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BUILDING A **SAFE** AND **RESILIENT CANADA**

Flash Flooding in Canada: An Emergency Management Perspective

ICFM10 Webinar
August 5, 2025

Data Science and Engineering Team

Canada

Introduction

The objective of this presentation is to present Public Safety Canada's (PS) roles in Emergency Management, present information on pluvial flood hazard and flash flood hazard in Canada.

This presentation brings together insights from Public Safety to explore how we are advancing our understanding of flash and pluvial flooding hazards, improving risk quantification, and supporting emergency management and policy development in Canada.

Definitions

Pluvial flooding: The temporary inundation of normally dry land, independent of an overflowing body of water. This includes surface water floods (which occur when drainage systems are overwhelmed by rainfall) and flash floods (characterized by high velocity torrents, triggered by heavy rain falling within a short amount of time) (PS).

Flash flooding: A flood caused by heavy or excessive rainfall in a short period of time, generally less than 6 hours. Flash floods are usually characterized by raging torrents after heavy rains that rip through river beds, urban streets, or mountain canyons sweeping everything before them. They can occur within minutes or a few hours of excessive rainfall. They can also occur even if no rain has fallen, for instance after a levee or dam has failed, or after a sudden release of water by a debris or ice jam (NOAA).

Flood Risk Management in Canada

Federal Government

- Develops flood mapping guidelines
- Funds and coordinates disaster mitigation
- Leads emergency response coordination

Provincial/Territorial Governments

- Set land-use planning policies
- Administer floodplain mapping with municipalities
- Coordinate emergency management
- Support municipalities

Municipal Governments

- Implement local land-use planning
- Maintain stormwater infrastructure
- Conduct local risk assessments and awareness
- Lead local emergency preparedness

Indigenous Governments

- Lead flood risk and emergency management
- Collaborate with other governments

Disaster financial assistance arrangements facilitate post-disaster support and are one of the main federal incentives and involvements in disaster-management.

Flood warnings are the jurisdiction of provinces, territories, Indigenous Nations and other delegated authorities. Environment and Climate Change Canada provides provinces and territories with weather forecasts.

Public Safety Canada: Mandate and Responsibilities

Public Safety Canada (PS) is the federal department with a mandate to keep Canadians safe from a range of risks, including crime, terrorism, and 'natural disasters'.

The Emergency Management Act describes Public Safety's responsibilities relating to emergency management in Canada:

> (m) establishing policies and programs respecting emergency management;
>
> (o) promoting a common approach to emergency management, including the adoption of standards and best practices;
>
> (p) conducting research related to emergency management;

Public Safety Canada's Role: Understanding and Quantifying Risk

Keeping Canadians safe – physically and economically – requires a comprehensive understanding and quantification of risk.

To meet the challenges presented by disasters in Canada, and Public Safety's mandate to keep Canadians safe, strong support is required for science-based risk quantification and analysis, and policy development designed to protect Canadians.

Public Safety has developed leading edge capability in disaster risk estimation and quantification, including financial loss estimation, on the Data Science and Engineering Team (DSET).

Public Safety Canada: Canada-wide Flood Hazard Modelling

In 2023, Public Safety launched a competitive bid process for a Canada-wide flood hazard model with:

- Coverage for all of Canada;
- Multiple return periods (annual exceedance probabilities);
- Multiple flood generating mechanisms (fluvial, pluvial, and coastal);
- Resolution at 30m horizontal or better;
- Ability to share derived products openly.

The contract was awarded to a joint bid from Fathom and Impact Forecasting (FIF).

Quality Control Process

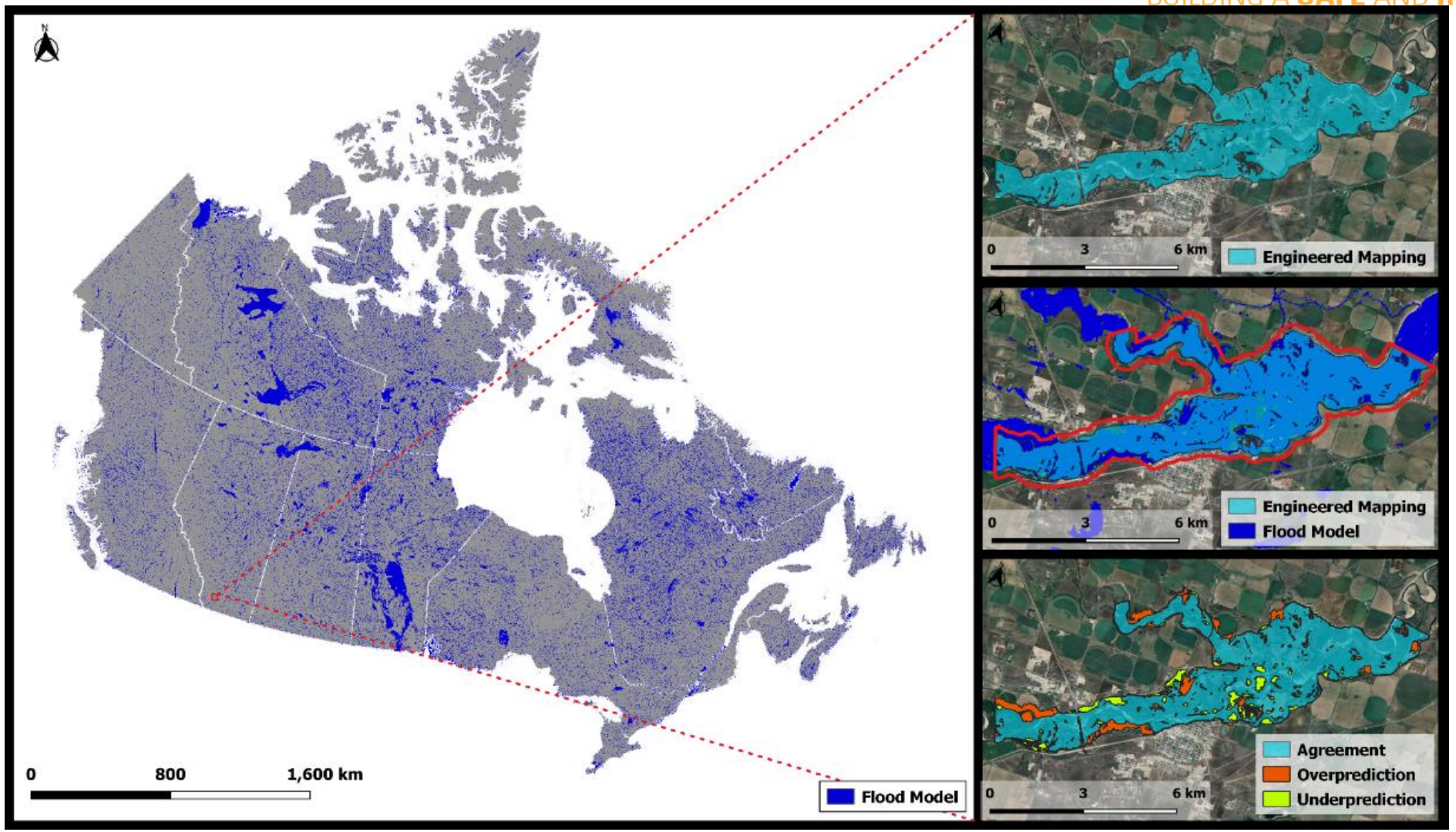
As the saying goes, ‘all models are wrong, but some models are useful’.

The objective of our Quality Control process was to determine what use cases, including Public Safety policy programs, the model could support.

This included evaluating the FIF Model and establishing performance metrics, and understanding the uses and limitations of both the FIF Model and any reanalysis products.

The focus was primarily on the fluvial hazard layers, for which we have hundreds of evaluation sites across Canada. There are very few pluvial / flash flooding hazard studies available in Canada.

Public Safety Canada: Fluvial Flood Risk Quantification

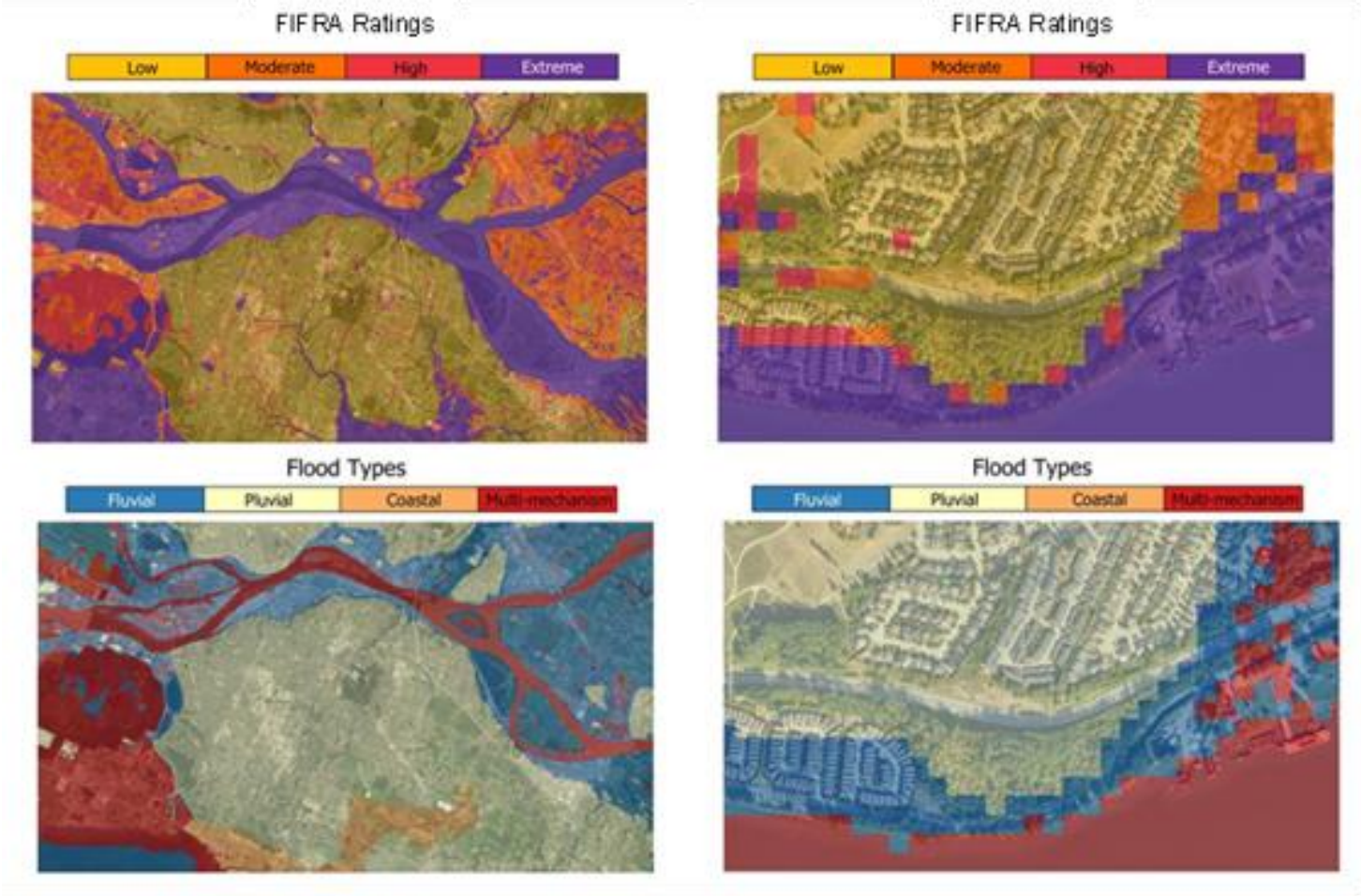


Public Safety FIFRA Program: Flood Hazard Communication and Screening

Most Canadians are unaware of their flood hazard and pluvial / flash flood hazard is unavailable for most of Canada.

The Federally Identified Flood Risk Areas (FIFRA) Initiative was developed to help address gaps in Canada-wide flood information.

The goal of the FIFRA datasets is to provide screening-level hazard identification information for a consistent understanding of flood hazard across Canada and help guide federal risk-reduction efforts.



Conclusion for PS Policy Programs: Model Uses

Flood Hazard Screening

- Useful for screening as a first step in a decision-making process, with the understanding that site-specific information is required for decision-making.

Large-Scale & Relative Analysis

- Useful when data is aggregated across large areas for things like insurance or large-scale risk analysis.

Consistent Communication

- Enables consistent understanding and communication of flood hazard across Canada.

Emergency Management Support

- Potential to support rapid forecast-to-impact assessments for emergency response.

Multi-Hazard Integration

- Can complement other hazard models (e.g., wildfire, seismic) for a comprehensive national risk profile.

Flash Flooding in Canada

In Canada, pluvial and flash flood hazards are increasing and causing more damage.

Canada has diverse geography and hydrology which contribute to flood mechanisms that may cause flash floods including rainstorms and hurricanes, rain-on-snow events, and ice jam or other infrastructure failures. Areas with steep terrain and urbanized drainage are particularly susceptible.

The rapid onset of flash floods challenges forecasting and warning systems that are primarily designed for slower-developing weather events.

Flash Flooding in Canada

- Increasing average and extreme temperatures leading to more moisture in the atmosphere
- More temperature fluctuations leading to rain on snow events
- Changing storm tracks and increasing severe weather
- Less predictability due to non-stationarity
- Increased runoff due to forest fires and development

Pluvial Flooding in Canada

Canadian cities, including Montreal, Toronto, and Vancouver, are vulnerable to flash flood events resulting from high-intensity, short-duration rainfall. Urban development in Canadian cities has contributed to increased flash flood risk. The primary financial risks of pluvial flooding in Canadian cities are driven by basement flooding and sewer backup.

In 2024, the Insurance Bureau of Canada reported that three pluvial flooding events resulted in insured damages of $2.5 billion in southern Quebec, $1 billion in Toronto, and $110 million in southern British Columbia.

Managing pluvial flood risk requires distinct strategies and collaboration with different stakeholders than those involved in traditional floodplain management.

Pluvial Flood Hazard Estimation and Uncertainty

Pluvial flooding presents a significant challenge to flood risk management in Canada, due to limitations in pluvial flood hazard modelling at both local and Canada-wide scales.

The resolution of Canada-wide flood hazard model does not capture the spatial and temporal variability of pluvial events and the local effects that infrastructure has on flooding, limiting their effectiveness for emergency management at the local and Canada-wide scales.

The lack of local-scale engineered pluvial flood hazard maps in Canada limits our ability to conduct quality control and understand uncertainty in the same way we can for fluvial flood hazard maps.

Case Study: Halifax, Nova Scotia

Nova Scotia

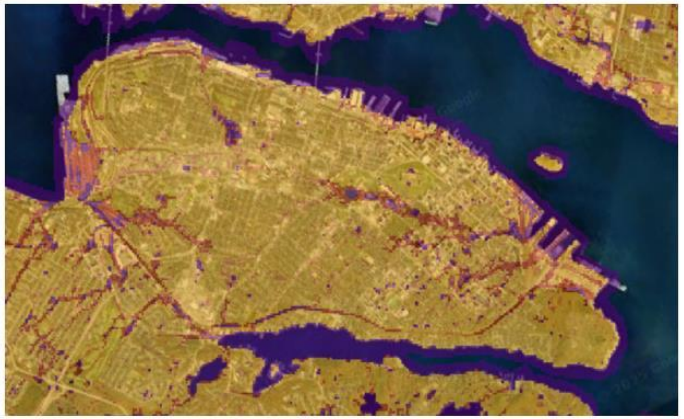
'A tough couple months': Flood forces 750 Halifax residents from their homes

Provincewide state of emergency declared, residents urged to stay off roads

A man wearing chest waders walks past cars abandoned in floodwater in a mall parking lot following a major rain event in Halifax on Saturday, July 22, 2023. THE CANADIAN PRESS/Darren Calabrese

Location	Date	Rainfall & Duration	DFAA Triggered	DFAA Cost	Insurable Losses
Halifax, NS	July 21-22, 2023	200+mm in 24hrs	✅	$67M	$170M

FIFRA Ratings



Flood Types

Case Study: Vancouver, British Columbia

'Never had a flood like this,' says mayor of flooded B.C. town

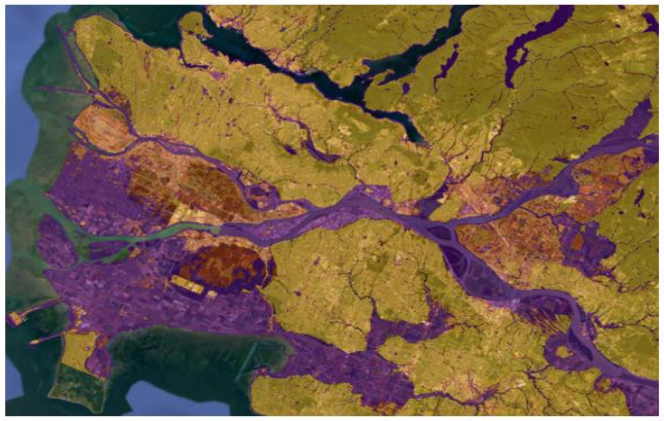
Princeton residents were among several communities across B.C. forced to evacuate do to flooding Sunday and Monday

Chelsea Powrie
Nov 15, 2021 12:53 PM

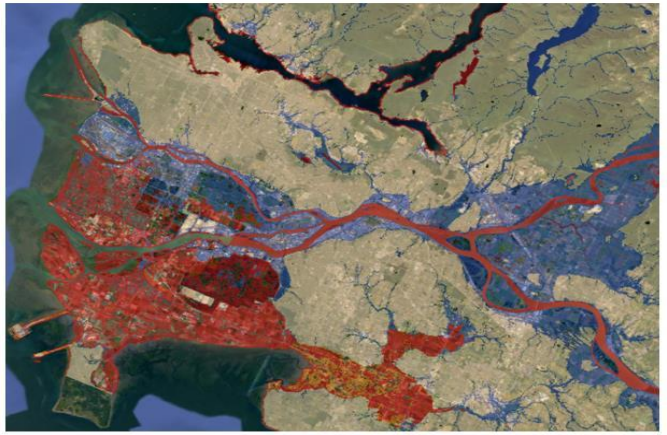
The B.C. towns of Princeton faced significant flooding Monday as municipalities across the province faced devastating flooding. | Rhonda Viaucaron/Castanet

Location	Date	Rainfall & Duration	DFAA Triggered	DFAA Cost	Insurable Losses
Southwest B.C.	November 13-15, 2021	~300mm in 48hrs	✅	$1B	$675M

FIFRA Ratings



Flood Types



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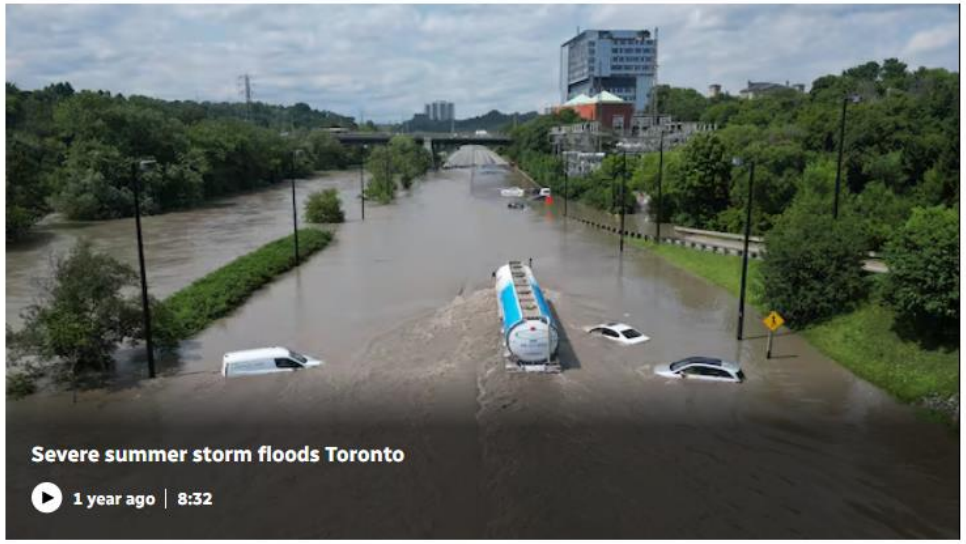
Case Study: Toronto, Ontario

Severe Toronto storm causes flooding, major power outages

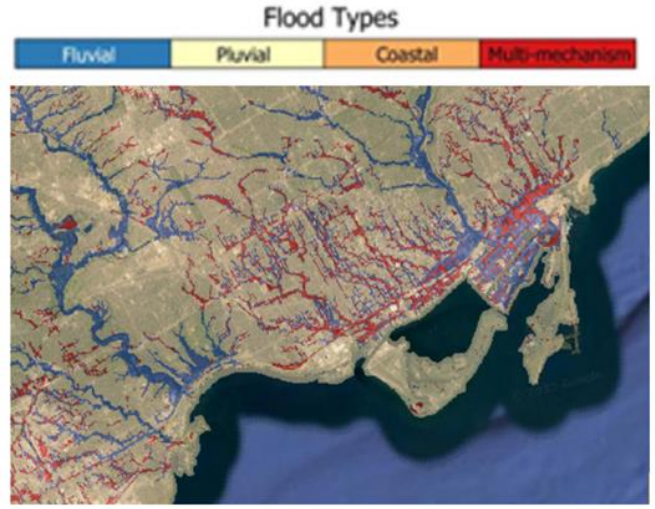
Storms from London to Toronto lined up 'like jumbo jets on the airport tarmac': climatologist

Rochelle Raveendran, Lucas Powers · CBC News ·
Posted: Jul 16, 2024 10:29 AM EDT | Last Updated: July 16, 2024



A severe storm dumped more than 10 centimetres of water on Toronto, causing flash floods, closing highways, and knocking out power for thousands. Experts say Toronto and other communities need to expect more severe weather because of climate change.

Location	Date	Rainfall & Duration	DFAA Triggered	DFAA Cost	Insurable Losses
Toronto, ON	July 15-16, 2024	123mm in 24hrs	✗	-	$940M



Addressing Pluvial and Flash Flood Risks in Canada

PS's increased focus on addressing the risks from pluvial and flash floods includes:

- Public Safety anticipates the inclusion of pluvial hazard in the DFAA Program's definition of high risk in 2030;
- Identifying pluvial hazard through using existing global flood hazard models and developing an open-source global model (Open-FRANC);
- Highlighting flood hazard and risk quantification through presentations and research;
- Technical support for planned federally backed flood insurance for Canada.

Generally, management of pluvial flooding needs to consider strategies and involve partners outside of the traditional floodplain management.

As increasing pluvial and flash flood risks drives damages, understanding and quantifying these risks is an increasingly important part of flood management.

Collaboration: Open-FRANC

Public Safety Canada is collaborating with federal departments, academic partners, and community partners to develop Open-FRANC.

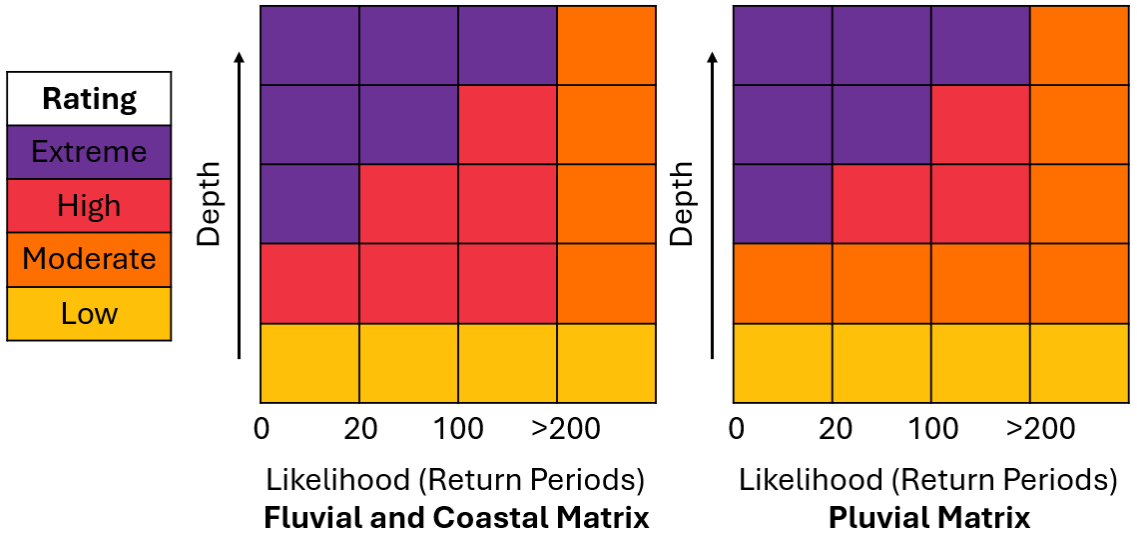
The main goal of Open-FRANC is to develop a Canada-specific, Canada-wide model. Key objectives of Open-FRANC include:

- Providing scalable, accurate, and accessible flood hazard data;
- Canada-specific flooding mechanisms, e.g., atmospheric rivers and ice jams;
- Developing predictive tools specific to Canada;
- Empowering all levels of government and communities, and rightsholders;
- Strengthening policy, planning, and adaptation efforts under a changing climate

FIFRA Datasets: Matrix

The FIFRA uses a **matrix approach** to combine depth and probability to create a risk rating.

PS conducted research to determine the thresholds for flood depth, probability, and social risk tolerances.



FIF Model: QC of fluvial flood hazard extent methods