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# Flood Management in Ontario

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Flooding has historically been the most frequent and costliest natural disaster in Canada, and it is becoming a greater problem due to more extreme weather patterns, increasing population, and rising asset values. This paper provides a short summary of federal programs to address flooding and an overview of Ontario's flood management framework. It also explores recent developments in managing flood risk with respect to flood insurance, flood mapping, and the use of green infrastructure.

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# Introduction

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According to the [World Meteorological Organization](#), floods make up 44% of natural disasters around the world and account for 31% of disaster-related economic losses. Flooding is often the result of heavy or prolonged rainfall, snowmelt, or some combination.<sup>1</sup> Flood events can happen along rivers, lakes, and streams that are considered “floodplains,” as well as in urban settings when excessive runoff from a storm event exhausts infrastructure capacity.<sup>2</sup> There is concern that the likelihood of flooding will increase with a changing climate.<sup>3</sup>

Flooding has historically been the most frequent and costliest natural disaster in Canada, and it is becoming a greater problem due to more extreme weather patterns, increasing population, and rising asset values.<sup>4</sup> Between 2008 and 2018, the Canadian Disaster Database recorded 170 major disasters resulting in tens of billions of dollars in damages; of these, 108 were flooding incidents, including flooding from major storms.<sup>5</sup> Ontario alone experienced [19](#) recorded flood events in the last two decades.<sup>6</sup>

Flooding in Canada accounts for roughly three-quarters of federal Disaster Financial Assistance Arrangements (DFAA) payments.<sup>7</sup> According to the Auditor General of Ontario, federal government disaster relief spending rose from an average of \$40 million per year in the 1970s to \$100 million per year in the 1990s, hitting a record of \$1.4 billion in 2013.<sup>8</sup>

The increasing frequency and severity of flood events have encouraged policy makers to revisit existing frameworks for flood management, especially those regarding mitigation (e.g., flood mapping and flood resilient infrastructure) and recovery (e.g., financial relief programs and insurance frameworks).

This paper provides a short summary of federal programs to address flooding, and an overview of Ontario’s flood management framework. It also explores recent developments in managing flood risk with respect to flood insurance, flood mapping, and the use of green infrastructure.

# Flood Management in Canada

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Flood management in Canada is a complex arrangement of roles and responsibilities, including municipal, provincial, and federal governments, as well as special purpose agencies such as Ontario's conservation authorities. These actors use a combination of **structural** and **non-structural** measures to mitigate flood risk. Flood control structures such as dams, dykes, and levees were the primary mitigation measures until the late 1960s, when the emphasis started to shift to non-structural measures such as land use planning to limit development in floodplains.<sup>9</sup>

As discussed below, the federal government mainly focuses on disaster recovery, while the provinces are primarily responsible for flood management. Provinces set policy guidance and minimum standards for municipalities and other local agencies to carry out flood management in their jurisdictions.

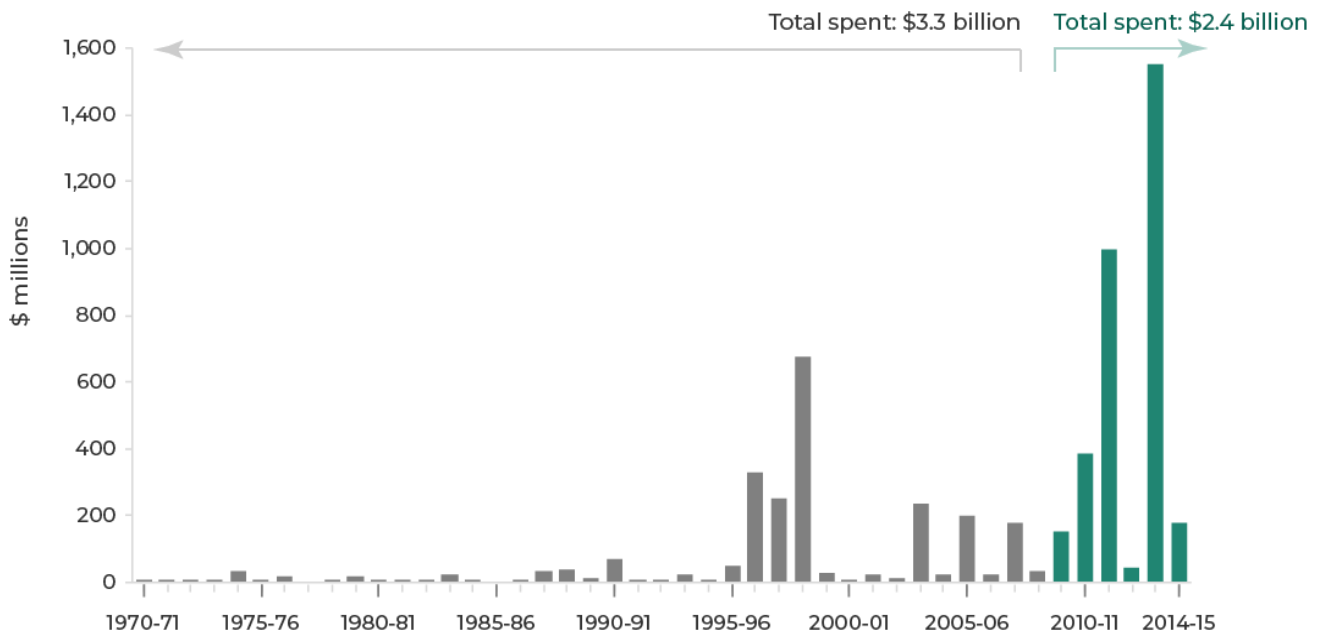
## Federal Programs

### *Disaster Financial Assistance Arrangements*

The main role of the federal government in flood management is to provide financial assistance to affected communities following a disaster, under the [Disaster Financial Assistance Arrangements](#) (DFAA). When response and recovery costs exceed what individual provinces or territories could reasonably be expected to bear on their own, the DFAA is activated. Eligibility is determined using a per capita [formula](#).<sup>10</sup> Through the DFAA, assistance is paid to the province or territory—rather than directly to affected individuals, small businesses or communities.

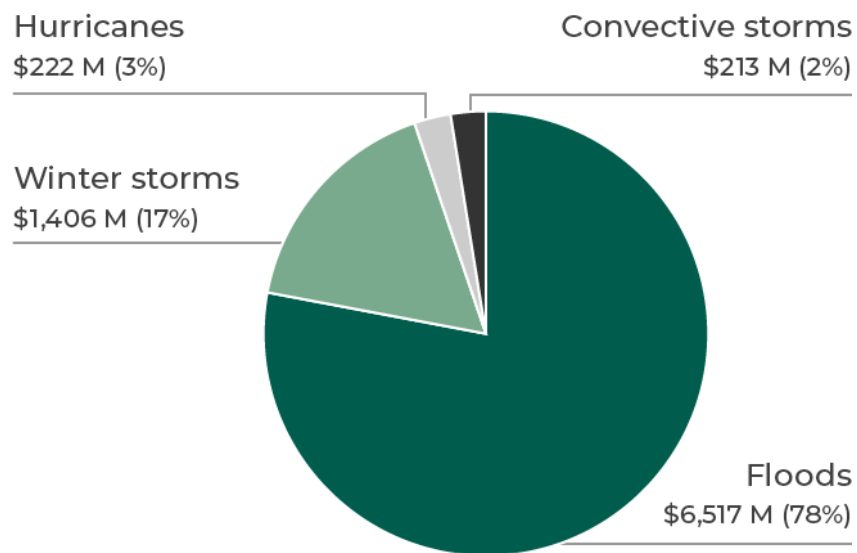
Since the inception of the program in 1970, the Government of Canada has paid out more than \$5 billion in post-disaster assistance to help provinces and territories with the costs of their response and of returning infrastructure and personal property to pre-disaster condition. Half of this amount has been paid in the last five years, which suggests that disasters are increasing in both number and cost (see Figure 1). As of 2014, flood disasters accounted for 78% of all DFAA payments (see Figure 2). Following the adoption of the [National Disaster Mitigation Strategy](#) in 2008, the DFAA was revised to require that 15% of funds be spent on mitigation enhancements after a disaster has taken place.<sup>11</sup>

**Figure 1:**  
**Disaster Financial Assistance Arrangements (DFAA) payments**  
**1970-2009 vs. 2010-2015**



Source: Office of the Auditor General of Canada, [Mitigating the Impacts of Severe Weather](#), p. 2. Graphic by Legislative Research.

**Figure 2:**  
**Disaster Financial Assistance Arrangements (DFAA) payments**  
**(by catastrophe, 1970-2014; \$ millions in 2014)**



Source: Office of the Parliamentary Budget Officer, [Estimate of the Average Annual Cost for Disaster Financial Assistance Arrangements due to Weather Events](#), 2016, pp. 19-20. Graphic by Legislative Research.

## ***National Disaster Mitigation Program***

To date, Canada has had two federal initiatives for flood mitigation. The Flood Damage Reduction Program (FDRP), the predecessor to the National Disaster Mitigation Program, was launched in 1975 in response to concerns regarding the efficiency of structural responses to flooding. Using a non-structural approach to flood mitigation, the FDRP immensely contributed to flood hazard mapping and identification of floodplains in Canada to inform land use decisions. After the program was cancelled in 1996, provinces became solely responsible for mapping their jurisdictions. Only wealthier provinces such as Alberta and Ontario were able to continue this costly undertaking.<sup>12</sup>

In 2013, a catastrophic flood washed across one-quarter of Alberta. The so-called “[super flood](#)” prompted the largest evacuation in Canada’s recent history, with up to 100,000 Albertans told to leave their homes, and cost \$4.1 billion in DFFA payments and over \$5 billion in total damages.

Following the disaster, the federal government’s 2014 budget earmarked \$200 million over five years to establish the [National Disaster Mitigation Program](#) (NDMP) to help address the increasing risks and costs associated with flood disasters. The main objectives of the program are (1) focusing investments on significant, recurring flood risk and costs; and (2) advancing work to facilitate private residential insurance for overland flooding.

Designed as a competitive and merit-based process, the NDMP offers funding to projects in four areas: flood risk assessment, flood mapping, flood mitigation planning, and non-structural and small-scale structural mitigation projects. Provincial and territorial governments are eligible for funding, and they may also collaborate with, and redistribute funding, to eligible entities such as municipal or other local governments and public/private sector bodies.<sup>13</sup>

According to Public Safety Canada’s [evaluation](#) of the program in 2019, provincial and territorial representatives stated that without NDMP funding, many small communities would not have the resources available to complete mitigation projects. In 2020, the federal government announced the renewal of the NDMP and earmarked \$25 million over two years.

# Flood Management in Ontario

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Flooding is the most significant natural hazard in Ontario in terms of death, damage and civil disruption. The most severe flooding on record with respect to loss of life in the province occurred in 1954 when [Hurricane Hazel](#) took 81 lives and caused \$1 billion (in current dollars) in damages. Ontario can experience flood events at any time of the year. More recently, the province witnessed significant flooding and associated damages in the summer of 2013 (\$1 billion in insurable losses), the spring of 2017 (\$8 million in damages), the mid-winter and summer of [2018](#) (nearing \$1 billion in insured damages), and in the spring of [2019](#) (\$74 million in insured damages).<sup>14</sup>

Ontario's flood management framework involves multiple actors. Each participates in a range of roles regarding flood mapping, flood forecasting and warning, land use planning, water management, emergency response, and disaster recovery. While the Ministry of Natural Resources and Forestry is the provincial lead for flooding, municipalities and conservation authorities are central to the wellbeing of local flood management, having distinct delegated roles from the province along with legislated and regulatory responsibilities to ensure new development is directed away from natural hazards.

## Ministry of Natural Resources and Forestry

The Ministry of Natural Resources and Forestry (MNRF) works with conservation authorities and [Environment Canada](#) to forecast when and where flooding is likely to occur. The [Flood Forecasting and Warning Program](#) prepares provincial and local authorities by regularly updating flood information and publishing [Ontario's flood map](#), which includes local and provincial flood messages. These flood messages allow municipalities to notify the public of developing unsafe river and lake conditions.

In the wake of the 2019 spring flooding, MNRF initiated an internal [task force](#) to consult with municipalities and other stakeholders on ways to improve Ontario's flood resilience. Following these engagements, MNRF appointed a special advisor for an independent review of the province's current flood management framework. The [report](#) made 66 recommendations to all levels of actors to improve flood resilience in Ontario and concluded that neither human error nor negligent operation of water control structures caused the 2019 flooding; rather, the culprit was the sheer amount of water.

Recently, MNRF published its [flooding strategy](#), which includes steps to be taken to strengthen flood resiliency and courses of action recommended by the special advisor on flooding. The strategy's priorities include, among others, understanding flood risks, enhancing flood preparedness, and investing in flood risk reduction.

## Conservation Authorities

Unique to Ontario, conservation authorities are created and governed under the [Conservation Authorities Act](#) and its regulations. Introduced by the Ontario Legislature in 1946 in response to concerns about the state of renewable natural resources in the province at the time, the Act allows municipalities in a common watershed to petition the province to establish a conservation authority. There are [36](#)



conservation authorities in Ontario, organized on a watershed basis. Members are appointed by the municipal councils within the relevant watershed.

Conservation authorities undertake watershed-based programs to protect people and property from flooding and other natural hazards, and to conserve natural resources for economic, social and environmental benefits. Programs and services to prevent and control flooding offered by these special purpose bodies include

- undertaking floodplain mapping and monitoring streamflow, rainfall and snowpacks;
- providing planning support and advice to municipalities to minimize flood impacts and issue warnings;
- acquiring important floodplain lands and flood-vulnerable structures; and
- operating over 900 dams, dykes, channels and erosion control structures with an estimated asset replacement value of \$2.7 billion in 2018.<sup>15</sup>

Conservation authorities are funded primarily through municipal levies and self-generated revenue (typically around 53% and 35% of total revenue respectively), while provincial grants and special projects typically make up 8%, and federal grants or contracts, 4% of revenue.<sup>16</sup> Prior to the 2019 Budget, MNRF annually provided \$7.4 million for program operations and \$5 million for flood infrastructure to conservation authorities. With the 2019 Budget, funding for program operations was reduced while infrastructure funding remained unchanged.

In 2019 and 2020, [Bill 108](#) and [Bill 229](#) respectively amended the *Conservation Authorities Act*.<sup>17</sup> Some of the changes include

- redefining the objectives of the mandatory programs and services delivered by conservation authorities;
- introducing additional oversight mechanisms for municipalities and the province;
- implementing requirements for conservation authorities to publish information such as audited financial reports, meeting agendas and minutes, and municipal agreements on funding for non-mandatory programs and services; and
- reorganizing conservation authorities' permitting and land use planning review processes.<sup>18</sup>

In 2021, the province proposed the first phase of regulatory amendments to implement the recent legislative changes.<sup>19</sup>

## Provincial Policy Statement, 2020

The [Provincial Policy Statement \(PPS\), 2020](#) is a consolidated statement of the government's policies on land use planning, in effect since May 1, 2020. Although policies regarding flood-prone areas remain mostly unchanged from the previous version, the new PPS includes additional direction that is responsive to the recommendations of the special advisor on flooding.<sup>20</sup>

The PPS covers policies about managing growth, using and managing natural resources, protecting the environment, and public health and safety. Issued under [section 3 of the Planning Act](#), it gives provincial policy direction on key land use planning issues that affect communities including, but not limited to

- efficient use and management of land and infrastructure;
- protection of the environment and resources including farmland, natural resources (e.g., wetlands and woodlands) and water;
- appropriate transportation, water, sewer and other infrastructure required to accommodate current and future needs; and
- protection of people, property and community resources by directing development away from natural or human-made hazards, such as flood prone areas.

## Municipalities

Municipalities are the primary decision makers for local communities in Ontario. According to the *Planning Act*, all decisions affecting planning matters must be consistent with the PPS. Municipalities implement provincial policies through municipal official plans and planning-related decisions. Municipalities are also delegated the responsibility under the [Emergency Management and Civil Protection Act](#) of identifying areas subject to natural hazards and developing management plans to limit exposure to public health and safety risks. This includes identifying floodplains in municipal plans and incorporating policies to address new development consistent with the PPS. Municipalities may or may not include their conservation authorities in this process.<sup>21</sup>

Ontario's municipalities are responsible for municipal stormwater management (i.e., the collection of urban surface runoff by sewer systems). This role is critical in mitigating urban flooding events such as street flooding, basement flooding, and flooding of other low-lying areas due to the overflow of local drainage systems.<sup>22</sup> Revenue constraints for stormwater infrastructure are common in Ontario as this service is mainly funded by municipal property taxes and water rates. In 2016, inadequate funding created a \$6.8 billion stormwater infrastructure deficit in Ontario.<sup>23</sup> Aging and inadequate sewer systems along with more frequent extreme weather events further compound municipal financial constraints.

## Provincial Recovery Programs

Ontario offers two programs that provide financial assistance following unexpected natural disasters. After such events, the Ministry of Municipal Affairs and Housing (MMAH) activates the [Disaster Recovery Assistance for Ontarians](#) program for a defined geographic area and for a defined period of time. It reimburses individuals, small owner-operated businesses, farms and not-for-profit organizations for costs associated with the repair or replacement of essential property that is not covered by private insurance. The program includes a \$500 deductible that is waived for low-income households.

The [Municipal Disaster Recovery Assistance](#) program allows municipalities to recover capital costs to repair public infrastructure or property and/or extraordinary operating costs required to protect public health, safety or access to essential services. When the MMAH activates the program, the province and municipality enter into a grant agreement. All payments under the grant agreement are based on eligible costs incurred by the municipality as a result of the natural disaster.

# Recent Developments in Flood Risk Management

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## Flood insurance

Although floods are Canada's most frequent and costliest natural disasters, until 2015 comprehensive flood insurance was unavailable to Canadian homeowners. Canadian insurers generally provided coverage for water damage caused by indoor plumbing issues, malfunction of appliances, and sewer backups, but not for water damage caused by overland flooding, which is defined as "water entering a home through windows, doors and cracks."<sup>24</sup> This distinction ensured that insurance companies were not responsible for financing flood damages, as the insurance industry considered flood protection to be economically unviable.<sup>25</sup> Despite the previous exclusion of full coverage, and its continued unavailability for some properties, water damage has become the principal source of claims for insurers, surpassing fire and theft combined.<sup>26</sup>

In the absence of a flood insurance model, government aid funded through taxation (e.g., DFFA) has provided coverage for damages after major flood events in Canada. Smaller disasters, on the other hand, have historically been self-financed by homeowners. Researchers have identified several drawbacks with this model, including the absence of incentive mechanisms for homeowners to engage in flood mitigation measures or for the development of flood hazard maps, as well as the unfairness of relying on taxpayers to universally finance flood damages.<sup>27</sup>

As discussed above, the catastrophic 2013 Alberta flood led the federal government to investigate alternative models of financing flood risk and the Canadian insurance market to look into insuring overland flooding. The 2014 federal budget declared that the government would "explore options for a national approach to residential flood insurance in Canada."<sup>28</sup> The NDMP, launched afterwards, created a funding stream for [risk assessment](#) to help "further discussions on developing a residential flood insurance market."

At the same time, Alberta victims of the flood pressured insurers to provide compensation even though policy wording did not cover this hazard. Flood victims started to organize into community groups and publicly disclosed the companies that refused to offer coverage. Several large insurance companies ultimately agreed to reverse denied claims and offer coverage.<sup>29</sup>

As a highly competitive industry with over 210 operating firms, the Canadian insurance market came under broader pressure to revisit its approach to overland flooding. In 2015, the three largest insurance companies (Aviva Canada, The Co-operators and RSA Canada) introduced some form of overland flood insurance. By 2017, many more insurers were offering optional add-on overland flood coverage.<sup>30</sup> Scholars expect that the growing availability of private insurance coverage could alter government financial relief programs.

In 2019, the Insurance Bureau of Canada (IBC) called on the federal government to lead a [National Action Plan on Flooding](#). IBC proposed that such an action plan should prioritize citizen awareness and education on the risk of flooding, relocate those at the greatest risk of repeated flooding, develop high-risk insurance mechanisms for residents remaining in high-risk areas, and deny disaster assistance to new buildings in floodplains.<sup>31</sup>

## Flood mapping

Flood mapping is considered to be foundational in reducing flood risk. According to [Public Safety Canada](#), mitigation measures such as flood mapping, risk assessment, and flood forecasting offer significant returns on investment: “For every \$1 invested in mitigation efforts, \$7 to \$10 can be saved in post-disaster recovery costs.”

Flood maps are non-structural mitigation tools that municipalities rely on for land use decisions and infrastructure deployment purposes. These maps show flooding extents and depths for given periods, along with the annual probability of occurrence. In Canada, flood hazard maps typically show fluvial (riverine) flooding only; they do not consider pluvial (rainfall), coastal, ice jam and other types of flooding. Therefore, they are also referred to as “floodplain maps.”<sup>32</sup>

As mentioned above, the origins of Canada’s flood maps date back to the late 1970s when the federal government launched the FDRP to support the joint federal-provincial initiatives for limiting development in flood-prone areas. The development of flood hazard maps under this program laid the foundation for risk identification across most of Canada.<sup>33</sup> After the FDRP wound down during the 1990s, provinces have been individually responsible for maintaining and updating their flood hazard maps.<sup>34</sup>

Today, however, in many areas of Canada, flood hazard maps are either unavailable or outdated. According to the Auditor General of Ontario, “three-quarters of the existing floodplain maps in Ontario are outdated [and] it will cost an estimated \$136 million to update them.”<sup>35</sup> As land use and the built environment change with urbanization, so too does flood risk, which is not accurately reflected in outdated maps.

Moreover, a University of Waterloo [study](#) found that only a few Canadian flood maps had been digitized and most were not publicly accessible as of 2019, which is critical considering that individuals usually are motivated to take measures to protect their property from flooding when they are aware of their personal risk. Indeed, a Canada-wide [survey](#) in 2016 revealed that only 6% of Canadians living in high-risk flood zones were aware of their risk.

Furthermore, the existing flood maps in Canada are considered “hazard” maps, which are useful for land use planning decisions but are not ideally suited for the purpose of insurance underwriting. “Risk” maps, on the other hand, identify degrees of probability, using information about the frequency and severity of flooding that an insurer could use to set differential rates based on location.<sup>36</sup> To adequately underwrite risk, insurers also require access to maps that show all potential sources of overland flooding (fluvial, pluvial and coastal).<sup>37</sup>

Recently, the insurance industry under the leadership of IBC started to amass property-level risk data and initiated comprehensive data collection on flooding across Canada to produce its own flood models and maps.<sup>38</sup> In 2019, IBC reported working with Public Safety Canada and Natural Resources Canada to design and launch a flood risk portal.<sup>39</sup>

Ontario does not regulate flood hazard mapping, or provide funding for new or updated mapping initiatives. The province has, however, provided small transfer payments for pilot projects related to mapping technologies in the last few years.<sup>40</sup> In 2019, Ontario announced that it would establish a multi-partner flood mapping technical [team](#).

## Green infrastructure

[Green infrastructure](#) (GI) solutions for flood mitigation are becoming increasingly popular, especially as a potential solution to urban flooding. GI involves almost all structures that are not built or “grey.” It includes a wide array of tools, from preservation of natural resources such as wetlands, dunes and forestlands, to green roofs, rain gardens, urban farming, and tree planting, all of which are effective tools to manage stormwater.<sup>41</sup> In contrast, grey infrastructure refers to hard (often concrete) engineering structures aimed at discharging stormwater into local water bodies. Examples include treatment facilities, wastewater, and stormwater systems.<sup>42</sup>

GI is considered multi-functional as it provides co-benefits alongside its primary purpose of stormwater management, such as improving air and water quality, providing habitat for plants and animals, and enhancing public health.<sup>43</sup> Planners and policy makers increasingly identify green and grey infrastructure as complementary solutions, rather than mutually exclusive strategies.

One of the easiest and most cost-effective GI solutions to mitigate flood risk is to keep natural resources in the floodplains intact. Wetlands, dunes, and forests provide the most resilient flood protection.<sup>44</sup> Wetlands, in particular, act as natural stormwater management ponds, slowing the speed of flood waters and storing large quantities of surface water. According to a [study](#) commissioned in part by MNR in 2017, maintaining wetlands can reduce flood damages and costs by 29% in rural areas and by 38% in urban areas.

In its 2018 [report](#), IBC advocated promoting wetlands and other natural infrastructure as an alternative to grey infrastructure options and “a cost-effective way to mitigate material financial losses that would otherwise result from flooding.” Recently, the special advisor on flooding recommended that Ontario “support municipalities and conservation authorities to ensure the conservation, restoration and creation of natural green infrastructure (i.e., wetlands, forest cover, pervious surfaces) during land use planning to reduce runoff and mitigate the impacts of flooding.”<sup>45</sup>

GI solutions are especially lauded to deal with urban flooding, which has become a more frequent public safety hazard. Urban flooding occurs during heavy rainfall events independent of an overflowing river or stream. Because urban areas have an abundance of hard and impervious surfaces, the ground simply cannot absorb the water quickly enough. Excessive runoff overwhelms the fixed capacity of drainage systems, potentially causing sewers to back up into basements and raw sewage to overflow into lakes and natural watercourses.<sup>46</sup>

The principles of stormwater management in Canada and the United States have been shifting recently. The current focus is not solely the quantity of stormwater but the quality as well (e.g., pollution reduction).<sup>47</sup> GI, particularly “[low impact development](#)” (LID), offers solutions in both reducing runoff amounts and improving runoff quality. While grey infrastructure solutions focus on runoff—draining rainwater away from the site as much and as quickly as possible—LID solutions do the reverse, retaining as much water as possible on site. Such design elements can include using permeable surfaces, detention of stormwater by on-site storage solutions, and rooftop raingardens. LID prioritizes limiting new

development to “pre-development” rates of stormwater runoff, so that the drainage system downstream will see the same volume of water after development as before.<sup>48</sup>

Ontario does not regulate the drainage standards of municipal stormwater systems in urban areas. In 2019, the special advisor on flooding recommended that the province should consider regulating urban drainage standards in favour of pre-development runoff rates.<sup>49</sup>

To overcome revenue constraints for stormwater infrastructure, some local governments in the United States and Canada have been levying stormwater fees based on the amount of impervious surfaces, and issuing stormwater credits for properties that implement GI practices. For example, since 2016 the City of Mississauga has imposed a stormwater charge on all properties, calculated according to rooftop area, which—according to the City—is the largest contributor to total hard surface area on residential properties.<sup>50</sup> The City has a stormwater credit available for non-residential and multi-residential properties that are able to prove their GI practices.<sup>51</sup>

Ontario is also accepting applications for the [Green Infrastructure](#) stream of the cost-shared [Investing in Canada Infrastructure Program](#). New projects will focus on tackling immediate and critical local water, wastewater and stormwater needs. Successful projects could receive up to \$3 million for eligible costs.

## Conclusion

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Flood management policy in Canada is mainly a provincial responsibility, with enforcement largely left to municipalities. Provinces facilitate communication and knowledge generation about flood risk, invest in structural and non-structural mitigation measures, and set policy guidance and minimum standards for municipalities and other local agencies to carry out flood management in their jurisdictions. The federal government's main role has historically been providing financial relief after major disasters through the DFFA.

The increasing frequency and severity of flood events and associated costs have prompted policy makers to revisit existing policies for flood mitigation and disaster relief programs. In response to record-high DFFA payments after the 2013 Alberta flood, the federal government launched a \$200 million mitigation program with a special focus on developing a residential flood insurance market in Canada. Pressured by public opinion, insurance companies started to offer optional add-ons for overland flooding to homeowners in 2015. Since then, the insurance industry has been urging all levels of government to adopt a risk-based flood policy, and is advocating for the development of flood risk maps and the application of green infrastructure solutions to increase flood resiliency.

## Notes

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<sup>1</sup> Ministry of Natural Resources and Forestry, [Protecting people and property: Ontario's flooding strategy](#), 2019, p. 3.

<sup>2</sup> Doug McNeil, [Independent review of the 2019 flood events in Ontario \(Ontario's Special Advisor on Flooding Report to Government\)](#), 2019, p. 22.

<sup>3</sup> Ontario, [Protecting people and property](#), p. 3.

<sup>4</sup> Jason Thistlethwaite, "The Emergence of Flood Insurance in Canada, Navigating Institutional Uncertainty," *Risk Analysis*, 37:4, 2017, p. 748.

<sup>5</sup> Public Safety Canada, [Evaluation of the National Disaster Mitigation Program](#), 2019, p. 6.

<sup>6</sup> This data does not include the flood events since 2018.

<sup>7</sup> Insurance Bureau of Canada, [Options for Managing Flood Costs of Canada's Highest Risk Residential Properties](#), 2019, p. 6.

<sup>8</sup> Auditor General of Ontario, [2019 Annual Report Volume 2](#), pp. 27-28.

<sup>9</sup> Greg Oulahan, "Flood Insurance in Canada: Implications for Flood Management and Residential Vulnerability to Flood Hazards," *Environmental Management* 2015 (55), p. 605.

<sup>10</sup> Based on the current formula, Ontario could access funding if a disaster cost the province in excess of \$46.2 million. Ontario has only qualified three times since the late 1990s—the 1998 ice storm, the 2004 Peterborough flood, and the 2013 ice storm (McNeil, [Independent review of the 2019 flood events in Ontario](#), p. 62).

<sup>11</sup> Oulahan, "Flood Insurance in Canada," p. 607.

<sup>12</sup> Matthew McClearn, "[Poor flood-risk maps, or none at all, are keeping Canadian communities in flood-prone areas](#)," *Globe and Mail*, April 23, 2019.

<sup>13</sup> As the only federal program with dedicated funding for jurisdictions to conduct flood mapping or flood risk assessments, the NDMP complements Infrastructure Canada's [Disaster Mitigation and Adaptation Fund](#) (DMAF). While the latter focuses on large-scale infrastructure projects (with a minimum threshold of \$20 million in expenditures), the NDMP focuses on small-scale infrastructure projects specifically dedicated to flood disaster mitigation.

<sup>14</sup> McNeil, [Independent review of the 2019 flood events in Ontario](#), pp. 57-58.

<sup>15</sup> Conservation Ontario, [Flooding in Ontario, Fact Sheet](#), April 2018.

<sup>16</sup> Conservation Ontario, [About Conservation Authorities](#).

<sup>17</sup> The amendments were not yet in force at the time of writing.

<sup>18</sup> Ontario, [Conservation Authorities](#).

<sup>19</sup> Environmental Registry of Ontario, [Regulatory proposals \(Phase 1\) under the Conservation Authorities Act](#).

<sup>20</sup> Environmental Registry of Ontario, [Provincial Policy Statement Review – Proposed Policies](#).

<sup>21</sup> McNeil, [Independent review of the 2019 flood events in Ontario](#), p. 81.



<sup>22</sup> Toronto and Region Conservation Authority, [Understand – Flood Risk Management](#).

<sup>23</sup> Environmental Commissioner of Ontario, [Urban Stormwater Fees: How to Pay for What We Need](#), November 2016, p. 3.

<sup>24</sup> Oulahen, “Flood Insurance in Canada: Implications for Flood Management and Residential Vulnerability to Flood Hazards,” p. 605.

<sup>25</sup> Heather Bond, “The Changing Nature of Financing Flood Damages in Canada, in *Flood Risk Management: Global Case Studies of Governance, Policy and Communities* (eds.), 2019, p. 32.

<sup>26</sup> An insurer may decide to pay out a water damage claim despite it not being covered as stipulated in the policy contract (Oulahen, “Flood Insurance in Canada: Implications for Flood Management and Residential Vulnerability to Flood Hazards,” pp. 603, 605).

<sup>27</sup> Bond, “The Changing Nature of Financing Flood Damages in Canada,” p. 32.

<sup>28</sup> Thistlethwaite, “The Emergence of Flood Insurance in Canada, Navigating Institutional Uncertainty,” p. 751.

<sup>29</sup> Ibid, p. 750.

<sup>30</sup> Bond, “The Changing Nature of Financing Flood Damages in Canada, p. 33.

<sup>31</sup> Floodlist, [Insurance Body Calls for National Flood Action Plan After Costly Spring 2019 Floods](#).

<sup>32</sup> Insurance Bureau of Canada, [A Primer on Severe Weather in Canada](#), 2019, pp. 9-10.

<sup>33</sup> Ontario, as an exception, already had policies and procedures for floodplain management through the work of its conservation authorities. With the FDRP, these maps were brought to a Canadian standard.

<sup>34</sup> Oulahen, “Flood Insurance in Canada,” p. 605.

<sup>35</sup> Auditor General of Ontario, [Special Audit of the Niagara Peninsula Conservation Authority](#), p. 29.

<sup>36</sup> Oulahen, “Flood Insurance in Canada,” pp. 605-606.

<sup>37</sup> Insurance Bureau of Canada, [A Primer on Severe Weather in Canada](#), 2019, p. 10.

<sup>38</sup> Matthew McClearn, “[Poor flood-risk maps, or none at all, are keeping Canadian communities in flood-prone areas](#),” *Globe and Mail*, April 23, 2019.

<sup>39</sup> Insurance Bureau of Canada, [A Primer on Severe Weather in Canada](#), 2019, p. 10.

<sup>40</sup> McNeil, [Independent review of the 2019 flood events in Ontario](#), 2019, p. 81.

<sup>41</sup> Derek Antrobus, “Smart green cities: from modernization to resilience?,” *Urban Research & Practice*, 4(2), 2011, 207-214.

<sup>42</sup> D. Vineyard et al., “Comparing Green and Grey Infrastructure Using Life Cycle Cost and Environmental Impact: A Rain Garden Case Study in Cincinnati, OH,” *Journal of American Water Resources Association*, 51(5), 2015, 1342-1360.

<sup>43</sup> McNeil, [Independent review of the 2019 flood events in Ontario](#), 2019, p. 5.

<sup>44</sup> Madeline Bodin, [A higher tide](#), *Planning Magazine*, 2015.

<sup>45</sup> McNeil, [Independent review of the 2019 flood events in Ontario](#), p. 7.

<sup>46</sup> Ibid, pp. 22-23, 121.

<sup>47</sup> Stormwater runoff is considered the fastest growing source of freshwater pollution in the world. [Stormwater pollution](#) is caused when rainwater falls on impervious surfaces (sidewalks, parking lots and roads), where it mixes with oil, sediment, trash and other pollutants.

<sup>48</sup> Brian Barth, "[The Silver Lining of Sea-Level Rise](#)," *Planning Magazine*, 2018.

<sup>49</sup> McNeil, [Independent review of the 2019 flood events in Ontario](#), 2019, pp. 9, 81.

<sup>50</sup> City of Mississauga, [Stormwater charge](#).

<sup>51</sup> City of Mississauga, [Stormwater credit for non-residential and multi-residential properties](#).