City of Niagara Falls Draft Climate Change Adaptation Implementation Plan

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Land Acknowledgement

We respectfully acknowledge the many land treaties that overlay the city of Niagara Falls and Niagara Region and we acknowledge and thank the Indigenous peoples who have been stewards of this land for a millennia before us. The work undertaken to develop and subsequently implement this Plan takes place on the traditional territory of the Haudenosaunee and the Anishinaabe peoples, many of whom continue to live and work here today.

Executive Summary

Climate change is a reality that our community is currently facing. Already, we are seeing how climate change impacts our local infrastructure, economy, and well-being. The City of Niagara Falls (City) has taken a proactive approach to reducing the impacts of a changing climate and extreme weather on the community's built, social, natural, and economic systems by guiding the development of this Climate Change Adaptation Implementation Plan (hereafter referred to as Adaptation Plan). The development of this Adaptation Plan, along with forthcoming implementation of its actions, will help the city minimize the negative impacts of climate change by addressing local risks while also seizing any local opportunities to increase resilience.

The adaptation planning process has been supported by ICLEI Canada and a core City team out of the Municipal Works Department and Mayor and CAO's Office. A Niagara Falls climate change working group was formed to provide input into the development of the community's Adaptation Plan from February to August 2023 and consisted of a dedicated network of community members, organizations, City staff and stakeholders. The Adaptation Plan development process also included targeted engagement with the business community.

The goals and actions in the Adaptation Plan have been developed to address the impacts of climate change that are the highest priority to the community. They are presented in this plan under 5 themes; Nature & Biodiversity, Infrastructure, Health & Wellbeing, Economy & Workers, and Resilient Governance. Climate change mitigation actions have been included within some of the goals and actions in order to build on the momentum of this adaptation work and drive action towards greenhouse gas reduction. The Adaptation Plan of Niagara Falls will be implemented over the next 5 years, at least, with annual reports to the City's Senior Leadership Team and a report every second year to City Council.

Acknowledgements

PROJECT TEAM

The Adaptation Plan was coordinated by a core team consisting of three dedicated staff from the Mayor, CAO and Business Development Offices and the department of Municipal Works. ICLEI Canada guided the Adaptation Plan's development and is part of a global network of more than 2500 local and regional governments committed to sustainable urban development and whose not-for-profit work influences sustainability policy and drives local action for low-emission, nature-based, equitable, resilient and circular development.

ADAPTATION WORKING GROUP

The on-the-ground experience and insights provided by those who live and work in Niagara Falls have contributed to the development of robust and relevant goals and actions to address local climate change impacts. The City of Niagara Falls would like to thank all those who contributed to the development of the Adaptation Plan and acknowledge the following individuals for their dedication to climate adaptation.

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Message from the Mayor

Glossary of Terms

ADAPTATION

Includes any initiatives or actions in response to actual or projected climate change impacts and which reduce the effects of climate change on built, natural, and social systems.

ADAPTIVE CAPACITY

The ability of built, natural, and social systems to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

CLIMATE

The weather of a place averaged over a period of time, often 30 years. Climate information includes the statistical weather information that tells us about the normal weather, as well as the range of weather extremes for a location.

CLIMATE CHANGE

Refers to a statistically significant variation in either the mean stake of the climate or in its variability, persisting for an extended period (decades or longer). Climate change seen today is due to persistent anthropogenic changes in the composition of the atmosphere or in land use.

CLIMATE CHANGE SCENARIO

A climate change scenario is the difference between a future climate scenario and the current climate. It is a simplified representation of future climate based on comprehensive scientific analyses of the potential consequences of anthropogenic climate change. It is meant to be a plausible representation of the future emissions based on a coherent and consistent set of assumptions about driving forces (such as demographic and socioeconomic development, technological change, etc.) and their key relationships.

CLIMATE IMPACT

The effects of existing or forecasted changes in climate on built, natural, and human systems. One can distinguish between potential impacts (impacts that may occur, given a projected change in climate, without considering adaptation) and residual impacts (impacts of climate change that would occur after adaptation).

CLIMATE PROJECTIONS

Climate projections are predictions of the response of the climate system to emissions or concentration scenarios of greenhouse gases. These projections depend upon the climate change (or emission) scenario used, which are based on assumptions concerning future socioeconomic and technological developments that may or may not be realized and are therefore subject to uncertainty.

EXTREME WEATHER EVENT

Extreme weather includes unusual, severe, or unseasonal weather; weather at the extremes of the historical distribution seen in the past. An extreme weather event would normally occur very rarely or fall into the tenth percentile of probability.

IMPACT STATEMENT

Statements that outline locally relevant projected threats and how those changes are expected to affect the built, natural, social, and economic systems of the municipality.

INFRASTRUCTURE

The fundamental facilities and systems serving the city of Niagara Falls and its citizens including both green and grey infrastructure, such as transportation systems, utilities, public facilities, and urban trees.

GREENHOUSE GAS

A gas in the atmosphere that absorbs and emits radiation within the thermal infrared range, causing the greenhouse effect. The primary greenhouse gases in the Earth’s atmosphere are water vapour, carbon dioxide, methane, nitrous oxide, and ozone.

GREEN INFRASTRUCTURE

Natural and human-made infrastructure that address urban and climatic challenges, while providing other co-benefits, by building with nature. Green infrastructure can include natural heritage features and systems, parklands, storm-water management systems, street trees, urban forests, natural channels, natural permeable surfaces, and green roofs.

GREY INFRASTRUCTURE

Human-made traditional infrastructure such as sewers and pipes.

LOW CARBON RESILIENCE

The coordination of adaptation and mitigation strategies to reduce both greenhouse gas emissions and climate change impact risk and vulnerability.

MITIGATION

The promotion of policy, regulatory, and project-based measures that contribute to stabilization or reduction of greenhouse gas concentrations in the atmosphere. Renewable energy programs, energy efficiency frameworks, and substitution of fossil fuels are examples of climate change mitigation measures.

RESILIENCE

The capacity of a system, community, or society exposed to hazards to adapt by resisting or changing in order to reach and maintain an acceptable level of functioning and structure.

RISK

The combination of the likelihood of an event occurring and its negative consequences. Risk can be expressed as a function where Risk = *likelihood x consequence*. In this case, *likelihood* refers to the probability of a projected impact occurring and *consequence* refers to the known or estimated outcomes of a particular climate change impact.

WEATHER

The day-to-day state of the atmosphere and its short-term variation in minutes to weeks.

Introduction

THE NEED FOR BOTH ADAPTATION & MITIGATION

The impacts of climate change have been recognized as crucial issues in Canada, Ontario, and for the city of Niagara Falls. It is widely recognized that the impacts of climate change affect the services and infrastructure of local governments, and thus require both adaptation strategies to increase municipal resilience.

Climate change adaptation refers to any initiative or action that seeks to reduce the vulnerability of social, economic, built, and natural systems to a changing climate. Adaptation efforts may focus on changing individual behaviours, updating municipal by-laws and policies, enhancing the capacity of physical infrastructure, and improving ecological services. A community-based adaptation approach can further support local governments in building resilience while reducing vulnerability via meaningful engagement of communities and residents throughout the entire process of adaptation. The co-creation of an adaptation plan ensures the important involvement of a wide range of community stakeholders, allowing for the collaborative co-development of a plan that addresses climate risks across multiple sectors and systems. This process also recognizes and aims to shift the power dynamics amongst decision-makers and other actors within the participatory process.

Climate change mitigation refers to the implementation of policy, regulatory, and project-based measures that contribute to the reduction of greenhouse gas concentrations in the atmosphere. These could include building retrofits to conserve energy, transitioning to low-carbon energy sources, and reducing car-dependency. Mitigation efforts are ultimately essential in protecting against climate change impacts by addressing the source of

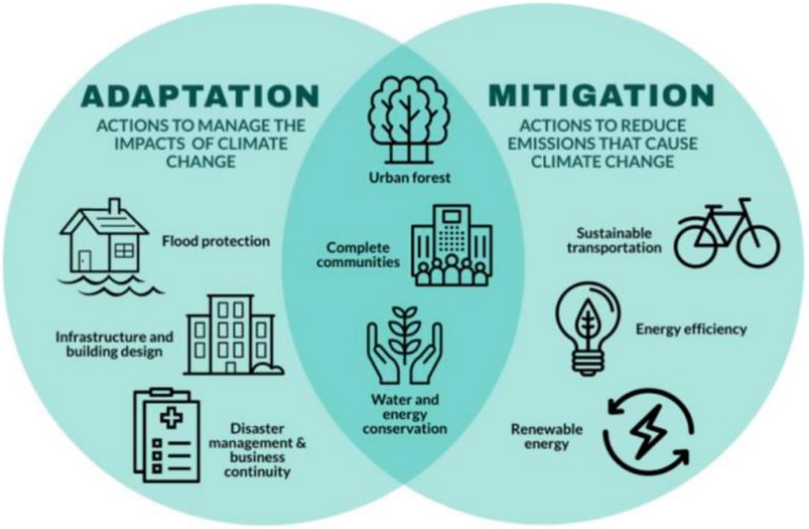

Figure 1: Adaptation, mitigation, and low-carbon resilient actions. Source: ICLEI Canada, 2019

the impacts themselves, and thus working to avoid potentially unmanageable consequences.

Taking action on climate change will require a diversity of responses. While mitigation efforts work to contain the long-term impacts of climate change, adaptation measures are needed to address the climate change impacts now and in the short-term future. Adaptation does not replace or undermine mitigation efforts, but rather compliments local government efforts to protect and improve their long-term sustainability. In some instances, local governments can implement low carbon resilience actions which integrate both mitigation and adaptation approaches to both reduce greenhouse gas emissions and reduce the vulnerabilities to the impacts of climate change in order to realize the co-benefits of their activities.

RECENT EXTREME WEATHER IN NIAGARA FALLS

The development of this plan responds to the projected increase in intensity and frequency of extreme weather events in Niagara Falls. Niagara Falls is vulnerable to more frequent extreme heat events, more frequent heavy precipitation and associated flooding risks and damages, and more extreme weather events. These pose threats to the natural environment, built infrastructure, and human health and wellbeing. Recent events in Niagara Falls include an increase in the frequency and temperatures of heatwaves, such as those experienced in 2018, 2020, 2021, and 2022. Extreme rain and flood events have been experienced in the Niagara Region nearly every year in the last 10 years, and have resulted in basement flooding, sewer backups, flooded agricultural lands and have caused road closures, infrastructure damage, shoreline erosion, overwhelmed sewer and stormwater systems, park and beach closures, and power outages. Additionally, the Niagara Region experienced a severe blizzard with freezing rain, heavy snowfall, wind gusts over 105-124km/h, storm surges on Lake Erie, and -20°C temperatures. Across the US border, in December of 2022, the Buffalo Region received nearly four feet of snow, hurricane force winds, whiteout conditions, and thousands of calls to emergency services over the course of four days. As Niagara Falls has already begun experiencing climate change impacts, the community is committed to reducing vulnerabilities and improving our resiliency.

POLICY DIRECTION ON ADAPTATION

International

Climate change affects all nations and regions of the world, making international agreements and intentions to address climate change imperative. The 2015 Paris Agreement is an international treaty signed by 195 countries, including Canada, that aims to limit increases in global temperatures to below 1.5℃ above pre-industrial levels. Not only are clear targets set to achieve this, but the agreement also outlines the goal of enhancing adaptive capacity, strengthening resilience, and reducing vulnerabilities of global climate change by individual signatory nations. Fulfilling the Paris Agreement relies on the governments, organizations, and citizens of each nation to take place-based actions through initiatives such as mitigation and adaptation policies and plans.

The United Nations International Panel on Climate Change (IPCC)'s Assessment Reports (AR), including the most recent Sixth Assessment report (AR6), provide climate change scenarios and the underlying socioeconomic contexts which may present challenges to mitigation and adaptation policies. The Shared Socio-Economic Pathways (SSP)s incorporate socioeconomic characteristics and other human-caused climate drivers (e.g., population growth, education levels, GDP growth, income inequality, use of technology, energy use, political contexts, land-use change) to derive scenarios that describe differing influences on greenhouse gas emissions. The AR6 incorporates new data, new models, and updated climate research from around the world to allow for a standardized comparison of society's choices and their resulting levels of climate change. The IPCC's AR6 – 2022 Climate Change: Impacts, Adaptation and Vulnerability states that:

"Human-induced climate change, including more frequent and intense extreme events, has caused widespread adverse impacts and related losses and damages to nature and people, beyond natural climate variability. Some development and adaptation efforts have reduced vulnerability. Across sectors and regions the most vulnerable people and systems are observed to be disproportionately affected. The rise in weather and climate extremes has led to some irreversible impacts as natural and human systems are pushed beyond their ability to adapt (*high confidence*)."

Federal

In addition to signing onto the Paris Agreement, the Government of Canada has produced several policy documents that inform and guide decision-makers on climate change adaptation. Most recently, Canada's first National Adaptation Strategy was released in June 2023 and outlines a shared path to a more climate-resilient Canada. This document sets out five common directions for action, which include; disaster resilience, health and wellbeing, nature and biodiversity, infrastructure, and economy and

workers. This whole-of-society blueprint guides action in Canada to better adapt to and prepare for the impacts of climate change and addresses key climate risks in Canada. The National Adaptation Strategy complements other national strategies that build resilience and reduce greenhouse gas emissions, including Canada's 2030 Emission Reduction Plan, National Housing Strategy, Poverty Reduction Strategy, Canadian Wildland Fire Strategy, the Emergency Management Strategy for Canada, and others. The Strategy was developed over several years with the involvement of provincial, territorial, and municipal governments, Indigenous Peoples, and other key partners. The new National Adaptation Strategy will coordinate efforts and investments to ensure climate adaptation actions are taken across the country.

Provincial

The Government of Ontario's *A Made-in-Ontario Environment Plan* addresses climate change through both mitigation and adaptation strategies. These strategies include emissions performance standards and regulations to reduce emissions from the transportation sector, programs to enhance and expand public transit networks, funding for extreme weather resistant infrastructure, a province-wide multi-sector provincial climate change impact assessment, and the *Protecting People and Property: Ontario's Flooding Strategy* to reduce flood risk. Additionally, the *Provincial Policy Statement* has been updated to include direction for planning authorities to prepare for the impacts of a changing climate, climate change decision-making in land-use and development policy, and enhancements for storm water management policies for climate resilience.

Regional

In early 2023, the Niagara Region completed a corporate greenhouse gas emission inventory using 2018 data—the most recent year for which comprehensive energy and emissions data is available—to establish its baseline year. This inventory looked at energy consumption, energy expenditure and emissions generated and provided forecasting and trend analysis. This process was undertaking using the Partners for Climate Protection (PCP) program, which is a partnership between ICLEI Canada and the Federation of Canadian Municipalities (FCM). This first milestone of creating an inventory is the first of a five-milestone program. The Niagara Region is now also looking at undertaking an adaptation planning process for the region using the same Building Adaptive and Resilient Communities (BARC) framework as the City of Niagara Falls.

THE ROLE OF LOCAL GOVERNMENTS

The National Adaptation Strategy recognizes the important role of municipalities in implementing climate solutions on a local level throughout the country. While federal and provincial governments provide strategic focus, standards, and potential funding streams for adaptation, it is local governments who tailor climate change adaptation strategies to their local circumstances and to the unique set of climate change impacts they already experience and are projected to face in the future.

It is widely recognized that the impacts of climate change affect the services and infrastructure of local governments and has the potential to affect all City departments. Thus, municipal governments have a unique interest and opportunity in planning to adapt to climate change and already possess many of the tools necessary to increase resilience, such as emergency response groups, standards, codes, and official plans. Ontario's 2014 *Provincial Policy Statement* references climate change in a number of policies and mandates local planning authorities to support climate change adaptation through land use and development decisions. Through the development of this Adaptation Plan the City of Niagara Falls is upholding this local government responsibility to ensure optimal wellbeing for the entire community.

Our Approach

Municipalities of all sizes across Canada are employing planning processes to adapt to the realities of climate change. Adaptation plans must be relevant to local circumstances, resources, and capacity. The adaptation planning process has been supported by ICLEI Canada and a core City team out of the Municipal Works Department and Mayor and CAO's Office. A Niagara Falls climate change working group was formed to provide input into the development of the community's Adaptation Plan from February to August 2023 and consisted of a dedicated network of community members, organizations, City staff and stakeholders. The Adaptation Plan development process also included targeted engagement with the business community.

THE BARC METHODOLOGY & PROCESS

Development of the Adaptation Plan was guided by ICLEI Canada's Building Adaptive and Resilience Communities (BARC) Framework. BARC is a five-milestone planning framework for communities aimed at preparing them for the impacts of climate change. BARC is a comprehensive planning methodology that guides users through areas of research and climate impact identification, vulnerability and risk assessment, plan development, implementation planning, and monitoring and review strategies. This Canadian-designed program is flexible in its ability to adjust to the needs and circumstances of each community with a goal to protect the people, property, and prosperity of a community. It uses a systems approach to municipal climate change adaptation and has been used by hundreds of municipalities throughout Canada. The development of this Adaptation Plan completed the first three of the milestones.

Collaborative Approach

BARC, is at its core is a collaborative process that derives information through a bottom-up process where the people participating are core to identifying what projected climate change actually will result in locally. Enhancing awareness and building capacity are cornerstones to the BARC approach to climate adaptation planning, bringing together key community stakeholders, municipal decision-makers, and cross-jurisdictional partners to co-develop Niagara Falls' Adaptation Plan. The climate change impacts, goals, and actions presented in this plan have been centred on workshops and engagement activities that leveraged the expertise and local knowledge to ensure that the overall plan aligns with existing organizational priorities and can be integrated within departmental functions. These collaborative efforts have been instrumental to strengthen existing partnerships, to draw on community expertise, and to identify where additional engagement may be required to implement the adaptation actions identified. This strong collaborative approach builds climate action momentum and was followed to ensure:

- Local knowledge and experience integration;
- Involvement of decision-makers and City staff, and stakeholder engagement throughout the process;
- Reflection of the practical needs and fiscal realities of the city; and
- Integration of actions into existing plans and policies.

Milestone One: Initiate

Within this milestone, the project core team was created and worked to identify stakeholders to be involved in the working group. The project's scope and stakeholder roles were clarified. The project core team also reviewed existing initiatives and knowledge related to climate change impacts.

Milestone Two: Research

The second milestone developed the community's understanding of climate change impacts. A Climate Science Report (see the Appendix B) was developed that looked closely at the projected changes in the local climate including increases in temperature and temperature variability, changes in precipitation, and increased frequency and severity of extreme weather events.

Armed with this data on projected climate threats the project working group identified a list of impacts across four broad systems; built infrastructure, natural environment, social, and economic. The impact long-list, which for Niagara Falls included 65 impacts and 12 potential opportunities, was then refined into concise impact statements that include the climate trend, the outcome, and the consequence. The refined 38 impacts statements were then prioritized using a vulnerability assessment followed by a risk assessment, which brought the number of impact statements first down to 26 and then finally to 19 high priority impacts to Niagara Falls.

This research phase of the BARC process included two-in person workshops, one online survey, and several individual follow ups in order to identify and prioritize which impacts Niagara Falls is particularly susceptible to.

Milestone Three: Plan

The third milestone established a vision for the Adaptation Plan, set goals, identified actions, and examined current local initiatives to build upon. Numerous engagement opportunities were held in Niagara Falls during this milestone including; a goal and action setting workshop, a business breakfast, a City Senior Leadership team meeting and associated worksheet, and several individual follow ups. Implementation schedules were then drafted to include details including; monitoring metrics and baseline data, financing and budget, involvement and responsibilities of organizations/departments, and timeline. The implementation schedules were developed over one action validation and three focused implementation detail virtual workshops, as well as numerous individual follow up engagements. Throughout this milestone actions and their details were reviewed, refined and analyzed for their ability to build on existing initiatives and that address prioritized impacts by the project team. The drafting and development of this Adaptation Plan completes this milestone.

Milestone Four: Implement

In the fourth milestone, communities work to ensure that they have the approval and support of council, municipal staff, and the community in order to move forward on implementation. Communities will also make sure they have the appropriate implementation tools to ensure the ongoing success of the Plan.

Milestone Five: Monitor & Review

The fifth and final milestone serves to assess whether the goals and actions of the Plan have been achieved, and serves to identify any problems that have been encountered and develop solutions. Additionally, the fifth milestone helps communities communicate their progress to City Council and the broader community.

Climate Science & Impacts

It has long been identified by scientific evidence that the global climate is changing at rates quicker than ever before. Human activity is the cause of rising concentrations of heat-trapping greenhouse gases in the atmosphere which align with long term, exponential trends of increases in global average temperatures since the 1800s. This kind of rapid warming leads to many other effects as warmer air contains more moisture than cooler air, which provides "fuel" for extreme events.

All areas of the world have already been or will be affected by climate change, including Canada. In fact, Canada's rate of warming over the last seven decades has been almost double that of global averages over the same period. Canada's average annual over land surface air temperatures have warmed by 1.7℃ since 1948. Canada has also experienced increases in average annual precipitation by 16% from 1950-2010, and more so since then. These changes and others will lead to more and longer heat waves, torrential rainstorms, windstorms, drought, and extreme wildfires. Although these changes and their impacts are felt to varying degrees across the country, Ontario and the Niagara Falls area are already experiencing many of these impacts.

CLIMATE CHANGE PROJECTIONS FOR THE CITY OF NIAGARA FALLS

Information throughout this section is derived from the Niagara Falls Climate Science Report (Appendix B), which used data from Climatedata.ca.

Temperature

Temperatures in the Niagara Falls region are expected to rise, aligning with the Ontario projection of a 4.8℃ average temperature increase by the end of the century[1]. More specifically, Niagara Falls is expected to experience an average temperature increase of 2.4℃ in the immediate future and as much as a 4.6℃ increase by 2080[2]. This coincides with average summer temperatures rising to 30.3℃ in the near future (2051-2080). This prediction does not include warming due to the humidex, which can make temperatures feel an additional 5-10℃ warmer[3].

Overall, the number of extreme heat days in summers (when the maximum temperature is 30℃ or greater) are expected to increase in Niagara Falls from 11 to 60 days in the 2051-2080 period – a six-fold increase by 2080[4]. Days reaching or exceeding 30℃ pose threats to community

health from heat-related illnesses. This includes heat cramps, heat edema, heat exhaustion, and heat stroke. Heat-related illnesses can manifest quickly and can lead to long-term health problems and even death. Additionally, specific groups, such as outdoor workers, infants and youth, adults above the age of 65, those with chronic medical conditions, people experiencing homelessness, people participating in outdoor sports or activities, and those with limited mobility may be more adversely affected by extreme heat[5].

The increase in average temperatures includes warmer winters and less extreme cold days. This has implications for life in Niagara Falls as extreme cold temperatures affect health and safety, determine what plants and animals live in the area, limit or enable outdoor activities, dictate building and vehicle design, and shape transportation and energy use. Frost days (when the minimum temperature is below 0℃) and ice days (when the maximum temperature is below 0℃) are both expected to decrease. Among other impacts, this may affect the survival and spread of ticks and Lyme disease, as ticks can thrive in temperatures above 4℃ and delays in cold weather can extend the duration of their activity[6]. Less extreme cold temperatures also implies that there is a decrease in freeze-thaw cycle days (when the minimum temperature is below 0℃ and the maximum temperature is above 0℃ on the same day). On these days, water on the surface can transition between water and ice. Freezing, melting, and refreezing can greatly damage roadways, sidewalks, and other outdoor infrastructure. Therefore, a decrease in these conditions can reduce instances of potholes or other such damages.

Precipitation

Overall, precipitation across Canada has increased by approximately 20% over the past 50 years[7]. The intensity of this change is felt to varying degrees across the country, with Ontario experiencing less dramatic changes in precipitation patterns compared to other regions such as Northern Canada. Accordingly, by the end of the century Niagara Falls is expected to experience greater precipitation accumulations seasonally, with the most intense increases during spring and winter. Combined with relatively steady summer rainfall and projected increases in summer temperatures and longer heatwaves, increased instances of summer drought are expected. As with all climate impacts, the severity of these projections depends on the amount of future greenhouse gas emissions. In a high emissions scenario, from the baseline average annual precipitation of 840 mm, Niagara Falls can expect to experience an average annual precipitation increase of 84 mm from 2021-2050 and 123 mm from 2051-2080[8]. This is contrasted by a less noticeable 25 mm increase from 2021-2050 and 42 mm from 2051-2080 in a low emissions scenario[9].

Extreme Weather

Canada’s most frequent or intense extreme weather events on record have been experienced in the last 50-60 years. This includes extreme heat days, precipitation events and

flooding, wind storms, wildfires, and ice storms. In the last 40 years, extreme weather events have resulted in $31 billion of damages in Canada and $5 trillion globally[10]. These economic burdens are certain to continue to increase, should the expected intensification of extreme weather events materialize. It will be necessary for more resources to be allocated to addressing damage to infrastructure and critical services, economic and industry productivity, and the health of vulnerable populations[11].

Heavy and extreme rain events are the most pronounced weather changes in Niagara Falls and are expected to become increasingly intense and frequent[12]. As Southern Ontario is the most intensely urbanized area in the province, the costs of insured and uninsured damages associated with flooding is significantly higher than elsewhere in Ontario[13]. In the Niagara region, extreme rain and flood events have already been increasing over the last 10 years.

Heavy precipitation days (when at least 10 mm of rain or frozen precipitation falls) are expected to continue to increase, reaching an average of 30 days annually from 2051-2080[14].

These increases in extreme precipitation events coincide with changes in freezing rain patterns and occurrences. A study by the Meteorological Service of Canada and the Science and Technology branch of Environment and Climate Change Canada finds an increase in the percentage of freezing rain mostly during January in this region, and secondarily during December and February[15]. Overall, severe freezing events (when there is freezing rain for longer than 6 hours per day) are projected to increase 30% by 2100[16].

Overview of climate change projections for the city of Niagara Falls

Temperature

Mean temperatures will increase annually and in every season, and temperature extremes will become more severe.

+ 4.6°C
Annual Mean Temperature

+ 49
Extreme Hot Days

+ 4.4°C
Summer Mean Temperature

Precipitation

Annual precipitation will increase and winter and spring will become significantly wetter. Summer precipitation will remain similar, however, paired with increased temperatures, will result in drought conditions.

+ 96 mm
Annual Mean Precipitation

+ 4
Heavy Rainfall Days

+ 44 mm
Winter Mean Precipitation

Extreme Weather

Precipitation events, such as freezing rain events for > 6 hrs/day, will increase 30% by 2100 and will become more intense. Heavy rainfall days are also projected to increase.

+ Frequency
Faster Falling Precipitation

+ Intensity
More Intense Short Storms

Short Duration
Quicker Return of Storms

PRIORITY IMPACTS FOR THE CITY OF NIAGARA FALLS

The City of Niagara Falls is committed to advancing climate change adaptation planning to reduce vulnerabilities, minimize threats to our environment, lifestyle, economy, governance, and overall quality of life, and holistically improve resilience. Given the aforementioned climate change projections, priority impacts for Niagara Falls have been identified by assessing risks associated with temperature, precipitation, and extreme weather changes. 65 potential climate change impacts were identified by the project working group. Through a refinement process, a vulnerability assessment and a risk assessment a final list of 19 impacts received a risk score of medium-low or higher. Of these impacts, seven are related to temperature, seven to precipitation, and five to extreme weather.

Temperature-Related Priority Impacts

TEMP1 Increase in annual temperature and shifting ecozones resulting in additional stress to ecologically sensitive areas, migratory species, managed vegetation, and biodiversity loss.

TEMP2 Increased average summer temperatures and extreme heat days (>30 C) resulting in increased demand for indoor facilities with air conditioning (hospitals, libraries, etc.) shaded outdoor spaces especially for vulnerable populations.

TEMP3 Increased frequency and duration of hot days (>30 C), leading to health and safety risks (e.g. domestic violence/violent altercations, cardiovascular disorders, heat stress, food-borne/water-borne illnesses, etc.) to vulnerable populations (e.g. seniors, women, children, those with chronic health conditions, temporary foreign workers, those without AC, etc.).

TEMP4 Increased frequency and duration of hot days (>30 C), resulting in project delays, reduced productivity (e.g. from heat stress to workers) and increased need to redesign infrastructure to adhere to higher resilience standards (i.e. more research, staff capacity, cost, etc.).

TEMP5 Increased frequency and duration of hot days (>30 C), causing reduced air quality leading to health and safety risks especially for vulnerable populations (e.g. seniors, women, children, those with chronic health conditions, temporary foreign workers, etc.).

TEMP6 Increase in hot days over 30 °C leading to heat stress on outdoor workers (e.g. City staff, agriculture and construction workers, etc.), those who use active transportation for mobility, and outdoor recreational activities (e.g. watersports, hikers, etc.)

TEMP7 Increased frequency and duration of hot days (>30 C), and no change in precipitation, resulting in deterioration of and increased maintenance requirements for roads, culverts, water mains, sidewalks, trails, parking lots, and public spaces (arenas, pools, etc.).

Precipitation-Related Priority Impacts

PRECIP1 Increase in freezing rain occurrences requiring more salt use on roads, resulting in an increase in the amount of salt in water systems, soil, and stormwater ponds, and negatively affecting ecosystems.

PRECIP2 Increased frequency and intensity of precipitation and rapid increase in river water level resulting in increased erosion of riverbanks and hillsides, loss of riparian habitat and reducing water quality.

PRECIP3 Increase in water and air temperatures resulting in increased evaporation of wetlands and no change in precipitation amount negatively affecting wetland species.

PRECIP4 Increase in intensity of precipitation resulting in damaged vegetation, either from impact of precipitation, flooding, or inability for plants to access water that runs off in a short period of time (e.g., trees, vineyards, etc.)

PRECIP5 Increase in flash flooding occurrences overwhelming the sewage system resulting in stormwater system failures that cause damage to buildings and assets and negatively affect the health of humans and ecosystems.

PRECIP6 Increased spring, fall, winter precipitation leading to increased frequency of flooding resulting in damage to buildings, homes, ecosystems and built infrastructure such as bridges and roadways.

PRECIP7 Hotter summers and no change in precipitation amount resulting in damaged or dead vegetation, including trees, reducing their benefits and increasing maintenance and replacement costs.

Extreme Weather-Related Priority Impacts

EXT1	Increased extreme weather events resulting in damage to urban forest and green spaces (e.g., trees, bushes, etc.) resulting in a loss of ecosystem services and a decrease in biodiversity.
EXT2	Increased frequency/intensity of extreme weather events resulting in more frequent vehicle accidents and property damage leading to increased legal, financial, and insurance implications.
EXT3	Increased extreme weather resulting in damage and disruption to critical infrastructure causing an increase in service needs (EMS, municipal operations, transportation).
EXT4	Increased extreme weather events resulting in tree damage leading to downed power lines, utility distribution issues, and increased costs to maintain power infrastructure.
EXT5	Increased frequency and intensity of extreme weather events, including freezing rain, resulting in unsafe road conditions leading to difficulty enacting emergency protocols and increased maintenance, fleet scheduling challenges, labour costs, etc.

Vision

Niagara Falls will reduce greenhouse gas emissions and be a resilient, climate-ready city working proactively to promote sustainable practices, preserve and enhance our natural beauty and assets, and take continued action to support residents and visitors to adapt to climate change.

The intent of this Adaptation Plan is to provide strategic direction to the City and community of Niagara Falls in order to achieve the vision and become a climate-ready city.

Themes, Goals & Actions

The following section presents themed-groupings of the goals and actions identified to address each of the prioritized climate impacts in Niagara Falls. The goals and supporting actions in this Adaptation Plan are the fundamental pieces of the path forward for Niagara Falls to move closer to our vision of a climate resilient and low carbon community.

The five themes are interconnected and are one way to relate the goals and actions into our community's vision. The themes, in most cases, mirror the five themes in Canada's National Adaptation Strategy and are; Nature & Biodiversity, Infrastructure, Health & Wellbeing, Economy & Workers and Resilient Governance.

The goals break down the broad Adaptation Plan vision into more theme-specific outcomes we want to achieve in Niagara Falls.

The 41 actions include those that will build a climate-ready Niagara Falls and address the 19 prioritized climate change impacts. Many of the actions build upon current initiatives within the city, including those that are perhaps not labelled as 'climate action'. A focus on the Adaptation Plan is to align current resources to increase the resilience of the community and strengthen policies, develop new programs or practices where gaps exist, work collaboratively amongst partners, and undertake the steps necessary to integrate climate action as a core function of the community. Those actions that will also address low-carbon and mitigation goals are indicated with a climate mitigation icon.

Action implementation details and considerations, including supporting actions are included in the Adaptation Plan's appendices under the Implementation Schedules.

NATURE & BIODIVERSITY

Goal: To foster the resilience of Niagara Falls' natural landscape to ongoing changes in climate and enhance its value in providing both climate change adaptation and mitigation benefits

Action 1 Integrate and align regional management of the urban forest, parks, open spaces and natural features with City plans, policies and procedures.

Action 2 Complete the development of the City's Urban Forest Strategy and implement its recommendations.

Action 3 Enhance partnerships and engage the community to protect, plant and maintain plants, especially those that are native and climate resilient, including through academic research, educational events, tree programs, planting initiatives and through media.

Goal: To integrate the management of the urban forest, parks, open spaces and natural features into City plans, policies and procedures

Action 4 Enhance naturalization of buffer zones around waterways and wetlands, including stormwater ponds.

Action 5 Identify opportunities to expand natural assets and low-impact development as alternatives to traditional grey infrastructure.

Action 6 Identify opportunities to better protect existing natural assets such as tree canopy, green spaces, wetlands, rivers, and floodplains as part of a stormwater management plan.

Action 7 Continue to update IDF curves with most up to date modelling and update/build infrastructure in accordance with the latest data.

Action 8 Work in partnership to ensure that Niagara Falls' watersheds are protected and enhanced in the face of climate threats and address emerging water issues.

INFRASTRUCTURE

Goal: To design, construct, and maintain physical infrastructure that is resilient to climate impacts while considering affordability, energy efficiency, natural assets, and reduction in greenhouse gasses

Action 9 Ensure infrastructure risk assessments include climate change considerations and buildings are built or retrofitted accordingly, using best practices in the design, construction, and maintenance to minimize service disruptions and increase resilience.

Action 10 Improve the resilience and sustainability of transportation infrastructure.

Action 11 Identify opportunities and resources to include carbon reductions and climate resilience in buildings when new builds and retrofits or renovations are planned, including updates to building envelope, flood reduction measures, and site level energy generation.

Goal: To manage land use that ensures that community assets and livelihoods are sustainable, counter urban-sprawl, optimize existing infrastructure, enhance neighbourhood connections and are resilient to the impacts of climate change

Action 12 Develop 'Green Design Guidelines' and update Engineering Design Standards for new developments and retrofits that include low-impact development and green infrastructure to manage heat and flooding.

Action 13 Review zoning by-laws to encourage densification that will provide net energy and land savings and conserve or enhance ecological functions.

Action 14 Update parking lot bylaws to reduce parking requirements and require a minimum amount of permeable surface and green infrastructure and trees in order to provide on-site stormwater management and shade, and promote alternative transportation.

Action 15 Identify and preserve land for future green spaces through the Official Plan and By-laws.

Action 16 Integrate natural assets into the City's asset management plans.

Goal: To ensure energy supply and infrastructure is sufficient, affordable, net-zero and resilient to weather-related disruptions

Action 17 Identify at-risk energy and communication infrastructure and opportunities to increase resilience to power outages as a result of increased demand or extreme weather.

Action 18 Undertake a greenhouse gas inventory and undertake actions to reduce GHG emissions from corporate and community energy sources, working off of the Region's recently completed corporate GHG inventory.

Action 19 Monitor peak energy consumption to better understand how strategies to mitigate brown and blackouts can be implemented.

HEALTH & WELLBEING

Goal: To build a resilient and sustainable local food system that promotes social justice and supports local production, storage, processing, sale and distribution of food

Action 19 Monitor peak energy consumption to better understand how strategies to mitigate brown and blackouts can be implemented.

Goal: To improve social connectedness of residents to their community and to organizations to minimize and better manage climate-related health and safety risks

Action 21 Improve community connection opportunities in collaboration with local organizations so that members are supported and more resilient during extreme weather events.

Goal: To ensure all have access to cooling during heat events

Action 22 Establish maximum-temperature by-law and air-quality standards for rental and multi-unit properties.

Action 23 Expand access to existing cooling and warming centres for use during other extreme weather events such as flooding and power outages and extend hours of operation.

Action 24 Work with businesses and organizations to identify and promote cooling spaces for tourists.

Action 25 Identify opportunities to retrofit existing City corporate buildings and assets with air conditioning and air filters to combat extreme heat and air quality impacts.

Action 26 Develop specific strategies and resources to support those in need of housing, medical and social support services during extreme weather.

Action 27 Work with local school boards to enhance the cooling abilities of all schools.

Action 28 Review and update policies, procedures, and training to ensure Niagara Falls staff and emergency responders are safe during extreme weather conditions.

Goal: To improve outdoor and indoor air quality

Action 29 Identify and promote the use of technology to improve indoor air quality in homes and businesses, and the value of trees to improve outdoor air quality (during heat and wildfire smoke events).

ECONOMY & WORKERS

Goal: To support businesses to becoming resilient to the impacts of climate change through clear guidance and resources

Action 30 Communicate business-specific strategies to build resilience to extreme weather events.

Action 31 Develop a business community climate best practices working group to develop and deliver business level risk assessments, emergency plans, and retrofit funding opportunities (heat pumps, renewable retrofits, building envelope enhancements, etc.).

Action 32 Expand upon federal/provincial guidelines for safe working conditions for workers exposed to extreme weather using best practices.

RESILIENT GOVERNANCE

Goal: To integrate climate change adaptation into operational procedures as well as land-use, financial, and strategic planning

Action 33 Systematically incorporate climate consideration into the City's Official, Strategic, Asset Management and Financial Plans.

Action 34 Develop a coordinating structure to implement and report on the plan.

Goal: To work with local, provincial and federal partners to prepare for, respond and recover effectively from sustained and/or multiple extreme events

Action 35 Create a climate working group with federal, provincial, regional, and indigenous governments, as well as businesses and community networks to improve the ability of Niagara Falls to prepare for, respond to, and recover from extreme weather events.

Action 36 Update emergency response plan to include expected climate hazards (such as extreme heat, flooding and storms).

Action 37 Continue to promote emergency preparedness week and 72-hour emergency kits.

Action 38 Work with Niagara Region, Niagara Peninsula Conservation Authority, Niagara Region Public Health, and municipalities within the Region to better understand roles and responsibilities, fill gaps in data collection, and expand sharing agreements in order to improve response to extreme weather events and increase efficiency of service delivery.

Goal: To support the community through education on how to prepare for, respond to, and recover from extreme weather events

- **Action 39** Develop a climate adaptation and mitigation communications strategy that focuses on actions one can take.

Goal: To identify project-specific and ongoing funding for climate projects that are in line with financial planning

- **Action 40** Identify financing opportunities to support climate resilience and mitigation efforts.
- **Action 41** Increase budgets to strengthen tree and natural infrastructure protection, planting and maintenance
- **Action 41** Integrate and align regional management of the urban forest, parks, open spaces and natural features with City plans, policies and procedures.

OPPORTUNITIES

Adaptation planning can increase benefits and reduce risks associated with climate change impacts. Through proactive action, Niagara Falls can achieve its climate adaptation goals and simultaneously realize a host of community benefits including economic development, community health and wellness, and the continued development of a sustainable and liveable city over decades to come. Climate adaptation is an opportunity to drive sustainable development by combining synergies between different levels of governments, private partners, and local residents.

Key findings from the Intergovernmental Panel on Climate Change Assessment Reports predict that climate change impacts will have significant effects on migration flow and patterns of investment. If Niagara Falls can show that it is climate-ready, it can capitalize on the opportunity to attract businesses, people, and investments. With the development of this plan the City will also become well-positioned to access potential sources of funding from the federal and provincial governments in the future.

Additionally, a few potential opportunities were identified by the project working group that could arise from the projected climate changes in Niagara Falls:

- Increase in annual temperatures creating a longer growing season resulting in opportunities to grow different crops and extend the growing season.
- Increase in winter temperatures resulting in a change in species range and opportunity to plant an increasing diversity of species.
- Increase in annual temperatures resulting in an extended fair weather tourism season and increasing revenue for businesses.
- Increase in precipitation resulting in greater hydro-energy generation opportunities.
- Increased average summer temperatures and extreme heat days (>30 C), resulting in an increase for services that cool people down such as ice cream, splash pads and falls misting opportunities.
- Increasing annual temperatures resulting in reduced snowpack and less spring flooding (freshet events).
- Increased annual temperatures resulting in less snow removal needs and salt usage, reducing associated costs.
- Increase in annual temperature resulting in longer outdoor sport seasons (e.g. golf, baseball, tennis, soccer, etc.)

Implementation, Monitoring and Evaluation

IMPLEMENTATION

Niagara Falls is well-positioned to adapt to the challenges of climate change. With strong leadership, collaboration, and dedicated resources, Niagara Falls can become a climate-ready city. This Adaptation Plan, including the Implementation Schedules, provides the roadmap to make this happen. The Adaptation Plan is a long-term initiative that will require participation and engagement across City departments and community stakeholders in order to successfully achieve the vision. The Adaptation Plan is intended to be a living document that will be further refined as the City moves forward into the implementation phase of Milestone Four of the BARC process. Details and prioritization of the actions may change to reflect the existing procedures, decision-making processes, evaluation, annual review, and external factors. Best practices, internal structures, and collaboration will inform successful implementation of the actions that are presented in the Adaptation Plan.

Implementation Schedules

Preliminary implementation schedules have been developed that outline the necessary steps and considerations to execute our adaptation actions. The schedules were developed through consultation with City staff and various external stakeholders, and is subject to staff availability and budgetary considerations. Notably, actions aimed at high-risk impacts could require more resources, meaning that higher priority doesn't always translate to immediate implementation. The implementation schedules do not delve into the specifics of how each initiative will be carried out. In some cases, further studies and detailed program design will be necessary.

Moreover, it is important to note that the schedules are not rigid. They are part of a dynamic, living document that will evolve in response to new data, newly identified adaptation priorities, and new funding opportunities. The implementation schedule scan be found in Appendix A and includes the following for each action.

- Supporting Actions: Actions to help support the implementation of the action, that are already underway, or that are smaller steps to achieve a larger action.
- Immediate Next Steps: Immediate, specific next step(s) that would need to happen to begin implementation.

- Involved Organization(s) and or City Department(s) – The department(s)/organization(s) needed to implement the action. Leads (L) are indicated where possible to indicate a convener or undertaker of the action.
- Time Scale: When implementation would begin in the context of Quick-Win (QW) (<1 year), Short-Term (ST) (1-3 years), and Long-Term (LT) (4-5 years).
- Monitoring Metric and Baseline: Metric to monitor the action and evaluate progress. These indicators will likely focus on processes that measure progress towards the achievement of an outcome (e.g. policies created, funding secured) as opposed to outcome indicators which demonstrate that an objective has been achieved. Prioritize indicators/measures that are already being collected where relevant.
- Priority Impact Addressed: Identification of the prioritized impact(s) that this action addresses including TEMP (refers to impacts that are primarily temperature related), RECIP (refers to impacts that are primarily precipitation related), and EXT (refers to impacts that are primarily extreme weather related).

MONITORING

Monitoring and review are an essential part of the adaptation planning process. To ensure the effectiveness of our Adaptation Plan, it is important that we keep a close eye on our progress and build in opportunities to examine the lessons learned and recalibrate actions, as well as integrate emerging knowledge into our strategies. Through this process of continuous learning and adjustment, we ensure our strategies stay effective and relevant, even as climate conditions evolve. Keeping track of our progress not only lets us see if our strategies are working as intended, but it also gives us the chance to share and celebrate in our achievements as we collectively navigate our way towards a more resilient future.

Indicators

This Plan uses two types of indicators: process-based and outcome-based. Process-based indicators help measure progress towards our specific targets, tasks or activities. On the other hand, outcome-based indicators help measure whether the expected changes and benefits of our actions are being achieved. While the Adaptation Plan uses many process-based indicators, outcome-based indicators will be utilized where applicable. This is especially the case when there can be alignment with indicators that the City or community is already tracking.

EVALUATION

A five-year Adaptation Plan has been recommended to guide future implementation, monitoring and evaluation activities. This five-year formal review will culminate in a review of the Adaptation Plan's impacts, goals and actions. This process would involve using the first three milestones of the BARC process again in order to complete project working group engagement, a formal science review, impact identification, vulnerability and risk assessments, and a review of goals and actions.

During those five-years of implementation an annual report on progress, challenges and prioritized next steps will be brought forward to the City's Senior Leadership Team and the Project Working Group members. A more formal report to the community and City Council will take place with every second year's report. Progress will be reported on from a consistent baseline year of 2023. Reporting will be undertaken by the project's core team until such time as a designated climate change staff person is assigned. Action monitoring considerations, identified in each Action Implementation Schedule will be used to help communicate progress trends. Prioritization of actions is expected to change from year to year based on existing decision-making processes, evaluation, annual review, budget, and external factors.

Conclusion

The city of Niagara Falls has made significant strides in adaptation through the development of the Climate Change Adaptation Implementation Plan. Maintaining the momentum that has been developed through the co-development of the Adaptation Plan will be essential and will require committing to the implementation of its actions through the allocation of resources, governance, and monitoring. As we continue to anticipate changes to federal and provincial policies and funding opportunities, understand the continued lived experience of the impacts of climate change, and see advancements in technology over the Adaptation Plan's five-year duration, it will be necessary for the plan to be regularly monitored, modified, and reviewed. This flexibility will enable Niagara Falls to adapt and seize new opportunities that may emerge, without being limited to predetermined guidelines.

This Adaptation Plan sets forth a clear path to achieve the vision it set of reducing Niagara Falls' greenhouse gas emissions and being a resilient, climate-ready.

Call to Action

Can you be an action supporter?

Not only can you look for ways to work with community organizations to implement actions in this plan, you can also implement resilience building actions at home, work or in your neighbourhood.

- Champion the action
- Provide needed data or reports
- Create a resource
- Host a meeting or an event
- Seek funding
- Research or gather information
- Recruit volunteers and be a volunteer
- Provide resources
- Distribute information
- Attend a meeting or event
- Promote

Climate-Ready Actions

Prepare before and stay safe during and after an extreme weather event.

- Work with the Conservation Authority to identify whether your property is vulnerable to flooding and what you can do to protect it
- Have an emergency plan and discuss your plan with employees/family/friends to prepare everyone
- Have 72-hour emergency information and kits ready
- Understand your flood insurance coverage and have a detailed and up-to-date inventory of your assets
- Prepare for heat with building and property upgrades where applicable
- Install a rain garden and increase natural vegetation
- Have backup transportation routes and options
- Monitor and make plans for poor air quality
- Have a backup power generation plan
- Locate nearby cooling/heating centres
- Make a list of resources and service providers accessible to you in case of emergency need for housing, social, or medical services

Greenhouse Gas Reduction Actions

Reduce your impact on the climate.

- Install a programmable thermostat
- Fix More, Less Trash & Refuse and Reuse
- Increase active and public transportation use. Reduce car and plane travel.
- Eat more leftovers and less meat
- Swap out natural gas appliances for electric
- Upgrade to 100% renewables

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Appendices

Appendix A: Action Implementation Schedules

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Action Implementation Schedules Definitions

PRIORITY IMPACT ADDRESSED

Identification of the prioritized impact(s) that this action addresses.

SUPPORTING ACTIONS

Actions to help support the implementation of the action, that are already underway, or that are smaller steps to achieve a larger action.

IMMEDIATE NEXT STEPS

Immediate, specific next step(s) that would need to happen to begin implementation.

INVOLVED ORGANIZATION(S) AND OR CITY DEPARTMENT(S)

The department(s)/organization(s) needed to implement the action. Leads (L) are indicated where possible to indicate a convener or undertaker of the action.

TIME SCALE

When implementation would begin. Quick-Win (QW) (<1 year), Short-Term (ST) (1-3 years), Long-Term (LT) (4-5 years).

MONITORING METRIC AND BASELINE

Metric to monitor the action and evaluate progress. These indicators will likely focus on processes that measure progress towards the achievement of an outcome (e.g. policies created, funding secured) as opposed to outcome indicators which demonstrate than an objective has been achieved. Prioritize indicators/measures that are already being collected where relevant.

NATURE & BIODIVERSITY

Goal: To foster the resilience of Niagara Falls' natural landscape to ongoing changes in climate and enhance its value in providing both climate change adaptation and mitigation benefits

Action 1

Integrate and align regional management of the urban forest, parks, open spaces and natural features with City plans, policies and procedures.

Supporting Actions	1.1 Include vegetation management standards in construction requirements, with respect to Niagara Region’s regional tree canopy assessment.
	1.2 Integrate into the current documents/processes: Official Plan Update, Natural Asset Management Plan, PRC Master Plan, Design Standards, and Niagara Parks’ Queen Victoria Park Master Plan and Urban Forest Management Plan.
	1.3 Update construction and planting standards to ensure plants and trees have adequate soil volume and quality to ensure the living green infrastructure's full lifecycle, and associated ecosystem services, are achieved.
Immediate Next Steps	Gather plans, policies and procedures from the region (e.g. Town of Lincoln (waterfront development), the region, etc.).
Involved Organization(s) and/or City Departments	City: Planning (L) Cemetery Municipal Works Rec, Culture and Facilities Land Care Niagara (volunteer group supported by the province) - support

	Environmental Action Committee (PITC); Niagara Parks Commission (partner); Niagara Peninsula Conservation Authority (NPCA) Environmental section of Niagara Region
Time Scale	ST
Budget	$$ (implementation of staff time, or bring in a consultant) * Construction Standards could be more involved process requiring more money Funding opportunity: Integrated urban forest management – City budget
Monitoring Metric and Baseline	# of plans with natural feature considerations Completion of policies and plan itself # of development proposals that increase tree canopy, and naturalized land
Priority Impact Addressed	TEMP 1; TEMP 2; TEMP 3; TEMP 5; TEMP 6; TEMP 7 PRECIP 1; PRECIP 2; PRECIP 3; PRECIP 4; PRECIP 5; PRECIP 6; PRECIP 7 EXT 1; EXT 4

Action 2

Complete the development of the Urban Forest Strategy and implement its recommendations.

Supporting Actions	2.1 Identify and plant climate resilient trees and shrubs.
	2.2 Integrate results of Urban Heat Mapping and prioritize planting in hotspots.
	2.3 Undertake an urban tree canopy study to identify tree and vegetation canopy targets (on public and private land). (build upon City's boulevard tree asset mapping and Woodland/Woodlot Management Plan).
Immediate Next Steps	Continue completing urban forest strategy. Align with the Region's Urban Forest Management Plan (Niagara Parks). Measure current coverage of tree canopy cover (using GIS), to determine baseline – entire land holdings or public land holdings.
Involved Organization(s) and/or City Departments	City: • Forestry (L) • Planning • GIS • Municipal Works • Cemetery • Rec, Culture and Facilities Environmental Action Committee Niagara Region; NPEI Vineland Research and Innovation Center (VRIC); Niagara Peninsula Conservation Authority (2B Trees);

	Community Niagara Falls Nature Club (tree inventory)
Time Scale	ST
Budget	Develop plan - $$ Implement plan - $$$$ Funding opportunity: Urban Forest Management Budget (approved in 2023) Potential funding opportunity: OMAFRA, OMNRF
Monitoring Metric and Baseline	Completion of urban forest strategy
Priority Impact Addressed	TEMP 1; TEMP 2; TEMP 3; TEMP 6; TEMP 7 PRECIP 1; PRECIP 2; PRECIP 3; PRECIP 4; PRECIP 5; PRECIP 6; PRECIP 7 EXT 1; EXT 4

Action 3

Enhance partnerships and engage the community to enhance the protection, planting and maintenance of plants, especially those that are native and climate resilient, including through academic research, educational events, tree programs, planting initiatives and through media.

Supporting Actions	3.1 Enhance partnership with school boards to enhance educational and field trip opportunities related to climate change impacts, the importance of ecosystem health and function, and actions that increase resilience at the local level (e.g., EAC tree planting, community tree planting events).
	3.2 Develop an education and outreach campaign - in partnership with Niagara Parks, Brock University, NPCA, Niagara College, Land Care Niagara. Highlight Niagara Falls' natural spaces

	and how residents can better enjoy and maintain these assets, videos and graphics for social media campaign to promote increase, protection and maintenance.
Immediate Next Steps	Reach out to stakeholders, form committee. Consider reconvening Staff Green Team, branch out to form sub-committees.
Involved Organization(s) and/or City Departments	City: • Communications ○ Utilize Let's Talk • Staff Green Team • Rec, Culture and Facilities (L) Environmental Action Committee; Niagara Peninsula Conservation Authority (identify native plants) Niagara College Brock University Land Care Niagara Walker Industries Mayors Youth Advisory Committee Niagara Region School boards
Time Scale	ST
Budget	Building partnerships $-$$ Implementation - $$ Funding opportunity: NPEI provides funding to City for tree planting

	Funding opportunities: amongst partners listed above
Monitoring Metric and Baseline	# of partners engaged # of outreach efforts (e.g., media announcements, educational events) – comms team # of events held (# of trees planted at said events) Green infrastructure: Types of plants planted Increase % in tree canopy or naturalized habitat on private and public lands # of events where enhancement is realized # of events on public land
Priority Impact Addressed	TEMP 1; TEMP 2; TEMP 3; TEMP 5; TEMP 6; TEMP 7; PRECIP 1; PRECIP 2; PRECIP 3; PRECIP 4; PRECIP 5; PRECIP 6; PRECIP 7; EXT 1; EXT 4

Goal: To ensure that water resources in the local watershed are resilient, protected and enhanced through the engagement of various stakeholders.

Action 4

Increase naturalization of buffer zones around waterways and wetlands, including storm water ponds.

Supporting Actions	4.1 Update the Official Plan, zoning by-laws, Secondary Plans and Engineering Development and Design Standards to enhance water buffer zones, including areas around provincially significant wetlands.
Immediate Next Steps	Identify existing inventory of waterways, stream channels, buffer zone conditions, including storm water ponds. (Sub-watershed studies within Secondary plans)

Involved Organization(s) and/or City Departments	City: • Municipal Works- Engineering • Planning • Council – support for political buy-in Niagara Peninsula Conservation Authority (L) Land Care Niagara; Peninsula Field Naturalists (St. Catherine) Niagara Falls Nature Club Rowing club – engage early [Angler + Waterfowl organizations]
Time Scale	LT
Budget	$$-$$$ Funding opportunity: Niagara Peninsula Conservation Authority Funding opportunity: Niagara community foundation
Monitoring Metric and Baseline	% area increase in naturalized waterways
Priority Impact Addressed	TEMP 1; TEMP 7; PRECIP 1; PRECIP 2; PRECIP 3; PRECIP 4; PRECIP 5; PRECIP 6; PRECIP 7; EXT 1

Action 5

Identify opportunities to expand natural assets and low-impact development as alternatives to traditional grey infrastructure.

Supporting Actions	5.1 Educate City Staff on Low Impact Design (LID), which has been included in the Engineering Design Standards, as well as other stormwater management practices that promote groundwater recharge – referencing Region's Stormwater Management Design Guidelines.
	5.2 Increase LID and other stormwater management practices to promote groundwater recharge into retrofit and development/redevelopment projects, in alignment with the 2017 Master Drainage Plan (to be updated within next 5 years).
	5.3 Introduce and expand programs that manage stormwater onsite for both private and public properties including rain barrels, rain gardens, bioswales, permeable pavement, and other LID projects.
Immediate Next Steps	Educate City Staff on Low Impact Design (LID) as well as other stormwater management practices that promote groundwater recharge.

Involved Organization(s) and/or City Departments	City:
	• Planning
	• Communications
	  ○ Share City's work and guidance for public
	• Finance (data: water expenditure bills)
	• Municipal Works- Engineering (L)
	  ○ Development
	
	NRCA
	
	NR
	
	Community garden groups Niagara Region community garden network (works regionally with NR)

	master gardeners School of Horticulture
Time Scale	LT
Budget	Identification $-$$ Expand/ implementation $$$
Monitoring Metric and Baseline	# of staff trained # of LIDs Community uptake of different programs Uptake of development community of LID + stormwater mgmt. designs Increase in community gardens Change in total sewer flow, municipal water use
Priority Impact Addressed	TEMP 1; TEMP2; TEMP 4; TEMP 5; TEMP 6; PRECIP 5; PRECIP 6; EXT 1; EXT 2; EXT3;

Action 6

Identify opportunities to better protect existing natural assets such as tree canopy, green spaces, wetlands, rivers, and floodplains as part of a stormwater management plan.

Supporting Actions	6.1 Implement a salt management plan, in alignment with the Region's SWM guidelines, that seeks to better manage and reduce salt usage and limit salt runoff into waterways.
	6.2 Utilize and update existing Engineering Design Standards and the Woodland Management Plan to protect natural assets.

	6.3 Development of Stormwater master plan currently underway.
Immediate Next Steps	Complete Stormwater Master Plan with ID of green infrastructure opportunities.
Involved Organization(s) and/or City Departments	City: • Cemetery • Parks • Forestry • Municipal Works/ Engineering (L) >Operations • Planning Landscape Architects NPCA NR Niagara Escarpment Commission Environmental Action Committee (PITC) Niagara Regional Public Health - support streetscape
Time Scale	ST (completion of stormwater master plan)
Budget	Identification $$ (within stormwater master plan budget) Protection $$ Funding opportunity: Direction from Council: explore of 'cash-in-lieu tree contribution' for development

Monitoring Metric and Baseline	Protected land area of natural assets (total acreage/ hectares)
Priority Impact Addressed	TEMP 3; PRECIP 1; PRECIP 2; PRECIP 3; PRECIP 4; PRECIP 5; PRECIP 6; PRECIP 7; EXT 1; EXT 2; EXT 3; EXT 5

Action 7

Continue to update IDF curves with most up to date modelling and update/build infrastructure in accordance with the latest data.

Supporting Actions	7.1 Complete a risk assessment of stormwater management facilities and overland flow routes for major storms in light of climate change.
Immediate Next Steps	Continue updating IDF curve data.
Involved Organization(s) and/or City Departments	City: • Municipal Works- Engineering • Information Technology • Facilities? NR NPCA
Time Scale	ST
Budget	Staff time, resourced needed to update IDF curves - $$ Updating infrastructure - $$$

Monitoring Metric and Baseline	Degree to which IDF curves are updated # of buildings and other infrastructure (culverts, roads) updated in accordance
Priority Impact Addressed	PRECIP 1; PRECIP 2; PRECIP 3; PRECIP 4; PRECIP 5; PRECIP 6; PRECIP 7; EXT 1; EXT 2; EXT 3; EXT 4; EXT 5

Action 8

Work with partners to ensure that Niagara Falls watersheds are protected and enhanced in the face of climate threats and address emerging water issues.

Supporting Actions	8.1 Leverage Region's Official Plan and the Niagara Peninsula Conservation Authority's Strategic Plan, both of which address climate change and protection of natural heritage/ resources, to update the City's Secondary Plan process for new area development including sub-watershed plans.
Immediate Next Steps	Initiate some of climate actions within Secondary Plans.
Involved Organization(s) and/or City Departments	City: • Municipal Works - Water/Wastewater • Planning • Rec, Culture and Facilities Niagara Region Climate Change Municipal Community of Practice (CCMCP) Niagara Peninsula Conservation Authority (L) Niagara Region Public Health
Time Scale	ST
Budget	Staff time -$$

	Implantation - $$$$
Monitoring Metric and Baseline	Look to NPCA in terms of how they measure water quality/ quantity (water temps, species, health of in/vertebrate populations) ID specific measures taken within plans to address specific climate threats
Priority Impact Addressed	TEMP 1; TEMP 3; PRECIP 1; PRECIP 2; PRECIP 3; PRECIP 5; PRECIP 6; EXT 1

INFRASTRUCTURE

Goal: To design, construct, and maintain physical infrastructure that is resilient to climate impacts while considering affordability, energy efficiency, natural assets, and reduction in greenhouse gasses

Action 9

Ensure infrastructure risk assessments include climate change considerations and buildings are built or retrofitted accordingly, using best practices in the design, construction, and maintenance to minimize service disruptions and increase resilience.

Supporting Actions	9.1 Identify and prioritize corporate buildings and assets in-need of upgrades or retrofits.
	9.2 Complete the Wet Weather Management strategy as part of the Master Servicing Plan.
	9.3 Complete the engineering and design standards update to create a more resilient infrastructure network that utilize risk assessment protocols such as PIEVC Engineering Protocol or ISO 31000 and that include climate-related risk and vulnerability.
	9.4 Reduce all sources of inflow and infiltration into the sanitary sewer system including public and private property sources, as per the DWQMS Risk Assessment.
	9.5 Update City's storm sewer design standards from a 5 to a 10-year storm. Storm and sanitary risk assessments to be done in 2024 as per new CLI ECAs.
	9.6 Identify assets and infrastructure nearing end of life-cycle to retrofit or replace with climate-resilient materials .
Immediate Next Steps	Complete actions already in progress. 9.1 (largest emitter and largest capital cost associated) – in the middle of BCAs 9.2, 9.3 (in progress)

	9.4 (LT undertaking), 9.5 (challenging undertaking) - Update model to understand risk constraints, constraining locations 9.6 underway (some quick wins)
Involved Organization(s) and/or City Departments	City: • Facilities(L) – shared lead • Municipal Works- Engineering (development review team) (L) – shared lead • Asset management team • Water/ wastewater • Council - support
Time Scale	LT
Budget	$$$$ Funding opportunity: NR will be putting in a grant application for FCM's GMF - GHG emission reduction feasibility study of 12 buildings Niagara Region - Wet weather management fund (some extent) on some capital projects that limit wet weather flows
Monitoring Metric and Baseline	# of buildings evaluated; renovated 9.2, 9.3 – completion of plans 9.4 % of system reductions (flows entering treatment plants) Km of combined sewers
Priority Impact Addressed	TEMP 2; TEMP 3; TEMP 4; TEMP 5; TEMP 7; PRECIP 4; PRECIP 5; PRECIP 6; PRECIP 7; EXT 2; EXT 3; EXT 4

Action 10

Improve the resilience and sustainability of transportation infrastructure.

Supporting Actions	10.1 Utilize risk assessment protocols such as PIEVC Engineering Protocol or ISO 31000 to assess the specific climate-related risk of vulnerable transportation assets.
	10.2 Continue to update the Transportation Master Plan and Engineering Development and Design Standards with a climate resilience and net-zero lens.
	10.3 Install and update EV charging stations and City EV fleet.
	10.4 Develop and encourage sustainable methods of transportation including through connected trails and paths, expanded GO services, EV chargers, and public transit.
	10.5 Update the Niagara Peninsula Standard Contract Document with opportunities to increase the resilience and carbon output of road infrastructure through the integration of updated materials (e.g. warm-mix asphalt).
	10.6 Develop a communications plan to highlight sustainable methods of transportation and related initiatives such as a "Sustainable Travel Week" campaign.
Immediate Next Steps	10.2, 10.4 in progress – continue and complete 10.5 fairly straightforward – reach out to NR Invite NPSCD committee to take on 10.5 leadership role 10.3 undertake feasibility and implementation strategy 10.4 (policy related – to review in OP and via Secondary Plans) – in progress – start in early Aug, will take roughly 1 year
Involved Organization(s) and/or City Departments	City: • Municipal Works – Transportation Services, Fleet (L) • Communication • NPSCD (L) – for 10.5

	• Planning and Building • Traffic • Parking Niagara Region Transit Niagara Region Public Health (Active Transportation)
Time Scale	LT
Budget	$$$ - $$$$ Possible funding source: NRCAN Zevip (for EV chargers)
Monitoring Metric and Baseline	# of updated plans # of EV chargers
Priority Impact Addressed	TEMP 4; TEMP 6; TEMP 7; PRECIP 6; EXT 2; EXT 3; EXT 4; EXT 5

Action 11

Identify opportunities and resources to include carbon reductions and climate resilience in buildings when new builds and retrofits or renovations are planned, including updates to building envelope, flood reduction measures, and site level energy generation.

Supporting Actions	11.1 Encourage homeowners and businesses to implement and maintain best practices in stormwater management to reduce flood risk.
	11.2 Identify and promote retrofit programs and materials for home and business owners.

	11.3 Require flood sensors/alarms in basements, and water-driven sump pumps that can function without power in new builds.
	11.4 Incentivize developments to include solar panels for on-site energy generation.
Immediate Next Steps	Policy perspective – include policy statements in the Official Plan Create communications strategy Create Best Practice/ Standards Guide (e.g., for applying for permits) Developers, land owners (need to be engaged)
Involved Organization(s) and/or City Departments	City: • Climate Action Team Reps • Facilities Staff (L - for internal facilities) • Finance • Planning • Communications; • Business Development Developers, land owners (need to be engaged) Hydro/ Utility – NPEI Lean on other levels of government (NR) for broader community implementation
Time Scale	LT
Budget	$$ (policy, information resources, NOT infrastructure) Funding opportunity: Leverage existing collaboration with NPEI and Enbridge (e.g. save-on-energy and CDM programs)
Monitoring Metric and Baseline	# of incentive programs + resources developed # of uptake, # of people involved in the programs

	# of discussions with developers, businesses Social media - # of people reached via comms
Priority Impact Addressed	TEMP 2; TEMP 3; TEMP 4; TEMP 5; TEMP 6; TEMP 7; PRECIP 4; PRECIP 5; PRECIP 6; EXT 2; EXT 3; EXT 4; EXT 5

Goal: To manage land use that ensures that community assets and livelihoods are sustainable, counter urban-sprawl, optimize existing infrastructure, enhance neighbourhood connections and are resilient to the impacts of climate change.

Action 12

Develop 'Green Design Guidelines' and update Engineering Design Standards for new developments and retrofits that include low-impact development and green infrastructure to manage heat and flooding.

Supporting Actions	12.1 Develop standards for green roofs in residential and industrial development.
	12.2 Continue to implement the Weeping Tile Removal assistance program.
	12.3 Develop an incentive program and/or update the approval process (e.g. reduction in development charges) for developers to include resilience measures.
	12.4 Enhance and enforce by-laws regarding downspout disconnection; and lot grading to ensure flow of water is directed appropriately.
	12.5 Ensure new development, redevelopment and intensification preserve and contribute to quality green spaces.
Immediate Next Steps	Planning – continue to explore using urban design in policies and implementation.

Involved Organization(s) and/or City Departments	City: • Facilities • Municipal Works -Engineering (Development) • Planning (L) Utilities (when planning new builds)
Time Scale	Urban design - ST LT
Budget	Developing Standards (staff time) $$
Monitoring Metric and Baseline	Completion of GDG Updates design standards Completion of plan
Priority Impact Addressed	TEMP 2; TEMP 3; TEMP 4; TEMP 5; TEMP 6; TEMP 7; PRECIP 5; PRECIP 6; PRECIP 7; EXT 2; EXT 3; EXT 4; EXT 5

Action 13

Review zoning by-laws to encourage densification that will provide net energy and land savings and conserve or enhance ecological functions.

Supporting Actions	13.1 Identify neighbourhoods and corridors for densification.
	13.2 Update Official Plan and align with Regional OP policies, providing benefit for increased coverage where natural areas are preserved.
Immediate Next Steps	Continue initiation of 13.1 + 13.2

	Account for Net energy savings around infrastructure that's built + movement of people Council decisions on current development applications (increasing dense development + asset expansion)
Involved Organization(s) and/or City Departments	City Planning Niagara Peninsula Energy GIS
Time Scale	ST LT – zoning by-laws (comprehensive zoning changes in association with updated OP)
Budget	Reviewing by-laws - $
Monitoring Metric and Baseline	Increased densification/ reduced expansion Intensification rates
Priority Impact Addressed	TEMP 1; TEMP 5; EXT 2; EXT 3; EXT 4

Action 14

Update parking lot bylaws to reduce parking requirements and require a minimum amount of permeable surface and green infrastructure and trees in order to provide on-site stormwater management and shade, and promote alternative transportation.

Supporting Actions	14.1 Utilize the results from the parking rate study to inform and support the planning and implementation of parking on-site green infrastructure.
Immediate Next Steps	Develop recommendation for parking lot bylaw adjustment.

Involved Organization(s) and/or City Departments	City: • Parking • Planning, Bylaw (L) • Municipal Works – Engineering, Water/ Wastewater
Time Scale	LT
Budget	$
Monitoring Metric and Baseline	Number of parking lot spaces required (is reduced) % of permeable and green infrastructure in parking areas
Priority Impact Addressed	TEMP 1; TEMP 2; TEMP 4; TEMP 5; TEMP 6; TEMP 7; PRECIP 1; PRECIP 4; PRECIP 5; PRECIP 6; PRECIP 7; EXT 1; EXT 2; EXT 3

Action 15

Identify and preserve land for future green spaces through the Official Plan and Bylaws.

Supporting Actions	15.1 Review and update Official Plan, urban boundary expansion, secondary planning, and parkland by-laws in alignment with Niagara Parks land management zones.
Immediate Next Steps	Create list of potential lands to preserve.
Involved Organization(s) and/or City Departments	City: • Council • Planning (L) • Municipal Works • Rec, Culture & Parks • Business Development

	• GIS Environmental Action Committee NPCA Development Community
Time Scale	LT
Budget	$
Monitoring Metric and Baseline	Use greenspace targets identified in the Parks, Rec and Culture Master Plan to drive action. Acres of preserved lands
Priority Impact Addressed	TEMP 1; TEMP 2; TEMP 3; TEMP 5; TEMP 6; PRECIP 1; PRECIP 3; PRECIP 5; PRECIP 6; EXT 1

Action 16

Integrate natural assets into the City's asset management plans.

Supporting Actions	16.1 Undertake a natural asset inventory.
	16.2 Align natural asset management with the Region's tree canopy assessment, and the City's Woodlot Management Plan and Forestry's inventory of street trees.
Immediate Next Steps	Define scope of work for natural asset inventory.
Involved Organization(s) and/or City Departments	City: • Forestry (L) • Parks • Cemeteries

	• Planning • Finance • Municipal Works • Infrastructure & Asset Management team • GIS Landscape Architects Niagara Region Environmental Action Committee (PITC)
Time Scale	LT
Budget	$$
Monitoring Metric and Baseline	Natural Assets are included in asset management plans, policies and reports
Priority Impact Addressed	TEMP 1; TEMP 2; TEMP 6; TEMP 7; PRECIP 1; PRECIP 2; PRECIP 3; PRECIP 4; PRECIP 5; PRECIP 6; PRECIP 7; EXT 1; EXT 2; EXT 3; EXT 4; EXT 5

Goal: To ensure energy supply and infrastructure is sufficient, affordable, net-zero and resilient to weather-related disruptions

Action 17

Identify at-risk energy and communication infrastructure and opportunities to increase resilience to power outages as a result of increased demand or extreme weather.

Supporting Actions	17.1 Support the Region's upcoming Community/ Municipal Energy Plan.
	17.2 Work collaboratively with NPEI regarding annual pole testing and replacement programs.
	17.3 Continue collaboration with the Public Service Committee's utility work and include climate projections in future work.
Immediate Next Steps	Continue to support existing initiatives. Create group to collaborate on energy infrastructure. Start bigger conversations with utilities. Vulnerability assessment of energy infrastructure. Scan what energy demands are, local carbon alternatives-looking at risk in particular.
Involved Organization(s) and/or City Departments	City Facilities; looking at specific issues on specific buildings NPEI; ON Hydro (L) NRBN (would need to include other telecoms if comms strat is undertaken) City Public Services Committee NR
Time Scale	ST
Budget	$$-$$$

Monitoring Metric and Baseline	# of power outages related to climate impacts Days of power outages (how quick recovery is) Completion of Regional Energy plan Vulnerability assessment – ID of at-risk infrastructure
Priority Impact Addressed	TEMP 2; TEMP 4; PRECIP 6; EXT 2; EXT 3; EXT 4; EXT 5

Action 18

Undertake a greenhouse gas inventory and undertake actions to reduce GHG emissions from corporate and community energy sources, working off of the Region's recently completed corporate GHG inventory.

Supporting Actions	18.1 Identify opportunities to shift consumption to off-peak hours, especially during summer months.
	18.2 Create and implement energy conservation strategies for City facilities and fleet (e.g., cemetery equipment), including undertaking energy audits, investigating alternative energy sources, retrofits and enhancing outdoor shading and cooling features.
Immediate Next Steps	Going to council for support. Applying for funding. Apply to PCP program. Prepare inventory (consolidate existing data) - – keep regular update of emissions.
Involved Organization(s) and/or City Departments	City: • Facilities (L) - Corporate • Department Leads

	• Finance/ Account Payable (to provide data) • Council • Municipal Works NR (to measure emissions from [community] waste) Community data providers (e.g., NPEI) Consultant
Time Scale	ST - Inventory LT – retrofits/ climate actions
Budget	Inventory - $$ Retrofits - $$$$
Monitoring Metric and Baseline	Inventory Completion of inventory Retrofits # of buildings retrofitted Total GHG reductions (tC02e)
Priority Impact Addressed	TEMP 2; TEMP 4; TEMP 6

Action 19

Monitor peak energy consumption to better understand how strategies to mitigate brown and blackouts can be implemented.

Supporting Actions	19.1 Collaborate with NPEI to continue their engagement surrounding energy use, choice for rate plans, and microfits and renewable energy solutions.
Immediate Next Steps	Create + communicate database on energy consumption. NPEI already has available data for corporate emissions. Continue mitigating impacts already experienced (corporate-level).
Involved Organization(s) and/or City Departments	Facilities – NPEI, ON Hydro partnership
Time Scale	ST
Budget	$$ Funding opportunity: NPEI will provide ultra-low plan for residents in November
Monitoring Metric and Baseline	# of brownouts + blackouts
Priority Impact Addressed	TEMP 2; TEMP 7; PRECIP 6; EXT 4

HEALTH AND WELLBEING

Goal: To build a resilient and sustainable local food system that promotes social justice and supports local production, storage, processing, sale and distribution of food.

Action 20

Support, implement and localize the Region's work in developing a resilient and sustainable community food working group and strategy.

Supporting Actions	20.1 Create a food strategy working group.
	20.2 Conduct a scan of existing resources, policies and activities.
	20.3 Identify how this strategy would align and multi-solve other local mandates.
	20.4 Undertake a Community Food Assessment.
	20.5 Working group to develop a food strategy that explores and leverages local/regional partnerships.
	20.6 Consider requesting the working group to become a committee of council.
Immediate Next Steps	Build off momentum of the Regional Forum (June 7 food security event with United Way) and bring all partners together to determine who should be involved.
Involved Organization(s) and/or City Departments	City: • Planning (ID of land for additional community gardens) • Rec, Culture and Facilities (community gardens) Environmental Action Committee (PITC); local famer's market/ NF exchange;

	local agricultural organizations and businesses; Park in the City Committee Niagara Region (L) United Way Public Health Regional garden network Ontario Food Collaborative GROW Niagara Falls FEAST program Farmers Links for Greener Learning Small Scale Farms Program Project Share Food Banks Feed Ontario Brock – Niagara agriculture municipal learning network (https://brocku.ca/niagara-community-observatory/NAMLN/)
Time Scale	ST
Budget	$$ (staff time) Funding opportunity: working w/ United Way
Monitoring Metric and Baseline	Developed/ completed work plan/strategy # of (or acreage) community gardens/ time

	Established working group
Priority Impact Addressed	TEMP 1; TEMP 4; PRECIP 1; PRECIP 4; PRECIP 5; PRECIP 7; EXT 1; EXT 3

Goal: To improve social connectedness of residents to their community and to organizations to minimize and better manage climate-related health and safety risks

Action 21

Improve community connection opportunities in collaboration with local organizations so that members are supported and more resilient during extreme weather events.

Supporting Actions	21.1 Amplify existing initiatives and support more residents to engage with them.
	21.2 City Comms to share community resources during extreme weather events and create a resource page on niagarafalls.ca to consolidate the information.
Immediate Next Steps	Create inventory of what currently exists. • Vulnerable pop • Engagement Initiatives + events
Involved Organization(s) and/or City Departments	City: • Mayor's office (L) • Communications • Rec & Culture; United Way Older Adults groups and centers;

	Project Share; Café on Queen Street; Niagara Falls Public Library; McBain Centre; CSSN Community support Services of Niagara Church groups Gale Centre Neighbourhood groups Summer street shelter Former coronation building Soup kitchen
Time Scale	ST
Budget	$$
Monitoring Metric and Baseline	Completion of 2 inventories # of supports, initiatives # of people engaged
Priority Impact Addressed	TEMP 2; TEMP 3; TEMP 4; TEMP 5; TEMP 6; PRECIP 5; PRECIP 6; EXT 2; EXT 3; EXT 4; EXT 5

Goal: To ensure all have access to cooling during heat events.

Action 22

Establish maximum-temperature bylaw and air-quality standards for rental and multi-unit properties

Supporting Actions	22.1 Identify partners (such as Niagara Region Public Health, Tenant Board, Gateway of Niagara – AJ Heafey and team, etc.) to determine safe standards for indoor temperature.
	22.2 Identify grant programs for tenants and landlords to finance building retrofits.
	22.3 Train and work with by-law officers/ front-line workers to implement monitoring and enforcement protocols.
	22.1 Identify partners to determine safe standards.
Immediate Next Steps	Champion on council Get Property Standards (Building dept) involved Initiate awareness and education campaign Consider what minimum temp standards are
Involved Organization(s) and/or City Departments	City: • Mayor's office (lower tier L) -> Region's Social services committee (PHSSC) • Council (champions) (lower tier L) • Communications • Rec & Culture; • Property Standards - enforcement Coronation/ Older Adults Centre; NRH/ shelter system Public Health (upper tier L)
Time Scale	LT

Budget	Review of guidelines, related enforcement of by-laws - $$-$$$
Monitoring Metric and Baseline	Establishment of bylaw
Priority Impact Addressed	TEMP 2; TEMP 3; TEMP 4; TEMP 5

Action 23

Expand access to existing cooling and warming centres for use during other extreme weather events such as flooding and power outages and extend hours of operation.

Supporting Actions	23.1 Communicate and promote the access of heating and cooling centers for all (including public access to pools and splash pads).
	23.2 City to define thresholds for "extreme" in order to activate additional cooling/warming centres (i.e., City buildings that can remain open during these occurrences), working with HIRA and emergency response plans/
Immediate Next Steps	Host event to bring together stakeholders to expand policies.
Involved Organization(s) and/or City Departments	City: • CAO (L) • Facilities • Council (champion) • Communications • Fire • Rec, Culture and Facilities Regional Community Services (Housing and Homelessness coordinator) NASO Convention Centre

	Gale Centre
Time Scale	ST
Budget	$$$
Monitoring Metric and Baseline	# of cooling/ warming centres (space/ hours/ threshold) during extreme weather events
Priority Impact Addressed	TEMP 2; TEMP 3; TEMP 4; TEMP 5; PRECIP 5; PRECIP 6; EXT 3; EXT 4; EXT 5

Action 24

Work with businesses and organizations to identify and promote cooling spaces for tourists.

Supporting Actions	24.1 City/ Business working groups (BDD Dept) work together to designate and maintain cooling spaces, taking into consideration Niagara Parks potential to increase size of public realm (e.g., area adjacent to falls; increased access to the new power station tunnel).
Immediate Next Steps	Host event to have discussion with collaborating stakeholders, beginning the process of looking at viable options.
Involved Organization(s) and/or City Departments	City: • Business Development (L) • Communications NF Tourism BIAs Casino

	Hotels Convention Centre Niagara Parks Commission
Time Scale	ST
Budget	$$
Monitoring Metric and Baseline	# of businesses involved Amount of space allocated to cool tourists
Priority Impact Addressed	TEMP 2; TEMP 3; TEMP 5; EXT 1

Action 25

Identify opportunities to retrofit existing City corporate buildings and assets with air conditioning and air filters to combat extreme heat and air quality impacts.

Supporting Actions	25.1 Continue conducting Building Condition Assessments for City facilities – Identifying/ assessing full capacity efficacy.
Immediate Next Steps	Leverage ongoing BCAs to help assess opportunities .
Involved Organization(s) and/or City Departments	City: • Facilities (L) NPEI
Time Scale	ST Implementation LT
Budget	Implementation - $$$

	Funding opportunity: Provincial grants (e.g., save-on-energy)
Monitoring Metric and Baseline	# of facilities w/ systems that fully address cooling needs
Priority Impact Addressed	TEMP 2; TEMP 3; TEMP 4; TEMP 5; TEMP 6; TEMP 7

Action 26

Develop specific strategies and resources to support those in need of housing, medical and social support services during extreme weather.

Supporting Actions	26.1 Leverage past community events (e.g., Fire Dept 'Push for Change') and Communications' existing scripts and media to spread awareness and enhance social supports for vulnerable populations.
Immediate Next Steps	Develop inventory Expand upon existing resources Create working group to allocate resourcing, ID and build upon existing strategies
Involved Organization(s) and/or City Departments	Niagara Region - Community Services -NR Homelessness Services (L) Gateway of Niagara/ Niagara Assertive Outreach Team (NASO); Shelter Operator City and regional comms
Time Scale	ST
Budget	Plan development - $$-$$$ Resource implementation - $$$$ (meeting adequate housing needs)

Monitoring Metric and Baseline	# of strategies; resources created or expanded
Priority Impact Addressed	TEMP 2; TEMP 3; TEMP 4; TEMP 5; TEMP 6; PRECIP 5; EXT 2; EXT 3; EXT 4; EXT 5

Action 27

Work with local school boards to enhance the cooling abilities of all schools.

Supporting Actions	
Immediate Next Steps	Begin conversations with school boards
Involved Organization(s) and/or City Departments	Mayor's Youth Advisory Niagara Region; Public Health School boards City Council – can provide support, political leverage Outside contractors – HVAC; consultant Planning – land-use, encouragement through policy (no enforcement capacity)
Time Scale	LT
Budget	Conversations: $ Implementation: $$$-$$$
Monitoring Metric and Baseline	# of schools engaged in ID'ing cooling opportunities Implementation

	# of schools with implemented cooling abilities
Priority Impact Addressed	TEMP 2; TEMP 3; TEMP 4; TEMP 5 PRECIP 7; EXT 1

Action 28

Review and update policies, procedures, and training to ensure Niagara Falls staff and emergency responders are safe during extreme weather conditions.

Supporting Actions	
Immediate Next Steps	Convene group to review exiting policies/procedures/training
Involved Organization(s) and/or City Departments	City: • HR – Health and Safety (L) • Unions • Department Leads • Fire • Corporate Services NR: • Police • Paramedics
Time Scale	ST
Budget	$$ (enhancements of existing policies/ procedures) Implications for productivity + additional staffing need to be accounted for

Monitoring Metric and Baseline	# of updated policies/procedures/ training Change in updated policies/procudres/ training from baseline (total #)
Priority Impact Addressed	TEMP 5; TEMP 6; TEMP 7; PRECIP 5; PRECIP 6; PRECIP 7; EXT 2; EXT 3; EXT 5

Goal: To improve outdoor and indoor air quality.

Action 29

Identify and promote the use of technology to improve indoor air quality in homes and businesses, and the value of trees to improve outdoor air quality (during heat and wildfire smoke events).

Supporting Actions	
Immediate Next Steps	Gathering of potential stakeholders
Involved Organization(s) and/or City Departments	City: ● Planning ● Communications ● Business Development – could support promotion to businesses ● Fire (wildfire risk assessments + plans) Public Health (L) – as potential convener Park in the City Committee Construction and heating/cooling companies

Time Scale	ST
Budget	$-$$ Implementation - $$$-$$$$
Monitoring Metric and Baseline	Citywide air quality level (baseline) Indoor air quality (baseline) # of statements issued from Environment Canada # of recipients of communications (engagement metrics)
Priority Impact Addressed	TEMP 1; TEMP 2; TEMP 3; TEMP 4; TEMP 5; TEMP 6; EXT 1; EXT 3; EXT 4

ECONOMY & WORKERS

Goal: To support businesses to becoming resilient to the impacts of climate change through clear guidance and resources

Action 30

Communicate business-specific strategies to build resilience to extreme weather events.

Supporting Actions	30.1 Leverage Business Development's contacts with local businesses, providing community with guidance and standards for building retrofits, emergency backup power generation, and/or onsite power generation.
Immediate Next Steps	Develop list of strategies that need to be communicated. Maintain engagement with business group to facilitate further discussion and develop further plans to accomplish this goal.
Involved Organization(s) and/or City Departments	City: • Business Development (L) • Communications Climate Experts (internal/external) Niagara Region – Communications BIAs Businesses/Orgs
Time Scale	ST
Budget	$$
Monitoring Metric and Baseline	# of businesses engaged # of strategies implemented

Priority Impact Addressed	TEMP 2; TEMP 3; TEMP 4; TEMP 5; TEMP 6; TEMP 7; PRECIP 5; PRECIP 6; EXT 2; EXT 3; EXT 4; EXT 5

Action 31

Develop a business community climate best practices working group to develop and deliver business level risk assessments, emergency plans, and retrofit funding opportunities (heat pumps, renewable retrofits, building envelope enhancements, etc.).

Supporting Actions	31.1 Promote Falls and facilities as 'cool' places during heat waves.
	31.2 Identify tourist hotspots in need of cooling infrastructure such as increased tree canopy or shade structures, water features such as fountains, misting stations, etc.
	31.3 Explore alignment with The Coordinating Committee's launch of the 'Niagara Climate Change Action Network' initiative.
Immediate Next Steps	Action Lead to convene working group
Involved Organization(s) and/or City Departments	City: ● Building ● Business Development ● Council (Champions) ● Communication Environmental Action Committee (PITC) (L) Region ● Facilities and energy management

	• Economic development Climate experts BIAs Chamber of Commerce
Time Scale	ST
Budget	$$ Funding opportunity for implementation: Independent Electricity System Operator (IESO) provides conservation programs to businesses for retrofit opportunities. Incentives under the CIPs for employment include design elements that increase possible grant amounts based on efficient building and site design (Gateway CIP).
Monitoring Metric and Baseline	# of engaged businesses taking climate action
Priority Impact Addressed	TEMP 2; TEMP 3; TEMP 4; TEMP 5; TEMP 6; TEMP 7; PRECIP 5; PRECIP 6; EXT 2; EXT 3; EXT 4; EXT 5

Action 32

Expand upon federal/provincial guidelines for safe working conditions for workers exposed to extreme weather using best practices.

Supporting Actions	32.1 Inform worker of best practices by working with labour boards, trade unions, Niagara Parks, NPEI, the City and local businesses.
	32.2 Utilize and promote City's existing extreme weather alert monitoring system, Public Health's weather advisory statement releases.

Immediate Next Steps	Gather and review federal (CCOHS- Canadian centre for occupational health and safety) and provincial guidelines.
Involved Organization(s) and/or City Departments	City: ● Health and Safety (L) ● Human Resources ● Business Development BIAs Chamber of Commerce; NF Tourism/ Hotel Association; Labour Board; Trade Unions
Time Scale	LT
Budget	$$
Monitoring Metric and Baseline	# of enhanced best practices/ guidelines
Priority Impact Addressed	TEMP 2; TEMP 3; TEMP 4; TEMP 5; TEMP 6; TEMP 7; PRECIP 5; PRECIP 6; PRECIP 7; EXT 1; EXT 2; EXT 3; EXT 4; EXT 5

RESILIENT GOVERNANCE

Goal: To integrate climate change adaptation into operational procedures as well as land-use, financial, and strategic planning

Action 33

Systematically incorporate climate adaptation consideration into the City's Official, Strategic, Asset Management and Financial Plans.

Supporting Actions	
Immediate Next Steps	Identify staff lead(s) to coordinate incorporation of climate considerations. Identify which City strategic plans are up for their next review and when.
Involved Organization(s) and/or City Departments	All City departments • Finance • Asset Management • Planning
Time Scale	ST
Budget	$$
Monitoring Metric and Baseline	Number of City Strategic Plans that include climate adaptation considerations
Priority Impact Addressed	TEMP 1; TEMP 2; TEMP 3; TEMP 4; TEMP 5; TEMP 6; TEMP 7; PRECIP 1; PRECIP 2; PRECIP 3; PRECIP 4; PRECIP 5; PRECIP 6; PRECIP 7; EXT 1; EXT 2; EXT 3; EXT 4; EXT 5

Action 34

Develop a coordinating structure to implement and report on the plan.

Supporting Actions	34.1 Designate staffing and resources to Climate Change Mitigation and Adaptation.
	34.2 Develop Individual Departmental Work Plans and Initiatives related to Climate Change Adaptation.
Immediate Next Steps	Build off of roles and responsibilities precedent set by City Communication Department.
Involved Organization(s) and/or City Departments	City ● Mayor and CAO's office (L) ● Finance ● Senior Leadership Team
Time Scale	ST
Budget	$$$
Monitoring Metric and Baseline	Staff and resources dedicated to climate change action Scheduled reporting structure
Priority Impact Addressed	TEMP 1; TEMP 2; TEMP 3; TEMP 4; TEMP 5; TEMP 6; TEMP 7; PRECIP 1; PRECIP 2; PRECIP 3; PRECIP 4; PRECIP 5; PRECIP 6; PRECIP 7; EXT 1; EXT 2; EXT 3; EXT 4; EXT 5

Goal: To work with local, provincial and federal partners to prepare for, respond and recover effectively from sustained and/or multiple extreme events.

Action 35

Create a climate working group with federal, provincial, regional, and indigenous governments, as well as businesses and community networks to improve the ability of Niagara Falls to prepare for, respond to and, recover from extreme weather events.

Supporting Actions	
Immediate Next Steps	Identify stakeholders and create working group mandate.
Involved Organization(s) and/or City Departments	City: ● Fire ● Mayor and CAO's office ● Business Development Region (EMS) Indigenous governments Business community Federal and Provincial representatives
Time Scale	ST
Budget	$$
Monitoring Metric and Baseline	Meeting(s) held to coordinate adaptation efforts
Priority Impact Addressed	TEMP 1; TEMP 2; TEMP 3; TEMP 4; TEMP 5; TEMP 6; TEMP 7; PRECIP 1; PRECIP 2; PRECIP 3; PRECIP 4; PRECIP 5; PRECIP 6; PRECIP 7;

	EXT 1; EXT 2; EXT 3; EXT 4; EXT 5

Action 36

Update emergency response plan to include expected climate hazards (such as extreme heat, flooding and storms).

Supporting Actions	36.1 Create incident pre-plans with hotels, contractors, municipal water services and residents for evacuation or relocation situations.
	36.2 Explore opportunities for collaboration between emergency response plans from the City and the Region.
Immediate Next Steps	Identify staff to lead the Plan update.
Involved Organization(s) and/or City Departments	City: • Health and Safety • Communication • Fire, Police (L) • Municipal Works Region (EMS) Hotel Associations; Contractors (such as tree line workers)
Time Scale	LT
Budget	$
Monitoring Metric and Baseline	Emergency response plan updated with climate hazards
Priority Impact Addressed	TEMP 2; TEMP 3; TEMP 4; TEMP 5; TEMP 6; TEMP 7; PRECIP 2; PRECIP 5; PRECIP 6; PRECIP 7;

	EXT 1; EXT 2; EXT 3; EXT 4; EXT 5

Action 37

Continue to promote emergency preparedness week and 72-hour emergency kits.

Supporting Actions	
Immediate Next Steps	Organizing individual/group to identify additional promotion and partners for emergency preparedness.
Involved Organization(s) and/or City Departments	City: • Health and Safety (L) • Communication • Fire, Police and EMS
Time Scale	ST
Budget	$
Monitoring Metric and Baseline	
Priority Impact Addressed	TEMP 2; TEMP 3; TEMP 4; TEMP 5; TEMP 6; TEMP 7; PRECIP 2; PRECIP 5; PRECIP 6; PRECIP 7; EXT 1; EXT 2; EXT 3; EXT 4; EXT 5

Action 38

Work with Niagara Region, Niagara Peninsula Conservation Authority, Niagara Region Public Health, and municipalities within the Region to better understand roles and responsibilities, fill gaps in data collection, and expand sharing agreements in order to improve response to extreme weather events and increase efficiency of service delivery.

Supporting Actions	38.1 Work with Niagara Region to integrate results of Niagara Region's Climate Mitigation Plan.
Immediate Next Steps	Establish working group
Involved Organization(s) and/or City Departments	City: ● Municipal Works ● Fire, Police, EMS ● Human Resources ● Decision Support Services Niagara Region (L) Niagara Region Public Health; Niagara Peninsula Conservation Authority The Niagara Parks Commission
Time Scale	LT
Budget	$
Monitoring Metric and Baseline	A coordinated plan for extreme weather response is established
Priority Impact Addressed	TEMP 2; TEMP 3; TEMP 4; TEMP 5; TEMP 6; TEMP 7; PRECIP 2; PRECIP 5; PRECIP 6; PRECIP 7; EXT 1; EXT 2; EXT 3; EXT 4; EXT 5

Goal: To support the community through education on how to prepare for, respond to, and recover from extreme weather events

Action 39

Develop a climate adaptation and mitigation communications strategy that focuses on actions one can take.

Supporting Actions	39.1 Develop communications products and educational campaigns for different audiences, including homeowners, renters, business owners, tourists, students and land managers that identify the impacts of severe weather events and what they can do to prepare and reduce risk.
	39.2 Develop and provide internal City education and staff training regarding adaptation efforts and key climate-related risks and opportunities to enhance resilience.
	39.3 Utilize existing City committees such as Park in the City and Mayor's Youth Advisory to continue to promote climate change awareness.
	39.4 Work with municipal and educational partners in promoting climate change awareness and consistent messaging.
	39.5 Create an awards/honours/certification process that recognizes organizations that have increased their climate resilience.
	39.6 Utilize City intranet to provide educational links and information regarding climate change and climate change science.
Immediate Next Steps	Identify a staff lead and coordinate partners
Involved Organization(s) and/or City Departments	City: ● Communications ● Human Resources ● CAO and Mayor's office

	Park in the City Committee; Mayor's Youth Advisory Committee; BIAs; School Boards
Time Scale	LT
Budget	$$
Monitoring Metric and Baseline	Number of engagements Number of individuals engaged
Priority Impact Addressed	TEMP 1; TEMP 2; TEMP 3; TEMP 4; TEMP 5; TEMP 6; TEMP 7; PRECIP 1; PRECIP 2; PRECIP 3; PRECIP 4; PRECIP 5; PRECIP 6; PRECIP 7; EXT 1; EXT 2; EXT 3; EXT 4; EXT 5

Goal: To identify project-specific and ongoing funding for climate projects that are in line with financial planning

Action 40

Identify financing opportunities to support climate resilience and mitigation efforts.

Supporting Actions	
Immediate Next Steps	Identify lead staff to track opportunities and applications.
Involved Organization(s) and/or City Departments	City: ● Finance ● Rec, Culture ● Municipal Works

	• CAO and Mayor's Office Region NPCA
Time Scale	ST
Budget	$ Funding opportunities: Environmental exhibition in the OPG gallery has great materials
Monitoring Metric and Baseline	$ leveraged to support climate action
Priority Impact Addressed	TEMP 1; TEMP 2; TEMP 3; TEMP 4; TEMP 5; TEMP 6; TEMP 7; PRECIP 1; PRECIP 2; PRECIP 3; PRECIP 4; PRECIP 5; PRECIP 6; PRECIP 7; EXT 1; EXT 2; EXT 3; EXT 4; EXT 5

Action 41

Increase budgets to strengthen tree and natural infrastructure protection, planting and maintenance.

Supporting Actions	
Immediate Next Steps	Identify capital and operational planting, protection, maintenance needs
Involved Organization(s) and/or City Departments	City: • Finance • Municipal Works • Cemeteries • Rec, Culture and Parks
Time Scale	LT

Budget	$$$
Monitoring Metric and Baseline	$ allocated to planting, protection, maintenance
Priority Impact Addressed	TEMP 1; TEMP 2; TEMP 3; TEMP 4; TEMP 5; TEMP 6; TEMP 7; PRECIP 1; PRECIP 2; PRECIP 3; PRECIP 4; PRECIP 5; PRECIP 6; PRECIP 7; EXT 1; EXT 2; EXT 3; EXT 4; EXT 5

*City Legal Department- will support each and any stage of the plan as required, through the preparation of agreements or engaging outside council as required. This includes risk management advisory services.

*City Procurement Department- will support procurement process for any elements of the plan that require acquiring goods and services in accordance with procurement by-law

Appendix B: Climate Science Report

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Tables

Figures

Glossary of Terms

Definitions have been taken from the Intergovernmental Panel on Climate Change (IPCC), climatedata.ca, and the Climate Atlas of Canada.

Baseline

A climatological baseline is a reference period, typically three decades (or 30 years), that is used to compare fluctuations of climate between one period and another. Baselines can also be called references or reference periods.

Computerized Tool for the Development of Intensity-Duration-Frequency Curves Under Climate Change (IDF_CC) Version 6.0

IDF_CC is a publicly available web-based intensity-duration-frequency tool to update and adapt local extreme rainfall statistics to climate change. The IDF_CC tool is pre-loaded with 898 Environment and Climate Change Canada rain stations. Users can select any rain station with 10 or more years of data and develop IDF curves based on historical data and curves adjusted to reflect climate change. The tool also allows the development of IDF curves for ungauged locations in Canada.

Climate Change

Climate change refers to changes in long-term weather patterns caused by natural phenomena and human activities that alter the chemical composition of the atmosphere through the build-up of greenhouse gases which trap heat and reflect it back to the earth's surface.

Climate Projections

Climate projections are a projection of the response of the climate system to emissions or concentration scenarios of greenhouse gases and aerosols. These projections depend upon the climate change (or emission) scenario used, which are based on assumptions concerning future socioeconomic and technological developments that may or may not be realized and are therefore subject to uncertainty.

Climate Change Scenario

A climate change scenario is the difference between a future climate scenario and the current climate. It is a simplified representation of future climate based on comprehensive scientific analyses of the potential consequences of anthropogenic climate change. It is meant to be a plausible representation of the future emission amounts based on a coherent and consistent set of assumptions about driving forces (such as demographic and socioeconomic development, technological change) and their key relationships.

Ensemble Approach

An ensemble approach uses the average of all global climate models (GCMs) for temperature and precipitation. Research has shown that running many models provides the most realistic projection of annual and seasonal temperature and precipitation than using a single model.

Extreme Weather Event

A meteorological event that is rare at a place and time of year, such as an intense storm, tornado, hail storm, flood or heatwave, and is beyond the normal range of activity. An extreme weather event would normally occur very rarely or fall into the tenth percentile of probability.

General Circulation Models (GCM)

General Circulation Models are based on physical laws and physically-based empirical relationships and are mathematical representations of the atmosphere, ocean, ice caps and land surface processes. They are therefore the only tools that estimate changes in climate due to increased greenhouse gases for a large number of climate variables in a physically consistent manner.

Greenhouse Gas (GHG) Emissions

Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation, emitted by the Earth's surface, the atmosphere itself, and by clouds. Water vapour (H_2O), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3), and chlorofluorocarbons (CFCs) are the six primary greenhouse gases in the Earth's atmosphere in order of abundance.

Heat Wave

A heat wave occurs when at least three days in a row reach or exceed 30°C.

Hot Days

A hot day occurs when temperatures meet or exceed 30°C.

Intensity-Duration-Frequency curve

An Intensity-Duration-Frequency curve (IDF Curve) is a graphical representation of the probability that a given average rainfall intensity will occur. Rainfall Intensity (mm/hr), Rainfall Duration (how many hours it rained at that intensity) and Rainfall Frequency/Return Period (how often that rainstorm repeats itself) are the parameters that make up the axes of the graph of the IDF curve. An IDF curve is created with long term rainfall records collected at a rainfall monitoring station.

Radiative forcing

The change in the value of the net radiative flux (i.e. the incoming flux minus the outgoing flux) at the top of the atmosphere in response to some perturbation, in this case, the presence of greenhouse gases.

Representative Concentration Pathways

Representative Concentration Pathways (RCPs) are four greenhouse gas concentration (not emissions) trajectories adopted by the IPCC for its fifth Assessment Report (AR5) in 2014. It supersedes Special Report on Emissions *Scenarios* (SRES) projections published in 2000.

Temperature anomaly

A departure from a reference value or long-term average. A positive anomaly indicates that the observed temperature was warmer than the reference value, while a negative anomaly indicates that the observed temperature was cooler than the reference value.

Climate Indices

The climate indices included in this study are listed and defined in the table below. The indices represent a broad range of important climate variables that impact daily life in Niagara Falls. Each indicator is discussed in more detail in their respective sections below.

Table 1: Climate Indices Definitions

Climatic Driver	Climate Indicator	Description	Units
Hot Temperature	Mean Temperature	The average temperature of the season (or annually).	°C
	Mean Monthly Maximum Temperature	The average monthly maximum temperature.	°C
	Mean Monthly Minimum Temperature	The average monthly minimum temperature.	°C
	Very Hot Days (+30°C)	A Very Hot Day is a day when the temperature rises to at least 30 °C. This is the temperature where a Heat Alert is issued by Environment Canada.	Days
	Number of Heat Waves	The average number of heat waves per year. A heat wave occurs when at least three days in a row reach or exceed 30°C.	Number of heatwaves
	Average Length of Heat Waves	The average length of a heat wave. A heat wave occurs when at least three days in a row reach or exceed 30°C.	Days
Cold Temperature	Freeze-Thaw Cycles	This is a simple count of days when the air temperature fluctuates between freezing and non-freezing temperatures.	Days
	Frost Days	A frost day is one on which the coldest temperature of the day is lower than 0°C.	Days
	Icing Days	An Icing Day is a day on which the air temperature does not go above freezing (0°C).	Days
	Winter Days (-15°C)	A Winter Day is a day when the temperature drops to at least -15°C.	Days
Agricultural Indices	Growing Season Start Date	The first day of the year when Tmin > 0°C (last frost)	Date of Year
	Growing Season End Date	The last day of the year when Tmin > 0°C (first frost)	Date of Year
	Growing Season Length	The number of days between the growing season start and end days (frost-free period)	Days
	Mean Precipitation	The average precipitation for a given season (or annually)	mm
	Heavy Precipitation Days (20mm)	A Heavy Precipitation Day (20 mm) is a day on which at least a total of 20 mm of rain or frozen precipitation falls.	Days

	Max. 1-day Precipitation (mm)	The amount the precipitation that falls on the wettest day of the year.	mm
	Max 5-day Precipitation (mm)	The wettest five-day period.	mm
Extreme Weather	Freezing Rain Events	Average percentage change in the number of daily freezing rain events (≥1 hr, ≥4 hr and ≥6 hr).	Days
	Rainfall IDF Curves	The annual maximum rainfall intensity for specific durations. Common durations for design applications are: 5-min, 10-min, 15-min, 30-min, 1-hr, 2-hr, 6-hr, 12-hr, and 24-hr.	Mm/h

Introduction

Climate change is an increasingly critical issue at the national and local level. Recent events in Canada including flooding, ice storms, and other occurrences of extreme weather over the past several decades, have highlighted the need to be prepared for ongoing challenges. The goal of the Building Adaptive Resilient Communities (BARC) Program is to build capacity within municipalities to better understand impacts resulting from climate change and develop localized climate change adaptation plans to address their community's priority risks.

Recent events in Niagara Falls include an increase in the frequency and temperatures of heatwaves, such as those experienced in 2018, 2020, 2021, and 2022. Extreme rain and flood events have been experienced in the Niagara Region nearly every year in the last 10 years, and have resulted in basement flooding, sewer backups, flooded agricultural lands and have caused road closures, infrastructure damage, shoreline erosion, overwhelmed sewer and storm water systems, park and beach closures, and power outages. Additionally, the Niagara Region experienced a severe blizzard with freezing rain, heavy snowfall, wind gusts over 105-124km/h, storm surges on Lake Erie, and -20°C temperatures. Across the US border, in December of 2022, the Buffalo Region received nearly four feet of snow, hurricane force winds, whiteout conditions, and thousands of calls to emergency services over the course of four days.

This report will primarily focus on changes in temperature and precipitation patterns which will affect the social, natural, built, and economic systems in Niagara Falls at the community level. The localized projections will help determine what vulnerabilities and risks the city faces as a result of climate change and inform how the City can better prepare for projected impacts and increase their resilience to them.

Data Collection

Data for this report was collected through several platforms. Primarily, localized climate change data was collected from three online, publicly available tools. These include:

- Climate Change Data and Scenarios Tool - Climatedata.ca
- The Climate Atlas of Canada was used to collect data relating to CMIP5 climate projections where CMIP6 data was unavailable from climatedata.ca

- Computerized Tool for the Development of Intensity-Duration-Frequency Curves under Climate Change Version 6.0 - http://www.idf-cc-uwo.ca/home

More information concerning these online tools are provided in the Glossary. Other information pertaining to expected climatic changes in Ontario were taken from various academic or government reports. These are identified and cited where applicable.

Climate Change Modelling and Downscaling

Wherever possible, the data presented in this report is based on global climate models (GCMs) and emission scenarios defined by the Intergovernmental Panel on Climate Change (IPCC), drawing from the Sixth Assessment Reports. Data projecting temperature and precipitation changes have been constructed using Coupled Model Intercomparison Project (CMIP) 6 data as they are the most current global climate model data available. CMIP6 improves upon CMIP5 by including 49 climate modelling groups running 100 climate models.

Many different methods exist to construct climate change scenarios, however GCMs are the most conclusive tools available for simulating responses to increasing greenhouse gas concentrations, as they are based on mathematical representations of atmosphere, ocean, ice cap, and land surface processes.[1]

Wherever possible, this report uses an ensemble approach, which refers to a system that runs multiple climate models at once. Research has shown that this provides a more accurate projection of annual and seasonal temperatures and precipitation than a single model would on its own.[2]

Greenhouse Gas Emissions Scenarios

Climate change scenarios are based on models developed by a series of international climate modeling centers. They are socioeconomic storylines used by analysts to make projections about future greenhouse gas emissions and to assess future vulnerability to climate change. Producing scenarios requires estimates of future population levels, economic activity, the structure of governance, social values, and patterns of technological change. In this report, climate change scenarios from the Fifth and Sixth IPCC Assessments are considered.

SSP Scenarios - IPCC Sixth Assessment Report (AR6)

Shared Socio-economic Pathways (SSPs) are the newest set of climate change scenarios that provide the basis for IPCC's Sixth Assessment report (AR6). While the Representative Concentration Pathways (RCPs) used in the IPCC's Fifth Assessment Report (AR5) focuses on mitigation targets to address physical climate change, the SSPs focus on the underlying socioeconomic contexts which may present challenges to mitigation and adaptation policies. The SSPs incorporate socioeconomic characteristics and other human-caused climate drivers (e.g., population growth, education levels, GDP growth, income inequality, use of technology, energy use, political contexts, land-use change) to derive scenarios that describe differing influences on greenhouse gas emissions. AR6 assesses and compares the RCP and SSP scenarios and incorporates new data, new models, and updated climate research from around the world to allow for a standardized comparison of society's choices and their resulting levels of climate change. The premise is that every radiative forcing pathway (see Glossary) can result from a diverse range of socioeconomic and technological development scenarios. SSP-based scenarios are categorized by their

[1] Climatedata.ca. (2022).
[2] Ibid.

relationship to both adaptation and mitigation, and their approximate total radiative forcing in the year 2100 relative to pre-industrial levels, and are labeled as SSP1-SSP5.

These five pathways range from SSP1, where challenges to mitigation and adaptation are low, to SSP3 where challenges to mitigation and adaptation are both high, and the remaining SSPs are representative of the spectrum of possible societal futures.

For this report, where possible, projections will use both SSP2-4.5, and SSP5-8.5, as they represent a carbon reduced future with support of adaptation actions, and a 'fossil-fueled development' scenario with high challenges to mitigation and low challenges to adaptation. These scenarios were chosen because they represent a wide-range of possible future climates, have associated projections available from many different climate models, and correspond with Representative Concentration Pathways (RCP) 4.5 and 8.5 utilized in the IPCC's AR5. Additionally, it is important that municipalities are aware of some of the most potentially dramatic effects of climate change should global emissions persist. Table 2 provides a description of SSP scenarios 1,2, and 5, while Figure 1 illustrates the projected global warming associated with the three scenarios.

Table 2: IPCC Sixth Assessment Report Climate Change Scenario Characteristics[3]

Scenario	Description
SSP1-2.6 – Sustainability ***Taking the Green Road***	● Low challenges to both mitigation and adaptation ● Policy focused on sustainable development ● Effective international cooperation ● Reduced inequality within and across countries ● Low consumption ● Low population growth
SSP2-4.5 ***Middle of the Road***	● Medium challenges to both mitigation and adaptation ● Current development and consumption patterns continue ● National and global institutions are slow to achieve sustainable development goals ● Environmental systems decline ● Slow improvements to inequality ● Moderate population growth
SSP5-8.5 – Fossil-fueled Development ***Taking the Highway***	● High challenges to mitigation, low challenges to adaptation ● Policy focused on free markets ● High consumption ● Effective international cooperation

[3] Keywan Riahi, Detlef P. van Vuuren, Elmar Kriegler, Jae Edmonds, Brian C. O'Neill, Shinichiro Fujimori, Nico Bauer, Katherine Calvin, Rob Dellink, Oliver Fricko, Wolfgang Lutz, Alexander Popp, Jesus Crespo Cuaresma, Samir KC, Marian Leimbach, Leiwen Jiang, Tom Kram, Shilpa Rao, Johannes Emmerling, Kristie Ebi, Tomoko Hasegawa, Petr Havlik, Florian Humpenöder, Lara Aleluia Da Silva, Steve Smith, Elke Stehfest, Valentina Bosetti, Jiyong Eom, David Gernaat, Toshihiko Masui, Joeri Rogelj, Jessica Strefler, Laurent Drouet, Volker Krey, Gunnar Luderer, Mathijs Harmsen, Kiyoshi Takahashi, Lavinia Baumstark, Jonathan C. Doelman, Mikiko Kainuma, Zbigniew Klimont, Giacomo Marangoni, Hermann Lotze-Campen, Michael Obersteiner, Andrzej Tabeau, Massimo Tavoni, The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview, Global Environmental Change, Volume 42. https://doi.org/10.1016/j.gloenvcha.2016.05.009.

	• Reduced inequality • High economic growth • Low population growth

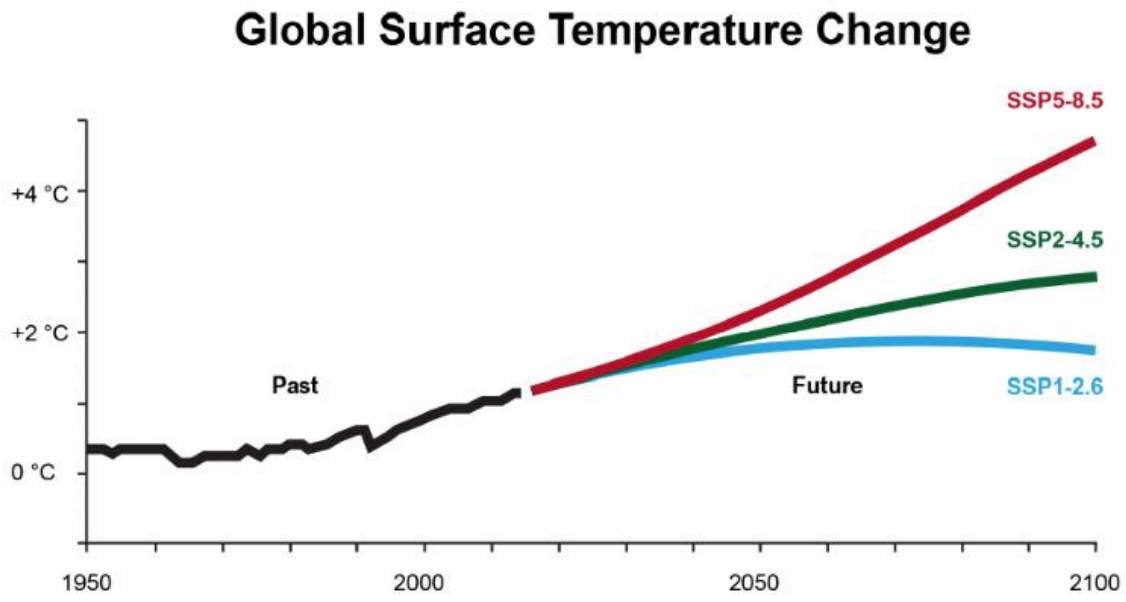


Figure 1: Projected Global Surface Temperature Change for CMIP6 SSP Scenarios

Time Periods

Climatic projections are typically provided within time periods of 20-30 years. Additionally, a consistent baseline period is established so that projections can be accurately compared with historical trends. In this report, the time periods of 2021-2050 and 2051-2080 are used most frequently. In some cases, timeframes are divided into three: "2020s" (2016-2035); "2050s" (2046-2065); and "2080s" (2081-2100). Many climate indices are also divided into seasonal periods, defined below.

Table 3: Seasonal timeframes

Season	Months
Winter	December, January, February
Spring	March, April, May
Summer	June, July, August
Fall	September, October, November

Uncertainty

It is important to note that uncertainty is an integral part of the study of climate change. Uncertainty is factored into climate change scenarios, models, and data, and reflects the complex reality of environmental change and the evolving relationship between humans and the planet. Climate change cannot be predicted with absolute certainty in any given case, and all data must be considered with this

in mind. While it is not possible to anticipate future climactic changes with absolute certainty, climate change scenarios help to create plausible representations of future climate conditions. These conditions are based on assumptions of future atmospheric composition and on an understanding of the effects of increased atmospheric concentrations of greenhouse gases (GHG), particulates, and other pollutants.

Temperature

Ontario

Over the last six decades, Canada has become warmer, with average temperatures over land increasing by 1.5°C between 1950 and 2010.[4] This rate of warming is almost double the global average reported over the same period.[5] Assuming emissions continue at the current rate of global output, the Province of Ontario is projected to experience an increase in annual average temperature of 4.8°C by the end of the century.

Table 4 displays the expected seasonal temperature change in Ontario based on the IPCC Fifth Assessment Report (AR5). Climate modelling suggests that these changes will continue and the climate change associated risks will increase in the future.

Table 4: Annual and Seasonal Temperature in Ontario for RCP8.5*

Emissions Scenarios	T Mean (℃)	Baseline (1976-2005)	2021-2050			2051-2080		
			Low	Mean	High	Low	Mean	High
RCP8.5	Spring	-0.6	-1.2	1.4	4.3	0.8	3.6	7
	Summer	15.7	16.2	17.8	19.4	17.9	20	22
	Fall	3.4	3.8	5.6	7.3	5.9	7.8	9.6
	Winter	-16.2	-16.3	-13.3	-10.3	-13.1	-10.1	-6.9
	Annual	**0.6**	**1.5**	**3**	**4.5**	**3.6**	**5.4**	**7.4**

*Provincial wide data not available for SSP5-8.5

City of Niagara Falls

Temperatures in the Niagara Falls are expected to rise in congruence with the provincial changes observed in the data above. The climatedata.ca tool was used to collect downscaled climate projections, using a baseline of 1971-2000.

In Niagara Falls there is a projected annual temperature increase between 2.4°C in the immediate future and 4.6°C by 2080 from the baseline mean under scenario SSP5-8.5. Table 5 and Figure 2 depict the projected temperatures using an ensemble of global climate models and applying the SSP2-4.5 and SSP5-8.5 scenario.

Table 5: Projected Mean Temperatures for Niagara Falls (°C) by Season – SSP2-4.5 and SSP5-8.5

Emissions	T Mean		2021-2050	2051-2080

[4] Douglas, A.G. and Pearson, D. (2022). Ontario; Chapter 4 in Canada in a Changing Climate: Regional Perspectives Report, (ed.) F.J. Warren, N. Lulham, D.L. Dupuis and D.S. Lemmen; Government of Canada, Ottawa, Ontario.
[5] Ibid.

Scenarios	(°C)	Baseline (1971-2000)	Low	Mean	High	Low	Mean	High
SSP2-4.5	Spring	6.8	8.7	9.3	10	9.6	10.2	11.4
	Summer	20.5	22.0	22.5	23.7	22.8	23.8	25.0
	Fall	10.9	12.5	13.0	14.4	13.2	14.0	15.7
	Winter	-2.9	-1.0	-0.3	0.7	0.1	1.0	2.8
	Annual	**9.0**	**10.7**	**11.2**	**12.3**	**11.5**	**12.4**	**13.6**
SSP5-8.5	Spring	6.8	8.6	9.5	10.2	10.8	11.4	12.3
	Summer	20.5	22.2	22.8	24.1	23.8	25.0	27.1
	Fall	10.9	12.6	13.3	14.3	14.4	15.2	17.7
	Winter	-2.9	-1.0	0.3	1.7	1.1	2.6	4.7
	Annual	**9.0**	**10.8**	**11.4**	**12.7**	**12.8**	**13.6**	**15.4**

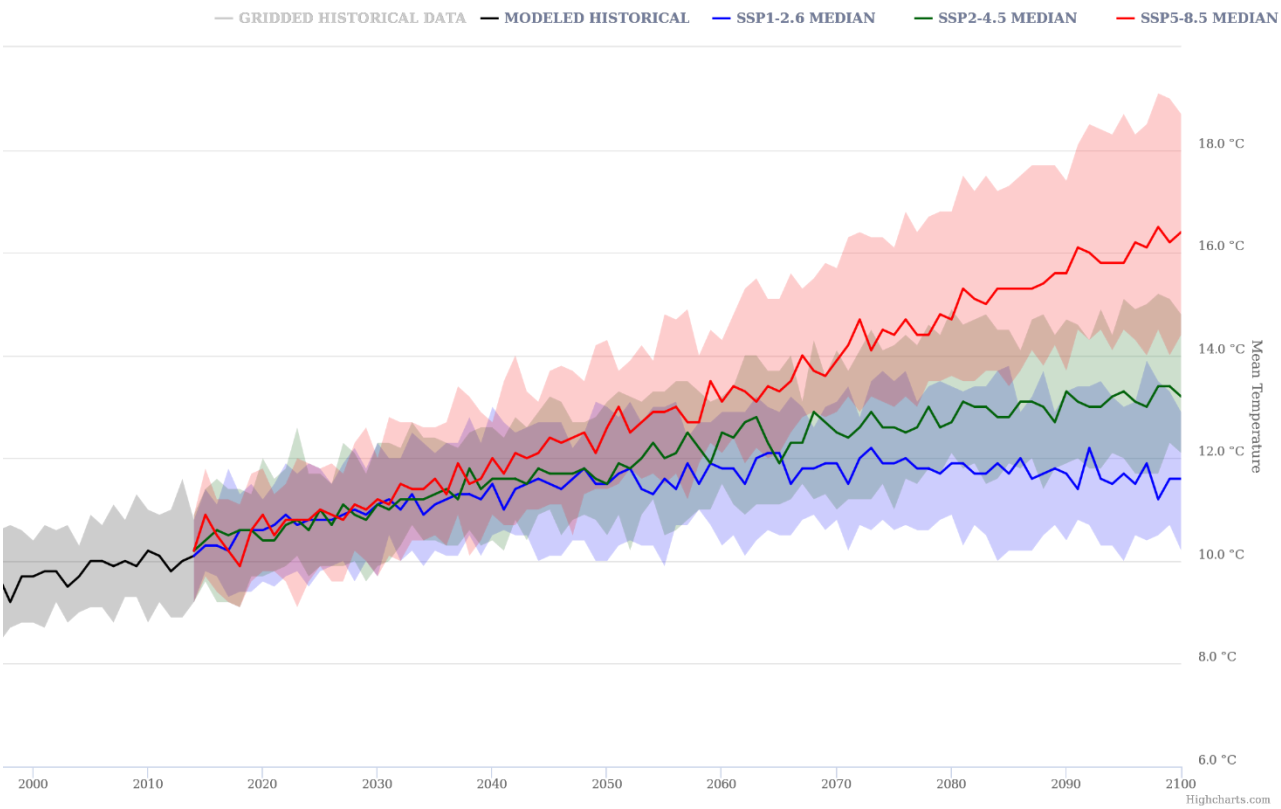


Figure 2: Projected Mean Temperature Change for Niagara Falls SSP1-2.6, SSP2-4.5, SSP5-8.5

Hot and Cold Days

Maximum and minimum temperature trends show the average high temperatures and the average low temperatures for a given season.

In terms of minimum temperatures, the baseline mean minimum temperatures across each season were 2.3, 15.5, 6.8, and -6.4°C for spring, summer, fall and winter respectively. Minimum seasonal temperatures under an SSP5-8.5 scenario are projected to increase substantially, with an increase of 4.2°C in spring, 4.4°C in summer, 4.1°C in fall and nearly 6°C in winter 2051-2080.

Table 6: Projected Average Seasonal Minimum Temperatures for Niagara Falls – SSP2-4.5 and SSP5-8.5

Emissions Scenario	T Mean (℃)	Baseline (1971-2000)	2021-2050			2051-2080		
			Low	Mean	High	Low	Mean	High
SSP2-4.8	Spring	2.3	3.8	4.3	5.0	4.8	5.1	6.0
	Summer	15.5	17.0	17.4	18.2	17.7	18.5	19.4
	Fall	6.8	8.2	8.7	10.0	9.0	9.7	11.4
	Winter	-6.4	-4.2	-3.6	-2.1	-2.9	-2.1	0.1
	Annual	**4.6**	**6.4**	**6.8**	**7.7**	**7.3**	**7.9**	**9.3**
SSP5-8.5	Spring	2.3	3.8	4.6	5.1	5.9	6.5	7.2
	Summer	15.5	17.1	17.7	18.6	18.9	19.9	21.3
	Fall	6.8	8.3	8.9	9.8	10.1	10.9	13.3
	Winter	-6.4	-4.2	-2.9	-1.1	-1.8	-0.3	2.3
	Annual	**4.6**	**6.5**	**7.2**	**8.1**	**8.6**	**9.2**	**10.9**

In terms of Average Seasonal Maximum Temperatures, seasonal average baseline temperatures for Niagara Falls were 12.0, 25.6, 15.1, and 0.6˚C for spring, summer, fall and winter respectively. Niagara Falls will experience an increase in all seasonal maximum temperatures, with Average Summer Maximum Temperatures reaching 30.3˚C in the years 2051-2080 under SSP5-8.5. Average Winter Maximum Temperatures will increase 5.5˚C by 2051-2080 according to SSP5-8.5.

Table 7: Projected Average Seasonal Maximum Temperatures for Niagara Falls – SSP2-4.5 and SSP5-8.5

Emissions Scenarios	T Mean (C˚)	Baseline (1971-2000)	2021-2050			2051-2080		
			Low	Mean	High	Low	Mean	High
SSP2-4.5	Spring	12.0	13.5	14.3	14.8	14.3	15.2	16.5
	Summer	25.6	26.9	27.7	29.0	27.9	29,0	30.8
	Fall	15.1	16.7	17.3	18.8	17.4	18.3	20.2
	Winter	0.6	2.2	2.9	3.5	3.1	4.1	5.3
	Annual	**13.4**	**15.0**	**15.7**	**16.7**	**15.7**	**16.8**	**18.1**
SSP5-8.5	Spring	12.0	13.5	14.4	15.3	15.5	16.5	17.7

	Summer	25.6	27.2	27.9	29.4	28.8	30.3	32.9
	Fall	15.1	16.7	7.5	19.0	18.6	19.5	22.1
	Winter	0.6	2.2	3.4	4.5	4.0	5.5	6.8
	Annual	13.4	**15.1**	**15.7**	**17.1**	**17.0**	**17.9**	**19.8**

For Niagara Falls, the baseline Average Warmest Maximum Temperature was 25.5°C. According to SSP5-8.5, the Average Warmest Maximum Temperature will increase to 27.9°C in the immediate future (2021-2050), and 30.3°C in the near future (2051-2080) according to the scenario mean. These temperatures do not factor in additional warming due to the humidex which could make it feel 5 to 10°C warmer. These extreme temperatures can cause heat-related illnesses in not only vulnerable populations but also healthy, young adults.

Days where the daily maximum temperatures exceed 30°C present the greatest threats to community health due to heat-related illnesses. Examples of these include heat cramps, heat edema, heat exhaustion, or heat stroke. Specific groups, such as those who work outside, infants and young children, older adults (over the age of 65), those with chronic medical conditions, people experiencing homelessness, people playing outdoor sports or activities, and those with limited mobility may be more adversely affected.[6] Moreover, while higher summer temperatures increase electricity demand for cooling, at the same time, it also can lower the ability of transmission lines to carry power, possibly leading to electricity reliability issues during heat waves.[7]

The baseline average number of days when the maximum temperature was greater than or equal to 30°C was 11 days for Niagara Falls. This is expected to increase to an average of 60 days in the 2051-2080 period under the SSP5-8.5 scenario. This means there will be nearly a six-fold increase in days above 30°C by 2080 in the City.

Table 8: Extreme Heat Days (Tmax ≥30°C) for Niagara Falls - SSP2-4.5 and SSP5-8.5

Emissions Scenario	Tmax (days)	Baseline (1971-2000)	2021-2050			2051-2080		
			Low	Mean	High	Low	Mean	High
SSP2-4.5	30°C or more	11	21	30	43	32	44	65
SSP5-8.5	30°C or more	11	22	33	48	43	60	91

[6] Health Canada. (2011). Adapting to Extreme Heat Events: Guidelines for Assessing Health Vulnerability. Ottawa, ON. Retrieved from http://www.hc-sc.gc.ca/ewh-semt/pubs/climat/adapt/index-eng.php

[7] Centre for Climate and Energy Solutions (n.d.). Heat Waves and Climate Change. C2ES. Retrieved from https://www.c2es.org/content/heat-waves-and-climate-change/

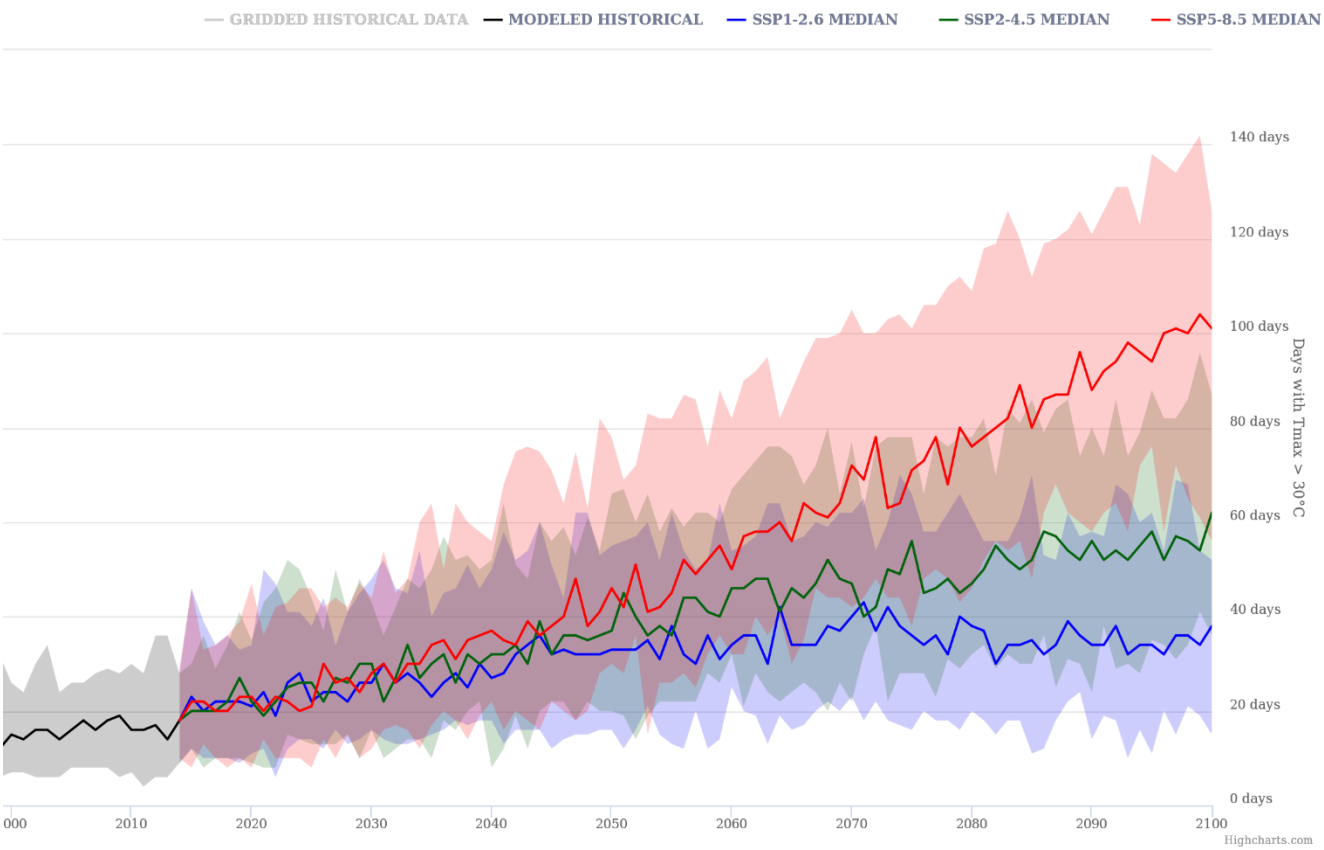


Figure 3: Projected Very Hot Days (30°C) for Niagara Falls under SSP5-8.5

The Climate Atlas of Canada defines a heat wave as three days in a row that reach or exceed 30°C and considers two variables for heatwaves; the annual average length of heat waves, and the annual number of heat waves. The annual number of heatwave events measures the average number of times per year where the temperature reaches or exceeds 30°C. The baseline number of heat waves for Niagara Falls is 1.7 as presented in Table 9. In the 2051-2080 period according to RCP8.5, Niagara Falls can expect to experience over six heat wave events per year.

Table 9: Number of Annual Heat Waves for Niagara Falls - RCP4.5 and 8.5*

Emissions Scenarios	Baseline (1976-2005)	2021-2050			2051-2080		
		Low	Mean	High	Low	Mean	High
RCP4.5	1.7	1.6	4.3	7.4	2.6	5.6	8.7
RCP8.5	1.7	1.9	4.7	7.7	3.9	6.6	9.6

*Heatwave data is currently not available for SSP2-4.5 or SSP5-8.5

With regards to the average length of heat waves (in days), the Niagara Falls experienced an average of 3.4 days of heatwave conditions in the baseline period as displayed in Table 10. In the 2051-2080 period,

according to RCP8.5, Niagara Falls can expect to see an average heatwave event occurring for 8.7 days – over double the current length.

Table 10: Average Annual Length of Heatwaves for Niagara Falls - RCP4.5 and 8.5*

Emissions Scenarios	Baseline (1976-2005)	2021-2050			2051-2080		
		Low	Mean	High	Low	Mean	High
RCP4.5	3.4	3.4	5.3	7.8	3.9	6.3	9.5
RCP8.5	3.4	3.6	5.6	8.4	5.0	8.7	14.0

*Heatwave data is currently not available for SSP2-4.5 or SSP5-8.5

Overall, heatwave events are projected to occur more frequently and for longer periods of time. These changes become more pronounced as time goes on, and with regards to the higher emissions scenarios. Sustained over several days at a time, these extreme temperatures will have significant impacts on the health of individuals in Niagara Falls – heat illnesses can manifest quickly, and lead to long-term health problems and even death. Overexposure to extreme heat is especially dangerous for children and elderly adults, and those who work outside or are physically active in the outdoors.[8]

Cold Weather

Cold weather is an important aspect of life in Canada, and many places in Canada are well adapted to very cold winters. Overall, the frequency and severity of cold days are decreasing across Canada, and in Niagara Falls, while the number of hot days is increasing. However, it is important to know how our winters will change in the future, because cold temperatures affect health and safety, determine what plants and animals can live in the area, limit or enable outdoor activities, define how we design our buildings and vehicles, and shape our transportation and energy use.

Winter Days

Winter days, defined as a day where the temperature drops to at least -15°C, are projected to decrease in Niagara Falls. In fact, by the end of the century Niagara Falls is expected to experience zero days a year where temperatures dip below -15°C.

Frost Days and Icing Days

Other indicators of cold temperatures are Frost Days and Icing Days - frost and ice days can help to understand freeze and thaw patterns throughout the region, and document risks relating to morbidity and mortality from traffic accidents, damage to roads and infrastructure, facility closures and more.

A frost day is a day with frost potential – meaning the **minimum** temperature is below 0°C. Frost days are predicted to decrease an average of 60 days, and as infrequently as 29 days by the 2080s in SSP5-8.5.

[8] Berry, P., & Schnitter, R. (Eds.). (2022). Health of Canadians in a Changing Climate: Advancing our Knowledge for Action. Ottawa, ON: Government of Canada.
https://changingclimate.ca/site/assets/uploads/sites/5/2022/02/CCHA-REPORT-EN.pdf

Table 11: Projected Frost Days for Niagara Falls - SSP2-4.5 and SSP5-8.5

Emissions Scenarios	Baseline (1971-2000)	2021-2050			2051-2080		
		Low	Mean	High	Low	Mean	High
SSP2-4.5	123	77	98	105	51	81	92
SSP5-8.5	123	64	92	101	29	63	77

Similarly, the number of ice days are projected to decrease. Ice days are the total number of days when the when daily **maximum** temperature is at or below 0°C. A reduction in days below 0°C could have an impact on the survival and spread of ticks and Lyme disease, as ticks can be active in temperatures above 4°C.[9] While deer ticks are most active in spring and fall, warmer winters could extend their window of activity. Icing Days are expected to decrease by nearly 75% by the 2080s in SSP5-8.5.

Table 12: Projected Icing Days for Niagara Falls - SSP2-4.5 and SSP5-8.5

Emissions Scenarios	Baseline 1976-2005	2021-2050			2051-2080		
		Low	Mean	High	Low	Mean	High
SSP2-4.5	46	22	27	34	10	21	27
SSP5-8.5	46	15	25	34	5	11	19

Freeze-Thaw

A freeze-thaw cycle is any day where the minimum temperature is below 0˚C and the maximum temperature is above 0˚C. The SSP5-8.5 ensembles project that freeze-thaw cycles will decrease due to overall warmer temperatures. This is likely due to the fact that overall, the days are getting warmer, and Niagara Falls is likely to experience a decrease in the number of days that reach a minimum temperature below 0°C.

Under these conditions, it is likely that some water at the surface was both liquid and ice at some point during the 24-hour period. Freeze-thaw cycles can have major impacts on infrastructure. Water expands when it freezes, so the freezing, melting, and re-freezing of water can over time cause significant damage to roadways, sidewalks, and other outdoor structures. Potholes that form during the spring, or during mid-winter melts, are good examples of the damage caused by this process.

Table 13: Average Annual Freeze-Thaw Cycles for Niagara Falls - SSP2-4.5 and SSP5-8.5

Emissions Scenarios	Baseline (1971-2000)	2021-2050			2051-2080		
		Low	Mean	High	Low	Mean	High
SSP2-4.5	61	41	54	58	28	46	52
SSP5-8.5	61	37	52	55	13	38	46

[9] Alberta Health. (2019). Lyme disease tick surveillance. Retrieved from https://www.alberta.ca/lyme-disease-tick-surveillance.aspx

Agricultural Indices

Growing Season Start Date, End Date, and Length

Climate change creates both risks and opportunities for Ontario agriculture. Changes in seasonal temperatures, precipitation events, the length of growing seasons, and the timing of extreme heat and cold days all determine the types of crops that can be grown now and in the future.[10] While increased temperatures will extend the growing season of some crops, it will bring with it a series of deleterious factors which may negate any benefit. For instance, increased temperatures may also increase the likelihood of drought conditions, reduce the water supply for crop irrigation, improve conditions for some pests, and disrupt pollination patterns.[11] Managing for increased agricultural productivity and working to reduce risks under climate change will require careful consideration of changing weather and climate conditions, as well as key landscape and soil characteristics, crop suitability, farm management options, and policy and program support.[12]

Agricultural indices include the start and end of the growing season, as respectively defined by the last and first frosts, as well as the total length of the growing season. The SSP5-8.5 ensembles project earlier start dates and later end dates to the growing season in Niagara Falls as shown in Table 14. The baseline start date is typically around April 19th, while the end date is typically November 1st, resulting in a growing season of approximately 194 days. According to the SSP5-8.5 ensemble, by the end of the 21st century, the growing season is projected to occur approximately 19 days earlier, while the end date will likely occur approximately 19 days later. This means, on average, the growing season will likely increase by up to 1 month, following the high emissions scenario.

Table 14: Growing Season Length for Niagara Falls under SSP8.5

	SSP5-8.5		
	Mean Start date (Date of Last Spring Frost)	**Mean End date (Date of First Fall Frost)**	**Mean frost-free days**
1971-2000 (Baseline)	Apr. 19	Nov. 1	194
2021-2050	Apr. 10	Nov. 11	215
2051-2080	Mar. 31	Nov. 20	236

[10] Prairie Climate Centre (2020). *Climate Variables*. Climate Atlas of Canada. Retrieved from https://climateatlas.ca/variables

[11] Capital Regional District. (2017, July 17). *Climate Projections for the Capital Region.* Retrieved from www.crd.bc.ca: https://www.crd.bc.ca/docs/default-source/climate-action-pdf/reports/2017-07-17_climateprojectionsforthecapitalregion_final.pdf

[12] OCCIAR (2017). The Ontario Climate and Agriculture Assessment Framework. Retrieved from http://www.climateontario.ca/doc/p_OCAAF/OCAAF_FinalReport_June2017.pdf

Precipitation

Ontario

Canada has, on average, become wetter during the past half century, with average precipitation across the country increasing by approximately 20%.[13] Other parts of the country can expect to see a significant percentage increase in precipitation, particularly Northern Canada, projections for Ontario show less dramatic changes to precipitation patterns. Below are the projected precipitation changes for the province of Ontario under the RCP8.5 scenario.

Table 15: Projected Annual Precipitation (mm) by Season for Ontario – RCP8.5*

Emissions Scenario	Total Precipitation (mm)	Baseline 1976-2005	2021-2050			2051-2080		
			Low	Mean	High	Low	Mean	High
RCP8.5	Spring	136	110	147	185	119	160	205
	Summer	224	180	229	181	173	225	278
	Fall	202	170	216	263	174	222	276
	Winter	122	106	136	168	118	151	183
	Annual	**684**	**637**	**728**	**814**	**665**	**758**	**853**

*Provincial wide data not available for SSP5-8.5

Niagara Falls

On a seasonal basis, in Niagara Falls, spring, winter and autumn precipitation accumulations are projected to increase by the end of the century with spring and winter experiencing the greatest increases. These seasonal trends, including relatively stable summer rainfall amounts paired with the projected increases in summer temperatures and heatwave lengths may lead to increased instances of drought. Table 16 presents the precipitation accumulation projections for Niagara Falls according to seasons under SSP2-4.5 and SSP5-8.5. Figure 4 presents the precipitation accumulation projections for Niagara Falls according to SSP5-8.5.

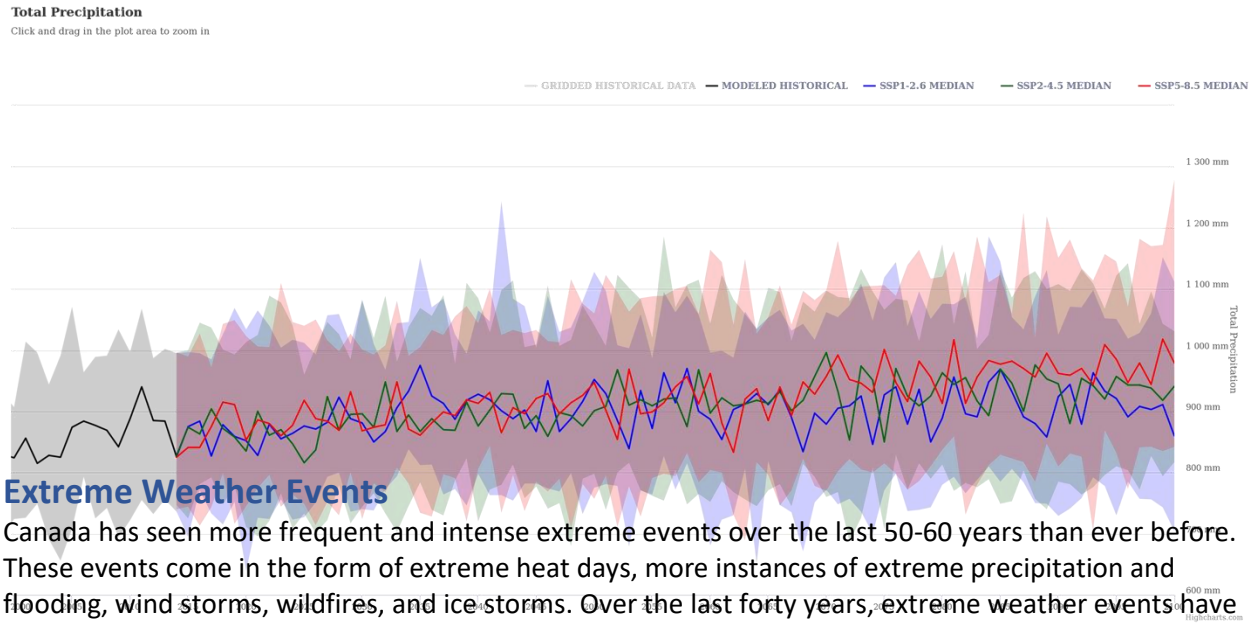
For Niagara Falls, the baseline average annual precipitation 840 mm. In a high emission scenario, Niagara Falls can expect to experience an average annual precipitation increase of 63mm during 2021-2050 and 105mm during 2051-2080.

Table 16: Projected Annual Precipitation (mm) by Season for Niagara Falls – SSP2-4.5 and SSP5-8.5

Emissions Scenario	Total Precipitation (mm)	Baseline (1971-2000)	2021-2050			2051-2080		
			Low	Mean	High	Low	Mean	High
SSP2-4.5	Spring	214	219	228	248	228	240	259
	Summer	213	201	219	235	195	218	239
	Fall	231	226	239	254	223	247	262
	Winter	201	203	221	229	220	238	253

[13] Natural Resources Canada. (2019) *Canada in a Changing Climate.* *https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/Climate-change/pdf/CCCR_FULLREPORT-EN-FINAL.pdf* *Government of Canada, Ottawa, ON. p.156.*

	Annual	**840**	**865**	**891**	**924**	**882**	**930**	**963**
SSP5-8.5	Spring	214	219	234	252	225	252	270
	Summer	213	198	223	243	183	222	243
	Fall	231	216	238	261	219	252	264
	Winter	201	221	229	241	228	245	255
	Annual	**849**	**858**	**903**	**937**	**889**	**945**	**986**



Extreme Weather Events

Canada has seen more frequent and intense extreme events over the last 50-60 years than ever before. These events come in the form of extreme heat days, more instances of extreme precipitation and flooding, wind storms, wildfires, and ice storms. Over the last forty years, extreme weather events have resulted in damages of $31 Billion In Canada alone, with global costs estimated at nearly $5 Trillion. The likelihood and the severity of these events are increasing with climate change, and are expected to cause hundreds of trillions of dollars in economic damage globally.[14] Extreme weather events will affect communities across Canada, from damage to infrastructure and critical services, to economic and industry productivity, and the health of vulnerable populations.[15] Future extreme weather models predict shorter return periods of extreme events – that is, an increase in the likelihood of 25, 50, and 100 year events – in the future.

Heavy or Extreme Precipitation

Extreme and heavy rain events are expected to become more intense and more frequent.[16] As Southern Ontario is the most intensely urbanized area of the province, the magnitude and costs to insured and uninsured damages associated with flooding is significantly higher than elsewhere in the province.[17] Extreme rain and flood events have been experienced in the Niagara Region nearly every year in the last

[14] Feltmate, B. and M. Moudrak. 2021. Climate Change and the Preparedness of 16 Major Canadian Cities to Limit Flood Risk. Intact Centre on Climate Adaptation, University of Waterloo
[15] Ibid.

[16] Chiotti, Q. and Lavender, B. (2008): Ontario; *in* From Impacts to Adaptation: Canada in a Changing Climate, 2007, *edited by* D.S. Lemmen, F.J. Warren, J. Lacroix and E. Bush; Government of Canada, Ottawa, ON, p. 227-274.
[17] Feltmate, B. and M. Moudrak. 2021. Climate Change and the Preparedness of 16 Major Canadian Cities to Limit Flood Risk. Intact Centre on Climate Adaptation, University of Waterloo

10 years, and with projected increases in annual precipitation there is the potential of increased flood risk and high intensity storms.

The projections of several extreme precipitation indices are presented in this section. Heavy Precipitation Days (both 10 mm and 20 mm) are days on which at least a total of 10 mm (or 20 mm) of rain or frozen precipitation falls. Frozen precipitation is measured according to its liquid equivalent: 10 cm of snow is usually about 10 mm of precipitation.[18]

Max 1-Day precipitation and Max-5 Day precipitation indicate the amount of precipitation that falls on the wettest day of the year, and the five wettest days of the year respectively. The Max 1-Day precipitation amount could be the result of a short but intense precipitation event such as a storm or because a moderate amount of snow/rain falls continuously all day, rather than all at once.

Table 17 shows the projected Heavy Precipitation Days (both 10 mm and 20 mm), as well as the Max 1-Day and 5-Day Precipitation for Niagara Falls.

Table 17: Extreme Precipitation Indices for Niagara Falls - SSP2-4.5 and SSP5-8.5

Variable	Emissions Scenario	Baseline 1976-2005	2021-2050			2051-2080		
			Low	Mean	High	Low	Mean	High
Wet Days (>=10 mm)	**SSP2-4.5**	26	27	28	30	27	30	31
	SSP5-8.5	26	27	29	30	28	30	32
Wet Days (>=20 mm)	**SSP2-4.5**	6	7	8	8	7	8	9
	SSP5-8.5	6	6	8	8	8	9	10
Max 1-Day Precipitation (mm)	**SSP2-4.5**	39	38	42	45	42	45	49
	SSP5-8.5	39	39	43	46	42	46	49
Max 5-Day Precipitation (mm)	**SSP2-4.5**	66	66	71	78	69	75	81
	SSP5-8.5	66	67	72	76	73	78	84

Heavy Precipitation Days in Niagara Falls are expected to increase by approximately 4 days for 10 mm days and 3 days for 20 mm days according to SSP5-8.5 by 2051-2080. Maximum 1-Day and 5-day events are also expected to increase in the city, with the greatest increase in 5-day events. For example, Max 5-Day events are projected to increase from a baseline of 66 mm to 78 mm by 2051-2080 for RCP8.5.

Intensity-Duration-Frequency

Intensity-duration-frequency (IDF) curves represent one way to analyze and predict heavy precipitation under a changing climate. They provide a graphical representation of the probability that a given average rainfall intensity will occur. Rainfall Intensity (mm/hr), Rainfall Duration (how many hours it rained at that intensity) and Rainfall Frequency/Return Period (how often that rain storm repeats itself) are the parameters that make up the axes of the graph of IDF curve.[19]

[18] Prairie Climate Centre (2020). *Climate Variables*. Climate Atlas of Canada. Retrieved from https://climateatlas.ca/variables

[19] IDF Curve. The Climate Workspace. Accessed from: http://www.glisaclimate.org/node/2341

The Institute for Catastrophic Loss Reduction (ICLR) and the University Waterloo's Facility for Intelligent Decision Support has developed a tool that assists users in developing and updating IDF curves using precipitation data from existing Environment Canada hydro-meteorological stations. Available precipitation data is integrated with predictions obtained from Global Climate Models to assess the impacts of climate change on IDF curves. Global climate models and scenarios developed for the IPCC Fifth Assessment Report (AR5) are used to provide future climate projections.

The station selected to produce localized IDF curves for Niagara Falls was the Niagara Falls Station. Projections are based on increases from the precipitation rate baseline, which is the average amount of precipitation in the years the station was active. For the Niagara Falls Station, this baseline was calculated between 1965 and 1990. Table 18 and Figure 5 depict baseline precipitation intensity for Niagara Falls.

Table 18: Baseline Precipitation Intensity Rates for Niagara Falls (mm/h) (1965-1990)

T (years)	2	5	10	20	25	50	100
5 min	85.47	114.01	132.60	150.21	155.75	172.68	189.29
10 min	64.49	82.78	92.71	100.89	103.24	109.80	115.43
15 min	54.42	70.35	79.16	86.51	88.64	94.65	99.87
30 min	34.87	45.70	52.83	59.65	61.81	68.44	75.00
1 h	20.35	27.75	33.49	39.72	41.86	49.01	56.99
2 h	12.59	16.82	19.98	23.30	24.42	28.08	32.05
6 h	6.21	7.85	8.81	9.63	9.87	10.58	11.21
12 h	3.59	4.66	5.41	6.16	6.41	7.19	8.00
24 h	2.04	2.61	3.00	3.40	3.53	3.94	4.36

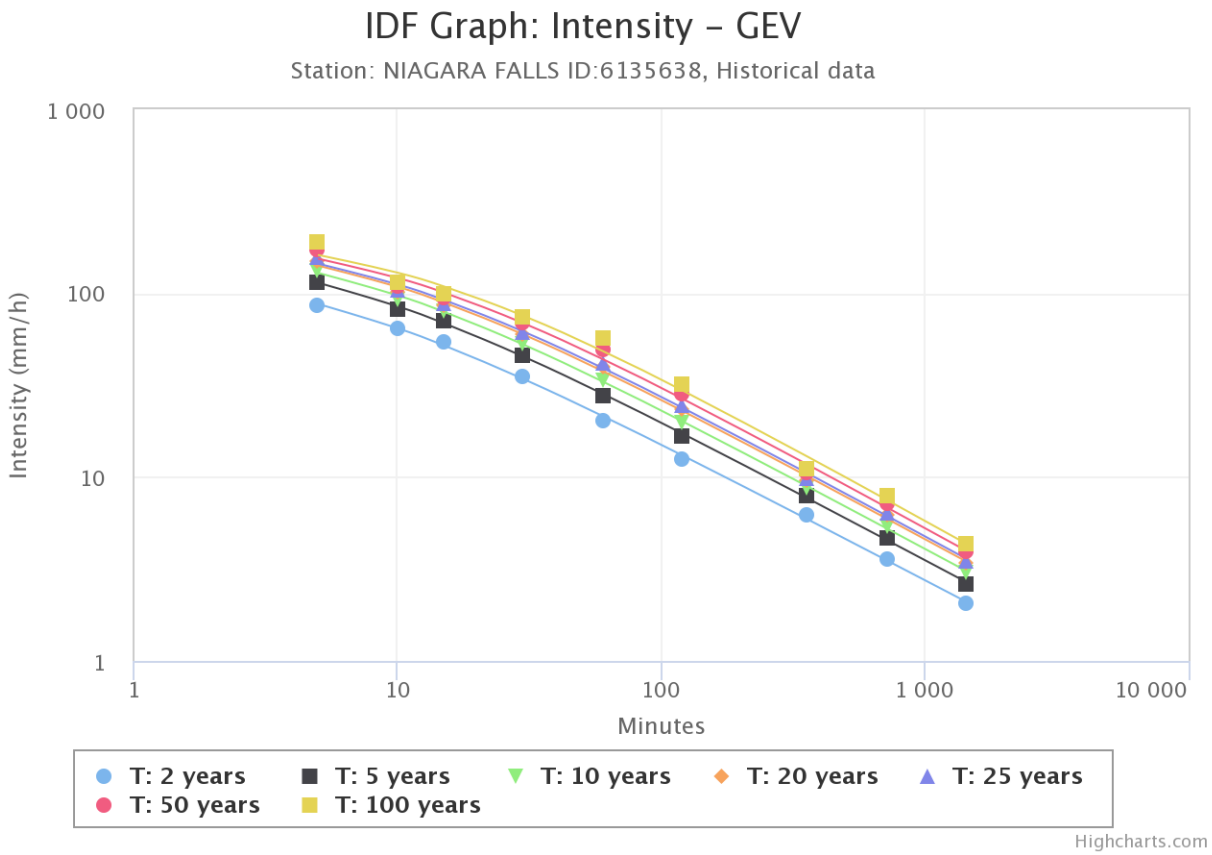


Figure 5: Baseline Precipitation Intensity Rates for Niagara Falls (mm/h) (1993-2017)

Tables 19 and 20, and Figures 6 and 7 below represent the change in IDF curves under a high emissions scenario. The projections cover a 30-year frame from 2021-2050, and 2051-2080. As seen in the graphs, the intensity of rainfall is projected to increase. While longer, more frequent rainfall events (e.g. a typical rainy day) will bring slightly higher amounts of rain, the intensity of rainfall during more infrequent, extreme storms (i.e. 1 in 20, 25, 50, 100-year storms) is projected to significantly increase.

Table 19: Projected Precipitation Intensity Rates (mm/h) for Niagara Fall 2021-2050 under SSP5-8.5

T (years)	2	5	10	20	25	50	100
5 min	92.23	122.16	144.36	168.88	177.46	200.78	226.10
10 min	69.40	88.69	101.26	114.31	118.26	127.55	138.51
15 min	58.56	75.37	86.43	98.02	101.62	110.07	119.70
30 min	37.67	48.84	57.40	66.97	70.42	79.72	90.33
1 h	21.94	29.69	35.99	43.88	47.00	56.35	65.74
2 h	13.58	18.00	21.53	25.87	27.57	32.46	37.63
6 h	6.71	8.44	9.61	10.85	11.28	12.31	13.33
12 h	3.87	4.98	5.84	6.88	7.27	8.35	9.59
24 h	2.31	2.96	3.44	4.03	4.20	4.77	5.39

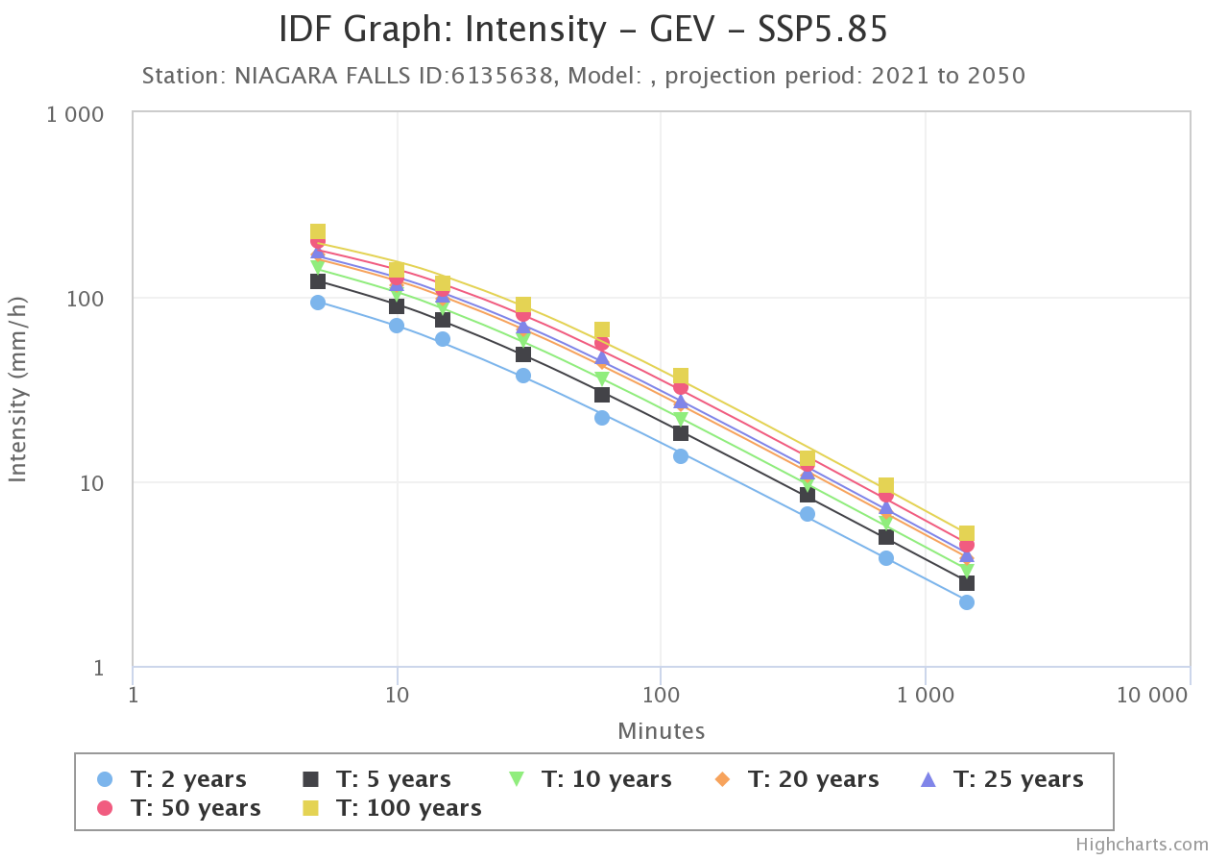


Figure 5: Projected Precipitation Intensity Rates (mm/h) for Niagara Falls 2021-2050 under SSP5-8.5

Table 20: Projected Precipitation Intensity Rates (mm/h) for Niagara Fall 2051-2080 under SSP5-8.5

T (years)	2	5	10	20	25	50	100
5 min	98.32	132.71	156.36	181.94	190.04	216.22	239.41
10 min	73.94	96.72	110.04	122.02	125.28	135.95	145.88
15 min	62.41	82.19	93.93	104.69	107.64	117.38	126.14
30 min	40.13	53.14	62.24	72.13	75.33	85.64	94.90
1 h	23.51	32.11	39.14	47.15	49.83	60.57	72.44
2 h	14.53	19.49	23.41	27.83	29.28	34.85	40.76
6 h	7.13	9.16	10.41	11.66	12.03	13.18	14.15
12 h	4.14	5.40	6.35	7.40	7.75	8.95	10.18
24 h	2.35	3.02	3.53	4.08	4.27	4.91	5.55

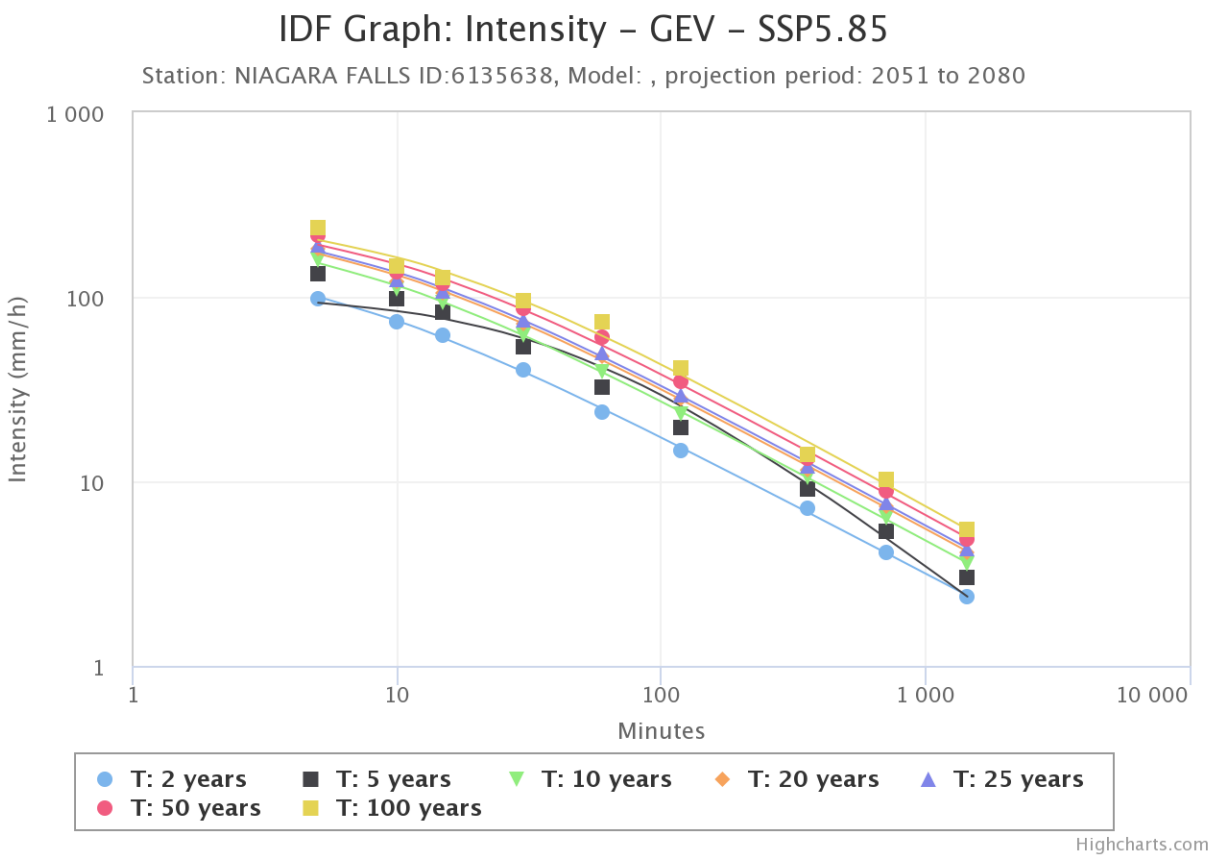


Figure 6: Projected Precipitation Intensity Rates (mm/h) for Niagara Falls 2021-2050 under SSP5-8.5

The projected IDFs curves above demonstrate that the intensity (mm/h) of rainfall will increase, with more rain falling in shorter time periods. Storms that occur less frequently (e.g. 100-year storms) are projected to see the greatest increase in intensity. Furthermore, such heavy precipitation events are projected to become more common than they once were.

Freezing Rain

A study conducted by the Meteorological Service of Canada and the Science and Technology branch of Environment Canada observed the possible impacts of climate change on freezing rain using downscaled future climate scenarios for Eastern Canada. This study used climate scenarios from the IPCC AR4 report.

Region I of the study encompasses a portion of Southwestern Ontario, including Niagara Falls. The study conducted analysis on the projected average percentage change in the number of daily freezing rain events. Figure 7 presents the averaged percentage change in the number of daily freezing rain events for ≥1 h, ≥4 h and ≥6 h events per day. The percentage increase is most pronounced in the months of January, with slight changes in the months of December and February, and an overall decrease in the months of November, March and April. Severe freezing rain events (>6 h per day) are projected to increase up to 30% by 2100.[20]

[20] Chad Shouquan Cheng , Guilong Li & Heather Auld (2011) Possible Impacts of Climate Change on Freezing Rain Using Downscaled Future Climate Scenarios: Updated for Eastern Canada, Atmosphere-Ocean, 49:1, 8-21, DOI: 10.1080/07055900.2011.555728

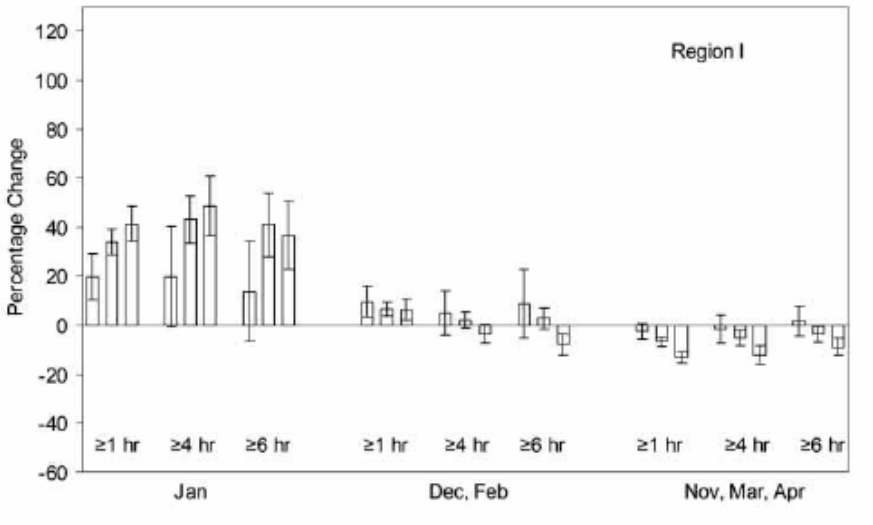


Figure 7: The average percentage change in the number of daily freezing rain events (%) for Region I relative to 1957-2007 baseline conditions

Water Levels

The Great Lakes Basin

The Great Lakes Basin, including both within Canada and the U.S., covers more than 765,000 square kilometers and contains 21% of the world's fresh surface water.[21] Climate change is expected to impact the Great Lakes in the form changes to ice cover, warming water temperature, and increased variability of water levels. Annual surface water temperatures of the Great Lakes have increased between 0.02°C and 0.06°C per year since 1980 and are expected to continue to warm under a changing climate, and warming air temperatures have contributed to a 71% decline in annual ice cover across the Great Lakes in the period of 1973-2010.[22] Year to year variability in water levels is expected to remain large, as the period from 1998-2013 saw lower than average water levels across the lakes, with near or above high-record water levels experienced in July of 2019 (see table 21).[23]

Table 21: July 2019 Monthly Mean Water Levels

Lake	Compared to Monthly Average (1918-2019)	Compared to 2018
Superior	35 cm above	21 cm above
Michigan	79 cm above	39 cm above
Erie	80 cm above	31 cm above
Huron	79 cm above	74 cm above

[21] Douglas, A.G. and Pearson, D. (2022). Ontario; Chapter 4 in Canada in a Changing Climate: Regional Perspectives Report, (ed.) F.J. Warren, N. Lulham, D.L. Dupuis and D.S. Lemmen; Government of Canada, Ottawa, Ontario. https://changingclimate.ca/regional-perspectives/chapter/3-0/

[22] Ibid.

[23] Ibid.

These changes can have major regional impacts on ecosystems and biodiversity, commercial and industrial activities such as energy generation, shipping, and tourism, reduced water quality and quantity, strain on water treatment infrastructure, less opportunities for recreation, significant damage to infrastructure and property, and physical and psychological impacts to human health.[24]

Water Temperatures

Increases in nearshore temperatures have been recorded at several locations around the Great Lakes since the 1920s. They are most pronounced in the spring and fall and are positively correlated with trends in global mean air temperature.[25]

With changing climatic conditions in Ontario, wetlands in Southern Ontario are particularly vulnerable to drying. Animals and plants that require wetland habitat will be threatened, and the ecosystem services provided by wetlands will be diminished.

Stream temperatures in Lake Ontario are also expected to increase by up to 1.4°C.[26] In Lake Ontario under a high emissions scenario, 23% of the streams may warm from coldwater to coolwater habitat.[27] This change can cause decreased presence of coldwater fish while increasing coolwater habitat, altering species makeup and possibly leading to increased spread of invasives. Furthermore, warmer temperatures will affect walleye (coolwater species) biomass, causing a decline of ~10-15% in the Lake Ontario basin.[28]

Table 22 below depicts the predicted maximum surface temperatures in the Lake Ontario basin. The predicted temperatures were developed using ensemble climate projections of air temperature under the IPCC Fourth Assessment scenarios. The high emissions scenario (A2) projections are displayed below. The time periods for the projections include the 2020s, 2050s, and 2080s.

Table 22: Maximum Surface Temperature Projections for Lake Ontario Basin

Basin	# of main stem lakes	Current	2020s	2050s	2080s
Ontario	893	23.9°C	25.6°C	27.1°C	28.9°C

Conclusion

The information provided in this report provides a clear indication that climate change is affecting Canada, and specifically Niagara Falls. Rising annual temperatures as well as increases in precipitation and extreme events are major climate impacts that can have tremendous ecological, infrastructural, economic, and sociological effects for the community. This report is meant to act as a background and an introduction to climate change in this area, and additional research should be conducted to retrieve more precise downscaled climate projections where available.

[24] Ibid.

[25] Chu, Cindy. (2016). Climate Change Vulnerability Assessment for Inland Aquatic Ecosystems in the Great Lakes Basin, Ontario. Retrieved from: http://www.climateontario.ca/MNR_Publications/CCRR-43.pdf

[26] Ibid.

[27] Ibid.

[28] Ibid.