# NVCA Climate Change Strategy and Action Plan 2016-2018

## Milestone 3

Approved in Principle by the NVCA Board of Directors, May 19, 2017

**Nottawasaga Valley**
Conservation Authority

## About this Report

**Authors:** This report was prepared by NVCA staff with input from multiple stakeholders. The lead team comprised: Gayle Wood, CAO – Team Lead; Glenn Switzer, Director, Engineering and Technical Services; Fred Dobbs, Manager, Stewardship Services; Lyle Wood, GIS Analyst; Kris Robinson, GIS Technician (Co-op); Heather Kepran, Communications Coordinator; and Laurie Barron, Coordinator, CAO and Corporate Services.

**Acknowledgement:** The format and content of this report was based on the June 2016 Climate Change Strategy by Kawartha Conservation.

**Cover Image:** Silver Creek babbling through The Blue Mountains by Ian Ockenden, NVCA Watershed Monitoring Specialist, 2016

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# Introduction and Background

Globally, various levels of governments have accepted climate change as a reality.

> *"Climate Change is a fact in our daily living – raising the cost of our food, causing extreme weather that damages property and infrastructure, threatening outdoor activities we love….*
>
> *It affects every aspect of our lives, so it is our collective responsibility to fight climate change together to ensure our children benefit from a cleaner planet."*
>
> *Honourable Glen Murray*
> *Ontario Minister, Environment and Climate Change*

Canada has committed to a "new approach to global climate action" built on:

- Fact-based decision making and robust science;
- Recognition of the necessity of transitioning to a low-carbon, climate-resilient economy;
- Strong collaboration with provinces to take concrete climate action; and
- Support for climate-resilient development and adaption in countries that need it.

Provincially, the Ministry of the Environment and Climate Change has:

- Posted a Climate Change Discussion Paper;
- Developed a Climate Change Strategy; and
- Passed legislation followed by Ontario's Five Year Climate Change Action Plan – 2016 to 2020.

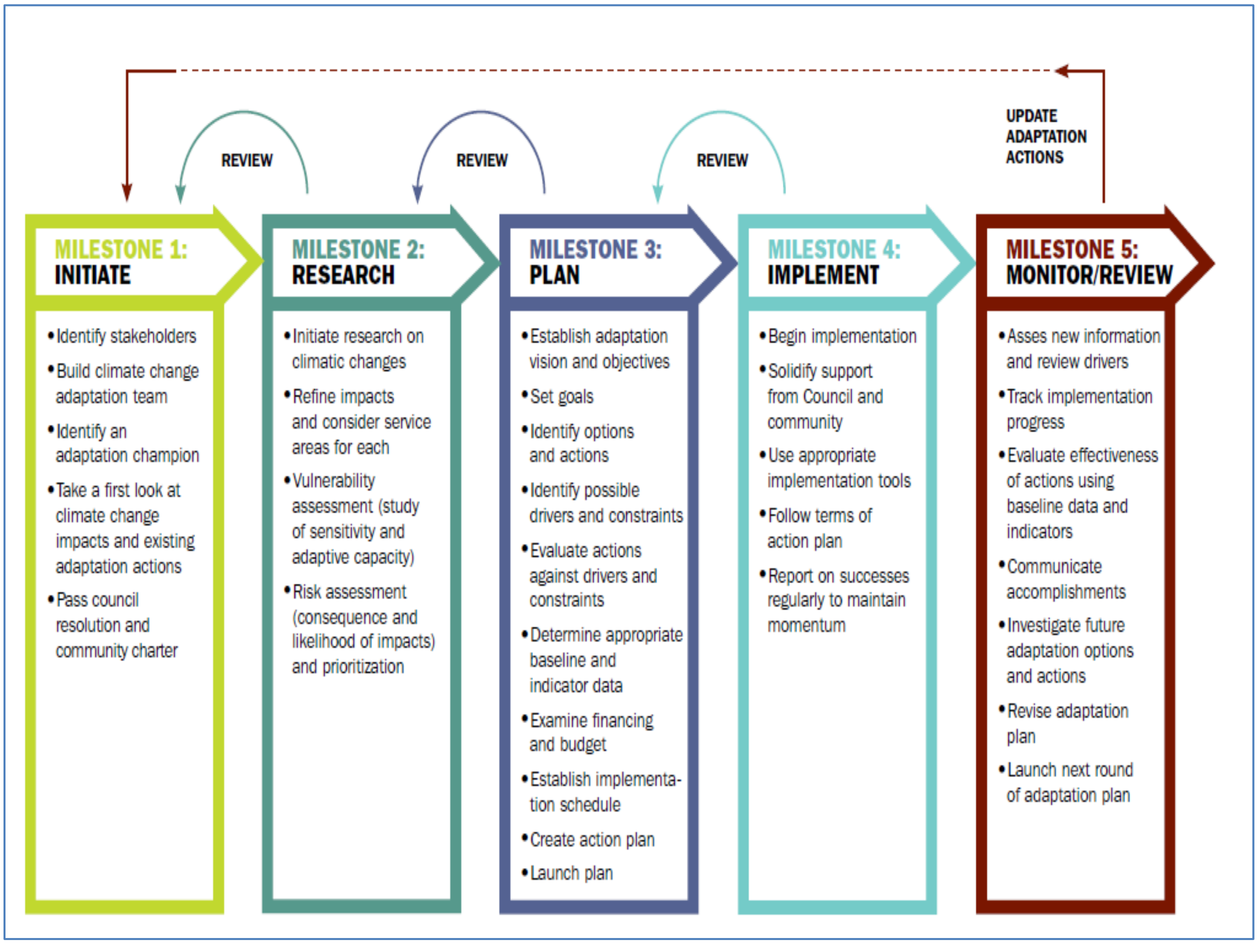
A number of conservation authorities and municipalities have followed suit by developing their own climate change strategies.

On June 24, 2016, the Nottawasaga Valley Conservation Authority's Board of Directors approved the development of a ***NVCA Climate Change Strategy and Action Plan*** based on the "Local Governments for Sustainability" (ICLEI) framework.

## NVCA’s Climate Change Strategy Framework

NVCA committed to the following strategy framework, as presented in *Changing Climate, Changing Communities: Guide and Workbook for Municipal Climate Adaptation*, 2014, by ICLEI Canada.

*Figure 1: Climate Change Strategy Framework*




This ***Climate Change Strategy and Action Plan*** addresses Milestones 1, 2, and 3 of the framework, as approved by the NVCA’s Board of Directors.

# Milestone 1 – Initiating the Strategy

NVCA's 2014-2018 Strategic Plan provides an overarching set of key principles that were considered when developing the ***Climate Change Strategy and Action Plan:***

**NVCA Vision** – Innovative watershed management supporting a healthy environment, communities and lifestyles

**NVCA Mission** – Working together to lead, promote, support and inspire innovative watershed management.

**NVCA Strategic Goals and Objectives**

Strategic Direction - **Protect, Enhance & Restore**

- *Goal:* To protect, enhance and restore the watershed to support a healthy environment, healthy communities and healthy lifestyles by anticipating and taking action to address watershed impacts and pressures.
- *Objectives:* Protect life and property from hazards, and protect, enhance and restore watershed health and promote sustainable development.

Strategic Direction – **Learn & Discover**

- *Goal:* To inspire others - through active collaboration, leadership and innovation - to take action to improve the health of the watershed, and to cultivate greater knowledge of the watershed to advance effective decision making.
- *Objectives:* Promote the watershed and the NVCA, and seek new knowledge and share information.

Strategic Direction – **Connect**

- *Goal:* To connect people to the environment through outdoor watershed experiences.
- *Objectives:* Connect people with the watershed, and promote partnerships and collaboration.

## NVCA's Climate Change Vision

NVCA's strategic vision, mission, goals and objectives offered an important link when developing an the Climate Change Vision (as approved by the authority's board of directors):

> *NVCA's Climate Change Strategy and Action Plan will support global, federal and provincial goals by focusing on our watershed to support climate change adaption and mitigation.*

## NVCA's Internal Climate Change Team

NVCA had several internal teams that played critical roles in the development of the ***Climate Change Strategy and Action Plan.***

| NVCA Internal Team | Roles and Responsibilities |
|---|---|
| **NVCA Board Members** | • Our governing body – the Board of Directors – oversaw all aspects of the ***Climate Change Strategy and Action Plan*** development and approval, including all policies, programs, and budget<br>• The Board approved all staff reports associated with the milestones of the climate change strategy.<br>• The Board members participated in stakeholder meetings.<br>• The Board will consider the ***Climate Change Strategy and Action Plan***.<br>• The Board members promoted the Climate Change initiative with their respective municipalities. |
| **Lead NVCA Team**<br>• Gayle Wood, CAO – Team Lead<br>• Glenn Switzer, Director, Engineering and Technical Services<br>• Fred Dobbs, Manager, Stewardship Services<br>• Lyle Wood, GIS Analyst<br>• Kris Robinson, GIS Technician (Co-op)<br>• Heather Kepran, Communications Coordinator<br>• Laurie Barron, Coordinator, CAO and Corporate Services | • Our lead team developed the Terms of Reference for the climate change initiative which were approved by the Board.<br>• Our lead team completed staff reports for all milestones of the initiative.<br>• The lead team conducted relevant research with the assistance of Georgian College.<br>• The lead team ensured implementation of the milestones 1, 2, and 3 of the initiative.<br>• The lead team coordinated stakeholder workshops and produced reports in partnership with Georgian College.<br>• The lead team coordinated all publications, stakeholder input, external communications and communications planning. |
| **Supporting NVCA Team**<br>• Senior Management Team<br>• Management Team | • The Senior Management and Management Teams were involved in reviewing stakeholder input, and responding to the proposed NVCA Action Plan in terms of their programs. |
| **NVCA Staff** | • The full team was involved in initial work related to the climate change vulnerability study.<br>• The full team was involved in the development of action items and strategies draft ***Climate Change Strategy and Action Plan***. |

## Stakeholder Advisory Group

| Sector | Representatives |
|---|---|
| Municipalities (3)<br>3 municipalities at stakeholder workshops; all watershed municipalities consulted on action plan | • City of Barrie – Katie Thompson<br>• Township of Mono – Councillor Fred Nix<br>• Town of New Tecumseth – Rick Vatri |
| Academic Institutions (2) | • Georgian College – Nicole Barbato and students<br>• Lakehead University – Orillia – Dr. Sreekumari Kurissery |
| Agricultural Sector (3) | • NVCA Agricultural Advisory Committee:<br>○ Colin Elliott<br>○ Hugh Simpson<br>○ Jim Partridge |
| Building Industry (2) | • BILD Simcoe Chapter Chair – Cheryl Shindruk, Nicole MacInnis<br>• Patrick Turner, CounterPoint Engineering |
| NGOs (2) | • Aware Simcoe – Sandy Agnew<br>• Blue Mountain Watershed Trust (unable to participate) |
| Province (2) | • MOECC – Chris Hyde<br>• MNRF – Kate Gee |
| School Boards (2) | • Simcoe Muskoka Catholic District School Board – Glenn Clarke<br>• Simcoe County District School Board – Jessica Kukac |
| Recreation & Tourism (2) | • Free Spirit Tours – Jennie Elmslie (unable to attend)<br>• Tourism Simcoe – Brendan Matheson |
| Health Unit (1) | • Simcoe Muskoka District Health Unit – Morgan Levinson |
| Conservation Authority (1) | • Lake Simcoe Region CA – Ben Longstaff, Hailey Ashworth |

## NVCA’s Climate Change Champions

Mr. David Philips and Dr. Brad Dibble agreed to support and promote the NVCA Climate Change initiative.

| Climate Change Champions | Profile and Role |
|---|---|
| David Phillips | • Senior Climatologist, Environment and Climate Change Canada<br>• Publications: “The Climate of Canada”, “The Day Niagara Falls Ran Dry” and “Blame it on the Weather”<br>• Originator and author of the “Canadian Weather Trivia Calendar”<br>• Numerous award winner and recipient of three honorary doctorates. Named to the Order of Canada in 2001<br>• Guest speaker at the NVCA’s Annual General Meeting on January 27, 2017 and provided media quotes |
| Dr. Bradley Jon Dibble | • Cardiologist, Medical Degree University of Western, Ontario, 1990<br>• Lives in Midhurst; Practices in Barrie and Newmarket<br>• Appointed to the federal Sustainable Development Advisory Committee in 2009<br>• Received training from Nobel Laureate and former US Vice President Al Gore<br>• Written book, Comprehending the Climate Crises – Everything you need to Know About Global Warming and How to Stop It |

## Watershed Climate Change Charter

The Board of Directors approved the following guiding charter:

> “Scientific evidence shows climate change is happening now. This consensus that greenhouse gas emissions are seriously affecting Earth’s climate and that climate change is having increasing negative global impacts, effects the NVCA watershed’s environment and economy.
>
> The NVCA agrees that we need to take responsibility at the local, watershed level and act to address both climate change adaptation and mitigation. We need to prepare for climate change impacts in ways that promote environmental integrity, economic prosperity, and health benefits for all.
>
> It is important for individuals and organizations to share ideas and best practices and coordinate efforts to accomplish these goals as effectively as possible. NVCA agrees that we need to be part of this coordination and conversation.”

Councillor Doug Lougheed, Chair NVCA — Approved August 26, 2016

## Historic Climate Observations

As noted in the ICLEI framework, Milestone 1 required an initial review of climate change impacts. This section of the report outlines the review results.

In conjunction with the increasing concentration of greenhouse gases, it is certain that temperatures globally have been rising since the late 19th century and even more notably since the late 1940s onwards:

> …each of the past three decades has been successively warmer at the Earth's surface than all previous decades in the instrumental record.[1]

Reconstruction of past climates using ice core, tree rings and other datasets indicate it is very likely that in the Northern Hemisphere the 30 year period from 1983 to 2012 was the warmest in the past 800 years. Temperatures in the Northern Hemisphere have been climbing faster than the global average. Importantly, it is extremely likely that human activities have caused more than half of the warming observed since 1951.

Problems with the data quality have made it impossible to have the same level of confidence as is possible with historical temperature records. However, studies conducted for the Inter-governmental Panel on Climate Change have noted with high confidence that an increase in precipitation has occurred in the Northern Hemisphere."[1]

As an initial effort to assess the applicability of these observations to the Nottawasaga Valley, temperature and precipitation data reaching as far back as 1866 were examined from three weather stations in the watershed: Barrie (1866-1985), Barrie Water Pollution Control Centre (1977-2006) and Midhurst (1947-1996). Utilizing data from each of these sources a continuous monthly dataset from 1965 to 2006 was assembled. Trends identified in this 41-year period were compared with trends identified by the Intergovernmental Panel on Climate Change – Assessment Report 5 for a similar time period: 1951 to 2012 (60 yrs).

### Assembling the Data

As mentioned, temperature and precipitation data were gathered from three weather stations in the Nottawasaga Valley. Monthly values were extracted from the stations' datasets using the first available record for each month from the following stations:

1. Barrie
2. Barrie Water Pollution Control Centre (WPCC)
3. Midhurst

A continuous dataset lasting 41 years from January 1965 to December 2006 was created. The Midhurst station provided the majority of data used for 1965 to 1977, while the Barrie WPCC station provided the majority of 1977 to 2006. Monthly temperatures from each year were averaged to find the mean annual temperature. The hottest month of each year was

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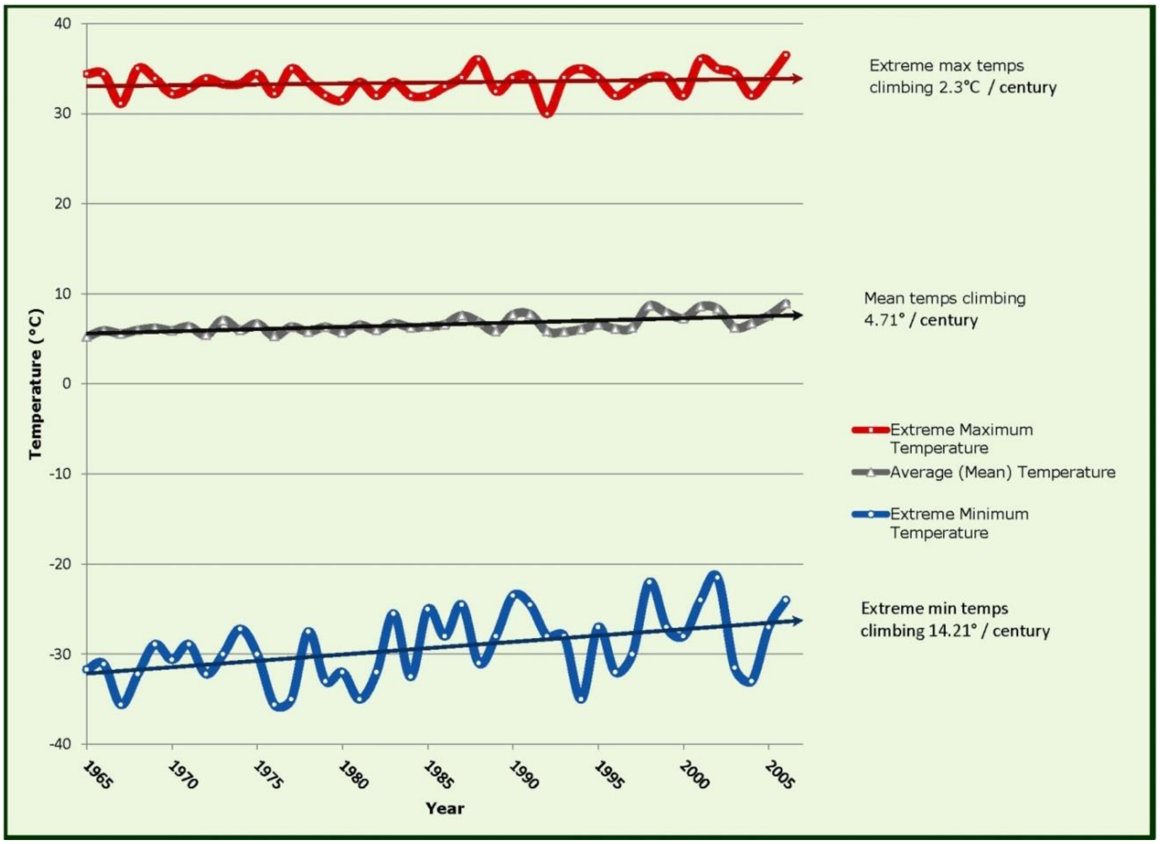
[1] Source: Inter-governmental Panel on Climate Change (IPCC) Working Group 1, Assessment Report 5 (AR5), 2013, p.161. Note that all global/continental data in this section are taken from this same report.

selected as the extreme maximum annual temperature. The coldest month of each year was selected as the extreme minimum annual temperature. Total precipitation from each month was added to find total annual precipitation. The data was then plotted onto graphs for further analysis and can be found in the following sections.

### Temperature Observations

The graph that follows conveys the temperature trends that have been observed over the 40 year span of 1965 to 2006.

*Figure 2: Watershed Temperature Trends*




While global temperatures climbed 0.72°C degrees over the 60 year span of 1951 to 2012, temperatures climbed more than two and a half times that much in two-thirds the amount of time in the Nottawasaga Valley. In just 40 years (1965 – 2006) average yearly temperatures climbed 1.93°C.

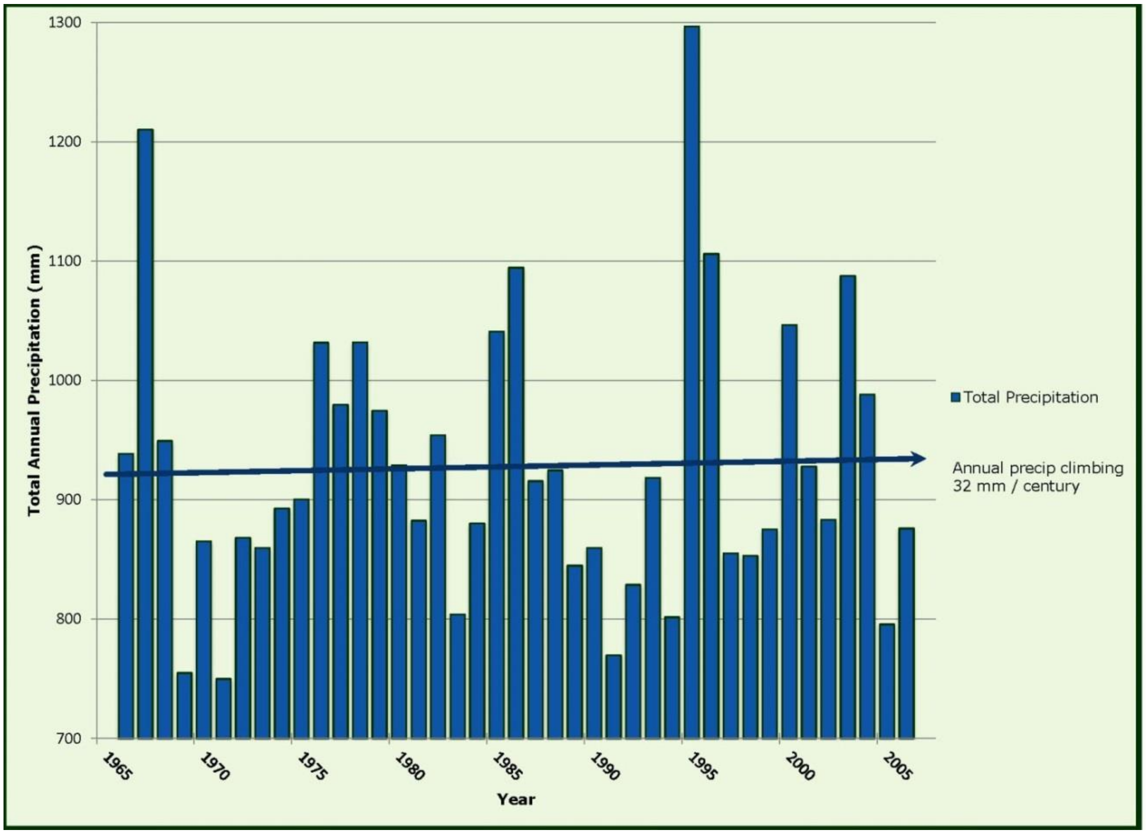
If current trends continue:

- Average monthly temperatures in 2065 will be 4.71°C warmer than in 1965
- Extreme maximum monthly temperatures will rise 2.53°C to an average of 33.05°C
- Extreme minimum monthly temperatures will rise 14.21°C to an average of -18.04°C

### Precipitation Observations

The graph below conveys the precipitation trends that were observed over the same 40 year period of 1965 to 2006.

*Figure 3: Watershed Precipitation Trends*




The Nottawasaga Valley experienced a 13 mm per year (1.4%) increase in rainfall over the study period. This observation is in accordance with the trend of small positive changes in the amount of annual precipitation received in the Northern Hemisphere.

If the current trend continues, total annual precipitation will climb from 921.3 mm per year to 952.7 mm per year (a 3.4% increase).

## Milestone 2 – Climate Change Research

The complete Milestone 2 Research Report is located in Appendix A of this document. This document addresses current and future climate conditions in the Nottawasaga Valley watershed under a variety of scenarios.  It focuses on temperature, precipitation, stream temperature, extreme rainfall and other anticipated climatic changes.

Appendix B provides a vulnerability assessment in order to identify the degree of impact climate change has on the NVCA program areas.

## Milestone 3 – Responding to Climate Change

Based on two stakeholder meetings and internal NVCA staff meetings, a series of strategies and actions are offered for climate change adaption and mitigation within the NVCA watershed.

*Key to the Charts*

Estimated Cost

| | |
|---|---|
| $ | $0 to $5,000 |
| $$ | $5,000 to $10,000 |
| $$$ | $10,000 to $20,000 |
| $$$$ | $20,000 to $50,000 |
| $$$$$ | $50,000 plus |

Priority

- Low Priority
- Medium Priority
- High Priority

Duration (How Long)

- Short – within 1 year
- Medium – 1 to 3 years
- Long – 3 years +

Frequency (How Often)

- One-Off
- Recurrent – re-occurs with regular frequency
- Ongoing – occurs daily or weekly

## Protect, Enhance, Restore – Protect life and property from natural hazards

**NVCA STRATEGIC GOAL:** To protect enhance and restore the watershed to support a healthy environment, healthy communities, and healthy lifestyles by anticipation and taking action to address watershed impacts and pressures.

**CLIMATE CHANGE ACTION PLAN OBJECTIVE:** Protect life and property from natural hazards in the face of changing climatic conditions.

**WHY IT IS IMPORTANT?** Implementing recommendations will ensure a high degree of protection from flooding, erosion and low-water conditions for local residents, private and public property and infrastructure. Natural hazard planning and proactive preventive measures will reduce risks and provide cost saving for municipalities and the public.

| Strategy | Action | NVCA Teams | Potential Partners | Estimated Cost | Priority | Duration | Frequency |
|---|---|---|---|---|---|---|---|
| Enhance our knowledge of future flooding and erosion hazard | Complete flood risk assessment to determine the need for updated floodplain mapping and policies to accommodate changes in climate | • Engineering<br>• Planning<br>• GIS/IT | • Municipalities<br>• Province<br>• Other funders | $$$ | High | Medium | One-off |
| | Based on the risk assessment completed, develop or update where required floodplain mapping | • Engineering<br>• Planning<br>• GIS/IT | • Municipalities<br>• Province<br>• Federal NDMP | $$$$$ | High | Medium | One-off |
| | Complete a geotechnical assessment to evaluate erosion incorporating the impacts of climate change (e.g., change in ice cover, low soil moisture, unpredictable temperature fluctuations, etc.) | • Engineering<br>• Planning | • Municipalities<br>• Province<br>• Other funders | $$$$ | High | Medium | One-off |
| | Upgrade and refine digital elevation data to improve floodplain mapping and the planning review process | • GIS/IT | • Municipalities<br>• Province<br>• FCM Climate Change Program | $$$$ | High | Medium | One-off |
| | Make flood mapping information more accessible. | • GIS/IT | • Municipalities<br>• Province<br>• Other funders | $$ | Medium | Short | One-off |
| Update planning policies and procedures to implement the enhanced understanding of natural hazards | Review and improve where needed internal guidelines related to stormwater management and other natural hazards<br>Develop staff and resources capacity to implement new policies | • Planning<br>• Engineering<br>• Legal Services | • Province (MNRF, MMAH, OMAF)<br>• Municipalities<br>• Special interest groups (agriculture, aggregate, developers) | $$<br>Internal with facilitation | High<br>Primarily objective | Medium | Recurrent<br>Every 5 years |

| Strategy | Action | NVCA Teams | Potential Partners | Estimated Cost | Priority | Duration | Frequency |
|---|---|---|---|---|---|---|---|
| | Continue streamlining the permitting and planning process with member municipalities and partner agencies (for example, such as Mulmur Low Risk Screening Protocol) | • Planning<br>• Communication<br>• GIS/IT<br>• Corporate Services | • Municipalities<br>• Special interest groups | $ | Medium<br>If business as usual | Short | Recurrent |
| Promote efficient and complete communities | Get partnerships for funding – advocate for more incentives | • Corporate Services<br>• Communication<br>• Engineering | • Municipalities<br>• Federal and Provincial partners | $$ | Medium | Medium | Recurrent |
| Communicate and collaborate with partners | Identify stakeholders and prioritize engagement with them | • Planning<br>• Communications | • Agriculture, aggregate, build, GTI, real-estate, municipalities, counties, province | $ | Medium | Medium | Recurrent |
| | Develop key messaging targeted to audiences; use social media | • Communications | • Media<br>• Municipalities<br>• Academia<br>• Conservation Ontario | $$ | Low | Short | Ongoing |
| | Consider partnership for funding communication initiatives | • Corporate Services<br>• Communication<br>• Foundation | • Municipalities<br>• Provincial and Federal Governments | $ | Low/Medium | Short | Recurrent |
| Enhance storm water management practices to mitigate increased runoff | Continue to encourage and assist member municipalities in updating design standards for infrastructure, stormwater facilities, and major and minor drainage systems to address more frequent, high intensity flow events | • Engineering<br>• Planning<br>• Monitoring<br>• Communications | • Municipalities<br>• Conservation Authorities<br>• Industry-tech and building<br>• Province (MOECC, MMOH) | $ | High | Long | On-going |
| | Continue to promote development of green infrastructure as a tool to enhance storm water management and protect communities from adverse weather and climate changes such as increased runoff, deterioration of water quality and heat stress | • Planning<br>• Engineering | • Municipalities<br>• Development Industry | $ | High | Long | On-going |
| | Integrate Low Impact Development (LID) practices into planning processes and guidelines | • Planning<br>• Engineering | • Municipalities<br>• Development Industry | $ | High | Long | On-going |

| Strategy | Action | NVCA Teams | Potential Partners | Estimated Cost | Priority | Duration | Frequency |
|---|---|---|---|---|---|---|---|
| | Develop LID planning and regulation policies and procedures. This will include: (a) developing policy manual, (b) extensive consultations with MNRF, MOECC and the public, and (c) having the policies approved by the board of directors | • Planning<br>• Engineering<br>• Communications | • Municipalities<br>• Development Industry | $$ | High | Short | Recurrent |
| | Promote retrofitting of the existing stormwater systems | • Engineering<br>• Planning<br>• Stewardship | • Municipalities | $ | High | Long | On-going |
| | Employ new and emerging technologies in real-time monitoring and flood forecasting | • Engineering<br>• GIS/IT | • Province<br>• Municipalities | $$$$ | High | Long | On-going |
| Support municipalities in improving flood emergency response | Continue supporting member municipalities in development of flood emergency response plans | • Engineering | • Province<br>• Municipalities | $$ | High | Long | On-going |
| | Incorporate updated and new floodplain mapping into Municipal Emergency Plans that will enhance flood response | • Engineering<br>• GIS/IT | • Province<br>• Municipalities | $$ | High | Short | On-going |
| | Continue enhancing communication protocol for flood emergency to ensure seamless information flow and exchange | • Engineering<br>• Communications | • Province<br>• Municipalities | $$ | High | Long | On-going |
| Further enhance low water/drought conditions monitoring and response | Continue to implement the low water groundwater indicators for the Provincial Groundwater Monitoring Network, PGMN, wells (as per MOECC protocol) | • Engineering | • Federal Government<br>• Ag. Community<br>• Province | $$ | Medium | Short | On-going |
| | Review drought response policies and procedures, receive stakeholder input, and revise drought response guidelines | • Engineering | • Municipalities<br>• MNRF<br>• Key stakeholders such as ag. community | $ | High | Short | On-going |
| | Develop education/outreach materials on drought response | • Communications | • Municipalities<br>• MNRF<br>• Stakeholders | $ | High | Short | As needed |
| Encourage member municipalities to develop low water response planning | Encourage member municipalities to develop low water/drought emergency response plan | • Engineering | • Municipalities<br>• MNRF/Province | $ | High | Short | One-off |

| Strategy | Action | NVCA Teams | Potential Partners | Estimated Cost | Priority | Duration | Frequency |
|---|---|---|---|---|---|---|---|
| Understand and respond to climate change effects on vulnerable sector populations | Identify vulnerable sectors for climate change outcomes under authority mandate (flooding through updated floodplain mapping, drought further identification of vulnerable areas) | • Engineering<br>• Communications | • Public Health<br>• MNRF | $$ | Medium | Long | One-off |
| | Work with Public Health to create maps indicating where each sector is located and use GIS tools to identify patterns/areas of concerns | • GIS/IT | • Public Health<br>• MNRF<br>• Environment and Climate Change Canada (NDMF) | $$$ | Medium | Long | One-off |
| | Identify the needs of each sector, and develop actions plans (including communications plans) for those at highest risk in cases of flooding/drought | • Engineering<br>• Communications | • Public Health | $ | Medium | Long | One-off |

## Protect, Enhance, Restore – Increase resilience through conservation and restoration

**NVCA STRATEGIC GOAL**: To protect enhance and restore the watershed to support a healthy environment, healthy communities, and healthy lifestyles by anticipation and taking action to address watershed impacts and pressures.

**CLIMATE CHANGE ACTION PLAN OBJECTIVE:** Increase watershed resilience to climate change and ability to mitigate it through conservation, restoration and improvement natural ecosystems

**WHY IT IS IMPORTANT?** Implementing recommendations will enhance local ability to adapt to changing climate conditions through further development of green infrastructure. The actions will support mitigation of climate change by increasing the watershed's capacity to sequester greenhouse gases by protecting water quality and quantity and natural heritage features.

| Strategy | Action | NVCA Teams | Potential Partners | Estimated Cost | Priority | Duration | Frequency |
|---|---|---|---|---|---|---|---|
| Increase ecosystem resilience and watershed's ability to capture carbon dioxide ($CO_2$) and other greenhouse gases by protecting its natural features | Continue to support and assist counties and municipalities in development and implementation of tree conservation by-laws | • Planning<br>• Forestry<br>• Stewardship<br>• Monitoring | • Municipalities<br>• Counties<br>• Province<br>• Federal Species at Risk | $ | Medium | Long | On-going/ Recurrent |
| | While enhancing natural heritage systems, focus on connecting green spaces, and riparian and shoreline areas. Consider expanding riparian zones. | • Forestry<br>• Stewardship<br>• Planning<br>• Lands<br>• GIS/IT | • Municipalities & Counties<br>• Land owners<br>• Provincial and Federal Governments<br>• NGOs | $$$$ | High | Medium | On-going |
| Maintain existing and develop new programs that preserve and improve watershed's natural features | Continue developing watershed-wide reforestation program; use genetically & site appropriate species for reforestation projects | • Forestry<br>• Stewardship<br>• Planning<br>• Lands (holdings) | • NGOs<br>• Provincial<br>• Land owners | $$$$$ | High | Long | On-going |
| | Monitor changes in climate for resource-related impacts and develop adaptation strategies | • Monitoring | • Municipalities<br>• Funding Partners | $$$$$ | High | Long | On-going |

| Strategy | Action | NVCA Teams | Potential Partners | Estimated Cost | Priority | Duration | Frequency |
|---|---|---|---|---|---|---|---|
| | Develop partnerships and support initiatives that increase ecosystem resilience and support watershed's natural health | • Stewardship<br>• Forestry<br>• Monitoring | • NGOs<br>• Provincial and Federal Governments<br>• Sponsorship | $ | High | Long | On-going |
| Develop an integrated watershed management plan | Review and update the NVCA watershed management plan with consideration of climate change adaptation and targets | • Planning<br>• All Staff | • Municipalities<br>• External stakeholders | $$$$$ | High | Short | Re-current |
| Develop a comprehensive aquatic natural heritage program to identify and integrate climate change adaptation and mitigation opportunities | Review and update Fisheries Management Plan with consideration of the changing watershed climate | • Stewardship<br>• GIS/IT | • Provincial and Federal Governments | $$$$$ | Medium | Medium | Re-current |
| Maintain and improve health of local watercourses and their aquatic communities by implementing targeted programs, projects and actions | Develop a program to remove/mitigate watershed and in-stream features that contribute to stream warming, and install/maintain features that contribute to stream cooling. | • Stewardship<br>• Forestry<br>• Monitoring<br>• Planning | • MNRF<br>• DFO<br>• NGOs | $$$$$ | High | Long | On-going |
| | Develop a program to education private dam owners on the importance of water quality and quantity, and the effects of their dams on these two important factors. | • Stewardship<br>• Communications<br>• Planning | • Land owners<br>• MNRF | $$$ | Medium | Long | Recurrent |
| | Continue to implement NVCA's Invasive Species Strategy | • Stewardship<br>• Monitoring<br>• Forestry<br>• Communications<br>• Lands | • NGOs<br>• Provincial and Federal Governments<br>• Municipalities<br>• Land owners | $$ | Medium | Long | On-going |
| | Identify, improve and protect the natural heritage of significant water recharge areas with incentive-based approaches. | • Forestry<br>• Hydrogeology | • Provincial and Federal Governments<br>• NGOs<br>• Municipalities<br>• Land owners | $$$$$ | High | Long | On-going |

| Strategy | Action | NVCA Teams | Potential Partners | Estimated Cost | Priority | Duration | Frequency |
|---|---|---|---|---|---|---|---|
| Provide watershed stewardship leadership through education, outreach, and increased awareness | Continue working with watershed landowners promoting best management practices | • Stewardship<br>• Forestry<br>• Education<br>• Communications<br>• Planning | • Land owners<br>• Boards of Education<br>• Ag. Comm.<br>• Municipalities | $$ | Medium | Long | On-going |
| | Continue to reach out to local landowners through local events, direct contact campaigns, and educational and promotional events | • Forestry<br>• Stewardship<br>• Communications | • NGOs<br>• Schools<br>• Ag. Comm. | $$ | Medium | Long | On-going |
| | Provide more frequent information to stakeholders (particularly agricultural and municipal) to allow them to react to issues with more informed and up-to-date knowledge. | • Forestry<br>• Stewardship<br>• Communications | • NGOs<br>• Schools<br>• Ag. Comm. | $$ | Medium | Long | On-going |
| | Produce an annual summary outlining the volunteer plantings in the watershed. | • Forestry<br>• Stewardship<br>• Lands<br>• Communications | • NGOs<br>• Schools<br>• Ag. Comm. | $ | High | Short | On-going |
| | Continue to partner with funders and project stakeholders to steer local delivery of the 50 Million Tree Program and any other similar initiatives. | • Forestry<br>• Stewardship | • Provincial funders | $$$ | High | Long | On-going |
| | Maintain existing and develop new partnerships delivering projects that increase watershed resiliency to climate change. | • Forestry<br>• Stewardship<br>• Communications | • NGOs<br>• Schools<br>• Ag. Comm. | $$ | Medium | Long | On-going |
| Allocate stewardship resources based on natural heritage systems and potential runoff reduction and mitigation | Create stewardship prioritization mapping tool for terrestrial and aquatic stewardship combining natural heritage system and stormwater considerations (permeability, level of development, existing stormwater infrastructure). Use the tool to make resource allocation decisions and promote the use of the tool to implementation partners. | • Stewardship<br>• Planning<br>• Forestry<br>• GIS/IT<br>• Monitoring<br>• Engineering | • Counties<br>• Province | $$$ | High | Long | On-going |
| | Continue the Healthy Waters Program and develop a cost-share program between landowners, municipalities, government agencies and other partners. | • Stewardship<br>• Corporate Services | • Provincial and Federal Governments<br>• Landowners<br>• Municipalities<br>• NGOs | $$$$$ | High | Long | On-going |

| Strategy | Action | NVCA Teams | Potential Partners | Estimated Cost | Priority | Duration | Frequency |
|---|---|---|---|---|---|---|---|
| Develop and deliver targeted programs and projects for rural, urban and shoreline landowners | Seek out opportunities to pilot, demonstrate and showcase innovative technology, land and runoff management practices that increase watershed resiliency (e.g., nutrient management, erosion control, LID sites) | • Stewardship<br>• Forestry<br>• Engineering | • Government<br>• Land owners<br>• NGOs | $ | Medium | Long | On-going |
| Incorporate climate change considerations into conservation lands management | Make sustainability a guiding principle in further conservation land management. Continue managing and enhancing our conservation lands for the changing climate.<br>For example:<br>Maintain forest canopy by planting trees which are better suited to longer growing seasons<br>Develop and implement list of species for climate change adaptation in conservation areas<br>Plan for increased need for conservation lands maintenance that will result from the changing weather conditions | • Lands<br>• Planning<br>• Communications | • Municipalities<br>• Consultants<br>• Foundation<br>• Local interest groups<br>• Similar organizations (e.g., OLTA) | $$$ | Medium | Long | On-going |
| | Continue further land securement focusing on enhancing our existing Conservation Areas and areas vulnerable to flooding and erosion | • GIS/IT<br>• Lands<br>• Communications<br>• Planning | • Municipalities<br>• Consultants<br>• Foundation<br>• Local interest groups<br>• Similar organizations<br>• Private landowners | $$$$$ | High | Long | On-going |

## Learn & Discover – Enhance knowledge for informed decision making

**NVCA STRATEGIC GOALS:** To inspire others – through active collaboration, leadership and innovation – to take action to improve the health of the watersheds. To cultivate greater knowledge of the watershed to advance effective decision making.

**CLIMATE CHANGE ACTION PLAN OBJECTIVE:** Enhance our knowledge of our watershed's natural environment and its response to a changing climate through monitoring for informed decision making

**WHY IT IS IMPORTANT?** Implementing recommendations will improve our knowledge of watershed resources and our understanding as to how they may be affected by changing climate. It will provide a basis for more informed planning, decision making and development of proactive actions.

| Strategy | Action | NVCA Teams | Potential Partners | Estimated Cost | Priority | Duration | Frequency |
|---|---|---|---|---|---|---|---|
| Enhance existing watershed monitoring network | Evaluate existing watershed monitoring network | • Monitoring | • Municipalities<br>• Environment and Climate Change Canada<br>• MOECC/MNRF<br>• NGOs | $ | High | Short | Recurrent |
| | Assess how current monitoring addresses the current and future information needs. Identify information gaps. | • GIS/IT<br>• Monitoring | • Municipalities<br>• Environment and Climate Change Canada<br>• MOECC/MNRF<br>• NGOs | $$ | High | Short | Recurrent |
| | Develop comprehensive Watershed Monitoring Strategy that takes into consideration monitoring, required to recognize changes in ecosystem as a result of changing climate | • Monitoring<br>• GIS/IT | • Municipalities<br>• Environment and Climate Change Canada<br>• MOECC/MNRF<br>• NGOs | $$$$ | High | Short | Recurrent |
| | Establish partnerships and pursue cost-sharing approaches in developing new monitoring locations | • GIS/IT<br>• Monitoring | • Municipalities<br>• Environment and Climate Change Canada<br>• MOECC/MNRF<br>• NGOs | $$$ | High | Long | On-going |

| Strategy | Action | NVCA Teams | Potential Partners | Estimated Cost | Priority | Duration | Frequency |
|---|---|---|---|---|---|---|---|
| Increase ecosystem resilience and watershed's ability to capture carbon dioxide ($CO_2$) and other greenhouse gases by protecting its natural features through the planning and regulation process | Develop and implement an Integrated Watershed Management Plan, including a Natural Asset Plan/Heritage Strategy for the watershed | • Planning<br>• Stewardship<br>• Forestry<br>• GIS/IT<br>• Monitoring | • Municipalities<br>• Counties<br>• MNRF<br>• MMAH (Places to Grow)<br>• Ontario Nature | $$$$$ | High | Medium | On-going |
| Strengthen monitoring of groundwater resources | Continue source water protection through ongoing monitoring | • Hydrogeology<br>• GIS/IT | • Municipalities<br>• MOECC<br>• Regional Source Water Protection Program (LSCRA and SSEA)<br>• Counties | $$$ | Medium | Long | On-going |
| | Complete studies to better understand the role of climate change on aquifers | • Hydrogeology | • Municipalities<br>• Ontario Geological Survey<br>• MOECC<br>• Geological Survey of Canada | $$$$$ | Medium | Medium | One-off |
| Continue enhancing our knowledge how climate change will impact watershed resources | Estimate vulnerability of watershed's water resources under the changing climate conditions | • Engineering | • Province<br>• Municipalities | $$ | Medium | Short | One-off |
| | Conduct research to identify vulnerable aquatic ecosystems, anticipated changes associated with climate change, and acceptable mitigation/adaptation approaches | • Monitoring<br>• Stewardship<br>• GIS/IT | • Province<br>• NGOs<br>• Municipalities | Desktop -$$<br><br>In-Field - $$ | Desktop - Medium<br><br>In-Field - High | Desktop- Medium<br><br>In-Field - Long | Desktop - One-off<br><br>In-Field - Recurrent |
| | Continue to evaluate changes in terrestrial ecosystems and adjust mitigation and adaptation actions | • Monitoring<br>• Stewardship<br>• GIS/IT | • Municipalities<br>• Counties<br>• Province | $$$ | Medium | Long | On-going |
| Share monitoring data in open and transparent manner | Develop a monitoring data portal to allow NVCA, CA staff and any other members of the public to examine data to facilitate data sharing, comparison, and trends analysis | • GIS/IT | • Municipalities<br>• Counties | $$$ | Medium | Short | On-going |

## Connect – Ensure recreational use of conservation lands is responsive to a changing climate

**NVCA STRATEGIC GOAL**: To connect people to the environment through outdoor watershed experiences.

**CLIMATE CHANGE ACTION PLAN OBJECTIVE**: Ensure that recreational use of NVCA conservation lands and programs is responsive to the effects of climate change so that the authority can continue connect people to their watershed through quality outdoor experiences.

**WHY IT IS IMPORTANT?** Outdoor recreation builds people's love of nature, and their desire to protect and enhance natural spaces. With more residents moving into the area and the anticipated effects of climate change, it is important that NVCA strike a balance between safe and enjoyable recreational experiences and the natural carrying capacity of sensitive natural lands and waters.

| Strategy | Action | NVCA Teams | Potential Partners | Estimated Cost | Priority | Duration | Frequency |
|---|---|---|---|---|---|---|---|
| Ensure NVCA and stakeholders have a strong understanding of the landscape | Set carrying capacity standards for preserving key natural features and functions on NVCA lands. Develop monitoring for areas prone to overuse. | • Monitoring<br>• Lands<br>• Corporate Services<br>• Communications | • Service club/interest groups<br>• Volunteers<br>• Provincial and Federal governments<br>• Academia | $$$$ | Medium | Long | On-going |
| | Develop standards to ensure sustainable recreational use of environment within communities. | • Communications<br>• Lands<br>• Education | • Public<br>• Municipalities<br>• Volunteers | $$ | Medium | Long | On-going |
| Develop approaches to outdoor recreation that are responsive to a changing climate | Developing new and maintain existing trails, consider future climate and ecosystem changes.<br>Develop trail maintenance plans to address anticipated effects of climate change. | • Lands<br>• Stewardship<br>• Monitoring<br>• Communications<br>• GIS/IT | • Volunteers<br>• Contractors<br>• Service clubs | $$ | Medium | Long | Recurrent |
| | Consider using web-based monitoring programs to track recreational use and/or to gather information from recreational users (e.g., Fulcrum program, used by Parks Canada) | • GIS/IT<br>• Lands<br>• Communications | • Academia<br>• Conservation Authorities | $$ | Medium | Medium/ Long | Recurrent-Long |
| | Develop recreational plans to address changing outdoor recreational opportunities during shoulder seasons. Consider new activities (e.g., fat biking) | • Lands<br>• Communications | • Tourism offices<br>• Sporting groups<br>• Service clubs | $$ | Medium- | Long | On-going |

| Strategy | Action | NVCA Teams | Potential Partners | Estimated Cost | Priority | Duration | Frequency |
|---|---|---|---|---|---|---|---|
| | Advocate and support development of regional marketing research and materials/literature that focuses on sustainable tourism | • Communications<br>• Lands | • Tourism office<br>• Volunteers<br>• Chambers of Commerce | $$$ | Low | Long | On-going |
| | Working collaborative with tourism sector, develop educational programs/literature/social media strategies for recreation-specific sectors (trails, parks, beaches) that convey weather, safety and other climate-related messaging. | • Communications<br>• Lands<br>• Education<br>• GIS/IT | • Tourism offices, sporting groups<br>• Media<br>• Outfitters | $$ | Medium | Long | On-going |
| | Support healthy lifestyle choices and help offset the negative effects of climate change on human health by offering watershed's residents high-quality recreational opportunities in our conservation areas | • Communications<br>• Education<br>• Lands | • Health Unit<br>• Tourism offices<br>• Province<br>• Municipalities<br>• Counties | $ | High | Long | On-going |
| Reduce the climate footprint of those travelling to recreational opportunities | Advocate for regional transit (e.g., GO) to tie into trail networks to ensure "sustainable" tourism is not contributing to GHG emissions.<br>Support efforts to tie conservation areas into biking and hiking trail systems | • Communications<br>• Lands | • Counties<br>• Tourism offices<br>• Via/GO Transit, MTO | $ | Low | Long | On-going |

## Connect – Communicate to raise awareness around climate change

**NVCA STRATEGIC OBJECTIVE:** To connect people with the watershed and promote partnerships and collaboration.

**CLIMATE CHANGE ACTION PLAN OBJECTIVE**: Effectively communicate with partners from all sectors to raise awareness around the effects of and responses to a changing climate in the Nottawasaga Valley watershed.

**WHY IT IS IMPORTANT?** Education and outreach with community partners is a cornerstone of all NVCA programs. Climate change information needs to be shared with both technical and non-technical stakeholders to support shared goals of health, safe and resilient communities. Effective climate change education for youth will help them prepare for the effects – both negative and positive – that will shape their lives in the foreseeable future.

| Strategy | Action | NVCA Teams | Potential Partners | Estimated Cost | Priority | Duration | Frequency |
|---|---|---|---|---|---|---|---|
| Collaborate with stakeholders from all sectors that are developing climate change strategies so that individual plans become a cohesive regional approach | Participate on regional climate change working group (currently in early stages/discussion) | • Senior Mngt Team<br>• Mngt Team<br>• NVCA Climate Change Team | • Stakeholders<br>• Municipalities<br>• Health Unit | $ | Medium | Long | On-going |
| Train educators so they can properly inform today's youth about climate change | Integrate a climate change education program into the NVCA Education Strategy (consider both teacher/train-the-trainer and student focussed programs) | • Education | • School boards<br>• Provincial and Federal Governments | $$ | High | Short | On-going<br>Delivery |
| Communicate with the stakeholders and the interested public to improve their understanding of the local effects of climate change | Create and implement a Climate Change Communications Strategy. | • Communications | • Municipalities<br>• Stakeholders | $$ | High | Medium | On-going |

## Responsible Business Operations – Reduce our carbon footprint

**NVCA STRATEGIC PRIOIRTY**: To support and advance our strategic priorities against a platform of Organizational Excellence.

**CLIMATE CHANGE ACTION PLAN OBJECTIVE:** Reduce our corporate carbon footprint by developing a business culture of conservation, using best practices and solutions

**WHY IT IS IMPORTANT?** Implementation of actions will assist in a reduction of our corporate footprint, demonstrate our corporate culture of conservation and provide possible cost savings to our business operations

| Strategy | Action | NVCA Teams | Potential Partners | Estimated Cost | Priority | Duration | Frequency |
|---|---|---|---|---|---|---|---|
| Enhance and promote corporate culture of conservation in order to reduce business carbon footprint | Assess our corporate performance in energy, water use and waste production; identify opportunities to reduce wasted resources<br>Create an action plan to address areas to address areas to improve our corporate performance and decrease our carbon footprint | • Corporate Services | • County of Simcoe<br>• Municipalities<br>• Utilities | $ | High | Short | One-off |
| | Develop long-term recommendations on further improving our performance, focusing on most efficient and emerging technologies in transportation, energy and water use. The best energy, heat and water efficient solutions will be considered to improve our corporative performance and decrease our footprint | • Corporate Services<br>• Lands | • County of Simcoe<br>• Municipalities<br>• Utilities<br>• Governments<br>• Contractors | $$$$$ | Medium | Long | One-off |
| | Develop and implement waste management plan, including comprehensive recycling program and composting of organic waste | • Corporate Services<br>• Lands<br>• Senior Mngt Team<br>• Mngt Team | • County of Simcoe Waste Management | $ | High | Long | On-going |

| Strategy | Action | NVCA Teams | Potential Partners | Estimated Cost | Priority | Duration | Frequency |
|---|---|---|---|---|---|---|---|
| Ensure business practices align with best practices to reduce carbon emissions and to respond to changing climate conditions. | Develop and implement a "Environmentally Sustainable Business Practices" document which includes policies and procedures regarding:<br>• Maximizing carpooling to meetings<br>• Purchasing fuel efficient and/or hybrid corporate vehicles<br>• Developing formal recycling, organics and paper reduction policy and procedures<br>• Electing an "Office Sustainability Champion"<br>• Using sustainability language in NVCA procurement policies<br>• Maximising use of teleconferencing<br>• Setting internal and conditioning and heating standards<br>• Setting safety standards for outside works and clients for extreme temperatures<br>• Including climate mitigation and adaptation programs in annual budget process<br>• Developing a vehicle idling policy<br>• Promoting litter-less lunches | • Senior Mngt Team & Mngt Team (lead)<br>• Communication<br>• All Staff | • Municipalities<br>• Conservation Authorities<br>• Industry leaders | $ - practices<br><br>$$$$$ - fleet | High | Long | On-going |

## Moving Forward and Key Priorities

Upon endorsement of this ***Climate Change Strategy and Action Plan***, in principle, by the NVCA board of directors, Milestone 4 - Implementation will begin. Implementation of strategies and actions will start with the integration of the climate change strategies into the 2018 budget deliberations. They will also be included into the Nottawasaga Valley Conservation Authority's new Strategic and Business Plans for 2018-2021.

Recommended actions will be prioritized based on several criteria including but not limited to:

- Anticipated impact of the action;
- Feasibility of implementation in the short, medium and long term;
- Priority and resources required to implement the action;
- Anticipated implication of not implementing the recommended action;
- Availability of alternative or additional sources of funding where additional costs are required;
- Capacity to continue providing the required level of service to the public, member municipalities and partner agencies; and
- Synergy with other program and strategic priorities

Key priority programs which emerged through stakeholder consultation and legislative responsibility include:

- Continuing to update floodplain mapping and risk assessment;
- Leading flood warning/forecasting and low water response initiatives;
- Promoting low impact development with municipalities and the development industry;
- Communicating and educating on climate change;
- Updating the NVCA's Integrated Watershed Management Plan in light of climate change;
- Implementing watershed restoration projects and reforestation; and
- Watershed reporting *vis a vis* climate change and reporting.

Some projects and programs recommended within this document are already being implemented, often with climate change considerations being a significant impetus in their development. The current floodplain mapping efforts under the federal National Disaster Mitigation Program is an example of such a watershed initiatives. Provincially, conservation authorities already work with ministries and municipalities regarding flood warning and forecasting and in the Low Water Response Program, and have been delegated with the leadership of local response activities. Other initiatives, such as the development of an updated Integrated Watershed Management Strategy, including consideration of a regional natural heritage system, will provide a basis for identifying best options for protecting and enhancing green infrastructure.

Several actions recommended in this strategy will require significant effort and/or additional funds for implementation. Investment in a more comprehensive watershed monitoring network, including weather, surface water, aquifer recharge, aquatic and terrestrial monitoring is required to quantify climate change impacts and to evaluate adaptation measures and will also require significant support. Enhanced communication strategies and implementation was identified as a high priority by the stakeholders.

For specific projects or program areas that are not currently in place or which will require an investment of funds and resources to implement, plans will be developed to determine costing estimates to fund the work. Alternative funding opportunities will also be identified. As both provincial and federal governments are becoming proactive on the climate change issue, we anticipate that funding to support mitigation and adaptation efforts by conservation authorities and municipalities might become available in the near future.

Many decisions and actions require consensus at various government levels. Collaboration with partner agencies and watershed stakeholders that reflect climate change mitigation and adaptation efforts will be integral. As adaptive management is a key when considering climate change, the strategies and actions will be reviewed and modified where necessary. A comprehensive review and update will take place every four years in conjunction with our strategic plan review.

An annual summary and evaluation of program accomplishments relative to this strategy will be provided to our board of directors. In addition, the watershed community will be informed of our progress through various communication mechanisms.

## Supporting Documents

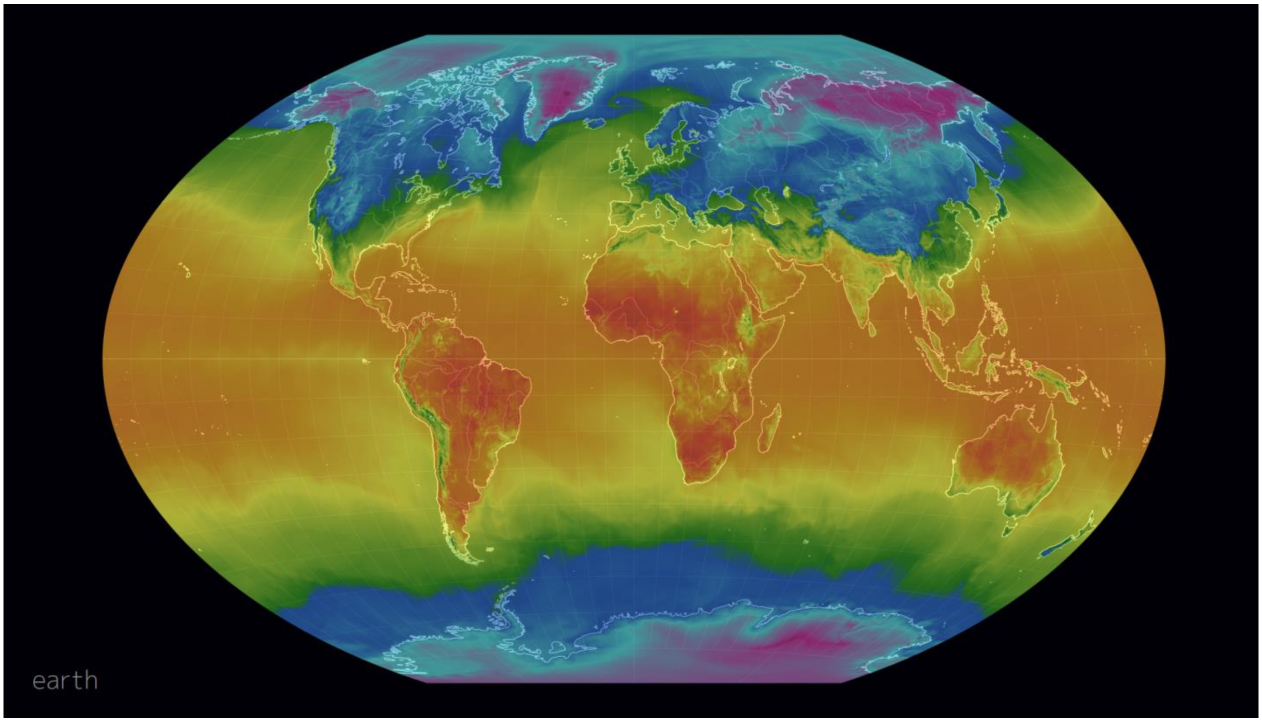
NVCA Climate Change Strategy and Action Plan 2016-2016: Milestone 1 – Initiating the Strategy, August 26, 2016 (available at http://www.nvca.on.ca/watershed-science/climate-change)

NVCA Climate Change Strategy and Action Plan 2016-2016: Milestone 2 – Research, December 16, 2016 (available at http://www.nvca.on.ca/watershed-science/climate-change and follows as Appendix A)

NVCA Climate Change Strategy and Action Plan: Stakeholder Advisory Group Meeting 1, February 15, 2017, Summary Document, March 13, 2017 (available at http://www.nvca.on.ca/watershed-science/climate-change)

NVCA Climate Change Strategy and Action Plan: Stakeholder Advisory Group Meeting 2, March 22, 2017, Summary Document, April 7, 2017 (available at http://www.nvca.on.ca/watershed-science/climate-change)

## Appendix A: NVCA Climate Change Strategy and Action Plan Report, Milestone 2 – Research




# NVCA Climate Change Strategy and Action Plan 2016-2018

## Milestone 2 — Research

December 16, 2016

**Nottawasaga Valley**
Conservation Authority

# Contents



## List of Tables

**Authors:** This report was prepared by NVCA staff members Lyle D. Wood, MES, (GIS Analyst) and Kristopher J. H. Robinson (GIS Technician).

**Cover Image:** Earth Surface Temperatures on November 30, 2016, from earth: a visualization of global weather conditions (earth.nullschool.net)

**Alternative Formats:** If you require this document in an alternative format, please contact NVCA at 705-424-1479 or admin@nvca.on.ca

# Introduction

As projected, the local impacts of global climate change are becoming more prevalent. Climate data observations within the Nottawasaga Valley watershed confirm that temperatures have been climbing steadily, particularly in winter months, and annual precipitation has been increasing. Recent extreme weather events such as flash flooding, heat waves, drought, and tornadoes illustrate the extent to which weather can impact daily life. They also emphasize the need to be prepared for changing weather regimes where such events are expected to become more commonplace.

The intention of this report is to provide a basic overview of climatic changes projected to occur in the Nottawasaga Valley from present until the turn of the century. Projected temperature and precipitation changes are emphasized, while attention is also provided to increasing stream temperatures, and extreme rainfall intensity, duration and frequency. These changes can be expected to have wide ranging impacts for the people and ecology of the Nottawasaga Valley.

This report presents efforts taken on behalf of the Nottawasaga Valley Conservation Authority (NVCA) to fulfill Milestone 2 of its ***Climate Change Strategy and Action Plan: Initiate Research on Climatic Changes.*** It will be used as a resource to guide future research, actions and measures to be taken in mitigating and adapting to climate change.

# Background

The climate projection data used in this report comes primarily from emissions scenarios and climate models included in Intergovernmental Panel on Climate Change (IPCC) Assessment Reports 4 and 5 (AR4 & AR5). The most current AR5 projections were used to present changes that are projected for Canada and the province of Ontario. Examining climate change specifically within the Nottawasaga Valley required climate model data that had been downscaled – a process of using global data to make projections on a local scale. Downscaled AR5 climate model data was not available at the time this report was written, so AR4 climate model data was used in its place.

Almost all climate change data included in this report was gathered from Environment Canada's Canadian Climate Data and Scenarios website (2016). The intensity duration frequency (IDF) curve information and charts were gathered from the Computerized Tool for the Development of Intensity-Duration-Frequency Curves under Climate Change website (2016).

Before examining expected climatic changes in the Nottawasaga Valley, one should be aware of the uncertainty inherent with the exercise of developing a climate change model scenario. Atmospheric composition, specifically regarding greenhouse gases (GHG), plays a significant role in climate modelling. Future GHG concentrations will depend heavily on whether society, on a global scale, continues to increase emissions or whether efforts to mitigate those emissions will be successful. Emission scenarios reflecting a range of plausible future concentrations are used in climate modelling to include this uncertainty into the process – each based on a range of assumptions regarding future emissions levels.

Aside from GHG concentrations, the response of Earth's climate to those concentrations must also be simulated. Climate models – specifically general circulation models (GCMs) – are the most advanced tools available for predicting the response of Earth's climate to the complex interactions taking place between increasing GHG concentrations and our oceans, atmosphere, glaciers and land surfaces. It is common practice in climate modelling to take into consideration the average of many climate models in preference to relying on any one particular model as it is assumed that the average will possess a smaller degree of error (IPCC, 2007). In the case of national and provincial climate projections, the range of scenarios provided in the AR5 series of models was considered. Where an ensemble approach was not available the CGCM3T47 model, created by the Canadian Centre for Climate Modelling and Analysis, and the NCARPCM, created by the National Center for Atmospheric Research, were used as they have been used extensively in IPCC climate modelling studies.

## Emissions Scenarios

As mentioned, central to the process of modelling future climate change is developing a range of plausible futures regarding the level of anthropogenic GHG emissions. These futures provide a qualitative description of how human demographic, technological and socio-economic systems may develop in the future and attempt to provide a plausible quantification of the GHG emissions that might result from such developments. GHGs are a significant driving force of how Earth's climate will change in the future.

Both the AR4 and AR5 climate models use a variety of emissions scenarios including:

- scenarios with an early peak in GHG emissions followed by a decline thereafter;
- stabilizing scenarios where emissions are assumed to stay relatively close to present-day levels; and
- scenarios where emissions levels continue to climb as they have in the past.

More information is available regarding the AR5 emissions scenarios through the *Towards New Scenarios for Analysis of Emissions, Climate Change, Impacts and Response Strategies*, *IPCC Expert Meeting Report (2007).* Information on the AR4 emissions scenarios is available through the *IPCC Special Report: Emissions Scenarios* (2000).

## Temperature Change

### Canada

Like much of the Northern Hemisphere, Canada as a nation has warmed faster than the global average — about 1.5°C over the last 60 years (Government of Canada, 2014). The tables below show the median of projections aggregated from the AR5 climate models and illustrate the temperature change expected on a national level from the average temperature of the baseline years (1986 to 2005) extending outward as far as the years 2081-2100.

One table is presented for each Representative Concentration Pathway (RCP) included in the AR5 climate modelling process. RCP 2.6 assumes that global GHG concentrations will peak before 2020 and substantially decline thereafter. RCP 4.5 assumes GHG concentrations will not peak until the 2040s, but will then decline and RCP 8.5 assumes that GHG concentrations will continue to rise throughout the 21st century (Meinshausen, et al., 2011).

The information was gathered from the Environment Canada's Canadian Climate Data and Scenarios web site. Temperature values are displayed in degrees Celsius of change from the baseline. Negative values are displayed in brackets.

*Table A-1: Seasonal and annual change in temperature based on RCP 2.6 nationwide (°C)*

| RCP 2.6 National | 2020s Median | 2020s Range | 2050s Median | 2050s Range | 2080s Median | 2080s Range |
|---|---|---|---|---|---|---|
| Spring | 1.2 | 0.8 – 1.6 | 1.6 | 1.1 – 2.3 | 1.5 | 1.0 – 2.3 |
| Summer | 1.0 | 0.7 – 1.5 | 1.5 | 0.9 – 2.0 | 1.4 | 0.8 – 2.0 |
| Autumn | 1.3 | 1.0 – 2.0 | 1.8 | 1.5 – 3.0 | 1.8 | 1.3 – 3.0 |
| Winter | 1.4 | 0.9 – 2.1 | 2.2 | 1.6 – 3.1 | 2.4 | 1.5 – 3.4 |
| **Annual** | **1.2** | **0.9 – 1.7** | **1.8** | **1.3 – 2.5** | **1.8** | **1.1 – 2.5** |

*Table A-2: Seasonal and annual change in temperature based on RCP 4.5 nationwide (°C)*

| RCP 4.5 National | 2020s Median | 2020s Range | 2050s Median | 2050s Range | 2080s Median | 2080s Range |
|---|---|---|---|---|---|---|
| Spring | 1.1 | 0.7 – 1.7 | 2.1 | 1.7 – 3.0 | 2.8 | 2.1 – 4.0 |
| Summer | 1.1 | 0.7 – 1.4 | 2.0 | 1.4 – 2.6 | 2.6 | 1.7 – 3.4 |
| Autumn | 1.3 | 1.0 – 2.0 | 2.5 | 2.3 – 3.7 | 3.1 | 2.9 – 4.8 |
| Winter | 1.5 | 1.0 – 2.2 | 3.2 | 2.5 – 4.3 | 4.2 | 3.2 – 5.7 |
| **Annual** | **1.2** | **0.9 – 1.7** | **2.4** | **2.0 – 3.2** | **3.2** | **2.5 – 4.2** |

*Table A-3: Seasonal and annual change in temperature based on RCP 8.5 nationwide (˚C)*

| RCP 8.5 National | 2020s Median | 2020s Range | 2050s Median | 2050s Range | 2080s Median | 2080s Range |
|---|---|---|---|---|---|---|
| Spring | 1.3 | 0.9 – 1.9 | 2.9 | 2.5 – 3.9 | 5.4 | 4.8 – 7.1 |
| Summer | 1.2 | 0.9 – 1.6 | 2.9 | 2.2 – 3.6 | 5.4 | 4.2 – 6.6 |
| Autumn | 1.5 | 1.3 – 2.2 | 3.6 | 3.4 – 5.0 | 6.1 | 6.0 – 8.6 |
| Winter | 1.8 | 1.2 – 2.4 | 4.4 | 3.7 – 5.7 | 8.2 | 7.2 – 10.8 |
| **Annual** | **1.4** | **1.1 – 1.9** | **3.5** | **3.0 – 4.3** | **6.3** | **5.6 – 7.7** |

## Ontario

Ontario is expected to warm at a rate very similar to the national average. This rate of warming is approximately twice the global average reported during the years 1950 to 2010 (Warren & Lemmen, 2014). As above, model runs from AR5 were gathered and the median values presented below. The information was gathered from the Environment Canada's Canadian Climate Data and Scenarios website.

*Table A-4: Seasonal and annual change in temperature based on RCP 2.6 for the Province of Ontario (˚C)*

| RCP 2.6 Ontario | 2020s Median | 2020s Range | 2050s Median | 2050s Range | 2080s Median | 2080s Range |
|---|---|---|---|---|---|---|
| Spring | 1.1 | 0.7 – 1.4 | 1.6 | 1 – 2.1 | 1.4 | 0.8 – 1.9 |
| Summer | 1.1 | 0.8 – 1.5 | 1.4 | 1 – 2.2 | 1.3 | 0.9 – 2.0 |
| Autumn | 1.2 | 0.9 – 1.5 | 1.7 | 1.2 – 2.5 | 1.6 | 1.0 – 2.3 |
| Winter | 1.4 | 0.8 – 1.9 | 2.2 | 1.5 – 2.8 | 2.4 | 1.4 – 3.0 |
| **Annual** | **1.4** | **1.4 – 1.8** | **1.7** | **1.2 – 2.3** | **1.7** | **1.0 – 2.1** |

*Table A-5: Seasonal and annual change in temperature based on RCP 4.5 for the Province of Ontario (˚C)*

| RCP 4.5 Ontario | 2020s Median | 2020s Range | 2050s Median | 2050s Range | 2080s Median | 2080s Range |
|---|---|---|---|---|---|---|
| Spring | 1.1 | 0.6 – 1.6 | 2.0 | 1.4 – 2.6 | 2.5 | 1.8 – 3.7 |
| Summer | 1.1 | 0.8 – 1.4 | 2.1 | 1.6 – 2.8 | 2.9 | 1.8 – 3.6 |
| Autumn | 1.3 | 0.9 – 1.6 | 2.2 | 1.8 – 2.9 | 2.8 | 2.4 – 3.8 |
| Winter | 1.6 | 0.9 – 2.0 | 3.2 | 2.4 – 4.1 | 4.4 | 3.1 – 5.3 |
| **Annual** | **1.3** | **0.8 – 1.6** | **2.4** | **1.8 – 2.8** | **3.2** | **2.3 – 3.8** |

*Table A-6: Seasonal and annual change in temperature based on RCP 8.5 for the Province of Ontario (°C)*

| RCP 8.5 Ontario | 2020s Median | 2020s Range | 2050s Median | 2050s Range | 2080s Median | 2080s Range |
|---|---|---|---|---|---|---|
| Spring | 1.2 | 0.8 – 1.7 | 3.0 | 2.3 – 3.4 | 5.2 | 4.5 – 6.3 |
| Summer | 1.3 | 1.0 – 1.6 | 3.1 | 2.6 – 3.9 | 6.0 | 4.7 – 6.9 |
| Autumn | 1.4 | 1.1 – 1.8 | 3.3 | 2.8 – 4.0 | 5.8 | 4.9 – 7.0 |
| Winter | 1.9 | 1.2 – 2.2 | 4.6 | 3.4 – 5.4 | 8.2 | 6.9 – 9.7 |
| **Annual** | **1.4** | **1.0 – 1.9** | **3.5** | **2.8 – 4.0** | **6.3** | **5.3 – 6.9** |

## The Nottawasaga Valley Watershed

The Nottawasaga Valley watershed covers approximately 3,700 square kilometres of Southern Ontario and is comprised of a number of physiographically and socio-economically diverse areas. To ensure that the information below was representative of the entire watershed locations in the four corners of the watershed were included in the analysis: Collingwood, Innisfil, Shanty Bay, and Shelburne. The data is presented in 1 degree latitude by 1 degree longitude cells, which divides the Nottawasaga Valley into four separate study cells. Despite this, the difference between cells was in almost all circumstances less than 0.1°C, so the values from all four locations have been condensed into one set of tables that are reflective of the entire watershed as a whole.

The tables report a departure from baseline conditions, however the reference period for the tables below was the average from 1971 to 2000. All tables are in degrees Celsius and negative values are shown in brackets.

*Table A-7: Seasonal and annual change in temperature based on AR4 emissions scenarios A1B, A2 and B1 for the Nottawasaga Valley watershed (°C)*

| | 2020s | | | 2050s | | | 2080s | | |
|---|---|---|---|---|---|---|---|---|---|
| **Emissions Scenario** | **A1B** | **A2** | **B1** | **A1B** | **A2** | **B1** | **A1B** | **A2** | **B1** |
| Spring | 1.5 | 1.6 | 1.2 | 2.9 | 3.0 | 2.2 | 3.7 | 4.7 | 2.7 |
| Summer | 1.4 | 1.5 | 1.3 | 2.9 | 2.9 | 2.1 | 3.7 | 4.8 | 2.6 |
| Autumn | 1.3 | 1.3 | 1.3 | 2.6 | 2.8 | 2.0 | 3.4 | 4.6 | 2.5 |
| Winter | 1.7 | 1.6 | 1.3 | 3.1 | 3.3 | 2.3 | 3.9 | 4.8 | 2.9 |
| **Annual** | **1.5** | **1.5** | **1.3** | **2.8** | **3.0** | **2.2** | **3.7** | **4.7** | **2.7** |

# Precipitation Change

## Canada

Canada's rainfall has increased by about 13% in the last 59 years (Warren & Lemmen, 2014) but Bush and others (2014) comment that detecting trends in precipitation is inherently more difficult than for temperature. Similarly, future projections of precipitation range much more greatly than for temperature, owing to the complexity and smaller spatial scale of precipitation events.

For these tables the AR5 model was used. The information was gathered from the Environment Canada's Canadian Climate Data and Scenarios website. The information is displayed in percent change (% change) and negative values are displayed in brackets.

*Table A-8: Seasonal and annual change in precipitation based on RCP 2.6 nationwide (% change)*

| RCP 2.6 National | 2020s Median | 2020s Range | 2050s Median | 2050s Range | 2080s Median | 2080s Range |
|---|---|---|---|---|---|---|
| Spring | 4.3 | (1.2) – 10.1 | 6.1 | 0.0 – 12.8 | 6.6 | 0.3 – 13.5 |
| Summer | 2.8 | (3.2) – 8.9 | 5.0 | (1.5) – 12.0 | 5.2 | (1.4) – 12.4 |
| Autumn | 4.4 | (1.4) – 10.3 | 7.0 | 0.9 – 13.9 | 7.4 | 0.8 – 14.4 |
| Winter | 5.4 | (0.5) – 12.4 | 9.1 | 1.9 – 17.0 | 9.1 | 2.0 – 17.3 |
| **Annual** | **4.3** | **(1.6 ) – 10.4** | **6.8** | **0.3 – 13.9** | **7.1** | **0.4 – 14.4** |

*Table A-9: Seasonal and annual change in precipitation based on RCP 4.5 nationwide (% change)*

| RCP 4.5 National | 2020s Median | 2020s Range | 2050s Median | 2050s Range | 2080s Median | 2080s Range |
|---|---|---|---|---|---|---|
| Spring | 4.3 | (1.6) – 10.6 | 8.6 | 2.1 – 15.9 | 10.6 | 3.5 – 19.1 |
| Summer | 2.2 | (3.4) – 8.5 | 2.1 | (1.7) – 12.6 | 6.5 | (0.4) – 14.5 |
| Autumn | 4.8 | (0.8) – 10.6 | 10.1 | 3.7 – 17.1 | 11.9 | 5.1 – 19.9 |
| Winter | 5.9 | 0.1 – 12.1 | 12.9 | 6.2 – 20.2 | 17.6 | 9.1 – 26.4 |
| **Annual** | **4.3** | **(1.4) – 10.4** | **9.2** | **2.6 – 16.5** | **11.6** | **4.3 – 20.0** |

*Table A-10: Seasonal and annual change in precipitation based on RCP 8.5 nationwide (% change)*

| RCP 8.5 National | 2020s Median | 2020s Range | 2050s Median | 2050s Range | 2080s Median | 2080s Range |
|---|---|---|---|---|---|---|
| Spring | 5.3 | (0.4) – 11.3 | 11.7 | 4.9 – 19.4 | 23.3 | 13.6 – 34.6 |
| Summer | 3.0 | (2.9) – 9.3 | 6.4 | (0.6) – 14.2 | 10.6 | 0.7 – 21.3 |
| Autumn | 5.2 | (0.4) – 10.9 | 13.7 | 6.8 – 21.3 | 24.9 | 15.7 – 36.1 |
| Winter | 7.2 | 0.4 – 13.9 | 18.1 | 10.5 – 26.7 | 37.8 | 24.8 – 52.8 |
| **Annual** | **5.2** | **(0.8) – 11.4** | **12.5** | **5.4 – 20.4** | **24.2** | **13.7 – 36.2** |

## Ontario

Ontario is not exempt from the expectation of a wetter Canada, though it is not projected to experience as strong of an increase as is projected throughout the rest of the nation. It should also be noted that while annual values are likely to increase, the increase is not distributed equally between seasons, and comparatively drier summers are expected across all emissions scenarios.

For these tables the AR5 model data were used. The information was gathered from the Environment Canada’s Canadian Climate Data and Scenarios website. The information is displayed in percent change (% change) and negative values are displayed in brackets.

*Table A-11: Seasonal and annual change in precipitation based on RCP 2.6 province-wide (% change)*

| RCP 2.6 Ontario | 2020s Median | 2020s Range | 2050s Median | 2050s Range | 2080s Median | 2080s Range |
|---|---|---|---|---|---|---|
| Spring | 3.7 | (1.6) – 8.4 | 6.5 | 0.7 – 12.8 | 5.5 | 0.1 – 11.2 |
| Summer | 0.5 | (3.8) – 4.6 | 2.6 | (2.6) – 7.9 | 1.2 | (3.4) – 7.6 |
| Autumn | 3.6 | (1.4) – 8.2 | 5.0 | 0.8 – 9.7 | 6.0 | 0.2 – 11.1 |
| Winter | 5.3 | 0.2 – 10.8 | 8.9 | 3.2 – 14.9 | 7.9 | 2.7 – 13.4 |
| **Annual** | **3.3** | **(1.6) – 8.0** | **5.7** | **0.5 – 11.3** | **5.2** | **(0.1) – 10.8** |

*Table A-12: Seasonal and annual change in precipitation based on RCP 4.5 province-wide (% change)*

| RCP 4.5 Ontario | 2020s Median | 2020s Range | 2050s Median | 2050s Range | 2080s Median | 2080s Range |
|---|---|---|---|---|---|---|
| Spring | 3.7 | (0.9) – 10.1 | 8.5 | 3.8 – 14.2 | 10.7 | 4.0 – 18.8 |
| Summer | 0.4 | (4.5) – 5.3 | 2.7 | (3.0) – 7.4 | 3.3 | (2.0) – 8.3 |
| Autumn | 3.3 | (1.6) – 9.0 | 7.8 | 3.3 – 13.2 | 7.7 | 3.1 – 13.5 |
| Winter | 5.7 | 1.8 – 11.2 | 12.9 | 7.6 – 18.2 | 16.4 | 10.0 – 23.5 |
| **Annual** | **3.3** | **(1.3) – 8.9** | **8.0** | **2.9 – 13.3** | **8.5** | **3.8 – 16** |

*Table A-13: Seasonal and annual change in precipitation based on RCP 8.5 province-wide (% change)*

| RCP 8.5 Ontario | 2020s Median | 2020s Range | 2050s Median | 2050s Range | 2080s Median | 2080s Range |
|---|---|---|---|---|---|---|
| Spring | 4.0 | (0.8) – 9.7 | 13.1 | 5.3 – 21.5 | 24.2 | 14.1 – 36.9 |
| Summer | 0.7 | (3.5) – 5.1 | 1.3 | (3.8) – 6.2 | (0.5) | (8.2) – 5.9 |
| Autumn | 3.1 | (1.1) – 7.9 | 7.7 | 1.7 – 13.6 | 13.6 | 6.3 – 19.9 |
| Winter | 6.6 | 1.6 – 12.1 | 17.5 | 10.9 – 23.9 | 31.8 | 21.6 – 41.7 |
| **Annual** | **3.6** | **(0.9) – 8.7** | **9.9** | **3.5 – 16.3** | **17.3** | **8.5 – 26.1** |

## The Nottawasaga Valley Watershed

The Nottawasaga Valley has experienced a 13 millimetre per year (1.4%) increase in rainfall over the 40 year period of 1965 to 2006. This observation is in accordance with the trend of small positive changes in the amount of precipitation received in the Northern Hemisphere. Similar to projections for the province of Ontario, the Nottawasaga Valley watershed is projected to experience only a small increase in annual precipitation. What is noteworthy is that across all emissions scenarios, the consensus in current modelling is that drier hotter summers are to be expected along with notably wetter, warmer winter and spring seasons.

The tables report a departure from baseline conditions, which in this case refer to the period of 1971 to 2000. The information is displayed in percent change (% change) and negative values are displayed in brackets.

*Table A-14: Seasonal and annual change in precipitation based on AR4 emissions scenarios A1B, A2 and B1 for the Nottawasaga Valley watershed (% change)*

| | | 2020s | | | 2050s | | | 2080s | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Season** | **Baseline** | **A1B** | **A2** | **B1** | **A1B** | **A2** | **B1** | **A1B** | **A2** | **B1** |
| Spring | 274 mm | 3.1 | 5.0 | 5.1 | 11.1 | 13.6 | 9.7 | 17.9 | 22.3 | 13.1 |
| Summer | 243 mm | (3.2) | (2.9) | (2.8) | (2.9) | (6.3) | (3.0) | (5.2) | (5.2) | (4.4) |
| Autumn | 237 mm | 2.0 | 1.2 | 3.2 | 4.1 | 8.2 | 3.0 | 7.0 | 4.9 | 4.8 |
| Winter | 243 mm | 5.6 | 9.3 | 4.1 | 13.4 | 17.6 | 10.4 | 21.2 | 27.9 | 14.1 |
| **Annual** | 997 mm | **1.9** | **3.2** | **2.5** | **6.6** | **8.4** | **5.2** | **10.5** | **12.8** | **7.1** |

## Stream Temperature Change

In addition to changes in air temperature, stream temperatures will also be impacted by climate change. Changes in stream temperature can have many environmental, recreational and water quality impacts. Rising water temperatures are likely to negatively impact cold- and cool-water fisheries and macro-invertebrates that are sensitive to warm temperatures while simultaneously increasing algae growth and the occurrence of water quality issues (Dodson, 2005), (Eaton & Scheller, 1996).

After conducting a brief analysis of air temperature and stream temperature in a groundwater-rich system in the upper reaches of the Nottawasaga River, it was found that an increase in air temperature of 1°C was correlated with a 0.65°C increase in stream temperature. This observation was supported in the literature where multiple journal articles mention groundwater-fed streams being observed to increase 0.6°C for every 1.0°C increase in air temperature and surface water systems increasing on a 1-to-1 basis. (Kurylyk, MacQuarrie & Voss, 2013; Menberg, Blum, Kurylyk & Bayer, 2014; Snyder, Hitt &Young, 2015).

The table below show the increases of stream temperature over time based on air temperature increases projected by AR4 climate models. Streams that are fed primarily from groundwater discharge (seeps and springs) respond more slowly to changes in air temperature than streams that get their water from surface water runoff. In the table below, the lower values would be more applicable to a groundwater fed stream, whereas the upper values would be more accurate for a surface-water fed stream.

*Table A-15: Estimated stream temperature change in response to a warming climate, based on AR4 projections. (°C)*

| Stream Temperature Change | 2020s Range | 2050s Range | 2080s Range |
|---|---|---|---|
| SR-A1B | 0.9 – 1.5 | 1.7 – 2.8 | 2.2 – 3.7 |
| SR-A2 | 0.9 – 1.5 | 1.8 – 3.0 | 2.8 – 4.7 |
| SR-B1 | 0.8 – 1.3 | 1.3 – 2.2 | 1.6 – 2.7 |

# Extreme Rainfall

The intensity, duration and frequency of intense rain events are projected, "with an associated increased risk of flooding" (Warren & Lemmen, 2014). This is of particular concern to NVCA as this increases the risk of loss of life and property due to storm-related flooding and erosion.

The Facility for Intelligent Decision Support (FIDS) based out of the University of Western Ontario has assembled a web-based tool to develop Intensity-Duration-Frequency curves corresponding to precipitation changes projected in AR5 climate models. The reference period for these curves is the 1979 to 2007 period, and change values have been calculated for the 2020s, 2050s and 2080s periods using RCPs 2.6, 4.5 and 8.5. Storm intensities are listed in millimetres per hour (mm/h).

The tables show a consistent trend toward higher intensity (mm/h) for the various durations and return frequency storms. As an example, currently in Barrie a storm lasting one full hour with a precipitation rate of 49 mm/hr, would be expected to have a 1% chance of happening any given year and be referred to as a 100-year storm event. The AR5 climate models forecast that by the 2080s the 100-year storm event will have precipitation rates of 56 to 65 mm/hr.

These tables can be found in the Appendix of this report. Following from the methodology listed previously, four locations were selected as representative of the Nottawasaga Valley Watershed: Barrie Water Pollution Control Plant (WPCC), Collingwood, Egbert and Shelburne. The baseline data in these figures is based on historic weather gauge data.

# Other Climatic Change

There are numerous metrics to account for the climatic changes that are projected in the Nottawasaga Valley watershed between present and the end of the 21st century. The following chart briefly mentions other projected changes that may have significant outcomes or impacts on the environment and residents of the watershed. The figures were prepared utilizing AR4 climate model data using Special Report Emissions scenarios A1B, A2 and B1. The information for these charts was gathered from Environment Canada's Canadian Climate Data and Scenarios website and baseline data from 1979-2007. Data from the CGCM3T47 and NCARPCM climate models were used to assemble the following tables.

*Table A-16: Assorted climatic changes projected using AR4 scenarios A1B*

| Climatic Changes Projected – Scenarios A1B | Current | 2080s | Difference |
|---|---|---|---|
| Daily Extreme Air Temp Range (°C) | 67.6 | 64.0 | -3.6 |
| Mean Max Air Temp (°C) | 12.4 | 16.1 | 3.7 |
| Mean Min Air Temp (°C) | 2.5 | 6.4 | 3.9 |
| Mean Min Air Temp Winter (°C) | (9.6) | (4.7) | 4.9 |
| Days of Frost (Days) | 165.5 | 146.0 | (19.5) |
| Max Consecutive Dry Days (Days) | 15.6 | 15.4 | (0.2) |
| Growing Season (Days) | 191.6 | 207.1 | 15.5 |
| Max Heat Wave (Consecutive Days) | 7.3 | 11.4 | 4.1 |

*Table A-17: Assorted climatic changes projected using AR4 scenarios A2*

| Climatic Changes Projected – Scenarios A2 | Current | 2080s | Difference |
|---|---|---|---|
| Daily Extreme Air Temp Range (°C) | 67.6 | 64.3 | (3.3) |
| Mean Max Air Temp (°C) | 12.4 | 17.2 | 4.8 |
| Mean Min Air Temp (°C) | 2.5 | 7.5 | 5.0 |
| Mean Min Air Temp Winter (°C) | (9.6) | (3.7) | 5.9 |
| Days of Frost (Days) | 165.5 | 143.1 | (22.4) |
| Max Consecutive Dry Days (Days) | 15.6 | 15.5 | (0.1) |
| Growing Season (Days) | 191.6 | 207.7 | 16.1 |
| Max Heat Wave (Consecutive Days) | 7.3 | 12.3 | 5.0 |

*Table A-18: Assorted climatic changes projected using AR4 scenarios B1*

| Climatic Changes Projected – Scenarios B1 | Current | 2080s | Difference |
|---|---|---|---|
| Daily Extreme Air Temp Range (°C) | 67.6 | 65.0 | (2.6) |
| Mean Max Air Temp (°C) | 12.4 | 15.1 | 2.7 |
| Mean Min Air Temp (°C) | 2.5 | 5.3 | 2.8 |
| Mean Min Air Temp Winter (°C) | (9.6) | (6.0) | 3.6 |
| Days of Frost (Days) | 165.5 | 152.4 | (13.1) |
| Max Consecutive Dry Days (Days) | 15.6 | 15.6 | 0.0 |
| Growing Season (Days) | 191.6 | 200.0 | 8.4 |
| Max Heat Wave (Consecutive Days) | 7.3 | 10.8 | 3.5 |

# Conclusion

This report provides a brief overview of the immense number of ways that the climate of the Nottawasaga Valley is anticipated to change in the coming years. Over the course of the next century temperatures are projected to climb between 2.7 to 4.7°C, and annual precipitation is projected to increase somewhere between 71 and 128 mm (7.1 to 12.8%). The increase in annual precipitation will likely occur primarily in the spring and winter seasons; summers are expected to become drier. Stream temperatures can be expected to increase between 1.6 and 4.7°C although this response will not be uniform; it will vary significantly from stream to stream.

Changing temperature and precipitation regimes and the numerous outcomes that arise as a result – such as rising stream temperatures – are going to have major impacts to the environmental, physical, and socio-economic systems for the communities situated within the watershed.

The next phase of research will be to identify the risks and impacts that are associated with climate change that is observable today and projected to come in future years. This is meant to be the beginning of the research that NVCA will be doing in regards to climate change and will also be a stepping stone for the authority, our partners, stakeholders and residents. As more information comes to light and more sophisticated models and projections are made available it will be incorporated into the NVCA's Climate Change Strategy and Action Plan, but uncertainty will not be used as an excuse for inaction.

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# Appendix: Storm Intensity and Duration Curves

The information in the following tables was generated using the IDF CC Tool for deriving rainfall Intensity-Duration-Frequency Curves for Future Climate Scenarios (2016).

*Table App1: Historical IDF Curve information for the Barrie WPCC location.* All values are displayed in mm/h.

| Barrie WPCC-Baseline | | | | | | |
|---|---|---|---|---|---|---|
| | 2 Year Storm Event | 5 Year Storm Event | 10 Year Storm Event | 25 Year Storm Event | 50 Year Storm Event | 100 Year Storm Event |
| 5 min | 102 | 132 | 151 | 176 | 194 | 212 |
| 10 min | 74 | 98 | 114 | 134 | 149 | 164 |
| 15 min | 61 | 82 | 95 | 112 | 125 | 138 |
| 30 min | 39 | 51 | 60 | 70 | 78 | 85 |
| 1 hr | 23 | 30 | 35 | 41 | 45 | 49 |
| 2 hr | 14 | 20 | 23 | 28 | 31 | 35 |
| 6 hr | 6 | 9 | 10 | 12 | 14 | 15 |
| 12 hr | 4 | 5 | 6 | 7 | 7 | 8 |
| 24 hr | 2 | 3 | 3 | 4 | 4 | 5 |

*Table App2: 2020s IDF Curve projections for the Barrie WPCC location.* All values are displayed in mm/h.

| Barrie WPCC-2020s | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 Year Storm Event | | | 5 Year Storm Event | | | 10 Year Storm Event | | | 25 Year Storm Event | | | 50 Year Storm Event | | | 100 Year Storm Event | | |
| Scenario | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 |
| 5 min | 112 | 116 | 116 | 142 | 146 | 150 | 161 | 166 | 172 | 185 | 191 | 197 | 203 | 210 | 216 | 221 | 230 | 235 |
| 10 min | 82 | 85 | 85 | 107 | 110 | 113 | 122 | 126 | 131 | 142 | 147 | 152 | 157 | 163 | 168 | 172 | 179 | 183 |
| 15 min | 67 | 71 | 71 | 89 | 91 | 95 | 102 | 105 | 109 | 119 | 123 | 127 | 132 | 136 | 141 | 144 | 150 | 154 |
| 30 min | 43 | 45 | 45 | 56 | 57 | 59 | 64 | 66 | 68 | 74 | 77 | 79 | 82 | 85 | 87 | 89 | 93 | 95 |
| 1 hr | 25 | 26 | 26 | 32 | 33 | 34 | 37 | 38 | 40 | 43 | 44 | 46 | 47 | 49 | 50 | 52 | 54 | 55 |
| 2 hr | 16 | 17 | 17 | 22 | 22 | 23 | 25 | 26 | 27 | 30 | 31 | 32 | 33 | 34 | 36 | 37 | 38 | 39 |
| 6 hr | 7 | 7 | 7 | 10 | 10 | 10 | 11 | 11 | 12 | 13 | 14 | 14 | 15 | 15 | 16 | 16 | 17 | 17 |
| 12 hr | 4 | 4 | 4 | 5 | 5 | 5 | 6 | 6 | 6 | 7 | 7 | 7 | 8 | 8 | 8 | 8 | 9 | 9 |
| 24 hr | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 5 |

*Table App3: 2050s IDF Curve projections for the Barrie WPCC location.* All values are displayed in mm/h.

| Barrie WPCC-2050s | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 Year Storm Event | | | 5 Year Storm Event | | | 10 Year Storm Event | | | 25 Year Storm Event | | | 50 Year Storm Event | | | 100 Year Storm Event | | |
| Scenario | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 |
| 5 min | 116 | 121 | 128 | 149 | 154 | 161 | 171 | 174 | 185 | 198 | 200 | 215 | 219 | 219 | 238 | 238 | 239 | 262 |
| 10 min | 85 | 89 | 95 | 112 | 117 | 122 | 130 | 133 | 142 | 153 | 154 | 167 | 170 | 170 | 186 | 186 | 186 | 205 |
| 15 min | 70 | 74 | 79 | 94 | 97 | 102 | 109 | 111 | 119 | 128 | 129 | 140 | 142 | 142 | 156 | 156 | 156 | 172 |
| 30 min | 45 | 47 | 50 | 59 | 61 | 64 | 68 | 69 | 74 | 80 | 80 | 87 | 88 | 88 | 96 | 96 | 97 | 106 |
| 1 hr | 26 | 27 | 29 | 34 | 35 | 37 | 39 | 40 | 43 | 46 | 46 | 50 | 51 | 51 | 56 | 56 | 56 | 61 |
| 2 hr | 17 | 17 | 19 | 23 | 24 | 25 | 27 | 28 | 30 | 32 | 33 | 35 | 36 | 36 | 40 | 39 | 40 | 44 |
| 6 hr | 7 | 8 | 8 | 10 | 11 | 11 | 12 | 12 | 13 | 14 | 14 | 15 | 16 | 16 | 17 | 17 | 17 | 19 |
| 12 hr | 4 | 4 | 5 | 5 | 6 | 6 | 6 | 6 | 7 | 7 | 8 | 8 | 8 | 8 | 9 | 9 | 9 | 10 |
| 24 hr | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 6 |

*Table App4: 2080s IDF Curve projections for the Barrie WPCC location.* All values are displayed in mm/h.

| Barrie WPCC-2080s | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 Year Storm Event | | | 5 Year Storm Event | | | 10 Year Storm Event | | | 25 Year Storm Event | | | 50 Year Storm Event | | | 100 Year Storm Event | | |
| Scenario | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 |
| 5 min | 116 | 122 | 141 | 148 | 155 | 179 | 171 | 178 | 203 | 199 | 204 | 233 | 218 | 223 | 255 | 240 | 242 | 276 |
| 10 min | 85 | 91 | 106 | 112 | 117 | 137 | 131 | 136 | 157 | 153 | 158 | 181 | 170 | 173 | 199 | 187 | 189 | 217 |
| 15 min | 70 | 75 | 88 | 93 | 98 | 115 | 109 | 114 | 131 | 128 | 132 | 152 | 142 | 145 | 167 | 157 | 159 | 182 |
| 30 min | 45 | 48 | 55 | 59 | 61 | 71 | 68 | 71 | 81 | 80 | 82 | 94 | 88 | 90 | 103 | 97 | 98 | 112 |
| 1 hr | 26 | 28 | 32 | 34 | 35 | 41 | 39 | 41 | 47 | 46 | 47 | 54 | 51 | 52 | 60 | 56 | 57 | 65 |
| 2 hr | 17 | 18 | 21 | 23 | 24 | 29 | 27 | 28 | 33 | 32 | 33 | 39 | 36 | 37 | 43 | 40 | 41 | 47 |
| 6 hr | 7 | 8 | 9 | 10 | 11 | 13 | 12 | 12 | 14 | 14 | 15 | 17 | 16 | 16 | 19 | 18 | 18 | 20 |
| 12 hr | 4 | 4 | 5 | 5 | 6 | 7 | 6 | 7 | 8 | 7 | 8 | 9 | 8 | 8 | 10 | 9 | 9 | 11 |
| 24 hr | 2 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 6 | 5 | 5 | 6 |

*Table App5: Historical IDF Curve information for the Collingwood location.* All values are displayed in mm/h.

| Collingwood-Baseline | | | | | | |
|---|---|---|---|---|---|---|
| | 2 Year Storm Event | 5 Year Storm Event | 10 Year Storm Event | 25 Year Storm Event | 50 Year Storm Event | 100 Year Storm Event |
| 5 min | 89 | 111 | 126 | 145 | 159 | 173 |
| 10 min | 66 | 86 | 99 | 115 | 127 | 139 |
| 15 min | 52 | 68 | 78 | 91 | 101 | 110 |
| 30 min | 34 | 43 | 49 | 56 | 61 | 67 |
| 1 hr | 21 | 27 | 31 | 35 | 39 | 42 |
| 2 hr | 13 | 16 | 19 | 21 | 24 | 26 |
| 6 hr | 6 | 8 | 9 | 11 | 12 | 14 |
| 12 hr | 3 | 4 | 5 | 6 | 7 | 7 |
| 24 hr | 2 | 2 | 3 | 3 | 3 | 4 |

*Table App6: 2020s IDF Curve projections for the Collingwood location.* All values are displayed in mm/h.

| Collingwood-2020s | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 Year Storm Event | | | 5 Year Storm Event | | | 10 Year Storm Event | | | 25 Year Storm Event | | | 50 Year Storm Event | | | 100 Year Storm Event | | |
| Scenario | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 |
| 5 min | 95 | 99 | 99 | 118 | 122 | 124 | 133 | 136 | 141 | 153 | 155 | 161 | 167 | 169 | 175 | 182 | 184 | 190 |
| 10 min | 72 | 75 | 75 | 91 | 95 | 97 | 105 | 107 | 112 | 122 | 124 | 129 | 134 | 136 | 142 | 147 | 149 | 155 |
| 15 min | 57 | 59 | 59 | 72 | 75 | 77 | 83 | 85 | 89 | 96 | 98 | 102 | 106 | 108 | 112 | 116 | 118 | 122 |
| 30 min | 37 | 38 | 38 | 45 | 47 | 48 | 51 | 53 | 55 | 59 | 60 | 62 | 64 | 65 | 68 | 70 | 71 | 73 |
| 1 hr | 23 | 24 | 24 | 28 | 29 | 30 | 32 | 33 | 34 | 37 | 38 | 39 | 41 | 41 | 43 | 44 | 45 | 46 |
| 2 hr | 14 | 14 | 14 | 17 | 18 | 18 | 20 | 20 | 21 | 23 | 23 | 24 | 25 | 25 | 26 | 27 | 28 | 29 |
| 6 hr | 6 | 7 | 7 | 8 | 9 | 9 | 10 | 10 | 11 | 12 | 12 | 12 | 13 | 13 | 14 | 14 | 15 | 15 |
| 12 hr | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 6 | 6 | 6 | 7 | 7 | 7 | 7 | 7 | 8 | 8 | 8 |
| 24 hr | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 |

*Table App7: 2050s IDF Curve projections for the Collingwood location.* All values are displayed in mm/h.

| Collingwood-2050s | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 Year Storm Event | | | 5 Year Storm Event | | | 10 Year Storm Event | | | 25 Year Storm Event | | | 50 Year Storm Event | | | 100 Year Storm Event | | |
| Scenario | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 |
| 5 min | 100 | 103 | 111 | 125 | 129 | 138 | 140 | 146 | 155 | 159 | 168 | 176 | 174 | 185 | 193 | 188 | 200 | 209 |
| 10 min | 76 | 78 | 85 | 97 | 101 | 109 | 111 | 116 | 124 | 128 | 135 | 143 | 140 | 150 | 157 | 153 | 163 | 171 |
| 15 min | 60 | 62 | 67 | 77 | 80 | 86 | 88 | 92 | 98 | 101 | 107 | 113 | 111 | 118 | 124 | 121 | 129 | 135 |
| 30 min | 38 | 40 | 43 | 48 | 50 | 53 | 54 | 56 | 60 | 61 | 65 | 68 | 67 | 71 | 74 | 73 | 77 | 81 |
| 1 hr | 24 | 25 | 27 | 30 | 31 | 33 | 34 | 36 | 38 | 39 | 41 | 43 | 42 | 45 | 47 | 46 | 49 | 51 |
| 2 hr | 14 | 15 | 16 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 26 | 28 | 29 | 28 | 30 | 31 |
| 6 hr | 7 | 7 | 8 | 9 | 9 | 10 | 10 | 11 | 12 | 12 | 13 | 14 | 14 | 15 | 15 | 15 | 16 | 17 |
| 12 hr | 4 | 4 | 4 | 5 | 5 | 6 | 6 | 6 | 7 | 7 | 7 | 8 | 7 | 8 | 8 | 8 | 9 | 9 |
| 24 hr | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 |

*Table App8: 2080s IDF Curve projections for the Collingwood location.* All values are displayed in mm/h.

| Collingwood-2080s | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 Year Storm Event | | | 5 Year Storm Event | | | 10 Year Storm Event | | | 25 Year Storm Event | | | 50 Year Storm Event | | | 100 Year Storm Event | | |
| Scenario | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 |
| 5 min | 99 | 104 | 120 | 124 | 130 | 148 | 141 | 146 | 167 | 163 | 167 | 191 | 180 | 182 | 208 | 197 | 197 | 225 |
| 10 min | 75 | 79 | 93 | 97 | 102 | 118 | 112 | 116 | 134 | 131 | 134 | 155 | 146 | 148 | 170 | 160 | 161 | 185 |
| 15 min | 59 | 63 | 74 | 77 | 81 | 93 | 89 | 92 | 106 | 104 | 106 | 123 | 116 | 117 | 135 | 127 | 127 | 146 |
| 30 min | 38 | 40 | 46 | 48 | 50 | 57 | 55 | 56 | 64 | 63 | 64 | 73 | 70 | 70 | 80 | 76 | 76 | 87 |
| 1 hr | 24 | 25 | 29 | 30 | 31 | 36 | 34 | 36 | 41 | 40 | 41 | 47 | 44 | 44 | 51 | 48 | 48 | 55 |
| 2 hr | 14 | 15 | 18 | 18 | 19 | 22 | 21 | 22 | 25 | 24 | 25 | 29 | 27 | 27 | 31 | 30 | 30 | 34 |
| 6 hr | 7 | 7 | 9 | 9 | 10 | 11 | 11 | 11 | 13 | 13 | 13 | 15 | 14 | 14 | 17 | 16 | 16 | 18 |
| 12 hr | 4 | 4 | 5 | 5 | 5 | 6 | 6 | 6 | 7 | 7 | 7 | 8 | 8 | 8 | 9 | 8 | 9 | 10 |
| 24 hr | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 |

*Table App9: Historical IDF Curve information for the Egbert CS location.* All values are displayed in mm/h.

| Egbert CS-Baseline | | | | | | |
|---|---|---|---|---|---|---|
| | 2 Year Storm Event | 5 Year Storm Event | 10 Year Storm Event | 25 Year Storm Event | 50 Year Storm Event | 100 Year Storm Event |
| 5 min | 97 | 126 | 145 | 169 | 186 | 204 |
| 10 min | 69 | 90 | 104 | 122 | 135 | 148 |
| 15 min | 55 | 73 | 85 | 100 | 111 | 123 |
| 30 min | 34 | 44 | 50 | 57 | 63 | 69 |
| 1 hr | 22 | 30 | 35 | 42 | 47 | 51 |
| 2 hr | 13 | 17 | 20 | 24 | 27 | 30 |
| 6 hr | 5 | 7 | 8 | 10 | 11 | 12 |
| 12 hr | 3 | 4 | 4 | 5 | 6 | 6 |
| 24 hr | 2 | 2 | 2 | 3 | 3 | 3 |

*Table App10: 2020s IDF Curve projections for the Egbert CS location.* All values are displayed in mm/h.

| Egbert CS-2020s | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 Year Storm Event | | | 5 Year Storm Event | | | 10 Year Storm Event | | | 25 Year Storm Event | | | 50 Year Storm Event | | | 100 Year Storm Event | | |
| Scenario | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 |
| 5 min | 107 | 111 | 110 | 137 | 139 | 144 | 157 | 160 | 166 | 181 | 186 | 191 | 199 | 205 | 209 | 217 | 225 | 228 |
| 10 min | 76 | 79 | 79 | 98 | 100 | 104 | 113 | 115 | 120 | 131 | 134 | 138 | 144 | 149 | 152 | 157 | 164 | 166 |
| 15 min | 61 | 63 | 63 | 80 | 81 | 84 | 93 | 94 | 98 | 108 | 111 | 114 | 119 | 124 | 126 | 131 | 136 | 138 |
| 30 min | 37 | 39 | 39 | 47 | 48 | 49 | 54 | 54 | 56 | 61 | 63 | 64 | 67 | 69 | 70 | 73 | 76 | 77 |
| 1 hr | 25 | 26 | 26 | 33 | 34 | 35 | 39 | 39 | 41 | 45 | 46 | 48 | 50 | 52 | 53 | 55 | 57 | 58 |
| 2 hr | 14 | 15 | 15 | 19 | 20 | 20 | 22 | 23 | 24 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 34 | 34 |
| 6 hr | 6 | 6 | 6 | 8 | 8 | 8 | 9 | 9 | 10 | 10 | 11 | 11 | 12 | 12 | 12 | 13 | 13 | 13 |
| 12 hr | 3 | 3 | 3 | 4 | 4 | 4 | 5 | 5 | 5 | 6 | 6 | 6 | 6 | 6 | 6 | 7 | 7 | 7 |
| 24 hr | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 4 |

*Table App11: 2050s IDF Curve projections for the Egbert CS location.* All values are displayed in mm/h.

| **Egbert CS-2050s** | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 Year Storm Event | | | 5 Year Storm Event | | | 10 Year Storm Event | | | 25 Year Storm Event | | | 50 Year Storm Event | | | 100 Year Storm Event | | |
| Scenario | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 |
| 5 min | 111 | 115 | 122 | 143 | 148 | 155 | 164 | 169 | 177 | 191 | 194 | 206 | 211 | 213 | 228 | 229 | 230 | 251 |
| 10 min | 79 | 82 | 87 | 103 | 107 | 111 | 118 | 122 | 128 | 138 | 141 | 150 | 153 | 155 | 166 | 167 | 168 | 183 |
| 15 min | 63 | 66 | 70 | 84 | 87 | 91 | 97 | 100 | 106 | 114 | 116 | 124 | 127 | 128 | 138 | 139 | 140 | 152 |
| 30 min | 39 | 40 | 42 | 49 | 51 | 53 | 56 | 58 | 60 | 65 | 66 | 70 | 71 | 72 | 77 | 77 | 77 | 84 |
| 1 hr | 26 | 27 | 29 | 35 | 36 | 38 | 40 | 42 | 44 | 48 | 49 | 52 | 53 | 54 | 58 | 58 | 59 | 64 |
| 2 hr | 15 | 16 | 17 | 20 | 21 | 22 | 24 | 24 | 26 | 28 | 29 | 31 | 31 | 32 | 34 | 34 | 34 | 38 |
| 6 hr | 6 | 6 | 7 | 8 | 8 | 9 | 9 | 10 | 10 | 11 | 11 | 12 | 12 | 12 | 13 | 13 | 14 | 15 |
| 12 hr | 3 | 3 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 6 | 6 | 6 | 6 | 6 | 7 | 7 | 7 | 8 |
| 24 hr | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 |

*Table App12: 2080s IDF Curve projections for the Egbert CS location.* All values are displayed in mm/h.

| **Egbert CS-2080s** | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 Year Storm Event | | | 5 Year Storm Event | | | 10 Year Storm Event | | | 25 Year Storm Event | | | 50 Year Storm Event | | | 100 Year Storm Event | | |
| Scenario | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 |
| 5 min | 111 | 117 | 135 | 143 | 149 | 172 | 165 | 170 | 195 | 193 | 197 | 226 | 215 | 216 | 246 | 236 | 235 | 267 |
| 10 min | 79 | 83 | 97 | 103 | 107 | 125 | 119 | 123 | 141 | 140 | 143 | 165 | 156 | 157 | 179 | 172 | 171 | 195 |
| 15 min | 63 | 67 | 79 | 83 | 87 | 102 | 98 | 101 | 117 | 116 | 118 | 137 | 130 | 130 | 150 | 143 | 142 | 163 |
| 30 min | 39 | 41 | 47 | 49 | 51 | 59 | 56 | 58 | 66 | 65 | 67 | 76 | 72 | 73 | 82 | 79 | 79 | 89 |
| 1 hr | 26 | 27 | 32 | 35 | 36 | 43 | 41 | 42 | 49 | 48 | 49 | 57 | 54 | 55 | 63 | 60 | 60 | 69 |
| 2 hr | 15 | 16 | 19 | 20 | 21 | 25 | 24 | 25 | 29 | 28 | 29 | 34 | 32 | 32 | 37 | 35 | 35 | 40 |
| 6 hr | 6 | 6 | 8 | 8 | 8 | 10 | 10 | 10 | 11 | 11 | 11 | 13 | 13 | 13 | 15 | 14 | 14 | 16 |
| 12 hr | 3 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 6 | 6 | 6 | 7 | 7 | 7 | 8 | 7 | 7 | 8 |
| 24 hr | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |

*Table App13: Historical IDF Curve information for the Shelburne location.* All values are displayed in mm/h.

| Shelburne-Baseline | | | | | | |
|---|---|---|---|---|---|---|
| | 2 Year Storm Event | 5 Year Storm Event | 10 Year Storm Event | 25 Year Storm Event | 50 Year Storm Event | 100 Year Storm Event |
| 5 min | 76 | 114 | 139 | 170 | 193 | 217 |
| 10 min | 58 | 84 | 101 | 123 | 139 | 155 |
| 15 min | 49 | 70 | 84 | 101 | 114 | 127 |
| 30 min | 35 | 49 | 59 | 72 | 81 | 90 |
| 1 hr | 23 | 32 | 38 | 46 | 52 | 58 |
| 2 hr | 15 | 21 | 24 | 29 | 33 | 36 |
| 6 hr | 8 | 10 | 11 | 13 | 14 | 16 |
| 12 hr | 5 | 6 | 6 | 7 | 8 | 9 |
| 24 hr | 3 | 3 | 4 | 4 | 4 | 5 |

*Table App14: 2020s IDF Curve projections for the Shelburne location.* All values are displayed in mm/h.

| Shelburne-2020s | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 Year Storm Event | | | 5 Year Storm Event | | | 10 Year Storm Event | | | 25 Year Storm Event | | | 50 Year Storm Event | | | 100 Year Storm Event | | |
| Scenario | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 |
| 5 min | 91 | 87 | 89 | 133 | 128 | 131 | 161 | 157 | 158 | 196 | 192 | 194 | 221 | 217 | 219 | 246 | 241 | 244 |
| 10 min | 68 | 65 | 67 | 97 | 94 | 96 | 117 | 114 | 114 | 141 | 138 | 139 | 158 | 156 | 157 | 176 | 172 | 174 |
| 15 min | 57 | 55 | 57 | 81 | 78 | 80 | 96 | 94 | 94 | 115 | 113 | 114 | 129 | 127 | 128 | 143 | 140 | 142 |
| 30 min | 40 | 39 | 40 | 57 | 55 | 56 | 68 | 66 | 67 | 82 | 80 | 81 | 91 | 90 | 91 | 101 | 99 | 101 |
| 1 hr | 26 | 26 | 26 | 37 | 36 | 36 | 44 | 43 | 43 | 53 | 52 | 52 | 59 | 58 | 58 | 65 | 64 | 65 |
| 2 hr | 17 | 16 | 17 | 23 | 23 | 23 | 28 | 27 | 27 | 33 | 33 | 33 | 37 | 37 | 37 | 41 | 40 | 41 |
| 6 hr | 9 | 8 | 9 | 11 | 11 | 11 | 13 | 12 | 12 | 15 | 14 | 14 | 16 | 16 | 16 | 17 | 17 | 17 |
| 12 hr | 5 | 5 | 5 | 6 | 6 | 6 | 7 | 7 | 7 | 8 | 8 | 8 | 9 | 9 | 9 | 10 | 9 | 9 |
| 24 hr | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 5 |

*Table App15: 2050s IDF Curve projections for the Shelburne location.* All values are displayed in mm/h.

| **Shelburne-2050s** | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 Year Storm Event | | | 5 Year Storm Event | | | 10 Year Storm Event | | | 25 Year Storm Event | | | 50 Year Storm Event | | | 100 Year Storm Event | | |
| Scenario | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 |
| 5 min | 94 | 98 | 106 | 135 | 140 | 152 | 163 | 169 | 178 | 198 | 202 | 217 | 223 | 225 | 243 | 248 | 250 | 269 |
| 10 min | 69 | 73 | 78 | 99 | 102 | 110 | 118 | 122 | 129 | 142 | 145 | 155 | 160 | 161 | 174 | 177 | 178 | 191 |
| 15 min | 59 | 61 | 66 | 82 | 84 | 91 | 97 | 100 | 106 | 116 | 118 | 127 | 130 | 131 | 141 | 144 | 145 | 155 |
| 30 min | 41 | 43 | 46 | 58 | 60 | 64 | 69 | 71 | 75 | 82 | 84 | 90 | 92 | 93 | 100 | 102 | 103 | 110 |
| 1 hr | 27 | 28 | 30 | 38 | 39 | 42 | 44 | 46 | 48 | 53 | 54 | 58 | 59 | 60 | 64 | 66 | 66 | 71 |
| 2 hr | 17 | 18 | 19 | 24 | 25 | 26 | 28 | 29 | 31 | 34 | 34 | 37 | 37 | 38 | 41 | 41 | 42 | 45 |
| 6 hr | 9 | 9 | 10 | 11 | 11 | 12 | 13 | 13 | 14 | 15 | 15 | 16 | 16 | 16 | 17 | 18 | 18 | 19 |
| 12 hr | 5 | 5 | 5 | 6 | 6 | 7 | 7 | 7 | 8 | 8 | 8 | 9 | 9 | 9 | 9 | 10 | 10 | 10 |
| 24 hr | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |

*Table App16: 2080s IDF Curve projections for the Shelburne location.* All values are displayed in mm/h.

| **Shelburne-2080s** | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 Year Storm Event | | | 5 Year Storm Event | | | 10 Year Storm Event | | | 25 Year Storm Event | | | 50 Year Storm Event | | | 100 Year Storm Event | | |
| Scenario | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 | 2.6 | 4.5 | 8.5 |
| 5 min | 94 | 103 | 118 | 138 | 153 | 167 | 166 | 185 | 199 | 199 | 224 | 241 | 224 | 252 | 272 | 249 | 281 | 302 |
| 10 min | 70 | 76 | 87 | 100 | 111 | 120 | 120 | 133 | 143 | 143 | 160 | 172 | 160 | 180 | 194 | 177 | 200 | 216 |
| 15 min | 60 | 64 | 72 | 83 | 92 | 99 | 99 | 110 | 117 | 117 | 131 | 140 | 131 | 146 | 158 | 144 | 162 | 175 |
| 30 min | 42 | 45 | 51 | 59 | 65 | 70 | 70 | 78 | 83 | 83 | 93 | 100 | 93 | 104 | 112 | 102 | 115 | 124 |
| 1 hr | 27 | 30 | 33 | 38 | 42 | 45 | 45 | 50 | 53 | 53 | 60 | 64 | 60 | 67 | 72 | 66 | 74 | 79 |
| 2 hr | 18 | 19 | 21 | 24 | 27 | 29 | 29 | 32 | 34 | 34 | 38 | 40 | 38 | 42 | 45 | 41 | 46 | 50 |
| 6 hr | 9 | 9 | 10 | 11 | 12 | 13 | 13 | 14 | 15 | 15 | 16 | 17 | 16 | 18 | 19 | 18 | 19 | 21 |
| 12 hr | 5 | 5 | 6 | 6 | 7 | 7 | 7 | 8 | 8 | 8 | 9 | 9 | 9 | 10 | 10 | 10 | 11 | 11 |
| 24 hr | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 6 | 6 |

The information in the following figures was generated using the IDF CC Tool for deriving rainfall Intensity-Duration-Frequency Curves for Future Climate Scenarios (2016).

*Figure 1: 2020s IDF Curve Changes projected for the Barrie WPCC location under RCP 2.6 (AR5)*

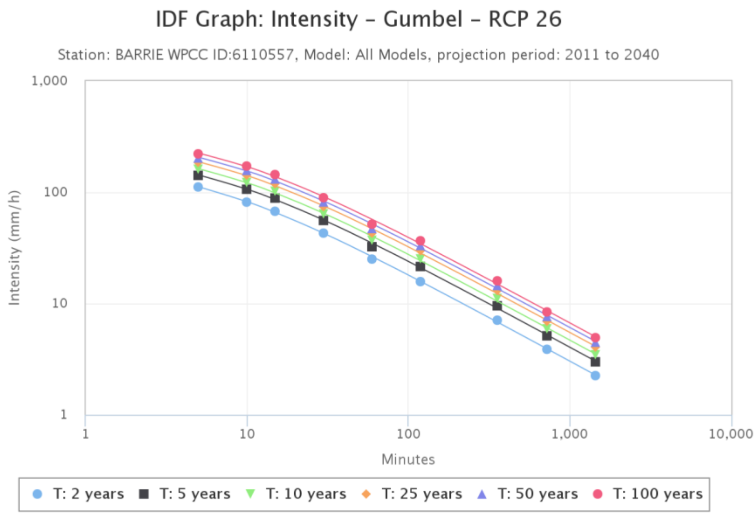



*Figure 2: 2020s IDF Curve Changes projected for the Barrie WPCC location under RCP 4.5 (AR5)*

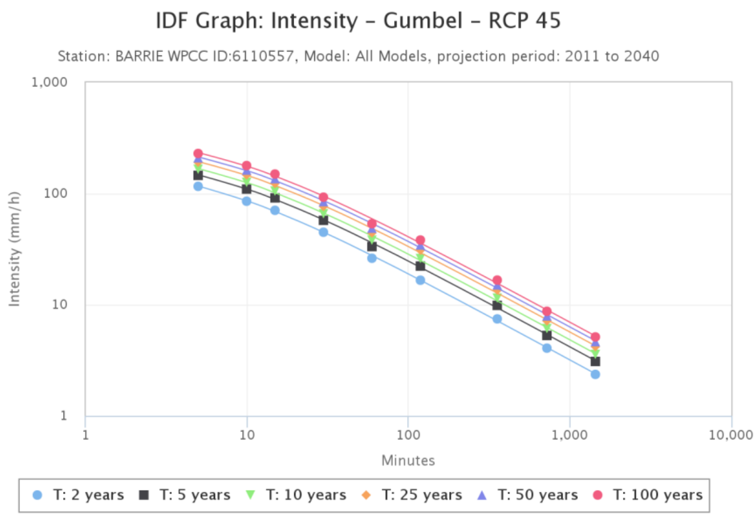


*Figure 3: 2020s IDF Curve Changes projected for the Barrie WPCC location under RCP 8.5 (AR5)*

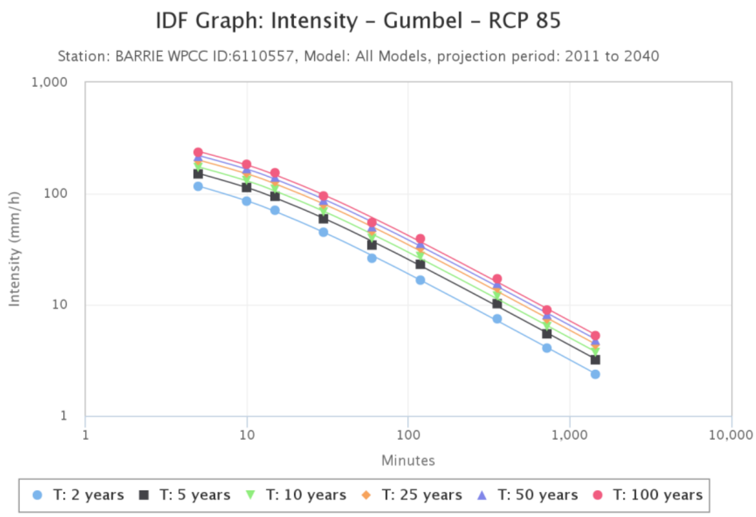



*Figure 4: 2050s IDF Curve Changes projected for the Barrie WPCC location under RCP 2.6 (AR5)*

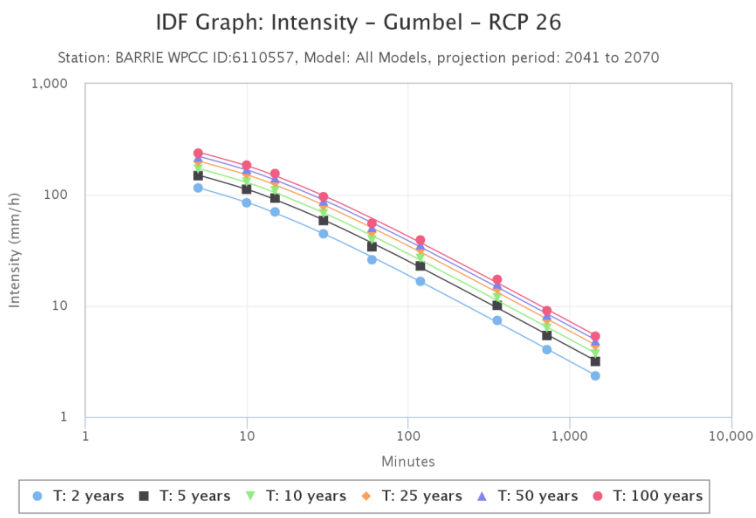


*Figure 5: 2050s IDF Curve Changes projected for the Barrie WPCC location under RCP 4.5 (AR5)*

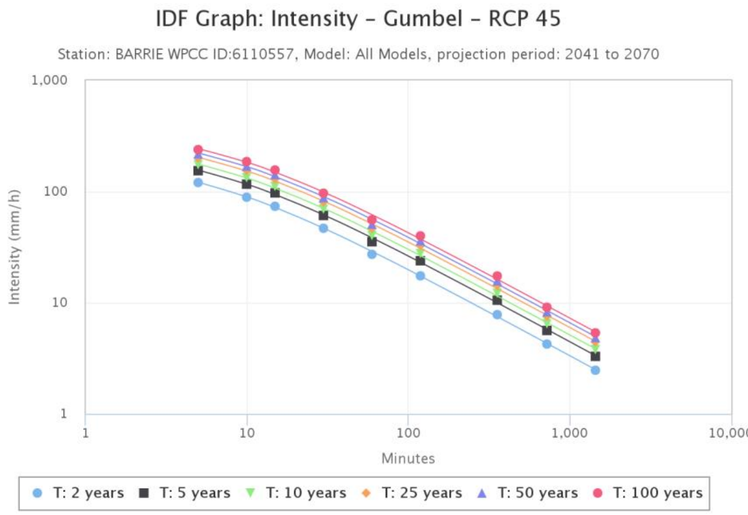



*Figure 6: 2050s IDF Curve Changes projected for the Barrie WPCC location under RCP 8.5 (AR5)*

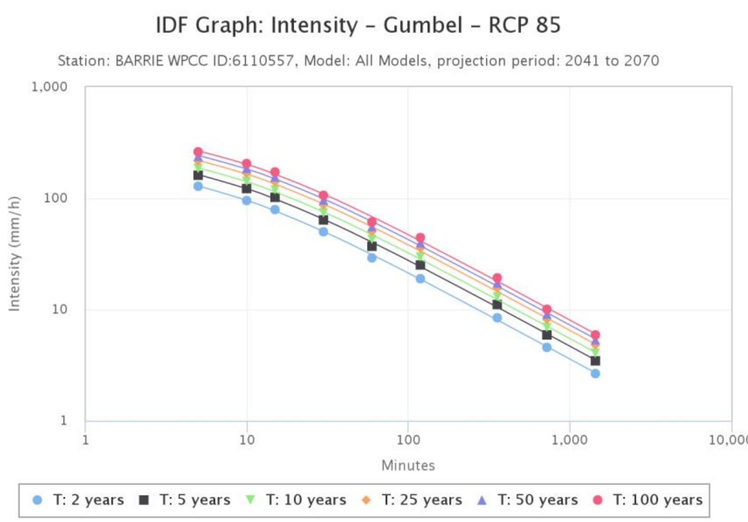


*Figure 7: 2080s IDF Curve Changes projected for the Barrie WPCC location under RCP 2.6 (AR5)*

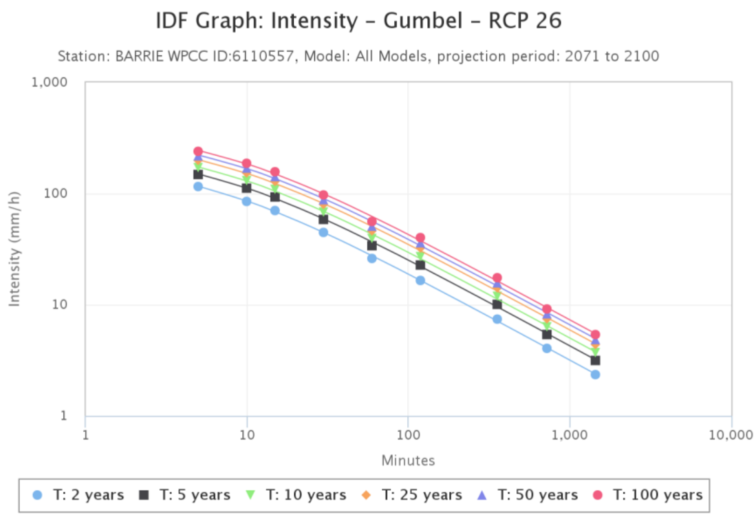



*Figure 8: 2080s IDF Curve Changes projected for the Barrie WPCC location under RCP 4.5 (AR5)*

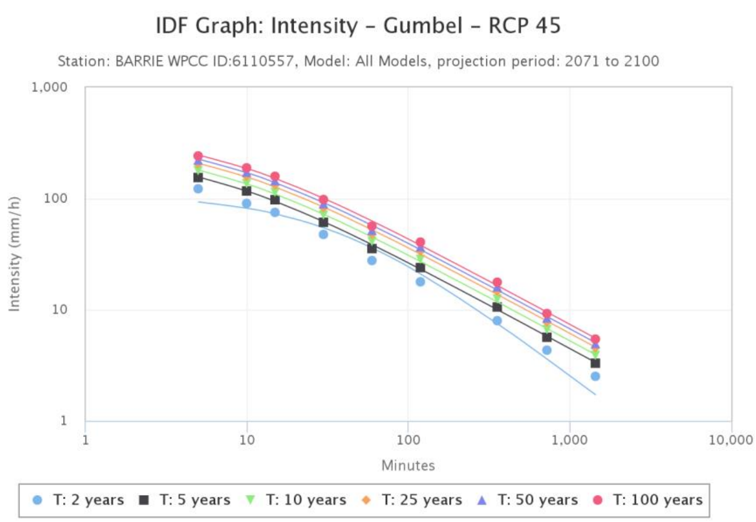


*Figure 9: 2080s IDF Curve Changes projected for the Barrie WPCC location under RCP 8.5 (AR5)*

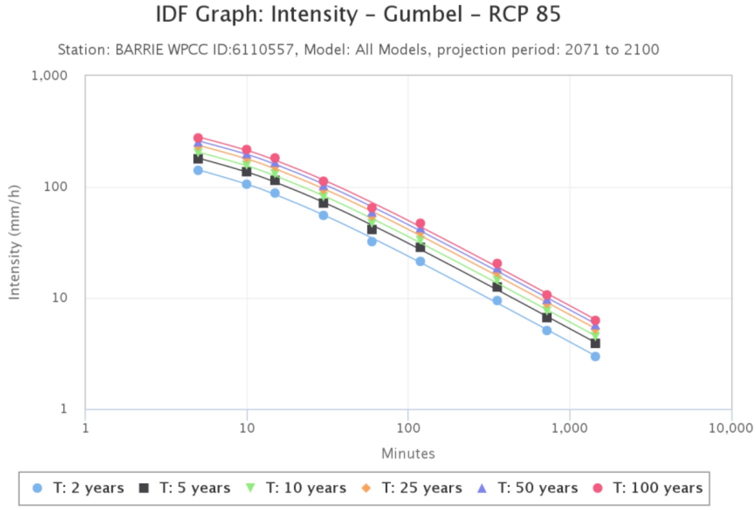



*Figure 10: 2020s IDF Curve Changes projected for the Collingwood location under RCP 2.6 (AR5)*

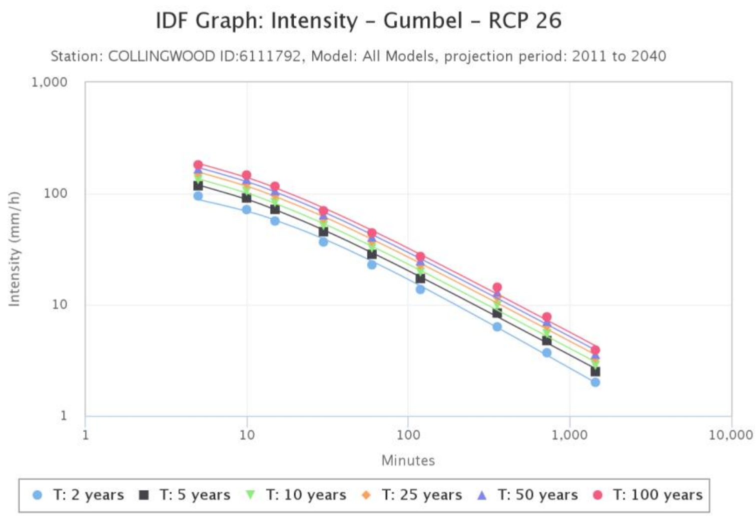


*Figure 11: 2020s IDF Curve Changes projected for the Collingwood location under RCP 4.5 (AR5)*

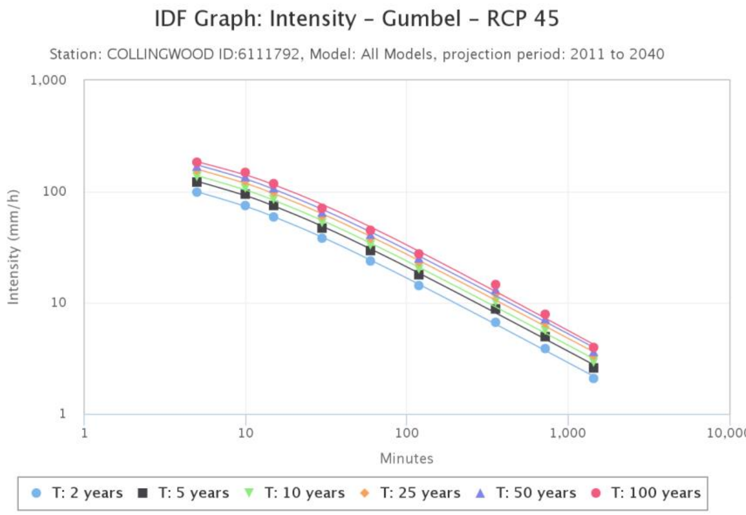



*Figure 12: 2020s IDF Curve Changes projected for the Collingwood location under RCP 8.5 (AR5)*

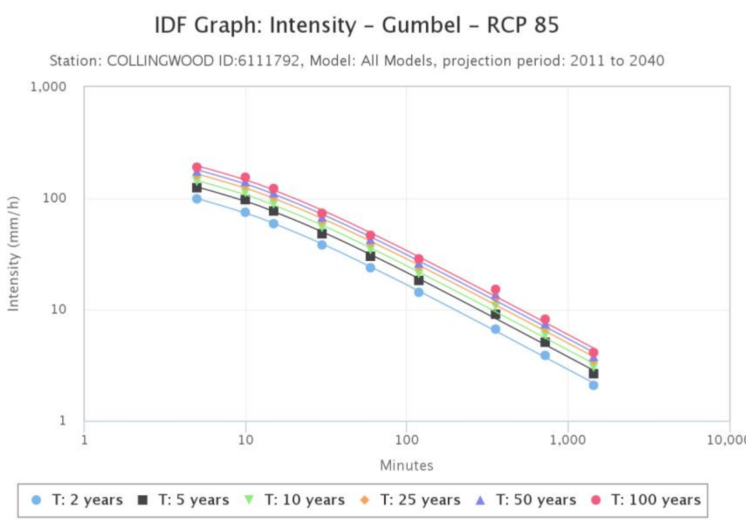


*Figure 13: 2050s IDF Curve Changes projected for the Collingwood location under RCP 2.6 (AR5)*

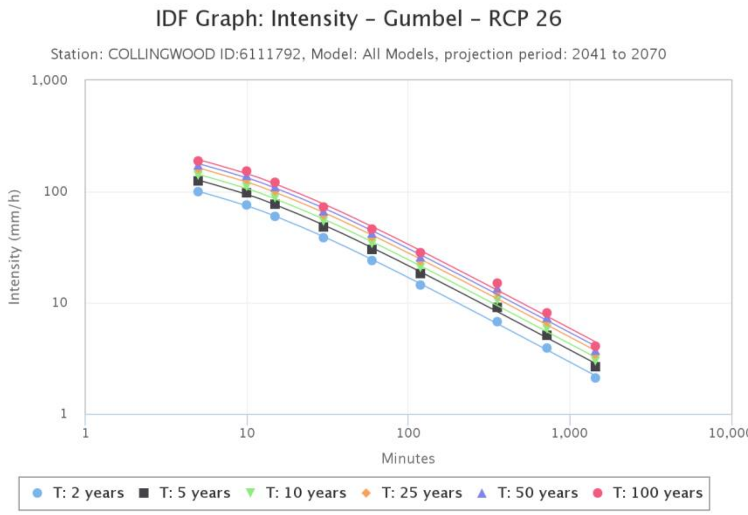



*Figure 14: 2050s IDF Curve Changes projected for the Collingwood location under RCP 4.5 (AR5)*

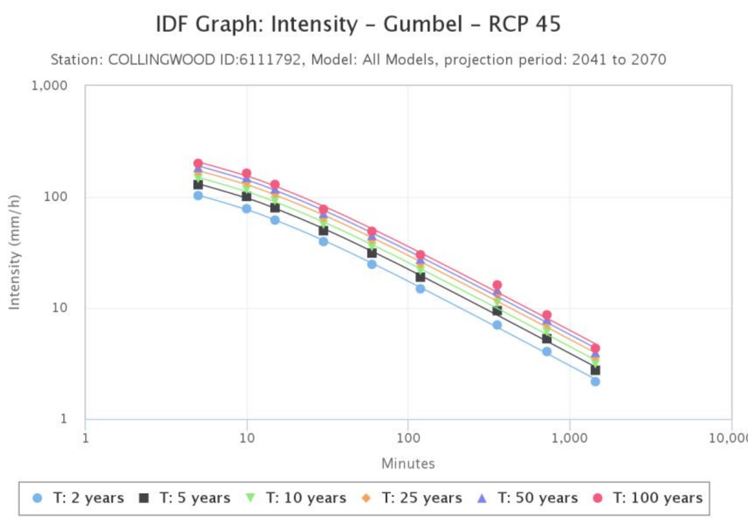


*Figure 15: 2050s IDF Curve Changes projected for the Collingwood location under RCP 8.5 (AR5)*

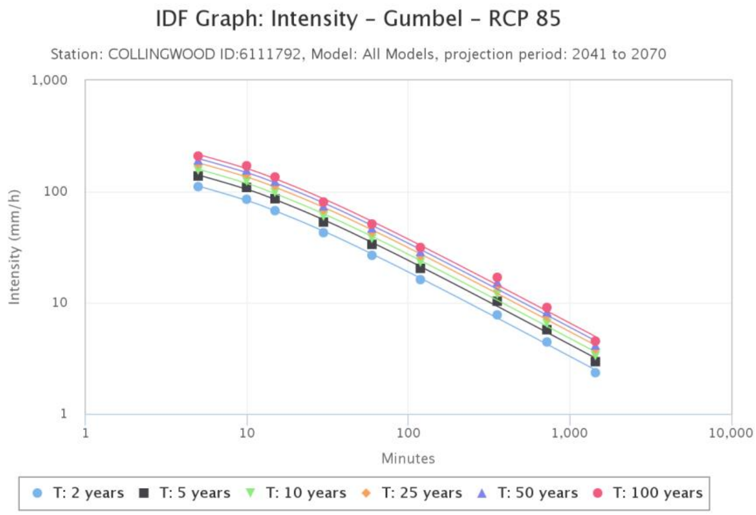



*Figure 16: 2080s IDF Curve Changes projected for the Collingwood location under RCP 2.6 (AR5)*

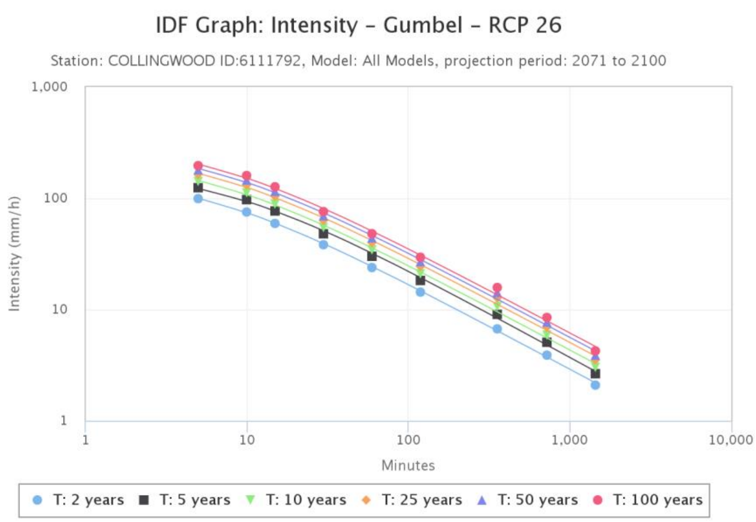


*Figure 17: 2080s IDF Curve Changes projected for the Collingwood location under RCP 4.5 (AR5)*

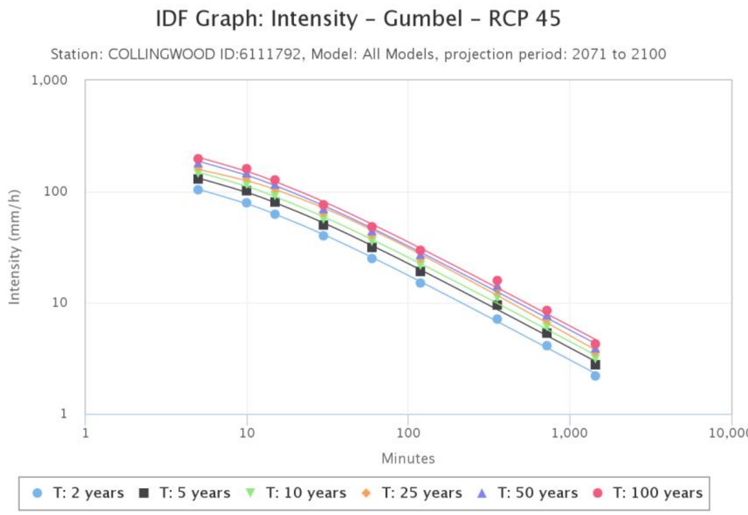



*Figure 18: 2080s IDF Curve Changes projected for the Collingwood location under RCP 8.5 (AR5)*

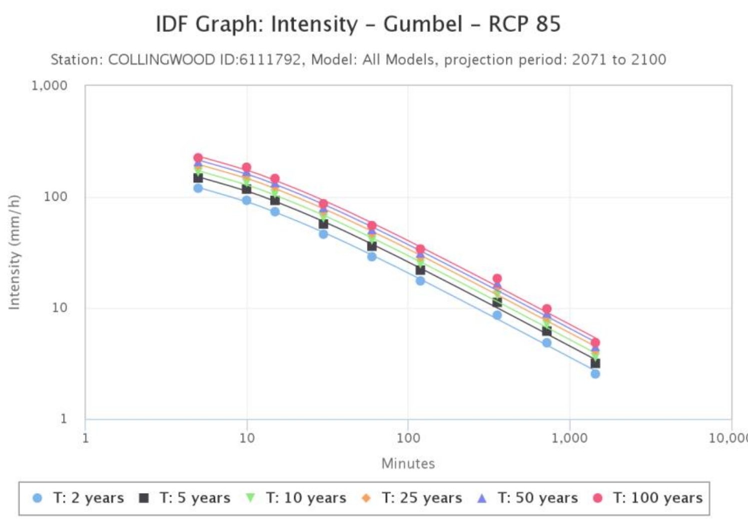


*Figure 19: 2020s IDF Curve Changes projected for the Egbert CS location under RCP 2.6 (AR5)*

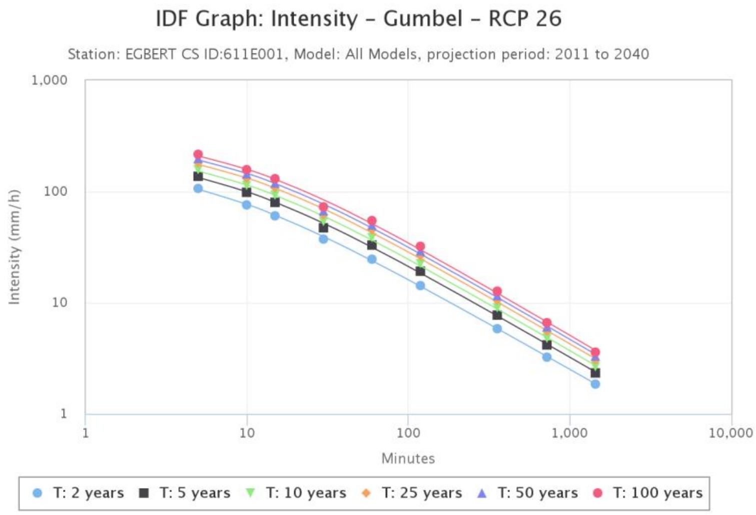



*Figure 20: 2020s IDF Curve Changes projected for the Egbert CS location under RCP 4.5 (AR5)*

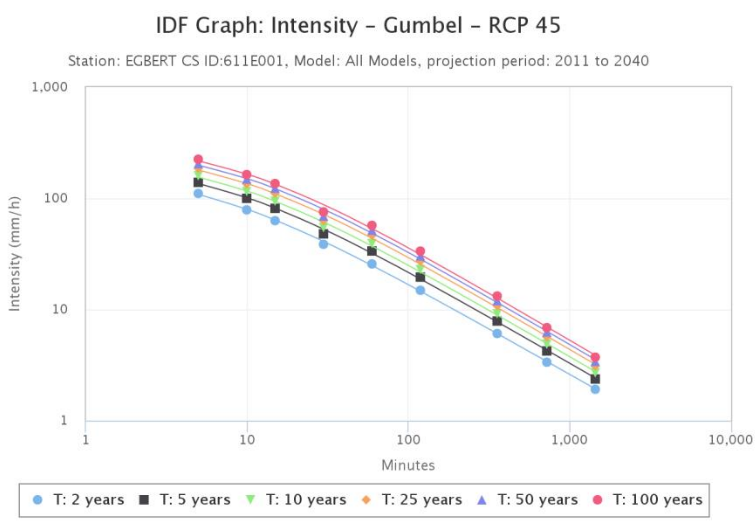


*Figure 21: 2020s IDF Curve Changes projected for the Egbert CS location under RCP 8.5 (AR5)*

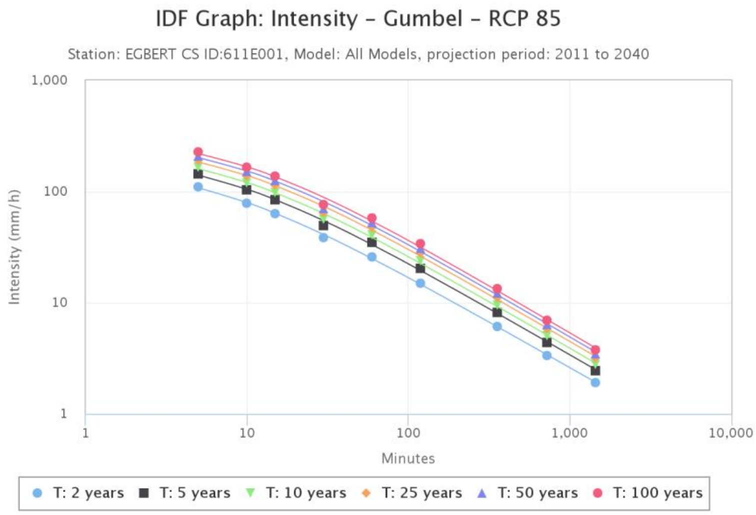



*Figure 22: 2050s IDF Curve Changes projected for the Egbert CS location under RCP 2.6 (AR5)*

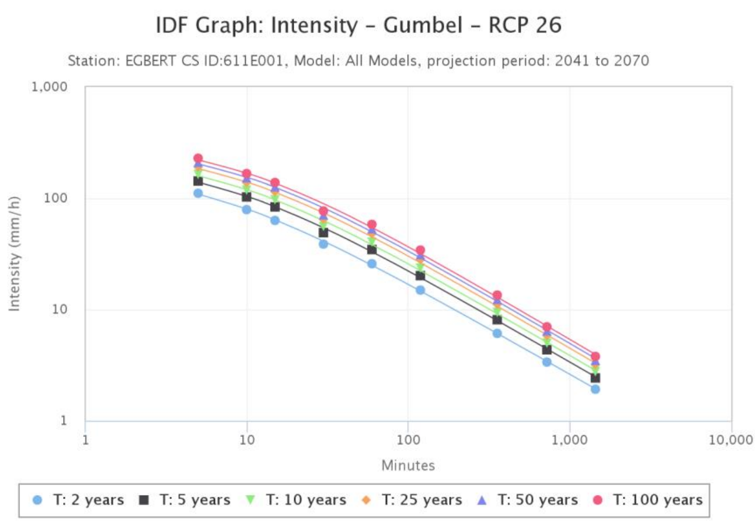


*Figure 23: 2050s IDF Curve Changes projected for the Egbert CS location under RCP 4.5 (AR5)*

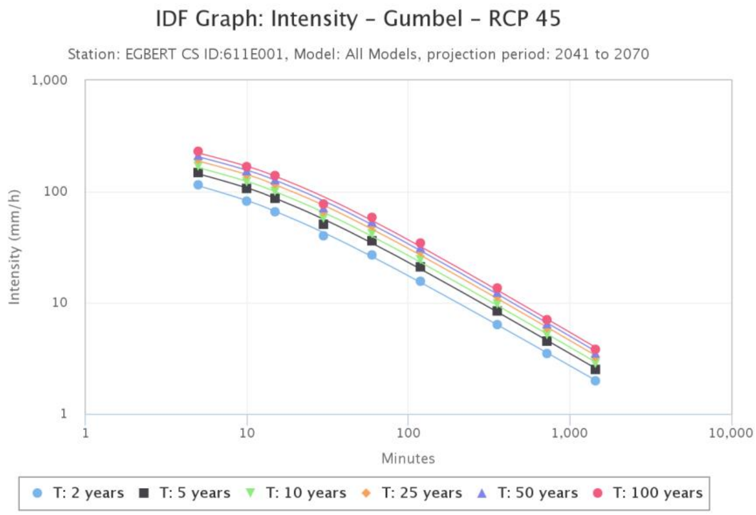



*Figure 24: 2050s IDF Curve Changes projected for the Egbert CS location under RCP 8.5 (AR5)*

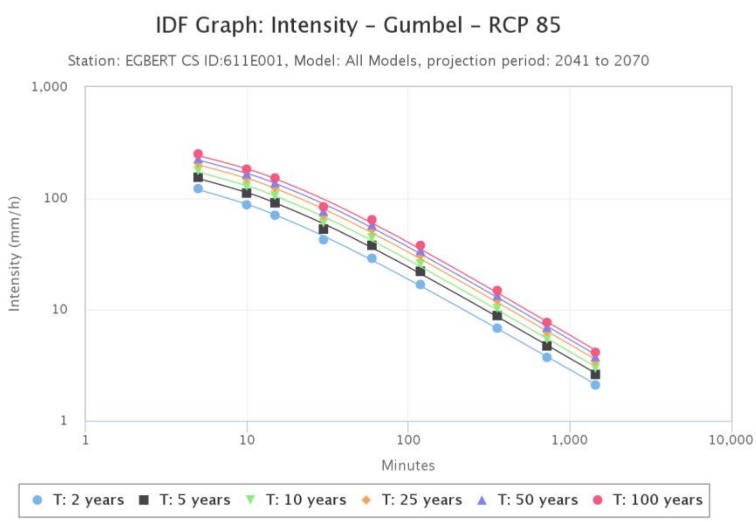


*Figure 25: 2080s IDF Curve Changes projected for the Egbert CS location under RCP 2.6 (AR5)*

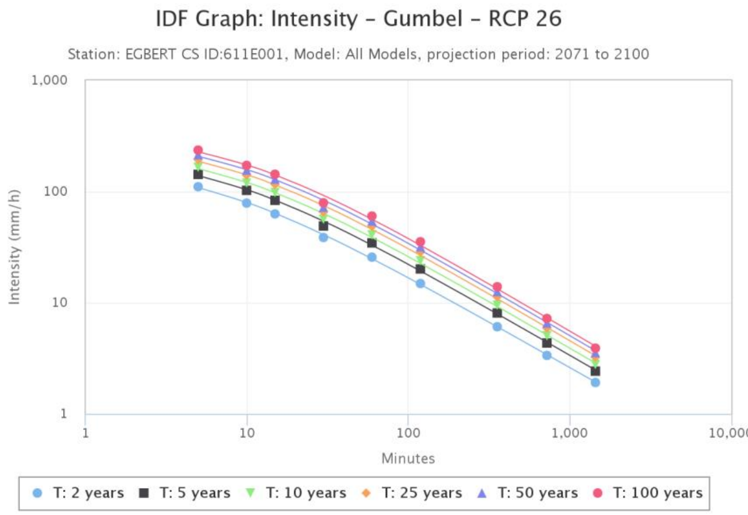



*Figure 26: 2080s IDF Curve Changes projected for the Egbert CS location under RCP 4.5 (AR5)*

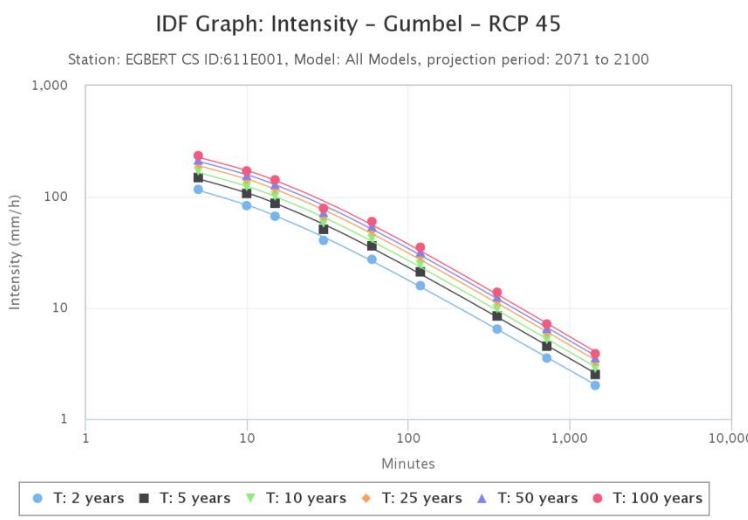


*Figure 27: 2080s IDF Curve Changes projected for the Egbert CS location under RCP 8.5 (AR5)*

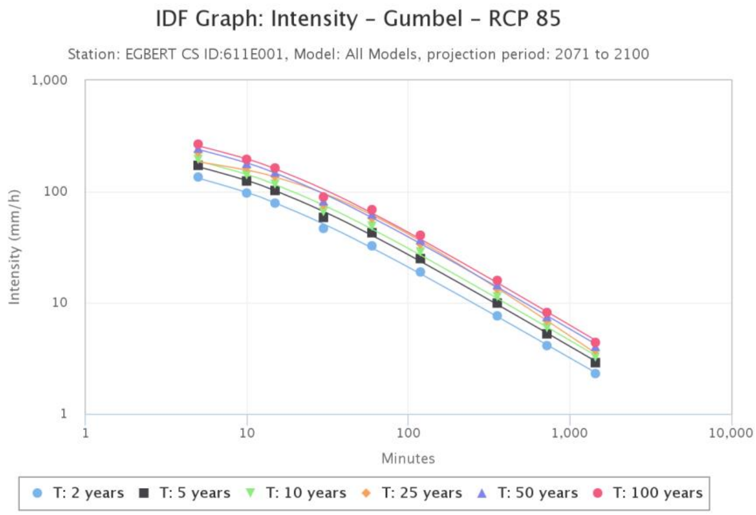



*Figure 28: 2020s IDF Curve Changes projected for the Shelburne location under RCP 2.6 (AR5)*

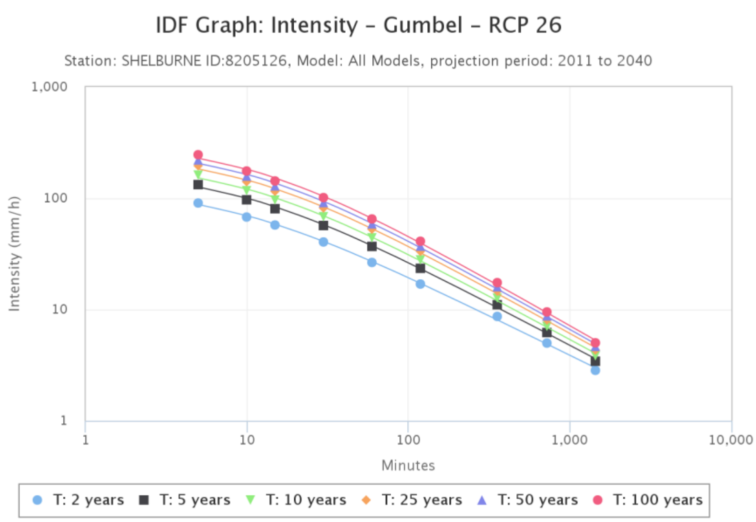


*Figure 29: 2020s IDF Curve Changes projected for the Shelburne location under RCP 4.5 (AR5)*

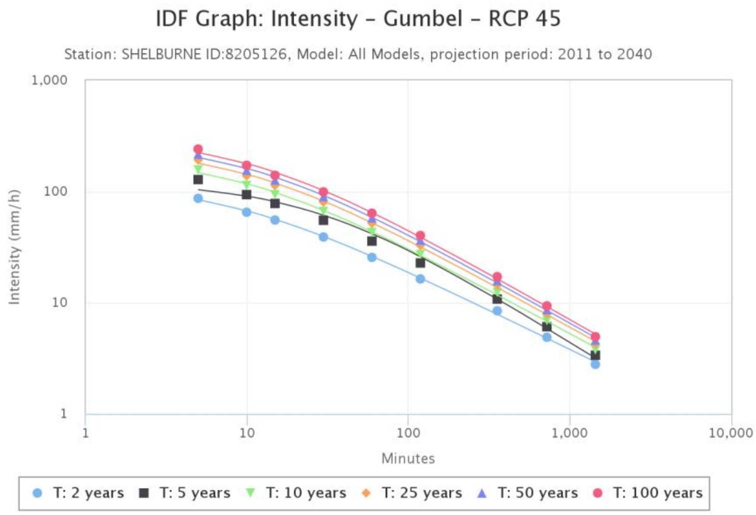



*Figure 30: 2020s IDF Curve Changes projected for the Shelburne location under RCP 8.5 (AR5)*

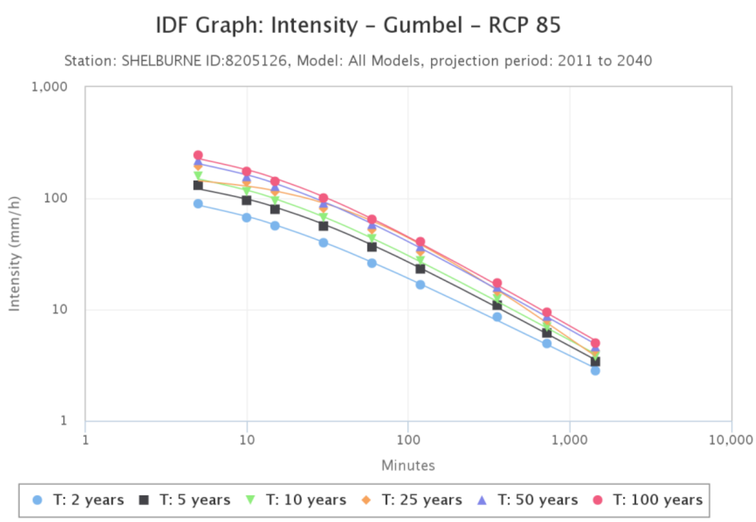


*Figure 31: 2050s IDF Curve Changes projected for the Shelburne location under RCP 2.6 (AR5)*

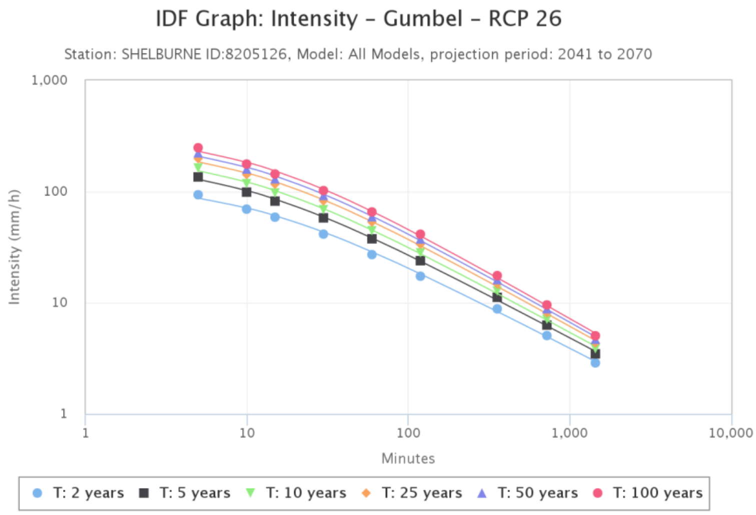



*Figure 32: 2050s IDF Curve Changes projected for the Shelburne location under RCP 4.5 (AR5)*

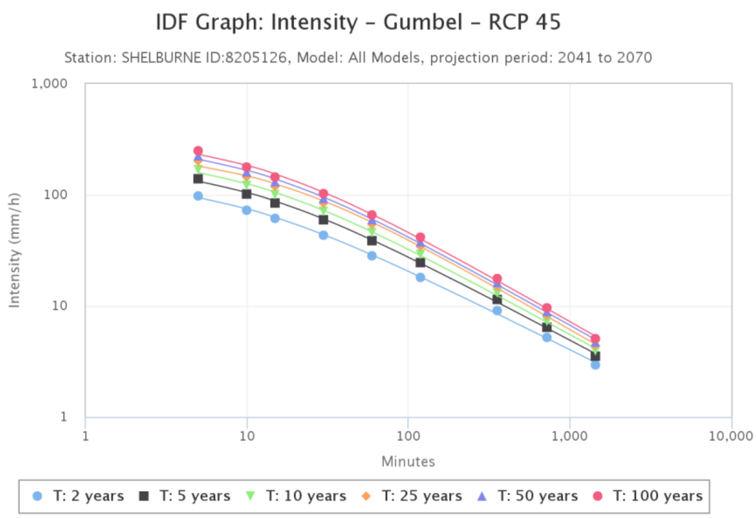


*Figure 33: 2050s IDF Curve Changes projected for the Shelburne location under RCP 8.5 (AR5)*

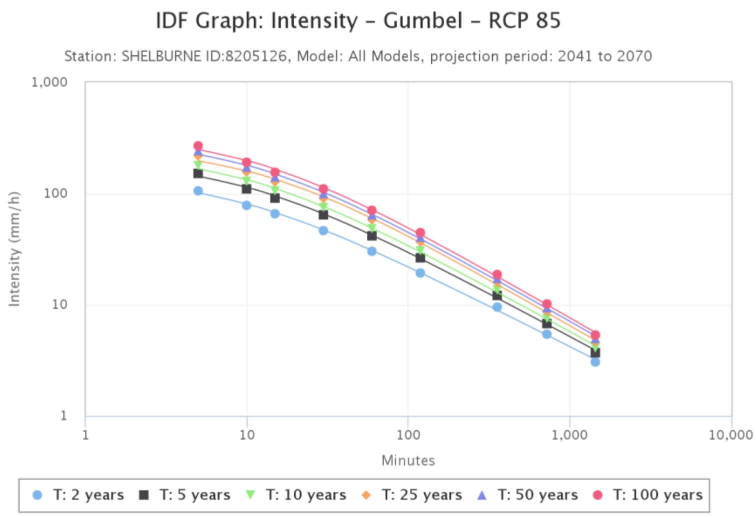



*Figure 34: 2080s IDF Curve Changes projected for the Shelburne location under RCP 2.6 (AR5)*

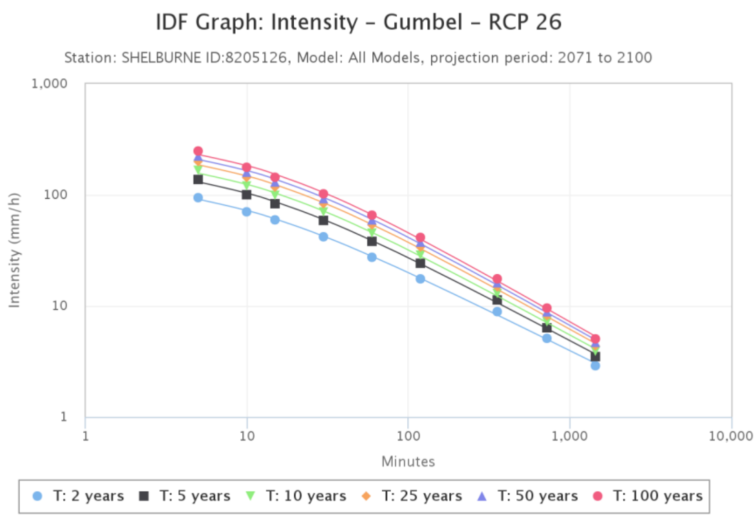


*Figure 35: 2080s IDF Curve Changes projected for the Shelburne location under RCP 4.5 (AR5)*

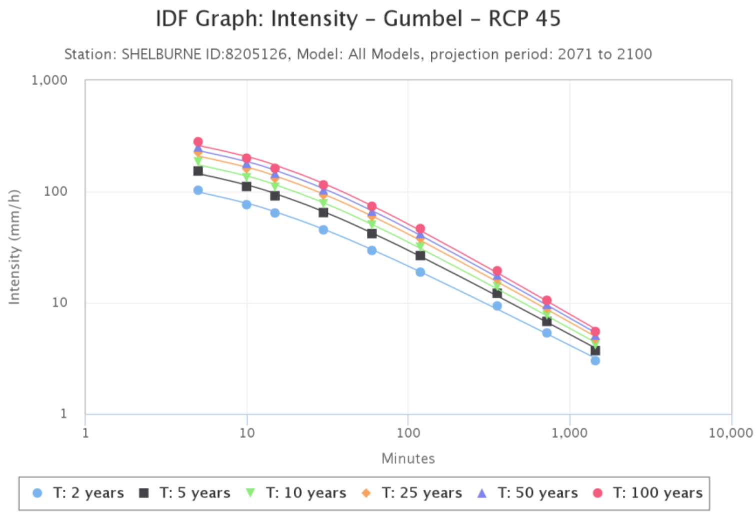
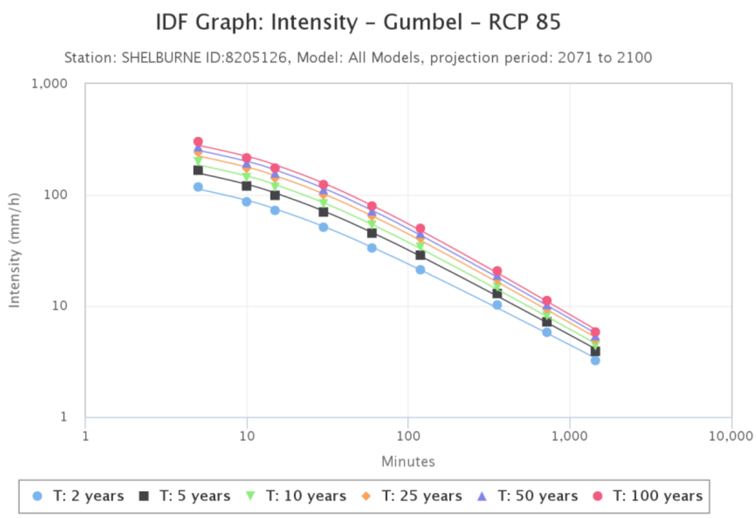


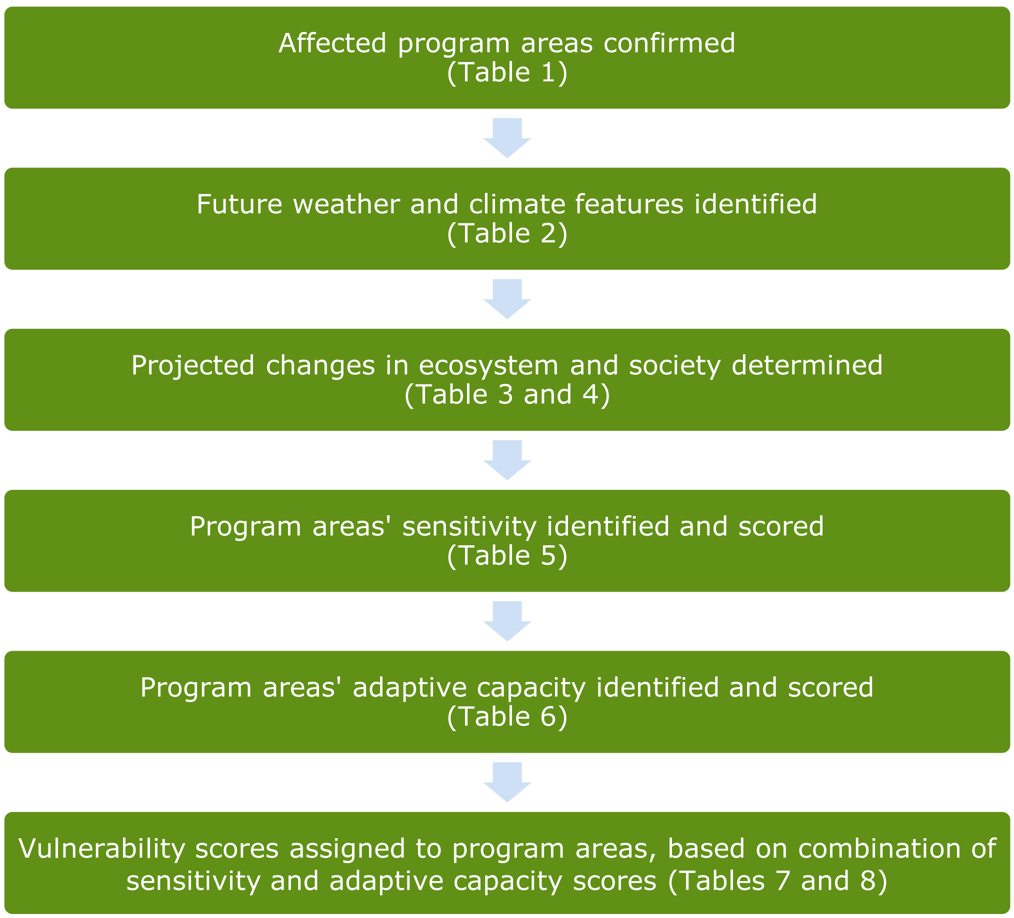

*Figure 36: 2080s IDF Curve Changes projected for the Shelburne location under RCP 8.5 (AR5)*



## Appendix B: Vulnerability Assessment

In order to identify the degree of impact of climate change to NVCA program areas, a vulnerability assessment was conducted.[2] This analysis was completed in several consecutive steps as seen in the figure below (Figure B1).

*Figure B1. Vulnerability assessment process*




The first step in the vulnerability assessment was to confirm key NVCA program areas affected by climate change. Nineteen program areas were identified by the staff and grouped according to the NVCA's strategic goals:

- **Protect, Enhance and Restore**,
- **Learn and Discover**; and
- **Connect**.

A category called **Business Functions** was added to reflect our business goals and commitments in mitigating and adapting to climate change (see Table B1).

[2] Acknowledgement: This vulnerability assessment was based on work conducted by Kawartha Conservation as part of their Climate Change Strategy (June 2016).

Step 2 involved the identification of future weather and climate features, based on literature review and local climate projections, and their high level impacts on NVCA programs (Table B2).

Anticipated changes in the ecosystem resulting from the projected weather/climate conditions were determined (Tables B3 and B4 - Possible Impact on watershed resources).

Once these changes were identified, program area sensitivity to the projected changes was assessed based on the sensitivity scoring criteria described in Table B5. Program area ability to adjust to the changes (adaptive capacity) was evaluated based on criteria defined in Table B6. These tables are adapted from the *Municipal Climate Adaptation Guide* (ICLEI Canada). Modifications were made to the scoring to make criteria more relevant to our program areas and provide tangible benchmarks when evaluating our program vulnerability to climate change.

The last step and end result is the vulnerability assessment, where High, Medium and Low scores were assigned to NVCA program areas based on their determined sensitivity to the climate change and its adaptive capacity.

*Table B1: Draft NVCA Program Areas Impacted by Climate Change (discussed at January 25, 2017 Staff Meeting by 24 staff members)*

| **Program Areas** |
|---|
| **Strategic Plan Goal - Protect, Enhance and Restore**<br>• Hazard Land Protection (mapping and regulation)<br>• Planning and Plan Review (including storm water management)<br>• Flood Forecasting and Warning<br>• Low Water Response<br>• Stewardship<br>• Forestry<br>• Natural Heritage Protection - Aquatic<br>• Natural Heritage Protection - Terrestrial<br>• Groundwater<br>• Conservation Lands Maintenance |
| **Strategic Plan Goal - Learn and Discover**<br>• Education and Outreach<br>• Monitoring |
| **Strategic Goal - Connect**<br>• Communications<br>• Events and Venues (weddings)<br>• Conservation Lands Recreation |
| **Business Functions**<br>• Daily Business Operations<br>• Facility Management (buildings, dams, roads, IT hardware)<br>• Fleet Management<br>• Human Resources/Health and Safety |

*Table B2. Changes Expected in Climate Parameters and Weather Pattern and potential impacts on NVCA Programs*

| Climate Parameters | Expected changes in the parameter | Potential impact to NVCA Programs |
|---|---|---|
| Temperature | | |
| Extreme Heat | • Increased average maximum daily temperature<br>• Increased extreme maximum temperature<br>• Increased number of days per year with temperature >30°C | • Impact on education program and outdoor work from extreme hot and cold temperatures, higher UV rays, increase vector-borne diseases<br>• Especially sharp increase in winter temperatures, both extremes and averages will have impact on outdoor workers<br>• Change in ice cover regime will impact on fishery<br>• Increased number of freezing-thaw cycles will impact CA roads, buildings and project implementation<br>• Potential increased growing season for tree planting<br>• Heat waves and increased humidex impacting recreational users and workers<br>• Increased costs for air conditioning and heating<br>• Warmed rivers leading to impaired water quality<br>• Increased soil and bank erosion rates (wind/water) impact to water quality leading to increased need for stewardship projects and potentially modifications to eligible projects<br>• Increased need for stewardship projects that mitigate coldwater fisheries stresses<br>• Changes to planting species recommendations (e.g., assisted migration)<br>• Changes of funding availability and/or goals to stewardship funding from public and private sources |
| Extreme Cold | • Increased average minimum daily temperature<br>• Increased extreme minimum temperature<br>• Decreased number of days per year with temperature <-10°C<br>• Decrease number of days per year with minimum <0°C (frost days)<br>• Increase number of freeze-thaw cycles | |
| Wind Chill | • Increase of extreme daily temperature<br>• Decrease number of days per year with temperature <-20°C | |
| Degree Days | • Increased number of degree days per year with temperature > 24°C (air conditioning required)<br>• Increased number of degree days per year with temperature > 0°C<br>• Decreased number of degree days per year < 0°C (heating required) | |
| Humidex | • Increased maximum temperature<br>• Increased average number of days per year with temperature >40°C | |
| Precipitation | | |
| Extreme Precipitation | • Increased maximum one-day precipitation<br>• Increased number of days per year with daily precipitation >25mm<br>• Increased annual total precipitation (mm) | • Increase in high intensity rain events leading to more flooding, flood warning requirements, impact to trails, conservation area events/revenue (weddings) and increased erosion from runoff<br>• Increased risk of drought leading to more NVCA Drought Response Coordination, loss of trees planted, forest fires, habitat reduction and wetland |
| Extreme Rainfall | • Increased maximum daily precipitation<br>• Increased number of days per year with precipitation >25mm | |

| Climate Parameters | Expected changes in the parameter | Potential impact to NVCA Programs |
|---|---|---|
| Extreme Snowfall | • Decreased maximum daily snowfall<br>• Decreased number of days per year with snowfall >5cm | impacts<br>• Increase in winter precipitation, leading to requirements for updated floodplain mapping<br>• Decreased snow cover impacts to hydrogeology<br>• Increased snow removal costs and impacts from salt on rivers<br>• Decrease in maximum amount of snow during the snowstorms<br>• Possible decrease in summer precipitation<br>• Increased frequency of ice storms<br>• Increased stream lateral erosion rates; may require re-mapping hazard zones, setbacks and bank stabilization<br>• Increased risk of bacterial contamination of surface and groundwater (e.g. storm events)<br>• Increased water/wind soil erosion due to storm events, longer periods with bare ground and freeze-thaw in winter, and droughts<br>• Increased chance of planting failure due to drought<br>• Potential tree seed availability changes (limits to species selection) |
| Strong Winds and Violent Storms | | |
| Potential for Violent Storms | • Increased number of days with high lightning potential per year<br>• Increased number of days per year potential for storms and tornadoes | • Increased number of violent storms impacting health and safety of conservation area recreational users and workers and impact on buildings, structures (dams) and technology<br>• Education/event program cancellations leading to lost revenue<br>• Increased cancellation of volunteer workdays (e.g., lightning storms)<br>• Higher risk of erosion (construction sites, agricultural erosion control structures, stream rehabilitation projects)<br>• Increased risk of damage to new projects and construction challenges (e.g. winter melts, flooding events)<br>• Increased applications to stewardship programs in response to increased erosion, etc. |

*Table B3. Possible Impact on Watershed Resources*

| Water Resources - Surface Water | Water Resources - Groundwater | Water Quality | Aquatic - Lakes | Aquatic - Tributaries | Terrestrial |
|---|---|---|---|---|---|
| Temperature Related Changes | | | | | |
| Changes in watercourse flow and hydrological regime including:<br>• Earlier and lower spring freshet<br>• Summer and fall low flows and water levels are lower and last longer<br>• Increased loss of water due to increased evaporation<br>• Soil moisture may increase by as much as 80% during winter, but decrease by as much as 30% in summer and autumn<br>• Increased frequency of low water/drought conditions<br>• Decrease in water levels (lakes and tributaries) | • Decreased groundwater recharge, with shallow aquifers being especially affected in the short-term<br>• Decreased groundwater levels<br>• Increased demand, especially in summer<br>• Decreased groundwater input to the streams, lakes, and wetlands especially in summer time<br>• Possible increase of groundwater recharge in winter time | • Increased water temperature in rivers and lakes<br>• Change in water chemistry parameters<br>• Higher concentration of nutrients and contaminants<br>• Possible increase in development of toxic algae (temperature and nutrient dependent)<br>• Higher periodic nutrient and sediment loads in winter and storm events<br>• Lower dissolved oxygen due to temperature increases, increased respiration and nutrient enrichment<br>• Possible increase in road-salt use (nearer to zero temperatures) | • Increase in exotic/invasive species presence<br>• Reduction in deep coldwater habitat and reduction in thermocline<br>• Increase in warmwater species productivity<br>• Decrease in cool/cold water species productivity<br>• Increased risk of fish die-offs due to reduced oxygen content<br>• Changes in lacustrine wetland habitat<br>• Changes in species diversity and fish population health as a result of reduced oxygen content<br>• Increased risk of toxic algae blooms | • Increase in exotic/invasive species presence<br>• Decrease in cool/cold water habitat and species productivity/ reproduction success<br>• Increase warmwater habitat and warmwater species productivity<br>• Higher chance of fish-kills<br>• Reduced volume of habitat during low-flow conditions<br>• Changes in riverine and palustrine wetland habitat<br>• Increased chance of toxic algae blooms (low-flow – Jack's Lake and impoundments – Tottenham dam)<br>• Decreased summertime flow in headwater streams | • Change in species range both flora and fauna<br>• Increase in insects and vector borne disease outbreaks<br>• Increase in invasive species<br>• Loss of species diversity<br>• Increase in disease in flora and fauna<br>• Increase in plant pests both native and non-native<br>• Loss of wetlands and wetland species<br>• Loss of species at risk due to vulnerability<br>• Loss of mature forest canopy<br>• Increased productivity of various flora and fauna species<br>• De-synching of dependent species life histories (e.g., bird nesting and insect) |

| Water Resources - Surface Water | Water Resources - Groundwater | Water Quality | Aquatic - Lakes | Aquatic - Tributaries | Terrestrial |
|---|---|---|---|---|---|
| Precipitation Related Changes | | | | | |
| • Increased frequency and magnitude of high water levels and flows following extreme precipitation events (flash floods), summer- fall<br>• Increased frequency of rain events in winter (rain-on-snow events), which can cause extra high runoff, increased water levels and possible flooding | | • Deteriorated water quality following high intensity precipitation events as a result of increased stormwater runoff (both increased soil erosion and bank erosion) | • Increased shoreline and land erosion, sedimentation<br>• Possible lake level changes (recreation, access, and fisheries impacts) | • Increased stream bank and land erosion, sedimentation, deposition<br>• Possible de-synching of spawning times with high flows (impacts recruitment success) | • Changes to types of precipitation (i.e. ice storms) negatively impacting forest cover<br>• Potential increase in wetland area<br>• Loss of tree cover protection of some species from increased potential for freeze thaw cycle |
| Wind and Violent Storms Related Changes | | | | | |
| • Increased storm surge on local lakes<br>• Increased erosion (riverine and lakeshore)<br>• Increased surface runoff, stream flashiness (stress on undersized infrastructure – culverts, bridges, stormwater management) | | • Increase is storm related shoreline erosion, particularly in longer ice-free winter – higher turbidity (associated with higher turbidity, fecal coliform re-suspension and survival – impacts to recreation) | • Increase is storm related shoreline erosion, particularly in longer ice-free winter | • Higher lateral erosion rates (ecological and possible infrastructure impacts)<br>• Higher windfall, bank destabilization and log jam potential | • Loss of tree cover, mature trees (species dependent)<br>• Urban tree canopy loss and resulting impacts to infrastructure<br>• Increased soil and wind erosion, particularly in fall to early spring |

*Table B4. Possible Impact on Society and Economics*

| Agricultural | Recreational | Urban/People |
|---|---|---|
| Temperature Related Impacts | | |
| • Longer growing seasons (may change crop types, and promote cropping vs. pasture)<br>• Frost/ freezing rain impacts on fruit set (e.g. apples) (and early flowering native species like silver maple)<br>• Changing productivity because of warmer temperature and changing precipitation<br>• Possibility of growing new crops<br>• Possibility of exploring new markets as demands from outside of Canada may grow<br>• Crop damage and livestock stress from extreme heat<br>• Increased weed growth, and new weeds species possible<br>• Diseases and insects outbreaks<br>• Less effective pesticides and herbicides<br>• Higher fertilizer application rates (compensation for more nitrogen loss for fall application)<br>• Higher potential for organic matter decay rates (loss of soil structure, fertilizer and water holding capacity)<br>• Increased pressures (local and global) to increase crop land from pasture/hay, marginal lands, bottomlands, and wetlands | • Decrease in winter recreation activities, including ice fishing, snowmobiling and skiing<br>• Deteriorating water quality (nutrients, salt and bacteria) and increased aquatic vegetation will negatively impact local tourism<br>• Possible increase of warm-water fishery<br>• Expansion of the 'summer' tourism season early in spring and later in fall<br>• Loss of enjoyment of shoreline properties because of changing water levels and aquatic plant and algae growth problems | • Increased heat stress<br>• Decreases air quality<br>• Increased demand for electricity in summer time (air conditioning)<br>• Decreased demand for gas/electricity for heating in winter time<br>• Increased pressure on water supply systems as demand for water (lawn/gardens irrigation) grows<br>• Decreased local recreational opportunity<br>• Spread of invasive plants and insects potentially harmful for humans |
| Precipitation Related Impacts | | |
| • Crop loss because of possible drought conditions<br>• Increased need for irrigation (higher moisture requirements) and higher risk of drought – more variability<br>• Decrease in water resources available for irrigation and livestock watering<br>• Increased water erosion as a result of high intensity precipitation events<br>• Increased wind erosion due to droughts, and during fall to early spring (longer uncovered soils – lack of protective soil cover)<br>• Changes to crop failure rates | • Changing recreational opportunity following high intensity precipitation event because of high flows, degraded water quality and erosion | • Increased risk of flooding in flood-prone areas<br>• Increased risk of winter flooding<br>• Development of new flood-prone areas<br>• Increased risk of erosion<br>• Less snow removal |

| Agricultural | Recreational | Urban/People |
|---|---|---|
| Violent Storms Impacts | | |
| • Crop damages a result of violent storms (seedling wash-outs; microbursts, wind damage particularly to soft fruit, fruit set risks)<br>• Damage to sugar bush trees<br>• Damage to forest/plantations – impacts to lumber/fiber harvest | • Limitation of recreational activities because of hazardous conditions during and following storms<br>• Typically higher beach fecal bacteria counts following storm events<br>• Increased hazard trees in conservation/trail areas<br>• Increased log jams/ deadheads in recreational boating areas (rivers and lakes) | • Increased risk of electricity loss because of storms<br>• Increased damage to the urban forest<br>• Increased cost of emergency response for municipalities<br>• Increased risk of property damages and personal injuries |

*Table B5. Sensitivity Score: How Sensitive is the Program to the Changes in Climate? Will a program be affected by changes in climate?*

| | As per Municipal Climate Adaptation Guide, ICLEI Canada (2011) | Adjusted to NVCA business |
|---|---|---|
| S1 | No.<br>Functionality will stay the same | No change in program is anticipated. |
| S2 | Unlikely.<br>Functionality will likely stay the same | Unlikely.<br>Program will likely stay the same |
| S3 | Functionality is likely to get worse | Yes.<br>Change in program will likely happen, require minor modifications |
| S4 | Functionality will get worse | Yes.<br>Program will not function as it is expected at its current format and require moderate modifications |
| S5 | Yes.<br>Functionality will become unmanageable | Yes.<br>Program will become non-functional and will require major modification (amendment) or termination |

*Table B6. Adaptive Capacity: Can the Program Area Adjust With a Minimal Cost and Disruption?*

| | As per Municipal Climate Adaptation Guide, ICLEI Canada (2011) | Adjusted to NVCA business |
|---|---|---|
| AC1 | No.<br>Will require substantial cost ($$$$$) and staff intervention | $50+ K in capital or operational; 2-3 additional staff units, partners will have to change their function as a result |
| AC2 | No,<br>Will require significant cost ($$$$) and staff intervention | $20-50 K in capital budget; 1 staff unit, partners will be affected |
| AC3 | Maybe.<br>Will require some cost ($$$) and staff intervention | $10-20 K; ½ of a staff unit, partners may be affected |
| AC4 | Yes.<br>But will require some slight cost ($$) and staff intervention | $5-10 K; existing staff, up to 10% of increase in staff time |
| AC5 | Yes.<br>No to little cost ($) and staff intervention are necessary | $0-5 K; existing staff, <10% of increase in staff time |

*Table B7. Sensitivity (S) and Adaptive Capacity (AC) Matrix and Vulnerability Score*

| | S1 | S2 | S3 | S4 | S5 | Vulnerability Score | |
|---|---|---|---|---|---|---|---|
| AC5 | V1 | V1 | V2 | V3 | V3 | V1 | Low Vulnerability |
| AC4 | V1 | V2 | V2 | V3 | V3 | V2 | Medium-Low Vulnerability |
| AC3 | V2 | V2 | V3 | V4 | V4 | V3 | Medium Vulnerability |
| AC2 | V2 | V2 | V3 | V4 | V5 | V4 | Medium-High Vulnerability |
| AC1 | V2 | V2 | V4 | V5 | V5 | V5 | High Vulnerability |

*Table B8. Sensitivity, Adaptive Capacity and Vulnerability Assessment – NVCA Program Areas*

| Impacts | Natural Hazard Protection | | | Planning and Regulation | | | Flood Forecasting and Warning | | | Low Water Response | | | Natural Heritage – Terrestrial | | | Natural Heritage - Aquatic | | | Conservation Lands | | | Urban Stewardship | | | Rural Lands Stewardship | | | Shoreline Stewardship | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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 |
| Change in ice cover regime | S3 | AC4 | V2 | S1 | AC5 | V1 | S3 | AC5 | V2 | S1 | AC5 | V1 | S2 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 |
| Change in a watercourse flow and hydrological regime | S4 | AC2 | V4 | S4 | AC2 | V4 | S4 | AC2 | V4 | S3 | AC3 | V3 | S2 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 |
| Increased risk of winter flooding | S3 | AC5 | V2 | S3 | AC5 | V2 | S4 | AC2 | V4 | S1 | AC5 | V1 | S2 | AC5 | V1 | S1 | AC5 | V1 | S3 | AC3 | V3 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 |
| Increased risk of flash flooding | S3 | AC5 | V2 | S3 | AC2 | V3 | S4 | AC2 | V4 | S1 | AC5 | V1 | S2 | AC5 | V1 | S3 | AC5 | V2 | S3 | AC3 | V3 | S4 | AC3 | V4 | S1 | AC5 | V1 | S1 | AC5 | V1 |
| Increased erosion | S4 | AC2 | V4 | S4 | AC2 | V4 | S1 | AC5 | V1 | S1 | AC5 | V1 | S2 | AC5 | V1 | S3 | AC5 | V2 | S3 | AC3 | V3 | S3 | AC3 | V3 | S3 | AC3 | V3 | S4 | AC3 | V4 |
| Increased risk of drought/low water conditions | S2 | AC5 | V1 | S2 | AC4 | V2 | S2 | AC5 | V1 | S4 | AC2 | V4 | S2 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 |
| Decreased summer/fall water levels (lakes and watercourses) | S2 | AC5 | V1 | S2 | AC5 | V1 | S1 | AC5 | V1 | S4 | AC2 | V4 | S2 | AC5 | V1 | S3 | AC5 | V2 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 |
| Increased and more competitive demand for water | S2 | AC5 | V1 | S2 | AC5 | V1 | S1 | AC5 | V1 | S4 | AC2 | V4 | S2 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S3 | AC3 | V3 | S1 | AC5 | V1 | S1 | AC5 | V1 |
| Decrease in soil moisture | S2 | AC5 | V1 | S3 | AC4 | V2 | S1 | AC5 | V1 | S3 | AC4 | V2 | S2 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 |
| Decrease in groundwater levels | S2 | AC5 | V1 | S3 | AC4 | V2 | S1 | AC5 | V1 | S5 | AC2 | V5 | S2 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 |
| Change /decrease in wetlands and wetland species | S3 | AC5 | V2 | S3 | AC4 | V2 | S2 | AC5 | V1 | S1 | AC5 | V1 | S2 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 |
| Increase in water temperature | S2 | AC5 | V1 | S3 | AC4 | V2 | S1 | AC5 | V1 | S1 | AC5 | V1 | S2 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 |
| Change in water chemistry parameters | S1 | AC5 | V1 | S2 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC4 | V1 | S2 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 |
| Deterioration of water quality | S2 | AC5 | V1 | S3 | AC4 | V2 | S1 | AC5 | V1 | S1 | AC3 | V2 | S2 | AC5 | V1 | S3 | AC5 | V2 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 |
| Change in fish community composition (toward warm- water community) | S2 | AC5 | V1 | S3 | AC4 | V2 | S1 | AC5 | V1 | S1 | AC5 | V1 | S2 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 |
| Increase of growing season | S2 | AC5 | V1 | S2 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S2 | AC5 | V1 | S1 | AC5 | V1 | S3 | AC3 | V3 | S1 | AC5 | V1 | S3 | AC3 | V3 | S3 | AC3 | V3 |
| Unpredictable temperature fluctuation | S3 | AC4 | V2 | S3 | AC4 | V2 | S1 | AC5 | V1 | S1 | AC5 | V1 | S3 | AC6 | V2 | S2 | AC6 | V2 | S3 | AC3 | V3 | S3 | AC5 | V2 | S3 | AC5 | V2 | S3 | AC5 | V2 |
| Change in species range both flora and fauna | S2 | AC5 | V1 | S2 | AC5 | V1 | S2 | AC5 | V1 | S1 | AC5 | V1 | S2 | AC5 | V1 | S1 | AC5 | V1 | S3 | AC5 | V2 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 |
| Increase in invasive/exotic species presents | S2 | AC5 | V1 | S3 | AC5 | V2 | S3 | AC5 | V1 | S1 | AC5 | V1 | S3 | AC4 | V2 | S1 | AC5 | V1 | S4 | AC2 | V4 | S3 | AC3 | V3 | S3 | AC3 | V3 | S3 | AC3 | V3 |
| Increase in insects and disease outbreaks | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S3 | AC4 | V2 | S1 | AC5 | V1 | S4 | AC2 | V4 | S3 | AC3 | V3 | S3 | AC3 | V3 | S3 | AC3 | V3 |
| Loss of species at risk due to vulnerability; loss of diversity | S1 | AC5 | V1 | S3 | AC5 | V2 | S1 | AC5 | V1 | S1 | AC5 | V1 | S2 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S3 | AC4 | V2 | S3 | AC4 | V2 | S3 | AC4 | V2 |
| Negative impact to the forest because of violent storms | S2 | AC5 | V1 | S2 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S2 | AC5 | V1 | S1 | AC5 | V1 | S3 | AC3 | V3 | S3 | AC4 | V2 | S3 | AC4 | V2 | S3 | AC4 | V2 |

| Impacts | Monitoring | | | Research & Innovative Approaches | | | Education & Outreach | | | Daily Business Operations | | | Facility & Fleet Management | | | Public & Partners Engagement | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S | AC | V | S | AC | V | S | AC | V | S | AC | V | S | AC | V | S | AC | V |
| Change in ice cover regime | S4 | AC3 | V4 | S2 | AC5 | V1 | S2 | AC5 | V1 | S2 | AC5 | V1 | S1 | AC5 | V1 | S2 | AC5 | V1 |
| Change in a watercourse flow and hydrological regime | S4 | AC2 | V4 | S2 | AC5 | V1 | S2 | AC5 | V1 | S2 | AC3 | V3 | S1 | AC5 | V1 | S2 | AC5 | V1 |
| Increased risk of winter flooding | S4 | AC2 | V4 | S2 | AC5 | V1 | S2 | AC5 | V1 | S4 | AC3 | V3 | S1 | AC5 | V1 | S3 | AC4 | V2 |
| Increased risk of flash flooding | S4 | AC2 | V4 | S3 | AC3 | V3 | S2 | AC5 | V1 | S4 | AC3 | V3 | S1 | AC5 | V1 | S3 | AC4 | V2 |
| Increased erosion | S1 | AC5 | V1 | S2 | AC4 | V2 | S2 | AC5 | V1 | S3 | AC5 | V2 | S2 | AC4 | V2 | S1 | AC5 | V1 |
| Increased risk of drought/low water conditions | S2 | AC3 | V2 | S3 | AC3 | V3 | S2 | AC5 | V1 | S4 | AC3 | V4 | S2 | AC4 | V2 | S3 | AC3 | V3 |
| Decreased summer/fall water levels (lakes and watercourses) | S2 | AC5 | V1 | S2 | AC4 | V2 | S2 | AC5 | V1 | S2 | AC4 | V2 | S1 | AC5 | V1 | S2 | AC5 | V1 |
| Increased and more competitive demand for | S2 | AC3 | V2 | S2 | AC4 | V2 | S2 | AC5 | V1 | S4 | AC3 | V4 | S4 | AC2 | V4 | S3 | AC3 | V3 |
| Decrease in soil moisture | S1 | AC5 | V1 | S2 | AC4 | V2 | S2 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 |
| Decrease in groundwater levels | S3 | AC3 | V3 | S3 | AC3 | V3 | S2 | AC5 | V1 | S4 | AC3 | V4 | S4 | AC2 | V4 | S3 | AC3 | V3 |
| Change /decrease in wetlands and wetland species | S2 | AC5 | V1 | S1 | AC5 | V1 | S2 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S3 | AC3 | V4 |
| Increase in water temperature | S3 | AC3 | V3 | S3 | AC3 | V3 | S2 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 |
| Change in water chemistry parameters | S1 | AC5 | V1 | S3 | AC3 | V3 | S2 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S2 | AC5 | V1 |
| Deterioration of water quality | S3 | AC3 | V3 | S3 | AC3 | V3 | S2 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S2 | AC5 | V1 |
| Change in fish community composition (toward warm-water community) | S4 | AC2 | V4 | S3 | AC3 | V3 | S2 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 | S2 | AC5 | V1 |
| Increase of growing season | S1 | AC5 | V1 | S3 | AC3 | V3 | S2 | AC5 | V1 | S1 | AC5 | V1 | S3 | AC4 | V2 | S2 | AC5 | V1 |
| Unpredictable temperature fluctuation (episodes of late frost/early heat) | S2 | AC6 | V2 | S3 | AC3 | V3 | S2 | AC5 | V1 | S1 | AC5 | V1 | S2 | AC5 | V1 | S1 | AC5 | V1 |
| Change in species range both flora and fauna | S4 | AC2 | V4 | S3 | AC3 | V3 | S2 | AC5 | V1 | S2 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 |
| Increase in invasive/exotic species presents | S4 | AC2 | V4 | S2 | AC4 | V2 | S2 | AC5 | V1 | S2 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 |
| Increase in insects and disease outbreaks | S2 | AC5 | V1 | S1 | AC5 | V1 | S2 | AC5 | V1 | S3 | AC4 | V2 | S3 | AC4 | V2 | S1 | AC5 | V1 |
| Loss of species at risk due to vulnerability; loss of species diversity | S2 | AC5 | V1 | S1 | AC5 | V1 | S2 | AC5 | V1 | S2 | AC5 | V1 | S1 | AC5 | V1 | S1 | AC5 | V1 |
| Negative impact to the forest because of violent | S2 | AC5 | V1 | S1 | AC5 | V1 | S2 | AC5 | V1 | S3 | AC4 | V2 | S4 | AC2 | V4 | S1 | AC5 | V1 |