in the potential for violent storms,
- 53% increase in the potential for tornadoes, and
- 74% more rain in July.
- 79% more rain in August
- Average annual temperatures increase of 4.0°C:
- Average winter temperatures increase by 5.8°C
- Average summer temperatures increase by 2.6°C
- Extreme daily minimum temperature "becomes less cold" by 12°C
- Extreme daily maximum temperature "becomes warmer" by 7.1°C
- Average wind speed about the same:
- Maximum hourly winds reduced
- Maximum wind gusts reduced about 13%
- "Comfort" remains similar but with some extreme events:
- Humidity and temperature taken together as the humidex remains similar (within 8% of present on average) for most of the year but shows increases in November (up 30%) and in May through to September (up 15%) and pushes past the “dangerous” level (45) on several summer days
- Wind Chill is reduced by about 50% on average but is reduced 25-45% during the winter months (Note: Environment Canada recognizes that Wind Chill is not confined to winter).

Implications

Based on these climate projections, we now need to assess the implications for our physical infrastructure, business continuity, government services, food production, health and security. Will there be increase flooding, heat stroke, vector-borne diseases, tornadoes, disruption to energy supply? What can we do to protect ourselves and make our community more resilient to these coming changes?

This is where we require the expertise of various sectors of the community to:

- Identify implications;
- Assess vulnerabilities;
- Identify measures and actions to reduce impacts and increase resilience; and
- Assist in the development of a proposed Community Climate Adaptation Plan for adoption and implementation by the public and private sectors in Durham Region.

The full SENES report is available on request to climatechange@durham.ca.

Table A2.1: Consolidated Projections (2000-2009 and 2040-2049 data)

Climate Parameter	Detailed Parameter	Ajax 2000-09	Ajax 2040-49	Whitby 2000-09	Whitby 2040-49	Oshawa 2000-09	Oshawa 2040-49	Clarington 2000-09	Clarington 2040-49	Uxbridge 2000-09	Uxbridge 2040-49	Port Perry 2000-09	Port Perry 2040-49	Beaverton 2000-09	Beaverton 2040-49	Pickering 2000-9	Pickering 2040-9
Extreme Precipitation	Max. in one Day (mm)	79	84	79	117	84	88	99	96	82	100	87	122	85	88	81	97
	# days/year >25mm	5	9	6	10	6	10	6	9	7	11	7	11	4	9	5	9
	Annual Total Precipitation (mm)	820	954	869	1004	880	1023	883	977	1025	1115	988	1104	828	955	822	960
Extreme rainfall	Max. in one day (mm)	79	84	79	117	84	88	99	96	82	100	87	122	85	88	81	97
	# days/year > 25mm	4	9	5	10	5	10	6	9	6	11	6	11	4	8	4	9
Extreme Snowfall	Max. in one day (cm)	29	14	28	17	29	18	27	21	40	26	39	25	27	31	33	29
	# days/year > 5 cm	8	2	9	2	9	3	9	1	13	6	11	4	12	5	8	2
Extreme Heat	Average max daily (°C)	24	26	25	28	24	28	24	27	25	29	25	29	24	29	25	28
	Extreme max. (°C)	31	40	33	40	32	40	32	40	37	43	35	44	33	40	35	43
	# days/year > 30(°C)	1	6	2	17	1	11	1	9	5	28	5	27	4	26	4	15
Extreme Cold	Average min Daily (°C)	-7	0	-8	-1	-8	-1	-7	-1	-9	-2	-9	-2	-10	-2	-8	-1
	Extreme min. (°C)	-24	-12	-25	-13	-25	-11	-25	-11	-28	-14	-27	-14	-29	-15	-25	-13
	# days/year < -10(°C)	24	0	27	1	27	0	25	0	36	2	36	2	39	2	27	1
	# days/year with min. <0 (frost days)	122	60	129	75	128	73	126	71	141	91	144	92	141	82	129	72
Wind Chill	Extreme Daily (°C)	-36	-17	-37	-19	-37	-17	-36	-17	-41	-20	-40	-20	-39	-21	-37	-20
	# days/year <-20 (°C)	13	0	15	0	16	0	14	0	24	0	23	0	25	0.3	14	0
Degree Days	# degree days/year > 24 (°C) (AC req'd)	4	17	8	49	6	38	5	32	12	90	10	80	6	68	9	43
	# degree days/year > 0 (°C)	3342	4329	3444	4508	3415	4459	3420	4443	3283	4378	3280	4384	3260	4365	3431	4490
	# degree days/year < 0(°C) (heating req'd)	444	50	475	70	474	69	457	64	614	132	602	127	627	121	463	62
Humidex	Max (°C)	43	48	47	51	46	50	45	48	45	54	46	54	45	54	48	53
	Average # days/year >40(°C)	1	6	3	19	3	16	2	13	3	24	4	25	4	25	4	17
Extreme Wind	Max hourly speed (km/hr)	65	57	62	54	65	56	70	56	69	50	69	49	75	59	62	57
	Max. gust speed (km/hr)	120	74	119	74	120	77	113	77	108	78	116	80	106	84	108	74
	# days/year with wind speed > 52 km/hr	3	0.3	2	0.1	2	0.2	3	0.1	2	0	2	0	4	0.6	2	0.2
	# days/year with wind speed > 63 km/hr	0	0	0	0	0	0	1	0	1	0	1	0	1	0	0	0
Potential for Violent Storms	# days with high lightning potential/year	27	43	29	42	27	43	27	41	26	32	25	32	22	29	29	44
	# days/year with EHI > 1	11.2	13.5	15.0	17.2	12.8	15.8	10.9	12.9	20.5	28.2	20.7	27.5	19.3	25.1	15.6	16.7
	# days/year with EHI 2-5			4.9	7.5												
	# days/year with EHI >= 5			0	0.3												

Appendix 3: Membership of the Expert Task Forces

(Past and current, as of February 29, 2016)

Buildings Sector

Bentley, Kyle (Co-Chair)
City of Pickering

Daubeny, Sheila
Town of Whitby

Ford, Ray
Town of Ajax

Lawlor, Gail
DSA

Marshall, Craig
Builder

McGregor, Grant (Co-Chair)
City of Pickering

Electrical Sector

Berdichevsky, Arthur
Veridian

Hall, Todd (Chair)
DRRCC

Lumley, Tom
OPG

Patel, Rajindra
Oshawa PUC

Shah, Jayesh
Oshawa PUC

Sing, Bob
Hydro One

Victal, Rui
Whitby Hydro

Wu, Daisy
OPG

Flooding Sector

Chalmers, Rick
Town of Ajax

Farrell, Laurian
TRCA

Hogenbirk, Tom
LSRCA

Jones, Christopher
TRCA and CLOCA

Lee, Patrick
City of Oshawa

Majchrowski, Mark
KRCA

Manoharan, Antony
Town of Whitby

Peacock, Mark (Chair)
GRCA

Sisson, Perry
CLOCA

Tryon, Kevin
Town of Ajax

Human Health Sector

Craven, Meaghan
Town of Whitby

Di Pietro, Anthony (Chair)
Region of Durham

Hazen, Shelley
TRCA

Klein, Sarah
Town of Whitby

Neil, Barry
DRRCC

Switzman, Harris
TRCA

Whitbread, Michelle
City of Oshawa

Roads Sector

Ambra, Anthony
City of Oshawa

Bishop, Justin
City of Oshawa

Hagner, David
Region of Durham

Ingram, Fay
Town of Whitby

Manoharan, Antony
Town of Whitby

Murphy, Tim
Town of Ajax

Rajendran, Mani (Co-Chair)
Region of Durham

Robinson, Barb
Region of Durham

Rynard, Bill
Township of Uxbridge

Siopis, Susan (Co-Chair)
Region of Durham

Food Security Sector

Cavallari, Carol
Owner, The Table

Drummond, Mary
Durham Food Policy Council

Elston, Suzanne (Chair)
City of Oshawa

Fast, Victoria
OEAC

Kinniburgh, June
Durham Food Policy Council

Kirby, Heather
Durham Sustain Ability

North, Barb
OEAC

Natural Environment Sector

Brooks, Heather (Co-Chair)
CLOCA

Carpentier, Geoff
Chair of DEAC

Del Giudice, Laura
TRCA

Fernandes, Shauna
LSRCA

Field, Tim
Town of Ajax

Goldie, Herb
DEAC

Kilbourne, Kristy
Town of Whitby

Lancaster, Pam (Co-Chair)
GRCA

Lembcke, David
LSRCA

McGregor, Susan
Town of Whitby

McKay, Scott
City of Pickering

Pridham, Dave
KRCA

Schofield, Jade
Town of Ajax

Stavinga, Rob
KRCA

Towle, Ken
GRCA

Tu, Christine
TRCA

Whitbread, Michelle
City of Oshawa

Appendix 4: Results of Risk Assessment Process

Table A4.1: Flooding Sector Risk Assessment

Expert Task Force Area	High Risk Impacts	Medium Risk Impacts
Urban Flooding	major & minor system conveyance, storm water facilities, roads and transportation, sanitary services, erosion, pollution, electrical services, communication services, social services, EMS, police, fire, public use of floodplains	None identified.
Riverine Flooding	social disruption, insurance, damage to private assets, business disruption	None identified.
Warning & Emergency Response	monitoring, forecasting, emergency communications, access for emergency vehicles	None identified.
Natural Hazard Definition	existing mapping, standards, methods, flood hazard policies and management, hazard reduction	None identified.

Table A4.2: Natural Environment Sector Risk Assessment

Expert Task Force Area	High Risk Impacts	Medium Risk Impacts
Groundwater Quantity	None identified.	changes to shallow aquifers, groundwater discharge and recharge areas
Urban Tree Health	changes to: insects or disease, species range, extreme events	changes to abiotic features
Surface Water Quantity	changes to: stream erosion, extreme high flows	changes in base flows, seasonal flows
Surface Water Quality	changes in: background conditions	changes in pathogen concentrations, nutrient concentrations
Terrestrial Habitat	changes to: landscape level connections, abiotic features of habitat	changes to habitat matrix and succession
Terrestrial Species	changes to: species range and presence, insects and diseases, life history traits	None identified.
Aquatic Habitat	changes in: hydrology, thermal regimes	changes to in-stream habitat
Aquatic Species	Changes in: trophic structures, species range and presence, alien invasive species and disease, life history traits	None identified.

Table A4.3: Buildings Sector Risk Assessment

Expert Task Force Area	High Risk Impacts	Medium Risk Impacts
Public Sector Buildings (new and existing)	failure of AC, damage to exterior and rooftop equipment	None identified.
New Residential Buildings	None identified.	backed-up drains/septic, flood damage to service equipment, failure of heating system, damage due to lightening, roof structure failure
New ICI Buildings	None identified.	backed-up drains/septic, flood damage to service equipment, roof structure failure, damage to exterior and rooftop equipment, secondary interior damage, damage to adjacent buildings, damage to exterior and rooftop equipment
Existing Residential Buildings	roof structure failure, backed-up drains/septic, flood damage to service equipment, AC failure, secondary interior damage, damage to exterior, collapse of light structures	backed-up drains/septic, flood damage to service equipment, failure of AC, collapse of light structures, damage to adjacent buildings, secondary interior damage, roof structure failure
Existing ICI Buildings	roof structure failure, backed-up drains/septic, flood damage to service equipment, AC failure, damage to exterior, secondary interior damage	damage to adjacent buildings, heating system failure, structural damage, building devastation

Table A4.4: Electrical Sector Risk Assessment

Expert Task Force Area	High Risk Impacts	Medium Risk Impacts
Extreme Heat	sag and annealing of wires – reduced asset life, accelerates challenges of ageing infrastructure	sag and annealing of wires – phase to phase short, transmission and distribution outages
Temperature	Vegetation management- longer growing season leading to damage and outage	None identified.
Precipitation *Impact of heat on outside workers is yet to be assessed	None identified.	None identified.
Freezing Rain (ice storms)	None identified.	Infrastructure failure leading to outages (due to ice accretion and trees falling on lines)
Extreme Winds	None identified.	Outages caused by infrastructure damage

Table A4.5: Human Health Sector Risk Assessment

Expert Task Force Area	High Risk Impacts	Medium Risk Impacts
Extreme Heat	heat related death and illness	None identified.
Air Quality	chronic exposure	acute exposure
Infectious Diseases	None identified.	tick borne Lyme disease, mosquito borne disease, rodent borne diseases
Contamination of Food and Water	None identified.	food borne illness, water borne illness
Extreme Weather Events and Natural Hazards	None identified.	Extreme weather events and natural hazards

Table A4.6: Roads Sector Risk Assessment

Expert Task Force Area	High Risk Impacts	Medium Risk Impacts
Extreme Storm Events	failure of culverts/bridges, storm sewers, and road embankments	bluff failure along waterfront, road failure through subsoil failure, and pavement structure failure
Extreme Heat	softening of asphalt, and pavement degradation,	buckling of pavement/bridges
Fewer & Less Cold Days	deterioration of road	reduction in the use of road salt (opportunity)

Table A4.7: Food Security Sector Risk Assessment

Expert Task Force Area	High Risk Impacts	Medium Risk Impacts
Increased Rainfall	None identified	soil erosion (crop production and rot
Violent Events and Rain Storms	crop destruction (reduced availability of local food, crop flattening), falling branches and power outages (electricity outages and food storage, handling, processing, access to money and fuel)	road flooding (interruption of food delivery, consumer access to food)
Summer Temperatures (averages and extremes)	water supply – quantity and quality (reduction in crops and availability, increased food prices, health impacts)	Livestock (heat stroke, increase in disease and pests, bacteria in water supply), dairy production (no outdoor grazing or exercise), electricity brownouts (food spoilage, health and safety)
Winter Temperatures (averages and extremes)	None identified	invasive species (increase in local pests), reduction in snow cover (impacts erosion and dormancy periods)
Humidex	None identified	heat stroke (people won't want to garden outside), mold (spoilage)
General	Crops (increased food prices, availability of local and nutritious food)	None identified

Appendix 5: Example Components of a Resilient House Standard

The following tables present some sample measures that could be considered during the development of a potential Resilient House Standard for Durham.

Table A5.1: Example House Structure Components of a Resilient House

Component	Measure	Rationale	Notes
Roof Trusses	Hurricane straps attaching every truss to the upper wall top plate	Prevent roof lift-off during high winds	None
Basement Windows	No basement windows below grade or within 20 cm of grade; OR waterproof windows only	Prevent overland flooding from entering the basement	None
Garage Doors	No double width garage doors	Prevent blowout in high winds	None
Entry Doors	No double entry doors without steel centre post	Prevent blowout in high winds	None
Eaves	Eaves over windows are at least 0.9 m wide (including eaves trough)	Reduce solar gain, especially in summer	None

Table A5.2: Example Exterior Finishing Components of a Resilient House

Component	Measure	Rationale	Notes
Roof Sheathing	To be attached every 10 cm to roof truss with minimum 6 cm nails	Reduce loss of sheathing in high winds	Nail size and spacing TBC
Roof Finishing	Shingles, tiles or metal roof finishing to be light coloured (albedo above xxx)	Reduce heat retention in attic and local exterior heating	Albedo numbers need to be set
Foundation Walls	Drainage membrane from grade to footings to be installed on all exterior foundation walls	None	Is this already part of code?

Table A5.3: Example Plumbing and Drainage Components of a Resilient House

Component	Measure	Rationale	Notes
Sanitary Sewage Outlet	Backflow prevention valve installed on sewage outlet from house	Prevent sewage backup into basement	None
Sanitary Sewage Connection	Sewage outlet and basement floor drains attached to separate sanitary sewage line (where available)	Ensure no cross-connection to storm sewers	None
Storm Water Connection	Footing drains connected through backflow prevention valve to separate storm sewer (where available) Downspouts drain to surface percolation features (LID)	Ensure no cross-connection to sanitary sewers; manage storm water on site	None
Driveways and Walkways	Porous pavement on driveways and walkways	Reduce Runoff	None

Table A5.4: Example Electrical Wiring Components of a Resilient House

Component	Measure	Rationale	Notes
Garage Electrical Service	220 volt roughed-in service to garage	To accommodate future electric car charging	None
Connection of External Electrical Generator	Convenient connection point for external generator, with grid isolation protection	To provide easy and safe connection of generator during blackouts	Can this connection point be external to the house?

Appendix 6: Original Proposal for the Ontario Climate Resilience Fund (October 2015)

Introduction

This preliminary paper outlines a proposed Ontario Climate Resilience Fund designed to assist municipalities to make critical investments in the infrastructure and programs necessary to protect their communities against the extreme weather associated with the changing climate in Ontario.

Rationale

The global climate is being altered and in Ontario this generally means warmer, wetter and wilder weather that will exceed the capacity of our current community infrastructure and programs to cope. Indeed, this is already happening as demonstrated by recent events in Ontario. The costs of adaptation to this “new normal” are significant and well beyond the ability of the municipal property tax base alone to fund. Moreover, this “climate deficit” is on top of the current “infrastructure deficit” which municipalities are already suffering as a result of aging and neglected infrastructure. An important part of the Province’s forthcoming Climate Action Plan could be a new, dedicated Climate Resilience Fund designed to strategically direct and financially assist municipalities to make the necessary investments in new and retrofitted physical infrastructure and new programs to monitor, respond to and prevent climate-related damage.

The Concept

The Ontario Climate Resilience Fund could be a major element of the Ontario Climate Action Plan intended to promote, prioritize and financially support meaningful investment of funds into programs by municipal governments to protect infrastructure and citizens against the impacts of a changing climate. It should be designed as a matching grant fund to which local governments make applications which meet prescribed criteria demonstrating proactive climate adaptation planning and local co-funding. Such a Fund would be a very tangible example of investing Cap and Trade Program revenues into measures which bring direct benefit to citizens and taxpayers.

Sources of Funding

This program could be self-funded from the sale of allowances under the Ontario Cap and Trade Program. Indeed, roughly half of the revenues from Cap and Trade Program could be allocated to adaptation programs to protect Ontario's infrastructure and its citizens from the inevitable effects of climate change. The other half could be invested in GHG mitigation programs.

Ontario municipalities would be expected to match provincial funding. Note that under the current situation, municipalities are essentially responsible for 100% of climate adaptation costs.

The new federal government should be requested to contribute an amount equal to the province's share.

The insurance industry could also be approached at the right time to also contribute an appropriate share. For the insurance companies, prevention should be less costly than payouts.

Ultimately, a 3:1 leverage proposition should be attractive to the four major contributors (See Financial Projections in Table A6.1).

Eligible Applicants and Participants

This Fund should be directed exclusively to municipal investments in:

Municipal, utility and conservation authority infrastructure (such as roads, bridges, culverts, stormwater management systems, water supply and wastewater treatment, electrical service, dams, weirs etc.);

Municipal or conservation authority programs to help affected citizens prevent or manage the impacts of changing climate (health programs, food security, cooling centres, improved building standards and upgrades, natural environment protection etc.).

The Fund should be mostly for capital investments but maintenance and program design and operating costs should also be eligible (with certain restrictions).

In order to promote cost-effective investments, a prerequisite for application to the fund should be the completion and adoption (by municipal council) of a comprehensive Community Climate Adaptation Plan which identifies climate trends, the resulting risks, adaptive measures and programs to implement the appropriate actions. The government should set out the model for an acceptable Adaptation Plan as a

requirement for application to the Climate Resilience Fund. The funding sought by applicants should relate to the high priority programs and actions identified in their Adaptation Plans and should be matched by municipal//utility funds.

Timing and Size of the Fund

The Ontario Climate Resilience Fund could be announced in the fall of 2015 as a major element of the Ontario Climate Action Plan.

Further details could be revealed in the 2016 Ontario Budget together with the linkage to the Cap and Trade Program as the major source of funding.

The Fund should be launched on January 1, 2017 with an initial provincial contribution of $500 million. The provincial contribution should be ramped up each year by about $200 million.

By 2020 the Fund should reach its designed maximum provincial contribution of $1 billion/year and remain flat at that level until 2025.

The rationale, operations, effectiveness and size of the fund should be thoroughly evaluated in 2024 with possible revision and renewal in 2025 and 5-year increments thereafter.

Positioning

In order to maximize the chances of success (increased resilience to extreme weather in Ontario), it will be necessary to position the Fund as:

- A “Made in Ontario” initiative in response to the growing recognition of the “climate deficit” in the province;
- A significant element of the provincial Climate Action Plan;
- Funded by provincial revenues from the sale of allowances under the Cap and Trade Program;
- A cost-shared program with the municipalities;
- A program calling for an equal federal contribution from the new federal government;
- A program that will request a significant annual contribution from the insurance industry;

- A fund dedicated exclusively to climate resilience investments by municipalities in Ontario;
- A fund requiring up-front analysis and planning by municipalities in order to optimize the results of the investments.

See Financial Projections in Table A6.1.

Table A6.1: Financial Projections Proposal for an Ontario Climate Resilience Fund

Year	Provincial Contribution	Municipal Matching Funds	Federal Contribution	Insurance Industry Contribution	Total Fund
2017	$500M	$500M	$500M	$500M	$2.0B
2018	$700M	$700M	$700M	$700M	$2.8B
2019	$900M	$900M	$900M	$900M	$3.6B
2020	$1B	$1B	$1B	$1B	$4.0B
2021 and beyond	$1B	$1B	$1B	$1B	$4.0B

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More Information:

For background information on the Durham Region Community Adaptation Plan and its development, please visit:

www.durham.ca/climatechange

Please direct any questions or comments to:

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