UNIVERSITY OF WATERLOO

INTACT CENTRE
ON CLIMATE ADAPTATION

UNDER ONE UMBRELLA: PRACTICAL APPROACHES FOR REDUCING FLOOD RISKS IN CANADA

SUPPORTED BY:

[intact]

SCC CCN

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ABOUT THE INTACT CENTRE ON CLIMATE ADAPTATION

The Intact Centre on Climate Adaptation (Intact Centre) is an applied research centre at the University of Waterloo. The Intact Centre was founded in 2015 with a gift from Intact Financial Corporation, Canada's largest property and casualty insurer. The Intact Centre helps homeowners, communities and businesses to reduce risks associated with climate change and extreme weather events. For additional information, visit: www.intactcentreclimateadaptation.ca

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DISCLAIMER

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EXECUTIVE SUMMARY

Since approximately 2010, flooding has emerged as the costliest extreme weather disaster affecting Canadians[1], leading to increases in disaster-assistance payouts by federal, provincial and territorial governments, and in insurable and uninsurable losses. Additionally, the burden on the mental health of Canadians who have experienced losses from flooding is increasingly evident.

To help alleviate the growing financial and social stresses caused by floods, Canadians have demonstrated leadership by developing a host of practical guidelines and standards designed to strengthen our individual and collective resilience to floods. **Practical solutions outlined in these guidelines and standards can be deployed TODAY to limit and/or mitigate flood risks.** These solutions range from simple home maintenance and renovations to more sophisticated community-planning approaches and regulations, business-wide activities, and infrastructure upgrades. The purpose of this report is to profile these solutions in a consolidated form — under one "umbrella" — so that Canadians can put them into action.

Experts from coast to coast participated in the development of the guidelines and standards for flood risk-reduction, contributing their knowledge of land-use planning; professional engineering; watershed management; conservation practices; community development; homebuilding; property and casualty insurance, and banking. The principal support for this work comes from both the public and private sectors, including the Standards Council of Canada (SCC); National Research Council of Canada (NRC); Canadian Standards Association (CSA Group); Insurance Bureau of Canada (IBC); Engineers Canada; Real Property Association of Canada (REALPAC), and Building Owners and Managers Association of Canada (BOMA Canada).

Collectively, Canadians now benefit from a range national guidelines and standards, including:

- Federal Flood Mapping Guidelines;
- Federal Climate Lens Guidelines;
- CSA W200: 18 Design of Bioretention Systems;
- CSA W201: 18 Construction of Bioretention Systems;
- CSA W204: 19 Flood resilient design for new residential communities;
- CSA W210: Prioritizing flood resilience work in existing residential communities (under development);
- CSA W211: Management Standard for Stormwater Systems (under development);
- CSA Z800: 18 Guideline on basement flood protection and risk reduction;
- CSA PLUS 4013: 19 Technical guide: development, interpretation and use of rainfall intensity-duration frequency (IDF) information: guideline for Canadian water resources practitioners;
- Insurance Bureau of Canada / International Institute for Sustainable Development / Intact Centre on Climate Adaptation: Framework for assessing the business case for natural infrastructure investments; and
- Intact Centre on Climate Adaptation / REALPAC / BOMA Canada: Flood resilience guideline for Canada's commercial real estate.

As illustrated above, the technical knowledge regarding ways to limit Canada's vulnerability to flooding is robust. However, **what has been lacking – until now – is a summary of practical actions that stakeholders in Canada can undertake to materially improve flood resilience in their homes, businesses and communities**. This "whole-of-society" approach, detailed in Table 1, is necessary to ensure that the expert guidance available is not overlooked by anyone who could act to reduce their flood risk in Canada.

> "The technical knowledge regarding ways to limit Canada's vulnerability to flooding is robust."

Table 1: Examples of Actions to Limit Flood Risks: A "Whole of Society Approach"

STAKEHOLDERS	SUGGESTED FLOOD RISK REDUCTION ACTIONS
Residents (homeowners and tenants)	Implement no-cost or low-cost flood risk-reduction actions, including: • Remove leaves and debris from roof gutters and catch basins; • Extend downspout and sump pump discharge pipes >2m away from foundation walls; • Install plastic covers over basement window wells; • Test sump pumps and install backup power and alarm systems to ensure that the pumps are operational, even during power outages; • Install and subsequently clean backwater valves to reduce the risk of backup flooding from storm and sanitary sewer surcharge; • Elevate electronics off the floor and store valuables in watertight containers; and • Landscape around the house to maintain a positive grade and increase permeable surfaces. Investigate your property's flood risk (for example, request flood-risk information from local governments and conservation authorities). Take advantage of the incentive programs that may be available through local governments and utilities to limit your flood risk. Learn about local flood forecasting and warning systems, and prepare an emergency plan and an emergency kit.
Local, regional, provincial and territorial governments	Provide up-to-date and future-looking flood-risk maps and property-level flood risk information through a free online portal, similar to the service provided by Flood Factor in the United States. Adopt nationally recognized best practices for flood resilience in policy and regulations, land use, urban planning and in design requirements for existing and new developments (for example, as outlined in CSA Z800, CSA W204, CSA W210, CSA 211, CSA W200, CSA W201 and CSA PLUS 4013). Distribute home flood-protection materials to residents through property-tax mailings and online channels (such as emails, newsletters, and social media) to encourage the use of simple actions to reduce the risks of basement flooding. Collaborate with partners, such as the Canadian Red Cross, who have trained staff and volunteers to promote flood resilience measures with door-to-door campaigns, events and online learning opportunities. Incorporate flood resilience measures into government asset-management plans and long-term financial planning; establish funding programs to offset the costs of flood resilience retrofits to homeowners. Ensure that flood forecasting and warning systems are in place and provide sufficient time to deploy flood-protection measures in case of a flood emergency.

STAKEHOLDERS	SUGGESTED FLOOD RISK REDUCTION ACTIONS
Federal government and agencies	Provide up-to-date and forward-looking flood-risk maps and property-level flood-risk information through a free online portal, similar to the service provided by Flood Factor in the United States. Co-operate with other jurisdictions to assess natural infrastructure assets at the watershed scale, in relation to the role they play in mitigating flood risks. For federally supported infrastructure projects, continue to require "Climate Lens" assessments, including resilience assessments. Update the National Building Code of Canada to reflect methods of reducing flood risks that were accepted during the development of national guidelines and standards.
Architects, developers, home builders and home renovation specialists	Use nationally recognized best practices for flood resilience in new home/community construction designs and redevelopments. When designing new subdivisions, maximize the amount of open natural space that will be permanently protected. Participate in professional training about adapting to climate change and reducing flood risks.
Insurance brokers	Participate in the professional training about home flood protection offered through the Insurance Brokers Association of Canada. When clients are buying or renewing homeowners' or tenants' insurance, inform them about practical ways to reduce the risk of basement flooding, as well as about available flood insurance coverage. Some insurance companies offer discounted premiums to homeowners who act decisively to reduce their risks.
Mortgage lenders	Develop incentives to encourage home buyers and homeowners to retrofit their homes to be more resilient to flooding (for example, through extending green mortgage programs to include support for flood resilience retrofits).
Mortgage brokers	Participate in professional training about home flood protection offered through Mortgage Professionals Canada. Educate clients who are securing or renewing mortgages about practical ways to mitigate flood risks at home.
Real estate agents	Participate in professional training about home flood protection. Give clients information about property flood risks, and practical ways to protect their homes.
Home Inspectors	Participate in professional training about home flood protection offered through the Canadian Association of Home and Property Inspectors and Carson Dunlop. Include an assessment of flood risks in home-inspection reports, and educate clients about how to mitigate their flood risk at home.
Retailers	Engage customers in campaigns to reduce their flood risks, focusing on people who are undertaking home renovations.

STAKEHOLDERS	SUGGESTED FLOOD RISK REDUCTION ACTIONS
Landscaping professionals	Offer clients advice about landscaping practices that would help to mitigate flood risks and reduce stormwater runoff.
Commercial real estate owners and managers	Adopt nationally recognized best practices for flood resilience. An in-depth analysis of such information can be found in the report Ahead of the Storm: Developing Flood Resilience Guidance for Canada's Commercial Real Estate. Educate tenants about steps they can take to minimize the potential for property damage, business disruptions and loss of life related to flooding. Integrate flood resilience into commercial asset-management plans and long-term financial planning.
Conservation and watershed authorities	Continue to assess the role that natural infrastructure plays in reducing flood risks and providing economic benefits. Work with local community groups, businesses and governments to publicize these benefits. Continue to protect existing natural infrastructure assets and prioritize restoration in areas with the greatest potential benefit. Continue to support local governments in managing flood and erosion hazards, and with flood forecasting and warning services. Publicly disclose existing data about flood risks, and assessments of the condition of flood-control structures within the purview of conservation authorities.
Environmental not-for-profit organizations	Continue to assess the role that natural infrastructure plays in reducing flood risks and providing economic benefits. Work with local community groups, businesses and governments to publicize these benefits. Continue to protect existing natural infrastructure assets and prioritize restoration in areas with the greatest potential benefit.
Neighbourhood associations and local community groups	Educate residents about available flood-risk maps and no-cost or low-cost flood risk-reduction actions using door-to-door campaigns, events and online learning opportunities. Send home flood-protection materials to residents in the mail. Educate residents about incentive programs that may be available through local governments and utilities to limit their flood risk. Learn about local flood forecasting and warning systems and help residents prepare emergency plans and emergency kits.
Local utility companies	Distribute home flood-protection materials to residents through utility bill mailings and online channels such as emails, newsletters, and social media. Engage with local businesses, as well as with owners and managers of industrial and commercial real estate about initiatives they can take to reduce their risk of flooding and related property damage. Develop incentives for utility customers to retrofit their properties to increase flood resilience; offer credits for actions that reduce stormwater runoff.

STAKEHOLDERS	SUGGESTED FLOOD RISK REDUCTION ACTIONS
Institutional investors	Identify the most material physical climate risks that can affect the performances of companies within a given industry sector. If flooding is a material risk, inquire whether appropriate steps have been taken to mitigate it.
Professional regulatory bodies	Establish, monitor and enforce standards of practice for flood assessments that take into account the changing climate. Provide continuing-education opportunities to support members in offering professional services that consider flood risk reduction and climate adaptation best practices.

The risk of flooding will continue to challenge Canada, driven by several forces: climate change that is effectively irreversible, aging infrastructure, and rapid urbanization and densification that are accelerating the loss of natural infrastructure. Despite this foreboding challenge, however, there is good news. A proliferation of data and technology can help us identify geographic areas at the greatest flood risk, and experience has given us solutions to mitigate these risks.

As we head into a challenging future, **one of Canada's most important tasks is to apply our knowledge about reducing flood risks** — as reflected above — **with immediate and unremitting resolve**.

> “One of Canada's most important tasks is to apply our knowledge about reducing flood risks with immediate and unremitting resolve.”


Caution
Children
Playing

CHAPTER 1

INTRODUCTION – THE NEED FOR IMPROVED FLOOD RESILIENCE IN CANADA

Natural disasters and extreme weather events are on the rise in Canada. Driven by climate change, these calamities are resulting in ever-increasing costs to governments, businesses, and ultimately all Canadians.[2]

Over the past decade (2009-2019), flooding has emerged as the costliest and most pervasive type of natural disaster in Canada, causing many Canadians to suffer financial and mental distress.

This report highlights examples of practical approaches that can be deployed by a wide range of stakeholders to limit flood-related risks in Canada. It focuses primarily on methods of mitigating flood risks in urban and sub-urban settings. Further consideration will be required for coastal and riverine flood risks, as well as northern environments. Although the measures outlined here are expected to be relevant across Canada, their application will be limited in areas with permafrost, such as Yukon, Northwest Territories and Nunavut, and in coastal areas of Canada, where sea level rise, coastal erosion and storm surge pose additional flood risks.

1.1 The Rising Cost of Floods in Canada

The Intergovernmental Panel on Climate Change, the United Nations body for assessing climate science, projects that **global warming is effectively irreversible and that there will be an increase in the frequency, intensity and duration of extreme weather events, causing floods, droughts and heat waves, throughout the 21st century**.[3]

Canada is warming, on average, at twice the global rate, with annual mean temperatures increasing by 1.7 °C between 1948 and 2016.[4] This anthropogenic (human-induced) change in climate has resulted in more extreme precipitation events, which are projected to become even more frequent and severe in the future.[5]

In concert with the changing climate, the costs of natural disasters and extreme weather events are rising. According to Public Safety Canada, the number of natural disasters for which provinces and territories in Canada required and obtained federal assistance, under the Disaster Financial Assistance Arrangements (DFAA) program, increased dramatically between 1970 and 2015. In the six years from 2009 to 2015, DFAA's compensation to provinces and territories was greater than that in the previous 39 years combined, with flooding accounting for 75 per cent of all weather-related expenditures. The annual expected cost of the DFAA program currently exceeds $900-million.

The Insurance Bureau of Canada has found that, since the 1980s, property and casualty (P&C) insurance payouts from extreme weather have more than doubled every five to 10 years. **While P&C insurance payouts in Canada averaged $405-million per year from 1983 to 2008, the next decade saw those figures more than double; in 11 of the 12 years leading up to 2020, payouts exceeded $1-billion**. Water-related losses were a significant driver of bigger payouts, accounting for more than 50 per cent of the increase. The insurance gap in Canada is also significant: for every dollar of losses borne by insurers in Canada, three to four dollars are borne by governments, homeowners and business owners.

Insured Catastrophic Losses in Canada

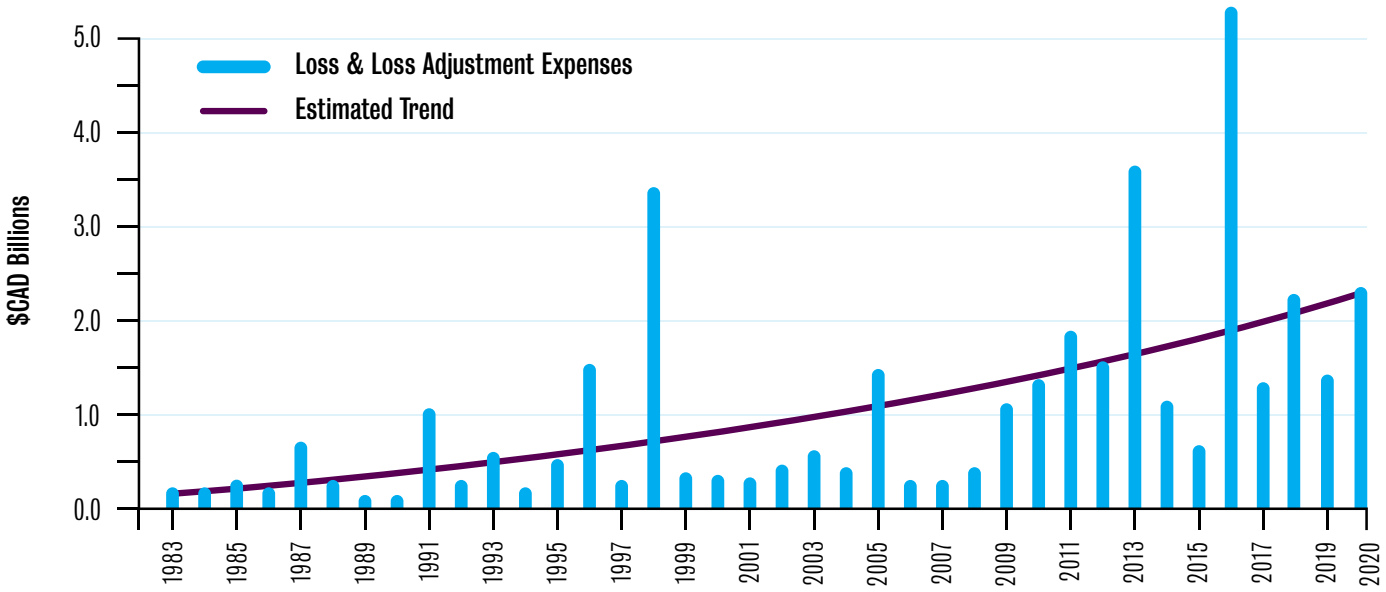


Figure 1: Catastrophic insured loss payments, Canada, 1983 – 2020. Total losses are normalized for inflation ($2020 CAN) and per-capita wealth accumulation, as of November 2020. Source: CatIQ, PCS, IBC Facts Book.

However, the heaviest financial and social burdens associated with flood events are borne by individual homeowners. In some residential areas in Canada, where repeated flooding has occurred, home flood insurance has become more expensive, or coverage is limited or no longer available. **With limited coverage or no flood insurance, some homeowners bear the full cost of flood repairs and may be unable to pay for damages when the next flood strikes. This hardship may force people to leave their homes, delay mortgage payments or even default on mortgages, if flooding renders their homes uninhabitable.**

" The industry average premium for homeowner insurance has risen by 20 to 25 per cent over the past five years in Canada. More than half of this increase is directly attributable to water damage and other extreme weather events. The remainder is due to the increase in insured values."

– Patrick Barbeau, Senior Vice-president, Claims at Intact Insurance, March 2019.

Furthermore, the physical and mental health effects of disasters often linger, with some people resorting to anti-anxiety medication, sleep aids and other prescription drugs for years following the events.[9] Research found that homeowners who experienced basement flooding were required to take an average of seven days off of work, which further exacerbated their financial burdens and stress.[10] A research study conducted after the 2019 floods in Québec found that people affected by the floods were four to five times more likely to suffer from anxiety, post-traumatic stress and mood disorders than people who were not affected by floods.[11]

Although Canada has been working hard on procedures to limit the risks of flooding and property damage, the country is not moving fast enough.[12] To help address this challenge, the chapters that follow offer a summary of immediately executable actions that can help protect Canadians from more challenging storms to come.

CHAPTER 2

APPROACHES TO LIMITING FLOOD RISKS AT HOME

To Canada's credit, information about how to protect homes from flooding is plentiful, with many communities producing educational materials and/or issuing subsidies to encourage homeowners and tenants to act to reduce their risks. However, relatively few people (less than 10 per cent) have taken advantage of the subsidy programs, even in places that have experienced repeated flooding in the past.[13]

In an effort to reach more property owners and tenants, several organizations have developed programs that can be used to increase participation in home flood-protection programs. Below are some examples.

2.1 Engaging Residents in Home Flood Protection

2.1.1 Mail Campaigns

Local governments and their industry partners, as well as not-for-profit organizations across Canada, can use infographics to motivate residents to take no-cost or low-cost actions in and around their properties to reduce the risks of flooding.

Such educational materials can be distributed to residents with utility bills or property tax mailings or through online channels (such as email, newsletters and

social media) to encourage the uptake of simple actions to reduce basement flooding risks. For example, to reflect the most actionable measures described in the CSA Z800 Guideline on Basement Flood Protection and Risk Reduction, the Intact Centre created an infographic called Three Steps to Cost-Effective Home Flood Protection.

Some local governments in Canada have distributed the infographic to their residents through property tax mailings (Case Study 1), followed with reminders by newsletter and social media. More local governments across Canada could adopt this approach to raise residents' awareness of practical ways to mitigate flood risks at home.

CASE STUDY 1:

Home Flood Protection Campaign in Nova Scotia

In June 2020, Antigonish County, the Town of Antigonish, and the Paqtnkek Mi'kmaw Nation in Nova Scotia collaborated to launch a coordinated, region-wide distribution of the infographic Three Steps to Cost-Effective Home Flood Protection.

More than 25,000 residents received the information through a combination of property tax bill inserts, newsletters from councillors, posters in community centres, and hand-delivered flyers.

The infographic illustrates 15 things residents can do to protect their property; 10 of these are simple to implement, and cost either nothing or less than a few hundred dollars. Some examples of "no-cost" actions include testing sump pumps to ensure they are in working order; removing leaves and debris from catch basins, storm drains and eavestroughs to allow stormwater to drain; and regularly cleaning backwater valves. The infographic also highlights some "low-cost" actions, such as installing plastic covers over basement window wells, extending downspouts and sump pump discharge pipes a safe distance from the house, and storing valuable items in watertight containers.

The partners have found that residents are more likely to read the page of information — rather than dismiss it as junk mail — if it is distributed as part of the property tax mailing, and if it shows the logos of all the parties or businesses involved.

Antigonish County, the Town of Antigonish and Paqtnkek Mi'kmaw Nation have set an example that can be followed by other governments in Canada, as well as local utility companies, conservation authorities, neighbourhood associations and community groups.

THREE STEPS TO COST-EFFECTIVE HOME FLOOD PROTECTION

Complete these 3 steps to reduce your risk of flooding and lower the cost of cleanup if flooding occurs. For items listed under step 3 check with your municipality about any permit requirements and the availability of flood protection subsidies. *Applicable only in homes with basements

STEP 1: MAINTAIN WHAT YOU'VE GOT AT LEAST TWICE PER YEAR

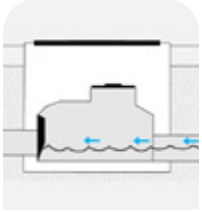
Do-It-Yourself for $0

Remove debris from nearest storm drain or ditch & culvert

Clean out eaves troughs

Check for leaks in plumbing, fixtures and appliances

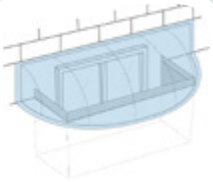
Test your sump pump*



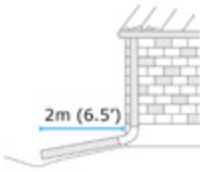
Clean out your back-water valve

STEP 2: COMPLETE SIMPLE UPGRADES

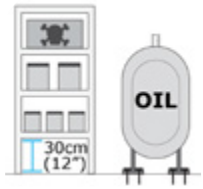
Do-It-Yourself for Under $250



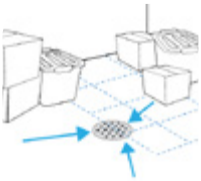
Install window well covers (where fire escape requirements permit)*



Extend downspouts and sump discharge pipes at least 2m from foundation



Store valuables and hazardous materials in watertight containers & secure fuel tanks

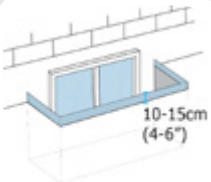


Remove obstructions to floor drain

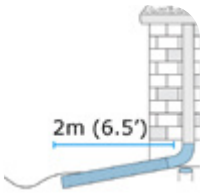
Install and maintain flood alarms

STEP 3: COMPLETE MORE COMPLEX UPGRADES

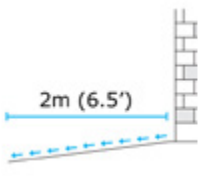
Work with a Contractor for Over $250



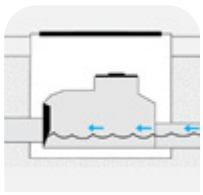
Install window wells that sit 10-15cm above ground and upgrade to water resistant windows*



Disconnect downspouts, cap foundation drains and extend downspouts to direct water at least 2m from foundation



Correct grading to direct water at least 2m away from foundation



Install backwater valve

Install backup sump pump and battery*

Note: Not all actions will be applicable to each home. Completing these steps does not guarantee the prevention of flooding.

2.1.2 Home Flood Protection Check-Up Web App

The Home Flood Protection Check-Up web app takes a resident on a 10-minute journey inside and outside their home to assess the most common flood vulnerabilities and identify actions they can take to limit their flood risk.

Created by the Intact Centre, the app is user-friendly, free, and contains tips and links to relevant sources of information. It includes questions that people can ask their insurance broker about flood insurance, and information about subsidies available for retrofitting a home to better protect it from flooding.

In the spring of 2020, Green Learning Canada, a national not-for-profit organization that creates free online education programs about energy, climate change and the green economy, used the app to help elementary and high-school students better understand their household's flood risk and what they could do to reduce it. Local governments, utility companies, conservation authorities, neighbourhood associations and community groups can also encourage their residents and customers to use the app.

2.2 Scaling Up Home Flood Protection by Training Trusted Advisers

2.2.1 Insurance, Mortgage and Home Inspection Professionals

A lack of easy-to-digest information about the risks of flooding is a significant barrier that may be preventing Canadians from maintaining and upgrading their homes in ways that could make them more flood-resilient. Research shows that residents tend to be overly optimistic about their exposure to flood risks,[14] and that they have difficulty appreciating the long-term benefits of flood-resilience investments.[15]

However, when a trusted adviser (such as a home inspector, insurance broker or mortgage specialist) explains flood-risk exposure and provides practical and actionable guidance about how to limit the risks for a particular property, people tend to listen and act. This is why industry associations — which can provide their members with professional training about home flood protection — are critical for expanding a network of trusted advisers who can teach Canadians about flood risks, and encourage them to protect themselves.

The Intact Centre has collaborated with industry associations to advance efforts to reach out and educate Canadians about protecting their properties (Case Study 2). Amplifying this example could help raise public awareness about the initiatives taking place across Canada to reduce flood risks to property.

For example, it is important to engage real estate professionals, who act as advocates, agents and consultants for potential home buyers, in this effort. Real estate agents offer their clients local knowledge about homes and neighbourhoods, and should be encouraged to make sure that their clients are aware of regional and property-specific flood-related risks. In the United States, real estate listings already contain flood risk information on prominent platforms, including realtor.com, and agents help their clients understand practical ways to improve their property's score. Similarly, home renovators educated about ways to reduce the risks of flooding can help their clients better assess priority retrofits that improve their home's value and minimize its flood risk.

CASE STUDY 2:

Home Flood Risk Assessment Training

In July 2018, CSA Group published its Guideline on Basement Flood Protection and Risk Reduction, (CSA Z800), which was the first national, standardized approach for reducing the risks of home flooding in Canada.

Based on the CSA Z800 guideline, Seneca College and Fleming College produced a 14-week online Home Flood Risk Assessment Training Course that aims to enhance the understanding of the most common vulnerabilities to flooding that properties can have, and to correct them through home maintenance and retrofitting. The course is offered by Fleming College and is intended for home and property inspectors; insurance brokers and adjusters; mortgage professionals; engineers and planners; emergency managers and first responders; real estate brokers and agents; landscapers and home builders and renovators.

A condensed, 1.5-hour version of the course has been prepared for industry associations seeking to provide continuing-education and professional-development opportunities to their members about flood risk-reduction. Currently, five industry associations are offering the 1.5-hour course:

- **Insurance Brokers Association of Canada** (**IBAC**): A national association representing more than 38,000 property and casualty (P&C) insurance brokers to advocate for the best interests of brokers and consumers.
- **Mortgage Professionals Canada** (**MPC**): A national mortgage industry association representing 12,000 individuals and 1,000 companies, including mortgage brokerages, lenders, insurers and industry service providers.
- **Canadian Association of Home & Property Inspectors** (**CAHPI**): A national association that represents more than 500 professionals and whose mission is to promote and develop the home-inspection profession.
- **Carson Dunlop**: An international inspection and training company that offers inspectors education, report-writing solutions, and successful inspection concepts. It represents more than 1,500 professionals in Canada.

2.2.2 Government Employees

In 2017, Natural Resources Canada launched a program called Building Regional Adaptation Capacity and Expertise (BRACE). Its objective is to help communities and a variety of other organizations find and use information that can help them adapt to climate change, thus building resilience to the impacts of flooding and other climate-related challenges. The BRACE program, which runs to 2022, will establish priorities for building region-specific resilience that is informed by local community needs and priorities, as outlined in the Pan-Canadian Framework on Clean Growth and Climate Change.

Every province applied for BRACE funding. In 2019, the Government of Prince Edward Island and the University of Prince Edward Island's Climate Lab were awarded funding for a proposal to develop and run two climate-adaptation programs: (1) The "Early Career Adaptation Professional" program, intended to enhance knowledge about climate-change adaptation for new climate-change students and recent graduates at UPEI; and (2) a program to educate 350 employees of the PEI government about the rising risks of coastal and urban flooding, using the "Intact Centre on Climate Adaptation Training and Professional Development" course.

The Intact Centre course will provide free resources about flood risk-reduction to PEI government officials and other interested parties, including local home inspectors, insurance brokers, mortgage professionals and community groups. The course provides a broad national perspective on home flood protection, and highlights specific resources available to support on-the-ground action by PEI residents. Participants who successfully complete its training programs will receive certificates. The goal is to adapt this course to each province.

Among other projects supported through BRACE funding, the New Brunswick Environmental Network (NBEN) will promote the use of nature-based solutions, including natural infrastructure, for reducing flood risks and adapting to climate change. It will prepare a public inventory of existing initiatives in the province, develop and deliver training programs, and facilitate a regional community of practice to promote knowledge-sharing and collaboration in implementing and monitoring nature-based solutions.

As natural disasters intensify over time, governments should also seek to deepen their expertise in flooding and responses to other climate-related emergencies. This expertise may be distributed across offices of planning, engineering, water and waste, public works and emergency management, or concentrated in an internal support office focusing on climate adaptation and resilience.

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As natural disasters intensify over time, governments should also seek to deepen their expertise in flooding and responses to other climate-related emergencies.”

CHAPTER 3

APPROACHES TO LIMITING FLOOD RISKS FOR COMMERCIAL REAL ESTATE

Commercial real estate owners and managers are not immune to the effects of flooding. Apart from property damages, their tenants are becoming increasingly concerned about the potential for life loss, property damages and business disruptions associated with flood events.

To illustrate, **following the 2013 floods in Alberta, between 150,000 and 180,000 people could not access office buildings in downtown Calgary for approximately two weeks. This resulted in 5.1 million lost work hours, equivalent to half a billion dollars in GDP loss to the province**.[16] In August 2018, when a flash flood occurred in Toronto, two men were trapped in an elevator in a commercial building and nearly drowned, as the elevator was stuck at the basement level, nearly full of water.[17]

In 2019, the publication Ahead of the Storm: Developing Flood-Resilience Guidance for Canada's Commercial Real Estate, included a concise list of flood-resilience measures (Table 2) that commercial real estate owners can implement to reduce their vulnerability to floods. These measures were developed by a consortium of people with a diverse range of flood-risk expertise, supported by the REALPAC and the BOMA Canada. This guidance is already being used by commercial real estate owners and property managers to inform flood-resilience assessments and retrofits (Case Study 3).

CASE STUDY 3:

Healthcare of Ontario Pension Plan: Climate Risk and Resilience Assessment

The Healthcare of Ontario Pension Plan (HOOPP) is a major commercial property owner that has investigated its exposure to climate-change risks and ways that it can use flood-resilience strategies to protect its assets.

In collaboration with Quinn & Partners and AON, HOOPP undertook an assessment of climate-change risk and resilience across its global $14-billion commercial real estate portfolio. Completed in 2018, the research clarified that the main climate-related risk to HOOPP's properties in Canada is flooding. In response to this finding, in 2019 HOOPP introduced flood-resilience guidelines for all its high-value and high-flood-risk properties, leveraging insights from "Ahead of the Storm: Developing Flood-Resilience Guidance for Canada's Commercial Real Estate." The pension plan now has the capacity to understand how its properties are improving their climate-change resilience, and which investments in flood-protection pay off.[18]

HOOPP is also using property-level resilience measures to reduce exposure to climate change-related risks in its investment, development and asset-management practices.[19]

Table 2: Key Flood-Resilience Measures for Commercial Real Estate*

PLANS AND PROCEDURES	EQUIPMENT AND SUPPLIES	MAJOR RETROFITS
Flood-risk assessment: Each property is assessed relative to its flood-risk exposure, and mitigation measures put in place to limit damages. This assessment considers interdependencies with local actors engaged in flood-risk management and emergency response (including local government and providers of transportation, electricity and telecommunications), and forms the basis of investment planning and risk mitigation efforts. **Emergency preparedness and response plans**: Emergency preparedness and response plans are in place and include procedures to be followed in the event of floods, and pre-established conditions that would trigger an emergency response. **Practice drills**: Building operations staff are trained in flood-event procedures. Annually, practice drills are performed with building tenants and procedures are updated as required. **Emergency funds**: Dedicated funds are available for emergency operations, including floods. Designated employees have access to both credit cards and sufficient amounts of cash for emergency operations. **Tenant communications**: Communication channels are established with tenants and stakeholders for emergency situations, including flood events. Tenant contact details are regularly updated. **Business continuity planning**: Tenants are given information that helps them to prepare business-continuity plans (such as standardized checklists, damage-assessment forms, etc.)	**Critical equipment and supplies**: Critical equipment and supplies are available on site to respond to flood emergencies (such as sandbags; sump pumps; portable generators; fuel; portable lights; extension cords; dehumidifiers; protective clothing, etc.). **Portable flood barriers and sandbags**: In buildings with critical operations, such as data centres, portable flood barriers and sandbags are available to protect the property from overland flooding. **Backup generation**: On-site backup generation equipment and fuel are available and have the capacity to provide electrical power to: at least one elevator; all building sump pumps; potable water pumps; heat pumps; boilers; smoke evacuation fans; fire sprinkler and fire alarm systems; stairwell pressurization systems and emergency lighting equipment for 24 to 72 hours. **Emergency lighting**: Battery-operated emergency lighting is available in critical mechanical and electrical rooms, as well as in emergency exit stairwells for building evacuations, should backup generation equipment malfunction. A process is in place to regularly test all battery-operated lighting and systems. **Elevator water sensors**: Elevators are equipped with water sensors that prevent them from traveling to flood-inundated floors of the building. **Backwater valves**: Backwater valves are installed on storm and sanitary sewer pipes.	**Critical equipment**: Heating, ventilation and air conditioning (HVAC) equipment, switchgear and service panels, electrical transformers and communication systems are protected by being elevated above expected flood levels. **Server rooms**: Server rooms are located on higher floors, preferably on a raised platform, with a sump pump installed at the lowest point. Water sensors and alarms are installed to detect leaks. **High-voltage and telecommunications pull rooms**: High-voltage and telecommunication pull rooms are waterproofed and equipped with drainage. **Electrical circuits**: In multi-level and underground parkades, there is a separate electrical circuit for each parking level. **Electrical panels**: Electrical panels are equipped with WIFI-enabled breaker switches to allow them to be shut off remotely. **Building materials**: Building retrofits below ground should consider materials capable of withstanding direct and prolonged contact with flood waters without sustaining significant damage, and which are resistant to mould.

Table continues on following page

PLANS AND PROCEDURES	EQUIPMENT AND SUPPLIES
Building condition assessments: Building inspection and maintenance procedures are updated to include preventive maintenance activities that reduce the risk of flooding and increase climate-change resilience. Results are integrated into building condition assessments. **Emergency operations centres**: Space is designated for building operations staff to use as emergency operations centres. This space is equipped with water, non-perishable food supplies and emergency kits, and is located above expected flood levels. **Emergency response contracts**: Standing orders are in place with fuel suppliers and restoration and landscaping companies to provide goods and services at pre-arranged prices, under set terms and conditions, as required for flood events. **Emergency contact information**: Contact information for risk-management personnel, insurance adjusters and insurance brokers is up-to-date and regularly maintained. Regular communication is maintained with local personnel involved in flood-risk management and emergency response. **Insurance documentation**: Documentation required to apply for business-interruption insurance (such as financial statements, lease agreements and inventory counts) is updated regularly, backed up electronically, and stored off site.	**Hazardous materials storage**: Hazardous materials are protected from flooding. For example, chemicals used in building operations are stored in sealed containers or non-flammable cabinets located above expected flood levels). Where hazardous materials are stored, floor drains are protected from spills. **Landscaping**: Green roofs, bioswales, rain gardens and other landscaping features are installed on the property to contain stormwater on site and minimize runoff. **Building automation systems**: The building's automation systems are upgraded to allow remote access and management.

* Many measures described in this table apply to other asset classes, including retail, industrial and multi-unit residential buildings.

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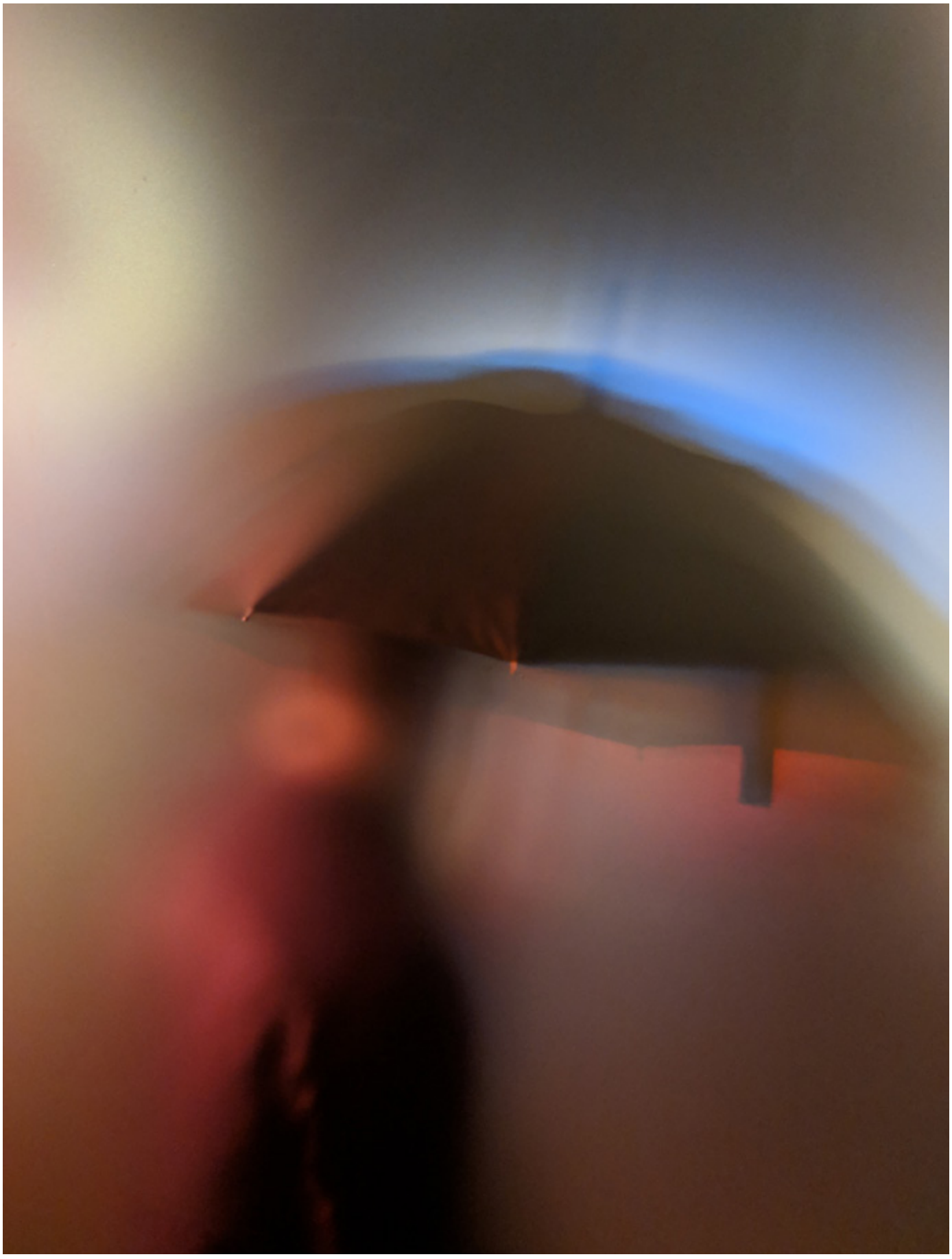
Commercial real estate tenants are becoming increasingly concerned about potential for life loss, property damages and business disruptions associated with flood events.”



CHAPTER 4

APPROACHES TO LIMITING FLOOD RISKS IN NEW AND EXISTING RESIDENTIAL COMMUNITIES

In Canada, flood risk mitigation is typically the responsibility of local government (Indigenous communities, municipalities, regional governments, conservation authorities, boards and commissions). Local governments plan, review and approve new developments, maintain stormwater management systems, leverage land-use regulations to guide developments away from high flood-risk areas, and facilitate the adoption of flood-resilient standards for the design of residential communities.

A combination of these efforts helps local governments to limit the potential for flood damages, reduce insurable losses, and minimize the probability of flood-related lawsuits and downgraded credit ratings in the aftermath of a flood.

One way local governments can demonstrate due diligence when managing flood risks is to incorporate nationally recognized guidelines and standards in their official plans; urban-planning policies; zoning bylaws; climate-adaptation plans; engineering design standards and stormwater management guidelines.

Similarly, regional, provincial and territorial governments could adopt the same guidelines and standards for inclusion in their regulations and policies. The resulting agreement among different jurisdictions would help to streamline flood risk-reduction efforts.

The following guidelines and standards are of relevance:

- CSA W200-18 Design of bioretention systems;
- CSA W201-18 Construction of bioretention systems;
- CSA W204-19 Flood resilient design of new residential communities;

- CSA W210: Prioritizing flood-resilience work in existing residential communities (under development);
- CSA W211: Management Standard for Stormwater Systems (under development) and,
- CSA Z800-18 Guideline on basement flood protection and risk reduction;
- CSA PLUS 4013: 19 Technical guide: development, interpretation and use of rainfall intensity-duration frequency (IDF) information: Guideline for Canadian water resources practitioners.

Table 3 shows examples of flood-resilient considerations for designing new housing developments, referenced in the Intact Centre report Preventing Disaster Before It Strikes: Developing a Canadian Standard for Flood-Resilient Residential Communities, which served as a foundation for "Flood resilient design for new residential communities" (CSA W204). Table 4 shows some risk-reduction approaches for existing communities that are referenced in the Intact Centre report Weathering the Storm: Developing a Canadian Standard for Flood-Resilient Existing Communities, which informed the development of the forthcoming CSA standard "Prioritizing flood-resilience work in existing residential communities" (CSA W210). In Section 4.1, testimonials from professionals in the field support the utility of guidelines and standards to inform flood risk-reduction activities in Canada.

Table 3: Examples of Flood Risk Reduction Approaches for New Communities

CATEGORIES	EXAMPLES OF FLOOD-RESILIENT DESIGN CONSIDERATIONS
General Principles	• Residential buildings and structures should not be located in areas where flood-risk assessments and local and traditional knowledge indicate a high exposure to risk (such as exceeding a 1 percent annual probability of a flood event), including erosion, debris and ice jams. • Existing and future climate-change impacts should be accounted for in the placement, design and drainage modeling for new communities, and should factor into new infrastructure design, especially of bridges and culverts. • Natural infrastructure features and associated flood-plain functions should be preserved to avoid increasing flood risks. Any discharges to natural infrastructure systems should not exceed their carrying capacity. • Construction of new communities should not increase the risk of flooding and erosion elsewhere in the watershed. • After construction, the quantity of stormwater runoff should not increase, as compared with predevelopment conditions.

Table 3: Examples of Flood Risk Reduction Approaches for New Communities	
CATEGORIES	**EXAMPLES OF FLOOD-RESILIENT DESIGN CONSIDERATIONS**
Stormwater system design	• Major and minor stormwater systems should be planned and designed concurrently, taking into account pedestrian and vehicular safety during major storm events. • Storm and sanitary sewer systems should be fully separated. • In grading designs for new communities, depressed (reverse-slope) driveways should be avoided. • Street patterns should be designed to minimize runoff flowing through private properties. • During major storm events, the maximum depth of water flowing on local roads should not exceed 0.3 metres and velocity should not exceed 3 metres per second. • Roads should be designed to channel excess water flows to a safe outlet during major storm events. • Bridge and culvert design should consider potential high water levels and debris blockage.
Sanitary sewer system design*	• Discharges from downspouts, foundation drains and sump pumps should not be directed to sanitary sewers. • The design of sanitary sewers should consider infiltration and inflow during major storms. • Sanitary sewer manholes should not be located in low-lying areas. If low-lying areas cannot be avoided, manhole covers should be sealed to minimize stormwater runoff flowing into the sewer.
Wastewater pumping stations	• Wastewater pumping stations should be located in areas where they can be fully operational and accessible during major flood events. • Wastewater pumping stations should be equipped with backup power generators and/or alternative power supplies. • Wastewater pumping stations should be designed to accommodate major storm events even if the largest pump is out of service.

* Note: Please refer to Reducing the Risk of Inflow and Infiltration (I/I) in New Sewer Construction: A National Foundational Document for the Development of a National Standard of Canada by Barbara Robinson, Dan Sandink and David Lapp, for comprehensive guidance on sanitary sewer system design considerations.

Table 4: Examples of Approaches for Reducing Flood Risks in Existing Communities

CATEGORIES	EXAMPLES OF FLOOD-RESILIENT DESIGN CONSIDERATIONS
Riverine/Fluvial Flooding Occurs when water levels in watercourses rise and spill over their banks. Flooding is a natural river process but may be exacerbated by climate change, as well as past human intervention in the watershed. Riverine flooding is often seasonal, with contributing and compounding factors including snowmelt, spring thaw, extreme rainfall, ice and debris jams.	• Proactively maintain and replace culverts, bridges, dikes, levees, pump stations and other flood-control structures, and resize these structures during infrastructure replacement/renewal cycles to accommodate extreme weather event conditions. • Proactively manage vegetation and maintain riparian buffer zones — vegetated "buffer-strips" — along watercourses, including debris removal. • Flood-proof properties on flood plains through the use of elevation, flood-resilient materials and design, and the elevation of mechanical and electrical equipment, to achieve a level of tolerable flood risk as defined by a local, regional, or provincial/territorial authority. • In high-risk areas, build community-scale structural flood mitigation works (such as berms and dikes) to supplement other flood-proofing measures. • In areas of chronic flood concern, buy out property owners and/or relocate properties. • Establish forecasting and warning systems that can provide sufficient operational lead time to deploy flood-protection measures in case of a flood emergency.
Overland/Pluvial Flooding Occurs when excess stormwater flows over private properties, entering homes through their lowest openings (such as basement windows and doors) and causing damage.	• Proactively clear catch basins and culverts. • Remove snow from critical overland flow paths before the spring thaw. • Regrade lots and roadways to carry overland water away from properties, onto rights-of-way. • Upstream of populated areas, attenuate and store stormwater and runoff using natural systems and grey infrastructure.
Storm/Sanitary Sewer Backup* Occurs when the storm and/or sanitary sewer systems are overloaded, causing surcharge and backup into basements.	• Install backwater valves on storm and sanitary sewer laterals. • Disconnect roof leaders from storm and sanitary sewers. • Seal and bolt manhole covers in low-lying areas, where stormwater accumulates and has a higher risk of contributing to sewer surcharge. • Implement stormwater diversion projects (for example, install pipes to carry excess stormwater from overwhelmed areas to areas with greater capacity).
Foundation System Failures* Occurs when foundation drainage systems fail and water enters basements though foundation drains or seeps through foundation walls.	• Disconnect downspouts and sump pump discharge pipes from foundation drains. • Install sump pumps and sump pump backup power systems, equipped with alarms. • Repair foundation cracks and install flood-damage-resistant materials in basements during home renovations. • Install an impermeable layer of soil around homes (that is, in foundation backfill areas) to reduce the risk of water infiltration and seepage through foundation walls.

* Note: Please refer to the Guideline on Basement Flood Protection and Risk Reduction (CSA Z800:18) for a comprehensive list of best practices to address storm and sanitary sewer backup, and foundation system failure risks.

“One way local governments can demonstrate due diligence when managing flood risks is to incorporate nationally recognized guidelines and standards in their official plans; urban-planning policies; zoning bylaws; climate-adaptation plans; engineering design standards and stormwater management guidelines.”

4.1 Testimonials about the Utility of Guidelines and Standards for Flood Risk-Reduction in Canada

Testimonials from the City of Calgary and from EPCOR, a utility company owned by the City of Edmonton, illustrate the practical utility of national guidelines and standards for local governments as they work to reduce flood risks and manage stormwater.

"Severe thunderstorms are a fact of life in the City of Edmonton. Often, during the summer months, rainstorms drench the city in short periods of time and cause flooding issues.

EPCOR's Stormwater Integrated Resource Plan (SIRP) envisions citizens, businesses, industry, the City of Edmonton and EPCOR working together to address flooding issues to build a more flood-resilient future. The goal of the SIRP is to slow, move, secure, predict, and respond to flooding events to prevent or reduce the impact of flooding.

SIRP, supported by the City of Edmonton council in May 2019, reflects public input relative to flood-management priorities, and expert input on optimal flood risk-reduction approaches. SIRP development also leveraged best-practice guidance outlined in national guidelines and standards on flood resilience and climate adaptation.

For example, to slow the entry of stormwater into the drainage network, green infrastructure and low-impact development (LID) projects will be implemented at the City of Edmonton. The LID projects will utilize guidance available through the CSA W200 and CSA W201 standards on bioretention systems design and construction.

To move excess water safely away from areas at risk, storm and sanitary sewers will be separated in some areas of the city, reflective of the guidance provided in the CSA W204 standard.

To secure individual properties in higher-risk areas against sewer backups, overland flooding and river flooding, 40,000 homeowners in targeted areas will be engaged to identify and implement flood-proofing measures on their properties, including backwater-valve installation and repairs to reduce stormwater inflow/infiltration issues. These approaches are consistent with the CSA Z800 guideline on basement flood protection and risk reduction.

Lastly, parts of the CSA 4013 standard will be utilized for regional storm modeling to predict and manage the movement of stormwater through smart sensors and technologies that integrate into the stormwater collection system.

As EPCOR and the City of Edmonton move forward to implement best-in-class flood resilience approaches for the benefit of citizens, businesses and industry, national guidelines and standards on flood risk-reduction and climate adaptation will continue to provide valuable insight."

– **Susan Ancel,** Director One Water Planning, EPCOR, Edmonton, Alberta

"Flooding can occur at any time in the City of Calgary. Reducing flood damage is a collaborative effort among the city, the provincial and federal governments, and Calgarians.

Calgary's Flood Resilience Plan provides guidance on timely, cost-effective, and practical flood risk management, while respecting community values and staying adaptable to future uncertainties. The plan includes three components: (1) upstream risk mitigation, (2) community-level risk mitigation and (3) property-level risk mitigation.

The actions outlined in the plan are complemented by a range of policies, zoning bylaws and building regulations that are well aligned with national standards and guidelines, including CSA Z800, CSA W200, CSA W201 and CSA W204.

The City of Calgary welcomes further effort by the Standards Council of Canada and the standards development organizations to create standards for enhanced stormwater management and flood risk-reduction, and will continue providing expert [advice] on the relevant technical committees to advance national dialogue on climate resilience and adaptation."

– **Bert van Duin,** Drainage Technical Lead, Development Planning, Infrastructure Planning, Water Resources, City of Calgary

Guidelines and standards help engineering firms and contractors carry out flood-resilience work more efficiently by specifying the correct design approaches, optimal methods of construction, and most appropriate materials. They reduce project risks and improve transparency in performance monitoring. The testimonial below from EMS Ingénierie, a civil and structural engineering firm headquartered in Québec, illustrates the practical value of the standard in informing engineering design.

"The standards "CSA W200: Design of bioretention systems" and "CSA W201: Construction of bioretention systems" were used in the design and construction phases of the project Réaménagement de l'espace Roland-Beaudin (Redevelopment of the Roland-Beaudin space) in Québec City.

Québec City chose this four-hectare site to implement multiple stormwater-management strategies to create additional relief for sewer systems located downstream. Bioretention systems were chosen as an optimal solution to provide relief, based on their hydraulic performance and potential to improve water quality.

The CSA W200 standard offered clear guidance to EMS Ingénierie when we were in the conception phase of the project. It helped us chose the appropriate materials, size the system, determine bioretention system dimensions and select the other parameters for bioretention system design.

A particular strength of this standard is that it proposes a range of parameter values that can be adapted, depending on the objectives of the system (such as to maximize infiltration rates or to maximize water treatment performance). It also provides great information relative to the choice of plants to consider for cold climates such as the climate of Québec City. Thus, the CSA W200 standard makes it easier for engineers to design a well-performing bioretention system, depending on the context it is implemented in.

However, your design won't be worth anything if it is poorly constructed. The CSA W201 standard provides a good overview of the pitfalls to avoid during bioretention system construction that could compromise its performance. Since bioretention systems are somewhat new in the Québec City area, most construction contractors are not familiar with the required precautions while constructing these systems.

There were delays in execution of the Réaménagement de l'espace Roland-Beaudin project, leading to surface drainage into the bioretention system, while surrounding areas remained unpaved for a number of months (during winter). Since EMS Ingénierie included references to the CSA W201 in our tender documents, the contractor responsible for bioretention system construction was well aware he could not build all the bioretention layers before the adjacent surfaces were paved, and he could hardly divert the stormwater elsewhere. This would have led to premature clogging of the bioretention system due to the high total-suspended-solids content, as well as resulted in other contamination issues. The contractor was able to proactively address the problem, by filling the excavation trenches with material to protect it while all the remaining landscaping work was being completed, respecting all of the recommendations in the CSA W201. The CSA W201 standard truly is a step-by-step educational tool and a guide, which is easy to follow for the contractors. It is also a great tool for our field supervisors to ensure that our plans and specifications for bioretention systems are followed well throughout the construction cycle. Lastly, the standard helped us plan infiltration testing and informed the development of a bioretention system monitoring program."

– **Béatrice Pineau**, Junior Engineer, Urban Infrastructure, EMS Engineering, Québec

Provincial and territorial governments in Canada set regulations and policies that direct flood risk-reduction efforts at regional and local scales. They also provide funding for a range of water and wastewater infrastructure projects, including flood risk-reduction and disaster-mitigation projects. The following testimonial, from the British Columbia Ministry of Forests, Lands, Natural Resource Operations, and Rural Development, indicates the relevance of national guidelines and standards for ensuring efficient funding allocations in existing communities.

"Flooding is a common occurrence in British Columbia. The most common occurrences of flooding in British Columbia, are the result of freshet, heavy rain, storm surges and ice jams.

Fortunately, a range of practical solutions can be deployed to reduce and limit risks of flooding, including an integrated approach of:

- *Managing land use in flood hazard areas;*
- *Managing flood-protection systems and maintaining dike safety; and*
- *Mitigating, responding to and recovering from flood emergencies.*

Each of these measures individually contributes to the reduction of flood risk and damage, but the most effective strategies combine all three.

In order to implement suitable protection measures, and to avoid making a problem worse or displacing the problem to another jurisdiction, it is important to understand:

- *Type of flood;*
- *Source of flooding;*
- *Probability of flooding; and*
- *Vulnerability of assets.*

The CSA W210 standard will outline voluntary guidance on a flood-hazard and vulnerability-screening framework that local governments can use to prioritize flood risk-reduction work within existing residential neighbourhoods.

We recognize that the application of the CSA W210 standard will help local governments select flood resiliency initiatives in a transparent and cost-efficient manner and welcome this effort to further inform flood risk-management in British Columbia"

– **Jesal Shah**, Manager, Dam Safety and Water Utilities, Water Management Branch, Ministry of Forests, Lands, Natural Resource Operations, and Rural Development, British Columbia

CHAPTER 5

PRACTICAL USES OF NATURAL INFRASTRUCTURE TO ENHANCE FLOOD RESILIENCE

There is growing evidence in Canada that natural infrastructure assets provide demonstrable and valuable climate-resilience benefits.

Natural assets — intact ecosystems, including wetlands, forests, coastal marshes, dunes and other naturally occurring systems, as well as engineered systems that mimic natural processes — can be strong complements, or viable alternatives, to grey infrastructure solutions for flood mitigation[20] and other infrastructure services (Case Study 4). **Moreover, natural infrastructure assets offer additional environmental and social benefits that are often not attained through the use of only traditional, grey infrastructure solutions**. Additional benefits (often referred to as "co-benefits" or "ancillary benefits") can include increased biodiversity; habitat protection; carbon storage and sequestration; improved water and air quality; a reduced "heat island" effect, and aesthetic, cultural, recreational and health benefits.

The value of natural infrastructure can be assessed in dollars and cents (Case Study 4). Governments at all levels, conservation and watershed authorities, non-government organizations and others working "on the ground" to protect environmentally sensitive lands should be aware that methods exist to calculate the economic value of natural infrastructure assets. These stakeholders should develop and maintain inventories of natural features (including their condition), assess the services and benefits that they provide (including stormwater management and flood risk-reduction) and include them in their overall asset-management plans, alongside traditional grey infrastructure.

CASE STUDY 4:

Quantifying the Economic Value of Natural Infrastructure Assets for Flood Resilience Benefits

Natural infrastructure assets play a role in climate resilience, and much of their financial contribution can be quantified. In 2016, a framework was established by the Insurance Bureau of Canada, the International Institute for Sustainable Development and the Intact Centre on Climate Adaptation to help assess this contribution, highlighting the value of natural assets for flood resilience.[21]

Since 2016, various groups across Canada, including the Municipal Natural Assets Initiative (MNAI), have made inventories of natural infrastructure assets and determined their economic contributions in a variety of potential future climate scenarios. The work is done in partnership with local governments and engineering firms. **Efforts like these help local governments to understand the value of the ecological goods and services provided by natural infrastructure, and to include it as an asset on their books (just as they do with built infrastructure**).

To illustrate the significance of natural assets applied to stormwater management and flood resilience, here are a few examples from the MNAI assessments:

- A seven-kilometre-long riverbank in the Oshawa Creek watershed in Ontario provides $18.9-million worth of stormwater conveyance benefit to nearby communities;
- Naturally occurring ponds in White Tower Park in Gibsons, British Columbia, provide between $3.5-million and $4-million in stormwater storage services;
- Widening and naturalizing 1,292 metres of the Courtenay River riverbank in Courtenay, British Columbia, would provide $2.4-million worth of protection from flood damage to downstream properties affected by a one-in-200-years flood event; and
- Protecting four wetlands covering nearly 13,800 square metres (1.38 hectares) in the Mill Creek watershed near Moncton, New Brunswick. would deliver $1.4-million in benefits in the event of a one-in-100-years flood.[22]

Other organizations in Canada have also assessed the economic value of natural infrastructure, and documented a business case for its retention and maintenance over time:

- A restored and engineered wetland in Manitoba was valued at $3.7-million for reducing floods, improving water quality, sequestering carbon, and other benefits.[23]
- The ability of wetlands to manage excess rainwater helps to reduce flood damages in the metropolitan area of Québec City, and is worth $49.8-million.[24]

- In the National Capital Region, which contains the cities of Ottawa, Ontario and Gatineau, Quebec, urban and rural forests provide annual erosion-control services worth an estimated $327,500 and more than $5.2-million respectively.[25]
- In the City of Hamilton, Ontario, a wetland complex that cost approximately $15.3-million to restore (compared with $28.5-million for an engineered solution) will reduce floods and provide recreation and other services valued at up to $44.2-million.[26]

Generally, in order of preference, the most cost-effective ways of using natural systems to mitigate flood losses are these:

(i) retain and maintain what you have;

(ii) restore what you've lost; and

(iii) build what you must.

However, despite a growing recognition of the ecological, economic and societal benefits of natural infrastructure, Canada continues to lose natural features at a rapid pace. Wetlands are a prime example.

In southern Ontario, an estimated 72 per cent of naturally occurring wetlands have been lost to land conversion such as agriculture, housing development and mineral extraction over the past century.[27] In Alberta, approximately 64 per cent of naturally occurring wetlands in settled areas no longer exist.[28] In British Columbia, more than 70 per cent of naturally occurring wetlands have disappeared in the lower Fraser Valley and parts of Vancouver Island, and an 85-per-cent wetland loss has been documented in the South Okanagan.[29] Saskatchewan has lost 70 per cent of its original wetlands in the settled areas of the province, and as much as 90 per cent in some areas.[30] In the Montreal region, more than 80 per cent of the St. Lawrence wetlands present during the earliest days of colonization have disappeared.[31]

A few jurisdictions have enacted policies or laws aimed at wetland conservation and restoration, including the charging of fees for permanent wetland loss. Examples are The Alberta Wetland Policy [32] and in Quebec, Bill 132, *An Act Respecting the Conservation of Wetlands and Bodies of Water*.[33] However, most areas of Canada lack even a "no-net-loss" policy for wetlands.

Furthermore, public-sector financial statements do not recognize natural infrastructure as a valuable asset. A prohibition in the "CPA Canada Public Sector Accounting Handbook" states:

> "Purchased natural resources and Crown lands are recognized in government financial statements. However, when natural resources and Crown lands have been inherited by the government in right of the Crown and have not been purchased, they are not given accounting recognition as assets in government financial statements. These items are not recognized as assets because the costs, benefits and economic value of such items cannot be reasonably and verifiably quantified using existing methods." [34]

This exclusion includes the outdated belief that the value of natural infrastructure cannot be quantified. This results in conservative financial reporting, and means that users of financial statements have no way of knowing the extent or value of the natural infrastructure on public property. Without assessing and recognizing their value, it is impossible to know how natural assets may contribute to a public-sector entity's ability to provide future services, or the extent of any liability should the natural assets become degraded and result in a failure to continue providing services. Users of public-sector financial statements also have no way to gauge changes in the value of these natural assets (for example, their deterioration over time).

Ultimately this accounting approach creates a gap or failure in public-sector financial reporting, as important contributions to financial health are overlooked: the enormous fiscal benefits to be gained by protecting underappreciated and undervalued ecological goods and services, and the loss of economic value when natural assets are degraded or lost, go virtually unnoticed in Canada.[35]

To correct this problem, it is crucial for all levels of government to begin to assess the value of natural infrastructure assets (including those on private land) in partnership with NGOs, watershed groups and conservation authorities. These values should be disclosed, and where flood-resilience benefits are apparent, a coordinated effort should be mounted to conserve, restore and manage these assets.

It is critical to consider natural infrastructure at the watershed scale, because often, upstream conservation and restoration efforts govern the flood risks for downstream communities. An example of inter-jurisdictional coordination for a large watershed is the Red River Basin Commission, which oversees the management of, and flood risk-reduction activities for, the Red River, which flows through North Dakota, South Dakota, Minnesota and southern Manitoba.[36]

Finally, it would be of strategic importance for Canada to develop a national standard for assessing the value of natural infrastructure assets, based on the ecosystem, economic and societal benefits that they provide. Such a standard would align Canada with international efforts to include nature-based solutions and natural infrastructure in various aspects of government planning and decision-making.[37] It would support Canada's role as a co-chair of the Nature-Based Solutions Action Track, which is part of the Global Commission on Adaptation and is trying to motivate leaders "to implement large-scale, coordinated approaches to nature-based solutions" that can minimize climate-related risks and maximize economic, social, and environmental benefits.[38]

CHAPTER 6

FACTORING CLIMATE RISK, SPECIFICALLY FLOODING, INTO INVESTMENT DECISIONS

Damages caused by worldwide flooding, including rising sea levels, could range between $14-trillion and $27-trillion (U.S.) annually by 2100, according to a projection by the UK National Oceanographic Centre.[39] Such losses would result in a 2.8-per-cent drop in global Gross Domestic Product (GDP) by 2100.[40]

Society's failure to integrate the impacts of climate change into economic decisions puts investors, financial institutions, credit rating agencies, securities commissions and capital markets at unnecessary risk. With regard to climate change, institutional investors in particular are faced with two outstanding challenges: (1) to identify which extreme weather events have the highest probability of affecting individual industry sectors, and (2) to assess whether potential investment recipients have implemented appropriate actions to mitigate extreme weather risks specific to their sectors.

To address this challenge, t**he Global Risk Institute, Scotiabank and the Intact Centre developed a unique framework**[41] **to incorporate the risks from the physical impacts of climate change and extreme weather into capital markets**. The **Climate Risk Matrix** framework identifies the top one or two climate-related physical risks in any given sector that investment portfolio managers should prioritize, because they have the most potential to materially affect the performance of companies within that sector.

The top climate-related risks for each sector were determined with expert advice from operations officers or similarly experienced personnel who were best positioned to identify a short list of material ways that flooding, drought, fire, wind and other events may convey particular risks to companies in specific sectors.

It is established that flooding is the costliest and most pervasive natural disaster in Canada. The financial burdens on society include increases in government disaster-assistance spending and insurable and

uninsurable losses; unscheduled repairs to buildings and infrastructure; lost revenue; and damage to public infrastructure. Therefore, institutional investors should pay particular attention to whether flood risks are mitigated appropriately by the companies and communities in which they invest – that is, in line with the aforementioned national standards and guidelines.

This guidance is consistent with the direction of the Task Force on Climate-Related Financial Disclosures, an international panel of 32 members from G20 countries, and with the Government of Canada's Expert Panel on Sustainable Finance. It will help investors maintain fiduciary responsibility, while promoting sustainable business practices.

CHAPTER 7

CONCLUSIONS AND NEXT STEPS

Canada deserves praise for having developed well informed, practical and cost-effective guidance to limit the risks to society of flooding and flood damage.

This guidance has benefited from the leadership of such organizations as the Standards Council of Canada; National Research Council of Canada; Canadian Standards Association; Insurance Bureau of Canada; Engineers Canada; REALPAC; BOMA Canada, and a diverse array of flood-mitigation experts.

Looking ahead, the challenge for Canada resides not in a lack of practical information about how to limit exposure to flood risks, but rather in the need to act with resolve and haste to incorporate existing guidelines and standards on flood-risk mitigation and adaptation into the design of new developments, and the refurbishment and upgrades of existing infrastructure.

Why should the public and private sectors act immediately to mitigate the risks of flooding? Simply put, it will help Canadians, and it is the only economically sensible thing to do:

- **The "Build it Right" Approach Maximizes Return on Investment**: The cost of building something "right" to adapt to climate change is not materially different than the cost of building "wrong," without flood-resilience and risk-reduction measures. But if something is built "wrong" from the start, the costs of fixing it later can be substantial. Therefore, the "build it right" approach maximizes the return on investment.
- **Benefits of Adaptation Accrue Locally**: For every dollar invested in adaptation, benefits accrue directly to the local economy.
- **Adaptation is the "Gift that Keeps on Giving"**: Climate-adaptation activities, once in place, not only

help to limit the financial and social costs resulting from the "next flood," but will also continue to do so for all floods to follow.

Whether it is viewed through a financial, social, environmental or political lens, the "upside" of using Canada's existing guidelines and standards to reduce the risk of flooding is overwhelmingly positive. Steps taken to mitigate flood risks result in new jobs, environmental protection, economic stability and fewer insurance claims. Canada must act with urgency to mitigate flood risk NOW – we have the knowledge, tools and hopefully the collective national wisdom to do so. **Time is not a luxury, as the risk of flooding grows in concert with the warming climate.**

DEFINITIONS

Backwater valve: A device that prevents storm or sanitary sewage in an overloaded main sewer line from backing up into a basement. The valve in a home automatically closes if the flow from storm or sanitary sewage reverses and attempts to back up into a basement from the main sewer.

Flood Plain: An area adjacent to a coast, lake, river or creek that can be expected to be regularly inundated or covered with water.

Flood Risk: Flood risk is a combination of the likelihood of occurrence of a flood event and the social or economic consequences of that event when it occurs.

Flood Risk Map: A map that shows the flood hazard or inundation delineations, along with additional socio-economic values, such as potential losses or property vulnerability levels. These maps serve to identify the social, economic and environmental consequences to communities during a potential flood event.

Flood Protection: Any combination of structural and non-structural improvements, additions, changes, or adjustments that reduce or eliminate the risk of flood damage to real estate, or improve real property, water and sanitation facilities.

Flood-proofing: Any combination of structural or non-structural measures that reduce or prevent flood damage to the structure and/or its contents.

Groundwater Seepage: Groundwater that enters through weeping tiles, sump pits, crawl spaces, cracks, cracked pipes, pores or gaps in foundation walls, or other openings.

Infiltration (**sewer**): Extraneous water from the ground that enters a sewer system (sanitary or storm), including sewers in buildings, through defective pipes, pipe joints, connections or manhole walls.

Inflow: Stormwater that enters sewer systems at points of direct connection to the systems.

Intensification: A land-use planning term to indicate place where existing urban lands are transformed into higher densities (of people and coverage).

Minor Drainage System: Storm sewers, catch basins, inlets, inlet control devices, street and roadway gutters, ditches and swales designed to convey runoff from frequent storms.

Major Drainage System: Streets, trunk sewers, channels, ponds, ditches, swales, natural streams and valleys that accommodate runoff, including excess runoff from storms over and above the capacity of the minor drainage system.

Runoff: The amount of water deriving from precipitation or snowmelt, not otherwise evaporated or stored, that flows across the landscape.

Stormwater: Precipitation that washes off of driveways, parking lots, roads, yards, rooftops and other surfaces, and enters a surface or subsurface collection and conveyance system to be discharged, typically into a natural water body or watercourse such as a river, a lake or ocean.

Sump pump: A mechanical device located in a sump pit (a depression proximate to the foundation, which collects the foundation water), used to pump foundation drainage discharge and/or groundwater to the surface of the lot, or to a sewer lateral.

ENDNOTES

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