CITY OF WATERLOO

CORPORATE CLIMATE CHANGE ADAPTATION PLAN

2019

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The preparation of this plan was carried out with assistance from the Government of Canada and the Federation of Canadian Municipalities. Notwithstanding this support, the views expressed are the personal views of the authors, and the Federation of Canadian Municipalities and the Government of Canada accept no responsibility for them.

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Executive Summary

The climate is changing – throughout Canada and around the globe. In its Fifth Assessment Report, the Intergovernmental Panel on Climate Change concluded that the warming of the climate system is unequivocal, and noted that recent changes are without precedent over the scale of decades to millennia[i].

Adaptation is an essential response to climate change. It complements mitigation efforts – measures that reduce greenhouse gas emissions – and is focused on reducing the negative impacts of climate change. Adaptation includes any actions taken in response to observed or expected impacts of climate change; it is the way we prepare for and react to the changes in our climate[ii].

Climate change is a global problem that requires local action. Municipalities are uniquely positioned to undertake adaptation efforts, as they are on the front lines of responding to impacts and therefore, have an interest in preparing for them[iii]. This document constitutes a Corporate Climate Change Adaptation Plan (CCCAP) for the City of Waterloo. It outlines how the municipality as a corporation will adapt its assets, operations, and services to the impacts of climate change. A corporate adaptation plan focuses on things that the City is responsible for – such as City-owned buildings and roads and City-run programs. The project utilizes Milestones One, Two, and Three of ICLEI Canada's Building Adaptive and Resilient Communities (BARC) methodology, a planning framework that guides municipalities through a series of milestones to develop and implement a climate change adaptation plan or strategy.

The CCCAP was developed based on input from staff from across the Corporation. An Adaptation Working Group (AWG), made up of representatives from multiple Divisions, was formed to guide the research and planning process, and work closely with the Project Team to identify actions to help address climate change impacts. The preparation of the Plan also involved input and review from senior management to ensure actions aligned with current strategies and resources.

The CCCAP includes 37 actions that the City will undertake to adapt to climate change. These actions are rooted in eight goals. The goals outline high-level intentions that the City will strive towards as it implements the CCCAP. They include:

1. Create conditions to minimize health and safety risks to outdoor workers and community members.
2. Generate awareness of changing climate conditions with staff and the public.
3. Ensure a coordinated response to and recovery from extreme weather events.
4. Consider climate change impacts in the design, construction, and maintenance of built infrastructure.
5. Foster resiliency within the urban forest and natural landscape.
6. Reduce risks associated with heavy rainfall and flooding.
7. Minimize disruption to City services.
8. Integrate climate change adaptation into the City's strategies, plans, policies, procedures, and operations.

An implementation schedule was developed for the actions to inform who, when, and how they will be implemented (Appendix A). For each action, the schedule outlines scope, lead and supporting Divisions, current practice, timelines, and estimated resource needs at a high level. The schedule will also be an important tool for reporting on the City's progress related to climate change adaptation.

The CCCAP is intended to be a living document that will be updated as opportunities arise, and new information becomes available. It will serve as a guide for the City as it continues to adapt its assets, operations, and services to the impacts of a changing climate.

Acknowledgements

The Project Team would like to gratefully acknowledge everyone who participated in the development of the Corporate Climate Change Adaptation Plan. It is a culmination of efforts from staff from across the Corporation and reflects a diverse range of knowledge and expertise from corporate stakeholders.

Adaptation Working Group

The Adaptation Working Group (AWG) was made up of staff from multiple Divisions and provided overall strategic direction to the Project Team. They provided input into the impact statements, vulnerability and risk assessments, adaptation actions, the implementation schedule, and overall Plan development.

Karen Anderson, Facility Design and Management Services
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Josh Bean, Arts and Culture
Helga Bowman, Transportation Services
Jim Bowman, Community Programming and Outreach Services
Greg Case, Information Management and Technology Services
Todd Chapman, City Utilities
Jessica Kellerman, Engineering Services
Cassandra Pacey, Asset Management
Steve Scherrer, Recreation Services
Ryan Schubert, Fire Rescue Services

Additional Municipal Staff

The Project Team would also like to acknowledge the additional staff that helped in the development and refinement of adaptation actions. This included staff from Divisions not captured in the AWG, as well as the City's Managers group and the Directors group.

Project Team

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1. Introduction

The impacts of climate change are already being experienced by the City of Waterloo. Some of these instances include the deadly thunderstorm of 2014, extreme rainfall in July 2010 and June 2017, heat waves in September 2017 and July 2018, ice storms in 2013, 2016, 2018, and 2019, and the wind storms of October 2017 and May 2018. These events have highlighted the need to be prepared for ongoing challenges, especially as Waterloo's climate will continue to change over the next century.

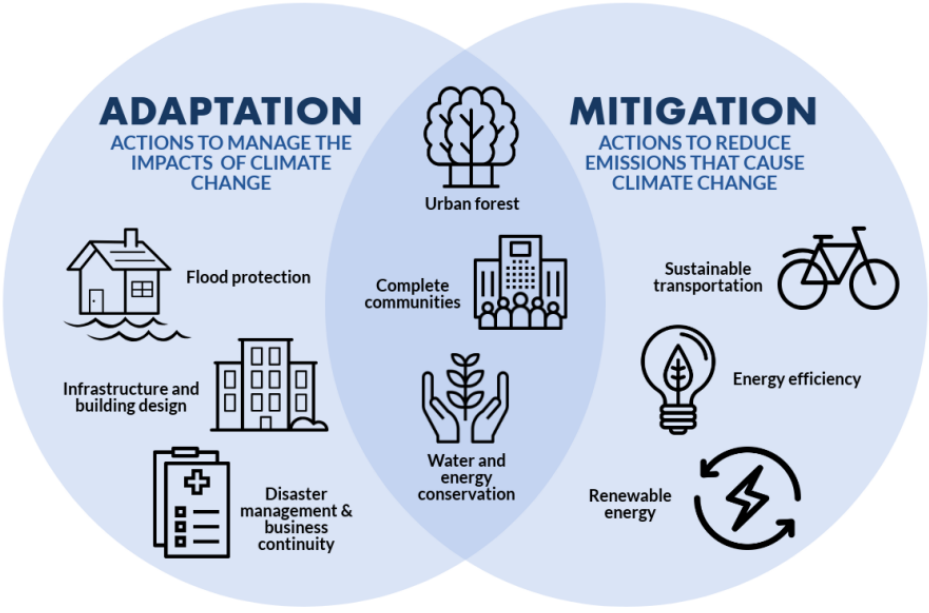
To address this, the City developed this Corporate Climate Change Adaptation Plan (CCCAP). The purpose of the Plan is to increase the adaptive capacity and resiliency of Waterloo's assets and services to future climate impacts, and to integrate climate change adaptation into day-to-day operations. The Plan focuses on things that the City is responsible for – such as City-owned buildings and roads and City-run programs. Limiting the Plan to these elements is a function of two key factors. First, the responsibility for addressing climate change threats largely rests with the organizations that deliver the programs and services in question; the City has little to no authority to address risk in circumstances beyond its control or mandate. The second factor is that the Region of Waterloo is coordinating a Community Climate Adaptation Plan. The Community Climate Adaptation Plan will be broad in scope to address region-wide community impacts, vulnerabilities and risks, and will engage a variety of stakeholders from across the community. It is anticipated that there will be opportunity to explore integrated solutions where there is joint interest, capacity, and jurisdiction.

The CCCAP was developed using Milestones One, Two, and Three of ICLEI Canada's Building Adaptive and Resilient Communities (BARC) methodology, a planning framework that guides municipalities through a series of progressive milestones.

Adaptation vs. Mitigation

The focus of this Plan is adaptation. Adaptation includes any actions that help us adjust to the impacts of climate change. Examples of adaptation actions include increasing the capacity of stormwater management systems, using different construction materials, updating operating procedures, and modifying outdoor work policies. In contrast, mitigation includes any actions that reduce the amount of greenhouse gases released into our atmosphere that contribute to climate change. Examples include improving the energy efficiency of buildings and using low-emission vehicles.

Adaptation and mitigation are not mutually exclusive. Some actions have co-benefits, meaning they contribute to both objectives. For example, planting trees will assist in providing shade and adapting to extreme heat, while also mitigating greenhouse gas emissions by acting as a carbon sink and potentially lowering energy use in both summer and winter months.



International and Federal Direction on Climate Adaptation

Canada was one of 195 countries to sign the Paris Agreement in December 2015. The Agreement aims to keep the increase in global average temperature to well below 2°C, and to drive efforts to limit the temperature increase even further to 1.5°C above pre-industrial levels. In terms of adaptation, the Agreement has a goal to enhance adaptive capacity, strengthen resilience, and reduce vulnerability to global climate change, in line with the temperature goal[iv].

The Government of Canada has also produced several policy documents that support and guide the country's position on climate change adaptation. For example, in 2016, it released its Pan Canadian Framework on Clean Growth and Climate Change, which includes adaptation considerations and actions to improve climate resiliency[v]. Major focus areas include building climate resilience through infrastructure, protecting and improving human health and well-being, and reducing climate-related hazards and disaster risks. The framework recognizes the important role that municipalities will play in implementing climate solutions locally.

Provincial Direction on Climate Adaptation

Provincial direction on climate change has focused largely on limiting greenhouse gas pollution, protecting the environment, increasing resilience to climate change impacts, and building a low-carbon, high productivity economy. Strategic direction for these measures is captured in some of the Province's key policy documents, such as Ontario's Provincial Policy Statement (2014)[vi], which provides direction on land use for municipalities, and directs municipalities to support climate change adaptation through land use and development patterns. Other key plans include the Growth Plan for the Greater Golden Horseshoe (2019)[vii], which includes measures to increase municipal resiliency to climate change. For example, the Plan requires municipalities to integrate stormwater management techniques such as low impact development and green infrastructure.

The new Ontario Government has also released a proposal for a Made-in-Ontario Environment Plan, which includes adaptation considerations such as updating the Building Code to include measures that will help homes and buildings withstand extreme weather, reviewing the Municipal Disaster Recovery Assistance Program, and updating policy direction on climate resilience through a review of existing land use planning policies.

While Federal and Provincial governments provide strategic focus, standards, and potential funding streams for adaptation, it will be up to local governments to tailor climate change adaptation strategies to their local circumstances and to the unique set of climate change impacts they expect to face.

City of Waterloo's Commitment to Climate Change

An objective of the City's 2015-2018 Strategic Plan was to "adopt a progressive approach to climate change". While the CCCAP focuses on climate adaptation, it is important to note that the City is also participating in a number of corporate and community-oriented mitigation initiatives. These include the development and implementation of the City's inward facing Corporate Energy and Greenhouse Gas Conservation and Demand Management Action Plan, and the outward facing Climate Action Plan for Waterloo Region developed by ClimateActionWR. It is through ClimateActionWR that the City, along with the Region and the Cities of Kitchener and Cambridge, committed to an 80% greenhouse gas reduction target by 2050[viii].

Other City-specific mitigation activities include:

- Updating the green building policy, which states that all new or renovated City facilities of a certain size must be LEED silver certified.

- Completing a LED streetlighting change-out project that converted approximately 8,200 existing cobra head HID Luminaires to LED.
- Conducting a solar idle reduction pilot project, with two fleet vehicles retrofitted with solar panels and a battery energy storage system.
- Launching a pilot program to install receptacles in parks that convert dog waste into energy. The project diverted 2,350 kilograms of dog waste from the landfill and an estimated 0.27 metric tons of carbon dioxide from the atmosphere after 156 days.

2. The Changing Climate

Global Climate Change

The Intergovernmental Panel on Climate Change (IPPC), the United Nations body for assessing the science related to climate change, published its Fifth Assessment Report in 2014. This publication is one of the most comprehensive reports about the state of scientific, technical, and socio-economic knowledge on climate change, its impacts and future risks, and options for reducing the rate at which climate change is taking place. In 2014, it concluded that "the range of published evidence indicates that the net damage costs of climate change are likely to be significant and will increase over time."[ix]

Between the years of 1983-2012, the Northern Hemisphere experienced its warmest period in 1400 years. More specifically, the global average temperature over the first decade of the 21st century was significantly warmer than any preceding decade, and this warming trend is projected to continue throughout this century and into the next[x]. Observable effects of global climate change include warming and acidification of oceans, sea level rise, widespread decreased snow cover, shrinking of ice sheets and glacial retreat, and increases in the frequency and intensity of extreme weather events.[xi]

Many regions facing warming temperatures are also facing shorter winters and increased precipitation. Falling more as rain and less as snow, the increased risk of freezing rain events is pervasive and can amplify flood-related risks, causing economic, environmental, and social impacts to communities across the board.

Climate Change in Canada

Similar to global trends, Canada has been warming over the last six decades, with average temperatures over land increasing by 1.5°C between 1950 and 2010[xii]. This rate of warming, however, is almost double the global average reported over the same period, meaning that an increase of 2°C globally could result in a 3-4°C change in Canada. The years 2011 and 2012 were found to be 1.5°C and 1.9°C warmer than the 1961-1990 average in Canada[xiii], with 2018 now standing as the warmest year on record globally[xiv]. More acute even than the average annual warming, is that what is currently a 1-in-20-year extreme hot day (or a hot day that has a 5% likelihood of happening any given year) is expected to become a 1-in-5-year event (or 20% likelihood) over most of the country by mid-century[xv].

In addition, Canada has also generally become wetter over the past several decades, with average annual precipitation across the country increasing by approximately 16% between 1950-2010[xvi]. With respect to more intense precipitation events, recent studies show that what is considered a 1-in-20-year storm (or a storm that has a 5% likelihood of happening any given year) will become a 1-in-10-year event (or 10% likelihood) by the 2050s[xvii].

Observations indicate that over the last 50 years Canada has experienced an increase in temperatures, altered precipitation patterns, and a steady increase in the frequency, intensity, and duration of extreme weather events. These changes have serious implications for future vulnerability as they threaten agriculture, water sources, power supplies, forests, public health and safety, local economies, and much more.

Climate Change Projections for the City of Waterloo

These global and national shifts in climate will be felt locally in terms of both extreme events and incremental change. Projections for the City are primarily focused on changes in temperature and precipitation patterns, but also provide insight into extreme weather events. The projections are based on historical weather data from the region, as well as an ensemble of 22 climate models, and are rooted in the "business-as-usual" greenhouse gas emission trajectory defined by the IPCC. This scenario represents a future where regular economic growth continues without substantially reducing greenhouse gas concentrations. The projection data comes from the 2015 Localized Climate Projections for the Region of Waterloo Report, written by the Interdisciplinary Centre on Climate Change at the University of Waterloo, and ICLEI's 2017 Climate Science Report for the Region of Waterloo. A summary of the projected changes for Waterloo is provided below. More detailed climate projections are included in Appendix B.

Exhibit 1: Summary of Projected Climate Changes in the City of Waterloo

Temperature 	• The annual mean temperature between 1981-2010 was 7°C. Waterloo can expect the annual mean temperature to increase to 8.4°C by the 2020s, to 10.2°C in the 2050s, and to 12.2°C in the 2080s • Trends show significant warming across seasons, with the greatest warming to occur in winter and spring • More freeze-thaw days are expected in the 2020s and 2050s with an eventual slight decline in the 2080s • The number of hot days (days above 30°C) is expected to increase from a baseline (1981-2010) of 10.1 days to 12.7 days by the 2020s, 30.9 days by the 2050s, and 59.3 days by the 2080s • The number of cold days (days below -15°C) is expected to decrease from a baseline of 22.1 days to 9.9 days by the 2020s, 5.8 days by the 2050s, and 2.8 days by the 2080s
Precipitation 	• The mean annual precipitation between 1981-2010 was 918.5 mm. Waterloo can expect the annual mean precipitation to increase to 953.4 mm by the 2020s, 1,014 mm by the 2050s, and 1,028.7 mm by the 2080s • Trends show precipitation events, in general, are expected to become more intense and extreme with winter, spring, and summer projected to become significantly wetter • Number of dry spells (6 or more consecutive days with no precipitation) are expected to decrease slightly over the century
Extreme Weather and Winter Precipitation 	• Increase in the intensity, duration, and frequency of extreme rainfall events • Severe wind events to increase in both frequency and magnitude by the end of the century • Annual mean snowfall is predicted to decrease while freezing rain events will increase by the end of the century

It is important to note that uncertainty is an inherent component in the study of climate change. While climate projections are powerful tools, they must be used with an understanding of their limitations. Uncertainty can be introduced through the parameters being studied, the structure of the models, the future global emissions trajectory, and even the weather observation instruments. Nonetheless, climate models provide the best available scientific assessment of how future social and economic conditions will influence the climate system.

Priority Impacts for the City of Waterloo

The projected changes in climate have the potential to profoundly impact the City's assets, operations, and services. From a built environment perspective, more freezing rain events, extreme weather, and volatile temperatures will likely lead to increased maintenance and replacement costs. From a people-focused perspective, extreme heat, cold, and other weather events will likely be disruptive and could limit access to key City services, impacting people's physical and mental health[xviii]; health and safety concerns for staff and the broader community will become an even more prominent issue. Furthermore, from an environmental perspective, climate change will likely add to existing pressures on Waterloo's ecosystems and could compromise the integrity of our natural features, areas, and systems.

A total of 11 priority impacts were identified for the City. These 11 impacts are listed on the following pages, organized by the climate threat to which they are tied. More information on how they were identified is provided in Section 3.

Potential Opportunities for the City of Waterloo

While the focus was primarily on identifying how the City's assets, operations, and services would be negatively affected by climate change, a number of potential opportunities were also identified. The intent behind identifying opportunities was not to suggest that climate change is desirable, but rather to assist us in our planning, as we know that some amount of change is inevitable based on historical emissions. The opportunities include:

- Reduced demand for heating due to warmer winter temperatures
- More year-round active transportation due to warmer winter temperatures
- Longer construction seasons (i.e. more productivity) due to longer shoulder seasons
- Increased time for festivals and outdoor activities due to longer shoulder seasons
- Increased plant selection due to increased annual temperatures

These opportunities have the potential to be realized as the result of the incremental changes expected in our climate. As such, it will be important to gauge if and how they come to be, and whether specific actions need to be identified for them as time moves forward.

FREEZING RAIN

- Increased freezing rain events resulting in increased damage to City-owned assets and infrastructure (trees, signs, street lights, buildings, roads, small equipment, etc.), leading to increased maintenance and repairs, increased health and safety risks to outdoor workers, increased call volumes to staff and increased competition to acquire recovery contractors.
- Increased freezing rain events leading to increased damage to power lines, resulting in more power outages and service disruptions.
- Increased freezing rain events leading to increased hazardous conditions on roads, parking lots, sidewalks and trails, resulting in increased demand on winter operations and increased safety risks to operations staff and outdoor workers.

EXTREME EVENTS

- Increased extreme weather events (e.g. windstorms, thunderstorms, tornadoes, etc.) resulting in increased damage to City-owned assets and infrastructure (trees, signs, street lights, buildings, roads, small equipment, etc.), leading to increased maintenance and repairs, increased health and safety risks to outdoor workers, increased call volumes to staff and increased competition to acquire recovery contractors.
- Increased extreme weather events (e.g. windstorms, thunderstorms, tornadoes, etc.) leading to increased electrical surges and power outages, resulting in service disruptions.
- Increased extreme weather events (e.g. windstorms, thunderstorms, tornadoes, etc.) leading to increased incidences of power outages, resulting in increased demand on emergency response resources and continuity of support.

Photo: Jason Thistlethwaite

CHANGE IN TEMPERATURE

- Milder winter temperatures resulting in increased insect/pest survival rates, leading to increased tree and vegetation maintenance requirements and asset loss.
- More volatile winter temperatures leading to increased freeze-thaw cycles, resulting in damage to, and decreased service life of City-owned buildings (e.g. foundations, roofs) and infrastructure (roads, sidewalks, trails, parking lots, outdoor recreation facilities, watermains, culverts, hardened channels, etc.).
- Increased summer temperatures resulting in increased frequency and duration of hot days (>30 C), leading to increased health and safety risks to the public, especially vulnerable populations (e.g. elderly, socially isolated, etc.).

Photo: Marc Bruxelle/Shutterstock.com

HEAVY RAINFALL

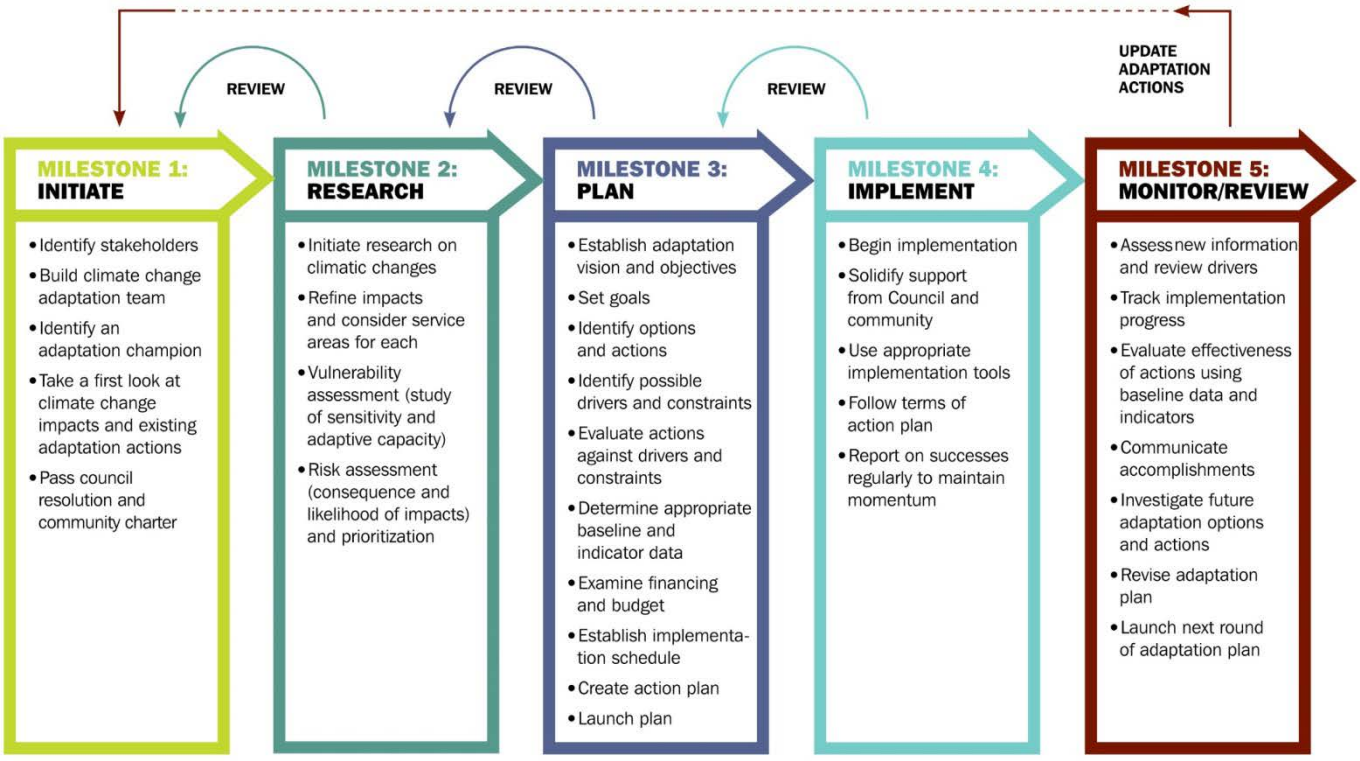
- Increased heavy rainfall events leading to increased erosion, resulting in damage to creeks, parks, natural areas and infrastructure (e.g. roads, trails, sports facilities, etc.).
- Increased heavy rainfall events causing riverine or overland flooding, resulting in disruption or damage to City-owned assets (e.g. buildings, roads, underground infrastructure, etc.).

3. Our Process

BARC Framework

This Plan was developed using ICLEI Canada's BARC Framework. The BARC Framework provides a structured approach to adaptation planning, moving through a series of five progressive milestones. Through the various milestones, impacts are identified, vulnerability and risk assessments are undertaken, goals are set, actions are identified and prioritized, and implementation is tracked.

Exhibit 3: BARC Framework



As part of this process, an Adaptation Working Group (AWG) was formed to provide strategic direction to the Project Team and input into each milestone. Made up of City staff from key Divisions, the AWG was crucial in providing topic-specific knowledge and input, ensuring that the Plan aligned with Divisional functions and objectives. By building upon the expertise of these staff, the CCCAP is reflective of a wide range of perspectives and identifies needs and priorities for the City of Waterloo. Throughout the planning process, the AWG was the central body to review and contribute to the CCCAP.

Impact Identification

To systematically identify how the City's assets, operations, and services could be impacted by climate change, a set of impact statements were developed. Impact statements are formulaic, concisely describing the anticipated change, outcome, and consequence of a specific climatic threat. A total of 46 impact statements were identified by the AWG, covering a range of affected areas including infrastructure, the natural environment, public health and safety, employee productivity, and more. These 46 impact statements formed the basis of the vulnerability assessment, and are presented in Appendix C.

Vulnerability Assessment

The AWG conducted a vulnerability assessment for each impact statement to help identify the areas where the City should focus its adaptation efforts. Vulnerability refers to the susceptibility of a given City Division to harm arising from climate change impacts. It is a function of a Division's *sensitivity* to climate change and its capacity to adapt to impacts (or its *adaptive capacity*).

To determine *sensitivity*, the AWG looked at each impact and assessed how a Division's functionality would be affected if the impact were to occur. This included considering how the impact would affect the Division's ability to provide its services and whether the Division was subject to any existing stress.

To determine *adaptive capacity*, impacts were assessed based whether a Division could adjust to the impact with minimal cost or disruption. When determining this, the AWG considered the time and resources needed for the Division to recover or return to its previous functionality as well as any current actions, plans, and policies in place that would help mitigate the impacts.

Using a 'dotmocracy' methodology, the AWG assigned a vulnerability ranking to each of the 46 impact statements based on their assessment of *sensitivity* and *adaptive capacity*. The following scale was used to assign the vulnerability rankings:

Low Vulnerability
Not very/not at all vulnerable to harm arising from the impact

Medium Vulnerability
Somewhat vulnerable to harm arising from the impact

High Vulnerability
Very vulnerable to harm arising from the impact

The results of the vulnerability assessment are provided in Appendix C.

Risk Assessment

The next step in the process was to carry out a risk assessment based on the results of the vulnerability assessment. Impacts that were assigned a Medium or High vulnerability ranking were put through the risk assessment. This included 28 impacts.

Risk is the combination of the probability of an impact occurring and its negative consequences, and can be expressed as a function where risk = *likelihood* x *consequence*.

Likelihood is based on how likely it is that an impact will occur and considers both the probability of the threat occurring (e.g. increased freezing rain) and the probability of the associated outcomes occurring (e.g. increased asset damage). *Likelihood* ratings from 1 to 5 were assigned to each impact, where 1 was 'rare' and 5 was 'almost certain', based on localized climate projections, as well as anecdotal knowledge of current conditions.

Consequence refers to the known or estimated outcomes of a particular impact. To determine *consequence*, the AWG assessed the 28 impacts against 12 consequence criteria. The consequence criteria were divided into three categories – social, economic, and environmental. *Consequence* ratings from 1 to 5 were assigned to each criterion, where 1 was 'negligible' and 5 was 'catastrophic'. For each impact, category-specific risk scores were calculated as well as an overall risk score by multiplying *consequence* ratings with *likelihood* ratings.

Exhibit 4: Consequence Criteria

Social Criteria	Economic Criteria	Environmental Criteria
Health and Safety	Property Damage	Air
Displacement	Local Economy and Growth	Soil and Vegetation
Loss of livelihood	Community Livability	Water
Cultural Aspects	Public Administration	Ecosystem Function

Additional details on the risk assessment process, including the results, are provided in Appendix C.

Based on the results of the risk assessment, the AWG identified 11 priority impacts. Impacts were prioritized if they had an overall risk score of Medium or higher, or if they had an overall risk score of Medium-Low but at least one category-specific risk score that was Medium or higher. This was done to ensure that impacts that posed a significant risk to a specific category were not left out of the process. With the priority impacts identified, the AWG was able to move forward with goal setting and action planning.

Goal Setting

To provide a foundation for action planning, a set of eight goals were developed by the Project Team and the AWG. The eight goals are presented in Section 5.

Action Identification and Prioritization

A variety of adaptation actions can be used to respond to climate change impacts, including both anticipatory actions (i.e. before an impact is observed) and reactive actions (i.e. after an impact has occurred). A workshop was held with the AWG to review best practices and brainstorm actions that would address the eight goals and the 11 prioritized impacts. A total of 37 actions were ultimately identified.

Following the action identification process, the AWG moved forward with action prioritization. Each action was evaluated across a series of sustainability, effectiveness, risk and uncertainty, opportunity, and implementation criteria. Scores were assigned based on a prioritization matrix. The result was a list of actions that, based on current circumstances, fell into three categories: Now, Soon, or Later.

Now	The action should be implemented within the short-term (e.g. <2 years)
Soon	The action should be implemented within the medium-term (e.g. 2-5 years)
Later	The action should be implemented within the long-term (e.g. 5+ years)

Exhibit 5: Prioritization Matrix

		1 Point	2 Points	3 Points
Sustainability	Mitigation Co-benefits	Could result in increased GHG emissions	Not likely to affect GHG emissions	Could reduce GHG emissions
	Equity	Benefits only to some people	Benefits to many people	Significant benefits to many people
	Implementation Cost	Cost is high relative to cost of inaction	Cost is moderate relative to cost of inaction	Cost is low relative to cost of inaction
Effectiveness	Robustness	Effective for a narrow range of plausible future scenarios	Effective across many plausible future scenarios	Effective across a wide range of plausible future scenarios
Risk and Uncertainty	Urgency	Impacts are likely to occur in the longer term	Impacts are likely in the near to mid term	Impacts are already occurring
Opportunity	Ancillary Benefits	Will contribute little to other City goals and programs	Will contribute somewhat to other City goals and programs	Will contribute significantly to other City goals and programs
	No Regret	Will have little or no benefit if climate change impacts do not occur	Will have some benefits regardless of actual climate change impacts	Will result in significant benefits regardless of actual climate change impacts
Implementation	Public (or political) Acceptability	Could face some public or political opposition	Not likely to receive much public or political attention	Likely to receive public/political support
	Funding Sources	Additional funding sources are required but have not been identified	Additional funding sources may be required	Funding is available or not required
	Capacity (information, technical, staff, resources)	Current capacity is insufficient and gaps cannot be easily addressed	Gaps exist in one or more areas but can likely be addressed	Current capacity is sufficient to implement the action
	Institutional	Implementation requires coordination with, or action by, other jurisdictions	Implementation may require external approval/coordination	Implementation is within City's control

This matrix was adapted from Environment Canada and University of British Columbia's Canadian Communities' Guidebook for Adaptation to Climate Change.

Out of the 37 actions, 15 were categorized as 'Now', 12 were categorized as 'Soon', and 10 were categorized as 'Later'. These actions are outlined in Section 5, with implementation details provided in Appendix A.

It is important to note that this Plan identifies actions for those impacts that are considered the most significant based on the vulnerability and risk assessment process. This is not to say that other impacts, such as those associated with lower levels of vulnerability and risk, do not merit action, or that other additional actions are not worth pursuing. It would be impossible to create an exhaustive list of everything the City is or will be doing, directly or indirectly, to adapt to climate change. This Plan is not a substitute for prudent and strategic decision-making; it identifies areas where the City should focus its efforts, but recognizes that climate change

has the potential to affect all of the work we do. In order to continue our forward-thinking approach to community building, climate change will need to be factored into all areas of City business and service delivery.

Community Engagement

Before this Plan was finalized, community engagement was undertaken. The engagement had two key objectives: 1) to get an understanding of the community's thoughts and concerns about climate change and to see how they align with the Plan's goals and actions, and 2) to provide education and awareness about the need for climate change adaptation locally.

Engagement took place through a series of four in-person engagement booths – using interactive activities, display boards, and comment cards – and online through the Engage Waterloo platform. These engagement opportunities were advertised through the City's social media and on the project webpage. In both cases, participants were asked to reflect on the impact of climate change on their daily lives, challenges for the City posed by climate change, and whether or not the suggested goals helped to address their concerns about climate change. In total, the engagement program reached 146 individuals and directly engaged 44.

Exhibit 6: Community Engagement Summary

Date	Location	Reached (information shared)	Engaged (provided input)
April 15	Waterloo City Centre	9	6
April 15	Waterloo Memorial Recreation Complex	8	4
April 17	John M. Harper Library/Stork Family YMCA	18	10
April 18	Waterloo Memorial Recreation Complex	21	13
April 19	Emailed Comments	2	2
April 15 to May 1	Engage Waterloo (Online Platform)	88	9
Total		**146**	**44**

One of the most frequently cited concerns was increased flooding; participants were concerned about the impact of flooding and violent storms on their daily lives. Many participants also stressed the importance of increasing awareness and education on climate adaptation – and climate change more generally – among members of the public.

Overall, participants were pleased to see that the City was working to address climate change locally and the feedback collected through the engagement program served to validate the core components of the Plan.

More details results from the community engagement program are provided in Appendix D.

4. Vision and Guiding Principles

To describe the City's desired future state in terms of climate change adaptation, the following vision statement was developed.

Vision: Waterloo is positioned to reduce, respond to, and recover from the local impacts of climate change, as it affects the City and the broader community.

A number of principles were also developed to guide the City as it implements the CCCAP.

Principles:

- Commit to climate adaptation as a continuous process.
- Focus on approaches that are flexible and adaptable to future conditions.
- Prioritize actions that are beneficial beyond the adaptation lens.
- Build on existing adaptation-related programs and policies, and integrate actions into existing planning cycles and staff workflows.
- Engage staff, stakeholders, and the wider community in corporate climate adaptation.
- Focus on proactive approaches for adaptation.

5. Goals and Actions

Eight goals were developed by the Project Team and the AWG. They outline high-level intentions that the City will strive towards in implementing the CCCAP. These goals were used to guide the action brainstorming process and are the basis for how the 37 identified actions are organized. The goals include:

Goal 1: Create conditions to minimize health and safety risks to outdoor workers and community members.

Goal 2: Generate awareness of changing climate conditions with staff and the public.

Goal 3: Ensure a coordinated response to and recovery from extreme weather events.

Goal 4: Consider climate change impacts in the design, construction and maintenance of built infrastructure.

Goal 5: Foster resiliency within the urban forest and natural landscape.

Goal 6: Reduce risks associated with heavy rainfall and flooding.

Goal 7: Minimize disruption to City services.

Goal 8: Integrate climate change adaptation into the City's strategies, plans, policies, procedures and operations.

Goal 1:

Create conditions to minimize health and safety risks to outdoor workers and community members

Actions:

1.1 Map areas vulnerable to heat extremes and use mapping to inform planning and programming initiatives.

1.2 Continue to carry out outreach activities that target vulnerable populations during extreme heat and cold events.

1.3 Update the Emergency Circumstances/Extreme Weather Policy and the Heat Stress/Cold Stress Policy to account for climate change impacts.

1.4 Review winter control practices to ensure climate change impacts are considered and to identify opportunities for improvement.

1.5 Carry out education and engagement activities to increase awareness of the importance of 72 hour emergency preparedness and emergency response plans for individuals and families, community organizations, and businesses.

1.6 Investigate the feasibility of implementing warming and cooling centres outside of normal business hours.

Goal 2:

Generate awareness of changing climate conditions with staff and the public

Actions:

2.1 Undertake a gap analysis of existing communication processes related to climate change and extreme weather.

2.2 Implement an opt-in email/text alert system to notify community members about extreme weather events and emergencies.

2.3 Investigate the feasibility of incorporating extreme weather event and emergency information into the Pingstreet app.

Goal 3:

Ensure a coordinated response to and recovery from extreme weather events

Actions:

3.1 Enable website updates outside of normal business hours to address extreme weather events and emergency situations.

3.2 Assess training needs for staff to ensure informed response to extreme weather events.

3.3 Ensure climate change considerations are incorporated into the City's Hazard Identification and Risk Assessment tool as part of the annual review process and training.

Goal 4:

Consider climate change impacts in the design, construction and maintenance of built infrastructure

Actions:

4.1 Upsize storm sewers to current standards as part of renewal (where possible).

4.2 Establish a process for reviewing localized climate projections at regular time intervals.

4.3 Provide training to staff to ensure climate change impacts and risks are considered as part of the Project Management Manual's risk management framework.

4.4 Incorporate climate change considerations into the City's approach to asset management and provide training to staff as required (e.g. lifecycle costing, asset level of service, accelerated deterioration rates).

Goal 5:

Foster resiliency within the urban forest and natural landscape

Actions:

5.1 Develop an Urban Forest Strategy, including a canopy target.

5.2 Review the canopy cover mapping protocol and identify tree deficit areas.

5.3 Update the Emergency Forestry Plan.

5.4 Continue to incorporate City-owned green infrastructure into the Asset Management Plan.

Goal 6:

Reduce risks associated with heavy rainfall and flooding

Actions:

6.1 Review existing regulatory floodplain mapping and prioritize opportunities for updates.

6.2 Map areas prone to urban flooding and model scenarios.

6.3 Review the protocols for inspecting creeks and stormwater infrastructure to minimize flood risks.

6.4 Increase public education on clearing catch basins.

6.5 Investigate the feasibility of a sump pump disconnection program.

6.6 Investigate the feasibility of a backwater valve program.

6.7 Complete and implement the Stormwater Management Master Plan.

6.8 Review and upgrade flood proofing measures in City-owned buildings in the regulatory floodplain where possible.

Goal 7:

Minimize disruption to City services

Actions:

7.1 Undertake business continuity planning and training to identify and plan for the City's essential and secondary services.

7.2 Review practices around back-up power generation and ensure critical facilities are covered.

7.3 Develop a fuel supply protocol to manage supplies during extreme events and emergencies.

7.4 Consider alternative work arrangements that reduce commuting during extreme weather events and hazardous road conditions.

7.5 Review the existing 211 service agreement to identify potential advancements of the 211 network.

Goal 8:

Integrate climate change adaptation into the City's strategies, plans, policies, procedures and operations

Actions:

8.1 Identify financial implications and incorporate adaptation-related costs into short and long-term financial budgets and projections.

8.2 Continue annual reviews of the General Operating Contingency Reserve Policy and the Winter Control Reserve Policy to ensure they appropriately account for extreme weather events.

8.3 Review plans, policies, and procedures for alignment with adaptation goals and update where appropriate (e.g. Official Plan, Emergency Response Plan, master plans, maintenance protocols).

8.4 Identify corporate champion(s) to help lead implementation of adaptation actions.

6. Implementation

To ensure that the actions set out in this Plan are implemented in an effective manner, an implementation schedule was developed. This schedule was the result of extensive feedback and consultation with the AWG and various City staff. The implementation schedule can be found in Appendix A.

The schedule takes into account existing projects and programs that are already planned or underway, and is intended to be a living document that will be updated over the course of its application, should differing parameters or new opportunities arise. Alongside every action, the implementation schedule includes:

Description/Scope: Description of the action, what it hopes to achieve, and its anticipated scope.

Implementation Lead: The Division(s) leading implementation.

Supporting Division(s): The Division(s) supporting implementation.

Current Practice: What the City is currently doing in relation to this action/focus area.

Anticipated Timing: When implementation would begin (year).

Duration and Frequency: How long implementation would take (e.g. 2 years, 2+ years, ongoing).

Estimated Resources: High-level operating and/or capital costs (indicated with one to three-dollar signs) and staff effort (indicated with one to three people to reflect intensity of effort).

7. Monitoring and Review

Monitoring and review are important parts of the adaptation process. This is mainly because climate adaptation decisions are made amidst multiple future uncertainties, and thus often need to be iterative and flexible in nature, and subject to periodic reviews. Monitoring the CCCAP will be essential in ensuring that progress is being made on implementation, and that implementation is leading to a decrease in vulnerability and risk. Lessons learned from monitoring can also be integrated into future adaptation actions.

The information below presents an indicator framework, as well as a review structure that the City will follow as it continues on with Milestone 4 of the BARC Framework.

Indicators and Measuring Plan Progress

Indicators are quantitative or qualitative factors that provide a means to describe an issue of concern, and track trends over time relative to a baseline. Indicators should meet SMART criteria: specific (target a specific area for improvement), measurable (quantify or at least suggest an indicator of progress), assignable (specific to who will do it), realistic (state what results can realistically be achieved, given available resources) and time-related (specify when the results can be achieved).

Indicators can be divided into two types – process and outcome-based. Process-based indicators measure activities and outputs, while outcome-based indicators measure whether expected effects/changes are being achieved in the short, intermediate, and long-term.

Process-based indicators are easier to establish initially. Once actions get underway, outcome-based indicators will assume a greater importance. As such, the City will use the following key process-based indicator to monitor the initial implementation of the CCCAP:

- Number of adaptation actions from the CCCAP that have been or currently are being implemented

Since this indicator will measure the degree to which the City is implementing the actions outlined in the CCCAP, but not measure if the actions have succeeded in reducing vulnerabilities to climate change, it will be important to develop outcome-based, action-specific indicators as implementation progresses.

Plan Review

Internal check-ins with Lead and Supporting Divisions will occur on regular basis (e.g. annual) to measure progress. Lead and Supporting Divisions will be responsible for providing updates on the status of action implementation, timelines, costs, action-specific indicators, and other additional reporting details as needed.

It is anticipated that a report to Council will occur every two years, with a review of the CCCAP occurring every five years. However, this schedule is intended to be flexible and may change according to perceived need and resources.

Next Steps

Next steps for the City will be to move forward with implementing the CCCAP based on the implementation schedule. More specifically, the actions set for the shorter term will start to get underway, while planning for the mid-to-longer term actions from a budgeting and work planning perspective will begin.

Appendices

Appendix A: **Implementation Schedule**

ID	Action	Description/Scope	Implementation Lead	Supporting Division(s)	Current Practice	Anticipated Timing	Duration and Frequency	Estimated Resources
1.1	Map areas vulnerable to heat extremes and use mapping to inform planning and programming initiatives.	By mapping areas vulnerable to heat extremes, the City will be able to identify areas that would benefit from additional tree planting, shade structures, parkland, site-specific planning policy, or outreach programming. The mapping process could include the following: • Using surface temperature data to identify hot spots. • Comparing hot spot mapping with locations of vulnerable populations. As part of this action, the City will likely engage the Region of Waterloo.	• Environment and Parks Services • Planning	• Community Programming and Outreach Services • Information Management and Technology Services	Through the Official Plan, tree planting within parks is encouraged to provide shade and to enhance the urban forest. Additionally, the City considers the provision of shade (natural or constructed) when planning for new City facilities. The City has also conducted community tree planting events.	2023 onwards	1 year; followed by ongoing implementation	Cost: $ Staff effort: 👤👤
1.2	Continue to carry out outreach activities that target vulnerable populations during extreme heat and cold events.	Extreme heat and cold pose a health and safety risk to vulnerable populations, including seniors and lower income families and individuals. The City will continue to carry out outreach activities to minimize the impacts of extreme heat and cold on vulnerable populations. Through this process, the following will be considered: • Increasing messaging to encourage buddy systems or checking in on others during times of extreme temperatures. • Looking outwards for information, tools, and best practices to share with staff and community members. • Researching and exploring options for transporting those in need to warming and cooling facilities.	• Community Programming and Outreach Services		The City currently works with neighbourhoods (primarily through Neighbourhood Associations) to help monitor vulnerable residents. The City also has the Telephone Security program whereby staff check on isolated seniors. Seniors are signed up for the program through referrals from the Waterloo Wellington Local Health Integrated Network.	2020 – 2023	Ongoing	Cost: $ Staff effort: 👤👤
1.3	Update the Emergency Circumstances/Extreme Weather Policy and the Heat Stress/Cold Stress Policy to account for climate change impacts.	The City will review and update the two policies to ensure climate change considerations are adequately addressed. Through this process, the following will be considered: • Ensuring the policies cover climate factors such as extreme cold and heat, high winds, freezing rain, intense rainfall, and heavy snowfall. • Promoting sun and heat protection measures during heat alerts and days with high UV index. • Work hour flexibility to avoid peak temperatures or other extreme weather.	• Human Resources		The City currently has a working agreement to adjust hours for outdoor staff during incidences of extreme heat and also conducts health and safety training for staff.	2020 – 2023	1 year; followed by ongoing implementation	Cost: $ Staff effort: 👤
1.4	Review winter control practices to ensure climate change impacts are considered and to identify opportunities for improvement.	The City will review its winter control practices set out in the Winter Control Plan as well as those applied to City-owned and managed facilities. Through the review, the City will incorporate climate change considerations into its winter control practices and identify opportunities for more informed winter maintenance service delivery. Through this process, the following will be considered: • Smart about Salt training for staff. • Protocol and practice standards for contractors. • Opportunities for salt reduction as well as types of salt-alternatives. • Developing a Representative Tour for sidewalks and trails	• Environment and Parks Services • Recreation Services • Transportation Services	• Facility Design and Management Services	The City's Winter Control Plan sets out a policy and procedure framework for ensuring that the winter maintenance procedures and practices of the City are followed to reduce hazards resulting from winter snow and ice. It currently speaks to roads but trails, bike lanes, and sidewalks will soon be added. The Winter Control Plan is updated on an as-needed basis. Winter control for City-owned and managed facilities is handled by a combination of City staff and contractors that take care of pedestrian	2020 – 2023	1 year; followed by ongoing implementation	Cost: $ Staff effort: 👤👤

ID	Action	Description/Scope	Implementation Lead	Supporting Division(s)	Current Practice	Anticipated Timing	Duration and Frequency	Estimated Resources
		and determining the frequency of these tours (e.g. every 8 hours). This would be similar to the Representative Tour already carried out for roads where staff drive the designated route inspecting the representative roads for winter road conditions. • Updating the Winter Control Plan to ensure extreme weather and shoulder season events are appropriately addressed. As part of this action, the City will likely engage the Region of Waterloo.			entrance/exists, walkways to the entrances/exists, and parking areas. The City also conducts snow fighter training for staff.			
1.5	Carry out education and engagement activities to increase awareness of the importance of 72 hour emergency preparedness and emergency response plans for individuals and families, community organizations, and businesses.	The City will conduct education and engagement activities to convey the importance of emergency preparedness and emergency response plans for different groups within the community. This could include the following: • Launching a public education campaign at strategic locations about the importance of emergency preparedness and personal/family response plans. • Hosting events and friendly competitions to gamify emergency preparedness when discussing extreme weather scenarios. • Hosting a public open house/event night for businesses and organizations to learn about climate change impacts as they relate to their daily operations, how to address these impacts in the event of an emergency, and resiliency measures they can adopt to minimize the impacts (e.g. green business practices, business continuity planning, adaptation measures). • Assessing local businesses' interest in participating in a local best practice network to meet annually and discuss adaptation measures in business operations. • Developing a personal emergency preparedness guide and other resources to disseminate through public engagement events, community agencies, and community groups. As part of this action, the City will likely engage the Uptown BIA. Engaging the tenants of City-owned buildings in the regulatory floodplain may also be considered.	• Fire Rescue Services	• Communications Services • Community Programming and Outreach Services (Neighborhood Coordinator)	Fire suppression personnel distribute home fire safety material that includes 72-hour plan brochures. The Public Education Officer also engages the community on social media during the Emergency Preparedness Week (which occurs in the first week of May) and the City (and Environment Canada) hosts an annual CANWARN Weather Watchers training course.	2019/2020	1 year; followed by ongoing implementation	Cost: $ Staff effort: 👤👤
1.6	Investigate the feasibility of implementing warming and cooling centres outside of normal business hours.	The City will investigate the viability and need for providing spaces for extreme temperature relief outside of normal business hours. This could include consideration of the following: • Extending pool and splashpad hours when required. • Identifying buildings that could serve as warming and/or cooling centres. • Identifying accessibility, capacity, and staffing considerations. • Reviewing locations and other information in context of the Region of Waterloo Emergency Plan. • Reviewing non-municipal venues offering City services. • Reviewing Kitchener's and Cambridge's approach to offering	• Community Programming and Outreach Services • Fire Rescue Services • Recreation Services	• Facility Design and Management Services	The City currently offers extreme weather relief during regular operating hours at several facilities.	2023 onwards	>1 year	Cost: $ Staff effort: 👤👤

ID	Action	Description/Scope	Implementation Lead	Supporting Division(s)	Current Practice	Anticipated Timing	Duration and Frequency	Estimated Resources
		similar services. As part of this action, the City will likely engage the Region of Waterloo, City of Kitchener, City of Cambridge, Waterloo Public Library, Region of Waterloo's 'Heat' Partners Working Group, and the Regional Community Emergency Management Coordinator.						
2.1	Undertake a gap analysis of existing communication processes related to climate change and extreme weather.	Through a gap analysis, the City will identify current practices (i.e. what is communicated, to who and how) and identify gaps and opportunities for improvement. The following will be considered during the process: • Internal and external communications. • Event-based, area-specific, and seasonal messaging. • Feedback received from the community when the CCCAP was being developed.	• Communications Services • Planning	All	Externally, extreme weather announcements and updates are communicated through the City's social media and website (news alerts, public notices). The website is also used to communicate where the public can seek relief during periods of extreme heat or cold. Internally, the Emergency Response Plan sets out communication protocols and response procedures for when an emergency is declared.	2020 – 2023	1 year	Cost: $ Staff effort: 👤👤
2.2	Implement an opt-in email/text alert system to notify community members about extreme weather events and emergencies.	Alongside our municipal partners, the City will implement an emergency notification system called Alert Waterloo Region. Through the system, municipalities, emergency management, and rescue services will be able to notify residents and businesses of public safety messages in the event of a large scale emergency such as a flood, severe weather, or significant power outage. Community members will be able to sign up for notifications on multiple devices. The system will also be used to notify City staff of staff-related urgent or emergency situations. This might include notifications and instructions following a facility closure or an inclement weather incident.	• Communications Services • Fire Rescue Services	• Information Management and Technology Services	Up until the launch of Alert Waterloo Region in March 2019, extreme weather announcements and updates were communicated through the City's social media and website (news alerts, public notices).	2019	Ongoing	Cost: $ Staff effort: 👤👤
2.3	Investigate the feasibility of incorporating extreme weather event and emergency information into the Pingstreet app.	The Pingstreet app is a location-based tool that provides real-time access to garbage and recycling calendars, current events, local government information and contacts, social media, and more. The City will explore opportunities within the Pingstreet app to improve access to information regarding weather alerts and emergency preparedness resources.	• Communications Services	• Information Management and Technology Services	The Pingstreet app currently provides information on a variety of local services.	2020 – 2023	1 year	Cost: $ Staff effort: 👤
3.1	Enable website updates outside of normal business hours to address extreme weather events and emergency situations.	Access will be provided to select staff to update the City's website outside of normal business hours. Updates could include notices of road closures, cancellations, news alerts, public notices, and more.	• Communications Services		Updates to the City's website are only made during regular business hours.	2019/2020	<1 year; followed by ongoing implementation	Cost: $ Staff effort: 👤
3.2	Assess training needs for staff to ensure informed response to extreme weather events.	The City will assess training needs on a Division-specific basis to determine if existing training programs need to be modified to incorporate climate change considerations. Through this process, the following will be considered: • Day-to-day operations (e.g. training related to heat and cold related illnesses and DZ licensing) and extreme circumstances (e.g. crowd management and weather-based emergency situations). • Cross-Divisional coordination. • Climate change fundamentals to increase awareness.	• Human Resources • Planning	All	The City currently conducts health and safety training for staff.	2019/2020	>1 year	Cost: $ Staff effort: 👤👤

ID	Action	Description/Scope	Implementation Lead	Supporting Division(s)	Current Practice	Anticipated Timing	Duration and Frequency	Estimated Resources
3.3	Ensure climate change considerations are incorporated into the City's Hazard Identification and Risk Assessment tool as part of the annual review process and training.	The purpose of the City's Hazard Identification and Risk Assessment (HIRA) tool is to assess the consequences and frequency of a hazard and to identify which hazards should be the focus of emergency management programs at a particular point in time. The tool assists emergency managers in preparing for the worst/most likely risks and allows for the creation of exercises, training programs, and plans based on the most likely scenarios. The City will ensure that climate change is adequately captured in the HIRA tool so that we are prepared for changing weather risks over time. This could include the following: • Using available localized climate change projections to determine the likelihood and magnitude of various extreme weather events.	• Fire Rescue Services		The Emergency Management Program Committee has identified realistic hazards that may occur in the City and assessed them in terms of probability, frequency of occurrence, and magnitude of consequence or impact. The HIRA tool is utilized and reviewed annually. Results of the HIRA assist with the development of training and exercise scenarios, and may initiate the development of hazard-specific plans or procedures in the event of an emergency.	2019/2020	<1 year; followed by ongoing implementation	Cost: $ Staff effort: 👤
4.1	Upsize storm sewers to current standards as part of renewal (where possible).	The City will continue to upsize the minor drainage system to a 1-in-5 year storm capacity to meet current minimum design requirements as part of renewal (where possible).	• Engineering Services		The City is currently upsizing pipes to the 5-year standard when completing new projects (e.g. road reconstruction, station upgrades, stormwater management projects). Additionally, the Stormwater Management Master Plan will provide a 10-15 year capital forecast related to stormwater management upgrades on infrastructure.	Ongoing based on capital budget	Ongoing	Cost: $$$ Staff effort: 👤👤
4.2	Establish a process for reviewing localized climate projections at regular time intervals.	Climate change projections demonstrate how a certain area's climate may change into the future. They are developed using a combination of climate models, historical weather data, and greenhouse gas emission trajectories. The City will develop a process for reviewing and obtaining, if required, localized, statistically downscaled climate projections on a regular basis. This will ensure that City decisions are based on up to date projections. Through this process, the following will be considered: • Aligning climate projection updates with release of future IPCC Assessment Reports. • Forming partnerships with local municipalities and organizations (e.g. University of Waterloo) to receive or share up to date climate projections.	• Planning		In 2015, the Interdisciplinary Centre on Climate Change at the University of Waterloo prepared a report entitled "Localized Projections for Waterloo Region". The purpose of the report was to contribute to ongoing collaborations on climate action between the Cities of Cambridge, Kitchener, and Waterloo, and the Region of Waterloo. The report summarized information on projected climate change for the region, and included projections on temperature, precipitation, and extreme weather. This information represents the most up to date localized climate projections available to the City.	2023 onwards	<1 year; followed by ongoing implementation	Cost: $ Staff effort: 👤
4.3	Provide training to staff to ensure climate change impacts and risks are considered as part of the Project Management Manual's risk management framework.	As part of the roll out of the new Project Management Manual, training will be provided to staff on how to incorporate climate change considerations into the Manual's risk management framework.	• Engineering Services • Planning		Climate change considerations are taken into account on a project by project basis, but in the absence of targeted training. The City also participates in a Benchmarking Program that compares metrics across Canadian municipalities on levels of services provided by sanitary and stormwater systems.	2019/2020	>1 year; followed by ongoing implementation	Cost: $ Staff effort: 👤👤
4.4	Incorporate climate change considerations into the City's approach to asset management and provide training to staff as required (e.g. lifecycle costing, asset level of service, accelerated deterioration rates).	To improve the resilience and adaptive capacity of assets, the City will incorporate climate change considerations into its asset management planning. Through this process, the following will be considered: • Integrating climate change into risk management. • Implementing a cost analysis for investment decision-making processes, taking into account the change in lifecycle events based on climate change/environmental factors. • Assessing the financial impacts of climate change on	• Asset Management		The City's Asset Management Plan was approved by Council in 2016. The Plan describes the characteristics and condition of assets, the levels of service expected from them, planned actions to ensure the assets are providing the expected level of service, and financing strategies to implement the planned actions. Currently, the Plan does not include climate change considerations.	2020 – 2023	2 years; followed by ongoing implementation	Cost: $ Staff effort: 👤👤👤

ID	Action	Description/Scope	Implementation Lead	Supporting Division(s)	Current Practice	Anticipated Timing	Duration and Frequency	Estimated Resources
		upholding levels of service. • Undertaking these actions through upcoming asset management activities and discussions.			Climate adaptation needs will be identified in the updated Corporate Asset Management Policy (A-030). The policy was tabled at Council on March 18, 2019. Also, as per Ontario Regulation 588/17, climate risks for core assets (e.g. roads, sanitary, storm, and water) will have to be identified by July 1, 2021. Similar information for the remaining assets will need to be identified by July 1, 2023.			
5.1	Develop an Urban Forest Strategy, including a canopy target.	An Urban Forest Strategy will provide tools for growing and maintaining a healthy and resilient urban forest and natural landscape. Waterloo's urban forest includes street trees, parks, and natural areas. The strategy should provide direction on all aspects of the maintaining an urban forest; identify challenges and opportunities for improving the urban forest; set goals and objectives for the long-term sustainability of the urban forest; recommend actions including programs, policies, and partnerships; and project short and long-term resource requirements and monitoring indicators. Through this process, the following will be considered: • Identifying tree species for planting that are highly resilient to invasive species and changing climatic conditions. • A re-planting program for trees lost during ice and wind storms. • Overall connectivity of the natural system.	• Environment and Parks Services		The Forestry Operation Program outlines maintenance standards for the urban forest (e.g. annual inspections, hazard tree maintenance, brace and cabling, debris removal, erosion control, control of invasive species), management of City-owned natural areas, planting standards, and more. The Urban Forest Policy further guides planning, funding, areas of responsibility, managing mature neighborhoods, and new planting details, design, and spacing requirements. Additionally, the City plants around 1,200 new trees on public property every year as part of the current tree-planting goal.	2023 onwards	2 years; followed by ongoing implementation	Cost: $$ Staff effort: 👤👤
5.2	Review the canopy cover mapping protocol and identify tree deficit areas.	The City will review the current canopy cover mapping protocol to identify opportunities for refinement and, with the mapping produced through the protocol, will identify tree deficit areas. The identification of deficit areas can be used to inform planting and programming efforts.	• Environment and Parks Services			2019/2020	< 1 year; followed by ongoing implementation	Cost: $ Staff effort: 👤
5.3	Update the Emergency Forestry Plan.	The City will review and update the Emergency Forestry Plan to incorporate climate change considerations.	• Environment and Parks Services		The Emergency Forestry Plan sets out protocols in case of emergencies.	2019/2020	1 year; followed by ongoing implementation	Cost: $ Staff effort: 👤
5.4	Continue to incorporate City-owned green infrastructure into the Asset Management Plan.	Under Ontario Regulation 588/17, green infrastructure is defined as assets consisting of natural or human-made elements that provide ecological and hydrological functions and processes and includes natural heritage features and systems, parklands, stormwater management systems, street trees, urban forests, natural channels, permeable surfaces and green roofs. To make sure it is appropriately accounted for and managed, the City will continue to incorporate its green infrastructure in the Asset Management Plan.	• Asset Management • City Utilities • Engineering Services • Environment Parks Services	• Information Management and Technology Services	The Asset Management Plan currently includes some types of green infrastructure (e.g. street trees and parks). In 2019, the park inventory will be updated and included in the Plan. The Stormwater Management Master Plan, which is currently being developed, will also provide information on stormwater-related green infrastructure. Further, as per Ontario Regulation 588/17, climate risks for core assets (e.g. roads, sanitary, storm, and water) will have to be identified by July 1, 2021. Similar information for the remaining assets will need to be identified by July 1, 2023.	2020 – 2023	< 2 years; followed by ongoing implementation	Cost: $$ Staff effort: 👤👤👤

ID	Action	Description/Scope	Implementation Lead	Supporting Division(s)	Current Practice	Anticipated Timing	Duration and Frequency	Estimated Resources
6.1	Review existing regulatory floodplain mapping and prioritize opportunities for updates.	Riverine flooding, which happens when water levels rise and creeks overtop their banks, is managed using regulatory floodplain mapping. Regulatory floodplain mapping shows the area that would be subject to flooding and is based on standards set by the Province. The City will work with the Grand River Conservation Authority to review existing regulatory floodplain mapping and prioritize areas to update. This could include consideration of the following: • Relative hazard level • Relative risk level • Age of existing modelling/mapping • Development pressure	• Planning	• Engineering Services	Regulatory floodplain mapping is included in the City's Official Plan. The floodplain mapping for part of Laurel Creek and Clair Creek is currently being updated. The project began in 2016.	2023 onwards	>1 year	Cost: $ Staff effort: 👤👤
6.2	Map areas prone to urban flooding and model scenarios.	Urban flooding occurs when there is more water than the storm sewers can handle, or when there is a lack of an overland flow route. It can include street and basement flooding as well as flooding of other low lying areas. The City will map areas prone to urban flooding and model scenarios to determine the impact of various rainfall events.	• Engineering Services		The Stormwater Management Master Plan currently being developed will include a comprehensive stormwater management model to determine flood-prone areas.	2023 onwards	>2 years; followed by ongoing implementation	Cost: $ Staff effort: 👤👤
6.3	Review the protocols for inspecting creeks and stormwater infrastructure to minimize flood risks.	The City has protocols in place for inspecting creeks and stormwater infrastructure on a regular basis to ensure systems are functioning normally and are not in need of repair or intervention. As precipitation events are projected to become more frequent and intense, the City will review these protocols to ensure they are adequate to address changing climatic conditions.	• City Utilities		As part of ongoing maintenance, the City inspects creeks, catch basins, oil and grit separators, and stormwater management ponds. As part of the Stormwater Management Master Plan, which is currently being developed, an inventory of all creeks and stormwater infrastructure is being completed and will be updated every 10-15 years. Additionally, all ponds will be subject to bathymetric surveys on a 5-10 year basis to determine sediment volumes.	2020-2023	>1 year; followed by ongoing implementation	Cost: $ Staff effort: 👤👤
6.4	Increase public education on clearing catch basins.	Recognizing that leaves, snow, and other debris can block catch basins and prevent rain from entering the storm sewer system, the City will generate awareness on the importance of clearing catch basins. This could include consideration of the following: • Creating website or social media content. • Developing messaging and placing it in strategic locations (e.g. water bills). • Working with community partners.	• City Utilities	• Communications Services		2019/2020	6 months; followed by ongoing implementation	Cost: $ Staff effort: 👤
6.5	Investigate the feasibility of a sump pump disconnection program.	Sump pumps are routinely utilized in buildings to pump groundwater away from foundation walls. Some sump pumps discharge into the sanitary sewer, which can contribute to overloading and lead to backups of sewage water into basements. The City will explore the feasibility of creating a disconnection program for sump pumps connected to the sanitary sewer. This could include consideration of the following: • Identifying data sources that can be used to indicate if, and where, sump pump flows are problematic. • Categorizing areas based on risk. • Identifying implementation mechanisms (e.g. education campaign, subsidy program, collaborative initiatives) • Undertaking a cost-benefit analysis.	• City Utilities	• Engineering Services	The City's 2013 Development Engineering Manual provides design guidelines for site plan and subdivision development in the City of Waterloo. Concerning sump pumps, the manual reads "Storm flows from foundation drains may be directed to a sump pump and pumped to the storm sewer service connection. Under no circumstances should sump pumps be allowed to discharge on the ground or to the sanitary sewer".	2023 onwards	2 years	Cost: $ Staff effort: 👤👤

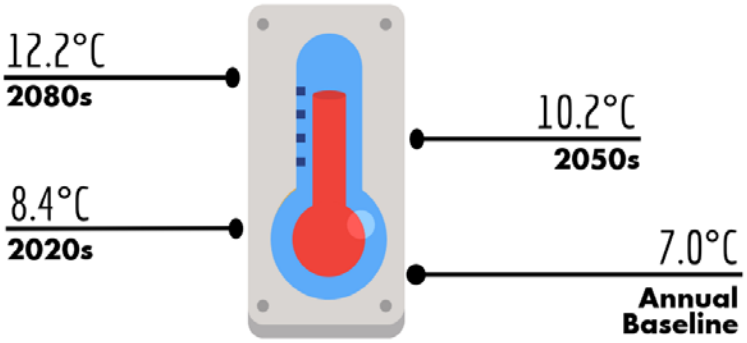
ID	Action	Description/Scope	Implementation Lead	Supporting Division(s)	Current Practice	Anticipated Timing	Duration and Frequency	Estimated Resources
6.6	Investigate the feasibility of a backwater valve program.	The City will investigate the feasibility of developing a program to increase the installation of backwater valves. Backwater valves prevent water or sewage from flowing into houses in the event that the main sewer line becomes overloaded. Through this process, the following will be considered: • Identifying high risk areas. • Reviewing options for increasing uptake, including education, incentives, and subsidies.	• City Utilities	• Engineering Services		2023 onwards	>2 years	Cost: $ Staff effort 👤👤
6.7	Complete and implement the Stormwater Management Master Plan.	The Stormwater Management Master Plan will provide the City with a preferred stormwater management strategy to identify, protect, and enhance natural features, ecological functions, and biophysical integrity. The plan will assist staff in appropriately managing risks through the establishment of environmental targets for water quality, water quantity, erosion, infiltration (water balance) and guidance with respect to the protection of natural features. The plan will also address infrastructure issues, such as flooding, and form part of the overall asset management program. The plan will establish a stormwater management policy and guidelines and will also address stormwater infrastructure and identify and prioritize identified works.	• Engineering Services	• City Utilities	The City's last Master Drainage Study was completed in 2005. The new Stormwater Management Master Plan is anticipated to be completed by the end of 2019.	Ongoing	>10 years	Cost: $$$ Staff effort: 👤👤👤
6.8	Review and upgrade flood proofing measures in City-owned buildings in the regulatory floodplain where possible.	The City will review the extent to which existing City-owned buildings in the regulatory floodplain are floodproofed and identify opportunities for improvement.	• Facility Design and Management Services			2023 onwards	>5 years; followed by ongoing implementation	Cost: $$$ Staff effort: 👤👤👤
7.1	Undertake business continuity planning and training to identify and plan for the City's essential and secondary services.	The City will carry out business continuity planning using an all-hazards approach to address daily operations, roles and responsibilities, critical activities (e.g. emergency shelters, emergency staffing), critical interdependencies with non-municipal infrastructure/facilities), along with other key items. This could include the following: • Conducting an impact analysis to identify essential and secondary City services and operations, lines of authority, potential financial and operational impacts, timelines in which essential operations, processes, and services should resume, and resources needed to resume services and for general division recovery. • Cross-training staff, researching alternative suppliers, and storing City records, documents, and vital data off-site. • Communicating the Business Continuity Plan process and responsibilities to staff. • Developing facility and service closure/extension criteria and policies.	• CAO's Office • Fire Rescue Services	All	As set out in the 2016-2018 Business Plan, Information Management and Technology Services is implementing disaster recovery and business continuity planning. Additionally, the City's Emergency Response Plan includes the governance structure for emergency response, roles and responsibilities, response goals for emergency operations within the application of an all hazards and plan-specific approach where applicable. It also includes a Hazard Identification and Risk Assessment of realistic hazards that may occur in Waterloo.	2019/2020	1 year; followed by ongoing implementation	Cost: $ Staff effort: 👤👤👤
7.2	Review practices around back-up power generation and ensure critical facilities are covered.	Climate change poses a major threat to electricity infrastructure, including damage to transmission lines from increased freezing rain or grid overloads from prolonged heat waves. The City will review existing practices and ensure all buildings and assets delivering critical services to the community have reliable back-up power. This could include consideration of the following:	• Facility Design and Management Services		City facilities with onsite generators include Waterloo City Centre, Waterloo Service centre, Waterloo Memorial Recreation Complex, RIM Park, and Albert McCormick Community Centre.	2020 – 2023	2 years; followed by ongoing implementation	Cost: $$ Staff effort: 👤👤

ID	Action	Description/Scope	Implementation Lead	Supporting Division(s)	Current Practice	Anticipated Timing	Duration and Frequency	Estimated Resources
		• Preparing an inventory of critical facilities and assets that identifies those with and without back-up power systems. • Considering renewable and distributed energy solutions where feasible • Developing a policy regarding backup power for critical facilities						
7.3	Develop a fuel supply protocol to manage supplies during extreme events and emergencies.	Severe weather can affect fuel supply chains. To address this, the City will develop a fuel supply protocol to manage the supply of available fuel during extreme weather events and emergencies. This may also include contingencies and measures that can be taken by the City in the event of a fuel shortage. Through this process, the following will be considered: • Identifying fuel requirements to retain basic function of critical facilities and to run other critical services. • Identifying an alternative source of fuel in the event the City reserves are not sufficient.	• Fleet and Procurement Services	• City Utilities • Environment and Parks Services • Facility Design and Management Services • Fire Rescue Services • Transportation Services	The City maintains three fuel storage locations (Service Centre, Waterloo Park and Parkview Cemetery).	2023 onwards	1 year; followed by ongoing implementation	Cost: $ Staff effort: 👤👤
7.4	Consider alternative work arrangements that reduce commuting during extreme weather events and hazardous road conditions.	Alternative work arrangements can help increase public safety and reduce strain on transportation networks. They can also improve employee productivity and enable continuity of work on days where employees would have been unable to come into work. The City will explore flexible work days, stay-at-home days, and telecommuting options for staff during periods of extreme weather and hazardous conditions. Through this process, the following will be considered: • Defining extreme weather events and thresholds. • Identifying eligible staff.	• Human Resources		Existing provisions allow for certain positions to engage in flexible working arrangements on a general basis. However, based on operational requirements, some positions are not well suited to such arrangements. The City has recently implemented a pilot project for flexible working arrangements for the management group.	2020 – 2023	1 year; followed by ongoing implementation	Cost: $ Staff effort: 👤
7.5	Review the existing 211 service agreement to identify potential advancements of the 211 network.	Ontario 211 is a helpline that connects residents to community and social services 24 hours a day. The City will review its existing 211 service agreement, its parameters, and potential advancements of the network. Based upon new features of 211, staff will be trained to forward information prior to and during emergencies.	• Communications Services		211 provides information on a variety of topics including community programs, emergency/crisis, food, healthcare, housing, and more.	2020 – 2023	1 year	Cost: $-$$ Staff effort: 👤👤
8.1	Identify financial implications and incorporate adaptation-related costs into short and long-term financial budgets and projections.	The City will integrate adaptation-related costs into capital budget project sheets and operating estimates, as appropriate, to help guide short and long-term implementation of adaptation measures. Conducting proactive financial planning around climate change will reduce municipal vulnerability and costs in the long-run.	All		The City's Capital Budget covers municipal projects related to new assets or rehabilitating existing ones, including roads, sewers, parks, fire stations, arenas, libraries, parking lots, stormwater management infrastructure, fleet replacements, and more. The Operating Budget covers the day-to-day operations of the City and funds such municipal services and programs as leaf pickup, snow removal, sewer maintenance, fire protection services, by-law enforcement, economic development, road maintenance and repair, and park, recreation, culture, and leisure services and programming.	2020 – 2023	Ongoing	Cost: $$ Staff effort: 👤👤

ID	Action	Description/Scope	Implementation Lead	Supporting Division(s)	Current Practice	Anticipated Timing	Duration and Frequency	Estimated Resources
8.2	Continue annual reviews of the General Operating Contingency Reserve Policy and the Winter Control Reserve Policy to ensure they appropriately account for extreme weather events.	The City will continue to annually review and update as needed the two reserve policies to ensure climate change impacts are adequately addressed.	• Financial Planning	• City Utilities • Environment and Parks Services • Transportation Services	The Winter Control Reserve funds winter maintenance in the event of a shortfall in the Winter Control Operating Budget. It is required to maintain a minimum balance of 25% of the 5-year average spending on winter maintenance. A maximum balance of $2 million has been set for this reserve. The General Operating Contingency Reserve funds operating expenditure variations resulting from cyclical spending, unanticipated operating opportunities and pressures, and anticipated expenditures for which the timing cannot be anticipated, such as expenditures relating to significant storm events. The maximum level of this reserve has been set at 4% of the net tax levy (2017 ~ $2.5M) Should Winter Control and General Operating Contingency not be adequate to fund a significant event, the Tax Rate Stabilization Reserve provides for unforeseen events that might put pressure on the tax rate. This reserve has a maximum balance of 5% of the Net Tax Levy (2017 $3.5M).	Ongoing	Ongoing	Cost: $ Staff effort: 1
8.3	Review plans, policies, and procedures for alignment with adaptation goals and update where appropriate (e.g. Official Plan, Emergency Response Plan, master plans, maintenance protocols).	The City will incorporate climate change considerations into its guiding documents, policies, and procedures to ensure it is represented and formalized at the decision-making level. General alignment opportunities could include the following: • Identifying gaps, conflicts, and synergies. Where gaps exist, strengthen policies and develop new practices to reduce vulnerability and risk. Where conflicts exist, modify policies to build resiliency. • Identifying approaches that address both adaptation and greenhouse gas mitigation. Specific alignment opportunities could include the following: • As part of the 2019 review of the Purchasing by-law, include language around identifying opportunities to incorporate emergency response support into operational supplier contracts. • Development of a Facility Roof Snow Load Management Plan that would address risks associated with snow loads	• CMT/OLT	All	Many of the City's plans, policies, and procedures address climate change directly or indirectly.	2019/2020 (to coincide with Business Plans)	>2 years; followed by ongoing implementation	Cost: $$$ or Staff effort: 3 (depending on how it is resourced)
8.4	Identify corporate champion(s) to help lead implementation of adaptation actions.	The City will identify individuals within the organization to help lead the integration of CCCAP actions into planning and operations. Leadership in implementing adaptation actions across the corporation ensures an organizational focus and an integrated voice in adapting to the effects of climate change.	• CMT	All	An Adaptation Working Group was created to support the development of the CCCAP. It is made up of staff from 12 Divisions.	2019	<6 months; followed by ongoing implementation	Cost: $ Staff effort: 1

Appendix B: **Climate Change Projections**

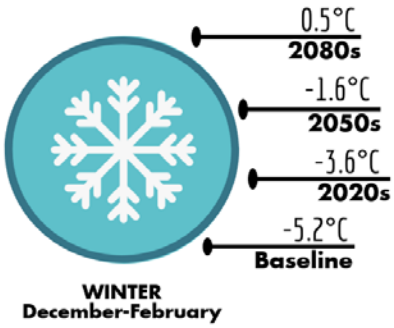
THE CITY OF WATERLOO
FUTURE CLIMATIC PROJECTIONS
April 2018



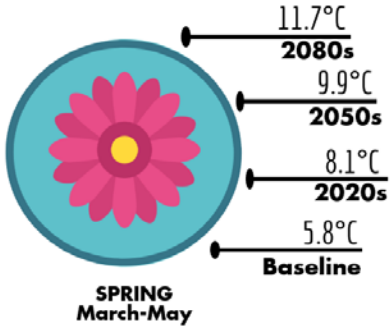
ANNUAL MEAN TEMPERATURES

Mean, minimum & maximum daily temperatures are projected to significantly increase in every season.

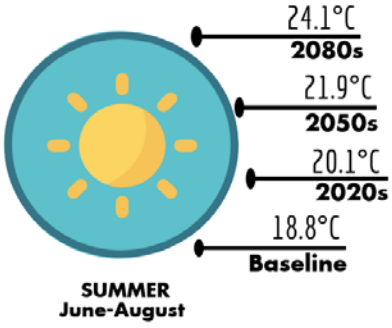
SEASONAL MEAN TEMPERATURES



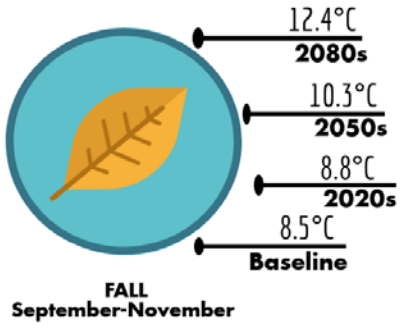
WINTER
December-February



SPRING
March-May



SUMMER
June-August

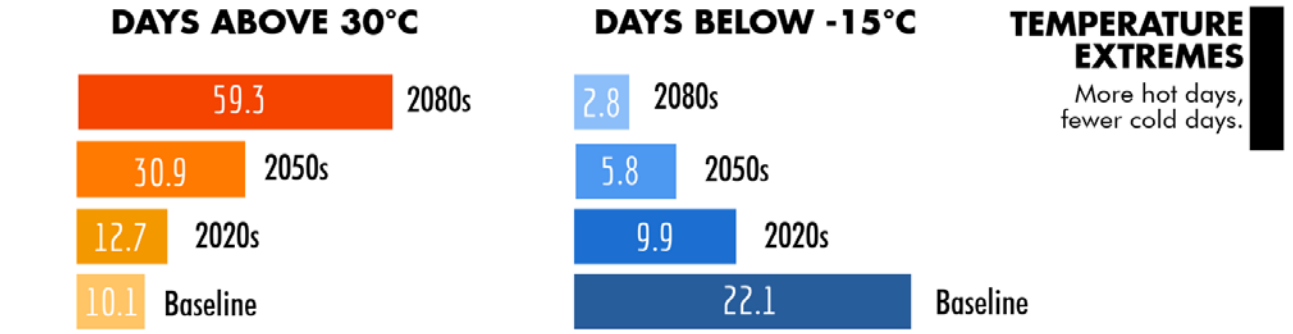


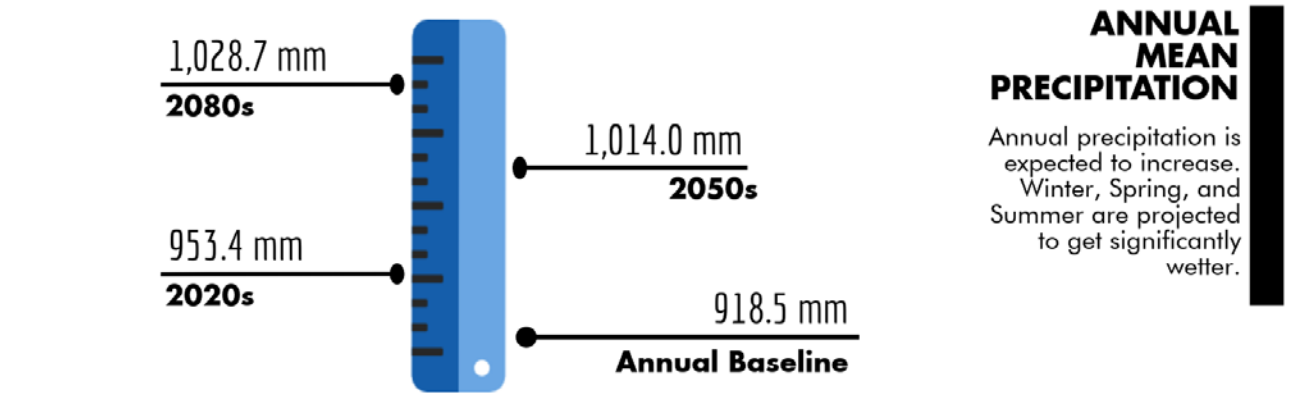
FALL
September-November

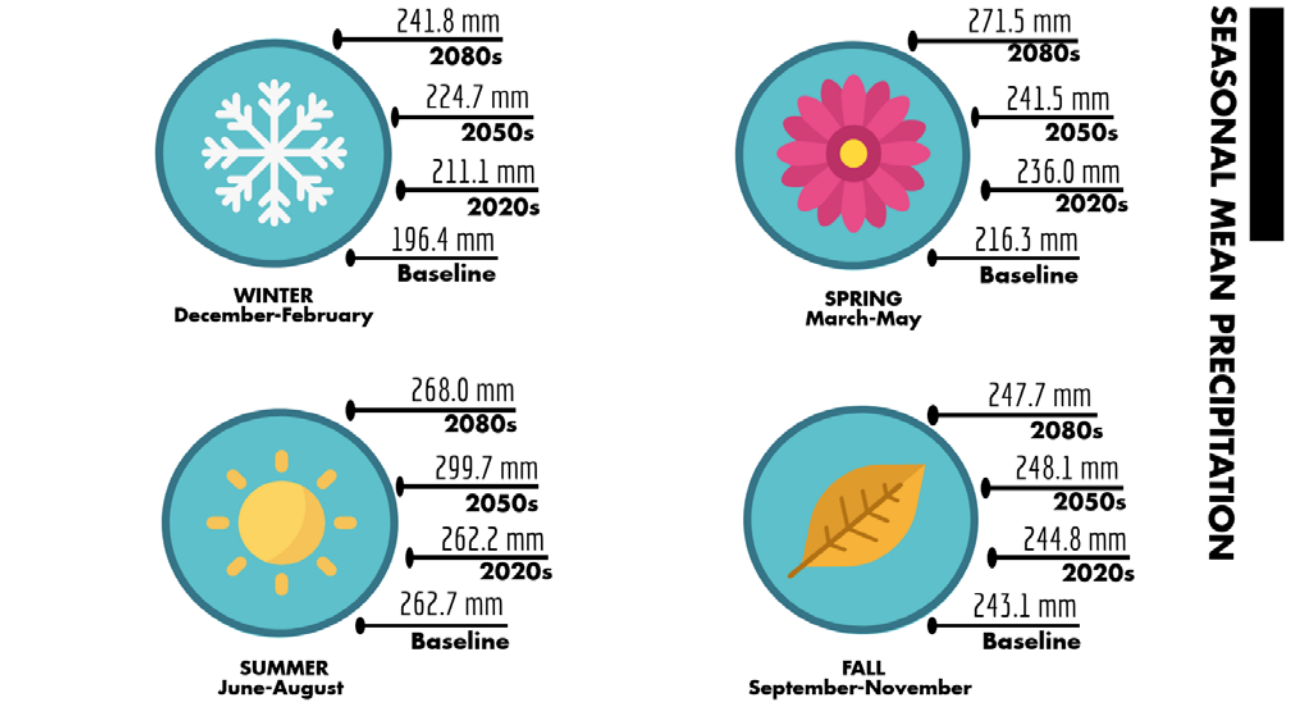
DAYS WITH FREEZE-THAW CYCLES

FREEZE-THAW CYCLES

More freeze-thaw days expected, with an eventual slight decline.


DAYS ABOVE 30°C
59.3
2080s
30.9
2050s
12.7
2020s
10.1
Baseline
DAYS BELOW -15°C
2.8
2080s
5.8
2050s
9.9
2020s
22.1
Baseline
TEMPERATURE EXTREMES
More hot days, fewer cold days.


1,028.7 mm
2080s
1,014.0 mm
2050s
953.4 mm
2020s
918.5 mm
Annual Baseline
ANNUAL MEAN PRECIPITATION
Annual precipitation is expected to increase. Winter, Spring, and Summer are projected to get significantly wetter.


241.8 mm
2080s
224.7 mm
2050s
211.1 mm
2020s
196.4 mm
Baseline
WINTER
December-February
271.5 mm
2080s
241.5 mm
2050s
236.0 mm
2020s
216.3 mm
Baseline
SPRING
March-May
268.0 mm
2080s
299.7 mm
2050s
262.2 mm
2020s
262.7 mm
Baseline
SUMMER
June-August
247.7 mm
2080s
248.1 mm
2050s
244.8 mm
2020s
243.1 mm
Baseline
FALL
September-November
SEASONAL MEAN PRECIPITATION

ANNUAL NUMBER OF DRY SPELLS

DRY SPELLS

Dry spells are defined as periods of 6 or more consecutive days with no precipitation.

Compared to the 2000s historical averages, frequency of wind gusts greater than

40 km/h

are projected to increase by

10-20%

...and wind gusts greater than

70 km/h

are projected to increase by

20-40%

WIND

Severe wind gust events are expected to increase in both frequency and magnitude by the end of the century.

PRECIPITATION EVENTS

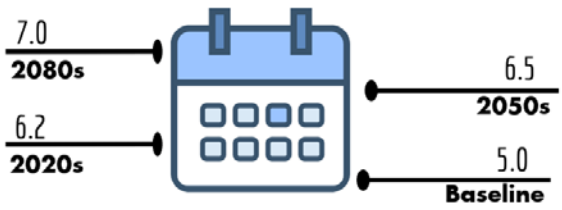
Precipitation events in general are projected to become more intense and extreme.

MAXIMUM TOTAL PRECIPITATION FOR A 5-YEAR RETURN PERIOD

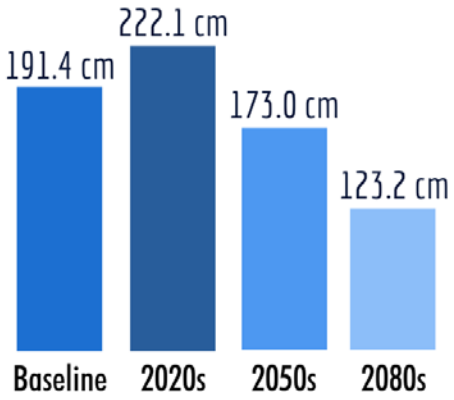
Baseline	2020s	2050s	2080s
Max 1-day total: 66.5 mm	Max 1-day total: 78.0 mm	Max 1-day total: 66.9 mm	Max 1-day total: 67.4 mm
Max 5-day total: 92.0 mm	Max 5-day total: 112.9 mm	Max 5-day total: 102.2 mm	Max 5-day total: 106.7 mm

DAYS WITH PRECIPITATION OVER 10 mm

DAYS WITH PRECIPITATION OVER 25 mm



ANNUAL MEAN SNOWFALL



FREEZING RAIN

Freezing rain events are predicted to increase by **40%** by the year **2050**

...and further increase by **45%** by the year **2080**

WINTER PRECIPITATION EVENTS

* Baseline period: 1990s (1981-2010); Projection periods: 2020s (2011-2040), 2050s (2041-2070), 2080s (2071-2100).

Source:

Interdisciplinary Centre on Climate Change & University of Waterloo (2015). Localized Climate Projections for Waterloo Region.

ICLEI Local Governments for Sustainability

Appendix C: **Vulnerability and Risk Assessment Outcomes**

Milestone Two of the BARC Framework involves developing impact statements which detail the ways in which climate change will affect a municipality. These impacts are then run through a vulnerability assessment and a risk assessment in order to prioritize the areas on which the City should focus its efforts. A total of 46 impacts statements were identified and run through the vulnerability assessment. Of those 46 impacts, 28 earned a Medium or High vulnerability ranking. Those 28 impacts were then carried forward to the risk assessment.

Vulnerability Assessment

Vulnerability refers to the susceptibility of a given City Division to harm arising from climate change impacts. It is a function of a Division's *sensitivity* to climate change and its capacity to adapt to impacts (or its *adaptive capacity*). Using a 'dotmocracy' methodology, and under the premise of the impact occurring today, both *sensitivity* and *adaptive capacity* were considered when assigning a vulnerability ranking to each of the 46 impact statements. The following scale was used to assign the vulnerability rankings:

Low Vulnerability
Not very/not at all vulnerable to harm arising from the impact

Medium Vulnerability
Somewhat vulnerable to harm arising from the impact

High Vulnerability
Very vulnerable to harm arising from the impact

Risk Assessment

Risk is a function of the *likelihood* and *consequence* of an impact.

Likelihood is based on the probability of an impact occurring, and considers both the probability of the climate threat occurring and the probability of the associated outcomes occurring. *Likelihood* ratings from 1 to 5 were assigned to each impact, where 1 was 'rare' and 5 was 'almost certain', based on localized climate projections, as well as anecdotal knowledge of current conditions.

Exhibit 7: Likelihood Ranking Scale

Likelihood Rating	Recurrent Impact	Single Event
Almost Certain (5)	Could occur several times a year	More likely than not – probability greater than 50%
Likely (4)	May arise about once per year	As likely as not – 50/50 chance
Possible (3)	May arise once in 5 years	Less likely than not but still appreciable – probability less than 50% but still quite high
Unlikely (2)	May arise once in 5 to 10 years	Unlikely not but not negligible – probability low but noticeably greater than zero
Rare (1)	Unlikely during the next 10+ years	Negligible – probability very small, closer to zero

Consequence refers to the known or estimated outcomes of a particular impact. To determine *consequence*, the 28 impacts subject to the risk assessment were assessed against 12 consequence criteria. The consequence criteria were divided into three categories – social, economic, and environmental. *Consequence* ratings from 1 to 5 were assigned to each criterion, where 1 was 'negligible' and 5 was 'catastrophic'.

Exhibit 8: Social Consequence Criteria

CONSEQUENCE RATING	CRITERIA CATEGORY: SOCIAL			
	Public Health and Safety	Displacement	Loss of Livelihood	Cultural Aspects
Catastrophic	Large number of fatalities or serious injuries, or permanent illness	Large number of permanently displaced people on a widespread scale	Large disturbances leading to permanent changes in people's normal routines and way of life	Unprecedented loss of cultural identity (i.e. traditions and customary practices) across the wider community (i.e. cancellation of flagship annual event)
	5	5	5	5
Major	Isolated instances of fatalities or serious injuries, or long-term illness	Isolated instances of permanently displaced people on a widespread scale	Large disturbances leading to prolonged changes in people's normal routines and way of life	Significant loss of cultural identity (i.e. traditions and customary practices) for multiple social groups
	4	4	4	4
Moderate	Small number of injuries or cases of illness	Isolated instances of temporary displaced people on a widespread scale	Moderate disturbances leading to short-term changes in people's normal routines and way of life	Moderate impact on cultural identity (i.e. traditions and customary practices) for multiple social groups
	3	3	3	3
Minor	Near misses or minor injuries	Isolated instances of temporary displaced people in localized areas	Minor and short-term changes to people's normal routines and way of life	Minor impact on cultural identity (i.e. traditions and customary practices) for a small number of social groups
	2	2	2	2
Negligible	Appearance of a threat but no actual harm	Appearance of a threat but no actual displacement	No changes to people's normal routine and way of life	Appearance of a threat but no actual impact on cultural identity (i.e. traditions and customary practices)
	1	1	1	1

Exhibit 9: Economic Consequence Criteria

CONSEQUENCE RATING	CRITERIA CATEGORY: ECONOMIC			
	Property Damage	Local Economy and Growth	Community Livability	Public Administration
Catastrophic	Catastrophic damage and costs incurred by the owner ($$$$$)	City-scale decline leading to widespread business failure, loss of employment and hardship	Permanent decline in services, causing the city to be seen as very unattractive, moribund, and unable to support the community	Public administration would fall into decay and cease to be effective
	5	5	5	5
Major	Major damage and costs incurred by the owner ($$$$)	City-scale stagnation such that businesses are unable to thrive	Widespread and severe decline in services and quality of life within the community	Pubic administration would struggle to remain effective and would be in danger of failing
	4	4	4	4
Moderate	Moderate damage and costs incurred by the owner ($$$)	Isolated areas of reduction in economic performance relative to current forecasts	Isolated but noticeable examples of decline in services	Public administration would be under severe pressure on several fronts
	3	3	3	3
Minor	Minor damage and costs incurred by the owner ($$)	Inconveniences that cause minor shortfall relative to current forecasts	There would be minor areas in which the community is unable to maintain its current services	There would be minor instances of public administration being under more than usual stress
	2	2	2	2
Negligible	No damage and costs incurred by the owner ($)	No real impact to the local economy and growth	No real pressure on current services	No real stress on public administration
	1	1	1	1

Exhibit 10: Environmental Consequence Criteria

CONSEQUENCE RATING	CRITERIA CATEGORY: ENVIRONMENTAL			
	Air	Water	Soil and Vegetation	Ecosystem Function
Catastrophic	Very frequent periods of reduced air quality.	Irreversible, widespread reduction in water quality/quantity	Irreversible, widespread impacts to soil or vegetation	Major and widespread loss of ecological functions and irrecoverable damage
	5	5	5	5
Major	Considerable increase in periods of reduced air quality in the medium term	Major, widespread reduction in water quality/quantity in the medium/long-term	Major, widespread impacts on soil or vegetation in the medium/long-term	Severe and widespread loss of ecological functions and damage that could be reversed with intensive efforts
	4	4	4	4
Moderate	Moderate increase in periods of reduced air quality in the short/medium term	Moderate, widespread reduction in water quality/quantity in the short/medium-term	Moderate, widespread impacts on soil or vegetation in the short/medium-term	Isolated but moderate instances of damage to the ecosystem that could be reversed with intensive efforts
	3	3	3	3
Minor	Minor increase in periods of reduced air quality in the short-term	Minor, localized reduction in water quality/quantity in the short-term	Minor, localized impacts on soil or vegetation in the short-term	Isolated but minor instances of damage to the ecosystem that could be reversed
	2	2	2	2
Negligible	Appearance of a threat but no real impact to air quality	Appearance of threat but no real reduction in water quality/quantity	Appearance of threat but no real impacts on soil or vegetation	Appearance of a threat but no real damage to the ecosystem and its functions
	1	1	1	1

For each impact, category-specific risk scores were calculated as well as an overall risk score by multiplying *consequence* ratings with *likelihood* ratings. Those scores were then compared against two risk spectrums. The first risk spectrum was applied to the category-specific risk scores. The second risk spectrum was applied to the overall risk score.

Exhibit 11: Category-Specific Risk Spectrum

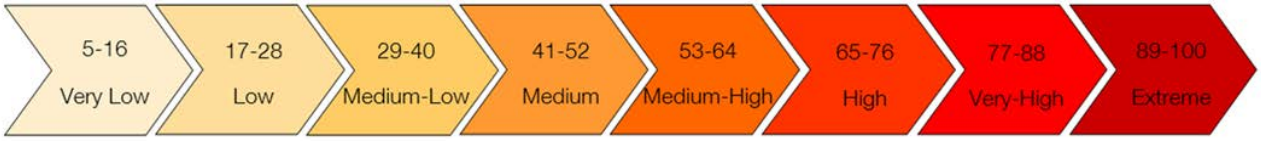
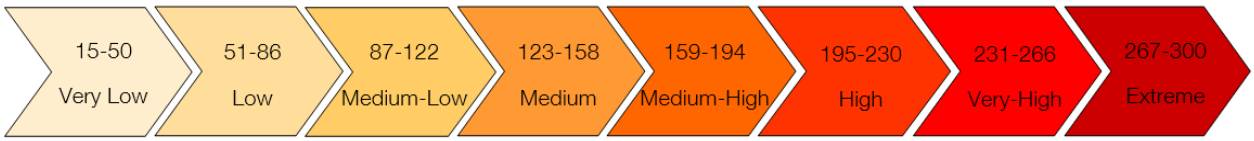


Exhibit 12: Overall Risk Spectrum



The purpose of calculating one overall risk score, as well as three category-specific risk scores, was to capture impacts that scored high in certain categories, but low in others. This ensures that impacts that pose a high risk to certain aspects of the corporation are still considered, despite having a lower overall risk score.

Limitations

The risk assessment process was an exercise that evaluated participants' perceptions of the risks that impacts pose to the City's assets, operations, and services. Outputs of the exercise were dependent on those that participated in the assessment. While great effort was made to engage key staff, the exercise did not capture every stakeholder perspective in the corporation. It is also important to acknowledge that the impact statements themselves are considered subjective. Once again, however, great effort was made to ensure the list was both inclusive and exhaustive and captured how climate change could affect the City of Waterloo.

Results

The results of the vulnerability assessment and the risk assessment are summarized below. Provided are the vulnerability rankings for the 46 impacts subject to the vulnerability assessment, as well as the overall risk scores and rankings for the 28 impacts subject to the risk assessment. The impacts are organized based on their identification number and the climate threat to which they are tied.

Exhibit 13: Vulnerability and Risk Assessment Results

Impact ID	Climatic Threat	Impact Statement	Vulnerability Ranking	Overall Risk Score	Overall Risk Ranking
1	Increased summer temperatures	Increased frequency and duration of hot days (>30°C) leading to increased energy use to cool City-owned facilities.		N/A	N/A
2	Increased summer temperatures	Increased electricity demand, resulting in more power outages and service disruptions.		N/A	N/A
3	Increased summer temperatures	Increased frequency and duration of hot days (>30°C), resulting in demand for cooling centres outside of regular business hours.		DELETED Captured in Impact 4	
4	Increased summer temperatures	Increased frequency and duration of hot days (>30 C), resulting in decreased use of outdoor recreation areas and facilities and increased demand for indoor facilities.		N/A	N/A
5	Increased summer temperatures	Increased frequency and duration of hot days (>30 C), leading to increased demand for aquatic facilities and programs and splash parks.		N/A	N/A
6	Increased summer temperatures	Increased frequency and duration of hot days (>30 C), resulting in increased damage to roads, culverts, sidewalks, trails, parking lots and outdoor recreation facilities (e.g. play courts and skateboard park).		72	**Low**
7	Increased summer temperatures	Warmer temperatures, leading to more operational stress on vehicles and equipment and increased maintenance requirements.		48	**Very Low**
8	Increased summer temperatures	Increased heat and smog alerts, leading to health and safety risks to outdoor workers, shortened windows to work outdoors and increased project/task duration.		100	**Medium -Low**
9	Increased summer temperatures	Increased frequency and duration of hot days (>30 C), leading to increased health and safety risks to the public, especially vulnerable populations (e.g. elderly, socially isolated, etc.).		110	**Medium -Low**
10	Increased summer temperatures	Increased frequency and duration of hot days (>30 C), leading to decreased survivability of trees, increased maintenance requirements and increased need for shade trees and structures.		N/A	N/A
11	Increased summer temperatures	Increased dust in public spaces, leading to greater maintenance requirements (e.g. street sweeping, ball diamond maintenance).		N/A	N/A
12	Increased summer temperatures	Increased dry periods, leading to increased irrigation requirements for sports fields and overall water demands (e.g. lawn watering, pool filling).		N/A	N/A
13	Increased summer temperatures	Increased dry vegetation, leading to increased risk of fires (e.g. wildfire, grassfire, etc.).		N/A	N/A
14	Increased annual temperatures	Longer shoulder seasons, leading to extended maintenance seasons and issues hiring students as seasonal staff.		60	**Low**
15	Increased annual temperatures	Warmer temperatures, leading to increased incidences of vector-borne illness due to longer exposure periods.		N/A	N/A

Impact ID	Climatic Threat	Impact Statement	Vulnerability Ranking	Overall Risk Score	Overall Risk Ranking
16	Increased annual temperatures	Longer growing seasons resulting in increased spread of invasive species (e.g. Phragmites, Giant Hogweed).		N/A	N/A
17	Increased temperature variability in shoulder seasons	Longer growing seasons, leading to increased issues optimizing City fleet (e.g. leaf pick up equipment vs. snowplows).		64	**Low**
18	More volatile winter temperatures	Increased freeze-thaw cycles, resulting in damage to, and decreased service life of, City-owned buildings (e.g. foundations, roofs) and infrastructure (roads, sidewalks, trails, parking lots, outdoor recreation facilities, water mains, culverts, hardened channels, etc.).		110	**Medium -Low**
19	More volatile winter temperatures	Increased freeze-thaw cycles causing damage to, and hazardous conditions on, transportation infrastructure, leading to increased liability and insurance claims.		76	**Low**
20	More volatile winter temperatures	Increased salt use, resulting in accelerated deterioration of City fleet (e.g. rust) and infrastructure/assets (e.g. concrete corrosion) and increased maintenance requirements.		80	**Low**
21	More volatile winter temperatures	Rapid snowmelts, resulting in overburdening of stormwater infrastructure.		DELETED Captured in Impact 22	
22	More volatile winter temperatures	Increased rainfall events during winter while ground is frozen, resulting in overland flooding.		88	**Medium -Low**
23	More volatile winter temperatures	Extreme seasonal conditions (e.g. February melt), resulting in disruption to outdoor events and programming and decreased winter-based recreation (e.g. skating).		N/A	N/A
24	Milder winter temperatures	Increased insect/pest survival rates, leading to increased tree and vegetation maintenance requirements and asset loss.		120	**Medium -Low**
25	Extreme cold temperatures	Increased frozen water services and water main breaks.		100	**Medium -Low**
26	Extreme cold temperatures	Increased mechanical failure of operational and maintenance equipment, leading to increased stress on operations and decreased service levels.		54	**Low**
27	Extreme cold temperatures	Reduced use of active transportation and increased demand on roadways.		N/A	N/A
28	Increased heavy rainfall events	Overburdening of storm sewers and stormwater management facilities, resulting in overland flooding.		75	**Low**
29	Increased heavy rainfall events	Increased inflow and infiltration into sanitary sewers, causing sewage backups and flooding.		81	**Low**
30	Increased heavy rainfall events	Riverine or overland flooding, resulting in disruption or damage to City-owned assets (e.g. buildings, roads, underground infrastructure, etc.).		116	**Medium -Low**
31	Increased heavy rainfall events	Riverine or overland flooding, resulting in increased public emergencies and evacuations.		81	**Low**

Impact ID	Climatic Threat	Impact Statement	Vulnerability Ranking	Overall Risk Score	Overall Risk Ranking
32	Increased heavy rainfall events	Inundation of parks and sports fields, leading to temporary loss of facilities, increased maintenance requirements, and need to reconstruct and/or engineer drainage systems.		80	**Low**
33	Increased heavy rainfall events	Increased erosion, resulting in damage to creeks, parks, natural areas and infrastructure (e.g. roads, trails, sports facilities, etc.).		120	**Medium -Low**
34	Increased heavy rainfall events	Cancellations of City-delivered outdoor programming and outdoor rental space (e.g. public events, picnics, weddings).		N/A	N/A
35	Increased frequency/severity of drought	Increased stress on trees and natural areas, resulting in higher disease susceptibility and decreased rates of establishment for new plantings.		N/A	N/A
36	Increased frequency/severity of drought	Increased damage and compaction of turf and grass surfaces, leading to increased sport field closures.		N/A	N/A
37	Increased freezing rain events	Increased damage to City-owned assets and infrastructure (trees, signs, street lights, buildings, roads, small equipment, etc.), leading to increased maintenance and repairs, increased health and safety risks to outdoor workers, increased call volumes to staff and increased competition to acquire recovery contractors.		160	**Medium -High**
38	Increased freezing rain events	Increased damage to power lines, resulting in more power outages and service disruptions.		140	**Medium**
39	Increased freezing rain events	Increased hazardous conditions on roads, parking lots, sidewalks and trails, resulting in increased public safety issues and more insurance claims.		96	**Medium -Low**
40	Increased freezing rain events	Increased hazardous conditions on roads, parking lots, sidewalks and trails, resulting in increased demand on winter operations and increased safety risks to operations staff and outdoor workers.		110	**Medium -Low**
41	Increased extreme weather events (e.g. windstorms, thunderstorms, tornadoes, etc.)	Increased damage to City-owned assets and infrastructure (trees, signs, street lights, buildings, roads, small equipment, etc.), leading to increased maintenance and repairs, increased health and safety risks to outdoor workers, increased call volumes to staff and increased competition to acquire recovery contractors.		140	**Medium**
42	Increased extreme weather events (e.g. windstorms, thunderstorms, tornadoes, etc.)	Delays in maintenance and construction projects, resulting in issues with scheduling and completing projects on time.		72	**Low**
43	Increased extreme weather events (e.g. windstorms, thunderstorms, tornadoes, etc.)	Increased tree branches and other debris blocking catch basins and culverts, leading to increased flooding potential and maintenance requirements.		N/A	N/A

Impact ID	Climatic Threat	Impact Statement	Vulnerability Ranking	Overall Risk Score	Overall Risk Ranking
44	Increased extreme weather events (e.g. windstorms, thunderstorms, tornadoes, etc.)	Increased electrical surges and power outages, resulting in service disruptions.		140	**Medium**
45	Increased extreme weather events (e.g. windstorms, thunderstorms, tornadoes, etc.)	Increased incidences of power outages, resulting in increased demand on emergency response resources and continuity of support.		104	**Medium -Low**
46	Increased extreme weather events (e.g. windstorms, thunderstorms, tornadoes, etc.)	Increased incidences of power outages, resulting in public health and safety risks associated with heating, cooling, and cooking.		63	**Low**

Appendix D: **Community Engagement Summary Report**

COMMUNITY ENGAGEMENT SUMMARY REPORT

City of Waterloo Corporate Climate Change Adaptation Plan

Prepared For: City of Waterloo

Prepared By: LURA Consulting

May 2019

Introduction

Overview

Community engagement played an important role in the development of the Corporate Climate Change Adaptation Plan. This Community Engagement Summary Report outlines the activities and tools that were used as part of the engagement program and summarizes the input received.

Engagement Objectives

Community engagement on the draft version of the Plan took place between April 15 and May 1, 2019. This engagement had two key objectives: 1) to get an understanding of the community's thoughts and concerns about climate change and to see how they align with the goals and actions set out in the Plan; and 2) to provide education and awareness about the need for climate change adaptation locally.

Engagement Overview

Engagement took place through a series of four in-person engagement booths – using interactive activities, display boards, and comment cards – and online through the Engage Waterloo platform. These engagement opportunities were advertised through the City's social media and on the project webpage.

Engagement Numbers

As outlined below, nearly 150 individuals were "reached" during engagement. This means that they visited an in-person event or the online engagement platform. Forty-four individuals were directly "engaged", meaning they participated in one or more engagement activities.

Date	Location	Reached (information shared)	Engaged (provided input)
April 15 1:00 – 3:00 pm	Waterloo City Centre	9	6
April 15 4:00 – 7:00 pm	Waterloo Memorial Recreation Complex	8	4
April 17 4:00 – 7:00 pm	John M. Harper Library / Stork Family YMCA	18	10
April 18 10:00 am – 1:00 pm	Waterloo Memorial Recreation Complex	21	13
April 19	Emailed Comments	2	2
April 15 to May 1	Engage Waterloo – online platform	88	9
Total		**146**	**44**

Engagement Results[1]

Climate Impacts

In order to generate conversation at the in-person events, participants were presented with a series of "climate impact cards". These cards featured images of various climate impacts, such as downed power lines and individuals experiencing heat stress. Participants were asked: **"Are there things you've noticed happening in the city that could be related to climate change?"** and were then directed to the cards. Staff recorded which impacts they identified. Overall, sixteen individuals participated in this activity, and their observations are presented below.

Observed Impact	Count
Ice Storm or Freezing Rain	9
Pot Holes or Other Infrastructure Damage	9
Basement Flooding	6
Road Washout	4
Other Impacts	3
Erosion	2
Fallen Trees or Branches	2
Invasive Species	1
Personal Property Damage	1
Power Outage or Downed Power Lines	1
Hot Temperatures	1
Heat Stress for Outdoor Workers	0
Heat Stress for Vulnerable Populations	0

As shown above, ice storms/freezing rain and pot holes/infrastructure damage were the most commonly mentioned climate-related impacts. It should be noted that not all respondents attributed these impacts to a changing climate, however they recognized the relative increase in the number of such events.

The online engagement platform posed a similar, open-ended question about observed climate impacts. However, no responses were received for this question.

[1] Due to the design of this consultation program and the small sample size, quantitative analysis is not recommended.

Concerns

Both online and in-person, participants were asked: **"What are you most worried about when it comes to climate change in Waterloo?"**. One of the most frequently cited concerns was increased flooding. Participants were concerned about the impact of flooding and violent storms on their daily lives, citing both the possibility of service disruption and the costly repairs associated with infrastructure damage. A number of respondents also cited concern for the health of the population. Finally, participants were concerned about the lack of climate action at the individual and government (Provincial) levels. A number of participants were pleased to see that the City was working to address climate change locally.

Adaptation

Next, participants were asked: **"What do you think the City should do to adapt to climate change?"**. Many participants stressed the importance of increasing awareness and education of climate adaptation – and climate change more generally – among members of the public. Participants felt that the City has a role to play in educating residents on their role in climate adaptation (and mitigation). A few participants noted that the City should continue to make investments in stormwater management infrastructure and support stormwater management on private land (i.e. encourage residents to undertake native plantings). A large number of participants provided suggestions that were not directly aligned with climate change adaptation but rather climate change mitigation or broader sustainability goals, such as: increasing renewable energy generation; decreasing single-occupancy vehicle use; waste reduction; and supporting community gardens.

Goals

Next, participants were presented with the eight goals as listed in the Plan (below) and asked: **"Do these goals help to address your concerns about climate change?"**. Participants at the in-person events were given coloured stickers to indicate: Yes (green sticker); Somewhat (yellow sticker); or No (red sticker). Results are presented in the table below. As shown, the majority of participants felt that the goals did address their concerns about climate change. No participants selected "no".

Goal	Yes	Somewhat	No
1. Create conditions to minimize health and safety risks to outdoor workers and community members	11	3	0
2. Generate awareness of changing climate conditions with staff and the public	16	0	0
3. Ensure a coordinated response to and recovery from extreme weather events	15	2	0
4. Consider climate change impacts in the design, construction and maintenance of built infrastructure	17	0	0
5. Foster resiliency within the urban forest and natural landscape	14	1	0
6. Reduce risks associated with heavy rainfall and flooding	19	1	0

Goal	Yes	Somewhat	No
7. Minimize disruption to City services	12	4	0
8. Integrate climate change adaptation into the City's strategies, plans, policies, procedures and operations	16	0	0

Online, participants were presented with the complete list of goals, but asked to reflect on the goals overall. When asked: **"Do these goals help to address your concerns about climate change?"**, one participant indicated "Yes", four participants indicated "Somewhat" and one participant indicated "No".

Participants provided additional comments about the goals, which are summarized in the Other Comments section of this document. Overall, 121 "Yes" votes were received, compared to 15 "Somewhat" and one "No".

Communication

Both online and in-person, participants were asked: "**How do you want us to communicate with you about climate change and extreme weather?"**. Participants were presented with a series of options regarding the type of information and the method of communication. Eleven individuals participated in this activity (six in-person and five online). Results are provided below.

Type of Information	Pop-Ups	Online	Total
Emergency weather alerts	6	4	**10**
Municipal closure information	5	4	**9**
Information about City projects	5	4	**9**
Tips to prepare for extreme weather	5	2	**7**
General education on climate change	5	2	**7**
Other (please specify)	3	N/A	**3**

Communication Method	Pop-Ups	Online	Total
Social media	6	5	**11**
Website	5	3	**8**
Email	3	5	**8**
Text message	5	2	**7**
Other (please specify)	4	N/A	**4**

As shown, participants were most interested in hearing about: emergency weather alerts; municipal closure information; and information about City projects related to climate change. In terms of communication method, participants preferred social media, followed by updates via the City's website and email. Other suggested communication methods included: local radio and TV, as well as newspaper articles.

Other Comments

Finally, participants were invited to provide any other comments. Again, there was a large focus on protecting the health of residents, and there was some additional concern for vulnerable populations. Participants reiterated the importance of encouraging awareness, and stated that all levels of government should be working together to address climate change. Again, participants referenced a number of items that are not within the scope of the adaptation plan, such as mitigation and Regional programs (i.e. rain barrels).

Conclusions

Overall, the feedback collected through the community engagement program served to validate the core components of the Plan.

Appendix E: **Glossary**

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 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.

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 heat wave, 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

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.

Mitigation: The promotion of policy, regulatory, and project-based measures that contribute to the stabilization or reduction of greenhouse gas concentrations in the atmosphere.

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.

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

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