RAIN COMMUNITY SOLUTIONS

URBAN FLOODING IN ONTARIO

Toward Collective Impact Solutions

DISCUSSION PAPER

Draft 2.0

Mar 2017

Green Communities CANADA
RAIN COMMUNITY SOLUTIONS
Ontario Trillium Foundation / Fondation Trillium de l'Ontario
An agency of the Government of Ontario
Un organisme du gouvernement de l'Ontario

416 Chambers Street, Second Floor
Peterborough Ontario K9H 3V1
Direct inquiries and comments to: Clara Blakelock,
cblakelock@greencommunitiescanada.org 705-745 7479 ext 159
Project Editors: Clifford Maynes and Clara Blakelock
Lead Researcher: Anastasia Kaschenko

Cover photo courtesy of the City of Peterborough

EXECUTIVE SUMMARY

WELCOME to the revised draft of Urban Flooding in Ontario: Toward Collective Impact Solutions. This report lays the foundation for a practical and collaborative approach to addressing a difficult, costly, and complex issue facing our province in the years to come: urban flooding.

Complex problems like urban flooding require a collective impact approach

Urban flooding is a multi-billion dollar challenge for the province of Ontario that must be addressed. It is a growing problem with multiple damaging impacts and multiple causes. Urban flooding will require complex solutions, involving diverse stakeholders, and a combination of grey and green stormwater infrastructure investments, incentives, and strategies.

In this paper, we define urban flooding as the inundation of the built environment by rainfall, overwhelming the capacity of stormwater management systems. We include in this definition surface flooding, basement sewer backups, seepage/infiltration flooding, sewer overflows and wastewater treatment bypasses.

The impacts of urban flooding are wide-ranging. Economic impacts include property damage, both insured and uninsured, as well as damage to public infrastructure, lost productivity and business, and potentially lowered property values. Exposure to flood waters can spread disease, especially when untreated sewage has been discharged. People may face long-term health effects from exposure to mould, and mental health effects of flood-related trauma and loss. Social structures face upheaval as people are forced to shuffle living arrangements and experience financial strain. Runoff also pollutes receiving water bodies (especially when untreated or undertreated sewage is released), and increases erosion and sedimentation, impacting fish habitats and drinking water sources.

We outline three main causes for urban flooding in Ontario. Increased hard surfaces due to urbanization have increased runoff volumes five-fold or more relative to predevelopment conditions. Stormwater management systems in older developments were not designed to protect from flooding, and are unable to accommodate the volumes from today's extreme events. And climate change is predicted to increase the number of extreme wet weather events in Ontario going forward.

Many players are working in different ways to address urban flooding, including nonprofits, conservation authorities, the insurance industry,

Ontario Trillium Foundation / Fondation Trillium de l'Ontario
An agency of the Government of Ontario
Un organisme du gouvernement de l'Ontario

academics, and governments at all levels. We outline the responses being undertaken by different groups. While individual actors are making an impact, there is a compelling need for greater collaboration among the players. With limited resources, a coordinated strategy is required to address this problem at a provincial level. Preliminary thoughts about actions for consideration are included at the end of this paper, not as recommendations but as prompts for discussion.

This paper is part of the first phase of a larger Collective Impact project. With this project, we aim to bring together a broad range of stakeholders to develop and implement a collective urban flooding action plan.

The Collective Impact project, outlined in more detail in Appendix C, includes three phases:

- Phase one (2016-2017): Develop this background paper identifying the problem, its impacts, causes, and current responses, and circulate to key stakeholders for feedback.

- Phase two (2017-2019): Pending funding, phase two will engage a wide range of stakeholders from different sectors in developing an urban flooding action plan, mapping roles and responsibilities, and establishing a shared measurement framework for evaluating progress.

- Phase three: Participants collaborate in implementing the action plan, including shared progress reporting.

Thanks to the Ontario Trillium Foundation for supporting this work with a Groundwork grant under its Collective Impact funding stream. The project is led by Green Communities Canada, a national non-profit active in helping to transform how rain is managed on the urban landscape. The GCC team comprises Chief Researcher Anastasia Kaschenko, Water Programs Director Sharyn Inward, Water Programs Manager Clara Blakelock and Executive Director Clifford Maynes.

Thanks also to our steering committee, Dan Sandink of the Institute for Catastrophic Loss Reduction, and Phil James of the Credit Valley Conservation Authority. Dan and Phil have contributed much to our work to date, but cannot be held responsible for remaining deficiencies.

Key Terms

Types of flooding

- **Riverine flooding** (aka fluvial flooding), which occurs when runoff causes a river to overflow its banks. This may be caused by excessive rainfall or snowmelt. The area adjoining a watercourse, subject to riverine flooding, is known as the flood plain.[1]
- **Urban flooding** (aka pluvial flooding) which, occurs when water is not absorbed into the ground, and/or when volumes exceed storm water system capacity, forcing water to flow overland. We also include sewer backups, combined sewer overflows, and sewage treatment plant by passes in our definition of urban flooding, when these are .... caused by heavy rainfall.[2]

1-in-100-year events; 100-year flood

- A "100-year flood" has a 1-percent chance of occurring in any given year. Similarly, a five-year storm, also known as a 1-in-5-year event, has a 20% chance of occurring any given year. See the US National Weather Service Flood Return Period Calculator to see how this translates into probabilities over a number of years. But probabilities are not predictions: the fact that it rained 250 mm in a single day one year doesn't mean it won't rain 250 mm in a single day again the next year.[3]

Types of sewer systems

- **Stormwater systems** (storm sewers) are designed exclusively to carry stormwater to measures such as detention ponds, or directly to receiving waters such as rivers and lakes. Minor systems are under ground sewer systems typically designed to carry the 1 in 2 or 1 in 5 year storm events. Major systems are overland systems designed to carry up to the 1 in 100 year event. In Canada, most areas developed before the 1970s were not designed with major systems.
- **Sanitary sewers** are designed to carry brown and grey water to waste water treatment plants (aka sewage treatment plants). Although not the intent, stormwater may also find its way into sanitary sewers as a result of inflow and infiltration (see below). As a result, capacity is exceeded, leading to basement sewer backups and sanitary sewer overflow (SSOs) from sewer pipes into receiving waters. Wastewater treatment plants may also be overloaded, resulting in releases of un treated or undertreated water, known as bypasses.
- **Combined sewer systems** are an older form of infrastructure de signed to collect both rainwater runoff and sanitary sewage in the same pipe, for conveyance to wastewater treatment. During periods of heavy rainfall or snowmelt, however, volumes in a combined sewer system can exceed the capacity of the system. For this reason, combined sewer systems are designed to overflow occasionally and discharge excess wastewater directly to nearby streams, rivers, or other

water bodies. Combined sewer overflows (CSOs) contain not only storm water but also untreated human and industrial waste, toxic materials, and debris. High water volumes in combined sewers can also cause wastewater treatment bypasses and sewer backups (see above).[4]

Inflow and infiltration (I&I)

- **Inflow** occurs when rain water enters the sanitary sewer through holes in manhole covers, catch basins, or improper plumbing connections, such as downspouts and foundation drains connected to the sanitary sewer.
- **Infiltration** occurs when ground water seeps into the buried sanitary sewer through cracks or joints.
- Rainfall-derived inflow and infiltration is a primary factor in the occurrence of sanitary sewer overflows (SSOs) to basements and water bodies.[5]

Sanitary sewer laterals

- The sewer line that carries wastewater from the sanitary fixtures and floor drains inside homes or businesses to the city's sewer mains is called a sewer lateral. The property owner is responsible for maintaining the sewer lateral from inside the building to the point where it connects with the city street main.[6]

Weeping tiles (foundation drain)

- A weeping tile system (also known as a foundation drain) is a perforated pipe or clay tile system installed at the base of a foundation in order to drain away excess groundwater. These systems prevent groundwater from building up against a foundation, thus protecting the foundation from leaking or shifting. In older areas, weeping tiles may discharge to sanitary sewer systems. In newer construction, they usually discharge to storm sewers or to the surface via sump pumps.[7]

Green infrastructure / green stormwater infrastructure / low impact development (LID)

- Definition from Provincial Policy Statement, 2014: "Natural and human made elements that provide ecological and hydrological functions and processes. Green infrastructure can include components such as natural heritage features and systems, parklands, stormwater management sys tems, street trees, urban forests, natural channels, permeable surfaces, and green roofs."

INTRODUCTION

1

Urban flooding occurs when rain overwhelms drainage systems and makes its way into the basements, backyards, and streets of homes, businesses, and other properties.[8] Urban flooding is the inundation of land or property in the urban built environment that occurs when rainfall exceeds the capacity of drainage systems, backing up or surcharging wastewater and stormwater. Urban flooding in Ontario principally results from extreme wet weather events, where a high volume of rainfall occurs in a short period of time. Thunderstorms and flash storms are the most common examples.[9]

2

Urban flooding is distinct from riverine flooding, typically occurring outside of areas identified as riverine flood hazard areas (flood plains). However, urban and riverine flooding are related and it can be difficult to distinguish them in practice, since water flowing over land may come from either overflowing rivers or backed up stormwater systems (a modelling study in Cobourg re-classified some flood damage as urban previously thought to be riverine).[10] Further, increased runoff from urbanized areas causes stream volumes to increase and speed up and can hasten riverine flooding. Many reports and studies discuss flooding in generic terms and fail to make the distinction. Riverine ("fluvial") flooding results from water flowing beyond stream banks. Urban ("pluvial") flooding results from rainfall overwhelming stormwater system capacity. For the purposes of this paper, urban flooding includes:

- Urban surface flooding: Rainfall flooding roadways and private property. Surface flooding may enter into buildings causing interior flooding. This type of flooding may also be referred to as overland flooding, stormwater flooding, surface water flooding, and localized flooding.
- Sewer backup: When flows exceed the capacity of the sanitary sewer (because sewers are combined, or because of inflow and infiltration), human sewage backs up into basements.
- Combined sewer overflows, sanitary sewer overflows and wastewater treatment plant bypasses: When excess stormwater and groundwater enters sanitary sewers (or combined sanitary and stormwater sewers) they may overflow by design into receiving waters. When excess flows reach a wastewater treatment plant (sewage treatment plan), untreated wastewater may be discharged, again by design as a safety measure. This is known as sewer bypass. See box on page for why we include overflows and bypasses as part of our definition of urban flooding.

3

An example of urban flooding is shown in Figure 1 below. The red dots represent flood complaints following the 2004 flood in Peterborough, Ontario. For the most part, the dots are concentrated well outside the outlined green area, which is the demarcated riverine floodplain along the Otonabee River.

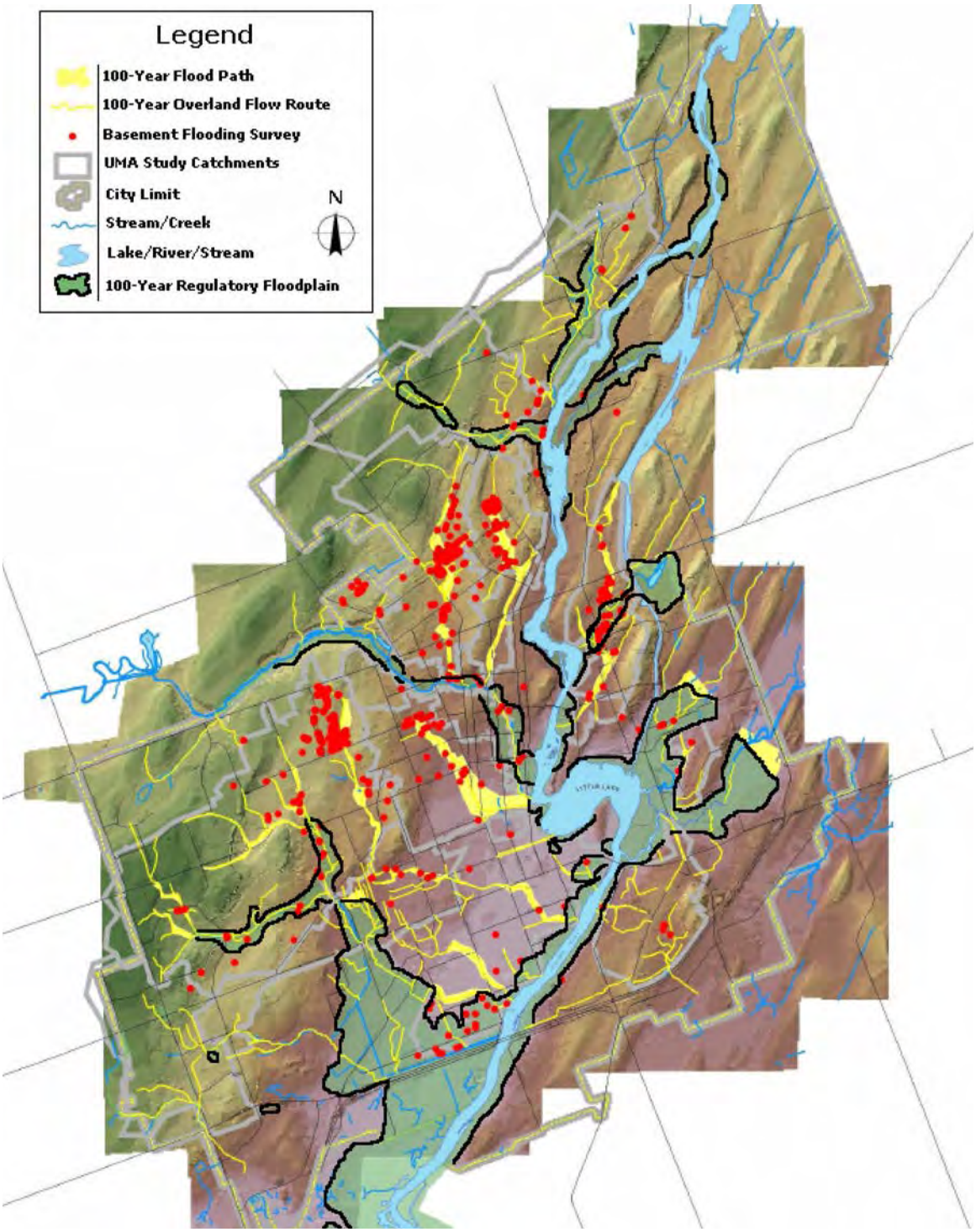


Figure 1. Red dots represent flood complaints from the 2004 flood in Peterborough, ON. Source: Peterborough Flood Reduction Master Plan

IMPACTS

4

Homeowners are deeply affected.

Early reports of flooding in Ontario dating back to the 1700s are primarily riverine, because the urban footprint was relatively small and drainage systems largely comprised open ditches. The first severe flood in the Toronto region was recorded in 1878.[11] In October 1954 the notorious Hurricane Hazel generated 210 millimeters of rain fall in less than 12 hours. A natural disaster of unprecedented impact, Hurricane Hazel catalyzed mapping and development restrictions in flood plains, and investments in riverine flood mitigation (e.g., berms, dams, channelization, and bank protection).

5

These measures have been effective in limiting damage from riverine flooding. However, since 1995, Ontario has declared a provincial state of emergency almost every year linked to severe weather, particularly floods.[12] In recent major floods in Toronto, 97 to 99% of flooded properties were located beyond river flood vulnerable areas.[13] The major flood problem we now face is urban, not riverine.

6

There is large flood loss potential within the Greater Toronto Area due to its high population and development density, and the high market values of properties.[14] The economic loss for a modeled 200-year scenario flood for the GTA is projected at $6.4 billion, the insured loss at $2.5 billion.[15]

7

Notable urban flooding events have occurred over the past decade across Canada in the cities of Windsor, Peterborough, Montreal, Thunder Bay, Calgary, Hamilton, Burlington and Toronto. 2012 was named the Year of the Urban Flood by Environment Canada.[16] Flood-related water damage is replacing fire as the leading cause of insurance claims (the 2016 fire in Fort McMurray, AB made fire more expensive in that year, but flooding losses are increasing nearly every year).[17] Facts of the Property and Casualty Insurance Industry in Canada 2016, published by the Insurance Bureau of Canada, provides a table detailing the major urban flooding events as part of catastrophic losses from 1983 to 2008.

8 Urban flooding is responsible for the most expensive disaster ever recorded in Ontario.[18] On 8 July 2013, over 125 mm of rain fell over Toronto.[19] The rainfall flowed into basements over land and up through floor drains, flooded roads, shut down major transit lines, delayed and cancelled flights, and affected over 300,000 people.[20] The insurance industry experienced losses exceeding $1 billion, while an additional $60 million in costs were absorbed directly by the City of Toronto.[21]

Economic Impacts

9 Economic impacts from flooding come in a range of forms. Property damage first comes to mind, but other impacts include lost income when people can't get to their jobs, lost business when stores and companies can't open and customers can't get access, lowered property values and damage to public infrastructure. Only a portion of these losses is covered by insurance.

10 Recent models predict that a combined urban and riverine flood across western Canada (a one-in-200-year event) could cause losses of $13 billion, less than half of which would be covered by insurance.[22] In a recent study by the Insurance Bureau of Canada, a major (one-in-25-year) 2040 event in Mississauga with no climatic changes could cost an estimated $195 million.[23] Damages attributed to recent urban flooding events are frequently totaling tens if not hundreds of millions of dollars.[24] The following table lists major urban flooding events in the Greater Toronto Area since 2004 and associated insurance claims.

11 Homeowners are deeply affected. Approximately 40% of all personal property claims result from flooding and water-related damages, making flooding the leading source of Canadian personal disaster claims.[25, 26]

Insurance Claims associated with extreme weather in the GTA

Date	**Location**	**Insurance claims submitted**
July 2004	Peterborough	$100 million
August 2005	Toronto	$500 million
July 2009	Hamilton	$200 million
July 2013	Mississauga/Toronto/Brampton	$1 billion

Figure 2. Insurance claims in the Greater Toronto Area, Ontario since 2004. Source: Advancing Low Impact Development as a Smart Solution for Stormwater Management (2015)

12 Further, most homeowners are covered only for sewer backup, and not for overland flooding and related basement flooding. Until 2016, Canada was the only G7 country that left homeowners largely unprotected from non-sewage flood losses, and dependent on government relief.[27] Even with financial assistance from the government, flood victims are often out of pocket by tens of thousands of dollars per household.[28] Overland flood insurance policies were introduced in Canada in early 2016.[29]

13 In addition to direct economic losses from flooding, homeowners may also experience decreases in property values, although evidence is mixed.[30] Research conducted in Chicago found that previously flooded basements can lower property values by 10-25%, and make homes harder to sell.[31]

14 Businesses are also impacted by urban flooding. In the United States, over 40% of small businesses that experience flooding never reopen their doors.[32] Calgary, Alberta experienced heavy rainfall in 2013 that resulted in some of the worst flooding in the history of the province.[33] Although much of the flooding was riverine, stormwater system capacity was also exceeded. Approximately 5.1 million hours of work were lost, resulting in $485 million of lost economic output by the private sector.[34]

15 In Canada, flooding claims have increased by an order of magnitude as a percentage of total disaster relief costs since 1970. From 2005-14, 93% of payouts from the Disaster Financial Assistance Arrangements (DFAA) were for flooding.[35] Figure 4 in Appendix A depicts in further detail Ontario's per capita payments. Ontario's relatively low claim statistics may paint a false picture, as the threshold for federal contributions is much higher for Ontario than other provinces and territories.[36] Increased strain is placed on municipalities and the province to cover rising costs.

Social and health impacts

16 The social and health impacts of urban flooding arrive in two stages – the initial impacts during and immediately after the flood, and the longer term consequences. Health impacts include disease spread by floodwaters, the risk of drowning, increases in road accidents, stress and mental health, and effects of mould exposure. Social impacts include upheaval of living situations (because of the need to move out of and clean up basement spaces), loss of historical or irreplaceable artifacts and financial problems.

17 Flooding and sewer backups are the leading cause of property damage in Canada,[37] leaving homes in disrepair and homeowners in despair. Stresses of relocation and loss of possessions add to out-of-pocket expenses incurred by homeowners. While not as easily quantifiable, social impacts of urban flooding extend far beyond economic loss.[38] Urban flooding can be a trigger for mental health issues.[39] Further, children and elderly are identified as particularly vulnerable, and individuals may feel anxiety, anger, helplessness, confusion, and guilt. Some may experience profound grief.[40] Urban flooding exacerbates existing health inequities and the stresses placed on poor and vulnerable groups.[41] Basement apartments in particular are often the lowest cost rentals and likely to be occupied by low-income individuals.

in Canada, most homeowners are covered only for sewer backup

18 Chronically damp houses resulting from single or repeated incidences of flooding are linked to an increase in respiratory problems, mostly from mold growth.[42] Dampness and mold following flood events are associated with increases of 30-50% in respiratory and asthma-related health outcomes.[43]

19 Basement flooding can destroy irreplaceable personal items and valuables. It can also damage house foundations, and result in high costs beyond insured property damages, resulting in financial strain on property owners. Relationships can suffer from the stress of dealing with the effects of flood damage.

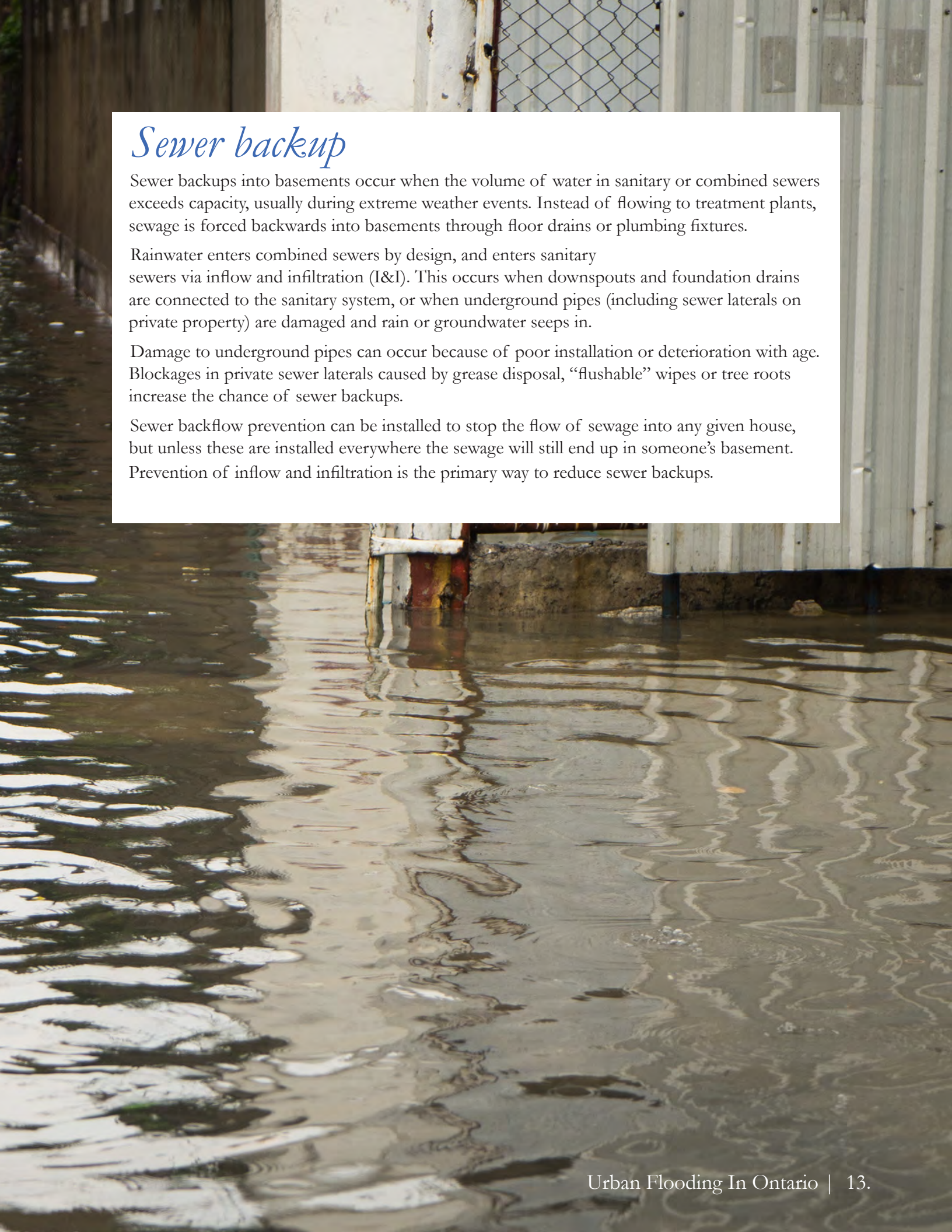
20 Power outages result from urban flooding events. Neighborhoods in west Toronto have experienced extended-duration power outages twice in the past five years due to surface floods at a local transformer station. Residents in high rise buildings were unable to use elevators, flush toilets, or shower.[44]

21 Flood waters in basements and local waterways often contain diluted sewage, which can cause serious illness. Beaches are often affected for several days afterwards. See Health effects of flooding in Canada: A 2015 review and description of gaps in research from the Canadian Water Resources Journal.

Environmental impacts

22 Even in the absence of flooding, runoff from smaller rainfall events carries pollution picked up from hard surfaces in cities (oil, salt, cigarette butts, pet wastes, etc.). Flood waters may also contain more serious toxic substances as a result of spills.[45] Urban runoff is usually warmer than receiving waters and can cause thermal pollution. Further, runoff from extreme events can result in streambank erosion and increased sedimentation, altering flows and increasing riverine flooding damage. Fish habitats, recreational water uses, and source water for drinking can all be impacted.[46]

23 Sanitary sewer overflows and sewage treatment plant bypasses discharge untreated or partially treated sewage into receiving water bodies. During extreme weather events this sewage is usually heavily diluted with rainwater, less so during more moderate events. Wastewater contains pathogenic protozoa, pharmaceuticals that can contaminate fish, and nutrients which can promote the growth of algal blooms (which in turn damage fish habitat).[47]



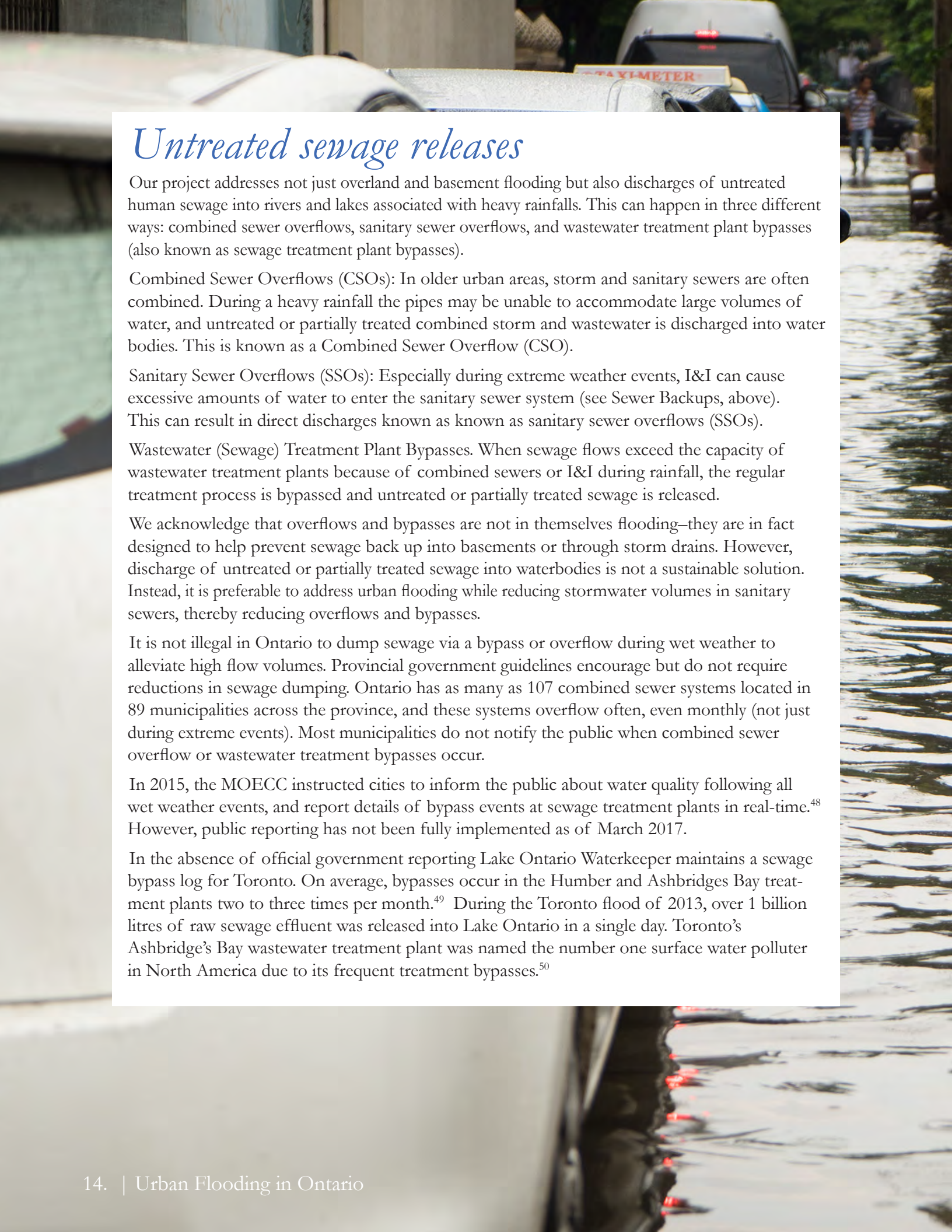
Sewer backup

Sewer backups into basements occur when the volume of water in sanitary or combined sewers exceeds capacity, usually during extreme weather events. Instead of flowing to treatment plants, sewage is forced backwards into basements through floor drains or plumbing fixtures.

Rainwater enters combined sewers by design, and enters sanitary sewers via inflow and infiltration (I&I). This occurs when downspouts and foundation drains are connected to the sanitary system, or when underground pipes (including sewer laterals on private property) are damaged and rain or groundwater seeps in.

Damage to underground pipes can occur because of poor installation or deterioration with age. Blockages in private sewer laterals caused by grease disposal, "flushable" wipes or tree roots increase the chance of sewer backups.

Sewer backflow prevention can be installed to stop the flow of sewage into any given house, but unless these are installed everywhere the sewage will still end up in someone's basement. Prevention of inflow and infiltration is the primary way to reduce sewer backups.



Untreated sewage releases

Our project addresses not just overland and basement flooding but also discharges of untreated human sewage into rivers and lakes associated with heavy rainfalls. This can happen in three different ways: combined sewer overflows, sanitary sewer overflows, and wastewater treatment plant bypasses (also known as sewage treatment plant bypasses).

Combined Sewer Overflows (CSOs): In older urban areas, storm and sanitary sewers are often combined. During a heavy rainfall the pipes may be unable to accommodate large volumes of water, and untreated or partially treated combined storm and wastewater is discharged into water bodies. This is known as a Combined Sewer Overflow (CSO).

Sanitary Sewer Overflows (SSOs): Especially during extreme weather events, I&I can cause excessive amounts of water to enter the sanitary sewer system (see Sewer Backups, above). This can result in direct discharges known as known as sanitary sewer overflows (SSOs).

Wastewater (Sewage) Treatment Plant Bypasses. When sewage flows exceed the capacity of wastewater treatment plants because of combined sewers or I&I during rainfall, the regular treatment process is bypassed and untreated or partially treated sewage is released.

We acknowledge that overflows and bypasses are not in themselves flooding–they are in fact designed to help prevent sewage back up into basements or through storm drains. However, discharge of untreated or partially treated sewage into waterbodies is not a sustainable solution. Instead, it is preferable to address urban flooding while reducing stormwater volumes in sanitary sewers, thereby reducing overflows and bypasses.

It is not illegal in Ontario to dump sewage via a bypass or overflow during wet weather to alleviate high flow volumes. Provincial government guidelines encourage but do not require reductions in sewage dumping. Ontario has as many as 107 combined sewer systems located in 89 municipalities across the province, and these systems overflow often, even monthly (not just during extreme events). Most municipalities do not notify the public when combined sewer overflow or wastewater treatment bypasses occur.

In 2015, the MOECC instructed cities to inform the public about water quality following all wet weather events, and report details of bypass events at sewage treatment plants in real-time.[48] However, public reporting has not been fully implemented as of March 2017.

In the absence of official government reporting Lake Ontario Waterkeeper maintains a sewage bypass log for Toronto. On average, bypasses occur in the Humber and Ashbridges Bay treatment plants two to three times per month.[49] During the Toronto flood of 2013, over 1 billion litres of raw sewage effluent was released into Lake Ontario in a single day. Toronto's Ashbridge's Bay wastewater treatment plant was named the number one surface water polluter in North America due to its frequent treatment bypasses.[50]

CAUSES

24

Urban flooding has three main drivers:

- **Land-use changes:** As the natural landscape is urbanized, vegetation and exposed soils disappear, and impervious surfaces like buildings, roads, and parking lots proliferate. The land becomes less like a sponge and more like a plate. As a result, runoff volumes expand several times, and stormwater moves quickly over the surface, overwhelming drainage system capacity.

- **Design capacity:** Stormwater management systems in older developed urban areas were never designed to accommodate today's volumes and peaks. In many cases these systems are aging and poorly maintained, exacerbating flooding.[51]

- **Climate change:** Climate change in Ontario is projected to result in more extreme wet weather events, contributing to urban flooding. There is inherent uncertainty in predicting the effects of climate change, but even without any climatic changes urban flooding will continue to be a serious problem.

25

A number of other factors contribute to basement flooding at the individual lot level, including failure to clean out eaves troughs, and downspouts that release rain near the foundation.

26

Land-Use Changes–interruption of the water cycle

In nature, very little of the rain that falls results in stormwater runoff. In fact, 90% of rainfall events by volume are retained where the rain falls and returned to nature through infiltration and evapotranspiration. Even in tight clay soils (found in much of the Greater Toronto Area), in predevelopment conditions much of the rainfall was stored or conveyed on the surface or near surface and allowed to slowly infiltrate or evapotranspirate. However, land use changes associated with urbanization interrupt the water cycle. There is a reduction in absorbent soils, trees, and other vegetation, and an increase in impervious surfaces such as roads, rooftops and parking lots that do not absorb rainfall, resulting in greatly increased surface runoff and little near-surface storage capacity.[52] An urbanized landscape experiences a five-fold or greater increase in stormwater runoff volumes compared to an undeveloped watershed.[53] *See Figure 3 below.*

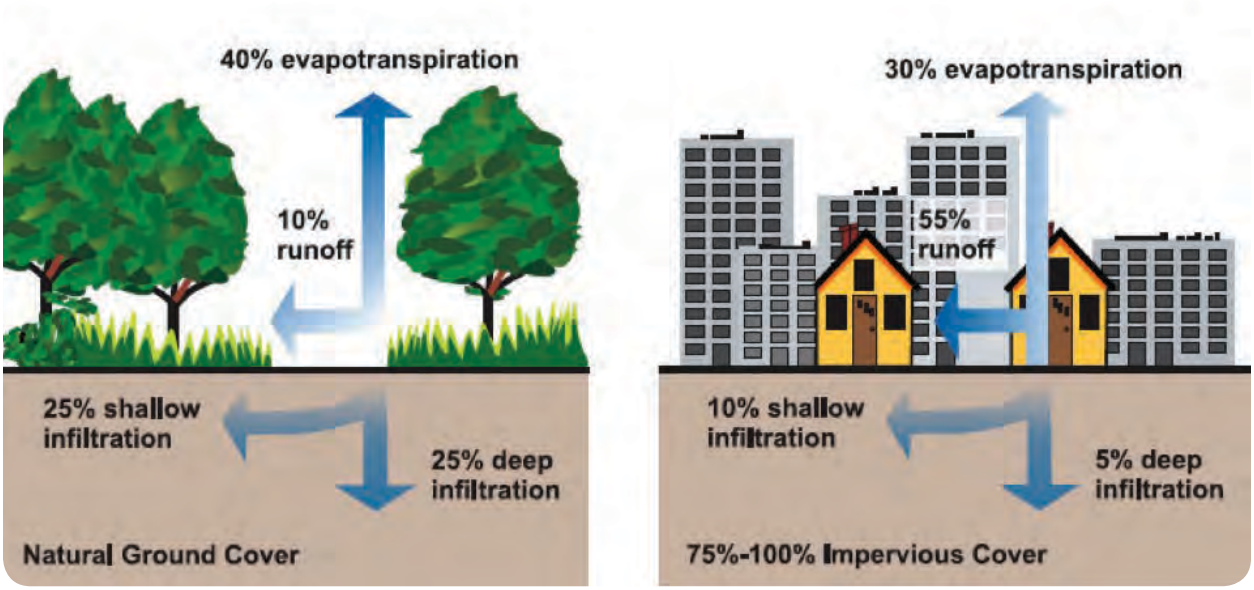


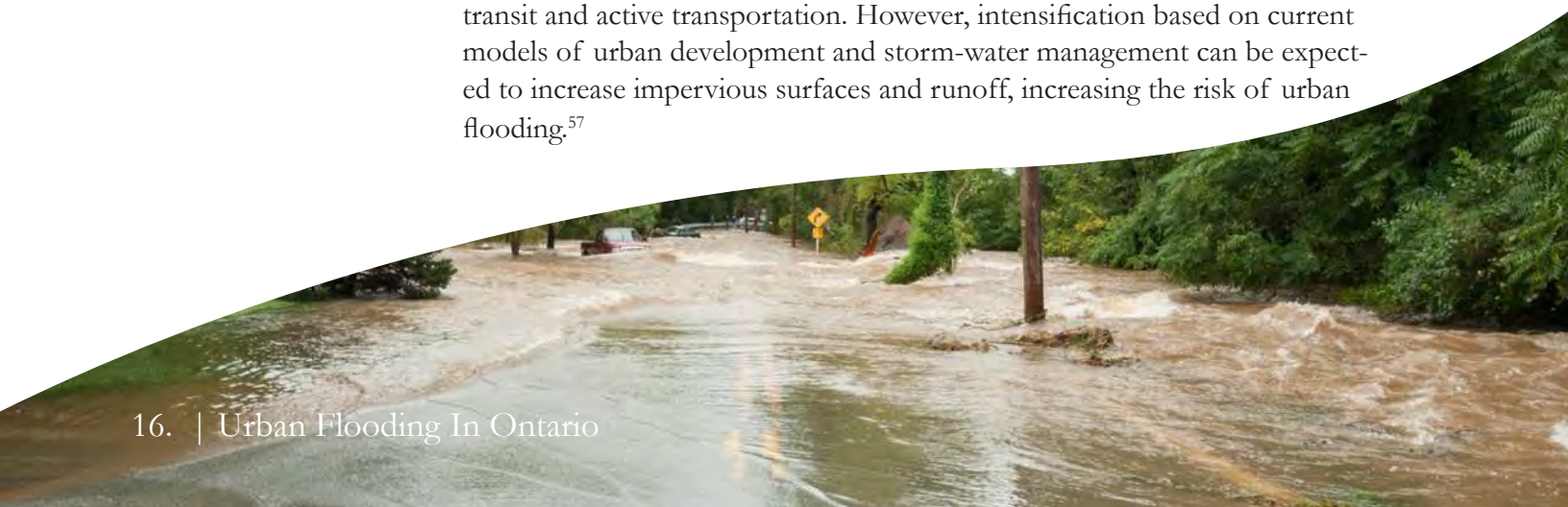
Figure 3. The impact of urbanization on the water cycle and stormwater runoff. Source: US EPA.

27

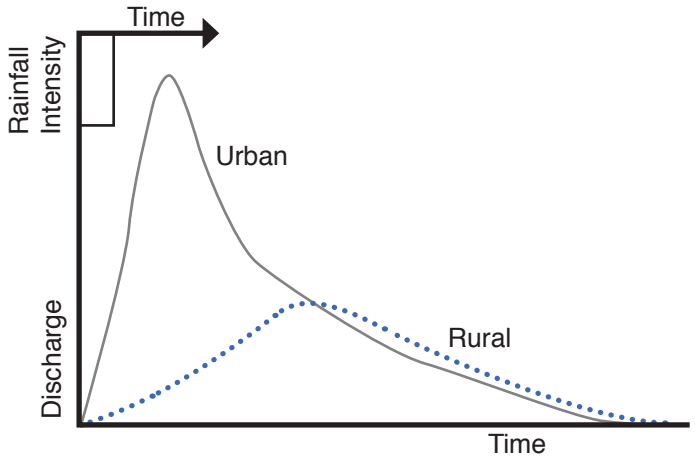
Land use changes have a huge impact on total stormwater runoff volumes – from 10% of rainfall in the figure above to 55% in a highly urbanized environment. In addition, the system also becomes very "peaky." With the increase in impervious surfaces, peak discharges occur more rapidly, peak at higher levels, and last longer.[54, 55] This is crucial during storms when peak flows determine the extent of damage. See Figure 4.

28

Increased frequency and intensity of urban flooding in Ontario is anticipated due to continuing urbanization.[56] The government's "intensification first" policy may be adding to the problem. The Growth Plan for the Greater Golden Horseshoe seeks to accommodate future population growth within existing urban boundaries, as opposed to low-density sprawl. This policy has a number of environmental benefits, including reduced loss of farmlands and natural heritage due to urbanization, a reduced carbon footprint, more efficient use of land and infrastructure, and increased success for public transit and active transportation. However, intensification based on current models of urban development and storm-water management can be expected to increase impervious surfaces and runoff, increasing the risk of urban flooding.[57]



Flood hydrographs for urbanized and natural drainage basins



Runoff peak discharges in urbanized compared to natural drainage systems. Source: Credit Valley Conservation Authority "Low Impact Development Stormwater Management Planning and Design Guide

Aging infrastructure

29 In modern Ontario developments, stormwater management systems are designed with minor and major systems for conveyance of rainwater. The minor system comprises the buried pipes (storm sewers) designed to convey more frequent rainfall events such as the one-in-five-year storm. The major system conveys through overland systems (streets, swales) runoff from less frequent but heavier rainfalls of up to a one-in-100-year return period.[59] Other flood management measures include underground tanks and dry and wet ponds to hold and gradually release floodwaters.

30 Generally, these flood management measures are effective. Newer developments are more likely to flood due to poor water management at the lot level (downspouts directing toward foundations or poor lot grading), or because of high groundwater.

31 However, much of the development in urban areas across Ontario occurred before these flood management measures were common practice. These neighborhoods often have very poor flood management, if any. Further, they often have sewer systems built decades ago with different demands in mind; and aging and sometimes neglected infrastructure is failing to keep pace.[58] Because we see only a small portion of the stormwater management systems in the form of manholes and sewer grates in roadways, 78% of Canadians think our stormwater infrastructure is modern and up to date. In reality, Ontario's stormwater management system is vast and aging, and many areas are in need of upgrading. The typical service life of stormwater infrastructure is 30-100 years, and much existing infrastructure is past its prime.[60] Local

governments face over $55 billion in replacement costs for failed systems, while 50% of local governments assessed in the 2012 Canadian Infrastructure Report Card have no data on the state of their stormwater infrastructure.[61] The 2016 Canadian Infrastructure Report Card reports extrapolated replacement values of stormwater management assets in poor or very poor condition at $10 billion. In the absence of adequate funds to maintain, replace, and upgrade drainage systems, deteriorating infrastructure is a leading driver in increased urban flood risk.[62, 63] See City of Mississauga's Drainage and Flooding (2010) for more on the relationship and impact of infrastructure conditions on urban flooding.

Climate change

32 One consequence of a warming climate will be an increase in extreme wet weather events. As temperatures increase, so does the amount of water held in the atmosphere, at a ratio of about seven percent more water per degree Celcius.[64]

33 Ontario has experienced a 1.4°C increase in annual temperature over the past 60 years, with projected increases of 2.5°C to 3.7°C by 2050.[65] The Intergovernmental Panel on Climate Change specifically references Ontario for impacts of climate change on urban flooding, projecting a decrease in snowmelt-induced floods and an increase in rain-induced floods.[66]

34 Ontario's Ministry of the Environment and Climate Change notes that "as a result of climate change, stormwater management facilities constructed today will be expected to perform under climatic conditions that may be significantly different than the recent past."[67] As currently structured and funded, Ontario's flood management system does not have the capacity to cope with the resulting changes in flood patterns from climate change.[68]

RESPONSES

35 Who is responsible for fixing urban flooding in Ontario? Our review found numerous players with a degree of responsibility and involvement in various aspects of urban flooding, but no clear or defined chain of responsibility. The parties involved include municipalities, the provincial and federal governments, conservation authorities, nongovernmental organizations, the insurance industry, academic institutions, contractors, developers, consultants, academics, property owners, and others. No single entity is in charge of leading the effort to solve this challenging and pressing issue, nor is there any organized coordination among the players. This section provides an overview of current activities and mandates as a basis for increased collaboration.

Federal government

36 Through the Disaster Financial Assistance Arrangements (DFAA) administered by Public Safety Canada, the federal government provides relief funds to provinces following natural disasters; see Figure 4 and Figure 5 in Appendix A for DFAA payments. In Ontario, DFAA funds are administered through the Disaster Recovery program, which provides assistance to homeowners, small businesses, small farms, and non-profits to cover uninsured losses. Only low income households are eligible to receive funds for damage due to sewer backup, as this is normally covered by insurance.[69]

37 The federal government is also a funder of municipal stormwater infrastructure.

38 Environment and Climate Change Canada (ECCC) collects weather and climate data and develops rainfall intensity-duration-frequency (IDF) curve information, which is widely used across Canada for stormwater management planning.

39 The Infrastructure and Buildings Working Group (IBWG), part of the Natural Resources Canada Adaptation Platform, has developed resources related to urban flood risk reduction.[70] Cities Adapt to Extreme Rainfall comprises 20 case studies of communities addressing risks associated with extreme rainfall.

40 The Canadian Environmental Protection Act broadly addresses the treatment of stormwater before runoff containing toxic substances reaches ecosystems.[71] The Fisheries Act similarly includes protection of fish habitat from stormwater effluent and runoff.[72]

41 The Government of Canada has recently launched Flood Ready, a public awareness campaign that provides an overview of overland urban flooding, the cost of flooding, reasons and ways to be "flood ready". The guide also outlines community flood planning steps, tools, and government programs.

42 Floodplain mapping that accurately delineates flood hazards serves as a necessary precondition for urban flooding mitigation activities and is therefore the first step to increasing community resilience with regard to flooding. Natural Resources Canada in partnership with Public Safety Canada published in March 2017 the first version of the Federal Floodplain Mapping Guidelines Series aimed at establishing a national approach to floodplain mapping that will facilitate a common best practice and improve the sharing and use of flood hazard information. This will contribute to the development of a better foundation from which further mitigation efforts can be initiated.

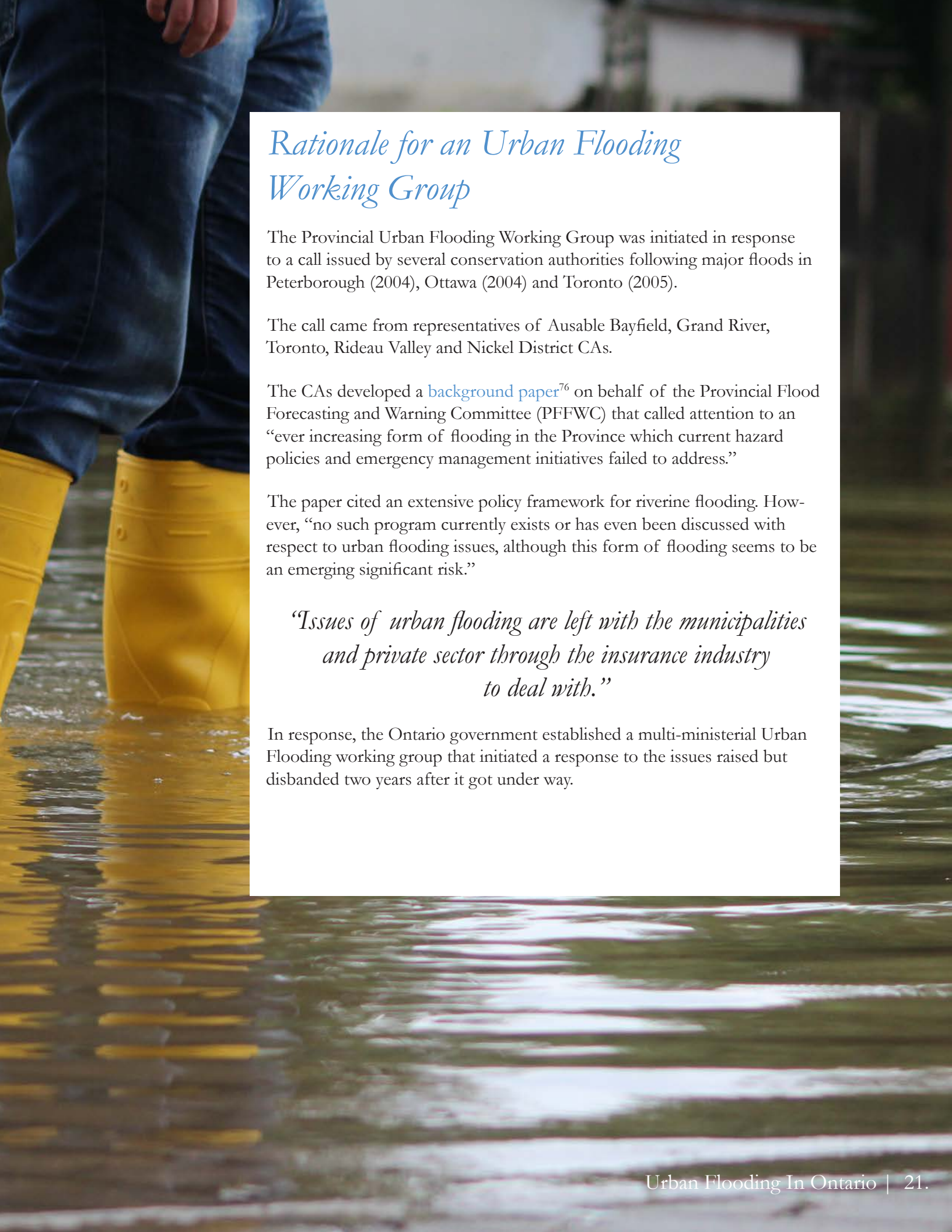
43 The Flood Plain Characterization Program at the Canada Centre for Mapping and Earth Observation (CCMEO) of Natural Resources Canada is carrying out development of earth observation (EO)-based techniques and methodologies for a) pre-disaster risk and vulnerability analysis to support urban flooding disaster preparation and b) timely delineation of urban flooded areas to support flooding disaster response management.[73]

Ontario government

44 The Ontario government is involved with urban flooding in a variety of ways. Like Ottawa, Queen's Park funds stormwater infrastructure, and provides flood-related disaster relief.[74] The provincial government is also responsible for establishing the legal and policy context for stormwater management, including flood management, and for providing advice and guidance.

45 In 2008, the province initiated a Provincial Urban Flooding Working Group, jointly chaired by the Ministry of Natural Resources and Forestry and the Ministry of Municipal Affairs and Housing. The Working Group comprised members from provincial ministries, municipalities, conservation authorities and other relevant organizations including the Institute for Catastrophic Loss Reduction, the Insurance Bureau of Canada, and Environment Canada. The Working Group's main product was a framework for a Provincial Urban Flooding Strategy, which identified the following elements: governance; knowledge, data and research; urban drainage systems and infrastructure; funding; and education and public awareness. The Group also created a Municipal Stormwater Management and Urban Flooding Survey, though it is unclear whether the survey was ever undertaken. A Roles and Responsibilities document detailed relevant legislation at all government levels and CAs. However, by 2010 Working Group activity tailed off without further work on developing and implementing the strategy.[75]

"Ontario must begin adapting to climate change immediately ..."



Rationale for an Urban Flooding Working Group

The Provincial Urban Flooding Working Group was initiated in response to a call issued by several conservation authorities following major floods in Peterborough (2004), Ottawa (2004) and Toronto (2005).

The call came from representatives of Ausable Bayfield, Grand River, Toronto, Rideau Valley and Nickel District CAs.

The CAs developed a background paper[76] on behalf of the Provincial Flood Forecasting and Warning Committee (PFFWC) that called attention to an "ever increasing form of flooding in the Province which current hazard policies and emergency management initiatives failed to address."

The paper cited an extensive policy framework for riverine flooding. However, "no such program currently exists or has even been discussed with respect to urban flooding issues, although this form of flooding seems to be an emerging significant risk."

"Issues of urban flooding are left with the municipalities and private sector through the insurance industry to deal with."

In response, the Ontario government established a multi-ministerial Urban Flooding working group that initiated a response to the issues raised but disbanded two years after it got under way.

46 In 2010, in response to an application under the Environmental Bill of Rights, the Ontario Ministry of Environment produced a key document: Policy Review of Municipal Stormwater Management in Light of Climate Change. The Review was deemed to be consistent with a 2009 report by the Expert Panel on Climate Change Adaptation, Adapting to Climate Change in Ontario.[77]

47 The Policy Review was the product of a working group comprising over 20 agencies, including provincial and federal ministries, municipalities, conservation authorities, and the Municipal Engineers Association. The Review identified stormwater management issues related to urbanization, infrastructure deficiencies (including combined sewers and inflow and infiltration), and climate change. It concluded: "Ontario must begin adapting to climate change imminently, and should not wait for climate change models to evolve to the desired level," notwithstanding the lack of localized climate impact projections.

48 The Review called for a policy framework to support "resilient municipal stormwater management systems and adaptation to climate change and other identified stressors, for new and existing developments." (emphasis added) Other recommendations called for:

a. updating the 2003 Stormwater Management Planning and Design Manual

b. public education, demonstration projects, and incentives to promote resilient stormwater management, in particular source control.

c. a collaborative effort by multiple Ontario government departments, municipalities, and conservation authorities to "seek solutions for resilient municipal stormwater management systems"

49 The Review supported a hybrid of conventional conveyance and end-of-pipe stormwater management and source controls, including low impact development/green stormwater infrastructure. The Review recommended that the Ministry approval process be revisited to promote source control best practices.

50 The Review acknowledged the lack of a provincial regulation specifically for stormwater. However, it concluded that new regulations (e.g., under the Water Opportunities and Water Conservation Act) are unnecessary. Instead, with appropriate revisions to guidance and approvals process, "the Ontario Water Resources Act and the Environmental Protection Act are anticipated to provide a sufficient legislative framework for implementing adaptation to climate change for municipal stormwater management." No detail is provided.

51

In 2015, the Ministry of Environment and Climate Change released an interpretation bulletin clarifying the first priority of provincial stormwater management policy: to manage rain where it falls and reduce runoff volumes. In 2016, MOECC initiated development of a Low Impact Development Guidance document, as complement to the 2003 stormwater manual (and an alternative to a complete update).

52

As part of the LID Guidance Document, the Ministry began to develop its stormwater runoff volume control expectations. When implemented, new developments and major redevelopments will be required to eliminate runoff for all but major storms, and to replicate natural pre-development hydrology. The new volume control expectations represent a paradigm shift in provincial stormwater policy and practice. On average (depending on geographic location) new developments and major redevelopments will be required to retain more or less the first inch of rainfall onsite as a condition of being granted Environmental Compliance Approval.

53

further action will be needed to address resilience for existing/ new developments

A consultant's report to the Ministry says runoff volume control will contribute to "urban flood and combined sewer overflow prevention" by achieving "reduced volume and peak flows, as well as delayed time-to-peak.".[78] However, there appears to be limited research to quantify the contribution to flood-risk reduction of green infrastructure. One installation, The Elm Drive demonstration site in Mississauga, was shown to delay the peak discharge of stormwater by 20 minutes and slow the rate at which stormwater enters overburdened storm sewers during the 8 July 2013 storm. Volumes were reduced 30%, reducing stress on infrastructure, providing erosion control, and reducing pollutants entering storm sewers and streams.[79] In a study monitoring six LID sites across Canada, several reduced volumes by over 90%, even during storms greater than 30mm. One bioretention site in Montreal showed no outflow for all 204 events monitored, even during a 36.7mm event.[80] Several cities in the U.S. are investing billions in green infrastructure for the reduction of combined sewer overflows.

54

The Ontario government's climate change adaptation plan has been promised for 2017, and should provide an opportunity to revisit specific commitments to address urban flooding. In addition, a chapter on climate change is planned for the LID Guidance Document under development in 2017.

56 Ontario land-use policies under the Ministry of Municipal Affairs and Housing have been updated to increase attention to climate resilience and LID/green infrastructure measures. The 2014 Provincial Policy Statement under the Planning Act includes a definition of green infrastructure, and various statements promoting green infrastructure and LID to address water quality and quantity. The need for climate adaptation is also cited. These land-use policies are expressed largely in terms of aspirational goals rather than explicit and specific requirements. Further, they address only developments requiring planning approvals, so it appears they will have little impact on the existing developed landscape.

57 The proposed growth plan amendments under the province's Coordinated Land Use Planning Review support the need to address flooding. The proposed new growth plan requires stormwater master plans for settlement areas throughout the Greater Golden Horseshoe. The plans will be informed by watershed planning and will address flood risk vulnerability, subject to provincial guidance for stormwater management and watershed planning yet to be developed.

58 The Institute for Catastrophic Loss reduction has pressed for amendments to the Ontario Building Code to increase flood resilience, viewed by the environment ministry as an "opportunity to enhance existing stormwater and water conservation measures."[81] Proposed Building Code changes have been released for public review that include a requirement for sewer backflow prevention in all new houses.[82]

Municipalities

59 Municipalities are on the front lines for stormwater and flood management. Impacts of flooding are felt most intensively within communities, including costly damage to municipal infrastructure, homes, businesses, and public institutions.[83] Municipalities have primary responsibility for stormwater management, infrastructure, emergency planning, land use, development approvals, and building code enforcement. Municipalities are also responsible for localized climate change adaptation planning, a complex technical process with limited senior government support.

60 Many municipalities in Ontario and across Canada have employed various measures to mitigate urban flooding in their region.[84] For example, Markham has prohibited construction of reverse-sloped driveways. Ottawa requires sewer backflow prevention valves in new construction. Stratford invested in above-standard stormwater systems designed to handle 250 year storms. Welland is using an infrastructure vulnerability tool (PIEVC) to design and

manage its stormwater system based on rainfall Intensity-Duration-Frequency (IDF) curves under climate change.[85] Thunder Bay provides a rebate for drainage measures of up to 100% of cost, to a maximum of $500 including sump pump and weeping tile disconnections, and backflow prevention. London, Ontario offers a basement flooding grant program to help property owners disconnect weeping tiles from sewers and install backwater valves.[86] Hamilton addresses basement flooding through its Protective Plumbing Program which provides $500 in rebates for backwater valve installation.[87] Peel Region offers a Downspout Disconnection and Backwater Valve Rebate program.[88]

61

Some municipalities are incorporating flood management in stormwater management master plans. The Lake Simcoe Protection Plan requires development of stormwater master plans in the Lake Simcoe basin.[89] See Orillia,[90] Barrie,[91] East Gwillimbury,[92] and Innisfil[93] plans, which include flood reduction measures such as stormwater retrofits, special policy areas, stormwater fees and credits, and low impact development.

62

Safe overland routes for floodwaters (a "major system") can play a big role in addressing urban flooding,[94] but older communities often lack a major system. Municipal flood management plans have been developed, largely by municipalities who have experienced major flood events. Thunder Bay identified several hundred potential sites for stormwater best management practices.[95] Cornwall developed a comprehensive plan to deal with issues such as basement flooding mitigation and water infrastructure awareness.[96]

63

Funding for stormwater infrastructure maintenance and upgrades is a challenge faced by many Ontario municipalities. Several municipalities are creating a sustainable funding source by implementing stormwater user fees (also known as the stormwater utility model), in which property owners pay for stormwater services based on the area of impervious surface.[97] Charging fees based on impervious area is fairer because it shifts the financial burden of stormwater management to properties that contribute the largest volumes, e.g., parking lots. Municipalities can also use volumetric stormwater user fees to promote runoff volume reductions by offering credits and incentives for implementing source control measures. The stormwater utility model is widely used by US cities, sometimes in conjunction with innovative market-based instruments.[98] In Ontario, Mississauga,[99] Kitchener-Waterloo,[100] and Vaughan,[101] have launched stormwater charges, and Guelph is proceeding,[102] Toronto is studying a similar approach.

The stormwater utility model is widely used by US cities

64 Toronto's Wet Weather Master Plan includes an extensive Basement Flooding Protection Program, which involves studying basement flooding areas across the city and implementing solutions. Solutions include upgrading stormwater systems and providing subsidies for lot-level flood prevention measures. Toronto also has a mandatory downspout disconnect program which makes it illegal to connect roof drains to storm or sanitary sewers.

65 In May 2016, City of Toronto was selected to join 100 Resilient Cities Network. A Chief Resilience Officer is being hired to work with leaders in the private, government, and non-profit sectors to respond to the resilience challenges ahead.[103]

66 Peterborough experienced major floods in 2002 and 2004. Recent flood reduction efforts include a $3.5 million catch-basin installation, with financial support from the province.[104] Flooding solutions include relief and diversion storm sewers, and upgrading storm sewers to 100-year capacity.[105] A major diversion project is designed to prevent repeat flooding by a creek that winds through the downtown, with $27.1 million funding already made available.[106]

67 Mississauga's Cooksville Creek Flood Evaluation Study highlights flood reduction options, including more traditional mitigation measures (enlarging road/railway crossings, channels, flood proofing, etc.) and non-traditional stormwater management alternatives such as LID measures and treatment train approaches.

68 Many Ontario municipalities are addressing combined sewers and overflows. In St. Catharine's, where 15% of the sewer system carries both storm and waste water, 1,486m3 of sewer separation projects were planned.[107] See the 2013 Great Lakes Sewage Report Card for more information and a rating of 12 Ontario cities and their efforts to address CSOs. Ottawa has implemented Combined Sewer Overflow (CSO) Real Time Control (RTC) System to fully utilize the existing wastewater collection to minimize CSOs. In addition, Hamilton has initiated an RTC system for CSO control, with Phase 1 completed as of January 2017 and Phase 2 underway.[108]

69 Note that these are just examples of some of the actions Ontario municipalities are undertaking and not a comprehensive list.

Conservation Authorities

70 A system of watershed-based Conservation Authorities (CA) is in place throughout southern Ontario, with a mandate that includes water management. However, CAs generally focus on mitigation of riverine flooding, including mapping of riverine flood plains and maintaining works such as dams and berms. Urban flooding is not part of the CA mandate through the Conservation Authorities Act.[109] The 2016 Conservation Ontario submission of the Act did not mention urban flooding.[110]

71 However, a number of CAs are engaged in addressing the issue. Following the extreme rainfall on 8 July 2013, Peel Region and Mississauga undertook a joint vulnerability assessment for the watershed, with participation of Credit Valley Conservation Authority. A management strategy was recommended, including stormwater ponds, increased creek conveyance, and retrofitting parts of the watershed with LID.

72 Credit Valley Conservation is developing a decision support tool, funded by the National Disaster Mitigation Program, which will quantify the risks and costs with extreme rainfall events, including impacts on vulnerable populations and health. The tool will help municipalities prioritize investments based on the current state of infrastructure, the environment, and community needs.

73 Three CAs—Toronto, Lake Simcoe, and Credit Valley—are updating their 2010 Low Impact Development Planning and Design Guide, which will include advice on the use of LID for flood control.

74 Several CAs and municipalities are partnering to develop a framework for implementing "decentralized stormwater management practices" on private lands through public-private partnerships. The framework will harness economies of scale, grants, and stormwater utility incentives to achieve economic efficiencies in design, construction, operation, and maintenance.

75 Credit Valley Conservation Authority's Climate Change Vulnerability Assessment will continue updating hydrologic models and design storms used for generating peak flows. Flood inundation maps (including urban and riverine flooding) will be developed to quantify flood vulnerability, now and in the future. Vulnerable buildings and infrastructure will be identified.

76 Ganaraska Conservation Authority has used 3D modelling to assist Cobourg in understanding how its stormwater management system functions during times of flooding.

77 This section as well is not a comprehensive list of all Conservation Authority activities on flooding.[111]

Others

78 Many nongovernmental organizations are involved in actions to address urban flooding. This section includes a brief summary of activities.

79 The Institute for Catastrophic Loss Reduction (ICLR) is an independent, not-for-profit research institute affiliated with Western University, established by Canada's property and casualty insurance industry. ICLR has produced numerous reports authored by Dan Sandink and others on homeowner flood reduction[112] and on ways local governments seek to influence private behavior.[113] ICLR notes that lot-level flood reduction measures must be tailored to the individual property, and are necessarily idiosyncratic.[114, 115] ICLR also co-chairs the Infrastructure and Buildings Working Group, part of Canada's Adaptation Platform.[116]

80 Green Communities Canada (GCC), a national non-profit, addresses urban flooding through its RAIN Community Solutions programs. GCC is leading development of this report, as part a collective impact project to address urban flooding. GCC's Groundbreakers program works with vulnerable neighborhoods to reduce flood risk at a neighborhood scale by installing rainwater harvesting and infiltration landscaping to reduce peak volumes and repeated flooding. The award-winning RAIN Home Visit program engages homeowners through a hands-on site visit in managing rain on their property and keeping their basements dry. The Soak it Up! Toolkit identifies community programs and policies for changing the way rain is managed across the urban landscape.

81 The Green Infrastructure Ontario Coalition (GIO) is a unique multi-sectoral alliance that provides input on related policy issues, including runoff volume reduction expectations, asset management, infrastructure funding.[117] land-use planning, Great Lakes water protection, and climate adaptation and resilience.[118]

82 Partners for Action (P4A) is an applied research network advancing flood resiliency in Canada, founded by The Co-operators Group Ltd and Farm Mutual Reinsurance Plan Inc. A 2016 study At the Front Lines of Flood: How prepared are Canadian communities? examines flood resiliency of smaller Ontario communities through interviews with municipalities, First Nations, and Conservation Authorities.[119] P4A's website FloodSmartCanada shares information related to floods, flood risks, and emergency preparedness.

83 The Intact Centre on Climate Adaptation, supported by Intact Insurance, conducts applied research on cost-effective adaptations to extreme weather events. The Centre's Homeowner Adaptation Assessment Program (HAAP).[120] is similar to the RAIN Home Visit program created by Green Communities Canada. A recent report Climate Change and the Preparedness of Canadian Provinces and Yukon to Limit Potential Flood Damage recommends that provinces and territories each appoint a Chief Adaptation Officer with responsibility for flood mitigation, issue audited flood preparedness reports, restrict development in flood zones, and replace damaged infrastructure with climate resilient infrastructure ("Build Back Better").

84 The Insurance Bureau of Canada (IBC) developed the Municipal Risk Assessment Tool (MRAT) (now owned by Tesera systems)[121] to help municipalities identify risks and vulnerabilities in their sewer and stormwater infrastructure, and prioritize capital investments. MRAT identifies high-risk neighborhoods that would most benefit from flood mitigation measures and is being piloted in three cities: Coquitlam, BC; Hamilton, ON; Fredericton, NB.[122, 123]

85 Engineers Canada established the Public Infrastructure Engineering Vulnerability Committee (PIEVC),[124] which developed a tool for assessing the vulnerability of public infrastructure to flood and other climate-related risks. The tool is about "design, construction, maintenance, and regulation" of public infrastructure rather than flood-risk reduction.

86 International Council of Local Environmental Initiatives (ICLEI) Canada is leading a Collective Implementation Group (CIG) Project consisting of about 13 municipalities in Southern Ontario to address climate adaptation issues, including flooding prevention.[125]

87 Ontario Coalition for Sustainable Infrastructure (OCSI)[126] is an umbrella organization that presses for sustainable infrastructure funding.[127]

88 The Canadian Water Network aims to put research into the hands of decision-makers. CWN's 2015 Canadian Municipal Water Priorities Report[128] identified four priority areas, including resilience to storms and extreme weather. The report confirmed an increased focus on options for municipalities to manage stormwater as a resource, and the move to long-term planning models which include combinations of grey and green infrastructure approaches.

89 The Federation of Canadian Municipalities promotes Sustainable Neighbourhood Development,[129] including the use of green stormwater infrastructure for stormwater management.[130] Stormwater infiltration projects are eligible for support from FCM's Green Municipal Fund.[131] FCM is receiving $75 million in new funding from the federal government "to support the development of resilient and low-carbon cities and communities."[132]

90 The Municipal Natural Capital Initiative is developing ways to value, protect, restore, and/or imitate natural assets that provide valuable services to municipalities, including flood-risk reduction. Project partners are currently working with pilot municipalities.[133]

91 Ryerson University's Urban Water department is developing an Integrated Water Resource Evaluation Tool in collaboration with Waterfront Toronto, Toronto Water, and Toronto Region Conservation Authority. Ryerson's decision-making support tool compares the sustainability performance of alternative strategy and technologies for integrated urban water management. Ryerson Urban Water (RUW) is a multi-disciplinary collective of research experts whose objective is to provide practical solutions to urban water challenges.

92 At University of Western Ontario, an Intensity-Duration-Frequency Climate Change tool for projecting future rainfall is being developed.[134] The Ontario Climate Change Data Portal provides precipitation projections with the latest climate data under low and extreme climate scenarios.[135]

93 Dr. Andrew Binns at the University of Guelph examines the relationship between flooding and urban land-use as part of FloodNet's Project 1-5 (spatial changes to flood prone areas in urban environments).[136] Project outcomes include: updated urban development guidelines to minimize risk of flooding; an evaluation of the effectiveness of various stormwater management features; stormwater retrofit recommendations for Canadian cities; and engineering guidelines for flood-resilient waterway modifications.[137]

THE CASE FOR COLLECTIVE IMPACT

94 Our research confirms that urban flooding is an urgent issue for Ontario, with multi-billion dollar economic impacts for homeowners, businesses, municipalities, senior governments, the insurance industry, and others. In addition, urban flooding has health, environmental, and social impacts. Further, compounding factors suggest that urban flooding will become more severe over time due to land-use changes (impervious area, intensification), inadequate and deteriorating infrastructure, and climate change.

95 Urban flooding in Ontario is a complex problem, rooted in the cumulative impact over decades of multiple land-use and infrastructure practices across hundreds of thousands of properties and thousands of square kilometres. Urban flooding arises from the very nature of the cities we have created and the way we manage rain on the landscape—complicated by infrastructure deficiencies and the impending increase in severe wet weather events.

96 The problem of urban flooding is being acknowledged with dozens of reports and conferences (albeit often failing to make the distinction between urban and riverine flooding, and often focusing on climate change rather than land-use and infrastructure).

97 Action is being taken by a wide range of governmental and non-governmental organizations in attempts to solve this problem. Actions fall into broad categories:

- Stormwater system upgrades (grey infrastructure)
- Incentivizing, encouraging or requiring action on private properties (flood proofing and disaster preparedness)
- Predicting flooding (floodplain mapping and updating IDF curves)
- Research on impacts of flooding
- Green infrastructure as a method of urban flood reduction

98 Currently, there is isolated collaboration among different actors on different projects, but a more deliberate, organized approach is needed to address of problem of this scale, scope, and complexity. Current activities need to be better coordinated so that scarce resources are put to the best use. As these diverse organizations plan their future activities there is a great opportunity to work together to solve this problem that continues to threaten our communities.

99 The collective impact approach will allow a broad range of stakeholders to come to an agreement on a shared mission and vision, shared indicators to measure progress, and a collective theory of change and work plan to guide future activities. Together, we will identify gaps that must be filled and create a plan for how to fill them.

ACTIONS

As a prompt for discussion, we offer the following list of potential actions. The collective impact process (Phase 2) will develop consensus about priorities for action, and determine the role of stakeholders in a coordinated approach. The options here are listed in random order. Are these suitable options for consideration? Are there others that should be on the list?

NOTE: the options for action outlined below are not recommendations. They are designed to provoke thought and solicit feedback.

A

Establish a collaborative working group to "seek solutions for resilient municipal stormwater management systems" involving multiple ministries and other stakeholders (as recommended in the Policy Review of Stormwater Management in Light of Climate Change). This working group could complete the strategy outlined by the disbanded provincial Urban Flooding Working Group. Should this group be hosted outside government in order to help ensure broad participation, continuity, and a collaborative "collective impact" approach?

B

Clarify roles and responsibilities with respect to urban flood-risk reduction, including leadership roles. Establish a permanent multi-ministerial and multi-stakeholder vehicle for provincial-level collaboration on urban flood risk reduction, possibly in the context of a broader water management mandate.

C

Implement full public disclosure of all combined sewer overflow and sewage bypass events. Adopt regulatory requirements for eliminating CSOs in a timely manner, as in the US, based on water quality protection. Evaluate least-cost measures to address CSOs.

D

Implement systematic flood prevention retrofits of buildings using tools such as incentives, financing, and mandatory installation at time of sale.

E

Conduct a formal review of the recommendations outlined in the Policy Review of Municipal Stormwater Management in Light of Climate Change. What has been accomplished? What remains to be completed? What is the plan for moving forward? What changes are needed? This progress report could take the form of a public workshop, including original participants in the multi-agency working group, to discuss a formal document.

F Clarify the legislative/regulatory/policy framework that will drive action across the landscape, potentially including stormwater effluence quality and quantity standards based on receiving water carrying capacity. How can the Ontario Water Resources Act and Environmental Protection Act meet this need? Do we need (also) to establish regulations for water sustainability planning under the Water Opportunities and Water Conservation Act, as some have suggested?

G Make federal/provincial infrastructure financing for stormwater management conditional on established municipal asset management plans that include least-cost planning for flood-risk reduction (including CSOs where appropriate).[138]

H Incorporate expectations and support for flood prevention in provincial emergency relief in order to ensure that relief spending results in increased resilience.[139, 140]

I Establish conservation authorities as the lead for developing, implementing, and maintaining local urban flood-risk reduction strategies, in partnership with their municipalities and the province.

J Identify and evaluate effective urban flood-risk reduction measures, including overland flood routes, detention, and green stormwater infrastructure/LID. Research and document best practices, including monitoring, results, maintenance, cost. Quantify effectiveness.

K Build technical capacity for design and construction of flood risk reduction measures, including training, research, and advice.

L Establish a multi-sectoral integrated water management collaborative or institute – build skills and capacity, share best practices, coordinate research, promote benefits.

M Provide detailed guidance for the preparation of stormwater management master plans, including urban flood management. Require stormwater management master plans province-wide for all settled areas (not only the Greater Golden Horseshoe).

N Map areas subject to flooding, including urban and riverine flood zones. Restrict development in identified urban areas subject to urban flooding, pending the adoption of local flood risk-reduction/management plans.

O Address the full range of building code amendments required to make new buildings more flood proof.

P Undertake a partnership-based public engagement campaign to improve understanding and uptake of lot-level and community-level actions. This could include outreach, events, and demonstration projects. Establish a province-wide site visit program for residential and commercial property owners. Undertake projects with flood-vulnerable neighborhoods to identify and implement risk reduction actions.

Q Develop quality management standards or systems (QMS) plan for stormwater and wastewater similar to the drinking water quality management standard, which has proven successful. The QMS would assist municipalities with adaptive management of their infrastructure in light of climate change. The QMS could be a tool to manage risks, document procedures, demonstrate diligence, engage elected officials, and secure commitment to invest in stormwater.

Endnotes

[1] http://albertawater.com/what-is-flooding
[2] http://albertawater.com/what-is-flooding
[3] https://water.usgs.gov/edu/100yearflood.html
[4] https://www3.epa.gov/region1/eco/uep/cso.html
[5] https://www.iclr.org/images/I_I_Best_Practices_Guidelines.pdf
[6] http://www.cornwall.ca/en/municipalworks/sewers.asp
[7] http://www.durham.ca/departments/works/sewer/foundationdrain.pdf
[8] http://www.cnt.org/sites/default/files/publications/CNT_PrevalenceAndCostOfUrban Flooding2014.pdf
[9] http://www.cleanairpartnership.org/webinar4/Climate%20Change%20and%20 Urban%20Flooding.pdf
[10] http://www.grca.on.ca/Case_Study_Flood_Damage_Reduction.pdf
[11] https://trca.ca/conservation/flood-risk-management/history/
[12] http://media.swissre.com/documents/The_road_to_flood_resilience_in_Canada.pdf
[13] Muir, R. "Urban flood risks: from flood plains to floor drains" https://www.slideshare.net/RobertMuir3/urban-flood-risk-from-flood-plains-to-floor-drains
[14] http://media.swissre.com/documents/The_road_to_flood_resilience_in_Canada.pdf
[15] http://www.cbc.ca/news/canada/calgary/canada-flood-damage-costs-insurance-1.3636470
[16] http://0361572.netsolhost.com/images/Urban_Flooding_in_Canada_-_ICLR_-_2013.pdf
[17] http://tvo.org/article/current-affairs/climate-watch/climate-roundup-ontario-flood-risk-increases-despite-driest-season-in-25-years
[18] http://business.financialpost.com/news/fp-street/toronto-storm-the-costliest-natural-disaster-in-ontario-history-for-insurers
[19] activehistory.ca/2013/07/the-toronto-flood-of-2013-decisions-of-the-past-a-warning-for-the-new-normal/
[20] www.thestar.com/news/gta/2013/09/17/flood_will_cost_city_of_toronto_more_than_60_million.html
[21] www.thestar.com/news/gta/2013/09/17/flood_will_cost_city_of_toronto_more_than_60_million.html
[22] http://media.swissre.com/documents/The_road_to_flood_resilience_in_Canada.pdf
[23] http://www.ibc.ca/on/resources/media-centre/media-releases/new-study-estimates-future-costs-of-climate-change
[24] http://sustainabletechnologies.ca/wp/wp-content/uploads/2013/01/LID-SWM-Guide-v1.0_2010_1_no-appendices.pdf
[25] http://www.creditvalleyca.ca/wp-content/uploads/2015/07/Advancing-Low-Impact-Development-as-a-Smart-Solution-for-Stormwater-Management1.pdf
[26] http://assets.ibc.ca/Documents/Natural%20Disasters/Barrel/RainBarrelPilot-Report.pdf
[27] http://media.swissre.com/documents/The_road_to_flood_resilience_in_Canada.pdf
[28] http://www.insuranceinstitute.ca/en/cipsociety/information-services/advantage-monthly/0316-flood-insurance.aspx
[29] http://www.insuranceinstitute.ca/en/cipsociety/information-services/advantage-monthly/0316-flood-insurance.aspx
[30] http://www.cnt.org/publications/the-prevalence-and-cost-of-urban-flooding
[31] http://www.cnt.org/sites/default/files/publications/CNT_PrevalenceAndCostOfUrban Flooding2014.pdf
[32] http://www.cnt.org/sites/default/files/publications/CNT_PrevalenceAndCostOfUrban Flooding2014.pdf

[33] http://www.businessinfocusmagazine.com/2013/09/the-impacts-of-flooding/
[34] https://www.albertacanada.com/files/albertacanada/SP-Commentary_09-06-13.pdf

[35] See Appendix A for a table of DFAA payouts by province and natural disaster type.
[36] Personal communication, manager at Ministry of Municipal Affairs and Housing.
[37] http://www.climateontario.ca/doc/factsheets/RiskManagmentProcess-Final.pdf
[38] http://www.nrcan.gc.ca/environment/resources/publications/impacts-adaptation/reports/assessments/2008/ch6/10363

[39] http://globalnews.ca/news/2064958/after-the-flood-part-iii-mental-health-programs-future-uncertain/
[40] https://www.ec.gc.ca/eau-water/default.asp?lang=En&n=02A71110-1

[41] A study 2015 by Karen Morrison, Ph.D. titled Application of the multiple exposures, multiple effects model to four flood events in Canada: Lessons learned for public health adaptation to extreme precipitation and flooding in the context of climate change explored the effects of urban flooding on public health.
[42] http://www.cnt.org/sites/default/files/publications/CNT_PrevalenceAndCostOfUrbanFlooding2014.pdf

[43] http://sustainablepeterborough.ca/wp-content/uploads/2015/01/Morrison-MEME-Flood_Events-Final_updated.pdf

[44] Personal communication, Clean Air Partnership.
[45] http://albertawater.com/what-are-the-consequences-of-flooding/environmental
[46] http://www.cnt.org/sites/default/files/publications/CNT_PrevalenceAndCostOfUrbanFlooding2014.pdf
[47] https://www.owp.csus.edu/research/wastewater/papers/SSO-Lit-Review.pdf
[48] http://docs.assets.eco.on.ca/reports/environmental-protection/2015-2016/EPR-Small-Steps-Forward_Vol1-EN.pdf
[49] http://www.waterkeeper.ca/blog/2015/6/16/toronto-sewage-bypass-log
[50] http://www.waterkeeper.ca/toronto-sewage/
[51] Flood Risk Mapping for the City of Toronto(2014). http://www.sciencedirect.com/science/article/pii/S2212567114009460
[52] http://www.coastal.ca.gov/nps/watercyclefacts.pdf

[53] https://www.conservationgateway.org/ConservationPractices/Freshwater/HabitatProtectionandRestoration/Documents/A%20Flood%20of%20Benefits%20-%20J.Opperman%20-%20May%202014.pdf

[54] Nirupama, N. & Simonovic, S.P. Nat Hazards (2007) 40: 25. doi:10.1007/s11069-006-0003-0

[55] http://sustainabletechnologies.ca/wp/wp-content/uploads/2013/01/LID-SWM-Guide-v1.0_2010_1_no-appendices.pdf

[56] Urban flooding in Canada: Lot-side risk reduction through voluntary retrofit programs, code interpretation and by-laws, Dan Sandink, February 2013
[57] See Provincial Policy Statement under the Planning Act, 1.1.3.3
"Planning authorities shall identify appropriate locations and promote opportunities for intensification and redevelopment where this can be accommodated taking into account existing building stock or areas …"

[58] https://www.thestar.com/news/gta/2013/07/09/toronto_flooding_released_raw_sewage_in_a_sweep_to_lake_ontario.html

[59] http://www.cnt.org/sites/default/files/publications/CNT_PrevalenceAndCostOfUrbanFlooding2014.pdf

[60] The Canadian Infrastructure Report Card and personal communication from Credit Valley Conservation Authority

[61] http://www.iclr.org/citiesadaptrain.html
[62] Urban flooding in Canada: Lot-side risk reduction through voluntary retrofit programs, code interpretation and by-laws, Dan Sandink, February 2013
[63] Nirupama, N. & Simonovic, S.P. Nat Hazards (2007) 40: 25. doi:10.1007/s11069-006-0003-0
[64] https://www.thestar.com/news/insight/2012/08/19/climate_change_how_toronto_is_adapting_to_our_scary_new_reality.html
[65] http://www.climateontario.ca/doc/factsheets/RiskManagmentProcess-Final.pdf
[66] http://www.ipcc.ch/publications_and_data/ar4/syr/en/contents.html
[67] See MOECC Interpretation Bulleting Expectations RE: Stormwater Management
[68] http://conservationontario.ca/projects/floodstatus/pdf/Protecting%20People%20and%20Property%20_Full_Final%20Report_%202009.pdf
[69] http://www.mah.gov.on.ca/Page13744.aspx
[70] http://www.nrcan.gc.ca/environment/impacts-adaptation/adaptation-platform/17176
[71] http://www.thunderbay.ca/Assets/City+Government/Departments/Dept++T+$!26+W/docs/Stormwater+Management+Plan+for+web+-+Vol.+I.pdf
[72] http://laws-lois.justice.gc.ca/eng/acts/f-14/
[73] Stakeholder feedback, Senior Policy Analyst, Public Safety Canada
[74] The 2005 Finch Avenue Washout ranks as the Province's most expensive natural disaster in Ontario. https://www.thestar.com/news/insight/2012/08/19/climate_change how_toronto_is_adapting_to_our_scary_new_reality.html
[75] http://www.mississauga.ca/file/COM/march30_cooksville_minutes3.pdf
[76] To begin the discussion, a background report to the Provincial Water Directors titled Urban Flooding in Ontario was prepared and presented by the chair of the PFF WC. Link: http://greencommunities.nonprofitwebsites.ca/wp-content/uploads/2016/12/Urban-Flooding-in-Ontario-Background-Report-to-the-Provincial-Water-Directors.pdf
[77] http://www.climateontario.ca/doc/publications/ExpertPanel-AdaptingInOntario.pdf
[78] P. 103, Runoff Volume Control Targets for Ontario: Final Report, October 2016, prepared by Aquafor Beech, Earthfx.
[78] http://www.creditvalleyca.ca/wp-content/uploads/2015/07/Advancing-Low-Impact-Development-as-a-Smart-Solution-for-Stormwater-Management1.pdf
[80] Aquafor Beech (2015). LID Performance monitoring: 6 Canadian case studies. CMHC (unpublished).
[81] https://www.ontario.ca/page/policy-review-municipal-stormwater-management-light-climate-change
[82] Personal communication, steering committee meeting, July 2016.
[83] https://www.iclr.org/images/Urban_Flooding_in_Canada_-_ICLR_-_2013.pdf
[84] http://www.iclr.org/citiesadaptrain.html
[85] http://www.iclr.org/citiesadaptrain.html
[86] http://www.iclr.org/citiesadaptrain.html
[87] https://www.hamilton.ca/home-property-and-development/water-sewer/protective-plumbing-program
[88] http://peelregion.ca/pw/water/sewage-trtmt/basement-flooding.htm
[89] Greening Stormwater Management in Ontario (2011) http://cielap.org/pdf/GreeningStormManOntario.pdf

[90] http://orillia.ca/en/livinginorillia/resources/Environmental_Services/Notice-of-Completion-March-14-2016.pdf
[91] http://www.barrie.ca/Doing%20Business/Development-Services/Documents/City-Standards/StormDrainageandStormwaterManagementPoliciesandDesignGuidelines.pdf
[92] http://www.eastgwillimbury.ca/Assets/5+2015+Government/0.4+Publications/0.1+Town+Plans+and+Strategies/SWMMP-Text.pdf
[93] http://www.innisfil.ca/sites/all/files/uploads/Engineering/Stormwater%20Master%20Plan%20Phase%201%20-%20Text.pdf
[94] https://www.iclr.org/images/Basement_Flood_Handbook_-_ICLR_-_2009.pdf
[95] https://cfapps.thunderbay.ca/TenderDocs/9014/Report%20-%20Stormwater%20Management%20for%20the%20City%20of%20Thunder%20Bay.pdf
[96] http://www.abca.on.ca/news_item.php?ItemID=388
[97] https://media.assets.eco.on.ca/web/2016/11/Urban-Stormwater-Fees.pdf
[98] http://institute.smartprosperity.ca/sites/default/files/stormwaterreport.pdf
[99] http://www.mississauga.ca/portal/stormwater/charge
[100] https://www.kitchener.ca/en/livinginkitchener/Stormwater_Utility.asp
[101] https://www.vaughan.ca/services/residential/stormwater/Pages/default.aspx
[102] http://guelph.ca/2016/03/council-approves-user-fees-to-fund-stormwater-management/
[103] http://www.canindia.com/toronto-selected-to-join-global-100-resilient-cities-network/
[104] http://www.thepeterboroughexaminer.com/2016/02/20/city-of-peterborough-receives-2m-in-provincial-funding-for-35m-marina-boulevard-flood-prevention-project
[105] http://www.peterborough.ca/Assets/City+Assets/Flood+Reduction/Documents/Storm+Drainage+Flood+Reduction+Initiatives/Jackson+Creek+Flood+Reduction+Class+EA++Final+Report.pdf
[106] http://www.mykawartha.com/news-story/6953554-transformation-of-peterborough-s-bethune-street-could-cost-40-million/
[107] http://www.ecojustice.ca/wp-content/uploads/2014/08/FINAL-The-Great-Lakes-Sewage-Report-Card-2013.pdf
[108] Personal communication, City of Hamilton municipal official.
[109] Personal communication, Credit Valley Conservation Authority
[110] http://conservationontario.ca/library?view=document&id=332:conservation-ontario-s-submission-on-climate-change-mitigation-and-low-carbon-economy-act-2016-ebr-012-6844&catid=47:climate-change
[111] http://www.grca.on.ca/Case_Study_Flood_Damage_Reduction.pdf
[112] http://www.basementfloodreduction.com/
[113] Cities Adapt to Extreme Rainfall - http://www.iclr.org/citiesadaptrain.html.
[114] https://www.iclr.org/images/Moncton_release_May_16_2012.pdf
[115] https://www.iclr.org/images/Retrofit_lessons_learned_Sandink.pdf
[116] http://www.nrcan.gc.ca/environment/impacts-adaptation/adaptation-platform/17176#tab-f
[117] http://www.greeninfrastructureontario.org/gio-press-release-cities-need-living-green-infrastructure-well-grey
[118] See GIO's submission titled: The role of green infrastructure in climate change adaptation and resilience.
[119] https://uwaterloo.ca/partners-for-action/what-partners-action-p4a
[120] http://www.intactcentreclimateadaptation.ca/programs/
[121] http://www.ibc.ca/nb/resources/media-centre/media-releases/insurance-bureau-of-canada-and-tesera-systems-inc-announce-transfer-agreement-for-the-municipal-risk-assessment-tool
[122] http://www.cbc.ca/news/business/insurers-zero-in-on-flood-prone-areas-1.2693427
[123] http://www.canadianunderwriter.ca/catastrophes/ibc-tesera-systems-announce-transfer-agreement-bureaus-municipal-risk-assessment-tool-1004088018/

[124] https://pievc.ca/assessments
[125] Personal communication, City of Hamilton municipal official.
[126] http://www.on-csi.ca/
[127] Municipal Engineers Association, Ontario Good Roads Association, Ontario Public Works Association, Ontario Water Works Association,
[128] http://www.cwn-rce.ca/focus-areas/blue-cities/canadian-municipal-water-priorities-report/
[129] https://www.fcm.ca/Documents/tools/GMF/Sustainable_Neighbourhood_Development_Practical_Solutions_to_Common_Challenges_EN.pdf
[130] Under Solutions, it is stated "Given that municipal infrastructure lasts 50–100 years, and the neighbourhood patterns are in place for the life of a city, built-in flexibility is essential to providing long-term value. Practically, this can be as simple as designing flexible layouts for houses or ensuring universally accessible sidewalks and easy transit access for seniors. It could mean avoiding floodplains through cluster development, or even integrating a climate adaptation strategy into early planning phases."
[131] http://www.fcm.ca/home/programs/green-municipal-fund/what-we-fund/projects/water-funding.htm
[132] http://www.fcm.ca/home/media/news-and-commentary/2016/fcm-congratulates-the-federal-government-on-signing-the-paris-climate-change-agreem.htm
[133] http://www.davidsuzuki.org/publications/2016/Call%20for%20Expressions%20of%20Interest%20MNCI_Final_Jan%2027.pdf
[134] See www.ifd.cc.uwo.ca
[135] See www.ontarioccdp.ca
[136] http://www.nsercfloodnet.ca/people/people.aspx?pic=12
[137] See project summary: http://www.nsercfloodnet.ca/files/Project_1_5_Year2_Binns.pdf.
[138] www.greeninfrastructureontario.org/sites/greeninfrastructureontario.org/files/ The_Case_for_Green_Infrastructure_in_Ontario.pdf
[139] In January 2014, 19 mayors and three municipal chairs of the Greater Toronto Area requested disaster relief funding as well as urged for better Provincial leadership for climate adaptation. http://docs.assets.eco.on.ca/reports/climate-change/2014/2014-GHG-Sink-Swim.pdf
[140] For example, the Ministry of Infrastructure did not follow through on mandating in frastructure vulnerability assessments or explain the concept of these tools to municipalities. This represents a lost opportunity to incorporate urban flood mitigation planning in municipal infrastructure plans.

Appendix A

1.4.2.2 Ministry of Environment and Climate Change

The MOECC administers multiple acts with relationships to stormwater management as follows:

Ontario Water Resources Act, RSO 1990, c 0-40	• Regulates stormwater works, including requirements of owners to conduct ongoing maintenance and monitoring • Prohibits the discharge of any material that may impair surface or groundwater quality • Requires erosion controls to protect downstream watercourses • Regulates permits to take water in addition to well construction, operation and abandonment.
Environmental Protection Act, RSO 1990, c E-19	• Prohibits release of contaminants into the natural environments that may cause adverse effects and requires prompt reporting and clean-up of pollutant spills • Requires projects to comply with conditions defined in provincial Certificates and Approval.
Clean Water Act, SO 2006, c 22	• Requires local communities to reduce or eliminate significant existing or potential threats to their municipal drinking water sources through development and implementation of source protection plans and followed by ongoing monitoring and reporting
Safe Drinking Water Act, SO 2002, c 32	• Requires municipal drinking water systems to obtain approval from the Director of the MOECC in order to operate. Operators must be trained and certified to provincial standards. • Defines framework for testing with legally-binding drinking water contaminant standards.
Nutrient Management Act, SO 2002, c 4	• Defines standards for nutrient storage and application and a framework for best practices for nutrient management, to reduce potential for surface water, groundwater, or other environmental contamination.
Environmental Assessment Act, RSO 1990, c E-18	• Requires an environmental assessment of any major public or private undertaking in order to determine the ecological, cultural, economic and social impact of the project. • Establishes a "Class Environmental Assessment" process for planning certain municipal projects, including road, water, and sewage and storm water projects.

The Ministry of Environment and Energy published Water Management: Policies, Guidelines, Provincial Water Quality Objectives (PWQO) in 1994 (also referred to as the Blue Book) to assist in managing quality, quantity of surface and groundwater as required for approval under the Ontario Water Resources Act and the Environmental Protection Act. (20)

Figure 1A. Acts administered by the Ontario Ministry of Environment and Climate Change related to stormwater management. Source: Canadian Environmental Law Association "Fact Sheet: What is the provincial and legal structure around water in Ontario?

Responsibilities of Provincial Ministries Related to Stormwater Management

Ministry of the Environment

- Developed the Stormwater Management Planning and Design Manual to provide guidance for planning, designing, ... operating and maintaining stormwater management infrastructure
- Issues Environmental Compliance Approvals for stormwater infrastructure

Ministry of Municipal Affairs and Housing

- Administers the Provincial Policy Statement, which provides direction to municipalities on land use planning, including restricting development from lands subject to flooding or erosion hazards
- Operates the Ontario Disaster Relief Assistance Program, which provides some compensation for property damaged or destroyed due to natural disasters

Ministry of Natural Resources

- Ministry assigned provincial lead for water-related natural hazards including flood hazards
- Monitors weather, rainfall and stream flows, provides advisories to conversation authorities and MNR district offices on flood potential
- Shares aspects of public safety and natural hazard prevention with municipalities
- Administers Conservation Authorities Act, delegating flood management responsibilities to conservation authorities where they have been established in the province
- Provides, through Emergency Management Ontario, support to municipalities during flooding when municipal resources are overwhelmed

Ministry of Transportation

- Provides design standards for provincial culverts, bridges and highway drainage system

Ministry of Infrastructure

- Is responsible for administering infrastructure investment and managing sustainable growth

Figure 2A. Various Ontario provincial ministries involved in stormwater management and their responsibilities. Source: Environmental Commissioner of Ontario. "Sink, Swim or Tread Water: adapting infrastructure to extreme weather events

DFAA payments by province and territory*

$ millions in 2014

Province	$ all years	% of total	Per capita	2005-2014	% of total	Per capita
NL	296	4%	561	174	4%	329
PE	32	0%	220	3	0%	21
NS	134	2%	143	16	0%	17
NB	269	3%	357	87	2%	115
QC	2,062	25%	251	166	4%	20
ON	387	5%	28	125	3%	9
MB	1,505	18%	1,174	767	19%	598
SK	914	11%	812	812	20%	722
AB	2,325	28%	564	1,758	43%	427
BC	391	5%	84	162	4%	35
NT	9	0%	200	6	0%	131
YT	25	0%	693	12	0%	332

Sources: DFAA and PBO.
Notes: Per capita is based on 2014 population.
*Nunavut isn't included in this analysis since it was only created in 1999 and only has had one event ($5.3 million flood in 2008)

Figure 3A. DFAA payments by province and territory as a percentage of total. Source: Office of the Parliamentary Budget Officer "Estimate of the Average Annual Cost for Disaster Financial Assistance Arrangements due to Weather Events"

Historical DFAA payments by catastrophe

$ millions in 2014	All years	1970-1974	1975-1984	1985-1994	1995-2004	2005-2014
Total all events	8,358	511	465	379	2,907	4,096
Total flood	6,517	458	399	263	1,595	3,803
Flood as % of total	78%	90%	86%	69%	55%	93%
Total convective	213	38	46	116	0	13
Convective as % of total	3%	7%	10%	31%	0%	0%
Total hurricane	222	15	0	0	51	156
Hurricane as % of total	3%	3%	0%	0%	2%	4%
Total winter	1,406	0	20	0	1,260	125
Winter as % of total	17%	0%	4%	0%	43%	3%

Sources: DFAA and PBO.

Figure 4A. Historical DFAA payments and flooding as a percentage of catastrophic events. Source: Office of the Parliamentary Budget Officer "Estimate of the Average Annual Cost for Disaster Financial Assistance Arrangements due to Weather Events"

Appendix B

We circulated the first draft of this paper to over 130 stakeholders and received comments from 35 reviewers. In this second draft, we have incorporated some of the comments we received. Others we were not able to address in this draft of the paper but we intend to address in the next phase of the Collective Impact project (see project description, Appendix C for a description of phase 2). Broad categories of comments we received included:

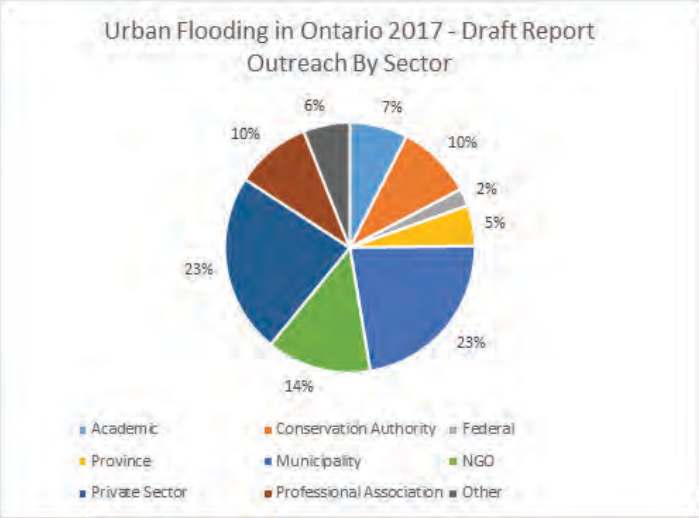
- Suggestions for other stakeholders to get involved (other non-profits, insurers, re-insurers, citizen science groups, private sector)
- Comments on funding models and mechanisms
- Issues specific to smaller municipalities and municipalities where conservation authorities are not in place
- Comments on the use of green infrastructure for flood mitigation (both for and against)
- Comments on the impacts of climate change on urban flooding
- Data sharing

Urban Flooding Collective Impact Project

Urban flooding is a complex problem with multiple causes and impacts across Ontario. Many different groups - governments at all levels, property owners, non-profit organizations, professional associations, the insurance industry, academics - are working to find and implement solutions. Green Communities Canada (GCC) believes that there is a need for greater collaboration among these groups in order to achieve the shared goal of reducing urban flood risk in Ontario. We aim to bring these diverse stakeholders together as part of a Collective Impact project to create and implement a coordinated action strategy to address urban flooding.

We define urban flooding to include surface flooding caused by overwhelmed stormwater system capacity, basement sewer backups, infiltration flooding in basements, and wastewater treatment bypasses and overflows.

GCC is proposing a collaborative approach to addressing this complex issue is known as "collective impact." This is an increasingly popular way of tackling the big problems in our society and our communities that have no easy solutions. Urban Flooding Collective Impact is a three-phase project structured as follows:



- **Phase one (2016-17).** Phase one, currently nearing completion, will result in the generation of a report[1] that includes a proposed definition of urban flooding, impacts, key drivers, and current activities to address the problem. The document has been circulated to over 130 key stakeholders, and comments have been received from over 35 reviewers to date. Once reviewer input has been incorporated, the report will provide a foundation for working together to develop an action strategy.

- **Phase two (2017-19).** Pending funding, phase two will engage a wide range of stakeholders from different sectors in developing an urban flooding action plan, mapping roles and responsibilities, and establishing a shared measurement framework for evaluating progress.
- **Phase three (2019-).** In phase 3, participants will collaborate in implementing the action plan, including shared progress reporting.

[1] "Urban Flooding in Ontario – toward collective impact solutions"

Contact: Clara Blakelock, Green Communities Canada
cblakelock@greencommunitiescanada.org

Collective impact

The collective impact process involves the participation of players from all affected sectors – in this case, property owners, NGOs and community organizations, private sector contractors and consultants, the insurance industry, engineers, wastewater and stormwater professionals, landscape architects, planners, academics, conservation authorities, municipal governments, and others.

To succeed, the process needs to include a common agenda, shared measurement, mutually reinforcing activities, continuous communication, and backbone support.

As the backbone organization for the project, GCC is responsible for supporting good process, i.e., ensuring that all stakeholders are included, everyone is heard, and participants are guided toward reaching consensus on a shared agenda and a division of roles and responsibilities.

The Ontario Trillium Foundation provided funding for phase one under its Collective Impact stream, and Natural Resources Canada supported an internship with GCC for Anastasia Kaschenko as lead writer and researcher for the phase one report. Trillium is also the prospective funder for phase two. Ultimately, if the process is successful Trillium could provide substantial funding for implementation, as part of a larger funding consortium.

Phase two of the Urban Flooding Collective Impact project

The goal of phase two of our project is to develop an action plan for addressing urban flooding – a shared agenda – with broad-based multi-sectoral support. During this phase we will:

- Formalize participation of at least 25 organizations or entities representing a broad range interest and involvement in urban flooding in Ontario
- Adopt a shared mission and vision.
- Compile a complete list of participant priorities for action, and the roles and responsibilities they see for their own organization
- Investigate and consider these action priorities, through research, analysis, and review by focused working groups
- Create a consolidated action plan, with buy-in from participating organizations
- Map out a theory of change showing how proposed actions will lead to desired outcomes
- Develop a detailed budget and funding plan for phase three.

GCC will continue to act as the backbone organization, with the support of an expanded Leadership Committee.

Contact: Clara Blakelock, Green Communities Canada
cblakelock@greencommunitiescanada.org