CITY OF HAMILTON

VULNERABILITY & RISK ASSESSMENT REPORT

FALL, *2021*

Hamilton

ICLEI Local Governments for Sustainability CANADA

Contents

1. Introduction

From flooding and extreme heat to increased storms, the impacts of climate change are being experienced by municipalities across Ontario. The City of Hamilton has experienced its share including recent ice storms, heat waves, wind storms, and heavy rain have clearly shown the need for local action. To address these impacts and build its resiliency, the City of Hamilton is in the process of developing a Climate Change Impact Adaptation Plan.

This document represents significant progress towards completing that plan. A multi-disciplinary internal core group of city staff has been created which, through sharing knowledge and professional expertise, assisted with the completion of Hamilton's corporate vulnerability and risk analyses. Efforts have also produced an engaged group of external stakeholders who have assessed the impacts of climate change on the community. The purpose of this report is to document the work done to date and to provide information on the methodology and results of the City's corporate and community vulnerability and risk assessments. These assessments have revealed key impacts that must be prioritized and planned for as climate change persists.

1.1 Climate Change Impact Adaptation Plan

The City of Hamilton is pursuing the development of a practical and implementable Climate Change Impact Adaptation Plan (hereby referred as The Plan). The purpose of The Plan is to scope and plan for the effects of a changing climate on the community as well as on City-managed infrastructure, assets, and services in order to reduce the risks climate change poses to Hamilton's physical, economic, social, and ecological systems. A series of workshops and surveys have been conducted to identify climate change impacts and assess vulnerability and risk. This in turn will inform the identification of potential actions that the City can take to address prioritized impacts. The Plan will recommend specific measures to enhance the City's ability to address climate change impacts and assign agreed-upon responsibilities for undertaking related actions.

The Plan builds on a history of other climate change-related work done by the city. This work is followed by the City's joining of FCM's Partners for Climate Protection (PCP) in 1996, which included the development of a Strategic Air Quality & Climate Change Plan, Community Climate Change Action plan among other climate change related deliverables. City Council's recent declaration of a climate emergency and the subsequent formation of a Corporate Climate Change Task Force (2019) has also re-affirmed its commitment to addressing climate change. Since 2019, the City of Hamilton has been highly active in their climate-change related work. Refer to the Table below for a complete list of work to date.

Table 1: Hamilton's Historical Climate Change Work and Milestones

Year	Activity/Milestones
1996	Joins FCM Partners for Climate Protection (PCP)

2004	GRIDS 1 Climate Change Vulnerability Study
2008	Corporate Strategic Air Quality & Climate Change Plan
2009	Corporate and Community GHG Emissions Inventory: GHG Targets
2010	GTA Clean Air Council Recognition for Clean Air and Climate Change
2011	Hamilton Climate Change Charter
2013	New GHG Targets: 20% by 2020, 50% by 2030, 80% by 2050
2015	Council endorses Hamilton's Community Climate Change Action Plan
2016	Achieves Milestone 2 of ICLEI's Building Adaptative and Resilient Communities (BARC)
2018	Formation of the Bay Area Climate Change Office and Bay Area Climate Change Council
March 2019	Declares Climate Change Emergency
December 2019	Corporate Goals and Areas of Focus for Climate Mitigation and Adaptation
February 2021	Corporate Energy and Sustainability Policy
May 2021	Corporate Green Fleet Strategy

1.2 BARC Methodology

The City of Hamilton's Climate Impact Adaptation Plan is guided by ICLEI's Building Adaptive and Resilient Communities (BARC) Framework. The BARC Framework guides municipalities through a comprehensive planning methodology that includes research and climate impact assessment, plan development, action-setting, implementation planning, and monitoring and review strategies. ICLEI's BARC Framework is a proven methodology that has been implemented by municipalities across the country including, but not limited to: Thunder Bay, Windsor, Oakville, Vancouver, Fredericton, Calgary, Edmonton. A model of BARC's Milestone process is shown in Figure 1 below.

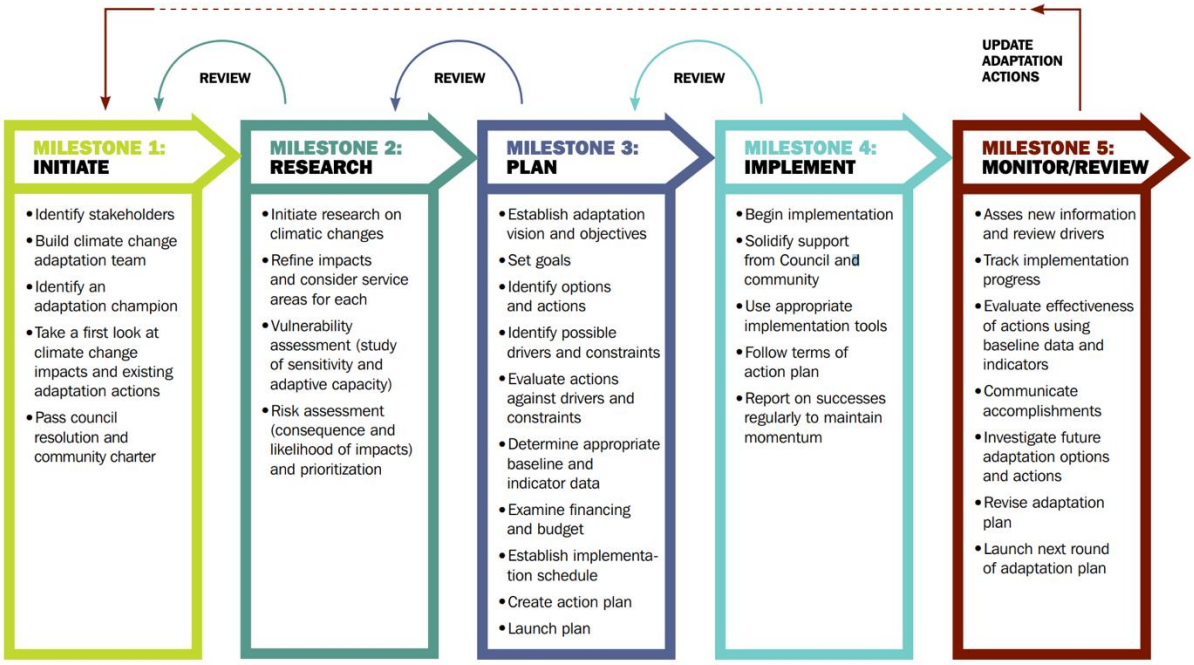


Figure 1:BARC 5-Milestone Framework

1.3 Moving Through the BARC Framework

This report fulfills Milestone 1 and Milestone 2 of the BARC Framework. Following the vulnerability and risk assessments, the City of Hamilton will begin the planning (Milestone 3) process. The City's work towards these milestones was briefly paused in 2018 before being pursued once again in 2020. Summaries below and throughout the document reflect this.

2016-2017

In fulfilling the criteria of Milestone 1, the City intially identified relevant internal stakeholders to the adaptation planning process and formed an internal working group which elicited input from the wider coporation in a concerted effort. External stakeholders were identified in a later process in 2017 through ICLEI Canada's Train-the-Trainer (TtT) program. More than 20 external stakeholders were identified and participated in the project with varied levels of knowledge on climate change. This included organizations representing businesses, utilities, vulnerable populations, transportation, and faith-based organizations.

To fulfill the criteria of Milestone 2, the City, along with ICLEI Canada, created a localized Climate Science Report outlining the climatic projections for Hamilton out to 2100. Next, the city developed a list of 46 corporate-focused impacts statements across multiple categories addressing the implications of climate change and extreme weather on the City of Hamilton. These impact statements served as the foundation for initial vulnerability and risk assessments and are discussed further in Sections 2 and 3. After completion of Milestone 2 corporately, the City endeavored to repeat the process with community stakeholders in 2017 through the Train-the-Trainer (TtT) Project, with a more focused list of 23 project climate impacts. Using both

traditional methods of scoring and a dotmocracy approach, 6 impacts were identified to be of greatest concern to the community. These include:

- Dryer, hotter and longer summers may affect the health and safety of local vulnerable populations.
- More extreme weather events will increase instances of health and safety-related issues due to hazardous outdoor conditions, including accidents.
- Changing climatic norms and increased extreme weather events may increase property damage, including trees and vegetation.
- Changes to distribution of flora and fauna habitat due to changing climatic conditions.
- Changes in the frequency of extreme rainfall events will result in increased instances of flooding on private and public properties.
- More frequent and serious droughts may affect the availability and price of local foods, and the financial viability of local farms.

2020-2021

In 2020 the City of Hamilton reengaged with Milestone 2 of the BARC framework, the first step of which was updating their localized Climate Science Report. The report reaffirmed many of the earlier findings and provides climatic projections out to the 2080's under a variety of emissions scenarios. It will be explored further in the section titled *Climate Science* below. Next, the city looked to reassess initial vulnerability and risk assessment results from both corporate and community participants through a variety of channels. With the completion of reassessment, the city has embarked on the preliminary stages of Milestone 3 including community focused objective and action brainstorming.

1.4 Internal and External Contributors

The internal core group for the Climate Impact Adaptation Plan Project was formed in 2021. Climate action has been prioritized and accelerated after the 2019 declaration of a climate emergency in the City of Hamilton. As a part of this renewed push, Hamilton committed again to undertaking a City-wide vulnerability and risk assessment utilizing ICLEI Canada's BARC framework.

The internal core team consists of the following members:

Department/Division	Member
Healthy and Safe Communities, Healthy Environments	Andrea McDowell (Project Lead)
Corporate Services, Risk Management	Gavin Chamberlain
Planning and Economic Development, Strategic Initiatives	Marty Hazel
Healthy and Safe Communities, Healthy Environments	Trevor Imhoff

Healthy and Safe Communities, Healthy Environments	Matthew Lawson
Public Works, General Managers Office	Arlen Leeming
Healthy and Safe Communities, Emergency Management	Kirsten Marples
Planning and Economic Development, Community Planning	Christine Newbold
Healthy and Safe Communities, Emergency Management	Connie Verhaeghe
Healthy and Safe Communities, Children Services and Neighbourhood Development,	Adam Watson
Public Works, General Managers Office	Andrea Vargas

External Contributors

As briefly mentioned above, external contributors were first approached in 2017 through ICLEI Canada's TtT project. A wide array of community stakeholders aided in identifying climate impacts of concern and the scoring of these impacts through two separate workshops – the first focused on vulnerability assessment while the second was an opportunity to carry through results to the risk assessment stage.

These contributors were as follows:

- Hamilton Regional Indian Centre
- Green Venture
- Royal Botanical Gardens
- Union Gas
- Hamilton Industrial Environmental Association (HIEA)
- Sustainable Hamilton Burlington
- McMaster University
- YWCA
- Hamilton Conservation Authority
- Environment Hamilton
- HCE Energy Inc
- CREW
- Faith and the Common Good
- Hamilton Port Authority
- Social Planning and Research Council of Hamilton
- Hamilton Halton Home Construction Association
- Wesley Urban Ministries
- Limeridge Mall
- Hamilton Health Sciences
- Hamilton Utilities Corporation
- Hamilton Airport

When the City of Hamilton's reengagement with the BARC process occurred in 2020, external stakeholders were approached once again to provide their opinion and insight in light of updated climate data and recent weather events experienced by the City. External stakeholders provided their vulnerability and risk reassessments through one of two channels:

- A web-based survey hosted on the Engage Hamilton website. This acts as a hub for online community engagement on City projects ranging from transit accessibility to voter experiences, city park upgrades, and more.

- Stakeholders were also engaged through a series of workshops in which they discussed the impacts they were most concerned about and provided updated scores. Along with the rescoring, the participants also discussed some preliminary suggestions for actions that would address those impacts, as well as potential barriers that could be faced in employing those actions.

External stakeholders that participated in the online community vulnerability re-assessment survey included:

- Bay Area Climate Change Council
- Royal Botanical Gardens
- Green Venture
- West End Homebuilders Association
- Alectra
- Hamilton Industrial Environmental Association
- Hamilton Health Sciences
- Mohawk College
- Social Planning and Research Council of Hamilton
- Hamilton-Oshawa Port Authority
- Hamilton Poverty Roundtable
- Hamilton Regional Indian Centre
- United Way Halton and Hamilton
- EcoWHAM
- Hamilton Regional Indian Centre
- Community Response to Extreme Weather

External stakeholders that participated in guided workshops focused on the community vulnerability and risk re-assessment included:

- Hamilton Health Sciences
- Environment Hamilton
- Faith and the Common Good
- Hamilton Poverty RoundTable
- YWCA
- ACORN Hamilton
- Welcome Inn
- Immigrant Working Centre
- Senior Advisory Council/Age Friendly
- Social Planning and Research Council of Hamilton

Climate Science

The City of Hamilton is already experiencing the impacts of climate change. Some of these instances include a deadly windstorm in 2018, extreme rainfall and flooding in 2009 and again multiple times in 2017, record high temperatures in the summers of 2016 and 2018 (the former of which led to drought conditions), and ice storms in 2013 and 2018. These recent events have highlighted the need to be prepared for ongoing challenges, especially as Hamilton's climate will continue to change over the next century.

To gain an understanding of the changes to come and to help with adaptation planning and decision-making, the City of Hamilton developed and subsequently updated their Climate Science Report. The most significant changes between the 2016 Climate Science Report and the current one center around freeze-thaw cycles and lake level changes. The effects of freeze-

thaw now appear to be less of a concern as warming will reduce the number of days in which the temperature fluctuates above and below freezing. Even though freeze-thaw days may become less of a concern into the future, planning efforts should still take freeze-thaw events into account. Additionally, lake levels are now projected to be more sporadic than in earlier reports.

The 2021 Climate Science Report examines climate trends and projections on a national, provincial, and local scale. It provides more in-depth information on some of the climate change impacts that are expected to occur in the City of Hamilton out to the 2080s. Projections in this report are focused on temperature, precipitation, wind, freezing rain, and other extreme events. A summary of these projections is outlined below:

- **Temperature:** All temperature indices show significant warming across seasons, with an increase in the frequency of days above 30°C and a decline in days below -15°C.
- **Precipitation:** Precipitation events in general are expected to become more intense. Annual precipitation is expected to increase, and winter, spring, and fall are projected to become significantly wetter.
- **Wind:** Severe wind events are to increase in both frequency and magnitude by the end of the century.
- **Winter Precipitation:** severe freezing rain events are expected to increase by as much as 30% by 2100.

Impact Statements

Climate-related impact statements are concise statements that outline locally relevant projected threats and how those changes are expected to affect the built, natural, social, and economic systems across the city. Based on the Climate Science Report, these statements are the foundation of the Vulnerability and Risk Assessments and are formed by answering the following questions:

- What are the climatic changes?
- What are the outcomes of these changes?
- What are the consequences associated with these outcomes?

In 2016, alongside crafting impact statements, the internal working group along with a number of City departments also outlined the primary and secondary Divisions affected by each of the impacts. A large list of impact statements was initially crafted and then revised, tested, and further revised to more closely and concisely reflect the changes that are expected to affect the infrastructure, assets, and services for which the city is responsible. In the end, 50 impact statements moved forward to the Vulnerability Assessment.

In 2017, external stakeholders brainstormed some initial impact statements during the two-day training workshops. Impacts identified through this process related to extreme weather events, drought, extreme heat, and more. After being refined by Hamilton staff and ICLEI, and in consultation with the Climate Science Report, 23 community focused impacts statements were produced.

Upon reengagement with the BARC framework in 2020, Hamilton's 50 corporate and 23 community-based impact statements were analyzed individually and compared against each other to ensure that redundancies were eliminated and that all impacts which remained were concise and relevant. Ultimately, the community impacts list remained the same, and 54 impacts including some high-priority community impacts were chosen to move forward to the internal reassessment stage.

The combined corporate and community impact statements cover a range of affected areas including infrastructure, natural environment, public health and safety, and more. The statements have been further organized by climate event to help the city better understand the focus and scope of each impact. Climate event categories include:

- Increase in temperature (fall, winter, spring)
- Drier conditions (summer)
- Increasing extreme summer temperatures and heatwaves
- Changes in precipitation (all seasons) and changes in Intensity-Duration-Frequency (IDF)
- More extreme weather
- Increased frequency and intensity of ice storms
- Increased frequency and intensity of windstorms
- Increased intensity and duration of extreme heat
- Local risks from non-local impacts

2. Vulnerability Assessment

2.1 Vulnerability Assessment Methodology (as per BARC method)

Vulnerability is a function of two criteria – the **sensitivity** of the community to a given climate change impact, and its **adaptive capacity** (ability to respond, recover and/or cope). To determine sensitivity, how the functionality of the community would be affected should the impact occur today should be considered. This includes considering how the impact would affect the community's ability to deliver and access services, continue regular functionality, etc. Adaptive capacity refers to the ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.[i] To determine adaptive capacity, we should consider the time and resources required to restore the community to its previous functionality should the impact occur today, as well as consider any plans, policies, and actions already in place to address this issue.

2.2 Vulnerability Assessment Workshops 2016/2017

The City of Hamilton has undertaken two separate vulnerability assessments including a corporate focused process in 2016 followed by a community-based assessment through their 2017 participation in ICLEI Canada's Train the Trainer program.

The corporate focused vulnerability assessment adopted a traditional methodology and was completed during a workshop in April of 2016. The assessment required City staff to assess

identified impacts against the definitions of sensitivity and adaptive capacity outlined above. Participants were asked to consider these definitions in relation to the primary department affected and to provide sensitivity and adaptive capacity rankings for a group of impacts for of which they were assigned. The internal core group and department representatives were asked to consider how an impact would affect their own ability to function should the impact occur today. When assigning a vulnerability ranking, the participants considered both *sensitivity* and *adaptive capacity* for each impact statement as well as provided a rationale for their scoring.

The community focused vulnerability assessment was completed during a workshop in 2017. Five to six participants representing a variety of groups were stationed at each table along with a facilitator. Much like the corporate process, participants were asked to consider impacts in relation to sensitivity and adaptive capacity. Each participant was asked to assess community vulnerability from their own perspective as it represented their stakeholder group. Unlike the corporate process, each group of participants assessed the totality of impacts identified (23). Ultimately, a combined 73 impacts statements were considered through a vulnerability assessment.

3. Risk Assessment

3.1 Risk Assessment Methodology (as per BARC method)

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

3.2 Risk Assessment Workshops

Likelihood

The first part of the Risk Assessment involved determining *likelihood*. *Likelihood* was based on how likely is it that a projected impact will occur and considered both the probability of the climate event occurring, as well as the probability of the impact occurring. This was informed by localized climate projections as well as anecdotal knowledge of current conditions. *Likelihood* was measured on a scale of 1 – 5, whereby 1 indicates a 'Rare' occurrence, and 5 indicates an 'Almost Certain' occurrence.

When determining *likelihood*, it was also important to identify if something would be recurrent impact or a single event. This helped to determine whether to assign a *likelihood* rating based on a probability of occurrence or a frequency of occurrence. A recurrent impact is something that can happen more than once – such as a flood event or infrastructure damage. A single event is an impact that can only happen once and is definitive, such as a permanent loss of species.

The *likelihood* matrix is presented in Figure 3 below.

LIKELIHOOD RATING	RECURRENT IMPACT	SINGLE EVENT
Almost Certain (5)	Could occur several times per 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 years to 10 years	Unlikely but no negligible – probability low but noticeably greater than zero
Rare (1)	Unlikely during the next 10+ years	Negligible – probability very small, closer to zero

Figure 2: Likelihood Matrix

For the 2017 community-based risk assessment, ICLEI recommended that *likelihood* be determined internally by experts and municipal staff prior to the workshop. This was done as many community members may not feel as they have the expertise to assign a likelihood rating, as they are less familiar with the climate science. The 2016 corporate assessment asked the internal core team and selected city staff to work together to discuss and come to consensus on the likelihood ratings.

Consequence

The second part of the risk assessment involved assigning *consequence* scores. In this instance, corporate and community risk assessments differed. Participants in the community workshop were asked to assign a *consequence* rating ranging from Negligible (1) to Catastrophic (5) for each of the *consequence* criteria, which were divided into social, economic, and environmental categories, as shown in Figure 6 below. In addition to the numerical score, participants were asked to give justification for the rating they assigned to provide transparency for future reference. The detailed consequence tables can be found in Appendix A.

Social Factors	Economic Factors	Environmental Factors
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

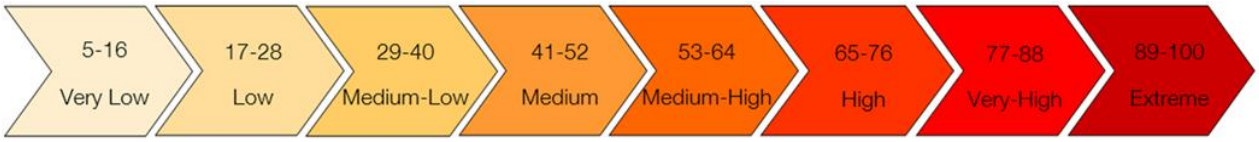
Figure 3: Consequence Categories

The corporate risk assessment entailed the use of an abridged consequence rating matrix which included 5 consequence criteria: public health and safety, local economy and growth, community and lifestyle, environment and sustainability, and public administration (See Appendix A).

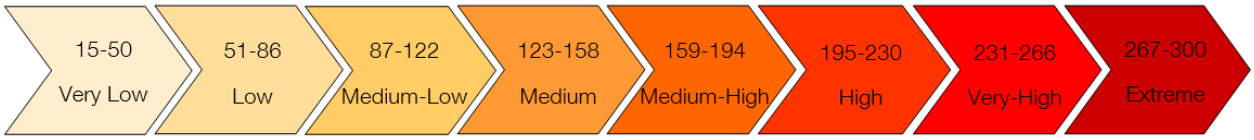
When determining consequence, the corporate group was asked to keep in mind consequences on different community groups or individuals of different socioeconomic status, how consequences may differ should they occur in various seasons, and whether impacts were appropriate to be considered for additional risk assessment (i.e. the PIEVC Protocol). Within the community workshop, participants considered the degree to which the impact will affect the community across the risk categories. When doing so, participants were asked to think about what has happened in the community before, which areas of the community were already experiencing stress, and whether there were mitigating factors already in place to deal with the issue.

Risk Spectrums

The evaluation of *likelihood* and *consequence* resulted in risk scores for each consequence category (e.g. social, economic, and environmental) as well as one overall risk score. The level of risk per consequence category was calculated using the spectrum below:



The total risk score (the sum of each risk category score multiplied by *likelihood* of the impact occurring) was obtained using the spectrum below:



The purpose of providing one overall risk score, as well as three category-specific risk scores, is to try and capture certain impacts that may score high in certain categories, but low in other categories. This is intended to ensure the impacts that may pose a high risk to certain aspects of the corporation will still be captured, despite having a lower overall risk score.

Limitations of the Risk Assessment

It is important to note that the Risk Assessment process is not an exact science. The Risk Assessment is a subjective exercise that evaluates participants' perceptions of the risks that impacts pose to the City's infrastructure, assets, services or to the wider community. Outputs of the exercises are dependent on those that participated in the assessment. While great effort was made to engage key stakeholders in the corporation and in the community, the exercise does not necessarily capture every stakeholder perspective. It is also important to acknowledge that the impact statements themselves are also subjective, however, great effort was made to ensure the lists were both inclusive and exhaustive and captured how climate change could impact the City of Hamilton.

2020/2021 Community and Corporate Vulnerability & Risk Re-Assessment

In the period after the Train the Trainer program (2017), new provincial leadership brought with it a change in funding to projects and initiatives and so focus was shifted from the climate adaptation process for a number of years. In these interim years it became apparent, both through the occurrence of impacts that were scored to be unlikely and through the updating of climate data, that Hamilton's climate impacts needed to be reassessed. Upon the City's reengagement with the BARC process in early 2020, a new Climate Science Report was drafted, and reassessment began.

The reassessment process took 3 forms, outlined below.

1. Community Vulnerability & Risk Reassessment Survey through Engage Hamilton

The first part of the reassessment process provided external stakeholders with a link to an online survey hosted by the City of Hamilton's *Engage Hamilton* platform. As mentioned above, the Engage Hamilton site acts as a hub for online community engagement on a number of topics and city led actions ranging from transit accessibility to voter experiences, city park upgrades, and more. The survey provided participants the opportunity to rescore those impacts they felt stood out as inaccurate. The webpage also included an infographic on the main findings of the updated Climate Science Report as well as a reference tool to aid users in their rescoring.

2. Facilitated online Vulnerability & Risk Reassessment Mini-Workshops

External stakeholders who did not take part in the *Engage Hamilton* survey were invited to re-score a group of impacts most relevant to them and also worked through a process of brainstorming possible consequences, adaptative actions and barriers to adaptive actions associated with each chosen impact. Andrea McDowell of the City of Hamilton's internal core team facilitated a total of 6 such workshops. Participants were also presented with a series of slides which was meant to give an overview of the broader project and to refresh participants on the core concepts of vulnerability and risk assessment.

3. Corporate Vulnerability & Risk Reassessment (completed via e-mail-distributed worksheets)

In order to conduct the corporate reassessment, a number of materials were distributed to relevant departments and internal core members. Materials included a slide deck with essential background information on the project as well as an overview of relevant terms, a comprehensive list of previous corporate impacts and scores, and a spreadsheet containing reassessment instructions and fillable cells in order to complete rescoring and provide justification on any scoring changes.

3.3 Final Vulnerability & Risk Assessment Results

After the completion of the all relevant assessments and reassessments, the final results for vulnerability and risk are discussed below. Detailed results are provided in Appendix B.

Through the Community Vulnerability & Risk Reassessment (online survey and mini-workshops), the following impacts were scored and discussed to be of greatest risk to the community:

- Increased temperatures and changes in precipitation increasing incidences of infectious diseases and vector borne diseases as result of longer transmission periods or changes in geographic distribution of disease vectors.
- Increase in average annual temperatures (especially in the summer) leading to increased food insecurity in the region (i.e. decrease in local crop yields, food cost fluctuations, etc.)
- Rising summer temperatures and extreme heat will increase energy demand for air conditioning, causing a financial burden for low-income households.
- More frequent and intense heatwaves will increase instances of heat-related health and safety issues, particularly for households without access to reliable air-conditioning and the homeless
- Changes in the frequency of extreme rainfall events will result in increased instances of flooding on private and public properties.
- More intense summer precipitation combined with increasing temperatures lowering water supply as well as increasing water demand for drinking, landscaping, and irrigation. (rural)
- Increased intensity and frequency of ice storms leading to increased hazardous roads, pathways and sidewalk conditions.
- Prolonged power outages during winter months due to an increase in ice storms resulting in public safety concerns.

The results from the Corporate Vulnerability Reassessment represent the opinions and perceptions of the community stakeholders as well as corporate staff at the City. Out of 53 impacts, the distribution of the vulnerability assessment results is as follows:

Vulnerability Ranking	Number of Impacts
High	3
Medium-High	21
Medium	21
Medium-Low	5
Low	3

Figure 4:Corporate Vulnerability Assessment Ranking Distribution

Many of the Low-ranking impacts were seen as mostly social or recreational in nature (i.e. climate change and its effects on recreational facilities, activities, and programming) and would not pose a major threat to public health and safety. Other low-ranking impacts, such as those that addressed the natural environment (i.e. rapid snowmelts causing sewer surcharge/runoff floods, decreased functionality of electrical transformers causing power outages, extreme cold causing health & safety concerns, water quality & quantity impacts, etc.) are either impacts that

are already being addressed or are perceived to not pose a significant threat at this time. In addition, a few impacts that related to increased energy and maintenance requirements were perceived to require mostly a financial intervention that could be effectively managed over time. Key impacts to which the City is highly *sensitive* or has low *adaptive capacity* to respond are indicated below.

Impact Statement
44. Increased damage to the natural environment as a result of more intense and frequent windstorms.
27. Reduced capacity of flood protection measures and water storage caused by an increase in rainfall intensity leading to flooding.
18. Decreased survivability of and increase damage to urban trees, vegetation and amenity grass due to water stress caused by drier conditions.

Figure 5: High Vulnerability Impacts

The distribution of the Corporate Risk Re-Assessment Results is displayed below:

Risk Ranking	Number of Impacts
Medium-High	1
Medium	7
Medium-Low	18
Low	12
Very Low	10

Figure 6: Risk Assessment Ranking Distribution

There were no High or Extreme risks identified. This is not unusual in the Risk Assessment process, as an impact will rarely rank high or extreme across all 5 risk categories. The highest overall risk score was 75 (medium-high) which was allocated to the impact: *"27. Reduced capacity of flood protection measures and water storage caused by an increase in rainfall intensity leading to flooding".* This is consistent with the Vulnerability Assessment, which assigned this impact a High vulnerability score.

Through the corporate reassessment results, it was also highlighted that heat-related health & safety concerns due to extreme heat (especially as they relate to outdoor workers and households without access to reliable air-conditioning) was of particular concern to the City. Also of concern are impacts related to erosion of natural systems and consequential washouts of roads/bridges, runoff of sediment, nutrients, pollutants and other materials into rivers and lakes, and hazardous roads, walkways, and sidewalk conditions caused by ice storms.

In terms of impacts that scored Low or Very Low, they covered a diverse set of climate events and impact categories (e.g. social, environmental, or economically focused). The scores assigned to these impacts reflect either a very low likelihood, or probability, of these impacts occurring or are impacts that seem be more readily managed or may not be a significant burden on the City to manage, and that would have likely negligible negative consequences on

the corporation and community as a whole. Impacts of Low risk will be maintained under review, but it is expected that existing controls will be sufficient, and no further actions will be required to address them unless they become more severe.

3.5 Impacts Moving Forward to Planning

The purpose of the Vulnerability and Risk Assessment process was to prioritize impacts that pose a significant threat to the City of Hamilton. It is intended that those impacts which scored the highest in the assessment process will be brought forward into Milestone 3 (planning phase) of the BARC Framework, where the City and community will brainstorm adaptive actions to address them.

When selecting priority impacts to be considered as part of the planning phase, the Project Team included impacts that had an overall risk score of Medium or higher from the Corporate Vulnerability & Risk Reassessment. Additionally, there were impacts that were identified as being of particularly high risk for the community. These were identified through the results of the community re-assessment survey as well as through qualitative discussions with community stakeholders. Some of these impacts were not scored medium or higher through the corporate re-assessment, but due to their importance to the community, these impacts are included in the final risk of prioritized risks moving forward into planning.

The final list of 13 impacts to be brought forward to the planning phase are outlined below:

Impact Statement	Risk Ranking
27. Reduced capacity of flood protection measures and water storage caused by an increase in rainfall intensity leading to flooding.	Medium-High
50. Increased instances of heat-related issues due to extreme heat.	Medium
(4.) Dryer, hotter and longer summers may affect the health and safety of local vulnerable populations.	Medium
(19.) More frequent and intense heatwaves will increase instances of heat-related health and safety issues, particularly for households without access to reliable air-conditioning and the homeless	Medium / High risk to the community
29. Increased intensity of rainfall leading to increasing runoff into rivers and lakes, and washing of sediment, nutrients, pollutants and other materials.	Medium
(23.) Rising summer temperatures and extreme heat will increase energy demand for air conditioning, causing a financial burden for low-income households.	Medium / High risk to the community

Impact Statement	Risk Ranking
40. Increased intensity and frequency of ice storms leading to increased hazardous roads, pathways and sidewalk conditions.	Medium / High risk to the community
30. Changes in precipitation resulting in resulting in erosion of natural systems (i.e. waterbanks, escarpment erosion) leading to washouts of bridges and roadways.	Medium
12. Increased temperatures and changes in precipitation increasing incidences of infectious diseases and vector borne diseases as result of longer transmission periods or changes in geographic distribution of disease vectors.	Medium-Low / High risk to the community
(1.) Changes in the frequency of extreme rainfall events will result in increased instances of flooding on private and public properties.	Medium-Low / High risk to the community
42. Prolonged power outages during winter months due to an increase in ice storms resulting in public safety concerns.	Medium-Low / High risk to the community
16. More intense summer precipitation combined with increasing temperatures lowering water supply as well as increasing water demand for drinking, landscaping, and irrigation. (rural)	Medium-Low / High risk to the community
19. Increase in average annual temperatures (especially in the summer) leading to increased food insecurity in the region (i.e. decrease in local crop yields, food cost fluctuations, etc.)	Very Low / High risk to the community

4. Next Steps

The risk and vulnerability reassessment brings the City of Hamilton to the completion of Milestone 2 of ICLEI's BARC Framework. The City has partially commenced Milestone 3 by engaging in a Community-focused Actions Workshop in which both preliminary objectives and actions were formed through a workshop activity. A similar workshop will be conducted with relevant internal stakeholders.

Following this, an online community & corporate implementation workshop will be held. The workshop is planned for February or March of 2022. This workshop will serve to finalize appropriate adaptation actions and walk through the considerations and plans surrounding their implementation. The implementation plan will outline details such as supporting actions (to be taken to achieve the overarching action/strategy), timelines, leading and supporting actors and partners in implementation, and indicators to measure progress and allow for course correction as needed. Finally, a draft adaptation plan will be circulated for review in the Spring of 2022.

Appendix A – Risk Assessment Materials

CONSEQUENCE TABLES

Social Factors

CONSEQUENCE RATING	SOCIAL FACTORS			
	Public Health & 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

Economic Factors

CONSEQUENCE RATING	ECONOMIC FACTORS			
	Property Damage	Local Economy & 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

Environmental Factors

CONSEQUENCE RATING	ENVIRONMENTAL FACTORS			
	Air	Water	Soil & 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

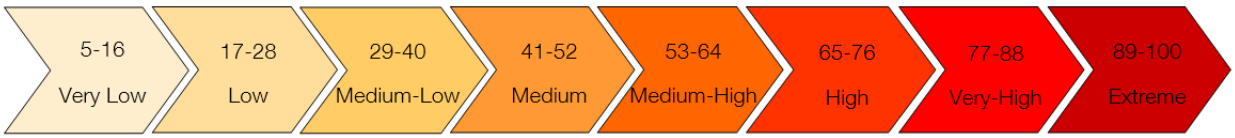
Abridged Consequence Rating Criteria

CONSEQUENCE RATING	CRITERIA				
	Public Health & Safety	Local Economy & Growth	Community & Lifestyle	Environment & Sustainability	Public Administration

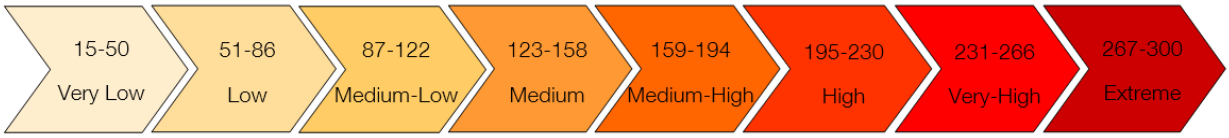
Catastrophic	Large number of fatalities or serious injuries, or permanent illness	City-scale decline leading to widespread business failure, loss of employment and hardship	The city would be seen as very unattractive, moribund and unable to support the community	Major widespread loss of environmental amenities or progressive irrecoverable environmental damage	Public administration would fall into decay and cease to be effective
	5	5	5	5	5
Major	Isolated instances of fatalities or serious injuries, or long-term illness	City-scale stagnation such that businesses are unable to thrive	Widespread and severe decline in services and quality of life within the community	Severe loss of environmental amenities or danger of continuing environmental damage	Pubic administration would struggle to remain effective and would be in danger of failing
	4	4	4	4	4
Moderate	Small number of injuries or cases of illness	Isolated areas of reduction in economic performance relative to current forecasts	Isolated but noticeable examples of decline in services	Isolated but significant instances of environmental damage that might be reversed with intensive efforts	Public administration would be under severe pressure on several fronts
	3	3	3	3	3
Minor	Near misses or minor injuries	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	Minor instances of environmental damage that could be reversed	There would be minor instances of public administration being under more than usual stress
	2	2	2	2	2
Negligible	Appearance of a threat but no actual harm	No real consequence on the local economy and growth	No real pressure on current services	Appearance of a threat but no real environmental damage	No real stress on public administration
	1	1	1	1	1

RISK SPECTRUMS

FOR RANKING OF 12-CONSEQUENCE CATEGORIES



Extreme Risk – immediate controls required
High Risk – high priority control measure required
Moderate – some controls required to reduce risk
Low Risk – controls likely not required
Very Low – do not require further consideration



FOR RANKING OF 5-CONSEQUENCE CATEGORIES

Appendix B – Detailed Corporate Vulnerability and Risk Assessment Results

*impacts highlighted in yellow are the highest ranking impacts of community significance

Impact Statement	Final/New Vulnerability Score (averaged out)	Vulnerability Ranking	Likelihood	Final/New Risk Total (averaged out)	Final/New Risk Score (multiplied by Likelihood)	Final Risk Ranking
27. Reduced capacity of flood protection measures and water storage caused by an increase in rainfall intensity leading to flooding.	5	High	5	15	75	**Medium-High**
(4.) Dryer, hotter and longer summers may affect the health and safety of local vulnerable populations.	2.7	Medium	5	12	60	**Medium**
50. Increased instances of heat-related issues due to extreme heat.	4	Medium-High	5	12	60	**Medium**
29. Increased intensity of rainfall leading to increasing runoff into rivers and lakes, and washing of sediment, nutrients, pollutants and other materials.	3	Medium	5	11.7	58.5	**Medium**
19.) More frequent and intense heatwaves will increase instances of heat-related health and safety issues, particularly for households without access to reliable air-conditioning and the homeless	3	Medium	5	11.7	58.5	**Medium**
30. Changes in precipitation resulting in erosion of natural systems such as waterbanks leading to washout of bridges and roadways.	3.25	Medium	5	11	55	**Medium**
(23.) Rising summer temperatures and extreme heat will increase energy demand for air conditioning, causing a financial burden for low-income households.	4	Medium-High	5	11	55	**Medium**
40. Increased intensity and frequency of ice storms leading to increased hazardous roads, pathways and sidewalk conditions.	4	Medium-High	4	13	52	**Medium**
31. Changes in precipitation leading to more hazardous roads, pathways and sidewalks conditions, especially on frozen ground (e.g. black ice).	4	Medium-High	4	12	48	**Medium-Low**
16. More intense summer precipitation combined with increasing temperatures lowering water supply as well as increasing water demand for drinking, landscaping, and irrigation. (rural)	3	Medium	4	11	44	**Medium-Low**
37. Increased instances of safety-related issues due to hazardous outdoor conditions caused by more intense snow storms.	3.5	Medium-High	4	11	44	**Medium-Low**
14. Rising summer temperature and extreme heat leading to greater demand for air conditioning and electricity generating more NOx emissions that contribute to smog.	4	Medium-High	3	14.7	44	**Medium-Low**
26. Increase rainfall intensity while ground is frozen resulting in sewer system surcharge and flash floods.	4	Medium-High	4	11	44	**Medium-Low**
52. Increased damage to and breakdowns of powerlines and transportation systems as a result of more severe heatwaves.	4.25	Medium-High	3.5	12.5	43.8	**Medium-Low**
36. Increase in snow storm intensity leading to more hazardous roads, pathways and sidewalks conditions.	2.5	Medium	5	8.5	42.5	**Medium-Low**

Impact Statement	Final/New Vulnerability Score (averaged out)	Vulnerability Ranking	Likelihood	Final/New Risk Total (averaged out)	Final/New Risk Score (multiplied by Likelihood)	Final Risk Ranking
12. Increased temperatures and changes in precipitation increasing incidences of infectious diseases and vector borne diseases as result of longer transmission periods or changes in geographic distribution of disease vectors.	2.6	Medium	5	8.2	41	**Medium-Low**
38. Increased damage to built infrastructure and assets as a result of more intense and frequent ice storms.	3.5	Medium-High	3	13.5	40.5	**Medium-Low**
13. Decreased survivability of trees caused by drier conditions contributing to urban heat island and air pollution.	2.8	Medium	4	10	40	**Medium-Low**
49. Rising summer temperatures and extreme heat increasing energy demand for air conditioning - potentially leading to more frequent blackouts or brownouts.	3	Medium	5	8	40	**Medium-Low**
(6.) More frequent and rapid spread of invasive species due to more favourable climatic conditions	4	Medium-High	5	8	40	**Medium-Low**
44. Increased damage to the natural environment as a result of more intense and frequent windstorms.	5	High	4	10	40	**Medium-Low**
28. Changes in precipitation resulting in increased flooding and increased need for evacuation of impacted citizens.	3.5	Medium-High	3	13	39	**Medium-Low**
41. Increased instances of safety-related issues due to hazardous outdoor conditions caused by ice storms.	4	Medium-High	4	9.5	38	**Medium-Low**
(1.) Changes in the frequency of extreme rainfall events will result in increased instances of flooding on private and public properties.	3.3	Medium	3.5	10.75	37.7	**Medium-Low**
6. Increased freeze-thaw cycles during the winter months leading to hazardous roads, pathways and sidewalks conditions.	3.3	Medium	3	12	36	**Medium-Low**
42. Prolonged power outages during winter months due to an increase in ice storms resulting in public safety concerns.	3.75	Medium-High	3.5	10.25	35.9	**Medium-Low**
11. Increase in temperatures leading to earlier and longer summers, creating more demand for cooling.	3.3	Medium	5	7	35	**Low**
43. Increased damage to built infrastructure and assets as a result of more intense and frequent windstorms.	3.5	Medium-High	3	11.5	34.5	**Low**
1. Increase in temperatures leading to less snow-based recreation opportunities.	2.25	Medium-Low	5	6.5	32.5	**Low**
3. Increased freeze-thaw cycles during the winter months leading to increased damage and mortality on the natural environment.	4	Medium-High	4	8	32	**Low**
39. Increased damage to trees and other vegetation on public property as a result of more intense and frequent ice storms.	4	Medium-High	4	8	32	**Low**
4. Increased freeze-thaw cycles during the winter months damaging public infrastructure (e.g. roads, sidewalks, buildings, bridges, sewer system).	4	Medium-High	3	10.3	30.9	**Low**
23. Changes in precipitation resulting in decreased functionality of sewers, combined sewers and storm water ponds causing surcharge.	3	Medium	5	6	30	**Low**
33. Increased snow storms intensity leading to more frequent shut down of City services.	3	Medium	5	6	30	**Low**

Impact Statement	Final/New Vulnerability Score (averaged out)	Vulnerability Ranking	Likelihood	Final/New Risk Total (averaged out)	Final/New Risk Score (multiplied by Likelihood)	Final Risk Ranking
17. Ecological stress on aquatic habitats caused by a decrease in water quality and quantity.	2.6	Medium	4	6.8	27.2	**Low**
32. Increased instances of safety-related issues due to hazardous outdoor conditions caused by increasing rainfall intensity.	3	Medium	3	7.3	21.9	**Low**
35. Increased damage to trees and other vegetation on public property as a result of more intense snow storms.	4	Medium-High	3	7.25	21.8	**Low**
5. Increased freeze-thaw cycles during the winter months causing damage on private property (i.e. building and landscaping).	3	Medium	3	7	21	**Low**
15. More intense summer precipitation combined with increasing temperatures lowering water supply as well as increasing water demand for drinking, landscaping, and irrigation. (urban)	3	Medium	4	5	20	**Very Low**
19. Increase in average annual temperatures (especially in the summer) leading to increased food insecurity in the region (i.e. decrease in local crop yields, food cost fluctuations, etc.)	1.25	Low	3.5	5.3	18.55	**Very Low**
7. Temperature fluctuations leading to more rapid snowmelt events causing sewer system surcharge and runoff floods.	1.7	Low	2	9	18	**Very Low**
51. Increased demand on roadways and transit due to fewer people walking, running or cycling in extreme heat.	2	Medium-Low	4	4	16	**Very Low**
46. Increased depth of frost penetration due to extreme cold temperature causing water service lines and water pipes to freeze.	4	Medium-High	2	7.5	15	**Very Low**
25. Changes in precipitation resulting in decreased functionality of electrical transformers and/or vaults causing power outage.	2	Medium-Low	3	4	12	**Very Low**
34. Increased damage to public and private assets as a result of more intense snow storms.	3	Medium	1	10.4	11.4	**Very Low**
47. Increased depth of frost penetration due to extreme cold temperature leading to greater frost heaving and damages to built infrastructure (e.g. gas pipes, building foundation, roadways, sidewalks).	4	Medium-High	2	5.7	11.4	**Very Low**
45. Increased intensity and frequency of windstorms leading to more hazardous roads, pathways and sidewalks conditions.	3	Medium	3	3	9	**Very Low**
48. Increased instances of cold-related health issues due to duration of extreme cold temperature (e.g. citizens, tourists, outdoor workers, homeless people).	2.2	Medium-Low	2	3.3	6.6	**Very Low**

Appendix C – Full list of impacts assessed by community stakeholders

1. Increased freeze-thaw cycles during the winter months causing damage on private property (eg. buildings and landscaping)
2. Increased freeze-thaw cycles during the winter months causing damage on private property (i.e. building and landscaping).
3. Temperature fluctuations leading to more rapid snowmelt events causing sewer system surcharge and runoff floods
4. Increased temperatures and changes in precipitation increasing incidences of infectious diseases and vector borne diseases as a result of longer transmission periods or changes in geographic distribution of disease vectors
5. Increase in temperature and changes in precipitation allowing more invasive or exotic plant species to thrive
6. Ecological stress on aquatic habitats caused by a decrease in water quality and quantity
7. More frequent and serious droughts may affect the availability and prices of local foods, and the financial viability of local farms
8. Increasing water temperatures caused by an increase in temperatures will decrease water quality in streams, creeks, and lake, with impacts on aquatic habitat and species
9. Changes in the frequency of extreme rainfall events will result in increased instances of flooding on private and public properties.
10. Overall wetter conditions may affect outdoor tourism, recreation and activity
11. Changes in precipitation resulting in decreased functionality of wastewater treatment plant causing surcharge/discharge/overflow
12. Reduced capacity of flood protection measures and water storage caused by an increase in rainfall intensity leading to flooding
13. Changes in precipitation leading to more hazardous roads, pathways and sidewalks conditions, especially on frozen ground (e.g. black ice).
14. Changing climatic norms and increased extreme weather events may increase property damage, including trees and vegetation.
15. Changes to climatic norms including more extreme weather events will increase damage to built infrastructure and assets, causing social disruptions such as disruptions to employment, education and service access etc..
16. Prolonged power outages due to an increase in extreme weather events will result in disruptions to business, schools, and service organizations, creating economic impacts for them, their employees, and the communities they serve
17. More extreme weather events will increase instances of health and safety-related issues due to hazardous outdoor conditions, including accidents.
18. Rising summer temperatures and extreme heat will increase energy demand for air conditioning, causing a financial burden for low-income households.
19. Increased instances of heat-related issues due to extreme heat
20. Rising summer temperatures and extreme heat increasing energy demand for air conditioning, potentially leading to more frequent blackouts or brownouts
21. Increased damage to and breakdowns of power lines and transportation systems as a result of more severe heatwaves
22. Changing climate patterns in other geographic locations (e.g. Drought in California) may increase the price of imports, such as food, creating a burden for vulnerable communities
23. More intense and frequent weather events will increase disruption to transportation systems, consequently affecting the availability and/or price of imported products locally for consumers.

[i] IPCC, 2014: Annex II: Glossary [Mach, K.J., S. Planton and C. von Stechow (eds.)]. In: Climate Change 20 Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPC Geneva, Switzerland, pp. 117-130.