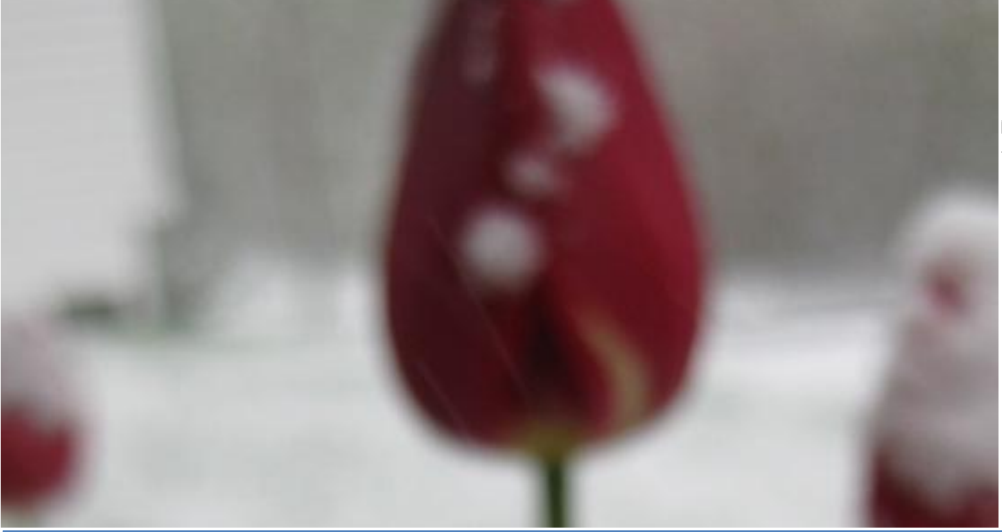

2010

Barrie in a Changing Climate: a Focus on Adaptation

Final Report

Ontario Centre for Climate Impacts
and Adaptation Resources
OCCIAR

Ontario Centre for Climate Impacts and Adaptation Resources

OCCIAR is a university-based, resource hub for researchers and stakeholders that provides information on climate change impacts and adaptation. The Centre communicates the latest research on climate change impacts and adaptation, liaises with partners across Canada to encourage adaptation to climate change and aids in the development of tools to assist with municipal adaptation. The Centre is also a hub for climate change impacts and adaptation activities, events and resources.

http://www.climateontario.ca

Regional Adaptation Collaborative

The Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR) is an Ontario partner in Natural Resources Canada's Regional Adaptation Collaboratives (RACs) Climate Change Program. It is a three year program to help Canadians reduce the risks and maximize the opportunities posed by climate change. The Program helps communities prepare for and adapt to local impacts posed by our changing climate, such as: decreasing fresh water supplies; increasing droughts, floods and coastal erosion; and changing forestry, fisheries and agricultural resources. The goal of the Program is to catalyze coordinated and sustained adaptation planning, decision-making and action, across Canada's diverse regions. The RACs Program is a partnership between the federal government, provinces and territories, working with local governments and organizations.

http://adaptation.nrcan.gc.ca/collab/index_e.php

Acknowledgements

OCCIAR would like to thank Natural Resources Canada for their generous support of the Ontario Regional Adaptation Collaborative. For more information please contact:

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Barrie in a Changing Climate: A Focus on Adaptation

Final Workshop Report

City of Barrie

March 30, 2010
City of Barrie
70 Collier Street, Council Chambers

Ontario Centre for Climate Impacts and Adaptation Resources
at
MIRARCO

Workshop Highlights

- Knowing that the information used to provide guidance for building and design criteria is out of date (uses old climate data), engineers and planners stressed the importance of updating these standards to recognize changing climate effects.

- Conservation Authorities in the Barrie area (Nottawasaga Valley Conservation Authority and the Lake Simcoe Conservation Authority) are continuously seeking new information on climate change impacts and adaptation in order to assess their watershed risks and plan for the impacts of changing weather and climate.

- Environment Canada is working with the Canadian Standards Association (CSA) to improve rainfall intensity duration curves. The first part is to develop a guide to define what IDF curves are and how to use them. The second part will include more recent climate data.

- It is important to use language that will catch the attention of, and encourage stakeholders to participate in adaptation planning. Risk and probability language is useful as some people ask for one number (temperature or precipitation or frequency of extreme events) and plan for that. Those people need to be reminded that planning to that point in time is not advisable due to tuncertainty in the models. Climate projections are educated estimates that can help to explain the need for adaptation.

- The 49th parallel storm was a real event, in fact it was one of the largest on record for Ontario, but there is still no decision on whether this storm will become the new regulatory storm.

- Federal and provincial governments need to set reasonable standard with respect to flood design, but need the support of the community. Communities need to work together to meet these standards.

- Conservation Authorities are uniquely positioned to help municipalities plan for the impacts of climate change through adaptation.

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Workshop Agenda

8:30 – 8:45	Welcome/Introduction – Councillor Lynn Strachan, City of Barrie
8:45 – 9:15	The Science of Climate Change Dr. David Pearson, Co-chair of Ontario's Expert Panel on Climate Change Adaptation
9:15 – 10:15	Roundtable Discussion
10:15 – 10:30	**Break**
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3:45 – 4:30	Summary Presentation: Roles and Responsibilities of the Municipality and Next Steps
4:30	Closing Remarks

Presentations

The following are brief summaries of the presentations made at the workshop. Presentations are available for viewing on the www.climateontario.ca website.

The Science of Climate Change

No going back… Managing the unavoidable while avoiding the unmanageable (we hope).

Dr. David Pearson, Co-chair of Ontario's Expert Panel on Climate Change Adaptation

Dr. Pearson began his presentation with an annual temperature trend graph (1948-2008) of Canada indicating that most of the warming has occurred in the northwest of the country. In the Barrie area, the annual mean temperature has increased approximately 1.6°C over the past 30 years, with winter temperature increasing slightly more than summer temperatures. Dr. Pearson stated that this has implications for winter tourism. Climate change has already affected winter tourism in Ottawa where Winterlude has been changed to 3 weekends due to warmer winter temperatures and variability in the weather.

When looking at the global temperature trend over the last 140 years, temperature begins to increase around 1920 to about 1945 where it begins to decrease. This trend continues to the mid 1970's where it begins to increase again. The cooling that occurred between 1945 and 1970 was due to aerosol particles in the atmosphere acting like clouds, reducing the amount of solar radiation reaching the ground. Once abatement program began, reducing the amount of aerosols in the atmosphere, the temperature began to increase again. Dr. Pearson continued by talking about the geometry of the earth, the geological past and the ocean and their connection to temperature and carbon dioxide.

Looking forward, communities need to look at the past and the climate record to see where the critical thresholds (or coping ranges) have been exceeded (e.g. Peterborough Flood). Vulnerability becomes evident when these thresholds have been passed. With climate change, there may be a greater probability that the coping ranges will be exceeded. Adaptation will be required to extend the coping range.

Impacts have already been and will continue to be seen in many sectors into the future. For example, winter tourism is expected to be impacted because of shorter, warmer winters. Less reliable snow conditions, more rain and less snow and a shorter lake ice cover period will have an impact on cross country skiing and snowmobiling. Downhill skiing operations will have to rely increasingly on snow-making.

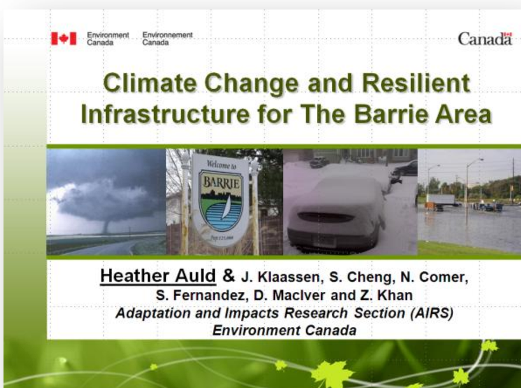
Climate Change Impacts and Municipal Infrastructure

Climate Change and Resilient Infrastructure for the Barrie Area

Heather Auld, Environment Canada

Climate change is not about mitigation or adaptation, it's about both. We need to reduce our greenhouse gas emissions in order to stabilize the climate while adaptation will help us deal with the inevitable impacts that are already locked in due to past and current emissions. Mitigation may be seen as a choice, but we will have to take adaptation actions. The changing climate will impact our safety, security and economy for centuries (along with create some opportunities). How well are we doing? We are tracking worse than the one of the worst case emission scenarios developed by the Intergovernmental Panel on Climate Change.

In Canada, $300 billion of infrastructure is constructed on the assumption that the past climate extremes will represent the future. This is important when you consider that small increases in weather and climate extremes have the potential to result in large increases in damages to existing infrastructure (e.g. 25% increase in peak gusts causing a 650% increase in building damage-Australian study).

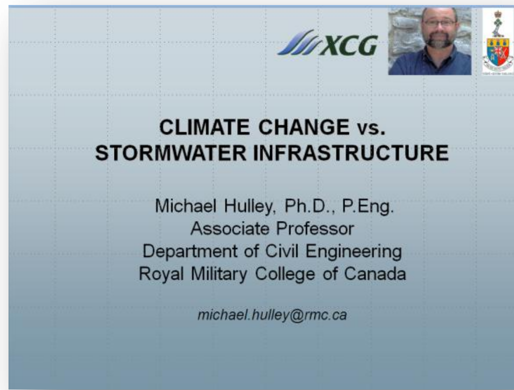


Increasing climate/weather extremes will pose risks to various types of infrastructure. For example, extreme wind, experienced in the US due to warm fronts, will come north with increasing temperatures.

Adaptation measures such as tornado proofing measures for homes (anchoring mobile homes) are sometimes easy to do and are considered 'low hanging fruit'. Other adaptations such as "flexible design" are needed to accommodate future changes in rainfall (e.g. TRCA is designing flood control berms to handle an extra meter of flooding). The City of Ottawa has made changes to their winter road and sidewalk maintenance by-laws to accommodate their changing winters. Human health will be impacted by increase in extreme heat and the increased risk of new diseases (e.g. Lyme disease and West Nile Virus). Toronto's Health Heat Alert began as a one year pilot project and has now been in effect for 9 years. Currently the demand for energy is greater in the winter months for warming. Under climate warming, that demand could shift to summer months for cooling.

Climate Change versus Stormwater Infrastructure

Mike Hulley, XCG Consulting Ltd



The consensus is that global average temperatures are increasing due to increased emissions of greenhouse gases. It is projected that southern Ontario will experience increases in precipitation and changes in the number of drought days. This has implications for stormwater design.

Intensity/Duration/Frequency (IDF) curves (return periods) are the basis for stormwater infrastructure design. Recent research addressed IDF rainfall design curves and analysed the longest and strongest precipitation records across Canada. A rigorous methodology was developed and the only location with statistically significant positive rainfall trend was in Yellowknife.

The Storm Sewer Era, between 1880 and 1970, was focused on collecting and moving water away. During the Stormwater Management Era, between 1970 and 1990, the focus was on controlling the flow and quality (to minimize erosion). During the Urban Stormwater BMP Era, between 1990 and 2007, the focus was on peak flow and quality control. The focus today (and tomorrow) will be on Low Intensity Development (e.g. green roofs, bio-filters) to maintain base flow with infiltration.

The sensitivity to stormwater infrastructure to climate change depends on the magnitude of expected changes and the type of infrastructure. If rainfall increases, do we increase the size of the pipe or increase storage (and by how much)? If rainfall increases, existing infrastructure may be under-designed, and more frequent maintenance may be required, but retrofitting opportunities do exist.

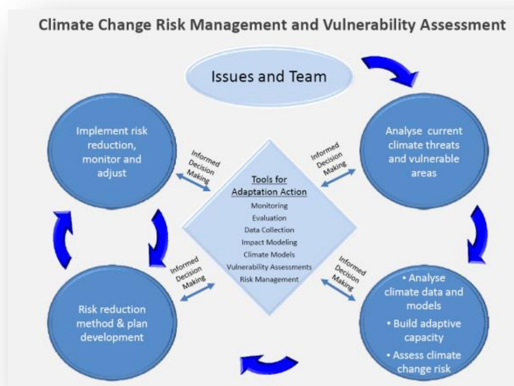
Stormwater design criteria and methodology should be examined as they have not changed in many years, may not reflect current or future risk and in many cases does not reflect advances in science or best available technology. Furthermore, climate change should be viewed as an additional uncertainty (other uncertainties include future population growth, new standards, new financing models) and design criteria should relate to this uncertainty. Finally, when considering adaptation, planning and design should be flexible. Plans should be revised as criteria and methodologies evolve.

Towards Adaptation in Ontario: Tools and Frameworks

Al Douglas, Ontario Centre for Climate Impacts and Adaptation Resources

The impacts of climate change are being felt in Ontario and as we continue to emit CO_2, adaptation becomes more important. There are tools and frameworks available to enable adaptation. The trajectory of global fossil fuel emissions are tracking worse than the 'worst-case-scenario' developed by the IPCC. Historical climate trends help determine how temperature and precipitation has changed and future climate projections can help us understand how it will continue to change. Climate data and observations of climatic hazards (i.e. winter roads, water levels, ice cover, flooding, etc) drive the need for adaptation.

Adaptation is happening in Ontario. For example, the Toronto Region Conservation Authority is conducting modeling and analysis exercises to understand how the watershed will respond to the impacts of climate change and the Credit Valley Conservation Authority has updated its strategic plan to elevate the importance of climate change in their operation.



How do we adapt? There are several methods and tools that support adaptation: sensitivity analysis, impact assessments, vulnerability assessments, risk management, adaptive management and others. A climate change risk management approach has been developed and stems from an International Standard for risk management. Vulnerability analyses which help identify current vulnerabilities also ascertain how impacts have been coped with in the past and with climate change in mind and determines the extent of additional vulnerability in the future. OCCIAR has also seen the benefit of combining the risk management and vulnerability assessments together.

All of these methods have a few common principals. For example: understand the risks, thresholds and uncertainties and prioritize risks; address risks associated with today's climate vulnerability and extremes; use adaptive capacity to cope with uncertainty; recognize the value of no or low regrets and win-win adaptation options; avoid actions that limit future adaptation; and review the effectiveness of adaptation decisions.

There are many guidebooks available to assist communities with adaptation as well as protocols for industries, such as Engineers Canada's PIEVC protocol.

Introduction to the Vulnerability/Risk Assessment Framework

Al Douglas, Ontario Centre for Climate Impacts and Adaptation Resources

Risk management is a framework that is already understood by stakeholders and decision-makers. It is appropriate for quick scans or large adaptation projects and deals with uncertainty relatively well. Collaborating between multiple departments and considered along side of multiple stressors, it helps develop feasible adaptation options.

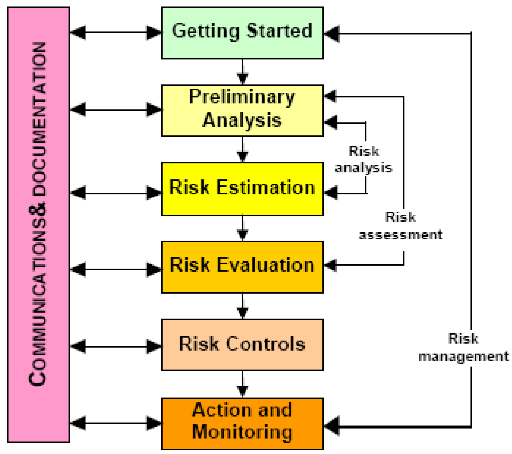


Figure 1: Steps in the risk management process

Risk Assessment Process breakout sessions are a component of OCCIAR workshops. The facilitated sessions take participants through the process, step-by-step, using a fictitious case study. There are several steps in the risk process, which are as follows.

In the first step climate hazards are identified, the project team is established and a risk library is started. Climate hazards can include higher intensity rainfalls, higher nighttime temperatures and/or more frequent storms. The next step is the preliminary analysis where risk scenarios are developed for each of the hazards identified in the first step. In the risk estimation step, the frequency or likelihood and the consequences of possible outcomes are estimated and risk is prioritized in the risk evaluation step. The next step involves identification and evaluation of adaptation or risk control options, beginning with the highest priority risks. In the last step, implementation plans and monitoring processes are developed.

There are challenges posed by this process such as perceived linearity, dealing with critical thresholds, the flexibility of adaptive measures, speed of responses due to changes in climate or other factors, the perception of “economy versus ecology” and the ability to apply it to small communities.

Adaptation is happening in Ontario. This framework and others are available to help guide communities. The process can be tailored to fit your specific community.

Flooding in the City of Peterborough – Lessons Learned
Dan Ward, Flood Reduction Program Manager, City of Peterborough

On July 14 and 15, 2004, Peterborough experienced a significant rainfall that led to city wide flooding. Damage from the flood affected virtually every part of the city.

Previously in 2002, the town experienced flooding to a lesser extent but failed to develop a systematic response to the flooding issue. The flood in 2004 was ten times worse.

Roads were washed out, roads and bridges were underwater and downtown businesses and basements were completely flooding.

Five years after the flood, the true cost to the city taxpayers is still unknown. Damage estimates range from 50 million to 100 million dollars (or higher). The Flood Reduction Master Plan, which was prepared shortly after the 2004 flood, suggested that it will take 10 to 20 years to complete all the flood reduction projects.

Picking up flood related garbage and debris was a major undertaking. Approximately 12,500 metric tonnes was placed in the landfill between July 16th and 27th (compared to a normal period with 3000 metric tonnes) and on July 15th the sewage treatment plant recorded a peak flow of 7 million gallons (compared to normal flow of 1.3 million gallons/day).

Unlike the lack of response following the 2002 floods, city council knew they had to take action. The city commissioned a Flood Specialty Engineering firm to prepare the Flood Reduction Master Plan (FRMP). The FRMP was adopted by council and is the blueprint for the City's present and future flood reduction projects.

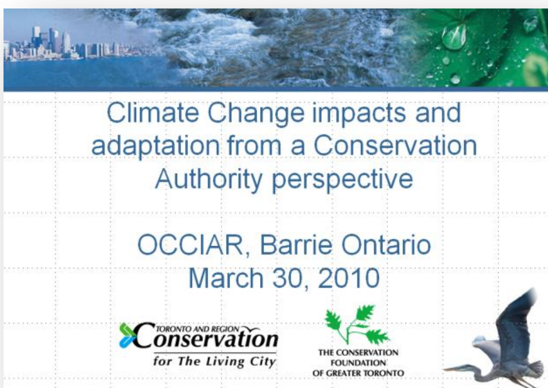
The city was divided into 8 distinct watersheds and to date Environmental Assessments have been completed on seven of them. Other studies include: a storm and sanitary system survey, smoke and dye testing, soil and groundwater inventory, CCTV inspection of pipes, sewer flow rate and rainfall survey and detailed sanitary sewer environmental assessment. In 2005, council approved funds for a Backwater Valve Subsidy Program ($1 million plus). The program, which is still available, subsidizes BWV installation to a maximum of $800 and foundation drain disconnection from sanitary sewer system and sump pit installation to a maximum of $800 ($1800 if both done together). To date, approximately $525,000 has been spent.

What did Peterborough learn from the experience? Communication can always be better, electronic data makes everything easier, your Emergency Preparedness Plan is not as good as you think, it is important to keep good records from the beginning, keep the media up to date and have a funding source, hire experts where needed, do not forget that normal business must continue, accept that recovery will take a long time, be open and truthful with the public and keep the need in front of council well after the event starts to fade from their minds.

Climate Change from a Conservation Authority Perspective
Don Haley, Toronto Region Conservation Authority

The TRCA has identified that meeting the challenges of climate change will be critical in achieving a healthy, sustainable urban region into the future. They have developed "*Meeting the Challenge of Climate Change: TRCA Action Plan for the Living City*".

Natural systems are already stressed due to land use change. Climate change will add more stress to the existing vulnerabilities. While some aspects of climate change are well documented (e.g. anticipated change in mean annual temperature), others have increased uncertainties. Uncertainty cannot be seen as a reason to hesitate in integrating anticipated changes into management programs. Events like the August 2005 storm in Toronto should serve as a reminder of what we can expect in the future.



Within the TRCA watersheds, they are already dealing with impacts of urbanization on the ecosystem (heat island effect, smog, urban flooding, erosion, invasive species and impacted water quality). Climate change will create significant, new challenges.

The TRCA believes that Conservation Authorities are in a unique position to be able to deal with climate change from both an adaptation and mitigation perspective. CAs already manage systems and already understand the issues of multiple stressors. CAs can provide effective direction and input around managing watershed changes and ecosystems under the challenges that climate change will create.

To integrate climate change into the business of the TRCA and to provide direction to their municipal clients, their strategy will include: developing and maintaining a knowledge base of climate change issues; creating a process that fits into their existing business framework; creating a process to pass along this knowledge to their clients; and creating partnerships with public and private sectors to accelerate implementation.

Other Conservation Authorities, such as the Upper Thames, Grand, Credit and Mississippi are all involved in assessing climate impacts in their watersheds with the intent to develop comprehensive strategies to position themselves to adapt to a changing climate.

Resources

Atmospheric Hazards – Canada www.hazards.ca

Adapting to Climate Change in Ontario
Report of the Expert Panel on Climate Change Adaptation
http://www.ene.gov.on.ca/publications/7300e.pdf

Meeting the Challenge of Climate Change: TRCA Action Plan for The Living City
http://www.trca.on.ca/dotAsset/16642.pdf

Adapting to Climate Change: An Introduction for Canadian Municipalities
http://www.gnb.ca/0009/0369/0018/0006-e.pdf

Preparing for Climate Change: A Guidebook for Local, Regional and State Governments
http://cses.washington.edu/db/pdf/snoveretalgb574front.pdf

Climate adaptation: Risk uncertainty and decision-making
http://www.ukcip.org.uk/images/stories/Pub_pdfs/Risk.pdf

Cities preparing for Climate Change: A Study of Six Urban Regions
http://www.cleanairpartnership.org/pdf/cities_climate_change.pdf

An Overview of the Risk Management Approach to Adaptation to Climate Change in Canada
http://adaptation.nrcan.gc.ca/pdf/NobleBruceEgener2005_e.pdf

Adapting to Climate Change: A Risk-based Guide for Ontario Municipalities
http://adaptation.nrcan.gc.ca/projdb/pdf/176a_e.pdf

City of Peterborough Flood Reduction Master Plan
http://www.peterborough.ca/Assets/City+Assets/Flood+Reduction/Documents/Flood+Documents/Flood+Reduction+Master+Plan.pdf

Appendix A – Delegate Package

Climate Change

Climate is naturally variable and has changed significantly over the history of the Earth. Over the past two million years, the Earth's climate has alternated between ice ages and warm interglacial periods. There are a number of climate variability drivers, from changes in the Earth's orbit, changes in solar output, sunspot cycles, volcanic eruptions, to fluctuations in greenhouse gases and aerosol concentrations. When considered together, they effectively explain most of the climate variability over the past several thousand years. These natural drivers alone, however, cannot account for the increase in temperature and accompanying suite of climatic changes observed over the 20th century.

Climate change may manifest itself as a shift in mean conditions or as changes in the variance and frequency of extremes of climatic variables. Eleven of the last twelve years (1995-2006) rank among the twelve warmest years in the instrumental record of global surface temperature (since 1850) (IPCC 2007). There is growing recognition that planning for these changes may pose challenging problems for natural resource managers (IPCC 2001). There is confidence in the ability of climate simulation models to provide natural resource managers with useful projections of future climate scenarios to support planning and management across a range of space and time scales.

Globally, two broad policy responses to address climate change have been identified. The first is mitigation, which is aimed at slowing down climate change by emitting less greenhouse gases in the atmosphere or capturing it through various sequestration methods. The second is adaptation, which is aimed at adjusting resource uses and economic activities in order to moderate potential impacts or to benefit from opportunities associated with climate change. The primary focus of this workshop is on the latter approach.

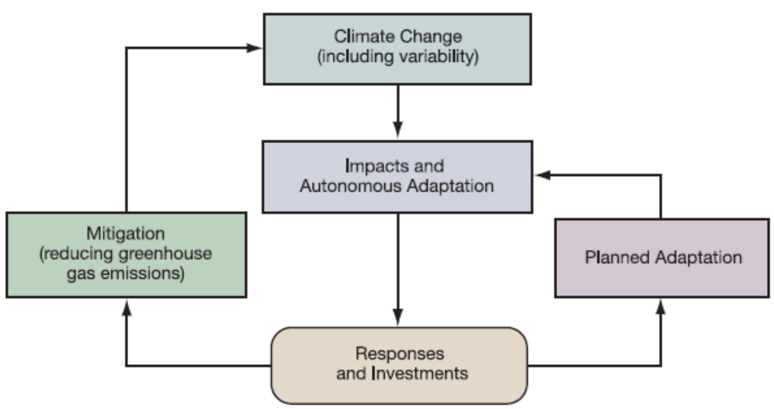


Figure 1: Adaptation and mitigation in the context of climate change (*modified from* Smit et al., 1999 cited in Lemmen et al., 2008).

Impacts and Adaptation

There is consensus among scientists from around the world that climate change is occurring, that the impacts are already being felt in regions all around the world and that they will only get worse. "Impacts due to altered frequencies and intensities of extreme weather, climate and sea-level events are very likely to change" (IPCC 2007).

Even after implementing measures to reduce greenhouse gas emissions, some degree of climate change is inevitable and is already having economic, social and environmental impacts on communities. Adaptation limits the negative impacts of climate change and takes advantage of new opportunities. It is not an alternative to reducing greenhouse gas emissions in addressing climate change, but rather a necessary complement. "Adaptation will be necessary to address impacts resulting from the warming which is already unavoidable due to past emissions" (IPCC 2007). Reducing greenhouse gas emissions decreases both the rate and overall magnitude of climate change, which increases the likelihood of successful adaptation and decreases associated costs. Adaptation is not a new concept as many approaches have already allowed us to deal with our extremely variable climate. The nature and rate of future climate change, however, poses some new challenges.

Ontario is relatively well adapted to present climatic conditions; however, it may not be ready for the impacts resulting from changes in average and extreme climatic conditions. Recently, Ontario has experienced climatic events such as such as drought, flooding, heat waves and warmer winters. These have resulted in a wide range of impacts including water shortages, lower Great Lakes water levels, declines in agricultural production, power outages and outbreaks of water-borne diseases.

Developing an effective strategy for adaptation requires an understanding of our vulnerability to climate change. "Future vulnerability depends not only on climate change but also on development pathway" (IPCC 2007). Vulnerability is determined by three factors: the nature of climate change, the climatic sensitivity of the system or region being considered, and our capacity to adapt to the resulting changes. The tremendous geographic, ecological and economic diversity of Canada means that the 3 factors mentioned above, and hence vulnerabilities, vary significantly across the country. In many cases, adaptation will involve enhancing the resiliency and adaptive capacity of a system to increase its ability to deal with stress.

Adaptation responses include biological, technical, institutional, and economic, behavioural and other adjustments that reduce vulnerability to the adverse impacts, or take advantage of positive effects, from climate change. Effective responses to climate change require an integrated portfolio of responses that include both mitigation and adaptation.

Ontario is generally well equipped to adapt to climate change, but this adaptive capacity is not uniformly distributed across the province. Indicators such as: economic resources; availability of, and access to, technology, information and skills; and the degree of preparedness of its infrastructure and institutions (Smit, et al., 2001) are all necessary in developing and acting on a climate change adaptation strategy.

It is imperative that decision-makers understand current vulnerabilities and the extent of future change to make well-informed adaptation planning decisions. Without this, insufficient actions or actions that inadvertently increase vulnerabilities could be made.

Ontario Centre for Climate Impacts and Adaptation Resources

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

The mandate of the Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR) is to: effectively communicate the science of climate change including its current and future impacts; encourage the development and implementation of adaptation strategies in order to reduce climate vulnerability and increase resiliency; create and foster partnerships with stakeholder groups; and support the work of Ontario's Expert Panel on Climate Change Adaptation. . The Centre will also be a hub for climate change impacts and adaptation activities, events and resources.

The objectives of today's workshop are to:

- Present the global and local context of climate change and help increase awareness of the potential impacts of climate change in Ontario and the need for resilience-building in the area;
- Identify what municipalities/counties and conservation authorities can do and are doing to both help mitigate and adapt to climate change;
- Present different methods of adaptive planning and facilitate an interactive climate change risk assessment framework; and
- Introduce the Ontario Centre for Climate Impacts and Adaptation Resources and its role in developing resources and communicating climate change throughout the province of Ontario.

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4:30	**Closing Remarks**

Historic Climate and Climate Trends

The following is a compilation and summarization of weather and climate data for Barrie, Ontario. Data were obtained from Environment Canada.

Daily Weather

Daily climate data from Barrie WCPP weather station, obtained from Environment Canada, was averaged to obtain monthly values for temperature and precipitation (Environment Canada, 2008). Seasonal climate values (winter –DJF and summer -JJA) were calculated by averaging the monthly data. In the following section, temperature and precipitation data, for the years 1956 to 2008, are displayed annually and seasonally (summer and winter) with line charts (Figures 2 to 13) and includes mean, maximum and minimum temperature and annual precipitation. Data was missing from 1980, 1987, 1988, 1994, 2005, 2006, 2007 and 2008. Annual means could not be calculated for these years. Winter means could not be calculated for 1980, 1988, 1995, 2007 and 2008. Summer means could not be calculated for 1980, 1988, 2006, 2007 and 2008. Annual mean for precipitation could not be calculated for 2005, 2006, 2007 and 2008.

Mean temperature is defined as the average of temperature readings taken over a specified amount of time; for example, daily mean temperatures are calculated from the sum of the maximum and minimum temperatures for the day, divided by 2 (Environment Canada, 2008). Maximum temperature is the highest or hottest temperature observed for a specific time interval and minimum temperature is the lowest or coldest temperature for a specific time interval (Environment Canada, 2008). Precipitation includes any and all forms of water, liquid or solid, that falls from clouds and reaches the ground and is expressed in terms of the vertical depth of water that reaches the ground during a stated period (Environment Canada, 2008). Total precipitation (mm) is the sum of all rainfall and the water equivalent of the total snowfall observed during the day (Environment Canada, 2008). According to Environment Canada (2008), most ordinary stations compute water equivalent of snowfall by dividing the measured amount by ten; however, at principal stations it is usually determined by melting the snow that falls into Nipher gauges. This method normally provides a more accurate estimate of precipitation than using the "ten-to-one" rule (Environment Canada, 2008).

Historical Mean Temperature and Precipitation Data for Barrie

Annual

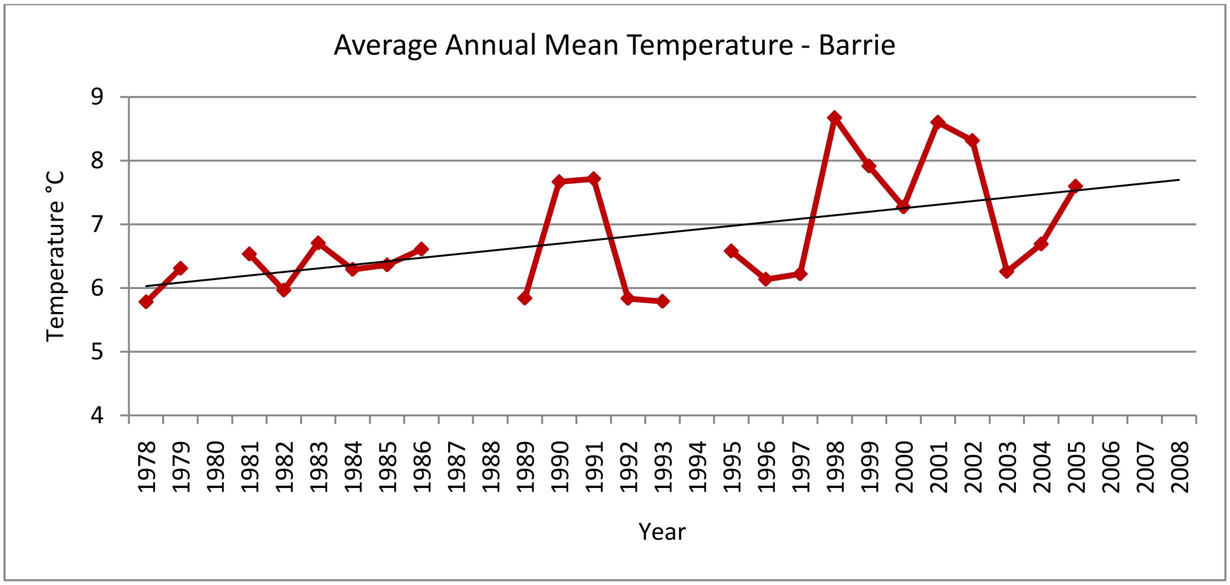

Figure 2: Average annual mean temperature (°C) from 1978 to 2008. Data from Barrie WPCC (Environment Canada, 2010) **shows that the temperature at this location has increased 1.7 °C over the 31 years of record**

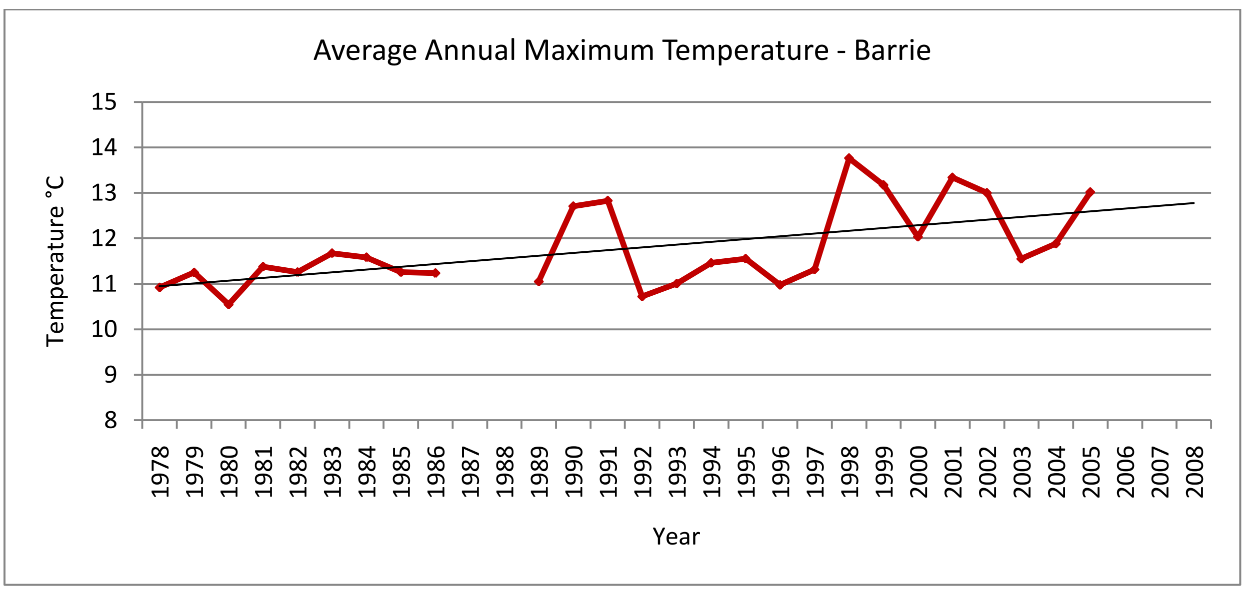

Figure 3: Average annual maximum temperature (°C) from 1978 to 2008. Data from Barrie WPCC (Environment Canada, 2010) **shows that the temperature at this location has increased 1.9 °C over the 31 years of record**

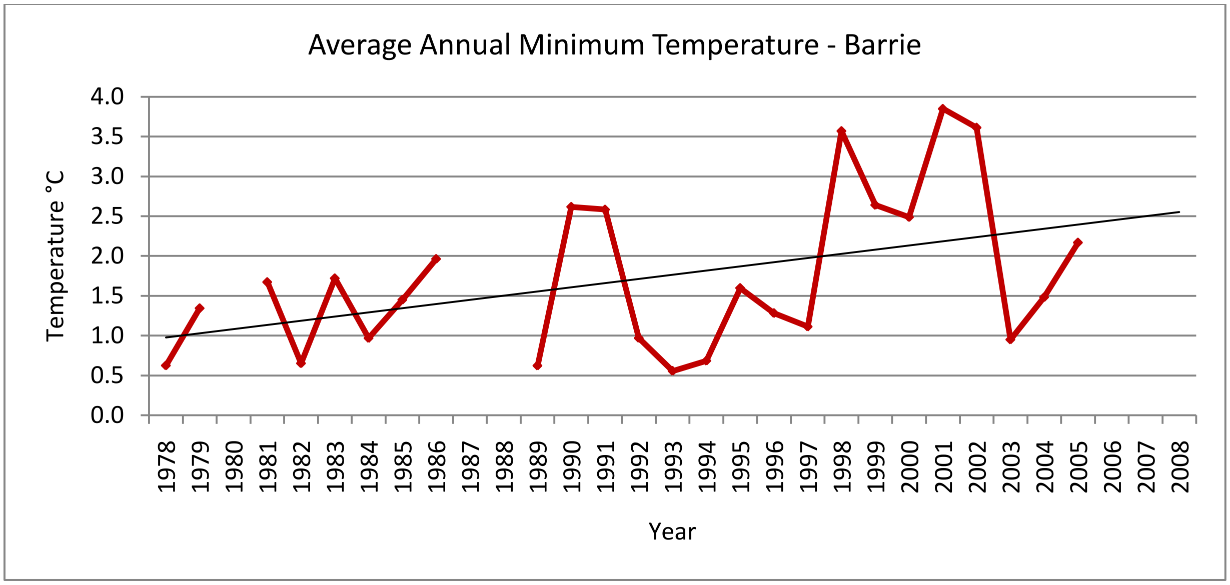

Figure 4: Average annual minimum temperature (°C) from 1978 to 2008. Data from Barrie WPCC (Environment Canada, 2010) **shows that the temperature at this location has increased 1.6 °C over the 31 years of record**

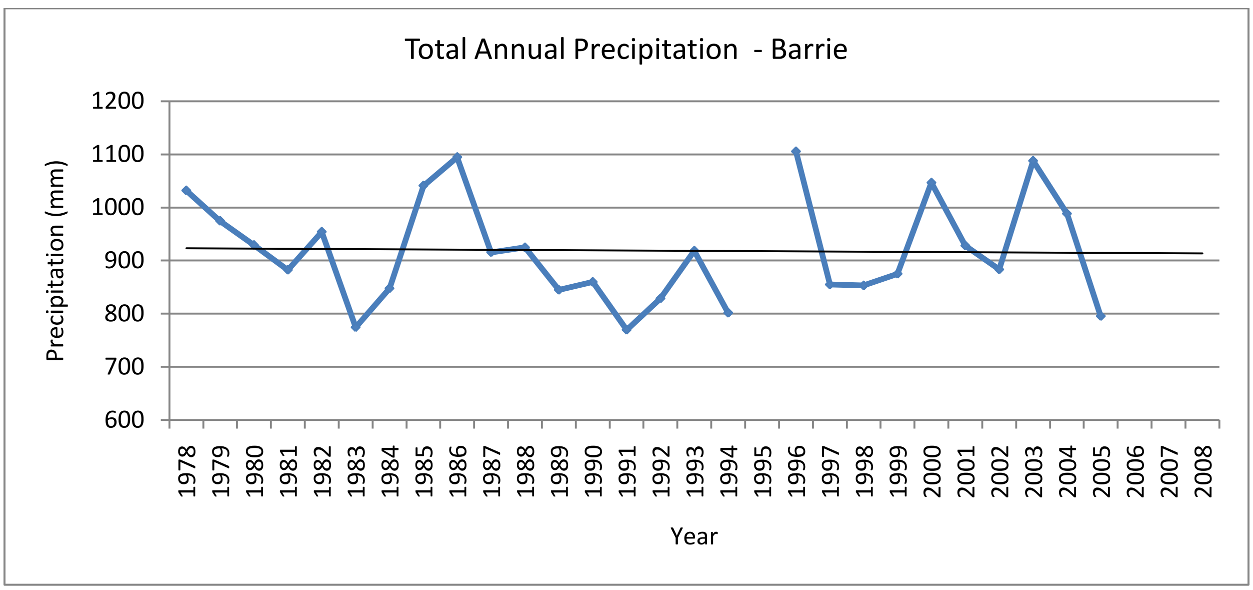

Figure 5: Total annual precipitation (mm) from 1978 to 2008. Data from Barrie WPCC (Environment Canada, 2010) **shows that the precipitation at this location has decreased slightly (10 mm) over the 31 years of record**

Winter

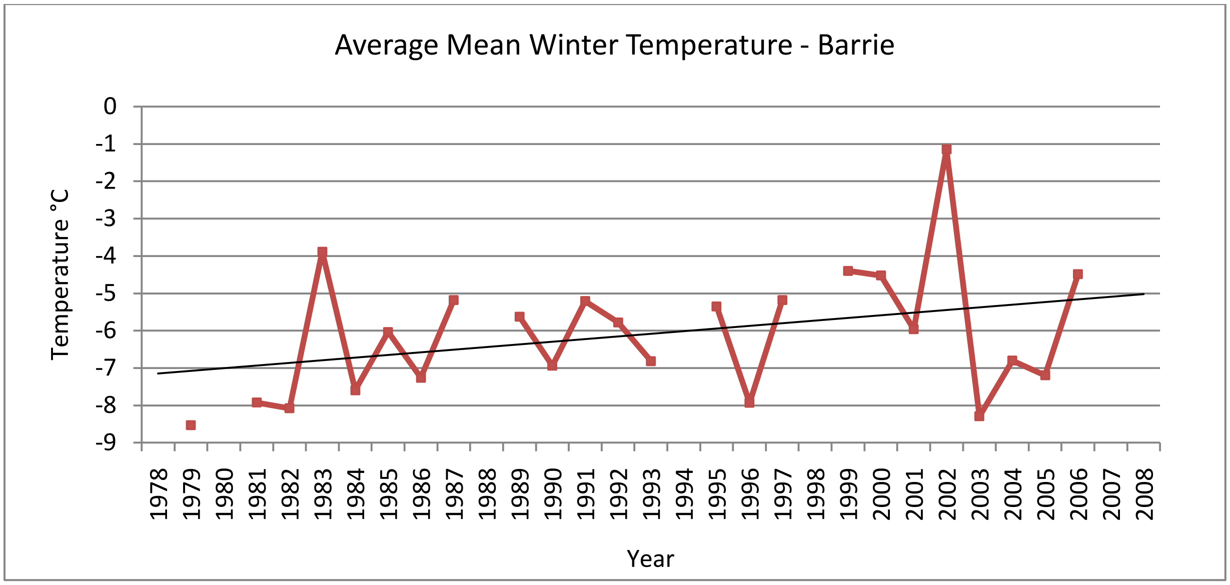

Figure 6: Average mean winter temperature (°C) from 1978 to 2008. Barrie WPCC (Environment Canada, 2010) **shows that the temperature at this location has increased 2.2 °C over the 31 years of record**

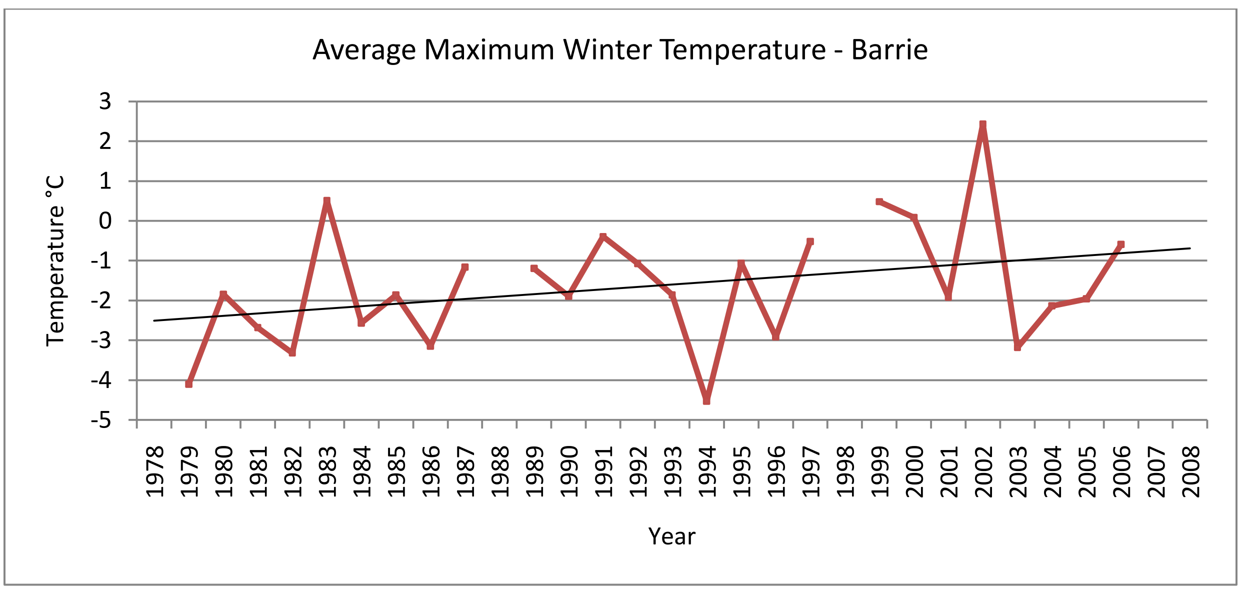

Figure 7: Average maximum winter temperature (°C) from 1978 to 2008. Barrie WPCC (Environment Canada, 2010) **shows that the temperature at this location has increased 1.9 °C over the 31 years of record**

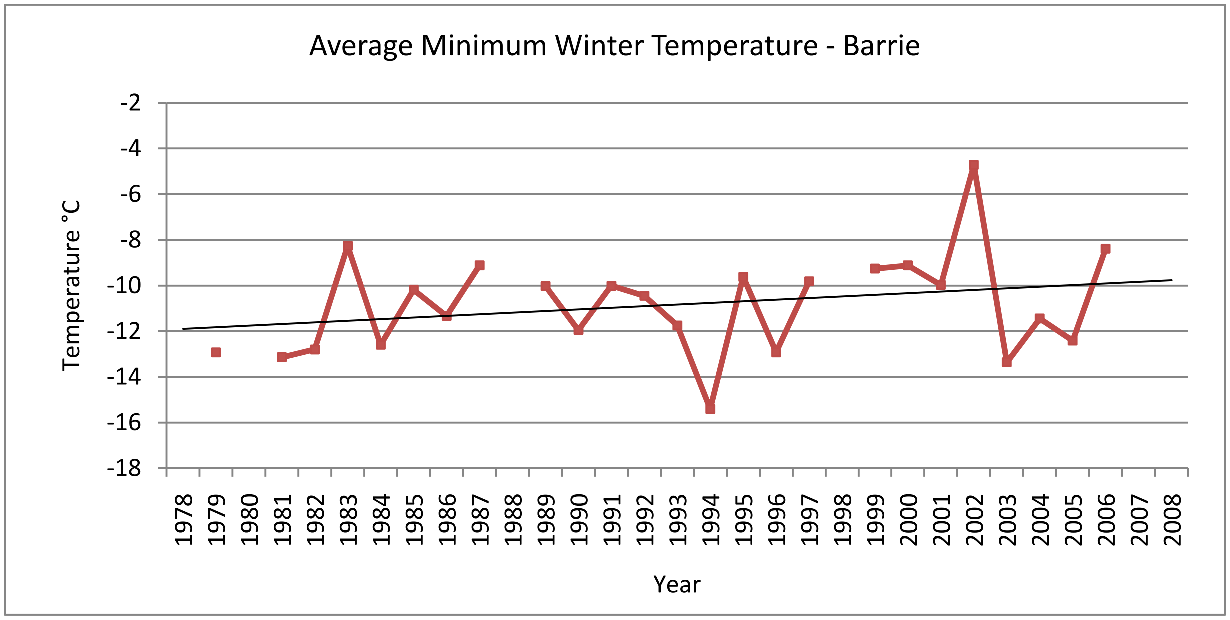

Figure 8: Average minimum winter temperature (°C) from 1978 to 2008. Barrie WPCC (Environment Canada, 2010) **shows that the temperature at this location has increased 2.3 °C over the 31 years of record**

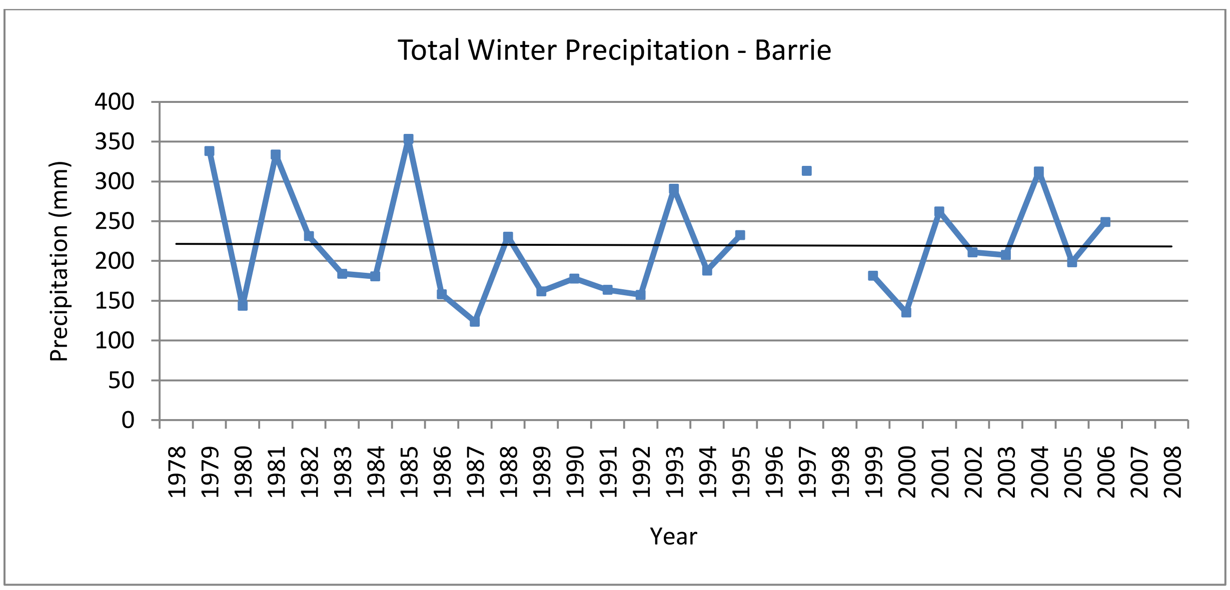

Figure 9: Total winter precipitation (mm) from 1978 to 2008. Data from Barrie WCPP (Environment Canada, 2010) **shows that the precipitation at this location has remained unchanged over the 31 years of record**

Summer

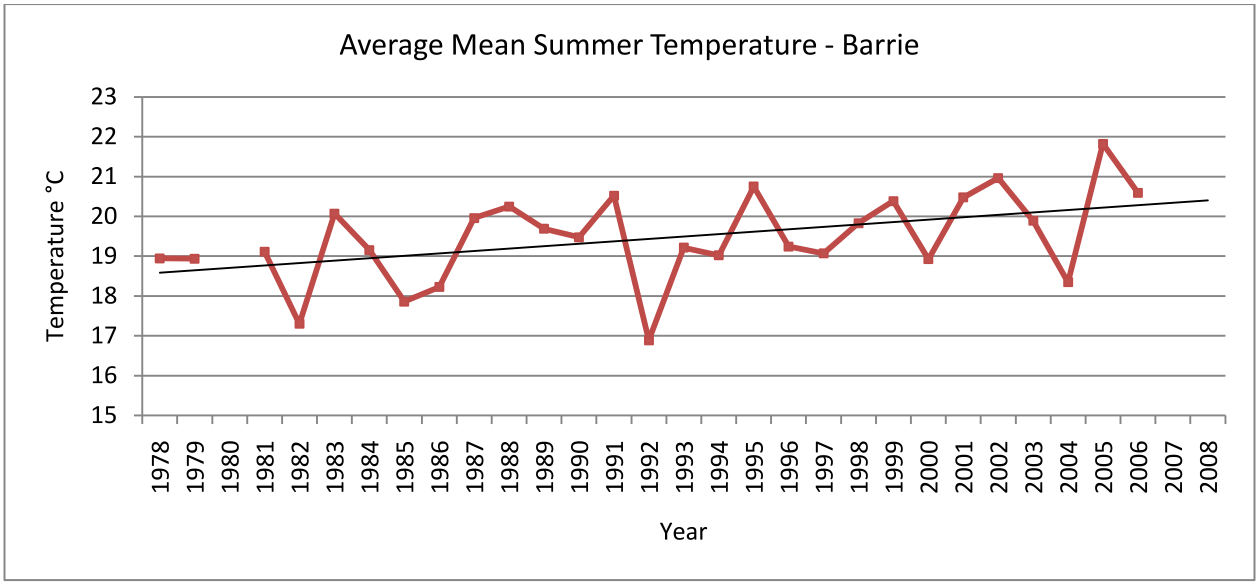

Figure 10: Average mean summer temperature (°C) from 1978 to 2008. Barrie WPCC (Environment Canada, 2010) **shows that the temperature at this location has increased 1.8 °C over the 31 years of record**

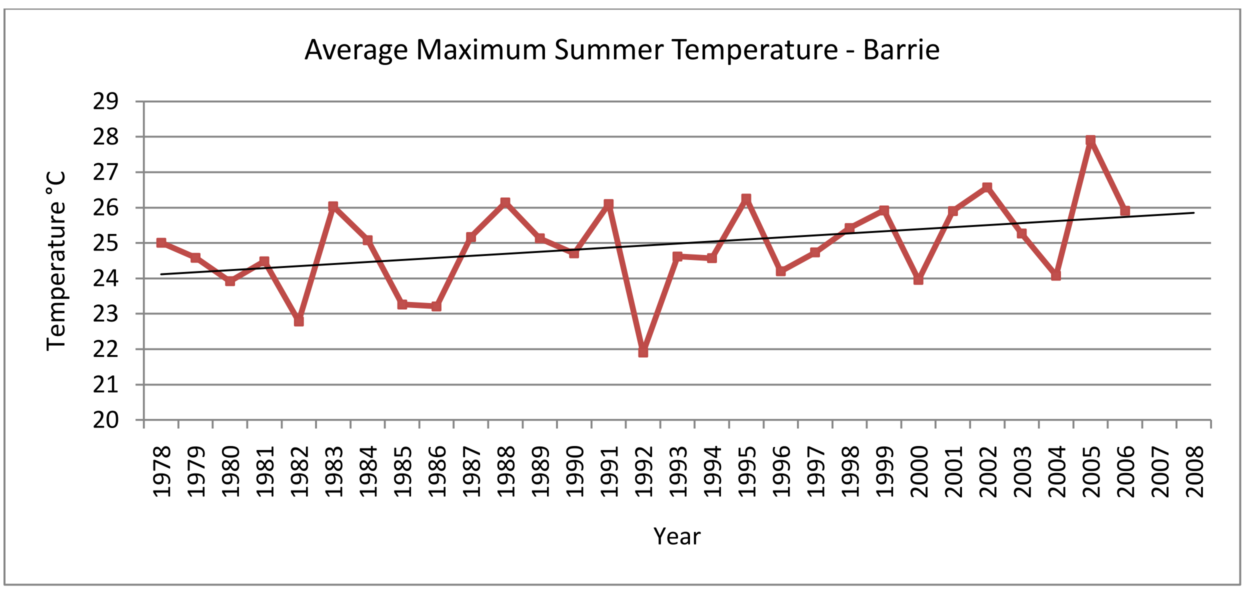

Figure 11: Average maximum summer temperature (°C) from 1978 to 2008. Barrie WPCC (Environment Canada, 2010) **shows that the temperature at this location has increased 1.8 °C over the 31 years of record**

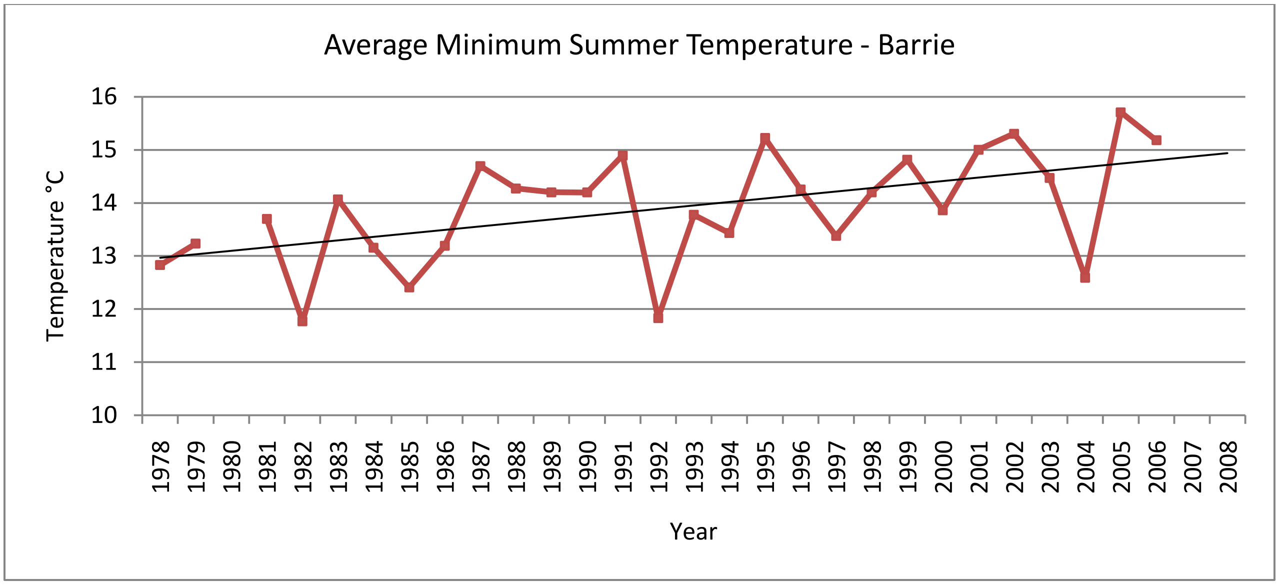

Figure 12: Average minimum summer temperature (°C) from 1978 to 2008. Barrie WPCC (Environment Canada, 2010) **shows that the temperature at this location has increased 2.1 °C over the 31 years of record**

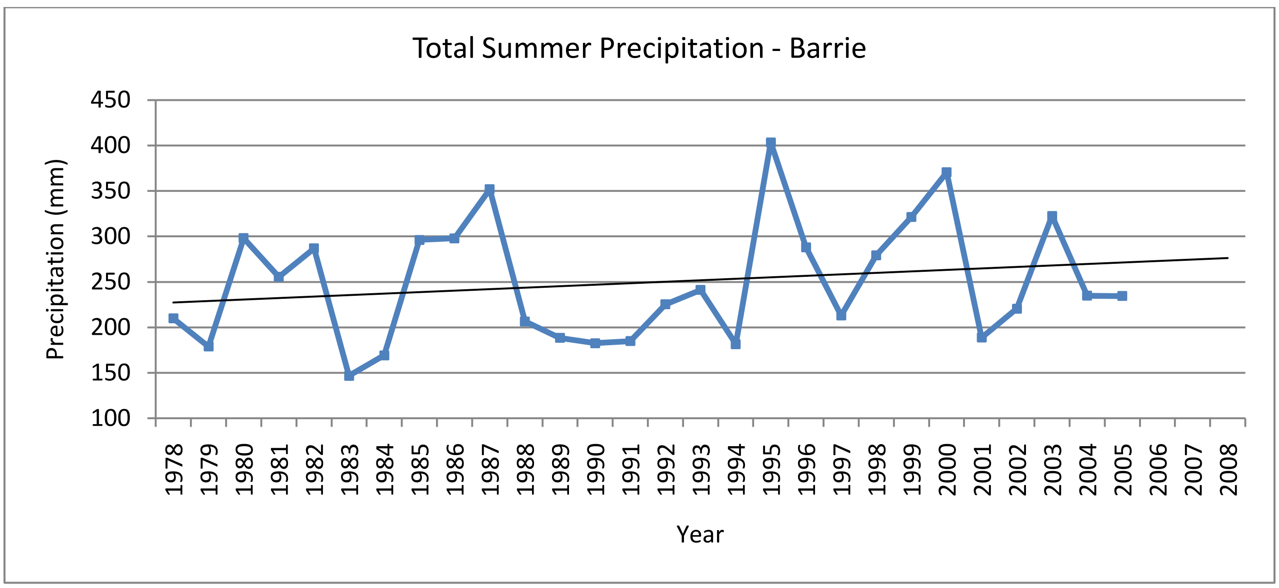

Figure 13: Total summer precipitation (mm) from 1978 to 2008. Data from Barrie WCPP (Environment Canada, 2010) **shows that the precipitation at this location has increased by 50 mm over the 31 years of record**

Future Climate Projections for Barrie

Future climate projections were obtained from Environment Canada's Canadian Climate Change Scenarios Network (CCCSN) (www.ccsn.ca, accessed February 2010). The CCCSN describes climate change as a difference over a period of time with respect to a baseline or a reference point. It corresponds to a statistically significant trend persistent over a long period of time (Environment Canada, 2007). Reference periods of typically 3 decades (1971-2000) are of sufficient length to adequately represent the climate of the period, and can be used to compare fluctuations of climate between one period and another (Environment Canada, 2007).

Projections from Global Climate Models (GCMs) exhibit a great deal of climate variability. Because of this, the IPCC (2001a) has recommended using at least 30 year averaging periods for GCM output (Environment Canada, 2007). Output generated by climate models is typically as follows: the 2020s (2010-2039), the 2050s (2040-2069), and the 2080s (2070-2099) (Environment Canada, 2007).

The bioclimate profiles produced for Essa Hydro near Barrie, Ontario were created using the CCCma Third Generation Coupled Global Model (CGCM3), version T47). The T47 version has a surface grid whose spatial resolution is roughly 3.75 degrees lat/long and 31 levels in the vertical (Environment Canada, 2005). Data is displayed for the B1 and A2 emission scenarios and is compared to the period of 1971-2000.
(http://cccsn.ca/Scenarios/BioclimateTool/Bioclimate-e.phtml, accessed February 2010.

Emission scenarios (B1 and A2) are described as follows (IPCC, 2007 cited in Environment Canada, 2007).

A2 – High Growth

The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population (15 billion by 2100). Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other storylines.

B1 – Low Growth

The B1 storyline and scenario family describes a convergent world with the same global population that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

Temperature

Table 1: Change in mean temperature, extreme maximum temperature and extreme minimum temperature data compared to 1971-2000 for Essa Hydro near Barrie, Ontario from www.cccsn.ca, accessed February 2010). Projected values are obtained using AR4 (2007), CGCM3T 47 – Run 1 for each of the emission scenarios A2, A1B and B1.

	AR4 (2007), CGCM3T47 - Run 1						
	Observed Data	**SR-B1**		**SR-AIB**		**SR-A2**	
		Change in Mean Temperature (°C)					
	1971-2000	2011-2040	2041-2070	2011-2040	2041-2070	2011-2040	2041-2070
Winter	-6.2	0.9	2.1	1.4	3.3	0.9	2.6
Spring	5.3	1.3	2.8	2.1	3.3	2	3.3
Summer	18.9	1.6	2.3	1.6	3	1.7	3
Autumn	8.5	1.4	2.1	1.4	2.8	1.6	3.1
Annual	6.6	1.3	2.3	1.7	3.1	1.6	3
		Change in Extreme Maximum Temperature (°C)					
	1971-2000	2011-2040	2041-2070	2011-2040	2041-2070	2011-2040	2041-2070
Winter	19	1.1	1.8	1.2	2.5	1.4	2.5
Spring	35	2.2	2.7	2.4	3.6	2.3	3.9
Summer	36	2.3	3.1	2.4	3.6	2.2	3.8
Autumn	33.9	1.8	2.4	1.3	3.5	2.3	3.6
Annual	36	2.3	3.1	2.4	3.6	2.2	3.8
		Change in Extreme Minimum Temperature (°C)					
	1971-2000	2011-2040	2041-2070	2011-2040	2041-2070	2011-2040	2041-2070
Winter	-37.5	2.4	3.8	3	5	1.9	4.5
Spring	-32	1.2	3.2	2.1	4.5	1.6	3.8
Summer	-2	2	2.3	2.3	3.5	1.9	3.3
Autumn	-22	0.8	1.6	1	2.4	1.2	2.5
Annual	-37.5	2.4	3.8	3	5	1.9	4.5

Precipitation

Table 2: Change in precipitation, extreme maximum precipitation and water surplus and deficit data compared to 1971-2000 for Essa Hydro near Barrie, Ontario www.cccsn.ca, accessed February 2010). Projected values are obtained using AR4 (2007), CGCM3T 47 – Run 1 for each of the emission scenarios A2, A1B and B1 (Environment Canada, 2010).

	AR4 (2007), CGCM3T47 - Run 1						
	Observed Data	**SR-B1**		**SR-A1B**		**SR-A2**	
		Change in Precipitation (mm)					
	1971-2000	2011-2040	2041-2070	2011-2040	2041-2070	2011-2040	2041-2070
Winter	204.8	14.6	30.8	15.5	46.2	22	35.5
Spring	179.9	-5.1	4.7	-9.3	3.8	8.5	0.6
Summer	240.4	-13.4	-9.8	0.2	-18.9	-14	-21
Autumn	241.2	-10.8	-3.6	1.3	-14	5.9	15.5
Annual	866.4	-14.8	21.9	7.6	16.9	22.2	30.4
		Change in Extreme Maximum Precipitation (mm)					
	1971-2000	2011-2040	2041-2070	2011-2040	2041-2070	2011-2040	2041-2070
Winter	388.9	63.9	95.2	64.6	129.4	77.1	106.4
Spring	381.3	-69.6	-52.6	-78.6	-54	-45.9	-61.8
Summer	559.2	-20.3	-13.7	7.7	-34.7	-26.7	-44
Autumn	565.4	-31	-16.9	-2.7	-45.7	1.2	26.2
Annual	1894.8	-57.1	12	-9	-5	5.7	26.7
		Change in Mean Water Surplus/Deficit (mm)					
	1971-2000	2011-2040	2041-2070	2011-2040	2041-2070	2011-2040	2041-2070
Surplus	379	4	14	9	4	31	15
Deficit	61	39	43	29	67	36	67

Climate Change Considerations

Responses to climate change can either be mitigative – energy conservation, energy efficiency, greenhouse gas reductions, alternative energy sources, carbon capture/storage; or adaptive – managing stormwater/flood protection, heat alert plans, drought plans, water budgeting, tree planting and others.

1. Is there recognition within your community and watershed that changes in climate are affecting, and will continue to have an impact on natural and built systems?

2. Has your municipality considered developing a climate change plan (mitigation and/or adaptation)? Has climate change been considered in any planning process?

Excess waste water and extreme weather events leading to flooding have been specifically challenging to cities and conservation authorities across the province. Changes to the timing and extent of peak river/stream flow challenge traditional ways of dealing with the natural waste water.

3. Do you think that changes to temperature and precipitation over the past 20-30 years have imposed greater challenges in managing stormwater? Has your municipality made any changes to reflect that? What barriers are there that may impede structural changes to those systems (budget constraints, limited human resources, lack of technology, lack of time, other priorities, other)?

4. Are there other sectors or components of sectors that would be threatened by climate variability/climate change, i.e. ice fishing, skiing, agricultural operations, forests (fire), local lakes, fish populations, buildings, bridges, groundwater wells, human health and well-being, locally valued species, invasive species or pests, etc?

Water and energy conservation are ways to combat climate change, both on the mitigation and adaptation front. Opportunities exist for economic growth in the green energy sector through local power generation. The Province of Ontario is committed to reductions of greenhouse gases – 6% below 1990 levels by 2014 and 15% by 2020.

5. Has your community developed any programs or policies related to energy/water conservation or efficiency?

6. Have any local companies expressed an interest in developing green energy (products), i.e. wind, solar, wood pellets, fibre, biomass, etc?

Impediments and facilitators for climate change planning and action exist and can be a function of capacity within a community setting. Although some Ontario communities tend

to have fewer resources, they also have inherent strengths that give them an advantage when it comes to facing weather/climate adversity.

7. Are there specific items that would enable mitigation/adaptation planning in your area (specifically for storm water management planning) (climate/weather data, information, tools, human resources, $$, political support)?

Additional Questions

8. Has climate change been a consideration with emergency management personnel?

9. Are you aware of any benefits that may result from a changed climate and how might your community take advantage of such changes? E.g. extended summer tourism, agricultural opportunities, harvesting of stormwater for irrigation, etc.

Definitions

Adaptation

- Initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected *climate change* effects. Various types of adaptation exist, e.g. *anticipatory* and *reactive*, *private* and *public*, and *autonomous* and *planned*. Examples are raising river or coastal dikes, the substitution of more temperature-shock resistant plants for sensitive ones, etc.

Adaptation benefits

- The avoided damage costs or the accrued benefits following the adoption and implementation of *adaptation* measures.

Adaptation costs

- The costs of planning, preparing for, facilitating, and implementing adaptation measures, including transaction costs.

Adaptive capacity

- The ability of a system to adjust to climate variability and change to moderate potential damages, to take advantage of opportunities, or cope with the consequences.

Barrier

- Any obstacle to reaching a goal, *adaptation* or *mitigation* potential that can be overcome or attenuated by a policy, programme, or measure. *Barrier removal* includes correcting market failures directly or reducing the transactions costs in the public and private sectors by e.g. improving institutional capacity, reducing risk and uncertainty, facilitating market trans- actions, and enforcing regulatory policies.

Climate scenario

- A plausible and often simplified representation of the future *climate*, based on an internally consistent set of climatological relationships that has been constructed for explicit use in investigating the potential consequences of *anthropogenic climate change*, often serving as input to impact models.

  Climate projections often serve as the raw material for constructing climate scenarios, but climate scenarios usually require additional information such as about the observed current climate. A *climate change scenario* is the difference between a climate scenario and the current climate.

Climate variability (CV)

- Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the *climate* on all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the *climate system* (*internal variability*), or to variations in natural or *anthropogenic external* *forcing* (*external variability*).

Event

- An incident induced or significantly exacerbated by climate change that occurs in a particular place during a particular interval of time, e.g. floods, very high winds, or droughts.

Hazard

- A source of potential harm, or a situation with a potential for causing harm, in terms of human injury; damage to health, property, the environment, and other things of value.

Hazard identification

- The process of recognizing that a hazard exists and defining its characteristics.

(Climate change) Impacts

- The effects of *climate change* on natural and *human systems*. Depending on the consideration of *adaptation*, one can distinguish between potential impacts and residual impacts:
    - *Potential impacts*: all impacts that may occur given a projected change in climate, without considering *adaptation*.
    - *Residual impacts*: the impacts of climate change that would occur after adaptation.

Projection

- A potential future evolution of a quantity or set of quantities, often computed with the aid of a model. Projections are distinguished from predictions in order to emphasize that projections involve assumptions concerning, for example, future socio-economic and technological developments that may or may not be realized, and are therefore subject to substantial *uncertainty*.

Residual risk

- The risk remaining after all risk control strategies have been applied.

Resilience

- The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change.

Risk

- The chance of injury or loss as defined as a measure of the probability and severity of an adverse effect to health, property, the environment, or other things of value.

Risk communication

- Any two-way communication between stakeholders about the existence, nature, form, severity, or acceptability of risks.

Risk control option

- An action intended to reduce the frequency and/or severity of injury or loss, including a decision not to pursue the activity.

Risk information library

- A collection of all information developed through the risk management process. This includes information on the risks, decisions, stakeholder views, meetings and other information that may be of value.
- **Risk perception**
  The significance assigned to risks by stakeholders. This perception is derived from the stakeholder's needs, issues, and concerns.

Risk scenario

- A defined sequence of events with an associated frequency and consequences.

Vulnerability

- The degree to which a system is susceptible to, or unable to cope with adverse effects of climate change, including climate variability and extremes. Vulnerability is the function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.

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Notes