

# National Flood Hazard Data Layer Project Environmental Scan Current State of Flood Mapping in Canada

Final Report



11 December 2020



Cover Image: Excerpt of a flood depth map (Ebbwater Consulting Inc. and Palmer (2020): City of Dawson Creek Flood Mapping. Prepared for the City of Dawson Creek). CC BY-NC-SA 4.0.

## Disclaimer

This document has been prepared by Ebbwater Consulting Inc. and Minerva Intelligence Inc. for the exclusive use and benefit of Natural Resources Canada (NRCan).

The contents may be used and relied upon by the officers and employees of Natural Resources Canada. However, Ebbwater Consulting Inc. and Minerva Intelligence Inc. deny any liability to other parties who access and use this report.

## Copyright

All material presented in this report is provided under a Creative Commons License CC BY-NC-SA 4.0, with the exception of any content supplied by third parties. This license allows someone to copy and redistribute the material in any medium or format, under the following terms:

- You must give appropriate credit (i.e., you must include the name of the provider (see citation below) and a license notice.
- You may not use the material for commercial use.
- If you remix, transform, or build upon the material, you must distribute your contributions under the same licence.



Details for the Creative Commons License CC BY-NC-SA 4.0 (Attribution-NonCommercial-ShareAlike 4.0 International) are available on the Creative Commons website:

<https://creativecommons.org/licenses/by-nc-sa/4.0/>

Citation: Ebbwater Consulting Inc. and Minerva Intelligence Inc. (2020). National Flood Hazard Data Layer Project - Environmental Scan - Current State of Flood Mapping in Canada. Prepared for Natural Resources Canada.

## Acknowledgements

Funding for this project was provided by Natural Resources Canada to support the development of a National Risk Profile under Canada's Emergency Management Strategy led by Public Safety Canada.

The authors wish to acknowledge the support of the NRCan team, Étienne Bonhomme, Tina Lynn Lindsay, and Yannick Blain, who provided guidance and support throughout the project.

We also would like to thank all of the provincial and territorial government personnel who generously shared their time for the survey, interview, follow-up questions, and for reviewing the provincial/territorial sections in this report, as well as for supporting our flood hazard data collection. This is much appreciated. For a list of provincial/territorial departments and agencies who have supported this project, see Table A-1 below. A full contact list is provided in Appendix B.

We also thank Dr. Heather McGrath from NRCan for providing us with information on a metadata tool for flood maps currently under development, and to Dr. Donald Forbes, also of NRCan, for providing information on flood-related projects in Nunavut. Further we wish to acknowledge Alexander Wilson from CBCL Limited and Nicole O'Brien from Dillon Consulting Limited for supporting the data collection for Nova Scotia.

The National Flood Hazard Data Layer project was conducted by Minerva Intelligence Inc. (Minerva) and Ebbwater Consulting Inc. (Ebbwater), and the interviews were conducted as a joint effort. This environmental scan report was written by Dickon Wells, M.Eng., C.Eng., Silja Hund, Ph.D., and Tamsin Lyle, M.Eng., MRM, P.Eng. of Ebbwater. Robert Larson, M.Sc., P.Ag., of Ebbwater, provided support on French translation and the interview with Québec. Minerva's Dave Bigelow, M.Sc., P.Eng., Jake McGregor, B.A., and Sharon Lam, B.Sc., provided the Management of Flood Hazard Data sections, as well as reviewing the report. Sarah MacKinnon from Interwoven Editing provided copy editing.

We would like to acknowledge that this report was written at the Ebbwater and Minerva offices and home offices, which are located on the unceded and Traditional Territory of the *Sḵw̓x̓wú7mesh* (Squamish), *Selilwitulh* (Tseil-Waututh) and *x̓m̓əθk̓əj̓əm* (Musqueam) Nations.

**Table A-1: Provincial/territorial departments and agencies who supported this project via the engagement and data collection phases.**

Province/Territory	Departments and agencies who were engaged in this project
Alberta	Alberta Ministry of Environment and Parks
British Columbia	British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development, Emergency Management British Columbia, DataBC, GeoBC
Manitoba	Manitoba Infrastructure
New Brunswick	New Brunswick Department of Environment and Local Government, Service New Brunswick
Newfoundland and Labrador	Newfoundland and Labrador Department of Environment, Climate Change and Municipalities
Nunavut	Nunavut Department of Environment, Crown-Indigenous Relations and Northern Affairs Canada
Nova Scotia	Nova Scotia Department of Municipal Affairs and Housing
Northwest Territories	Northwest Territories Cumulative Impact Monitoring Program (CIMP), Department of Lands
Ontario	Ontario Ministry of Natural Resources and Forestry, Conservation Ontario
Prince Edward Island	Prince Edward Island Department of Environment, Water and Climate Change
Québec	Québec Ministère de l'Environnement et de la Lutte contre les changements climatiques
Saskatchewan	Saskatchewan Water Security Agency
Yukon	Yukon Department of Environment

## Executive Summary

### Project Background and Objectives

Floods are common disasters that affect many Canadians. Effective flood management requires flood mapping as baseline information. However, the federal government lacks an authoritative source of information that provides up-to-date, accessible, consistent, and comprehensive data on flood hazards across Canada. Therefore, Natural Resources Canada (NRCan) retained the services of Minerva Intelligence Inc. (Minerva) and Ebbwater Consulting Inc. (Ebbwater) to develop a National Flood Hazard Data Layer (NFHDL) to store existing flood hazard information developed by Provinces and Territories (P/Ts), and other authoritative sources. As part of this project, the consultant team engaged with map regulators and holders from across the country, primarily at the P/T level, to understand their data collections and anticipated data needs. Through this engagement, the team also learned about broader flood mapping governance in each P/T. This report summarizes the findings of this evolved engagement process, outlining the opportunities and challenges to developing flood maps in each P/T, and then providing guidance based on the main archetypal models for flood hazard data development and management at the P/T level. Specific details on the NFHDL will be provided in the accompanying National Flood Hazard Data Layer Project Schema Design and Data Transformation Report by Minerva and Ebbwater (expected spring 2021).

### Flood Hazard Data Management Approaches in Canada

Several key themes with respect to flood hazard data management have emerged through this project:

- **Limited flood map coverage.** The production of modern flood maps remains a relatively new sector in many P/Ts, and many areas still need to be mapped. Table E-1 provides a summary of the current state of flood hazard data development for each P/T.
- **Widely varying methodology.** While most modern maps are made using standard engineering processes, there are substantial differences in the way flood hazard data are modelled and mapped across Canada, including assessed hazards and likelihoods. Data can also vary substantially within a single P/T (especially where no centralized authority for producing flood hazard data exists).
- **Limited incorporation of climate change.** In some areas, climate change is not included in mapped data. In others, it is only included for specific flood hazards. Overall, the approach taken to climate change is diverse and generally lacking.
- **Opportunities for lesson sharing and cross-border cooperation.** Given the variability in flood data availability, and technical advances by some P/Ts for different flood hazards, there are substantial opportunities for greater lesson sharing and cross-border cooperation.
- **Shift toward open data.** Many P/Ts are either looking to make data publicly available, or already do so.
- **Variability in approach to flood governance.**
  - Flood mapping is led centrally and data are housed centrally in Alberta, Manitoba, New Brunswick, Newfoundland and Labrador, Prince Edward Island, Québec, and Yukon.
  - Flood mapping and data ownership is mostly central, but some local flood mapping exists in the Northwest Territories and Saskatchewan.

- Flood mapping and data ownership are decentralized in British Columbia, Nova Scotia, and Ontario.
- No territorially authorized flood mapping exists in Nunavut.

**Table E-1: Current state of flood hazard data development in each P/T.**

P/T	Current State of Flood Hazard Data Development
AB	Flood mapping is well developed in Alberta and they have made major progress in the last 5 years, including the replacement of 50% of the older (Flood Damage Reduction Program, FDRP) flood maps, mapping an additional 900 km of frontage, and creating the central flood data portal, FAMA (Flood Awareness Mapping Application). Alberta has a long-term plan for flood mapping and intends to map an additional 600 km of frontage over the coming year (2021). Climate change is not explicitly included in flood map data, but Alberta maps 13 different Annual Exceedance Probabilities (AEPs), up to 0.1% AEP. Alberta has established workflows to manage flood mapping data and ensure its currency.
BC	Flood mapping is relatively well developed in British Columbia, and many flood hazard maps exist. The vast majority of these have been made in the last 5 years, mostly under the National Disaster Mitigation Program (NDMP) and provincial cost-sharing programs. The lack of a centralized authority for flood hazard mapping means that it is difficult to estimate how much of BC remains to be mapped, but there are likely many areas that have no flood maps, or only outdated FDRP flood maps. Flood mapping conducted under provincial/federal funding programs is submitted to the provincial government for approval to adherence to grant requirements etc., but no technical approval according to standards is conducted. BC has well-established guidelines, which are, however, not very prescriptive and have led to variation in mapping products and mapping quality. Incorporation of climate change varies from study to study.
MB	Flood mapping in Manitoba is a developing sector with all modern flood maps having been produced over the last few years. Manitoba has a plan for areas that they would like to map in the current (2020) and next fiscal years. However, the need for additional mapping on top of this is likely to be substantial. Manitoba Infrastructure suggested that much of the province is likely to be exposed to flooding to some degree, and only 9 areas are included in recent maps. Climate change is not explicitly covered in new maps, although they have increased the regulatory AEP from 1% to 0.5%.
NB	By the end of 2020/early 2021, New Brunswick plans to completely replace its flood maps, which were all produced during the FDRP and are not considered authoritative by the provincial government. These maps will include all areas considered under the FDRP, as well as some additional inland maps, and they will produce a new set of coastal flood maps, which did not previously exist. Climate change is considered for both new riverine and coastal flood maps. Once the flood-map update is complete, there is no specific plan for further flood mapping. However, flood maps may require updating every 5–10 years going forward, which would be in part dependent on climate change projections.
NL	Flood mapping is well established in Newfoundland and Labrador. The provincial government is relatively technically advanced in the map products that it creates, and its approach to climate change. However, many of the flood maps being used still date back the FDRP-era. There is an ongoing plan for new flood maps to be produced, and maps are updated and produced whenever resources allow.
NU	There are no flood maps currently in Nunavut, and no plans to develop any soon.
NS	Nova Scotia is currently producing a Provincial Specification to be used for future maps and to bring them to modern standards. There is also a desire to take more ownership in the production and management of flood maps at a provincial level. While there is currently no centralized register

P/T	Current State of Flood Hazard Data Development
	of flood mapping, it is thought that coverage is likely to be patchy and that much more mapping is required. If funding can be found, Nova Scotia thinks that they can do this over the next 5 years.
NWT	The Northwest Territories currently relies on FDRP-era maps. There is a desire in the territory to update these maps in the near future. However, there are several obstacles in the way of updating the flood maps, and no formal plan to do so. Future flood map updates are also dependent on the ongoing work with NRCan to review flood hazard guidance for a northern environment.
ON	As there is no central authority or up-to-date register of flood hazard data in Ontario, it is difficult to estimate how much flood mapping remains to be done. A Metadata Inventory completed by the Ganaraska Region Conservation Authority, Otonabee Conservation Authority, and Conservation Ontario indicated that, on average, flood maps were over 24 years old in 2015. The inventory also indicated that most conservation authorities believed that there were more areas without any flood maps that will need to be mapped. Most flood maps focus on the design storm for the area or the 1% AEP. Climate change is rarely included.
PEI	Prince Edward Island plans to completely replace their currently available coastal flood maps with maps done to modern technical standards by the end of 2020/early 2021. Climate change is considered in the coastal flood map updates. Once these flood maps are complete, no additional flood maps are expected until these new maps are considered out of date, likely after 5–10 years.
QC	Flood mapping in Québec has been harmonized within a central provincial database, which is publicly available. Québec is also currently developing a system called INFO-Crue (flood-info), which will provide real-time updates and flood early-warning systems to Québec.
SK	Saskatchewan is currently conducting a large-scale update of their flood maps. This update is the first that has been conducted since the FDRP maps were completed, and it represents approximately 50% of the areas that require flood maps in the province. It should be noted that while these maps represent a major update to the FDRP maps, they do not account for climate change.
YT	Yukon currently does not have any authoritative flood maps, but is producing flood maps, which are due in 2021. New maps are based on frequency analysis and not on hydraulic modelling, and do not include climate change (but climate change is expected to be included in new versions of these maps over the next 3-5 years). The current maps are being done primarily for emergency management purposes, rather than regulation and policy. Once these maps are finalized, there are many more areas that need to be mapped.

## Lessons for the National Flood Hazard Data Layer

Several key themes with respect to the National Flood Hazard Data Layer were learned from partners (e.g., interviewees from P/Ts) throughout the engagement phase of this project. These include:

- The **unification of data** from decentralized P/Ts for the NFHDL will be challenging due to the diversity in methods and products.
- There are potential future challenges for **maintaining an authoritative dataset in Canada**. Especially in decentralized P/Ts, the definition of authoritative data is challenging, as data are not technically reviewed and quality-approved by a central P/T agency.
- Several P/Ts are concerned about **data ownership** and want to ensure that they remain the definitive source for flood data.

- Future **funding programs** could be more directive with respect to providing data back to P/Ts and the federal government.

The stakeholders also noted some opportunities that have emerged or will emerge through the delivery of the NFHDL:

- **Opportunity for data and lesson sharing.** (E.g., with respect to developing metadata standards, developing a common schema, unifying data, data entry systems, etc.).
- **Opportunities for linking the NFHDL and other programs/initiatives.** There are several national programs and groups that the NFHDL could be linked to for efficiency and consistency (e.g., the National Research Council’s development of Mapping Standards, Insurance Bureau of Canada, NRCan’s Indigenous Flood Hazard Mapping project, etc.).

## Recommendations

Based on the engagement, data collection, and analysis in this report, several recommendations have emerged. Note that more specific recommendations on future use and maintenance of the NFHDL will be included in the main report of the NFHDL project.

### Recommendations for Federal Support for Flood Hazard Mapping in P/Ts

#### A. Flood Mapping Program

1. Provide continued and sustained funding.
2. Ensure accessibility of flood hazard data.

#### B. Federal Guidance

1. Increase federal flood mapping guidance.
2. Use the NFHDL to encourage adoption of metadata standards.
3. Develop guidelines for a northern environment.
4. Support the development of new technical approaches.
5. Strongly encourage the consideration of climate change.

#### C. Federal Support for Diversity of Flood Management Archetypes

1. Support P/Ts with limited flood mapping, technically and financially.
2. Support decentralized P/Ts with guidance and enable knowledge exchange with other P/Ts.
3. Support centralized P/Ts by providing adequate funding and technical guidance.

#### D. Support Continued Collaboration and Cross-Provincial/Territorial Learning and Knowledge Exchange

### Recommendations Related to the NFHDL

#### A. Make the NFHDL Public

Many P/Ts stated that they would be happy for flood data to be made public, but additional consultation would be needed. Some P/Ts also had reservations about this, but many P/Ts are moving toward open data themselves. Some P/Ts also indicated they would adopt the NFHDL if it would remove the need to develop their own public data system.

#### B. Ensure Data Quality for Future Additions to the NFHDL

## Table of Contents

<b>EXECUTIVE SUMMARY .....</b>	<b>VI</b>
<b>TABLE OF CONTENTS.....</b>	<b>X</b>
<b>1 INTRODUCTION .....</b>	<b>1</b>
1.1 PROJECT BACKGROUND .....	1
1.2 REPORT OBJECTIVES.....	2
1.3 TERMINOLOGY.....	2
1.4 REPORT STRUCTURE.....	3
<b>2 METHODOLOGY.....</b>	<b>4</b>
2.1 ENGAGEMENT METHODOLOGY.....	4
2.2 SUPPORTING INFORMATION.....	5
2.3 LIMITATIONS .....	6
<b>3 FLOOD HAZARD DATA REVIEW BY PROVINCE/TERRITORY.....</b>	<b>7</b>
3.1 ALBERTA .....	7
3.2 BRITISH COLUMBIA.....	12
3.3 MANITOBA .....	18
3.4 NEW BRUNSWICK.....	22
3.5 NEWFOUNDLAND AND LABRADOR.....	25
3.6 NORTHWEST TERRITORIES .....	29
3.7 NOVA SCOTIA.....	32
3.8 NUNAVUT .....	36
3.9 ONTARIO.....	39
3.10 PRINCE EDWARD ISLAND.....	45
3.11 QUÉBEC .....	49
3.12 SASKATCHEWAN.....	53
3.13 YUKON .....	57
<b>4 NATIONAL FLOOD HAZARD DATA REVIEW.....</b>	<b>61</b>
4.1 KEY THEMES FOR FLOOD HAZARD DATA .....	61
4.2 KEY THEMES FOR THE NFDHL.....	71
<b>5 RECOMMENDATIONS.....</b>	<b>75</b>
5.1 FEDERAL SUPPORT FOR FLOOD HAZARD MAPPING IN P/Ts.....	75
5.2 RECOMMENDATIONS FOR THE NFHDL.....	77
<b>6 CONCLUSION .....</b>	<b>78</b>
<b>7 GLOSSARY.....</b>	<b>79</b>
<b>8 REFERENCES .....</b>	<b>85</b>
<b>APPENDIX A STAKEHOLDER ENGAGEMENT METHODOLOGY .....</b>	<b>A-1</b>
<b>APPENDIX B STAKEHOLDER CONTACTS .....</b>	<b>B-1</b>

## TABLES

TABLE 1: ALBERTA PRESENT-DAY “AUTHORITATIVE” FLOOD HAZARD MAPPING SUMMARY. ....	7
TABLE 2: BRITISH COLUMBIA PRESENT-DAY “AUTHORITATIVE” FLOOD HAZARD MAPPING SUMMARY. ....	12
TABLE 3: MANITOBA PRESENT-DAY “AUTHORITATIVE” FLOOD HAZARD MAPPING SUMMARY. ....	18
TABLE 4: NEW BRUNSWICK PRESENT-DAY “AUTHORITATIVE” FLOOD HAZARD MAPPING SUMMARY. ....	22
TABLE 5: NEWFOUNDLAND AND LABRADOR PRESENT-DAY “AUTHORITATIVE” FLOOD HAZARD MAPPING SUMMARY. ....	25
TABLE 6: NORTHWEST TERRITORIES PRESENT-DAY “AUTHORITATIVE” FLOOD HAZARD MAPPING SUMMARY. ....	29
TABLE 7: NOVA SCOTIA PRESENT-DAY “AUTHORITATIVE” FLOOD HAZARD MAPPING SUMMARY. ....	32
TABLE 8: ONTARIO PRESENT-DAY “AUTHORITATIVE” FLOOD HAZARD MAPPING SUMMARY. ....	39
TABLE 9: PRINCE EDWARD ISLAND PRESENT-DAY “AUTHORITATIVE” FLOOD HAZARD MAPPING SUMMARY. ....	45
TABLE 10: QUÉBEC PRESENT-DAY “AUTHORITATIVE” FLOOD HAZARD MAPPING SUMMARY. ....	49
TABLE 11: SASKATCHEWAN PRESENT-DAY “AUTHORITATIVE” FLOOD HAZARD MAPPING SUMMARY. ....	53
TABLE 12: YUKON PRESENT-DAY “AUTHORITATIVE” FLOOD HAZARD MAPPING SUMMARY. ....	57
TABLE 13: THE CURRENT STATE OF FLOOD MAPS IN CANADA FOR CURRENT AND IN-PROGRESS MAPPING, BASED ON INFORMATION OBTAINED IN ENGAGEMENT AND DATA COLLECTION PHASE. ....	61
TABLE 14: DESCRIPTION OF FLOOD MAPPING CURRENTLY IN PROGRESS (AND THAT COULD NOT BE OBTAINED WITHIN THE TIMELINE OF THIS PROJECT). ....	62
TABLE 15: CURRENT STATE OF FLOOD HAZARD DATA DEVELOPMENT IN EACH P/T. ....	63
TABLE 16: SUMMARY OF FLOOD SCENARIOS CONSIDERED IN EACH PROVINCE OR TERRITORY. ....	65
TABLE 17: SUMMARY OF OPEN DATA FOR EACH P/T. ....	67
TABLE 18: SUMMARY OF ORGANIZATIONAL STRUCTURES AND DATA MANAGEMENT. ....	68

## FIGURES

FIGURE 1: FLOOD HAZARD CRITERIA ZONES OF ONTARIO AND CONSERVATION AUTHORITIES. (FIGURE FROM OMNR (2001), PRINTED WITH PERMISSION). ....	43
--	----

## LIST OF ACRONYMS

AB	Alberta
ACASA	Atlantic Climate Adaptation Solutions Association
AEP	Annual Exceedance Probability
BC	British Columbia
BCREA	BC Real Estate Association
BDZI	Base de données des zones à risque d'inondation
CCQ	Convention Canada-Québec
CEHQ	Centre d'expertise hydrique du Québec
CEPF	Community Emergency Preparedness Fund
CIRNAC	Crown-Indigenous Relations and Northern Affairs Canada
DEM	Digital Elevation Model
EGBC	Engineers and Geoscientists British Columbia
EMBC	Emergency Management British Columbia
FAMA	Flood Awareness Mapping Application
FDRP	Flood Damage Reduction Program
FME	Feature Manipulation Engine
GIS	Geospatial Information System
IPCC	Intergovernmental Panel on Climate Change
ISC	Indigenous Services Canada
LIDAR	Light Detection And Ranging
MB	Manitoba
MELCC	Ministère de l'Environnement et de la Lutte contre les changements climatiques
NB	New Brunswick
NDMP	National Disaster Mitigation Program
NFHDL	National Flood Hazard Data Layer
MFLNRORD	BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development
NL	Newfoundland and Labrador
NU	Nunavut
NRCan	Natural Resources Canada
NS	Nova Scotia
NWT	Northwest Territories
OMNRF	Ontario Ministry of Natural Resources and Forests
ON	Ontario
PEI	Prince Edward Island
P/T	Province/Territory
PDCC	Programme de détermination des cotes de crues
PIBC	Planning Institute of British Columbia
PSC	Public Safety Canada
QC	Québec

QP	Qualified Professional
SK	Saskatchewan
SOREM	Senior Officials Responsible for Emergency Management
UBCM	Union of BC Municipalities
YT	Yukon

## 1 Introduction

Floods are common disasters that affect many Canadians. With climate change, flooding will pose an increasing risk to Canada's economic vitality, infrastructure, environment, and citizens.

Effective management of flood that has the goal of reducing risk and losses over time requires flood mapping as baseline information. However, the federal government lacks an authoritative source of information that provides up-to-date, accessible, consistent, and comprehensive data on flood hazards across Canada.

This is in part because flood management in Canada is in a period of rebuilding. The Federal Damage Reduction Program (FDRP) was instrumental in the development of many of the flood maps that are available across Canada today. Unfortunately, the FDRP ceased to exist in the late 1990s. For the next 20 years, flood mapping in Canada was not well coordinated or well funded. It was left to individual Provinces/Territories (P/Ts) and, in some cases, individual local governments to fund and manage. Without guidance from the national FDRP, flood mapping fell off the priority list. In the wake of the costly Alberta and Ontario floods in 2013, the federal government established the National Disaster Mitigation Program (NDMP) in April 2015. The program has several priorities including providing support to P/Ts to identify and mitigate high-risk flood areas and establishing conditions for the introduction of a residential flood insurance market in Canada. These two priorities rely on flood mapping, and therefore the NDMP has re-ignited a focus on the creation of flood maps.

There are now many dozens of new flood maps that have been created in Canada. But because of the devolved nature of the regulatory system in Canada, where P/Ts have the authority and responsibility to manage floods and flood mapping, there is a patchwork of mapping and mapping approaches across the country.

Given the diversity in mapping and mapping approaches, and the continued reliance and expectation that P/Ts will have the primary authority for flood management and flood mapping, it is important for the federal government to have a baseline picture of map coverages and diverse approaches. This baseline will enable them to develop targeted strategies, policies, guidance, and funding programs that will support P/Ts where they are.

### 1.1 Project Background

Natural Resources Canada (NRCan) has retained the services of Minerva Intelligence Inc. (Minerva) and Ebbwater Consulting Inc. (Ebbwater) to develop a National Flood Hazard Data Layer (NFHDL) to store existing, high-quality flood hazard information developed by provinces, territories, municipalities, and other authoritative sources.

This NFHDL project required engagement with map regulators and holders from across the country, primarily at the P/T level, to understand their data collections and anticipated data needs. However, in addition to the technically focused engagement (e.g., number of maps, type of hydraulic modelling, database management, etc.) that was designed to support the development of a robust schema for the

NFHDL, the consultant team also had the opportunity to learn about broader flood mapping governance in each P/T. This report summarizes the findings of this evolved engagement process, outlining the opportunities and challenges to developing flood maps in each P/T, and then providing guidance based on the main archetypal models for flood hazard data development and management in Canada.

## 1.2 Report Objectives

The overall goal of this work is to provide a baseline summary of how the diverse P/Ts have approached and hope to approach flood hazard mapping, and to provide the federal government with some clear directions on how to best support the various P/Ts. This summary will in turn support the federal government in the development of a consistent and comprehensive picture of flood hazard across Canada. Specific objectives in support of this goal addressed in this report include:

1. Engage, record, and learn from P/Ts authorities about the current state of flood mapping.
2. Engage, record, and learn from P/Ts authorities about the current approach to flood mapping.
3. Engage, record, and learn from P/Ts authorities about future directions in flood mapping.
4. Engage, record, and learn from P/Ts authorities about opportunities and obstacles, especially those related to federal government services.
5. Analyze and summarize the results in order to develop archetypal information.
6. Provide the federal government clear directions on how to best support P/Ts to continue to build a robust flood mapping inventory for Canada.

## 1.3 Terminology

For the purposes of this report it is assumed that the reader has a base understanding of flood and flood-mapping concepts, as well as the overarching NFHDL project. However, a few key terms that are necessary to understand this report are defined below, and a full glossary is provided in Section 7.

**Flood Map:** The delineation of flood extents and elevations on a base map. This typically takes the form of flood lines on a map that show the area that will be covered by water, or the elevation that water would reach during a specified flood event. The data shown on the maps, for more complex scenarios, may also include flow velocities or depth (NRCan, 2018).

**Authoritative:** Jurisdictional agency vested with the power to define policy and regulations with respect to flood management issues (i.e., the province, territory, municipality, regional district, conservation authority etc.).

**Authoritative Flood Map** (to be included in the NFHDL) must:

1. be a “Flood Map”, as defined above, provide the best available and most recent source for the jurisdiction  
AND
2. be provided by the authoritative body in which the flood map has been produced  
OR
3. be produced using standard hydrologic and hydraulic modeling procedures, as outlined in the federal guidelines (NRCan, 2019)

**Regulatory:** Used to describe data or data sources that are used, or planned to be used, for policy/regulation. For flood hazard data, this should be based on the best available and most recent source

for the jurisdiction, as defined by the local authoritative agency. It typically describes the regulatory flood scenario, which is used for planning and policy-making.

**Schema:** A formal description of data, data types, and data file structures. In a database, the schema describes the structure in terms of feature (table) names, property (column) names, constraints (e.g., primary, foreign keys), etc. to maintain the integrity of the data.

## 1.4 Report Structure

This report provides a brief description of the methods used (Section 2), followed by a summary of the current state of flood mapping for each P/T (Section 3). These summaries are then used to build the national picture of flood mapping, and identify archetypes (Section 4), followed by recommendations (Section 5) and conclusions (Section 6). A glossary and references are provided in Sections 7 and 8, respectively. Lastly, Appendix A provides details on the stakeholder engagement methodology, and Appendix B provides a stakeholder contact list.

## 2 Methodology

The following describes the methodology used to meet the objectives outlined in the previous section. The primary purpose of the engagement and research was to support the outcomes of the NFHDL project, rather than this evolved project, and therefore the methods should not be considered comprehensive for the purposes of this project.

The NFHDL project was primarily targeted at the collection of authoritative flood hazard data, and the development of a schema and National Flood Hazard Data Layer. The project had a flood hazard data collection phase and an engagement phase, which both informed this report. The provincial/territorial summaries in Section 3 were reviewed by the P/T stakeholders for accuracy.

Data collection was conducted by reaching out to P/T governments to obtain flood hazard data. In cases where flood hazard data are managed at the local or regional jurisdiction level, data were obtained from these authorities.

The focus was primarily on flood hazard data that is used for regulation, and that defines the best available and most recent source for the jurisdiction, as defined by the authoritative agency (see additional information in Section 1.3). Specifically, the target data were coastal and riverine flood hazard data that has been developed using standard engineering practices, and that has been approved by the relevant jurisdiction (i.e., authoritative data). Superseded flood data (which may have been authoritative prior to being superseded by more recent flood mapping) were not included in the data collection. However, it should be noted here that the NFHDL will include a ‘deprecated’ flag to indicate when currently authoritative flood maps have become replaced by newer data.

A summary of the engagement methodology are provided in the section below.

### 2.1 Engagement Methodology

This section contains a summary of the engagement methodology; a more detailed description is included in Appendix A.

#### 2.1.1 Engagement Objectives

The original principal purpose of the engagement was to inform the design of the NFHDL development, specifically:

- To understand stakeholder’s geospatial infrastructure to provide the tools appropriate for developing and maintaining the NFHDL.
- To get a sense of geospatial data management proficiency within the P/Ts, and how flood data are currently managed; the schema design will hinge on how P/Ts currently manage their flood data.
- To understand the needs (if any) of the P/Ts from the NFHDL, and any concerns or opportunities they foresee for this project.

This document utilizes the data and information provided throughout the engagement and data collection process to provide a summary of the current status of flood hazard data in Canada.

### 2.1.2 Engagement Activities

Engagement was done through an online survey and a series of semi-formal interviews conducted between June 2020 and August 2020. The engagement approach was designed based on best practice guidelines by the International Association for Public Participation (IAP2 Canada, 2020), the National Research Council (Murphy et al., 2020), and the University of Toronto (Batmanabane & Kfourri, 2017).

To achieve the purpose of engagement laid out above, input was sought from the following roles within P/T government:

- **Geospatial Data Management.** Has knowledge of what the data contains, how the data are stored, shared, accessed, visualized, etc. (geomatics expertise).
- **Planning and Policy.** Has knowledge of how flood data are used, which level of government is responsible for flood regulation/authorization, and future plans for flood hazard/risk management.
- **Technical Flood Knowledge.** Has knowledge of flood mapping methodologies and standards that are used, as well as maintaining scientific accuracy and relevancy.

People in these roles, where they existed, were contacted and interviewed in all P/Ts except Nunavut (where currently no territorial flood hazard data exists, and it was therefore determined with Nunavut that an engagement interview would not be worthwhile).

A semi-structured interview format was used. This format uses a set of long-answer questions as a guide, but allows freedom for the interviewee to influence the direction of what is discussed. This approach is well suited to situations where only one phase of engagement is planned (Batmanabane & Kfourri, 2017). It allows all necessary information to be gathered in a single interview, while still allowing for flexibility to adjust the interview based on the different approaches taken by different provincial and territorial governments. To optimize time spent in the interview, a short survey was provided to attendees beforehand. This helped to guide interview questions, and allowed the inclusion of further short-answer questions in the survey, which were not well suited to the style of interview conducted.

In some cases, brief follow-up questions for clarification during data collection and report writing were also posed to some P/Ts. Lastly, the provincial/territorial sections in Section 3 were reviewed by the P/T stakeholders.

## 2.2 Supporting Information

The following previous scans and documents also provided additional information to the provincial/territorial summaries, where applicable, or where no newer information from the engagement and data collection phase was available:

- Status of Flood Maps in the Atlantic Canada Provinces (CBCL, 2017).
- Metadata Inventory of Existing Conservation Authority Flood Mapping (Ganaraska Region Conservation Authority, Otonabee Conservation Authority, Conservation Ontario, 2017).
- National Floodplain Mapping Assessment Final Report (MMM Group, JFSA, & Matrix Solutions Inc., 2014).

- Floodplain Mapping Funding Guidebook for BC Local Governments (BC Real Estate Association, Sustainability Solutions Group and Ebbwater Consulting, 2014); and BC Floodplain Map Inventory Report (Parsons, C., and British Columbia Real Estate Association, 2015).

### 2.3 Limitations

It is important to highlight that the information reported in the following sections was mostly based on the data collection and engagement phases of the NFHDL project (which had a different objective to this environmental scan report). Details reported are therefore dependent on the accessible information, and are associated with some uncertainty. In particular, estimates of the number of flood maps available in each P/T, as well as the number of maps per funding program, are associated with high uncertainty, as only limited information was available, and these estimates should therefore be referred to with caution. In many P/Ts, this information was not available at a conclusive level, especially for provinces with decentralized flood hazard mapping, such as British Columbia, Ontario, and Nova Scotia.

It should further be noted that the focus was on provincial and territorial governments alone, and there was no engagement with Indigenous governments as part of this project— a separate project from NRCan is currently underway that addresses flood hazard mapping in Indigenous communities.

Lastly, conversations and data collection focused on clearwater flooding (riverine (open-water), ice-jam, coastal, pluvial and lake). The following hazards were raised in the engagement, but were outside of the scope of this project:

- Debris flow and debris flood
- Fluvial hazards (e.g., channel erosion)
- Coastal erosion
- Tsunami flooding (note that data were collected where available, but no specific efforts were dedicated to, for instance, reporting different technical approaches)
- Flooding due to permafrost thawing
- Dam breach
- Sea ice ride-up and pile-up

### 3 Flood Hazard Data Review by Province/Territory

This section provides a summary of the current state of flood hazard data in each province or territory. The data in this section was taken primarily from the engagement exercise completed for the NFHDL project, a review of the data and reporting provided, and other project communications. Data taken from other sources is referenced where used. Note that the numbers of maps and funding sources provided for each P/T are estimates based on available data and information, and should be used with caution.

#### 3.1 Alberta

##### 3.1.1 Flood Hazard Data Summary

**Flood Mapping Authority** – Alberta Ministry of Environment and Parks.

**Flood Hazards Mapped** – Riverine, ice-jam, and lake.

**AEPs Included in Most Recent Maps**

- Riverine flood: 50%, 20%, 10%, 5%, 2.86%, 2%, 1.33%, 1%, 0.5%, 0.286%, 0.2%, 0.133%, 0.1% AEP.<sup>1</sup>
- Ice-jam flood: 2%, 1% and 0.5% AEP.

**Regulatory Flood** – 1% AEP flood.

The current state of flood-hazard mapping in Alberta is summarized in Table 1. The total flood mapping budget post-FDRP from 1999 to spring 2015 was M\$2.8 from the provincial government. The total budget for flood mapping between fall 2015 to fall 2020 was M\$16.7, and included funding from the provincial government (M\$11), NDMP (\$4.7), and Indigenous Services Canada (ISC) (M\$1). NDMP projects between 2016 and spring 2020 were jointly funded by NDMP (~50%) and provincial government (~50%), for a total of M\$9.4 (also including M\$0.2 from ISC). Another M\$7.3 was spend by the provincial government (M\$6.6) and ISC (M\$0.8) on non-NDMP projects, which included five large studies started in 2015 and three studies started in fall 2020. Please note that estimates provided in Table 1 are associated with some uncertainty.

**Table 1: Alberta present-day “authoritative” flood hazard mapping summary.**

Areas Mapped*		Average Year Produced <sup>†</sup>	Year Range	Funding Program for Authoritative Maps <sup>§</sup>		
Current	In Progress			FDRP	NDMP	Other
54	70	2007	1983–2020	26%	9%	65%

Note that the numbers provided are for authoritative maps only. The current map column includes all current authoritative maps. The remaining columns assume that these maps have been superseded by maps in progress, where applicable.

\*The number of mapped areas was approximated based on the number of map reports provided. The number of areas in progress was approximated based on the interview response. Note that these new maps are still in progress, or are currently being reviewed by municipal and First Nation stakeholders and the public, and thus have not yet been available for inclusion in the NFHDL within the timeline of this project.

† The average age assumes the historic maps (pre-FDRP and FDRP) were produced in an average year of 1993 and that 50% will be replaced by new maps, produced in an average year of 2020. The latter assumption is based on an interview response.

<sup>1</sup> Annual Exceedance Probability (AEP) is the likelihood of a flood of a specific magnitude occurring or being exceeded in any given year, expressed as a percentage.

§ Describes the percentages of authoritative flood hazard data produced under different programs for current and pending data. This assumes current data are superseded by pending data where applicable. Funding percentage estimates are based on number of maps for each period, and funding numbers provided by the provincial government.

### 3.1.2 Flood Mapping Governance

#### 3.1.2.1 Roles and Responsibilities

The authority for planning and managing flood hazard data lies with the provincial government (the Alberta Ministry of Environment and Parks). Alberta has invested heavily in flood hazard mapping over the last five years and in the development of their online Flood Awareness Map Application (FAMA). This is the system used in Alberta to host and manage flood mapping. Flood mapping has been led by the provincial government since the time of the FDRP, and flood maps are held centrally. Flood hazard modelling and mapping is conducted by consultants, but they are overseen by the provincial government.

Alberta's system is heavily centralized, which supports consistency across the province.

#### 3.1.2.2 Historic and Future Mapping Catalogues

Alberta currently holds a range of flood mapping data, dating from the FDRP period maps to the present day. The FDRP started in 1989, and flood maps completed before the FDRP (between 1983 – 1988) were assessed by the joint technical steering committee of the FDRP and deemed fine to use under the FDRP with a few modifications (Calgary is an example).

Alberta is currently in the process of finalizing a substantial mapping update, most of which was jointly funded by the NDMP and the Province of Alberta. When complete, this new data will replace around 50% of the existing mapping and will contribute some newly mapped areas. In their interview, Alberta stated that in the 30 years before 2015, they had completed flood mapping along 1,200 km of watercourses (covering approximately 50 communities). In the last 5 years alone, they have created an additional 1,500 km, 900 km of which are newly mapped areas, covering more than 60 municipalities and First Nations across Alberta. They have a long-term plan for the production of new and updated flood maps and are planning on completing an additional 600 km in the coming years.

#### 3.1.3 Technical Mapping Approach

Recent flood mapping in Alberta follows an established technical flood mapping standard; these terms of reference are typically provided as part of requests for proposals (Alberta Environment and Parks, 2020). Note that there are discrepancies between the current standards and how the older studies were conducted. The current terms of reference meet a high engineering standard, as they make use of LiDAR<sup>2</sup> data and detailed hydraulic modelling techniques. Ice-jam and (open-water) riverine floods are both mapped. Alberta produces the following map types:

---

<sup>2</sup> LiDAR (Light Detection And Ranging) is a remote sensing method used to examine the surface of the Earth, and provides, among other products, high-resolution topography data.

- **Flood Inundation Maps** – Flood extents for the 50%, 20%, 10%, 5%, 2.86%, 2%, 1.33%, 1%, 0.5%, 0.286%, 0.2%, 0.133%, and 0.1% AEP riverine (open-water) floods. And, if applicable, more recent maps include 2%, 1%, and 0.5% AEP ice-jam floods. These maps show directly flooded areas (i.e., no structural flood defences), as well as areas that could be flooded if local flood protection structures fail.
- **Flood Hazard Maps** – Show the area of land that will be flooded during the 1% AEP design flood. The flood hazard area is typically divided into two zones, the floodway and the flood fringe. This is the regulatory map; no freeboard is included in mapping.
- **Flood Water Surface Elevation and Depth Data** – Grid files for each of the 13 modelled flood scenarios, which provide information at 1-m horizontal resolution.

Older maps typically consider the 2%, 1%, and 0.5% AEP floods only.

Previously, an encroachment analysis was included in the mapping approach, but the latest terms of reference suggest that this is no longer incorporated. There is an intention to move toward the option of using 2D hydraulic modelling (Alberta Environment and Parks, 2020), whereas, encroachment analysis is more appropriate for 1D models.

Alberta does not currently account for climate change in their flood maps, but an assessment is included in the reporting. They stated in the interview that part of the reason that climate change is not accounted for is the large number of likelihoods mapped, which allows identification of a range of changes in flow that might result from climate change.

### **3.1.3.1 Regulatory Flood**

The provincial guidance is to plan for and design to the 1% AEP flood, however Alberta does not specifically regulate the flood hazard area as this is done at a local government level. No freeboard is added in the provincial mapping, but freeboard can be applied at the discretion of local governments when using data for regulations.

The provincial government defines two flood hazard areas:

- **Floodway** – The portion of the 1% AEP flood hazard area where flows are deepest, fastest, and most destructive. The floodway includes areas where the water is 1 m deep or greater, or where the local velocities are 1 m/s or faster.
- **Flood Fringe** – The portion of the 1% AEP flood hazard area outside of the floodway, where flows are shallower and slower moving.

### **3.1.4 Management of Flood Hazard Data**

#### **3.1.4.1 Data Structure**

Alberta has developed a data model to manage flood data in both vector and raster formats using Esri geodatabases and file folders. The primary flood vector features include flood hazard areas, flood inundation areas, flood control structures (berms and dikes), cross sections, and historical flood extents.

Raster flood data include water surface elevation and water depth. All flood data are linked by a unique identifier to a flood study feature, which represents the flood study area boundary. For flood studies covering more than one river, the flood study polygon is split into multiple polygons so that each flood study polygon refers to one river. Each flood study has properties indicating its status, the type of flood data available, a hyperlink to the study report, and study metadata.

The primary vector features are stored in an Esri geodatabase. The flood hazard feature represents the 1% AEP design flood, with a “Zone” property that indicates if a polygon is a floodway, flood fringe, or overland flow. Other properties include river name, flood mechanism, and design flood flow. The flood inundation feature represents flooded areas for different-sized floods and is typically used for emergency response planning. Each polygon is described by its flood return period, flood AEP, flood probability, flood flow, type of inundation, river name, and flood mechanism. Historical flood extents are mapped with a date property that references the date of the aerial photography that the mapping was based on, if available. Vector features for cross-sections and flood control structures are also available.

Water surface elevation and water depth grids are available at 1-m resolution. Grid datasets are stored in geodatabases, with one geodatabase per flood study. Water surface elevation TINs are also available and stored in file folders, with one folder per flood study. Individual datasets follow a strict naming convention that references the data type, study ID, return period, and flood mechanism. Alberta also retains intermediate datasets, such as the cross-section extents for TIN (Triangulated Irregular Network) generation and flow zones.

#### **3.1.4.2 Data Processing**

The Alberta Environment and Parks Department updates provincial flood data within the department, and it is responsible for managing the database. Service Alberta is responsible for hosting FAMA and runs the enterprise geospatial infrastructure. A combination of ArcMap and FME (Feature Manipulation Engine) are used to add new data or studies, remove old flood studies, and update portions of an existing study. The data are created and finalized in desktop software and a data upload is sent to Service Alberta once or twice a year to update the map services on FAMA.

#### **3.1.4.3 Data Services**

Flood data are available for viewing on the FAMA website through an interactive web mapping interface and are currently used by provincial employees, members of the federal government, municipal governments, First Nations, and the public. Data are available for download on request, as shapefiles or a geodatabase, and are delivered by a data distribution team. Alberta is considering alternatives for more efficient download options. FAMA is available at <https://floods.alberta.ca>, which was publicly released in the spring of 2020.

### 3.1.5 Challenges and Opportunities – Flood Hazard Data

#### 3.1.5.1 Challenges

While many of the FDRP maps have been superseded, around 50% are still in use. Alberta does not explicitly include climate change in flood mapping, although it is considered in reporting and partially accounted for in the wide range of AEPs mapped.

#### 3.1.5.2 Opportunities

Alberta has a well-established, well-organized flood mapping program and substantial technical expertise within the provincial government. Alberta is technically advanced and produces outputs that are still relatively uncommon in Canada, including a wide range of AEPs, multiple AEPs for ice-jam floods, and depth maps.

### 3.1.6 Challenges and Opportunities – NFHDL

#### 3.1.6.1 Challenges

Alberta raised some specific concerns regarding the development of the NFHDL.

- Alberta expressed concern over the ownership and consistency of data in the NFHDL. They prefer to be in charge of the data going into the NFHDL so that it is consistent with their flood maps, and because they (as data owners) are in the best position to answer questions or provide information on the data. It is especially important to highlight Alberta as the data owner and authoritative data source, in case the NFHDL becomes public, to avoid “two versions of the truth” scenarios.
- Differing methodologies and data quality in flood hazard maps across Canada was also raised as a concern, in that it needs to be made clear how data were produced to inform on the reliability of the data. Related to this, they recommend that data should go through a provincial/territorial approval process before being uploaded. In this respect, confirmation of the authoritative source will be required for each P/T.
- Another discussion item that was raised is the scenario where a local authority has more detailed information than is available at the provincial level. For instance, for the City of Calgary, the Province of Alberta provided the footprint and let Calgary fill in more robust data that they need for permitting.
- Adding a lot of metadata could be a burden on P/Ts.

#### 3.1.6.2 Opportunities

Alberta has recently made substantial investments in centralizing their flood mapping data and building their flood mapping data system, FAMA, through which their data are shared publicly. There are substantial lessons that can be learned for the NFHDL and by other P/Ts regarding the development of a centralized flood mapping data system. Alberta is still developing this system and is keen to learn lessons from others as they do so.

## 3.2 British Columbia

### 3.2.1 Flood Hazard Data Summary

**Flood Mapping Authority** – Local government with guidance and funding from the British Columbia (BC) Ministry of Forests, Lands and Natural Resource Operations and Rural Development (MFLNRORD) and Emergency Management BC (EMBC). Engineers and Geoscientists BC (EGBC) provides professional guidance for qualified professionals.

**Flood Hazards Mapped** – Coastal, tsunami, lake, riverine (open-water), ice-jam, and combinations thereof. Varies widely.

**AEPs Included in Most Recent Maps** – Varies widely.

**Regulatory Floods** – Varies. Typically, 0.5% AEP, 0.2% AEP, or the flood of record (e.g., 1894 for the Lower Fraser River) are used.

A summary of the availability of flood hazard data is provided in Table 2. As there is no central register of flood maps available in BC, the table is a combination of three different sources: the Historic Flood Map layer from DataBC, communication with municipalities identified in a BC Real Estate Association Report (Parsons & British Columbia Real Estate Association, 2015), and a list of provincially and federally funded projects provided by EMBC. As these are separate datasets, and not all individual pieces of data were provided to the NFHDL project, it is unclear which maps are currently authoritative, and which have been superseded, and the estimates in Table 2 for map numbers, average age, and funding program should be considered with caution.

**Table 2: British Columbia present-day “authoritative” flood hazard mapping summary.**

Areas Mapped*		Average Year Produced*†	Year Range	Funding Program for Authoritative Maps†		
Current	In Progress			FDRP	NDMP	Other
95	33	2003	1975–2020	33%	15%	52%

\* Includes 66 historical maps, based on unique file numbers in the BC data catalogue Historic Flood Map Data layer (this includes 24 pre-FDRP maps (1975-1987) and 42 FDRP maps). In some cases, historical maps, as well as newer flood maps, might exist for the same location and would be double counted here. Note that numbers are estimates due to limited data, and further maps might exist. Screening-level flood mapping was excluded from counts.

† Assumes none of the FDRP maps are superseded, which is unlikely to be the case. Note that numbers are estimates, due to limited data. Screening-level flood mapping was excluded from counts.

### 3.2.2 Flood Mapping Governance

#### 3.2.2.1 Roles and Responsibilities

Amendments to the *Local Government Act* [2004] shifted the primary responsibility for flood mapping in BC to local governments from the provincial government. Local governments include both incorporated municipalities, as well as large regional districts.

Flood services are provided at a provincial level by MFLNRORD and by EMBC. Since 2016, EMBC has managed a number of direct access grants for local governments, and is collecting data from projects completed under these grants. This is a requirement for projects produced using federal funding. EMBC is currently collecting this data, and reviews it for completeness, as well as adherence to contract,

application, and guidelines; that is, EMBC ensures that the project met the objectives and deliverables of the grant. However, they do not approve the technical work itself, as there are no technical standards that are required to be followed.

Local governments in BC use a model of professional reliance for the development of flood maps, whereby Qualified Professionals (QPs) provide Letters of Assurance to local governments for flood maps, especially if they are used in policy. However, not all recent mapping projects include a signed and sealed Letter of Assurance. Engineers and Geoscientists BC (EGBC) provides a guidance document on the selection of QPs, and on flood modelling and mapping methods.

In 2011, in order to support local governments, who generally lack the capacity and expertise to manage flood mapping programs, the Government of BC commissioned a number of reports that provide guidance for land use planning and mapping in consideration of coastal flood hazards and sea-level rise (Ausenco Sandwell 2011a, 2011b, 2011c; Kerr Wood Leidal 2011). The guidance in these documents was further refined in the Association of Engineers and Geoscientists British Columbia (now EGBC) Professional Practice Guidelines for Flood Mapping in BC, released in 2017 (EGBC, 2017), and the EGBC Professional Practice Guidelines – Legislated Flood Assessments in a Changing Climate in BC (EGBC, 2018).

Historic data from FDRP maps are managed by DataBC through British Columbia’s open data catalogue.<sup>3</sup>

The provincial government sees advantages in taking a more active role in flood hazard mapping and is currently in discussions as to how this can be done and what form this may take. This could involve providing further guidance and coordination of flood mapping, providing a centralized approving authority, or publishing flood data from a central location.

One other unique component of flood mapping governance in BC is the leadership provided by the private sector. The BC Real Estate Association (BCREA) has been active in promoting the need for flood mapping since 2013. Since then, they have produced guidebooks for communities on the need for mapping, and on funding opportunities, in addition to producing occasional reports on the state of mapping within the province. The BCREA’s interest in flood mapping stems from the need for their Realtors™ to provide accurate information to clients.

### **3.2.2.2 Historic and Future Mapping Catalogues**

A large number of flood maps were completed in British Columbia from 1976 to 1987 (under a provincial flood mapping program) and under the FDRP from 1988 to 1998 (after the provincial government had entered an agreement with the federal government under the FDRP in December 1987). These maps are currently published by the Government of BC via their online data catalogue. While these maps are generally considered out of date, they are still in use in many areas. The FDRP maps typically consider the 0.5% AEP flood, and some also include a flood fringe of 5.0% AEP. They also include allowance for freeboard (0.3 m or 0.6 m).

---

<sup>3</sup> <https://data.gov.bc.ca/>

Between 1998 and 2015, under the amendments to the *Local Government Act* [2004], mapping was driven by local government requirements with little provincial guidance or involvement. The need was driven by local planning policy and bylaws. It was a relatively quiet period for flood mapping in BC. As no centralized mapping register exists other than for the historic flood mapping, it is difficult to quantify how many maps originate from this period; it is believed approximately 8–10 flood maps were created.

In 2015, the introduction of the federally funded NDMP led to an increase in flood mapping in the province, and around 19 flood maps have been completed (or are currently in progress) under this program (this number does not include screening-level flood hazard mapping, which was conducted for some NDMP projects). Another approximately 28 flood maps have been completed via different provincial funding streams, including the Community Emergency Preparedness Fund (CEPF), which is administered through the Union of BC Municipalities (UBCM), an arms-length organization charged with supporting local governments.

Although substantial effort was taken to identify all maps, this report is unlikely to be a complete list of maps produced in BC. Maps have also been produced using funding from Indigenous Services Canada (ISC) and from self-funded projects by larger municipalities. There are also a number of flood studies in BC that are not considered authoritative flood maps, such as the 2019 flood mapping of the Lower Fraser River developed for the Fraser Basin Council. While this project created map products, the regional scale of the project means it cannot be classed as an authoritative flood map.

BC is currently in the process of reviewing potential funding programs with a plan to initiate these in the future. They envision that multiple programs will be run in tandem to increase the chances of funding.

### 3.2.3 Technical Mapping Approach

Modern flood modelling and mapping follow the BC Provincial Guidelines and BC Professional Practice Guidelines (see above). These guidelines, however, are not prescriptive and not overly detailed, and there is a substantial degree of variety in the way maps are produced.

Several types of map exist, for example, flood inundation maps, flood hazard maps, flood risk maps, and flood construction level maps. Due to the non-prescriptive nature of the guidelines, there is a variance in how these terms are defined and what is included. It is the responsible authority (local governments, regional districts, or First Nations) who decide on the flood map they require, typically in consultation with their QP. QPs are to follow the Professional Practice Guidelines by EGBC in developing the maps. However, there are known instances where flood maps have been made in the absence of consultation with the guidelines.

A wide range of AEPs are produced depending on the local authority and the QP. There is some guidance on the expected AEP used for regulation, which requires consideration of the flood of record<sup>4</sup> (such as on Lake Okanagan or the Lower Fraser River), the 0.2% AEP, the 0.5% AEP, and the 1% AEP.

---

<sup>4</sup> The flood of record means the largest recorded event (e.g., with hydrometric equipment), and is not necessarily the largest known event, especially with consideration of oral histories of local Indigenous communities.

Methods to account for climate change in estimating sea-level rise are relatively well defined in the Provincial and Professional Practice Guidelines, typically for 1 m of sea-level rise by 2100, unless better data exist. However, how climate change is to be accounted for in evaluating other flood hazards (such as inland riverine flooding) is poorly defined in the guidelines and is left to the decision of the QP. In many cases, climate change is not included for riverine flooding or a simple percentage increase is added to historic flows. Some studies also include a more quantitative approach to climate change where different emission scenarios and future time periods are considered.

Interviewees noted that the current standards are not prescriptive enough. There is a general desire to update this, but there are many factors that would make this difficult. However, a BC-administered funding program could require any criteria established by the provincial government to be met as part of the funding requirements. The substantial variation in current flood maps would present major challenges in creating a centralized flood management system (such as that used in Alberta) as unification of data will be a large and complex task. Flood maps produced using federal and provincial funding are currently being collected and reviewed for completeness and adherence to contract by the provincial government (EMBC), but they are not approved to a technical standard or authorized by EMBC. Additional resources would be necessary to create a centralized authorizing role.

### **3.2.3.1 Regulatory Flood**

The provincial government does not have the mandate to determine a regulatory flood but does have guidelines for communities to follow. Local authorities (local governments, regional districts, or First Nations) decide on the appropriate regulatory floods, typically in consultation with their QPs.

In general, regulatory flood maps show the 0.5% AEP flood scenario, except where a larger flow has been recorded. For example, for the Lower Fraser River, the 1894 flood of record, has an approximate AEP of 0.2%. The 0.2% AEP is also used in some coastal areas. Some coastal communities also decide to use an AEP (e.g., the 0.5% AEP) with sea-level rise (e.g., 1 m) as the regulatory flood. For river systems with dikes regulated provincially, the AEP is typically 0.5%. For river systems with dikes regulated federally (i.e., those on First Nation Reserve lands managed by Indigenous Services Canada), the AEP may only be 1%. Some agricultural dikes are designed to withstand a 2% AEP flood.

Flood construction level maps are often used in land use regulation and include the design flood scenario plus a freeboard of (typically) 0.6 m. Freeboard is thus included in flood mapping (in contrast to many other provinces and territories). Flood construction level maps are typically provided as one of the outputs of a flood mapping project.

## **3.2.4 Management of Flood Hazard Data**

### **3.2.4.1 Data Structure**

As flood mapping is currently managed at a local and regional level, it is difficult to comment on the data structure for flood maps in British Columbia in a collective manner. Data structures vary substantially from

study to study. These variances are influenced primarily by the consultancy who produced the maps, as well as the applied methodology, and site-specific conditions.

Historic flood maps (pre-FDRP and FDRP maps) have been unified into a single polygonal feature, *Mapped Floodplains in BC (Historic)*. This feature contains 132 polygons, with some notable properties. One property “FEAT\_NAME” indicates the original feature type of the polygon, “Floodplain”, “Alluvial Fan”, and “Nothing” are the three values found in this column. There is also a “Name” column that identifies the watercourse associated with the polygon. Other attributes include IDs from different systems.

#### **3.2.4.2 Data Processing**

Flood mapping data are not currently managed or processed at a provincial level. Historic mapping (pre-FDRP and FDRP) has been collated into a single layer.

#### **3.2.4.3 Data Services**

British Columbia also has a data catalogue for data serving, which is operated by DataBC,<sup>5</sup> and is used both internally and externally to the government. This system serves data in various formats. The Mapped Floodplains in BC (Historic) Layer is available as a KML link, a WMS layer, or for download as Shapefile, CSV, File Geodatabase, or GeoJSON.

### **3.2.5 Challenges and Opportunities – Flood Hazard Data**

#### **3.2.5.1 Challenges**

Management of flood hazard data in BC is complex, and while central organizations are in place (e.g., MFLNRORD, EMBC, and GeoBC), there is little coordination at a provincial level. This means that there is no province-wide view of the availability of flood mapping and potential gaps. In addition, the non-prescriptive guidelines and the lack of centralized technical approving agency has led to a large variation in produced flood maps (and their quality). In some cases, maps are produced that are not considered authoritative due to the screening-level nature of the approach used, geographic scale of the map, or limited data/methods. There are also cases where multiple flood maps exist for the same area. This has led to confusion in locations, such as the Lower Fraser River, as to what flood extent to use for regulation. Flood mapping has largely been driven by the needs of local authorities, and coverage is therefore patchy.

#### **3.2.5.2 Opportunities**

There are provincial guidelines in place, and while these are not prescriptive, they have in some cases lead to flood maps that are relatively technically advanced when compared to other areas of Canada. Multiple AEPs are often included, as is an allowance for climate change. More complex maps, such as depth and velocity maps, are also often produced. However, it should be noted that there is a large degree of

---

<sup>5</sup> DataBC. <https://data.gov.bc.ca/>

variation in flood map quality, and while there are some well-advanced, high-quality maps, there are also flood maps that are completed to a low standard and/or not considered authoritative.

EMBC are currently collecting data from provincially and federally funded programs, and are sharing this data with GeoBC and MFLNRORD. This could be leveraged to support a more centralized system in future, should policy be changed. BC also has a well-established open web mapping system (iMapBC), which could be used to publish flood hazard data.

BC is also relatively well advanced in terms of regulation, through the guidelines available and the produced flood construction level maps. These maps include freeboard, which is relatively well defined through the guidelines. This is not typically done in other P/Ts or is often done as part of the regulation process, instead of as part of a flood mapping project.

### 3.2.6 Challenges and Opportunities – NFDHL

#### 3.2.6.1 Challenges

The provincial government warned in the interview, that populating the NFHDL database for BC is likely to be a huge undertaking due to the large amount of highly diverse data and the lack of definition as to what would be considered authoritative. In some cases, maps are produced that are not considered authoritative due to the regional and screening-level approach. There are also cases where multiple flood maps exist for the same area.

Future data updates to the NFHDL will likely be challenged by the high degree of diversity of flood hazard data in BC. While EMBC is collecting completed flood hazard data and review them for adherence to the grant application, they do not authorize them. Further, there are also flood mapping studies led by local authorities without provincial/federal funding, which would not be collected by EMBC. Therefore, continued input into the schema is likely to require input from individual local governments and their QPs, which can be complex, as it involves dealing with many different parties with different skill sets.

There are no current plans to create a centralized register of flood hazard data. Data produced using federal and provincial funding will continue to be collected by EMBC, however projects produced independently, using other funding sources, may not be recorded at a provincial level.

For future engagement with respect to flood mapping services within the provincial government MFLNRORD, EMBC and GeoBC would need to be included. EGBC should also be consulted with respect to technical standards, as they currently provide professional guidance for qualified professionals. However, it must be noted that guidance documents developed by EGBC represent the position of the document authors and may not represent the full diversity of approaches in the Province, especially leading-edge concepts. And therefore, broader consultation with the engineering and geoscientist community is warranted. Further, given that flood maps are ultimately implemented by local government planners, consultation with the Planning Institute of BC (PIBC) and its members is recommended.

**3.2.6.2 Opportunities**

Flood maps produced using federal funding are currently being collated to be passed to Public Safety Canada (as a requirement of the NDMP). BC suggested that if a particular requirement or specification can be set for the addition of new data to the NFHDL, this can be included in specifications for future funding programs currently being considered by the provincial government. It would be critical to act as soon as possible, as BC is considering their options now.

British Columbia stated that a big benefit of the NFHDL project could be the unification of information used to support insurance across the country, as this is currently highly varied. They also suggested that an enhanced metadata standard resulting from this project could be a benefit to data owners when producing additional flood maps.

There are discussions and projects currently ongoing in British Columbia that align with the goals of the NFHDL, such as the discussions around increasing provincial involvement in flood hazard mapping. For instance, the Fraser Basin Council is currently working on developing a Flood Strategy for British Columbia, part of which are an analysis of current flood hazard mapping and recommendations for future steps of flood mapping (NHC, 2020; reviewed by Ebbwater). Another ongoing study is by the BC Real Estate Foundation with the goal to provide a detailed overview of currently available flood hazard maps (including independently funded flood mapping). Note that the consultant team has reached out and had separate discussions with the project teams that are working on parallel projects to look for efficiencies and to compare recommendations. This is a critical time for flood mapping in British Columbia and collaboration between these independent projects and lessons learned in other P/Ts (such as FAMA) could help ease future updates to the NFHDL.

**3.3 Manitoba**

**3.3.1 Flood Hazard Data Summary**

**Flood Mapping Authority** – Manitoba Infrastructure (Technical Services & Operations Division).

**Flood Hazards Mapped** – Riverine (open-water) and ice-jam.

**AEPs Included in Most Recent Maps** – 0.5% AEP.

**Regulatory Flood** – 0.5% AEP.

A summary of the availability of flood hazard data is provided in Table 3.

**Table 3: Manitoba present-day “authoritative” flood hazard mapping summary.**

Areas Mapped*		Average Year Produced	Year Range	Funding Program for Authoritative Maps		
Current	In Progress			FDRP	NDMP	Other
7	2	2019	2018–2020	0%	100%	0%

Note that the provided numbers are for authoritative maps only.

### 3.3.2 Flood Mapping Governance

#### 3.3.2.1 Roles and Responsibilities

The Technical Services & Operations Division of Manitoba Infrastructure has the responsibility for planning and managing flood hazard data in Manitoba. Manitoba Infrastructure consults with local government when producing flood hazard data. The production of post-FDRP flood maps has occurred over the last 3 years, and Manitoba therefore continues to develop best practices for flood hazard data management.

#### 3.3.2.2 Historic and Future Mapping Catalogues

There were 17 communities mapped in Manitoba under the FDRP. These maps were the main source of flood hazard information in the province until recent years (Hossein, 2017). Manitoba has made progress in updating flood mapping over the last 3 years under the NDMP and has produced new maps covering 7 communities. There are 2 additional projects currently in progress, including a map of the Red River south of Winnipeg. The FDRP maps are no longer considered regulatory and authoritative by Manitoba Infrastructure. New maps use the 0.5% AEP as the regulatory flood, in contrast to the 1% AEP on the FDRP maps.

Manitoba Infrastructure has a general understanding of additional areas they wish to map in the future, and a concrete plan for some of these areas to be mapped over the current and next fiscal years. This is dependent on resources and will be prioritized based on consultation with local government. It was stated in the interview that it is difficult to say how much of Manitoba has been mapped, but the need for additional mapping is likely to be substantial. Manitoba Infrastructure suggested that much of the province is likely to be exposed to flood hazards to some degree. They gave the example of a 0.1% AEP<sup>6</sup> flood experienced in 2020, which highlighted new areas of potential exposure that had not previously been considered.

### 3.3.3 Technical Mapping Approach

The production of flood hazard data in Manitoba post-FDRP is relatively new and they are developing processes as they go. There is currently no formal provincial standard or guideline for flood mapping, but there is a *de facto* standard, which is based on the Souris River flood mapping study (Hatch Ltd., 2018). This was the first of the post-FDRP studies conducted by Manitoba Infrastructure, and they went through an enhanced internal consultation exercise to approve it to be used as a standard. For this reason, despite the lack of a formal standard, outputs are relatively consistent. There is some variation based on the technical approach used (e.g., 1D or 2D modelling). Manitoba Infrastructure is working to incorporate more of the federal guidelines into their mapping.

---

<sup>6</sup> River Dam, July 1, 2020: <https://watchers.news/2020/07/03/rivers-dam-hits-highest-level-causing-1-000-year-flooding-manitoba-canada/> (accessed in August 2020).

Manitoba Infrastructure has substantial technical capacity in-house and takes a more involved role in producing flood maps, as compared to most other P/Ts. Manitoba Infrastructure, for instance, processes raw flood water level data produced by consultants in GIS using a digital elevation model (DEM) derived from LiDAR to create depth files and flood extents. A visual check is also performed to remove areas that do not flood, based on knowledge of the flood hazard area. Manitoba Infrastructure prefers this approach as they claim it allows them to ensure that the outputs are suitable for their requirements. They also claim that their advanced local knowledge, for example, of flood protection structures, creates a more accurate result. This is done for the 0.5% AEP flood scenario only. Manitoba Infrastructure also stores additional outputs from flood studies, which they do not currently process. These additional outputs include velocity maps and flood extents from a broader range of flood likelihoods, typically ranging from 2% to 0.29% AEP (50 to 350-year return period).

In addition to processing results produced by consultants, Manitoba Infrastructure is currently producing flood maps for a few communities. Work is done in-house, where resources allow.

Manitoba currently maps ice-jam and open-water riverine flood hazards.

Climate change is not explicitly accounted for in Manitoban flood hazard maps. However, when producing post-FDRP maps, Manitoba chose to base the regulatory flood on a 0.5% AEP rather than a 1% AEP flood. This was done based on an observed increase in riverine peak flows and an increase in water level for ice jams. The decision to change the regulatory AEP was also made in part to account for climate change.

### **3.3.3.1 Regulatory Flood**

The regulatory flood in Manitoba is the 0.5% AEP. The magnitude of the regulatory flood was increased from the 1% AEP used during FDRP mapping, in part to account for climate change.

## **3.3.4 Management of Flood Hazard Data**

### **3.3.4.1 Data Structure**

Current authoritative flood maps in Manitoba are quite simple and the most common feature is the 0.5% AEP flood extent. This polygonal feature contains few meaningful attributes aside from a “source” property that states which types of floods were considered in the modelling. Precipitation-driven (pluvial) or riverine are the two values found in these “source” columns. Some study areas also have cross sections; these are represented as linear features with some attributes, such as the associated river name. Some other study areas, such as the Seine River, also have a polygonal feature representing the modelling extent for the 0.5% AEP flood extent feature.

### **3.3.4.2 Data Processing**

The data described above is derived from water level outputs produced by consultants. The process to derive the final flood extent features is carried out internally by the provincial government. In this process, the water levels are generally delivered as shapefiles, which are converted to raster files. The raster files have the DEM height subtracted to create depth maps. From these depth maps, non-flooded areas are

deleted based on local knowledge to determine the final flood extent to be used for regulatory purposes. ArcMap is used within the organization to process and store the data.

### **3.3.4.3 Data Services**

Manitoba is looking to implement a central GIS server, but it is currently unknown what this system will look like. Manitoba is currently reviewing how data are approved and is undergoing a consultation process for the Souris River. Once this is complete, the data will be approved and released publicly within a web-map interface. Once this process is established and the infrastructure complete, other mapped areas will also be included.

## **3.3.5 Challenges and Opportunities – Flood Hazard Data**

### **3.3.5.1 Challenges**

The production of flood hazard data in Manitoba is a relatively new initiative, and therefore there are several issues related to flood hazard mapping that should be considered:

- There is no current provincial standard or guideline for the development and format of flood hazard data. Manitoba is instead using a previous project as the basis for new mapping. They are currently working to integrate recommendations from the federal guidelines.
- Climate change is not explicitly considered in flood hazard mapping. Instead, all maps now consider a higher regulatory AEP (0.5% AEP) than was previously used (1% AEP).
- There are a large number of areas still to be mapped.
- Flood hazard data only consider a single AEP. Although typically more AEPs are provided as water surface elevation data by consultants, these do not indicate the associated flood extent.

### **3.3.5.2 Opportunities**

Manitoba Infrastructure has internal technical capacity and plays an important role in creating new flood hazard data. Manitoba Infrastructure prefers this approach as it allows them to produce their own flood hazard data and to ensure that flood hazard products produced by others are suitable for use. This approach is, however, dependent on adequate training, capacity, and resources within Manitoba Infrastructure.

## **3.3.6 Challenges and Opportunities – NFHDL**

### **3.3.6.1 Challenges**

Manitoba warned that some of its flood hazard data may be more controversial, namely those associated with dike breach. There may be more complications with regards to sharing this sort of data more widely.

### 3.3.6.2 Opportunities

With regards to sharing data, Manitoba Infrastructure is currently working on a process for making data public and is looking to obtain approval for this. Once approval is granted, they would be happy for NRCan to make the NFHDL data public. When requested, Manitoba has already previously shared some of their flood data with other provinces.

Manitoba saw benefits in learning lessons from other P/Ts by seeing how flood data are produced elsewhere. They also raised the benefits of improving management of cross-border watercourses. They mentioned that there is a major dam upstream in Saskatchewan, the failure of which would likely have flood impacts in Manitoba.

## 3.4 New Brunswick

### 3.4.1 Flood Hazard Data Summary

**Flood Mapping Authority** – New Brunswick Department of Environment and Local Government.

**Flood Hazards Mapped** – Coastal, riverine, and ice-jam.

**AEPs Included in Most Recent Maps** – 5% and 1% AEP.

**Regulatory Flood** – 5% and 1% AEP; see notes in the regulatory flood section.

The current state of flood hazard mapping in New Brunswick is summarized in Table 4.

**Table 4: New Brunswick present-day “authoritative” flood hazard mapping summary.**

Areas Mapped*		Average Year Produced	Year Range	Funding Program for Authoritative Maps		
Current	In Progress			FDRP	NDMP	Other
17	35	2020	2020	0%	100%	0%

Note that the numbers provided are for authoritative maps only. The current map column includes all current authoritative maps. The remaining columns assume that these maps are superseded by maps in progress, where applicable.

\* Current number is based on the unique IDs on digital data. The number in progress is estimated based on the interview, all 17 inland maps are being updated and some additional maps added, and 14 new coastal areas are being added. Note that the new maps were not yet available at the time of report writing.

### 3.4.2 Flood Mapping Governance

#### 3.4.2.1 Roles and Responsibilities

Flood hazard data in New Brunswick is managed centrally at the provincial level by the Department of Environment and Local Government. Flood hazard data are managed by the Service New Brunswick, Land Information Infrastructure Secretariat. The Land Information Infrastructure Secretariat is a separate institution from the Government of New Brunswick, but the two agencies are linked.

#### 3.4.2.2 Historic and Future Mapping Catalogues

Flood maps for New Brunswick typically date back to the FDRP era. These generally show the 5% and 1% AEP floods, or in some cases, extents of historic flood events. Since the FDRP period, some additional flood maps were produced based on the extents of historic flood events, such as the flooding in the 2008

and the 2018 Lower Saint John River floods (these maps were released in August 2020). Currently, none of these flood maps are considered authoritative and used for regulation. These maps consider inland (riverine open-water and ice-jam) flooding only, and no coastal flooding. In some locations, maps have been divided into floodway (areas over 1 m deep) and flood fringe. The spatial data of historic flood extents are currently publicly available through New Brunswick's open data catalogue.<sup>7</sup> Reports and pdf flood maps are also available from the Flood Map Index<sup>8</sup>. Historic flood extents as well as the recent 2008 and 2018 flood event data is also available on the interactive Flood Information Viewer<sup>9</sup>.

New Brunswick is currently completing a large flood mapping program. This is being done as two separate projects for coastal and inland flooding. The new inland flood maps will supersede the existing inland flood maps and include some newly mapped areas as well. The coastal flood maps will cover the entire coastline of New Brunswick, which has been broken down into 14 zones. These maps are expected to be completed in late 2020/early 2021.

There is no specific plan for further flood mapping, once the current project is complete. However, it is assumed by New Brunswick that flood maps may require updating every 5–10 years going forward, and that this would be in part dependent on climate change projections.

Once approved, the new flood maps will be made available to the public through New Brunswick's open data catalogue.

### 3.4.3 Technical Mapping Approach

No data has been provided from the ongoing flood hazard studies in New Brunswick, and the information in this section is therefore based on the responses in the engagement activity only.

There is no provincial standard for flood mapping and the approach New Brunswick is using for the new maps is based loosely on their interpretation of the Federal Flood Mapping Guidelines and relevant local knowledge. The flood maps produced will use hydraulic models to estimate flood hazard extents for coastal and riverine floods. While multiple AEPs may be considered in the reporting, only the 5% and 1% AEP will be mapped. Ice jams are relatively rare in New Brunswick and there is limited data available. Extents from historic ice-jam events are included in the FDRP maps but will not be included in the updated maps.

Climate change will be accounted for in flood maps from two studies, which cover the entire province. For inland flooding, a report by the University of Moncton (El-Jabi, Caissie, & Turkkan, 2015) provides estimates for increases in flow at gauging stations across the province. Sea-level rise estimates are based on the Updated Sea-Level Rise and Flooding Estimates for New Brunswick Coastal Sections report (R. J.

---

<sup>7</sup> New Brunswick's open data catalogue: <http://www.snb.ca/geonb1/e/DC/catalogue-E.asp>

<sup>8</sup> New Brunswick's Flood Map Index: <http://elg-egl.maps.arcgis.com/apps/PanelsLegend/index.html?appid=30b97c1830b84fbd8e581a6d05243bb9>

<sup>9</sup> New Brunswick's Flood Information Viewer: <https://geonb.snb.ca/flood/index.html>

Daigle Enviro, 2014). This study divides the coastline into 14 characteristic areas, which are used to define the 14 coastal map zones. Climate change is assessed at 30-year intervals for 2040, 2070, and 2100.

### **3.4.3.1 Regulatory Flood**

There is no current authoritative flood mapping in New Brunswick. The new 5% and 1% AEP flood extents are planned to be adopted as regulatory flood extents; however, these AEPs must first be approved as authoritative.

## **3.4.4 Management of Flood Hazard Data**

### **3.4.4.1 Data Structure**

Authoritative data has not yet been made available, and the data structure can therefore not be commented on. Historic FDRP data are currently available with 1,826 features mapped and include estimates of historic flooding and prominent flood events, such as ice-jam flooding in 1976. Data from riverine flooding in 2008 and 2018 is also available.

### **3.4.4.2 Data Processing**

New Brunswick is currently generating new flood maps for the province. Historic mapping (FDRP) has been collated into a single layer.

### **3.4.4.3 Data Services**

As the Province is primarily focused on producing new flood maps, no decision has been made yet on sharing of the new data. New map data will likely be available for download as shapefiles on New Brunswick's open data catalogue, like the historic data. Historic flood data and the recent flood event extents (2008 and 2018) are currently available for viewing in a web map (the Flood Information Viewer), but there are no current plans to update the web map with the flood data in progress.

## **3.4.5 Challenges and Opportunities – Flood Hazard Data**

The production of flood hazard data is relatively new in New Brunswick. As such, there are a number of areas which are currently still under development. They do not currently have a provincial guideline for flood mapping and are reliant on the federal guidelines, which are not particularly prescriptive. This is partially mitigated in that all flood mapping is being done under two projects, one for coastal and one for inland flooding. This means that the outputs are likely to be consistent. The forthcoming flood hazard data for New Brunswick will hopefully solve many of the challenges currently faced by the province, by:

- Updating out-of-date inland maps.
- Creating coastal flood hazard data.
- Incorporating climate change into maps.
- Producing flood hazard data that can be used to inform policy and regulation.

### 3.4.6 Challenges and Opportunities – NFHDL

New Brunswick suggested that data should be made publicly available. They also suggested that a private federal dataset could lead to public distrust, should it be discovered by the press (i.e., that the government knows what areas may potentially be flooded, but did not share this information with the general public). Disclosure of information and datasets is therefore considered important.

The NFHDL could enable national programs, such as identifying locations that reside within a certain hazard level and creating a national flood strategy.

## 3.5 Newfoundland and Labrador

### 3.5.1 Flood Hazard Data Summary

**Flood Mapping Authority** – Newfoundland and Labrador Department of Environment, Climate Change and Municipalities (Water Resources Management Division).

**Flood Hazards Mapped** – Coastal, lake, riverine, ice-jam, and combinations thereof.

**AEPs Included in Most Recent Maps** – 5% and 1% AEP for current climate, and 5% and 1% AEP for climate change.

**Regulatory Floods** – 5% and 1% AEP current climate and 1% AEP climate change (3 regulatory floods). The 5% AEP is defined as the floodway, and the 1% AEP as the flood fringe.

A summary of the availability of flood hazard data is provided in Table 5. With respect to the funding program, it should be noted that FDRP and NDMP studies were funded by federal and provincial budgets on a 50/50 basis. Some projects were also funded by the Atlantic Climate Adaptation Solutions Association (ACASA) via NRCan, on a 50/50 basis between federal and provincial budgets. Lastly, some projects were also funded 100% by provincial budgets.

**Table 5: Newfoundland and Labrador present-day “authoritative” flood hazard mapping summary.**

Areas Mapped		Average Year Produced <sup>†</sup>	Year Range <sup>†</sup>	Funding Program for Authoritative Maps <sup>†</sup>		
Current*	In Progress			FDRP	NDMP	Other
27	2	2001	1984–2020	62%	7%	31%

Note that the numbers provided are for authoritative maps only. The current map column includes all current authoritative maps. The remaining columns assume that these maps are superseded by maps in progress, where applicable.

\*Assumes that 4 areas have been superseded by more recent maps.

<sup>†</sup> Includes in-progress maps. Note that the funding program percentage estimates are approximate.

### 3.5.2 Flood Mapping Governance

#### 3.5.2.1 Roles and Responsibilities

Flood hazard mapping in Newfoundland and Labrador is managed by the Newfoundland and Labrador Department of Environment, Climate Change and Municipalities. This is a relatively small team, which is responsible for flood map planning and coordination.

### 3.5.2.2 Historic and Future Mapping Catalogues

Flood hazard mapping was stopped after the FDRP-era and restarted in 2009. Since 2009, flood hazard mapping has been relatively continuous and the produced maps have continued to develop and improve over this time. Flood mapping is therefore relatively extensive with 27 communities mapped. Many of the FDRP-era maps are still in use however, with only 4 areas superseded.

Newfoundland and Labrador has an ongoing plan for areas they would like to map. This is dependent on several criteria, including the age of the maps, any expected changes in flood extent, and whether map data are available in a digitized format. Typically, when flood maps are more than 10 years old or when new flood maps are requested by communities, they are added to a priority list. New maps are produced when funding is available.

### 3.5.3 Technical Mapping Approach

The flood hazard mapping approach and the standards used in Newfoundland and Labrador are continuously changing and improving. It was stated in the interview that the latest technical mapping standard (Water Resources Management Division, 2018) is included in requests for proposals for new studies.

Flood hazard mapping in Newfoundland and Labrador is well developed, and is relatively technically advanced, particularly in terms of combined hazards and climate change.

It was stated in the interview that the geography of Newfoundland and Labrador lends itself to a particular mapping methodology. As the rivers are generally narrow and confined, they are usually modelled in HEC-RAS 1D (in contrast to 2D). In addition, all flood maps are a combination of riverine and coastal hazards as most rivers are impacted by tides at the downstream boundary. This combined hazard approach is done in different ways, depending on the location; however, it is generally a combination of riverine flooding, storm surge, and high tide. Wave impacts are also assessed, depending on the location. The flood maps are either based on the joint probability of a combined coastal and riverine hazard, or else separate coastal and riverine flood hazard areas (with associated probabilities) are provided. The approach is based on the recommendation of the consultant that produced the map.

Newfoundland and Labrador also produces more advanced flood maps in the form of velocity maps, depth maps, and combined velocity and depth maps that highlight hazards for first responders. Climate change has been included in flood maps in Newfoundland and Labrador since 2009. The province maintains a Climate Change Atlas, which is usually updated when a new Intergovernmental Panel on Climate Change (IPCC) report comes out. This atlas defines the worst-case climate change conditions applicable to a given location. Sea-level rise comes from a separate publication by the Geological Survey of Newfoundland and Labrador. The effect of climate change on ice-jam floods is included in more recent studies. Since the worst-case conditions vary spatially, different future time periods are provided in different studies—commonly 2050, 2080, and 2100 are used.

### 3.5.3.1 Regulatory Flood

The 5% and 1% AEPs current climate and 5% and 1% AEPs climate change are the likelihoods for which flood extents are included in flood maps from Newfoundland and Labrador. However, only 5% and 1% AEPs current climate and 1% AEP climate change are used for defining the regulatory floods. The 5% AEP is defined as the floodway, and the 1% AEP as the flood fringe. These maps are used for public information, municipal planning, development control, and the setting of structural design criteria. A freeboard of 0.6 m is added in regulation, but is not included in the mapped areas. In Newfoundland and Labrador, once a flood hazard area has been mapped, nothing can be built in it unless a permit is obtained from the provincial government.<sup>10</sup> The permit is based on the Policy for Flood Plain Management,<sup>11</sup> and all permits are publicly available.<sup>12</sup> The freeboard is applied in the issued permits.

## 3.5.4 Management of Flood Hazard Data

### 3.5.4.1 Data Structure

The data structure of flood hazard maps in Newfoundland and Labrador varies by study area, but generally follows a consistent structure. There are multiple 5% and 1% AEP features, each corresponding to a specific climate change scenario. This climate change scenario is sometimes a specific year, and sometimes is simply specified as “Climate Change” without a specified date. Each of these features includes a numeric code, indicating the water depth class.

Most study areas also include “AEP Floodline” cross-section or cutline features as well. Climate change is accounted for in the development of these features, in the same way as the 5% and 1% AEP flood extent features. The cutline or cross-section features contain valuable attributes that describe the flood-modelling approach.

### 3.5.4.2 Data Processing

Since 2009, data has been requested from consultants in GIS formats and then converted to CAD formats, both of which are circulated. There is no dedicated GIS staff or team within the Department of Environment, Climate Change and Municipalities, although they do have ArcMap software. Data are typically received on a hard drive from consultants, and it is then added to an internal file geodatabase for use and analysis. No changes are made to the data content after it is received.

---

<sup>10</sup> For example, for a permit, see [https://www.gov.nl.ca/eccm/files/ALT10889-2020\\_Construction-of-Placentia-Wellness-Centre\\_Signed.pdf](https://www.gov.nl.ca/eccm/files/ALT10889-2020_Construction-of-Placentia-Wellness-Centre_Signed.pdf)

<sup>11</sup> <https://www.gov.nl.ca/eccm/waterres/regulations/policies/flood-plain/>

<sup>12</sup> <https://www.gov.nl.ca/eccm/waterres/permits/water-alt/>

### 3.5.4.3 Data Services

Flood maps, reports, and data are all publicly available for download<sup>13</sup>. Spatial data from this website is available in both DWG and SHP formats. They also have a Flood Risk Mapping Application (an ArcGIS online application) with all flood hazard data displayed, which was launched recently.<sup>14</sup>

## 3.5.5 Challenges and Opportunities – Flood Hazard Data

### 3.5.5.1 Challenges

Newfoundland and Labrador has a small, dedicated water resources management team, but limited resources. As their mapping includes climate change and combined hazard mapping (and is thus relatively advanced), they receive multiple data requests from academia, consultants, and other P/Ts. However, they do not have the resources to answer regular requests, but make all flood mapping documents and geospatial data publicly accessible on their website.

Although flood mapping has been relatively continuous since the 1980s, much of the available mapping is still relatively old, and in need of upgrading to modern technical standards. Newfoundland and Labrador has a list of maps that they would like to update, but they have been restricted by funding.

### 3.5.5.2 Opportunities

Newfoundland and Labrador has a well-established and technically-advanced flood mapping program. They produce products that are more advanced than those produced in many other areas of Canada. For example, accounting for climate change in ice-jam floods, combined tidal and riverine mapping, and combined hazard and velocity mapping all represent advanced flood mapping practices.

## 3.5.6 Challenges and Opportunities – NFHDL

Newfoundland and Labrador's data are publicly available and can be sourced from their website.

Newfoundland and Labrador believes that a unified and interoperable schema, such as that produced for the NFHDL, would be useful in enabling the P/Ts to better understand and exchange data between jurisdictions.

---

<sup>13</sup> <https://www.gov.nl.ca/eccm/waterres/flooding/frm/>

<sup>14</sup> <https://www.gov.nl.ca/eccm/waterres/flooding/frm/>

## 3.6 Northwest Territories

### 3.6.1 Flood Hazard Data Summary

**Flood Mapping Authority** – Northwest Territories Department of Municipal and Community Affairs.

**Flood Hazards Mapped** – Coastal, riverine, and ice-jam.

**AEPs Included in Most Recent Maps** – 1% AEP (where available) or observed historical floods of record (historical maximum).

**Regulatory Flood** – 1% AEP (where available) or observed historical flood of record (floodway), and flood fringe (in some communities, an addition of 1 m elevation to floodway).

The current state of flood hazard mapping in the Northwest Territories is summarized in Table 6.

**Table 6: Northwest Territories present-day “authoritative” flood hazard mapping summary.**

Areas Mapped		Average Year Produced	Year Range	Funding Program for Authoritative Maps		
Current	In Progress			FDRP	NDMP	Other
9	0	1986	1984–1988	100%	0%	0%

Note that the current map column includes all current authoritative maps. The remaining columns assume that these maps are superseded by maps in progress, where applicable.

### 3.6.2 Flood Mapping Governance

#### 3.6.2.1 Roles and Responsibilities

The authority for planning and managing flood hazard mapping primarily lies with the Northwest Territories Department of Municipal and Community Affairs. However, several other departments also have responsibility, including the Department of Environment and Natural Resources, the Department of Lands, and the Centre for Geomatics. During the interview, Northwest Territories stated that they are struggling to find someone to take ownership of new flood mapping projects.

#### 3.6.2.2 Historic and Future Mapping Catalogues

The Northwest Territories currently rely on the flood mapping conducted under FDRP in the 1980s. In many areas, the Northwest Territories have updated these maps using the available flood elevations and updated DEMs. These updates are done on a semi-regular basis when data becomes available. These updated maps are publicly available on the Northwest Territories online data system “ATLAS”<sup>15</sup> but are not considered authoritative. The original FDRP maps are still considered the authoritative data source.

Additional mapping studies have been done by two local communities, Aklavik and Tuktoyaktuk. These are owned by the communities and there is no central register. A PDF map was provided to the NFHDL project team by Aklavik, but no digital data were available. It was theorized in the interview that these

<sup>15</sup> [https://www.maps.geomatics.gov.nt.ca/HTML5Viewer\\_Prod/index.html?viewer=ATLAS](https://www.maps.geomatics.gov.nt.ca/HTML5Viewer_Prod/index.html?viewer=ATLAS)

studies may have been done as research projects rather than for flood planning by the community themselves.

The Northwest Territories would like to create new flood hazard data. However, this is dependent on ongoing work with NRCan to review flood hazard guidance, and how this could apply in a northern environment. Pilot projects are being put together to help test the guidelines when they are complete.

### 3.6.3 Technical Mapping Approach

In the Northwest Territories, the FDRP maps were generally not based on standard engineering methods (in contrast to other P/Ts) and were instead generalized based on observed historic flood event outlines with some limited hydrotechnical analyses conducted in select locations. Most of the flood maps were derived using historical records of flood events held by church records, the RCMP, and by community member observations. These maps remain the authoritative sources of flood hazard data. The approach of flood maps based on observed historical floods of record was taken for 6 out of the 9 available flood maps. Two of the available flood maps were a combination of observed historical floods of record and flood frequency analysis (for one study, the Hay River, this was based on the 1% AEP). Lastly, one map (for Nahanni Butte) was entirely based on flood frequency analysis (1% AEP).

The floodway is taken as the 1% AEP flood in those communities where flood frequency analysis was undertaken. In the remaining communities (i.e., the majority of the communities), the floodway is the observed historical flood of record extent. The flood fringe is indicated on the authoritative and non-authoritative maps, and in some cases, it is calculated as the area within 1 m vertically of the floodway (the 1% AEP extent and elevation). But the approach to the flood fringe varies from community to community.

The Northwest Territories is currently working on a pilot project with NRCan to review flood hazard assessment guidance in a northern setting. It was stated in the interview that the flood mechanisms that are applicable in this environment, are complex and different to those in much of the rest of Canada. The current guidelines are therefore considered difficult to apply. It was stated that the updated guidelines would be a necessary step for the Northwest Territories to formally update their flood hazard maps.

#### 3.6.3.1 Regulatory Flood

The regulatory flood extents for the Northwest Territories are based on historic flood event outlines in 6 out of 9 flood maps, and on the 1% AEP flood extent in the communities where it is available. The designated flood elevation includes the floodway (either the 1% AEP where available, or the historical flood extent) and the flood fringe (which varies from community to community, but for some communities is calculated as adding 1 m elevation to the floodway elevation).

### 3.6.4 Management of Flood Hazard Data

#### 3.6.4.1 Data Structure

The flood data for the Northwest Territories is available as one feature. This feature has five properties of note. The “Type” column (property) identifies whether a polygon represents the floodway or flood fringe

and the “Community” column identifies which study area the polygon is a part of. There are also “Elevation”, “Date”, and “Description” properties in the feature.

#### **3.6.4.2 Data Processing**

The floodway and flood fringe polygons are generated in AutoCAD. The CAD files are then converted to shapefiles and added to a centrally maintained geodatabase. This work is completed by the Territorial Land Administration Branch with geomatics support from the Northwest Territories Centre for Geomatics. These teams have access to ArcGIS Pro and FME as their primary data processing tools.

#### **3.6.4.3 Data Services**

Flood maps are available for public viewing and download via the provincial web GIS, ATLAS. ATLAS is a Geocortex, Esri-powered web application. Data maintained in geodatabases by the Land Administration Branch are accessed by an ArcGIS Server that generates WMS layers that are brought into ATLAS. The system allows users to directly download the provincial flood map data in a variety of formats (GDB, SHP, DXF, DWG, DGN, KMZ). ATLAS has been in place for 16 years and is therefore well known.

### **3.6.5 Challenges and Opportunities – Flood Hazard Data**

#### **3.6.5.1 Challenges**

The Northwest Territories expressed a concern that they may be perceived by other P/Ts as unable to “keep up” with the rest of Canada with regards to flood mapping. Flood hazard mapping in the territory is considered particularly challenging for several reasons, including the northern setting and limited resources. The Northwest Territories is currently working with NRCan to review the Federal Flood Mapping Guidelines for a northern environment. It is hoped that this will help to address some of these issues.

The Northwest Territories has limited resources to manage flood hazard, and they do not have a central organization fully responsible for flood hazard management. The territorial government is responsible for a large land mass with a relatively low population density and limited funding. This has led to a lack of ownership and investment in the creation of new flood maps.

The flood hazards experienced in the Northwest Territories are particularly complex. These include floods stemming from ice jams and permafrost thawing. Assessment for these hazards are relatively undeveloped as compared to the riverine and coastal hazards experienced elsewhere. The change in these hazards due to climate change is also particularly complex and poorly understood.

#### **3.6.5.2 Opportunities**

The Northwest Territories is happy to share results from ongoing work with NRCan to review the Federal Flood Mapping Guidelines for a northern environment. They are also keen to learn lessons about flood hazard mapping and data management from other P/Ts.

### 3.6.6 Challenges and Opportunities – NFHDL

#### 3.6.6.1 Challenges

The Northwest Territories expressed a concern with the NFHDL project regarding who is considered the owner of flood hazard data. If data are shared outside of NRCan, it must be made clear that the Northwest Territories is the data owner and the authoritative source of information on this data.

#### 3.6.6.2 Opportunities

The Northwest Territories is pleased that this project draws attention to the data gaps and challenges to flood hazard mapping in northern Canada, and that this attention can be used as a starting point to improve research and understanding of these challenges.

## 3.7 Nova Scotia

### 3.7.1 Flood Hazard Data Summary

**Flood Mapping Authority** – Local governments, with oversight from the Nova Scotia Department of Municipal Affairs and Housing.

**Flood Hazards Mapped** – Coastal, riverine, and ice-jam.

**AEPs Included in Most Recent Maps** – 5% and 1% AEP.

**Regulatory Floods** – 5% and 1% AEP. These are respectively defined as the floodway and flood fringe in Nova Scotia.

A summary of the availability of flood hazard data is provided in Table 7. Complete flood hazard data could not be collected for Nova Scotia, as no provincial-level flood hazard data compilation exists. Despite substantial efforts to obtain flood data from local governments, not all data could be obtained within the timeline of this project. The details in this table are based on a report produced by CBCL Limited on the status of flood maps in Atlantic Canada (CBCL, 2017) in addition to the interview. Funding for post-FDRP flood mapping has been provided by the NDMP, a provincial program (the Flood Assessment Fund), which provided 50% funding for flood studies in the province (CBCL, 2017), as well as a mix of activities undertaken with independent funding by local governments, and activities as part of NRCan’s Regional Adaptation Collaborative program for adaptation to climate change.

**Table 7: Nova Scotia present-day “authoritative” flood hazard mapping summary.**

Areas Mapped		Average Year Produced	Year Range	Funding Program for Authoritative Maps		
Current	In Progress			FDRP	NDMP*	Other*
14	3	2016	2008–2020	0%	Unknown	Unknown

Note that the numbers provided are for authoritative maps only. The current map column includes all current authoritative maps. The remaining columns assume that these maps are superseded by maps in progress, where applicable.

\*Note that total numbers of flood maps are unknown, and while it is known that the provincial Flood Assessment Fund provided 50% funding for flood studies in the province, there are also further funding sources (e.g., self-directed, NRCan’s Regional Adaptation Collaborative program), which would classify into the “Other” category, and therefore, the total percentage of “Other” funding cannot be determined with the available information.

### 3.7.2 Flood Mapping Governance

#### 3.7.2.1 Roles and Responsibilities

The responsibility for producing flood hazard data in Nova Scotia currently resides with local governments as mandated under the *Municipal Government Act Statement of Provincial Interest* administered by the Nova Scotia Department of Municipal Affairs and Housing. This statement of interest mandates that municipalities and local governments must act, should they be aware of a flood hazard. There is a desire by the provincial government to take more ownership in the production of flood hazard data. This would include producing and storing flood hazard data centrally.

#### 3.7.2.2 Historic and Future Mapping Catalogues

As there is no central record of flood maps in Nova Scotia, it is difficult to ascertain how many flood maps exist. Within the time frame of this project, only 7 studies have been received for the NFHDL project. The following information was taken from the interview, CBCL's 2017 report on the status of flood maps in Atlantic Canada (CBCL, 2017), and discussions with the lead author of that report. There were 5 flood maps completed in Nova Scotia under the FDRP. These maps have since been updated, and 9 new areas have also been mapped. This more recent mapping has been done over the last 15 years, with the majority completed over the last 5 years (CBCL, 2017).

It was stated in the interview that recent mapping has largely been driven by flood events and that coverage is therefore spotty. It was stated that a substantial number of new maps would be required to cover all areas at risk in Nova Scotia.

The vast majority of flood maps in Nova Scotia cover riverine flooding. However, many municipalities have developed a climate action plan and some of these plans looked at the likelihood of coastal flooding but that there was a high degree of variation as to how this was examined.

There is a desire in Nova Scotia to complete flood mapping centrally. This will be done by the Department of Municipal Affairs and Housing. They have recently completed 3 pilot projects following their new draft specification (standard) and are about to complete 3 more projects. Nova Scotia is currently exploring funding sources to complete this work. This could potentially be accomplished using a "Green Fund" raised by the carbon tax. The provincial government has a plan for areas they would like to map, and if sufficient funding can be raised, the Department of Municipal Affairs and Housing plans to complete flood mapping within the next 5 years. Nova Scotia has a desire to make new flood hazard data publicly available. If mapping is done centrally, the intention is to make maps publicly available through a web mapping platform. After this, updates would likely be based on a 10-year recommended update interval, and changes brought by incoming planning applications.

#### 3.7.3 Technical Mapping Approach

Nova Scotia has not historically had a provincial flood mapping standard or guidelines other than those used to produce the FDRP maps. Flood maps are produced independently by municipalities and local governments, which has led to a substantial level of variation in the produced outputs, including the

assessed hazards, such as the inclusion of ice jams or climate change. The 5% and 1% AEP floods are produced for all flood maps, in accordance with the standard set by the FDRP maps. In Nova Scotia, these two AEPs are referred to as the floodway and flood fringe, respectively.

Much post-FDRP flood mapping in Nova Scotia has been conducted by one consultant, CBCL Limited. In their 2017 report, CBCL indicate that they have endeavoured to complete studies to modern standards and have included a climate change assessment in most reports, even if it was not requested and is not included in the final maps (CBCL, 2017). Other flood hazard mapping has also been conducted by Dillon Consulting Limited.

Nova Scotia is currently in the process of finalizing the *Draft Nova Scotia Municipal Flood Line Mapping Specification*. This will act as the provincial standard and will help to unify flood data, both in terms of methodology and metadata. While studies may consider multiple AEPs, this specification will maintain the 5% AEP floodway and 1% AEP flood fringe as the required outputs, as in the FDRP standard. It will also contain more detail in terms of flood mechanisms, hazards to be mapped, and the inclusion of climate change. This will include climate change for both coastal and riverine flood hazards. Climate change considerations will account for 20-year and 100-year time spans from the time of the study. The provincial government is also considering other planning horizons and may add a 35-year time span, as this corresponds well with development timescales. The intention is for the specification to be fairly flexible, to allow space for innovation in methodology.

The vast majority of flood maps completed to date cover inland flooding, as this is the only hazard covered under the *Municipal Government Act*. A new *Coastal Protection Act* is currently in development to address coastal flood hazards. This act will establish a Coastal Protection Zone based on a minimum building elevation and setback for the entire coastline. The methodology used to do this is not fully known, but it will be based on tide levels and a coastal erosion factor. This Coastal Protection Zone will act to support the production of more formal flood mapping. Note that tsunami flood hazard is currently not considered an important hazard for the province, and tsunami flood mapping was not mentioned in the interview.

### **3.7.3.1 Regulatory Flood**

The regulatory flood in Nova Scotia continues to be as defined under the FDRP—the floodway is defined as the 5% AEP and the flood fringe as the 1% AEP. It should be noted that these definitions for floodway and flood fringe differ substantially from those used in other P/Ts, and those contained in the Federal Flood Mapping Guidelines (2018).

In addition to the areas defined within flood map studies, the *Coastal Protection Act*, currently under development, will establish a Coastal Exclusion Zone for the whole province, which will restrict development along the coastline.

### 3.7.4 Management of Flood Hazard Data

#### 3.7.4.1 Data Structure

As flood mapping data are not currently managed or processed at a provincial level, few comments can be made on the data structure. The few municipal datasets that were obtained during this project mostly have no additional properties beyond the modelled inundation extent for the 1% AEP and 5% AEP floods.

#### 3.7.4.2 Data Services

Nova Scotia currently has geomatics infrastructure to host flood data in a centralized database and display the data on web maps if sufficient funding is raised to complete flood mapping at the provincial level.

### 3.7.5 Challenges and Opportunities – Flood Hazard Data

#### 3.7.5.1 Challenges

The current devolved nature of flood mapping in Nova Scotia and the lack of a modern provincial standard have led to several challenges in flood hazard management. There is no centralized register of flood maps, which makes planning for flood hazard at a provincial level difficult. The lack of a provincial data or technical standard has also led to substantial variability in produced flood maps, likely caused by different requirements requested in the requests for proposals (RFPs) for each study.

Nova Scotia stated in the interview that they believe flood mapping to be limited and patchy, and that there are many areas that still need flood maps. In addition, climate change impacts and coastal flood hazard assessment are largely underdeveloped in the province and not currently included in legislation.

Multiple datasets have been provided covering the same area in Nova Scotia. It is not clear which is the authoritative dataset for this area.

#### 3.7.5.2 Opportunities

Many of the challenges currently being faced in Nova Scotia should be addressed by current initiatives. Critically, the introduction of a modern Provincial Specification will help to unify new flood maps, and ensure a consistent quality of output, including an assessment of climate change impacts.

The desire to complete more flood mapping centrally will also help to unify produced data and will allow better management of flood hazard at a provincial level. If funding can be found, Nova Scotia has a desire to substantially increase the number of flood maps and to complete mapping within the next 5 years. If additional flood maps are produced, then the data will be made publicly available.

### 3.7.6 Challenges and Opportunities – NFDHL

#### 3.7.6.1 Challenges

If flood mapping continues to be conducted by local governments in Nova Scotia, this would continue to introduce major challenges for the NFHDL, as it increases the number of contacts required to update and maintain data. In addition, without a centralized register, it would not be possible to establish when new areas are mapped. Within the time frame of this project, the NFHDL project team have only been able to obtain data from 7 local governments, though it is known that more flood data exists. In addition, there are likely to be data sharing restrictions that would limit the use of this data by NRCan in the NFHDL.

#### 3.7.6.2 Opportunities

The Nova Scotia Department of Municipal Affairs and Housing is at the beginning of a process to take a more active role in flood hazard mapping at a provincial level. If NRCan establishes and maintains contact with Nova Scotia throughout this process at this critical stage, it could lead to many efficiencies for the future of the NFHDL. For example, Nova Scotia suggested that they would be able to align with national standards (e.g., for metadata) over time. Nova Scotia is also willing to share data that they develop. Alternatively, if this responsibility is retained by local governments, a clause could be added to funding criteria that Nova Scotia would be a joint owner of the data and thus able to supply the flood data to the NFHDL.

There are also opportunities for Nova Scotia to benefit and learn lessons from the NFHDL, for example, in creating a centralized data management system. A centralized data management system, as currently envisioned by Nova Scotia, would allow for automatic updates to the NFHDL, especially if Nova Scotia were to incorporate a federal metadata standard. This would also create a central register, which would reduce the risk of new flood maps being missed for upload to the NFHDL.

## 3.8 Nunavut

### 3.8.1 Flood Hazard Data Summary

**Flood Mapping Authority** – Undefined.

**Flood Hazards Mapped** – Coastal, pluvial (overland), riverine, and tsunami (note, however, that while assessments of these flood hazards have been conducted, no territorially authorized flood mapping for regulation exists). Another hazard in Nunavut is flooding due to sea ice ride-up and pile-up.

**AEPs Included in Most Recent Maps** – None.

**Regulatory Floods** – None.

Three individuals in Nunavut’s territorial government and one individual in the federal government (Crown-Indigenous Relations and Northern Affairs Canada) were consulted through the data collection and engagement phase. For the territorial government, this covered a range of departments, including technical and environmental services. It should be noted that water resources are a responsibility of the federal government in Nunavut because they have not yet been devolved.

It was established through this communication that no authoritative territorial flood hazard data currently exist for Nunavut. For this reason, it was determined an engagement interview would not be worthwhile. Further, given that no authoritative flood hazard maps currently exist, the information provided in this section differs from that of other P/Ts. It should be noted that Nunavut was not part of the FDRP and the NDMP funding programs, as impacts from flood hazards were considered minimal in the territory by Public Safety Canada (Public Safety Canada, 2019). Nunavut had very limited resources to participate in any of NRCan’s technical working groups (though they do engage as available), and flood mapping is not a priority. It was noted in the correspondence that for 23 of the territory’s 25 communities, data (such as LiDAR data) that might serve to create flood hazard maps is not being collected. Any territorially led flood hazard mapping for Nunavut was said to be “decades away” in the correspondence.

### 3.8.2 Flood Mapping Governance

#### 3.8.2.1 Roles and Responsibilities

There is no specific department in Nunavut responsible for coordinating flood hazard mapping. While different departments might be interested in flood maps, were they to be developed, there is no one who was reached for this project who considers them necessary for the work they do, as flood risk is considered generally relatively low.

Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC) participates on behalf of the territory in the National Hydrometric Program, as this responsibility has not yet been devolved.

#### 3.8.2.2 Historic and Future Mapping Catalogues

As discussed above, no territorially authorized flood hazard maps exist for Nunavut.

### 3.8.3 Technical Mapping Approach

Despite the lack of territory-lead projects, several studies have been conducted by NRCan and other institutions, including the Memorial University of Newfoundland, to identify flood hazards. Information in the sections below was primarily provided by Dr. Donald Forbes (Research Scientist Emeritus, Geological Survey of Canada, NRCan) and other members of NRCan.

The primary flood-related hazards of concern in Nunavut are the impacts of permafrost thawing, coastal flooding, sea ice ride-up and pile-up (and consequent melting) leading to excess water and flooding on land. Pluvial (overland) flooding, riverine flooding, and tsunamis can present additional hazards.

**Permafrost thawing** and its impact on river morphology are of concern in Nunavut. The Nunavut Department of Community and Government Services has permafrost hazard maps for some Nunavut communities, as well as community drainage plans. In a recent summary of provincial and territorial preparedness for climate change by the Intact Centre for Climate Change (Feltmate, Moudrak, & Bakos, 2020), Nunavut reported that it has completed permafrost (loss) maps for 7 of 25 communities, driven by the perception that permafrost degradation is the greatest climate change–related threat affecting Nunavut.

**Coastal flooding** is of concern in Nunavut, as most Inuit communities are on the coast, along with much of their infrastructure. For example, coastal flooding occurred in Iqaluit in 2003, when increased coastal erosion was also observed (Hatcher & Forbes, 2015). Coastal flooding for both present and future conditions and the potential impacts to infrastructure were assessed for Iqaluit by Hatcher and Forbes (2015), with consideration of storm waves, sea ice ride-up and pile-up, as well as flooding due to storm surges and high tides. The study was based on field surveys, wave and water-level monitoring, ocean current measurements, sea-ice surveys, topographic and bathymetric surveys, infrastructure surveys, climate and sea-ice records, and sea-level change projections (using precautionary estimates of a rising sea level). A Canada-wide mapping project of the sensitivity of coasts to a changing climate has also been conducted, called CanCoast 2.0 (Manson, G K; Couture, N J; James, 2019), which included Nunavut. The project assembled datasets on coastal materials and slope, as well as projections of changing wave height and sea level under climate change, to develop indices of sensitivity to sea-level rise and erosion.

**Sea ice ride-up and pile-up** is a concern on Arctic coasts along with coastal storm impacts, as it can lead to flooding when the ice melts on land. The study discussed above by Hatcher and Forbes (2015) also addressed sea ice hazards for Iqaluit. With climate change, and a longer open-water season, this hazard may increase.

**Pluvial (overland) and riverine flooding** also occurs in Nunavut. For instance, a June 2008 flash flood destroyed two bridges in Pangnirtung, Baffin Island, due to heavy rainfalls and consequent thermo-erosion of the river banks (Hsieh, Tchekhovski, & Mongeau, 2011). A heavy rainfall event in Kugluktuk caused overland flooding and gulying in the community (Smith, 2014), and ponding overland water has also been observed in Cambridge Bay (associated with inadequate design and maintenance of the drainage system) (Smith & Forbes, 2014).

**Tsunamis** can also be of concern in some fjord communities, especially in northeastern Baffin Island (e.g., Clyde River, Pond Inlet). It is a seismically active region, where earthquakes could trigger landslides and subsequent displacement waves (tsunamis), potentially affecting coastal communities (Gosse et al., 2020)

It should be noted that none of the above-mentioned studies and datasets were collected for the NFHDL, as they are not authoritative territorial flood hazard mapping, and they fall outside of the scope of the project.

### **3.8.3.1 Regulatory Flood**

Currently, no flood hazard maps exist to be used for regulation, and therefore, no regulated design floods have been defined, as far as the knowledge of the project team goes.

### **3.8.4 Challenges and Opportunities – Flood Hazard Management and NFHDL**

As currently no flood hazard data are being produced or managed at the territorial level, and no authoritative flood hazard maps exist, no data could be incorporated into the NFHDL for Nunavut. However, it is recommended that NRCan continue to engage with Nunavut, in case future territorially led flood hazard mapping is conducted.

## 3.9 Ontario

### 3.9.1 Flood Hazard Data Summary

**Flood Mapping Authority** – Conservation authorities and municipalities.

**Flood Hazards Mapped** – Lake, riverine, and ice-jam.

**AEPs Included in Most Recent Maps** – Regional Design Storm (Hurricane Hazel, or the Timmins Storm) or the 1% AEP.

**Regulatory Floods** – Regional Design Storm (Hurricane Hazel, or the Timmins Storm) or the 1% AEP.

A summary of the availability of flood hazard data is provided in Table 8. Because of the complex nature of flood mapping in Ontario, the figures in this table are estimates and are largely based on the Metadata Inventory for Ontario produced in 2015 and updated in 2017 (Ganaraska Region Conservation Authority, Otonabee Conservation Authority, Conservation Ontario, 2017).

**Table 8: Ontario present-day “authoritative” flood hazard mapping summary.**

Areas Mapped		Average Year Produced	Year Range	Funding Program for Authoritative Maps		
Current	In Progress			FDRP	NDMP	Other
736	Unknown	1991	1971–2020	52%	Unknown	Unknown

### 3.9.2 Flood Mapping Governance

#### 3.9.2.1 Roles and Responsibilities

Within the provincial government, the responsibility for flood hazard management lies with the Ontario Ministry of Natural Resources and Forestry (OMNRF).

Responsibility for flood mapping in Ontario is shared among the provincial government, municipalities, and conservation authorities (where they exist). Conservation authorities are unique to Ontario and were established in the 1940s. Conservation authorities are local watershed management agencies that are responsible for delivering services related to water and natural resources. There are 31 conservation authorities in Southern Ontario and 5 in Northern Ontario (Conservation Ontario, 2020). Conservation authorities are coordinated at a provincial level by Conservation Ontario. Municipalities that lie within a conservation authority often rely on conservation authorities to undertake flood mapping and therefore flood mapping in Ontario is largely undertaken by conservation authorities (i.e., conservation authorities are typically the body that develops flood maps in their jurisdiction).

Of Ontario’s 444 municipalities, 159 are located outside a conservation authority (and 285 are located within a conservation authority). However, approximately 95% of Ontario’s population lives in an area management by a conservation authority<sup>16</sup>, as the conservation authorities are located all across southern

<sup>16</sup> Conservation Ontario. <https://conservationontario.ca/conservation-authorities/about-conservation-authorities>. Accessed on December 1, 2020.

Ontario and in the most populated areas and urban centres in the north. In the area outside of a conservation authority, local government is responsible for producing their own flood maps and often contract consulting engineering firms to complete flood mapping.

In 2020, Ontario is in the process of forming a Flood Mapping Technical Committee with representatives from provincial ministries, municipalities, conservation authorities and the federal government. It will be responsible for coordinating a number of initiatives designed to improve the state of flood mapping in Ontario, including the production of provincial flood mapping guidelines.

### **3.9.2.2 Historic and Future Mapping Catalogues**

Due to the complex and decentralized nature of flood mapping in Ontario, it is difficult to ascertain what flood mapping exists in the province as there is no central register. The NFHDL project has been able to collect flood mapping from 18 conservation authorities (out of 36) within the time frame of the project. In 2015, Ontario completed a metadata inventory for the areas covered by conservation authorities, which was updated in 2017 (Ganaraska Region Conservation Authority, Otonabee Conservation Authority, Conservation Ontario, 2017). This metadata inventory gathered information on flood maps in Ontario and contains a mostly complete record of maps that existed at that time.

Ontario joined the FDRP in 1978, and the program ran in the province until 1996. Numerous flood maps were produced under the FDRP, many of which are still in use today. While flood hazard mapping has been largely continuous since then, more than 52% of the maps available in Ontario in 2015 were from the FDRP period. The average age of flood maps in 2015 was 24 years old, and the Metadata Inventory contains 739 entries for flood maps across Ontario, covering over 30,000 km of watercourse and lake frontage (Ganaraska Region Conservation Authority, Otonabee Conservation Authority, Conservation Ontario, 2017). In some areas, individual maps have been combined into a single hazard extent layer. While updated mapping has been completed since 2015, it is not known how many maps have been completed in total.

In the Metadata Inventory, approximately 50% of conservation authorities claimed that they had between 1 km<sup>2</sup> and 250 km<sup>2</sup> of flood hazard areas remaining to map, and 15% said that they had more than 250 km<sup>2</sup> remaining to map (Ganaraska Region Conservation Authority, Otonabee Conservation Authority, Conservation Ontario, 2017). For most of the other conservation authorities, the area remaining was unknown. Work on the Metadata Inventory has been continued as of recently by Dr. Heather McGrath<sup>17</sup> from NRCan, who has been building a web application that can ingest metadata. The entry form allows users to enter data via a shapefile or by selecting an area on the map; in total 93 attributes are collected, which are based on the 2015 metadata report. The web application also includes a viewer to show geographical boundaries of where metadata has been collected. Work on the metadata inventory web app is ongoing as of this report publication.

---

<sup>17</sup> Dr. Heather McGrath, Geospatial Scientist, Natural Resources Canada.

Through the formation of the Technical Committee, Ontario plans to undertake several initiatives designed to improve the state of flood mapping in Ontario, including the development of a new flood mapping standards and guidelines. Part of the role of Ontario’s envisioned technical committee will be to identify gaps in current flood mapping to plan future flood mapping activities.

### 3.9.3 Technical Mapping Approach

The mapping approach in Ontario varies substantially from other P/Ts, in particular with respect to the considered AEPs and the inclusion of climate change. There is a guideline from 2002—Ontario MNR’s River and Stream Systems: Flood Hazard Limit (Ontario Ministry of Natural Resources, 2002)—but is considered incomplete by the provincial government, and implementation guidance is very light. For example, there is a LiDAR specification but no channel survey specification. In this guideline, the province is broken up into three zones that specify a design storm. Generally speaking, most flood maps are based on a Regional Design Storm. This is Hurricane Hazel (1954) in the south central and southwestern portions of the province and the Timmins Storm (1961) in the north. Southeastern Ontario uses the 1% AEP as the design flood scenario.

In 2017, a technical guidance document<sup>18</sup> was produced in a collaboration between 6 conservation authorities in the Greater Toronto Area (Environmental Water Resources Group Ltd., 2017). This guidance is unofficial, but it is being used by some conservation authorities. It is a detailed guidance document and includes descriptions on the inclusion of climate change and recommended multiple flood likelihoods to model, including the Regional Storm, and the 50%, 20%, 10%, 4%, 2%, and 1% AEPs.

Flood maps are typically produced using HEC-RAS in both 1D and 2D (depending on the watercourse), although other methods are also used. Most conservation authorities have joined their flood hazard data from multiple projects in different areas into a single regulatory flood hazard layer. This layer thus typically contains spatial flood extents from different years and methods. In some cases, for different parts of the conservation authority, a different AEP (typically the 1% AEP) and the Regional Storm are also applied, so the regulatory flood hazard layer could contain multiple likelihoods. The Metadata Inventory identified that only 2 of the 739 projects considered climate change.

There are three flood map types typically used as authoritative sources in Ontario, listed below. However, note that not all of these map types are available for each jurisdiction:

- **Floodplain Mapping** – Based on hydraulic modelling, and typically can include information on infrastructure at risk.
- **Regulation Layer** – Includes everything that the conservation authorities can regulate, such as flooding, slope failure, and conservation areas, in a single layer (i.e., is not flood-specific). Flood extents typically include an exclusion zone buffer.

---

<sup>18</sup> <https://s3-ca-central-1.amazonaws.com/trcaca/app/uploads/2016/02/17161112/Technical-Guidelines-For-Flood-Hazard-Mapping-March-2017-Final.pdf>

- **Flood Risk Mapping** – Includes multiple likelihood scenarios and can include flood water depth and velocity mapping.

Ontario is currently looking to make a series of improvements to the way they manage flood hazard at a provincial level. These improvements will include the formation of a provincial flood management panel (the technical committee). Ontario is also looking to produce new flood mapping guidelines, which will include a recommendation for the inclusion of climate change. As part of this process, the guidance document used in the Greater Toronto Area will be reviewed.

### 3.9.3.1 Regulatory Flood

Ontario is broken into three zones in OMNRF's technical guidelines (Ontario Ministry of Natural Resources, 2002) (Figure 1).

In Zone 1 (Parts of South Central and Southwestern Ontario), the flooding hazard limit is defined as the greater of:

- i. the flood resulting from a rainfall experienced by the Hurricane Hazel storm (1954) transposed over a specific watershed and combined with the local conditions;
- ii. the 1% AEP flood; or
- iii. a flood that is greater than i) or ii) that was actually experienced in a particular watershed or portion thereof, as approved by the OMNRF.

In Zone 2 (Southeastern Ontario) the flooding hazard limit is defined as:

- i. the 1% AEP flood; or
- ii. a flood that is greater than i) that was experienced in a particular watershed or portion thereof, as approved by the OMNRF.

In Zone 3 (Parts of South Central and Northern Ontario), the flooding hazard limit is defined as the greater of:

- i. the flood resulting from a rainfall experienced during the Timmins Storm (1961) transposed over a specific watershed and combined with the local conditions;
- ii. the 1% AEP flood; or
- iii. a flood that is greater than i) or ii) that was experienced in a particular watershed or portion thereof, as approved by the OMNRF.

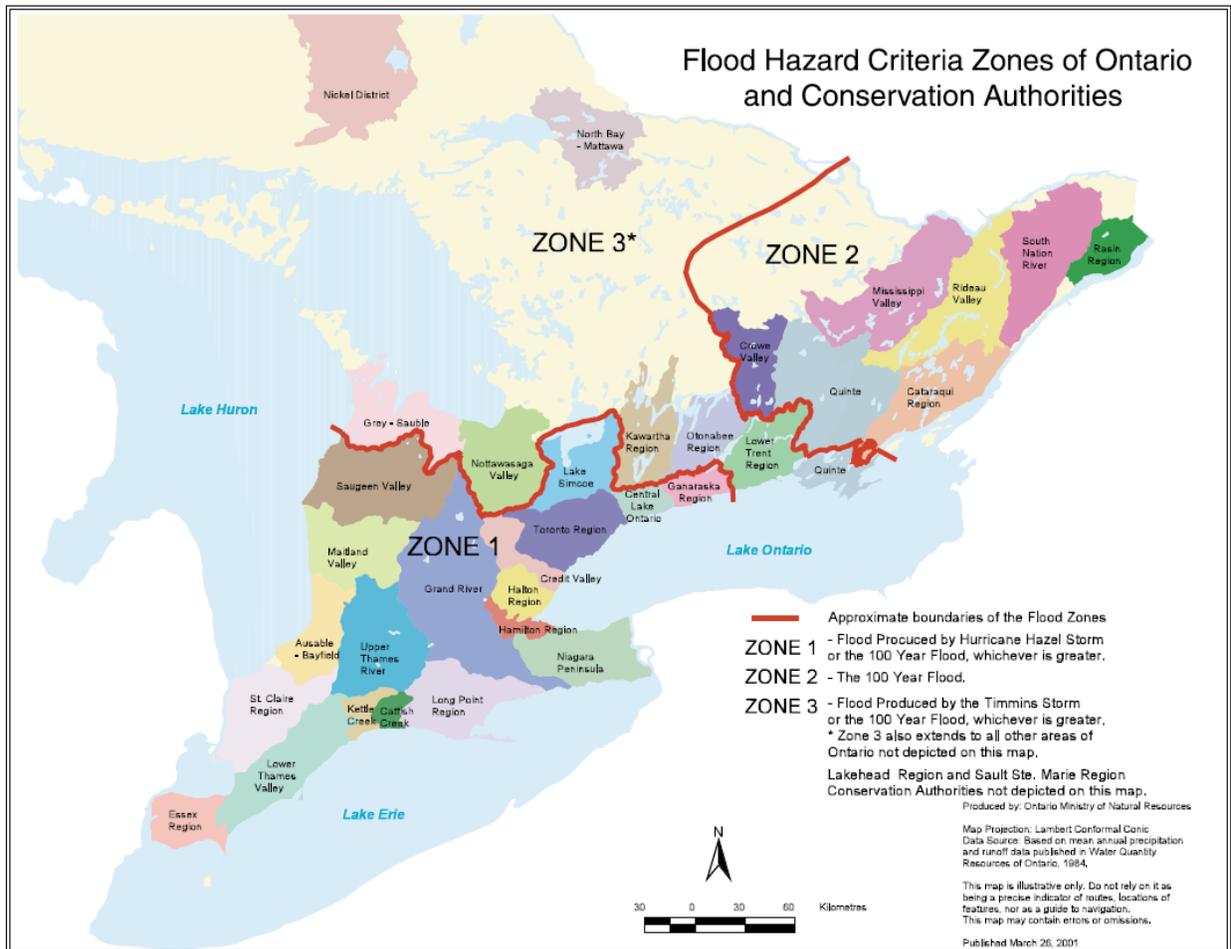


Figure 1: Flood Hazard Criteria Zones of Ontario and Conservation Authorities. (Figure from OMNR (2001), printed with permission).

### 3.9.4 Management of Flood Hazard Data

#### 3.9.4.1 Data Structure and Data Processing

Because flood maps are managed at the municipal or conservation authority level, rather than the provincial level, there is substantial variability in flood map structure and processing methodology across the province. It is therefore not possible to comment on the data structure or data processing tools used at a provincial level.

#### 3.9.4.2 Data Services

Some conservation authorities in Ontario have portals or websites where flood maps and the associated reports can be downloaded directly, while many maintain datasets that are not available to the public.

### 3.9.5 Challenges and Opportunities – Flood Hazard Data

#### 3.9.5.1 Challenges

While Ontario has more flood maps than any other P/T, most of them are more than 20 years old and are considered out of date. The lack of prescriptive guidelines in Ontario and the decentralized mapping authority has led to a large variation in flood hazard data. There is no centralized source to approve whether maps are considered of sufficient quality to be considered authoritative. Climate change is not considered in the majority of flood maps.

Differences in resourcing across the conservation authorities mean that some areas are much more advanced in terms of flood mapping than others.

#### 3.9.5.2 Opportunities

The Government of Ontario, in partnership with municipalities, conservation authorities, and federal departments, is looking to make substantial improvements to the way flood hazard is managed in the province, including:

- Setting up a flood advisory technical committee.
- Developing new provincial standards and guidelines.

These improvements are currently in progress and the advisory committee is expected to be established by the end of 2020. The committee will then be able to begin reviewing gaps in provincial guidance documents and flood mapping and identifying areas in need of updates.

### 3.9.6 Challenges and Opportunities – NFHDL

#### 3.9.6.1 Challenges

The biggest challenge for the NFHDL is the lack of a centralized flood mapping authority or register. Conservation Ontario and the OMNRF agreed in the interview that this would be required to ensure that data coming in was authoritative, particularly for areas outside of conservation authorities. Ontario specified that if the NFHDL project can clearly define its long-term requirements for continuation and updating of the NFHDL (e.g., including the provision of the national data schema), then they can work to provide the right contacts at the provincial level who would be able to authorize data.

There was interest from Conservation Ontario to link the NFHDL to the Metadata Inventory. However, as the Metadata Inventory does not currently include geospatial data, the two datasets will not match. They are currently considering the inclusion of geospatial data into the Metadata Inventory, but this was not within the timeline to inform the design of the NFHDL prototype.

Conservation authorities own the majority of the data in Ontario. Many of these authorities require data sharing agreements in order to share their data. This will limit how the NFHDL can be used in the future, as these agreements are likely to need updating every time new data are added to the NFHDL.

Another challenge of integrating flood hazard data from conservation authorities into the NFHDL is that often a single regulatory floodplain file exists for one area, which combines several studies from different years, with different methods and likelihoods. In some cases, it is however not clear which polygon features are associated with which study year or likelihood.

### 3.9.6.2 Opportunities

Ontario’s interests are clearly aligned with those of the federal government. They are also interested in a better understanding of flood hazard data in Ontario to help with planning and policy setting, not just with the departments that were contacted for this project, but also with other departments, such as Infrastructure Ontario.

The provincial government and Conservation Ontario are currently putting in place several directives that would make updating the NFHDL easier in the future, such as the technical committee and the Metadata Inventory. There are many opportunities for learning and collaboration between the NFHDL and Ontario, should the timelines match.

## 3.10 Prince Edward Island

### 3.10.1 Flood Hazard Data Summary

**Flood Mapping Authority** – Prince Edward Island Department of Environment, Water and Climate Change.

**Flood Hazards Mapped** – Coastal.

**AEPs Included in Most Recent Maps** – 100%, 10%, 1%, and 0.1% AEP.

**Regulatory Floods** – Unknown (will be defined upon completion of the ongoing coastal flood mapping project).

A summary of the availability of flood hazard data is provided in Table 9.

**Table 9: Prince Edward Island present-day “authoritative” flood hazard mapping summary.**

Areas Mapped		Average Year Produced <sup>†</sup>	Year Range <sup>†</sup>	Funding Program for Authoritative Maps		
Current <sup>*</sup>	In Progress <sup>†</sup>			FDRP	NDMP	Other
~7	Complete Coastline	2020	2020	0%	100%	0%

Note that the current map column includes all current authoritative maps. The remaining columns assume that these maps are superseded by maps in progress, where applicable.

\* Current flood mapping is widely varied. See note under Map History and Future.

† Assumes that in-progress coastal flood mapping will replace all previous maps, based on interview. Note that new coastal flood hazard data has only been received partially and with limited documentation, at the time of writing this report.

### 3.10.2 Flood Mapping Governance

#### 3.10.2.1 Roles and Responsibilities

Flood hazard mapping in Prince Edward Island is the responsibility of the Department of Environment, Water and Climate Change. In collaboration with the Department of Justice and Public Safety, they are currently working on a project to produce coastal flood maps for the whole island.

#### 3.10.2.2 Historic and Future Mapping Catalogues

Prince Edward Island was not included in the FDRP, and therefore no FDRP maps exist. More recently, there have been various coastal flood hazard studies completed for Prince Edward Island. In their 2017 report on the Status of Flood Mapping in Atlantic Canada (CBCL, 2017), CBCL lists studies covering 7 separate areas. In all but 2 areas, these studies were conducted in the form of climate change vulnerability assessments, rather than flood hazard mapping studies. Most of these studies considered sea-level rise and storm surge projections, but did not include hydrodynamic models nor did they consider wave impacts. The exception to this is the Charlottetown Waterfront Assessment.

At a provincial level, it was confirmed during the interview that a flood study was done focusing on Charlottetown in 2004 and later updated in 2012. The results of this study have been used to create flood hazard zones based on the 2-m and 4-m elevation contours (< 2 m is high risk, between 2 and 4 is moderate, and > 4 m is low). Over 6 m is generally considered beyond the flood risk area. This was applied to the whole Prince Edward Island coastline. Note that these flood hazard zones are not used in planning regulations.

Prince Edward Island is currently finalizing a new flood mapping project that will map the entire coastline. Once complete, no further flood maps will be produced until updated maps are required in the next 5–10 years.

#### 3.10.3 Technical Mapping Approach

Prince Edward Island maps coastal flood hazard only, as they do not consider riverine flooding to pose a major risk. Currently available maps for Prince Edward Island are based primarily on sea-level rise estimates and storm surge levels. These maps were adapted from a 2012 study completed for Charlottetown and the north coast of the island in conjunction with LiDAR from 2008. The maps were often produced in a case-by-case manner in response to planning applications, and some have since been published by communities.

Prince Edward Island is currently finalizing a project to develop maps for the entire coastline. As there is no current provincial flood mapping standard, they are reliant on the consultant to complete these maps to federal guidelines and modern mapping standards, such as those defined by the US Federal Emergency Management Agency (FEMA) (FEMA, 2020). The new flood maps will divide the coastline into 260 coastal reaches and will produce extent and flood water level maps for the 100%, 10%, 1%, and 0.1% AEP floods. This will be based on 2008 LiDAR data, and extents may be updated by the province using LiDAR data collected in 2020. This will be done for the present-day, as well as for 2050 and 2100. Climate change will

include both the impact of sea-level rise and changes in storm surge. An additional improvement of this new mapping project is the addition of seven additional gauges. While the record of these gauges is relatively short, they provide data on storm surge at different points around the island. The previous 2012 study was based on a single tide gauge, and the provincial government was uncertain as to how well this represented local conditions.

### **3.10.3.1 Regulatory Flood**

Prince Edward Island currently informs property owners of potential risk based on the flood hazard zones developed using the 2-m, 4-m, and 6-m elevation contours. Note, however, that the provincial government does currently not regulate this, and the flood hazard zones are not used in planning regulations. Some municipalities have adopted development regulations, but they only apply to their jurisdiction. The flood hazard zones were based on a study for Charlottetown and LiDAR, and do not refer to specific AEPs, but rather, the Charlottetown study had shown that these elevation contour intervals are wetted under flood scenarios with different likelihoods. Prince Edward Island had therefore designated these contours as High, Moderate, and Low Hazard areas and applied them to the whole island. This approach will likely change with the release of the new coastal flood hazard mapping, and definition of a new regulatory flood scenario.

## **3.10.4 Management of Flood Hazard Data**

### **3.10.4.1 Data Structure**

New coastal flood mapping data will include raster files of coastal flood water levels throughout the province, based on the provincial 1.5 m DEM (2008) and using the 1% AEP storms (tide, surge, and relative sea-level rise plus wave set-up). In addition to the raster files, the new data includes relative sea-level rise scenarios for each decade between 2020 and 2100. Further, vector-format shapefiles will summarize watershed-scale flood levels for a wide range of probabilities and years. As the data are still being produced and has only been shared partially, other details are unknown.

### **3.10.4.2 Data Services**

Data are shared internally through a government FTP site; static flood maps are shared with individuals and small communities who do not have GIS capabilities. The province currently has numerous web mapping applications that are externally facing and multiple internal ones. Prince Edward Island intends to combine these applications into a single Esri enterprise system.

## **3.10.5 Challenges and Opportunities – Flood Hazard Data**

### **3.10.5.1 Challenges**

Current flood mapping for Prince Edward Island is limited and is based on substantial assumptions and limited tide gauge data, and it also does not include modelling of wave impacts, which are a key component of coastal flood levels.

Prince Edward Island feels that coastal flood mapping (which is relevant for the province) is generally less well developed than riverine flood mapping (which is conducted in many other provinces, but not relevant for Prince Edward Island), and coastal flood mapping is not as clearly defined in guidelines. For this reason, they feel that their flood mapping program is less well developed than those in other parts of Canada. Prince Edward Island does not have an established provincial flood mapping standard and is therefore largely reliant on their consultant to define the format of the produced flood hazard data.

### **3.10.5.2 Opportunities**

Many of the challenges stated above should be resolved by the new coastal flood hazard mapping that is currently being finalized. Prince Edward Island has also discussed the need for the development of guidelines and/or regulations, but has not yet established how to accomplish this objective.

### **3.10.6 Challenges and Opportunities – NFHDL**

#### **3.10.6.1 Challenges**

Current coastal flood mapping is being finalized as this report and the NFHDL are developed. A small amount of preliminary data has been received for review, but the incorporation of Prince Edward Island's flood maps into the NFHDL will be very limited.

As an island province, Prince Edward Island expressed concern that the uniqueness of their data should be captured in the NFHDL. Without any completed flood map data to draw from, it is difficult to establish the specifics of what these differences might be.

#### **3.10.6.2 Opportunities**

Prince Edward Island is keen to learn from other P/Ts. While riverine flooding is not considered a major risk in Prince Edward Island, they are concerned about combined coastal and pluvial (overland) flooding.

Prince Edward Island plans to make their new maps public. Should NRCan make the NFHDL public, Prince Edward Island would prefer to use the NFHDL system instead of developing their own. They also mentioned that the Canadian Centre for Climate Services is talking to them about releasing data through the ClimateData website (<https://climatedata.ca/>).

## 3.11 Québec

### 3.11.1 Flood Hazard Data Summary

**Flood Mapping Authority** – Local governments (currently under review).

**Flood Hazards Mapped** – Lake and riverine.

**AEPs Included in Most Recent Maps** – 50%, 5%, and 1% AEP.

**Regulatory Floods** – 5% and 1% AEP. These are defined as the *zone de grand courant* (high velocity zone; similar to floodway) and *zone de faible courant* (weak velocity zone; similar to flood fringe).

A summary of flood hazard data availability is provided in Table 10. The values are based on unique “report numbers” listed in Québec’s *Base de données des zones à risque d’inondation* (BDZI; database of flood hazard zones), which was initially released in 2018. Due to a lack of metadata, it is not known how many of these maps are still considered authoritative or are still in use. During the FDRP period, maps were produced in Québec with funding from the federal government under the Convention Canada-Québec (CCQ); this has been used in Table 10 in place of FDRP funding. Québec was not part of the NDMP program (no agreements were signed regarding the NDMP between the provincial and federal governments), and therefore, no projects were funded under this program (Public Safety Canada, 2019).

**Table 10: Québec present-day “authoritative” flood hazard mapping summary.**

Areas Mapped		Average Year Produced	Year Range	Funding Program for Authoritative Maps		
Current	In Progress			CCQ	NDMP	Other
192	8	2001	1979–2014	25%	0%	75%

### 3.11.2 Flood Mapping Governance

#### 3.11.2.1 Roles and Responsibilities

In the recent past, the responsibility for flood mapping in Québec was with local governments. Maps were produced by larger municipalities and regional municipal counties to support the development of their own bylaws. Québec is currently shifting this system through the INFO-Crue program (see details in later sections), which was started in 2018 and is led by the *Ministère de l'Environnement et de la Lutte contre les changements climatiques* (MELCC). The initiative has been complemented by mapping completed through financial assistance agreements between the *Ministère des Affaires municipales et de l'Habitation* (MAMH) and 8 local governments<sup>19</sup> as part of the *Plan de protection du territoire face aux inondations*.

<sup>19</sup> The local governments include the following metropolitan communities and municipal regional counties: Montréal; Québec; Argenteuil, Vaudreuil-Soulanges, and Deux-Montagnes; Beauce-Sartigan, de la Nouvelle-Beauce, and Robert-Cliche; Bonaventure; Maskinongé; Gatineau, Collines-de-l'Outaouais, Papineau, and Pontiac; and Sherbrooke, Coaticook and Haut-Saint-François.

Outputs from INFO-Crue and the *Plan de protection du territoire face aux inondations* programs will align within a new regulatory framework that is currently under development, and that is expected to be in place in 2021. The new regulation will build on the *Politique de protection des rives, du littoral et des plaines inondables* (Protection Policy for Lakeshores, Riverbanks, Coastal Zones and Floodplains). Supporting documents and methods are currently being developed, and these will guide flood map development across Québec. The definition of flood hazard zones will now be driven by the provincial government, where previously this was done by local governments.

### 3.11.2.2 Historic and Future Mapping Catalogues

Between 1976 and 2001, flood maps were produced in Québec with funding from the federal government under the CCQ program (simultaneous to FDRP in other P/Ts). More than 500 maps were produced in this period, covering around 250 municipalities. Following historic floods in 1996 in Saguenay, the *Ministère de l'Environnement* launched a separate program known as the *Programme de détermination des cotes de crues* (PDCC, Program to determine flood extents), which lasted from 1998 to 2004 and targeted 155 rivers and lakes across the province (Ministère de l'Environnement et de la Lutte contre les changements climatiques, 2020b). Approximately 75% of the maps collated in this layer fall under the CCQ or PDCC programs. The remaining maps were produced between 2005 and 2014.

In 2018, MELCC began their INFO-Crue program, and the MAMH began mapping for the 8 local governments, starting with starting with the metropolitan communities of Montréal (whose maps are due to be completed in late 2020 or early 2021) and Québec. Both programs are due to be completed over the same 5-year timeline (2023). The consolidated program outputs aim to offer tools to allow the delineation of flood zones in a large part of southern Québec for land use planning, taking into account climate change (Ministère de l'Environnement et de la Lutte contre les changements climatiques, 2020a). As an initial step under the INFO-Crue program, Québec created the *Base de données des zones à risque d'inondation* (BDZI) data layer to collate flood data created by local governments into a single consistent database.

Under the INFO-Crue and the MAMH agreement programs, Québec plans to conduct flood mapping according to modern standards. The initiatives include updates to existing maps, as well as the production of flood maps in previously unmapped areas. The existing *Politique de protection des rives, du littoral et des plaines inondables* will evolve into a regulation that will drive all flood mapping activities moving forward. Standards for flood mapping have not yet been developed, but it is likely that various types of hazard maps will be recommended.

### 3.11.3 **Technical Mapping Approach**

Flood mapping in Québec is currently highly varied and dependent on the local governments. All flood maps however include the 5% and 1% AEP flood extents. These are the regulatory extents and are defined as the *zone de grand courant* (floodway) and *zone de faible courant* (flood fringe). In some cases, maps also include the 50% AEP flood extent.

Most of the hydrologic and hydraulic analyses and floodplain mapping has been done in-house by the *Centre d'expertise hydrique du Québec* (CEHQ) (MMM Group et al., 2014), which has now been amalgamated into the MELCC.

MELCC are currently drafting a new provincial regulation for flood mapping, that is due for completion in 2021. It is envisioned that in addition to the 5% AEP and 1% AEP floods, the 0.5% and 0.29%<sup>20</sup> AEP may also be added. The 0.29% AEP is being considered for inclusion in the mapping completed for the 8 local governments that are part of the MAMH agreements program. These two larger AEPs are being considered in part to account for increases in flood levels due to climate change. However, the approach to climate change is still being developed. It is also envisioned that the new regulation will include additional flood maps, which will describe the magnitude of hazard based on combinations of indices related to likelihood, depth, velocity, and potentially flooding duration.

In Québec, freeboard is not included in flood hazard mapping, but is applied at the stage when considering engineering designs. Uncertainty is accounted for via a conservative mapping approach, where the mapping methods include decisions that yield conservatively high water level calculations in the hydraulic models (for instance, estimating conservatively high hydrology flows as input to the hydraulic models, or using parameters and coefficients in the models that yield conservatively high flows).

#### **3.11.3.1 Regulatory Flood**

Current flood maps include 5% and 1% AEP. These are the regulatory extents and the 5% AEP is defined as the *zone de grand courant* (floodway), while the 1% AEP is defined as the *zone de faible courant* (flood fringe).

### **3.11.4 Management of Flood Hazard Data**

#### **3.11.4.1 Data Structure**

The BDZI spatial data consists of 4 feature sets with 9 total features. The feature properties are extensive, making use of code lists and containing valuable metadata. The schema structure was thoughtfully designed, and comprehensive documentation is available on the Données Québec website.<sup>21</sup> The schema was designed to be implemented in an ArcGIS 9.2 file geodatabase system.

*Archives\_zones inondables*/Archived Flood Zones (ARCH\_ZOI) is a feature set containing three features: point, line and polygonal representations of superseded flood zone maps.

*Zones Inondables*/Flood Zones (ZOI) is the central feature set which contains both linear and polygonal representations of flood inundation areas and is linked to study extents. The *Zones Inondables Polygones*/Flood Zones Polygon (ZOI\_S), the polygonal flood zone feature, and the *Zones Inondables*

---

<sup>20</sup> The 0.29% AEP refers to the 350-year return period.

<sup>21</sup> Données Québec: <https://www.donneesquebec.ca/recherche/fr/dataset/base-de-donnees-des-zones-inondables>

*Lignes/Flood Zone Lines (ZOI\_I)* feature both have a description property that indicates the AEP or flood hazard type of the specific feature. Other properties for these features include study report title, original data format, data ownership, mapping program, and other relevant metadata. *Cartes de Zones Inondables/Flood Maps (Carto\_ZI)* is a polygonal flood map area extent,<sup>22</sup> and *Études de Zones Inondables/Flood Zone Studies (Etudes\_ZI)* is the linear study extent. The *Etudes\_ZI* feature is unique in that it represents the linear segment of river associated with the flood study rather than the polygonal area within which the study was conducted.

*Cotes de Crues/Flood Lines (CO\_Crue)* is a point feature representing locations where flood heights have been modelled for the 50%, 5%, and 1% AEP floods. The *Cote\_2\_ans*, *Cotes\_20\_ans* and *Cote\_100\_ans* properties express these flood water heights in metres above sea level. Other relevant data are further captured, such as the flood study section. Report number, report title, date, and other relevant information is also present in the table properties.

*Crue Historique/Historic Floods (HIST\_CRUE)* is a linear representation of historic flood extents. Some of these lines are regulatory as indicated by the *Val\_legal* property. Other important properties include date of the event, watercourse name, and watercourse ID.

The BDZI is a good example of flood data standardization, as it harmonizes information from various time periods that apply various methodologies.

#### **3.11.4.2 Data Processing**

Data for the BDZI are housed internally within a file geodatabase and duplicated in an SQLite relational database. These databases are managed by the MELCC's IT department. No details were captured about the plans for future data processing within the INFO-Crue system, although it is known that this system has the objective of providing short-term flood warnings/forecasts for emergency management.

#### **3.11.4.3 Data Services**

The BDZI database, along with documentation, is available for download from the Données Québec website.<sup>21</sup> The database is available for download in file geodatabase format, SQLite format, and as an OGC Web Map Service.

### **3.11.5 Challenges and Opportunities – Flood Hazard Data**

#### **3.11.5.1 Challenges**

Québec is a large province with over 1,000,000 lakes and 130,000 watercourses (MMM Group et al., 2014). While the province has more flood maps than almost any other P/T in Canada, around 75% of these maps are over 15 years old and in need of updates. Many areas also remain unmapped. The province does

---

<sup>22</sup> The layer is also linked to a PDF map.

not currently have a provincial standard, and while most maps are done centrally by the CEHQ (now part of the MELCC), there is a considerable degree of variability in flood maps.

### 3.11.5.2 Opportunities

Québec has made substantial progress in recent years via the creation of a centralized flood hazard database (the BDZI), which is publicly available through their open data system. They are also currently improving mapping standards under a new regulation and have a plan to update flood mapping to modern standards through work done under the INFO-Crue program.

### 3.11.6 Challenges and Opportunities – NFHDL

#### 3.11.6.1 Challenges

Québec has limited resources, which are currently focused on developing the INFO-Crue project. Québec is keen that the NFHDL does not increase the workload of staff. With such a large number of mapped areas in Québec, maintaining an up-to-date dataset and superseding old data is likely to be a substantial task. As Québec also has their own online database management system, they voiced concerns on potentially having two different versions online, should the NFHDL become publicly available, and that the Québec database should remain the primary authoritative database.

#### 3.11.6.2 Opportunities

Québec is well organized, and data are publicly available through a centralized source with a single point of contact. The provincial government has already done most of the work in harmonizing data produced by local governments and is producing further regulations that should help to further unify data produced in the future.

## 3.12 Saskatchewan

### 3.12.1 Flood Hazard Data Summary

**Flood Mapping Authority** – Saskatchewan Water Security Agency and some municipalities.

**Flood Hazards Mapped** – Lake, riverine, and ice-jam.

**AEPs Included in Most Recent Maps** – 10%, 5%, 2%, 1%, and 0.2% AEP.

**Regulatory Floods** – 0.2% AEP with floodway and flood fringe.

A summary of the availability of flood hazard data is provided in Table 11.

**Table 11: Saskatchewan present-day “authoritative” flood hazard mapping summary.**

Areas Mapped		Average Year Produced <sup>†</sup>	Year Range <sup>†</sup>	Funding Program for Authoritative Maps		
Current*	In Progress			FDRP	NDMP <sup>†</sup>	Other
18	24	2020	2020	0%	100%	0%

Note that the current map column includes all current authoritative maps. The remaining columns assume that these maps are superseded by maps in progress, where applicable.

\* Includes currently valid and designated maps only. Note that there have been 20 flood maps designated from the FDRP, however, 2 of these (Estevan and Roche Percée) are no longer considered valid by the provincial government.

† It is assumed that all current maps are due to be superseded based on the currently ongoing province-wide flood map update. Note, however, this new flood hazard data has not been received within the timeline of this project.

### 3.12.2 Flood Mapping Governance

#### 3.12.2.1 Roles and Responsibilities

The overall responsibility for flood hazard data management sits with the provincial Water Security Agency. They are largely responsible for creating new flood hazard data and managing existing data. In 2020, 4 municipalities also produced flood maps. These maps are currently undergoing review by Saskatchewan to be officially designated as authoritative maps.

#### 3.12.2.2 Historic and Future Mapping Catalogues

Until 2020, the only flood maps available for Saskatchewan were those created under the FDRP. Of the FDRP maps, 18 are officially designated as authoritative flood maps. These maps have since been scanned and digitized by the provincial government. Note that there were 20 flood maps designated from the FDRP, however, two of these (flood maps for Estevan and Roche Percée) are no longer considered valid due to subsequent development of the Rafferty Reservoir and the Boundary-Rafferty Diversion Channel, changes to the river channel and to river crossings, and the extreme flood of June 2011. FDRP mapping also exists for Regina, Saskatoon, Swift Current, and Prince Albert, but these maps were never officially “designated”.

In 2020, 20 new maps are being produced in a single project managed by the Saskatchewan Water Security Agency, along with 4 maps that were produced by the municipalities of Prince Albert, Corman Park, Melville, and Swift Current. All maps, including those produced by municipalities, are currently under review to be integrated into new authoritative mapping. This will happen gradually over the next year (2021) and will be made public. This is considered a pilot project for future mapping. Saskatchewan has found additional budget internally to cover 18 months of further flood mapping, and they are currently reviewing which areas should be included for this. Once the current mapping project is complete, Saskatchewan believes they will have completed mapping for around 50% of the communities that require it.

#### 3.12.3 Technical Mapping Approach

Current maps for Saskatchewan considered authoritative by the provincial government were produced under the FDRP. These map the 0.2% AEP along with a floodway and flood fringe. In some cases, the FDRP maps also include historical flood event lines.

There is currently no provincial standard for flood mapping. Saskatchewan is currently developing flood maps based on the federal guidelines, and their own views of flood hazard mapping in Saskatchewan. All of the flood maps currently under development by the provincial government are being done under a single project and are therefore likely to be relatively consistent. There may be more variation in the maps produced by municipalities, but they are being reviewed by Saskatchewan before being officially

designated. New maps will include the 10%, 5%, 2%, 1%, and 0.2% AEPs. These will be produced for lake and riverine flood hazards. Ice-jam flooding is relatively rare in Saskatchewan and is therefore being considered on a case-by-case basis in terms of the methodology used and the scenarios mapped.

Climate change is currently not included in flood maps. This is under review by the provincial government.

### **3.12.3.1 Regulatory Flood**

The regulatory flood in Saskatchewan for both FDRP and recent mapping is the 0.2% AEP. The floodway and flood fringe are being retained in recent mapping with the following definitions:

- **Floodway** – The portion of the 0.2% AEP flood area where:
  - The depth of flooding would be greater than or equal to 1.0 metres; or,
  - The flow velocity would be greater than or equal to 1.0 metres per second.
- **Flood Fringe** – The portion of the 0.2% AEP flood area where:
  - The depth of flooding would be less than 1.0 metre; or,
  - The flow velocity would be less than 1.0 metres per second; or,
  - Where complete infill of the flood fringe would not cause an increase of upstream flood levels of more than 0.3 m.

Freeboard is not included in mapped flood data, but 0.5 m is added to 0.2% AEP flood levels in regulation.

## **3.12.4 Management of Flood Hazard Data**

### **3.12.4.1 Data Structure**

The currently authoritative FDRP-era maps are stored in a single file geodatabase, which consists of four features. Each feature contains a “Location” property identifying which study area the individual polygons or lines belong to. There is a 0.2% AEP flood polygon feature, a floodway polygon feature and a flood fringe polygon feature, as well as a flood lines line feature. None of these features contain valuable attribute information.

### **3.12.4.2 Data Processing**

Existing FDRP maps were digitized from PDF scans of the original maps. These PDF maps still contain some valuable information that has not been captured in the digital files. New maps are provided to the Water Security Agency as shapefiles, with limited structure. These shapefiles are ingested into an Esri-based system using file geodatabases. Once the data are ingested, Saskatchewan intends to provide the data to the public in a standardized format. The specific format and data structure have yet to be determined.

### **3.12.4.3 Data Services**

Saskatchewan has a Geocortex web GIS application (Saskatchewan Interactive Mapping).<sup>23</sup> Currently, flood data are not available through this platform, but there is a desire to host the new flood map data there.

### **3.12.5 Challenges and Opportunities – Flood Hazard Data**

#### **3.12.5.1 Challenges**

Flood hazard is an emerging sector in Saskatchewan, as all recent flood maps were developed in the last year. Saskatchewan is therefore learning lessons and developing processes as they go. There is currently no provincial standard for flood mapping, and they are reliant on the federal guidelines and their adaptations to make these more relevant to Saskatchewan. The current mapping project is considered a pilot for future flood mapping. The Water Security Agency has limited resources and expects to approve these 24 new maps by late 2021.

Climate change is currently not included in flood maps, although its inclusion is under review.

Saskatchewan believes that once the current round of flood mapping (for which funding is available) has been completed, that they will have mapped around 50% of the communities that need flood mapping. However, they have not yet identified funding for mapping the remaining communities.

#### **3.12.5.2 Opportunities**

Saskatchewan has made significant steps toward creating modern flood maps for the province this year (2020) and has plans in place and funding identified to continue flood mapping for the next 18 months. This will be a substantial improvement over relying on the FDRP maps that are currently in use in the province. While there is no provincial standard for flood mapping, most of the maps are being managed centrally under a single project. The remaining maps are being reviewed centrally by the provincial government. This increases the consistency of flood hazard data available for Saskatchewan. The additional AEPs being considered for new maps will improve the ability to manage smaller, more frequent floods.

### **3.12.6 Challenges and Opportunities – NFDHL**

#### **3.12.6.1 Challenges**

There were no specific concerns raised by Saskatchewan regarding the NFHDL.

---

<sup>23</sup> Saskatchewan Interactive Mapping:  
<https://gisappl.saskatchewan.ca/Html5Ext/index.html?viewer=saskinteractive>

### 3.12.6.2 Opportunities

Saskatchewan plans to make flood hazard data public. There may be a slight delay while data are approved, but any approved data would be openly available for the NFHDL to use.

This is a critical time for Saskatchewan, as they are currently developing processes and systems related to flood hazard data. They are keen to learn from the NFHDL and may wish to use the schema developed for their internal data management and storage. This would also make future updates to the NFHDL easier.

Saskatchewan are also looking to develop their own systems to make data publicly available. They envision that this could be similar to the FAMA system developed by Alberta. Producing a front-end interface to the NFHDL would avoid the need for this to be done at a provincial level, should the NFHDL become available to the provinces, or made public. Should Saskatchewan develop their own system, there is an opportunity to use this to update the NFHDL.

## 3.13 Yukon

### 3.13.1 Flood Hazard Data Summary

**Flood Mapping Authority** – Yukon Department of Environment.

**Flood Hazards Mapped** – Lake, riverine, and ice-jam.

**AEPs Included in Most Recent Maps** – 50%, 5%, and 1% AEP (not fully confirmed).

**Regulatory Floods** – None, currently.

A summary of the availability of flood hazard data is provided in Table 12.

**Table 12: Yukon present-day “authoritative” flood hazard mapping summary.**

Areas Mapped		Average Year Produced	Year Range	Funding Program for Authoritative Maps		
Current	In Progress			FDRP	NDMP	Other*
0	14	2020	2020	0%	70%	30%

\*Mapping is ongoing. It has not yet been confirmed whether final maps will be delivered in-house or externally. Future funding may be available related to Government of Yukon’s strategy for climate change, energy and a green economy.

### 3.13.2 Flood Mapping Governance

#### 3.13.2.1 Roles and Responsibilities

A current flood hazard mapping project is being managed by the Yukon Department of Environment. At the moment, in the event of an emergency related to flooding, the Department of Environment provides forecasting with support from Environment and Climate Change Canada and Government of Yukon meteorologists, and the Water Survey of Canada, to Government of Yukon’s Emergency Measures Organization to manage the hazard.

### 3.13.2.2 Historic and Future Mapping Catalogues

Yukon currently does not have any authoritative flood maps. It was mentioned in the interview that there have been a number of studies that included coarse maps and figures going back to the 1970s, however none of these have been approved and they are not used.

Yukon is currently producing flood maps for 14 communities. These maps are being produced primarily for emergency management purposes. There is a possibility that this could lead to flood regulation, but this is not currently being considered.

It should be noted that 2 of the communities (Destruction Bay and Burwash), which were historically believed to be at risk of flooding, are no longer exposed to flooding due to the Slims River Piracy Event of 2016 (Shugar et al., 2017)—when the ongoing retreat of the Kaskawulsh Glacier led to the meltwater, which previously flowed in part into the Slims River, being instead redirected to flow into the Kaskawulsh River. This led to a drop of several metres in summer water levels in Kluane Lake, which is fed by the Slims River.

Flood maps for smaller communities, such as Stewart Crossing, may be developed at a later stage. In addition, as populations grow, currently mapped areas may need to be subdivided to provide better resolution.

### 3.13.3 Technical Mapping Approach

Historically, the understanding of flood hazard extents was based heavily on local knowledge and engineering judgment. A range of different flood likelihoods have been used for forecasting in different areas, based on judgment of the most important likelihood for each area, including the 50%, 20%, 10%, 5%, 1%, and 0.5% AEPs.

The mapping approach for the upcoming flood maps has not yet been fully finalized. However, the flood maps are expected to provide estimated extents for 50%, 5%, and 1% AEP floods for all 14 communities. These estimates are not based on hydraulic modelling but have been produced using historical Water Survey of Canada and Yukon territorial records of high-water levels during the open-water season and during freeze-up and break-up. Projections were created for different event likelihoods based on a frequency analysis of water-level profiles from this historic record. The length and consistency of these records vary, with the oldest records extending back to the 1950s. Yukon stated in the interview that infilling of incomplete records was possible for some areas, for example the Southern lakes, given good correlation between the available records. Detailed methods for flood mapping are still being developed.

Yukon has streamflow forecasting models (MESH) for the Yukon River Basin, Porcupine River and Liard River that were produced under the NDMP. It is possible that these could be used to evaluate results from the frequency analysis, however, the focus of these models is on forecasting, and the models are coarse and not as detailed as hydraulic models made for flood mapping. Yukon also has river ice break-up forecasting models in operational use and in development for several Yukon communities.

Yukon has not yet confirmed whether the rest of project, the production of the final maps for 14 communities, will be completed in-house, with consultant advice, or externally by consultants.

Climate change has not been included in mapping and analysis to date and will also not be included in the upcoming 14 maps. A climate change, energy and green economy strategy was recently developed by Yukon covering the next 10 years. The impact of climate change on flooding forms part of this strategy, and it is expected that this will be included in new versions of maps over the next 3–5 years.

### **3.13.3.1 Regulatory Flood**

There is currently no specific regulatory flood used in Yukon. While this may be initiated in the future, it is not part of the current mapping plans.

## **3.13.4 Management of Flood Hazard Data**

### **3.13.4.1 Data Structure**

Flood map data structure in Yukon cannot be commented on at this point. In the interview, it was mentioned that Yukon is interested in adopting the NFHDL schema and to leverage the work done at the federal level. In broad terms: vector data are stored in Esri File Geodatabases, mass points (LiDAR) in compressed LAS and LAS Datasets, and raster data in lossless compressed georeferenced TIFF.

### **3.13.4.2 Data Processing**

The Yukon Department of Environment has a variety of spatial data housing and processing technologies in use. The platforms and databases include ArcGIS Desktop and Server, ArcGIS Online, FME workstation, Oracle spatial, SQL Server, PostGIS, and Microsoft Access. For hydrology and flood data, they will proceed with one database system and are open to recommendations based on the outcomes of the NFHDL project.

### **3.13.4.3 Data Services**

Data internal to the Department of Environment is transferred and used within file geodatabases. GeoYukon<sup>24</sup> is a Geocortex web GIS infrastructure managed by Yukon to make public data accessible and downloadable. Much of the data available here is also available through the GeoYukon FTP site<sup>25</sup>, and indexed on the Yukon Open Data site<sup>26</sup>.

## **3.13.5 Challenges and Opportunities Flood Hazard Data**

### **3.13.5.1 Challenges**

Flood-mapping resources in Yukon are very limited. Yukon currently does not have any flood maps available and was not part of the FDRP. They are therefore establishing a flood mapping program from

---

<sup>24</sup> GeoYukon: <https://mapservices.gov.yk.ca/GeoYukon/>

<sup>25</sup> GeoYukon FTP site: <ftp://ftp.geomaticsyukon.ca/GeoYukon/>

<sup>26</sup> Yukon Open Data site: <https://open.yukon.ca/data/>

scratch. This means establishing, for instance, which AEPs to focus on, and developing a flood mapping methodology. The understanding of flood hazard is highly variable across the territory, and regulation is minimal.

Ice-jam flooding is one of the more common causes of flooding in Yukon. This flood mechanism is particularly complex and is only beginning to be assessed in detail, even in areas with well-established mapping programs (such as Alberta).

Yukon's chosen mapping methodology at this time will likely be conducted at a higher level than the approaches used in most regions of Canada. Flood maps are being produced using frequency analysis rather than hydraulic modelling. This approach is particularly challenging for rare likelihood scenarios, as these will likely have to be extrapolated beyond the historic record. Some areas may be verified in the future using hydraulic modelling, or the streamflow models used for flood forecasting. While this approach may be well suited to the difficult conditions and limited resources available in Yukon, the results are likely to be less accurate than elsewhere in Canada.

### **3.13.5.2 Opportunities**

A review of the Federal Flood Mapping Guidelines is currently being conducted in the Northwest Territories for northern conditions, and the lessons learned there are likely to be applicable to Yukon as well. Yukon could also learn from other areas that are currently considering ice-jam flood hazard (e.g., Alberta).

## **3.13.6 Challenges and Opportunities NFHDL**

### **3.13.6.1 Challenges**

There are no current flood maps that can be added to the NFHDL. The methodologies used by Yukon are likely to differ substantially from those used in the rest of Canada, and the NFHDL must be able to capture this discrepancy. Without any completed flood mapping, it is difficult to fully establish what these differences might be.

### **3.13.6.2 Opportunities**

Yukon plans to make the flood hazard data that they produce publicly available. If NRCan were to publish the NFHDL, this would avoid the need for Yukon to do so. Yukon is keen to learn from both the NFHDL project and other P/Ts, in terms of flood hazard mapping, as well as metadata and schema development.

## 4 National Flood Hazard Data Review

This section provides a review of information gathered during the engagement and data collection phases. It has been divided into two sections, including key themes related to the production and management of flood hazard data, and key themes related to the development of the NFHDL project.

### 4.1 Key Themes for Flood Hazard Data

This section provides key themes raised through the engagement and data collection phases of the NFHDL project that relate to flood hazard data:

1. A summary of flood hazard data (presently, as well as future plans).
2. Flood map methodologies and products.
3. Management of flood hazard data.
4. Approaches to regulation.
5. National challenges in flood hazard mapping.

#### 4.1.1 Summary of Flood Hazard Data

This section provides a summary of flood hazard data in Canada, including a summary of current and planned flood hazard data, and an estimate of additional mapping required in each province or territory.

Table 13 provides a summary of the current state of flood mapping in Canada for current and in-progress mapping. More details are provided in Section 3. It should be noted that flood data indicated as “In Progress” typically includes ongoing flood hazard mapping projects, and thus, the data has not yet been received for review. Also note the “Current Areas Mapped” column includes all maps currently available for the P/T, whereas the other columns (“Average Year Produced”, “Year Range”, “Funding Program”) assume that currently available maps are superseded by in-progress maps, where applicable.

**Table 13: The current state of flood maps in Canada for current and in-progress mapping, based on information obtained in engagement and data collection phase.**

	Areas Mapped		Average Year Produced	Year Range	Funding Program for Current and Pending Authoritative Maps		
	Current	In Progress			FDRP	NDMP	Other Program
AB	54	70	2007	1983–2020	26%	9%	65%
BC	95	33	2003	1975–2020	33%	15%	52%
MB	7	2	2019	2018–2020	0%	100%	0%
NB	17	35	2020	2020	0%	100%	0%
NL	27	2	2001	1984–2020	62%	7%	31%
NU	0	0	N/A	N/A	N/A	N/A	N/A
NS	14	3	2016	2008–2020	0%	Unknown	Unknown
NWT	9	0	1986	1984–1988	100%	0%	0%
ON	736	Unknown	1991	1971–2020	52%	Unknown	Unknown
PEI	~7	Complete Coastline	2020	2020	0%	100%	0%

	Areas Mapped		Average Year Produced	Year Range	Funding Program for Current and Pending Authoritative Maps		
	Current	In Progress			FDRP	NDMP	Other Program
QC	192	8	2001	1979–2014	25% (CCQ)	0%	75%
SK	18	24	2020	2020	0%	100%	0%
YT	0	14	2020	2020	0%	70%	30%

The numbers presented in Table 13 are based on the engagement exercise completed for this project, as well as the data provided by each P/T and other communications. At the time of writing, the following mapping is currently in progress, or could not be obtained within the timeline of the project (Table 14).

**Table 14: Description of flood mapping currently in progress (and that could not be obtained within the timeline of this project).**

P/T	Description of Flood Hazard Mapping Currently in Progress
AB	Flood hazard mapping conducted after 2015 (mostly NDMP-related data) is currently undergoing an authorization and review process and will be available in 2021 (draft maps are available currently online for engagement with the public).
BC	Some NDMP and provincially funded projects are still in progress (due in 2021), or data has not yet been shared with the provincial government of BC (due soon). Further flood hazard mapping from independent funding may also exist or be in progress.
MB	Two flood hazard mapping projects currently in progress.
NB	Complete data refresh in progress for coastal and riverine flood hazard data, which will be available in late 2020/early 2021.
NL	Currently completing flood hazard mapping for two additional areas, which should be completed and authorized in late 2020/early 2021.
NU	Currently no territorially authorized flood data available, and no current plans for future mapping.
NS	Three flood hazard mapping projects are currently underway. Due to the decentralized approach to flood mapping, it is not clear if there are any further studies in progress. Within the timeline of this project, flood data could be obtained from 7 out of 11 local governments for which it was known that flood mapping had been completed.
NWT	Pilot projects are being put together to help test federal guidelines adjustment to a northern environment.
ON	Due to the decentralized approach to flood mapping, it is not known if there are any projects currently in progress. Within the timeline of this project, flood data could be obtained from 18 out of 36 conservation authorities (however, not all of these conservation authorities may have flood hazard maps). No data were available for municipalities outside of conservation areas.
PEI	Coastal flood hazard mapping of the entire coastline is in final stages, and partial data have been shared within the timeline of this project. The final dataset should become available by the end of 2020/early 2021.
QC	Updated data for metropolitan community of Montréal due by the end of the 2020/early 2021, and further studies (including the metropolitan community of Québec) due later.
SK	Province-wide flood data update over 2020 and being authorized in 2021.
YT	Currently producing flood maps, which are due in 2021.

The production of modern flood maps remains a relatively new sector in many P/Ts, and there remains a large number of areas still to be mapped. Table 15 provides a summary of the current state of flood hazard data development in Canada for each P/T.

**Table 15: Current state of flood hazard data development in each P/T.**

P/T	Current State of Flood Hazard Data Development
AB	Flood mapping is well developed in Alberta and they have made major progress in the last 5 years, including the replacement of 50% of the older (Flood Damage Reduction Program, FDRP) flood maps, mapping an additional 900 km of frontage, and creating the central flood data portal, FAMA (Flood Awareness Mapping Application). Alberta has a long-term plan for flood mapping and intends to map an additional 600 km of frontage over the coming year (2021). Climate change is not explicitly included in flood map data, but Alberta maps 13 different Annual Exceedance Probabilities (AEPs), up to 0.1% AEP. Alberta has established workflows to manage flood mapping data and ensure its currency.
BC	Flood mapping is relatively well developed in British Columbia, and many flood hazard maps exist. The vast majority of these have been made in the last 5 years, mostly under the National Disaster Mitigation Program (NDMP) and provincial cost-sharing programs. The lack of a centralized authority for flood hazard mapping means that it is difficult to estimate how much of BC remains to be mapped, but there are likely many areas that have no flood maps, or only outdated FDRP flood maps. Flood mapping conducted under provincial/federal funding programs is submitted to the provincial government for approval to adherence to grant requirements etc., but no technical approval according to standards is conducted. BC has well-established guidelines, which are, however, not very prescriptive and have led to variation in mapping products and mapping quality. Incorporation of climate change varies from study to study.
MB	Flood mapping in Manitoba is a developing sector with all modern flood maps having been produced over the last few years. Manitoba has a plan for areas that they would like to map in the current (2020) and next fiscal years. However, the need for additional mapping on top of this is likely to be substantial. Manitoba Infrastructure suggested that much of the province is likely to be exposed to flooding to some degree, and only 9 areas are included in recent maps. Climate change is not explicitly covered in new maps, although they have increased the regulatory AEP from 1% to 0.5%.
NB	By the end of 2020/early 2021, New Brunswick plans to completely replace its flood maps, which were all produced during the FDRP and are not considered authoritative by the provincial government. These maps will include all areas considered under the FDRP, as well as some additional inland maps, and they will produce a new set of coastal flood maps, which did not previously exist. Climate change is considered for both new riverine and coastal flood maps. Once the flood-map update is complete, there is no specific plan for further flood mapping. However, flood maps may require updating every 5–10 years going forward, which would be in part dependent on climate change projections.
NL	Flood mapping is well established in Newfoundland and Labrador. The provincial government is relatively technically advanced in the map products that it creates, and its approach to climate change. However, many of the flood maps being used still date back the FDRP-era. There is an ongoing plan for new flood maps to be produced, and maps are updated and produced whenever resources allow.
NU	There are no flood maps currently in Nunavut, and no plans to develop any soon.
NS	Nova Scotia is currently producing a Provincial Specification to be used for future maps and to bring them to modern standards. There is also a desire to take more ownership in the production and management of flood maps at a provincial level. While there is currently no centralized register

P/T	Current State of Flood Hazard Data Development
	of flood mapping, it is thought that coverage is likely to be patchy and that much more mapping is required. If funding can be found, Nova Scotia thinks that they can do this over the next 5 years.
NWT	The Northwest Territories currently relies on FDRP-era maps. There is a desire in the territory to update these maps in the near future. However, there are several obstacles in the way of updating the flood maps, and no formal plan to do so. Future flood map updates are also dependent on the ongoing work with NRCan to review flood hazard guidance for a northern environment.
ON	As there is no central authority or up-to-date register of flood hazard data in Ontario, it is difficult to estimate how much flood mapping remains to be done. A Metadata Inventory completed by the Ganaraska Region Conservation Authority, Otonabee Conservation Authority, and Conservation Ontario indicated that, on average, flood maps were over 24 years old in 2015. The inventory also indicated that most conservation authorities believed that there were more areas without any flood maps that will need to be mapped. Most flood maps focus on the design storm for the area or the 1% AEP. Climate change is rarely included.
PEI	Prince Edward Island plans to completely replace their currently available coastal flood maps with maps done to modern technical standards by the end of 2020/early 2021. Climate change is considered in the coastal flood map updates. Once these flood maps are complete, no additional flood maps are expected until these new maps are considered out of date, likely after 5–10 years.
QC	Flood mapping in Québec has been harmonized within a central provincial database, which is publicly available. Québec is also currently developing a system called INFO-Crue (flood-info), which will provide real-time updates and flood early-warning systems to Québec.
SK	Saskatchewan is currently conducting a large-scale update of their flood maps. This update is the first that has been conducted since the FDRP maps were completed, and it represents approximately 50% of the areas that require flood maps in the province. It should be noted that while these maps represent a major update to the FDRP maps, they do not account for climate change.
YT	Yukon currently does not have any authoritative flood maps, but is producing flood maps, which are due in 2021. New maps are based on frequency analysis and not on hydraulic modelling, and do not include climate change (but climate change is expected to be included in new versions of these maps over the next 3-5 years). The current maps are being done primarily for emergency management purposes, rather than regulation and policy. Once these maps are finalized, there are many more areas that need to be mapped.

#### 4.1.2 Flood Map Methodologies and Products

The methodologies used to create flood mapping vary widely across Canada. An understanding of the methodology and the products is critical in understanding flood hazard data on a national scale. It ensures that like is compared to like, and indicates the relative quality of the mapping and therefore, the likely accuracy of outputs.

A summary of the flood scenarios considered in each P/T is provided in Table 16.

Table 16: Summary of flood scenarios considered in each province or territory.

P/T	Flood Hazards	AEPs	Regulatory Flood AEP	Regulated Zones	Climate Change	Freeboard
AB	Riverine, ice-jam, lake	Riverine - 50%, 20%, 10%, 5%, 2.86%, 2%, 1.33%, 1%, 0.5%, 0.286%, 0.2%, 0.133%, and 0.1%  Ice-jam - 2%, 1% and 0.5%	1%	Floodway (deepest fastest section of 1% AEP); flood fringe (remaining 1% AEP extent)	Not included in data, but included in reporting (plus AEPs up to 0.1% are modelled)	Not included in mapping, but applied at discretion of municipalities in regulation
BC	Coastal, lake, riverine, tsunami, ice-jam	Varies widely	Typically 0.5%, sometimes 0.2% or flood of record	Not applied	Varies	0.6 m freeboard typically included in flood construction level maps for regulation
MB	Riverine, ice-jam	0.5% (more AEPs are sometimes mapped, but not processed by Manitoba)	0.5%	Not applied	Not included	Not included in mapping
NB	Coastal, riverine, ice-jam	5% and 1%	5% and 1% (once approved)	Floodway and flood fringe in some older maps	Included in new mapping	Not included in mapping
NL	Coastal, lake, riverine, ice-jam	5% and 1% AEP (current climate) and 5% and 1% AEP for climate change.	5% and 1% AEP current climate and 1% AEP climate change	Floodway (5% AEP), flood fringe (1% AEP)	Included	0.6 m freeboard included in regulation, but not in mapping
NU	Coastal, pluvial, tsunami, riverine, sea ice ride-up and pile-up (not authoritative territorial maps)	N/A	N/A	N/A	N/A	N/A
NS	Coastal, riverine and ice-jam	5% and 1%	5% and 1%	Floodway (5% AEP), flood fringe (1% AEP)	Varies	Not included in mapping
NT	Coastal, riverine, and ice-jam	1% (where available), or historic flood event extent	1% (where available), or historic flood event extent	Floodway (Historic flood event extent, or 1% AEP (where available)); Flood fringe (varies, but for some, 1 m is added to floodway)	Not included	Varies, for some communities, 1 m freeboard is added.
ON	Lake, riverine, ice-jam	1%, or Regional Design Storm: Hurricane Hazel or Timmins Storm	1%, or Regional Design Storm: Hurricane Hazel or Timmins Storm	Not applied	Not included in most cases	Not applied
PEI	Coastal	100%, 10%, 1%, and 0.1% (for new maps)	Unknown	Unknown	Included in new maps	Unknown

P/T	Flood Hazards	AEPs	Regulatory Flood AEP	Regulated Zones	Climate Change	Freeboard
QC	Lake and riverine	50%, 5%, and 1%	5% and 1%	Floodway (5% AEP), flood fringe (1% AEP)	Not included (0.29% AEP will be added in future to account in parts for climate change)	Not included in mapping, but applied when considering engineering designs.
SK	Lake, riverine, ice-jam	10%, 5%, 2%, 1%, and 0.2% (in new maps)	0.2%	Floodway (deepest fastest section of 0.2% AEP); flood fringe (remaining 0.2% AEP flood extent)	Not included	Not included in mapping, but 0.5 m freeboard applied in regulation
YT	Lake, riverine, ice-jam	50%, 5%, and 1% (not confirmed – mapping in progress)	No regulatory flood currently	Not applied	Not included	Not included

While most modern maps are developed using standard engineering processes, there are substantial differences in the way flood hazard data are modelled and mapped across Canada. This includes the types of assessed hazards, the number of different likelihoods, and the methodologies.

While this section focuses on differences between different provinces or territories, it should also be noted that in some cases, data can vary substantially within a single province or territory. This is particularly the case where the authority for producing flood hazard data is not centralized.

Some P/Ts produce unique datasets, such as Newfoundland’s combined depth and velocity maps. These maps give an understanding of the level of impact this scenario could have, for example, on risk to life. This approach could also be used by other P/Ts.

The approach taken to climate change is also very diverse. In some areas, climate change is not included in mapped data. In others, it is only included for specific flood hazards. It was noted that the effect of climate change on ice-jam flooding is particularly complicated and little understood. Where climate change is applied, different P/Ts use different approaches (such as the inclusion of increased storminess). They also use different planning periods, although most include projections for the year 2100.

This variability in flood hazard data presents a challenge when comparing flood hazard data across the country. An understanding of the relative quality of flood hazard data and the applied methodologies is essential when reviewing flood hazard data on a national scale. For example, if that data are used in a gap analysis (for instance to determine flood map coverage and identify areas with no maps), the quality, age, and types of hazard are important, in addition to the pure existence of the map. Similarly, if data are being used for emergency management, the availability of different types and magnitudes of flood hazard data is important to understand the magnitude of an emergency and potential impacts. The quality of data is also critical in this instance as this reflects how accurate data are likely to be, and therefore how the data might compare with real-world floods. One issue raised during the interviews with regards to the

variability of the data is the lack of a consistent approach in mapping to support both flood insurance and government regulation.

There are substantial opportunities for greater lesson sharing and cross-border cooperation in Canada due to this variation in flood hazard data production, management, and availability.

#### 4.1.3 Management of Flood Hazard Data

There is a general shift in Canada toward open data. Many P/Ts are either looking to make data publicly available, or already do so currently. Table 17 provides a summary of the openness of data in each P/T.

Table 17: Summary of open data for each P/T.

Category	P/T	Open Data Summary
Data are currently publicly available	Alberta	Alberta has done a lot of work over the last few years to bring data together centrally and host it in its FAMA system. Data are available to view publicly. <a href="#">Link</a>
	New Brunswick	Spatial data are available to view online on New Brunswick's Flood Information Viewer ( <a href="#">Link</a> ), and can be downloaded as map along with the report ( <a href="#">Link</a> ) and spatial data ( <a href="#">Link</a> ).
	Newfoundland and Labrador	Reports and data are available to download through their website ( <a href="#">Link</a> ), and viewable through their Flood Risk Mapping Application ( <a href="#">Link</a> ).
	Northwest Territories	Spatial data are available to view and download via Northwest Territories' ATLAS system. <a href="#">Link</a>
	Québec	Spatial data can be downloaded via Québec's open data portal. <a href="#">Link</a>
There is a plan to make data publicly available	Manitoba	Manitoba is in the final stages of gaining approval to make data publicly available.
	Nova Scotia	There is a desire in Nova Scotia to make data publicly available and discussions are ongoing. This is not likely to happen for a few years.
	Prince Edward Island	Prince Edward Island plans to make data publicly available but is currently unsure as to how this will be done.
	Saskatchewan	Data are currently not public, but there is a desire to host new flood mapping data on Saskatchewan's web GIS application.
Public data availability varies depending on local jurisdiction	British Columbia	There is a desire to make data publicly available in BC, but it is unlikely to happen for a while. Data are highly varied and owned by local authorities; some data are made publicly available by these authorities.
	Ontario	Data are highly varied and typically owned by local conservation authorities; some data are made publicly available by these authorities. Conservation Ontario is also developing a metadata application for flood maps together with the federal government, but this will likely not be made public.
Other	Nunavut	Nunavut does not house flood hazard data.
	Yukon	Flood maps are currently in development, no authorized historical flood data exists.

There is also a general shift toward housing data centrally and managing flood mapping centrally (Table 18).

Table 18: Summary of organizational structures and data management.

Category	P/T	Summary
Flood mapping is led centrally, and data are housed centrally	<b>Alberta</b>	Data are housed and reviewed centrally by Alberta. Flood mapping is conducted by consultants but reviewed and authorized by the provincial government.
	<b>Manitoba</b>	Flood mapping is led by the provincial government (Manitoba Infrastructure), and they take an involved role in producing flood maps (e.g., creating depth maps from raw flood-level data obtained from consultants). Data are housed centrally.
	<b>New Brunswick</b>	New Brunswick is currently leading a large flood mapping program, which will replace all existing maps and map new areas in the province. Data are housed centrally.
	<b>Newfoundland and Labrador</b>	Flood mapping is led by the provincial government, with work conducted by consultants and reviewed and authorized by the provincial government. Data are housed centrally.
	<b>Prince Edward Island</b>	Responsibility for flood mapping and data is with provincial government, who is leading a new flood mapping program (for which, flood mapping is conducted by a consultant, but authorized by the provincial government).
	<b>Québec</b>	In the recent past, responsibility for flood mapping was with local governments, but it is now shifting to the provincial government. Data are held centrally.
	<b>Yukon</b>	Flood maps are currently being developed, which is led by the territorial government. No authorized historical flood maps exist.
Flood mapping and data ownership mostly centralized, but some local flood mapping exists	<b>Northwest Territories</b>	Historic flood mapping is housed centrally. Some local communities have also conducted flood studies, which are owned by the community.
	<b>Saskatchewan</b>	Responsibility for flood data is with Saskatchewan. They are mostly creating new flood maps and managing existing data, but some municipalities have also produced flood maps, which need to be authorized by the provincial government.
Flood mapping and data ownership are decentralized	<b>British Columbia</b>	In BC, flood mapping is conducted by local and regional jurisdictions, and data are held at that level. The provincial government is currently gathering data from provincially and federally funded projects, but that will likely not consist of all available flood maps. BC reviews the collected data for adherence to grant requirements etc., but the provincial government cannot authorize flood maps.
	<b>Nova Scotia</b>	Responsibility for flood mapping is with local governments, and data are held at a local level. Currently, no central register of flood maps exists. There is a desire in Nova Scotia to change that and to produce and store data more centrally.
	<b>Ontario</b>	Responsibility for flood mapping in Ontario is shared among the provincial government, municipalities, and conservation authorities (where they exist). Municipalities often rely on conservation authorities to undertake flood mapping and therefore flood mapping in Ontario is largely undertaken by conservation authorities. There is no central register of available flood maps (though a metadata tool is in development), and data ownership sits with the conservation authorities and municipalities.

Category	P/T	Summary
Other	Nunavut	Nunavut does not have any territorially authorized flood maps. Some flood hazard assessments exist from academic studies.

#### 4.1.4 Approaches to Regulation

How flood hazard data are put into regulation varies between P/Ts. Some P/Ts have extensive and well-defined provincial/territorial regulation. For instance, in Newfoundland and Labrador, once a flood hazard area has been mapped, development is prohibited in the area unless a permit is obtained from the provincial government, in which a 0.6 m freeboard is added. In British Columbia, provincial and professional guidelines describe how extents and flood construction levels should be mapped and used for land-use planning and for flood protection infrastructure design. In contrast, other P/Ts have little provincial/territorial regulation with regards to flood hazards, or freeboard is applied at time of planning applications and not as part of the mapping process.

A particular area of difference between P/Ts is the flood hazard likelihood used in regulation, and whether and how climate change is included. The AEP used for regulation ranges from the single regulatory 0.2% AEP flood used in Saskatchewan to the 5% AEP floodway and 1% AEP flood fringe approach used in Nova Scotia (see also Table 16 for details on regulated AEPs in each P/T). There are also P/Ts, such as the Northwest Territories and Ontario, that use historic flood events to define regulatory flood extents, and Yukon does not currently have a regulatory flood as flood maps are in development. Regulation, if applicable, is dominantly based on the FDRP maps and methods, which were produced over 40 years ago. While the effect of climate change is assessed in many P/Ts, it is rarely included in regulation or in spatial data files.

Freeboard is included in very few of the flood data outputs that were collected. Some P/Ts indicated that freeboard is added by planners at local authorities, which was sometimes backed up by guidance from the P/T. This however creates a disconnect from those creating data and those using data for regulatory purposes.

#### 4.1.5 National Challenges and Opportunities in Flood Hazard Mapping

##### 4.1.5.1 Technical Challenges and Opportunities

There are several technical challenges that were raised through the engagement phase, in particular with regards to climate change and ice-jam flooding. There are substantial opportunities for cross-P/T learning on these issues to produce better quality and more consistent flood hazard data.

The impact of climate change on flood hazards in Canada is complex and highly varied across the country. Many P/Ts are currently not including climate change in their flood hazard assessments, or only including it for certain hazards (see also Table 16). Others have applied climate change in a simplified manner; for example, by analyzing higher-likelihood scenarios or by adding a simple percentage increase to hydrological flows.

Ice-jam flooding affects many P/Ts in Canada but is still relatively poorly understood. In P/Ts where ice jams are considered a potential source of flood hazard, they are still often not assessed to the same degree as other flood hazard mechanisms. In some areas, historic outlines of ice-jam floods are used. In some other areas, AEP scenarios are used, but fewer likelihoods are considered, and they are only included in the most recent mapping. One particular area of high uncertainty is the effect of climate change on ice-jam flooding (as mentioned above). Most P/Ts are only just starting to consider what the impact of this might be.

The Northwest Territories and Yukon are struggling to update maps based on the methodologies currently used elsewhere, due to the additional complexity of hazards in these northern areas and the lack of resources and ownership. Nunavut does not currently have any plans to produce flood maps and are represented by CIRNAC in the National Hydrometric Program, as this responsibility has not yet been devolved.

There is a wealth of knowledge across the country, and many P/Ts excel at different aspects of flood hazard mapping. Flood hazard is a relatively new subject in many P/Ts with most development occurring over the last few years. This means that there are substantial opportunities for cross-provincial/territorial learning. A few examples are listed below.

- **Ice-Jam Flooding** – Several P/Ts stated that they had difficulties in assessing ice-jam flooding. However, the most recent flood maps in Alberta, for example, consider ice-jam hazard at multiple likelihoods. The impact of climate change on ice-jam flooding is also a developing field and is currently being researched in Newfoundland and Labrador.
- **Coastal Flooding** – Prince Edward Island stated that they would be interested in learning from other coastal P/Ts with regards to coastal hazard mapping, as this is considered less understood than riverine flooding. Prince Edward Island was also concerned about the combined hazards of flooding and coastal erosion, and combined coastal and pluvial hazards.
- **Climate Change** – Climate change is applied differently across the country and in some cases is not included in spatial flood hazard data at all. Some P/Ts, such as Newfoundland and Labrador, have invested substantially in understanding the impacts of climate change on their P/T across multiple relevant hazards.
- **Flood Hazard in a Northern Environment** – The Northwest Territories described the difficulties of flood hazard mapping in a northern environment, including the complexity of the hazards and the limited resources for flood hazard assessment. They are currently working with NRCan to review guidelines for a northern environment. They were keen to share the outcomes from this review, as well as to learn methodologies from other northern P/Ts.
- **Flood Hazard Data Management** – A large number of P/Ts are currently updating or creating systems to store flood hazard data in a central location (see Table 17). Alberta has recently completed a similar program with their FAMA database. In addition to the technical data management side, greater cross-provincial/territorial learning could generally improve and help standardize flood hazard data across the country.

#### **4.1.5.2 Funding and Resourcing**

Several P/Ts mentioned that funding and resources were a severe limitation to their ability to produce additional flood mapping. Many of these P/Ts have extensive lists of flood maps that they would like to develop but stated that these were dependent on the availability of funding. In P/Ts where flood hazard mapping is not centrally managed, such as British Columbia and Ontario, the system favours local authorities with more resources and capacities. These are not necessarily communities with higher risk.

The NDMP appears to have been highly effective in driving flood mapping in Canada, as discussed in Table 13, and there has been a substantial increase in the number of flood maps produced under this program. In addition, P/Ts have made substantial advances in updating processes and systems that support the development of these maps. However, all P/Ts also indicated that a substantial number of areas still remain to be mapped, or currently only have outdated flood maps from the FDRP program available. Thus, continued and consistent funding of flood mapping is essential for ensuring adequate coverage of flood maps across the country.

#### **4.1.5.3 Guidelines**

Many P/Ts do not have a specific flood hazard mapping standard or guideline and are relying on or trying to adapt to federal guidelines. These guidelines are not very prescriptive, and do not fully capture the variability of flood hazard across the country. This also means that different P/Ts are forced to solve similar problems independently of one another. Other P/Ts, such as BC, have guidelines that are also not very prescriptive. This results in a high variability in the type and quality of collected data. NRCan is currently working on a project in collaboration with the Northwest Territories to look at how the guidelines could better be applied to a northern environment. While some of the knowledge is transferred between P/Ts by the consultants working on these projects, there are many opportunities for more cross-provincial/territorial learning. Some P/Ts specifically stated that additional and more prescriptive federal guidelines would be welcomed.

## **4.2 Key Themes for the NFDHL**

Key themes related to the creation and maintenance of the NFHDL are presented in this section. These include:

1. Maintaining an Up-To-Date Authoritative Dataset
2. Challenges Related to Flood Mapping Methodologies
3. Opportunities for Data and Lesson Sharing
4. Linking the NFHDL and Other Programs/Initiatives

### **4.2.1 Maintaining an Up-To-Date Authoritative Dataset**

There are several issues related to maintaining an authoritative dataset in Canada.

#### **Designated Flood Authority**

The way flood hazard is managed, and the ownership of flood hazard mapping and flood management, varies across the country. This creates challenges when viewing this data at a national scale. Where data

are not managed centrally, there is generally much greater variance in the data produced within the P/T, both in terms of the methodologies and the types of maps produced. This creates a particular challenge when trying to unify data and ensure that like is compared to like. In addition, data collection becomes difficult as there may not be a central source or register of what maps exist. This will make it very difficult to source maps in the future, as there is no central contact.

A further issue raised through the interviews was the lack of a central approving source in decentralized P/Ts. The lack of central authority means that there is no party checking whether a flood map is authoritative, ensuring sufficient quality, and defining a single authoritative source for a specific area. This could result in conflicting or low-quality mapping.

This lack of ownership at a central level also creates difficulties in progressing new flood initiatives, particularly in areas where resources are limited.

It should be noted that there are benefits of a devolved flood authority. For example, it promotes local ownership and helps ensure that the data are fit for use at a local level, where planning decisions are made.

#### **Unification of Data**

Unification of data from decentralized P/Ts for continued additions to the NFHDL will be challenging due to the diversity in methods and products.

#### **Data Ownership**

There has been a concern raised by multiple consultees around data ownership. It should be clear within the NFHDL that the data are owned by the jurisdiction (provincial, territorial, or local government), and that they remain the definitive source for that data. This is particularly true if the data are shared to a wider audience than NRCan.

For decentralized flood mapping (in particular for conservation authorities in Ontario), a major hurdle for data collection is also the execution of data sharing agreements with each conservation authority, which can differ widely and would need renewal every time the data are updated.

#### **Data Collection Through Funding Programs**

There is a requirement for flood hazard data produced under NDMP to be provided to Public Safety Canada. However, this was not prescriptive and thus has not been fully implemented by most jurisdictions. A more directive system could be used for future federal funding programs to maintain the NFHDL. A specification could be made to ensure data are provided in the right format for the NFHDL, and to ensure that data are provided in a timely manner. It was suggested, for instance, by British Columbia that they could use a similar approach with provincial funding programs.

New federal funding programs should be more directive with regards to providing data back to the federal government.

#### 4.2.2 Flood Mapping Methodologies

As stated previously, there are a wide range of methodologies used to create flood maps, scenarios considered, and data and maps produced. This creates major challenges when deciding what data to include, ensuring that all the data can be captured in the NFHDL, and ensuring that data are compared like-for-like.

In addition to the different methodologies, there is also a wide range of terminology used across the country. Inconsistent terminology creates a challenge when viewing flood hazard data at a national scale, as it makes it more difficult to compare like-for-like. The main areas of difference were:

- **The terms floodway and flood fringe.** Floodway and flood fringe represent different hazard levels within the flood hazard area (the floodway presents the areas of greatest hazard). The definition of these terms differs nationally. In some cases, these areas represent different flood likelihoods, (e.g., the 1% and 5% AEP). In other cases, they are based on a single likelihood scenario, but represent areas of different depth or velocity. Flood fringe is also sometimes used to describe the area of floodplain behind a flood protection structure.
- **The names used for different types of flood map.** *Flood Hazard Map, Flood Inundation Map, Flood Risk Map, Flood Regulation Map, and Flood Probability Map* are all terms used for different types of map, but the definitions of these terms vary widely between P/Ts.

#### 4.2.3 Data and Lesson Sharing

Flood hazard data management is a relatively new and rapidly developing sector in Canada. There are many projects happening in parallel with the NFHDL, and many opportunities exist to drive efficiency through national policy and lesson sharing between P/Ts.

Many P/Ts are creating, or are looking to create, centralized systems to hold and manage flood hazard data. There is an opportunity to shape how this is done as part of the NFHDL and for lesson sharing between P/Ts; for example, with respect to developing metadata standards, developing a common schema, harmonizing data, sharing lessons on data entry and management systems, and data use.

#### 4.2.4 Linking the NFHDL and Other Programs/Initiatives

It was also mentioned in the engagement phase that there are multiple national programs and groups looking to do similar things to the NFHDL project, and the NFHDL project should link into these programs to ensure work is efficient and not repeated.

- There are currently discussions with the National Research Council on the development of Mapping Standards. These could help to unify data for the NFHDL. This could also be used as an opportunity to resolve some of the issues being faced by the P/Ts.
- During the interviews, people asked whether the project had any links with the Senior Officials Responsible for Emergency Management (SOREM) or Insurance Bureau of Canada. There is an opportunity to review whether data could be shared more widely to others involved in flood hazard management in Canada to increase national resilience.

- Prince Edward Island advised that they had been approached by Environment and Climate Change Canada to host data on ClimateData.ca. Data sharing with this program could help improve resilience to climate change.
- It was mentioned in the interview with BC, that there is a cross-provincial working group working to standardize different datasets across the country (may no longer be active). It was not thought that flood data were part of this list, but collaboration between programs could help with the development of a new national data standard.
- Data are currently being collected from the P/Ts for the National Forestry Database. Lessons could be learned from this program with regards to maintaining a federal dataset based on data from P/Ts.
- There is also an ongoing NRCan-led project on Indigenous flood hazard mapping.

## 5 Recommendations

Based on the stakeholder engagement, data collection, and the analysis in this report, several recommendations have emerged. These are directed both with respect to federal support for flood hazard mapping and data management in the P/Ts, as well as some more specific recommendations on future steps with the NFHDL.

### 5.1 Federal Support for Flood Hazard Mapping in P/Ts

Several key themes have emerged with respect to federal support for flood hazard mapping:

#### A. Flood Mapping Program

##### 1. Provide Continued and Sustained Funding

- While P/Ts have made substantial improvement in developing processes and systems, and creating new flood hazard maps, there are still many communities relying on outdated mapping from the FDRP era or that have no flood maps available at all. Continued ongoing federal financial support is crucial to continue the momentum in flood hazard mapping and management across Canada.

##### 2. Ensure Accessibility of Flood Hazard Data

- To ensure continued accessibility of generated flood hazard data for both federal programs, as well as P/T governments, and ideally, the general public, it is essential that flood hazard data generated for a local or provincial/territorial jurisdiction is shared back to NRCan. The NDMP program had language to encourage this, but it was not prescriptive enough (some P/Ts are currently putting together NDMP data packages, however, data will not become available from all P/Ts nor all studies). Therefore, it is recommended that any new funding programs require data and reports to be shared back to the provincial/territorial, and ultimately, the federal governments, to receive full funding allocations.
- Further, data specifications and other requirements (such as adequate metadata) should be defined for the purposes of providing consistent data.
- As federal funding programs are funded by public dollars, there could also be a consideration to require authorities to publish flood hazard mapping results online to the general public as part of the funding requirements (see also Section 5.2 for discussion of open data).

#### B. Federal Guidance

##### 1. Increase Federal Flood Mapping Guidance

- Many P/Ts do not currently have a guidance document and are reliant on the Federal Flood Mapping Guidelines Series.
- It was mentioned in the interviews that updated and more specific federal guidelines would be welcomed in many areas. However, these also should not outweigh guidelines developed by individual P/Ts.
- Given the reliance and use of many P/Ts on the federal flood mapping guidance, it is recommended that guidance be up-to-date, and reflect quality standards in a rapidly developing field.

##### 2. Use the NFHDL to Encourage Adoption of Metadata Standards

- It was also suggested that the NFHDL project could serve as the basis for the adoption of consistent metadata standards throughout Canada, potentially supported by developing it

into a federal flood hazard metadata guideline or recognizing it as such. It was mentioned by several P/Ts that they would be happy to adopt this.

### **3. Develop Guidelines for a Northern Environment**

- Northern regions indicated the challenges of flood hazard mapping in a northern environment, where different drivers of flood hazards are more important than in southern parts of Canada. The importance of adapting the federal guidelines to a northern environment was highlighted, and northern regions (Yukon, Northwest Territories, and Nunavut) should be further supported with technical capacity for flood mapping.

### **4. Support the Development of New Technical Approaches**

- Many P/Ts stated that they are limited by technical approaches, in particular with respect to complex hazards (e.g., ice jams, climate change, coastal erosion, combined coastal and pluvial flooding). Additional support from federal initiatives in developing adequate methods to address these complexities could better encourage P/Ts to include them in their flood mapping.

### **5. Strongly Encourage Consideration of Climate Change**

- Many P/Ts currently do not include, or do not require the inclusion of, climate change in their flood hazard mapping. In a rapidly changing world, where climate impacts will likely continue to increase, and where flood hazard mapping should allow jurisdictions to prepare for the future, the inclusion of climate change projections in flood hazard mapping is essential. It is therefore recommended that funding agencies require new flood hazard map producers to consider climate change.
- It is further recommended to continue to develop technical methods and guidance documents on how to best include climate change for different types of flood hazards (riverine, coastal, ice-jam, lake, and combinations thereof).

## **C. Federal Support for Diversity of Flood Management Archetypes**

### **1. P/Ts with Limited Flood Mapping and Resources**

- Particular technical and financial support, as well as capacity-building activities are recommended for the northern territories (Nunavut, Yukon, Northwest Territories), who currently have limited flood hazard mapping, due to the complexity of flood hazards in the North, limited technical capacity, and financial resource limitations.
- It is further recommended to support responsibility allocation for flood hazard mapping in these territories, as responsibility allocation for flood hazard mapping is unclear, or it has so far not been a priority for the territorial governments (or responsibility for water resources has not been devolved yet from the federal government to the territorial government, as is the case for Nunavut).

### **2. Decentralized P/Ts**

- It is also recommended that the federal government support decentralized provinces (such as British Columbia, Nova Scotia, and Ontario) in creating more centralized technical review or authorization procedures or flood map inventories, if that is of interest for the provincial government (one of these provinces is already considering this). This support can be in the form of providing guidance and enabling knowledge exchange with other P/Ts, who already may be doing some of that, as well as encouraging ongoing flood mapping by providing funding and technical guidance.

### 3. Centralized P/Ts

- The federal government can ensure ongoing flood mapping by providing adequate and sustained funding and technical guidance for the more centralized provinces (such as Alberta, Newfoundland and Labrador, Prince Edward Island, and Québec) and provinces, such as Saskatchewan and New Brunswick, who are currently undergoing large flood mapping programs led at the provincial level.

## D. Support Continued Collaboration and Cross-Provincial/Territorial Learning

### 1. Encourage Collaboration and Learning

- There is currently a lot of change ongoing in Canada with regards to flood mapping with P/Ts developing new flood hazard mapping standards, creating new mapping for the first time since the 1990s over the last years, and developing centralized data management systems. These changes provide an opportunity for the federal government to keep in contact with P/Ts, as they develop new systems, as there are a lot of opportunities for influencing aspects like metadata standards, ensuring data compatibility, and allowing cross-provincial/territorial learning.
- The federal government can also encourage knowledge sharing and exchanges between P/Ts, by providing space for these discussions to occur, for instance, via workshops or technical committees. This can also encourage capacity building in P/Ts with less-developed flood mapping programs.

## 5.2 Recommendations for the NFHDL

The following section provides some initial, high-level recommendations for the NFHDL—it should be noted that more specific recommendations on future use and maintenance of the NFHDL will be included in the main report of the NFHDL project. The following section solely highlights a few of the key themes that emerged through the engagement activities.

### 1. Making the NFHDL Public

- Although many P/Ts have stated that they would be happy for flood data to be made public, an additional consultation is suggested if NRCan chooses to pursue such an initiative in the future. It should be noted that while some P/Ts had reservations about this, most P/Ts said they would want data to be made public and many of them are also moving toward making their data publicly available. Several would also adopt the NFHDL if it removed the need for them to develop and maintain their own public data-sharing system. However, consultation and engagement with the P/Ts, and a detailed publication strategy, will be needed to address all potential concerns of P/Ts (e.g., ensuring that data ownership and authority stay with the P/Ts).
- Overall, the recommendation is for NRCan to consider the possibility of making the NFHDL public in the future. It provides important information for the public (also given that most flood mapping is funded by public agencies), and it may encourage future flood hazard and data management projects and support innovation. Lastly, there is a strong movement overall in Canada and worldwide for open, accessible and interoperable data; this sentiment is aligned with the responses provided by the Canadian P/Ts.

### 2. Ensure Data Quality for Future Additions to NFHDL

- It will be important to continually ensure quality and actuality of the NFHDL, including addition of metadata for future projects.

## 6 Conclusion

This report emerged from the engagement and data collection phases of the National Flood Hazard Data Layer project. It provides a baseline summary of how the diverse P/Ts have approached and hope to approach flood hazard mapping and management. Furthermore, the report provides directions for the federal government on how to assist the various P/Ts in their flood mapping and management efforts. It is hoped that this will support the federal government in the development of a consistent and comprehensive picture of flood hazard across Canada.

## 7 Glossary

Term	Definition
<b>Annual Exceedance Probability (AEP)</b>	Annual exceedance probability (AEP) is the likelihood of a flood of a specific magnitude occurring or being exceeded in any given year, expressed as a percentage.
<b>Authoritative Flood Map</b>	Authoritative Flood Map to be included in NFHDL must: <ol style="list-style-type: none"> <li>1. be a “Flood Map”, as defined below, provide the best available and most recent source for the jurisdiction AND</li> <li>2. be provided by the authoritative body in which the flood map has been produced OR</li> <li>3. be produced using standard hydrologic and hydraulic modeling procedures, as outlined in the federal guidelines (NRCan, 2019)</li> </ol>
<b>Authority</b>	Jurisdictional agency vested with the power to define policy and regulations with respect to flood management issues.
<b>Catchment</b>	Also known as drainage area, drainage basin, or watershed. It is the area of land draining to a particular location and includes the upstream drainage area of the main waterway as well as any tributary streams. (NRCan, 2018)
<b>Climate Change</b>	Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use. (NRCan, 2018)
<b>Cross-section</b>	A survey string of channel and floodplain elevations that is taken perpendicular to the main flow direction in a river. (NRCan, 2018)
<b>Database</b>	A structured collection of data generally stored and accessed electronically from a computer system.
<b>Design Flood</b>	A specific flood magnitude that is used for a regulatory or design purpose. In Canada, the 1% AEP flood is generally used as the minimum design flood for delineating regulatory flood extents, and many jurisdictions use higher magnitude floods (e.g., 0.5% AEP flood) or design storms (NRCan, 2018). In some jurisdictions, an additional allowance for uncertainty (freeboard) is added to the design water levels.
<b>Design Storm</b>	A rainfall time-series input, based on a historic event or synthesized using intensity-duration-frequency curves, that is used to calculate flow and to delineate a flood hazard area. In Canada, design storms are often used instead of design floods in jurisdictions where a historic event was of higher magnitude than the design flood. (NRCan, 2018)
<b>Digital Elevation Model (DEM)</b>	A file with terrain elevations recorded for the intersection of a fine-grained grid and organized by quadrangle as the digital equivalent of the elevation data on a topographic base map. (NRCan, 2018)
<b>Digital Terrain Model (DTM)</b>	A land surface represented in digital form by an elevation grid or lists of three-dimensional coordinates.

Term	Definition
<b>Feature</b>	A feature is an object that is an abstraction of a real-world phenomenon. This object has a set of attributes associated with it, each having a name, a type, and a value. An example of a feature might be road with a name, location (line geometry), width, speed limit, and jurisdiction. Typically, these features are stored in a spatial database, shapefile, or other format. (Open Geospatial Consortium, 2020)
<b>Flood</b>	An overflowing of water beyond its normal confines over what is normally dry land.
<b>Flood – Coastal Storm</b>	Coastal flooding can be defined as flooding associated with a defined shoreline along an ocean or great/large lake. This can be due to a combination of high tides, storm surges, wind and wave effects, rising sea levels, and riverine flooding (NRCan, 2018).
<b>Flood – Groundwater Flooding</b>	The inundation by water of normally dry land caused by increased groundwater levels and the emergence of water from below ground at the surface.
<b>Flood – Ice-Jam Flooding</b>	The temporary inundation by water of normally dry land adjacent to a river and caused by stream blockages resulting from ice jams (ice-affected conditions). Flooding can occur at freeze-up, at break-up, or during a mid-winter thaw (NRCan, 2018).
<b>Flood – Lake Flooding</b>	Flooding associated with a defined shoreline along a lake. This can be due to a combination of high water levels, waves, wind, storm surges, and riverine flooding (NRCan, 2018).
<b>Flood - Pluvial</b>	The temporary inundation by water of normally dry land, usually caused by extreme rainfall events and not necessarily near to water bodies. Pluvial flooding is common in urban areas where water temporarily accumulates due to more rainfall entering an area than can be removed by infiltration into the ground (e.g., due to impervious surfaces where infiltration is limited) or discharge through infrastructure (NRCan, 2018).
<b>Flood – Riverine</b>	The temporary inundation by water of normally dry land adjacent to a river and caused by rainfall, snowmelt, stream blockages, failure of engineering works, or other factors (NRCan, 2018). Note that riverine flooding can also be referred to as fluvial flooding. For the purpose of this report, riverine flooding only considers open water conditions, and excludes flooding caused by ice jams.
<b>Flood – Tsunami</b>	Tsunamis are large waves or series of waves generated by the rapid displacement of large volumes of water due to seismic events, volcanic eruptions, landslides, glacier calving, meteorite impacts, and other disturbances.
<b>Flood Fringe</b>	The area outside of the floodway and within the delineated extent of the flood hazard area. Water in the flood fringe is generally shallower and flows more slowly than in the floodway. The technical criteria to define the flood fringe varies by jurisdiction, and is often defined as having a flood depth below 1 metre and a velocity less than 1 metre per second (NRCan, 2018).
<b>Flood Hazard Area</b>	Represents the areal extent of water for the design flood, which is the specific flood scenario defined by authoritative sources that guides regulation and design. Freeboard may be added to the modelled or measured inundation extent, to account for uncertainties in the analysis. In some cases, the flood hazard area can be further distinguished into floodway and flood fringe features.
<b>Flood Map</b>	The delineation of flood extents and elevations on a base map. This typically takes the form of flood lines on a map that show the area that will be covered by water, or the

Term	Definition
	elevation that water would reach during a specified flood event. The data shown on the maps, for more complex scenarios, may also include flow velocities or depth (NRCan, 2018).
<b>Floodplain</b>	A low-lying, relatively flat area of land adjacent to a river or stream that is subject to flooding. Floodplains are generally made up of alluvium (sand, silt, and clay) deposited by past flood events. (NRCan, 2018)
<b>Flood Protection</b>	Any combination of structural and non-structural additions, changes, or adjustments to structures, which reduce or eliminate risk of flood damage to real estate or improved real property, water and sanitation facilities, or structures with their contents. (NRCan, 2018)
<b>Flood Scenario</b>	The set of assumptions that define a single case assessed in a flood study. These assumptions can include, but are not limited to, flood mechanism, AEP, climate change scenario, etc.
<b>Flood Study</b>	A technical assessment of the level of flood hazard for a geographic area.
<b>Floodway</b>	The portion of the flood hazard area where flows are deepest, fastest, and most destructive. The technical criteria to define the floodway varies by jurisdiction, and is often defined as having a flood depth greater 1 metre and a velocity greater than 1 metre per second (NRCan, 2018). The floodway typically includes the main channel of a watercourse and a portion of the adjacent overbank area.
<b>Freeboard</b>	A vertical height of water added to calculated flood elevations to provide additional protection from flooding, or to account for uncertainty from sources including climate change and data limitations. (NRCan, 2018)
<b>Geographic Information System (GIS)</b>	A computer system designed to capture, store, manipulate, analyze, manage, and visualize non-spatial and spatial data. GIS applications (or GIS apps) are computer-based tools, that allow the user to create interactive queries (user-created searches), analyze spatial information output, edit datum presented within maps, and visually share the results of these operations. (Open Geospatial Consortium, 2020)
<b>Geographic Markup Language (GML)</b>	Geography Markup Language (GML) is an XML application that provides a specialized vocabulary for working with geographic data. The main purpose of GML is to provide a standard means for representing information about geospatial features—their properties, interrelationships, and so on. Features describe real world entities and are the fundamental objects used in GML. (Open Geospatial Consortium, 2020)
<b>Historic Flood Extent</b>	The delineated areal extent of inundation from a real historic flood event, typically measured from field studies or remote-sensing methods (e.g., from aerial or satellite imagery). These features are sometimes associated with specific flood hazard scenarios when analyses have been conducted after the event. Historic flood extents are associated with a specific study area feature via the Study Area ID.
<b>Hydraulic Analysis</b>	An engineering analysis of flow scenarios carried out to provide estimates of the water surface elevations and behaviour for selected recurrence intervals. (NRCan, 2018)
<b>Hydraulics</b>	The study of the dynamics of movement of a given amount of water in a watershed. (NRCan, 2018)
<b>Hydrologic Analysis</b>	An engineering analysis of a flooding source carried out to establish peak flood discharges and their frequencies of occurrence. (NRCan, 2018)

Term	Definition
<b>Hydrology</b>	Scientific study of the movement, distribution, and quality of water as it relates to the land. (NRCan, 2018)
<b>Inundation Area</b>	This feature represents the modelled or measured areal extent of water for a specific flood scenario, as defined by annual exceedance probability, climate change assumptions, etc. (NRCan, 2018)
<b>Light Detection and Ranging (LiDAR)</b>	A remote sensing technology that uses lasers to collect accurate continuous elevation data. (NRCan, 2018)
<b>Metadata</b>	Data about data or a service. Metadata is the documentation of data. In human-readable form, it has primarily been used as information to enable the manager or user to understand, compare, and interchange the content of the described dataset. (Open Geospatial Consortium, 2020)
<b>Methodology – 1D Hydraulic Modelling</b>	An engineering analysis of flow scenarios carried out to provide estimates of the water surface elevations and velocities. The analysis is based on standard engineering techniques and a hydraulic computer model that models flow in one dimension (1D) (NRCan, 2018)
<b>Methodology – 2D Hydraulic Modelling</b>	An engineering analysis of flow scenarios carried out to provide estimates of the water surface elevations and velocities. The analysis is based on standard engineering techniques and a hydraulic computer model that models flow in 2 dimension (2D). (NRCan, 2018)
<b>Methodology - Combined 1D and 2D Hydraulic Modelling</b>	An engineering analysis of flow scenarios carried out to provide estimates of water surface elevations and velocities. The analysis is based on standard engineering techniques and a hydraulic computer model that uses a combination of 1D and 2D components to represent flow parameters. (NRCan, 2018)
<b>Methodology - Hydrodynamic Coastal Modelling</b>	An engineering analysis of coastal storm surge, tides, sea-level rise, and wind and wave effects carried out to provide estimates of the water surface elevations on the shore. The analysis is based on standard engineering techniques and a hydrodynamic computer model that typically models off-shore dynamics in 2D, and onshore dynamics in either 1D or 2D. It can also include 3D modelling.
<b>Methodology – Screening-Level</b>	The flooded area has been estimated using engineering judgment and a non-modelled approach. This could include analysis based on review of the ground elevations and watercourses present, a combination of coarse hydraulic modelling and engineering judgment, or other approaches.
<b>Layer</b>	A map layer contains groups of point, line, or area (polygon) features representing types of real-world entities, such as streets or lakes, in any digital map environment. A layer contains both the visual representation of a geographic dataset and a link to each feature’s attributes in the database.
<b>Property</b>	A facet or characteristic of an object described, referenced by a name, which may have one or more values. For example, a property of a river can be “width” for which its value may be “five metres”.
<b>Prototype</b>	A preliminary set of tools to demonstrate and evaluate a new design or concept.
<b>Regulatory</b>	Used to describe data or data sources that are used, or planned to be used, for policy/regulation. For flood hazard data, this should be based on the best available and

Term	Definition
	most recent source for the jurisdiction, as defined by the local authoritative agency. It typically describes the regulatory flood scenario, which is used for planning and policy-making.
<b>(Relative) Sea-Level Change</b>	The change in sea level that is observed or experienced relative to a fixed location on land. Relative sea-level change is the combination of absolute/global sea-level change and vertical land motion. Land uplift decreases relative sea-level rise and land subsidence increases relative sea-level rise.
<b>Return Period</b>	Annual exceedance probability expressed in terms of years, rather than annual probability of a specific flood occurring. For example, the 1% AEP is equivalent to the 100-year return period flood. (NRCan, 2018).
<b>Schema</b>	A formal description of data, data types, and data file structures. In a database, the schema describes the structure in terms of feature (table) names, property (column) names, constraints (e.g., primary, foreign keys), etc. to maintain the integrity of the data.
<b>Server</b>	A computer that provides and manages access to data and applications that it stores.
<b>Service</b>	A computation performed by a software entity on one side of an interface in response to a request made by a software entity on the other side of the interface. A collection of operations, accessible through an interface, that allows a user to evoke a behavior of value to the user. (Open Geospatial Consortium, 2020)
<b>Standards</b>	Geospatial standards are technical documents that detail interfaces or encodings. Software developers and data producers use these documents to build open interfaces and encodings into their products and services. The standards may also provide for indicators of quality, as well as structures for encoding metadata to help identify geospatial data.
<b>Spatial Data</b>	Data that has information referencing a location or describing geometric shapes (e.g., point, line, polygon).
<b>Spatial Database</b>	A database designed to store information that represents features in a geometric space and supports location-based queries. For example, a building record can store the geometry representing the building footprint as a polygon.
<b>Web Feature Service (WFS)</b>	An Open Web Service defined by the OpenGIS Specification that supports reading, writing, and updating of geographic features. WFS delivers GML representations of simple geospatial features in response to queries from HTTP clients. Clients access geographic feature data through WFS by submitting a request for just those features that are needed for an application. (Open Geospatial Consortium, 2020)
<b>Web Mapping</b>	Dynamic query, access, processing, combination, and portrayal of different types of spatial information over the web. (Open Geospatial Consortium, 2020)
<b>Web Mapping Service (WMS)</b>	An Open Web Service defined by the OpenGIS Specification that standardizes the way in which web clients request maps. Clients request maps from a WMS instance in terms of named layers and provide parameters, such as the size of the returned map, as well as the spatial reference system to be used in drawing the map. (Open Geospatial Consortium, 2020)
<b>Web Services</b>	Web services are self-contained, self-describing, modular applications that can be published, located, and invoked across the web. Web services perform functions that can be anything from simple requests to complicated business processes. Once a web

Term	Definition
	service is deployed, other applications (and other web services) can discover and invoke the deployed service. (Open Geospatial Consortium, 2020)

## 8 References

- Alberta Environment and Parks. (2020). Rocky Mountain House Flood Study – Terms of Reference. River Engineering and Technical Services Environmental Knowledge and Prediction Alberta Environment and Parks.
- Ausenco Sandwell. (2011a). Climate Change Adaption Guidelines for Sea Dikes and Coastal Flood Hazard Land Use - Draft Policy Discussion Paper. Prepared for BC Ministry of Environment.
- Ausenco Sandwell. (2011b). *Climate Change Adaption Guidelines for Sea Dikes and Coastal Flood Hazard Land Use - Guidelines for Management of Coastal Flood Hazard Land Use*. Prepared for BC Ministry of Environment.
- Ausenco Sandwell. (2011c). Climate Change Adaption Guidelines for Sea Dikes and Coastal Flood Hazard Land Use - Sea Dike Guidelines. Prepared for BC Ministry of Environment.
- Batmanabane, V., & Kfoury, J. (2017). Qualitative Data Collection Interviews. University of Toronto. *An Introduction to Health Services Research*, 99–113.
- BC Real Estate Association Sustainability Solutions Group and Ebbwater Consulting. (2014). Floodplain Mapping Funding Guidebook for BC Local Governments. Prepared for the BC Real Estate Association.
- CBCL. (2017). Status of Flood Maps in the Atlantic Canadian Provinces. CBCL Limited Consulting Engineers. Prepared for Natural Resources Canada. <https://doi.org/10.1017/CBO9781107415324.004>
- Conservation Ontario. (2020). About Conservation Authorities. Retrieved September 15, 2020, from <https://conservationontario.ca/conservation-authorities/about-conservation-authorities>
- EGBC. (2017). Flood Mapping in BC - APEGBC Professional Practice Guidelines - V1.0. Prepared For British Columbia Ministry of Forests, Lands and Natural Resource Operations.
- EGBC. (2018). Professional Practice Guidelines – Legislated Flood Assessments in a Changing Climate in BC. Version 2.1. Engineers & Geoscientists British Columbia. <https://doi.org/10.1002/ejic.201200009>
- El-Jabi, N., Caissie, D., & Turkkan, N. (2015). Flood analysis and flood projections under climate change in New Brunswick. *Canadian Water Resources Journal*. <https://doi.org/10.1080/07011784.2015.1071205>
- Environmental Water Resources Group Ltd. (2017). Technical Guidelines for Flood Hazard Mapping. Prepared for the Central Lake Ontario Conservation, Ground River Conservation Authority, Toronto and Region Conservation Authority, Credit Valley Conservation, Ganaraska Conservation and Nottawasaga Valley Conservation Authority.
- Feltmate, B., Moudrak, M., & Bakos, K. (2020). Climate Change and the Preparedness of Canadian Provinces and Territories to Limit Flood Risk, (August). Retrieved from <https://www.intactcentreclimateadaptation.ca/recent-reports/>
- FEMA. (2020). Guidelines and Standards for Flood Risk Analysis and Mapping Activities Under the Risk MAP Program. Federal Emergency Management Agency, United States of America. Retrieved from <https://www.fema.gov/flood-maps/guidance-partners/guidelines-standards>
- Ganaraska Region Conservation Authority, Otonabee Conservation Authority, Conservation Ontario.

- (2017). *Metadata Inventory of Existing Conservation Authority Flood Mapping*.
- Gosse, J. C., Tremblay, T., Broom, L. A., Campbell, D. C., Wenzel, G., Nedimoviæ, M. R., & Brisson, L. F. (2020). Initial results from the ULINNIQ seismicity and tsunami hazard project , northeastern Baffin Island , Nunavut, 101–124.
- Hatch Ltd. (2018). Manitoba Infrastructure - Souris River Hydrodynamic Modelling Study Final Report. Produced for Manitoba Infrastructure.
- Hatcher, S. V., & Forbes, D. L. (2015). Exposure to coastal hazards in a rapidly expanding northern urban centre, Iqaluit, Nunavut. *Arctic*, 68(4), 453–471. <https://doi.org/10.14430/arctic4526>
- Hossein, B. (2017). Flood hazard maps in Manitoba : present status and future provincial plans with respect to climate change. Technical Report (National Research Council of Canada. Ocean, Coastal and River Engineering), 2017-03-30. <https://doi.org/10.4224/40000415>.
- Hsieh, E., Tchekhovski, A., & Mongeau, R. (2011). Collapse of permafrost and failure of bridges in the community of Pangnirtung , Nunavut. Pan-AM CGS Geotechnical Conference.
- IAP2 Canada. (2020). *iap2 Inspiring Better Decisions Together*.
- Kerr Wood Leidal. (2011). Coastal Floodplain Mapping – Guidelines and Specifications. Prepared for Ministry of Forests Lands & Natural Resource Operations.
- Manson, G K; Couture, N J; James, T. S. (2019). CanCoast 2.0: data and indices to describe the sensitivity of Canada’s marine coasts to changing climate. Geological Survey of Canada, Open File 8551, 2019, 18 pages. <https://doi.org/https://doi.org/10.4095/314669>
- Ministère de l’Environnement et de la Lutte contre les changements climatiques. (2020a). Projet INFO-Crue. Retrieved September 15, 2020, from <https://www.cehq.gouv.qc.ca/zones-inond/info-crue/index.htm>
- Ministère de l’Environnement et de la Lutte contre les changements climatiques. (2020b). Zones inondables - Réalisations par le gouvernement du Québec. Retrieved September 15, 2020, from <https://www.cehq.gouv.qc.ca/zones-inond/realisations-Qc.htm>
- MMM Group, JFSA, & Matrix Solutions Inc. (2014). *National Floodplain Mapping Assessment Final Report*.
- Murphy, E., Lyle, T., Wiebe, J., Hund, S. V., Davies, M., & Williamson, D. (2020). Coastal Flood Risk Assessment Guidelines for Buildings & Infrastructure Design Applications. Published by the National Research Council of Canada. Report No. CRBCPI-Y5-R2.
- NHC. (2020). Investigations in Support of Flood Strategies in BC ISSUE B-2: FLOOD HAZARD INFORMATION Draft Final Report. Prepared by Northwest Hydraulic Consultants for the Fraser Basin Council.
- NRCan. (2018). Federal Flood Mapping Framework Version 2.0. Natural Resources Canada, General Information Product 112e, 2018, 26 pages, <https://doi.org/10.4095/308128> (Open Access).
- OMNR. (2001). Natural hazards. *Natural Hazards*. Ontario Ministry of Natural Resources. <https://doi.org/10.1201/b11433-414>
- Ontario Ministry of Natural Resources. (2002). *Technical Guide River & Stream Systems: Flooding Hazard*

*Limit. Ontario Ministry of Natural Resources.*

Open Geospatial Consortium. (2020). OGC Glossary of Terms. from OGC: <https://www.ogc.org/ogc/glossary> in August 2020.

Parsons, C., & British Columbia Real Estate Association. (2015). BC Floodplain Map Inventory Report. Prepared for British Columbia Real Estate Association.

Public Safety Canada. (2019). *Evaluation of the National Disaster Mitigation Program - Evaluation Report*. Retrieved from <https://www.passengerprotectiondespassagers.gc.ca/cnt/rsrscs/pblctns/vltn-ntnl-dsstr-mtgn-prgrm-2019/vltn-ntnl-dsstr-mtgn-prgrm-2019-en.pdf>

R. J. Daigle Enviro. (2014). Updated Sea-Level Rise and Flooding Estimates for New Brunswick Coastal Sections Based on IPCC 5<sup>th</sup> Assessment Report, 49. Retrieved from <https://www2.gnb.ca/content/dam/gnb/Departments/env/pdf/Flooding-Inondations/SeaLevelRiseAndFloodingEstimates.pdf>

Shugar, D. H., Clague, J. J., Best, J. L., Schoof, C., Willis, M. J., Copland, L., & Roe, G. H. (2017). River piracy and drainage basin reorganization led by climate-driven glacier retreat. *Nature Geoscience*, 10(5), 370–375. <https://doi.org/10.1038/ngeo2932>

Smith, I. R. (2014). Reconnaissance assessment of landscape hazards and potential impacts of future climate change in Kugluktuk, western Nunavut. *Canada-Nunavut Geoscience Office Summary of Activities 2013 Summary of Activities 2013*, 149–158. Retrieved from <http://cngo.ca/summary-of-activities/2013/>

Smith, I. R., & Forbes, D. L. (2014). Reconnaissance assessment of landscape hazards and potential impacts of future climate change in Cambridge Bay, western Nunavut. *Canada-Nunavut Geoscience Office Summary of Activities 2013 Summary of Activities 2013*, 149–158. Retrieved from <http://cngo.ca/summary-of-activities/2013/>

Water Resources Management Division. (2018). Technical Document for Flood Risk Mapping Studies Newfoundland Labrador. Water Resources Management Division, Department of Municipal Affairs and Environment, Government of Newfoundland and Labrador.