

## Ganaraska Region Conservation Authority

## CLIMATE CHANGE STRATEGY

## June 2014

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The Ganaraska Region Climate Change Strategy provides direction for addressing climate change through adaptation and mitigation measures. Recommendations provide information required to integrate climate change considerations into programs and operations of the Ganaraska Region Conservation Authority. This Strategy will also serve as a resource to member municipalities and local businesses, industries, and the general public.

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## **Executive Summary**

The Ganaraska Region Conservation Authority (GRCA) is dedicated to taking a leadership role in understanding and promoting actions that adapt to or mitigate climate change. The current focus and methods of sustainable natural resource management will need to be evaluated and possibly modified to address a changing climate.

The GRCA Climate Change Strategy has and will generally follow the five milestones contained within *Changing Climate, Changing Communities: Guide and Workbook for Municipal Climate Adaptation*<sup>1</sup>. These are defined within this document as: initiate, research, plan, implement and monitor/review; and will continually be considered in an adaptive management framework. The milestones were generated within the context of municipal governance; however, they have been revised to address the structure of a Conservation Authority.

For the purpose of this Strategy, the following definitions are being used.

**Adaptation** is an adjustment in natural and human systems in response to actual or projected climate changes and their effects.

**Mitigation** is an anthropogenic (human) intervention to reduce the anthropogenic forcing of the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks.

Generally, mitigation is necessary to reduce the rate and magnitude of climate change, while adaptation is essential to reduce the damages from climate change that cannot be avoided<sup>2</sup>.

The mission of the GRCA Climate Change Strategy is to "Create a resilient watershed and community that will evolve, in the most positive way, as climate change occurs."

Eleven goals have been identified for the GRCA Climate Change Strategy, which address the Authority's program areas. Each goal contains recommendations that are to be implemented in order to achieve the mission of the Climate Change Strategy. Recommendations are broken into those that address adaptation and/or mitigation.

- Goal 1: Refine the definition of natural hazard areas to address the protection of people and property under climate change conditions.
- Goal 2: Improve flood forecasting methods to better warn residents of potential flooding and erosion events.
- Goal 3: Incorporate new science that addresses climate change impacts on surface water and groundwater management.

<sup>&</sup>lt;sup>1</sup> ICLEI Canada. 2011. *Changing Climate, Changing Communities: Guide and Workbook for Municipal Climate Adaptation.* ICLEI Canada, Toronto, ON.

<sup>&</sup>lt;sup>2</sup> Natural Resources Canada. 2014. Adaptation 101: What is Adaptation?

http://www.nrcan.gc.ca/environment/impacts-adaptation/adaptation-101/10025 [accessed March 2014].

- Goal 4: Incorporate new standards and requirements that address climate change into proposed and existing development recommendations.
- Goal 5: Improve the GRCA's natural heritage system to build watershed resilience, and assist in adaptation to and mitigation of climate change.
- Goal 6: Build resilience into aquatic and riparian habitats to improve and conserve fish and aquatic communities.
- Goal 7: Incorporate climate change considerations into current watershed monitoring programs.
- Goal 8: Incorporate climate change adaptation and mitigation information into GRCA education and outreach programs.
- Goal 9: Evaluate and adapt management and use of GRCA lands.
- Goal 10: Make the GRCA the partner of choice for local climate change adaptation and mitigation initiatives.
- Goal 11: Evaluate and improve GRCA business activities in light of climate change.

The GRCA Climate Change Strategy is to be implemented adaptively; and a comprehensive update will occur every 5 years in order to address gaps or changes in watershed science, and issues or opportunities associated with implementing the strategy.

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# Background



## Introduction

The Ganaraska Region Conservation Authority (GRCA) is dedicated to taking a leadership role in understanding, undertaking and promoting actions for adaptation to and mitigation of climate change. The current focus and methods of sustainable natural resource management will need to be evaluated and possibly modified to address a changing climate.

The GRCA Climate Change Strategy provides recommendations to global atmosphere and which is in addition to natural climate variability, another consideration within decision making and management planning, the GRCA will be in a position to provide leadership and support watershed communities and partners in addressing climate change. The Climate Change Strategy will complement watershed management and monitoring programs through an adaptive process, thereby strengthening conservation of local watersheds.

#### **Climate change** is defined as a change of climate, which can be attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability, observed over comparable time period<sup>3</sup>.

### **Evidence and Projections of Climate Change**

The Intergovernmental Panel on Climate Change (IPCC) released the "Working Group I Contribution to the IPCC Fifth Assessment Report *Climate Change 2013: The Physical Science Basis* Summary for Policymakers" on September 30, 2013. This document "considers new evidence of climate change based on many independent scientific analyses from observations of the climate system, paleoclimate archives, theoretical studies of climate processes and simulations using climate models."<sup>4</sup> Nineteen conclusions have been made regarding the state of global climate conditions, providing evidence of a changing climate. A number of these conclusions are relevant to the GRCA, including:

"Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased."

"Each of the last three decades has been successively warmer 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."

"The atmospheric concentrations of carbon dioxide  $(CO_2)$ , methane, and nitrous oxide have increased to levels unprecedented in at least the last 800,000 years.  $CO_2$  concentrations have increased by 40% since pre-industrial times, primarily from fossil fuel emissions and secondarily from net land use change emissions. The ocean has absorbed about 30% of the emitted anthropogenic carbon dioxide, causing ocean acidification."

<sup>&</sup>lt;sup>3</sup> Environment Canada. 2006. Canada's Fourth National Report on Climate Change: Actions to Meet Commitments under the United Nations Framework Convention on Climate Change. Ottawa, Ontario.

<sup>&</sup>lt;sup>4</sup> IPCC, 2013: Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

"Human influence on the climate system is clear. This is evident from the increasing greenhouse gas concentrations in the atmosphere, positive radiative forcing, observed warming, and understanding of the climate system."

"The global ocean will continue to warm during the 21st century. Heat will penetrate from the surface to the deep ocean and affect ocean circulation."

"Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions."

Within the Great Lakes basin, realized and potential ecosystem changes due to climate change have been noted, including<sup>5</sup>:

"The ice cover season on the Great Lakes has been shortened by about one to two months during the last 100 to 150 years."

"Nearshore lake temperatures have increased at several locations since the 1920s. These increases are likely associated with extensive algae blooms and invasion of non-native species."

"Shifts in fish communities are expected to occur with declines in coldwater species in the Great Lakes. Warmwater species such as bigmouth buffalo and flathead catfish are already being seen more frequently in the Great Lakes basin."

"Additional stressors on already fragile habitats such as coastal wetlands and terrestrial ecosystems may impair their functions under increased climate change."

There have been few comprehensive studies conducted at the local-level. However, based on a preliminary analysis of air temperature records in the Town of Cobourg, there is an apparent warming trend since at least the mid-1970s. Figure 1 shows the mean annual maximum daily temperature, the mean annual minimum daily temperature and the mean annual air temperature from 1973 to 2005. There is an increasing trend in the mean annual air temperature since 1973 at a rate of approximately  $0.5^{\circ}$ C per decade (n=31, r=0.53, p = 0.002).

In 2013, the Durham Region Roundtable on Climate Change retained SENES Consultants to conduct a study<sup>6</sup> to understand what the geographic area of Durham Region currently experiences in terms of climate and what it may be expected to experience in the future based on climate change projections.

The study provides projections of the climate that Durham Region will experience in the decade 2040 to 2049 compared to the 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 1km x 1km). Eight locations were selected for the study, which included Bowmanville, in the Municipality of Clarington. Model results are shown in Table 1, and are relevant to the GRCA.

<sup>&</sup>lt;sup>5</sup> Chiotti, Q and Lavender, B. 2008. Ontario: in From Impacts to Adaptation: Canada in a changing climate 2007, edited by D.S. Lemmen, F.J. Warren, J. Lacroix and E. Bush; Government of Canada, Ottawa, Ontario.

<sup>&</sup>lt;sup>6</sup> SNES Consultants. December 2013. Durham Region's Future Climate (2040-2049) Volume 1 – Overview. Prepared for The Durham Region Roundtable on Climate Change.



Figure 1: Air temperature at the Cobourg STP Environment Canada Station 1973 to 2005

Climate Parameter	Detailed Parameter	2000-2009	2040-2049
	Maximum in one Day (mm)	99	96
Extreme precipitation	Number of days/year >25mm	6	9
	Annual Total Precipitation (mm)	883	977
Eutrope a reinfall	Maximum in one day (mm)	99	96
Extreme faillian	Number of days/year >25mm	6	9
Extromo cooutoll	Maximum in one day (cm)	27	21
Extreme showidh	Number of days/year >5 cm	9	1
	Average maximum daily (°C)	24	27
Eutromo host	Average maximum daily ( C)	24	27
Extreme neat	Extreme maximum ( C)	32	40
	Number of days/year >30( C)	1	9
	Average minimum Daily ( C)	-/	-1
Extreme cold	Extreme minimum ( C)	-25	-11
	Number of days/year <-10( C)	25	
	Subserve Deily (C)	120	/1
Wind chill	Extreme Daily (C)	-36	-1/
	Number of dames days (sear > 24 (%C) (air conditioning	14	0
	number of degree days/year >24 ( C) (air conditioning required)	5	32
Degree days	Number of degree days/year >0 (°C)	3420	4443
	Number of degree days/year <0 (°C) (heating required)	457	64
	Maximum (°C)	45	48
Humidex	Average Number of days/year >40(°C)	2	13
		-0	= 0
	Maximum hourly speed (km/hour)	70	56
Extreme wind	Maximum gust speed (km/hour)	113	77
	Number of days/year with wind speed >52 km/hour	3	0.1
	Number of days/year with wind speed >63 km/hour	1	0
Potential for	Number of days with high lightning potential/year	27	41
violent storms	Number of days/year with Energy Helicity Index >1	10.9	12.9

Fable 1: Climate Projections	for Bowmanville,	Municipality of	Clarington, 2040-2049
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## **Dealing with a Changing Climate**

Since its establishment in 1946, the GRCA has managed its watersheds through locally developed programs and initiatives that address particular issues or opportunities. In order to address climate change, actions associated with adaptation and mitigation must now be considered.

A changing climate is heavily influenced by human *Mitigation* is an anthropogenic (human) interference, as is the response to climate change. Adaptation can occur at differing times during a response to a change in climate. As depicted in Figure 2, adaptation can occur autonomously after the initial impact or effect. This response is and enhancing greenhouse gas sinks'. unconsciously triggered by ecological changes in natural systems and by market or system changes in human systems. Autonomous adaptation is also referred to as spontaneous adaptation.

Adaptation is an adjustment in natural and human systems in response to actual or projected climate changes and their effects'.

intervention to reduce the anthropogenic forcing of the climate system; it includes strategies to reduce greenhouse gas sources and emissions



Planned adaptation, which is the result of a deliberate decision, is emphasized within the GRCA Climate Change Strategy. This type of adaptation is based on an awareness that conditions have changed or are about to change, and that action is required to return to, maintain or achieve a desired state.

Mitigation also occurs as a result of human intervention in hopes to reduce anthropogenic impacts on variables influencing climate

change.

Figure 2: Places of Adaptation when Dealing with Climate Change<sup>8</sup>

<sup>&</sup>lt;sup>7</sup> The Expert Panel on Climate Change Adaptation. 2009. Adapting to Climate Change in Ontario: Towards the Design and Implementation of a Strategic Action Plan. Report to the Minister of the Environment

<sup>&</sup>lt;sup>8</sup>Smit, B and Pilifosova O. 2001. Adaption to Climate Change in the Context of Sustainable Development and Equity. *In* Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. McCarthy, J.J., Canziani, O.F., Leary, N.A., Doken, D.J. and White K.S., eds. Cambridge University Press, Cambridge, UK.

## **Principles of the Climate Change Strategy**

The process of creating this Climate Change Strategy will follow methods found in many local municipal climate change initiatives. As the GRCA makes decisions and implements programs focused on climate change adaptation or mitigation, the following principles will be followed.

- Where possible, actions of adaptation and mitigation will be used to address climate change.
- Integrating climate change adaptation and mitigation • measures into existing GRCA operations and programs will be a priority.
- Knowledge based decision making will guide actions. Emphasis will be placed on increasing staff knowledge of • Increasing natural riparian areas possible effects from climate change.
- It is imperative that the GRCA immediately move forward with the building of resilience into the aquatic and terrestrial natural heritage systems in order to reduce future climate change impacts on the local watershed ecology.

"No regret" actions are those that will result in benefits regardless of climate change. These actions include:

- Enhancing monitoring systems
- Increasing forest cover
- Diversifying habitat types
- Increasing biodiversity
- Increasing protection of people and property from natural hazards
- Collaboration with stakeholders (municipalities, governmental agencies, business and agricultural communities, organizations and the public) will be fundamental to implementing local actions to deal with climate change.
- Adaptive management will be used to allow for flexibility in delivering programs and services in light of climate change.
- "No-regrets" actions will be emphasized to improve the resilience of natural systems, regardless of the eventual climate change impacts.

### **Milestone Process**

The GRCA Climate Change Strategy generally follows the five milestones described within Changing Climate, Changing Communities: Guide and Workbook for Municipal Climate Adaptation<sup>9</sup>. These are defined within this document as: initiate, research, plan, implement and monitor/review; and will continually be considered in an adaptive management framework. The milestones were generated within the context of municipal governance; however, they have been revised to address the structure of a Conservation Authority. Some of these milestones have been completed, as milestone 3 includes the completion of this Strategy.

<sup>&</sup>lt;sup>9</sup> ICLEI Canada. 2011. Changing Climate, Changing Communities: Guide and Workbook for Municipal Climate Adaptation. ICLEI Canada, Toronto, ON.



Figure 3: Milestone Framework<sup>9</sup>

#### Milestone 1: Initiate

The purpose of milestone 1 is to initiate the planning process and build support for the process. Through the project planning phase, a Climate Change Adaptation Team was created consisting of Mark Peacock, P. Eng. and Pam Lancaster, B.Sc. to develop support and collect information through a series of working meetings undertaken with GRCA staff. Through this process, staff identified how climate change might affect their program areas and listed actions to improve adaptive capacity or mitigate climate change within the organization. Review of the Draft Climate Change Strategy by additional stakeholders will occur as this is an important component of this Strategy.

#### Milestone 2: Research

The purpose of this milestone is to research climate change and potential impacts for the GRCA thereby identifying the main program areas that would be impacted by those changes. Research involved literature review, consultation with experts within GRCA staff, and use of environmental data available to the GRCA (including our own). When considering impacts, four systems were involved, these being: physical, social, economic and ecological. Given the mandate of the GRCA, the ecological impacts were emphasized as part of this Strategy.

In order to identify GRCA program areas which require consideration to climate change impacts, staff conducted a vulnerability assessment (Appendix 1). The purpose of the assessment was to determine a program area's *sensitivity* to climate change and its capacity to adapt to climate change impacts (*adaptive capacity*). The vulnerability assessment process was completed in three steps. The first step was identifying program areas that would be impacted by climate change. Once these were identified, a sensitivity test and adaptive capacity test was conducted. The end result was a vulnerability assessment, where high, medium and low scores were assigned.

The final step recommended within the research milestone is to conduct risk assessments of specific impacts within each program area. The GRCA Climate Change Adaptation Team identified that the completion of risk assessments was beyond the scope of the Strategy, and would not be required to identify initial actions in all program areas. For this reason it is recommended that risk assessments only be undertaken where impacts are not characterized to the extent that implementation recommendations can be undertaken.

#### Milestone 3: Plan

The purpose of the planning milestone is to establish adaptation and mitigation recommendations within the GRCA Climate Change Strategy. During this phase, a mission statement was created and eleven goals were identified addressing different program areas. Each goal was presented with a list of adaptation and mitigation recommendations for action. Recommendations emphasized changes to existing programs, thereby limiting financial implications. The development of new programs was recommended in some cases, however financial implications were not considered.

#### Milestone 4: Implement

The purpose of the implement milestone is to secure support from municipal partners, the community and the GRCA, to implement the recommendations identified in this Strategy. This milestone will be initiated upon approval of the Strategy by the GRCA Full Authority Board. Tools needed in this milestone will be finances, training, development of pilot projects, internal and external communications, marketing, and consultation. It is envisioned that outputs will include support and approval from our municipal partners, identification of specific implementation tools and strong community engagement and partnership. In order to ensure that the GRCA Climate Change Strategy is implemented, recommendations will be reviewed during the annual GRCA budget development process. Specific climate change project funding should be identified in the budget so that the commitment to implementation is understood.

#### Milestone 5: Monitor and Review

The purpose of the final milestone is to assess the progress made towards meeting the goals and recommendations as set out in the Strategy. Additionally, the Strategy, will be revised to address new scientific information, lessons learned, and effectiveness of recommendations. This milestone will be ongoing and flexible (adaptive management). It is recommended that a comprehensive review of the Strategy be undertaken every 5 years.

# Strategy



## **Mission**

The mission of the GRCA Climate Change Strategy is to:

"Create a resilient watershed and community that will evolve, in the most positive way, as climate change occurs."

## **Goals and Recommendations**

Eleven goals have been identified for the GRCA Climate Change Strategy, which address the seven program areas. Each goal contains recommendations that are to be implemented in order to achieve the mission of the Climate Change Strategy. Recommendations are broken into those that address adaptation and/or mitigation.

Program Area	Goals
Natural Hazards	1, 2, 3 and 4
Natural Heritage	5 and 6
Monitoring	7
Education and Outreach	8
Land Holdings	9
Partnerships	10
<b>GRCA</b> Business Activities	11

#### Goal 1: Refine the definition of natural hazard areas to address the protection of people and property under climate change conditions.

The GRCA has a responsibility for protecting life, property and natural resources through the *Conservation Authorities Act* and Ontario Regulation 168/08. Conservation Authorities have delegated authority for addressing natural hazards under the *Planning Act*. The GRCA Natural Hazards Program works to protect local residents from natural hazards, which include riverine and lake shoreline flooding and erosion. The first step in natural hazard management is identifying the hazard.

#### Adaptation

#### Adaptation

Building upon existing and new data, science, methods and models, the GRCA Natural Hazards Program will work to implement new approaches for defining and mapping natural hazards. Current methods are based on historic data; a new standard should be defined using more extreme and predicted data. Analysis should include lake shoreline, riverine and local urban drainage and ice jam flooding. A plan must be put in place to address potential litigation issues evolving from what the GRCA ought to know based on the current science of climate change.

Intensity Duration Frequency (IDF) curves used for local watercourse management may need to be refined using predicted rainfall that reflects potential extreme events and changes in rainfall distribution. The use of Hurricane Hazel as the historical storm in defining flood hazard areas should be reevaluated given recent extreme storm events.

Erosion mechanisms and their impacts on lakes and rivers must be well understood through sound science and monitoring as the climate changes.

#### Mitigation

The GRCA in partnership with member municipalities and agencies will develop a land acquisition strategy for natural hazard lands. These lands will additionally enhance the natural heritage system, sequester carbon, and moderate extreme water levels for the benefit of local watersheds.

### What is the GRCA doing?

As part of the Showcasing Water Innovations Program, the University of Guelph Faculty of Engineering and GRCA Engineering Staff ran a series of models to assess erosion in Brook Creek, within the Town of Cobourg.

This analysis was expanded to consider climate change conditions in the period 2040 to 2049. Preliminary results showed significant increases in flow conditions that create stream erosion.

Recommendations were made on how to address potential erosion within Brook Creek.

#### *Goal 2: Improve flood forecasting methods to better warn residents of potential flooding and erosion events.*

The GRCA maintains a flood forecasting and warning system. The purpose of the system is to reduce risk to life and damage to property by providing municipalities, local agencies and the public with advanced notice, information and advice so that they can respond to potential flooding and flood emergencies. As climate change impacts the type and severity of runoff events that may be experienced, new methods of forecasting will need to be employed.

#### Adaptation

With the increasing frequency of high intensity short-duration storm events as a result of climate change, GRCA surface water and climate monitoring programs and models will need to be reevaluated and improved.

There is a need to better forecast spring-runoff under future climate change conditions. Over 80% of the historic major runoff events in the GRCA have occurred due to rainfall on snow or ice covered watersheds. As the number of average below zero days per year change, the spring freshet will also change in magnitude and time of occurrence. Therefore the critical floods may no longer be due to rainfall with snow and ice conditions.

Hurricanes may increase in severity and frequency due to climate change. The GRCA Flood Forecasting and Warning Program must be responsive to this potential.

River ice conditions may adjust due to climate change, therefore new modeling, forecasting and monitoring approaches may be required to address this impact.



## How are things changing?

On March 21, 1980 the Ganaraska River spilled its banks (pictured below left). Rainfall on frozen ground resulted in little to no infiltration. This event caused the river to experience a flow of 421 cubic metres/second, causing 66 acres of downtown Port Hope to be flooded with water depths to 1.5 meters and velocities sufficient to knock down building walls.

Now into the 21<sup>st</sup> century, rainfall on frozen ground may be more frequent. On January 25, 2010, the Town of Cobourg experienced a flood resulting from these conditions.

The GRCA is working at better predicting these events to provide early warning to municipalities and residents through implementation of the QUAHSI Data Management System.

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#### Goal 3: Incorporate new science that addresses climate change impacts on surface water and groundwater management.

The GRCA maintains a low water response program. The purpose of the program is to notify water users of low water quantity conditions and to reduce the impact to the environment by implementing water conservation measures. The program provides municipalities, local agencies and the public with advanced notice, information and advice so that they can respond to potential drought emergencies. As climate change impacts precipitation patterns and groundwater infiltration, new methods of defining drought and assisting water users will need to be implemented.

#### Adaptation

Water budget analysis will be advanced to incorporate projected climate data to develop an understanding of changing surface water and groundwater conditions.

The low water response program will need to be refined to incorporate new indicators and science in the definition of drought and drought response triggers (e.g., groundwater indicators and ecological flows).

Groundwater models will need to be improved to better define local aquifer extent and vulnerability (quality and quantity).

#### Adaptation

Targets associated with imperviousness and infiltration should be refined within watershed and subwatershed plans to maintain or improve the hydrologic/hydrogeologic system (e.g., baseflow).

#### Mitigation

Actions of stewardship that sequester carbon on private and public lands will be promoted and supported through the GRCA Clean Water-Healthy Land Stewardship Program. This mitigation action will in turn help to protect surface water and groundwater resources.



### What is Happening Now?

The Ontario Low Water Response (OLWR) program currently relies on precipitation and stream flow indicators to evaluate low water conditions in watersheds across the Province. These indicators provide water managers with objective information on the severity of low water conditions that may require a response to reduce water demand.

Low water conditions are described by one of three levels of increasing intensity: Level I (conservation), Level II (conservation and restriction) and Level III (conservation, restriction, and regulation).

The OLWR program has identified the need for a groundwater indicator to be added to the program and used in conjunction with the rainfall and stream flow indicators.

#### Goal 4: Incorporate new standards and requirements that address climate change into proposed and existing development recommendations.

As development and urbanization continues throughout the region, it is important to incorporate green building principles and improved stormwater management methods into designs. The GRCA provides a regulatory and advisory role to municipalities throughout the design stages of development.

Adaptation	Adaptation	Coboury Water
Adaptation The GRCA will assist member municipalities to assess the vulnerability of existing infrastructure and identify future climate change vulnerability and risks. The GRCA will assist member municipalities in protecting major drainage systems (includes overland flow routes and street flows). Current policies and standards for development will need to be evaluated and updated to adapt to potential impacts from climate change. This evaluation should include potential changes to urban drainage, sewer systems (stormwater and sanitary), flow regime, water guality and stream	AdaptationThe GRCA will work with member municipalities to embrace and implement more environmentally-sustainable infrastructure reconstruction and rehabilitation methods and materials.The water budget and flow regime will be considered when reviewing development proposals to ensure maintenance or enhancement of recharge and groundwater resources that may be impacted by climate change.Stream specific erosion strategies will need to be developed, based on the impact erosion will have on existing and proposed development.	Conservation Gara officially opened. 1 partnership betwe GRCA, Lakefront U Services Inc. and th of Cobourg was de to showcase the m drinking water sys water conservation gardening, backya management using plants, and water conservation techr and products. One of the product demonstrated is Hydromedia – a permeable concret material that allow groundwater infilt.
temperatures.	D <i>dikizaki</i> an	rather than surface
Stormwater management projects need to implement low impact development (LID) methods to reduce the variability of surface water runoff (riverine and local urban) which may cause flooding and erosion. The GRCA will encourage builders to incorporate green building design into developments (e.g., energy and	Mitigation The GRCA will encourage the incorporation of native vegetation into development in order to sequester carbon and to introduce shade into urban areas and reduce impacts from the heat island effect. The GRCA will encourage the consideration of innovative methods to increase public or passive transportation.	runoff. This produc with others such a Grid (a pervious su grid) could assist in reducing the impac urbanization on loc streams.

What is the GRCA Doing Now?

In 2013, the Town of Cohoura Water len was This en the tility he Town signed nunicipal tem, n rd g native niques

ts te vs ration e water ct along s Ecoirface n ct of cal

transportation methods, etc.).

#### Goal 5: Improve the GRCA's natural heritage system to build watershed resilience, and assist in adaptation to and mitigation of climate change.

A natural heritage system is made up of natural features and areas, linked by natural corridors which are necessary to maintain biological and genetic diversity, natural functions, and healthy ecosystems with viable populations of indigenous species. These systems can include lands that have been restored and areas with the potential to be restored to a natural state. In 2013, the GRCA Full Authority Board approved the *GRCA Terrestrial Natural Heritage Strategy, 2013*, which recommends a natural heritage system for the GRCA.

#### Adaptation

#### The GRCA will investigate the potential of incorporating diversified tree and shrub species into planting initiatives, in addition to undertaking pilot projects that will evaluate the success of this approach.

Vulnerable natural heritage ecosystems will be identified for monitoring and/or conservation actions (e.g., wetlands, aquatic and terrestrial habitats, Lake Ontario and Rice Lake shorelines).

Terrestrial invasive species and disease impacts will potentially be accelerated under a changing climate. As such, a robust invasive species programs and partnerships need to be developed by the GRCA.

Climate change impacts that alter abiotic conditions, thereby altering the ecosystem, need to be better understood and used to inform management actions.

#### Mitigation

The GRCA Natural Heritage System will be promoted and continually improved using stewardship actions that target the protection and enhancement of rare and vulnerable habitats (e.g., wetlands, tallgrass prairies and sand barrens).

Carbon sequestration potential within the natural heritage system (existing and future) will be studied.

The GRCA will investigate the possibility of improving the natural heritage system through carbon trading investments. Additionally, the use of carbon taxes to adapt at a local level will be investigated through partnerships.

The GRCA will work with member municipalities to identify and acquire lands for connecting existing protected lands and/or public greenspaces thereby protecting landscapes that sequester carbon.

Actions of stewardship that sequester carbon on private and public lands will be promoted and supported through the GRCA Clean Water-Healthy Land Stewardship Program. What is the GRCA Doing Now?

The GRCA offers native trees and shrubs to private and public landowners through the GRCA Tree Planting Program. Every year thousands of trees and shrubs are distributed or planted by the GRCA.

Local youth and businesses are engaged in tree planting through volunteer events. This engagement teaches the next generation about the importance of native vegetation on the landscape.

As of 2014, the GRCA watershed is comprised of 32% forest cover. Staff are now working to increase the amount of forest cover in strategic areas by implementing the GRCA Terrestrial Natural Heritage Strategy, 2013.

#### *Goal 6: Build resilience into aquatic and riparian habitats to improve and conserve fish and aquatic communities.*

Aquatic and riparian habitats include in-water components and the water/land interface (riparian areas). Building resilience into this portion of the ecosystem will allow fish and other aquatic organisms to adjust to impacts from climate change. The GRCA has completed Fisheries Management Plans and Fish Habitat Management Plans that will provide guidance for managing aquatic habitats.

Individual species should be managed to maximize resiliency. To achieve this, four pillars should be considered: abundance, diversity (life history and genetics), spatial distribution, and productivity. Each pillar is equally important, with stressors influencing each pillar in different ways.

For overall healthy aquatic ecosystems, sustained productivity requires a network of complex and interconnected habitats (e.g., longitudinal – length of stream, lateral – stream and floodplain, and vertical - surface and groundwater), which are created, altered, and maintained by natural physical processes in tributaries, estuaries, and lakes.

Adaptation	Mitigation
In-stream barrier removal should	Reforestation/naturalization of
be considered and prioritized to	riparian and upland areas will
allow for species movement to	be promoted and encouraged
other stream reaches.	for the benefit of aquatic
The GRCA will encourage changes to fishing/harvesting regulations	sequester carbon.
and seasons needed to be considered due to changes in species abundance, productivity, and environmental conditions (e.g. thermal regime and hydrology).	The GRCA will work with member municipalities and other partners to identify and acquire priority lands for protecting significant riparian
Maintain healthy watersheds to	
be more resilient against new aquatic species and disease (introduced or through natural range expansions/ contractions/invasions) and community changes.	Actions of stewardship within streams and rivers, and riparian areas will be promoted and supported through the GRCA Clean Water-Healthy Land
The GRCA will work with landowners to create and restore aquatic habitats as existing habitats may be reduced due to climate change impacts (e.g., erosion, changing flow regime and stream temperatures).	Stewardship Program.

### What is the GRCA Doing?

The GRCA is actively improving watershed health by focussing stewardship activities on increasing the amount of forest cover adjacent to watercourses and by removing or mitigating man-made barriers to allow aquatic species to freely migrate both up and downstream.

## Examples of stewardship projects include:

- Constructing fish passage structures to allow upstream fish movement.
- Community riparian planting projects completed through support of companies such as Enbridge Inc.
- Reconnecting side channels and floodplain habitats in Wilmot Creek to increase habitat diversity.

## *Goal 7: Incorporate climate change considerations into current watershed monitoring programs.*

The GRCA implements an Integrated Watershed Monitoring Program which includes a wide suite of monitoring activities. Data is collected in relation to meteorology; surface water quality and quantity; groundwater quality and quantity; and aquatic and terrestrial resources. In most cases, baseline conditions have been defined for many disciplines. This information allows staff to consider how climate change may impact local watersheds.

#### Adaptation

Groundwater, surface water, and meterologic monitoring networks need to be re-evaluated and potentially expanded to ensure that the current ambient conditions and changing trends in precipitation, temperature, hydrology, and hydrogeology are being captured and understood.

Vulnerable watershed features (e.g., wetlands, groundwater recharge areas and aquifers) must be monitored to ensure appropriate management actions are implemented.

Continue terrestrial and aquatic monitoring programs to evaluate watershed community heath. Monitoring programs will serve as early detection and warning against undesirable introduced/colonizing species. Monitoring will also provide data that will assist in understanding the ecological functions necessary for sustaining terrestrial and aquatic communities (e.g., groundwater/surface water interactions).



### What Monítoríng ís Happeníng Now?

In 2013, the GRCA began implementing a long term watershed monitoring strategy designed in part to evaluate trends in water quality and baseflow as well as supporting the data requirements of other programs.

New water quality sampling sites and sampling frequencies were established to address gaps in previous networks and to provide for a more thorough analysis of conditions. As well, 150 permanent monitoring sites were established where baseflow is measured annually during summer dry periods.

From these programs the GRCA will gain a better understanding of current watershed conditions and long term trends.

## *Goal 8: Incorporate climate change adaptation and mitigation information into GRCA education and outreach programs.*

The GRCA, through the Ganaraska Forest Centre, offers a multitude of curriculum-based educational programs to Ontario school children. Staff aim to help students realize that their actions have impacts on the environment, and teach them how to make choices to lessen their impact in positive ways. In addition, the GRCA offers a comprehensive program at other facilities, and within the community, offering numerous public education events on various topics. Continued education of staff, the GRCA Full Authority Board, partners and the public must occur regarding the need for both adaptation and mitigation to climate change.

Adaptation	Adaptation
Education programs offered at the	Demonstration sites and pilot
Ganaraska Forest Centre will need	projects will be supported by
to be evaluated and adjusted, if	the GRCA to increase
appropriate, to address changes in	knowledge transfer of low
weather patterns. Programs	impact development methods
related to winter activities	such as bioswales, permeable
(snowshoeing and skiing), or	paving, rain gardens, rain
summer topics (pond and stream)	harvesting, and green roofs.
may be limited or greatly impacted	
by changing weather patterns.	Mitigation
	Methods of educational
The GRCA will communicate the	programs delivery at the
science, projected climate	Ganaraska Forest Centre
changes, and potential impacts	should consider the impact to
that are relevant to the local	greenhouse gas emissions.
watersheds.	Other methods to deliver
	educational programing
Communication will emphasize	should be explored.
actions individuals and businesses	
can take to address climate	Public communications and
change.	workshops should be
	evaluated based on their
Implementation of the GRCA	impacts to greenhouse gas
Climate Change Strategy will be	emissions. Alternative forms
reported annually to ensure that	of communications that
recommendations are being	reduce energy use and waste
considered and/or implemented.	should be considered as
	should the transportation

methods participants take to

attend events (e.g., public

transportation or vehicle).

transportation, passive

What Programs are Being Implemented Now?

All educational programs offered at the Ganaraska Forest Centre (GFC) align with the Ministry of Education curriculum and are environment-based.

An example of a Climate Change program is "The Amazing Race to Save the Planet".

Teams of students visit outdoor information stations, where they stop at staffed checkpoints to discuss the information they learned and how they can make changes in their daily routines. The game culminates with students making a personal pledge to the environment. Back in the field centre, they each write their pledge on a paper leaf and hang it on a pledge tree that they bring back to their classroom. They then commit to a Community Action Project, in which they can all participate and share with their community, families and schoolmates (i.e., greening the school yard, conducting a school water audit, or an anti-idling campaign).

#### Goal 9: Evaluate and adapt management and use of GRCA lands.

The GRCA owns and manages the 11,000 acre Ganaraska Forest. In 1998 a management plan was completed for the Ganaraska Forest providing direction in the management of the Forest for a 20 year time period. A number of objectives were identified in the plan, including the conservation and protection of the headwaters of the Ganaraska River, the protection of heritage resources in the Forest, the maintenance of wildlife habitat and the provision of outdoor recreation and education.

Additionally, the GRCA manages other lands (e.g., nine conservation areas) throughout the jurisdiction. These lands are operated based on management plans. Other land holdings may be managed in the future by the GRCA.

Recreational use within the Ganaraska Forest and other GRCA lands will be affected by shorter milder winters and longer spring and fall seasons.Changes to use and management of GRCA lands with a riverine component may be affected by climate change impacts such as increasedThe changes in weather in relation to recreational use will need to be evaluated to determine effects on forest health and Authority revenues required for trail maintenance.temperature. Long term management goals may be required.Increased frequency, duration and intensity of rainfall events will influence trail erosion on GRCA lands and will impact trail maintenance. Trails will need to be evaluated to determine what best management practice should be used, including possible trail closures.Climate change impacts may change the liability associated with the general public's use of GRCA lands. Management change the valued ho
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Changes in forest successional contiens and use should be
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rates will be influenced by a reviewed considering potential
changing climate, as will the increased liability.
possible presence of new
diseases, insects, and additional Mitigation
tire risk. The effects of climate The ecological health of the
change on the health of Ganaraska Forest and GRCA
forested lands should be lands should be continually
evaluated and continually maintained through active or
monitored. passive management to allow
for continued carbon
Page 17 sequestration.

What Management is Happening Now?

The Ganaraska Forest hosts a multitude of recreational activities. Currently motorize use in the forest is restricted during certain times of the ear to protect trail ntegrity.

In addition, regular timber harvesting within the Ganaraska Forest allows for increased biodiversity by increasing the complexity of the understory in the existing forest. Without this form of active management, the plantations from the 1930s and 1940s would become stagnant and unhealthy.

RECOMMENDATIONS

## *Goal 10: Make the GRCA the partner of choice for local climate change adaptation and mitigation initiatives.*

The GRCA currently works in partnership with member municipalities, health units/departments, provincial and federal governments, academia, organizations, clubs and individual residents. By fostering these relationships, climate change and other watershed initiatives will be enhanced.

Adaptation	
The GRCA will consider existing	The
partnerships to determine how	agri
current programs can	reso
implement recommendations	to u
found within the GRCA Climate	and
Change Strategy.	fron

Through new partnerships, initiatives will be undertaken to implement the GRCA Climate Change Strategy.

The GRCA will work with governments, academia and industry to develop and improve climate change science so that impacts can be understood locally in the GRCA.

Opportunities for climate change research will be offered to universities and colleges by providing the GRCA land base on which to conduct this research (e.g., Ganaraska Forest and Conservation Areas). Adaptation The GRCA will engage the agricultural community and resource dependent industries to understand the local risks and opportunities resulting from climate change.

The GRCA will host public awareness events targeted to various stakeholders (e.g., municipalities, businesses, resource users, general public) related to the potential impacts of climate change and actions that can be taken to address the impacts.

The GRCA will partner with neighbouring conservation authorities to provide a consistent approach to climate change for the benefit of local communities.

#### Mitigation

Through partnerships, initiatives will be undertaken to mitigate climate change (e.g., tree planting).



What Partnerships have been Formed?

In 2010, the GRCA entered into a partnership with Trent University to study how water infiltrates into the Oak Ridges Moraine. The Oak Ridges Moraine is a major source of groundwater and baseflow of the Ganaraska River, Wilmot Creek, Cobourg Creek and other local watersheds.

Through the installation of wells, sampling of oxygen isotopes in infiltrated water and installation of weather equipment in different forest conditions, an improved view of the water budget for the Oak Rides Moraine is being developed.

With this information climate change modeling will be possible, that better reflects actual existing and potential future conditions.

## Goal 11: Evaluate and improve GRCA business activities in light of climate change.

The GRCA administers many programs, projects and services. As an organization, conducting day-to-day business, the GRCA can have positive and negative impacts on climate change. Therefore evaluating and improving Authority operations is required.

Adaptation	Mitigation
Field seasons and project	The GRCA Environmental
delivery timelines may be	Workplace Plan needs to be
extended, overlap or will shift	evaluated to ensure that it
which will influence the GRCA	contains best management
overall operations.	practices that will mitigate
	climate change. This plan needs
Increased staff resources may	to be fully integrated into the
be required to address clean-up	day-to-day operations of the
from damaging storms, fire or	Authority.
insect and disease damage, an	
extended growing season (e.g.,	Opportunities need to be
additional grass cutting), and	identified to corporately reduce
invasive species control.	greenhouse gas emissions.
·	
There is potential for an	The GRCA fleet plan will need to
increase in landowner inquiries	be continually updated to
related to issues associated with	ensure that fuel efficient and
climate change (e.g., increased	other vehicle options (current
presence of invasive species,	examples: hybrid and electric)
new species, drought, etc.). This	are equally considered when
increase in inquiries will require	new vehicles are purchased or
additional staff time and	leased.
resources to be addressed	
appropriately.	Electronic communications will
	be promoted over paper based,
Watershed residents may put	and conference calls and
increased pressure on GRCA	webinars will be encouraged
staff and conservation	over off-site meetings.
authorities as a whole to	
address climate change. The	Energy and waste audits will be
GRCA will need to prioritise and	conducted to identify potential
understand its role in	efficiencies, justify
supporting residents in adapting	improvements and measure
to climate change. With this in	effectiveness of policies and
mind, climate change programs	practices. These audits will also
will need to be continually	determine a baseline to
evaluated and assessed.	measure against and timelines
	in which changes are to be
	made. The audits will be part of
	the GRCA Climate Change

Strategy annual report.

### What has the GRCA done?

The new Ganaraska Forest Centre, built in 2009, is a *multi-use facility that* adheres to a LEED (Leadership in Energy and Environmental Design) system of construction. The building incorporates environmentally friendly wood species, a green roof area, solar energy, and materials made of recycled rubber, wood and ceramics, solar powered computer power supply; all in an effort to demonstrate our commitment to innovative conservation strategies.

The GRCA Administrative Offices also incorporate green energy through the use of in-ground construction, a geothermal system and energy efficient lighting.

# **Next Steps**



## Implementation

The GRCA Climate Change Adaptation Team identified that the completion of risk assessments was beyond the scope of this document, and would not be required to identify initial actions in all program areas. For this reason it is recommended that risk assessments only be undertaken within the GRCA Climate Change program where impacts are not characterized to the extent that implementation recommendations can be undertaken.

Recommendations contained within the GRCA Climate Change Strategy should be considered immediately, prioritized and implemented. Some recommendations require significant effort, including a risk assessment that would further refine implementation actions. Other recommendations will require consultation or financial commitments to allow implementation, and therefore may not be implemented immediately. Finally, some recommendations will only need to be considered once climate change impacts are realized (e.g., some changes in use of GRCA lands).

In order to ensure that the GRCA Climate Change Strategy is implemented, recommendations will be reviewed during the annual GRCA budget development process. Specific climate change project funding should be identified in the budget so that the commitment to implementation is understood.

Creating new and fostering existing partnerships with watershed stakeholders is required to ensure successful implementation. Many decisions and actions will require consensus at various levels of government.

## Reporting

Implementation of the GRCA Climate Change Strategy should be reviewed and reported on annually to ensure that recommendations are being considered and/or implemented. An annual report will be presented to the GRCA Full Authority Board, staff and member municipalities. In addition, an annual public communication piece will be created to report implementation/information to the community at large.

## **Planning/Review Cycle**

The GRCA Climate Change Strategy is to be implemented adaptively and a comprehensive update will occur every 5 years in order to address any gaps or changes in watershed science, and issues and opportunities associated with implementation of the plan.

# Appendix



## **Vulnerability Assessment**

### Vulnerability Identification

	Program Areas														
		Natural	GRCA Lands	RCA Lands											
Projected Climate Change Impacts	Hazard Definition	Flood Forecasting and Warning	Groundwater	Planning	Terrestrial	Aquatic		Ganaraska Forest Centre	Conservation Areas	Ganaraska Forest					
Temperature	Temperature														
Increase growing seasons	0	0	X	Х	Х	Х	Х	Х	Х	Х	Х				
Decrease snow accumulation	Х	Х	X	Х	Х	Х	Х	Х	Х	Х	Х				
Change in native plants and animal communities	0	0	0	Х	Х	Х	Х	Х	Х	Х	0				
Increase in invasive species presence	0	0	0	Х	Х	Х	Х	х	Х	Х	0				
Increase in forest fire (risk and actual)	0	0	0	0	Х	Х	0	Х	Х	Х	Х				
Increase in insect and disease outbreaks	0	0	0	0	Х	Х	х	0	Х	Х	Х				
Increase demand for water/drought	0	0	Х	Х	Х	Х	х	х	Х	Х	Х				
Increase in stream temperature	0	0	0	Х	Х	х	х	0	Х	Х	0				
Increase evapotranspiration	0	0	Х	Х	Х	Х	Х	0	Х	Х	0				
Precipitation															
Increase in high intensity events	Х	Х	Х	Х	0	Х	Х	0	0	Х	0				
Decrease in summer precipitation (not extremes)	0	0	Х	Х	Х	Х	х	0	Х	Х	0				
Increase in fall, winter and spring precipitation	х	х	0	Х	Х	Х	х	х	Х	Х	0				
Decrease lake water levels	х	0	0	Х	Х	х	х	0	0	0	0				
Decrease summer soil moisture	Х	Х	Х	Х	Х	Х	Х	0	0	Х	0				
Increase frequency of larger storms (hurricanes)	х	х	х	Х	Х	х	х	х	Х	Х	Х				
Changes in river ice	Х	Х	0	Х	0	0	Х	0	0	0	0				
Increase in lake erosion	Х	0	0	Х	Х	Х	Х	0	0	0	0				
Increase in riverine erosion	Х	0	0	Х	Х	Х	Х	0	Х	0	0				
Increase frequency of ice storms	0	0	0	0	Х	х	0	х	Х	Х	Х				

O = No Perceived Impact

X = Perceived Impact

Sensitivity, Adaptive Capacity and Vulnerability Assessment																																	
			Program Areas																														
Potential Climate Change Impacts		Natural Hazards											Natural Heritage						Monitoring Education and Outreach						GRCA Lands					GRCA Business			
		Hazard Definition		Flood Forecasting and Warning		Groundwater		Planning		Terrestrial			Aquatic						Ganaraska Forest Centre			Conservation Areas			Ganaraska Forest								
Assessment Category	S	AC	V	S	AC	V	S	AC	V	S	AC	V	S	AC	V	S	AC	V	S	AC	V	S	AC	V	S	AC	V	S	AC	V	S	AC	V
Temperature																																	
Increase growing seasons	S1	AC5	V1	S1	AC5	V1	S3	AC4	V2	S2	AC5	V1	S3	AC3	<b>V3</b>	S3	AC3	V3	S3	AC3	V3	S2	AC5	V1	S3	AC5	V2	S3	AC5	V2	S4	AC5	<b>V3</b>
Decrease snow accumulation	S2	AC3	V2	S3	AC3	<b>V3</b>	S3	AC2	<b>V3</b>	S2	AC3	V2	S4	AC3	V4	S4	AC3	V4	S3	AC3	V3	S5	AC2	V5	S4	AC4	<b>V3</b>	S5	AC3	V4	S2	AC3	V2
Change in native plants and animal communities	S1	AC5	V1	S1	AC5	V1	S1	AC5	V1	S3	AC5	V2	S5	AC3	V4	<b>S</b> 5	AC3	V4	S3	AC3	V3	S2	AC3	V2	S5	AC3	V4	S5	AC3	V4	S1	AC5	V1
Increase in invasive species presence	S1	AC5	V1	S1	AC5	V1	S1	AC5	V1	S3	AC3	<b>V3</b>	S5	AC2	<b>V5</b>	<b>S</b> 5	AC2	V5	S3	AC3	V3	S2	AC3	V2	S5	AC3	V4	S5	AC3	V4	S1	AC5	V1
Increase in forest fire (risk and actual)	S1	AC5	V1	S1	AC5	V1	S1	AC5	V1	S1	AC5	V1	S4	AC4	<b>V3</b>	S4	AC4	V3	S1	AC5	V1	S2	AC3	V2	S4	AC3	V4	S4	AC3	V4	S4	AC3	<b>V4</b>
Increase in insect and disease outbreaks	S1	AC5	V1	S1	AC5	V1	S1	AC5	V1	S1	AC5	V1	S5	AC2	<b>V5</b>	S5	AC2	V5	S3	AC3	V3	S1	AC5	V1	S5	AC3	V4	S5	AC3	V4	S4	AC3	<b>V4</b>
Increase demand for water/drought	S1	AC5	V1	S1	AC5	V1	S3	AC2	<b>V3</b>	<b>S</b> 3	AC3	<b>V3</b>	S3	AC1	V4	S4	AC1	V5	S3	AC3	V3	S2	AC3	V2	S3	AC3	<b>V3</b>	S3	AC3	<b>V3</b>	S2	AC3	V2
Increase in stream temperature	S1	AC5	V1	S1	AC5	V1	S1	AC5	V1	S2	AC5	<b>V1</b>	S2	AC4	V2	S5	AC2	V5	S3	AC3	<b>V3</b>	S1	AC5	<b>V1</b>	S4	AC4	<b>V3</b>	S4	AC4	<b>V3</b>	S1	AC5	V1
Increase evapotranspiration	S1	AC5	V1	S1	AC5	V1	S3	AC2	<b>V3</b>	S2	AC5	<b>V1</b>	S3	AC3	<b>V3</b>	S4	AC3	V4	S3	AC3	V3	S1	AC5	V1	S3	AC3	<b>V3</b>	S3	AC3	<b>V3</b>	S1	AC5	V1
Precipitation																																	
Increase in high intensity events	S4	AC1	<b>V5</b>	S5	AC1	<b>V5</b>	<b>S</b> 3	AC3	<b>V3</b>	S4	AC1	<b>V5</b>	S1	AC5	V1	S4	AC2	V4	S3	AC3	<b>V3</b>	S1	AC5	V1	S3	AC3	<b>V3</b>	S3	AC3	<b>V3</b>	S3	AC3	<b>V3</b>
Decrease in summer precipitation (not extremes)	S1	AC5	V1	S1	AC5	V1	S3	AC1	V4	S3	AC3	<b>V3</b>	<b>S</b> 3	AC3	<b>V3</b>	S4	AC3	V4	S3	AC3	<b>V3</b>	S1	AC5	<b>V1</b>	S3	AC3	V3	<b>S</b> 3	AC3	<b>V3</b>	S1	AC5	V1
Increase in fall, winter and spring precipitation	S4	AC2	V4	S4	AC3	<b>V3</b>	S1	AC5	V1	S4	AC2	V4	<b>S</b> 3	AC3	<b>V3</b>	S4	AC3	V4	S3	AC3	<b>V3</b>	S3	AC3	<b>V3</b>	S3	AC3	V3	S4	AC3	<b>V3</b>	S1	AC5	V1
Decrease lake water levels	S2	AC3	V2	S1	AC3	V2	S1	AC5	V1	S2	AC3	V2	<b>S</b> 3	AC3	<b>V3</b>	S4	AC3	V4	S3	AC3	<b>V3</b>	S1	AC5	<b>V1</b>	S1	AC5	<b>V1</b>	S1	AC5	V1	S1	AC5	V1
Decrease summer soil moisture	S2	AC3	V2	S2	AC3	V2	S3	AC2	<b>V3</b>	S2	AC3	V2	S4	AC3	<b>V4</b>	S2	AC3	V2	S3	AC3	<b>V3</b>	S1	AC5	<b>V1</b>	S1	AC5	<b>V1</b>	<b>S</b> 3	AC5	V2	S1	AC5	V1
Increase frequency of larger storms (hurricanes)	S4	AC1	<b>V5</b>	S4	AC2	V4	S1	AC3	V2	S4	AC1	<b>V5</b>	S4	AC3	V4	S4	AC3	V4	S3	AC3	<b>V3</b>	S3	AC3	<b>V3</b>	S4	AC3	V4	S4	AC3	V4	S3	AC3	<b>V3</b>
Changes in river ice	S4	AC2	V4	S4	AC2	<b>V4</b>	S1	AC5	V1	S4	AC2	V4	S1	AC5	V1	S1	AC5	V1	S3	AC3	V3	S1	AC5	V1	S1	AC5	V1	S1	AC5	V1	S1	AC5	V1
Increase in lake erosion	S4	AC2	V4	S1	AC5	V1	S1	AC5	V1	S3	AC2	<b>V3</b>	S3	AC3	<b>V3</b>	<b>S</b> 3	AC3	V3	S3	AC3	V3	S1	AC5	V1	S1	AC5	V1	S1	AC5	V1	S1	AC5	V1
Increase in riverine erosion	S4	AC2	V4	S1	AC5	V1	S1	AC5	V1	S4	AC2	V4	S3	AC3	<b>V3</b>	S4	AC3	V4	S3	AC3	V3	S1	AC5	V1	S3	AC3	<b>V3</b>	S1	AC5	V1	S1	AC5	V1
Increase frequency of ice storms	S1	AC5	V1	S1	AC5	V1	S1	AC5	V1	S1	AC5	<b>V1</b>	S4	AC2	V4	S2	AC2	V2	S1	AC5	V1	S4	AC3	<b>V4</b>	S4	AC3	<b>V4</b>	S4	AC3	V4	S4	AC3	V4
Sensitivity: How exposed is the program area and environment to the impacts of climate change.	Adaptive Capacity: Can the program area adjust to the projected impact with minimal cost and disruption. Will the natural system have capacity to adjust?											S= Sensitivity																					
S1: Functionality will stay the same		AC1: NO - TO COSTIV and adaptation not possible (human and environment)												AC:	= Adal	JUVE (	Lapac	ity															
S2: Functionality will likely stay the same		AC2: No - significant cost and unlikely numan and environmental capacity to adapt										V = Vulnerability																					
S3. Functionality is likely to get worse		AC 5. Waybe - Whitequire some cost and some ability for human and environmental capacity to adapt																															
54. Functionality will become unmanageable	$AC_{2}$ , $Te_{2}$ - Signit cost and ability for numarian environmental adaptive capacity is possible.																																
		ACS	162.			LUSL	anu	nunian	anu		onne	iiidi d	uapti	ive cap	acity	is ho	ssinie.																

Sensitivity and Adaptive Capacity Matrix

	S1	S2	S3	S4	S5
AC1	V2	V2	V4	V5	V5
AC2	V2	V2	V3	V4	V5
AC3	V2	V2	V3	V4	V4
AC4	V1	V2	V2	V3	V3
AC5	V1	V1	V2	V3	V3

Vulnerability Score

V1: Low Vulnerability V2: Medium-low Vulnerability

V3: Medium Vulnerability V4: Medium-high Vulnerability

V5: High Vulnerability

ICLEI Canada. 2011. Changing Climate, Changing Communities: Guide and Workbook for Municipal Climate Adaptation. ICLEI Canada, Toronto, ON.



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