



## City of Guelph Climate Adaptation Plan Final Report

Prepared for:  
City of Guelph

Prepared by:  
Matrix Solutions Inc.

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Guelph, Ontario

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# City of Guelph Climate Adaptation Plan

## Final Report

Prepared for the City of Guelph, July 2023



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## Message from the Chief Administrative Officer

On behalf of Council and all our staff, I'm proud to share the City of Guelph's first Climate Adaptation Plan. This plan marks a significant milestone, as it aligns with our strategic plan's commitment to addressing the impacts of climate change.

Climate change is a global challenge that requires local action. The City is committed to fighting climate change and is already implementing several measures to win the Race To Zero and become a net-zero carbon community by 2050.

Now we're taking a proactive approach to climate adaptation, recognizing that we must prepare for the impacts of climate change to protect our community and ensure our long-term sustainability. The Climate Adaptation Plan is the result of extensive research, consultation, and collaboration with internal teams across the City and community partners. It is a corporate strategy that ensures our community is prepared to withstand and recover from the effects of climate change, including extreme weather events, flooding, and heat warnings, by taking action to adapt our policies, plans, assets, operations and services.

Thank you to all the staff and community partners who contributed to the development of this plan. Your hard work and dedication have resulted in a comprehensive and forward-thinking strategy that will guide the City's efforts to adapt to the impacts of climate change.

I am proud to endorse the City of Guelph's Climate Adaptation Plan, and I look forward to working with all of you to implement its recommendations and ensure a sustainable future for our community.

Sincerely,

A handwritten signature in blue ink, appearing to read 'Scott Stewart', with a long horizontal flourish extending to the right.

Scott Stewart  
Chief Administrative Officer  
City of Guelph

# Executive Summary

## Introduction

The City of Guelph (the City) developed this Climate Adaptation Plan as a comprehensive strategy to outline how the City will implement actions to manage and reduce the risk of climate change impacts on Guelph and its infrastructure.

There are two overarching responses to climate change: mitigation measures and adaptation measures. Mitigation measures refer to actions that reduce the greenhouse gas (GHG) emissions that cause climate change. The City has set ambitious targets to reduce GHG emissions and become a net-zero carbon community by 2050 or earlier (in alignment with the United Nations’ “Race to Zero,” the global campaign to prevent future climate threats) and has a number of initiatives underway and planned to achieve this goal. Adaptation measures, the focus of this Climate Adaptation Plan, refers to actions that manage and reduce the risk of climate change impacts. There are also actions called co-benefits that benefit both mitigation and adaptation measures and those that generate additional benefits for ecosystems, biodiversity, and social well-being. The City’s One Canopy strategy is a co-benefiting action, with a goal of planting at least 3.6 million trees and achieving a 40% tree canopy in Guelph by 2070.

The City is taking a proactive approach to climate adaptation, recognizing that they must prepare for the impacts of climate change to protect the community and ensure long-term sustainability. The Climate Adaptation Plan is the result of extensive research, consultation, and collaboration with internal teams across Guelph and community partners. It is a corporate strategy that ensures the Guelph community is prepared to withstand and recover from the effects of climate change, including extreme weather events, flooding, and heat warnings, by taking action to adapt Guelph’s policies, plans, assets, operations, and services.

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The Climate Adaptation Plan’s vision is as follows:

“Guelph is adaptable and resilient in the face of a changing climate. We are leaders in environment and sustainability.

We protect city assets and sustain what we have for an equitable, strong, healthy, vibrant, and safe community.

We are future ready.”


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The implementation of the Climate Adaptation Plan will help meet Guelph’s immediate needs regarding its vulnerability and risks to the current climate, help position the City to take further action, and provide clearer direction regarding what the City needs to move forward to meet its

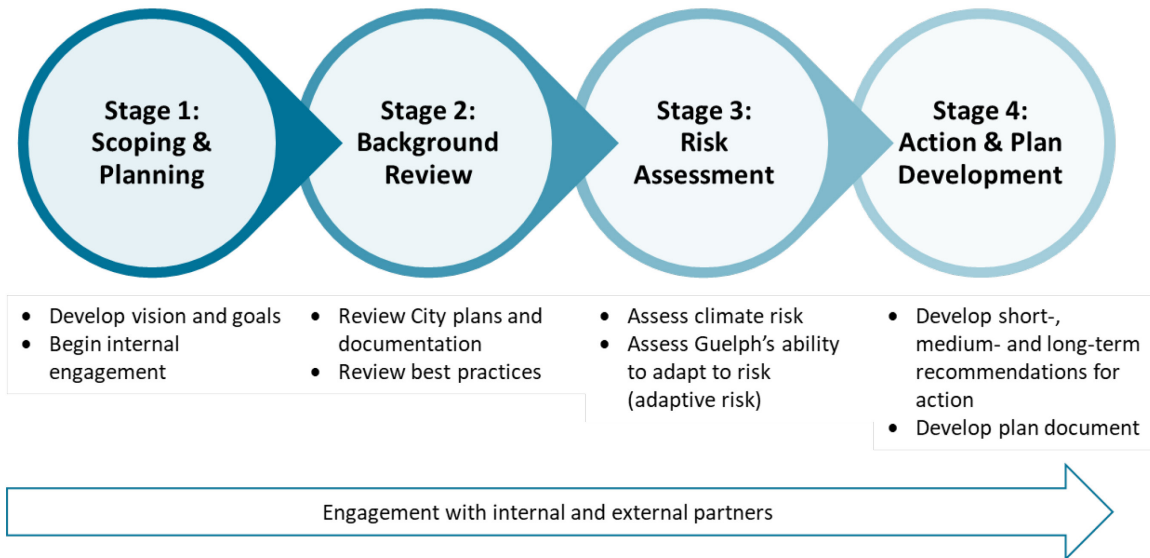
goal to become a net-zero carbon community by 2050. The Climate Adaptation Plan demonstrates the City’s leadership and innovation in environmental stewardship and social responsibility and supports the City’s vision of being a resilient city that adapts to a changing world.

As part of the overall framework for developing the Climate Adaptation Plan, the plan’s vision provides long-term direction with respect to climate adaptation planning, while the Climate Adaptation Plan’s strategic goals (Table ES.1) reflect the City’s commitment to environment and health, infrastructure, economy, safety, and equity.

**Table ES.1 Climate Adaptation Plan Strategic Goals**

Symbol	Strategic Goal
	<p><b>Environment and Health</b> Sustain environmental health, biodiversity, and individual well-being</p>
	<p><b>Infrastructure</b> Prepare for the future with resilient built and natural infrastructure, while protecting existing resources</p>
	<p><b>Economy</b> Strengthen economic prosperity by reducing the risk of economic loss; focus on adaptation actions that are fiscally responsible and achieve measurable long-term benefits</p>
	<p><b>Safety</b> Reduce risk, strengthen our community’s emergency preparedness and disaster response</p>
	<p><b>Equity</b> Ensure climate adaptation solutions cover all protected grounds under the Ontario Human Rights Code</p>

The Climate Adaptation Plan was developed over four stages, as illustrated in Figure ES.1.

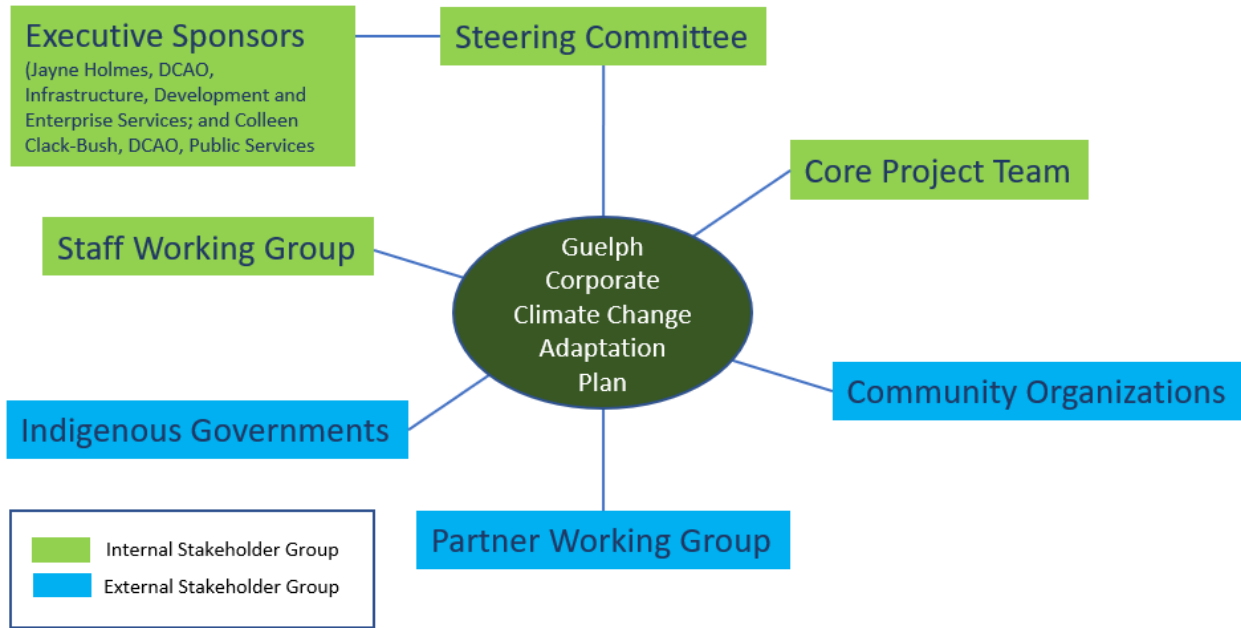


**Figure ES.1 Climate Adaptation Plan Stages**

### Stakeholder Consultation

The Climate Adaptation Plan is a corporate-focused plan and stakeholder engagement efforts were paramount in the plan's development and to facilitate ownership of the outcomes of the plan within the organization. Engagement and communications with internal and external stakeholders were a focus throughout all four project stages. Internal stakeholders include those within the Corporation of the City of Guelph and affiliated Services including Guelph Police Services and Guelph Library Services. Three internal project groups contributed to the success of the project, including: the Core Project Team, the Staff Working Group, and the Steering Committee (Figure ES.2). The City staff's knowledge of their own infrastructure, programming, operations and services was a key factor in developing the Climate Adaptation Plan and consultation with staff was conducted throughout the project to leverage their roles and knowledge risk assessment, adaptation action and plan development.

The Project Team also consulted external partner organizations, collectively denoted as the Partner Working Group, that provide adaptation-related services and programming in Guelph. Other external influencers included Indigenous governments, community organizations, and the general public. Guelph City Council was informed of the project progress and will be asked to provide approval of the final Climate Adaptation Plan.



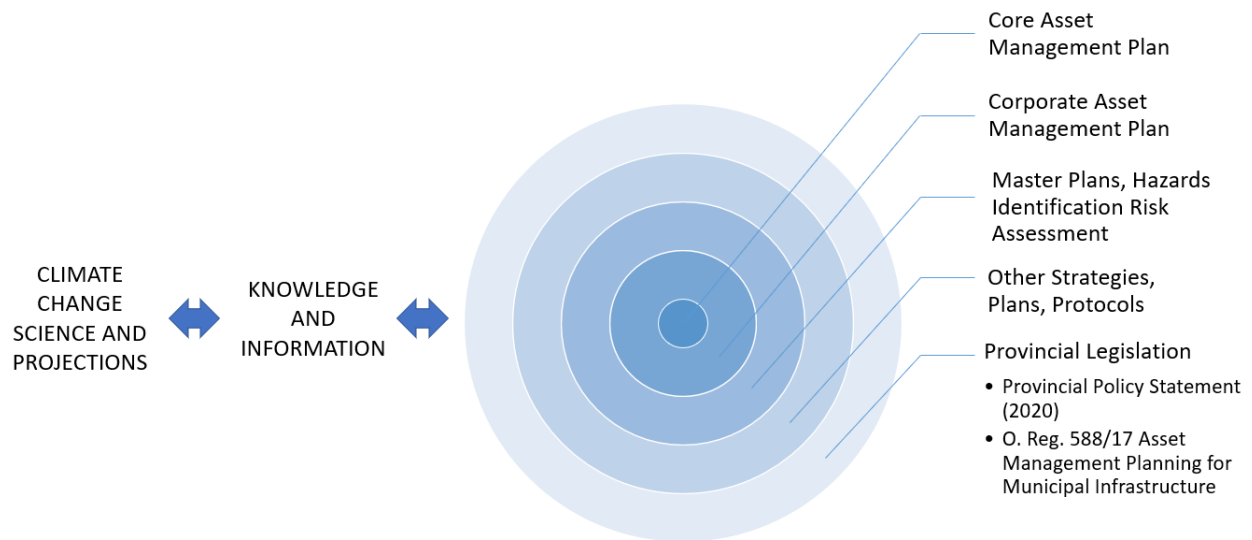
**Figure ES.2 Internal and External Stakeholder Groups**

Throughout the engagement process, the Project Team worked to apply an equity, diversity, and inclusion (EDI) lens and a reconciliation lens collaboratively with the City’s EDI Team and Indigenous-relations advisor. Advancing EDI through the Climate Adaptation Plan was important because climate change disproportionately impacts vulnerable populations, such as seniors, racialized communities, and low-income residents. By acknowledging and addressing inequalities in the development and implementation of adaptation actions, where possible, the Climate Adaptation Plan can help reduce the impact of climate change on vulnerable populations and ensure that the benefits of the adaptation actions are distributed fairly.

### Strategic Context

A strategic context review of internal and external documents was conducted during Stage 2 of the project and provided a high-level assessment of how the Climate Adaptation Plan could build upon the City’s current efforts to address climate change, to draw from Climate Adaptation Plan developed by other municipalities, and to identify where there may be opportunities for funding. This review was intended to help identify the City’s current adaptive methods (based on existing and planned actions) and areas where the City may enhance their adaptive capacity. The City’s Core and Corporate Asset Management Plans were at the centre of the review process, followed by key Master Plans that address both asset management and climate change risks, and then other strategies, plans, and protocols that could be modified and aligned with climate change adaptation goals. The City’s response to climate risks is largely

driven by provincial legislation, notably the Provincial Policy Statement, 2020 and Ontario Regulation 588/17: Asset Management Planning for Municipal Infrastructure (Figure ES.3).



**Figure ES.3 Strategic Context**

In recent years, the federal and provincial governments and various agencies have produced a wide range of climate change strategies, assessments, data, actions, and guidance. In the case of infrastructure, the goal of Canada’s National Adaptation Strategy (Government of Canada 2022a) is that all infrastructure systems in Canada will be climate-resilient and undergo continuous adaptation to adjust for future impacts to deliver reliable, equitable, and sustainable services to all of society. This is a challenge for towns and cities across Ontario, noting that public infrastructure is vulnerable to climate change, the application of adaptive management to climate risks is relatively fragmented, there is little evidence of adaptation being mainstreamed into municipal decision-making, and systems for monitoring and evaluating adaptation action and effectiveness remain inadequate (Douglas and Pearson 2022, Warren and Lulham 2021).

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The document review covered five key areas:

- (1) climate change science,
- (2) national and provincial climate change impact assessments,
- (3) municipal adaptation plans,
- (4) risk assessment frameworks, and
- (5) City department/division services and programs.

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There are a growing number of municipalities across Canada that have developed, or are in the process of developing, Climate Adaptation Plans or climate strategies. Many of the municipalities that have developed Climate Adaptation Plans are located in southern Ontario, including communities across the Greater Toronto and Hamilton Area. The Climate Adaptation Plans developed by these municipalities are the outcome of climate impact risk assessments that follow the International Organization for Standardization (ISO) 31000: Risk Management approach or other variations such as the International Council for Local Environmental Initiatives (ICLEI) Building Adaptive & Resilient Communities (BARC) methodology. However, with the primary focus still largely placed on the assessment of vulnerability and risk, progress on municipal adaptation planning and implementation remains limited in Ontario. In contrast, with the development and implementation of the Climate Adaptation Plan, along with other plans, practices, and protocols where climate change is considered, the City is well-positioned to progress toward achieving their goal of becoming climate resilient.

The “City of Guelph Strategic Plan 2019-2023” (City of Guelph 2019), for example, builds upon the vision of “A United Vision: Guelph's Community Plan” (City of Guelph n.d.) to strategize actions over the next few years. One of the strategic pillars is called “Sustaining our Future,” which references the Climate Adaptation Plan and includes goals to improve sustainability within Guelph with considerations for associated measures of success, initiatives, suggested implementation priorities, dependencies (i.e., other plans), and funding resources. The City’s forthcoming Strategic Plan (2024-2027) builds on this commitment. Similarly, “Current State and Trends Report” (City of Guelph 2022a) mentioned the Climate Adaptation Plan and its importance in asset management planning to make the City “future proof.” Proactive infrastructure investment will be a key component to providing a ready and resilient Guelph.

The City’s website lists 12 Master Plans and 38 additional plans, strategies, and design manuals. Many of these plans consider climate change impacts directly and are highly complementary to the Climate Adaptation Plan, particularly those that address natural and water utility infrastructure assets. Key plans with a climate change and asset management focus include:

- natural infrastructure:
  - ✦ City of Guelph Natural Assets Inventory, Condition, Risk and Service Attribution, 2022
  - ✦ City of Guelph Natural Heritage Action Plan, 2018
  - ✦ City of Guelph Urban Forest Management Plan, 2013-2032, 2012

- water utility infrastructure:
  - ✦ City of Guelph Tier Three Water Quantity Risk Assessment, 2017
  - ✦ City of Guelph Water Efficiency Strategy, 2016
  - ✦ City of Guelph Water Supply Master Plan, 2022
  - ✦ City of Guelph Water and Wastewater Servicing Master Plan, 2008
  - ✦ City of Guelph Wastewater Treatment and Biosolids Master Plan, 2009
  - ✦ City of Guelph Stormwater Management Master Plan, 2011

In addition, the “City of Guelph Emergency Response Plan, 2015” and the “City of Guelph Emergency Management Hazard Identification and Risk Assessment, 2018” have also considered extreme weather and climate-related hazards, although not specifically in reference to future climate change projections.

### Asset Management at the City of Guelph

Asset management planning is the process of managing an organization's physical assets, such as buildings, equipment, infrastructure, and other tangible assets, to ensure they are maintained, operated, and utilized in a cost-effective manner. The objective of asset management planning is to optimize the performance and value of assets while minimizing costs and risks. Not only is the evolving asset management approach becoming standard practice for managing infrastructure assets, but it is also a logical approach from which to establish a climate adaptation strategy and to incorporate climate adaptation actions into a municipality’s regular operating practice.

Municipalities in Ontario are required by the province to develop Asset Management Plans. On January 1, 2018, Ontario Regulation 588/17: Asset Management Planning for Municipal Infrastructure came into effect. This regulation requires that municipalities recommend actions to address the vulnerabilities to municipalities’ infrastructure assets that may be caused by climate change.

The City’s 2020 Corporate Asset Management Plan and the 2021 Core Asset Management Plan provide estimates of the current replacement value (CRV) for infrastructure-related assets.

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The asset management planning framework is the most appropriate method to address the costs of climate change for infrastructure because it provides for the ability to proactively plan for the long-term management of assets in a changing climate.

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The Corporate Asset Management Plan provides a framework for the long-term planning of capital, operations, and maintenance expenditures for each of the following asset management categories:

- core assets
  - ✦ stormwater
  - ✦ wastewater
  - ✦ transportation
  - ✦ water
  
- other corporate assets:
  - ✦ parking
  - ✦ solid waste
  - ✦ administrative facilities
  - ✦ corporate vehicles and equipment
  - ✦ transit
  - ✦ culture and recreation
  - ✦ parks (natural heritage)
  - ✦ emergency services
  - ✦ information technology

The Core Asset Management Plan is a detailed assessment of the City’s core asset types, which comprise more than 80% of the total infrastructure asset base owned and managed by the City, such as roads and related assets such as sidewalks, street lighting, and traffic controls; bridges; water services; wastewater services; and stormwater management.

The City has an infrastructure asset base with a 2020 calculated replacement value of approximately \$4.2 billion, approximately \$1.8 billion of which will need replacing within the next 10 to 20 years (32% of assets have below 40% remaining life). The City also has an investment backlog of infrastructure assets that have exceeded their service life, valued at approximately \$292 million for the City asset portfolio. Within the next 1 to 5 years there is almost \$1 billion of assets that are in “very poor” or “past due” condition that may require complete replacement or significant renewal efforts to ensure continued long-term performance. The Core Asset Management Plan provides a detailed financial analysis of the 25-year and 10-year forecast requirements for the City’s core assets. The plan identifies that over the 25-year period, there is an expected \$1.9 billion funding gap or an average of

\$77.5 million per year. Over the 10-year period, the predicted funding gap totals \$1.05 billion or \$105 million per year.

Methods for integrating climate change risk assessments into asset management are rapidly advancing. The Federation of Canadian Municipalities, under the Municipalities for Climate Innovation Program, commissioned the “Guide for Integrating Climate Change Considerations into Municipal Asset Management” (FCM 2019), which provides a roadmap that municipalities can use to understand climate change and its implications for municipal services and infrastructure. The Financial Accountability Office of Ontario’s (FAO’s) recent series of reports represent best practices in this field and provide useful insights and guidance regarding the treatment of climate hazards and their impacts on infrastructure asset performance.

### **City of Guelph’s Future Climate**

The primary source used for climate change projections for Guelph was the Canadian Centre for Climate Services and their web portal (<https://www.climatedata.ca>). Another source of future climate data that was used to confirm the direction and relative magnitude of change was a recent climate science-based report titled “The Climate Science Report for the Climate Change and Health Vulnerability Assessment for Waterloo Region, Wellington County, Dufferin County, and the City of Guelph” (ICLEI Canada 2022). The data published in this report was drawn from a provincial climate data portal that is comparable to the national portal in its use of ensemble model projections and consideration of different GHG emission scenarios. The localized climate projections developed for the City of Waterloo was a third (supplementary) source of climate information.

### **Climate Hazards**

A climate hazard refers to the potential occurrence of a climate-related physical event or trend that may cause damage and loss. Table ES.2 lists the climate hazards and key thresholds (where applicable) applied in this risk assessment. Climate parameters alone do not necessarily represent climate-related hazards but are at the root cause of hydrological events, changes in ecological conditions, and biophysical effects that can directly or indirectly cause significant impacts. Consideration of climate variables may also take into account cumulative, cascading, or compounding effects, in which a series or sequence of events and conditions occur over a short or longer period of time that creates the conditions for a severe effect.

**Table ES.2 Climate Hazards, Climate Parameters, and Thresholds**

Climate Hazards	Climate Parameters and Thresholds
Acute Weather Events	Number of days with high wind gusts >40 and 70 km/hour
Drought	Average summer soil water content (mm)
Extreme Cold	Number of days <-15°C
Extreme Heat	Number of days >30°C
Flooding	Return levels for maximum 24-hour and 5-day rainfall
Freeze/Thaw	Number of days experiencing freeze/thaw conditions
Snow	Days >5 cm
Freezing Rain	Days with freezing rain
Warmer Ambient Temperatures	Winter season mean temperatures and/or number of days >31°C and nights >20°C
Winter/Spring Rainfall	Days with rainfall ≥25 mm during January to March (rain on snow or frozen ground)

### Future Climate Conditions in 2050 and 2080

Generally, Guelph's future climate is expected to be warmer, wetter, and wilder compared to current and historical conditions. For the ten climate hazards and 11 critical thresholds, Table ES.3 outlines their historical baseline (1986-2005) and future projections (2050 and 2080) under a high GHG emissions scenario. Table ES.3 also indicates the projected direction and magnitude of change, with a single arrow (↑) representing an increase (or decrease) of 10% to 50% compared to the historical baseline, and double arrows (↑↑) representing an increase (or decrease) 50% to 100% compared to the historical baseline. Hazards that are projected to be within ±10% of their historical baseline are considered to have no appreciable changes in their likelihood of occurrence.

Generally, temperature hazards are expected to change significantly by 2050 and 2080, while changes in the likelihood of precipitation hazards are projected to change 50% to 100% from their historical baseline. For example, the number of days with maximum temperatures greater than 30°C are projected to increase from 9 days per year to 38 days per year by the 2050s and 67 days per year by the 2080s. In contrast, the number of extreme cold days below -15°C, which have occurred on average 22 days per year in the past, are projected to decrease to 6 days/year by the 2050s and become a rare event (occurring about once per year) by the 2080s.

For the City's Climate Adaptation Plan development, these climate projections were then converted into a likelihood score as input into the risk assessment process, where the method to determine scores was based on a best practice approach adopted by the "PIEVC [Public Infrastructure Engineering Vulnerability Committee] High Level Screening Guide"

(O’Driscoll et al. 2022). In this case a middle baseline approach was used, whereby scores were assigned from 1 to 5, with 3 representing the expectation of the status quo (where the historical and current conditions are projected to remain relatively the same for the forecasted timeline), and scores above or below represent increases or decreases that range from ±10% to 50% and ±50% to 100%, respectively.

**Table ES.3 Climate Conditions: Historical Baseline (1986-2005) and Future Projections (2050 and 2080) Under High Emissions Scenarios**

Climate Variables	Hazard Represented	Historical Baseline 1986-2005	Projections 2050s	Projections 2080s	Change from Baseline
Acute Weather Events	Number of days with high wind gusts >40 and 70 km/hour	-	+10-20% by 2100	+20-40% by 2100	↑
Drought	Number of periods with more than 5 consecutive dry days (less than 1 mm per day)	12	12	12	-
Extreme Cold	Number of days <-15°C	22	6	<1	↓↓↓
Extreme Heat	Number of days >30°C	9	38	67	↑↑↑
Flooding	Return levels for max 24-hour rainfall	39	43	46	↑
Flooding	Return levels for max 5-day rainfall	67	73	78	↑
Freeze/Thaw	Number of days experiencing freeze/thaw conditions	70	61	52	↓
Snow	Days >5 cm	11	10	7	↓
Freezing Rain	Days with freezing rain	-	+40%	+45%	↑
Warmer Ambient Temperatures	Winter season mean temperatures and/or number of days >31°C and nights >20°C	<1	9	28	↑↑↑
Winter/Spring Rainfall	Winter season precipitation (mm)	193	217	232	↑

Note: single arrow (↑) representing an increase (or decrease) of 10% to 50% compared to the historical baseline, and double arrows (↑↑) representing an increase (or decrease) 50% to 100% compared to the historical baseline.

## Risk Assessment

The risk/vulnerability assessment process provided an opportunity to apply existing knowledge and evidence about climate-related impacts and risks across the City into a formal climate risk assessment process based on best practices (e.g., ISO 31000, ISO 14091, ICLEI BARC, and the PIEVC Protocol). City staff played an essential role in this stage of the process and worked closely with the Project Team to quantify their perceived level of climate-related risks to their individual department's/division's assets, based on historical experiences, and in relation to projected climate change conditions. The risk assessment process essentially involved three main steps: risk identification, risk analysis, and risk evaluation, which is at the core of the risk management framework. The three steps in the risk assessment process, followed by implementation and monitoring steps are further outlined in Figure ES.4.



**Figure ES.4 Risk Assessment, Implementation, and Monitoring Steps (Source: adapted from ISO 31000)**

### Risk Identification: Climate Hazard/Asset Interaction

The risk identification step involved identifying where climate hazards can potentially impact infrastructure assets and service delivery. A climate hazard/asset interaction is the relationship between a climate hazard and built or natural infrastructure (assets, components, and subcomponents) that can involve individual assets or broader systems and networks and leads to a measurable impact. Of the 306 total potential interactions between a climate hazard and an infrastructure asset, the City staff confirmed that there were 56 cases where no interactions existed, while there were 250 cases where interactions existed, leading to a measurable consequence. Table ES.4 provides a small example of the risk identification exercise, whereby climate hazard/asset interactions were marked with an “x.” The distribution of interactions provided some initial insights regarding the extent that departments/divisions own, operate, and maintain infrastructure assets that are exposed to different climate hazards. In consultation with the Staff Working Group, the flooding hazard caused by different heavy rainfall events were amalgamated into a singular metric (e.g., treating return levels for a 24-hour and 5-day storm event as a single hazard).

**Table ES.4 Example of Climate Hazard/Asset Interactions**

Asset Subclass	Service	Drought	Extreme Cold	Extreme Heat	Freeze/Thaw
Water Treatment Plant	Providing potable water to residents and businesses	x	x	x	
Groundwater Well	Providing potable water to residents and businesses	x			
Hydrants	Fire protection		x		

### Consequences

A consequence is the direct or indirect outcome when an interaction occurs between a climate hazard and infrastructure asset that involves the exceedance of a critical threshold, leading to a measurable shift in asset condition and performance and LOS delivery. Consequences typically involve damage to a built or natural infrastructure asset, component, or subcomponent that leads to a measurable change in the LOS delivery. For example, changes in ambient temperatures could pose a health and safety hazard to people or affect the functionality of an asset. In the case of infrastructure asset condition and performance, heavy rainfall could exceed the capacity of a stormwater culvert, leading to asset failure and/or flooding that then impacts other infrastructure assets, property, and people.



Characterizing consequences generally followed a standard format in which the consequences were described within a range of categories that included economic, environmental, social, safety, and reputational considerations, and were evaluated in terms of their magnitude, extent, or duration of occurrence. These categories of concern were then refined to form five main pillars that were of key importance to the City and became the five consequence categories used in the calculation of the risk rating (Table ES.5):

- physical human health
- mental human health
- asset management (property and infrastructure)
- environment
- community and economy

The Project Team assigned values of consequences for the asset interactions and City staff reviewed these ratings. It was noted that, generally, City staff were reluctant to assign a negligible/no consequence score (e.g., a score of 1) or an extreme value consequence score (e.g., a score of 5).

**Table ES.5 Consequence Criteria**

Area	None	Low	Medium	High	Very High
Physical Human Health	Unlikely to result in injuries, illness, or fatalities.	Minor injuries or illness; few individuals; small portion of the City.	Minor injuries or illness. Many individuals. Small portion of the city.	Severe injuries, illness, or fatalities. Many individuals. Large portion of the city.	Mass severe injuries, illness, and fatalities. Many communities. Throughout the city.
Mental Health	Unlikely to result in mental and emotional distress.	Short-term mental or emotional distress. Few individuals. Small portion of the city.	Short-term mental or emotional distress. Many individuals. Small portion of the city.	Long-term mental or emotional distress. Many individuals. Large portion of the city.	Mass long-term mental or emotional distress. Many communities. Throughout the city.
Asset Management	Unlikely to result in property damage or damage or disrupt function of civic assets.	Minor property damage, infrastructure damage, or disruption. Few properties or civic assets. Small portion of the city.	Minor property damage, infrastructure damage, or disruption. Many properties or civic assets. Small portion of the city.	Severe property damage, infrastructure damage, or disruption. Many properties or civic assets. Large portion of the city.	Widespread severe property damage, infrastructure damage, or disruption. Many properties or civic assets. Throughout the city.
Environment	Unlikely to result in damage or loss of habitat or ecological function; no regulatory consequences.	Short-term damage or loss. Few ecological features. Small portion of the city. Regulatory reporting may be required.	Short-term damage or loss. Few ecological features. Small portion of the city. Reporting of regulatory violation required.	Long-term damage or loss. Many ecological features. Large portion of the city. Reporting of regulatory violation required.	Widespread long-term damage or loss. Many ecological features. Throughout the city. Reporting of regulatory violation required.
Community and Economy	Unlikely to impact access to support services, disrupt income generating activities or result in political or reputational impacts.	Short-term disruption or political/reputational damage. Few support services/individuals/businesses and a small portion of the city affected.	Short-term disruption or political/reputational damage. Many support services/individuals/businesses affected over a small portion of the city. Negative sentiment expressed on many media sources.	Long-term disruption or political/reputational damage. Many support services/individuals/businesses affected over a large portion of the city. Negative sentiment expressed on many media sources.	Widespread long-term disruption or political or reputational damage. Many support services, individuals, or businesses. Negative sentiment expressed on many media sources. Throughout the city.

Source: Adapted from the City of Guelph (2022)

## Risk Rating

The risk rating score represents the magnitude of change in risk from current to future climate conditions. After assigning consequence scores, the next step in the process was to calculate risk rating scores. The risk rating was calculated as consequence (severity) × likelihood (probability) of occurrence ( $R = S \times P$ ) to determine individual risk scores ranging from low to very high (e.g., low: 1-5; moderate: 6-12; high: 15 -16; and very high: 20-25), as outlined in the risk matrix (Figure ES.5). Likelihood scores were calculated based on the historical baseline (1986-2005) for each climate parameter, and projections under a high emissions scenario for 2050 and 2080. Noting that each asset and climate variable could generate five possible risk scores (i.e., one for each of the five consequence categories, which were physical human health, mental human health, asset management, environment, and community and economy), it was necessary to consider prioritization based on either valuing each consequence category equally and calculating an average score; weighing the consequence categories based on specific criteria and calculating a cumulative score across all categories; or selecting the maximum score, regardless of consequence category. Feedback from City staff indicated that extracting the maximum risk amongst the five categories of concern was favourable because it would ultimately represent the most conservative approach.

L I K E L I H O O D	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
		1	2	3	4	5
		CONSEQUENCES				

Risk Rating Level
Very High
High
Moderate
Low

**Figure ES.5 Climate Risk Matrix**

City staff were given two opportunities to reevaluate the risk ratings. A total of 80 (56 high risk and 24 very high risk, not considering any existing adaptive capacity measures in place) assets were reviewed and evaluated more closely drawing from City staff feedback, as well as the

broader literature and neighbouring studies. The top three hazards that warranted the most severe risks were extreme heat, acute weather events (high winds and hail), and flooding. These were generally triggered because of impacts to physical human health, mental human health, and asset management. Since likelihood for some climate hazards were projected to decline relative to the middle baseline, risk scores associated with climate hazards that are projected to become less severe or frequent (e.g., snow events, cold temperatures, and freeze/thaw cycles) were lower. As a result, projections of only six of the nine climate hazards were drivers of climate risk for the 80 assets deemed to be at high or very high risk.

Across 11 City departments/divisions there were a total of 306 interactions identified by the Staff Working Group (Table ES.6), distributed by risk level as follows: none (56), low (44), moderate (126), high (56), and very high (24).

**Table ES.6 Number of Climate Interactions Categorized by Risk Level (by Department/Division)**

Department(s)/Division(s)	Risk Rating Scores					Total
	None	Low	Moderate	High	Very High	
Engineering and Transportation Services	15	3	17	10	-	45
Emergency Services	4	3	13	6	1	27
Transit Services	7	5	15	5	4	36
Information Technology	2	1	4	1	1	9
Parks; Culture and Recreation	-	10	15	7	4	36
Parks; Planning and Building Services	3	4	8	3	9	27
Planning and Building Services; Operations	5	6	12	3	1	27
Solid Waste Services, Environmental Services	3	3	9	1	2	18
Stormwater Services, Engineering and Transportation	-	1	3	5	-	9
Wastewater Services, Environmental Services	2	2	9	4	1	18
Water Services, Environmental Services	15	6	21	11	1	54
<b>Total</b>	<b>56</b>	<b>44</b>	<b>126</b>	<b>56</b>	<b>24</b>	<b>306</b>

## Adaptative Capacity

The goal of the Climate Adaptation Plan is to understand the City's current adaptive capacity and provide feasible recommendations to strengthen it. In this context, adaptive capacity is defined as a system's ability to adjust to climate change and avoid or reduce damages while taking advantage of opportunities. Essentially, adaptive capacity demonstrates how well a system (asset, service, or department/division) can manage a change or disturbance. Staff were asked, "how well do the

City's currently-implemented plans/policies/programs address the assets, operations and services with high climate risks?" The staff were then engaged to put their filtered high-risk assets (as per the climate risk rating) on a scale to gauge the individual adaptive capacity based on their currently implemented plans, policies, and programs. Each at-risk asset was placed under one of the three headings: fully addressed, somewhat addressed, and not addressed by existing adaptive capacity actions implemented at the City.

Many assets had more than one adaptation measure that (partially or fully) addressed more than one asset or more than one climate risk. For example, increasing Guelph's tree canopy and urban forest (as recommended in the Urban Forest Management Plan and Natural Heritage Action Plan) promotes shade and lessens the impact of a warmer ambient temperature, and also promotes stormwater infiltration and uptake which lessens the impact of high intensity rainfall events. (Planting trees is also considered a mitigative action).

A total of 163 adaptation measures/actions were established through the development of the Climate Adaptation Plan. Of these, 89 were existing actions and 74 were recommended actions. Existing actions are measures that contribute to the City's current level of adaptive capacity, and represents actions that the City has already implemented or are planning to implement such as recommendations from approved master plan. In other words, more than 50% of the climate adaptation actions are existing and represents the important work that the City is already doing around responding to climate-related hazards and risks.

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The City of Guelph has existing and/or planned adaptive capacity measures addressing 95% of the high or very-high risk interactions.

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## Implementation

### Action Prioritization

The framework adopted to prioritize the 162 adaptive measures/actions was based on the following criteria, while scoring each as 1 (low), 2 (medium), or 3 (high):

- Measure of benefit: will it eliminate or partially eliminate the risk, in addition to consideration of both ancillary benefits and the co-benefits between mitigation and adaptation measures?
- EDI: does it benefit to many people including vulnerable populations?
- Ease of implementation: are the resources (staff and funding) identified and able to be secured?

### Adaptation Actions

The list of 163 climate adaptation actions (including both existing and recommended) was separated out by the department/division that was tasked to lead each particular action (denoted as the Managing Department/Division; Table ES.7). This was done for ease of integration of the Climate Adaptation Plan since the City's Capital and O&M budgets, Master Plans, and annual business plans are developed on a department-by-department/division-by-division basis. Implementation timeframes for the Climate Adaptation Plan are short-term actions (0 to 4 years); medium-term actions (4 to 7 years); long-term actions (over 7 years); and ongoing actions (ongoing).

**Table ES.7 Number of Recommended Climate Adaptation Actions (by Department/Division)**

Managing Department/Division	Ongoing Actions	Short-term Actions	Medium-term Actions	Long-term Actions
All Departments	1	1	-	-
Asset Management	6	4	2	-
CAO's Office	1	-	-	-
Communications	6	1	-	-
Environmental Services, Compliance and Performance	1	3	-	-
Economic Development	1	-	-	-
Emergency Services	4	3	3	1
Engineering (Contaminated Lands)	2	3	-	-
Engineering (Stormwater)	4	3	1	1

Managing Department/Division	Ongoing Actions	Short-term Actions	Medium-term Actions	Long-term Actions
Engineering (Transportation)	1	4	2	-
Equity, Diversity, and Inclusion	3	2	-	-
Facilities	2	3	3	-
Fleet	1	1	1	-
Guelph Public Library	3	1	1	-
Health and Safety	5	2	-	-
Information Technology	3	3	1	-
Parks	4	2	4	-
Culture and Recreation	3	1	1	-
Planning and Building Services	2	2	2	-
Public Works (Operations)	7	1	2	-
Environmental Services, Solid Waste Services	3	5	2	-
Transit Services	5	1	1	-
Environmental Services, Wastewater Services	5	1	2	-
Environmental Services, Water Services	4	6	3	-

Notes:

CAO - Chief Administrative Officer

Key City-wide adaptive capacity actions that are already being undertaken include communications and partnership building with internal (e.g., EDI) and external local groups, and emergency response measures such as continued involvement with emergency shelter support, providing buses as an emergency shelter when requested by Emergency Services, having Public Works staff on standby during inclement weather, and having backup generators available to supply power in the event of a power outage. Key recommended adaptive actions focus on expanded communication and consultation with various groups, namely, establishing regular meetings with the City’s Community Emergency Management Coordinator, Red Cross, and County of Wellington; conducting emergency drills that include many City departments/divisions (rather than conducting drills for each department/division in isolation); and engaging Indigenous governments in pre-consultation processes for projects. Prioritization of staff retention was highlighted as an important recommended action since staff knowledge is one of the City’s best assets in the event of an emergency situation.

The full list of adaptive capacity actions is found in the main Climate Adaptation Plan. Selected existing and recommended actions are highlighted in Table ES.8.

**Table ES.8 Selected Highlights of Adaptation Actions (Existing and Recommended)**

No. <sup>(1)</sup>	Adaptive Capacity Action	Managing Department/Division
3	Implement Guelphs Official Plan Natural Heritage Policies, which seek to protect and restore natural heritage features and areas for the long term.	Planning and Business Services
5	Continue performance condition assessment and LOS reviews on all assets. Work with project managers to recommend priority lists for upgrades and replacement.	Asset Management
6	Continue to undertake tree planting initiatives.	Parks
8	Continue assessing risk as per the Drinking Water Quality Management System.	Environmental Services (Water Services)
20	Maintain service and maintenance contracts for critical equipment to store or obtain spares within 4 hours.	Information Technology
24	Periodically review, maintain, and update use of recreation facilities as emergency shelter buildings. Review with an equity lens. This includes coordination with the County of Wellington and Emergency Services.	Culture and Recreation
26	Liaise with the fire department on a mock transfer station fire scenario.	Environmental Services (Solid Waste)
29	Pursue venture to create a City-wide urban heat island effect map.	Engineering (Transportation)
42	Include climate change in current planning/formula in asset state assessment (e.g., follow Municipal Finance Officers' Association for guidance)	Asset Management
50	Investigate and provide adequate shelter for users at popular transit stops, consider equity lens.	Transit
70	Establish an Integrated Water Management Strategy for Guelph. The strategy should look at water reuse opportunities from wastewater and stormwater for non-potable uses (industry, vehicle washing, fire suppression, etc.)	Environmental Services (Compliance and Performance)
74	Continue to have Public Works workers on standby for inclement weather based on forecasting.	Public Works
75	Continue conducting pilot project with the University of Guelph to optimize salt application during winter.	Public Works



No. <sup>(1)</sup>	Adaptive Capacity Action	Managing Department/Division
80	Complete a Facility Needs Assessment for all critical infrastructure to determine if a backup source of power available is required and available for onsite. Establish redundancy plan for power for critical buildings (e.g., diesel available if grid goes down).	Facilities and Energy Management
86	Continue inflow and infiltration investigation program. Explore means to add resources during rain events to investigate flows within the system.	Environmental Services (Wastewater)
87	Continue Complete Streets Design Guide project that includes consideration for street trees, stormwater management, and low impact development).	Engineering (Transportation)
88	Continue infrastructure upsizing to accommodate rainfall intensity-duration-frequency curve updates.	Engineering (Stormwater)
96	Develop a storm sewer maintenance program.	Engineering (Stormwater)
102	Liaise with Engineering (stormwater) to prioritize contaminated site clean ups on lands that can be used for stormwater management purposes (e.g., Bull Frog stormwater management project).	Engineering (Contaminated Lands)
107	Establish a business continuity plan in case an emergency building is compromised and provide alternate/redundant work environment in case the emergency buildings cannot be safely occupied.	Emergency Services
135	Continue to send out alerts on Guelph's alert system from the Community Emergency Management Coordinator.	Public Works (Operations)
137	Develop a list of support agencies to contact during an emergency to accelerate assistance to those in need. Create a plan outlining how and when these agencies will be contacted efficiently.	Communications
140	Engage Mississaugas of the Credit First Nations and Six Nations of the Grand River in the City's pre-consultation process.	All departments/divisions
142	Continue to play an active role in supporting new businesses and industries to Guelph that align with the City's sustainability and resiliency goals	Economic Development
145	Establish business continuity plan in case communications are not available.	Communications

No. <sup>(1)</sup>	Adaptive Capacity Action	Managing Department/Division
146	Work with City Departments to apply an equity, diversity, and inclusion lens when planning and prioritizing services or infrastructure upgrades/replacements. Establish a formal means of communication.	Equity, Diversity and Inclusion
147	Continue to follow and adopt the Community Engagement and Communications Plan, and coordinate community consultation with the Sustainability Master Plan.	Communications
148	Leverage appropriate communications tactics during climate-related events	Communications
157	Participate in regular emergency exercises with Wellington County, with whom paramedic services are shared and police services work closely together.	Emergency Services
161	Develop cold stress policy, policy for staff working outside in high winds, flooding, and update as needed heat stress policy. Communicate these to all departments.	Health & Safety
162	City managers to prioritize staff retention recognizing that the knowledge of staff is one of the City's best assets in an emergency situation.	All Departments/Divisions
163	Formalize incident tracking including identifying root cause. Flag those that are weather related.	Health & Safety

Notes:

(1) Action number (out of 163)

CAO - Chief Administrative Officer

**The Costs of Climate Change and Climate Change Adaptation**

Climate change can have significant economic costs on a municipality’s infrastructure and resulting operations and services. Some of the ways that climate change can impact costs faced by the City in the future include:

- damage from acute extreme weather events
- damage from chronic or long-term changes in climate parameters
- increased insurance costs
- higher energy costs
- reduced capacity to meet design criteria
- new community services and infrastructure

Estimating for these costs should be integrated into all of the City’s short-term and long-term programs including Master Plans and the asset management planning process.

In 2019, the FAO initiated the Costing Climate Change Impacts to Public Infrastructure (CIPI) project to analyze the costs that the impacts of climate change could impose on Ontario’s provincial and municipal infrastructure. The methodology developed as part of the CIPI project is very granular and includes the use of climate-cost elasticities to estimate the change in useful service life, operations and maintenance (O&M) costs, or adaptation costs for specific asset components (e.g., building foundation) and climate indicator of interest (e.g., freeze-thaw cycle) as a function of the CRV. The CIPI project applied this methodology to estimate the cumulative cost of climate change for all publicly-owned buildings (Afroz et al. 2021), transportation (Afroz et al. 2022a), or stormwater/wastewater assets (Afroz et al. 2022b). The FAO reports illustrate that the level of uncertainty is considerable for long-term cost projections.

The City has estimated the CRV for most of its assets through the “Corporate Asset Management Plan” (City of Guelph 2020a) and “Core Asset Management Plan” (City of Guelph 2021a). Using the results of the CIPI project, the total cost to maintain the City’s infrastructure under stable climate conditions for the 2022-2100 period will be more than \$14 billion or approximately \$184 million per year.

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**The additional annual cost of adapting the City’s infrastructure to climate change is about \$43 million to \$53 million, or about 25% additional cost.**

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Using the CIPI framework, the City’s total cumulative cost of adapting infrastructure to climate change ranges from \$3.4 billion to \$4.1 billion depending on the adaptation strategy used. On an annual basis, this total additional cost equates to a range of \$43 million to \$53 million which is approximately 25% of the cost of maintaining assets under a stable climate. This additional cost of climate change is incremental to the \$77.5 million per year funding gap already in place for the next 25-year period.

### **Funding Opportunities**

There are a limited number of ways that a municipality can raise revenue and cover the costs of climate adaptation measures for existing infrastructure assets, and for developing new infrastructure that incorporates a higher design standard in response to future climate change risks. Municipalities can allocate funds from its budget for O&M and asset management towards climate adaptation projects, such as setting aside resources for upgrading infrastructure, implementing nature-based solutions, and improving emergency services delivery. For existing infrastructure assets and services, the main financial source to support

adaptation actions by the City is internal, primarily through the asset management program and capital budget. There may be an opportunity to allocate some of the federal and provincial gas tax towards climate adaptation measures.

The recommended adaptation actions have not been adjusted as a result of Bill 23; however, it may require the City to implement projects at a faster pace (e.g., the 2023-2041 horizon may need to be accelerated to 2031). This impact will be addressed through the multiyear budget for 2024-2027 where resource and budgetary requirements from all City Master Plans are incorporated. Ultimately, Bill 23 and the associated pace of growth will require monitoring and future update of the Master Plans, which will occur in the next planned 5-year cycle.

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For existing infrastructure assets and services, the City's main financial source to support adaptation actions is internal, primarily through the asset management program and capital budget.

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The Government of Canada has taken an active role in addressing the need for public infrastructure to become climate resilient by providing funding for new infrastructure projects either directly or in partnership with other levels of government, and through the improvement of design standards that take climate change into account. The primary support by the federal government is through the Investing in Canada Plan, that was launched in 2016 as the pillar to the federal/provincial/territorial “Pan-Canadian Framework on Clean Growth and Climate Change: Canada’s Plan to Address Climate Change and Grow the Economy” (Government of Canada 2016). The plan commits Canada to over \$180 billion over 12 years for infrastructure that benefits Canadians and has three objectives including for new infrastructure to be sustainable and resilient. Investment streams include Public Transit, Green, Social, and Trade and Transportation. Other programs where municipalities across Ontario have received funding include the Disaster Mitigation and Adaptation Fund, and the Sustaining Healthy Communities Through a New Clean Water and Wastewater Fund.

The City has been relatively successful in receiving federal funds for various Infrastructure projects: over \$23 million to date from Infrastructure Canada, Canada Mortgage and Housing Corporation, Employment and Social Development Canada, and Regional Development Agencies. While opportunities will continue to exist to access federal funding towards new infrastructure, this option is neither expansive enough, nor sustainable to address all of the immediate and/or foreseeable needs for the City’s infrastructure and adaptation deficit. For example, the \$23 million the City has received from the federal government for various

infrastructure projects represents about 0.5% of the CRV of the City of Guelph’s infrastructure assets, or 33% of the estimated funding gap expected from the additional annual costs of managing assets under climate change over the next 25 years.

### **Department/Division Integration through Master Planning and Policy Documentation**

The City’s Master Plans can be a critical process for incorporating climate change into infrastructure management and planning framework. Integration at the master planning process allows for prioritization to maintain economic stability while furthering the City’s resilience. Further, the City can identify opportunities where these actions can also support their commitments to reduce greenhouse gas emissions. We recommend that future master planning documents specifically identify climate risks and the cost of climate change and the adaptation alternatives recommended to mitigate those risks. These would then be referenced in the next update to the Climate Adaptation Plan. Further, master plan recommendations should be sufficient to carry forward the information needed to embed the cost of climate change into the Asset Management Plan.

### **Lead Integration and Implementation by Asset Management**

We recommend that the City’s Asset Management Group manage the Climate Adaptation Plan update on a 5-year frequency, and take on the management and leadership of overseeing the implementation and integration of the Climate Adaptation Plan as the program leader. The program leader from the Asset Management Group would be responsible for reporting to the City on the annual progress of implementation of the Climate Adaptation Plan.

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**The City’s Asset Management Group will manage implementation of the Climate Adaptation Plan.**

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The Asset Management Group is the most appropriate department/division to lead the Climate Adaptation Plan implementation because the plan approach was an asset-based approach, with the climate risks initially evaluated at the asset level before expanding to develop adaptive capacity actions that consider both City assets and services.

The City has demonstrated considerable progress with the development of its asset management planning process, and within the next revision cycle should have the ability to incorporate the approach laid out by FAO’s CIPI project (FAO 2019) into its Corporate Asset Management Plan. Achieving this goal, however, will require the City to embed climate change planning into related master planning and departmental/divisional management activities to

ensure that these business functions can provide the information needed to account for the costs of climate change into future plans.

### **Key Performance Indicators**

Overall, developing climate adaptation key performance indicators (KPIs) is a critical step in helping municipalities evaluate their progress towards resiliency, the effectiveness of their actions, and to help them better prepare for new or unexpected impacts of climate change. Most importantly, by identifying and tracking key metrics, organizations can better understand their vulnerabilities and take action to reduce the risks associated with climate change. As part of the ongoing resilience plan monitoring, KPIs are recommended for each action that can be used to track the effects of mitigating strategies on reducing the risk exposure. Indicators must meet SMART criteria.

Based on best practice, there are two types of indicators that are recommended to be tracked: Process Indicators and Outcome Indicators. Process indicators measure the degree to which the City is implementing the actions outlined in the Climate Adaptation Plan, but do not measure if the actions have succeeded in reducing vulnerabilities to climate change. Outcome Indicators are outcome-based and by definition assume a greater importance but are more challenging to measure. This type of indicator may be something which the City can actively control or cannot control but still chooses to monitor, for example, the number of basement flooding complaints per year. A significant, prolonged change in outcome indicators would indicate that the potential risk exposure may have changed.

It is expected that the collection of data and reporting on the Climate Adaptation Plan's implementation success will be done on a yearly basis, with an annual update to Council once implementation begins. Annual reporting will allow City staff to identify trends and allow for the re-calibration of actions as needed. Public reporting on implementation may be done through Microsoft® PowerBI or other tool and in alignment with the City of Guelph's corporate webpage.

### **Monitoring, Review, and Update of the Climate Adaptation Plan**

The Climate Adaptation Plan is intended to be used as a living document, developed in consultation with City staff. The intention is that implementation is sustainable, effective, integrated, inclusive, and iterative. We recommend using the number of implemented/completed actions as the overall KPI for the implementation of the Climate Adaptation Plan, as a part of the City's Strategic Plan performance.

Consistent with the City's typical master planning cycle for most departments/divisions, a formal review and update to the Climate Adaptation Plan should be undertaken once every five years, taking into account any advances in climate change science and projections, improved understanding of vulnerability and risks to City assets and services, the City's progress in achieving their KPIs, and the overall effectiveness of integrating climate change into the City's Asset Management Plan, Master Plans, and other practices and protocols.

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The Climate Adaptation Plan will be updated every 5 years in collaboration with each department's/division's budgeting and master planning/policy update cycles.

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There is the opportunity to apply lessons learned and assess whether the context of the risks and vulnerabilities has changed, and whether the actions being implemented are reducing vulnerability and increasing resiliency and adaptive capacity.

As noted previously, it is recommended that the Climate Adaptation Plan update be managed by the City's Asset Management Group. We note that the current adaptive capacity of the City provides a good foundation of existing and planned actions. In responding to an increase in vulnerability and risk to climate hazards in the future, the City's departments/divisions will need to strengthen coordination between departments/divisions (e.g., where assets and services at high risk are the responsibility of multiple departments/divisions), address knowledge gaps through additional research (e.g., cumulative and compounding climate-related impacts), and adopt a more integrative approach to their management of assets and delivery of services (e.g., into key planning initiatives).