



# Come Hell or High Water: Flooding, Climate Change and Municipal Responses

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AMO Discussion Paper

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## Foreword

The purpose of this discussion paper is to explore how the global issue of climate change and changing weather patterns impact municipal policies and strategies as it relates to flooding, high water, and erosion. The paper was developed as a way to touch base with AMO members in order to identify what their experiences with flooding have been and what solutions they would like to see advocated for. This paper is meant to serve both as a starting point for local discussions or strategies on flooding, and to inform broader discussions on what directions AMO advocacy on flooding and climate change could go.

This paper is by no means an exhaustive analysis of flooding, high waters, and erosion in Ontario, and does not seek to duplicate or replace the extensive research work that is being done by a number of organizations and practitioners on this issue, such as the Intact Centre on Climate Change Adaptation at the University of Waterloo, the Climate Risk Institute, the Institute for Catastrophic Loss Reduction, and our partner conservation authorities (where they exist in Ontario). Instead, the angle of this paper is to add a municipal voice to the ongoing discussion. To that end, the paper includes an appendix which provides resources from these organizations and others on best management practices and studies of interest on the topic of municipal flooding and climate change adaptation strategies.

Flooding is a weather event that impacts municipalities all across Ontario and can occur from a number of different sources. This paper discusses flooding in generally broad terms so communities who face lake floods, river floods from snow melt and ice jams, flash or “micro-burst” floods, and/or urban floods can make use of the insights and strategies covered in the pages below.

However, in identifying municipalities to consult for the development of this paper, outreach efforts focussed on municipalities that have dealt with major flood events in recent years on the Great Lakes, in the Muskoka region, and along the Ottawa River. This was done to limit the scope of the paper and because these municipalities often sit at the intersection of a number of pressures such as high lake levels, strong winds, unstable shorelines, and more frequent and intense storms, that put them at a high risk of experiencing ongoing flooding events. This is not to discount the fact that floods also occur in non-shoreline urban municipalities and municipalities with rivers other than the Ottawa River, but rather to recognize that many municipalities in the Great Lakes, Ottawa River, and Georgian Bay regions have recent experiences with flooding and could thus provide insights and lessons-learned from those events.

Ultimately, all cases of flooding boil down to the fact that nature is throwing more water at municipalities than can be managed. This paper explores what options exist for municipalities to address this reality.

## Executive Summary

This discussion paper explores how the global issue of climate change and changing weather patterns impact local municipal policies and strategies related to storm, meltwater, and coastal flooding, as well as the related issue of shoreline erosion, and considers how municipalities can better adapt to these issues. This paper identifies various ways that municipal governments can anticipate and plan for extreme weather at the local level in order to improve outcomes. These strategies are identified based on findings from a survey circulated to shoreline municipalities and a number of teleconference meetings organized with relevant municipal staff.

Following the introduction, the first section of the paper sets the context, discussing how current and anticipated changes in weather patterns are leading to more frequent and intense weather events and flooding. This section highlights the impacts of human and urban development on the flood landscape in Ontario and also identifies the various outcomes of extreme weather on communities and local governments. These outcomes include the erosion of riverbanks and shorelines, floods in low lying areas, the overwhelming of stormwater infrastructure capacity, the loss of human life, property damage, the destruction of crops and loss of livestock, and negative impacts on economic activity. Flooding also has long-term effects for communities in supplying clean water, wastewater treatment, electricity, transportation, education, healthcare, and tourism.

The next section identifies what municipalities in Ontario require to better prepare for, manage, and recover from flooding, high water levels, and erosion. This section highlights lessons-learned and best practices undertaken by municipal governments across the Great Lakes and Ottawa River shorelines and the Georgian Bay/Muskoka region. Based on insights from municipal staff, this section touches on the political, social and economic costs of flooding, high water, and erosion on municipalities, current tools used (including a discussion of the feasibility of stormwater charges), the effectiveness of hazard avoidance policies and practices (including a discussion of the feasibility of buy-out strategies), what resources and infrastructure municipalities need, and the impact of the COVID-19 pandemic on future flooding and climate change work.

The final section uses the discussions and survey results outlined in the previous section to identify key tools and resources Ontario municipalities require to better prepare for, manage, and adapt to flooding and erosion in the context of a changing climate. It became clear from these discussions, that there are three crucial components or pillars required to ensure municipalities can better protect communities and infrastructure from floods, erosion, and other extreme weather events. They are:

- 1) Clarifying governance and sharing responsibility between levels of government, residents, private property-owners, and other stakeholders to address flooding;
- 2) Fixing the patchwork of floodplain mapping and other flood data available to municipalities across Ontario; and
- 3) Implementing dedicated federal-provincial funding for municipal flood protection and adaptation infrastructure, with a focus on promoting green infrastructure projects and natural asset strategies.

The paper concludes with final considerations, stressing the need for an allocation of resources based on the principle of sharing responsibility. A federal-provincial partnering investment would be a crucial first step. It would demonstrate that all three levels of government are prepared to face



the challenges that climate change has brought to bear on communities across Ontario, and a commitment to make communities stronger and more resilient for the future.

This paper also includes an appendix which provides further resources on best management practices and studies of interest on municipal flooding and climate change adaptation strategies. In creating this paper, AMO hopes to help municipalities have fewer disaster claims, protect people and property, and share best practices in responding to and preventing damage caused by flooding, high water, and erosion.

## 1. Introduction

As Ontario's most observed climate impact, flooding is a reality that communities across the province are facing. Generally, flooding is caused by heavy rain, snowmelt, or a combination of both. High intensity rainfall over a short amount of time often leads to flooding, and this type of flooding is particularly pronounced in denser urban watersheds with more hard surfaces leading to quick runoff. Meanwhile, high water levels and/or high winds cause shoreline flooding in communities that sit on the shores of the Great Lakes, regardless of their density.<sup>1</sup>

Flooding can happen at any time of the year, and small changes in the conditions of the watershed increase flood risk. According to the Government of Ontario, "Flooding is considered the most significant natural hazard in Ontario in terms of death, damage and civil disruption and is the costliest type of natural disaster in Canada in terms of property damage."<sup>2</sup> Managing increasing storm and flood waters is Ontario's most apparent climate change adaptation need in the immediate term. Adapting to more frequent extreme weather events will be key to ensuring long term social and economic stability across this province.

The purpose of this paper is to explore how the global issue of climate change and changing weather patterns impact local policies and programs related to storm and meltwater flooding, and consider ways municipalities can better adapt to these changes to improve outcomes. Because information and infrastructure are a core component of the physical services that municipalities offer, AMO has consistently called for better information, mapping, and adaptation funding.

Though *Ontario's Flooding Strategy*, a recently released report from the Ministry of Natural Resources and Forestry, begins to deliver on some of these needs, more is required. It is important to note that this paper is not focussed on what municipal governments can do to lessen greenhouse gases, also known as climate change mitigation, as that will be addressed in other AMO papers. Instead, this paper focuses on climate change *adaptation*.<sup>3</sup>

The paper is divided into three sections. First, some context will be provided. This section will discuss the current and anticipated changes in weather patterns, and the outcomes that local governments have had to grapple with after serious weather events. The second section will identify what municipal governments see as needed changes, lessons learned, and best practices for responding to flooding and extreme weather events. The final section will draw out what approaches ought to be considered to help municipal governments prepare for flooding, high lake levels, and shoreline erosion. The paper then concludes with final considerations, stressing the need for a coordinated and collective response to flooding in Ontario.

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<sup>1</sup> Ministry of Natural Resources and Forestry, *Protecting People and Property: Ontario's Flooding Strategy* (Toronto: Government of Ontario, 2020). <https://www.ontario.ca/page/protecting-people-property-ontarios-flooding-strategy>.

<sup>2</sup> Ibid., 3.

<sup>3</sup> Adaptation is the process of adjustment to actual or expected climate and its effects.

## 2. The Context: Climate Change, Weather Patterns & Outcomes

### 2.1 Weather Patterns and Climate Change

There is nothing more common in Ontario than talking to each other about the weather. Weather drives much of this province's success in agriculture, business, and our enjoyment of recreational time. The general stability and predictability of the climate has helped us invest in these areas over time, improving the prosperity of our province and communities. However, weather patterns have been changing across the country, and these changes are linked to the rise of global carbon dioxide emissions and other Greenhouse Gases (GHG).<sup>4</sup> Ontarians are already living with these consequences: research indicates that even with a moderate reduction of GHGs, average temperatures in Ontario will increase by at least 2.5 degrees Celsius by 2050.<sup>5</sup> This means that even with an elimination of carbon dioxide from human sources, there is sufficient concentration in the atmosphere to change weather patterns for a significant amount of time.

Changing weather has been the subject of scientific study for several decades. Because weather is impacted by many factors over a large area, local weather stations have been key to our understanding of weather patterns. Although the amount and accuracy of data from weather stations is used to run various weather models, one of the challenges is the lack of models which predict climate change on a regional or local level (models typically look at areas 100 – 250 square km). Improvements to modeling are starting to take shape and will be more readily available in the coming years.

Despite the challenges in climate change modelling and prediction, research shows that warming will have an effect on Ontario's environment. Increasing temperatures will cause less freezing of the Great Lakes, less snowpack, longer growing seasons, heat waves, increased cloud cover, increased precipitation, as well as increased drought.<sup>6</sup> The warmer the air, the greater the amount of evaporation, and ultimately, the amounts of rain or snow. This process also impacts the water table, hydroelectricity generation, and the frequency of wildfires. However, moisture levels vary by season: generally, winter and spring precipitation is projected to increase by as much as 20% in Northern Ontario by 2050, while summer and fall precipitation is projected to decrease by up to 10% in southern Ontario.<sup>7</sup> Over the last 60 years, northern Ontario has warmed by 0.8 degrees Celsius, and the Great Lakes-St. Lawrence Lowlands warmed by 0.6 degrees Celsius.<sup>8</sup>

The effects of this warming will increase cases of low surface and ground water levels throughout the Great Lakes Basin, leading to water shortages or drought.<sup>9</sup> Sections of Durham County, Waterloo and Wellington Counties, and the shoreline of southern Georgian Bay, will likely become

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<sup>4</sup> Elizabeth Bush and Donald S. Lemmen, *Canada's Changing Climate Report*, (Ottawa: Government of Ontario, 2019). [www.ChangingClimate.ca/CCCR2019](http://www.ChangingClimate.ca/CCCR2019).

<sup>5</sup> Expert Panel on Climate Change Adaptation, *Adapting to Climate Change in Ontario: Report of the Expert Panel on Climate Change Adaptation* (Toronto: Province of Ontario, 2009), 15. <http://www.ene.gov.on.ca/publications/7300e.pdf>.

<sup>6</sup> Donald Wuebbles et al., "An Assessment of the Impacts of Climate Change on the Great Lakes," *Environmental Law & Policy Center*, accessed July 30, 2020, <http://elpc.org/wp-content/uploads/2019/03/Great-Lakes-Climate-Change-Report.pdf>.

<sup>7</sup> Bush and Lemmen, 15.

<sup>8</sup> Jennifer Penney et al. *Protecting your Community from Climate Change: a Training Program for Ontario Municipalities* (Toronto: Clean Air Partnership, 2011).

[http://www.climateontario.ca/doc/ORAC\\_Products/CleanAirPartnership/CAP\\_Municipal\\_Adaptation\\_Training\\_Program.pdf](http://www.climateontario.ca/doc/ORAC_Products/CleanAirPartnership/CAP_Municipal_Adaptation_Training_Program.pdf).

<sup>9</sup> Ibid.

more vulnerable to shortages.<sup>10</sup> On the other end, climate projections also show that Ontario will see an increase in the frequency and severity of heavy precipitation and related flooding.<sup>11</sup>

While there are models which show the average increases in temperature and precipitation over large regions, there is no model to accurately predict the locations, frequency or severity of storms. However, if high GHG emissions continue, the amount of 24-hour extreme precipitation that occurs once in 20 years on average is projected to increase by 25% by the end of this century.<sup>12</sup>

With 98% of the population of Ontario living in the Great Lakes Basin and its role in supplying fresh drinking water for the most populous part of the province, the health and patterns of these lakes is a major concern to Ontarians.<sup>13</sup> The effects of changing weather patterns on the Great Lakes is extremely variable due to its vastness.

While evidence points to the fact that climate change is leading to increased precipitation, because climate change also increases air and lake temperatures across the basin, it is also leading to higher rates of evaporation. This has created a situation where precipitation and evaporation “act as competing forces on water levels.”<sup>14</sup>

Evaporation has increased over the last 70 years in Lake Superior and Lake Erie but has changed relatively little in the other lakes. Meanwhile, precipitation has increased in Lake Ontario but decreased in Lake Superior, and there is no evident precipitation trend for the other lakes.<sup>15</sup> Studies agree that there will continue to be large year-to-year and multi-year variability in lake levels.<sup>16</sup> These changes have large impacts on shoreline erosion, flooding, navigation, recreation, local economies, ecosystems, and public health.

## 2.2 Human and Urban Development

During the settlement of Ontario, survival depended on building where water was available. Navigable rivers and shorelines became preferred areas as both sources of drinking water and transportation routes. Mills needed running water and large ships needed safe harbours. Because of these realities, the vast majority of building and infrastructure investment took place in areas vulnerable to flooding, or on banks at risk of erosion. These buildings went on to form old downtowns and historic areas, and continue to be important for industry and economic needs today.

Historically, engineering techniques such as break walls have helped to overcome some of these hazards. Flood and hazard areas were identified, and policies were put in place to discourage building in flood prone areas. However, the desire not to waste prime lands in urban areas and the attractiveness of shorelines and riverbanks in rural areas meant that development continued in these locations. For example, there is extensive development with high value infrastructure within the main Muskoka Lakes, spread over approximately 14,000 lake lots, including 5,300-5,500

<sup>10</sup> Ibid, 64.

<sup>11</sup> Ibid, 68.

<sup>12</sup> Bush and Lemmen, 169.

<sup>13</sup> AMO, 8.

<sup>14</sup> Douglas McNeil, *Independent review of the 2019 flood events in Ontario: A report to the Hon. John Yakabuski, Minister of Natural Resources and Forestry* (Winnipeg: McNeil Consulting Inc), 32. <https://files.ontario.ca/mnrf-english-ontario-special-advisor-on-flooding-report-2019-11-25.pdf>.

<sup>15</sup> Bush and Lemmen, 297.

<sup>16</sup> Bush & Lemmen, 299.

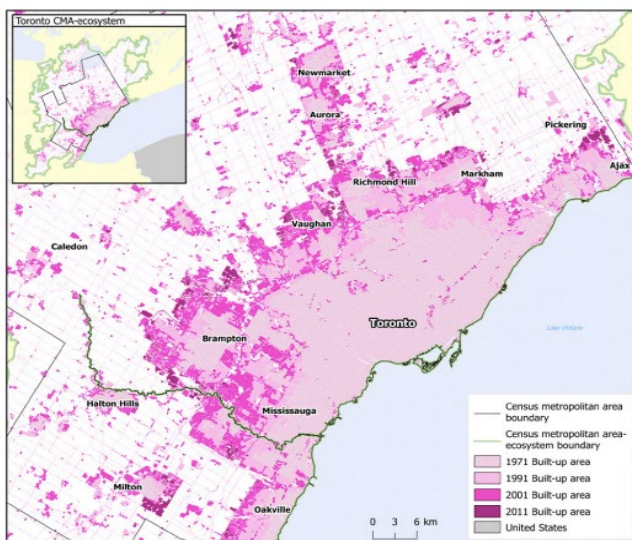


boathouses, over 6,500 docks, and approximately 41 marinas and 131 resorts.<sup>17</sup> The private residences in this area often started as small summer homes and grew in value as additions were made and the location of these homes became more desirable.

At the same time, the period from 1971 to the present has been a time of intense urbanization across Canada. In urban areas, permeable areas were replaced by hard surfaces such as roofs, roads, and parking lots. This required an increased use of storm sewers to quickly flush water into receiving water bodies. It should be noted that all towns have a certain degree of impervious surfaces. Figure 2 shows the increasing urban eco-system in the GTA, where the pink areas represent urban development between 1971 and 2011.

Figure 2: Growth of Urban Eco-system around Toronto.<sup>18</sup>

Map 3.29  
Built-up area, Toronto census metropolitan area (CMA) and census metropolitan area-ecosystem (CMA-E), 1971, 1991, 2001 and 2011



**Note:** Sources for 1971 built-up area do not contain the same level of detail as the more recent years.  
**Sources:** Statistics Canada, Environment, Energy and Transportation Statistics Division, 2016, special tabulation of data from Natural Resources Canada (NRCan), Canada Centre for Remote Sensing (CCRS), 1999, *Canada Land Inventory: CLU Land Use (circa 1966)*, [http://ftp2.cits.mcan.gc.ca/pub/geot/ci\\_250k/landuse/](http://ftp2.cits.mcan.gc.ca/pub/geot/ci_250k/landuse/) (accessed September 15, 2015); NRCan, CCRS, 1999, *Canada Land Use Monitoring Program (CLUMP): Land Use (1971)*, [http://ftp2.cits.mcan.gc.ca/pub/geot/clump/clump\\_1971/](http://ftp2.cits.mcan.gc.ca/pub/geot/clump/clump_1971/) (accessed September 15, 2015); Agriculture and Agri-Food Canada, 2015, *Land Use 1990, 2000 and 2010*, <http://open.canada.ca/data/en/dataset/1b6c7c-402c-402c-8126-aac1a3a8b0ec> (accessed September 16, 2015); NRCan, Canada Centre for Mapping and Earth Observation, 2014, *CarriVec+*, <http://ftp2.cits.mcan.gc.ca/pub/carvec+/shp/> (accessed August 10, 2015); United States Census Bureau, 2014, *Digital cartographic file in shapefile format – States, file: cb\_2014\_us\_state\_500k\_zip*, [http://www.census.gov/geo/maps-data/data/cbf/cbf\\_state.html](http://www.census.gov/geo/maps-data/data/cbf/cbf_state.html) (accessed October 29, 2015).

Likewise, where agricultural land was well-suited to produce crops, maximizing crop yields has led to tile draining the greater part of farmlands. This also increased the flow of water from the land to a receiving drain. In Ontario, about 11 million hectares of farmland is tile drained, and on average, 100 million feet of tile is installed annually (some of which is replacing damaged tile systems).<sup>19</sup> All of this drainage has had knock-on effects on the water levels and water quality of receiving bodies as nutrients and other substances are conveyed through the drainage systems.

Douglas McNeil's *Independent review of the 2019 flood events in Ontario* (henceforth referred to as “the Flood Advisor’s report”), commissioned by the Government of Ontario, fully explored the developments and infrastructure in various regions of the province that have experienced

<sup>17</sup> McNeil, 46.

<sup>18</sup> Statistics Canada, *Human Activity and the Environment 2015: The changing landscape of Canadian metropolitan areas* (Ottawa: Minister of Industry, 2016), 270.

<sup>19</sup> “Drainage statistics reveal some interesting facts about Ontario,” *Drainage Contractor*, November 13, 2012. <https://www.drainagecontractor.com/drainage-statistics-reveal-some-interesting-facts-about-ontario-628/>.

significant flooding over the past three years. For this paper, it is important to note the role that dams can play in flood prevention as well as how they might cause or worsen floods elsewhere.

One misconception is that all dams in Ontario are flood control structures. Generally, most dams in central Ontario are not meant to operate as flood control structures.<sup>20</sup> In total, there are 1,676 dams owned both privately and publicly across the province, with Ontario Power Generation (OPG) owning 241 dams located on 24 river systems for the purpose of producing hydroelectric power.<sup>21</sup> Most dams in the province have no reservoir capacity, and even those constructed for flood control with reservoirs can create floods upstream if overwhelmed, as storm events and wet conditions add more water to be held.<sup>22</sup>

Several decades ago, a relatively small number of dams were built by the Province and conservation authorities to assist in flood control but there are not many of these primarily where legacy development was being protected and their reservoirs are limited. While there may be some scenarios where enlargements or alterations to existing infrastructure may assist in abating a potential flood, for the most part the construction of new dams will not keep pace with the precipitation rise due to increasing levels of GHGs.

### 2.3 Outcomes of Flooding

Outcomes of flooding include the erosion of riverbanks and shorelines, the overwhelmed capacity of stormwater infrastructure, the loss of human life, property damage, the disruption of life due to relocation, the destruction of crops and loss of livestock, and negative impacts on human health from waterborne diseases.<sup>23</sup> If important infrastructure is damaged (power plants, roads, bridges, etc.), flooding can have a major effect on economic activity. Flooding can also have long-term effects for communities in supplying clean water, wastewater treatment, electricity, transportation, education, healthcare, and tourism.<sup>24</sup>

Many communities in Ontario are vulnerable to these outcomes. In urban areas with many impermeable surfaces, a high concentration of people and properties are dependent on storm systems that become overwhelmed from more frequent and intense precipitation. In rural areas, there may be more permeable surfaces to absorb water, but infrastructure damage such as road washouts then disproportionately affect a few members of the population more intensely.

For rural and urban municipalities alike, the economic impact of these outcomes include increased costs associated with the premature replacement of infrastructure and providing emergency services, compensating residents and businesses affected, insurance costs, lawsuits, increased energy costs, and disruptions to departmental budgets and productivity.<sup>25</sup> Though municipalities are not responsible for providing compensation, some municipalities provide this assistance to help residents, businesses, and local economies recover quicker from flooding events than they otherwise would.

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<sup>20</sup> McNeil, 46.

<sup>21</sup> Ibid.

<sup>22</sup> Ibid.

<sup>23</sup> Geoff Garrett, *Understanding floods: Questions & Answers* (Brisbane: State of Queensland, 2011).

[https://www.chiefscientist.qld.gov.au/\\_data/assets/pdf\\_file/0022/49801/understanding-floods\\_full\\_colour.pdf](https://www.chiefscientist.qld.gov.au/_data/assets/pdf_file/0022/49801/understanding-floods_full_colour.pdf).

<sup>24</sup> Ibid., 14-15.

<sup>25</sup> Penney et al., 80.

The above-mentioned flooding outcomes occurred during Ontario's major flooding events in 2017 and 2019, which demonstrate the destructive impact that changing water levels on the Great Lakes can have. For example, higher lake levels on Lake Ontario from precipitation, run-off and high-water levels on the Niagara River led to the inevitability of flooding in 2017.<sup>26</sup> Because the Great Lakes are connected, water levels in Lakes Superior, Michigan, and Huron, which had also rose to record highs, contributed to the Lake Ontario flooding.<sup>27</sup> However, only a few years earlier—from the late 1990s to 2013—communities on the Great Lakes shorelines faced record *low* water levels and were focussed on addressing the impacts of evaporation and water loss.<sup>28</sup> Because “a narrative of chronic drought took over during this drawn-out period of low water levels,”<sup>29</sup> the subsequent rapid rise in water levels was not anticipated, leaving communities with very little time to adjust and prepare. While the impacts of low lake levels sit outside the scope of this paper, this example highlights the need to anticipate the various challenges climate change presents for Ontario's river and lake systems.

Of immediate concern for many Ontarians currently is the effect of high-water levels on shoreline erosion and river floodplains. According to the Flood Advisor's report, areas with high flood risks also have high long-term erosion rates, such as high bluff areas like Marentette, Wheatley, and Erie Shore Drive.<sup>30</sup> High waters also prevent needed repairs on the shoreline, making existing developments on the shore even more vulnerable to erosion and flood waters.<sup>31</sup>

Municipalities along the Lake Erie shoreline have seen especially high lake levels in the last few years, with wave action causing erosion at the shore. Erosion can lead to agricultural land loss, the fragmenting of road networks, and the relocation of utility lines (among other costs).<sup>32</sup> Erosion has a major impact not just on communities that lose their infrastructure, but to wildlife and ecosystems in the area. Erosion shifts sediments and nutrients, and too many sediments entering a waterway negatively affects water quality downstream.

Flooding and erosion can also lead to the loss of habitat, the release of pollutants, lower fish production, and the loss of wetlands.<sup>33</sup> Although shoreline protection structures such as sheet pile walls and armour stone break walls have been implemented to try and slow down erosion, these structures have worked to make erosion worse. These structures do not impact erosion at the lake bottom in front of the structures, which leads to the creation of a deeper nearshore lake bottom slope and allows larger waves with greater energy to hit the shoreline.<sup>34</sup> Eventually, diverting the wave energy around the structures undermines the foundation, requiring repair or replacement. In turn, within time the cycle is repeated.

A major consequence of shoreline erosion is the disappearance of beachfront property. According to a 2015 Kettle Creek Conservation Authority study, the loss of shoreline in Elgin County exposes more than \$34 million worth of property to erosion hazards.<sup>35</sup> The effects of erosion can lead to the

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<sup>26</sup> JoAnna Wendel, “What caused the ongoing flooding on Lake Ontario?”, *Eos* 98 (2017): accessed July 30, 2020, <https://doi.org/10.1029/2017EO079079>.

<sup>27</sup> Ibid.

<sup>28</sup> Ibid.

<sup>29</sup> Ibid.

<sup>30</sup> McNeil, 55.

<sup>31</sup> McNeil, 54.

<sup>32</sup> W.F. Baird & Associates Costal Engineers Ltd, *Elgin County Shoreline Management Plan*, October 13, 2015, 63. <http://www.kettlecreekconservation.on.ca/wp-content/uploads/2015/10/ElginCoSMP-2015.10.13.pdf>.

<sup>33</sup> Garrett, 15.

<sup>34</sup> McNeil, 54.

<sup>35</sup> W.F. Baird & Associates Costal Engineers Ltd., 63.

relocation and even abandonment of buildings.<sup>36</sup> This puts an enormous strain not only on property-owners, but on municipalities who lose municipal infrastructure such as roads and rely on raising revenue from the property taxes collected from beachfront homes.

With climate change leading to less lake ice, shorelines will be exposed to higher amounts of erosion and wave energy.<sup>37</sup> In Lake Erie's western basin, this will mean more than double the winter wave energy, which will double the rate of erosion.<sup>38</sup> As Douglas McNeil warns, "Landowners who thought they were 100 years away from erosion hazards might now only be 50 years away, and significant lengths of municipal infrastructure (roads and utilities) are at risk of failure."<sup>39</sup> Municipal infrastructure, resources, and emergency response capacity are extremely vulnerable to erosion and other flooding outcomes if adaptive action is not taken.

### 3. Insights & Perspectives from Shoreline Municipalities along the Great Lakes, Georgian Bay, and Ottawa River

This section discusses the key issues faced by municipalities in responding to flooding, high water, and erosion, and highlights what Ontario municipalities need to better prepare for, prevent, and manage these events.

This is based on findings from a survey circulated to shoreline municipalities and flood-prone areas across the Great Lakes, Ottawa River, and Georgian Bay/Muskoka region, and a number of teleconference meetings organized with municipal staff. After contacting a total of 164 municipalities with invitations for staff to either participate in a teleconference meeting or complete the survey, approximately 91 staff members in total, representing 71 different shoreline municipalities, participated in one of these meetings.

Both upper-tier and lower-tier municipalities were represented across the six distinct shoreline regions of Lake Superior, Lake Huron, Georgian Bay and the Muskoka region, Lake Erie, Lake Ontario, and the Ottawa River. 67 municipal staff from both upper-tier and lower-tier municipalities also provided input through the survey.

Although flooding impacts municipalities across Ontario, this section focuses on the perspectives of shoreline municipalities for the sake of brevity and because these municipalities often sit at the intersection of a number of pressures that put them at a greater risk of experiencing ongoing flooding events. Many shoreline municipalities along the Great Lakes, Ottawa River, and Georgian Bay region have seen major flood events in the last few years due to factors such as high lake levels, strong winds, unstable shorelines, as well as more frequent and intense storms.

#### 3.1 The Political, Social and Economic Costs of Flooding, High Water, and Erosion for Municipalities

When reflecting on the costs of extreme weather events, municipal staff spoke to a number of ways flooding has impacted their communities economically. Of 52 survey respondents, 80% indicated that their municipality has public and private properties at a continuous risk of flooding.

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<sup>36</sup> Ibid.

<sup>37</sup> Mary Baxter, "How to save Lake Erie's disappearing shorelines," *TVO*, July 22, 2019, <https://www.tv.org/article/how-to-save-lake-eries-disappearing-shorelines>.

<sup>38</sup> Ibid.

<sup>39</sup> McNeil, 55.

Municipal staff spoke to the costs of building, replacing, and restoring impacted municipal infrastructure such as culverts, roads, bridges, break walls, and dykes more often as the intensity and frequency of storms and high waters increase. Many also pointed to the costs of maintaining and upgrading stormwater and pumping systems that are coming under increased pressure.

Additionally, there is the cost of restoration projects on municipal harbours, marinas, docks, wharfs, beaches and parks. This infrastructure is often a major funding source from tourism, and municipalities are economically impacted not only from the costs of repairs, but also from revenue lost when this infrastructure is inoperable. Furthermore, rebuilding or restoring these facilities diverts resources away that may otherwise have been directed at expanding the quantity and quality of infrastructure that could add value to local economies.

These costs are especially burdensome in municipalities that had to previously adapt to *low* lake levels just a few years ago. There are also the costs associated with garbage pick-up and immediate clean up in the wake of a flood event, especially if sewage and water treatment plants are impacted. Some municipalities also face costs in providing flooding-related grants and loans to residents and homeowners.

In many of these municipalities the tax base is too small to absorb the aforementioned costs presently, let alone into the future. An example heard from one municipality was of the damage from two storm events and high water to the municipal marina and boardwalk, which was estimated to cost somewhere between \$150,000 to \$250,000 to repair. This number represented almost a quarter of the municipality's total annual revenue.

Some municipalities have hundreds of shoreline residential properties worth tens to hundreds of millions of dollars at risk of flooding and/or erosion. Though these are not municipal properties, municipalities face costs in maintaining the infrastructure and utilities that support these neighbourhoods. Some staff also stressed that identifying the economic costs of flooding is difficult to gauge because of a lack of resources for comprehensive studies to undertake this work.

While impacting local economies, homes, businesses, and agriculture, many respondents also noted the emotional toll these events take on the mental health of the communities affected, especially for those who have lived through multiple floods. A number spoke to the environment of fear and anxiety the threat of flooding has cultivated, where residents are often afraid to leave their homes for extended periods of time in case they are away when a flood occurs. It is important to highlight that this fear and anxiety is felt disproportionately by the most vulnerable who are displaced by floods and have few or no supports for housing.

Many respondents also discussed how, in the years following major flood events in 2017 and 2019, flooding has become a major pressure point for local politicians due to these social impacts. In certain municipalities, residents have organized politically to demand action on flood protection from their local governments. Conversely, others noted that it can be difficult to keep flooding on the political agenda as communities get further away from their last major event and move towards recovery. However, most respondents agreed that residents and even cottagers have come to expect a certain level of assistance from their municipalities to protect them and their properties from flooding.

This issue begged the following set of questions, which animated a number of the discussions had with municipal staff:

- What responsibility do municipalities have to protect their residents' private property from flooding?
- Conversely, to what degree does responsibility lie with the property owner? And
- What role should other stakeholders play?

Though many respondents stressed the need for better education and communication with residents to clarify these roles, many also noted that this would be difficult to undertake because local governments are often not sure where this responsibility lies and are hesitant to commit to providing a level of service that they may not be able to deliver.

The political appetite for protecting private property from flooding varied considerably from municipality to municipality, but it spoke to larger questions around governance and what it means for public dollars to be used to protect private property. Sorting these questions out is crucial, and will be discussed further in the final section of this paper.

### 3.2 Current Tools Used by Municipalities to Prepare for, Manage, and Adapt to Floods, High Water, and Erosion: Opportunities and Challenges

When asked how prepared their municipality is for floods, high water, and erosion, of 50 survey respondents, 62% indicated they were somewhat prepared but with room for improvement. 24% felt their municipality was adequately prepared, while 10% said they were not prepared at all, and 4% said they were very prepared.

When asked what current tools are in place to prepare, it became clear that the capacity of municipalities to prepare for flooding and erosion varies greatly across the province. However, nearly all respondents spoke to having emergency management systems and evacuation plans in place, as well as providing sandbags to residents. Most municipal governments also had some sort of ongoing communication system in place to reach residents in advance of big storms and/or floods and to provide advice on how residents should prepare.

Participants identified a number of other tools and strategies currently in place to prepare for, manage, and adapt to floods, high water, and erosion in their municipalities. For example, many municipalities are developing tools to ensure neighbourhoods at risk of flooding have stormwater systems that can best catch and convey the water.

Some municipalities are reviewing their Drainage Plans and undertaking Inflow and Infiltration (I&I) studies. *Drainage Act* petitions have also been undertaken, as well as pump systems and the plugging of drains. Although the *Drainage Act* can be a useful way for municipalities to share costs, some warned that it is a burdensome legislative and regulatory process to undertake. Some municipalities with combined sewer systems have also undertaken sewer separation programs to strengthen their stormwater system.

On flood and/or erosion control infrastructure, some municipal governments have incorporated flooding and climate change adaptation into their respective Asset Management Plans. While some shoreline municipalities have invested in concrete, armour stone flood and/or erosion control infrastructure, many of these municipalities are also incorporating green infrastructure and low impact development (LID) measures, which protect communities from flooding and erosion through the enhancing of existing natural features and systems.

Some of the measures mentioned by respondents include storm ponds, rain gardens, bio swales, parkland channels, and smart sump-pumps. For repairing existing infrastructure impacted by flooding and erosion, many municipalities have been applying the “Build Back Better” principle to ensure impacted infrastructure such as roads are repaired or built back in ways that make them stronger and more resilient for the next flood or extreme weather event.

The Build Back Better principle is a necessary and cost-efficient strategy for climate change adaptation, saving municipalities from future costs associated with constant maintenance and repairs. An example of a Build Back Better strategy mentioned by one respondent was the replacement of old docks with flex docks that could adapt to both high and low lake levels.

While some shoreline municipalities have dedicated climate change adaptation funds for this work, many do not. This is especially the case for smaller lower-tier municipal governments, which have to fund any flood preparedness work from their reserves with no established protocol or dedicated funding budgeted for this work.

Some municipalities, often in collaboration with their local Conservation Authority, have had shoreline management studies done to identify what is needed to protect their shorelines from the impacts of climate change, and the costs associated with implementing an effective shoreline management strategy. However, staff from municipalities that have had these studies prepared note the gaps between what the study identifies as necessary for shoreline management and protection, and what the municipality can afford to do given its tax base and revenue tools.

Municipal staff also identified conservation authorities as an important resource for municipalities as they undertake work on flood and climate change adaptation. Many municipalities rely on floodplain mapping data and water level forecasting provided by their local Conservation Authority, and work closely with them to prevent land use development from occurring in flood risk areas and to improve their municipal emergency response for those that are in high risk areas. However, not every shoreline municipality has a local Conservation Authority. In discussions, respondents from municipalities that did not have a local Conservation Authority felt that their municipalities were at a significant disadvantage in preparing and adapting to flooding and climate change.

Collecting floodplain data and flood modelling is also being done in municipalities that have received funding for it. A few municipalities even employ surveyors to regularly measure water levels and take on flood mapping. These are mostly larger municipalities that have the capacity to be more proactive and have faced multiple flooding incidents. Smaller municipalities generally do not have the resources to hire surveyors or staff dedicated to flood management.

Regional meetings have also been occurring to organize more coordinated responses, especially among municipalities on Lake Erie and Lake Ontario. However, most respondents noted that the preparations that are in place for flooding are generally reactive, with less in place for adapting to flooding in the long run.

### 3.2.1 The Feasibility of Stormwater Charges

To address the challenge of limited dedicated stormwater resources, some municipalities have implemented development charges and/or stormwater fees to offset municipal drainage costs from stormwater. Stormwater charges provide municipalities with a dedicated fund which is used to build up stormwater infrastructure (such as investing in pipe renewal, stormwater management ponds, and culvert and sewer upsizing). However, staff from municipalities that have not

implemented these charges raised concerns about the feasibility of implementing stormwater rate charges, especially given the starker economic reality many residents are facing due to COVID-19.

Although this charge is dedicated as a separate reserve of funding for stormwater infrastructure, respondents noted that most residents would view it as a tax, paid by the property-owner. They also raised concerns about how long it would take to collect the revenues from the charge to recoup the current costs of flooding.

Additionally, in some municipalities, not all residents are connected to the municipal stormwater system. For these reasons, although stormwater charges have been generally beneficial for those municipalities that have implemented them, it is a strategy that will face many challenges to being implemented in the current political and economic climate.

### 3.3 Hazard Avoidance Policies and Practices: Opportunities and Challenges

Hazard avoidance policies refer to the use of municipal regulatory mechanisms such as building permits, official plans, zoning by-laws, and other land use planning measures to restrict development in erosion-prone areas and development within known floodplains. When asked about the effectiveness of their municipalities' hazard avoidance policies, of 50 survey respondents, 54% indicated they were somewhat effective but with room for improvement, 22% said they were adequately effective, 18% said they were not effective at all and 4% said they were very effective.

Generally, staff from shoreline municipalities felt that although their hazard avoidance policies have been effective in restricting new builds in unstable bank and flood-prone areas, the issue of legacy developments constructed before updated hazard avoidance policies came into effect have posed a major challenge. Even municipalities with relatively robust and enforced policies and by-laws cannot go back in time to prevent the development of homes and communities in current floodplains.

Respondents noted that it is especially challenging to keep further development away from legacy areas that have become intermingled with tourism over time and have seen neighbourhoods change from cottage homes to primary residences. Having homes in these hazard areas is especially concerning if emergency vehicles cannot pass through due to roads or culverts being damaged from weather events.

In addition to legacy developments, issues were raised about the current state of municipal hazard avoidance policies as well. Participants raised issues of disconnect between building permit processes, water resource engineering, Conservation Authority regulations, and municipal by-laws, which sometimes led to development occurring in known floodplains.

Further, in municipalities with inadequate data and outdated flood maps, hazard-prone areas are simply not known. Staff noted it is especially concerning that municipalities are already finding it difficult to keep up because hazard areas and flood lines will continue to change, and more often, due to the impacts of climate change. More modelling needs to be done so municipalities can have a sense of where their hazard areas and floodplains will be in 50 years. For this reason, updated floodplain mapping and forecasting are of utmost importance for making hazard avoidance policies more effective.

Some municipalities also noted that they need the resources to properly enforce their hazard avoidance policies. Even with adequate data available to identify floodplains, the economic, social and cultural desirability and dollar value of property close to water poses another challenge in



enforcing hazard avoidance. Respondents noted that property-owners do not want their properties identified as within a floodplain or hazard-prone area due to fears that this will impact their value.

As these voices can be quite prominent, especially in local contexts, some municipal staff noted that there needs to be provincial leadership on mandating hazard avoidance and addressing the loss in value of legacy development. Staff further noted that because these legacy buildings met provincial standards of the day, the province should take some responsibility for managing legacy issues.

### 3.3.1 The Feasibility of Buy-Out Strategies

In discussions, municipal staff from municipalities that have legacy builds in known floodplains or unstable shorelines observed that continuous repairs to these damaged properties often end up costing more than the value of the property itself. Additionally, many property-owners do not receive enough funding from provincial and federal disaster programs for adequate repairs and become locked into living in an unsellable and dangerous property. In response, some municipalities have been acquiring houses and infrastructure such as private roads that are at a continuous risk of being flooded, or have been severely impacted by erosion, as a hazard avoidance strategy.

However, wide-scale acquisitions or buy-outs of properties built within floodplains or unstable bank areas remains a controversial and unlikely hazard avoidance strategy to be taken by municipalities at this time. While many municipal staff expressed frustration at the issue of certain residential and commercial development constantly requiring flood protection because they never should have been built where they are in the first place, most conceded that buy-outs are likely not possible from the municipal government due to financial resource constraints. This is especially the case in municipalities where the highest-end properties are along the lakeshore.

Buy-outs were also generally viewed as controversial, given the implications of using public monies to buy private properties. Conversely, other respondents stressed that despite these economic and political factors, buy-outs should still be considered a feasible path of action for chronically at-risk properties, as it will be more costly for the municipality in the long-run to protect these properties from flooding, service them, and provide assistance to these residents during and after a flooding event.

While most municipalities simply do not have the funding on hand to undertake buy-outs, property acquisition might be something the province could consider. Currently, no such government program for buy-outs exists, nor is there funding available to municipalities for relocating or demolishing these properties.

### 3.4 Resources and Infrastructure needed to better prepare for, manage, and adapt to floods, high water, and erosion

A common theme across all municipalities consulted was the need for more data, resources, and infrastructure to better prepare for, manage, and adapt to floods, high water and/or erosion. When reflecting on the aftermath of a flooding event in their municipality, of the 41 respondents, 59% indicated that they did not have the tools they needed to recover from the event. This is a concerning state of affairs and points to the urgency to develop more comprehensive flood management and adaptation strategies across the province.

A common request heard from respondents is the need for funding which can address the persistent and widening infrastructure gap discussed above. Municipalities that have had shoreline and flooding studies done have found that there is anywhere from tens of thousands to hundreds of thousands of dollars—and all the way up to a few billion for heavily impacted shoreline municipalities—of potential needs to adequately protect communities from, and adapt to, flooding, high waters, and erosion.<sup>40</sup>

Most municipalities are already overwhelmed with maintaining and repairing existing infrastructure impacted by these events. Many shoreline municipalities are moving away from trying to secure funds for “grey” infrastructure, which refers to traditional engineered infrastructure, often concrete-based, for removing water that is not integrated into the surrounding ecosystem.<sup>41</sup> Examples of grey infrastructure include armour stone revetments, break walls, channels, dikes, and dams.

These projects are not only usually prohibitively costly, but they are known to be less effective for long-term resilience and can often have a negative environmental impact and contribute to the hardening of the shoreline. Instead, many municipalities are looking to invest in green infrastructure and strengthen stormwater systems by incorporating techniques to better capture and convey higher quantities of flow.

Shoreline municipalities require funding to pursue these infrastructure solutions, and staff members noted that wide-scale implementation of green infrastructure would require a federal-provincial economic stimulus, or major funding framework, to accomplish. This will be discussed in further detail in the final section of this paper.

Another key request made by many municipalities was the need for updated and comprehensive flood mapping. There was a strong desire from some municipalities to see a provincially-coordinated strategy for floodplain and shoreline mapping, as many municipalities were unsatisfied with the patchwork of flood mapping that currently exists given that conservation authorities are not all equally able to produce these materials, and some are using different technologies.

Shoreline municipalities, especially along the Lake Erie shoreline, noted that they require updated erosion mapping as well, based on both the standard 100-year mark and a 50-year mark due to the frequency with which erosion is occurring. Participants stressed the necessity of this data to legitimize the scale of the issues of flooding and shoreline erosion currently, and to predict the scale of the issue in the future.

They did not only discuss flood mapping, but other forms of data and technical resources necessary to make informed decisions as well, such as updated Intensity-Duration-Frequency (IDF) curves, knowledge from experts such as drainage engineers, and the development of technical guidelines and studies specific to their municipality or region.

Other resources mentioned include a comprehensive alerting program which can be adapted and localized for municipalities, upgrades to weather stations along major waterways to help

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<sup>40</sup> For more information, see Zuzek, Peter, *Chatham-Kent Lake Erie Shoreline Study (Draft)*, [https://portal.chatham-kent.ca/downloads/es/CKLakeErieSS\\_LR.pdf](https://portal.chatham-kent.ca/downloads/es/CKLakeErieSS_LR.pdf); Stantec Inc., *Upper Little River Watershed Master Drainage and Stormwater Management Plan*, <https://citywindsor.ca/residents/Construction/Environmental-Assessments-Master-Plans/Documents/ULR-ESR-2017-09-08-no-appendix.pdf>; and Zuzek, Peter, *Lake Ontario Shoreline Management Plan (Draft)*, <https://www.cloca.com/lake-ontario-shoreline-hazard-manag#:~:text=The%20key%20objectives%20of%20the,amenities%20along%20the%20shoreline%2C%20and>.

<sup>41</sup> “Grey infrastructure,” *Natural Water Retention Measures*, March 4, 2015, <http://nwr.m.eu/node/3837>.

municipalities better assess the cost/benefit of shoreline protection strategies, the development of regional networks for forecasting, monitoring, and reporting storms to ensure more accurate forecasting and better communications with residents, and mechanisms for more coordinated approaches to flooding with other municipalities on shared shorelines.

### 3.5 Impact of COVID-19 on Future Flooding & Climate Change Work

As the COVID-19 pandemic is still top of mind for municipalities across Ontario, it is important to understand how the pandemic has impacted municipalities' climate change and flooding responses. For the most part, participants indicated that COVID-19 has not significantly undermined their municipality's work on flooding and climate change adaptation. However, during lockdown measures in spring 2020, timelines for projects were put on hold or extended, and municipal staff were often diverted to work on matters related to the pandemic.

Respondents generally noted that it is not yet clear what effect COVID-19 and its associated impact on municipal finances will have on their municipality in the medium and long-term. Most conceded that it will likely impact future developments on flooding and climate change if financial and staffing resources are diverted away.

Many spoke to the relief they felt this year when spring flooding did not occur in their communities, noting that the municipalities would have been overwhelmed if flooding intersected with the onset of the pandemic. This demonstrates the precarious position many Ontario municipalities are in, where the new reality demands they be ready to handle multiple emergencies at any given time, even if they do not have the resources to do so.

## 4. Best Approaches for the Best Results

### 4.1 Clarifying Governance & Sharing Responsibility

The question of responsibility underlies many of the other issues around flooding, high waters, and erosion in Ontario. Clarity on this matter is critical for residents, private property owners, developers, other stakeholders, and all levels of government to better prepare for and adapt to flooding and erosion. There is a pressing need to sort these questions out, as flooding will continue to occur in Ontario at a more frequent and intense rate. While the Flood Advisor's report spoke to this issue, the report itself did not offer much in the way of decisive answers. This is understandable, as the question of roles and responsibilities for flooding is complex and would require consultation and discussion with all stakeholders to work out. However, as a starting point, it would be fair to say that responsibility, in differing degrees, lies with all stakeholders.

The degree of responsibility municipalities hold, and what that translates to in terms of the provision of a specific level of service or support to residents, remains unclear and varies drastically from municipality to municipality. This issue is especially important in municipalities that have faced litigation from residents who have felt that more should have done more to protect them from flooding. These lawsuits often cite negligence on the part of the local government in allowing for development in floodplains and not communicating the risks to the property-owner.

From the property-owner or landowner's perspective, the municipality is responsible when houses are built in flood hazard lands without proper protection measures in place because the regulation of development is a municipal responsibility. From this perspective, municipalities have a responsibility to support flooded or flood-prone properties. However, it is important to note that

much of this legacy development occurred mid-century when municipalities used provincial and national building codes to direct development. Therefore, both the province and federal government need to take a share of responsibility to address this matter.

On the other hand, others argue that it is the responsibility of private property-owners and landowners to know or learn the risks associated with their property, and are fundamentally responsible for protecting their property and absorbing any costs that occur from damages. As discussed earlier, local governments that implement flood protection strategies using public dollars to protect residential and commercial buildings have to negotiate the political risks that come with deciding to bear some of this responsibility.

Fortunately, clarifying governance and sharing responsibility for flooding and erosion are included in Ontario's recently-released Flood Strategy. The Strategy recognizes that governance regarding flood risks needs to be strengthened and clarified, and that roles and responsibilities for flooding need to be consistently applied. The Strategy identifies a number of ways the provincial government can encourage this, including by updating the Provincial Policy Statement and existing technical guidelines, enhancing the resiliency of provincial infrastructure and other buildings, and streamlining work permits.<sup>42</sup> The Strategy clearly indicates that all governments and Conservation Authorities need to work in greater collaboration.

Though the above-mentioned steps are helpful, the provincial government should also consider taking the lead in developing a plain-language graphical guide on what flood protections and responses are expected from different stakeholders, in collaboration or consultation with these stakeholders. In addition to local governments and residents, other stakeholders include rail and hydroelectricity companies. In certain regions, these companies engage in activities that create damming and flooding effects and operate in flood-prone areas.

Another key stakeholder are insurance companies that currently have an incentive to stop providing flood insurance for high-risk properties and municipalities, exacerbating costs and stresses on communities recovering from disasters. There are other important actors who play a role in the flooding landscape but currently do not bear any responsibility to help minimize flooding risks, such as real estate agents. Currently, real estate agents are not expected nor incentivized to inform buyers of the flood or erosion risks of a home, and likely do not know these risks themselves.

Likewise, developers or development interests must also be brought into the fold to both encourage the sector to take on flood preparedness strategies of their own, and to promote awareness and compliance with local hazard avoidance policies. It is important to recognize that there are groups that profit or benefit from floodplain development, and that they too must have their roles clarified.

There is currently no strategy in place to incorporate all these actors. In addition to hazard avoidance, the other main approach taken by the Ministry of Natural Resources and Forestry (MNRF) for managing flooding and erosion is the risk-based or risk management approach, which has not lent itself well to a sharing of responsibility. In theory, a risk-based approach is meant to "identify the risks associated with development in a floodplain and find ways to reduce those risks through enhanced floodproofing, flood forecasting and warning, and other measures."<sup>43</sup> However,

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<sup>42</sup> Ministry of Natural Resources and Forestry, 17.

<sup>43</sup> McNeil, 93.

its application at the municipal level has resulted in the perpetuation of development in hazard lands based on the expectation that through technology the risk will be managed.

A new approach is needed which lends itself to a sharing of responsibility in areas where legacy developments have ongoing flood or erosion problems. A new style of risk management, one in which risk sharing is incorporated, could deliver on this need. Risk sharing “involves sharing responsibility with those who contribute to flood risk, increasing the participation of stakeholders in decision-making, and allocating resources across a broader portfolio of technological, social, economic, and institutional measures to reduce and manage flood risk.”<sup>44</sup> What the municipal experience makes clear is that, with a few exceptions, flooding and erosion persists and jurisdictional confusion continues under the current risk management approach.

Clarity on the issue of responsibility must also be followed with public education and communication. Public education is especially critical as a recent study found that most people do not know if they are living in a flood-prone area, and if they do, many do not take the proper measures to protect themselves.<sup>45</sup> It is encouraging that Ontario’s Flooding Strategy includes a commitment to increasing public awareness by creating a provincial education program.

Further, some shoreline municipalities have developed special flood policies that detail what level of service the municipality will provide in cases of flooding or other extreme weather events to better manage resident expectations. This is a good place for municipalities to start the discussion with communities on sharing responsibility for flood protection and preparation.

## 4.2 Fixing the Patchwork of Flood Mapping & Data

AMO has been calling for better technology and data for floodplain mapping for over a decade. In the context of climate change, up-to-date technology and data are more pressing than ever. Currently, the state of floodplain and erosion mapping in Ontario continues to be a patchwork.

Updates to mapping are occurring locally on a largely ad-hoc basis and based on if funds are secured by municipalities and/or local conservation authorities to pursue this work. This is observed by McNeil in the Flood Advisor’s report, where he notes that “Neither the MNRF nor the Province provides funding for new or updated flood hazard mapping, nor approves new or updated mapping; however, the Province has provided small transfer payments for pilot projects related to mapping technologies in the last few years.”<sup>46</sup>

For example, some shoreline municipalities have secured funding for Light Detection and Ranging (LiDAR) data to better prepare for flood events and make sound planning decisions to mitigate flood risks. LiDAR measures distances by illuminating the earth surface with laser light to measure the reflection with a sensor, which provides a very accurate image of the landscape and helps to predict what would happen in cases of flooding from high water levels or storm events. However, even those that secured funding for LiDAR did not have enough funding to examine large swaths of their

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<sup>44</sup> Daniel Henstra and Jason Thistlethwaite, “Climate Change, Floods, and Municipal Risk Sharing in Canada,” Institute on Municipal Finance & Governance, Munk School of Global Affairs. *IMFG Papers on Finance and Governance* 30 (2017): 8. [https://munkschool.utoronto.ca/imfg/uploads/373/1917\\_imfg\\_no\\_30\\_online\\_final.pdf](https://munkschool.utoronto.ca/imfg/uploads/373/1917_imfg_no_30_online_final.pdf).

<sup>45</sup> Michael Drescher, “Urban floods: we can pay now or later,” *the Conversation*, May 14, 2018, <https://theconversation.com/urban-floods-we-can-pay-now-or-later-96160>.

<sup>46</sup> McNeil, 81.

unstable shoreline. Until additional funding is secured, these municipalities only have snapshots to work with.

Though municipalities would benefit from increased and dedicated funding to update flood and erosion-prone area mapping, AMO suggests the provincial government work in concert with the federal government to consider a system-level approach to standardizing flood and erosion mapping in a way which ensures municipalities across Ontario have the data they need to most effectively plan and prepare. Provincial leadership on flood and erosion mapping would allow local governments to better target their spending on necessary protection and adaptation infrastructure based on the data provided to them. Accurate, updated, and comprehensive floodplain and erosion mapping is a crucial first step. No flood adaptation strategy can begin without this mapping as we cannot solve a problem we do not know about, or where the scale of the issue is unknown.

Furthermore, the Ministry of Natural Resources and Forestry (MNRF) should invest in science to update flood mapping approaches, as this is especially necessary to account for the impacts of climate change. As the Flood Advisor's report notes, one challenge to managing flood risk is the lack of guidance for considering climate change in floodplain mapping.

Currently, the flood standards specified in the MNRF's technical guidance for rivers and streams are based on the greater of the 100-year flood, floods produced by a specific meteorological event, or an observed flood greater than the 100-year flood level.<sup>47</sup> There is little guidance on developing future climate change informed flood standards, especially in the case of riverine flooding, that would measure and identify how flood risk profiles would change over time.

Ontario's Flood Strategy is promising on this front as it recognizes the need for enhanced flood mapping and acknowledges that local decisions on how to best identify and manage flood risks need to be based on the latest data and science.<sup>48</sup> The Strategy indicates that the MNRF is considering the creation of an integrated and systemic flood mapping program designed in partnership with municipalities and conservation authorities.

The MNRF will also be reviewing and updating a large number of regulations and technical guidelines to better reflect recent flooding experiences and climate change projections, and has committed to working with the federal government to enhance flood forecasting to improve public warning information across the country. These provincial strategies are in line with the needs of Ontario municipalities and AMO encourages the Ministry to make this work a priority.

### 4.3 Dedicated Funding for Flood Protection & Adaptation Infrastructure

AMO has long called for dedicated federal and provincial funding for flooding infrastructure to help municipalities adapt to our changing climate. Upon research and discussions with shoreline municipalities, it is clear that this remains a pressing need as the current flood relief and adaptation funding environment is inadequate.

Though there is a provincial disaster relief program for municipalities—the Municipal Disaster Recovery Assistance program or MDRA, which included the “Build Back Better” pilot program—the threshold of damage required to be eligible for funds is quite high. This has created a major strain for communities recovering from a disaster that was not catastrophic enough to meet the threshold

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<sup>47</sup> McNeil. 88.

<sup>48</sup> Ministry of Natural Resources and Forestry, 10.

for funding but extremely damaging, nonetheless. Similarly, thresholds for accessing the national Disaster Mitigation and Adaptation Fund (DMAF) are currently not reflective of the economic means of different municipalities.

Furthermore, the provincial government's Disaster Recovery Assistance for Ontarians (DRAO) program for home-owners only provides funding for the cost of repairing infrastructure to make it functional again.<sup>49</sup> This runs counter to the well-known best management practice in disaster management, which is that recovery is most effective when damaged infrastructure is "built back better." However, even if the DRAO did provide funds for property-owners to build back better, this raises the question of if public dollars are being allocated most effectively when they are used to help property-owners rebuild and repair on hazard lands.

A one-time payment to affected property-owners, which includes the option to use the funds to move elsewhere may be a more cost-effective strategy for the provincial government to undertake, as it would lead to fewer future applications for disaster relief funding. In fact, Chatham-Kent's Lake Erie Shoreline Study found in its examination of its High Bluff region that the projected cost of adopting retreat measures, which include relocating buildings as required, sat at less than \$100 million, compared to the \$596-892 million costs associated with protecting buildings in the area with an armour stone revetment.<sup>50</sup>

While Ontario's Flooding Strategy recognizes the lack of funds for municipalities, it only promises a commitment to review the DRAO and MDRA programs and the Build Back Better pilot. The Strategy points to municipal governments as the lynchpin in addressing flooding but does not commit to increasing funding to ensure municipal governments can take on this responsibility and thus adds pressure to an already challenging infrastructure funding environment where demand far outstrips available funds.

For these reasons, a dedicated funding scheme for flood protection and stormwater management infrastructure, with a focus on green infrastructure solutions, should be developed. Green infrastructure solutions may help save municipalities billions of dollars down the line in flood damage costs.<sup>51</sup> For example, a study carried out by the Intact Centre on Climate Adaptation used modelling to predict the impacts of a rural wetlands green infrastructure pilot project located near Mississauga and an urban wetlands pilot in the City of Waterloo.

Results showed that if wetlands were maintained at the rural site, flood damages would be \$3.5 million, or 29%, lower than if the wetlands were replaced by agricultural development.<sup>52</sup> If wetlands were maintained at the urban site, the cost of flood damages would be 29-38% lower than if the wetlands were replaced with urban development.<sup>53</sup> Another example of the cost-saving potential of green infrastructure is a 250-metre naturalized channel in Oakville that provides approximately \$1.24 million to \$4 million of stormwater storage services annually.<sup>54</sup>

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<sup>49</sup> McNeil, 133.

<sup>50</sup> Zuzek, *Chatham-Kent Lake Erie Shoreline Study (Draft)*, 121.

<sup>51</sup> Mollame and Drescher, "How Investing in Green Infrastructure Can Jump-Start the Post-Coronavirus Economy."

<sup>52</sup> Natalia Moudrak, Anne-Marie Hutter, and Blair Feltmate, *When the Big Storms Hit: The Role of Wetlands to Limit Urban and Rural Flood Damage*, prepared for the Ontario Ministry of Natural Resources and Forestry (Intact Centre on Climate Adaptation: University of Waterloo, July 2017), ii. <https://www.intactcentreclimateadaptation.ca/wp-content/uploads/2017/07/When-the-Big-Storms-Hit.pdf>.

<sup>53</sup> Ibid.

<sup>54</sup> Moudrak et al. *Combating Canada's Rising Flood Costs: Natural infrastructure is an underutilized option*, prepared for Insurance Bureau of Canada (Intact Centre on Climate Adaptation: University of Waterloo, 2018), 4. <http://assets.ibc.ca/Documents/Resources/IBC-Natural-Infrastructure-Report-2018.pdf>.

Green infrastructure is defined as a “nature-based approach to providing ecological and hydrological services using living systems,”<sup>55</sup> and is “designed to replicate natural hydrology by managing water close to where it lands.”<sup>56</sup> Although grey infrastructure is still sometimes needed as a first line of defence and must be maintained/ repaired accordingly, green infrastructure can be an effective flood reduction strategy which provides a wide range of benefits different to, and in some cases better than, traditional engineered solutions.

Shoreline armouring in particular has an impact on the natural supply and movement of sediment, sometimes making erosion and flooding risks worse and having unintended negative consequences on the shorelines of other municipalities. Armouring also carries significant construction and maintenance costs. Green infrastructure, on the other hand, is flexible, decentralized, has a short implementation period, and requires little to no energy inputs.<sup>57</sup>

An example of green infrastructure for stormwater are Sustainable Urban Drainage Systems, which mimic natural drainage patterns to reduce surface water run-off and reduce the effects of flooding while also recharging groundwater stores, protecting water quality and promoting biodiversity.<sup>58</sup> Examples of sustainable urban drainage strategies include harvesting rainwater, utilizing filter strips and infiltration trenches, constructing green roofs, using permeable and porous pavement, and establishing reed beds and ponds.<sup>59</sup>

Other examples of green infrastructure to mitigate flooding include the use of natural heritage features and systems such as parklands, street trees, urban forests, natural channels, and permeable surfaces. In addition to flood risk mitigation and protection, green infrastructure provides a range of other benefits to strengthen community resilience to climate change, including reducing urban heat islands, reducing runoff, increasing local employment, improving air quality, providing opportunities for local food production, providing an aesthetic benefit to the community, and reducing energy consumption and greenhouse gas emissions.<sup>60</sup> A key benefit of green infrastructure is that it has both climate change adaptation and mitigation effects.<sup>61</sup>

However, it is important to note the challenges in implementing green infrastructure as well. Green infrastructure can have many variable costs compared to the relatively known and unchanging costs associated with traditional, grey infrastructure. One of these challenges with green infrastructure is a high cost of maintenance. This is often a barrier over and above the cost of installation, especially as municipalities often do not have dedicated funding for the maintenance of green infrastructure. Municipalities also often lack the enforcement and administrative resources to ensure developers maintain the green infrastructure they install.

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<sup>55</sup> Rohan Lilauwala and Chantelle Gubert, *Green Infrastructure for Climate Adaptation: Visualization, Economic Analysis, and Recommendations for Six Ontario Communities* (Green Infrastructure Foundation, 2019), 15. [https://static1.squarespace.com/static/58a5ddae6a49639715bab06d/t/5ebd778b9aa19c6124cbb597/1589475247361/GI\\_for\\_Climate\\_Adaptation\\_WEB.pdf](https://static1.squarespace.com/static/58a5ddae6a49639715bab06d/t/5ebd778b9aa19c6124cbb597/1589475247361/GI_for_Climate_Adaptation_WEB.pdf).

<sup>56</sup> Ibid.

<sup>57</sup> Lilauwala and Gubert, 22.

<sup>58</sup> Livia Bizikova, Tina Neale and Ian Burton, *Canadian communities' guidebook for adaptation to climate change: Including an approach to generate mitigation co-benefits in the context of sustainable development* (Environment Canada and University of British Columbia, 2008), 27.

[https://data.fcm.ca/documents/tools/PCP/canadian\\_communities\\_guidebook\\_for\\_adaptation\\_to\\_climate\\_change\\_EN.pdf](https://data.fcm.ca/documents/tools/PCP/canadian_communities_guidebook_for_adaptation_to_climate_change_EN.pdf).

<sup>59</sup> Ibid.

<sup>60</sup> Lilauwala and Gubert, 6.

<sup>61</sup> Lucas Mollame and Michael Drescher, “How Investing in Green Infrastructure Can Jump-Start the Post-Coronavirus Economy,” *The Conversation*, June 17, 2020, <http://theconversation.com/how-investing-in-green-infrastructure-can-jump-start-the-post-coronavirus-economy-139376>.



Another significant challenge is the progressive hardening of the urban environment, which works to undermine the positive benefits of any green infrastructure installed in the area. The installation of hard, sealed surfaces such as driveways, pools, and hard patios on private land contributes to increasing flooding risk by preventing rain from soaking into the soil, increasing the amount of surface water that needs to be managed by stormwater infrastructure. It is important that green infrastructure investments are implemented alongside strategies which encourage the overall de-hardening of urban communities and de-hardening Great Lakes shorelines through potential decommissioning of flood and/or erosion control infrastructure.

A major flooding and erosion infrastructure fund would be necessary to implement these green infrastructure strategies, preferably cost-shared between municipal governments, the provincial government, and the federal government. Currently, the Investing in Canada Infrastructure Program's Green Fund provides funding for green infrastructure. These investments should continue. However, more will be needed to protect communities and the environment from flooding and erosion.

Past programs such as the federal Flood Damage Reduction Program offer a potential framework for this funding. The federal National Disaster Mitigation Program could also be revived for this purpose, or be used as a model for a future funding program. Its 5-year funding structure was especially useful in allowing local governments to plan for what resources would best suit the particular needs of local communities. Municipalities have begun incorporating natural assets into their infrastructure planning and including stormwater and climate change in their municipal asset management plans, as recommended in the Flood Advisor's report. This is an important first step.

The need for major investments in flood protection and climate change adaptation infrastructure should not be viewed as just another cost for governments to shoulder, but rather an economic opportunity and effective avenue for stimulus funding as the province and country recover from the economic impacts of the COVID-19 pandemic. Currently, the green infrastructure sector in Ontario contributes over \$8 billion to the national economy, representing over 120,000 jobs.<sup>62</sup> As urban planning scholars Lucas Mollame and Michael Drescher have found, "Natural asset strategies [...] can contribute to generating the needed economic stimulus for recovery efforts. Nature-based solutions that support vital ecosystem services can reduce the financial costs of climate change, contribute to job creation, increase resilience and reduce poverty."<sup>63</sup> The Great Lakes St. Lawrence Cities Initiative estimates that for every million dollars of federal funding granted for shoreline protection, \$2.95 million is generated in economic activity.<sup>64</sup>

A major federal-provincial investment in green infrastructure "could save municipalities millions — if not billions — of dollars in infrastructure service costs."<sup>65</sup> This would serve as major fiscal relief to municipal governments with increasingly strained budgets as the pandemic continues, while adding revenues to provincial and federal governments through income taxes.

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<sup>62</sup> Mollame and Drescher, "How Investing in Green Infrastructure Can Jump-Start the Post-Coronavirus Economy."

<sup>63</sup> Ibid.

<sup>64</sup> Shreve, "Chatham-Kent joins coalition pushing for billions in shoreline-protection funding."

<sup>65</sup> Mollame and Drescher, "How Investing in Green Infrastructure Can Jump-Start the Post-Coronavirus Economy."

## 5. Final Considerations

This paper is by no means an exhaustive analysis of climate change impacts on flooding, high waters, and erosion in Ontario. Rather, its aim has been to provide a focussed but thorough review of municipal strategies and needs to better prepare for, manage, and adapt to flooding and erosion as a starting point for further discussion. This paper has provided an entrance into the complex environment of flooding and municipal responses in Ontario. Cutting through this complex environment, the three key recommended directions outlined in the previous section are interlinked in that they stress that a collective and coordinated response to flooding and erosion is needed in Ontario.

It is promising that clarifying governance, sharing responsibility, and promoting comprehensive floodplain mapping are strategies discussed in both Ontario's Flooding Strategy and the Flood Advisor's report. However, these strategies must be accompanied with financial resources for Ontario municipalities to protect people and property from flooding and erosion in the immediate term. As this paper has stressed, a changing climate is changing the parameters for storm water management and flood and erosion protection infrastructure, necessitating additional capacity and intensifying the need for investments that are already challenging municipalities.

Municipal governments across Ontario are ready and willing to do their share for flood protection programs, hazards map updates, and infrastructure projects, but do not have the financial buy-in from federal and provincial governments to turn these projects into a reality, and the costs are simply too prohibitive to absorb alone.

A federal-provincial partnering investment would demonstrate that all three levels of government are prepared to face the challenges that climate change has brought to bear on communities across Ontario, and are committed to making communities stronger and more resilient for the future. Importantly, social development and economic wealth cannot be created and fostered in situations of constant risk. If municipalities and communities are constantly reinvesting in repairing or rebuilding flood-damaged infrastructure, less can be invested in expanding the quantity and quality of the services in that community, impacting prosperity and liveability.

In sum, the allocation of resources based on the principle of sharing responsibility would help move Ontario towards a more comprehensive, robust system for responding to flooding, high waters, erosion, and other current and future climate change impacts. Moving forward, an analysis of the impacts of low waters and drought on municipalities, and an evaluation of what is needed to better prepare for these outcomes, would be an important topic for future research and discussion.

## Bibliography

- Association of Municipalities of Ontario. *Demonstrating Climate Action: AMO Climate Change Position Paper*. November 2010. <https://www.amo.on.ca/AMO-PDFs/Reports/2010/AMO-Climate-Change-Position-Paper.aspx>
- Baird, W.F., and Associates Costal Engineers Ltd. *Elgin County Shoreline Management Plan*. October 13, 2015. <http://www.kettlecreekconservation.on.ca/wp-content/uploads/2015/10/ElginCoSMP-2015.10.13.pdf>.
- Baxter, Mary. "How to save Lake Erie's disappearing shorelines," *TVO*. July 22, 2019. <https://www.tvo.org/article/how-to-save-lake-eries-disappearing-shorelines>.
- Bizikova, Livia, Tina Neale, and Ian Burton. *Canadian communities' guidebook for adaptation to climate change: Including an approach to generate mitigation co-benefits in the context of sustainable development*. Environment Canada and University of British Columbia, 2008. [https://data.fcm.ca/documents/tools/PCP/canadian\\_communities\\_guidebook\\_for\\_adaptation\\_to\\_climate\\_change\\_EN.pdf](https://data.fcm.ca/documents/tools/PCP/canadian_communities_guidebook_for_adaptation_to_climate_change_EN.pdf).
- Bush, Elizabeth, and Donald S. Lemmen. *Canada's Changing Climate Report*. Ottawa: Government of Ontario, 2019. [www.ChangingClimate.ca/CCCR2019](http://www.ChangingClimate.ca/CCCR2019).
- "Drainage statistics reveal some interesting facts about Ontario." *Drainage Contractor*. November 13, 2012. <https://www.drainagecontractor.com/drainage-statistics-reveal-some-interesting-facts-about-ontario-628/>.
- Drescher, Michael. "Urban floods: we can pay now or later." *The Conversation*. May 14, 2018. <https://theconversation.com/urban-floods-we-can-pay-now-or-later-96160>.
- Drinking Water Source Protection. *Upper Thames Source Water Protection Area Assessment Report*. September 16, 2015. <http://www.sourcewaterprotection.on.ca/wp-content/uploads/meetings/M28/Impervious%20Surface%20Maps.pdf>
- Expert Panel on Climate Change Adaptation. *Adapting to Climate Change in Ontario: Report of the Expert Panel on Climate Change Adaptation*. Toronto: Province of Ontario, 2009. <http://www.ene.gov.on.ca/publications/7300e.pdf>.
- Garrett, Geoff. *Understanding floods: Questions & Answers*. Brisbane: State of Queensland, 2011. [https://www.chiefscientist.qld.gov.au/\\_data/assets/pdf\\_file/0022/49801/understanding-floods\\_full\\_colour.pdf](https://www.chiefscientist.qld.gov.au/_data/assets/pdf_file/0022/49801/understanding-floods_full_colour.pdf).
- "Grey infrastructure." *Natural Water Retention Measures*. March 4, 2015. <http://nwrn.eu/node/3837>.
- Henstra, Daniel, and Jason Thistlethwaite. "Climate Change, Floods, and Municipal Risk Sharing in Canada." Institute on Municipal Finance & Governance, Munk School of Global Affairs. *IMFG Papers on Finance and Governance* 30 (2017): 1-43. [https://munkschool.utoronto.ca/imfg/uploads/373/1917\\_imfg\\_no\\_30\\_online\\_final.pdf](https://munkschool.utoronto.ca/imfg/uploads/373/1917_imfg_no_30_online_final.pdf)
- Lilauwala, Rohan, and Chantelle Gubert. *Green Infrastructure for Climate Adaptation: Visualization, Economic Analysis, and Recommendations for Six Ontario Communities*. Green Infrastructure Foundation, 2019. [https://static1.squarespace.com/static/58a5ddae6a49639715bab06d/t/5ebd778b9aa19c6124cbb597/1589475247361/GI\\_for\\_Climate\\_Adaptation\\_WEB.pdf](https://static1.squarespace.com/static/58a5ddae6a49639715bab06d/t/5ebd778b9aa19c6124cbb597/1589475247361/GI_for_Climate_Adaptation_WEB.pdf).

- McNeil, Douglas. *Independent review of the 2019 flood events in Ontario: A report to the Hon. John Yakabuski, Minister of Natural Resources and Forestry*. Winnipeg: McNeil Consulting Inc. <https://files.ontario.ca/mnrf-english-ontario-special-advisor-on-flooding-report-2019-11-25.pdf>.
- Ministry of Natural Resources and Forestry. *Protecting People and Property: Ontario's Flooding Strategy*. Toronto: Government of Ontario, 2020. <https://www.ontario.ca/page/protecting-people-property-ontarios-flooding-strategy>.
- Mollame, Lucas, and Michael Drescher, "How Investing in Green Infrastructure Can Jump-Start the Post-Coronavirus Economy." *The Conversation*. June 17, 2020. <http://theconversation.com/how-investing-in-green-infrastructure-can-jump-start-the-post-coronavirus-economy-139376>.
- Moudrak, Natalia, Blair Feltmate, H. Venema, and H. Osman. *Combating Canada's Rising Flood Costs: Natural infrastructure is an underutilized option*. Prepared for Insurance Bureau of Canada. Intact Centre on Climate Adaptation: University of Waterloo, 2018. <http://assets.ibc.ca/Documents/Resources/IBC-Natural-Infrastructure-Report-2018.pdf>.
- Moudrak, Natalia, Anne-Marie Hutter, and Blair Feltmate. *When the Big Storms Hit: The Role of Wetlands to Limit Urban and Rural Flood Damage*. Prepared for the Ontario Ministry of Natural Resources and Forestry. Intact Centre on Climate Adaptation: University of Waterloo, 2017. <https://www.intactcentreclimateadaptation.ca/wp-content/uploads/2017/07/When-the-Big-Storms-Hit.pdf>.
- Morrison, Jim. "Cities Around the Globe Are Eagerly Importing a Dutch Speciality—Flood Prevention," *Smithsonian Magazine*. December 5, 2019. <https://www.smithsonianmag.com/innovation/cities-around-globe-eagerly-importing-dutch-speciality-flood-prevention-180973679/>.
- Penney, Jennifer, Kevin Behan, Erica Pinto, Caroline Rodgers, and Nick Weigeldt. *Protecting your Community from Climate Change: a Training Program for Ontario Municipalities*. Toronto: Clean Air Partnership, 2011. [http://www.climateontario.ca/doc/ORAC\\_Products/CleanAirPartnership/CAP\\_Municipal\\_Adaptation\\_Training\\_Program.pdf](http://www.climateontario.ca/doc/ORAC_Products/CleanAirPartnership/CAP_Municipal_Adaptation_Training_Program.pdf).
- Shreve, Ellwood. "Chatham-Kent joins coalition pushing for billions in shoreline-protection funding." *the Chatham Daily News*. July 10, 2020. <https://www.chathamdailynews.ca/news/local-news/chatham-kent-joins-coalition-pushing-for-billions-in-shoreline-protection-funding>.
- Stantec Consulting Ltd. *Upper Little River Watershed Master Drainage and Stormwater Management Plan Environmental Assessment Environmental Study Report Windsor and Tecumseh, Ontario*. Prepared for Essex Region Conservation Authority. September 2017. <https://citywindsor.ca/residents/Construction/Environmental-Assessments-Master-Plans/Documents/ULR-ESR-2017-09-08-no-appendix.pdf>
- Wendel, JoAnna. "What caused the ongoing flooding on Lake Ontario?" *Eos* 98 (2017): accessed July 30, 2020. <https://doi.org/10.1029/2017EO079079>.
- Wuebbles, Donald, Bradley Cardinale, Keith Cherkauer, Robin Davidson-Arnott, Jessica Hellmann, Dana Infante, Lucinda Johnson, Rob de Loë, Brent Lofgren, Aaron Packman, Frank Seglenieks, Ashish Sharma, Brent Sohngen, Michael Tiboris, Daniel Vimont, Robyn Wilson, Kenneth Kunkel, and Andrew Ballinger. "An Assessment of the Impacts of Climate Change on the Great

Lakes." *Environmental Law & Policy Center*. Accessed July 30, 2020. <http://elpc.org/wp-content/uploads/2019/03/Great-Lakes-Climate-Change-Report.pdf>.

Zuzek, Peter J. *Chatham-Kent Lake Erie Shoreline Study (Draft)*. Prepared for the Municipality of Chatham-Kent. April 23, 2020. [https://portal.chatham-kent.ca/downloads/es/CKLakeErieSS\\_LR.pdf](https://portal.chatham-kent.ca/downloads/es/CKLakeErieSS_LR.pdf).

Zuzek, Peter J. *Lake Ontario Shoreline Management Plan (Draft)*. Prepared for Central Lake Ontario Conservation Authority, Ganaraska Region Conservation Authority, and Lower Trent Region Conservation Authority. June 10, 2020. <https://www.cloca.com/lake-ontario-shoreline-hazard-manag#:~:text=The%20key%20objectives%20of%20the,amenities%20along%20the%20shoreline%2C%20and>.

## Appendix: Further Readings/ Studies of Interest on Best Management Practices

- “Advancing Municipal Natural Asset Management Through Professional Planning: Twelve Action Steps.” *Municipal Natural Assets Initiative*. June 2019.  
[https://mnai.ca/media/2019/07/SP\\_MNAI\\_Report4\\_June2019.pdf](https://mnai.ca/media/2019/07/SP_MNAI_Report4_June2019.pdf).
- Atkins. *Flood Loss Avoidance Benefits of Green Infrastructure for Stormwater Management*. Prepared for U.S. Environmental Protection Agency. December 2015.  
<https://www.epa.gov/sites/production/files/2016-05/documents/flood-avoidance-green-infrastructure-12-14-2015.pdf>
- Binesh, Negin, Mohammad Hossein Niksookhan, Amin Sarang, and Wolfgang Rauch. “Improving Sustainability of Urban Drainage Systems for Climate Change Adaptation Using Best Management Practices: A Case Study of Tehran, Iran.” *Hydrological Sciences Journal* 64, no. 4 (2019.): 381–404. <https://doi.org/10.1080/02626667.2019.1585857>.
- Bowron, Beate, and Gary Davidson. *Climate Change Planning: Case Studies from Canadian Communities*. Prepared for the Canadian Institute of Planners. March 2012.  
[https://glslicities.org/wp-content/uploads/2015/09/Climate\\_Change\\_Planning\\_-\\_Case\\_Studies\\_from\\_Canadian\\_Communities\\_2012.pdf](https://glslicities.org/wp-content/uploads/2015/09/Climate_Change_Planning_-_Case_Studies_from_Canadian_Communities_2012.pdf)
- “Climate Change Adaptation Plans and Actions.” *Government of Canada*. February 5, 2020.  
<https://www.canada.ca/en/environment-climate-change/services/climate-change/adapting/plans.html#toc0>.
- “CLIMATE TILE.” Accessed May 25, 2020. <https://www.tredjenatur.dk/en/portfolio/climatetile/>.
- “Climate Change Strategy: Protecting Today for Resilience Tomorrow 2019-2023”. Credit Valley Conservation. July 2020. <https://cvc.ca/wp-content/uploads/2020/07/climate-strategy-final-web-spreads.pdf>
- “Climate Change Strategy”. Ganaraska Region Conservation Authority. June 2014.  
[https://www.grca.on.ca/wp-content/uploads/2017/07/GRCA\\_Climate\\_Change\\_Strategy\\_Final.pdf](https://www.grca.on.ca/wp-content/uploads/2017/07/GRCA_Climate_Change_Strategy_Final.pdf)
- Eastern Research Group, Inc. *Economic Assessment of Green Infrastructure Strategies for Climate Change Adaptation: Pilot Studies in the Great Lakes Region*. Written under contract for the National Oceanic and Atmospheric Administration Coastal Services Center. May 2014.  
[https://climatechange.lta.org/wp-content/uploads/cct/2015/04/GLPilots\\_Final\\_5-5-14v2.pdf](https://climatechange.lta.org/wp-content/uploads/cct/2015/04/GLPilots_Final_5-5-14v2.pdf)
- “Extreme Conditions and Challenges During High Water Levels on Lake Ontario and the St. Lawrence River.” *International Joint Commission*. July 8, 2017. <https://ijc.org/en/extreme-conditions-and-challenges-during-high-water-levels-lake-ontario-and-st-lawrence-river>.
- Feltmate, Blair and Marina Moudrak. *Climate Change and the Preparedness of Canadian Provinces and Yukon to Limit Potential Flood Damage*. Intact Centre On Climate Change Adaptation: University of Waterloo, 2016. <https://www.intactcentreclimateadaptation.ca/wp-content/uploads/2016/10/Intact-Centre-Climate-Change-and-the-Preparedness-of-Canadian-Provinces-and-Yukon-Oct-2016.pdf>
- Feltmate, Blair, and Natalia Moudrak. *Preventing Disaster Before it Strikes: Developing a Canadian Standard for New Flood-Resilient Residential Communities 20 Best Practices*, Intact Centre On Climate Change Adaptation: University of Waterloo, 2017.  
<https://www.intactcentreclimateadaptation.ca/wp-content/uploads/2017/10/Preventing-Disaster-Before-it-Strikes.pdf>.

- "Flood & Erosion Management." Conservation Ontario. Accessed April 29, 2020. <https://conservationontario.ca/conservation-authorities/flood-erosion-management/>.
- Great Lakes- St. Lawrence River Adaptive Management (GLAM) Committee. *Summary of 2017 Great Lakes Basin Conditions and Water Level Impact to Support Ongoing Regulation Plan Evaluation*. Prepared for the Great Lakes Boards and the International Joint Commission. November 13, 2018. [https://ijc.org/sites/default/files/2018-11/GLAM\\_2017\\_MainReport\\_FINAL-20181129\\_2.pdf](https://ijc.org/sites/default/files/2018-11/GLAM_2017_MainReport_FINAL-20181129_2.pdf).
- "Home." *Municipal Natural Assets Initiative*. Accessed July 21, 2020. <http://mnai.ca>.
- Kuffner, Alex. "A Stormwater Solution: Roger Williams Park Project a Model for Other Communities." *The Providence Journal*. June 21, 2020. <https://www.providencejournal.com/news/20200621/stormwater-solution-roger-williams-park-project-model-for-other-communities>.
- Laboratory of Mathematical Parallel Systems, York University. *Ontario Climate Data Portal*. <http://lamps.math.yorku.ca/OntarioClimate/>
- "Low Impact Development Life Cycle Costing Tool." *Sustainable Technologies Evaluation Program*. Accessed August 20, 2020. <https://sustainabletechnologies.ca/lid-lcct/>.
- Moura, N. C. B., P. R. M. Pellegrino, and J. R. S. Martins. "Best Management Practices as an Alternative for Flood and Urban Storm Water Control in a Changing Climate." *Journal of Flood Risk Management* 9, no. 3 (2016.): 243–54. <https://doi.org/10.1111/jfr3.12194>.
- Muir, Robert J. "Extreme Weather Resiliency and Climate Adaptation Through Strategic Asset Management & Infrastructure Investments." Association of Municipalities Ontario 2018 Annual Conference. <https://www.slideshare.net/RobertMuir3/extreme-weather-resiliency-and-climate-adaptation-through-strategic-asset-management-infrastructure-investments-136308636>
- Osti, Rabindra. "Case Study: Strengthening a City's Water Resources and Flood Management Capacity." *Development Asia*. Accessed July 24, 2020. <https://development.asia/case-study/strengthening-citys-water-resources-and-flood-management-capacity>.
- Perdeaux, Suzanne. *Climate Change Adaptation 'Stories' of Ontario: A collection of five adaptation initiatives from across Ontario*. Submitted to the Climate Change Impacts and Adaptation Division of Natural Resources Canada. Ontario Centre for Climate Impacts and Adaptation Resources: 2017. [http://www.climateontario.ca/doc/RACIII/Climate\\_Change\\_Stories\\_of\\_Ontario\\_Final.pdf](http://www.climateontario.ca/doc/RACIII/Climate_Change_Stories_of_Ontario_Final.pdf).
- "Publications and Reports." *Climate Risk Institute*. Accessed July 24, 2020. <https://climateriskinstitute.ca/publications-and-reports/>.
- Sandink, Dan. "Flood Risk Mitigation – Properties & Property." *Institute for Catastrophic Loss Reduction*. August 8, 2017. [http://www.climateontario.ca/doc/workshop/CCinMuskoka\\_WP/Presentations/DanSandink-FloodRiskMitigation-PropertiesAndProperty.pdf](http://www.climateontario.ca/doc/workshop/CCinMuskoka_WP/Presentations/DanSandink-FloodRiskMitigation-PropertiesAndProperty.pdf).
- Sheppard, Leah. "ULI Coastal Forum Looks at How Toronto Is Floodproofing for the Future." *Urban Land Magazine*. May 18, 2020. <https://urbanland.uli.org/sustainability/uli-coastal-forum-looks-at-how-toronto-is-floodproofing-for-the-future/>.

Standards Council of Canada. *Federal Flood Mapping Guidelines Series Standardization Workshop Summary Report*. Ottawa: Government of Canada, 2020.  
[https://www.scc.ca/en/system/files/publications/SCC-Flooding-Workshop\\_Report\\_FINAL\\_2020\\_06\\_10.pdf](https://www.scc.ca/en/system/files/publications/SCC-Flooding-Workshop_Report_FINAL_2020_06_10.pdf)

Statistics Canada. *Human Activity and the Environment 2015: The changing landscape of Canadian metropolitan areas*. Ottawa: Minister of Industry, 2016.