Analysis of Flood Resilience Policy and Planning Tools in the Okanagan Valley

Final Report

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UBCO Team
Kh Md Nahiduzzaman
Kasun Hewage
Sadia Ishaq
Saeed Mohammadiun
Peyman Yousefi
Sheikh Rubaiya Sultana
Anber Rana
and
Rehan Sadiq

Okanagan Basin WATER BOARD

UBC OKANAGAN

Table of Contents

Abbreviations

ALC	Agricultural Land Commission
ALR	Agricultural Land Reserve
BMP	Best Management Practices
CCP	Comprehensive Community Plan
DEM	Digital Elevation Model
DP	Development Permit
DPA	Development Permit Area
ECCC	Environment and Climate Change Canada
EIA	Environmental Impact Assessment
ESA	Environmentally Sensitive Area
EGBC	Engineers and Geoscientist British Columbia
ESDPA	Environmentally Sensitive Development Permit Area
FCL	Flood Construction Level
FIM	Foreshore Inventory Mapping
GHG	Greenhouse Gas
HWM	High water mark
ISMP	Integrated Stormwater Management Plan
MBE	Minimum Building Elevation
MOTI	Ministry of Transportation and Infrastructure
LiDAR	Light Detection and Ranging
LID	Low Impact Development
LWMP	Liquid Waste Management Plan
OBWB	Okanagan Basin Water Board
OCP	Official Community Plan
OWA	One Water Approach
QEP	Qualified Environmental Professional

RCS	Regional Context Statement
RDA	Rapid Damage Assessment
RDCO	Regional District of Central Okanagan
RDNO	Regional District of North Okanagan
RDOS	Regional District of Okanagan-Similkameen
RGS	Regional Growth Strategy
RFMP	Regional Flood Management Plan
RSLDPA	Riparian and Swan Lake Development Permit Area
SEI	Sensitive Ecosystem Inventory
SHIM	Sensitive Habitat Inventory Mapping
SRWSP	Shuswap River Watershed Sustainability Plan
TBL	Triple Bottom Line
TRCA	Toronto Region Conservation Agency
UBCO	University of British Columbia (Okanagan)
WPD	Watercourse Development Permit
WDPA	Watercourse Development Permit Area

Executive Summary

During the past decade, the region of Okanagan Valley has become at greater risk of recurrent floods. The intensity of flood risk has increased and, as a result, the residential neighbourhoods became more vulnerable to flood damage. The current planning tools and regulatory flood resilience policies are seemingly lagging behind the pace at which floods continue to cause damage to the communities. Understandably, there is a gap in the current flood planning/policy and the future vision for resilience. Lack of needed cooperation between the multilateral governance at the provincial, First Nations, regional district, and municipal tiers is another critical factor that influence the achievement of the flood mitigation goals in a region. As a result, the contemporary flood "protection" strategy seems not-so-capable to protect communities from adverse consequences, and calls for a paradigm shift from a flood *protection* approach to *adaptive* resilience.

This project aims to analyze the scope and current status of flood (resilience) policies practiced by the organizations across the Okanagan Valley. The project also includes research to understand the key practices of other organizations across Canada, which would help adapt and *re*-define the flood mitigation (non-structural) strategies for the Valley. The specific objectives lie in developing a complete inventory of existing flood control strategies (including visions, goals, objectives, policies, plans and regulatory tools) in the Okanagan Valley; analysis of gaps, challenges, successes, and opportunities related to the current strategies; and review of non-structural flood mitigation strategies being used in other communities in B.C., Alberta, and Ontario.

For this purpose, a detailed literature review was conducted to evaluate the existing regulations, guidelines, and policies of 22 selected organizations in the Okanagan Valley. This was completed to identify the current practices and gaps and outline the potential areas of improvement in design, operation, maintenance, and improvement of stormwater management capabilities in favor of an enhanced flood resilience. Following this was an evaluation of the flood resilience policies and planning tools of 6 (six) selected organizations outside the Okanagan Valley: the Cities of Chilliwack, Surrey, North Vancouver, Calgary, Halifax, and Mississauga. Each location was studied through the lenses of contexts and overall perspectives on flooding and risk management efforts, and notable (non-structural) mitigation strategies that are potentially applicable to the Okanagan Valley.

Based on a critical evaluation, this report identifies a set of recommendations to enhance flood resilience in the Okanagan Valley. These recommendations are pertinent to the development of green and permeable areas, compact housing and infill development, integrated stormwater management, energy-efficient technology, stakeholder and community engagement, flood risk assessment, interconnectedness of natural systems and human capital in favor of climate resilient community. Considering the long-term sustainability vision of Okanagan Valley, a "Sustainability Charter" is advocated for the decision makers (managing) in-charge of the organizations. The study concludes with a "whole systematic view" on *adaptive* flood resilience that aims to harmonize the current endeavors by the organizations in the Okanagan Valley and satisfy the triple bottom lines (TBL) of sustainability: environmental and social (and health) wellbeing, and economic prosperity.

Acknowledgments

We would like to express deepest appreciation to all those who provided us the possibility to complete this report. Special thanks goes to Dr. Anna Warwick Sears (OBWB) whose contribution in stimulating suggestions and encouragement helped us to collect relevant information for this project. Furthermore, we would also like to acknowledge with much appreciation the crucial role of Ms. Kellie Garcia (OBWB), who was the OBWB project manager and who also provided all required contacts to the municipalities in the Okanagan Valley. Last but not the least, we are highly appreciative to the managers of the 22 organizations across the Valley who invested their time in getting us the relevant information pertaining to flood mitigation strategies, planning, policies, and resilience.

Chapter 1: Introduction

With the increasingly pervasive consequences of climate change, the world is witnessing recurrent and sudden events, often turned into disasters, with a more heightened and irregular frequency than ever before [2, 6, 7]. Climate change has become a threat to human civilization and cities are at great risk of exposure to climate induced adversities, such as floods [4, 5]. In recent years, the increasing magnitude of climate challenges has led to frequent floods, the severity of which has been magnified by the rapid rate of urbanization. Floods also leave long lasting and substantial social, environmental, and economic impacts in cities. In the wake of these issues, as well as the need for environmental protection and preservation of natural resources, research in areas of surface water management and flood risk reduction have received significant attention [1]. One of the most effective approaches meant to enhance the managing prowess of surface water resource is flood resilience governance. From a governance perspective, water laws, regulations, and social norms are critical to stimulate societal transformations for flood risk management. This approach provides an appropriate capacity to minimize inundation for a flood control system and even ensures rapid recovery into an acceptable service level after/during a potential flood system failure [4].

Resilience refers to the ability of the water system to return to its original operational form after the exertion of a force, i.e. disaster. This concept has extensive applications in the planning, policy, regulations and engineering of urban water management in general, and urban stormwater drainage systems in particular. It is used to enhance the system's reliability while minimizing the frequency of service-level failure during an assumed storm event.

In practice, the establishment of a resilient drainage system requires technical as well as non-technical knowledge of legal instruments, policy strategies, and regulations pertaining to flood control and risk management. The availability of appropriate policy initiatives and governance mechanisms is critical to building an integrated resilience against floods. In recent years, floods have become a recurring phenomenon in the Okanagan Valley, British Columbia, which has adversely affected the local population and settlements across the Valley. The application of a conventional flood "protection" strategy has proven ineffective in preventing communities from flooding. Thus, there is a pressing

need to revisit the flood resilience policy while taking the opportunity for a paradigm shift from flood *protection* to *adaptive* resilience. In light of this, this study aims to

I. develop an inventory of flood policies, plans, and regulatory tools, including strategies, guidelines, and bylaws currently in place in the Okanagan Valley;
II. examining the gaps, challenges, successes, and opportunities pertaining to the current policy and planning tools used in the Okanagan Valley; and
III. identifying flood policies and planning tools used in other regions of Canada that are relevant to the Valley.

A total of 22 organizations (as shown in figure 1) across the Valley are directly (or indirectly) involved in implementing flood control measures and providing support to enhance community resilience. This report lays out a detailed inventory of regulatory flood control measures/tools envisioned and practiced by these organizations with a chronology of evolution and their presence in the official documents. This inventory offers an in-depth insight into the current status of flood resilience and supporting regulatory tools across different organizations of the Valley while identifying areas where necessary resources need to be employed to enhance flood resilience. In addition, the study provides a comprehensive overview of the gaps, challenges, fruitful initiatives, and opportunities related to the current flood policies and planning tools.

To identify the best practices and their relevancy for the organization in the Okanagan Valley, 6 (six) communities across Canada that are located outside the Valley were selected: the City of Chilliwack (BC), Surrey (BC), North Vancouver (BC), Calgary (AB), Halifax (NS), and Mississauga (ON) (see figure 2). The choice of communities was finalized after due consultation with OBWB. A variety of factors, including populations, geographical specifications, historical flood events, leadership and innovations in flood mitigation and adaptation are considered for the choice of these communities.

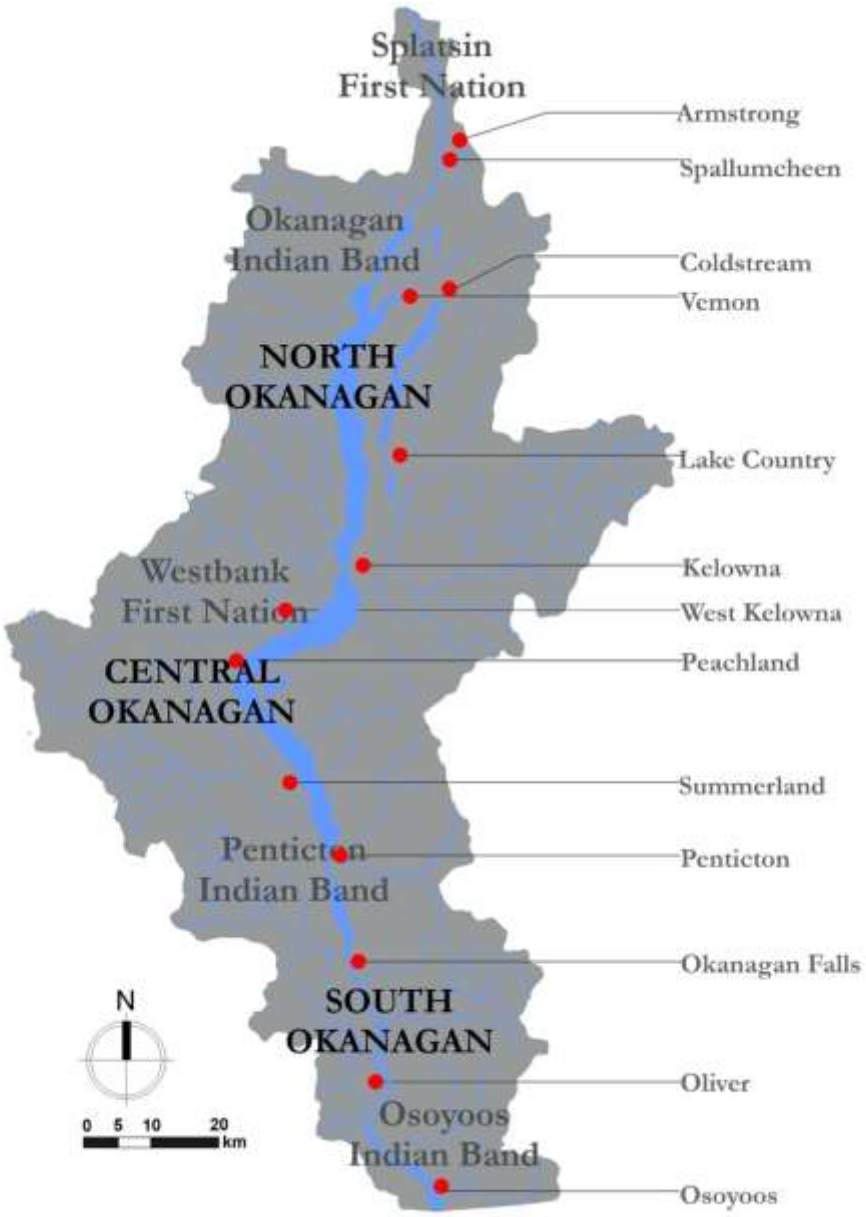

Figure 1. Locations of the selected organizations across the Okanagan Valley.

The present report is structured into six main chapters. Chapter 1 is a prelude to this report. Chapter 2 summarizes the methodological steps of this study in the development of the flood (resilience) inventory as well as the selection and evaluation of organizations outside the Okanagan Valley. Chapter 3 contains the key part of the report pertaining to 22 organizations in the Valley, accounting an inventory of current flood strategies and potential recommendations to enhance the flood resilience for each organization located inside the Okanagan. They are placed in the report following a geographical orientation (north to south Okanagan) as shown in Figure 1. Chapter 4 aims to evaluate three jurisdictions inside BC and outside the Okanagan Valley, including City of Chilliwack, Surrey, and North Vancouver. Chapter 5 covers a flood-related issue evaluation of three selected jurisdictions located outside BC, including Calgary, Halifax, and Mississauga. Finally, Chapter 6 contains all recommendations to enhance current flood control strategies in the Valley and a systematic approach to flood resilience.

Figure 2. Location of the organizations in other parts of Canada
(i.e. outside of the Okanagan Valley).

Chapter 2: Methodology

2.1 Analysis of Flood Strategies in the Okanagan Valley

A systematic literature search was conducted to identify articles and reports on flood risk management and resilience in the Okanagan Valley. Several relevant keywords were included in the search, as given in Table 2.1. Since flood resilience is a multidisciplinary topic, pertinent keywords were selected and prioritized for the search to hit the relevant documents and avoid any information overlap. In addition to listed keywords, their synonyms and abbreviations were also used in the search process. The collected documents were stored in a shared "Google Drive" folder for a detailed assessment, review, and future reference.

Table 2.1 List of keywords used in the literature search.

1st priority keywords	2nd priority keywords
Standards and codes, Flood regulations, Flood control, Flood policies, Flood resilience, Emergency management plan, Official community plans	Resilience improvement, Flood risk control, Flood control, Flood regulations, Flood management plan, Adaptation and mitigation plan, Land use regulation

Besides an online search, relevant staff(s) in each of the organizations including municipalities, regional districts, villages, and First Nations were requested to share relevant documents pertaining to flood strategies, plans, and regulatory tools, such as official community plans (OCPs), zoning bylaws, emergency management plans, wastewater/stormwater drainage plans, land use development schemes, and the like. On many occasions, follow-up Zoom meetings took place with the concerned person to develop a comprehensive understanding of project needs, expected deliverables, and benefits to the communities. These meetings further helped develop a common perception and appreciation of the need for a coordinated endeavor to enhance flood resilience across the Okanagan Valley.

After acquiring, the next task was to sort out, screen, and review the large number of documents. For the initial screening, the researchers reviewed the title, executive summary or abstract, key findings, and conclusions in order to decide whether to include them in the next step, i.e. detailed review. Then,

an in-depth review of the selected documents was conducted to identify and evaluate the flood resilient measures within various organizations in the Valley.

Flood resilience includes a set of adaption or mitigation measures. Adaption refers to adjustments in the existing practices, such as early warning systems, community preparedness, etc. for floods that help alleviate the negative impacts. Mitigation refers to interventions that address the causes of floods and help reduce the occurrence of floods and resulting consequences. Midaptive approaches refer to a combination of both mitigation and adaptation. In view of these measures, documents from each organization were systematically reviewed, compiled, and are reflected in Chapter 3.

2.2 Analysis of Flood Strategies in other parts of Canada

In BC, floods are recognized as one of the most common disasters. Commonly, floods occur due to spring freshet, extreme rain events, and sea level rise, and the major contributing factors include channel alterations, riverbed aggradation, land use change, and climate change. In principle, the responsibility of flood risk management lies with the local governments that promulgate viable and appropriate regulations to ensure protection and safety of the population.

Considering the role of local governments in flood risk management and preparedness, the second task of this project was to examine the flood resilience policy and planning tools for locations outside the Okanagan Valley. Thus, 6 (six) jurisdictions were selected as per the criteria mentioned earlier in this report (page 8). These criteria confirmed that the location has a history of flooding due to spring freshet, rain/snow event, or both, possesses socio-demographic features similar to the Okanagan Valley, and experiences more or less similar climatic conditions. The key focus of this review was to evaluate non-structural strategies, i.e. regulations, policy, planning, guidelines, communication mechanisms, and information sharing. Furthermore, each of these cities was studied for their specific contexts, overall perspectives on flood risk management, and notable non-structural strategies to minimize flood risk. The detailed review for the organizations inside and outside BC is available in Chapters 4 and 5 respectively.

Chapter 3: Current Inventory of Flood Strategies in the Okanagan Valley

An inventory of the current flood strategies in the Okanagan Valley is given in this chapter. The team has evaluated different strategies (including visions, goals, objectives, policies, plans and regulatory tools) as implemented by each organization to directly address the issues of flood resilience or tackle it indirectly via actions on climate change, natural environment preservation etc. A comprehensive review of official community plans, various bylaws, and reports was done to identify existing strategies of flood resilience. Further, these strategies were categorized into three groups: adaptive, mitigation, and midaptation for each organization. For the purpose of clarity, a description of each column heads used in the tables is given as follows:

- *"Local government or Indigenous Community"* refers to the name of the jurisdictions being reviewed;
- *"Overall perspectives on flooding"* shares a summary of the position of each jurisdiction to deal with the potential flood and related issues;
- *"Contexts"* consists of the key drivers affecting flood resilience in the future developments of the area;
- *"Placement of the measures and tools"* provides the reference of the documents in each organization that were assessed during the review process;
- *"Nature of strategies to support flood protection"* shares reviewer's evaluation about implemented strategies to address the flood related issues; and
- *"Action statements to enhance resilience"* introduces reviewer's suggestions to enhance the flood resilience condition under the organizational jurisdictions.

3.1 Splatsin First Nation

Table 3.1 Evaluation of flood strategies (Splatsin First Nation).

Indigenous Community	Overall perspectives on flooding	Contexts	Placement of the measures and tools	Nature of strategies to support flood protection	Action statements to enhance resilience
Splatsin	- Protection of environmentally sensitive lands and resources located in different reserves, especially by learning from the past and Elders.	- There are steep slope areas and some sensitive floodplain vulnerable to erosion and inundation in the reserves. Also, the high groundwater level is another issue in this area. - During a flood season, significant infrastructural damage has been experienced in IR#1 (Salmon River) reserve. - There is a lack of comprehensive planning for flood-related issues and management.	- Community Development Plan, 2001 - Comprehensive Community Plan, 2013 - CCP Handbook, 2016 - Annual Report 2017/2018, 2018	Although Splatsin has a valuable understanding of the application of mitigative strategies rooted in the rich history of this nation, there is a considerable lack of practical and inclusive risk-based flood management policies.	- Update the Comprehensive Community Plan (CCP) document to address climate change effects. - Perform floodplain mapping studies and risk assessments near watercourses. - An appropriate stormwater drainage plan and related design standards may be considered in future construction. - Enhance the resolution of the hazards maps. - Apply a detailed zoning map for development and construction. - Use Yucwmenlúcwu's (Caretakers of the Land) potential in collaboration with UBCO and OBWB resources to perform integrated flood management studies and projects. - Consider flood resilience and climate change adaption and/or mitigative requirements in objectives of the community design in CCP. - Share information about flood risk and climate change to enhance community engagement and support in future programs.

Nature of existing strategies to support overall perspectives on flooding:

Adaptive strategies:

- Emergency planning in order to respond to a range of emergency conditions such as flooding.
- Development of hazard maps showing steep slopes and floodplain areas.
- Enacting environmental impact assessment (EIA) requirements for development on reserves.
- Following federal and provincial building codes.
- Banning development in floodplain lands as well as lands with more than 30% slopes.

Midaptive (**Mitigative + Adaptive) strategies:**

- Establishment of the Title and Rights department to manage and protect resources through sustainable development.
- Performing environmental enhancement measures to improve run-off quality and enhance vegetation patterns.
- Working on training programs to keep the community informed about environmental issues and restoration programs.
- Emphasizing the necessity of land use planning and defining its basic principles.
- Planning for the development of sustainable principles through guidelines.
- Establishment of Yucwmenlúcwu to manage natural resource issues.

3.2 City of Armstrong

Table 3.2 Evaluation of flood strategies (City of Armstrong).

Local Government	Overall perspectives on flooding	Contexts	Placement of the measures and tools	Nature of strategies to support flood protection	Action statements to enhance resilience
City of Armstrong	- To facilitate the orderly development or redevelopment of lands efficiently and compactly within its existing boundaries. - To target the reduction in GHG emissions.	Developing areas that will increase the livability of the city and enhance the links to its roots of agriculture, logging, arts, and businesses.	Official Community Plan, 2014 Armstrong-Preparing for Severe Storms, 2011	- Mitigation measures focus on reducing the amount of runoff by minimizing impervious surfaces. - Adaptation measures emphasize infill development and compact housing. - Installation of energy-efficient interventions to achieve reduction targets of GHG emissions.	- Infill development should be considered to optimize the efficient use of land. -The development of LIDs can reduce quantity of runoff and improve operation of existing drainage.

Nature of existing strategies to support overall perspectives on flooding:

Adaptive strategies:

- The development consists of extensive planting of native trees, shrubs, or ground cover for slope and soil stabilization, habitat conservation, erosion control, and enhancing natural beauty of the area.
- Encouraging the planting of native vegetation and trees.
- Infill development within the surrounding area should be considered to optimize the efficient use of land that reduces overall imperviousness and risk of flooding
- Encourage green infrastructure to preserve ecological function and minimize negative environmental impacts of urban development.

Mitigative strategies:

- Require that stormwater runoff be equal to pre-development conditions for all new developments to ensure no impact on flows downstream.
- Minimize impervious surfaces where possible and encourage permeable land cover in order to achieve natural stormwater infiltration.
- Building construction should be set back at least 7.5 m from the periphery of lakes, ponds, swamps or marshes.
- Development should avoid siting within floodplains or on steep slopes.
- Land immediately adjacent to streams and wetlands shall be retained in a largely undisturbed state.
- Culvert repair, creek sediment removal plan preparation, culvert maintenance, and required environmental management plan preparation should be done to facilitate flood management.

3.3 Township of Spallumcheen

Table 3.3 Evaluation of flood strategies (Township of Spallumcheen).

Local Government	Overall perspectives on flooding	Contexts	Placement of the measures and tools	Nature of strategies to support flood protection	Action statements to enhance resilience
Township of Spallumcheen	Seek the cooperation of appropriate ministries to ensure that the development practices consider slope of failure and high potential areas for flooding in the Spallumcheen Valley.	Ensure that the proposed development is designed to withstand flooding and dangerous geotechnical, wildfire, or hydrogeological conditions.	- Zoning Bylaw No. 1700 (2008) - OCP Bylaw No. 1794 (2011)	Although Spallumcheen has considered the application of adaptive strategies in forest harvesting plans in community watershed, in addition to elevation considerations, mitigative policies are minimal and risk-based policies are needed.	- Identify catchment area with flow routes. - Identify drainage capacities in flood plain. - Identify hydraulic constraints and erosion.

Nature of existing strategies to support overall perspectives on flooding:

Adaptive strategies:

- Zoning areas should be 0.6 m higher than flood level (level of 200-years), or 3 m above the natural boundary of a lake or any watercourse.
- The surface of the slope should be protected from erosion caused by flooding in places where landfill is used to achieve requirements for appropriate elevation.
- No building shall be constructed, nor a mobile unit located within 15.5 m of the boundary of a lake and within 30.5 m of the boundary of other watercourses.

Mitigative strategies:

- Broadening a right of way should be allowed for flood and drainage control.

Midaptive (Mitigative + Adaptive) strategies:

- "Hazardous Condition Policies" council's policies ensure the proposed developments will not be affected by hazardous conditions, like floods, hydrogeological situations, and wildfire.

3.4 Okanagan Indian Band

Table 3.4 Evaluation of flood strategies (Okanagan Indian Band).

Indigenous Community	Overall perspectives on flooding	Contexts	Placement of the measures and tools	Nature of strategies to support flood protection	Action statements to enhance resilience
Okanagan Indian Band	The Okanagan Indian Band does not have any formal plans or policies related to flood at this time.	Provide appropriate quality water to users and having regard for the water sources.	Waterworks bylaw No. 2019	The waterworks bylaws mainly deal with the supply of water for residential and non-residential use.	- Sharing information on flood risk, flood resiliency, and emergency planning would be useful to ensure safety of people during a flood event. - Conduct land use planning with a focus on green spaces, vegetation area, and natural resource protection. - Introduce renewable energy technologies to reduce the impacts of changing climate. - Construct stormwater and wastewater drainage and maintain the system.

Nature of existing strategies to support overall perspectives on flooding:

Adaptive strategies:

- No person will pollute, damage, or tamper with the Water System.

Please note that review of the official documents suggests that the Okanagan Indian Band does not have flood resilient strategies or flood related policies in place at this time.

3.5 District of Coldstream

Table 3.5 Evaluation of flood strategies (District of Coldstream).

Local Government	Overall perspectives on flooding	Contexts	Placement of the measures and tools	Nature of strategies to support flood protection	Action statements to enhance resilience
District of Coldstream	To provide direction for community development while ensuring appropriate growth over the long term.	Building a strong, independent, and vital community that fosters the lifestyles of current and future residents in a sustainable way.	- Subdivision, Development and Servicing Bylaw No. 1535, 2008 - Official Community Plan, 2015	- The adaptation/mitigation measures are mainly focused on sustainable land use and energy-efficient buildings. - There is a recognition to manage stormwater via LID alternatives.	Assess flood risk and apply LIDs; Natural slopes and ravines need to be preserved by maintaining vegetation and to prevent property damage; An yearly inspection of ravine help preserve topography and manage the risk of erosion and landslides.

Nature of existing strategies to support overall perspectives on flooding:

Adaptive strategies:

- Focus on the protection and preservation of the environment.
- Modify the zoning bylaw to allow density averaging and density bonusing (i.e. to allow developers to build additional floor area, in return for an amenity e.g. parkland, walking trails) of the development.
- The rural landscape of the community must be retained and new development must fit within the rural and agricultural character of this district.
- Create mixed-use developments where jobs and homes are close together, reducing the need for driving and GHG emissions.
- The minimum building elevation (MBE) shall be established at minimum 0.6 m above the service connection invert and 0.3 m above the 100-year hydraulic grade line elevation.

Mitigative strategies:

- Encourage the construction of energy efficient buildings and Built GreenBC or equivalent standards.

- Require that stormwater management plans consider the collective basin-wide effect of all future requirements in the water basin, rather than the general minimal incremental effects of individual land developments.
- Stormwater ponds are required to be integrated with parks and open areas/spaces.
- Infiltration facilities should be encouraged to retain and hold frequent rainfall volumes at the site of origin. Typical examples of control facilities include dry detention ponds, infiltration trenches, rain gardens, and swales.

3.6 City of Vernon

Table 3.6 Evaluation of flood strategies (City of Vernon).

Local Government	Overall perspectives on flooding	Contexts	Placement of the measures and tools	Nature of strategies to support flood protection	Action statements to enhance resilience
City of Vernon	- With flooding in recent years, drainage projects became a priority for the City. Focus was put on drainage infrastructure prioritization to define overland flow routes and identify the risks they pose to the community under changing climate conditions. - Vernon's ability to reach flood fluctuations can improve the flood control system efficiency. - Flood forecasting systems and enhanced flood forecasting capacity in the area.	- Vernon is characterized by orchards, forested hillsides, lakes and rivers, wetlands, and grasslands; therefore, protective strategies of green environments and farmlands are essential for the community. - Around Kalamalka Lake, high lake levels caused lakeshore property flooding, foreshore erosion, and damage to retaining walls and docks.	-Bylaw No. 3843 (1992) -Bylaw No. 5277 -Bylaw No. 5151 (2008) -City of Vernon Emergency Management Plan (2008) -OCP (2015-2020) -Bylaw No. 5470 (Updated 2020) - City of Vernon Drainage Infrastructure Prioritization Plan (2019)	- Available policies are mostly focused on ecosystem features in wetland and habitat areas. - Most flooding alerts and policies are referred to as governmental master plan manuals and not specifically for Vernon. While general adaptive measures are useful overall, the characteristics of the region may need specific adaptive and mitigative policies.	- Complete a biophysical inventory and map of a site referring to adjacent lands for surface and groundwater features. - Re-evaluate the 200-year water levels and FCL elevations for Okanagan and Kalamalka lakes. - Prioritize and characterize the proposed listed strategies that can increase Vernon's ability to be flexible in weather variation and flood fluctuations.

Nature of existing strategies to support overall perspectives on flooding:

Adaptive strategies:

- Actions and activities performed to reduce flooding, erosion, or any immediate threats, including emergency flood protection works, obstruction cleaning from bridges, culverts, or drainage channels.
- Besides assisting local governments in managing group lodging needs, BC housing can offer guidance for post-earthquake or post-flooding rapid damage assessment (RDA) of buildings.
- Obtain and publicize current meteorological data and flood forecasted information by collaboration with the Ministry of Transportation and Infrastructure (MOTI) and Environment and Climate Change Canada (ECCC).

Mitigative strategies:

- Emergency procedures to reduce flooding, erosion, or any immediate threats, including repairing safety fences following the federal Fisheries and Wildlife Acts.
- Eliminate hazardous trees that pose a danger to the safety of pedestrians, and trees that are likely to damage properties during or after flooding.
- For any restoration works and activity in the area that requires a development permit, comply with provincial and federal legislation and notify the City of Vernon.
- Ensure that the storm water plan safely addresses storms greater than 20 mm of rainfall per day, up to and including 100-year rainfall events. Water must be safely carried to downstream watercourses without causing damage to property in extreme flood events.
- The 100-year hydraulic grade should be lower than the pavement centerline with a maximum depth of 300 mm for flow.
- Local roads that may be considered collectors can be used as a major flood path for flow depth of lower than 300 mm.

Midaptive (Mitigative + Adaptive) strategies:

- Any road that accommodates flow needs to lie below the line of properties nearby.
- Drainage pipes, tools, and catch basins are not efficient mechanisms for draining rainfall and flood water from nearby properties because of connectivity between the water table and continuous surface water.

3.7 Regional District of North Okanagan (RDNO)

Table 3.11 Evaluation of flood strategies (Regional District of North Okanagan).

Local Government	Overall perspectives on flooding	Contexts	Placement of the measures and tools	Nature of strategies to support flood protection	Action statement to enhance resilience
Regional District of North Okanagan (RDNO)	Protecting natural environments, rural, and agricultural land through sustainable development.	One of the most important aspects of this area is its natural scenery as well as winter and summer recreational activities attracting tourists. These aspects can be significantly affected by natural disasters such as flooding.	- Bylaw 1888 - Schedule H, 2003 - OCP Bylaw No. 1925, 2004 - OCP Bylaw 2368, 2008 - Bylaw No. 2500, 2011 - OCP Bylaw 2485, 2011 - OCP Bylaw 2626, 2014 - SRWSP, 2014 - OCP Bylaw 2702, 2016	Implementation of mitigative strategies and defining a unified vision emphasizing an integrated management approach are primarily considered by RDNO.	- Consider resilience and flood risk management concepts in reviewing the regional growth strategy. - More inclusive and clear actions on climate change and flood risk issues can be defined and taken by performing risk analysis. - Development of risk-based standards for design/rehabilitation of stormwater drainage systems. - Perform a more specific climate change study in Shuswap River Watershed.

Nature of existing strategies to support overall perspectives on flooding:

Adaptive strategies:

- Considering protection policies including the establishment of buffer strips for ALRs.
- Encouraging the application of integrated water management and source water protection approaches by different tiers of the government.
- Centralized form of community development at Silver Star.
- Designation of 15 m distance from the natural boundary of watercourses as 'Open Space' protected by restricting development.
- Enacting 'protection of development from hazardous conditions' in issuing a development permit area.
- Evaluation of construction impacts on local drainage ditches and watercourses through issuing a temporary commercial/industrial permit as well as the form and character development permit.

- A requirement of environmental and geotechnical information, including locations of watercourses and Environmentally Sensitive Areas (ESAs), for subdivision development permit application.
- Requiring stormwater management details and dimensions for the OCP amendment application.
- Conducting floodplain mapping in the city of Enderby.
- Banning further subdivision in Cabin Colony neighbourhood to protect the current condition and character of the area.
- Encouraging implementation of environmental management act on farming operations.
- Protection of ALRs against future major road expansions.
- Implementation of minimization and clustering concepts in new construction on agricultural lands.
- Designation of the assessment of flood vulnerability and water table elevation as one of the requirements for rezoning applications in rural lands.
- Requiring confirmation from the Agricultural Land Commission for rezoning in ALR for commercial and industrial projects.
- Consideration of stormwater management requirements in zoning change applications within the Swan Lake Commercial District.
- Encouraging to re-accommodate development on slopes greater than 30% or possibly providing geotechnical evaluations.
    - 30 m from the Natural Boundary of Ashton Creek, Bessette Creek, Cherry Creek, Duteau Creek, Ferry Creek, Kettle River, Kingfisher Creek, Monashee Creek, Shuswap River, Tsuis Creek, and Wap Creek; or
    - 15 m from the Natural Boundary of any other watercourse, lake, pond, and any standard dike right-of-way, or structure for flood protection or seepage control.
- Enacting the Riparian and Swan Lake Development Permit Area (RSLDPA) to regulate development activities in watercourse areas.
- Defining 30 m riparian strip from high water mark for a stream as well as 30 m and 10 m for a ravine less than and more than 60 m wide, respectively.
- Consideration of the stormwater management system and sedimentation control plans prepared by a Qualified Environmental Professional (QEP) as a requirement for Riparian and Swan Lake Development Permit Area (RSLDPA) and Environmentally Sensitive Development Permit Area (ESDPA).

- Considering a long-term protection plan for vegetation along natural watercourses, ponds, or lakes.
- Designation of stormwater management systems to control the quantity and quality of run-off from parking areas, internal loads, and buildings.
- Encouraging the application of low impact developments (LIDs) — including bio-retention bulbs and/or gardens, planter boxes, permeable pavement, and/or soil cells in parking lots as well as larger than 300 m^2 green roofs — through the retrofitting process; and construction of wetlands and naturalized drainage ways in new construction.
- Protecting and restoring riparian areas and holding pools to mitigate possible impacts of climate change.
- Consideration of the Shuswap River Watershed Sustainability Plan (SRWSP) to achieve sustainable management of the watershed.
- The requirement of a detailed hazard report addressing possible flooding issues for subdivision applications.
- The requirement of stormwater drainage systems for industrial developments.
- Banning future industrial development in flood vulnerable areas.
- Encouraging residential, commercial, and industrial developments to consider water conservation measures such as water storage facilities capturing rainwater and snowmelt.
- Considering "Land Development Guidelines for the Protection of Aquatic Habitat" to provide adequate drainage work for developments.

Mitigative strategies:

- Community engagement in order to improve environmental awareness.
- Improvement of transportation infrastructure including walkways, bicycle lanes, and public transportation to enhance their efficiency and emission reduction.
- Development of short-term and long-term GHG reduction targets and policies for the regional district.
- Engaging the community by raising awareness regarding climate change to obtain emission reductions.

Midaptive (Mitigative + Adaptive) strategies:

- Consideration of compact development concepts to minimize impacts on agricultural land and natural environment.
- Defining long-term rural protection areas to maintain the rural character of most areas.
- Considering integrated environmental policies as well as regional foreshore strategy to protect floodplains, watercourses, wetlands, and other water ecosystems.
- Maintaining habitat connectivity in natural environments and avoid making enclosed systems.
- Designation and protection of ESAs and specifically watercourses and riparian areas through OCPs.
- Application of best management practices as well as green and sustainable infrastructures for both stormwater and emission management.
- Designation of a regional growth strategy monitoring program to update the regional growth strategy.
- Protecting the natural environment and forested areas by defining the condition of natural environment protection in OCPs through different development areas.
- Defining the required setbacks to protect environmental conditions in development areas.
- Banning new development plans in local wetlands, ponds, and watercourses.
- Designating rural protection boundaries in growth management to preserve rural areas against urbanization negative impacts.
- Maintaining rural context and character of Electoral Areas "B", "C", "D", "E" and "F".
- Consideration of major aquatic systems as sensitive natural areas demanding significant attention during land development.
- Monitoring the impact of climate change on surface water sources.
- Collaborating with other agencies and governments to identify and mitigate climate change impacts that may increase the risk in floodplain areas.
- Flood-proof requirement for mobile homes or buildings located in flood-prone areas that can pollute watercourses.

- Encouraging environmental impact assessment through a required proposal for Comprehensive Resort Developments.
- Using SRWSP to facilitate collaboration among different stakeholders and agencies in RDNO for sustainable watershed management.
- Protecting and enhancing water quality and quantity, especially in streams and creeks, of Shuswap River Watershed by the development of SRWSP.
- Considering Splatsin First Nation's connections and concerns in preparation of SRWSP.
- Monitoring and management of subdivisions' effects on the environment and aquatic habitats in Shuswap River Watershed.

3.8 Village of Lumby

Table 3.7 Evaluation of flood strategies (Village of Lumby).

Local Government	Overall perspectives on flooding	Contexts	Placement of the measures and tools	Nature of strategies to support flood protection	Action statements to enhance resilience
Village of Lumby	- Over the last several years, the Village has undertaken emergency response works through temporarily diking, repositioning village resources, and utilizing provincial resources to protect the community. The Village recognizes an unavoidable need for development in the floodplain, but must manage it carefully to minimize risks and liability.	- The Village is considering floodplain management plan development and planning to update the floodplain mapping within the Lumby's boundaries by collaboration. - Flooding in the Village over the last few years has predominantly been associated with Duteau and Bessette Creeks. However, there has been some flooding on Creighton Creek and Blue Springs Creek as they enter the Village. -Much of the Village lies within the 200-year flood level floodplain of Bessette Creek and its tributaries.	-Zoning Bylaw No. 750 (2012) -Flood Plain Designation and Protection Bylaw No. 8204 (2012) -OCP (2014) -Bylaw No. 761 (Updated 2014) -Village of Lumby Annual Report (2015) -Lumby Flood Mitigation Plan (2019) -Flood Hazards in Village of Lumby (2018)	Most of the available measures are based on adaptive strategies. Since Lumby contains significant lands at risk to natural hazards, strategies are addressing the flood-related issues focused on land use and development plans considering the adaptive approach.	- Excavate deep below the existing channel with a wide bottom would reduce flood levels on Duteau Creek and Bessette Creek. - Floodplain maps can play a crucial role in showing minimum elevation for flood proofs as an administrative tool. However, mitigative strategies, in combination with information from flood maps, can play a crucial role in lowering the risk of flood hazards.

<u>Nature of existing strategies to support overall perspectives on flooding:</u>

Adaptive strategies:

- For the following, not lower than 1m of FCL and also more than natural ground elevation taken at any point on the perimeter of the building:
    - Closed-sided livestock housing with a wooden floor system.
    - Farms dwellings placed on eight-hectare or larger parcels, which are placed within farmland reserve.
    - For industrial purposes, the main electrical switchgear is placed beneath a wooden floor.

- Construction, re-construction, relocation, extension, or relocation of the following land fill or structural support is prohibited (Lumby flood mitigation plan, 2019):30 m range of natural boundaries of Duteau and Bessette Creeks, or
- 15 m range for natural edges of watercourses, marsh, ponds and lakes, or
- 15 m distance from structures, standard dike right of way for protection from flood and control of seepage.
- 7.5 m from any structure or standard dike right-of-way for protection of the flood or controlling seepage. The greater of the two Setback prescriptive shall be applied whenever more than one is applicable

- No area below the flood plain construction level shall be used to install furnaces or other fixed equipment that is susceptible to damage by flood.

Mitigative strategies:

- Any development within a floodplain should be subject to hazard management and flood proofing requirements. A qualified professional determines the requirements on a site-specific basis.

Midaptive (Mitigative + Adaptive) strategies:

- Verify compliance for a land surveyor for floodplain elevations and setbacks mentioned in sections 501.3b and 501.3c of Bylaw No. 750 by inspectors appointed by the Council of the Village of Lumby.
- The Village will minimize flood-related damages to properties by encouraging use of flood-susceptible lands for agriculture, parks, and open space recreation rather than for residential, commercial, or industrial use.

3.9 District of Lake Country

Table 3.8 Evaluation of flood strategies (District of Lake Country).

Local Government	Overall perspectives on flooding	Contexts	Placement of the measures and tools	Nature of strategies to support flood protection	Action statement to enhance resilience
District of Lake Country	- Protection of natural environments by consideration of sustainable development requirements. - Maintaining the rural pattern of the area through sustainable development.	- This area is located between several lakes and there is a considerable number of steep hillsides. So, there is a high potential of different types of acute floods. - A flood in 2017 was a challenge in Beaver and Oyama Lakes.	- Bylaw 561, 2007 (Updated 2020) - OCP, 2018 (Updated 2020) - Bylaw 1121, 2020 (Not official)	While most of the applied measures work based on an adaptive strategy, there are some mitigation measurements as well. Lake Country is going to address the flood related issues through the application of more comprehensive design standards.	- Consider more inclusive policies that emphasize application of LIDs and green building aspects in future developments. - More emphasis on applying resilient risk-based design can be considered for future constructions. - Action plan development can be considered for responding to climate change in a more systematic approach.

Nature of existing strategies to support overall perspectives on flooding:

Adaptive strategies:

- Enacting Stability, Erosion, and Drainage Hazard Development Permit for specific sensitive areas.
- Requirement of a stormwater/drainage management plan against a 100-year flood as well as an erosion control plan in subdivisions.
- Consideration of BMPs as a requirement in new developments in specific areas.
- Protection of the shoreline against development and consideration of a 30 m riparian setback from specific watercourses.
- Definition of a minimum distance from all bodies of water for construction.
- Consider natural resources and hillside protection aspects in issuing development permits (DPs) and establish security deposits to satisfy the requirements.
- Encouraging cluster development in predefined areas for urbanization.

- Minimizing impervious areas during future developments.
- Preparing a floodplain management plan for this area.

Mitigative strategies:

- Encouraging the application of green building features.
- Reduction of greenhouse gas (GHG) emissions through short and long-term plans.

Midaptive (**Mitigative + Adaptive) strategies:**

- Defining environmentally sensitive areas with protected buffers and limited growth regions to maintain the rural pattern of the district.
- Requiring a restoration program in subdivisions.
- Consideration of environmental farm aspects in the expansion of farming.

3.10 City of Kelowna

Table 3.9 Evaluation of flood strategies (City of Kelowna).

Local Government	Overall perspectives on flooding	Contexts	Placement of the measures and tools	Nature of strategies to support flood protection	Action statement to enhance resilience
City of Kelowna	- Protection of natural environment and reduction of GHG emissions by considering sustainable development goals. - Application of advanced stormwater adaptive measures through more inclusive and updated policies.	- There is a significant increase in population and developments in Kelowna, which is affecting the stormwater conditions. - High groundwater levels as well as the water level in Okanagan Lake and other watercourses, especially Mill Creek, are crucial aspects that should be considered in this area. - Quality of run-off discharging into Okanagan Lake is an important problem in this area. - Previous floods such as a severe event in 2017 are magnifying the effects of climate change in the area.	- Bylaw 8000, 2007 (Updated 2019) - Bylaw 10248, 2011 - OCP, 2013 (Updated 2018) - Community Trends reports, 2017 - Bylaw 7900, 2018 - Action Plan, 2018 - Community Climate Action Plan, 2018 - 10-Yr Capital Plan, 2018	There is a considerable number of midaptive strategies among Kelowna's measurements to address flood-related issues. Application of new and comprehensive water management systems is becoming a priority in this area.	- Development of an integrated monitoring and management model for water systems. - Perform a comprehensive uncertainty analysis on available long-term meteorological records considering uncertain input parameters of stormwater drainage models. - Conduct a cost-benefit analysis as a complementary step of uncertainty evaluation to select an appropriate design strategy for urban drainage systems. - Consider more inclusive policies emphasizing the application of LIDs and green building aspects in new construction.

<u>Nature of existing strategies to support overall perspectives on flooding:</u>

Adaptive strategies:

- Binding a security deposit to ensure the satisfaction of requirements related to natural environment development permit.
- Defining the minimum required setbacks from environmentally sensitive areas for construction and development.
- Consideration of cluster development in predefined urban areas.
- Implementation of stormwater management strategies to reduce the volume of run-off and enhance its quality.
- Utilizing BMPs for rehabilitation purposes to avoid exceeding peak flow from pre-development conditions as well as enhancing water quality.

- Considering and protecting riparian management areas near watercourses.
- Protecting areas with steep slopes.
- Imposing seepage assessment requirements in steep hillside areas.
- Requiring a sediment and erosion control plan for specific types of development projects.
- Minimizing the connection of rain-water leaders with the stormwater system.
- Imposing hazardous condition development permits on Mill Creek and Okanagan Lake adjacent areas to consider more inclusive and strict guidelines.
- Defining the minimum flood construction level in watercourses' floodplain, especially for Mill Creek.
- Floodplain mapping of Mission Creek.
- Design return periods of 5, 100, and 200 years were considered for minor systems, major systems, and major infrastructures, respectively.
- Considering a 15% increase in urban stormwater drainage systems' capacity to address the potential effects of climate change.
- Major projects should be designed based on hydrograph methods.
- Defining Minimum Building Elevation (MBE) near watercourses, which should be 600 mm above the calculated Hydrograph Grade Lines (100-yr) as well.
- Implementation of BMPs to control roof leaders' run-off.
- Considering maximum allowable flow depth of 300 mm on roadways with at least one flood-free lane.
- Considering maximum allowable flow depth of 300 mm and 150 mm for outside and inside stalls, respectively.
- Designation of detention storage, dry detention ponds, wet detention ponds, and infiltration systems' requirements to sustain pre-development conditions in substantial future constructions.

Mitigative strategy:

- Encouraging the application of green building features.

Midaptive (Mitigative + Adaptive) strategies:

- Imposing a Natural Environment Development Permit as well as suitable zoning on predefined protected areas.
- Designation of all watercourses as well as sparsely vegetated lands in development permit areas to improve and protect water quality and environmental aspects of the area.
- Implementation of "no net loss" requirement on long-term productivity of aquatic and terrestrial habitats in land use determination and development.
- Protection of sensitive areas against industrial development.
- Protecting Agricultural Land Reserve (ALR) from future developments.
- Defining tree coverage goals to enhance the natural environment.
- Development of a linear park master plan.
- Providing a design standard related to urban stormwater drainage systems to mitigate risks, enhance resilience, and minimize environmental impacts.
- Total predicted investment of about 12 M$ on construction and rehabilitation of urban stormwater drainage systems from 2018 to 2027 with special consideration to Mill Creek-related projects.

3.11 Regional District of Central Okanagan (RDCO)

Table 3.10 Evaluation of flood strategies (Regional District of Central Okanagan).

Local Government	Overall perspectives on flooding	Contexts	Placement of the measures and tools	Nature of strategies to support flood protection	Action statement to enhance resilience
Regional District of Central Okanagan (RDCO)	- Consideration of environmental responsibility and sustainability to protect central Okanagan's nature. - Impose some limitations on urban development in Ellison, Brent Road and Trepanier, South Slopes, and Westside, preserving rural and agricultural patterns to protect the environment.	- Floods in 2017 and 2018 caused considerable physical damages to properties and infrastructure. - Residential areas have been increasing over recent years, affecting stormwater conditions in Ellison. - Ministry of Transportation and Infrastructure (MOTI) has jurisdiction over a subdivision in considerable areas located in Brent Road and Trepanier limiting RDCO influence. - MOTI and the Ministry of Forests, Lands, Natural Resource Operations and Rural Development have jurisdictions over a certain aspect of storm drainage in this area. - The storm drainage system is identified as a problem in Westside. - A considerable number of major streams are located in South Slopes. - Quality of run-off discharging into Okanagan Lake is a serious problem in this area.	- Zoning Bylaw No. 871, 2000 (Updated 2018) - OCP Bylaw No. 1124, 2006 (Updated 2017) - OCP Bylaw No. 1274, 2010 (Updated 2014) - OCP Bylaw No. 1303, 2012 - OCP Bylaw No. 1304, 2012 - Floodplain Management Plan (Phase 1), 2016 - Flood Mapping Project: Peachland and Trepanier Creeks, 2019	A considerable number of midaptive and adaptive strategies can be found in the RDCO measures, primarily trying to manage the quality and quantity of water in watercourses, creeks, and lakes as well as protection of their adjacent areas.	- A detailed assessment of stormwater drainage systems in Ellison and other areas, and development of a comprehensive management plan. - Consider services and requirements to respond to severe flood events in the utilities and infrastructure section of the OCP. - Perform flood risk assessment and developing risk mitigation strategies in this region to complete floodplain management studies. - Consider flood risk aspects of different areas of RDCO in the determination of shore zones of the Okanagan Lake. - Development of a design standard for stormwater drainage system considering risk-based concepts as well.

Nature of existing strategies to support overall perspectives on flooding:

Adaptive strategies:

- Evaluation of development impacts on off-site run-off specifications and natural environment during construction in a planned area.
- Designation of Agricultural Land Commission (ALC) approval for subdivisions in ALRs considering the Regional District Agricultural Plan's requirements as well.
- Considering Landscape Buffer Specification and other required buffers in issuing future amendments on ALR by provincial ALC.
- Development of Ellison Stormwater and Wastewater Management Plan, which is necessary to be considered in residential developments.
- Updating Foreshore Inventory Mapping (FIM) and Ellison Sensitive Habitat Inventory Mapping (SHIM).
- Considering recommendations provided by provincial guidelines about watercourses (including recommendations about BMPs application) and working with resource managers to protect natural drainage patterns.
- Determination of riparian buffers in different projects and protecting the foreshore area against constructions' negative impacts.
- Consideration of different provincial regulations in construction on floodplains.
- Performing flood and erosion susceptibility assessment in different areas before development.
- Hazard reduction by mimicking natural patterns in constructions.
- Considering the requirement of continuous financial support for development with significant flood control works.
- Trying to access sustainable federal funding for major flood protection projects.
- Monitoring rural development impacts on the drainage system of the area.
- Evaluating the side-effects of drainage pattern alternation resulting from agricultural development in downstream areas.
- The requirement for environmental impact assessment, flood protection, and stormwater management evaluations in land use and development applications in defined areas.
- Development of regional parks and greenways to protect the natural environment and providing recreational opportunities.

- Management and monitoring of run-off rate discharging into the lake to reduce its negative impacts.
- Assessment of future residential development concerning natural hazards such as flooding.
- Banning the discharge of construction silt, gravel, and debris into natural drainage courses and watercourses.
- Partitioning the shoreline length of Okanagan Lake into different zones based on habitats' degree of value for planning and protections.
- Defining shoreline leave strips for different zones of the shoreline that should remain undisturbed.
- Minimum setbacks from water ecosystems are:
    - 15 m from the natural boundary of Okanagan Lake.
    - 7.5 m from the natural boundary of a lake, swamp, or pond.
    - 30 m from the natural boundary of Mission Creek.
    - 15 m from the natural boundary of any other nearby watercourses.
    - 7.5 m from the natural boundary of any standard dike right-of-way, or structure for flood protection or seepage control.
- Protecting leave strips, species, vegetation, and hydrological regimes against development.
- Protecting the wetlands and watercourses in the development of Crystal Mountain Ski and Gold Resort by conducting environment analysis during preliminary development phases.
- Considering Flood Hazard Land Use Management Guidelines of BC as a requirement for development.
- Protecting riparian areas from road construction to keep natural connectivity.
- Restoring and enhancing the vegetation pattern of riparian areas.
- Confining natural disturbances such as flooding to the no-disturb zones while trying to keep the natural condition of riparian areas.
- Maintaining vegetation covers of wetland to reduce runoff and enhancement of groundwater infiltration and keeping its natural processes.
- Design and application of land development and subdivision concerning the protection of vulnerable species and plants.

- Maintaining water quality in this area, especially against land alternation and erosion.
- The requirement of an Environmental Sensitive Areas (ESA) rating provision (with four levels) from Qualified Environmental Professionals (QEPs), based on provided criteria, to prioritize the protection plan.
- Referring to integrated stormwater management guidelines to protect the ecological integrity of watercourses and wetlands and mimicking natural conditions.
- All areas with slopes, greater than or equal to 30%, should be evaluated by engineers as a hazardous area.
- Maintaining the vegetation of steep slope areas to control erosion in addition to sensitive grading, revegetation, and soil amelioration work.
- Keeping the drainage rates discharging into offsite as close as possible to pre-development conditions.
- Encouraging the implementation of detention and retention ponds with a natural appearance.
- Performing a flood mapping study of Peachland Creek and Trepanier Creek as the first phase of regional floodplain management.
- Defining areas being flooded by a return period of 5 years and seasonally inundated channels as active flood plains requiring specific considerations.
- Defining short-term initiatives related to stormwater management in specific areas.

Mitigative strategies:

- Control measures on the interface of agricultural and urban areas, such as required setbacks and density reductions.
- Encouraging the application of energy-efficient products and green building principles in new construction.
- Policies considering GHG emission reduction in short and long-term plans.
- Regulation of outdoor burning conditions to reduce emissions in RDCO.
- Conducting the Regional Air Quality program to protect and improve the air quality in RDCO.
- Increasing walking and cycling opportunities in RDCO to enhance air quality and address climate change issues.

- Conducting the Central Okanagan Sensitive Ecosystem Inventory (SEI) project providing scientific information about sensitive environments.

Midaptive (**Mitigative + Adaptive) strategies:**

- Maintaining the rural character of the area and limiting future urban growth to predefined regions.
- Protect the rural resources of the area by considering BMPs' requirements, minimizing services, and keeping the rural pattern.
- Protecting ALR by not supporting future subdivisions.
- Conducting the Ellison Sensitive Habitat Inventory Mapping (SHIM) project providing detailed information about watercourses of the area.
- Supporting OBWB activities to protect water resources.
- Protecting the natural linkage in ecosystems with riparian areas, ravines, and steep slopes.
- Designation of the Aquatic Ecosystem Development Permit Area to protect both natural environment and developments (from potential hazards) on specific areas.
- Designation of the Sensitive Terrestrial; Ecosystem Development Permit Area to protect both terrestrial environment and developments.
- Considering the Okanagan-Shuswap Land Resource Management Plan in development to protect the natural environment.
- Consideration of flood protection, stormwater management and drainage plans, and environmental impact assessment in required reports for issuing some specific development permits.
- Reviewing proposal related to working below high water mark (HWM) on Okanagan Lake (e.g., 38.4 km shoreline in north-west side) based on a risk-based protocol of the Ministry of the Environment to protect aquatic habitants by avoidance, minimization, or compensation of impacts (rooted in no-net-loss principle).
- Enacting the Fisheries and Oceans Canada's principle of no net loss in fish habitant adjacent areas.

- Considering storm drainage, flooding/erosion issues, and environmental assessment requirement in reports necessary for Recreation Resort Study Area in South Slopes.

3.12 Okanagan Nation Alliance (ONA/Syilx)

Table 3.12 Evaluation of flood strategies (Okanagan Nation Alliance).

Indigenous organization	Overall perspectives on flooding	Contexts	Placement of the measures and tools	Nature of strategies to support flood protection	Action statement to enhance resilience
Okanagan Nation Alliance (ONA)	Linking knowledge of indigenous people in land-based-based decision making and reducing the risk floods and debris flow.	- Syilx Okanagan people are affected by ecosystem degradation, severe water quality deterioration, and species loss. - ONA aims to focus on risk reduction by applying community values and generating resources for everyone in the region.	Syilx Okanagan Flood and Debris Flow Risk Assessment, 2019	There is a recognition of the issues of sustainable land use and natural resource management. A number of adaptive measures are available in the flood risk assessment report.	Develop interventions specific to flood risk management under the vision of sustainable development and protecting the environment will be useful.

Nature of existing strategies to support overall perspectives on flooding:

Adaptive strategies:

- Land management and planning take account of the whole interconnected system, restore natural function, and make wiser decisions in consideration of the whole.
- Draw on multiple sources and types of knowledge, including traditional and land-based knowledge, to manage flood and debris flow.
- Adopt a watershed-based governance model by strengthening relationships with local governments and agencies in the region.
- Nurture connections with forestry and land developers to design effective control measures.

3.13 City of West Kelowna

Table 3.13 Evaluation of flood strategies (City of West Kelowna).

Local Government	Overall perspectives on flooding	Contexts	Placement of the measures and tools	Nature of strategies to support flood protection	Action statement to enhance resilience
City of West Kelowna	- West Kelowna prioritizes flood repair based on community effects. - Protection plan for the areas identified by the community, including sensitive regions for the ecosystem and natural regions like hillsides. - Considering the impact of urban development in mitigative strategies with drainage facilities best practices.	- Waterfront is important because of the visitor attraction to the area. Regulations and resilience are important factors for these areas since they assist in providing low-risk activities. - Restoration of areas with native plants and vegetation. The priority areas include areas with sensitive habitat, floodplain areas, and stream banks.	-Bylaw No. 1050 (2005) -Westside OCP (2007 and 2011) -Bylaw No. 0100 (2011) -West Kelowna Waterfront Plan (2011) -West Kelowna – Master drainage plan Vol. 2 (2011) - Storm Water Best Management Practices (2012) - Drainage Improvement (2017) -Climate action (2017) -West Kelowna Advisory Planning Commission (2019) -Bylaw 100.42 -Bylaw No. 0120.	While most of the applied measures are based on an adaptive strategy, there are some mitigation and measurements as well. The available policies are mostly focused on zoning adaptive and mitigative strategies. In addition, West Kelowna has a good drainage plan that prioritizes the flooding zone.	- Sensitive Habitat Inventory and Mapping Update gives an insight for prioritizing flood management plans. - Map inventory developed by Echoscope Environmental Consultants Ltd. in 2010. Should be updated by zone change over time (update every ten years). - Establish resilience strategies to maximize mitigation at the waterfront by dividing it into different parts by importance of resilience and priority fronts - Flood map discretion can increase the efficacy of the resilience plan. Discrete zones will give the option of prioritizing the zones based on flood risks. Decisions that are made in the selection of resilience strategies can therefore be more effective than policies that are applied per se -Management plans based on forecasting models are beneficial in short- and long-term plan development. - Existing mobile homes are non-compliant with the City's floodplain regulations - Develop flood forecasting systems and enhanced flood

					forecasting capacity in the area. - Map of the area can be discrete in 3 to 5 zones based on risk, the likelihood of flooding, after-flood damage assessment plus post-damage recovery time.

Nature of existing strategies to support overall perspectives on flooding:

Adaptive strategies:

- Several floodplain regulations within the Zoning Bylaw limit the ability of Green Bay Mobile Home Park to meet its requirements.
- Salvaging, reapplication of topsoil that is native to the area, and stockpiling are important re-vegetation efforts to re-establish native vegetation. It is recommended that topsoil management plan can play an active role in this regard.
- Horizontal setback from Okanagan lake is required to be 15 m from the natural boundary for any landfill place to elevate a floor system to achieve the requirement (see Section 3.24.1 Bylaw No. 0.154).
- In a space or room that is used for dwelling purposes and which is susceptible to flood damage, the top of the pads supporting that structure should be above 343.66 m Geodetic Survey of Canada datum (GSCD) for a parcel abutting Okanagan Lake (section 3.24.1(a) Bylaw No. 0.154).
- A 0.6 m vertical distance added to represent local variations in water level and uncertainty in estimates from science and engineering.
- Elevation requirements should be followed in places where construction occurs or will occur, and which may be affected by flooding.

Mitigative strategies:

- Controlling the rate of development increase in areas at risk of flooding because of nearness to a watercourse.
- Stabilization of soil based on erosion control strategies in best management plans.

- Covering and stabilization of soil includes the application of loose, bulky materials for reducing runoff, increasing infiltration stabilizing bare and disturbed soils. Materials used for this purpose include wood-bark chips, hydraulic matrices, and mulches and green materials.
- Natural or artificial mats to be used for stabilizing temporarily or permanently.

Midaptive (**Mitigative + Adaptive) strategies:**

- Stabilizing soil temporarily or permanently by seeding and planting trees, shrubs, grasses, vines, etc.
- Removal of permanent structures reduces the potential for damage associated with flooding on the property.
- Address long-term concerns associated with park's in risky areas nonconformities and ageing infrastructure.

3.14 Westbank First Nation

Table 3.14 Evaluation of flood strategies (Westbank First Nation).

Indigenous community	Overall perspectives on flooding	Contexts	Placement of the measures and tools	Nature of strategies to support flood protection	Action statement to enhance resilience
Westbank First Nation	Minimizing the hazard of floodplains on development by regulating any development/construction within the floodplains and locating lower intensity land uses in these areas.	The 2015 Westbank First Nation Community Plan guides economic growth, development, natural resource management, and community planning within the reserve lands, administrative area, and traditional territory of Westbank First Nation in the region.	Westbank First Nation Community Plan, 2015	Westbank First Nation members recognize their connection to the land, resources, and natural world. A number of adaptations to protect the land are available.	More specific adaptation and mitigation measures focused on flood management would enhance resilience.

Nature of existing strategies to support overall perspectives on flooding:

Adaptive strategies:

- Westbank First Nation thoroughly acknowledges its connection to the land, natural resources, and elements of the natural world.
- Westbank First Nation recognizes its bond with nature and responsibility to protect the land and her resources for today and future generations.
- Create and integrate environmentally sensitive laws that encourage sustainable development, resource conservation, and social harmony.
- Prioritize development to support compact communities.
- Retain significant native vegetation and trees of the area during development.

3.15 District of Peachland

Table 3.15 Evaluation of flood strategies (District of Peachland).

Local Government	Overall perspectives on flooding	Contexts	Placement of the measures and tools	Nature of strategies to support flood protection	Action statement to enhance resilience
District of Peachland	Background Review, Field Reconnaissance and Surveying, Hydrological Analysis, Hydraulic Analysis, include a description of important steps or assumptions that are considered as Peachland's flood strategy. Also, strategies are mostly focused on prevention regulations to reduce the consequences of floods.	- Downtown Peachland is generally at high risk or very high risk of damage during a flood. -Peachland and Trepanier Creeks were assigned a Preliminary Flood Risk Rating (PFRR) of High in the Regional Flood Management Plan (RFMP). -Peachland and Trepanier Creeks are both Community Watersheds located on the west side of the Okanagan Valley.	- District of Peachland Master drainage plan (1995) - OCP Bylaw No. 1600 (2001) - Regional Floodplain Management Plan: Phase 1 (2016) - Okanagan Lakeshore Flood Risk Assessment for the District of Peachland - Bylaw No. 2209 (2017) - OCP Bylaw No. 2220 (2018) - Zoning Bylaw No. 2100 - Bylaw No. 1865 - Bylaw No. 1956 - Flood Mapping Project: Peachland and Trepanier creeks (2019) - Okanagan Lakeshore Flood Risk Assessment project for the District of Peachland (Water Edge, 2020)	While most of the applied measures are based on an adaptive strategy, there are some mitigation measures as well. The available policies are mostly focused on restrictive policies to control flood hazards.	- The number of storm outfalls into natural watercourses should be minimized. - Review previous flood events and impacts on the area to developing a risk management plan - Floodplain mapping/dam breach mapping should be considered, at least, for each creek containing a very high or extreme hazard consequence of dam failure. - Flood forecasting systems and enhance flood forecasting capacity in the area.

<u>Nature of existing strategies to support overall perspectives on flooding:</u>

Adaptive strategies:

- Each lot should be grouped to drain to a drainage system or a natural drainage path independent of adjacent lots. Lowest lot grade to be 2% and should be uniform and consistent.
- Regions adjacent to proposed sites for buildings should be graded far from the suggested foundations to prevent flooding.
- Grading within 2 m of any structure or proposed sites should be considered with a 10% slope or a minimum 0.15 m drop.

- Any proposed building should be placed above the hydraulic grade line of the major system. The lowest building elevation should be noted on the drawing as well.
- For regions close to a watercourse where the floodplain elevation has been established, the lowest elevation for a building is 0.3 m above the instantaneous flood of 200-year return period.
- The Municipality's main drainage systems should be connected to all private properties' drain systems.
- The lowest building elevation needs to be a minimum 0.6 m above the service connections and 0.3 m above the of the 100-years hydraulic grade line.
- According to Bylaw No. 2100, it should be considered in construction that:
    - Any construction near watercourses and/or standing bodies of water should be 15 meters away from their boundaries.
    - The floor system of pads which supports a space should be 1.5 m above the boundaries of watercourses and/or standing body of water.
- One lane or at least 3 m of width at the crown should be free from flooding in partial, collector, or local roads.
- Main-level occupancies and entries should not be more than 1m from the front of street grade or sidewalk unless construction levels or water table dictate otherwise.

Mitigative strategies:

- Identify/prioritize flood hazard areas and flood hazard assessments (for priority areas) to develop a risk mitigation strategy according to priorities.

Midaptive (Mitigative + Adaptive) strategies:

- An individual drain to a natural watercourse requires the approval of provincial and federal agencies. In terms of the size and limitations of storage facilities, these should be based on the requirements, to have a graduated control structure based on the range of flow rates (1, 2, 5 and ten years).

3.16 District of Summerland

Table 3.12 Evaluation of flood strategies (District of Summerland).

Local Government	Overall perspectives on flooding	Contexts	Placement of the measures and tools	Nature of strategies to support flood protection	Action statement to enhance resilience
District of Summerland	Maintaining the agricultural character of the area as well as the protection of natural environments through sustainable development.	- Based on Regional Growth Strategy, the south Okanagan is one of the most environmentally vulnerable regions in Canada. Also, there are five major water features in Summerland. - Geographical specifications of Summerland, which is a vast area, is also stressing stormwater management. - Lack of sufficient hydraulic capacity to manage stormwater has been reported in some parts of Prairie Creek located in this area. - Unstable silt bluffs near watercourses may be negatively affected by performance of drainage systems. - High potential lands for development are located on the shoreline of Okanagan Lake in Lower Town.	- Water Master Plan, 2008 - Climate action plan, 2009 (Updated 2011) - Bylaw 2000-450, 2011 (Updated 2019) - OCP Bylaw 2014-002, 2015 (Started 1996, Updated 2018) - 2015 to 2019 Strategic Plan, 2015	A significant number of mitigative considerations concerning climate change and the reduction of GHG emissions can be found in the general strategies of Summerland.	- Conduct a new stormwater drainage study considering climate change effects. - Development of an on-line integrated monitoring and management water system. - Define clear and inclusive requirements based on hydraulic structures design and the latest achievements in urban stormwater drainage systems to protect people and structures against flood risk through Lower Town constructions. - Define flood risk management initiatives under vision components of "sustainable environment" and "safe community" in the next strategic plan. - Produce a detailed stormwater drainage guideline considering the application of Low Impact Developments as well. - Development of a watershed-scale plan to manage future flood issues in the area, especially in Trout Creek Watershed as the primary water source of Summerland with nine important reservoirs.

Nature of existing strategies to support overall perspectives on flooding:

Adaptive strategies:

- Enacting Watercourse Development Permit Area (WDPA) to protect riparian areas requiring an environmental assessment report.
- Limiting consequential construction to Primary/Urban Growth Area, which is shrunk by the OCP amendment.
- Protecting ALR against future development.
- Considering the application of Best Management Practices (BMPs) in order to manage stormwater and maintain pre-development conditions in new construction.
- Considering compact community development in future construction.
- Buffer requirement between urban development and ALRs.
- Avoid construction in areas with a slope of more than 30%.
- Reduction of required impervious areas in road construction.
- Designation of Agricultural Land Commission approval before starting road construction projects.
- Consideration of stormwater drainage service in the rural residential development.
- Conducting floodplain mapping for the adjacent areas of Trout Creek and Okanagan Lake.
- Identification of High Hazard Zone, which is highly susceptible to flooding, demanding setback complementary studies.
- Enacting Downtown Development Permit Area to reduce hazards of construction and protect natural environments in predefined areas.
- Exemption of governmental flood protection projects from WDPA and Environmentally Sensitive Development Permit Area (ESDPA).
- Enacting no net change concept in surface water volume and impermeability of non-disturbance areas in ESDPAs.
- Bonding requirement for conditional approval of some permits considering flood related issues.
- A site drainage plan requirement for industrial development under Bentley Road Indusial Development Permit Area.

- Considering 1.8 m minimum distance between artificial bodies of water, with a depth of more than 0.6 m and area of more than 5 m^2, and an interior side property line.
- Encourage the application of rainwater harvesting in new developments.

Mitigative strategies:

- Encourage application of green building features.
- Encourage expanding environmentally friendly industries.
- Renewable energy applications and efficiency improvement measures to reduce GHG emissions in both industrial and residential development.
- Considering solar, wind, and geothermal energy devices as the principal part of specific construction.
- Formation of climate action working group to enhance and monitor climate action related plans in the community.
- Considering integrated management concepts in water resources, social aspects, and effective growth management.
- Taking various short and long-term actions considering energy efficiency concepts in planning documents and processes.
- Generation of computerized inventory of trees in most areas in order to protect and preserve them.

Midaptive (Mitigative + Adaptive) strategies:

- Public engagement to satisfy the OCP's goals and involvement in environmental protection practices.
- Enacting ESDPA to protect vulnerable areas.
- Defining Riparian Area Regulations as well as considering provincial ones to address environmental aspects of fish habitat watercourses.
- Enacting the neighborhood planning process considering the major drainage system, environmental and hazard assessment, and setback evaluation.

- Intensification policies stated in the downtown strategic plan protecting agricultural and environmentally sensitive areas.
- Requiring a monitoring report to evaluate conditions of developments for up to two years on specific types of projects.
- Continuously and systematically monitoring OCP progress addressing both environmental and climate change issues.

3.17 City of Penticton

Table 3.17 Evaluation of flood strategies (City of Penticton).

Local Government	Overall perspectives on flooding	Contexts	Placement of the measures and tools	Nature of strategies to support flood protection	Action statement to enhance resilience
City of Penticton	In the 1950s, following a couple of massive floods, 39 drop structures were constructed to pass greater flood flow volumes while reducing the grade of the creek to control erosion. Also dam failure and large waves on Okanagan Lake caused flooding. Therefore, most of the policies of the area focus on low-lying regions that are affected by flooding.	- Safety in terms of mitigating environmental risk–wildfire, geotechnical hazards and flooding must be considered as the City grows and develops. - The impact of the flood is considered moderate in the area due to its infrequency. - Considering the low-lying river floodplain regions, the primary cause of the flood in the area is excessive rainfall.	- OCP 2045 Bylaw No. 2019-08 (2019) - OCP Bylaw No. 2002-20 - Zoning Bylaw No. 2017-08 - Penticton Master Plan (2017) - Penticton Creek Master Plan Restoration - Ellis Creek Master Plan (2020)	Because of the importance of fish habitat in the Penticton area, also having a history of high creek flows plus the high risk of seismic activities for the long shoreline, most of the adaptive and mitigative strategies are focused on prevention.	- Create a stable channel lining, (bed/surface covering), a widened floodplain is proposed for the south side of Penticton Creek. For future planning, cost estimating and design purposes, it would be useful to complete additional topographic surveying to establish a practical boundary defining past flood works (berms, etc.) within the M-178/185/195 Plan, where the City has authority to use the land for changes beside the creek (Available in Penticton Master Plan). - Having a canal that safely moves water through Penticton is vital for flood protection and must be considered while balancing elements that restore habitat for fish. - Continue to implement the Penticton Creek and Ellis Creek Masterplans to mitigate flooding and to restore habitat. .- Council approved flood protection plans in the 1950s and the 1970s to safeguard the community from flooding. Plans associated with the creek appear on the Title to private properties; however, as property ownership changes over time, current owners may not be aware of the notation or the importance of preserving the area. Therefore, updates are required on the approved plans in that period.

Nature of existing strategies to support overall perspectives on flooding:

Adaptive strategies:

- Following are the principles that guided the creation of the flood priorities list; It is more difficult to fix a failing infrastructure and bank erosion in an emergency than an isolated lack of freeboard or woody debris. Besides bridges and traffic flow, a specific bridge that serves as an area's only entrance or exit is also of great importance. Therefore, the priority for flooding was suggested as follows (Penticton Creek Master Plan Restoration): Drop structure failure, Lack of bridge clearance, Lining failure, Lack of bank freeboardack of bank freeboard. Provincial plans are not to exceed 65 m^3/s releases at Okanagan River, Penticton, to minimize the number of buildings flooded at and downstream of Penticton.
- Using the survey of the creek, HEC-RAS hydraulic analysis was computed for the Q200 instantaneous flood (60 cms) and maximum daily flood (48 cms) to determine bank locations that lacked freeboard or bridges that required clearance.
- The standard for the elevation of the river dike crest is the higher of 1 in 200-year instantaneous flow, plus 0.3m freeboard and maximum to 1 in 200-year daily flow plus 0.6 m freeboard.

Mitigative strategies:

- Avoid development in environmentally sensitive areas, geological and flood hazard areas, steep slopes, agricultural, and in areas not readily served by transit.
- Mitigate the impacts of potential flooding on buildings and properties in the floodplain area and affected by groundwater through design and site grading prior to construction.
- Increase public awareness of flood protection.
- In restricted areas, aim to maximize habitat values within flood protection constraints; recognizing any level of naturalization is a step forward, and the cumulative effects from this approach are large.

- To create a maintenance-free channel that retains gravel during annual floods, a 40 m floodplain would need to be created, which is unrealistic given the land use around this reach

Midaptive (**Mitigative + Adaptive) strategies:**

- Upgrade vegetation master plan for flood prevention and riparian aspects.
- As part of the expanded floodplain option, a ramp could be installed for collecting the accumulated gravel that will be reintroduced into the system at higher elevation.
- Flood forecasting systems and enhanced flood forecasting capacity in the area.

3.18 Penticton Indian Band

Table 3.18 Evaluation of flood strategies (Penticton Indian Band).

Indigenous community	Overall perspectives on flooding	Contexts	Placement of the measures and tools	Nature of strategies to support flood protection	Action statement to enhance resilience
Penticton Indian Band	The Penticton Indian Band envisions having a good way of living for people, whatever that looks like, and summarizes it as living the good life.	The Penticton Indian Band believes that community should be economically sound with their own resources and self-sufficient in a way that external support is not required.	Comprehensive Community Plan, 2013	The Penticton Indian Band is in the process of completing land use designations.	- Consider environmental sustainability and flood resilience in long-term development plan. - Land use planning and zoning plans would help community to achieve land protection, preservation, and development goals and flood resilience. - Preservation of natural resources, biodiversity, and forestry. - Introduce green business initiatives to strengthen sustainable economy.

Nature of existing strategies to support overall perspectives on flooding:

- Complete the lands designations through a Land Use Plan.

3.19 Town of Oliver

Table 3.19 Evaluation of flood strategies (Town of Oliver).

Local Government	Overall perspectives on flooding	Contexts	Placement of the measures and tools	Nature of strategies to support flood protection	Action statement to enhance resilience
Town of Oliver	- Steward and protect natural features and systems. - The town sets the target of reducing GHG emissions.	Make efforts to protect the natural environment to the greatest possible extent so that natural resources are protected, preserved, and maintained for the enjoyment and benefit of residents, tourists, and visitors to the town.	Official Community Plan Bylaw 1370	- The adaptation/mitigation measures are mainly focused on sustainable land use and energy efficient buildings. - Although the region is an arid climate, the idea to manage stormwater via low impact development alternatives is limited.	Assessment of flood risk and application of low impact developments should be thoroughly investigated.

Nature of existing strategies to support overall perspectives on flooding:

Adaptive strategies:

- Designate public lands that are undevelopable due to flood plain, topography, or natural or ecological features.
- Land designated as environmentally sensitive shall be maintained in its natural form and state.
- Development in designated Watercourse Development Permit (WPD) Areas is to occur according to guidelines.
- Support the sustainable use of water and promote water conserving procedures in domestic and yard use.
- Manage stormwater/rainwater in relation to the most recent integrated watershed management or rainwater best practices and design manuals.
- Native and drought-tolerant plants should be used for landscaping.

Mitigative strategies:

- Reduce GHG emissions in the Town of Oliver as per the BC Climate Action Charter reduction targets.
- Carbon neutral Town of Oliver government operations should be achieved.
- The use of renewable energy technologies (solar panels and geothermal energy technology) is encouraged for residential buildings and for accessory facilities such as swimming pools.
- Development should happen in a way that there is no net increase in post-development surface water flows and impermeability. Also, the quality of water available within the non-disturbance areas should not be affected.

3.20 Osoyoos Indian Band

Table 3.20 Evaluation of flood strategies (Osoyoos Indian Band).

Indigenous community	Overall perspectives on flooding	Contexts	Placement of the measures and tools	Nature of strategies to support flood protection	Action statement to enhance resilience
Osoyoos Indian Band	The Board of the Osoyoos Indian Band deems it advantageous to enact strategies to maintain, construct, and regulate waterworks systems on the reserve of the Band.	Development is restricted on lands that may be susceptible to natural hazards, as determined by the Regional District or other agencies. Also, Development is prohibited on lands identified as being susceptible to soil instability or potentially hazardous geotechnical conditions by the Regional Board.	- Corporate Plan 2018-2022 - The Osoyoos Indian Band Bylaw No. 2001-002 - Osoyoos Rural Plan Bylaw No. 2260 (2004)	Susceptibility to hazards including flooding, slope instability or wildfire risk.	- Reduce the rate of development in lands that can be affected by flooding. In addition, areas with mentioned liabilities should be considered for park, recreation, and agriculture use. - Protection of properties from flooding or any loss because of erosion of watercourses by maintaining the close lands in undisturbed states.

Nature of existing strategies to support overall perspectives on flooding:

Adaptive strategies:

- Development near floodplains and watercourses or waterfront needs to be regulated through defined strategies (e.g. strategies set by the Ministry of Environment and Climate Change).
- Construction or replacement of any structure for different purposes (e.g. business, habitation, storage, industry, etc.) that may be affected by flooding needs to be flood proofed if no alternative is available.

Mitigative strategies:

- Encourage volunteer supervising on lands and private properties within rural holdings for environmental issues.

3.21 Town of Osoyoos

Table 3.21 Evaluation of flood strategies (Town of Osoyoos).

Local Government	Overall perspectives on flooding	Contexts	Placement of the measures and tools	Nature of strategies to support flood protection	Action statement to enhance resilience
Town of Osoyoos	Osoyoos local government intends to foster social, economic, and environmental wellbeing of the community. It aims to guide organized and efficient phasing of land use, servicing, and public/private investment that can support provincial and regional growth and long-term resource management.	In line with the Regional Growth Strategy (RGS), the municipality lays a blueprint for development in Osoyoos and ensures that all growth initiatives are environmentally sustainable and offer economic and social benefits to the communities.	Official Community Plan, 2007	The OCP identifies specific actions in land development that would help in flood risk management. Many adaptation measures emphasize sustainability and natural resource management.	- More emphasis on the application of resilient risk-based design can be considered. - Sett targets for GHG emissions in response to climate change would be useful.

Nature of existing strategies to support overall perspectives on flooding:

Adaptive strategies:

- Information is available on construction and effective use of sandbags to protect homes or buildings from flood damage.
- Minimize urban growth demands on agricultural lands.
- Maintain a compact urban form.
- Xeriscaping is strongly encouraged to minimize water usage.
- Use of native plants is encouraged.
- Protect natural habitats and species diversity from negative growth impacts.
- Reduce risks from development to sensitive ecosystems and rare and endangered species.

Mitigative strategies:

- Set the flood plain level for all other watercourses as 1.5 m above their high water mark.
- Land within 7.5 m of the periphery of Osoyoos Lake, a swamp, or pond is designated as a Floodplain Setback Area.
- Hard surfaces should be kept to a minimum to reduce peak rain runoff and promote aquifer recharge; pervious surfacing materials are encouraged.
- Continue to pursue the BC Stormwater Planning Guidebook goal that impervious areas resulting in stormwater discharge into a receiving watercourse should not constitute more than 10% of the total developed municipal area.

3.22 Regional District of Okanagan-Similkameen (RDOS)

Table 3.22 Evaluation of flood strategies (Regional District of Okanagan-Similkameen).

Local Government	Overall perspectives on flooding	Contexts	Placement of the measures and tools	Nature of strategies to support flood protection	Action statement to enhance resilience
Regional District of Okanagan-Similkameen (RDOS)	Minimize flooding hazards and maintain the natural character of the area. Protecting the natural environment in the area is the overall goal of the available strategy for RDOS.	- Climate change models predict a higher frequency of more intense storms, which would increase the risk of flash flooding on streams. - Flood control structures have a negative influence on wildlife habitats like fish habitats. - High values of flow have happened periodically, most recently in 2018 when the area experienced a massive flood. - Flooding frequently occurs in narrow Valley bottoms during the wet years (e.g. 2017).	- Bylaw No. 1753 (1997) - Bylaw No. 1804 (1997) - OCP Bylaw No. 2450 (2008) - Bylaw No. 1690 (2016) - Bylaw No. 2764 (2017) - Regional Water Conservation Strategy (2017) - Bylaw No. 2805 (2018) - OCP Bylaw No. 2790 (2018) - Bylaw No. 2824 (2019) - Bylaw No. 2879 (2019)	Considerations are concerning environmental protection. Several adaptations are available to protect land use, and a few mitigative rules are for inspections.	- Reduce development in regions that are susceptible to flooding and increase the use of those lands for open-spaces areas (e.g. parks and recreation or agriculture purposes). - Preparation of a design brief provides background information and the results of any analysis in developing flood designs. - Determine the limitations of mapping data and flood levels, hydraulic analysis is practical. - RDOS might consider "local service area" status under the Local Government Act, which is the framework to provide authority for municipal governments to levy a parcel tax to recover all or part of flood protection costs.

<u>Nature of existing strategies to support overall perspectives on flooding:</u>

Mitigative strategies:

- Development of consequence of a design flood by combining the output of the hydraulic model with a spatial database that characterizes the various elements at risk (water infrastructure, natural environment, and transportation networks).
- Provide an Emergency Response Plan to reduce risk during flooding and/or before flooding takes place.

- Provide efforts that keep suitable riparian buffers, which are determined by skilled professionals that consider processes of natural streams boundaries, movement, natural erosion, and floodplain necessities.
- Identify and provide a conceptual design for structural flood mitigation projects for Keremeos and Princeton. The designs will be accompanied by order of magnitude cost estimates so Keremeos and Princeton will have the necessary information to apply for Provincial and Federal grants.

Midaptive (**Mitigative + Adaptive) strategies:**

- Encouraging the corresponding authorities in resource management to protect natural drainage patterns.
- Protect corridors that have adequate width to accommodate the dynamic of the hydrologic systems.
- Natural strategies to reduce flood hazards along with the prevention of any need for stabilization to protect the fish population and habitats.
- A regular check for the highest risk areas in terms of their effects (e.g. major culverts), or any time as it is needed, especially after flooding event or storm.

Chapter 4: Flood Mitigation Strategies: Organizations within BC

In this chapter, the cities of Chilliwack, Surrey, and North Vancouver are chosen that are located within the province of BC, but outside the Okanagan Valley to evaluate notable non-structural flood mitigation strategies. It consists of (i) a context containing a brief introduction of the city; (ii) type, nature and impacts of floods that the communities experience; (iii) overall perspective and non-structural approach to mitigate the flood-induced risks; and (iv) significant mitigative and adaptive (non-structural) strategies to address flood-induced challenges in enhancing the resilience. A relevant inventory of non-structural strategies consisting of innovative and distinct approaches is prepared after a comparison with the same identified for the organizations in the Okanagan Valley (see Chapter 3).

4.1 City of Chilliwack

List of Documents Reviewed

[8] Policy and Design Criteria Manual for Surface Water Management in the City of Chilliwack, CH2MHILL Consulting Company (2002).
[9] Chilliwack Downtown Land Use and Development Plan, City of Chilliwack (2010).
[10] Eastern Hillsides Comprehensive Area Plan, City of Chilliwack (2012).
[11] Official Community Plan Bylaw 2014, No. 4025, City of Chilliwack (2014).
[12] Chilliwack Proper and Fairfield Island Neighborhoods Plan, Dillon Consulting Company (2018).
[13] Floodplain Regulation Bylaw 2018, No. 4519, City of Chilliwack (2018).

Context

The City of Chilliwack, located 100 km east of Vancouver, is one of the main urban centers in the Fraser Valley. The city is confined between the Fraser and the Vedder/Chilliwack rivers in the north and south respectively. The current population of Chilliwack is about 92,000, which is expected to reach about 132,000 by 2040. The primary source of drinking water in Chilliwack is aquifers (groundwater). Farming and tourism are the prime economic drivers for the city and their presence are geographically spread over the major portion of downtown, Chilliwack Proper, Fairfield Island Neighborhoods (surrounding the downtown), Sardis-Vedder, and Eastern Hillsides. Only Sardis-Vedder area and steep slope regions of hillsides are not situated on the floodplain. While the remaining

areas experienced severe inundations in 1894, 1948, and 1975 due to substantial water level rise in the Fraser and Vedder Rivers.

Overall perspectives on flooding

The City of Chilliwack aims to develop infrastructure that supports population growth and helps develop a safe, compact and healthy community following their community development principles. Flood mitigation policies for enhanced resilience are a pivotal outcome for the development initiatives. Within this frame, structural mitigation strategies, including the construction of dikes (generally against a 200-year flood) and floodproof buildings, as well as a combination of detention units and flow diversion tunnels on rivers and creeks get the most prioritized attention. However, non-structural mitigation strategies are taken into consideration in tandem to further enhance flood resilience.

Non-structural strategies to enhance flood resilience

- Monitoring the city's development by means of defined environmental indicators [4]. Some of the indicators are used to establish a potential Early Warning System that is capable to detect aquatic ecosystem degradation [8].
- Application of a decision support tool (Water Balance Model) to determine design criteria for infiltration-based practices (source controls). The model helps evaluate the efficiency of stormwater source controls [8].
- Development of an integrated master drainage plan to find appropriate management strategies at the watershed, and sub-watershed levels (to protect life, properties, and natural systems) as well as catchment levels (highly detailed plan to improve drainage systems) [8].
- Establishment of an aquifer management protocol to protect the quality of groundwater. The following measures are considered through this policy: application of LIDs in enhancing the quality of surface runoff; public education and engagement concerning the importance of groundwater preservation; and zoning and land use controls to protect the capture zones [11].
- Expanding a database for the stormwater drainage system by monitoring its performance during various storms [11].
- Recording performance data of constructed source control units to improve their efficiency for future applications [8].

- Classification of all watercourses into five groups (i.e., A to E identified in the Watercourse Map- 8A), each of them with a specific set of requirements and setbacks [11].
- Educate the public on emergency response plans through neighborhood engagement programs [11].
- Expand public awareness about positive aspects of the application of LIDs in private lands [12].
- Create a "center of excellence" and research in green technologies, especially by involving academic centers. This policy may reduce GHG emissions (concerning climate change) and be extended to new ideas to flood control [11].
- Construction of a variety of single-detached houses is suggested as an appropriate choice for floodplain areas [12].
- Development of an official guideline that should be considered by a Qualified Professional engineer for their assessment, including general requirements, requirements for watercourse areas, alluvial fans, and areas subject to debris flows [9].
- Development of a comprehensive design manual for surface water management as a case study of "Stormwater Planning: A Guidebook for British Columbia" considering infiltration and source controls as its primary proactive approach [8].
- Considering a wide range of 170 rainfall events to design stormwater drainage systems [8].
- Optimization of retention, detention, and flow diversion methods considering practical constraints, costs, and performance of the system in order to achieve appropriate stormwater management [10].
- Consideration of specific flood protection requirements for alluvial fans, which are more applicable to areas near rivers [9].
- Performing a hydrological evaluation, creek erosion risk analysis (by defining an erosion index), and creek conveyance capacity analysis in potential areas for future developments in case of the pre- and post-development scenarios [10].

4.2 City of Surrey

List of Documents Reviewed

[14] City of Surrey. 2014. Plan Surrey 2013. Official Community Plan. Bylaw no. 18020.
[15] City of Surrey. 2019. Coastal Flood Adaptation Strategy (CFAS). CFAS project.
[16] Township of Langley. 2014. Anderson Creek Integrated stormwater management plan. Final Report. Project no. 60267316.

Context

The City of Surrey is vulnerable to major floods from the Fraser River, which forms approximately 22 km of water frontage and has dikes that preserve the shoreline. The Fraser River floodplain covers 776 ha of developed land, which hosts a high-density mixture of industrial properties and residential buildings. Historically, the Fraser River freshet has been the cause of flooding. The flooding is attempted to be controlled by flood protection and diking systems [14], including. floodwalls (3.9 km), earth dikes (1.4 km), raised ground (2.3 km), and temporary earth dikes. The floodplain is maintained by 4 pump stations that drain water from behind the dikes [14].

The coastal floodplain of the city has about 20% of Surrey's entire land area, which covers Boundary Bay and Mud Bay along the Nicomekl and Serpentine Rivers. Flood hazards pose a greater risk in certain areas of the city based on floodplain elevations, slope and soil conditions, and close proximity to the source of risk. The key to overcome this challenge lies in identifying and designing developments that eliminate hazard and ensure public safety [15].

Overall perspectives on flooding

A primary goal of the City of Surrey is to enhance greener infrastructures by introducing urban forests, riparian zones and wetlands, grasslands, and protected farmlands. In terms of development, the city plans to enhance more compact and connected development with a mix of residential and industrial uses. Another significant aspect of the city's development endeavor is to offer a healthier environment and ensure provision of clean, safe, adequate, and affordable services to its residents. On a broader perspective, this endeavor encourages sustainable practices, efficient energy-use, and continued adaptation to the changing climatic patterns [14].

Non-structural strategies to enhance flood resilience

- The city has opted for an approach of adaptive management and recognized the need for responsive and flexible planning for extreme weather conditions [15].
- The city encourages broad-based engagement with all major stakeholders including regulators, residents, academics, technical experts, and industry partners. The key purpose of this engagement is to enhance shared understanding of the significant environmental challenges ahead, considering the situation of climate change, coastal flooding, and sea level rise [15].
- Effective communication and information sharing of flood risks is required to improve coastal flood hazard awareness, monitoring, and management. The city has adopted an integrated "Communications and Media Framework" to inform the local community and stakeholders about the challenges posed by sea level rise [15].
- In the short-term, the prominent aspect of flood management policy is to take on "low regret" or "no-regret" projects, implementing low-cost actions that bring relatively large benefits considering predicted future climate conditions. Examples of such actions include development of smaller-scale drainage improvements, and revision of regulations, notably amendments to existing zoning bylaws to specify flood resilient construction level updates to the Provincial Building Code, and Development Variance Permits for the construction of more adaptable and climate-resilient buildings [14].
- In the long-term, the city has established the "Sustainability Charter 2.0" that provides the sustainability vision of Surrey for 40 years and guides policy and decision-makers to include social, environmental, and economic factors in climate mitigation actions [14].
- Actions against climate impacts should be multifunctional, diverse, and layered that encourage environmental connectivity, social gathering, and public art and heritage display [14].
- The city has initiated an "Integrated Stormwater Management Plan (ISMP)" with the aim to balance the requirements of land use and stormwater, flood, and erosion control [16].
- Guidance on onsite runoff retention and reduction control via low impact development (LID) measures is considered to protect the watershed health and natural resources. To minimize future flooding, urban development is encouraged to incorporate rain gardens, vegetated planters, pervious pavements, a water quality treatment system, and detention ponds at the residential and neighborhood levels [16].

4.3 City of North Vancouver

List of Documents Reviewed

[17] City of North Vancouver. 2014. Official Community Plan. Bylaw no. 8400.
[18] City of North Vancouver. 2013. Climate Change Adaptation Plan.
[19] City of North Vancouver. 2011. Corporate Climate Action Plan.
[20] City of North Vancouver. 2014. Coastal Flood Risk Assessment. Final report. Ref. No. 300227.

Context

Geographically, the City of North Vancouver is located between the Coast Mountains to the North and the Fraser Lowland to the south. Due to the Fraser Glaciation, the region is exposed to sea level rise following the deposition of gravel, sand, and silt on the land surface. Regarding environmental issues, the city identifies that population growth and climate change will put pressure on existing infrastructure. Considering the current growth rate, it is expected that the city's population will grow to 62,000 individuals by 2031 and will need a strategy to cope with the evolving nature of the water system. Being a coastal city, climate change will have considerable impacts on the city as is currently evident with the rise in temperature, rainfall, and extreme events in the recent past [17].

Due to changing weather patterns, the number of extreme precipitation days is expected to be 1.6 to 2.5 times more frequent in this region and three-hour precipitation events are also projected to increase to 2.5 to 5.5 times more frequent by the 2050s. Given this increase in precipitation, the BC government is interested in evaluating development planning for rising sea levels: 0.5 m by 2050, 1.0 m by 2100, and 2.0 m by the next century [18]. Consequently, these changes could lead to flooding, followed by property damage and loss of lives. Thus, the biggest challenge for the city is to increase the capacity of the storm drainage system to accommodate the impacts of climate-induced rainfall.

Overall perspectives on flooding

To deal with the impacts of climate change, the city envisions a future of highly vibrant, diverse, flexible, and resilient living space for its residents. The city plans to promote sustainability and strengthen natural, physical, human, social, cultural, and economic capital at the local level. On a large scale, the city aspires to use a combination of adaptation measures, land-use strategies, structural changes, and non-structural instruments. At the municipal level, the Integrated Stormwater Management Plan (ISMP) is the principal strategy to manage impacts of extreme events and natural disasters. Under the guidance of ISMP, the city

has established a separate sewer system and each development is bound to provide a Liquid Waste Management Plan (LWMP) that guides the municipality on actions with respect to the management, collection, treatment, and disposal of stormwater. In the long term, these efforts are meant to provide holistic protection against flooding and complement the adaptation and mitigation vision of the city [17].

Non-structural strategies to enhance flood resilience

- The City of North Vancouver has adopted a set of 10 guiding principles that recognize the need for flood protection for residents and lays the roadmap for urban development, climate resilience, and a sustainable transport system [17]. These guiding principles establish the foundation of a climate-resilient and sustainable community and include the following: Complete and Compact, Accessible and Active, Opportunity-Filled, Resilient and Adaptable, Durable and Timeless, Creative and Diverse, Healthy and Inclusive, Diverse and Affordable, Community Supporting Community, and Age-Friendly [20].
- The city recognizes the interlinking of natural systems and human capital and assures to modify decision-making and local activities aligned with climate adaptation measures so that communities can grow in a healthy local environment [17].
- The development of a Sustainable City Framework seeks to adapt to a new and emerging vision of developing a sustainable and resilient city. The framework encourages long-term flexibility of municipal systems to handle climate-induced disasters and fosters an integrated approach in the six major areas: natural systems, physical infrastructure, local economy, human potential, social connections, and cultural diversity [20].
- Considering the regulatory mechanisms, each municipality is required to prepare a Regional Context Statement (RCS) that explains the relationship between the local development plan and the Regional Growth Strategy (RGS). In order to achieve the goal of sustainable cities, the city has affirmed a number of policies, which include Public Utility Land Use Policies, Major Road, and Sewer and Water Infrastructure Systems. Similarly, the management of floods is addressed in a holistic manner via policies of Community Energy and Emissions Plan, Invasive Plant Strategy, Urban Forest Management Plan, Flood Control Level Bylaw, Streamside Protection Guidelines, and Stream and Drainage Protection Bylaw [17].
- To minimize future flooding, the traditional system of collect and convey is shifting towards the adoption of trenchless technologies and green spaces, as these alternatives are

economically efficient, less disruptive, and pro-environment. In this regard, the development of Recreational Greenways, Environmental Greenways, and Tree Planting Programs would offer onsite runoff retention and volume reduction in the receiving water body[18].

- Considering the role of land use planning in flood management, the city government is drawing attention to hazard land development permit areas (DPAs); regularly revising floodplain maps; restoring wetlands, marshes, and natural buffers; and analyzing other innovative policy and land use opportunities. In addition, building bylaws and codes, development guidelines, and zoning regulations will continuously be revised to adjust to updated climate projections and promote climate-resilient buildings and green communities [18].
- In order to deal with flooding, preparedness of the community and coordination with the emergency services are recognized as integral components. Coordination with the Fire Department, RCMP, North Shore Emergency Management Office, and Vancouver Coastal Health is highly encouraged to reduce the direct or indirect health and safety impacts of flooding. Additionally, engagement with stakeholders is necessitated to strengthen understanding of the floods and situations of key environmental challenges [20].

Chapter 5: Flood Mitigation Strategies: Organizations outside BC

In this chapter, the cities of Calgary, Halifax, and Mississauga, located outside the province of BC, are selected to evaluate their significant non-structural flood mitigation strategies. It follows the same structural organization as Chapter 4. Likewise, it includes a set of notable strategies consisting of innovative and distinguished approaches for each city that are identified after a comparison with the same drawn for the organizations in the Okanagan Valley (see Chapter 3).

5.1 City of Calgary

List of Documents Reviewed

[21] Calgary's Flood Resilient Future, Report from the Expert Management Panel on River Flood Mitigation (June 2014).
[22] Flood Mitigation Options Assessment Summary, City of Calgary (2017).
[23] Reducing Calgary's flood risk (June 2013).
[24] Calgary's Flood Resiliency Plan (January 2019)
[25] Help build Calgary resiliency to flooding (November 2016).
[26] Flood Mitigation (2016).
[27] Flood Mitigation Measures (January 2015).

Context

While having a flood history, the city of Calgary experienced a disastrous flood in 2013 when 80,000 residents were evacuated. Being one of the costliest flood induced disasters in Canada, it faced infrastructure damage worth $400 million while the total cost of damage was estimated at $5 billion for Alberta. The city is located at the confluence of the Elbow and Bow rivers. Characterized by a rapid urbanization, it is one of the largest cities in Canada and susceptible to increasing flood intensity and frequency [21]. Among other areas, the downtown (economic) core of the city is at a very high risk of flooding [21–23].

Overall perspectives on flooding

The city is attempting to develop a cost-effective flood management plan with a three-layer approach for flood protection i.e. upstream, community-level and property-level [23]. Its long-term plan is designed to return $10 for every dollar spent on the projects since the flood of 2013 [24]. The strategy develops

multiple line-of-defense plans to mitigate a flood equal to or bigger than the flood of 2013 [24]. Projects aiming to enhance flood resilience on the Elbow River [24] include Springbank Reservoir, an upstream flood protection project, and Glenmore Dam Gates, offering flood protection at the community-level. The combination of these two projects is suggested to reduce the potential damage by $3 billion [23]. Mitigation strategies considering the risks of flooding posed by the Bow River include upstream flood protection (new upstream reservoir on the Bow River, modified operations at TransAlta's Ghost Reservoir), and permanent flood barriers at the community-level [24]. It is claimed that these projects will reduce the damage from a 1 in 200-year flood event [23]. The Bow River is larger than the Elbow River (100 m3/s with the highest low in 2013 at 1840 m3/s) and the reservoirs upstream are used more for power generation than flood control [25].

Non-structural strategies to enhance flood resilience

- The City has divided the mitigation actions into three timeframes, including (i) immediate, (ii) mid-term and (iii) long-term. Each timeframe is prioritized based on the defined scenarios and importance of the action at the time, considering flood risks and potential damages.
- The general recommendations developed by the City of Calgary using technical assessment, sustainability analysis, community engagement, and in collaboration with advisory committee, are:
    - Sustainable watershed management;
    - Maximizing value for money;
    - Adaptability and flexibility in a changing climate; and
    - Community receptivity and shared responsibility.
- Flood mitigation strategies are to be developed following: (i) detailed risk and damage calculation models; (ii) investigating different scenarios and assessing the damage of each scenario; (iii) comparing costs and benefits of the scenarios with employment of mitigative frameworks; and (iv) proposing efficient measures to reduce potential flood damage [22].
- The city applied changes to the land use bylaw, such as removing "grandfathering" rules that allow buildings built before a certain date to be re-built without following the current floodproofing rule, and the "sliding scale" approach where the degree of required floodproofing in a building is proportional to the degree of building expansion [25].

- Removing some buildings from floodways, increasing restrictions of re-developments in flood hazard areas, preventing basement permits in flood fringe, prohibiting land use within the flood hazard areas, and increasing flood proof regulations in areas with higher flood risks [25].
- Contingency measures, such as (1) forecasting and warning systems, citizen education, updates about flooding, and emergency pre-assigned plans; (2) update of land use regulations; (3) update about property level flood proofing regulations; (4) providing flood insurance (to redistribute the financial risk and not damage prevention) [21,22].
- Multi-level mitigation and strategy
    - *Watershed level mitigation*: Independent technical supports through a technical community to advocate on time implementation of the projects. Advocate for commitment from corresponding governmental and non-governmental organizations in continuing work on the recommendations focusing on the Bow River. [26]
    - *Community Level Mitigation*: (i) Development of an implementation plan for the locations that need flood barrier (protecting wall etc.); (ii) Close engagement with communities with low-height barriers depends on requirement to provide them with the required information and updates; (iii) Investing in improvement of flood forecasting and warning systems [26].
    - *Property level mitigation*: (i) Incentive and education programs for residents regarding building resilience requirements; (ii) opening of a national floodplain discussion board. [21,26].
- The city held various online engagement events to collect opinions from residents regarding the proposed flood mitigative strategies. The workshops were arranged to be held in both flood affected and unaffected areas. The recommendations were based on decision factors, including science/expertise (planning principles, technical engineering studies, watershed management, subject matter expertise, etc.), citizen values and the Triple Bottom Line (TBL) considerations (environmental, social and economic impacts) [27].
- The City continues to work on improving real-time flood alerting systems (web-based alerting map and messaging systems).

5.2 City of Halifax

List of Documents Reviewed

[28] Planning for Sea-level Rise in Halifax Harbour (since 2002), HRM, 2006.
[29] World Population Review (2021). Halifax Population 2021.
[30] Kings County, NS Flood Preparedness & Response Plan (FPRP) (2019).
[31] Municipal Climate Change Action Planning Halifax Regional Municipality, HRM Energy & Environment (2013).
[32] Nova Scotia Wetland Conservation Policy, Province of Nova Scotia (2011).
[33] Sea level rise adaptation primer: a toolkit to build adaptive capacity on Canada's south coasts (2013).

Context

Halifax Regional Municipality, the capital of Nova Scotia, is Atlantic Canada's largest city and covers an area of about 5500 km^2. It is a major seaport with significant industrial, military, and municipal infrastructure [28]. The current population of the city is about 414,777 [29].

Overall perspectives on flooding

Halifax has experienced frequent extreme weather, including several major storms that caused extensive erosion and flood damage. Most notable was Hurricane Juan in September 2003, which damaged properties and infrastructure totaling a cost of $200 million [28]. Halifax had the first record of flooding in 1759. Since then, the subsequent floods have owed to a combination of snowmelt, heavy rain, and ice jams [30]. These events increased public concern about the potential impacts of climate change. In 2006, the City Council adopted the Regional Municipal Planning Strategy, an integrated land use planning guide for future development. The Strategy explicitly included policies to address climate change impacts and recognized the need to gather and use data on sea-level rise, storm surges, and associated vulnerability.

Non-structural strategies to enhance flood resilience

- Projections of future sea levels and stormwater levels in Halifax Harbour under different scenarios based on return periods of rainfalls. Based on the projected sea level rise, high-resolution mapping of possible future flood levels is generated for each scenario to simulate the extent and depth of flooding for various storm events. This sets a policy reference from which planners can move forward in developing an adaptation plan [28].

- Using LiDAR (Light Detection and Ranging) data covering Halifax Harbour and the East Petpeswick Peninsula to determine floodplain restrictions, vulnerability, and assessment mapping for Halifax Harbour [31].
- Creating a digital elevation model (DEM) using LiDAR data to identify flood risk around Halifax Harbour over the next 100 years and mapping future flood hazard zones [31].
- Wetland Conservation Policy provides direction and a framework for the conservation of wetlands [32]. It can be combined with flood mitigation strategies to protect natural vegetation in floodplains.
- Plan Testing Schedule and Responsibility, and Plan Review and Maintenance for coordinating annual testing of Regional Flood Preparedness and Response Plan to evaluate the overall effectiveness based on the current conditions (e.g., climatic and hydrometric conditions).
- The city launched ClimateSMART (Sustainable Mitigation & Adaptation Risk Toolkit) [28] to help mainstream climate change mitigation and adaptation to planning and decision making.
- *Flooding initiatives:* It includes an investigation of naturalized stormwater retention ponds, living shoreline pilot project [33], and updating the integrated stormwater management policy.

5.3 City of Mississauga

List of Documents Reviewed

[34] Project and strategies – environmental assessment
- Little Etobicoke Creek Flood Evaluation Study (in progress)
- Dixie-Dundas Flood Mitigation Study (in progress)

[35] Water quality report, South Peel Water Supply System 2010 (Mississauga, Bolton, Brampton)
[36] Strategic Plan, Our Future Mississauga (2009).
[37] Action Plan, Our Future Mississauga (2009).
[38] Mississauga Official Plan, 2020

Context

The word "Mississauga" comes from an Ojibwa word meaning "river of many mouths". It is located in the province of Ontario and is the largest of three municipalities in the Peel Region. The current population is about 775,000, expected to reach 812,000 by 2031. Mississauga hosts watersheds of the Credit River, Etobicoke Creek, and other watercourses that form part of the Great Lakes drainage basin. The Credit River is the longest with the heaviest flow. It divides Mississauga's western side from the central/eastern parts and enters the lake at the Port Credit harbor. Floods are the most common hazards

in the Credit River watershed, and global warming has further increased their severity. In 1954, Hurricane Hazel caused severe flooding in Mississauga. The Little Etobicoke Creek watershed's urbanized nature makes the Dixie-Dundas cluster vulnerable to flooding from summer thunderstorms. In August 2009, 67.6 mm rain caused extensive flooding, and four years later in July 2013, 100 mm rain occurred that resulted in a significant flash flood.

Overall perspectives on flooding

Mississauga's vision is to enhance sustainability to protect its natural and cultural heritage resources. Its strategic plan identifies Natural Hazard Lands as a part of the "Green system" that deals with the Credit River, Credit Valley, several creeks, and Lake Ontario Shoreline. To regulate flood risk and maintain drainage infrastructure within Mississauga, multiple government agencies work together by distributing their roles and responsibilities. Mississauga is responsible for road drainage, storm sewers, parks, greenbelt, trails, city trees, creek erosion, and flow management. The Region of Peel is responsible for regional roads, sanitary sewers, and water mains. The Conservation Authority is responsible for floodplain mapping and management policies, flood forecasting and warning, flood messaging, and flood hazard management [34]. To mitigate flooding risks, Mississauga is conducting environmental assessments on Little Etobicoke Creek and the Dixie Dundas community.

Non-structural strategies to enhance flood resilience

- Identifying "Natural Hazard Lands" covering Valley lands, floodplains, and Lake Ontario shoreline to provide policy framework for minimizing the impact on the environment and contributing to reversing climate change trend [35,36].
- Creating buffers to provide physical separation of development from the Natural Heritage System and Natural Hazard Lands, to ensure:
    - maintenance of slope stability and reduction of erosion on Valley slopes
    - attenuation of stormwater runoff [37].
- Designating Natural Hazard Lands and buffers as Greenlands and zoned to protect life and property. Uses will be limited to conservation, flood and/or erosion control, essential infrastructure, and passive recreation. Development in Greenbelt associated with natural hazards is restricted to provide for the protection, enhancement, and restoration of the Natural Heritage System [38].

- Development and site alteration within erosion hazards associated with Valley land and watercourse features will not be permitted. However, if permitted, it must be supported by detailed slope stability and stream erosion studies or must provide an appropriate buffer to erosion hazards, as established to the satisfaction of the City and appropriate conservation authority [38].
- Development in floodplains will be subject to the one-zone concept (the entire area within the flood hazard limit is considered to be a single component and one management unit), except where a special policy area or two-zone floodplain management concept has been approved [38].
- Development and site alteration are generally prohibited on the floodplains [36].
- In historic development that has occurred in the floodplain, minor works may be permitted subject to detailed studies to the satisfaction of the City and appropriate conservation authority [38].
- Flood protection measures to be implemented related to the construction of buildings or structures permitted in or adjacent to the floodplain will be determined by the City and the appropriate conservation authority [38].
- Development and site alteration will not be allowed within hazardous lands adjacent to the Lake Ontario shoreline, which is impacted by flooding hazards, erosion hazards, and/or dynamic beach hazards, without meeting the requirements of the appropriate conservation authority and the policies of the City [38].

Chapter 6: Recommendations and Way Forward

This chapter offers a summary of the current non-structural flood mitigation practices used by local and Indigenous governments in the Okanagan Valley and selected communities outside the Valley and identifies practices that are most prevalent. Based on that, flood mitigation measures are recommended that would further enhance the flood resilience endeavors in the Okanagan Valley.

6.1 Analysis of context and current practices across Okanagan Valley and other communities

A matrix of the current context, flood management practices, and recommendations is given in table 6.1. It provides a timely, individualized, and tangible evaluation of practices embedded in flood related policies, regulatory tools, and legislations and paves out the foundation for recommendations in enhancing flood resilience. Major findings on the current practices across the Okanagan Valley and the selected communities outside BC leading to flood resilience are:

- Primary drivers for flood resilience in the Okanagan Valley generally include the need to protect the natural resources and achieve environmental sustainability. Flooding being the recurring events for the local and Indigenous governments adopting sustainability approach marks the shift toward risk-aversion policies and design practices. Instead of focusing exclusively on structural defenses, incorporation of non-structural mitigations provides the ground for sustainable and resilient development.

- The analysis of regulations, guidelines, and policies suggests that the current practices for all the local and Indigenous governments attempt to enhance flood resilience are primarily achieved through land use planning and designation, sustainable development, and development of green and permeable areas. Most of them rely on land use planning bylaws to restrict development and prioritize type, density, construction, and location of development. The practices of land use planning and green landscaping when combined with integrated stormwater management offer a suite of tools to adapt to the recurrent floods and bolster sustainability.
- Considering the context and existing practices specific to the municipalities, suggested action statements for each of municipalities in the Okanagan Valley (as given in chapter 3) to enhance

resilience are indicative of potential flood mitigation. Among them, flood risk assessment and management, and the use of low-impact development (LIDs) are highly recommended to prepare for floods. There is an incredible potential to adopt LID initiatives as per the seasonal variations (e.g., temperature, precipitation, etc.) and thus, enhance flood resilience. Moreover, information sharing and public engagement to build flood risk awareness and evolving risk boundaries while strengthening community networks are seen to be important strategies.

Table 6.1. A summary of the current flood mitigation practices for the Okanagan Valley and other communities in Canada

Okanagan Valley Region	Municipality/ First Nations	Green and permeable area	Compact housing infill development	Use of LIDs	Land use planning	Sustainable development	Integrated stormwater management plan	Energy-efficient technology	Stakeholder and community engagement	Communication and information sharing	Flood emergency preparedness	Flood risk assessment
North Okanagan	Regional District of North Okanagan	✓	✓	✓	✓	✓	✓	×	✓	✓	-	✓
	Splatsin First Nation	✓	-	×	✓	✓	×	×	-	×	✓	×
	City of Armstrong	✓	✓	×	✓	✓	-	✓	-	-	-	-
	Township of Spallumcheen	-	-	×	✓	-	-	-	×	-	✓	-
	Okanagan Indian Band	-	-	-	×	✓	×	×	-	×	-	-
	District of Coldstream	-	-	✓	✓	✓	-	✓	-	-	-	×
	City of Vernon	✓	-	-	-	-	✓	-	-	×	✓	-
	Village of Lumby	✓	×	-	✓	-	-	-	-	×	-	-
Central Okanagan	District of Lake Country	✓	✓	×	✓	×	-	×	-	×	-	×
	City of Kelowna	✓	✓	✓	✓	✓	-	-	-	-	-	✓
	Regional District of Central Okanagan	✓	-	×	✓	✓	✓	×	-	×	-	✓
	City of West Kelowna	✓	×	×	✓	-	×	-	-	-	-	✓

	Westbank First Nations	-	✓	-	✓	✓	-	-	-	-	-	×
	District of Peachland	-	✓	×	✓	-	✓	-	-	-	✓	×
	District of Summerland	✓	✓	×	✓	✓	-	✓	-	×	-	✓
South Okanagan	City of Penticton	-	×	×	✓	×	-	-	-	-	✓	✓
	Penticton Indian Band	-	-	-	✓	-	-	-	-	-	-	×
	Town of Oliver	-	-	-	✓	✓	-	✓	-	-	-	×
	Osoyoos Indian Band	-	×	×	✓	-	-	-	-	-	-	-
	Town of Osoyoos	✓	✓	-	✓	✓	-	-	-	-	-	-
	Regional District of Okanagan-Similkameen	-	×	×	✓	-	-	-	-	-	✓	×
	Okanagan Nation Alliance	-	-	-	✓	✓	-	-	-	-	-	×
Other communities outside Okanagan Valley*												
British Columbia	North Vancouver	✓	-	-	✓	✓	-	-	-	-	✓	✓
	Surrey	-	✓	✓	-	✓	✓	-	✓	✓	-	-
	Chilliwack	-	✓	-	-	-	✓	-	-	✓	-	✓
Alberta	Calgary	-	-	✓	✓	-	-	-	✓	✓	✓	✓
Nova Scotia	Halifax	-	-	-	✓	-	✓	-	-	-	-	✓
Ontario	Mississauga	✓	-	-	✓	✓	-	-	-	-	-	✓

Note: Based on the reviewed documents, the tick (✓) mark represents an existing practice predominantly available in the policy documents of a community. The cross (✗) mark indicates recommended practice that aligns with local context of flood resilience in the community. The detailed description of the local context of flood resilience in the communities is given in the Chapter 3 of this report. The dash (-) represents a supporting practice, which can be implemented in a community given the economic, environmental, demographic, and social conditions are favourable for implementation.

* For six communities outside Okanagan Valley, the review of the planning, policy and regulatory documents is solely focused on identifying non-structural interventions. From the analysis of practices outside and within Okanagan Valley, a set of best practices is recommended as suitable options to enhance flood resilience in the Okanagan Valley. No recommendation is made for the communities outside of Okanagan as this is beyond the scope of this study.

6.2 Best practices suitable for Okanagan Valley

Best practices for flood mitigation include preventive actions that cover interrelationship and synergistic interactions between various stakeholders (e.g. regulators, residents, academics, technical experts, and industry partners.) within and across the communities. It also emphasizes the interconnection of natural systems and human capital to keep decision-making and local interventions in responding to the growing needs of development for flood resilient communities. Considering the need to manage environmental resources, following non-structural flood mitigation measures are recommended as the best practices to enhance flood resilience. They are applicable to the communities across the Okanagan Valley.

- Development of green and permeable areas – permeable pavements, rain gardens, green belts and other related structures that increase the percolation of runoff water.
- Compact housing and infill development – new construction preferred on vacant and under-used lots within the existing urban areas that are already developed. It should also satisfy the triple bottom lines (TBL) of sustainability: environmental wellbeing, social (and health) wellbeing, and economic prosperity.
- Integrated stormwater management – allows infiltration, reduces amount of storm water, improves water quality.
- Energy-efficient technology – renewable energy production, efficient building, heating and cooling system.
- Stakeholder and community engagement – encourage participation, understanding the common goals, and reduce conflict. It needs to be prioritized to enhance the understanding about changes to regulations (e.g. amendment in existing zoning bylaws, updates in the Provincial Building Code, Development Variance Permits for the construction of climate-resilient buildings, etc.) and their adequacy for responding to the increasing flood risk.
- Communication and information sharing – discussion forum and workshops to support community resilience against flooding. Effective communication needs to be established to share information on flood risk, monitoring, and management actions. To guide the local communities and stakeholders, the development of an "integrated communication and resource sharing" framework would be useful.

- Flood risk assessment – flood risk, vulnerability, impacts, identify areas under risk, frequency of inundation. Flood risk areas of the Okanagan Valley can be classified into (i) Valley land, (ii) floodplain, and (iii) lake shoreline to provide policy framework in order to help mitigate and/or adapt to the impacts of climate change and increase flood-proof regulations in the areas with moderate to high flood risks.

6.3 Way Forward: *Whole Systematic View*

Fundamentally, achieving flood resilience is complex as it has strong linkages to land use, infrastructure, climatic condition, regulatory tools and the nature of urbanization and densification strategies, among others. A whole-systemic view allows decision-makers to consider interdisciplinary interactions towards flood resilience at many levels of management (i.e. local, provincial, Indigenous and federal) and supports learning over time and continuous adjustments to absorb shocks. This section sheds light on the interdisciplinary connectedness of flood *adaptive* resilience to enhance all-inclusive understanding, beyond the context of individual organizations.

- Reinforcing the implementation of one water approach (OWA) based on the *one Valley- one water* concept. As an integrated management tool, OWA not only addresses water from a drinking perspective, but also emphasizes waste and stormwater purviews while considering their intertwined interrelationships. While OWA concept helps achieve synergistic benefits, its other positive aspect offers different tiers of governments with performance benchmarking ability, which is a process of measuring the performance of one entity against others, regardless of whether or not they are direct competitors. This aspect will help different local governments to evaluate their performance with others and try to continuously enhance their performance and ability based on their present conditions. Results of a comprehensive flood risk analysis in the Okanagan Valley may be considered through the development of different tools and management plans that can be obtained by the implementation of OWA.

- Development of a comprehensive resilience-based design standard for stormwater management for the Okanagan Valley. Different uncertainty analyses addressing the effects of climate change, unexpected severe events and system malfunctions, and uncertain parameters of rainfall and snowfall shall be considered in the preparation of the design standard. Moreover, a cost-benefit analysis being a complementary step of uncertainty evaluation needs to be performed to select a pertinent design strategy. The document should also provide

requirements for resilient design and implementation of new stormwater management strategies, such as the application of LIDs. This potential resilience-based design standard should address climate change centric issues in a more inclusive and systematic manner.

- A "Sustainability Charter" should be developed aiming to provide a sustainability vision for the Okanagan basin for 50 years. This, in turn, would guide policy and decision-makers to include TBL in flood mitigation actions.

- Current lake-flow management practices in the Okanagan Valley do not accommodate the effects of climate change, population growth, and controlled densification of the built environment. Re-evaluation of these plans and practices is critical to protect agriculture, fisheries, and residential land use while preventing flood damage(s) and its increasing severity in the Valley and surrounding regions.

References

[1] Duan, H. F., Li, F., & Tao, T. (2016). Multi-objective Optimal Design of Detention Tanks in the Urban Stormwater Drainage System: Uncertainty and Sensitivity Analysis. *Water Resources Management*, *30*(7), 2213–2226. https://doi.org/10.1007/s11269-016-1282-1

[2] Gaur, A. and Simonovic, S. Future changes in flood hazards across Canada under a changing climate, Water (Switzerland), vol. 10, no. 10, 2018.

[3] Mohammadiun, S., Yazdi, J., Salehi Neyshabouri, S. A. A., & Sadiq, R. (2018). Development of a stochastic framework to design/rehabilitate urban stormwater drainage systems based on a resilient approach. *Urban Water Journal*, *15*(2). https://doi.org/10.1080/1573062X.2018.1424218

[4] Nahiduzzaman, K.M, Aldosary, A., and Rahman, M.T. Flood induced vulnerability in strategic plan making process of Riyadh city, *Habitat International*, 2015.

[5] Rahman, M.T., Aldosary, S., Nahiduzzaman, K.M. and Reza, I. Vulnerability of flash flooding in Riyadh, Saudi Arabia, *Natural Hazards*, 2016.

[6] Schmidt, J., and Wolfe, G. (Ed). Climate Change: Picturing the Science. New York: W. W. Norton & Company, 2009.

[7] Thistlethwaite, J., Minano, A., Blake, J., Henstra, D. and Scott, D. Application of re/insurance models to estimate increases in flood risk due to climate change, *Geoenvironmental Disasters*, vol. 5, no. 1, 2018.

[8] Policy and Design Criteria Manual for Surface Water Management in the City of Chilliwack, CH2MHILL Consulting Company (2002).

[9] Chilliwack Downtown Land Use and Development Plan, City of Chilliwack (2010).

[10] Eastern Hillsides Comprehensive Area Plan, City of Chilliwack (2012).

[11] Official Community Plan Bylaw 2014, No. 4025, City of Chilliwack (2014).

[12] Chilliwack Proper and Fairfield Island Neighborhoods Plan, Dillon Consulting Company (2018).

[13] Floodplain Regulation Bylaw 2018, No. 4519, City of Chilliwack (2018).

[14] City of Surrey. 2014. Plan Surrey 2013. Official Community Plan. Bylaw no. 18020.

[15] City of Surrey. 2019. Coastal Flood Adaptation Strategy (CFAS). CFAS project.

[16] Township of Langley. 2014. Anderson Creek Integrated stormwater management plan. Final Report. Project no. 60267316.

[17] City of North Vancouver. 2014. Official Community Plan. Bylaw no. 8400.

[18] City of North Vancouver. 2013. Climate Change Adaptation Plan.

[19] City of North Vancouver. 2011. Corporate Climate Action Plan.

[20] City of North Vancouver. 2014. Coastal Flood Risk Assessment. Final report. Ref. No. 300227.

[21] Calgary's Flood Resilient Future, Report from the Expert Management Panel on River Flood Mitigation (June 2014).
[22] Flood Mitigation Options Assessment Summary, City of Calgary (2017).

[23] Reducing Calgary's flood risk (June 2013).

[24] Calgary's Flood Resiliency Plan (January 2019).

[25] Help build Calgary resiliency to flooding (November 2016).

[26] Flood Mitigation (2016).

[27] Flood Mitigation Measures (January 2015).

[28] Planning for Sea-level Rise in Halifax Harbour (since 2002), HRM, 2006.

[29] World Population Review (2021). Halifax Population 2021. https://worldpopulationreview.com/world-cities/halifax-population

[30] Kings County, NS Flood Preparedness & Response Plan (FPRP) (2019).

[31] Municipal Climate Change Action Planning Halifax Regional Municipality, HRM Energy & Environment (2013).
[32] Nova Scotia Wetland Conservation Policy, Province of Nova Scotia (2011).

[33] Sea level rise adaptation primer: a toolkit to build adaptive capacity on Canada's south coasts (2013).

[34] Project and strategies – environmental assessment.

[35] Water quality report, South Peel Water Supply System 2010 (Mississauga, Bolton, Brampton).

[36] Strategic Plan, Our Future Mississauga (2009).

[37] Action Plan, Our Future Mississauga (2009).

[38] Mississauga Official Plan, 2020.