Fish, Fish Habitat, and Fishing

Flood Risk And Management Planning Report

Prepared for:

Sḵwx̱wú7mesh Úxwumixw (Squamish Nation)

Emergency Planning & Response

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1. Introduction

Pacific salmon (Oncorhynchus spp.) can be found throughout Squamish Nation traditional territory in watersheds such as the Squamish, Capilano and Seymour watersheds.[1] Since time immemorial, these systems have had abundant returns of pacific salmon which played a crucial role in the Squamish Nation's food availability and culture.[1] All five species of Pacific salmon were caught within Squamish Territory: Chinook (O. tshawytscha), Coho (O. kisutch), Chum (O. keta), Pink (O. gorbuscha), and Sockeye (O. nerka).[1] However, mounting pressures from overharvesting, climate change and habitat destruction have led to the widespread decline in population abundance across their distribution.[2] As climate change increases the frequency and severity of flooding, it is important to understand how this will impact fish, specifically salmon, at all stages of their life cycle.[3] Additionally, comprehending how increased flooding will impact fish habitat and fishing opportunities is particularly important to the Squamish Nation. This report is one component of a broader, issue-based flood risk and management planning initiative focused on the reserve lands of the Squamish Nation. It addresses a critical and growing concern: how do floods affect fish health and fish habitat, and what planning guidance can help the Nation protect and restore these systems in the face of increasing flood frequency and severity?

1.1 Local Jurisdictions

Our report focuses on the Squamish, Capilano, and Seymour river systems, which are managed by multiple governing bodies outside of the Squamish Nation: notably the District of Squamish and the Metro Vancouver Regional District (MVRD).

Metro Vancouver Regional District

The MVRD is the primary governing body for the land surrounding the two main river systems in North Vancouver, the Seymour and Capilano. These rivers are included in the regional district's regional park network as the Lower Seymour Conservation Reserve [4] and the Capilano River Regional Park [5], respectively. Relevant plans include:

- The Regional Parks Natural Resource Framework [6]
    - This framework includes high-level goals to increase public participation in stewardship activities through partnerships, with strategies to engage First Nations in stewardship, education, and collaborative management of the park. The framework does not explicitly mention fish or fishing.

- The Lower Seymour Conservation Reserve Management Plan [7]
    - This plan breaks down key goals, strategies, and actions for the management of the river reserve. It includes:
        - Supports for recreation trout fishing in Rice Lake
        - Recognition of work accomplished as of 2022 to improve culverts and drainage to support safe fish passage
        - The consideration of fish and fish habitat for rock aggregate development in the area
        - Ecological stewardship in collaboration with the Seymour River Fish Hatchery
- The Ecological Health Framework [8]
    - This framework identifies the MVRD's role in supporting ecological health and outlines goals, strategies, and guiding principles towards supporting ecological health in the region.
    - It highlights the importance of collaboration across jurisdictions to protect fish habitat.
    - It also recognizes the MVRD's potential impacts through their liquid waste management and treatment on riparian areas and fish-bearing streams.
- The Joint Water Use Plan,[9] which outlines how Metro Vancouver's water resources are used and managed and was developed in collaboration with local First Nations.
    - This plan prominently identifies supporting healthy fish habitat as benefits of the agreed upon actions in the plan.

District of Squamish

The District of Squamish is the primary governing body for the land surrounding the Squamish River, which is primarily zoned as P-4: Ecological Reserve in the District's Zoning Bylaw (web map available here). Relevant plans and programs include:

- The Land Back Task Force[10]
    - This task force, made up of staff, councillors, and independent decision-making authorities from both Squamish Nation and District of Squamish, will focus on restoring the Nation's governance, access, stewardship, and cultural connection to lands under public jurisdiction including parks, traditional harvesting sites, and protected areas.
- The Integrated Flood Hazard Management Plan [11]
    - This plan provides an assessment of coastal and riverine flood risk in the District and outlines opportunities for flood mitigation and makes some mentions of fishing and protecting fish habitat.

- The Natural Asset Management Strategy [12]
    - This strategy provides an inventory of the District's natural assets, which includes estuaries, creeks, rivers, and wetlands. It also provides guidance on how to improve the District's natural asset management. This strategy does not explicitly include fish or fish habitat within the document.
- The Water Master Plan [13]
    - This plan provides an overview of the District's drinking water network and prioritizes actions to maintain and upgrade necessary infrastructure. It recommends assessing water needs during emergencies that take into account nearby fisheries and their flow requirements.
- The Integrated Flood Hazard Management Plan Background Report[14]
    - This report recognizes the risk that flooding poses to fish, fish habitat, and fisheries across the Squamish watershed.
        - Subsequent reports like the River Flood Risk Mitigation Options[15] include a more detailed assessment of the impacts of specific flood types on fish and fish habitat.
        - All reports related to Integrated Flood Hazard Management are hosted on the District's website.

2. Fishing, Floods, and Squamish Nation Priorities

The impacts of flooding and flood mitigation infrastructure on fish, fish habitat, and fishing access influence two of the key priorities outlined in Úxwumixw 2050: Sḵwx̱wú7mesh Generational Plan[16]**:** *Feeling of Security* and *Feeling of Belonging.*

2.1 Feeling of Security

The first relevant priority, *Feeling of Security,* is closely tied to the Nation's food sovereignty. Food sovereignty can be defined as "the ability and right to access, control, and produce what is needed for a healthy—and culturally and socially relevant diet".[17(p400)] For First Nations communities, traditional foods, including berries and locally-harvested and traditionally prepared or preserved fish, continue to play a fundamental role in community culture and identity, as well as member livelihoods, health, and sense of place.[18]

Fish are fundamental to the food sovereignty of the Sḵwx̱wú7mesh People. Through community engagement conducted in the development of Úxwumixw 2050, members shared desires for investment in fish processing infrastructure at local rivers (e.g. fish cleaning stations, etc.), investment in on-reserve fisheries to support member-owned businesses and enrich the community's economy, and educational opportunities relating to food harvesting, preparation, and preservation. As one member stated, the Nation can support member's *Feeling of Security* by teaching "people to fish, filet, and preserve salmon". Moreover, the importance of food sovereignty is highlighted in Action 9.3 in the Nation's Climate Legacy Strategy[19], which is to "[e]ducate and support our Sḵwx̱wú7mesh People in food sovereignty practices such as traditional hunting, gathering, fishing, preparation, and preservation". These comments highlight how the members' ability to access fishing sites, to share knowledge about fishing, and to feed themselves through fishing are all tied to Sḵwx̱wú7mesh Úxwumixw's ability to exercise and strengthen their food sovereignty.

2.2 Feeling of Belonging

The priority, *Feeling of Belonging,* is bolstered through fishing as a cultural practice. Food and food practices, like fishing, are recognized as "wealth, resilience, and a vital expression of continuance and identity. Indigenous food practices are a powerful medium for knowledge transmission across generations, which occur at harvesting sites and during food production".[17(p402)] Fishing also provides an

opportunity for members to spend more time on the land and waters, which can support members' mental and physical health and well-being.[20]

In Úxwumixw 2050, members expressed their ability to be on the land, engage in cultural practices like fishing, and share knowledge and experiences with other community members, especially youth, as key aspects to supporting *Feeling of Belonging*. Specifically, members requested increased access to and time on Squamish land and waters, as well as organized activities like fishing.

As we will discuss in the following sections, the potential increase in flooding frequency and severity due to climate change, as well as certain flood mitigation measures and infrastructure, pose a dual threat for the Sḵwx̱wú7mesh Úxwumixw: inhibited access to fishing sites (relating to physical access and political/governance restrictions) and negative impacts to fish and fish habitat.[17]

3. Flooding and Fish Health

This portion of the report specifically examines how flooding affects fish health across salmonid life stages, with a focus on the Squamish River system and its connection to the Skwelwil'em Estuary. It is intended to provide guidance to the Squamish Nation and their planning partners in making flood management decisions that account for fish and fish habitat as core values.

The report draws on regional news reporting, government guidance from Fisheries and Oceans Canada (DFO), information from conservation organizations, including the Pacific Salmon Foundation (PSF) and Watershed Watch Salmon Society and primary published literature.

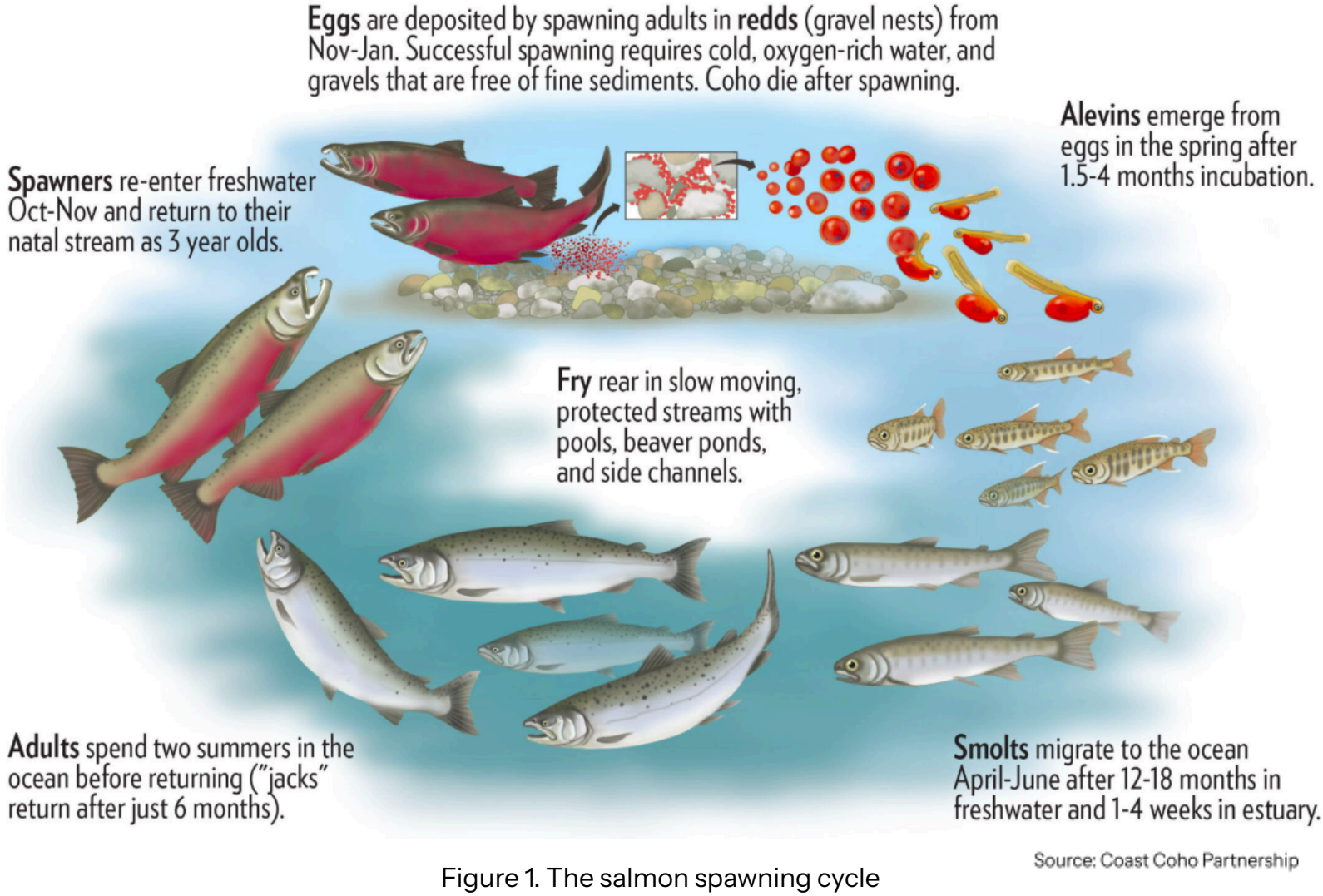


Figure 1. The salmon spawning cycle

3.1 How Floods Affect Fish Health

Flooding is a natural and historically important ecological process in riverine systems.[21] In their natural state, floods play a beneficial role by recruiting and depositing gravels, flushing fine sediments, reconnecting side channels and floodplains, and delivering nutrients throughout the watershed. However, the scale, timing, and increasing frequency of extreme flood events being driven by climate change and human made structures can transform this natural process into a significant threat to salmon populations across all life stages.[22]

Within a freshwater salmon-bearing system, multiple life stages may be present simultaneously. At any given time of year, adult spawners, eggs/redds, alevin, fry, and out-migrating smolts are all within the same river system. Floods impact each of these life stages differently, and a single extreme event can compound losses across an entire generation of fish. [23]

Impacts on Eggs and Redds

Adult salmonid species, including Chinook, coho, chum, pink, and steelhead deposit their eggs in gravel nests called redds during the summer and fall spawning season (Figure 1). These redds must remain intact, well-oxygenated, and free of fine sediments throughout the incubation period, which extends from late autumn through early spring.[24] Floods represent an acute threat to this vulnerable incubation stage.

The November 2021 atmospheric river event was one of the most significant flooding events ever recorded in southern British Columbia and provided a stark example of this vulnerability. Biologists feared that flood waters had scoured gravel beds in the Fraser, Vedder/Chilliwack, and Squamish River systems, dislodging eggs from their redds. Once embryos are washed free of gravel, they are exposed to predation and physical damage, leading to mortality. Beyond physical scouring, floods deposit large quantities of fine sediment into spawning gravels, reducing water flow within the gravel that delivers oxygen to developing embryos, essentially smothering them.[25]

Impacts on Juveniles, Fry, and Smolts

Fry that have recently emerged from the gravel and smolts actively out-migrating to the ocean are highly vulnerable to flood conditions. Their smaller body size means they have less swimming capacity to hold position against high current velocities. During flood events, juveniles that cannot find refuge in off-channel habitats, eddies, or floodplain areas risk being swept downstream and into marine environments prematurely.[24]

Premature ocean entry is particularly harmful as smolts undergo a physiological transformation called smoltification that prepares them for the transition from freshwater to saltwater.[26] This process is finely tuned to environmental cues, and juveniles forced into saltwater before completing smoltification face dramatically reduced survival rates in their marine environment.[24]

Impacts on Adult Spawners

Adult salmon returning to freshwater spawning grounds are not immune to flood impacts, though their larger body size and stronger swimming capacity provide some buffer against flood currents. The primary risks to returning adults include stranding, migration blockage, and habitat displacement.

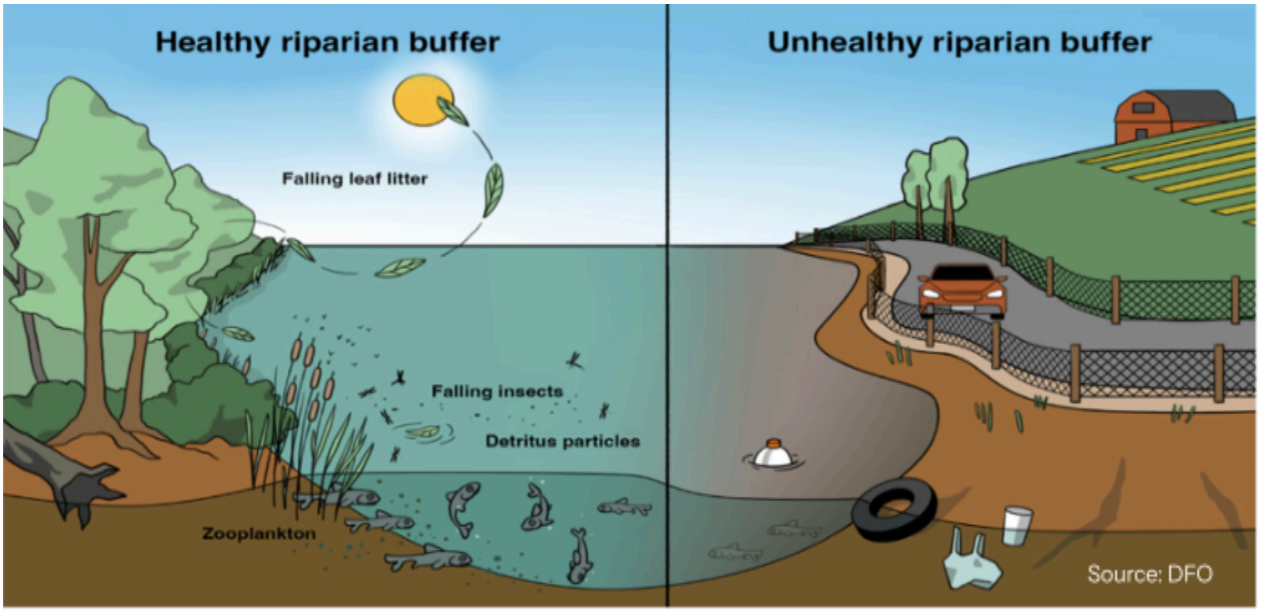
Stranding occurs when rapidly changing water levels isolate adult salmon in pools or side channels that become disconnected from the main river as floods recede.[27] Stranded adults that cannot return to the main channel before their energy reserves are exhausted will die without spawning, representing a complete loss of their reproductive contribution for that year. Floods can also deposit or shift sediment and debris in ways that block migration routes, preventing adults from reaching their natal spawning grounds.

3.2 Flood-Associated Pollution and Water Quality

Flood events not only alter the physical structure of river habitat but also introduce significant chemical and biological contaminants into salmon-bearing waterways, posing risks across all life stages. When flood waters inundate roads, urban areas, agricultural land, and industrial sites, they mobilize a broad suite of pollutants: petroleum products, fertilizers, pesticides, heavy metals, and sewage. These contaminants are carried directly into rivers and side channels, degrading water quality in habitats that salmon depend on.

4. Floods and Fish Habitat

Fish habitat is a crucial driver of the long-term survival of fish populations.[24] Floods are a natural ecological event that maintain the health of rivers, riparian zones, and floodplains, all of which make up critical fish habitat.[24,28,29] Through the creation of new channels and the maintenance of various stages of ecological succession in riparian ecosystems, floods play a major role in sustaining connectivity within a watershed.[24] Fish species have adapted to these dynamic conditions and rely on the seasonality of flood events to support diverse life history characteristics.



Wetlands, off-channels, and estuarine drainages are key seasonal habitats for fish, particularly juvenile salmon.[24] These habitats support greater species diversity, higher densities, and larger growth rates than areas where connectivity to floodplain habitat has been severed by urbanization and flood infrastructure.[24,30] Habitat types range from coastal rain-fed systems to glacier-fed rivers, and species preferences vary accordingly.[24] Species will move within mainstem river systems into various off-channels, depending on their seasonal needs. These off-channel areas, created by flood events, provide abundant food and shelter. They are characterized by mature forests, surrounded by mid-level succession wetlands, made up of cedars, sitka spruces, skunk cabbage, salmonberries and eelgrass. [28] Crucial estuarine zones are characterized by a mix of fresh and saltwater known as brackish water, to prepare the transition of juvenile salmon to the ocean.[29,31] The central takeaway, however, is that connectivity and the natural regulation of flooding together create vital habitat across species and landscapes.

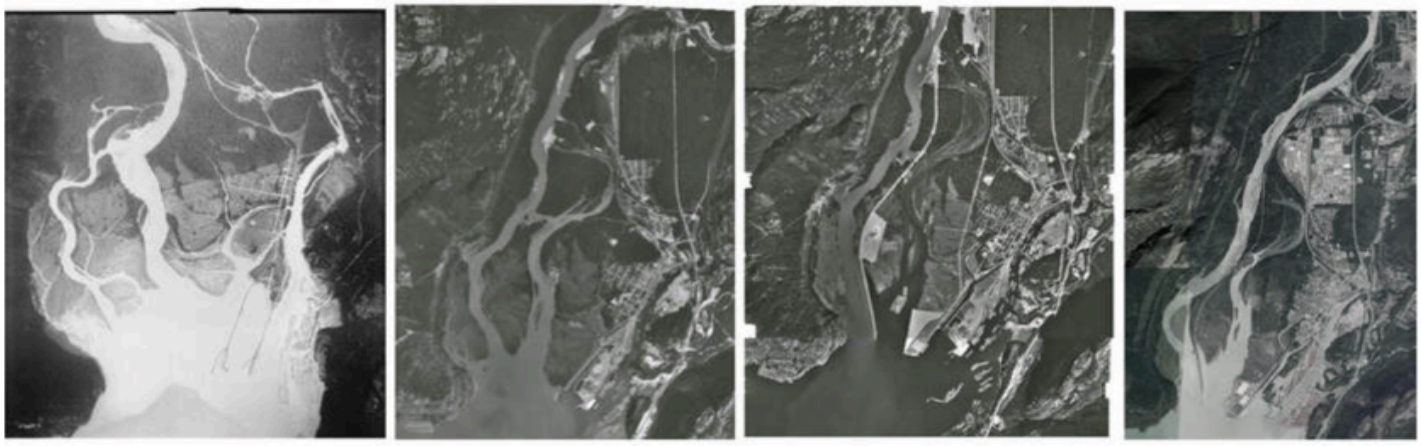
Historical flood infrastructure has fragmented watersheds and drained wetlands, reducing the amount of crucial habitat available for fish.[28,-30] These systems often work in conjunction with one another and, as a result, the negative impacts from each compound together. The following subsections examine each infrastructure type and its specific impacts on fish habitat.

4.1 Wetland Drainage and Loss of Riparian Zones

The loss of wetland and estuarine environments is a common consequence of flood infrastructure development. The Lower Fraser River is estimated to have lost 85% of its historical salmon habitat as a result of flood infrastructure, primarily through dams, diking and pump stations.[31] The proportion of wetland and fish habitat lost within Squamish Nation territory has not been formally quantified; however, flood maps of the Squamish area (Zoning Bylaw 2500, Schedule D) [11] indicate that much of the territory would historically have been floodplain habitat. This is further supported by historic pictures of the Squamish estuary,[32] which has significantly reduced in size. Along with the loss of wetlands, disappearing riparian buffers reduce the structural integrity of these ecosystems. Riparian buffers reduce erosion, maintain water temperatures, and contribute crucial detritus, e.g., dead leaves, to the system.[33]

The loss of these areas, along with wetlands, has resulted in decreased fish abundance and health.[31] Remediation efforts are underway in many areas to increase the productivity of many channels and rivers, such as Mamquam Blind Channel,[34] Evans Creek,[35] the Squamish estuary,[36] Brighton Park tidal flats[37] by increasing the connectivity of these areas and developing a greater network of wetland habitat, including estuarine habitat.

Squamish Estuary



1930 1969 1973 2019

Source: Squamish River Watershed Society

4.2 Dykes and Berms

Hard flood infrastructure, such as dykes and berms, is common throughout the Squamish Nation territory. While effective at protecting structures, these infrastructure types have significantly fragmented watershed connectivity and eliminated much of the area's original floodplain. Channelization associated with dyking reduces a river's ability to meander, particularly during flood events, increasing water velocity and erosive energy, resulting in the loss of critical riparian buffers and edge habitat. [38] Channelization is also broadly associated with declines in species diversity, as edge habitat, the transitional zone between two different environments, provides essential shelter from predators and supports important food resources.[34]

Armouring is typical along many dykes within the Squamish Nation territory to reduce erosion. A common form is the addition of rip-rap, large boulders stacked on top of each other. The natural cracks within rip-rap can provide refuge for juvenile salmon during flood events, offering some protection from high flows and predators.[24] However, it does not provide the habitat complexity necessary to support multiple age classes of fish that historical edge habitat would have, and it reduces the overall migration capacity of salmon species through these reaches due to increased velocities requiring greater energy stores to continue upstream than historically necessary.[24]

Many dykes adjacent to the Squamish Nation territory are currently undergoing upgrades to meet the recommendations of the Integrated Flood Hazard Management Plan.[11] Historical diking and channelization altered the paths of many rivers, severing their connections to estuaries and upper reaches, most notably the upper Coquitlam, Mamquam and Squamish rivers, all of which were redirected away from their historical channels.[28,34,36] While restoration work in recent decades has begun to improve connectivity, fish populations have been subjected to these adverse conditions since diking began and are still recovering. Dyking activities in Squamish dramatically reduced the size of and access to the estuary, eliminating the shallow, productive transition habitat that juvenile salmon depend on during their critical outmigration to sea.[36]

4.3 Dams

Dams and pump stations reduce flood events by altering the natural hydrograph of a river system, generally resulting in less variation in water levels. In some cases, controlled releases can be timed to assist spawning migration and maintain flows necessary for overwintering fish. However, the suppression of natural flood cycles limits a river's ability to develop the off-channel sites that provide critical rearing habitat for juvenile salmon.[24] The first freshet, ie: significant water-level rise as a result of snowmelt in the spring, plays a critical role in establishing off-channel habitat, but is often absorbed by reservoirs or released in a diminished capacity.[24]

Rapid changes in flow associated with forced spill events can be harmful to both fish and habitat. As water rises into previously dewatered areas, the associated sudden drop in water levels from dam activities can leave fish stranded in isolated pools.[24,39] If connectivity to mainstem systems is not reestablished, fish mortality is unavoidable. Stranding events are documented along the Cheakamus River as a direct consequence of operations at Daisy Lake Dam.[39,40]

4.4 Pump Stations and Flood Gates


Source: Watershed Sentinel

Pump stations for flood protection aim to move water from a place of low elevation to one of higher elevation, while floodgates prevent off-channels from flooding.[41] These can often be found at the mouth of streams and present a significant barrier to fish accessing certain habitats while also posing a serious threat to many juveniles. Top-mounted flood gates require large water height differences and, as a result, rarely open.[42] Impeller pumps have side-facing propellers responsible for moving water through pipes, which can result in the mortality of fish drawn into the system.[42]

Non-lethal wounds with pump stations can increase susceptibility to disease and infection for these individuals. The flood boxes associated with pump stations can provide some connectivity to off-channels; however, if not properly operated, these can create low flows in off-channels, increasing temperatures and reducing dissolved oxygen levels, ultimately increasing fish mortality.[41]

4.6 Culverts

Source: US Geological Survey

Culverts are often seen as a solution to the connectivity problems created by dyking, allowing movement within a watershed while maintaining hydrological function. However, poorly designed culverts frequently increase fish mortality and reduce habitat connectivity. Small circular culverts are low-cost and easy to install, but are often unusable by fish.[43] The Department of Fisheries and Oceans estimates that approximately 135,000 of the 200,000 culverts in BC impede fish passage.[30] These structures may be completely dry, perched too high above the water surface, or subject to flow velocities that fish cannot overcome.[43]

Box culverts were installed as part of Phase 1 of the Central Estuary Restoration Project in Squamish to reestablish connectivity and improve estuary access for juvenile Chinook and other species, an example of improved culvert design already underway in Squamish Nation territory.[32] Design guidance for future culvert installations is addressed in Section 6.

Source: Squamish Nation

5. Legislation, Resources & Frameworks

Effective disaster risk reduction (DRR) in First Nations contexts requires a framework grounded in Indigenous rights, governance, and knowledge systems, rather than conventional, top-down approaches. In Canada, this involves constitutional protections, international commitments, and federal programs shaping First Nations' engagement in flood mitigation, preparedness, and response. Recognition is growing that meaningful DRR must go beyond policy compliance to include participatory, community-led approaches integrating Traditional Ecological Knowledge (TEK) with scientific methods. For Nations like the Squamish Nation, this shift is vital, ensuring disaster planning reduces risk while upholding fishing rights, supporting cultural practices, and reflecting long-standing land and water relationships.

5.1 Squamish Nation Legislation and Resources

Squamish Indian Band, Bylaw No. 16: Preservation, Protection and Management of Fish (1992)

Bylaw No. 16[44] represents a direct exercise of Indigenous governance focused on protecting fish and fish habitat within Squamish Nation waters. It includes strict provisions against damaging spawning grounds, introducing pollutants, and obstructing waterways. The bylaw also enables active management through Band Fishery Officers, including the removal of harmful obstructions and habitat enhancement. In the context of flood mitigation, it supports reducing risks to fish habitat by controlling debris, managing blockages, and addressing environmental disturbances linked to flooding.

Xay Temíxw Land Use Plan (2023)

The Xay Temíxw Land Use Plan[45] positions fish, fishing, and flood management as deeply interconnected elements of Squamish Nation culture, governance, and environmental stewardship. Fishing is described as a fundamental cultural and subsistence practice, with species such as salmon, eulachon, and herring holding significant ecological and cultural value. The plan highlights serious concerns about the degradation of fish habitat due to logging, dredging, flood control works, and pollution, which have reduced both fish populations and access to fishing opportunities. In response, the Nation outlines clear management objectives, including rebuilding salmon stocks, restoring depleted species, and protecting aquatic ecosystems through measures such as riparian buffers and regulated harvesting under Squamish authority.

Flooding and erosion are addressed as critical challenges that must be managed in ways that align with ecological health and cultural priorities. The plan identifies industrial activities, particularly logging and road building, as contributors to increased runoff and flood risk, while also raising concerns about erosion impacting important cultural sites. Rather than relying solely on conventional hard infrastructure, the Squamish Nation expresses a preference for nature-based approaches, such as bank stabilization using vegetation and woody debris, which better support fish habitat. Overall, the plan reflects a holistic, Indigenous-led approach grounded in self-determination, long-term stewardship, and traditional knowledge, emphasizing the interconnectedness of land, water, and resources and prioritizing restoration and protection for future generations.

5.2 Federal Legislation and Resources

Relevant regulations and policies for First Nation involvement in disaster risk reduction (DRR) are rooted in Section 35(1) of the Constitution Act, 1982,[46] which recognizes and affirms existing Aboriginal and treaty rights. This legal basis is strengthened by the United Nations Declaration on the Rights of Indigenous Peoples,[47] establishing an international framework emphasizing Indigenous rights to self-determination, participation in decision-making, and the protection of Traditional Ecological Knowledge (TEK). In Canada, the United Nations Declaration on the Rights of Indigenous Peoples Act (Bill C-15)[48] provides a legislative route for aligning federal laws with these principles, explicitly fostering a shift from colonial governance toward equitable partnerships.

At the federal level, Indigenous Services Canada administers key programs such as the Emergency Management Assistance Program (EMAP)[49] and the First Nations Adapt Program[50] which provides funding for on-reserve mitigation, preparedness, and response initiatives. Policies such as the Building Back Better Strategy[51] aim to reduce long-term vulnerability and support resilient recovery following disasters. At the same time, the Crown's duty to consult and accommodate requires meaningful engagement with First Nations when decisions affect their lands and fisheries (First Nations Fishing Rights – Fact Sheet).[52] Technical guidance, including the Indigenous Engagement Guidelines for Flood Mapping,[53] further supports this by requiring the integration of TEK into federal programs such as the Flood Hazard Identification and Mapping Program,[54] while respecting First Nations data sovereignty through ownership, control, access, and possession (OCAP) principles.

Intergovernmental coordination also plays a critical role. As outlined in Flooding in First Nations communities,[55] Indigenous Services Canada maintains service agreements with provinces, including British Columbia, to deliver emergency management support on reserve. In British Columbia, ongoing work toward a multilateral emergency management agreement reflects a shift toward recognizing First Nations as sovereign partners in planning and response. These agreements often include funding for locally embedded Emergency Management Program Coordinators, ensuring that flood response is informed by community-specific knowledge and priorities.

5.3 Provincial Legislation and Resources

Various provincial policies, regional plans, and Indigenous-led governance frameworks shape how fish habitat, flooding, and disaster risk reduction (DRR) are managed in British Columbia. Collectively, these documents show a growing shift towards integrating ecological protection, climate adaptation, and Indigenous rights, especially relating to fisheries that are central to cultural and subsistence practices. While some policies mainly focus on environmental regulation or technical flood management, others highlight Indigenous governance, traditional ecological knowledge, and collaborative decision-making. Analyzing these documents offers valuable insights into how current frameworks support the links between fish habitat, flood mitigation, and Indigenous participation in planning and management.

BC Reg 178/2019 - Riparian Areas Protection Regulation

The Riparian Areas Protection Regulation (RAPR)[56] regulation emphasizes the ecological importance of riparian areas in maintaining fish habitat and supporting stream health. It highlights key functions such as regulating water temperature, providing nutrients, and stabilizing banks to prevent erosion. From a flood management perspective, it promotes permeable landscapes that support water infiltration, helping to regulate flow timing and reduce the impacts of fluctuating water levels. While it provides strong ecological guidance, it does not explicitly address the role of Indigenous nations.

From Flood Risk to Resilience: a B.C. Flood Strategy to 2035

B.C. Flood Strategy[57] promotes a shift toward proactive, resilience-based flood management that incorporates ecological and cultural considerations. It emphasizes the importance of "fish-friendly" design and nature-based solutions that protect salmon habitats within floodplain systems. The strategy is notable for its co-development with First Nations through a shared decision-making approach and its commitment to aligning with UNDRIP. It also acknowledges the disproportionate flood risks faced by First Nations communities and proposes governance mechanisms, such as a First Nations Flood Resilience Advisory Circle.

B.C. Coastal Marine Strategy (2024)

The B.C. Coastal Marine Strategy[58] focuses on protecting coastal ecosystems and ensuring the long-term sustainability of wild Pacific salmon, recognizing their central role in First Nations food systems and cultures. It highlights how intact coastal habitats, such as estuaries and kelp forests, provide natural protection against flooding by reducing wave energy and storm surge impacts. The strategy supports First Nations self-determination and collaborative stewardship, emphasizing nature-based solutions, such as living shorelines, as key tools for both ecological protection and climate adaptation.

BC First Nations Climate Strategy and Action Plan (2022)

The BC First Nations Climate Strategy and Action Plan[59] positions Indigenous rights and governance at the center of climate action, emphasizing the cultural and ecological importance of species like wild salmon. It identifies climate-related threats, including warming waters and ocean acidification, as major risks to fisheries and food security. The plan advocates for First Nation-led initiatives, such as Indigenous Guardians programs and fisheries management, while also addressing flooding as a key climate hazard. It recommends proactive mitigation measures, including restricting logging in flood-prone and sensitive watershed areas to reduce disaster risk.

Land and Resource Management Plans

British Columbia's Land and Resource Management Plans (LRMPs) guide sustainable land use across regions. LRMPs often involve collaboration with First Nations and integrate cultural values, traditional uses, and Indigenous knowledge. These plans incorporate Indigenous interests, emphasizing access for cultural and subsistence activities, such as fishing. They can include considerations to protect fish habitats, maintain watersheds, and manage environmental impacts affecting hydrology and flood risk. This helps connect land use—like forestry, development, and conservation—to impacts on fish populations, fishing, and flooding, promoting integrated and ecologically aware resource management.

An example of a relevant LRMP to the Squamish Nation is the Sea-to-Sky Land and Resource Management Plan (2008).[60] This plan takes a broader landscape-level approach to resource management, with a focus on maintaining and restoring fish populations and habitats through watershed planning and restoration. It recognizes the importance of access to land and waterways for Indigenous sustenance practices, including fishing, and seeks to protect culturally significant places. The plan also incorporates Indigenous knowledge, including oral histories related to flooding, and promotes the use of land-use zoning and risk assessments to address hazards such as flooding and landslides.

Sea-to-Sky Floodplain Management Plan (2010)

The Sea-to-Sky Floodplain Management Plan[61] integrates flood management with ecological conservation, prioritizing the protection of fish habitat, water quality, and riparian vegetation within floodplains. Developed in consultation with the Lil'wat and Squamish Nations, it incorporates cultural considerations by identifying and protecting significant sites. The plan also provides concrete land-use guidance to reduce flood risk, such as limiting forest harvesting in flood-prone areas to maintain watershed stability and ecosystem integrity.


Source: Squamish Nation

5.4 Participatory Disaster Risk Reduction Frameworks

For the Squamish Nation, incorporating Indigenous knowledge and fishing rights into flood disaster risk reduction involves shifting from top-down, technocratic approaches to more collaborative, rights-based methods. Fishing is a constitutionally protected inherent and Treaty right, vital to Indigenous culture, identity, and well-being (First Nations Fishing Rights – Fact Sheet).[52] As highlighted in the United Nations study on the promotion and protection of Indigenous rights in disaster risk reduction, prevention and preparedness initiatives,[62] disaster risk reduction should be seen as supporting human rights, with governments respecting Indigenous self-determination and securing free, prior, and informed consent for flood mitigation actions that impact traditional lands, waters, and fisheries.

A key strategy for this integration involves participatory frameworks that combine traditional knowledge and scientific knowledge. Mercer et al.'s (2010) report on a framework for integrating indigenous and scientific knowledge for disaster risk reduction[63] outlines a process starting with trust-based community engagement. It includes identifying vulnerability factors, such as external pressures (e.g., climate change) and internal changes (e.g., disruptions to fishing practices or access to harvesting sites). Indigenous methods—such as seasonal land-use planning, fishing practices, and social networks—are documented and integrated into comprehensive solutions. This approach enables communities to shape their own resilience strategies, ensuring flood mitigation supports rather than harms cultural practices.

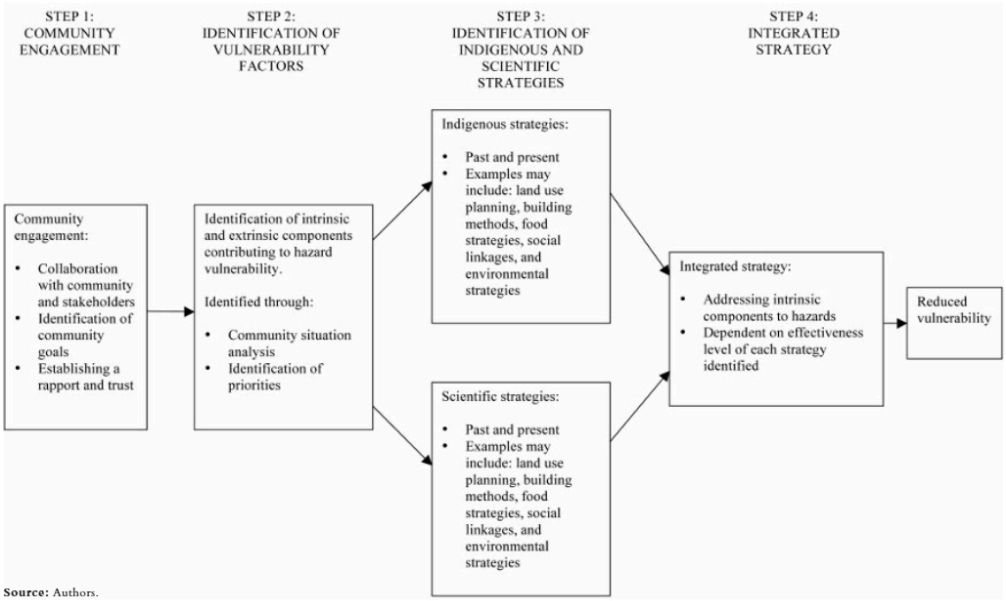


Figure 2. Process framework integrating indigenous and scientific knowledge (Mercer et al., 2010)[65]

6. Recommendations and Guidance

6.1 Co-Governance Pathways for River Ecosystems

There is an increasing recognition of the important social and ecological role of urban parks in communities, as well as the potential for urban parks to contribute to reconciliation and support cultural heritage of urban or urban-adjacent Indigenous communities.[64] With two of the significant river systems for the Nation, the Capilano and Seymour rivers, located in the urbanized environment of North Vancouver and are impacted by the governance of multiple jurisdictions: the Metro Vancouver Regional District, as well as the District and City of North Vancouver. While the Squamish river system is located in a smaller and more rural setting, it is also impacted by development and densification in the area, as well as the governance of the Squamish-Lillooet Regional District and the District of Squamish.

As outlined in previous sections, flooding and flood infrastructure can restrict community access to river systems and reduce their ability to be on the land and waters, and to engage in community or cultural activities like fishing. One approach to addressing these challenges and protecting community fishing access in urban river systems is to increase Indigenous leadership in the decision-making in urban river parks. In the following section, we synthesize key reports outlining possible pathways to increasing Indigenous decision-making on the conservation, restoration, and management of river systems.

Elevating Indigenous Governance and Leadership in Urban Parks

The 2024 report, Elevating Indigenous Governance and Leadership in Urban Parks,[65] outlines multiple potential opportunities and pathways to increasing Indigenous leadership in urban park governance: the first section of the report explores opportunities through the federal government's Urban National Park program, while the second section explores alternative governance models including Urban Indigenous Protected and Conserved Areas, collaborative governance arrangement with park governing bodies, not-for-profit governance models, increasing the presence of art and storytelling mediums in parks, and cultural programming.

NUPs are a relatively new initiative by Parks Canada,[66] with three foundational objectives: conserving nature, connecting people with nature and advancing reconciliation with Indigenous peoples. The four step designation process includes pre-feasibility, planning, designation, and implementation stages, and implementation stages, with Rouge National Park in Ontario becoming the first park to complete the process and receive NUP designation. While there are no current urban NUPs, the report outlines potential opportunities along each step of the designation process that could be applied within an urbanized park area, including community engagement with Nation members during the pre-feasibility stage, advocating for the establishment of an Indigenous Guardians[67,68] for care and stewardship of park during the planning stage, formalized co-governance or investment agreements with the federal government during the designation stage, and co-development of a management plan or establishment of an Indigenous Advisory Committee during the implementation stage.

Squamish Co-Governance Example:

Skwelwil'em Squamish Estuary Wildlife Management Area

Source: Squamish River Watershed Society

This Wildlife Management Area (WMA) covers 673 hectares at the mouth of the Squamish river and was established under the Provincial Wildlife Act. It is co-governed by the Ministry of Environment and Squamish Nation.

Establishment of the WMA included participation from diverse stakeholders, including the District of Squamish, the Federal government (DFO), and CN Rail.

The area's management plan outlines goals to protect and restore important ecosystems, including habitat for fish.[24-27]

As pursuing a NUP designation may not be realistic or favourable for all river systems and contexts, the next section of the report outlines additional and alternative pathways and mechanisms for increasing Indigenous governance in urbanized ecosystems. These include:

- Urban Indigenous Protected and Conserved Areas (IPCAs)
    - While IPCA designation and recognition remains a new and varied approach to Indigenous-led land stewardship and conservation, there are three core elements to all IPCAs: they are Indigenous-led, they represent a long-term commitment to conservation, and they elevate Indigenous rights and responsibilities.[69]
    - The IPCA Creation Guide[70] is a useful resource for pursuing the establishment of an IPCA.
- Formal and Informal Partnerships with Municipalities
    - The report highlights the Stanley Park Intergovernmental Committee[71], which includes the Squamish Nation, as an example of successful Nation-Municipality partnerships for the co-management of an urban park.
- Non-Profit Governance Model
    - Parkland may also be governed by a non-profit organization, created or partnered with by the Nation. This approach can support creative partnerships with other stakeholders, including Indigenous Land Trusts.

Lastly, the report outlines how programs to re-story the land and increase cultural connection to the land are important, regardless of the established or potential pathways available for governance of the park.

6.2 Rights-Based Response, Cultural Continuity, and Capacity Building

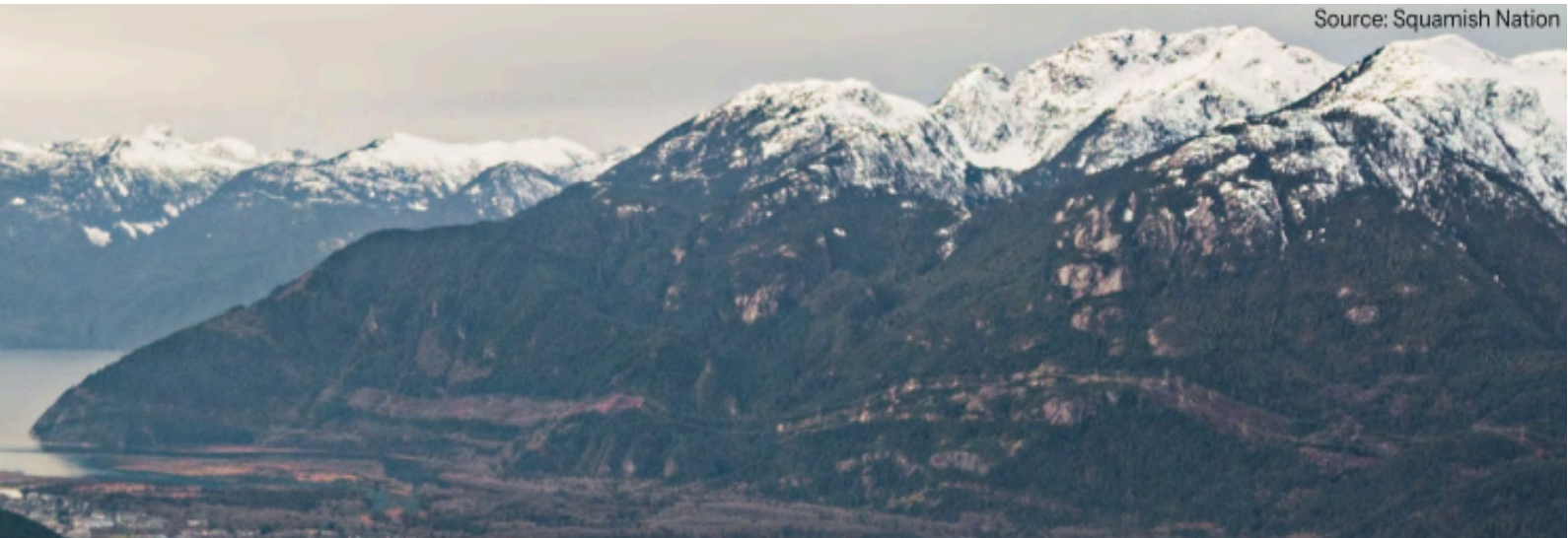
During disaster responses, Indigenous rights and customs can be upheld through culturally centred methods. The Flooding in First Nations communities[55] report highlights the “On the Land Initiative” in Ontario, which enables communities to evacuate to their traditional lands instead of urban areas. The First Nation secured funding from Indigenous Services Canada to evacuate part of their membership to higher ground at their traditional hunting camps. This community-driven effort offers an option for members who prefer not to move to a host community. While on their land, members engage in safe, culturally-relevant activities like traditional food harvesting, gathering, intergenerational knowledge sharing, and Indigenous language education.

Effective communication remains crucial. As highlighted in the United Nations report on the promotion and protection of Indigenous rights in disaster risk reduction, prevention, and preparedness initiatives,[62] early warning systems and signage, such as those downstream of the Capilano Dam, should be developed collaboratively with Indigenous communities to ensure they are culturally and linguistically appropriate, including the use of Indigenous languages. Additionally, intergenerational learning programs that integrate traditional ecological knowledge with modern technologies like GIS and environmental monitoring build community capacity for flood response. Larger initiatives, such as the United Nations report on Local, Indigenous and Traditional Knowledge (LTIK) for Disaster Risk Reduction in the Pacific,[72] emphasize the need for Indigenous peoples to have a real voice in all disaster planning stages.

6.3. Flood Mapping

Collaborative flood mapping plays a vital role in integrating Indigenous Knowledge into disaster risk reduction. The Indigenous Engagement Guidelines for Flood Mapping[53] document highlights that mapping should go beyond merely identifying physical hazards to include "areas of significance," such as traditional fishing grounds, harvesting sites, and culturally important landscapes. This is relevant across Squamish Nation territories, including the Squamish River watershed and the Capilano River, where fishing sites are closely connected to specific hydrological features influenced by flooding.

As an example, the Indigenous-led Flood Plain Mapping Project Combines Technology with Traditional Ecological Knowledge[73] showcases how the Chippewas of the Thames First Nation successfully integrated geographic information systems with traditional ecological knowledge to identify flood risks while building community capacity. This method guarantees that flood mitigation planning incorporates long-term environmental insights and considers impacts on fisheries, food security, and health. By including Indigenous observations over time of river behaviour and salmon migration, flood mapping becomes a tool not just for risk assessment but also for safeguarding culturally important fishing areas


Source: Squamish Nation

6.4 Traditional Fishing Practices, Access, and Flood Mitigation Design

Traditional fishing techniques should be considered when creating flood mitigation infrastructure that enhances Indigenous livelihoods rather than disrupting them. Methods such as weirs, fish traps, gaff-hooks, and dip netting are intricately linked to river morphology, seasonal water flow variations, and fish behaviour, all of which are affected by natural flood cycles.[74] For instance, weirs are usually built inside channels or narrow passages formed by floods, while net fishing depends on fish gathering in shallow waters, eddies, and estuarine areas.

These approaches reflect a deep understanding of hydrological processes, indicating that successful flood management should sustain ecological conditions that benefit both fish and fishing activities. Nature-based strategies—like reconnecting floodplains, installing setback dikes, and restoring side channels—support this by maintaining habitat diversity and flow variability. As discussed previously, traditional methods such as channelization and hard armouring tend to eliminate these features, thereby decreasing fish habitats and access to key fishing sites. When planning flood mitigation infrastructure, early collaboration with the Squamish Nation can help ensure that the design considers the retention of existing and opportunities for future fishing access. This approach allows for the continued use of traditional fishing methods and helps preserve the intergenerational transfer of related knowledge. Additionally, the decision to include measures, such as fish ladders, on upstream flood control also impacts salmon populations and downstream fishing prospects.

Wetland and Riparian Buffer Restoration

As described in Section 4, the loss of wetland and estuarine habitat has been extensive across Squamish Nation territory. Restoration of these areas represents a relatively inexpensive, nature-based solution to many flood management challenges. Wetlands reduce stream velocity, moderate flood severity, and provide critical fish habitat. Restoration of wetland areas can be achieved in approximately three to four years, and large-scale floodplain restoration has been shown to reduce peak floods by approximately 25%.[37] Riparian buffers that exist along the edges of wetlands are equally important to restore, as they help store water, stabilize banks and filter water before entering eelgrass meadows or marshes. These require moisture-adapted native plants and can often be impacted by invasive species less adapted to flood conditions.[37,75] Laying down coconut fibre matting in buffer zones can suppress unwanted grass species while being malleable enough to plant native shrubs and trees.[75]

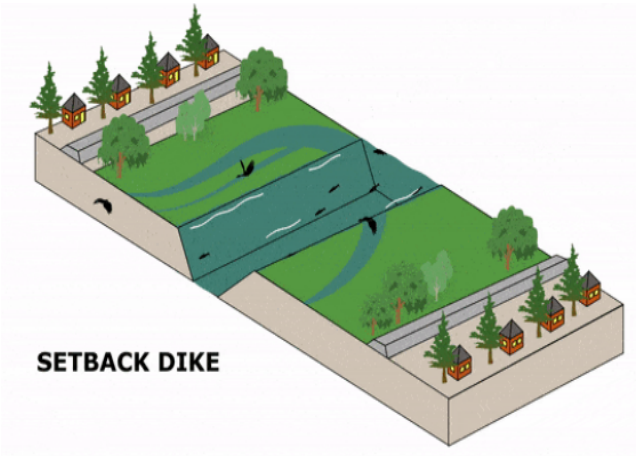
Unfortunately, these areas are often found along private property, leaving landowners responsible for restoration efforts.[37] Landowners can be reluctant to designate portions of their land to wetland restoration and riparian buffers.[37,75] Many dykes within the Squamish area are situated on private property and in need of upgrades.[32] Future conversations with private landowners may benefit from framing wetland restoration and riparian buffers as a cost-effective alternative to continued dyking, given their combined flood reduction and habitat benefits.

Setback Dikes

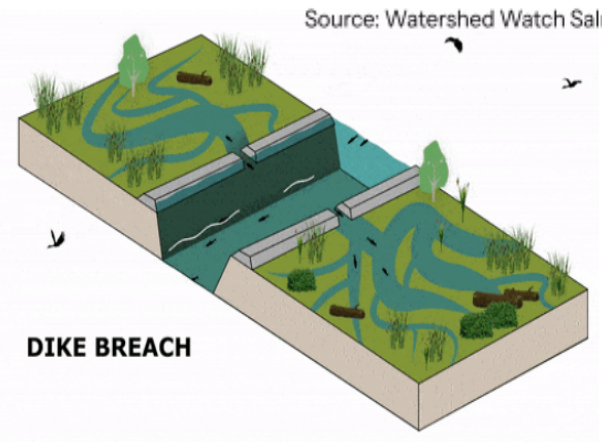
One of the most impactful planning decisions that can be made in biodiverse watersheds is where and how to build flood protection infrastructure. Traditional dike design places hard structures directly at the riverbank, effectively sealing the river off from its natural floodplain.[39] This approach protects property in the short term but eliminates floodplain habitat that fish depend on for refuge, rearing, and feeding during and after flood events.

Setback dikes are built with a deliberate offset from the riverbank, allowing the river room to overflow naturally into the adjacent floodplain.[42] Research modelling conducted by the Fraser Basin Council found that dike setbacks of 400 metres in Chilliwack reduced flood level heights by 0.15 metres compared to bank-top diking, meaning they were more effective at flood protection while simultaneously creating approximately six square kilometres of seasonal floodplain fish habitat.[76] The land between a setback dike and the river can function as a wetland habitat, a buffer zone from run-off pollutants, and fish rearing grounds outside of high-water events.[42] Dike breaches can be an alternative to setback dykes where a strategic opening diverts overflow water to a wetland.[42] The current upgrades to the Jimmy Jimmy (Judd) Slough dike plans to include a 3-metre setback.[77]

Where setback or breach configurations are not feasible, large woody debris (LWD) installations along the riverbank offer an alternative to traditional riprap armouring. LWD structures consist of whole logs and root wads anchored along the bank, which dissipates flood energy, reduces erosion, and, most importantly, provides realistic and complex habitat for fish and their food.[78]



Source: Watershed Watch Salmon Society



Dam Operations

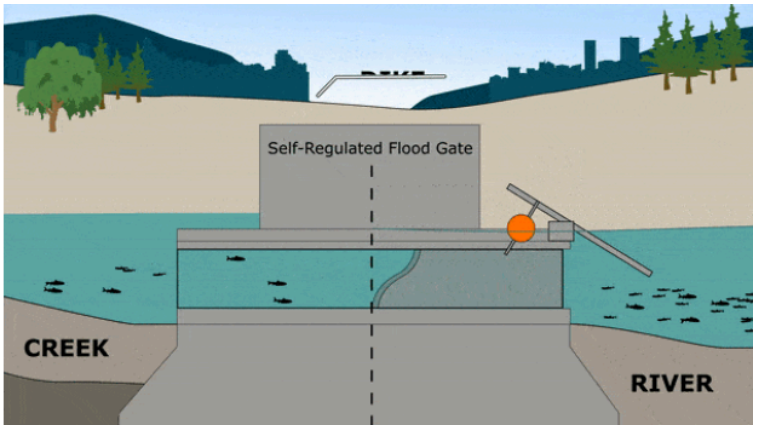
Higher minimum baseline flows for fish can help improve the health and habitat quality of fish downstream of dam infrastructures. Ramping events should be done carefully and slowly to reduce stranding potential and subsequent mortality of fish.[79] The Water Use Plan for the Daisy Lake Dam includes ramping protocols to reduce stranding events, however, these have not always been effective and should have stronger enforcement in the future.[80,81] Given that stranding events can occur despite these protocols, it is critical to develop pre-arranged emergency response agreements with the Department of Fisheries and Oceans Canada (DFO) prior to any high water event. Relocating stranded fish requires federal authorization under the Fisheries Act, which can take time as permits are being obtained, which could in turn increase fish mortality. A standing agreement with DFO would allow salvage operations to begin quickly and efficiently.[82]

When historic habitat has been lost as a result of dam activities, such as the upper Coquitlam watershed, resulting in the extirpation of migrating sockeye salmon, habitat compensation projects should be encouraged from BC Hydro, such as the ongoing 16,500 m^2 restoration of off-channel rearing habitat in the Coquitlam watershed.[28,82]

Fish-Friendly Pump Stations, Flood Gates, and Culverts

Much of the flood infrastructure in the Lower Mainland and Sea to Sky region was built without consideration of fish passage. Floodgates, culverts, and pump stations can create significant barriers to salmon migration, blocking fish from accessing side channels and tributaries and, in some cases, physically killing or injuring fish that pass through them. The following alternatives represent a transition toward infrastructure that maintains flood protection while reducing harm to fish.

- **Self-regulating floodgates:** These gates default to an open position, allowing free fish passage, and close only when water levels rise above a pre-set threshold. They are significantly more fish-friendly than traditional top-mounted gates that default to closed.[42] The Whittake Slough Flood Box Project upgraded the existing infrastructure to include a self-regulating gate through buoys.[83]

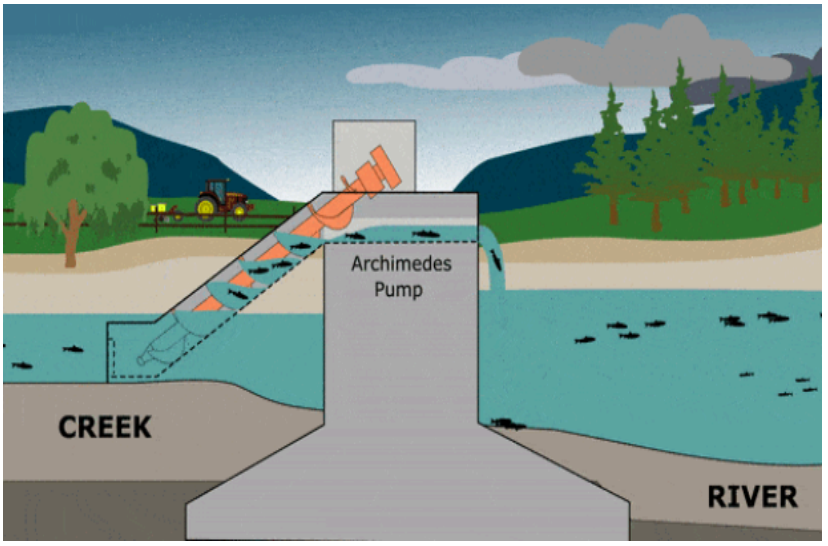


Source: Watershed Watch Salmon Society

- **Side-mounted floodgates:** These require less water pressure to open than top-mounted designs, open wider for longer periods, and create less turbulent flows, making fish passage substantially easier.[42]

- **Axial pump stations:** This pump design uses larger blade spacing and lower rotational speeds to reduce fish injury and mortality compared to traditional impeller pumps. They can be retrofitted into existing pump station infrastructure.[42]

- **Archimedes screw pumps:** These low-speed, screw-type pumps act as a conveyor belt for water and are highly fish-friendly, though they typically require complete reconstruction of existing pump infrastructure.[42]



Source: Watershed Watch Salmon Society

- **Fish-friendly culverts:** Culverts can be sized and designed to maintain natural flow conditions at gradients that allow fish to migrate upstream. Box culverts, as recently installed at the Skwelwil'em training berm road, are preferable to small round pipe culverts and allow for sediments to replenish the estuary.[41,42]


Source: Squamish River Watershed Society

7. Spatial Features

The following section provides maps of important spatial features of note for the Squamish Nation, particularly relating to flooding events. These include important fish spawning locations, fishing locations, and fish-related infrastructure that may be damaged, obstructed or destroyed in a flood.

Salmon are known to spawn in specific locations within the Squamish, Capilano and Seymour River systems.[1] Figure 3 shows a map of the Squamish system with common spawning areas noted. As mentioned in section 3, these spawning areas are sensitive to high flows, which can push spawning salmon out of the spawning grounds, dislodge and bury eggs and disrupt juvenile salmonid growth paradigms. The habitats can also be cut off after large flooding events, which can leave eggs, fry and spawners stranded, leading to large losses of salmon, which can impact future returns. Atmospheric rivers in particular have been known to strand salmon, which may become more intense and frequent in the future.[84] Ensuring these habitats are protected and monitored during and after flood events for connection can help to decrease future flooding-related mortality and diminishing salmon returns.

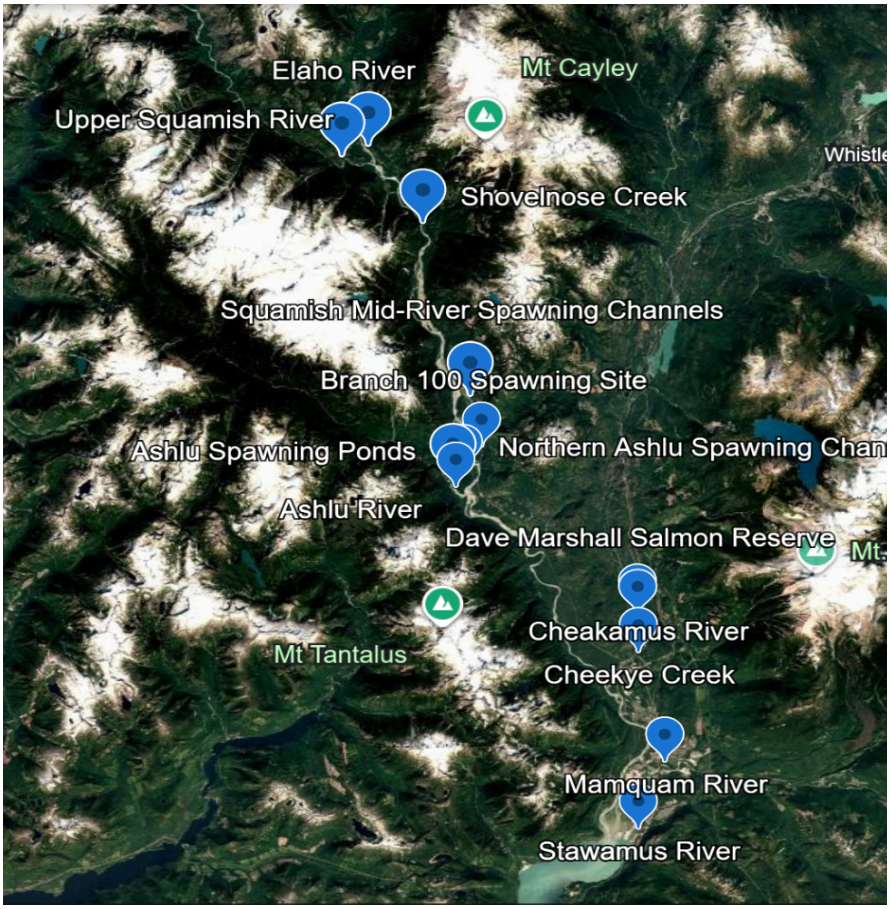


Figure 3: Map of common salmon spawning locations in the Squamish River system.

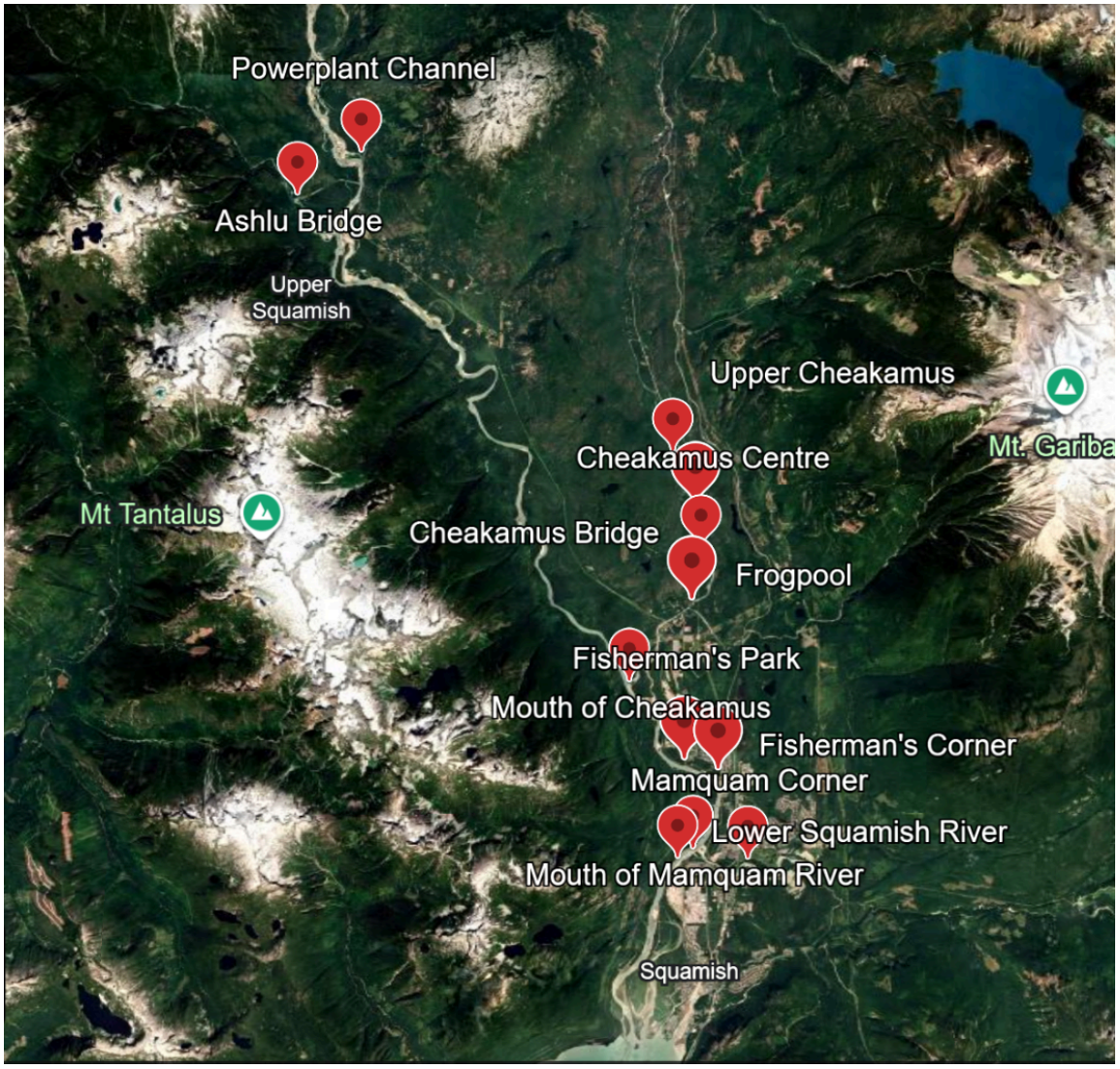


Figure 4: Map of common fishing locations along the Lower Squamish River and tributaries.

Fishing locations can also be impacted by flooding. These locations are usually where returning salmon group up, making them easier to catch. These locations are often slow-moving or deeper water, such as pools which provide resting and protected spots for returning salmon. Often, these spots are passed from fisher to fisher as good fishing locations, leading to successful multi-year fishing at these locations. However, flooding and flood mitigation infrastructure can damage or destroy these spots by filling the deep pools with sediment or can change the course of the river altogether. This can hinder the ability of fishers, especially Squamish Nation fishers, from successfully locating and targeting salmon. Additionally, these locations can attract large crowds of fishers, which can become hotspots for flooding-related injuries in the event of a flash flood or high waters.

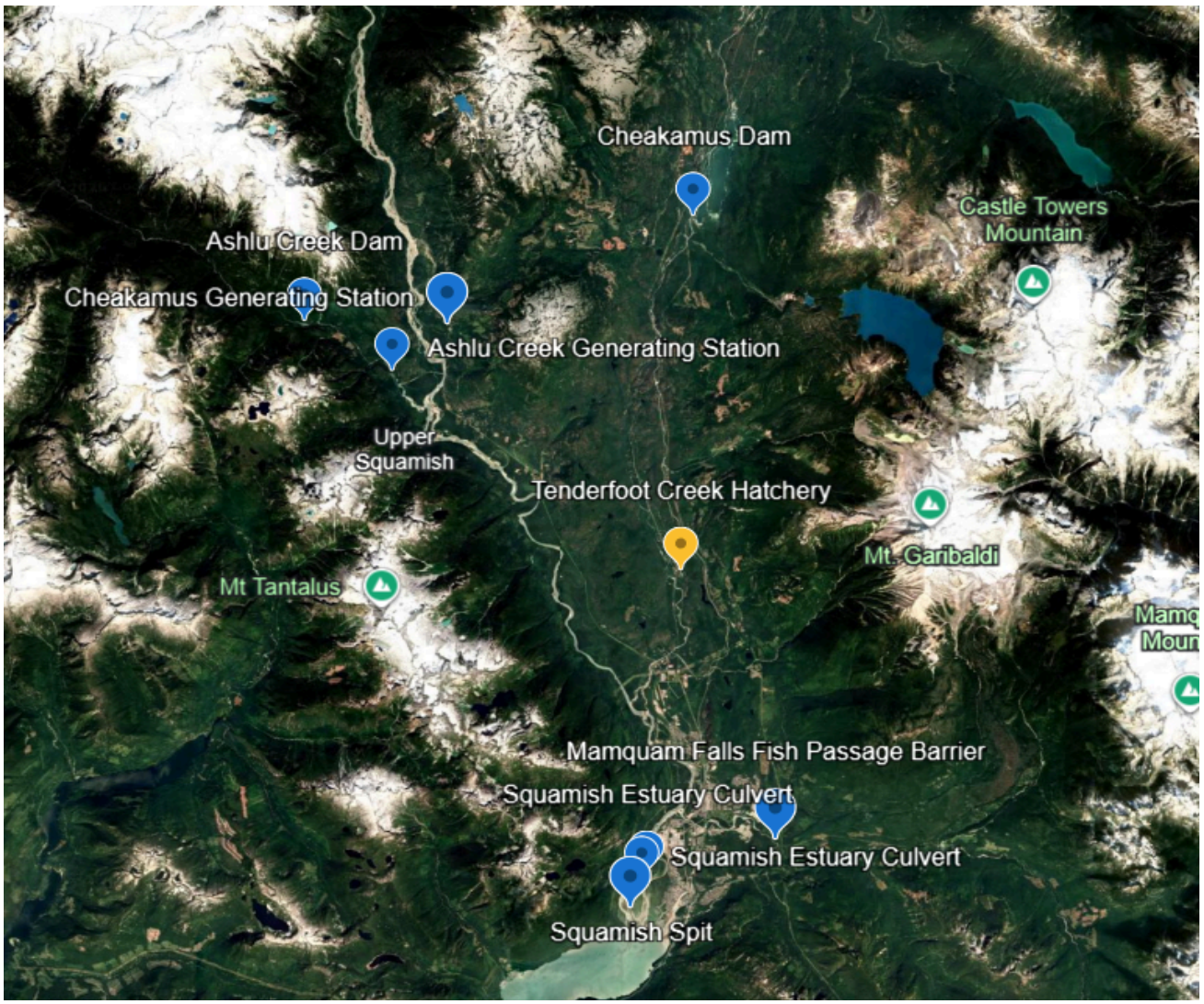


Figure 5: Map of important fish-related infrastructure.

Figure 5 shows important fish-related infrastructure within the Squamish River system, which may be sensitive to flooding. This includes hydrological features such as culverts, which can become blocked during floods, and generating stations/dams, which, as mentioned in the above sections, can influence the water level during flooding events and lead to stranding or injured fish. Additionally, the Tenderfoot Creek hatchery is a vital source of salmon for the Squamish system, especially the Cheakamus River. This facility is an important source of salmon in the river and is the only source of hatchery salmon that can be retained by anglers in the Squamish system. If this facility is damaged during flooding events, this could prevent the release of salmon for potentially multiple seasons, leading to severely decreased returns and limited fishing opportunities.

8. Conclusion

Fishing has been and continues to be an integral part of the Squamish Nation's food sovereignty, cultural practice, and recreational activities. Fish and their habitat can be impacted both positively and negatively by flooding. However, increasingly extreme flooding events present new risks for the survival of fish across their distinct lifestages. In addition, certain types of commonly used flood mitigation infrastructure poses physical risks to fish, can inhibit their ability to move throughout their environment for feeding or spawning, and can damage or deteriorate the quality of their habitat. Flooding events and flood mitigation infrastructure can also reduce community access to fishing sites.

To address these potential negative impacts, the Nation can continue to advocate for increased leadership in river management initiatives in many ways, including through co-governance approaches, partnership agreements, or the designation of Indigenous-led Protected and Conserved areas. In addition, the Nation can leverage relevant policies and legislation to advance the protection and restoration of important fish habitat, access to fishing areas, expanded flood mapping to include culturally important landscapes, and the collaborative development of culturally-appropriate disaster response plans. Lastly, tangible, site-level solutions include fish-friendly flood mitigation infrastructure (see Table 1) and restoration of fish habitat and riparian areas.

Source: Squamish River Watershed Society

Table 1: Flood Infrastructure: Problems, Solutions, and Co-Benefits

Problem	Solution	Co-Benefits		
		Fish Health	Fish Habitat	Nation Access
Bank-top dykes (eliminate floodplain, increase velocity, reduce edge habitat)	Setback dykes	✓	✓	✓
Riprap/armoured dyke banks (reduced habitat complexity, increased velocity)	Bioengineered bank stabilization; riparian buffer zone vegetation restoration	✓	✓	
Berms severing estuary from river (e.g. Skwelwil'em berm road)	Box culvert upgrades; berm removal/breaching	✓	✓	✓
Dams and reservoirs (suppress natural freshet, reduce off-channel habitat formation, stranding from spill events)	Managed flow releases timed to salmon migration; downstream off-channel habitat compensation	✓	✓	✓
Pump stations — impeller type (fish mortality, injury, swim bladder damage)	Fish-friendly axial pump or Archimedes screw replacement	✓		
Top-mounted floodgates (default closed, block fish passage)	Self-regulating or side-mounted floodgates	✓	✓	
Poorly designed culverts (perched, high velocity, impassable)	Box culverts; bottomless culverts; roughened inverts	✓	✓	✓
Loss of off-channel habitat (side channels, oxbows, ponds)	Off-channel habitat construction and reconnection (e.g. Mamquam Reunion Project)	✓	✓	✓
Lack of post-flood water quality monitoring (contaminant risk unknown)	Post-flood water quality monitoring protocol	✓	✓	✓

References

1. Golder Associates Ltd. *Squamish River Watershed Salmon Recovery Plan*. Squamish Watershed Society; 2005. https://www.squamishwatershed.com/uploads/1/1/2/1/11216935/squamish_salmon_recovery_plan.pdf
2. Connors K, Jones E, Peacock S, Belton K. *State of Salmon Report*. Pacific Salmon Foundation; 2024. doi:10.60740/3867-G827
3. Chen J, Shi X, Gu L, et al. Impacts of climate warming on global floods and their implication to current flood defense standards. *J Hydrol*. 2023;618:129236. doi:10.1016/j.jhydrol.2023.129236
4. Metro Vancouver. Lower Seymour Conservation Reserve. Metro Vancouver. Accessed April 8, 2026. https://metrovancouver.org/services/water/lower-seymour-conservation-reserve
5. Metro Vancouver. Capilano River Regional Park. Metro Vancouver. Accessed April 8, 2026. https://metrovancouver.org/services/regional-parks/capilano-river-regional-park
6. Metro Vancouver. *Regional Parks Natural Resource Management Framework*. Metro Vancouver; 2020. https://metrovancouver.org/services/regional-parks/Documents/regional-parks-natural-resource-management-framework-2020.pdf
7. Metro Vancouver. *Lower Seymour Conservation Reserve Management Plan*. Metro Vancouver; 2022. https://metrovancouver.org/services/water/Documents/lower-seymour-conservation-reserve-management-plan.pdf
8. Metro Vancouver. *Ecological Health Framework*. Metro Vancouver; 2018. https://metrovancouver.org/services/regional-planning/Documents/ecological-health-framework.pdf
9. Metro Vancouver. *Joint Water Use Plan – Fact Sheet*. Metro Vancouver; 2020. Accessed April 8, 2026. https://metrovancouver.org/services/water/Documents/fact-sheet-joint-water-use-plan.pdf
10. District of Squamish. Land Back Task Force. District of Squamish. Accessed April 8, 2026. https://squamish.ca/government-and-administration/squamish-nation/mou/land-back-task-force/

11. District of Squamish. *Integrated Flood Hazard Management Plan*. District of Squamish; 2017. Accessed April 8, 2026. https://squamish.ca/assets/IFHMP/1117/5dbb51bad9/20171031-FINAL_IFHMP_FinalReport-compressed.pdf
12. District of Squamish. *Natural Asset Management Strategy*. District of Squamish; 2022. Accessed April 8, 2026. https://squamish.ca/assets/Master-Plans/2022-Squamish-Natural-Asset-Management-Strategy-FINAL.pdf
13. District of Squamish. *Water Master Plan Update Report*. District of Squamish; 2024. Accessed April 8, 2026. https://squamish.ca/large_files/2024%20Water%20Master%20Plan%20Update.pdf
14. District of Squamish. *IFHMP Background Report*. District of Squamish; 2017. Accessed April 8, 2026. https://squamish.ca/assets/IFHMP/09252017/63a63fc5e6/FINAL-SquamishIFHMP-BackgroundReport_20170913.pdf
15. District of Squamish. *River Flood Risk Mitigation Options*. District of Squamish; 2017. Accessed April 8, 2026. https://squamish.ca/assets/IFHMP/09252017/0d6609c9a4/FINAL_SquamishIFHMP-RiverFloodRiskMitigationOptions-20170915.pdf
16. Sḵwx̱wú7mesh Úxwumixw (Squamish Nation). *Úxwumixw 2050 – Sḵwx̱wú7mesh Generational Plan*. Squamish Nation; 2024. Accessed April 8, 2026. https://www.squamish2050.net
17. Satterfield T, Robertson L, Vadeboncoeur N, Pitts A. Implications of a changing climate for food sovereignty in coastal British Columbia. In: Levin PS, Poe MR, eds. *Conservation for the Anthropocene Ocean*. Elsevier; 2017:399-421. doi:10.1016/B978-0-12-805375-1.00019-2
18. Marushka L, Kenny TA, Batal M, et al. Potential impacts of climate-related decline of seafood harvest on nutritional status of coastal First Nations in British Columbia, Canada. *PLoS ONE*. 2019;14(2):e0211473. doi:10.1371/journal.pone.0211473
19. Sḵwx̱wú7mesh Úxwumixw (Squamish Nation). *Climate Legacy Strategy*. Squamish Nation; 2024. Accessed March 21, 2026. https://www.squamish.net/wp-content/uploads/2024/10/ClimateLegacyStrategy_Final_Sep16_DIGITAL_Booklet.pdf
20. Hatala AR, Njeze C, Morton D, Pearl T, Bird-Naytowhow K. Land and nature as sources of health and resilience among Indigenous youth in an urban Canadian context: a photovoice exploration. *BMC Public Health*. 2020;20(1):538. doi:10.1186/s12889-020-08647-z

21. Fisheries and Oceans Canada. Habitat highlight: assessing aquatic connectivity in Nova Scotia. Government of Canada; 2025. https://www.dfo-mpo.gc.ca/publications/habitat/highlights-faitssaillants/nova-scotia-nouvelle-ecosse/connectivity-connectivite-eng.html
22. Hill A. The impacts of the floods on wild salmon. Watershed Watch Salmon Society. Accessed April 8, 2026. https://watershedwatch.ca/stories/aaron-hill-the-impacts-of-the-floods-on-wild-salmon/
23. The Narwhal. Restoring salmon habitat in BC after flooding. The Narwhal. Accessed April 8, 2026. https://thenarwhal.ca/restoring-salmon-habitat-bc-flooding/
24. Brown TG. *Floodplains, Flooding, and Salmon Rearing Habitats in British Columbia: A Review*. Research Document 2002/007. Fisheries and Oceans Canada, Canadian Science Advisory Secretariat; 2002. https://psf.ca/wp-content/uploads/2021/10/Download-PDF805-1.pdf
25. McSheffrey E. High fish mortality rates possible after record-breaking B.C. floods. *Global News*. November 25, 2021. https://globalnews.ca/news/8403667/fish-mortality-bc-floods/
26. Fisheries and Oceans Canada. Extreme environmental impacts on Pacific salmon. Government of Canada; 2024. https://www.pac.dfo-mpo.gc.ca/pacific-smon-pacifique/environmental-impacts-environnementaux-eng.html
27. Pacific Salmon Foundation. Top post-flood priorities for salmon. Pacific Salmon Foundation. Published December 22, 2021. https://psf.ca/news-media/top-flood-priorities-for-salmon/
28. Douglas T. *Lower Coquitlam River Fish Habitat and Flooding Assessment*. Fernhill Consulting, prepared for Watershed Watch Salmon Society and Kwikwetlem First Nation; 2011. https://watershedwatch.ca/wp-content/uploads/2011/02/Final-CoquitlamLowerRiverAssessment.pdf
29. Fisheries and Oceans Canada. Habitat highlight: fish, floods and habitat connectivity in the Lower Fraser. Government of Canada. Accessed April 8, 2026. https://www.dfo-mpo.gc.ca/publications/habitat/highlights-faitssaillants/pac/connectivity-connectivite-eng.html#3-2
30. ScienceDaily. Up to 85 per cent of historical salmon habitat lost in Lower Fraser region. ScienceDaily. Published August 5, 2021. https://www.sciencedaily.com/releases/2021/08/210805115525.htm
31. Restore the Shore. Why Restore the Shore is important. Restore the Shore. Accessed April 8, 2026. https://www.restoretheshore.ca/why-restore-the-shore-is-important

32. Squamish River Watershed Society. Background. Squamish River Watershed Society. Accessed April 8, 2026. https://www.squamishwatershed.com/background.html
33. Province of British Columbia. Information Note #1: Introduction to the Riparian Areas Regulation. Ministry of Environment, Province of British Columbia. Accessed April 4, 2026. https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/fish-fish-habitat/riparian-areas-regulations/introduction_to_rar.pdf
34. Squamish River Watershed Society. Mamquam River reunion. Squamish River Watershed Society. Accessed April 8, 2026. https://www.squamishwatershed.com/mamquam-river-reunion.html
35. Squamish River Watershed Society. Evans Creek re-watering. Squamish River Watershed Society. Accessed April 8, 2026. https://www.squamishwatershed.com/evans-creek-re-watering.html
36. Fisheries and Oceans Canada. Restoring salmon access and nutrient-rich habitat at the mouth of the Squamish River in British Columbia. Government of Canada; 2025. https://www.dfo-mpo.gc.ca/campaign-campagne/pss-ssp/stories-articles/2025-restoring-restauration-squamish-eng.html
37. City of Vancouver. *New Brighton Park Detailed Design Summary Report – Appendices*. City of Vancouver. Accessed April 8, 2026. https://vancouver.ca/files/cov/new-brighton-detailed-design-summary-report-appendices.pdf
38. Ishaq S. *Assessing the Potential for Flood Risk Mitigation and Salmon Habitat Restoration in the Lower Fraser*. UBC Sustainability Scholars Program, University of British Columbia; 2022. https://sustain.ubc.ca/sites/default/files/2022-051_Flood%20Risk%20Mitigation%20in%20Lower%20Fraser_Ishaq.pdf
39. Watershed Sentinel. Hydro dams and stranded fish: BC can do better. *Watershed Sentinel*. Published October 6, 2022. https://watershedsentinel.ca/article/hydro-dams-and-stranded-fish-bc-can-do-better/
40. BC Hydro. *Cheakamus Adaptive Stranding Protocol: Interim Report*. BCH20-668. BC Hydro; 2020. https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/environment-sustainability/water-use-planning/lower-mainland/bchydro-casp-interim-report.pdf
41. Watershed Sentinel. Pump stations, baby coho and bears, oh my: a summer in the field. *Watershed Sentinel*. Accessed April 8, 2026. https://watershedsentinel.ca/article/pump-stations-baby-coho-and-bears-oh-my-a-summer-in-the-field/

42. Watershed Watch Salmon Society. What makes flood control fish-friendly? Watershed Watch Salmon Society. Accessed April 8, 2026. https://watershedwatch.ca/what-makes-flood-control-fish-friendly/
43. US Geological Survey. *Scientific Investigations Report 2023-5132*. US Geological Survey; 2023. https://pubs.usgs.gov/publication/sir20235132/full
44. Squamish Indian Band. Bylaw No. 16: Preservation, Protection and Management of Fish. Squamish Indian Band; 1992.
45. Squamish Nation. Xay Temíxw Land Use Plan. Squamish Nation; 2023.
46. Constitution Act, 1982, Schedule B to the Canada Act 1982 (UK), 1982, c 11, s 35(1).
47. United Nations General Assembly. United Nations Declaration on the Rights of Indigenous Peoples. Resolution A/RES/61/295. United Nations; 2007.
48. United Nations Declaration on the Rights of Indigenous Peoples Act, SC 2021, c 14.
49. Government of Canada. Emergency Management Assistance Program. Indigenous Services Canada. Accessed April 8, 2026. https://www.sac-isc.gc.ca/eng/1534954090122/1535120506707
50. Government of Canada. First Nations Adapt Program. Crown-Indigenous Relations and Northern Affairs Canada. Accessed April 8, 2026. https://www.rcaanc-cirnac.gc.ca/eng/1481305681144/1594738692193
51. Government of Canada. Building Back Better: Emergency Management Assistance Program Strategy Guide. Indigenous Services Canada. Accessed April 4, 2026. https://www.sac-isc.gc.ca/eng/1534954506773/1535121720820
52. Assembly of First Nations. First Nations fishing rights – fact sheet. Assembly of First Nations. Accessed April 4, 2026.
53. Natural Resources Canada. *Indigenous Engagement Guidelines for Flood Mapping*. Version 1.0. General Information Product 156e. Government of Canada; 2024. doi:10.4095/pz2y3nucny
54. Natural Resources Canada. Flood Hazard Identification and Mapping Program. Government of Canada; 2025. https://natural-resources.canada.ca/science-data/science-research/natural-hazards/flood-mapping/flood-hazard-identification-mapping-program
55. Government of Canada. Flooding in First Nations communities. Indigenous Services Canada; 2026.
56. Province of British Columbia. Riparian Areas Protection Regulation, BC Reg 178/2019. CanLII; 2019. https://canlii.ca/t/562c5
57. Province of British Columbia. *From Flood Risk to Resilience: A B.C. Flood Strategy to 2035.* Province of British Columbia; 2024.
58. Province of British Columbia. B.C. Coastal Marine Strategy. Province of British Columbia; 2024.

59. First Nations Leadership Council. BC First Nations Climate Strategy and Action Plan. Union of British Columbia Indian Chiefs, First Nations Summit, and British Columbia Assembly of First Nations; 2022.
60. Province of British Columbia. *Sea-to-Sky Land and Resource Management Plan*. Province of British Columbia; 2008.
61. Integrated Land Management Bureau. Sea-to-Sky Floodplain Management Plan. Province of British Columbia; 2010.
62. Expert Mechanism on the Rights of Indigenous Peoples. Promotion and Protection of the Rights of Indigenous Peoples in Disaster Risk Reduction, Prevention and Preparedness Initiatives. Report No. A/HRC/27/66. United Nations General Assembly; 2014.
63. Mercer J, Kelman I, Taranis L, Suchet-Pearson S. Framework for integrating indigenous and scientific knowledge for disaster risk reduction. *Disasters*. 2010;34(1):214-239.
64. Blye CJ, Buxton R, DeLong C, Hassen N, Hvenegaard G, Scott J. Urban protected and conserved areas in Canada. In: *Protected and Conserved Areas in Canada: Advancing Conservation Policy, Practice & Indigenous Leadership*. 2026.
65. Roth R, Bishop A. *Elevating Indigenous Governance and Leadership in Urban Parks: Possibilities, Challenges, and Pathways*. 2024. Accessed April 1, 2026. https://ipcaknowledgebasket.ca/wp-content/uploads/2024/09/NationalUrbanParks_V05.pdf
66. Parks Canada Agency, Government of Canada. National urban parks. Parks Canada. Updated September 3, 2025. Accessed April 8, 2026. https://parks.canada.ca/pun-nup
67. Indigenous Leadership Initiative. Guardians. Indigenous Leadership Initiative. Accessed April 8, 2026. https://www.ilinationhood.ca/guardians
68. White E (hiǹačačišt). *Good for the Land, Good for the People, Good for the Economy*. Indigenous Leadership Initiative; 2022. Accessed April 6, 2026. https://www.wcel.org/sites/default/files/publications/2022-01-20-ipcas-indigenous-guardians-discussion-paper_final_web-min.pdf
69. The Indigenous Circle of Experts. *We Rise Together*. The Indigenous Circle of Experts; 2018. Accessed April 8, 2026. https://www.icce-caec.ca/wp-content/uploads/2022/07/PA234-ICE_Report_2018_Mar_22_web.pdf
70. Conservation through Reconciliation Partnership. *IPCA Creation Guide*. Conservation through Reconciliation Partnership; 2022. Accessed April 8, 2026. https://ipcaknowledgebasket.ca/wp-content/uploads/2023/06/IPCA-Creation-Guide-Printable-PDF_June-2022.pdf

71. Stanley Park Intergovernmental Committee. City of Vancouver. Accessed April 8, 2026. https://vancouver.ca/parks-recreation-culture/reconciliation-our-approach.aspx
72. United Nations Office for Disaster Risk Reduction. *Thematic Report: Local, Indigenous and Traditional Knowledge for Disaster Risk Reduction in the Pacific*. UNDRR; 2022. https://www.undrr.org/publication/thematic-report-local-indigenous-and-traditional-knowledge-ltik-disaster-risk-reduction
73. Amon E. Indigenous-led flood plain mapping project combines technology with traditional ecological knowledge. International Joint Commission; 2022.
74. Joseph B. First Nations and salmon fisheries. Indigenous Corporate Training Inc.; 2014.
75. WWF Canada. What are riparian buffers? World Wildlife Fund Canada. Accessed April 8, 2026. https://wwf.ca/stories/what-are-riparian-buffers/
76. Fraser Basin Council. *A Primer on Flood Management in BC's Lower Mainland and Fraser Valley*. Fraser Basin Council; 2019. https://www.fraserbasin.bc.ca/_Library/LMFMS_Maps/Summary_Flood_Primer_2019_MR.pdf
77. District of Squamish. Slough dike upgrade. District of Squamish. Accessed April 8, 2026. https://squamish.ca/projects-plans-and-initiatives/projects-and-initiatives/slough-dike-upgrade/
78. Pennsylvania State University Extension. Benefits of large woody debris in streams. Penn State Extension. Accessed April 8, 2026. https://extension.psu.edu/benefits-of-large-woody-debris-in-streams
79. BC Wildlife Federation. Salmon suffer from flow changes below power plant. BC Wildlife Federation. Accessed April 8, 2026. https://bcwf.bc.ca/salmon-suffer-from-flow-changes-below-power-plant/
80. BC Hydro. Cheakamus project. BC Hydro. Accessed April 8, 2026. https://www.bchydro.com/energy-in-bc/projects/cheakamus-project.html
81. Fisheries and Oceans Canada. Pacific salmon: environmental impacts. Government of Canada. Accessed April 8, 2026. https://www.pac.dfo-mpo.gc.ca/pacific-smon-pacifique/environmental-impacts-environnementaux-eng.html
82. BC Hydro. Fish and wildlife benefit. BC Hydro News Releases. Published 2012. https://www.bchydro.com/news/press_centre/news_releases/2012/fish-and-wildlife-benefit.html

83. District of Squamish. Fish-friendly Whittaker Slough flood box is a win-win for Squamish. District of Squamish. Accessed April 8, 2026. https://squamish.ca/government-and-administration/district-information/news/fish-friendly-whittaker-slough-flood-box-is-a-winwin-for-squamish/
84. O'Brien TA, Wehner MF, Payne AE, et al. Increases in future AR count and size: overview of the ARTMIP Tier 2 CMIP5/6 experiment. *JGR Atmospheres*. 2022;127(6):e2021JD036013. doi:10.1029/2021JD036