



Summary Report

Investigations in Support of Flood Strategy Development in British Columbia

July 2021

Prepared by



Fraser Basin Council

Project funded by



Acknowledgments

The **Investigations in Support of Flood Strategy Development in British Columbia** initiative, including preparation of this summary report, was supported by funding from the British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development.

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The project team acknowledges the leadership of George Roman and Mitchell Hahn of the Ministry of Forests, Lands, Natural Resource Operations and Rural Development who played a key role in guiding the overall initiative and providing advice on and review of this report.

The team appreciates the considerable efforts and expertise of the consulting teams that led the 11 individual projects within this initiative and reviewed the draft summary report. The project summaries in Section 2 of this report identify the firm(s) involved in each project. A small group of advisors also provided guidance and review for the overall initiative and individual projects.

Thanks also go to the over 150 individuals from all orders of government and non-government organizations who took the time to participate in this initiative, whether through surveys, interviews, or reviewing draft reports. The expertise, experience, and perspectives of these individuals contributed significantly to our collective understanding of the issues and opportunities for improving flood management in BC.

The Fraser Basin Council head office is located on the traditional, ancestral, and unceded territories of the xʷməθkʷəj̓əm (Musqueam), Skwxwú7mesh (Squamish), and səliłwətaʔ (Tsleil Waututh) Nations.



Fraser Basin Council

Disclaimer

This document has been prepared by the Fraser Basin Council for the information of all orders of government and other organizations and individuals in BC with responsibilities or interests in flood risk reduction. The document is for general background information only and is not intended to be relied on for specific decisions or actions on flood management. Accordingly, the Fraser Basin Council denies absolutely any and all liability for the use of, or reliance on, this document.

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Executive Summary

The **Investigations in Support of Flood Strategy Development in British Columbia** was a province-wide initiative aimed at developing a comprehensive understanding of current issues, challenges, and opportunities relating to flood management in BC. This initiative, undertaken from 2019 to 2021, consists of 11 interrelated Issues:

- | | |
|--|--|
| (A-1) Flood Risk Governance | (B-6) Non-Structural Flood Management Approaches |
| (B-1) Impacts of Climate Change | (C-1) Flood Forecasting Services |
| (B-2) Flood Hazard Information | (C-2) Emergency Response |
| (B-3) Flood Risk Assessment | (C-3) Flood Recovery |
| (B-4) Flood Planning | (D-1) Resources and Funding |
| (B-5) Structural Flood Management Approaches | |

Consulting teams conducted research, engagement, and analysis on a total of 43 investigations within these Issues. Their analyses and recommendations, presented in 11 separate project reports, are intended to inform the development of flood strategies and operations undertaken at different scales by different orders of government and other organizations with flood management roles and responsibilities in BC.

This report summarizes the scope, findings, and recommendations of the 11 projects. Section 2 provides a brief summary of each project. Section 3 presents a synthesis of common themes and findings that emerged from the investigations, including many of the challenges currently faced by responsible authorities in BC. It presents key recommendations from the projects under eight headings:

- | | |
|---|---|
| • Facilitate training, education, and knowledge sharing | • Support integrated flood management approaches |
| • Improve data, information, and tools | • Facilitate collaboration |
| • Develop vision and targets | • Provide strategic and comprehensive funding |
| • Strengthen guidelines and standards | • Adapt organizational roles and responsibilities |

All projects point to the need for enhanced funding, capacity, and governance for more effective flood management, including in the development of foundational information tools, flood management planning and emergency response planning, and implementation of flood mitigation measures. Although most of the recommendations are directed toward the provincial government, most aspects of flood management involve shared responsibilities and collaboration among all orders of government, professional associations, academic institutions, and other private and public sector organizations.

Further engagement, consultation, and cost-benefit analyses should be undertaken as part of responsible authorities' consideration and/or implementation of these recommendations. Actions should also make use of and build on new and existing initiatives and tools, some of which are highlighted in Section 4.

List of Acronyms Used

BC	British Columbia
CLEVER	Channel Links Evolution Efficient Routing (flood forecasting model)
DRIPA	<i>Declaration on the Rights of Indigenous Peoples Act</i>
DFA	Disaster Financial Assistance
EGBC	Engineers and Geoscientists British Columbia
EMBC	Emergency Management British Columbia
EOC	Emergency Operations Centre
FBC	Fraser Basin Council
LiDAR	Light Detection and Ranging
MFLNRORD	Ministry of Forests, Lands, Natural Resource Operations and Rural Development
UNDRIP	United Nations Declaration on the Rights of Indigenous Peoples

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1. Introduction

1.1 Context for the Initiative

Investigations in Support of Flood Strategy Development in British Columbia was a province-wide initiative aimed at developing a comprehensive understanding of current issues, challenges, and opportunities relating to flood management across BC. The focus is primarily on riverine and coastal floods, although other types of flooding are recognized where appropriate.

The BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (MFLNRORD) retained the Fraser Basin Council (FBC) to manage and coordinate investigations across a broad range of flood management issues. The issues include governance, hazard and risk assessment, planning, structural and non-structural mitigation, forecasting, emergency response and recovery, and funding and resources.

This initiative recognizes that flood management is a multi-faceted, ongoing process that requires the coordination of many organizations, agencies, and orders of government and linked with broader processes, including land use planning, engineering design, climate change adaptation, and disaster risk reduction, among others. It also recognizes that the current governance structure has perpetuated or created inequities across communities in BC, especially with Indigenous communities. This initiative responds to recent studies, such as the 2018 Auditor General report¹ and the Abbott/Chapman review of the 2017 wildfire and flood seasons², that highlight the need for changes to the current flood management approach in BC to reduce the flood risk faced by communities, particularly in light of a changing climate.

This work has been informed by, and can help further inform, initiatives at multiple scales including but not limited to:

- The forthcoming BC Flood Strategy;
- Modernization of the *BC Emergency Program Act*;
- Implementation of the *BC Declaration of the Rights of Indigenous Peoples Act* (DRIPA);
- Provincial and federal adoption of the Sendai Framework for Disaster Risk Reduction³;
- Local and regional efforts in flood hazard and risk assessment, planning, mitigation, response, and recovery; and
- Advancements in methods and technologies.

¹ Office of the Auditor General of British Columbia. 2018. [Managing Climate Change Risks: An Independent Audit](#).

² George Abbott and Chief Maureen Chapman. 2018. [Addressing the New Normal: 21st Century Disaster Management in British Columbia](#).

³ The [Sendai Framework for Disaster Risk Reduction](#) (Sendai Framework) is the global blueprint to reduce disaster risk and losses in lives, livelihoods, and health and in the economic, physical, social, cultural, and environmental assets of persons, businesses, communities, and countries.

1.2 Issues and Investigations

Forty-three investigations were undertaken across 11 Issues under four Themes. The Themes, Issues, and the general aims of each Issue are described in Table 1. Specific investigation titles can be found in the respective project summaries in Section 2. The topics were informed by – and built on – a scoping study completed by Associated Engineering in 2018⁴. MFLNRORD and FBC collaboratively scoped the investigations.

Table 1: Themes and Issues

Theme A – Governance		
A-1	Flood Risk Governance	Review current governance and delivery of flood management activities in BC involving government and non-government entities, identify challenges, and recommend changes to improve coordination, collaboration, and overall effectiveness.
Theme B – Flood Hazard and Risk Management		
B-1	Impacts of Climate Change	Investigate the state of climate change information and new and existing tools that can support authorities in integrating climate change impacts in flood management.
B-2	Flood Hazard Information	Examine the state of flood mapping and dike deficiency information and recommend ways to fill current gaps in flood mapping and manage and maintain information about flood hazards and dike deficiencies.
B-3	Flood Risk Assessment	Explore approaches to completing flood risk assessments at various scales, methods for prioritizing risk reduction actions, and standards- versus risk-based approaches to flood management.
B-4	Flood Planning	Examine the ability of local authorities to undertake integrated flood management planning and opportunities to improve capacity.
B-5	Structural Flood Management Approaches	Assess the potential for improvements to dike management, improve the capacity of diking authorities, and implement innovative structural flood risk reduction measures.
B-6	Non-Structural Flood Management Approaches	Investigate current and alternative approaches to managing development in floodplains and opportunities for implementing non-structural flood risk reduction actions.
Theme C – Flood Forecasting, Emergency Response and Recovery		
C-1	Flood Forecasting Services	Identify gaps and opportunities for improvement in the province's flood forecasting services.
C-2	Emergency Response	Investigate roles, plans, and capabilities for flood response and opportunities for improving emergency response.
C-3	Flood Recovery	Examine approaches that would support recovery efforts and help reduce future flood risk.
Theme D – Resources and Funding		
D-1	Resources and Funding	Investigate resource and funding needs associated with actions to strengthen flood management and evidence in support of proactive flood mitigation.

⁴ Associated Engineering (B.C.) Ltd. 2018. BC Flood Risk Strategy – Phase 1 Report.

Figure 1 provides a simple illustration of the 11 Issues in relation to the four Sendai Framework priorities for action. In reality, most of the Issues touch upon more than one priority (for example, almost all consider governance issues to some extent).

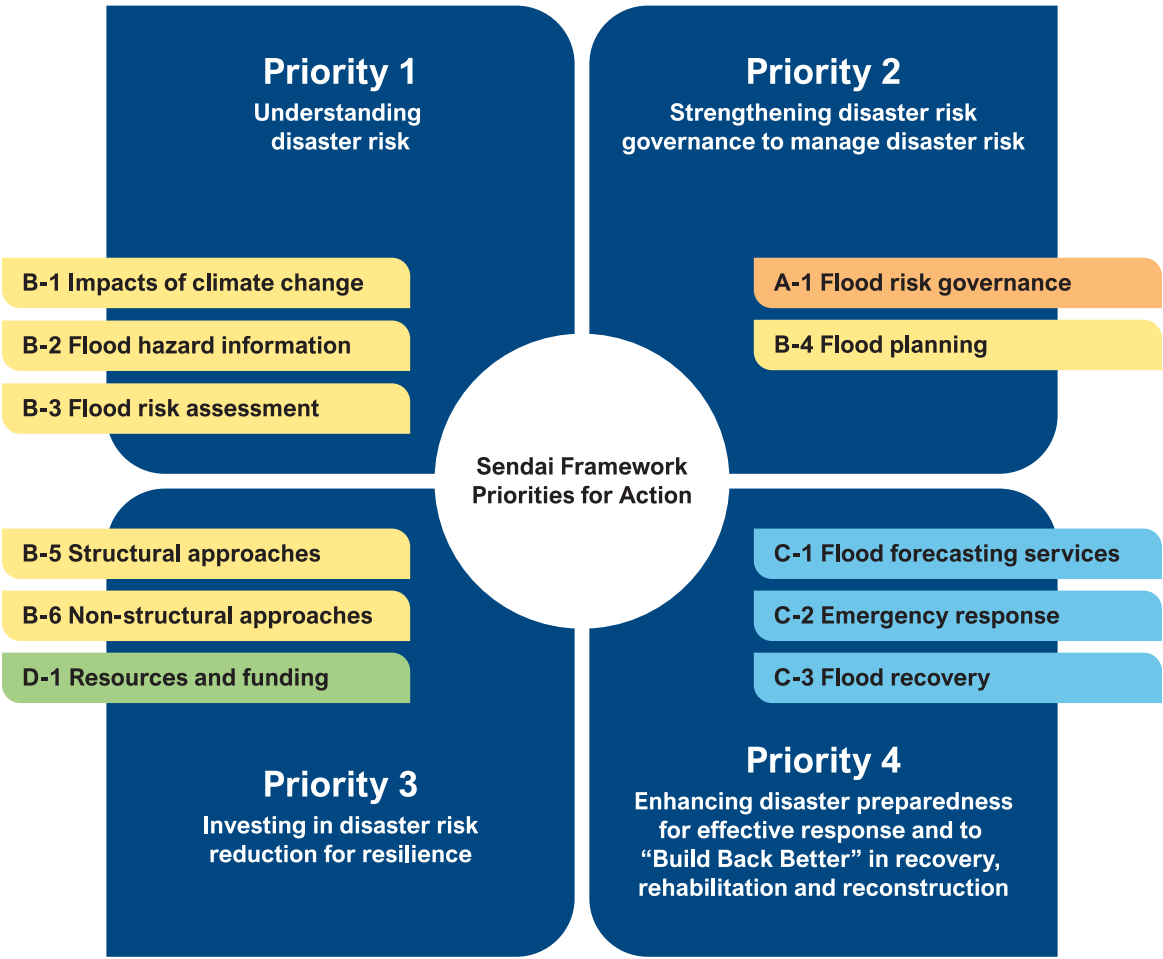


Figure 1. Mapping of the Issues to the four Sendai Framework priorities for action.

1.3 How Projects were Carried Out

Each of the 11 Issues constituted a single “project” and is presented in an individual report containing findings and recommendations. FBC retained consulting teams to undertake research and technical analysis with input from experts, practitioners, and staff from the federal, provincial, First Nations, and local governments, the private sector, and other organizations.

Consulting teams used a mix of methods including desktop and literature review, interviews, and surveys. In some cases, FBC engaged advisors (practitioners with expertise in an area) to provide guidance on a specific project, topic, or survey instrument. Project reports were reviewed by MFLNRORD, FBC, and in many cases additional reviewers from the public and private sectors as relevant to the Issue. Each project spanned a period of 4 to 12 months between March 2020 and June 2021. Some consulting firms led more than one project.

Due to the interrelated nature of the Issues and investigations, FBC facilitated opportunities for consulting teams to exchange information and ideas. FBC also coordinated surveys for diking authorities, First Nations, and a broader group of practitioners on behalf of the teams leading the Theme B projects. Figure 2 provides a basic illustration of key linkages among the 11 Issues.

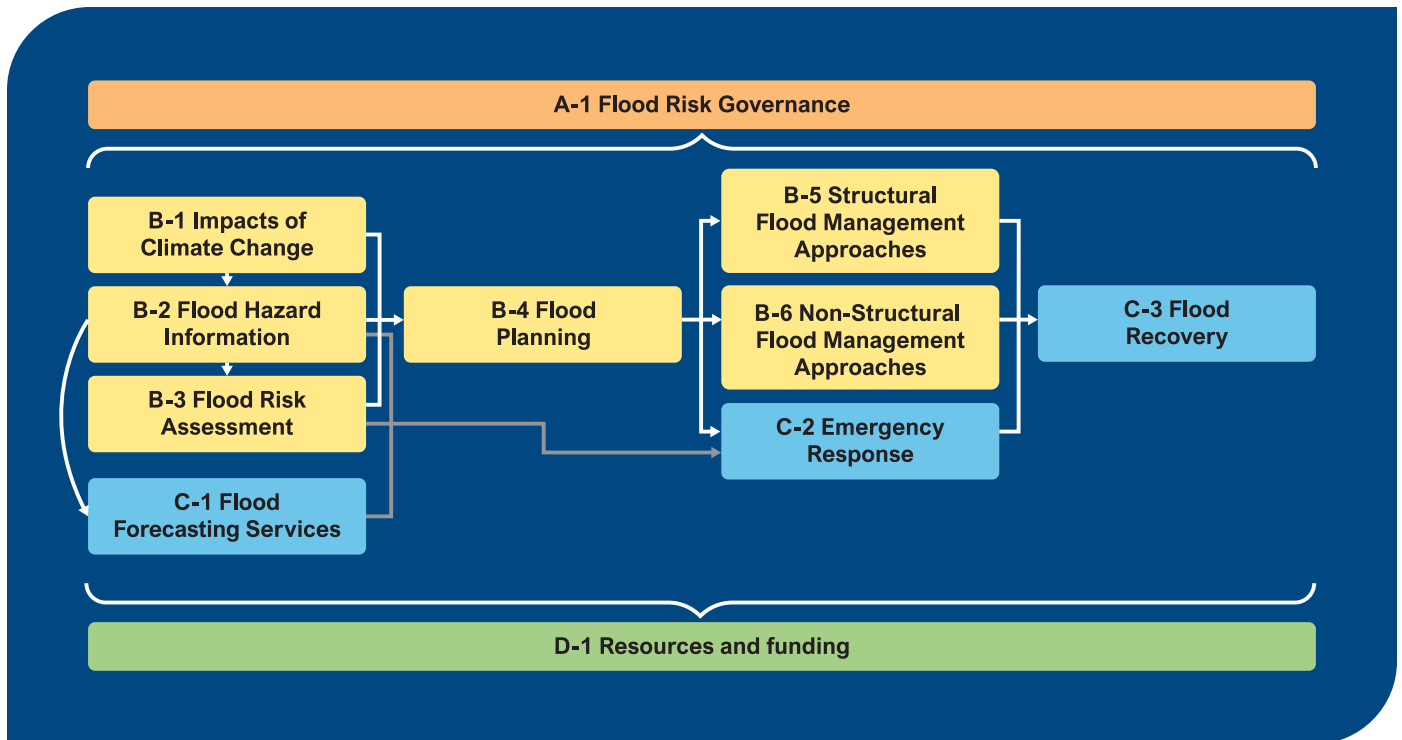


Figure 2. Simplified illustration of the functional linkages among the main topics investigated in each Issue.

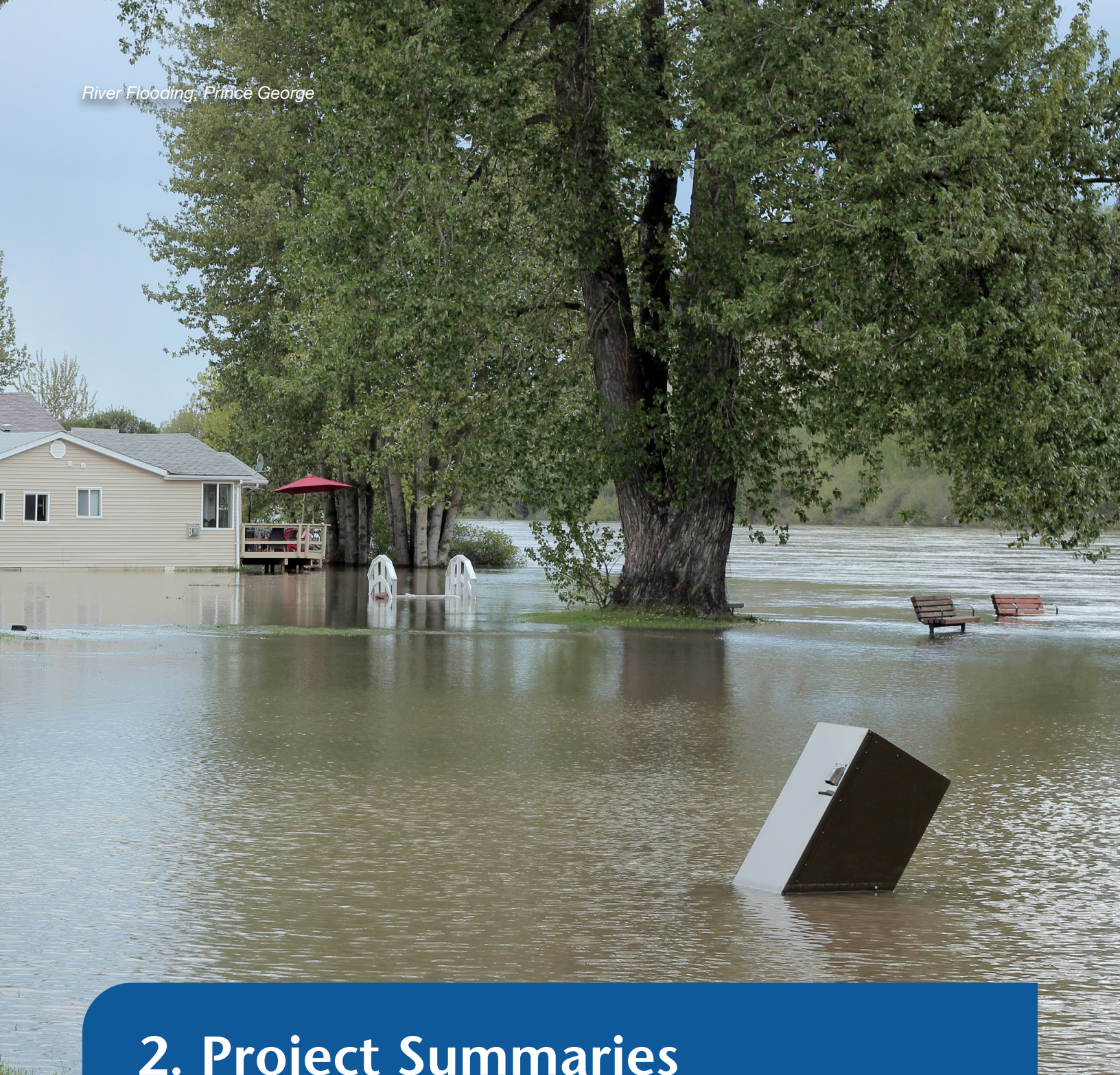
1.4 The Summary Report

This report summarizes findings and recommendations from the 11 projects. Section 2 presents a brief summary of each project. Section 3 synthesizes common themes found across findings and recommendations from these projects. These two sections represent FBC’s interpretation of content presented in these reports. While some judgment was made on the content for inclusion, inclusion does not represent FBC’s endorsement of the findings and recommendations, nor does exclusion of other content entail a lack of endorsement.

Although consultants were encouraged to use consistent terminology and language, and this report makes efforts to harmonize the style and terminology from the 11 project reports, there may be remaining variations that reflect the many voices that informed this summary report. For original wording, definitions, details, and a full presentation of each investigation, please read the respective project report (see Section 5 for the full list of reports). Section 4 includes observations and suggestions from FBC on potential next steps.

In this report:

- **“Flood management activities”** refers to the range of services and activities described within this set of Issues. A full breakdown of these activities and organizations responsible for them is presented in the A-1 project report.
- **“Flood risk”** refers to the combination of the likelihood of a flood hazard event and its negative consequences resulting from exposure and vulnerability to the flood hazard. A primer on flood risk can be found in the B-3 project report.
- **“Responsible authorities”** refers to government and non-government organizations with official or unofficial roles in a given flood management activity (or activities).
- **“Local authorities”** refers to local governments and First Nations governments. In the context of dike management, the term may also include dike management authorities. (It is understood that the actual scope of authority varies across these different types of local authorities.)



2. Project Summaries

This section presents brief summaries of the 11 projects. All projects except C-3 (Flood Recovery) and D-1 (Resources and Funding) included preliminary, high-level cost estimations for the major recommendations; please refer to the respective project reports for this information and to the D-1 report for an analysis of these preliminary cost estimates.

Investigations

A-1.1 Identify the flood management services provided by each order of government in BC.

A-1.2 Investigate the roles of non-government entities in flood management in BC.

A-1.3 Identify challenges, gaps, and limitations with current service delivery.

A-1.4 Identify opportunities for improving collaboration and coordination within and across authorities and adjusting non-government entities' roles to address challenges and improve efficiency and effectiveness.

A-1.5 Recommend changes to support improved collaboration and coordination in flood management, including an analysis of benefits and limitations for each recommendation.

A-1.6 Investigate alternative options for distributing and integrating flood management responsibilities among authorities, including an analysis of benefits and limitations for each option.

Ebbwater Consulting Inc. and Pinna Sustainability Inc. led this project.

2.1 Flood Risk Governance (Issue A-1)

The governance of flood risk involves diverse authorities that are each responsible for and make decisions regarding various flood management activities. Since the early 2000s, BC has adopted a decentralized approach to flood risk governance, with authority and responsibility spread across multiple orders of government. Local authorities carry much of the responsibility for flood management, while federal and provincial governments have limited their roles largely to funding, guidance, and post-disaster financial assistance. This marked a significant change from the previous model in which most responsibilities resided with the provincial government.

This project examines the current governance of flood management activities in BC and opportunities to improve upon gaps in the current governance model.

This project presents a visual framework for identifying flood management responsibilities and the respective roles of government and non-government entities.

There are numerous challenges in flood management related to participation in governance processes, vision and leadership, transparency and efficiency, accountability and clarity of roles and responsibilities, fairness, all-of-society ownership, alignment with related processes, and continued learning. The project highlights opportunities within the current governance model to address these gaps.

The project also presents the need and value of moving from the current governance model toward a “hybrid” model in which some key services are returned to the provincial government (Province). It proposes a new flood risk governance model that includes:

1. A strong provincial vision that acknowledges reconciliation with Indigenous peoples, sets direction, and supports accountability.
2. A central knowledge hub within the Province that supports collaboration with the federal government, provides technical services and funding in a consistent and efficient manner, and develops guidelines and tools to enable consistent and best practice flood management approaches.
3. Regional hubs that support collaboration on a regional and watershed basis and provides expertise and support to all (and especially less-resourced) communities.
4. Reliable and adequate funding for locally-driven flood mitigation activities that leverage local knowledge and processes and work toward a common vision.

The proposed model would be supported by strengthened support and coordination between the Province and professional associations and post-secondary institutions.

2.2 Impacts of Climate Change (Issue B-1)

Climate change, along with other factors, is expected to alter the conditions that influence the frequency and magnitude of floods in BC. Understanding broad climate trends across the province is a key first step to understanding the impacts of climate change on flooding, which in turn is necessary for flood hazard assessments and future planning.

This project examines current climate change information in relation to flood hazards and available capacity and guidance in BC for practitioners to integrate climate change impacts in flood assessment and planning.

The analysis includes six types of flood hazards: riverine flooding caused by spring freshet, atmospheric rivers, and ice jams; coastal flooding caused by sea level rise and storms; pluvial flooding caused by local precipitation; and compound event flooding.

Methods for applying climate change considerations to flood hazard assessment are rapidly evolving. Flood-specific climate science results allow flood practitioners to move from relatively ad hoc assessments to more detailed modelling, but there remains a gap between the knowledge and needs of flood practitioners and information produced by climate scientists. Many reference guidelines do not yet reflect current scientific knowledge.

BC-specific frameworks and knowledge sharing opportunities can help improve integration between these two bodies of knowledge. Climate scientists' and flood practitioners' expertise should be expanded and coordinated to support understanding among the public, private industry, and public agencies that are ultimately responsible for managing flood risk.

Developing and maintaining leading-edge knowledge and adequate human resources are needed to develop a province-wide understanding of climate science and impact modelling and support practitioners, stakeholders, and the public interest. Recommendations also include:

- Expand weather, climate, and water observation and monitoring to improve climate model validation and downscaling for flood-relevant applications.
- Develop built-for-purpose climate data and frameworks for flood practitioners.
- Strengthen guidance materials specific to different forms of flooding.
- Provide training for the public, governments, and technical professionals.
- Support collaboration networks bridging climate scientists and flood practitioners.

Investigations

B-1.1 Investigate the state of climate change science in relation to BC flood hazards and identify gaps and limitations in provincial legislation, plans, and guidelines related to flood hazard management in a changing climate.

B-1.2 Identify current sources of information and models used by experts in the province to predict future climate impacts and investigate opportunities for improved predictive modeling.

B-1.3 Investigate the capacity of responsible authorities and other professionals and practitioners in the province to integrate climate change impacts and scenarios to inform flood planning and management.

B-1.4 Investigate the legislative, policy, and regulatory tools available to responsible authorities for integrating climate change impacts in flood planning and management.

Associated Engineering (B.C.) Ltd. led this project.

Investigations

B-2.1 Investigate the current state of flood mapping in the province, including gaps and limitations.

B-2.2 Investigate the approximate level of effort to prepare flood hazard mapping to address current gaps for existing communities and future areas of development (including floodplain maps and channel migration assessments). Recommend an approach to improve the spatial coverage, quality, utility, and accessibility of flood hazard maps and other flood hazard information.

B-2.3 Investigate the current state of knowledge related to dike deficiencies and recommend an approach to improve the quality, consistency, review, utility, and accessibility of this information.

B-2.4 Investigate the status of LiDAR standards for flood mapping and develop recommendations to improve standards if applicable.

Northwest Hydraulic Consultants Ltd. led this project.

2.3 Flood Hazard Information (Issue B-2)

Flood management activities require good information about flood hazards as a foundation. Models and maps that characterize the extent and depth of flood scenarios can inform risk assessment, land use planning, floodplain regulation, dike design and alignment, and emergency response. Similarly, information about the condition of flood protection dikes can be invaluable to support many aspects of flood management.

This project examines the current state and coverage of floodplain mapping and knowledge of dike conditions and deficiencies in BC and recommends approaches to manage this information and address knowledge gaps.

In reviewing floodplain mapping, the project examines both historical mapping programs and more recent developments, focusing on high-quality maps that could be used for official designation of floodplains.

Challenges are identified with regard to the geographic coverage, quality, relevance, and reliability of flood hazard information, as well as technical capacity and funding constraints.

Key recommendations to overcome identified gaps include:

- Assess the quality and completeness of existing floodplain maps.
- Improve the coverage and online accessibility of flood maps in BC.
- Improve flood map guidance, standards, and practices.
- Improve map quality through training, adequate budgets, and an independent quality control group, including an increased role for the provincial government to achieve consistent, high-quality mapping.
- Establish and apply a standardized Dike Rating System and amend the definition of “adequate” dike in Engineers & Geoscientists BC Legislated Flood Assessments in a Changing Climate in BC guidelines⁵ (EGBC Flood Assessment guidelines).
- Increase the number of dike safety audits and publicize dike inspection reporting compliance information.
- Establish provincial LiDAR guidelines and specifications for flood mapping projects, including procedures for acquisition and dissemination.

⁵ EGBC. 2018. [Legislated Flood Assessments in a Changing Climate in BC Professional Practice Guidelines](#).

2.4 Flood Risk Assessment (Issue B-3)

A key step in reducing the negative consequences of flooding is to understand the level and distribution of flood risk in a given area. Understanding risk requires knowing the likelihood and extent of flood hazards as well as assets that are exposed and vulnerable to flooding. This understanding can be achieved through a flood risk assessment. Most communities in BC have not completed such an assessment to support flood risk reduction investments and decisions.

This project defines flood risk and flood risk assessment and examines approaches to support a transition to risk-based flood management in BC through flood risk assessment and holistic decision-making tools and methods.

Risk-based approaches to flood management, which account for the diversity of flood events and their potential impacts, are more effective at managing complex flood problems than a standards-based approach. Responsible authorities should adopt risk-based approaches that include risk reduction targets and holistic decision-making processes.

Flood risk assessments are a key tool to support this shift, but they are complex, resource-intensive, and dependent on adequate data, resources, and expertise. Determining values and assets and measuring less tangible impacts requires significant community engagement. The approximately 60 studies with a flood risk assessment component in BC (most being concentrated in southern BC) vary widely in terms of cost, approach, and coverage. Many were completed as an addition to flood hazard assessments and are not “true” flood risk assessments. Such efforts are hindered in part by a lack of comprehensive, high-quality exposure and vulnerability datasets and adequate capacity.

To support risk-based flood planning, prioritization, and decision-making at the provincial level, it is recommended that the Province lead a province-wide screening-level flood risk assessment. This would be a quicker and more cost-effective way to understand flood risk across the province compared with hundreds of individual communities leading their own flood risk assessments that are then combined. However, this high-level assessment should be complemented by First Nations- and local government-led detailed flood risk assessments to inform local-scale planning and engineering decisions. Developing and maintaining province-wide exposure and vulnerability databases and BC-specific professional practice flood risk assessment guidelines would significantly reduce the costs of individual projects and increase the quality, efficiency, and consistency of flood risk assessments at all scales.

Investigations

B-3.1 Evaluate and compare the benefits and costs/limitations of taking a risk-based approach to flood management versus a standards-based approach.

B-3.2 Investigate the effort required to develop and maintain a province-wide asset inventory and/or exposure dataset covering flood prone areas.

B-3.3 Investigate approaches to completing a province-wide flood risk assessment, addressing effort required, level of detail, types of flood risk, current and future scenarios, scale, and any information required and data gaps.

B-3.4 Investigate the level of effort to develop a coarse local-scale flood risk map based on available flood hazard map(s).

B-3.5 Determine the effort required to undertake a local-scale comprehensive flood risk assessment for multiple types of flood hazards and for varying degrees of available data on flood hazard, exposure, vulnerability, and risk.

B-3.6 Investigate methods for valuing the benefits and costs/limitations of flood risk reduction actions in a holistic and consistent manner.

Ebbwater Consulting Inc. led this project.

Investigations

B-4.1 Investigate the ability of responsible authorities in the province to develop adaptation plans and strategies for flood management.

B-4.2 Investigate opportunities to improve the knowledge and capacity of local authorities with regard to climate change adaptation and the benefits of proactive flood risk reduction.

B-4.3 Investigate the potential content of a provincial guideline to support the development of local integrated flood management plans.

B-4.4 Investigate the level of effort for a local authority to complete an integrated flood management plan and the possible role of the Province in reviewing and/or approving these plans.

Kerr Wood Leidal Associates Ltd. led this project.

2.5 Flood Planning (Issue B-4)

Flood management plans are strategic documents that outline preferred measures for managing flood risk within a jurisdiction. An integrated flood management plan, considered a best practice form of flood management plan, is integrated with other plans and policies in an organization and uses a holistic approach to advance a combination of structural and non-structural flood management measures. An integrated flood management plan relies on information about the flood hazards and risk as well as the values and objectives of the community.

This project examines the ability of local authorities to undertake integrated flood management planning and recommends actions and resources to improve the capacity and involvement of authorities in creating integrated flood management plans.

Since the early 2000s, the Province has played a reduced role in flood management, mostly focusing on guideline development, grant programs, and regulating dike systems. While some local authorities in BC have prepared flood management plans, there are significant gaps with regard to their consistency and scope.

Key barriers in undertaking this type of planning include limited staff capacity, limited financial resources or access to funding, gaps in technical information and knowledge, lack of tools and standards, and political sensitivities or conflicting priorities. In particular, there are limited guidelines and resources available to support flood planning and the selection of risk reduction measures. This project recommends a core set of contents for a future integrated flood management plan guideline to support three types of planning: hazard-based, risk-informed, and risk-based.

It recommends that the Province establish an integrated flood management planning program to support local-scale work with the following key features:

- Requirement (with associated resources) for local authorities to develop integrated flood management plans;
- Provincially-approved integrated flood management plans as a requirement for structural flood mitigation funding;
- Enhanced local authority staff capacity for flood management planning;
- Training opportunities to increase knowledge of flood management planning;
- Guidelines, including a “minimum requirements roadmap”, for developing integrated flood management plans;
- Minimum flood risk tolerance criteria for use in integrated flood management plans; and
- Provincial staff participation in and review and approval of integrated flood management plans.

2.6 Structural Flood Management Approaches (Issue B-5)

BC relies heavily on dikes as the main approach to structural flood protection. There are 216 regulated dikes in BC with a total length of about 1,100 km. They are owned and maintained by 106 government and non-government diking authorities that vary widely in terms of financial resources, technical expertise, and administrative authority. Diking authorities and their dikes are regulated by the provincial Inspector of Dikes under the *Dike Maintenance Act*.

This project examines opportunities to improve dike maintenance and future planning, improve the capacity of and coordination among diking authorities, and implement innovative structural flood risk reduction measures.

Diking authorities face a variety of challenges in maintaining and upgrading their diking systems. These include high staff turnover, low compliance with dike inspection reporting, lack of up-to-date dike operation and maintenance manuals, inadequate legal access for maintenance, lack of coordination with neighbouring authorities, and unequal access to funds for future planning and dike upgrading.

Recommendations in this project are primarily aimed at MFLNRORD, with other agencies such as Emergency Management BC (EMBC) and diking authorities also playing a key role:

- Incentivize and enforce the submission of dike inspection reports by diking authorities.
- Make designing dikes for climate change a condition of *Dike Maintenance Act* approvals for major upgrades, as supported by guideline documents and specific standards.
- Implement an integrated flood management planning program to encourage greater coordination among authorities and link provincial funding for structural works to non-structural measures such as adopting floodplain bylaws or other land use regulations.
- Provide training, including through dike safety audits and online training courses.
- Cost-share, coordinate, and lead “bundled” or regional-scale applications to the federal Disaster Mitigation and Adaptation Fund program to encourage coordination.
- Encourage innovative structural measures by including land acquisition as an eligible cost for setback dike projects, developing guidelines and standards, and sponsoring pilot projects for innovative approaches such as smart dikes and bio-grouting (a method to improve the seismic resilience of flood protection dikes).

While the investigations were focused on diking authority capacity for dike maintenance and planning, a key issue is that most dikes in BC do not meet provincial standards and many are likely to breach during floods well below the design event. This project recommends further investigation of a program and resources to upgrade the dikes to meet provincial standards along with funding that aligns with the actual costs of meeting standards.



Investigations

B-5.1 Investigate opportunities to incentivize or require diking authorities to maintain flood protection infrastructure and plan for future conditions such as changing flood hazards.

B-5.2 Investigate opportunities to improve the knowledge and capacity of local diking authorities regarding dike maintenance.

B-5.3 Investigate opportunities to improve coordination among diking authorities under non-emergency conditions.

B-5.4 Investigate impediments to and opportunities for implementing innovative structural flood risk reduction measures, including the role of incentives and regulation.

Northwest Hydraulic Consultants Ltd. led this project.

Photo: Dike work. Photo courtesy of the Province of British Columbia.



2.7 Non-Structural Flood Management Approaches (Issue B-6)

Non-structural flood management measures reduce the consequences of a flood by reducing the exposure and vulnerability of assets. Measures include limiting the type and extent of development in flood hazard areas, applying minimum construction elevations, floodproofing, managed retreat of existing development, and public education to improve awareness of flood risk and individual actions. Where structural measures such as diking exist, non-structural measures can work in conjunction to mitigate the risk of infrastructure failure.

This project investigates approaches to managing development in floodplains and opportunities to strengthen the use of non-structural measures for flood risk reduction.

Investigations

B-6.1 Investigate past and current approaches to land use and development decisions in floodplains by local and provincial authorities.

B-6.2 Investigate alternatives to the current approach to managing development in floodplains, including returning regulatory authority for development approvals in municipal floodplains to the Province, and analyze the benefits and limitations of both local and provincial authority.

B-6.3 Investigate impediments to and opportunities for implementing available non-structural flood risk reduction actions, including the role of incentives and regulation.

B-6.4 Investigate the nature of an educational campaign for regional, local, and First Nations governments to raise awareness of flood risk and possible risk reduction options.

Northwest Hydraulic Consultants Ltd. and Arlington Group Planning + Architecture Inc. led this project.

A critical turning point for non-structural flood management in BC was 2003, when the *Flood Hazard Statutes Amendment Act* endowed local governments with powers and responsibilities that previously resided with the Province. These include designating floodplains, flood construction levels, and subdivision and development requirements within flood hazard areas. The Province retained limited roles in subdivision approval outside of municipalities, provision of guidelines, and funding administration.

The lack of centralized direction has negatively impacted local-scale efforts. A reliance on guidelines rather than requirements for local governments to regulate development has contributed to inconsistent application of land use planning and development controls. Local authorities also contend with limited public understanding and competing local priorities.

The project evaluates three options to improve the governance and delivery of non-structural mitigation measures (without recommending one option):

1. The Province to regain a leadership role in many of the activities described above.
2. Local governments to retain existing authorities; the Province to provide a technical support role.
3. First Nations and local governments to form regional partnerships to perform these functions to improve consistency and efficient use of resources.

Key recommendations for the Province include:

- Review and update provincial land use guidelines and relevant acts and codes.
- Improve incentives and technical and financial capacity for local authorities to implement non-structural measures, including more challenging methods such as managed retreat.
- Adopt and support alternative floodproofing measures for new and existing buildings.
- Develop an educational framework and provide technical and financial resources to support the development and delivery of local-scale flood education campaigns. Suggested content and delivery mechanisms are provided.

Photo: House built to meet a given flood construction level.

2.8 Flood Forecasting Services (Issue C-1)

BC communities rely on flood forecasting services to plan for emergencies and to keep people safe.

This project analyzes user assessments of monitoring and modelling data availability and approaches to recommend how flood forecasting systems can be strengthened.

Local authorities responsible for emergency management require flood forecasts that include key flood hazard characteristics such as extent, intensity, and timing. Understanding flood characteristics is essential for Emergency Operations Center (EOC) directors to issue informed and timely evacuation orders and coordinate the deployment of flood response resources. The River Forecast Centre provides forecasts and flood advisories across the province based on the availability of Water Survey of Canada gauge locations and various hydrologic and hydraulic models. Detailed hydraulic models are available only for limited areas. While the accuracy of operational hydrologic models is good, significant uncertainties often remain based on uncertainties in meteorological forecasts (a key input into hydrological models) and existing limitations in the province's snow and river gauge data networks. Without very detailed hydraulic models, decisions must be based on flood monitoring (e.g., gauging station real-time data and field observations) and qualitative judgments. This can limit the ability of emergency response personnel to optimize preparation and response to flood events at a local scale.

There are challenges with developing and integrating a province-wide flood model into provincial flood forecasting services. Preparing hydraulic models and flood hazard maps is the responsibility of local governments, whose financial and technical capacities vary. Therefore, a wide range of models and maps have been developed by consultants following limited guidelines and standards. Due to professional governance legislation, flood modelling results based on flood forecasts are the responsibility of qualified professionals undertaking the work, not local governments.

Key recommendations for the Province include improving flow and snow gauge coverage in small watersheds (focus areas are listed in the report); exploring the potential for a province-wide model to integrate flood forecasts and hydraulic models within a Flood Early Warning System (FEWS), potentially leveraging BC Hydro's experience with this platform; and providing long-term funding to source, maintain, and upgrade a storm surge model for the coast of BC such as the BC Storm Surge Model recommended in the project.

Increased staff and technology resources are needed to strengthen the capacity of the River Forecast Centre. While other organizations provide input data to support forecasts (e.g., the BC Ministry of Environment and Climate Change Strategy runs the snow gauge network, the river/stream flow gauge network is part of the Water Survey of Canada, and the Meteorological Service of Canada conducts meteorological forecasts), the project did not evaluate the capacity of these agencies.

Actions are also required to assist with flood preparation and response at local levels. EOCs require geomatics resources, and training should be provided to local government users to interpret flood forecast data.

Investigations

C-1.1 Investigate current capacity, coverage, value, and gaps in flood forecasting services.

C-1.2 Visualize where flood forecasting gaps exist and estimate costs for improvement to end users.

BGC Engineering Inc. led this project.



2.9 Emergency Response (Issue C-2)

In the context of an imminent or occurring flood, emergency response is defined as the actions taken to manage the consequences. This requires careful planning, timely access to relevant data, and swift communication. Most communities in BC are ill-equipped for flood response.

This project examines the roles and capabilities of responsible authorities and identifies opportunities to improve flood response planning and implementation, including with First Nations.

Investigations

C-2.1 Investigate the future direction of the federal government related to a National Flood Risk Strategy.

C-2.2 Investigate the Province's expanding role in providing flood response to First Nations.

C-2.3 Investigate the status of local authority flood response plans and recommend an approach to manage, update, and improve this information.

C-2.4 Investigate flood response capabilities considering different flood hazards and different regions of the province.

C-2.5 Investigate opportunities for improved organizational planning for emergency response in all levels of government.

Red Dragon Consulting Ltd. and Clear Sky Consulting Ltd. led this project.

The federal government can play a critical role in providing overarching consistency in flood response planning. Federal initiatives and strategies, while providing leadership and guidance, must recognize diverse geographies and needs at the provincial and local levels.

While the Province has started implementing transparent processes to work with First Nations, improvements are needed. First Nations do not want information merely to be shared; they wish to be listened to, be involved in a collaborative fashion including through co-development of plans, and have access to appropriate resources. In designing monitoring plans and disseminating information, the Province should consider Indigenous values including environmental and cultural assets.

While local authorities are generally aware of the Provincial Flood Emergency Plan, there is inconsistent understanding of what a local flood response plan should be. Most First Nations and local governments have not completed such plans.

Federal grant programs and recent initiatives from EMBC are helpful for emergency coordination. Broadly, local response capability is greater for smaller floods and for larger jurisdictions; preparedness is greater where more flooding has occurred in the more recent past. In general, First Nations' response capability is lower than most local governments. Many are not aware of available provincial or federal resources. There is confusion resulting from differences in the Province's emergency response approaches for floods and wildfires, as well as a perception that the Province prioritizes the Lower Mainland in flood response regardless of province-wide risk.

To support flood response planning, the federal and provincial governments should improve flood hazard information (e.g., expand monitoring, enhance modelling and integrate with flood forecasting, and account for climate change) and provide the information through an open portal. Some practitioners see a need for a single provincial ministry for flood response support. The Province should also develop flood response plan guidance; for First Nations, guidance should be based on hazard and risk assessments that integrate traditional knowledge and values. With improved flood hazard and forecasting information, the Province can more effectively mobilize equipment to potentially flood-impacted locations. Finally, the organizational structure of response efforts could be revisited to be more effective and consistent with other hazard emergency support, such as the BC Wildfire Service.

Photo: Lake Country, 2017.

2.10 Flood Recovery (Issue C-3)

Flood recovery and assistance programs are evolving rapidly in BC. As flood losses rise, so does the need to reduce flood recovery timelines, effort, and costs. Provincial and federal disaster financial assistance programs are currently in place for uninsurable properties to support communities' recovery from floods and reduce the risk of future floods.

This project investigates opportunities to improve the federal and provincial disaster financial assistance programs, expand the coverage of overland flood insurance available to homeowners, and implement the concept of “build back better”.

The BC Disaster Financial Assistance (DFA) program helps homeowners recover losses resulting from flood to a maximum of \$300,000. The program is backed by a similar federal program when disaster costs exceed the capacity of the province. DFA eligibility can be unclear and is dependent on the availability of insurance locally. Increasing numbers of claims and associated costs are putting both provincial and federal assistance programs under significant financial strain. The provincial and federal governments are in the process of determining how to manage properties that are at high risk of flooding – for example, through managed retreat or creating a high-risk pool for overland flood insurance for such properties. Overland flood insurance in BC has been available since 2015 and is maturing.

EMBC and the federal government have roles related to financial assistance program improvements, matching resources to high-risk areas, and “build back better” principles. Local authorities, the insurance industry, and real estate organizations also play key roles.

The provincial and federal governments should conduct complementary revisions of their respective disaster financial assistance programs to increase clarity and transparency of criteria and raise program awareness. Revisions should consider the implications that local government decisions (e.g., land use planning) have on provincial and federal assistance program criteria and liability. It is recommended that risk reduction resources, including for managed retreat, be focused in areas where the largest assistance program payouts occur.

All governments should support the expansion, and increase public awareness, of available overland flood insurance. A grant or subsidy program should be developed to provide insurance for homeowners who cannot afford it. Governments should also require disclosure of flood risk information to homeowners, and prospective renters and buyers.

To help communities “build back better”, the Province should develop guidance and policy to support local authorities in recovery planning. This includes defining “build back better” principles. Pre-flood recovery plans, which are currently virtually non-existent in BC, would improve flood recovery timelines, effort, and cost.



Investigations

C-3.1 Investigate the current status of coverage of existing overland flood insurance available to homeowners and current disaster financial assistance programs.

C-3.2 Investigate the concept of “build back better” and impediments to implementation.

Red Dragon Consulting Ltd. and Clear Sky Consulting Ltd. led this project.

Photo: Flood recovery, Grand Forks, 2018. Photo courtesy of the Province of British Columbia.

Investigations

D-1.1 Investigate resource and funding needs associated with implementing recommendations to strengthen flood management in BC.

D-1.2 Investigate evidence in support of investment in proactive flood planning and mitigation activities.

AECOM Canada Ltd. led this project.

2.11 Resources and Funding (Issue D-1)

All flood management activities and initiatives require resources and funding. In addition to funding, human resources and information resources are needed, both of which are dependent on financial resources.

This project analyzes resource and funding needs associated with actions to strengthen flood management and examines evidence in support of proactive flood mitigation.

Large magnitude flood events, which occur infrequently, tend to drive policy and funding, and this occurs post-disaster. Between 2016 and 2020, 91% of funding for BC flood projects was allocated to post-disaster (69%) and structural mitigation (22%). A proactive, planned, and coordinated allocation of resources across issues and priorities can improve effectiveness. Decision-makers seek evidence using defensible approaches to support spending today's money to reduce or avoid possible future flood damages.

This project reviews the cost estimates associated with recommendations developed within nine of the ten other projects in this initiative. The cost estimates were found to use different costing strategies and bases such as benchmarks from previous similar studies, cost and resource units (e.g., \$/km, Full-Time Equivalents), surveys, and case study interviews. Standardized approaches were not used and some cost factors were not considered. This project recommends methods to improve the consistency and quality of the cost estimates. A dynamic spreadsheet tool is proposed to achieve a common estimating basis for flood management projects and enable updates over time.

The project also reviews and summarizes literature on benefit cost analysis and other considerations relevant to establishing the business case for proactive flood mitigation. Based on a review of benefit cost analyses applied to flood management, benefit calculations are built on the foundation of flood hazard and risk assessments and scenarios representing current-day pre-mitigation versus future post-mitigation. Modelled benefit components range from structure and contents damage avoidance to transportation and critical infrastructure like water, sewer, and electrical power. Intangible benefits such as public health, quality of life, and the environment may also be documented. Other qualitative criteria, including benefits to Indigenous and other vulnerable populations, risk reduction effectiveness, and climate change resilience also need strong consideration.

It is proposed that the Province establish its own benefit cost analysis standards and guidance. This would provide clarity on the resolution of flood hazard and risk assessments needed as inputs to a benefit cost analysis and a consistent basis for benefit calculations. The Province should also explore their options concerning flood mitigation project selection and the use of more qualitative criteria.

3. Cross-Project Themes

The 11 projects in this initiative reveal common interrelated themes with regard to challenges and gaps as well as opportunities and recommendations. While consulting teams undertook projects independently, in some cases projects also benefited from common information – for example, the same firm undertaking more than one project, consulting teams interacting with each other, or shared access to survey results.

Section 3.1 summarizes findings under nine themes common across multiple projects:

- Data, information, and tools;
- In-house technical capacity of local authorities;
- Staffing resources of local authorities;
- Access to financial resources;
- Path dependency;
- Clarity and alignment of responsibilities and authority;
- Requirements and oversight;
- Direction and targets; and
- Priorities and mandates.

Challenges associated with these themes have a variety of effects on flood management, notably variable approaches to assessing, planning for, mitigating, and responding to floods. They also include insufficient coordination and collaboration; inability to translate information into action; reliance on consultants; inequitable access to resources; inability to do long-term planning, prioritize, or make smart investments; reliance on limited risk reduction tools; low public awareness; and outputs that fall short of best practice.

All of the above ultimately highlight three key concerns present in the current approach to flood management in BC: less effective use of resources, persistent and inequitable distribution of flood risk, and in some cases continued increase in flood risk.

Section 3.2 summarizes recommendations to address the challenges outlined above. A recommended action can address more than one challenge, and a challenge can be addressed by multiple types of actions. Recommendations are arranged under eight types of actions:

- Facilitate training, education, and knowledge sharing;
- Improve data, information, and tools;
- Develop vision and targets;
- Strengthen guidelines and standards;
- Support integrated flood management approaches⁶;
- Facilitate collaboration;
- Provide strategic and comprehensive funding; and
- Adapt organizational roles and responsibilities.

⁶ Flood management approaches that involve a suite of structural and non-structural mitigation options and consider other planning processes and holistic impacts and values.

3.1 Findings

Overall, project findings highlight wide variations across the province with regard to:

- The quality and availability of relevant data, information, and services;
- The capacity (information, technical expertise, human resources, and financial resources) of local authorities to carry out their flood management responsibilities;
- Approaches to flood hazard and risk assessments, planning, risk reduction, and response; and
- The administrative or legal authorities of local governments, First Nations governments, and diking authorities.

In general, larger authorities with a substantial tax base, professional staff, and full local government powers are better positioned to develop necessary information, maintain flood protection infrastructure, prepare and implement plans, and access funding programs. Smaller, rural, or remote local authorities are more likely to lack many of these advantages, yet can have similar, or in some cases greater, flood risk and related responsibilities.

The uneven distribution of capacity, authority, and access to resources is a key underlying premise that spans across many of the following findings (and associated recommendations).

Data, Information, and Tools

Prior to the early 2000s, the provincial government led the development of most flood hazard and risk information in BC. Since the 2000s, local authorities have been responsible for developing much of this information, funded largely through periodically available federal and provincial programs. This has resulted in uneven accessibility, coverage, accuracy, and quality of data, information, and tools across the province. The lack of comprehensive flood hazard and risk information hinders a wide range of flood management activities, including flood management planning, dike design and construction, land use planning, and emergency response.

- Fine-scale flood hazard information currently does not cover the entire province, with gaps where communities at risk of flooding do not have adequate floodplain maps. Many existing maps are not current (having been developed under programs prior to 2000) and/or are of variable or uncertain quality, completeness, and consistency.
- BC-specific climate change information is needed to understand how flood hazards are likely to change in the future. While there is understanding of general trends, current global climate models are low resolution, and outputs are not suitable for local- or regional-scale flood assessments. There is no built-for-purpose, readily-usable climate data for flood management practitioners.
- Relatedly, there is no province-wide information on flood risk. Flood risk assessments have been completed for a very small proportion of local authorities in BC. Those that exist vary widely with regard to flood scenarios and consequence indicators used; many are smaller “add-on” tasks to a flood hazard assessment. One major constraint to undertaking flood risk assessments is the limited availability of relevant data. Available hazard mapping may not be compatible with risk assessment goals; for example, a flood risk assessment should include multiple flood hazard scenarios, but few communities have mapped more than one or two flood scenarios. There is also no province-wide exposure and vulnerability dataset, meaning that:
 - Datasets for many key assets and indicators (developed for purposes other than flood risk assessment) are not readily available (especially on First Nation reserve lands) and, where they exist, often provide only partial information, requiring the practitioner to do additional data collection or processing;
 - Access to data owned by other entities is restricted or requires data agreements or a fee payment;
 - Datasets are not always consistent among jurisdictions, hindering multi-jurisdictional assessments; and
 - The cost-effectiveness, efficiency, and scope of flood risk assessment projects are negatively impacted by these data-related constraints.
- The coverage of hydrometric gauge data, a critical component of flood response planning and forecasting, is not consistent across the province. Provincial flood forecasting services are not applicable to steep creeks. An incomplete network of river gauges and weather stations means data may not be available where or when required.
- Information on the status and condition of flood protection dikes is essential for dike operation and maintenance and other flood management activities. While there are multiple sources of information about dikes in BC, information on deficiencies and level of protection is lacking for many. Annual dike inspection reports are highly variable and not regularly submitted by all diking authorities. Changes in provincial standards and design criteria make it difficult to understand how “adequate” a given dike may be. Where this information exists, it is not all accessible in a format that is readily useful for planners and emergency responders.

Where data is available, access is sometimes a constraint. Available information is not always made public or easily found. The former is partly a product of political and administrative concerns about liability and impacts to development potential and property values. The latter is due in part to information storage being decentralized and inadequate understanding about roles and responsibilities.

For example, land covenants, where available, alert future property buyers, but are unlikely to ensure that existing occupants are aware of the flood hazards on their property. A lack of key hazard and risk information contributes not only to challenges for practitioners, but also to low public awareness of flood hazards and risk and, in turn, inaction and misconceptions by the public and political leaders. Furthermore, delays in disseminating and accessing available data, such as Province-flown LiDAR which is required for flood hazard assessments, can also constrain opportunities to apply for funding and carry out needed projects.

Recommendations to address the above challenges are presented in Section 3.2 under:



**Improve data,
information, and tools**



**Provide strategic and
comprehensive funding**

In-house Technical Capacity of Local Authorities

Like data availability, in-house technical capacity – or staff knowledge, experience, and expertise in flood assessment, planning, mitigation, and response – varies widely across local authorities. Multiple projects note that capacity limitations are especially challenging for smaller rural, remote, and/or First Nations governments that do not have experienced flood management staff. Reasons for this include under-resourcing of technical staff within local authorities, inexperience as a result of infrequent flooding (e.g., for response), and staff turnover, among others. Where tools and data are available, not all authorities have staff who know how to use them.

The lack – or, in some cases, periodic loss – of staff technical capacity negatively impacts different functional areas, including in:

- Developing new and understanding available technical hazard and risk information;
- Understanding and applying the impacts of climate change on flood hazard;
- Knowing local flood hazards and dike management techniques;
- Reviewing development applications in flood hazard areas and requests for exemptions from floodplain policies and regulations;
- Flood forecasting, which currently relies on a substantial degree of qualitative judgment based on experience;
- Planning for and implementing flood response;
- Awareness of funding opportunities and preparing strong funding applications;
- Regional or multi-jurisdictional collaboration; and
- Bridging disciplines (e.g., engineering, planning, emergency response) and flood management activities (e.g., climate science and flood hazard assessment, flood mapping and floodplain regulations, or flood mapping and emergency response).

This results in a reliance by many local authorities on private sector consultants and qualified professionals for a range of flood management activities, which could lead to inconsistent or variable quality outputs and outcomes (for example, if two different consultants are used or if consultants do not have sufficient knowledge of the local context or access to in-house information). This reliance also raises questions about accountability and liability, for example in the use of consultant-developed flood hazard and risk analysis results for mitigation and forecasting, siting and design of flood protection infrastructure, or development approvals by consultant planners.

Even with the use of consultants, local authority staff must still first identify the need, define the scope, secure the funding, manage the implementation of the project, and in some cases translate them into policy and action, tasks that require a certain amount of knowledge. Without expertise in the review or control of project delivery, there is substantial variability in project comprehensiveness and quality.

While projects consistently note that technical expertise is lacking within many local authorities, there is some disagreement about the availability of experts in the province generally. One project notes that there is a general lack of high-quality experts within and outside government to support flood management initiatives. Others note that there is a vast network of subject matter experts and world-class expertise in some areas (e.g., downscaling of climate change projections and flood modelling), but they are not evenly distributed across the public and private sectors or geographically, and relevant organizations are often under-resourced. There is agreement across projects that there is much room to grow technical capacity in all areas. There is also agreement that, while there are practitioners and experts innovating within their area of expertise, there are limited opportunities for – and, in some cases, interest in – interacting and sharing knowledge with each other, especially across disciplines.

Projects generally identify the Province as the desired source of additional technical support, delivered either through provincial staff through province-wide or regional-scale support hubs or by funding enhanced in-house expertise within local authorities. Partnerships with non-government organizations and neighbouring communities for knowledge building are also found to be beneficial for planning outcomes and coordinated, multi-jurisdictional approaches.

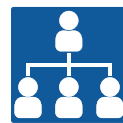
Recommendations to address the above challenges are presented in Section 3.2 under:



Facilitate training, education, and knowledge sharing



Strengthen guidelines and standards



Adapt organizational roles and responsibilities

Staffing Resources of Local Authorities

Apart from technical expertise, there is also unequal distribution of human resources more broadly in local authorities in terms of staff time and priorities. Smaller authorities, particularly many First Nations governments, have small staff teams with limited time to focus on core flood management activities alongside other non-flood-related responsibilities. Flood management is a part-time role in many positions, and associated responsibilities are not always clear.

This can also lead to inadequate attention on supporting activities, such as completing funding applications and collaborating with other jurisdictions, and to challenges in meeting regulatory requirements without additional external supports. Communities that experience frequent flooding are caught in a cycle of constant reaction, which forces disproportionate efforts toward activities such as flood response. This reduces the time available that could be spent on proactive activities such as planning, risk reduction, and recovery.

Collaboration on flood management activities is a challenge due in part to a lack of staff resources, especially for First Nations. It is difficult for staff in smaller communities to find time to participate meaningfully in the numerous flood management initiatives in BC or to lead collaborative, engagement-rich planning processes. Key parties’ knowledge and needs are therefore not always accounted for in projects, which can impact project legitimacy.

Multiple projects note turnover of staff in local authorities, including dikeing authorities, as a challenge for program success. Continued turnover means that valuable experience and capacity are lost and additional resources are needed for training.

In local governments, staffing issues also relate to interactions across departments and disciplines (e.g., engineering and planning), especially when the goals, approaches, and “language” of each group are different.

Recommendations to address the above challenges are presented in Section 3.2 under:



Facilitate training, education, and knowledge sharing



Provide strategic and comprehensive funding



Adapt organizational roles and responsibilities

Access to Financial Resources

While poor capacity can impede access to funding, challenges with access to and distribution of financial resources can also worsen the aforementioned capacity issues. First, authorities' financial capacity is not necessarily proportional to their community's flood risk; for example, a community with a small tax base may have large flood hazard areas and associated risks. Second, access to funding is largely dependent on federal and provincial funding programs (e.g., the National Disaster Mitigation Program, Community Emergency Preparedness Fund, and First Nations Adapt), which are available intermittently and for relatively short periods, provide set funding caps and eligible expense criteria, and have limited technical oversight. Funding is competitive, based on the merit of an application rather than a clear prioritization framework by need or risk (which is challenging without a consistent understanding of risk across the province). These realities contribute to:

- Local authorities “chasing money” when it is available, even if a community may not be ready or projects are not well thought through.
- Lower-resourced authorities being unable to “compete” with other applicants (typically larger or better-resourced municipalities) that have more staff time and experience, revenue streams to fulfill cost-share requirements, and/or the ability to form partnerships. This is noted especially for First Nations governments, small municipalities, and electoral areas in which the staff preparing applications often has no previous experience in this activity. Regional collaboration can help improve access to funding, as different groups are eligible for different funding sources and resources can be pooled.
- Challenges in developing and implementing long-term mitigation plans. Grant programs are structured toward siloed, one-off projects rather than a suite of holistic or integrated measures to be implemented over a longer period of time.
- Projects not meeting expected standards, quality, or anticipated scope, often forcing trade-offs between these goals. This is noted as the case particularly for flood hazard mapping, risk assessments, and dike upgrades. In some cases, consultants end up providing free services in order to complete the project.
- Inability to carry out mitigation measures that requires land acquisition, such as managed retreat or setback dikes. Typically, external funding for land purchase is only available following a disaster.

Recommendations to address the above challenges are presented in Section 3.2 under:



Provide strategic and comprehensive funding

Path Dependency

Flood management is an evolving field, with climate change, new technologies, risk-based methodologies, and multilateral initiatives such as the Sendai Framework and the United Nations Declaration of the Rights of Indigenous Peoples (UNDRIP) driving changes internationally in recent years. While practices in BC have evolved and will continue to evolve, historical or established practices create obstacles that constrain responsiveness, innovation, adaptability, and advances in equity in a range of flood management activities. Key challenges noted across projects include:

- **Legacy of colonialism:** The creation of First Nations reserves in flood hazard areas, exclusion of communities from flood protection infrastructure, misuse of Indigenous knowledge and information, and exclusion from policymaking and data gathering efforts have created significant challenges for flood management in Indigenous communities. There is limited flood hazard and risk information available for most First Nations reserve lands. Many existing asset datasets do not cover on-reserve assets, and those that do are not readily accessible. Indigenous values (for example, belief systems that consider long-term stewardship of traditional territories) are rarely reflected in funding programs and flood-related policy. Most First Nations governments do not have the same legal tools, revenue sources, and available land as local governments to reduce flood risk. Some risk reduction options such as managed retreat are not available to many First Nations which do not have additional land suitable for development. Currently, most interaction between the Province and First Nations happens during and after flood events. Despite the Province having adopted UNDRIP and DRIPA, there are currently no systems, tools, or guidance to operationalize associated principles in flood management.

- **Development on floodplains:** Historic development on floodplains has created challenges for reducing flood risk, for example by limiting options such as elevating roads, redevelopment, and land use regulations. As risk increases with climate change and with further development in flood hazard areas, technical and political challenges in retrofitting, establishing development restrictions, and elevating or setting back redevelopment in such areas also increase. Existing development on floodplains has also made it challenging to adopt more innovative structural measures such as setback dikes and super dikes.
- **Reliance on structural measures:** The focus in BC over the last half century has been the development of flood defence infrastructure such as dikes, with limited focus on non-structural approaches such as land use regulations. This practice both is a result of historical development in the floodplains and has allowed for continued development in areas behind dikes, despite the presence of residual risk even if the dike is well-maintained. Regulation and funding continue to promote the use of structural measures for flood control. Based on a high-level analysis of funding spent on flood management activities between 2016 and 2020 in BC, over \$140 million was spent on structural flood management approaches, while non-structural approaches represented a fraction of this amount. There is a need to better understand and adopt non-structural approaches beyond the toolbox commonly drawn from. For example, despite their value and use elsewhere in the world, alternative approaches to floodproofing (apart from the use of flood construction levels) are rarely applied, poorly defined, and not incentivized in BC.
- **Decisions based on monetized values:** Cost has been the primary criteria for flood mitigation project selection. Naturally, this has led to a focus on projects that can be monetized and compared through economics-based analyses such as benefit cost analysis. As a result, there has been less consideration for intangible values in project selection. For example, green infrastructure projects can provide important flood mitigation, environmental, and other benefits that have not been monetized. Indigenous communities often value environmental and cultural benefits equally to or more than economic benefits.
- **Focus on emergency response and recovery:** Despite recent funding programs for flood mitigation (totalling an estimated \$204 million between 2016 and 2020 in BC), there is still significant activity and investment in flood response and recovery and more limited activity related to proactive planning and mitigation. Based on a high-level funding analysis, approximately \$450 million was spent on flood response and recovery (including disaster financial assistance) in BC between 2016 and 2020, which represented 69% of the total spending on flood management activities. Response and recovery costs could reasonably be expected to decline over time with increased investment in proactive flood mitigation.
- **Hazard-based approaches:** Responsible authorities in BC historically employed hazard-based approaches to flood management. For example, the design standard for provincially-registered regulated dikes for most of the province is to protect against the 200-year flood (0.5% Annual Exceedance Probability). There is a strong argument that a risk-based approach, which accounts for multiple flood events as well as their consequences and is increasingly adopted around the world, is needed and would benefit BC, but there are challenges to a smooth transition.
- **Climate change:** Global climate change science and projections are advancing at a rapid pace that provincial guidelines, policy, and regulations for flood practitioners (both technical and planning/policy) have not kept up with. The limited content largely reflects the historical, now-outdated expectation that future flooding would occur with the same frequency and magnitude as historical flooding. Although many authorities consider climate change in their flood plans to some extent, and simple guidance for flood hazard assessments is available, there remains great variability in the way that flood management activities account for climate change impacts.

Recommendations to address the above challenges are presented in Section 3.2 under:



Improve data,
information, and tools



Develop vision
and targets



Strengthen guidelines
and standards



Support integrated
flood management
approaches



Provide strategic and
comprehensive funding

Clarity and Alignment of Responsibilities and Authority

A common finding across multiple projects is the lack of clear understanding of – and central information source on – flood management roles and responsibilities across and within orders of government. There is also insufficient understanding of potential alignments and synergies among government and non-government parties that have flood management roles. Despite increased engagement over the past few years, some project participants noted they do not know where to get relevant information at the provincial or federal government.

This limited understanding has led to delays or inaction with respect to identifying, assessing, and mitigating flood risk. Examples include local governments setting development regulations (e.g., due to confusion on who is responsible for establishing the criteria for setbacks and flood construction levels) and diking authorities maintaining flood protection infrastructure (e.g., due to uncertainty about who is responsible for sediment management to maintain dike design flood levels in aggrading river channels).

A clear understanding of who does what and when is particularly crucial for flood response. While tripartite agreements that recognize First Nations governments as equivalent partners in emergency management provide a foundation about roles and responsibilities, they are limited in their ability to enhance collaboration during a flood event.

There are also concerns about perceived overlaps in responsibilities. The federal government has developed a series of national guidelines on flood mapping and is exploring the development of associated standards. However, there is concern about potential inefficiencies at the provincial level when or if more specific guidelines need to be created to support local authorities and other practitioners in BC.

Projects also note some cases of misalignment between responsibilities and authority – or what is expected and what is legally possible. For example, many diking authorities do not have complete legal access for inspections, maintenance and upgrading of the dikes. Diking authorities also generally have no authority to manage vegetation or remove structures built on dikes located on private land, both of which can impact dike safety.

Recommendations to address the above challenges are presented in Section 3.2 under:



Improve data,
information, and tools



Adapt organizational roles
and responsibilities

Requirements and Oversight

There are regulatory processes and requirements for certain flood management activities, such as dike construction and upgrades, but decisions on many other activities are left up to the responsible local authority. The current flexible, decentralized approach enables local authorities to apply their knowledge of the local area's hazards and risks and community values to tailor solutions to their jurisdiction. Local governments in particular have a wide variety of tools, yet they have limited or no oversight or requirements to use them.

This “soft” regulatory regime, together with the capacity issues described above (and other factors described below such as liability and competing priorities), has contributed to limited consistency, efficiency, or uptake of certain approaches in many areas. When coupled with the fact that many provincial guidelines are out of date or do not yet exist, this approach constrains innovation and adoption of relatively newer concepts or activities such as flood risk assessment, integrated flood management planning, and nature-based approaches. Effects were noted in the following areas:

- **Flood hazard and risk assessment:** There is insufficient guidance, standards, and specifications for flood hazard and risk assessments and no mechanism to assess or assure that the quality of maps and information produced is suitable for the use intended. Current guidance allows a significant amount of interpretation and application of professional judgment. For site-specific flood hazard assessments, there is an expectation but no criteria to consider potential transfer of risk, and there is no mechanism to consider the cumulative impacts of multiple projects along a floodplain.
- **Dike inspection reporting:** Diking authorities are required under the *Dike Maintenance Act* to complete annual dike inspection reports to ensure adequate dike performance. However, this is not enforced. In recent years, 20% to 40% of diking authorities have not submitted the required annual inspection reports, and many of the reports submitted (20% to over 50%) have not been satisfactory.

- **Integrated flood management plans:** There is currently no guidance or requirement for flood management planning, and the Province does not have a formal role in developing, reviewing, approving, or implementing flood management plans, leading to considerable variability in completed plans.
- **Flood response plans:** There is currently no guidance or requirement for flood response plans. Definitions and standards range widely, with low numbers of governments holding instantly recognizable flood response plans.
- **Flood recovery plans:** Very few municipalities have undertaken significant recovery planning that incorporates “build back better” principles. Many cite the lack of capacity and time, relative newness of the concept, and lack of guidance as impediments.
- **Planning and development:** Not all local governments use available tools such as floodplain bylaws and development permit areas to manage flood risk. While the current Flood Hazard Area Land Use Management Guidelines is appreciated and often referenced, guidelines can be ignored or variably interpreted if there is no requirement to ensure they are met. At the same time, best practice or novel flood management concepts are not always reflected in provincial guidelines. Although not regulatory, these guidelines have weight in the eyes of decision-makers concerned about liability and of funders, who may be reluctant to fund projects that vary from provincial guidance.

This approach, together with local authorities’ limited capacity and other factors, also contributes to missed opportunities for coordination and collaboration among neighbouring authorities. There are examples of successful collaborative flood mapping and mitigation planning initiatives in BC and most authorities recognize the advantages of working with adjacent jurisdictions on flood management issues. In general, however, coordination among local authorities is ad hoc. For example, there are cases where recent floodplain mapping has been prepared for one side of a river but not for the adjacent municipality on the other side (even though the hydraulic modelling completed was applicable for both sides), and where one section of a shared dike was upgraded to higher standards, but the other section, owned by a different diking authority, remained at the original grade, leaving both municipalities vulnerable to the lower flood event.

While projects note a general preference by local governments to retain their existing authorities and autonomy over many activities including development approvals, they also highlight a broad desire for greater provincial government leadership and support, including, among some, increasing provincial standards and regulation related to disclosure and land use planning⁷.

Recommendations to address the above challenges are presented in Section 3.2 under:



Strengthen guidelines and standards



Support integrated flood management approaches



Facilitate collaboration



Provide strategic and comprehensive funding



Provide strategic and comprehensive funding

Direction and Targets

The current decentralized approach to flood management in BC also means that it is up to each local authority to set its own direction – vision, goals, targets, and evaluation processes – for flood management activities. As with other activities, there is variability in both the uptake and actual content of these matters.

The Province is currently developing a BC Flood Strategy, which will provide direction for the development of a provincial action plan, and the federal government has adopted an all-hazards emergency management strategy⁸. However, at this current time, there is no national or provincial flood risk strategy or operational targets for flood risk at the federal or provincial levels. Existing guidelines tend to be focused on process rather than outcomes. Although both the provincial and federal governments are signatories to the Sendai Framework, this has yet to be transformed into clear strategy, policy, or targets at either level.

⁷ For more information, refer to project B-6, which examines changes pre- and post-2003, when the *Flood Hazard Statutes Amendments Act* was established, and project A-1, which examines the current overall governance structure in more depth.

⁸ Emergency Management Strategy for Canada: Toward a Resilient 2030. <https://www.publicsafety.gc.ca/cnt/rsrscs/pblctns/mrgncy-mngmnt-strtyg/index-en.aspx>

As previously noted, flood management in BC has largely adopted a hazard-based approach. While there are some broad concepts of the use of flood risk tolerance to prioritize risk reduction activities within professional guidance documents (e.g., EGBC Flood Assessment guidelines⁹ and MFLNRORD Sea Dike Guidelines¹⁰), there are currently no risk targets in BC or guidelines for their development. As such, the likelihoods and consequences of flood events are not always considered in planning. While responsible authorities may be interested in applying a risk-based approach and defining flood risk tolerance criteria, the lack of guidance on risk tolerance is a barrier.

Finally, the extent and effectiveness of floodplain management across BC does not appear to be monitored to ensure targets are being met and to identify and remedy shortcomings. Although there was a review of the Fraser River Flood Control Program in 1994, there has been no broader, formal (or at least publicly available) evaluation of flood management programs to learn from past successes and failures. On the local scale, formal indicators are rarely used for performance monitoring, in part due to limited staff capacity and in part due to the lack of baseline risk information.

Recommendations to address the above challenges are presented in Section 3.2 under:



Develop vision and targets



Strengthen guidelines and standards

Priorities and Mandates

All authorities with limited resources face the inherent challenge of integrating and aligning multiple priorities and responsibilities. The reality of multiple – and sometimes competing – priorities and mandates compounds many of the challenges described above. Particular challenges for flood management are noted in the following areas:

- **Structural project permitting:** Flood-related infrastructure projects, particularly instream works, typically require several permits and/or approvals. Many different agencies and interests are involved, which can prolong the time to obtain various approvals by years. This can be particularly challenging with distinct and sometimes competing objectives such as those under the *Dike Maintenance Act*, *Fisheries Act*, *Water Sustainability Act*, and *Heritage Conservation Act*.
- **Disclosure of flood hazards:** Local governments can disclose flood hazard and risk information to the public and other interested parties but often do not do so out of concerns about reduced property values and development potential or liability (i.e., identifying and disclosing hazard and risk on a floodplain, and then not being able to address the risk in time, could open the door to legal contests). This concern also serves as a disincentive for conducting hazard and risk assessments in the first place. Both of these realities contribute to low awareness of – and action on – flood risk.
- **Land use regulation:** Local governments have many incentives and pressures to accommodate growth (which increases their tax base), and floodplains are often more appealing or accessible places to develop or redevelop than other areas. Requirements for floodproofing and restrictions on land use and development on flood hazard areas can impact property values and development feasibility, and governments often face resistance to restrictions, especially from existing landowners. This is exacerbated by the fact that accountability (in the form of financial assistance) for recovery from damaging flood events is generally perceived to be held by the provincial and federal governments or through private insurance.
- **Insurance:** There are (explicit and implicit) expectations from the federal and provincial governments that the private sector will manage residual financial risk through overland flood insurance policies. However, private insurers' mandate is to be profitable, which affects the degree to which their pricing models align with government policy and to which they may be willing to finance residual risk in high-risk areas at all.

Recommendations to address the above challenges are presented in Section 3.2 under:



Strengthen guidelines and standards



Provide strategic and comprehensive funding



Adapt organizational roles and responsibilities

⁹ EGBC. 2018. [Legislated Flood Assessments in a Changing Climate in BC Professional Practice Guidelines](#).

¹⁰ BC Ministry of Environment. 2011. [Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazards: Sea Dike Guidelines](#).

3.2 Recommendations

This section presents a best attempt at grouping similar types of recommendations from the 11 projects. Not all of the over two hundred identified opportunities and recommendations have been included. Very similar recommendations have been merged, and some were excluded because they are less directly relevant to the identified themes or are less clear or specific. As recommendations originated from multiple consulting teams, there may be recommendations that, if implemented, negate the need or value of others. More than one approach to addressing an issue may be presented. This report is limited in the extent to which it adjudicates among similar or incompatible recommendations. Readers should refer to the cited project report for the original wording as well as additional recommendations.

Recommendations from the original project reports were developed using a variety of analyses, including scans of other jurisdictions, engagement with practitioners, and consulting teams' own expertise and experience. In some cases, consulting teams sought further feedback on draft recommendations in a targeted way. However, as no comprehensive province-wide consultation was undertaken to determine support and feasibility, the recommendations should not be interpreted as having broad-based support.

Although the vast majority of recommendations are directed toward the provincial government, most aspects of flood hazard and risk management involve shared responsibilities and collaboration by all orders of government, professional associations, academic institutions, and other private and public sector organizations. Roles could include funding, technical support, province-wide or regional coordination, planning, and delivery at multiple scales. For many recommendations, the goal is to enable more effective flood management by local and First Nations governments and diking authorities. Some recommendations ultimately would include implementation roles by multiple jurisdictions. Further discussion is required to achieve clarity on jurisdictions' role in initiating, leading on, or collaborating on implementation.

The recommendations are presented under eight headings. Together, the recommendations help achieve:

- Adoption of risk-based flood management at multiple scales supported by direction, targets, guidance, and standards;
- Greater adoption of proactive, coordinated planning and a suite of non-structural and structural flood risk reduction measures spanning the concepts of “protect, accommodate, retreat, and avoid”;
- Enhanced quality, coverage, and accessibility of data and information;
- Enhanced capacity in the form of funding, staffing resources, knowledge, skills, and tools so all responsible authorities and actors can manage flood risk more effectively;
- Addressing variations across the province as noted at the outset of Section 3.1; and
- Staying up to date with emerging science, legislation, and best practices.

In this section, the source investigation from which a given recommendation is drawn is provided in parentheses.



Facilitate Training, Education, and Knowledge Sharing

Training and education can help improve technical capacity, public awareness, and innovation; bridge gaps across disciplines or competencies; and keep up with an evolving field of practice. Recommendations are provided for three main groups, some Province-led and some practitioner-guided. Professional associations could also play a key role in many of these actions. For practitioner networks, existing networks spanning public, private, and other sectors should be leveraged.



To support technical professionals (including in the private sector):

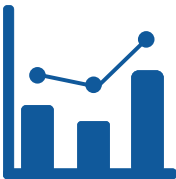
- Develop and support technical training for professionals to integrate climate change science and trends into flood assessments, including downscaling methods. (B-1.3)
- Support the development of collaboration practitioner networks bridging climate change science and flood hazard expertise from the public and private sectors, academia, and research institutions, focused on advancing climate change considerations within flood assessments and planning. (B-1.3)
- Develop and support training in flood hazard mapping to improve map quality. (B-2.2)
- Support knowledge sharing activities and workshops to increase capacity in flood risk assessments. (B-3.5)
- Increase the geographical coverage of regional collaborative groups, attended by subject matter experts and practitioners, for knowledge sharing of flood response planning and activities. (C-2.4)

To support local authority staff:

- Develop literacy training for local authority representatives on climate change impacts on floods to support them in consultant procurement for flood hazard assessments, reviewing outputs, and acting on findings and recommendations. (B-1.3)
- Expand the frequency, duration, and content of dike inspection and maintenance training opportunities for diking authorities. A comprehensive dike safety training and certification program should be considered. If financial capacity is a barrier to participation, consideration should be given to subsidizing travel expenses. (B-5.2)
- Develop and provide an online introductory training course in dike inspection and maintenance. Given considerable staff turnover in diking authorities, this would provide new staff with immediate access to basic training until they can participate in a regional dike safety workshop. (B-5.2)
- Provide training courses to local authorities in the interpretation and use of flood forecast data. (C-1.1)
- Develop and implement protocols for capturing in-house experiential knowledge in flood forecasting to mitigate loss of institutional knowledge resulting from staff turnover. (C-1.1)
- Develop a group of subject matter experts with flood response experience to support all orders of government in interpreting weather, snowpack, river, tidal, and geoscientific information to inform response planning and actions. Group members could deliver direct advice to the Province and directions to the communities at risk. (C-2.5)
- Develop training and exercises to validate flood response plans, train staff, and test procedures. (C-2.4)

To support the public and others:

- Develop an educational framework (with technical support and funding) to support local authorities in developing and delivering local-scale flood education campaigns. Topics, formats, and other considerations are detailed in project B-6. (B-6.4)
- Develop training for political leaders and administrators on navigating competing priorities, political sensitivities, and other challenges faced by decision-makers in flood management. This could be delivered by provincial staff and/or a peer network group. (B-4.2)
- Develop training for Indigenous communities on flood response through provincial and Indigenous collaboration. Training could include identifying community needs and training volunteers to install temporary flood barriers. (C-2.2)
- Develop climate literacy education for the public related to impacts on floods using web-based information services, public engagement, and engagement of climate change and flood specialists with leaders in close contact with the public. (B-1.3)
- Undertake an information campaign on the Province's DFA program for the public and for local government emergency programs, including clarifying the program's eligibility criteria. (C-3.1)
- Undertake a public education campaign to educate homeowners, business owners, agricultural producers, and local authorities about overland flood insurance in partnership with the Insurance Bureau of Canada and others. (C-3.1)



Improve Data, Information, and Tools

This section summarizes recommendations to improve the quality, consistency, and coverage of – and public access to – data, information, and tools. With regard to flood hazard and risk assessments, it is important that the information developed is suitable to facilitate subsequent activities, including flood management planning, infrastructure design, policy and bylaw development, flood forecasting, and emergency response.

To improve flood hazard and risk information:

- Develop BC-specific climate modelling, downscaling, and analysis frameworks and methodologies to improve consistency and reduce uncertainty in flood hazard assessments. (B-1.2)
- Update existing flood hazard maps and map additional areas including Indigenous communities to improve the flood map coverage in BC, with an increased provincial government role to achieve consistent, high-quality mapping. (B-2.2) Flood hazard assessments should be conducted with flood risk assessment needs in mind. (B-3.5)
- For coastal flood hazard assessments, responsible authorities should complete assessments for a range of relative sea level rise scenarios to facilitate risk-based approaches and adaptive management. (B-1.2)
- Undertake a province-wide screening-level flood risk assessment, led by the Province, that includes multiple flood hazard scenarios. This would cover areas outside of population centres that local flood risk assessments might not cover but may have other important vulnerable assets. It would provide a consistent risk profile for BC and help inform planning, prioritization, and funding decisions. (B-3.2)

- Responsible authorities should complete local detailed flood risk assessments that include multiple flood hazard (including climate change) scenarios, a diverse set of indicators, and engagement with First Nations and stakeholders. To ensure adequate quality and usefulness, these assessments should not be treated as an “add-on” task to a flood hazard assessment. (B-3.5) In the meantime, the MFLNRORD-led Community Binders approach¹¹, currently limited to the Lower Mainland, should be expanded to cover the entire province to support First Nations’ flood planning. (C-2.3)
- Develop a province-wide exposure and vulnerability database to support flood risk assessments in consultation with risk assessment practitioners, local authorities, and others. It should include a wide range of datasets, protocols for data sharing, and mechanisms for keeping it up to date. Collaborate with other initiatives (e.g., Natural Resources Canada and the forthcoming BC Disaster Risk Reduction Hub) that are working on related initiatives. (B-3.2)
- Establish and apply a standardized Dike Rating System and develop a method to estimate the level of protection. Better information on dikes would support a wide range of flood management activities as well as public awareness of flood risk and insurance provision. (B-2.3)
- Enforce the submission of satisfactory dike inspection reports to incentivize better dike maintenance. If diking authorities fail to comply, retain consultants to complete the inspections and charge the costs back to the diking authorities. (B-5.1)
- Increase the number of dike safety audits to help build knowledge and relationships among deputy inspectors of dikes and diking authority representatives. (B-5.2)
- Improve the coverage of streamflow and snow gauges in small watersheds. (C-1.1)
- Expand provincial weather, climate and water observation/monitoring efforts with a target of improving climate model validation and downscaling for flood-relevant applications. (B-1.2)
- Develop a provincially operated flood early warning system to couple flood forecasts to existing hydraulic models. (C-1.1)

For emergency response planning, there is a need to understand not only communities’ flood risk but also their capability – to know which communities, and in which functional areas, support would be needed. It is recommended that a province-wide capability assessment be conducted for provincial ministries, First Nations and local governments, diking authorities, and utility providers to better understand the state of readiness and distribution of capacity and resources for flood response. (C-2.4)

To improve access to existing information:

- Make flood maps available to the public online. (A-1.4, B-2.2)
- Make publicly funded flood risk assessment reports available to the public. (B-3.3)
- Publicize provincial dike inspection reporting compliance information (to incentivize compliance with provincial reporting requirements). (B-2.3, B-5.1)
- Improve on current practices of disclosure of flood hazard information on properties, for example through legislative or policy changes. (B-6.3)
- Provide clear, easy to find, and up-to-date information on government and non-government roles and responsibilities in flood management, including in the Provincial Flood Emergency Plan. The A-1 project developed a comprehensive framework to visualize flood management roles and responsibilities which could be refined in consultation with all involved parties and kept up to date. (A-1.5, B-6.3, C-2.5)
- Provide all flood-related data and information in a common central location. There are recommendations for this to take place at both the provincial and federal levels. (B-3.3, C-2.1)

¹¹ A tool to develop information on flood hazard, flood risk, and relevant important values on First Nations lands.



Develop Vision and Targets

To strengthen the Province's leadership in flood management and address challenges associated with the lack of a central direction, the following recommendations are provided:

- Develop a vision for flood management in BC that acknowledges reconciliation with Indigenous peoples, sets direction, and supports future accountability. The vision document should include information on roles, responsibilities, and expectations. (A-1.5)
- Additionally, develop a provincial strategic vision specifically for flood response. (C-2.5) Review and update the Provincial Flood Emergency Plan to include responsibilities for all levels of government, each with clear accountability for decision-making. (C-2.5)
- Develop a set of operational targets for flood management. Targets from the Sendai Framework could be used as a first step to developing BC-specific targets and indicators. (A-1.5)
- Define minimum flood risk tolerance criteria for use in integrated flood management planning and decision-making. The issue of risk tolerance is a societal one and minimum acceptable values are best defined at a provincial or national level. (B-3.1, B-4.3)
- Review and re-evaluate, in partnership with First Nations, the BC Emergency Management System goals' alignment with Indigenous priorities. Understanding Indigenous community priorities is fundamental in bridging a divide in emergency management, for example in the weighting of cultural safety, food security, and sacred values. (C-2.5)

The role of the federal government in setting direction through a national flood strategy should also be considered. Any future national strategy should guide the delivery of a BC strategy that balances national consistency with local context and closes inter-governmental gaps. The national strategy should support integrated, collaborative, all-hazard, and all-of-society approaches, and provide a range of relevant flood resilience actions that may be applied in BC. (C-2.1)



Strengthen Guidelines and Standards

Projects highlight the need for more consistent understanding regarding the process and content of floodplain mapping, flood risk assessment, flood management plans, and flood response plans. They also emphasize the need for policy and guidance to reflect current and emerging advances and best practices. Strengthening guidelines and standards can help improve the consistency, quality, and uptake of various flood management actions and outputs – and in turn lead to more effective use of project resources. Guidance should account for the diversity of geography, flood mechanisms, needs, hazard and risk levels, and resources of jurisdictions across the province.

To strengthen flood hazard and risk assessment:

- Develop guidelines and frameworks for ensemble approaches to climate change scenarios in flood hazard assessments. (B-1.4)
- Update all relevant provincial guidance, policy, and regulations to reflect current flood-relevant climate change science and data, including sea level rise information and standards for producing, managing, and reporting climate and hydrology data. (B-1.4)
- Develop more specific flood mapping guidelines that include specifications (e.g., for bathymetric surveys, climate change analyses, hydrology, geomorphic assessments, modelling standards) and provide for different categories of floodplain mapping studies based on the conditions of a particular community. More prescriptive standards are recommended in addition to guidelines. (B-2.2) To support qualified professionals in evaluating potential transfer of risk, guidance on floodplain encroachment analysis that accounts for the cumulative impacts of development along a floodplain should be considered as part of floodplain mapping standards. (B-6.3)

- Review and develop LiDAR guidelines and specifications, including procedures for LiDAR acquisition and dissemination, to improve the use of LiDAR data in flood-related studies, assessments, and maps. (B-2.4)
- Develop professional practice guidelines for flood risk assessment. Including minimum quality standards will help address the current range in quality. These could be adapted from the new federal guidelines¹² for the BC context. (B-3.3, B-3.5)

To strengthen flood planning and mitigation:

- Develop guidelines for risk-based flood management that include templates and decision-support tools that encourage holistic approaches to flood management. (B-3.1)
- Develop guidelines and a roadmap to guide the development of integrated flood management plans. The B-4 project report recommends guideline content and minimum requirements for three types of plans. (B-4.3)
- Co-develop, with Indigenous peoples, guidance on free, prior, and informed consent for flood planning and on the inclusion of Indigenous knowledge in technical projects. (A-1.5, C-2.2)
- Develop guidance and standards for benefit-cost analysis to improve mitigation project selection. Benefit methods should be established for the main tangible and intangible benefit categories to be included in all benefit-cost analyses. Besides standardizing benefit-cost analysis approaches, the Province also needs to consider the overall direction and focus of flood mitigation projects. Methods will change depending on whether a project is mitigating flood hazard or asset damages. Priorities may vary depending on project or asset types (e.g., residential, commercial, or governmental). (D-1.2) Alternatively or in tandem, develop a broader guideline for decision-making processes that incorporates Structured Decision-Making (and similar processes) and Scenario Analysis. (B-3.5)
- Develop guidance on structural approaches other than conventional diking, including the engineering and design of super dikes, floodwalls, habitat-friendly alternatives to riprap erosion protection, compartmentalization, and alternative approaches to standard sea dikes. This should build on work done by other organizations to date. (B-5.4)
- Develop guidelines and design standards for dike construction and upgrades to accompany a recommended new policy to require designing for climate change. (B-5.1)
- Amend the definition of “adequate” dike in the EGBC Flood Assessment guidelines¹³ with reference to the new provincial dike rating system, when available. Assessments and approval conditions outlined in the guidelines depend on whether the flood protection works are considered to be “adequate” as defined in the guidelines. (B-2.3)
- Update the Flood Hazard Area Land Use Management Guidelines¹⁴. In particular, strengthen guidance on risk-based approaches, wet and dry floodproofing, establishing setbacks, and translating floodplain mapping and designation into planning tools such as floodplain bylaws, development permit areas, and official community plans. (B-6.3)
- Update the BC Building Code, including provisions for climate change considerations, wet and dry floodproofing, and “building back better” to strengthen flood resilience when reconstructing on a floodplain. (B-6.3)

¹² Natural Resources Canada. 2021. [Federal Flood Damage Estimation Guidelines for Buildings and Infrastructure Version 1.0](#).

¹³ EGBC. (2018) [Legislated Flood Assessments in a Changing Climate in BC Professional Practice Guidelines](#).

¹⁴ MFLNRORD. 2018. [Flood Hazard Area Land Use Management Guidelines](#).

To strengthen flood response and recovery:

- Develop flood response plan standards or guidelines to facilitate consistent approaches that are based on flood hazard and risk studies and include provisions for integrating traditional knowledge and western science. (C-2.3)
- Develop guidance on recovery planning and recovery operations, especially as they relate to the concept of “build back better”. This would provide much needed clarity on what it actually means to “build back better” during flood recovery (C-3.2)

With regard to the federal versus provincial government role in providing guidance, there are recommendations that some guidance provision should be the responsibility of the federal government to set a national direction and influence provincial approaches, for example for flood response plan standards, cost-benefit analysis for proactive mitigation versus flood response, flood risk assessment, and climate science interpretation. (C-2.1) It is suggested that the Province participate actively in any federal guideline development initiatives to ensure that guidelines can be more easily adopted, with minimal adaptation, in the BC context. (A-1.4)



Support Integrated Flood Management Approaches

To supplement data and guidelines, additional recommendations are presented to expand beyond the relatively limited toolbox of non-structural and structural flood mitigation measures. Considering that a key first step to successful implementation of mitigation measures is planning:

- Implement a mechanism that will require responsible authorities with development in flood hazard areas to develop and report progress on integrated flood management plans. An alternative approach is to make IFMPs a requirement for structural mitigation funding. (B-4.4)
- Implement an Integrated Flood Management Planning Program. A formal program would set standards, define, and prioritize projects, and allocate annual funding to complete projects in collaboration with local authorities and other partners. Structural projects would be integrated with non-structural approaches within an integrated flood management planning framework, such as weighing the benefits of dike upgrading against the costs of land acquisition and moving vulnerable assets. (B-4.2, B-5.3)

While planning is a key step, there also needs to be programs to support the implementation of specific types of proactive flood mitigation measures. Recommendations that help encourage the use of innovative or less conventional measures include:

- Develop incentives for floodproofing existing structures, such as tax incentives, rebates, or exclusion of post-disaster funding to properties not floodproofed before a flood event. (B-6.3) Alternatively or in tandem, introduce legislation to allow the DFA program to compel funding recipients to use flood-resistant materials for remediation and make other changes to their properties to reduce the impact of future floods. (C-3.1)
- Create, with support from other orders of government, a managed retreat program to remove habitation and development from high-risk locations, particularly for locations that have been devastated by flood events. (C-3.2) Alternatively or in tandem, local governments should review options for managed retreat from flood hazard areas over time, potentially by incorporating flood risk reduction objectives with other objectives (e.g., parks planning and an accompanying park lands procurement fund). (B-6.3)
- Support, in partnership with local authorities and/or academia, pilot projects and monitor existing projects to support continuous learning. Recommendations include nature-based flood protection infrastructure, smart dikes, and bio-grouting (B-5.4) and small-scale policy tests (e.g., strengthening flood hazard disclosure practices in one region). (A-1.4)

Facilitate Collaboration

Greater collaboration among organizations can help overcome capacity deficiencies and the challenges of diverse and competing mandates and objectives. It can also help improve coordination and innovation and advance an all-of-society approach. Despite recent good examples, collaboration among authorities tend to be ad hoc and not formalized. To strengthen collaboration among governments and between government and non-government entities:



- Leverage existing watershed or regional relationships to support regional networks for flood management and expertise learning and sharing. For example, regional planning committees or forums where individuals have already established relationships could potentially be expanded to consider some elements of flood management. (A-1.4)
- Model and build on collaborative flood management initiatives that are being led by Indigenous communities. For example, some Indigenous communities have collaborated with local governments within their watershed on flood risk assessments that incorporate traditional knowledge and western science; others are proactively reaching out to neighbours and senior governments to build relationships and strengthen their flood response activities. (A-1.4)
- Strengthen government relationships with researchers and support and build on multi-disciplinary initiatives in post-secondary institutions to increase professional capacity related to flood management. There are significant relevant activities at BC's post-secondary institutions and in federal research institutions. (A-1.5)
- Incentivize or fund academic researchers to develop more applied academic research. This could include targeted partnerships between researchers and provincial programs. Academic researchers are typically incentivized to publish in academic journals to support traditional researcher metrics and continued federal research funding. More flood and climate change practitioner-relevant research could increase the quantity and quality of knowledge that could be applied to flood management in BC. (B-1.3)
- Professional associations should develop resources to support their members' understanding of the *Professional Governance Act*, climate change impacts, and a broader suite of flood risk reduction tools, as well as their ability to undertake multi-disciplinary, collaborative work. (A-1.5)
- First Nations and local governments should collaborate to advance each other's objectives on a regional basis, starting with grant application processes. (C-2.3)

The next two sections provide additional recommendations to improve collaboration.

Provide Strategic and Comprehensive Funding

To address current challenges associated with access to financial resources, many projects cited the need for consistent, flexible, multi-year funding sources for all components of locally-driven flood management activities. In general, it is recommended that more provincial resources be distributed to proactive flood management activities, including flood hazard and risk assessment, flood management planning, and mitigation measures. (D-1.2)



Specific areas for which targeted funding needs are highlighted include:

- Maintenance, operation, and upgrade of the BC Storm Surge Model. (C-1.2)
- Development of local or regional IFMPs (alongside a phased requirement for their development). (B-4.4)
- Development of local or regional flood response plans. The Union of BC Municipalities' Evacuation Route Planning funding program is recommended as an example to consider. (C-2.3)

- For under-resourced local authorities to dedicate staff time or hire third-party professionals to prepare flood-related grant applications. Supporting access to funding is crucial to help level the playing field and support more equitable outcomes. Alternatively or in tandem, training and/or direct technical support on grant application development would also be beneficial. (A-1.5, C-2.4)

Projects also recommended that existing and new funding programs:

- Incorporate some form of prioritization. For example, base funding for risk reduction initiatives on areas receiving frequent or high-cost DFA payouts (C-3.1) or on identified risk after a province-wide flood risk assessment has been completed. (A-1.5, B-3.3).
- Support a wider range of eligible expenses, including land acquisition (e.g., for setback dikes or managed retreat). (A-1.5, B-5.4, B-6.3)
- Be flexible to match the scope needs of the project. This includes allowing for the project to work at different scales such as a First Nation's traditional territory, incorporate Indigenous knowledge, or serve the community's planning needs (e.g., flood management plans that are developed as part of other community planning activities). (A-1.5, B-4.2, C-2.1)
- Address unmet needs in the province, including stronger consideration for intangible values that can inform decisions beyond a benefit cost analysis framework. (D-1.2)
- Provide sufficient funding amounts to allow for complete, high-quality projects that meet guidelines, standards, and best practices (e.g., funding that supports flood risk assessments to be completed as a project in its own right, or is aligned with actual dike upgrade costs to meet provincial dike standards). (B-3.5, B-5)
- Encourage coordination and collaboration between jurisdictions. There is potential for the Province to coordinate or lead "bundled" or regional-scale applications among multiple communities. (A-1.5, B-5.3)
- Enable timelines that support multi-year projects. This is particularly important for local governments with diverse or complex flood hazards and/or a limited tax base. More flexible timelines would allow for adequate hazard and risk assessments, incorporation of new information into planning, and sufficient community, First Nations, and stakeholder engagement. (B-4.2, B-6.3)
- If, or when, an integrated flood management planning program and/or new standards for land use regulations have been developed, make integrated flood management planning (and the adoption of floodplain bylaws or equivalent) a prerequisite for funding for structural flood mitigation works or for DFA after a flood event. This would help ensure that structural approaches are undertaken only in conjunction with full consideration of non-structural ones. (B-4.4, B-5.1)

A comprehensive provincial funding program for locally-driven flood management activities could incorporate the above considerations. Such a program would be risk-based, aligned with federal programs, and supported by technical experts, with strong monitoring systems. It is proposed in three parts:

1. Foundational Tools Fund. This would support projects that develop knowledge related to flood, including Indigenous knowledge, hydrometric, climate, bathymetric and topographic data collection, and hazard and risk assessments and mapping.
2. Planning and Resilience Fund. This would support planning activities related to risk reduction tools and resilience such as local or regional flood management plans and emergency response plans.
3. Implementation Fund. Where plans identify the need for significant expenditures related to flood mitigation, this would provide capital to support these investments. (A-1.5)

Adapt Organizational Roles and Responsibilities

In conjunction with training, guidance, funding, and other actions described above, projects underscore strengthening staffing resources and modifications in responsibilities and authorities as key in overcoming identified challenges.

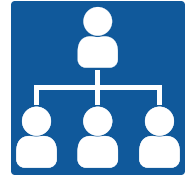
To address staff resource limitations, local authorities should consider:

- Learning from (particularly smaller or less well-resourced) communities that have advocated for and funded roles with responsibility for flood management. For example, one regional district held a referendum to create a Watershed Coordinator position which is responsible for managing flood risk. (A-1.4)
- Supporting a designated flood management staff role within each authority, funded through provincial grant funding. (B-4.2)
- Reviewing and enhancing the emergency program coordinator role to ensure it is resourced in line with the community's hazards, risks, and desired resilience level. (C-2.5)

For some lesser-resourced diking authorities, no amount of training, information, enforcement, requirements, or funding programs may address their limitations. In this case, where the consequences of dike failure provide sufficient justification, the responsibilities and assets of such diking authorities should be transferred to a “capable” diking authority. In the case of non-local government authorities, the assets could be transferred to the respective local government (if their capacity is sufficient). In the case of local governments that lack sufficient capacity, other governance models should be considered. (B-5)

While many responsibilities are suggested to remain with local authorities, increasing provincial staffing, technical support, and oversight is the subject of many recommendations. In addition to Province-led actions described previously, key recommendations for the Province include:

- Provide review of flood maps produced in BC. Alternatively, implement an independent quality control group for flood hazard mapping to evaluate the suitability of existing maps for intended uses such as official floodplain designation, development regulations, emergency response planning, public education, and so forth. A QA/QC mechanism would help ensure adherence to applicable guidelines and standards, improve consistency across the province, and improve the quality of maps over time. (B-2.2)
- Participate in the development, review, and approval of integrated flood management plans. A provincial delegate to an integrated flood management planning project would represent provincial flood safety interests, provide technical expertise, and empower local authority staff to incorporate provincial guidelines and best management practices, particularly when faced with internal, stakeholder, and/or political pressure. A review and approval process would ensure minimum standards are met and allow the Province to establish and maintain a database of such plans. (B-4.4) If a provincial integrated flood management planning program or guideline is developed, funding or approval of plans could be contingent on an authority's coordination and collaboration with adjacent jurisdictions. (B-5.3)
- Provide oversight and review of new or updated floodplain bylaws, development permit areas, and official community plans, and support on more challenging non-structural measures such as managed retreat. (B-6.3)
- Develop a provincial sign-off process for local flood response plans. The *Emergency Program Act* modernization discussion paper¹⁵ proposes replacing the audit role of EMBC to one of coordination and facilitation for emergency plans. As part of a future funding mechanism, the Province could include specific criteria and an approvals process for such plans. An alternative process is to allocate a subject matter expert as part of a “plan developing committee” to provide oversight and approval. (C-2.3)
- Provide resources to EOCs during flood emergencies, including geomatics/GIS staff to assist with data products and qualified professionals to assist in their analysis and interpretation. (C-1.2)



¹⁵ Emergency Management British Columbia. 2020. [Modernizing BC's Emergency Management Legislation](#).

To facilitate augmented provincial government roles and support to local authorities, a review of provincial government capacity and enhanced resourcing are recommended:

- Augment staff and technology resources within the BC River Forecast Centre to support EOCs with data interpretation and use; technical improvements to the CLEVER model; implementation of a flood early warning system to couple flood forecasts and hydraulic models; and downscaling and climate modelling efforts. (B-1.3, C-1.2)
- Conduct a provincial government capacity review to ensure adequate resources within the MFLNRORD flood unit for each of the EMBC operational regions. The complexity of hazard and risk information should also be factored into assigning resources within each region. (C-2.5)
- Examine the necessity of increasing the numbers of staff roles within EMBC regions to complement existing regional managers to provide flood specialist knowledge for decision-making. This would address the need for additional resources within EMBC's Provincial Regional EOC in each region. (C-2.5)
- Review the efficacy of emergency response decision-making and coordination to ensure appropriate allocation of resources during the provincial equipment deployment stage without delaying time-critical decisions. (C-2.5)
- Research, with local authorities, issues around the legality and liability of having one order of government making decisions (e.g., locally implemented land use planning and building construction approvals) that lead to legal and liability issues for other orders of government in terms of disaster compensation (e.g., DFA compensation). (C-3.1)

Several models to accomplish a wide range of recommendations are evaluated and proposed. The A-1 project, which focuses on overall flood risk governance, recommends two key governance arrangements to be implemented in tandem:

- Establish a central knowledge hub within the Province that supports collaboration with the federal government, provides technical services, manages foundational tools (e.g., flood mapping, flood forecasting, and flood risk assessment), connects disciplines and sectors, implements funding programs, develops guidelines, supports/leads changes to legislation and regulation, and supports research and pilot projects.
- Establish regional hubs, operated by the Province, that support collaboration on a regional and watershed basis, provide expertise and support to all communities, support local initiatives with region-specific flood knowledge and experience, support and coordinate funding applications, support local authorities in scoping projects, manage regional-scale projects, support EOCs in response and recovery, and report to the central hub. Such hubs would support local authorities in meeting their current responsibilities and, with a mandate to develop regional projects, would support regional collaboration. (A-1.5)

The B-6 project, which focuses only on non-structural flood mitigation, evaluates the pros and cons of three different governance options. They are presented below in order from most likely to least likely to address current shortcomings and from most to least amount of change required. While it does not recommend one option, the second model would align most closely with the above governance recommendations from the A-1 project:

1. The Province to regain a leadership role in floodplain designation, flood bylaws, and review of development/exemption applications upon request, with local government retaining land use planning roles.
2. Local governments to retain existing authority, but the Province to provide a technical support role to assist with the review of consultant work for local governments and review of development/exemption applications upon request.
3. First Nations and local governments to form regional partnerships or entities to provide flood assessment, land use planning, and/or permitting functions in flood prone lands, to ensure consistency and efficient use of resources across a region. (B-6.2)

The C-2 project, which focuses on flood response, proposes investigating the feasibility of a single flood response authority model similar to the BC Wildfire Service taskforce approach. In following the BC Wildfire Service model, the taskforce approach would have the ability to provide provincial subject matter experts, provide guidance and direction regarding flood warning and associated measures, and facilitate ministry decision-making for permits. Local responders could act quickly until the ministry arrives on scene. (C-2.5)

4. Next Steps

This report has summarized the key findings and recommendations from the 11 projects in this initiative, including current issues, challenges, and opportunities relating to flood management and governance in BC. Based on the above, the overarching priorities for responsible authorities in BC could be summarized as:

1. Accelerate the development – and improve the coverage and quality – of foundational tools, starting with flood hazard mapping, to facilitate planning, prioritization, and informed decisions and investments.
2. Ensure sufficient capacity for authorities with flood management responsibilities to develop necessary information, translate knowledge into action, and make effective and efficient use of available resources.
3. Provide adequate direction and guidance to ensure that consistent, robust, best practice approaches are applied in the full spectrum of flood management activities.

There is no single action that will advance these overarching priorities. Rather, a suite of recommended actions from across all of the projects will need to be implemented to address current limitations and advance progress on these priorities.

While most of the projects presented recommendations for the Province, many of them would ultimately include implementation roles by multiple jurisdictions. Further discussion is required on which (and how) jurisdictions would initiate, lead, or collaborate on these actions.

For responsible authorities considering and advancing recommendations from this initiative, it is advisable to undertake additional engagement and research to better understand Indigenous experiences related to the investigation topics plus any other topics that were not included as part of this initiative (for example, the implementation of UNDRIP and DRIPA in flood management). Despite efforts through a survey and interviews, most of the 11 projects undertook limited engagement with Indigenous communities, and the initial scoping of the investigations was not done in consultation with Indigenous communities.

Engagement on specific recommendations with affected governments and organizations is also advised. While some projects sought input on draft recommendations (for example through the diking authority survey, one-on-one calls with practitioners and experts, and draft report review), a more fulsome, representative consultation on the recommendations was not possible. Similarly, the scoping of investigations did not involve local governments or other organizations.

More detailed costing of recommended actions is also recommended. The D-1 project concluded that the cost estimates for recommendations provided in the project reports, while intended to be high-level, lack detail and are not consistent across projects. Investigation D-1.1 provides recommendations on how they could be refined. For example, cost characteristics, such as one-time versus annual ongoing costs, could be differentiated to account for inflation. Some recommendations also require further definition and specificity prior to developing more detailed and more accurate cost estimates.

Although this summary report primarily reflects projects' focus on challenges and recommendations to address them, it is important to note that there are many positive emerging developments that are accelerating progress on these issues and are worthy of learning from and building upon, including:

- Existing communities of professionals working and exchanging knowledge in disaster risk and resilience building, such as Understanding Risk BC;
- New tools, such as the Natural Resources Canada-funded open-source CanFlood flood risk modelling tool, damage functions developed for the Lower Mainland as part of the Lower Mainland Flood Risk Assessment, and others;
- A growing number of regional and watershed-scale collaborative efforts across the province, such as the forthcoming Lower Mainland Flood Management Strategy, a regional initiative that has identified – and aims to address – gaps and challenges similar to those highlighted through this present initiative;
- The BC Climate Preparedness and Adaptation Strategy (launched June 2021), which highlights the need for improved coordination of floodplain mapping with other levels of government and the completion and implementation of a BC Flood Strategy;
- The forthcoming BC Flood Strategy, for which a Discussion Paper has been released for comment by government partner agencies with a draft vision, outcomes, principles, proposed key program areas, and potential priorities based on the Sendai Framework;
- Modernization of the *BC Emergency Program Act*, which is expected to embody an “all of society” approach to build resilience at the individual and community levels and address all four pillars of emergency management (mitigation, preparedness, response, and recovery), with greater emphasis on proactive risk reduction; and
- Other forthcoming government- and practitioner-led initiatives, such as a BC Disaster Risk Reduction Hub and the federal government work's on a National Flood Hazard Layer and National Flood Risk Profile.

5. List of Project Reports

Ebbwater Consulting Inc. 2021. Investigations in Support of Flood Strategy Development in British Columbia.
Issue A-1: Flood Risk Governance.

Associated Engineering (B.C.) Ltd. 2021. Investigations in Support of Flood Strategy Development in B.C.
B-1: Impacts of Climate Change.

Northwest Hydraulic Consultants Ltd. 2021. Investigations in Support of Flood Strategy Development in BC.
Issue B-2: Flood Hazard Information.

Ebbwater Consulting Inc. 2021. Investigations in Support of Flood Strategy Development in British Columbia.
Issue B-3: Flood Risk Assessment.

Kerr Wood Leidal Associates Ltd. 2020. Investigations in Support of Flood Strategy Development in British Columbia.
Flood Planning (B-4).

Northwest Hydraulic Consultants Ltd. 2021. Investigations in Support of Flood Strategy Development in BC.
Issue B-5: Structural Flood Management Approaches.

Northwest Hydraulic Consultants Ltd. 2021. Investigations in Support of Flood Strategy Development in BC.
Issue B-6: Non-Structural Flood Management Approaches.

BGC Engineering Inc. 2021. **Issue C-1: Flood Forecasting Services.**

Red Dragon Consulting Ltd. 2021. Investigations in Support of Flood Strategy Development in British Columbia.
Issue C-2 Report - Emergency Response.

Red Dragon Consulting Ltd. 2021. Investigations in Support of Flood Strategy Development in British Columbia.
Issue C-3 Report - Flood Recovery.

AECOM Canada Ltd. 2021. Investigations in Support of Flood Strategy Development in British Columbia.
Issue D-1: Resources and Funding.



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Prepared by



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Project funded by

