Feasibility of nature-based solutions to enhance Stó:lō flood resiliency in the Lower Fraser Valley

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Disclaimer

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This project was conducted under the mentorship of Stó:lō Research and Resource Management Centre (SRRMC) staff. The S'ólh Téméxw Stewardship Alliance (STSA) is a political body that guides engagement and consultation processes within S'ólh Téméxw. The SRRMC offers professional and technical services for projects carried out within S'ólh Téméxw. The opinions and recommendations in this report and any errors are those of the author and do not necessarily reflect the views of SSRMC or the University of British Columbia.

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Executive Summary

The impacts of climate change such as sea level and increased frequency of extreme weather events are expected to exacerbate flooding risks across North America. Indigenous peoples, such as the Stó:lō peoples of the Fraser River, are disproportionately impacted by climate change due to their close relationships and ties with the lands and waters they live near (OECD, 2019). The 2021 floods in British Columbia resulted in significant cultural, economic and environmental damage to the Stó:lō peoples and enhanced the importance of creating a climate change adaptation plan (Austen & Isai, 2021).

This paper, prepared under the guidance of Stó:lō Research and Resource Management Centre (SRRMC) staff, introduces nature-based solutions (NbS) as it pertains to flood management across the Fraser Valley. The topics that were reviewed include:

1. Current state of flood infrastructure: The dikes that were originally constructed in 1960s and 1970s are aging and at risk of overtopping and geotechnical damage.
2. Regional flood strategies: Several regional strategies that are currently being developed include the provincial BC Flood Strategy, Lower Mainland Flood Management Strategy (LMFMS) Initiative, and Indigenous-led Emergency Planning Secretariat (EPS) Disaster Resilience Regional Action Plan called Hílekw Sq'eq'o.
3. Nature-based Solutions: Some NbS that may be incorporated in flood protection include soft shorelines, floodplain widening, wetland restoration, and green infrastructure.
4. Local organizations: A wide range of organizations support flood resiliency through various strategies either directly or indirectly.

A broad feasibility map was developed that places current NbS and regional flood maps in the context of Stó:lō reserves and S'ólh Téméxw ("our world, our land") Use Plan. Most of the NbS in the Lower Fraser Valley relate to protecting and enhancing salmon habitat through wetland restoration and development of off-channels. Although salmon restoration is the main objective, the wetlands and improved hydraulic connectivity also protects from floods, which just goes to show the importance of NbS that can provide multiple benefits. The map highlights how several reserves and culturally sensitive areas are at risk of freshet flooding due to sea level rise.

Lastly, a brief discussion of Natural Asset Management (NAM) as it currently stands, any potential issues, and ways in which it can be Indigenized was also completed. The key issue with NAM is that it reduces the rich interconnectedness of natural ecosystems down to the services it provides for humans. It can be Indigenized by incorporated Indigenous Knowledge, considering the cultural value of ecosystems and the benefits they provide to all organisms.

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Introduction

Across a global scale, Indigenous peoples are disproportionately impacted by the effects of climate change, largely due to their close relationship to and reliance on traditional lands. These longstanding ancestral relationships to the land also uniquely position Indigenous peoples to enhance local adaptation and planning responses to climate change. There is increasing recognition of these relationships and related Indigenous-led climate change adaptation and planning, particularly as Indigenous peoples across the globe exert their traditional rights to act as stewards of their lands and waters (OECD, 2019).

S'ólh Téméxw is the halq'eméylem name for the shared asserted territory of the Stó:lō peoples, centered on the Lower Fraser River in British Columbia. In English, it can be translated as 'our world' or 'our land'. 'Stó:lō' refers to 'People of the River', demonstrating the strong relationship that Stó:lō peoples have with the Fraser River. S'ólh Téméxw has experienced significant impacts to its lands and environments, resulting from road and freeway building, lake drainage, diking for flood prevention, and forestry and agricultural development. Climate change is causing impacts that are cumulative to these development pressures and resulting in observed effects such as warmer and drier summers, reduced snowfall, and increased risk of flooding and wildfires (Austen & Isai, 2021). Additionally, climate change impacts are often compounding. Drier conditions dry out vegetation, which can intensify fires. The fires can weaken or kill plants which results in soil that is less permeable and more prone to erosion, which can intensify floods and cause landslides (Austen & Isai, 2021). This compounding effect was evident during 2021 when massive wildfires and floods were observed in in British Columbia. There have also been noted declines in availability and health of culturally significant species like salmon, western red-cedar, and wild berries. Stó:lō peoples have an ongoing and vested interest in Indigenous-led climate change adaption and mitigation planning that will help to address some of these and other challenges for the region, its peoples, and its non-human species.

A key current concern is watershed-scale planning for resilient Stó:lō futures, as more frequent and more severe floods and droughts exacerbate pressures on Stó:lō culture and traditional livelihoods. The Pacific North West floods in 2021, in British Columbia resulted in the evacuation of 17,000 peoples, the death of three people, and caused significant economic and environmental damage (Austen & Isai, 2021). A Squiala First Nation burial site was washed downstream due to land erosion associated with the floods. Other First Nation communities such as Chawathil and Atchelitz were cut off from services and transportation routes, and experienced blackouts (Feinberg, 2021). Consequently, Stó:lō communities are increasingly involved in efforts to understand and respond to environmental change throughout the Fraser River watershed – including its tributary systems and in connecting upstream traditional territories to those at the Fraser River estuary.

The 2021 floods increased the urgency of creating a climate change adaptation plan, with an emphasis on the lower Fraser River flood plain. This project provides background research to ground the possible creation of a flood resiliency climate change adaptation plan. The project includes two components:

1. Broad map of Nature-based Solutions along the Fraser Valley from Hope to Abbotsford

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2. Detailed feasibility study of Nature-based Solutions at a location that was identified as an area of interest.

The focus of this work is on Nature -based Solutions, which hold the potential to be effective, beneficial to the environment, and in line with Indigenous values. A broad interpretation of nature-based flood resilience solutions is used throughout this project as further described in the next Section.

Locating Yourself

Within Indigenous worldviews, knowledge is considered relational, meaning that the knowledge we hold and present is shaped by our own relationships with the world around us (Wilson, 2007). As such, I believe it is important to briefly explain my own background and how I came to this project. After immigrating from India at the age of 12, I lived on the traditional territories of many Nations including the Mississauga's of the Credit, the Anishnabeg, the Chippewa, the Haudenosaunee and the Wendat peoples (Toronto, Ontario). Although I was acutely aware of race relations in Canada based on my presence as a visible minority, I wasn't aware of Indigenous relations in this country until I first heard of the 2015 findings of the Truth and Reconciliation Commission (TRC) Call to Action. Additional readings and podcasts of nuanced stories about the injustices Indigenous peoples face in this country contributed to my interest in pursuing small acts of reconciliation, where possible. In this journey, I pursued sustainability work that was supportive of advancing Indigenous priorities. This led me to working with the SRRMC.

I recognize that I grew up in predominately settler communities with a Western worldview and education system. The format of this report and the findings are therefore a product of my Western learnings and do not reflect Indigenous worldviews. Any mention of Indigenous values in this report is based on my extremely limited understanding of the vast variety of Indigenous worldviews and the priorities of Stó:lō peoples.

Background

S'ólh Téméxw

Stó:lō is the Halq'eméylem word for "river" and Stó:lō peoples are the collective peoples of the river, in this case the peoples who have lived in the lower Fraser River watershed since time immemorial (STSA, 2023a). S'ólh Téméxw is the halq'eméylem word for "our world, our land" and represents the Stó:lō-peoples relationships with their shared asserted territory. The geographic map of the S'ólh Téméxw is presented in Figure 1 below. Note that the although Stó:lō traditional territory extends into the United States, the map represents the area delimited by the International border (STSA, 2023b).

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Figure 1: S’ólh Téméxw Reserves, delimited by the International Boundary (STSA, 2023b)

Stó:lō Connect

A total of 17 Stó:lō First Nations are members of the S’ólh Téméxw Stewardship Alliance (STSA) to guide the engagement and consultation processes within the S’ólh Téméxw. The STSA’s operational wing, the People of the River Referrals Office (PRRO) completes a consultation process for any land and resource projects within S’ólh Téméxw (STSA, 2023c). The Stó:lō Connect is a custom referral management tool that was developed post-2009 and manages the Stó:lō’s uniquely complex engagement and consultation processes (STSA, 2023c). Although Stó:lō Connect provides a variety of features, their interactive mapping tool was crucial to this project. The Stó:lō Connect interactive map includes layers such as Reserve Lands, S’ólh Téméxw Use Plan areas (cultural landscape features, sanctuaries, heritage areas, culturally sensitive habitats, etc.), and BC’s Remote Access to Archaeological Data (RAAD) Sites that were used throughout the project (STSA, 2023c).

Flooding and Climate Change

Floods are among the most common natural disasters in North America. Flooding is expected to intensify further as climate change continues to increase the frequency of extreme weather and increase sea level rise (Denchak, 2019). River flooding generally refers to when a river overtops its natural banks and floods lands that are normally dry. River flooding is most common in spring and can result from extreme rainfall or melting snow (Denchak, 2019). There are also indirect human induced causes of flooding such as increased urbanization leading to increased impermeable surfaces and runoff (Denchak, 2019). One of the most intense floods in the Fraser Valley occurred in November 2021 due to a combination of factors (Austen & Isai, 2021). The direct cause was a weather event known as an “atmospheric river” which is a narrow but long band of fast-moving air with high moisture levels that forms in the Pacific Ocean (Austen & Isai, 2021). However, there were several compounding factors that increased the intensity of the flood event. The conditions to soak up water were poor as the ground was already saturated due to an unusually wet fall and the high-

altitude snow, which can soak up water, had melted through the summer (Austen & Isai, 2021). In addition, the 2021 summer season included extreme heat, drought, and wildfires which destroyed vegetation and led to increased erosion and mudslides (Austen & Isai, 2021).

Although there may not be a direct connection between the two, climate change exacerbates several factors that contribute to flooding. A warmer atmosphere leads to earlier snowmelt, increasing rain-on-snow events, and increasing precipitation when a rainfall does occur. The earlier snowmelt and increasing rain-on-snow events are leading to more springtime flows and risks of flooding due to spring freshet (Denchak, 2019). Fraser River experiences spring floods of varying intensity annually due to spring freshet, with one of the largest floods occurring in 1948 (Schmunk, 2021). The increasing precipitation is leading to an increase in extreme weather events such as atmospheric rivers. Although floods related to precipitation are not historically common in the Fraser River, the intense flood of 2021 mentioned above was caused by an atmospheric river, and their occurrences are only expected to increase (Denchak, 2019; Schmunk, 2021). Additionally, climate change is also leading to sea level rise, which could affect the flood conditions in the Fraser estuary (Denchak, 2019). BC Guidelines anticipate a 0.5m and 1.0m sea level rise by 2050 and 2100, respectively (Capital Region District, 2021).

Current Conditions

The current flood control measures are primarily 'gray' infrastructure (traditional stormwater infrastructure) methods which are easily measurable. This is evident as dikes are commonly present along most of the vulnerable areas along the Fraser River. The Fraser River Flood Control Program, a federal-provincial collaboration, led to construction or improvement of dikes along the Fraser River in the 1960s and 1970s (Fraser Basin Council, 2023a). A 2015 Lower Mainland Dike Assessment authorized by the Province of BC found that most of the dikes do not meet current provincial standards either due to risk of overtopping or risk of seismic damage (Northwest Hydraulic Consultants Ltd., 2015).. The report concluded that the risk of overtopping of the dikes is due to improvements in numerical flood modelling that considers the risk of flooding due to climate change. The geotechnical risk is due to increasingly stringent requirements and the presence of these dikes next to sloping river sediments overtopping or risk of seismic damage (Northwest Hydraulic Consultants Ltd., 2015). The aging and outdated flood control infrastructure is often increasing flood risk at the communities near the Fraser River.

The dikes along the Fraser river between Hope and are generally constructed along the cities of Agassiz, Chilliwack, Harrison Mills, and Hope to protect critical infrastructure such as schools, roads, railways, etc (B.C. Government, n.d.). Based on the BC Government's Lower Mainland dike inventory, the dikes are not classified as setback dikes, which are dikes set back further to allow the river to run its' natural meandering course. On the other hand, they also appear to be set back far enough to not channelize the river and allow it to form some small meanders and gravel deposits along its' course.

Regional Flood Strategy

The current model of BC's flood management has often been called ineffective at creating a comprehensive strategy (McElroy, 2021). In 2003/2004, the BC provincial government deferred the responsibility of floodplain management to local governments. Although the provincial government

regulated dikes, the individual municipalities were responsible for the operation and maintenance of dikes, which led to competition among the municipalities for funding applications (McElroy, 2021). Along with the need for coordinated action, the changing climate has also led to calls for an updated flood strategy.

The BC provincial government is in the process of creating a proposed BC Flood Strategy. The process began with an Intentions Paper which also included consultation with various First Nations, local government, technical partners, economic partners, and the public between October 2022 and January 2023. The summer of 2023 included What We Heard reports for the various consultations (B.C. Government, 2023). The First Nations and Local Government report concluded that the best approach is to achieve a challenging balance with a regional approach to flood management while also accounting for individual priorities (Alderhill Planning Inc., 2023). It also concluded that a community managed retreat (i.e. move from current homes to new homes away from the floodplain) would be complicated due to peoples' close relationship to their homes and lands (Alderhill Planning Inc., 2023). The next steps for the BC Flood Management Strategy is to incorporate the gathered feedback into the new comprehensive BC Flood Strategy (B.C. Government, 2023).

Several government bodies, First Nations, and other organizations that are concerned about flood risk in the region also came together to create the Lower Mainland Flood Management Strategy (LMFMS) Initiative. The LMFMS Phase 1 focused on analysing flood scenarios, vulnerabilities, and a review of flood protection measures in the lower mainland of BC. The LMFMS Phase 2 focused on advancing technical work to understand flood hazards and risks and drafting a preliminary regional draft strategy. The LMFMS Phase 2 is currently in development with the objective of considering the regional scope and receiving meaningful participation of First Nations (Fraser Basin Council, 2023b). It should be noted that although the LMFMS Phase 2 Leadership Committee does not include any members from the local First Nations or their affiliated organizations, their Pathways to Action Report identifies the need to strengthen First Nations participation as a key action item to improve resiliency and reduce risk (LMFMS Leadership Committee, 2023).

Emergency Planning Secretariat (EPS), a non-political organization that advocates for Mainland Coast Salish communities, is also in the process of completing a Disaster Resilience Regional Action Plan called Hílekw Sq'eq'o. Hílekw Sq'eq'o is a halq'eméylem phrase that translates to "get ready together" (Emergency Planning Secretariat, 2022). The Hílekw Sq'eq'o is based on United Nation's Sendai Framework for Disaster Risk Reduction and is rooted in UN's Declaration on the Rights of Indigenous Peoples (UNDRIP) (Emergency Planning Secretariat, 2022). The Hílekw Sq'eq'o focusses on a regional plan that assists the various communities to understand risk, reduce risk and impacts, build resiliency, and recover better following the disaster (Emergency Planning Secretariat, 2022). Additionally, the Plan will continue to uphold the self-determination, autonomy, and self-governance rights of the First Nations (Emergency Planning Secretariat, 2022).

Nature-Based Solutions (NbS)

Natural habitats and ecosystems play an important role in providing flood resiliency by reducing the impacts of flooding. On the other hand, poor management can lead to degraded ecosystems which may increase the risks. There is an increasing push to incorporate NbS, which are sustainable solutions that are inspired and supported by nature and provide wide-ranging benefits in addition

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to simply flood resilience. These solutions can range from natural solutions such as the conservation or restoration of natural ecosystems to hybrid solutions such as designing 'green' infrastructure. Some of these wide-ranging NbS that improve flood resiliency can include:

1. Widen the floodplain through relocating the dike inland or reducing land use in the floodplain (Asian Development Bank, 2022).
2. Meander restoration either through reconnecting meanders that have been disconnected or by creating a new meandering river course (Asian Development Bank, 2022).
3. Conservation, restoration, or construction of floodplain ecosystems, commonly wetlands, as they function as natural sponges that can store vast volumes of water prior to releasing it slowly (Asian Development Bank, 2022).
4. Increase the storage capacity of streams through cleaning garbage, restoring their natural floodplain, etc. (Asian Development Bank, 2022).
5. Increase the storage capacity by connecting channels that have been disconnected from the river due to 'gray' flood infrastructure (Asian Development Bank, 2022).
6. Soften the 'gray' infrastructure by creating living shorelines by planting native vegetation with roots that can hold the soil in place, reduce the flow of water, and consequently reduce erosion (Bilkovic et al., 2017).
7. Install green infrastructure such as green roofs, permeable pavements, rain gardens, retention ponds, etc. that can slow down the discharge of water in the communities that are located within the watershed (Denchak, 2022).

Natural Asset Management

Municipalities across Canada Nature use engineered assets to provide services including drinking water, flood resiliency, and stormwater management. Natural ecosystems also provide the same services but are generally not included in their accounting decisions. Natural Asset Management (NAM) is the concept of including the cost of services provided by natural assets in making decisions (MNAI, 2023b). The first incorporation of NAM into municipal asset management was started by the Town of Gibsons in BC in 2016 (MNAI, 2019). Within the project boundaries, the City of Abbotsford has also engaged with MNAI to begin incorporating NAM in their decision processes (MNAI, 2021). Adding an economic value to a natural asset through NAM could be useful in making the argument for conservation or restoration of natural ecosystems.

NAM is currently based on settler accounting principles and does not incorporate Indigenous knowledge or priorities. A literature review search conducted using 'Natural Asset Management' AND 'Indigenous' OR 'Aboriginal' OR 'First Nations' resulted in one relevant research paper: a thesis paper, which will be discussed in detail later in the report, completed by Christopher Pavsek for Simon Fraser University and in partnership with Municipal Natural Assets Initiative (MNAI). The MNAI, whose mission is to team up with local government to advance NAM, is currently calling for Indigenous partners. MNAI hopes to use these partnerships to evolve NAM by integrating Indigenous rights and responsibilities and interweaving Indigenous perspectives and knowledge (MNAI, n.d.).

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Methods

The key objective of this report is to assist the SRRMC in enhancing Stó:lō flood resiliency in contexts of environmental change in the Lower Fraser Valley. The following steps were conducted to achieve the objective:

1. Complete a desktop literature review and informal interviews with interested organizations to understand the current NbS relating to flood adaptation. Compile the information in a map format, along with additional information including potential flood scenarios and geographical areas of interest. Additionally, conduct a desktop review to compile a list of organizations that are working to achieve flood resiliency in the Lower Fraser Valley.

2. Complete a desktop review of Natural Asset Management as it currently stands in the lower mainland of British Columbia. Additionally, explore NAM in the context of Indigenous peoples and brainstorm ways in which it can be Indigenized.

Broad Feasibility Map

Mapping Project

The first step in creating a climate change adaptation plan is to understand the measures that are already being taken within the project area. A broad feasibility map was developed through desktop literature research and informal consultation with individuals from several affiliated organizations such as Watershed Watch, Resilient Waters, and Emergency Planning Secretariat. The feasibility map included the following information for the Fraser River watershed between Hope and Abbotsford:

1. Locations where NbS are implemented.

2. The Fraser River freshet (spring) flood scenario maps for a 100-year flood for Year 2050 (0.5 metre sea level rise [SLR]) and Year 2100 (1.0 metre sea level rise) (Fraser Basin Council, 2019). Note that these maps should only be used for regional planning purposes and not localized flood maps. The maps also assume that dikes will function as intended which is not a safe assumption based on the vulnerability of dikes in the Lower Mainland as mentioned above.

3. Geographical areas that are part of the S'ólh Téméxw Use Plan (STUP) such as reserves, sanctuaries, heritage areas, etc. that are of importance to the Stó:lō peoples (STSA, 2023c).

The map was initially created using Google Earth Pro and exported to an .xml file by myself before being converted into a PDF figure using GIS by SRRMC staff Wyatt Smith. Figure 1 and 2 below shows locations of current NbS and regional flood maps overlaid with Stó:lō reserves (Figure 1) and STUP (Figure 2). One key finding that this figure confirms is that the lack of flood infrastructure along the various reserves puts them at risk of a freshet flood, especially with climate change induced SLR. First Nations such as Leq'á:mel (Zaitscullachan, Lakway, etc.), Sq'éwqel (Seabird Island), Shxwhá:y Village (Skway), Sqwa (Skwah), etc. appear to be at risk of freshet flooding in the 100-year flood scenario in 2050 (i.e. 0.5m SLR). Some areas that are designated as Sanctuary zones within STUP is also at a risk of flooding.

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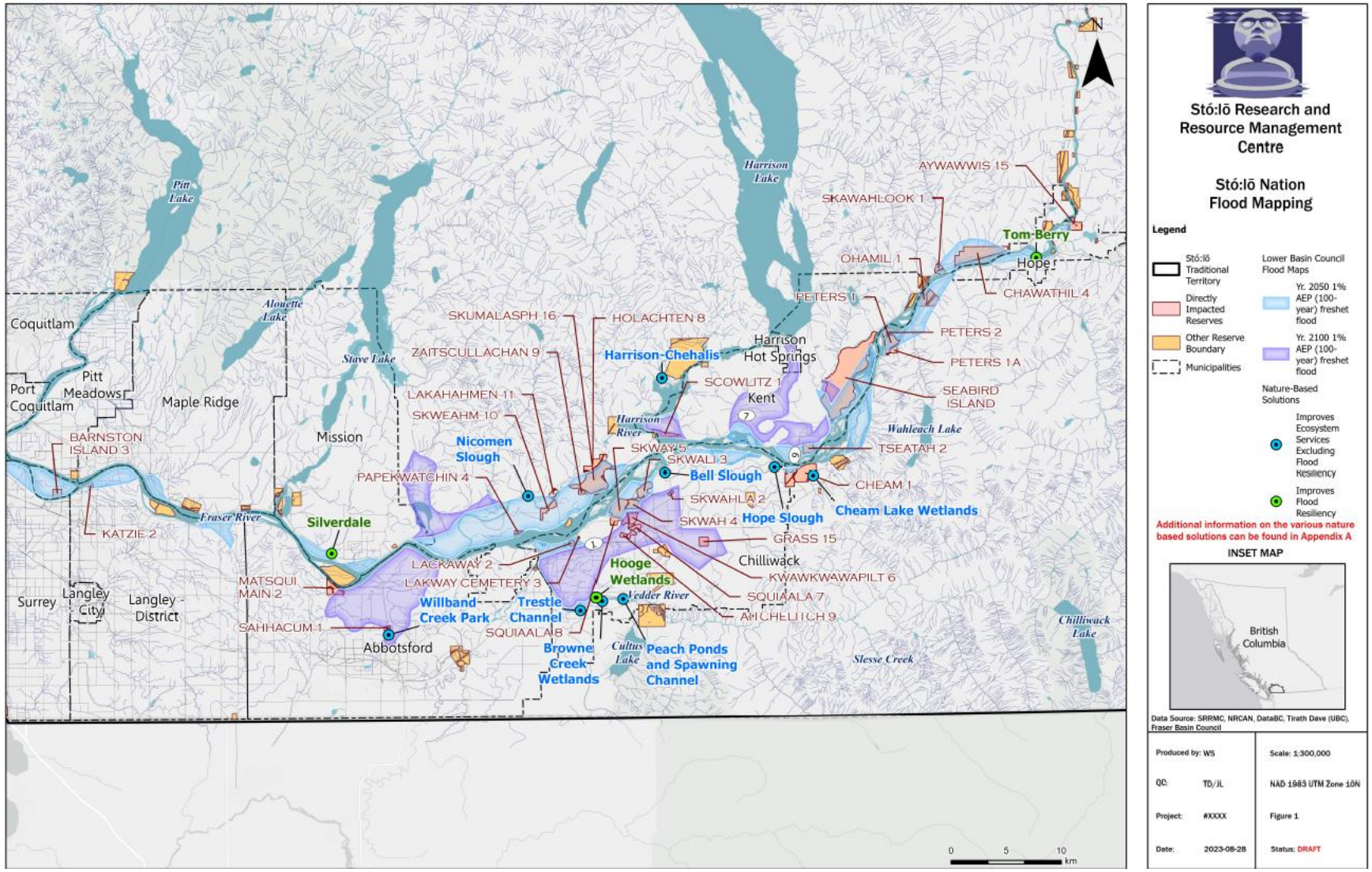

Figure 2: Current Nature-Based Flood Mitigation Solutions, Fraser Basin Council Flood Maps, and Stó:lō Reserves

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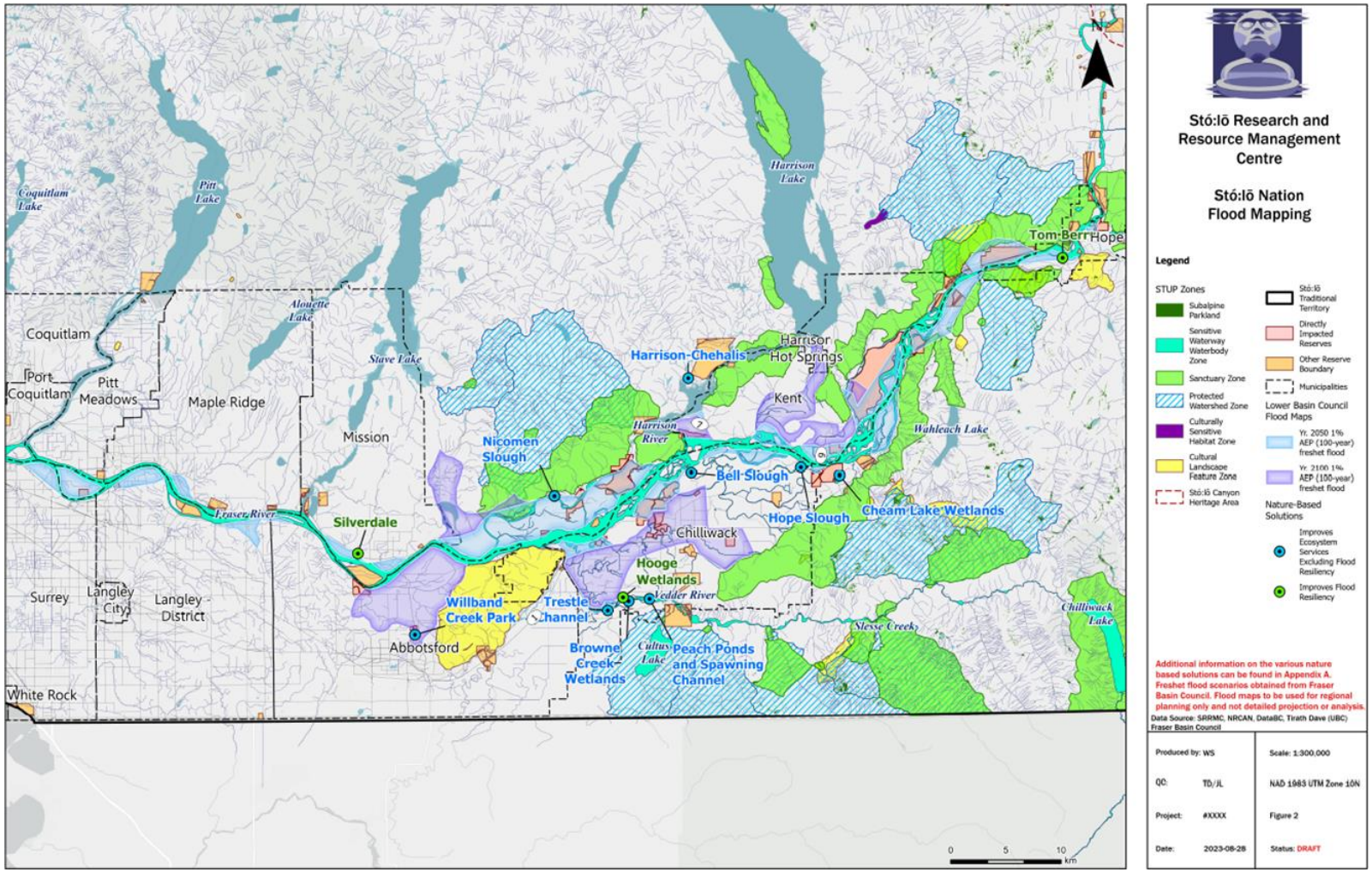

Figure 3: Current Nature-Based Flood Mitigation Solutions, Fraser Basin Council Flood Maps, and S'ólh Téméxw Use Plan

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Additional information about the various NbS that are currently implemented and aid in flood resiliency along the Fraser River between Hope and Abbotsford is presented in Appendix A. The Appendix includes each NbS shown on the map and their objectives, work completed, and how it impacts flood resiliency in the Fraser Valley. It is worth noting that not all NbS solutions that were discovered directly improved flood resiliency to the Fraser River. Some locations such as Cheam Lake wetlands, Hope Slough, etc. provides ecosystem services and likely improves localized flooding. Other locations such as Tom Berry, Hooge wetlands, and Silverdale wetlands provide direct benefit to flood resiliency in the Fraser River. Although the primary objective of most of these projects is to protect or enhance salmon habitat, they also provide flood benefits, emphasizing how NbS are useful in achieving different objectives.

Fraser Valley Flood Mitigation Organizations

The desktop research also included a compilation of the organizations that are working to improve flood resiliency and restore natural ecosystem functions within the Fraser Valley. The intent behind compiling a list of organizations is to allow SRRMC Staff to ensure that the various Stó:lō priorities can be achieved through collaboration with organizations that are pursuing similar objectives. The information identified for the list of organizations includes their background, partners, funders, relevant programs, and resources. The list of organizations is presented in Appendix B. Some of these organizations will be discussed further in the report as applicable.

Indigenous-led Emergency Planning Secretariat came together with an interdisciplinary group of BC-based organizations and experts to form the Lower Fraser Floodplains Coalition (LFFC). The group includes academics (UBC Coastal Adaptation Lab), Indigenous peoples (Stó:lō Tribal Council), lawyers (West Coast Environmental Law), consultants (Ebbwater Consulting Inc.), etc. and aims to improve BC's flood recovery and flood management (Azeez, 2023). The projects coming out of LFFC should closely tie to the SRRMC objectives of creating a climate change adaptation plan.

Nature-Based Flood Adaptation Tools

Nature-based solutions provide flood resiliency through various processes such as trapping of sediments, reducing stormwater runoff, increasing groundwater percolation, and creating storage capacity in rivers (CSA Group, 2021). Effective flood resiliency relies on the combined effects of a wide range of physical, biological, and social factors. These factors can range from land use management that determines stormwater runoff and public approval to habitat management that determines storage capacity and rates of post-storm repair. These factors are interconnected and a small part of a complex system that determines flood resiliency. As such, it is important to utilize a "systems-based" approach to flood resiliency (CSA Group, 2021). The systems-based approach acknowledges that the natural system is complex, interconnected, and includes interactions among a broad range of processes. The approach also recognizes that multiple, small interventions can impact the whole system just as much as a single significant intervention might (CSA Group, 2021).

Considering the whole system is critical for implementing NbS as it promotes the consideration of a wide range of spatial (site to neighbourhood to watershed level) and temporal (short-term to long-term) scales (CSA Group, 2021). Understanding the interconnectedness within the system

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also allows to achieve multiple priorities (CSA Group, 2021). For example, re-connecting waters that have been disconnected through traditional infrastructure can provide salmon habitat while also improving flood resiliency by increasing the carrying capacity of the river. Therefore, the best flood management strategies generally incorporate a host of NbS that work together.

The various NbS that can contribute to some aspect of increased flood resiliency in the Fraser Valley are presented in Table 1 and Figure 4 below. Additional details on each NbS are also presented in Appendix C. Some of the ways in which these NbS can be adopted in the Fraser Valley include:

4. Soft Shorelines: Incorporate soft shoreline principles in all new shoreline restoration and repair work to receive the added environmental benefits of soft shorelines.

5. Floodplain Widening/Meander and Tributary Restoration: Acquire agricultural land adjacent to dikes and create setback dikes that allow the river to run its natural course. Similarly, acquire lands adjacent to historical sloughs and hydraulically reconnect them to Fraser River. Focus should be placed on lands where the agricultural use can be adequately achieved elsewhere.

6. Wetland Restoration: Identify wetlands that are currently in a poor condition and aim to restore those. Additionally, design and construct engineered wetlands that are hydraulically connected to the Fraser River.

7. Green Infrastructure: Advocate for green infrastructure measures in urban areas that drain their stormwaters to the Fraser River. It is important to remember that retrofit or construction of green infrastructure is a slow process as it occurs on property-scale and therefore requires mass uptake for its benefits to be apparent.

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Table 1: Nature-based Solutions Description, Advantages, and Disadvantages

Nature-Based Solutions	Description	Advantages	Disadvantages
Soft Shorelines	Sometimes called living shorelines. Soft shorelines refer to practices that naturalizing current shorelines. It can range from adding vegetation along the current dike to designing a new shoreline with vegetation, logs, rootwads, etc.	Can be incorporated at a low-cost with the current flood infrastructure. Restores the natural shoreline and provides ancillary benefits such as reducing erosion, provide habitat, etc. (Green Shores, 2023)	High cost if the new project that focusses on flood protection is completed in areas without existing flood infrastructure. Requires ongoing operation and maintenance to ensure that the surrounding areas are protected.
Floodplain Widening/ Meander and Tributary Restoration	Humans have typically built dikes to reclaim the agriculturally fertile lands for human use. Floodplain widening includes removing the current and then constructing new dikes that are further back (Dobson Engineering Ltd., 2015).	Provides lands for the river to run their natural course (with meanders and tributaries) and reducing flood damage. Provides environmental benefits including improved biodiversity, groundwater recharge, and healthy habitat (FEMA, 2022)	Requires acquisition of land that is currently situated in the floodplain, leading to considerable economic and social cost. Requires operation and maintenance like the current dike system.
Wetland Restoration	Wetlands are land areas that are generally flooded with waters. Can act like "sponges" during a flood as they can hold excess water. Restoration activities can include trash cleanup, removal of invasive species, or planting of native species (US EPA, 2023)	Provides additional space for water to go during a flood event. Relatively low costs for restoration of existing wetlands. Environmental benefits including an important habitat, groundwater recharge, and sediment filtration (US EPA, 2023)	Significant cost for designing and constructing an engineered wetland. Requires some operation and maintenance to maintain healthy habitats. Requires considerable land area for an engineered wetland.
Green Infrastructure	Green infrastructure includes a set of approaches that lead to an increase in permeable surfaces in urban areas. These include permeable pavements, rain gardens, bioengineered swales, perforated pipes, etc.	Relatively low-cost to retrofit or construct green infrastructure instead of gray infrastructure in urban areas. Provides additional benefits such as heat mitigation, groundwater recharge, and improved water quality (Denchak, 2022)	Implemented on the property-scale and hence, requires significant uptake to get cumulative benefits. Less effective during spring freshet as it is dependent on snowmelt.

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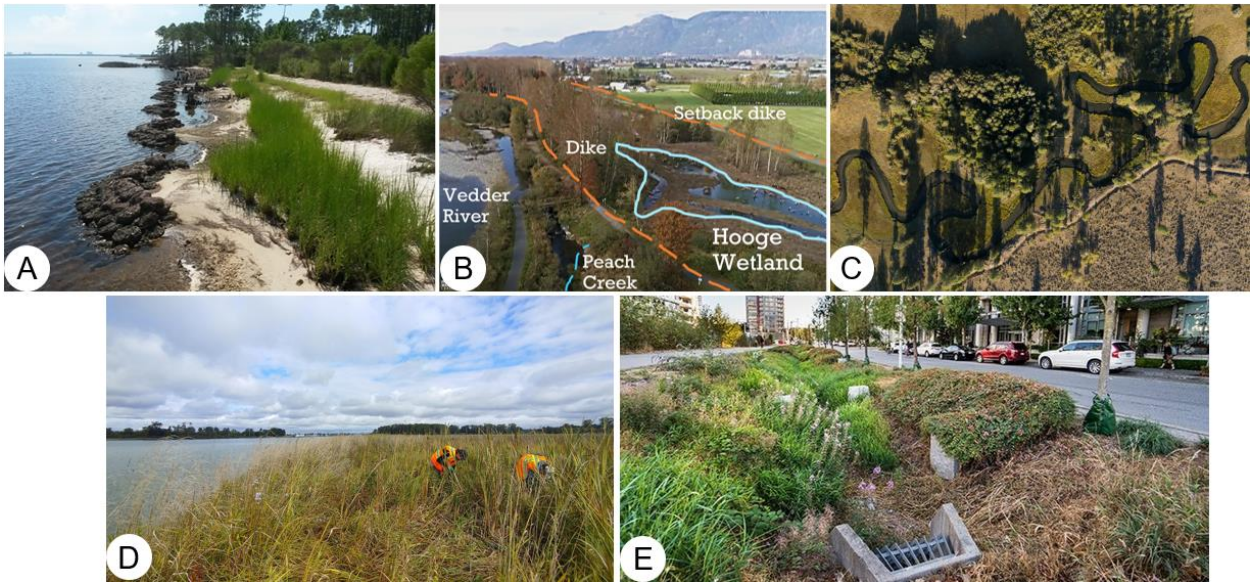

Figure 4: Examples of various NbS: (A) Soft Shorelines, (B), Floodplain Widening or Setback Dikes, (C) Meander Restoration, (D) Wetland Restoration, and (E) Bioengineered Swale or Green Infrastructure (City of Vancouver, 2023; Florida Living Shorelines, 2017; Fraser Valley Watersheds Coalition, 2021; Wetlands Workforce, 2021)

Case Studies

Wetland Restoration: MacKay Creek, North Vancouver, BC

MacKay Creek is a small salmon-bearing creek that is in North Vancouver. The creek commonly overflows during rain events, with floodwaters occasionally spilling into nearby streets. However, there was no overland flooding after the massive flood events of 2021 (Brennan, 2022).

The most likely reason for the lack of flooding in 2021 is the creation of a small wetland (MacKay Marsh) and a channel that was created adjacent to the creek (Brennan, 2022). The wetland restoration measures included planting of native species that hold the soil in place, slow the flow of water during storms, and provide a natural habitat for wildlife. The wetland was also connected to MacKay Creek such that any extra water can flow into the wetland during storm events (Brennan, 2022).

Floodplain Widening: Washington State, USA

The Nooksack River in the Washington State overtopped a natural bank and rerouted towards the Sumas Prairie during the 2021 floods (Wong & Fenton, 2021). Flooding in 1989-1990 along Canyon Creek, a tributary to the Nooksack further upstream of the overtopping location, led to the destruction of several homes due to debris flow or the erosion due to fast-moving waters (Baker, 2017). Although similar conditions in 2017 led to evacuation in nearby areas, houses along the Canyon Creek did not experience flooding (Baker, 2017). Similarly, the Puyallup River in Washington

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flooded the town of Orting in 2006 and 2009. However, the town remained without flood risk in 2014 when the river carried a similar volume of water (Dunagan, 2017).

The improvement in flood resiliency in both Canyon Creek and Pullayup River is attributed to new flood management projects that led to the design of setback dikes. Both projects effectively included widening of the river floodplains through the acquisition of houses along the river, demolition of the older dikes, and the construction of new dikes that are set back from the river (Baker, 2017; Dunagan, 2017). Following the floodplain widening project of the Pullayup River, the US National Weather Service has doubled the flow volume that would trigger a flood warning (Baker, 2017). This approach of working with nature and allowing the water to flow its natural course through widening the floodplain has also been endorsed by Tyrone Mcneil, Stó:lō Tribal Council Chief and chair of the First Nations Emergency Planning Secretariat (Gies, 2022).

Natural Asset Management

Municipal Natural Assets Initiative (MNAI) is a not-for-profit organizations that supports local governments across Canada to develop asset management plans that incorporate natural ecosystems which are typically sustainable and climate-resilient (MNAI, 2023a). The Natural Asset Management process is presented in Figure 5 below.

The District of Kent and City of Abbotsford are two municipalities within this report's study area that have engaged MNAI in completing an inventory of their natural assets. Additionally, MNAI is aiming to integrate inherent Indigenous rights and is currently looking to engage Indigenous communities so that MNAI can incorporate Indigenous knowledge with Western knowledge to improve their methodology as it relates to natural asset management (MNAI, n.d.). Consequently, SRRMC is interested in exploring ways in which natural asset management can be Indigenized. The following sections provide potential issues with NAM and a small first-step into exploring ways it can be Indigenized.

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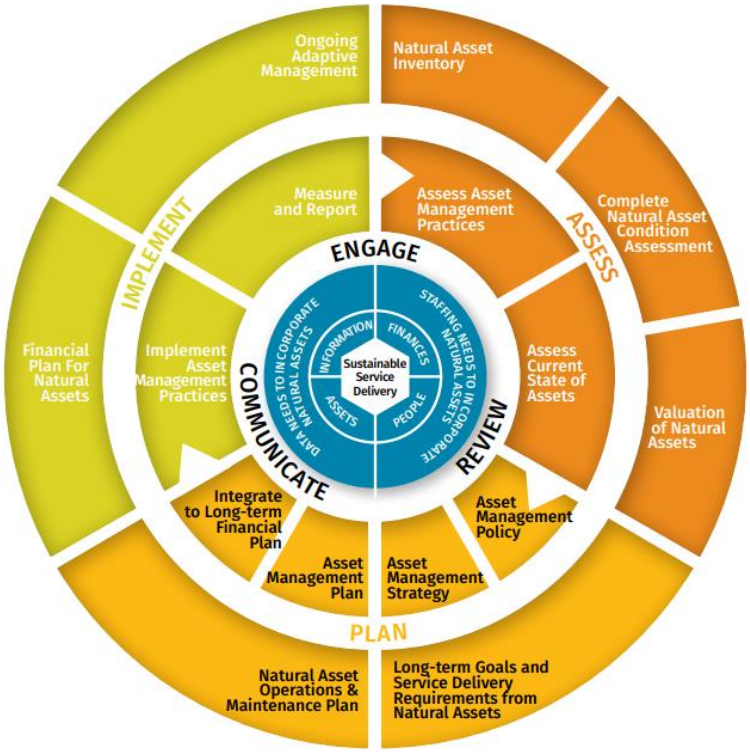

Figure 5: Natural Asset Management Process

Issues with NAM

Natural asset management (NAM) is a market-based approach that eventually advocates for conservation of natural ecosystems by accounting for the municipal services they provide. NAM develops methods where an economic value is assigned to "natural assets" (i.e. natural resources or ecosystems) that provide services such as climate regulation, water regulation, habitat provision, etc. The idea is that assigning an economic value to natural assets and including them in their accounting decisions would then lead the municipalities to conserve or restore natural ecosystems for the services they provide. One can already think of several potential issues with the basic concept of natural asset management that adds a monetary value to an ecosystem, especially from an Indigenous perspective.

First, NAM reduces ecosystems from multifaceted interconnected systems down to systems that provide individual services (i.e. ecosystem services) (Pavsek, 2021). NAM does not celebrate the compounding effects of various ecosystems and the rich relationships that exist within and between various ecosystems; relationships that are not yet fully understood by Western science but might be understood through Indigenous knowledge or Traditional Ecological Knowledge. Traditional Ecological Knowledge (TEK) is generally used to describe knowledge and beliefs about relationships with ecosystems that are acquired by Indigenous peoples throughout their history with the land (Robbins, 2018).

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Secondly, NAM recognizes natural ecosystems as the monetary value they provide to humans. It removes the "nature" from natural ecosystems and only considers the benefit to humans while negating or ignoring the benefits those ecosystem services provide to non-human species or ones that might harm humans (Pavsek, 2021). For example, floods are essential to a healthy floodplain ecosystem by adding nutrients and recycling water that is essential to several organisms other than humans while being harmful to humans that live in a floodplain. This raises the question of how to conserve ecosystems that are beneficial to non-humans but conflict with human interests. Ecological science doesn't fully understand the various relationships in nature (Sutherland et al., 2013) and hence, the true value of several ecosystems would not be accurately reflected in their assigned economic value. Additionally, since the value of natural ecosystems is tied to the value of the ecosystem services it provides, the natural ecosystems would lose protection if the same services can be provided through cheaper engineered means.

Lastly, it is worth noting that NAM is a product of settler colonial capitalist system which values nature for the economic value it provides to human. Although the discussion of economic systems and ideologies is not within the scope of the current project, it is worth considering whether the capitalistic approach within NAM aligns with Indigenous philosophies and ways of living which may differ from colonial capitalistic systems. Despite the various critiques mentioned above, one could conceive NAM's objective of promoting conservation of natural ecosystems by valuing them for their benefits as overall beneficial. It appears that the Municipal Natural Assets Initiative (MNAI), the leading Canadian initiative for NAM, is aware of some of these critiques as they clarify that their primary purpose is not to 'put a price on nature' but rather include ecosystem services in a government's decision-making (Brooke et al., 2017).

NAM Case Studies

In order to explore ways in which natural asset management can be Indigenized, a review of the current state of NAM in British Columbia was conducted. Two communities within the study area, District of Kent and City of Abbotsford, engaged MNAI to complete an inventory of their natural assets. A natural assets inventory includes details on types of natural assets, their conditions, and any risks (Municipal Natural Assets Initiative (MNAI), 2021). The inventory process for the City of Abbotsford included the following general steps (Municipal Natural Assets Initiative (MNAI), 2021):

8. Use various data sources provided primarily by the City of Abbotsford to classify the following natural assets: agriculture, flooded vegetation, forest, grassland, shrubland, urban park, water, and wetland.

9. Create a registry of each asset and an online dashboard to easily access and sort through the registry.

10. Assess the condition of each asset using the following criteria:

    1. Road density: Lowest road density in and around the asset was assigned the highest score as it is the most desirable.

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2. Surface permeability: Used to assess landcover and rated from nil (urban areas and industrial areas) to high (waterbodies, wetlands, and forests).

3. Adjacent land use: Used to assess anthropogenic impacts near the natural asset ranging from nil (airports and resource extraction within 100m) to high (no human uses within 100m).

4. Relative asset size: Understanding that ecosystem connectivity is important, asset size was rated based on its size within the categories.

11. Identify risks that may impact the natural assets and consider mitigation opportunities.

A similar process was followed to complete a natural asset inventory for District of Kent. Regarding adding an economic value to natural assets, the City of West Vancouver commissioned MNAI to compare the value of protecting an area from a 200-year storm event through daylighting a stream (i.e. natural state) versus a covered section (i.e. engineered). MNAI calculated the cost of daylighting a stream similar to any other engineering project. MNAI a created a theoretical design of the daylighted stream that would meet stormwater requirements, and then estimated the construction cost and any operation and maintenance costs (MNAI Technical Team, 2018). Some of the construction costs that were considered include earthmoving, construction materials, vegetation and landscaping, fencing, and moving existing sewer (MNAI Technical Team, 2018). Operation and maintenance costs that were considered include monitoring habitat, removing invasive species, restabilizing shoreline, replace signage, environmental monitoring, etc (MNAI Technical Team, 2018). These costs were then compared to the cost of increasing the size of the contained stormwater pipe to inform the city of the cost of utilizing a natural asset to provide stormwater management (MNAI Technical Team, 2018).

Indigenizing NAM

Based on the issues and case studies described above, there appear to be several ways in which NAM can be Indigenized. Some of those include:

12. Partner with MNAI using their current Call for Expressions of Interest - Integrating First Nations' Knowledge & Perspectives Natural Assets Inventory.

13. Review MNAI's natural asset inventory procedures (particularly their analysis of their condition and risk analysis) to see if Indigenous knowledge can be incorporated within the process.

14. Include the cost of social/cultural value of natural resources.

15. Include benefits to non-human organisms in the decision making.

16. Advocate for a variety of approaches to NAM instead of a cookie cutter framework to highlight the interconnected nature of ecosystems and the vast range of opinions regarding how Indigenous knowledge and priorities should be incorporated.

17. Incorporate land based assessments into natural asset inventory

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A massive risk of Natural Asset Management is that human's relationship with nature will be reduced to its economic value instead of its social, cultural, and ecological value. A widespread incorporation of NAM may lead to the conservation of some ecosystems but might change the way humans think about ecosystems. It is crucial to proceed with caution.

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Appendices

Appendix A - Current Nature-Based Solutions

Bell Slough Restoration

Project: Restoration efforts initiated include invasive species removal and native species planting. vCity of Chilliwack commissioned a study that indicated that the slough has been disconnected from the Fraser River and has poor water quality.

Importance: Revival of slough with

Flood Protection: Minimal as it is disconnected from Fraser River during high flows but improving flow should increase carrying capacity during floods.

Source(s): Bell Slough residents, Islamic Relief Canada come together to plant trees along slough in Chilliwack - Chilliwack Progress (theprogress.com); Cleaning up Bell Slough | Watershed Watch Salmon Society; Bell Slough Study - Draft - Apr 11, 2023.pdf (chilliwack.com)

Browne Creek Wetlands

Project: Creation of spawning channel by Fisheries and Oceans Canada and the Fraser Valley Watersheds Coalition. Also included the construction of recreational trails.

Importance: Improving salmon habitat in the Vedder River

Flood Protection: Some. Along with improving salmon habitat, it likely provides some flood protection due to its proximity to the Vedder River.

Source(s): Parks & Trails - City of Chilliwack

Cheam Lake Wetlands

Project: Remediation of a 1940-1990 limestone quarry into wetlands and a regional park. Currently, an important bird habitat.

Importance: A successful remediation of an inactive quarry that is now an important bird habitat.

Flood Protection: Minimal. It is not connected to the Fraser River but might provide some flood mitigation as it may hold some freshets from the North Cascades.

Source(s): Cheam Wetlands – BCWF Bog Blog; Get Outside! Cheam Lake Wetlands | Cascadia Magazine; Cheam Lake Wetlands Regional Park | Fraser Valley Regional District (fvrd.ca)

Harrison-Chehalis

Project: Establish the Lhá:lt / Harrison-Chehalis Wildlife Management Area (WMA) which would protect 1,000 hectares of crucial seasonally flooded wetlands at the confluence of Chehalis and Harrison rivers.

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Importance: Lhá:lt Cultural Value, dynamic river channels and active floodplain delta associated with Harrison and Chehalis rivers. Critical ecosystem for significant fish and wildlife.

Flood Protection: None for the Fraser River.

Source(s): Lhá:lt/Harrison-Chehalis Wildlife Management Area - Province of British Columbia (gov.bc.ca); Wildlife and fish habitat conserved in Harrison-Chehalis area | BC Gov News

Flooding Risks: The advisory from June 10, 2022 warned residents that rising water levels may flood low-lying areas not protected by dikes. These included a) properties in the Nicomen Island and Harrison Bay areas that are not protected by a dike; b) unprotected areas along the Harrison River; c) properties that are partly protected by the North Nicomen Dike; and d) low-lying parts of Laidlaw.

Hope Slough Restoration

Project: Restoration efforts completed include trash cleanup, invasive species removal, and native species planting in the riparian habitat. The objectives are to improve flow, water quality, and salmon habitat.

Importance: Revival of slough with historical and cultural significance

Flood Protection: Minimal as it is disconnected from Fraser River during high flows but improving flow should increase carrying capacity during floods.

Source(s): Chilliwack Middle School students clean up Hope Slough — Ducks Unlimited Canada; Revitalization of Chilliwack waterways the dream behind 'Hope for Hope Slough' event Thursday - Chilliwack Progress (theprogress.com); Spirit of Hope Slough (watershedwatch.ca); One year after the floods – community gathers to discuss restoring the waterways of Chilliwack (watershedwatch.ca)

Hooge Wetlands

Project: Restoration of Hooge wetlands which included removal of invasive species and planting of native species.

Importance: Restoring wetlands to support, restore, and enhance salmon and aquatic fish habitat.

Flood Protection: Yes, which was evident during the 2021 floods. During the flood, the wetlands and channel witnessed rearing salmon to escape high-flow velocities of Vedder River. The wetlands also soaked up excess stormwater, somewhat mitigating the flooding.

Source(s): Nature Based Climate Solutions: Investing in our Watersheds and the Future - Healthy Watersheds Initiative; Peach Creek & Vedder River Floodplain - Fraser Valley Watersheds Coalition (fvwc.ca)

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Nicomen Slough

Project: The Nature Trust of BC acquired the Nicomen Slough Conservation Area thanks to the generous donation of conservation-minded land owners through the Federal Ecological Gifts Program. The objective is to restore existing wetlands that are currently 1/3rd in natural state while 2/3rd in a disturbed state that needs remediation. Restoration works include improving salmon habitat and flow conditions to improve water quality. The project also works with First Nation partners and draws on Traditional Ecological Knowledge.

Importance: Within the "Heart of the Fraser" where Inch Creek and Norrish Creek join the Fraser River. Ecologically important for migrating waterfowl and prime salmon spawning habitat.

Flood Protection: Minimal as it is disconnected from Fraser River during high flows but improving flow should increase carrying capacity during floods.

Source(s): The Nicomen Slough: Restoring Balance in the Heart of the Fraser - The Nature Trust of British Columbia; Heart of the Fraser - Fraser Valley Watersheds Coalition (fvwc.ca)

Other: An old (2000) Deroche Creek Flood Hazard Management Study regarding Lakahahmen Reserve/community of Deroche which is developed on alluvial fan adjacent to Nicomen Slough.

Peach Ponds and Spawning Channel

Project: Create and enhance off-channel habitat for salmon spawning, rearing, and overwintering in the Vedder River floodplain and engage the community. Additionally, also extended groundwater salmon spawning channel by creating off-channel habitats to escape the high-flow velocities.

Importance: Improving salmon habitat in the Vedder River

Flood Protection: No. Creating water channels for salmon habitat.

Source(s): Peach Creek & Vedder River Floodplain - Fraser Valley Watersheds Coalition (fvwc.ca)

Silverdale

Project: Restoration of Silverdale Creek Wetlands (originally an overgrown field in 2007) as part of the Ministry of Transportation and Infrastructure (MOTI) Highway 7 – Silverdale to Nelson Four-Laning Project. The objective is habitat compensation efforts to improve salmon habitat through constructing new salmon channels, planting native species, and incorporating other biodiversity values.

Importance: Tidally influenced freshwater tributary of the Fraser River floodplain. Protected conservation area and municipal park.

Flood Protection: Yes. The objective is to be a floodplain forest. The wetlands, although separated from the Fraser River by the BC Highway 7, are hydraulically connected through a channel

Source(s): Silverdale Creek Wetlands - Salmon Habitat Restoration & Park Enhancement Project - City of Mission; BCWF Wetlands Workforce Healthy Watersheds Initiative 2021 - Fraser Valley

Watersheds Coalition (fvwc.ca); Lower water levels help drive out invasive species - DUC BC (ducks.ca) ;

Tom Berry

Project: Restoration of an inactive gravel pit through tree planting and construction and restoration of salmon channels. The objective is to provide a habitat for salmon and improve their access to the pit.

Importance: Restoration of an inactive quarry to the natural floodplain ecology.

Flood Protection: Some. The flooded gravel pit will act as a spillway for Fraser River during high freshet flows.

Source(s): https://fvwc.ca/our-work/tom-berry-starrets-pond-trail/

Trestle Channel

Project: Enlarge, complex, and connect off-channel with the Vedder River to improve salmon habitat Additionally, the riparian understory was cleared of intrusive species and planted with native trees and shrubs. also extended groundwater salmon spawning channel by creating off-channel habitats to escape the high-flow velocities.

Importance: Improving salmon habitat in the Vedder River

Flood Protection: Some. Along with improving salmon habitat, reconnecting a disconnected channel likely increases the carrying capacity of the Vedder River.

Source(s): Trestle Channel Effectiveness Monitoring Report Year 1 (pearsonecological.com)

Willband Creek Park

Project: Creation of an urban wetland in the City of Abbotsford as a storm water detention system.

Importance: Artificial nature-based storm water detention.

Flood Protection: Some. No direct flood protection for the Fraser River but it provides some as it's designed for storm water detention from the City of Abbotsford, some of which may have historically drained into the Fraser River.

Source(s): Willband Creek Park • Site Guide • Fraser Valley Birding (fvbirding.com); Willband Creek ISMP | City of Abbotsford

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Appendix B – List of Organizations in Flood Resiliency realm in the Fraser Valley

B.C. Wildlife Federation's Wetlands Workforce Project

Background: The Wetlands Workforce project is the largest collaborative wetland initiative of its kind in Canada. It has aimed to bring increased knowledge and understanding of the condition of B.C.'s wetlands to community, regional and provincial levels.

Years Active: 2021

Funding Sources: Healthy Watersheds Initiative, which is delivered by the Real Estate Foundation of BC (philanthropic organization) and Watersheds BC (launched in 2020 to support water leaders to improve decision-making for their home waters), with financial support from the Province as part of it's $10-billion COVID-19 response.

Partners: Nature Conservancy Canada, Nature Trust BC, Fraser Valley Watersheds Coalition, Ducks Unlimited, Yaqan Nukiy – Lower Kootenay Band, Langley Environmental Partners Society, Wildcoast Ecological Society.

Map: HWI Projects Map - Healthy Watersheds Initiative

Video to Check Out: Showcase Webinar - Wetlands Workforce

Final Report: Wetlands Workforce Final Report.indd

Emergency Planning Secretariat

Contact: Gillian Fuss | gillian.fuss@emplans.ca ; Mariah Mund | mariah.mund@emplans.ca

Source(s): Goal is to create a coordinated mainland flood management strategy. Mandate includes advocating for emergency and infrastructure work.

Funders: Indigenous Services Canada & Crown Indigenous Relations and Northern Affairs Canada

List of Grants: Grants & Funding (emergencyplanningsecretariat.com)

Flood Emergency Planning Resources: Information & Resources (emergencyplanningsecretariat.com)

Disaster Resilience Regional Action Plan: A Disaster Resilience Regional Action Plan called Hílekw Sq'eq'o. Hílekw Sq'eq'o is a halq'eméylem phrase that translates to "get ready together". The Hílekw Sq'eq'o is based on UN's Sendai Framework for Disaster Risk Reduction and is rooted in UN's Declaration on the Rights of Indigenous Peoples (UNDRIP). The Hílekw Sq'eq'o focusses on a regional plan that assists the various communities to understand risk, reduce risk and impacts, build resiliency, and recover better following the disaster. Additionally, the Plan will continue to uphold the self-determination, autonomy, and self-governance rights of the First Nations. Disaster Plan (emergencyplanningsecretariat.com)

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Flood Smart Canada

Background: Information hub for Canadians to prepare for flooding. Information on resources, flood risks, and emergency preparedness.

Funding/Parent Company: Partners of Action at University of Waterloo

Source(s): Communities and Organizations | FloodSmart Canada

Floodwise

Background: Portal that provides relevant information about flood risk management and the work underway to reduce flood risks for the region. Good source for understanding flood risks, flood impacts, flood glossary, identifying who does what, history, etc. Also includes resources on how to reduce flood risk, whether it's through land use changes, flood infrastructure, or emergency management.

Funding/Parent Company: Fraser Basin Council

Flood Strategy: Information about the Lower Mainland Flood Management Strategy (LMFMS). Lower Mainland Flood Management Strategy Development | FloodWise

Source(s): BC Lower Mainland Flood Information | FloodWise

Fraser Basin Council

Background: Charitable non-profit society that brings people together to advance sustainability in the Fraser Basin and across British Columbia. Established in 1997 and collaborates with federal, provincial, local, and First Nation governments as well as private sector and civil society.

Initiatives: The Lower Mainland Flood Management Strategy (LMFMS) & Floodwise (See below)

Flood Mitigation Planning Overview: A recap on flood mitigation planning in the Lower Mainland Flood Mitigation Planning Presentation (iclr.org)

Source(s): Fraser Basin Council - Home ; Fraser Basin Council - Lower Mainland Flood Management Strategy

Fraser Valley Regional District (FVRD)

Background: The Regional District (regional government) comprising of eight electoral areas and municipalities of Abbotsford, Chilliwack, Harrison Hot Springs, Hope, Kent, and Mission.

Flood Protection: Flood protection in several electoral areas. Flood Protection | Fraser Valley Regional District (fvrd.ca)

Climate Change Adaptation Strategy: Regional climate change adaptation strategy mentions changing risk of freshet floods but does not propose nature-based solutions. Fraser Valley Regional Adaptation Strategy Update.pdf (fvrd.ca)

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Source(s): Home | Fraser Valley Regional District (fvrd.ca)

Fraser Valley Wetlands Coalition (FVWC)

Background: Registered charity with a volunteer board of governors who believe healthy watersheds provide the foundation for vibrant, healthy communities. We take actions to conserve, restore, and enhance watersheds to benefit people and nature across the Fraser Valley, British Columbia. Founded by Fraser Valley Regional District, Fisheries and Oceans Canada, and the University of Fraser Valley.

Years Active: 1997-Present, Registered Society in 2005, Federal Charity Status in 2010.

Partners: Wetlands Workforce, Healthy Watersheds Initiative, Real Estate foundation, Watersheds BC, Vancouver Foundation, Habitat Conservation Trust Foundation, Canada, BC MOTI, Kwantien First Nation, University of the Fraser Valley, TD Friends of the Environment Foundation, Salmonid Enhancement Program, Fisheries and Oceans Canada, Pacific Salmon Foundation, Regional Districts, Municipal Governments, People of the River Referrals Office, SRRMC, Fraser Valley Conservancy, etc.

2022 Year in Review Report: https://fvwc.ca/wp-content/uploads/2022/12/2022-FVWC-Year-in-Review.pdf

Lower Mainland Flood Management Strategy (LMFMS)

Background: An initiative aimed at reducing flood risk and improving the flood resilience of communities. Opportunity for decision makers to work collaboratively on flood management. Phase 1 included developing flood scenarios and assessment of vulnerabilities and Phase 2 includes developing a long-term strategy.

Funding/Parent Company: Fraser Basin Council

Phase 1 Results: Phase 1 Included an analysis of flood scenarios, a regional assessment of flood vulnerabilities, and a review of current works and practices. Fraser Basin Council - Phase 1 Results

Lower Mainland Flood Maps: Lower Fraser River 2D Flood Modelling and Mapping Project that is completed for regional planning and is not detailed enough for local flood planning or analysis. Fraser Basin Council - Regional Flood Maps

Phase 2 Results: Continued on Phase 1 work with the final goal to create a regional flood management strategy. Work included flood risk assessment, floodwise website, assessment of Lower Mainland dikes. Work is currently paused as BC designs its Flood Strategy. Documents included Pathways to Action and Synthesis of Technical Analysis.

Source(s): Fraser Basin Council - Lower Mainland Flood Management Strategy

Raincoast

Background: A Conservation foundation composed of scientists and conservationists who aim to safeguard the land, waters, and wildlife of coastal BC. One of their priorities is protecting salmon habitat through collaborative, ecosystem-based conservation of plan for the Fraser River. Some

initiatives related to protecting salmon habitat include:
- Working with over 100 organizations to develop a Collective Vision for Salmon Habitat in the Fraser
- Completed a report that highlights the funding landscape surrounding restoration and conservation in the Lower Fraser River. Working on a similar report for the entire Fraser River watershed.
- Creating a Lower Fraser Working Group (LFWG) in collaboration with the Lower Fraser Fisheries Alliance, West Coast Environmental Law, and the Martin Conservation Decisions Lab at UBC. The LFWG is developing a governance strategy that prioritizes Indigenous communities and focusses on restoration.

Source(s): Lower Fraser River salmon conservation program | Raincoast Conservation Foundation ; Raincoast Conservation Foundation | Investigate. Inform. Inspire.

Resilient Waters

Contact: Dan Straker | dan@resilientwaters.ca

Background: Fixing flood infrastructure for salmon and communities. Focus on researching and developing best practices to remove or upgrade flood infrastructure to allow fish passage and reduce flood risk at sites that are most important to salmon and communities. Although salmon habitat isn't directly connected

Partners: Watershed Watch Salmon Society's Connected Waters Campaign

Funders: BC Salmon Restoration and Innovation Fund, Pacific Salmon Foundation, Fish Wildlife Compensation Program

Flood Resiliency: Info regarding the Lower Fraser Floodplains Coalition (formerly Build Back Better Together Collaborative) Flood Resilience | Lower Fraser Floodplains Coalition (resilientwaters.ca)

Flood Infrastructure Map: Map showing the opportunities to upgrade flood infrastructure to improve salmon habitat. Map | Resilient Waters

Resources: Research to advance best practices for flood infrastructure. Research | Resilient Waters

Vedder River Management Area Committee

Background: A committee formed to complete sediment removal to maintain the carrying capacity of the Vedder River to reduce flood risk.

Partners: City of Chilliwack, City of Abbotsford, BC Ministry of Forests, Lands and Natural Resource Operations (MFLNRO), Federal Department of Fisheries and Oceans

Source(s): Vedder River Management Area Committee

Watershed Watch Salmon Society

Contact: Lina Azeez | lina@watershedwatch.ca

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Background: Multiple projects to achieve the vision of thriving wild salmon running across BC rivers.

Connected Waters Campaign: Campaign to reconnect 1500 kilometres of salmon habitat currently blocked by outdated flood infrastructure in the lower Fraser floodplain. Started in 2016.
Connected Waters | Watershed Watch Salmon Society

Heart of the Fraser Project: A push to conserve and defend the Heart of the Fraser.
Homepage | Defend the Heart of the Fraser River

Flood Resiliency: Info regarding the Lower Fraser Floodplains Coalition (formerly Build Back Better Together Collaborative) Flood Resilience | Lower Fraser Floodplains Coalition (resilientwaters.ca)

Source(s): Watershed Watch Salmon Society - Defending BC wild salmon

West Coast Environmental Law

Background: Non-profit group of environmental lawyers and strategists who use the law to protect the environment. They also aim to revitalize and uphold Indigenous laws. Some of their current programs/campaigns are presented below.

Green Infrastructure: Implementing green infrastructure through a multidisciplinary approach and innovative use within current laws
Green Infrastructure | West Coast Environmental Law (wcel.org)

Community Climate Adaptation: Work with various communities to adapt to sea level rise, extreme weather events, flooding, etc.
Community Climate Adaptation | West Coast Environmental Law (wcel.org)

Indigenous Law: Acknowledges how Indigenous law acknowledges our relationships to land, spirit world, water, and resources. Project aims to articulate, revitalize, and apply Indigenous law to our communities.
Indigenous Law | West Coast Environmental Law (wcel.org)

Source(s): Lower Fraser leaders call for regional action on key priorities for flood management | West Coast Environmental Law (wcel.org); West Coast Environmental Law | Transforming the legal landscape (wcel.org)

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Appendix C – Nature-based Solutions (NbS) Details

Soft Shorelines

Soft shorelines, sometimes called living shorelines, are shorelines that are naturalized (i.e., include natural features). This concept could also be adapted the existing infrastructure by reinforcing the existing dikes with natural features. Naturalizing the shoreline or the existing dike infrastructure would be a small move towards NbS. The natural features can range from increasing vegetation along the embankment (no structural changes) to burying the dike with topsoil and associated vegetation (moderate structural change including a higher dike elevation) to a new soft shoreline with vegetation, log placements, and/or engineered wetlands (major change). Some additional information regarding soft shorelines is compiled in Table 2 below.

Table 2: Information regarding soft shorelines (Green Shores, 2023)

Category	Rating	Comments
Cost	Medium	Costs include design and installation of vegetative structures
Effectiveness	Medium	Reduces the flood impacts through energy dissipation and increased water storage
Durability	Medium	Requires operation and maintenance
Environmental Benefits	High	Provides additional environmental benefits including increased biodiversity and healthy habitats

The Stewardship Centre for BC and its funding partners created a program called Green Shores™ that promotes natural shorelines. Although the project is focused primarily on coastal communities, the lessons and ideas can be adapted to a freshwater environment. The Green Shores™ initiative aims to restore shoreline functions by restoring natural habitat and promoting the natural movement of water and sediments (Green Shores, 2023). A Green Shores™ illustration summarizing the potential improvements of soft shorelines as opposed to traditional dikes is included in Figure 6 below. Note that although the image is regarding property-scale changes in a coastal environment, the core principles can also be adapted on the community scale in a freshwater river environment.

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Figure 6: An illustration of soft shoreline principles, courtesy of Green Shores™ (Green Shores, 2023)

Floodplain Widening

A floodplain is the low-lying flat or nearly flat land that is adjacent to a river and is susceptible to river flooding. Humans build dikes or other measures to reduce the floodplain to reclaim the agriculturally fertile lands for human use. Reversing the process and returning the floodplain back to the river aids in flood resiliency as it provides more lands for the river to run their natural course and consequently reducing flood damage. Floodplain widening usually includes acquiring land that is adjacent to the current lands, removing the current dikes that channelize the river, and then constructing new soft shorelines (or dikes) that are further back past the acquired lands (Dobson Engineering Ltd., 2015). This adaptation tool is also referred to as setback dikes (Dobson Engineering Ltd., 2015). Some additional information regarding floodplain widening is compiled in Table 3 below.

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Table 3: Information regarding floodplain widening (FEMA, 2022)

Category	Rating	Comments
Cost	High	Costs include land acquisition and demolition and rebuilding of dikes
Effectiveness	High	Increases land where the river can flow naturally and store waters during a flood event
Durability	Medium	Requires operation and maintenance similar to current dikes
Environmental Benefits	High	Provides additional environmental benefits including increased biodiversity, water quality, groundwater recharge, and healthy habitats

Floodplain widening would not be feasible across the entire length of the Fraser River as the dikes protect crucial infrastructure and longstanding communities; removing and rebuilding the communities would lead to a significant economic and social cost. However, there may be some pockets along the Fraser River and its many tributaries where land in the floodplain may be acquired at a reasonable cost to allow for floodplain widening.

Meander and Tributary Restoration

Meanders and tributaries are both part of the natural movement of a river. Meanders are sinuous bends in a river that usually occur through erosion patterns when the river is travelling along a gentle slope. A meandering river is shown in Figure 7 below.

Figure 7: A meandering river (Photo by Dan Meyers on Unsplash)

Meanders are produced as faster moving water from the outer bank erodes sediments. These sediments are then deposited downstream by the slower moving water along the inner bank (Earle, 2015). The areas surrounding the rivers are often fertile and as such, humans have built dikes to

protect the fertile low-lying areas for agricultural uses. However, this has led to several tributaries being disconnected from the river and meanders being lost in the narrowing floodplain. Meander and tributary restoration is a flood adaptation tool that allows the river to run its' natural course in balance with the floodplain and consequently reducing potential flood damage (Kline, n.d.). Occasionally, the flow of water in the meanders or tributaries can also be disrupted through other anthropogenic impacts such as debris, removal of native plantation, and presence of intrusive species. Consequently, meander and tributary restoration can occur through adding flood infrastructure to re-connect disconnected waters or by completing restoration works such as removing debris, removing invasive species, and installing riparian plantings (Watershed Watch Salmon Society, 2022). Some additional information regarding meander and tributary restoration is compiled in Table 4 below.

Table 4: Information regarding meander and tributary restoration (Kline, n.d.; Watershed Watch Salmon Society, 2022)

Category	Rating	Comments
Cost	Medium	Costs include land manipulation and building flood structures in existing dikes
Effectiveness	Medium	Increases some land where the river can flow naturally and store waters during a flood event
Durability	Medium	Requires some operation and maintenance to maintain healthy habitats
Environmental Benefits	High	Provides additional environmental benefits including increased biodiversity, water quality, groundwater recharge, and healthy habitats

It appears that the Fraser River between Hope and Abbotsford is generally confined by the surrounding mountains or dikes that protect crucial infrastructure. The construction of dikes has led to several meanders and surrounding tributaries to be disconnected from the Fraser. There may be areas along the Fraser where meander restoration is possible through various methods that return the full extent of the floodplain back to the river. Additionally, the Watershed Watch Salmon Society is running a campaign called Disconnected Waters that aims to re-connect these blocked waterways (Watershed Watch Salmon Society, 2022). A map of the disconnected waters along the Fraser River between Hope and Abbotsford is presented on Figure 8 below. Although their primary focus is improving salmon habitat, it also improves flood resiliency of the surrounding lands.

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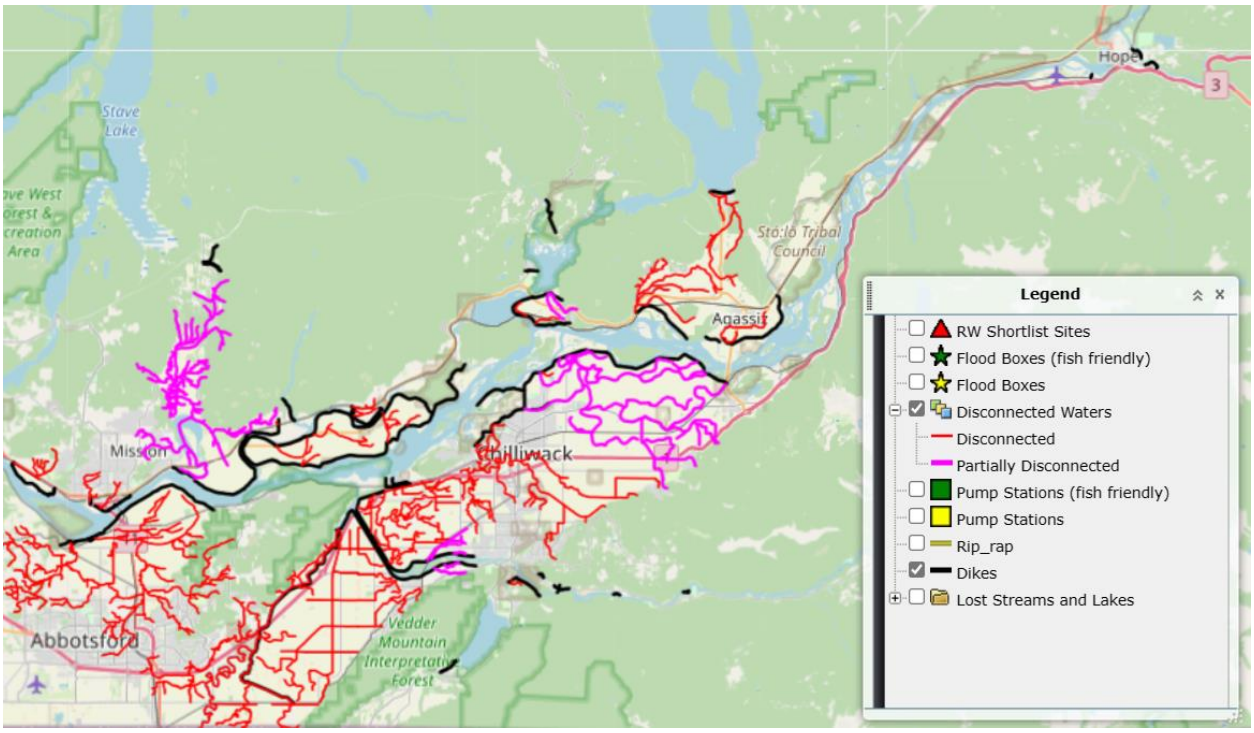

Figure 8: Disconnected Waters along Fraser River between Hope and Abbotsford (Watershed Watch Salmon Society, 2018)

Wetland Restoration

Land areas that are generally flooded with waters regularly are referred to as wetlands (US EPA, 2016). Consequently, they can absorb and store a large quantity of water which can aid in reducing the impacts of the flood as the additional water gets stored in wetlands surrounding the river (US EPA, 2016). There are currently several wetlands around the Fraser in varying levels of degradation, some of which are identified in the broad feasibility map. Wetland restoration activities can include trash cleanup, removal of invasive species, or planting of native plants all of which would improve the wetlands' water storage capacity to restoration (Lev, 2009). Similarly, cleanup or restoration of hydraulically connected streams can also aid in increasing the Fraser's carrying capacity. Some additional information regarding wetland restoration is compiled in Table 5 below.

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Table 5: Information regarding wetland restoration (US EPA, 2023)

Category	Rating	Comments
Cost	Medium	Costs range from cleanup and minor restoration of current wetlands (low) to major restoration of damaged wetlands (medium) to construction of engineered wetlands (high)
Effectiveness	Medium	Provides an ecosystem that can store excess waters and promote drainage
Durability	Medium	Requires some operation and maintenance to maintain healthy habitats
Environmental Benefits	High	Provides additional environmental benefits including an important ecosystem, groundwater recharge, and sediment and toxic metal filtration

Wetland restoration appears to be the most prevalent nature-based solution to improve flood resiliency within the Fraser Valley. That is unsurprising as wetlands provide a variety of additional benefits ranging from improving water quality to groundwater recharge to providing a crucial ecosystem for wetland plants and animals (Government of Canada, 2016). Although the primary reason for restoring some wetlands in Fraser Valley might be salmon habitat, they also improve flood resiliency in the region. Some projects, included in the mapping project described above, that aim to restore wetlands within the Fraser Valley include:

18. Silverdale Wetland: Create and restore salmon channels, upgrade river banks, and plant native trees (City of Mission, 2023).

19. Peach Creek and Hooge Wetland: Create salmon channels and off-channel pond, add wood and root wads, remove invasive species, and plant native riparian trees and shrubs (FVWC, 2022). Monitoring showed increased salmons and added space for fish and floodwaters during the 2021 floods (FVWC, 2022).

20. Browne Creek Wetland: Create salmon channels, re-water land, replant native riparian trees and shrubs, and remove invasive species (Cox, 2018). Monitoring showed added space for fish and floodwaters during the 2021 floods (FVWC, 2022).

Green Infrastructure

Green infrastructure refers to infrastructure that is modelled after nature. In terms of flood resiliency, impermeable surfaces in urban areas typically increase surface runoff which leads to increased water levels in the surrounding water bodies and eventually urban flooding (Denchak, 2022). Green infrastructure not already discussed above could include a set of approaches that lead to an increase in permeable surfaces. These include permeable pavements, rain gardens, bioengineered swales, perforated pipes, and stormwater detention ponds, all of which allow precipitation to percolate the ground and recharge the groundwater aquifer instead of enter the

surface water bodies (Denchak, 2022). Green infrastructure is typically conducted on smaller scales and the benefits aren't immediately apparent. However, it provides a myriad of other benefits including smog and heat mitigation, increased groundwater recharge, and improved water quality (Denchak, 2022). Some additional information regarding green infrastructure is compiled in Table 6 below.

Table 6: Information regarding green infrastructure (Denchak, 2022)

Category	Rating	Comments
Cost	Medium	Costs associated with engineering and construction on the property-scale
Effectiveness	Low	Green infrastructure primarily reduce surface runoff, one property at a time
Durability	Medium	Requires some operation and maintenance
Environmental Benefits	Medium	Benefits such as smog and heat mitigation, increased groundwater recharge, and improved water quality in urban areas

Green infrastructure projects are typically conducted on the property or neighbourhood-scale on new developments. Within the Fraser Valley, the City of Vancouver has begun integrating green infrastructure on municipal projects with over 300 projects collecting and cleaning surface runoff from 16 hectares (City of Vancouver, 2023). Promoting green infrastructure where possible could be part of a Comprehensive Plan that allows urbanized communities to restore some natural functions. An illustration showing potential green infrastructures that can help during storms is shown in Figure 9 below.

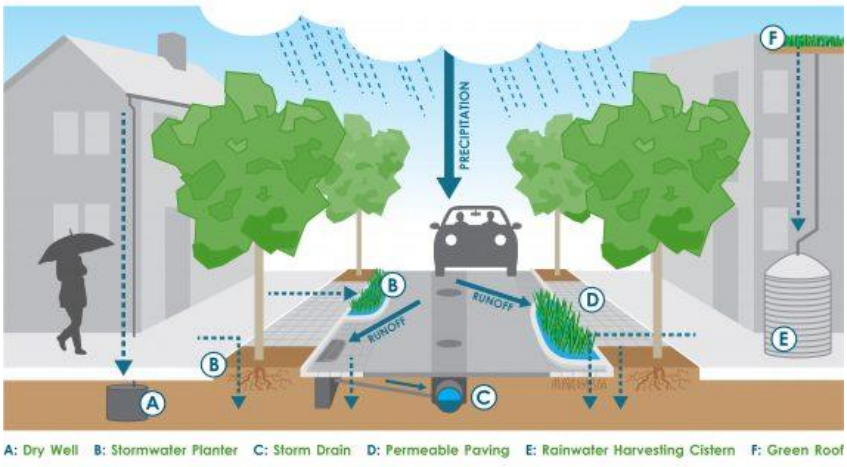

Figure 9: Types of Green Infrastructure for storm surges (Norwalk Tomorrow, 2019)

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