Anderson Creek fish ladder, Washington State Dept of Transportation, via [Flickr]

Designing for Flood Resilience: Prioritizing In-Stream Barrier Removal

June 2023

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RESILIENT WATERS

A project of MakeWay

WATERSHED WATCH SALMON SOCIETY

Disclaimer

This report was produced as part of the UBC Sustainability Scholars Program, a partnership between the University of British Columbia and various local governments and organizations in support of providing graduate students with opportunities to do applied research on projects that advance sustainability across the region.

This project was conducted under the mentorship of staff from Resilient-Waters (a project of MakeWay) and the Watershed Watch Salmon Society. The opinions and recommendations in this report and any errors are those of the author and do not necessarily reflect the views of Resilient-Waters, the Watershed Watch Salmon Society or the University of British Columbia.

Acknowledgements

The author acknowledges that the work for this project took place on the unceded ancestral lands of the xwməθkwəy̓əm (Musqueam), Skwxwú7mesh (Squamish), Stó:lō and Səl̓ílwətaʔ/Selilwitulh (Tsleil- Waututh) Nations and the Ts’elxwéyeqw Tribe.

The ‘Designing for flood resilience’ workshops seek to bring relevant stakeholders together to discuss issues related to watershed management as well as flood control infrastructure and its impacts on the land, the environment, and the people of the Lower Fraser River. The intention is that this work will help amplify the voices of First Nations in these conversations, whose lands are particularly vulnerable to flood risks and who have historically been excluded from decisions involving land management in the Lower Fraser.

EXECUTIVE SUMMARY

Aging flood control infrastructure along the Lower Fraser has fragmented critical salmon habitat. Identifying and removing specific in-stream barriers could help restore these disconnected ecosystems. Resilient Waters and partner organizations hosted a virtual workshop to discuss issues and approaches on how to choose which barriers should be prioritized for removal. The presentations at the beginning of the workshop described an indigenous-led restoration project, as well as tools used in Oregon (USA), the City of Surrey and in academic research to assess the potential of habitat restoration of barrier removal. The presentations highlighted the trade-offs that may exist between choices (e.g., losing agricultural land to restore more salmon habitat), and that different objectives may lead to different selections. All optimization tools need to be complemented by discussions about goals and values of stakeholders.

These ideas were tested during a team activity in which workshop participants, which included municipal employees, First Nations, academics, private consultants, among others, were able to discuss with each other in breakout groups. The activity presented a simplified representation of barriers in the Lower Fraser, as well as characteristics of salmon populations, land-uses, and intervention costs. Participants had to decide which barriers to prioritize for removal for different budget levels. Discussions during the exercise highlighted the need to properly understand issues such as land-use, projected future stream conditions and salmon population health in order to make informed decisions. As with the presentations, comments from participants also touched on cultural values, indigenous perspectives and the importance of understanding what different stakeholders want to achieve when removing in-stream barriers.

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INTRODUCTION

The Lower Fraser is a vital watershed for wild salmon at all stages of their life cycle. However, a significant portion of the floodplain habitat is inaccessible due to over 150 flood control structures[1] (See Appendix B) blocking at least 1,500 km of side channels tributaries and sloughs which are key salmon habitats. The existing infrastructure, which includes pumps, dikes and floodgates, is aging and often in poor or failing conditions. Valuable agricultural lands are also located along the floodplains, which are experiencing increased pressure for development for other land-uses. First Nations communities along the Lower Fraser are disproportionately affected due to the loss of salmon habitat, and increased flood risks of reserve lands due to climate change.

On June 1st, 2023 **Resilient Waters**, along with members from **Partners4Actions**, the **Watershed Watch Salmon Society**, and the **Raincoast Conservation Foundation,** facilitated a virtual workshop (the second in the *Designing For Flood Resilience* series) to discuss issues related to the impacts of in-stream barriers and the challenges to decide which ones to prioritize for removal. A total of 61 participants joined the workshop from a range of different sectors, including academia, NGOs, contractors, consulting firms, members of local, provincial, and federal governments, as well as First Nations (Figure 1). The main issues of interest to participants are summarized in Figure 2.

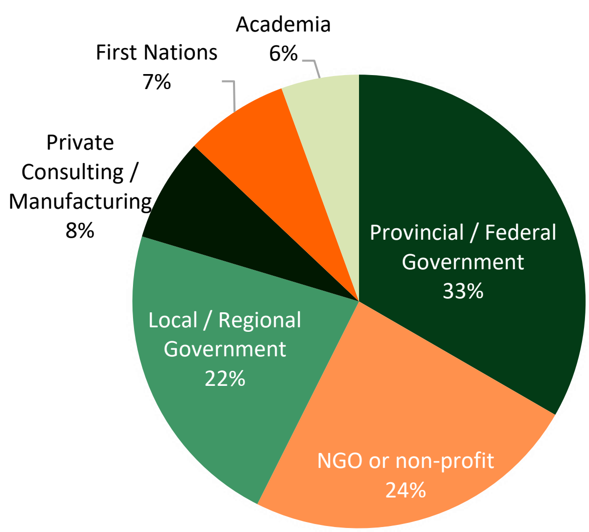


Figure 1: Sectors describing workshop participants.

> Removing in-stream barriers could restore salmon habitat and reconnect fragmented ecosystems in the Lower Fraser. How do we choose which ones to remove?

While there has been increased interest in removing in-stream barriers across the Lower Fraser, deciding which ones to remove can be complicated. There are multiple trade-offs that need to be considered, such as intervention costs, changes in flood risks (upstream and downstream), and potential ecological benefits. For instance, while removing a specific barrier could unlock and reconnect large areas of salmon habitat, it could also result in agricultural lands flooding during high water events or allow for saltwater intrusion.

[1] Watershed Watch Salmon Society (2018) Disconnected waters regional map, https://watershedwatch.ca/wp-content/uploads/2020/02/Disconnected-Waters-Regional-Map-Apr-27-2018.pdf accessed 2023-05-027

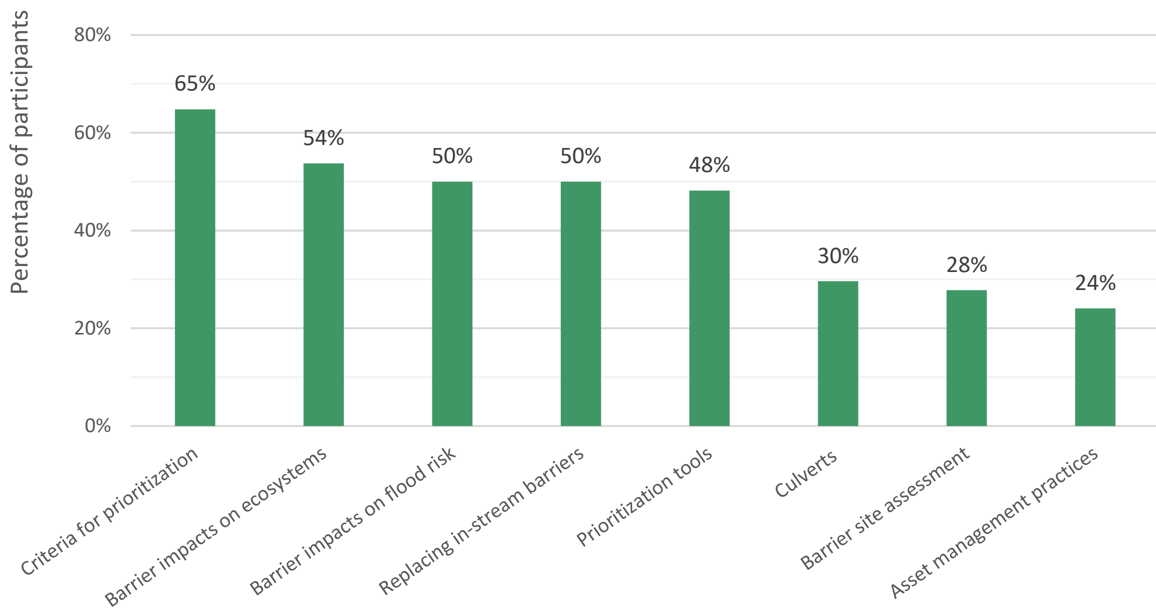


Figure 2: Issues participants were most interested in discussing (Zoom poll).

The first part of the workshop consisted of four presentations on approaches that have been used to identify and prioritize barriers for removal. Ernie Victor of Cheam First Nation and Eddie Gardner of Skwah First Nation provided a welcome prayer and presented on their work and vision to revitalize the Camp-Hope Slough system through an Indigenous lens. Eddie Gardner highlighted how the wetlands, which have been recognized as prime habitat for salmon, are being threatened by industrial development. The restoration works are based on 4 pillars:

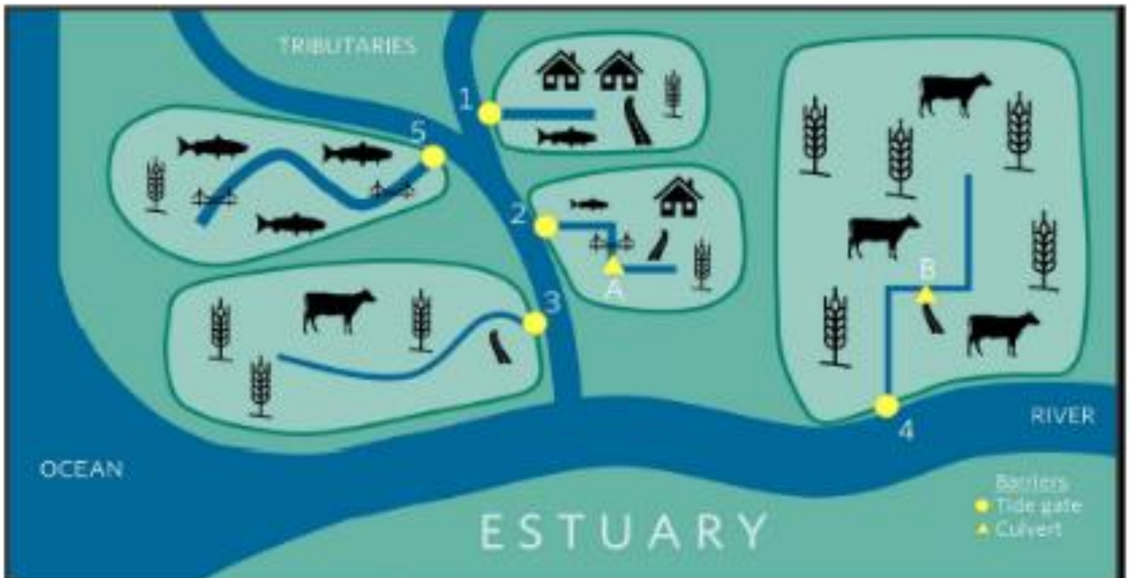
- Riparian area restoration.
- Fish habitat restoration.
- Water quality testing.
- Increasing water flow to improve oxygen levels and overall water flow health.

"We really enjoy the fact that we have this collaborative approach that includes the City of Chilliwack […] and our three First Nations. It is an indigenous led project." Eddie Gardner, Skwah Nation

Ernie Victor expanded on the issue, highlighting the importance of capacity building, particularly among the youth to help foster a sense of identity and preserve ancestral teachings. The current project includes multiple spawning beds, water testing over various sites, and land inventory around each site to better understand how surrounding lands may impact the slough water quality.

"We do have lawyers, and doctors, and nurses and all this other stuff, but what we are short of in our community is environmental scientists […] people who love water." Ernie Victor, Cheam Nation.

The second presentation, from The Nature Conservancy, described an optimization tool for tide gates in Oregon (USA). The tool identifies which barriers require intervention or removal to obtain the maximum gains in salmon habitat based on a given budget level. In order to run the computer model used, the tool requires detailed information on elements such as fish habitat, agricultural lands, private and public infrastructure, and sea level rise.



A. Optimization parameters	Barriers				
Benefit targets	1	2, A	3	4, B	5
Tidal inundation (ac)	200	250	550	825	510
Stream habitat (mi)	3	< 1	0	0	10
Agricultural Land (ac)	200	225	500	800	150
Buildings (#)	25	10	0	0	0
Bridges (#)	0	1	0	0	2
Roads (mi)	1	< 1	< 1	< 1	0
Cost ($1,000s)	300	600 & 100	400	525 & 75	800

B. Optimization Scenarios		$1 mil budget				
Scenario	Benefit targets	1	2, A	3	4, B	5
1	Coho habitat (tidal & stream habitat)					✓
2	Inundation habitat			✓	✓	
3	Agricultural land & buildings	✓	✓			
4	Agricultural land only			✓	✓	
5	Roads & bridges	✓	✓			

Figure 3: Example of information and scenarios considered by the tide gate optimization tool. (Jason Nuckols, The Nature Conservancy)

The presentation highlighted how the results from the optimization tool depend on the input information and the questions that are asked (Figure 3). For instance, is it ok to lose agricultural land to restore salmon habitat? What budget could be secured? Is there a minimum habitat restoration target? However, no matter how complete or complex optimization tools are, critical thinking and discussion between stakeholders are always needed to make a final decision.

"Running the model is an iterative process. There is no one answer. [The optimization tool] is not a decision-maker. It is a conversation starter." Jason Nuckols, The Nature Conservancy

The third presentation was from The City of Surrey. The City follows an "open watercourse" policy that was developed in the 90s. With over 1400 km of streams and watercourses, the City is running a pilot project for selecting areas that could offer the highest value for habitat restoration. The City is home to major water bodies such as Serpentine and Nicomekl Rivers, as well as multiple streams with salmon presence as well as others that could potentially become salmon habitat thanks to the nutrient content in the water and food availability. In order to help choose areas for restoration, the City is relying on an existing inventory of waterways using criteria such as channel stability and the state of existing infrastructure in order to assess the potential of each area (

"We are trying to create those opportunities to improve our natural assets and create environmental benefits as well as societal benefits." Liana Ayach, City of Surrey

Figure 4).

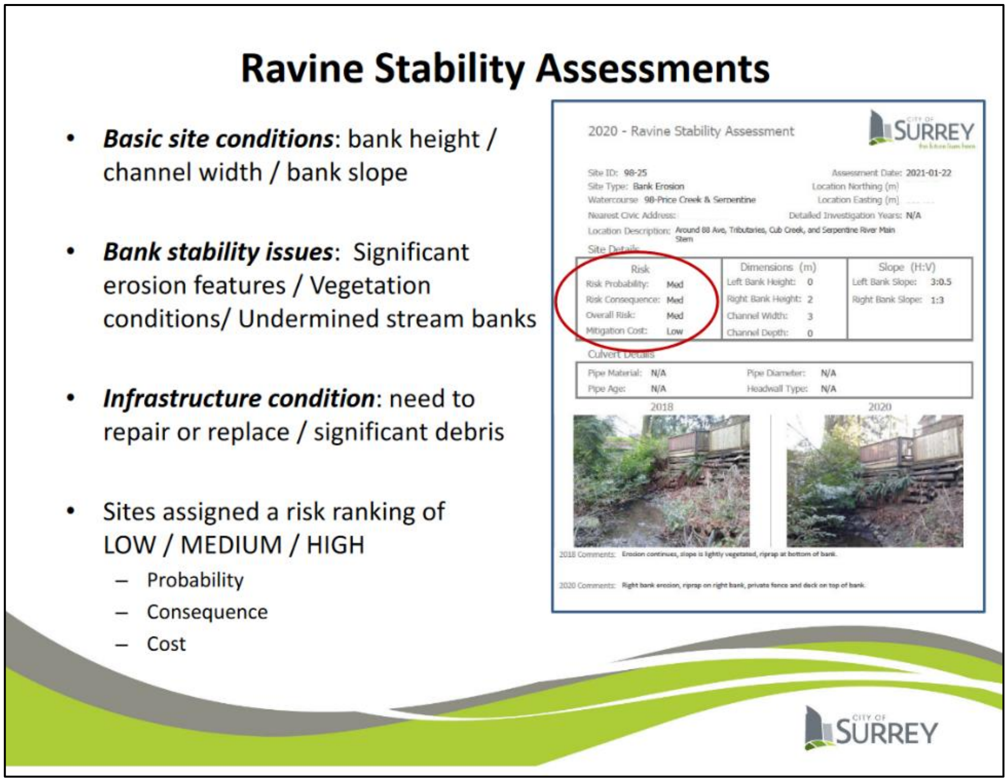


Figure 4: Example of stream inventory assessment for habitat restoration (Liana Ayach, City of Surrey)

The final presentation concerned a research project from the University of British Columbia (UBC) tackling the issue of barrier prioritization. An optimization model was built using data on stream network and barrier characteristics. Using different budgets, the model was run to determine which barriers needed to be removed depending on the goal (e.g., unlocking as much habitat as possible vs considering water quality). Given how the barriers identified for intervention would be different across goals and budget levels, the study proposed to prioritise barriers based on how often they were found to be part of the optimal solutions found across scenarios.

> "[Determining] where we might invest in the restoration and connectivity, this is really difficult because the cost varies by the structures, different amounts of habitat quantity and quality upstream of them, different species and populations, and also the spatial orientation of the barriers." Riley Finn, UBC

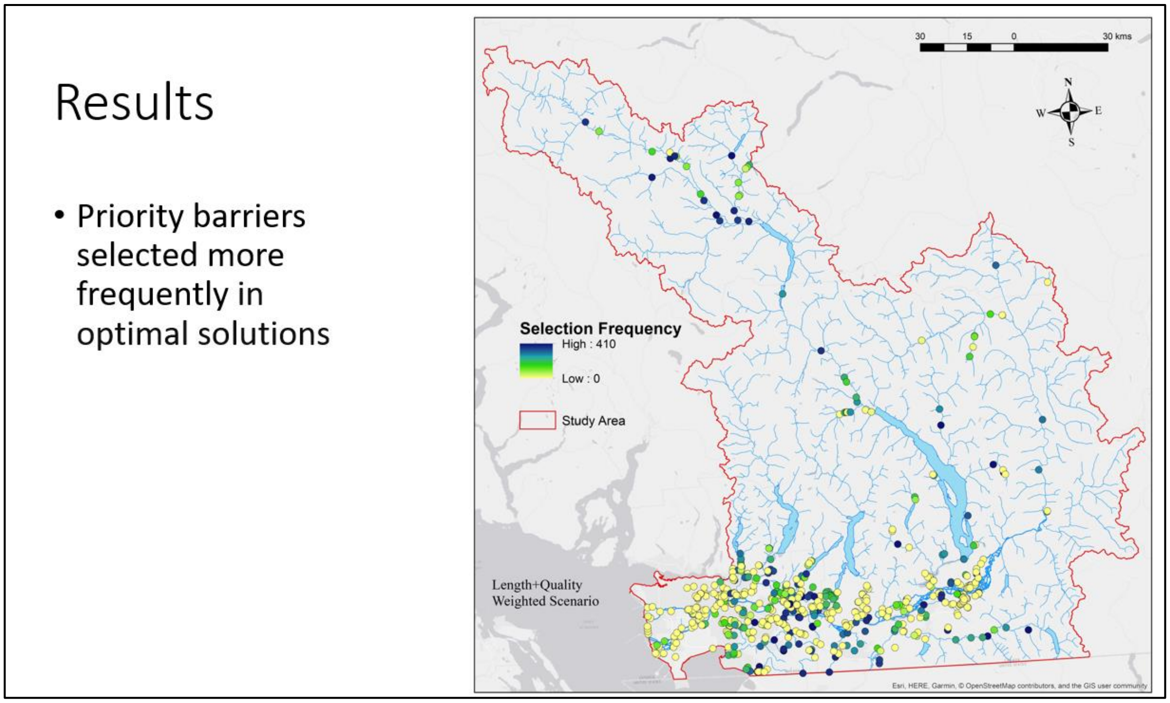


Figure 5: Research results on barrier prioritization (Riley Finn, UBC).

EXERCISE - PRIORITIZING IN-STREAM BARRIERS FOR REMOVAL

The final part of the workshops consisted of a team activity where participants were presented with a simplified representation of the Lower Fraser River and multiple streams that feed into it (Figure 6). The map used indicated the location of seven different in-stream barriers, which participants had to prioritize for removal based on the information provided in an accompanying table. The **cost** column indicated the budget level required to remove a particular barrier. Additional information provided included the **number of different salmon species** (coho, chinook or chum) found upstream from the different barriers, as well as the **size of watershed area** that could be unlocked (indicated in the 'quantity' column), and the **quality of the potential salmon habitat**. Finally, the map indicated the **land-uses** found along the different stream branches.

Participants went into small breakout rooms and carried out the activity for multiple rounds. For each round, participants where asked which barriers they would remove if they had a specific budget level. Additionally, participants were encouraged to discuss what other factors might influence their decisions and what other information would be useful to have. The following sections summarize the chosen barriers by different groups for each round as well as their justification.

Barrier	Cost	Species	Quantity	Quality
1	$$$	3	5	2
2	$$$	3	7	7
3	$$$	2	10	2
4	$$	1	4	5
5	$$	2	30	7
6	$$	1	40	8
7	$$	1	20	10

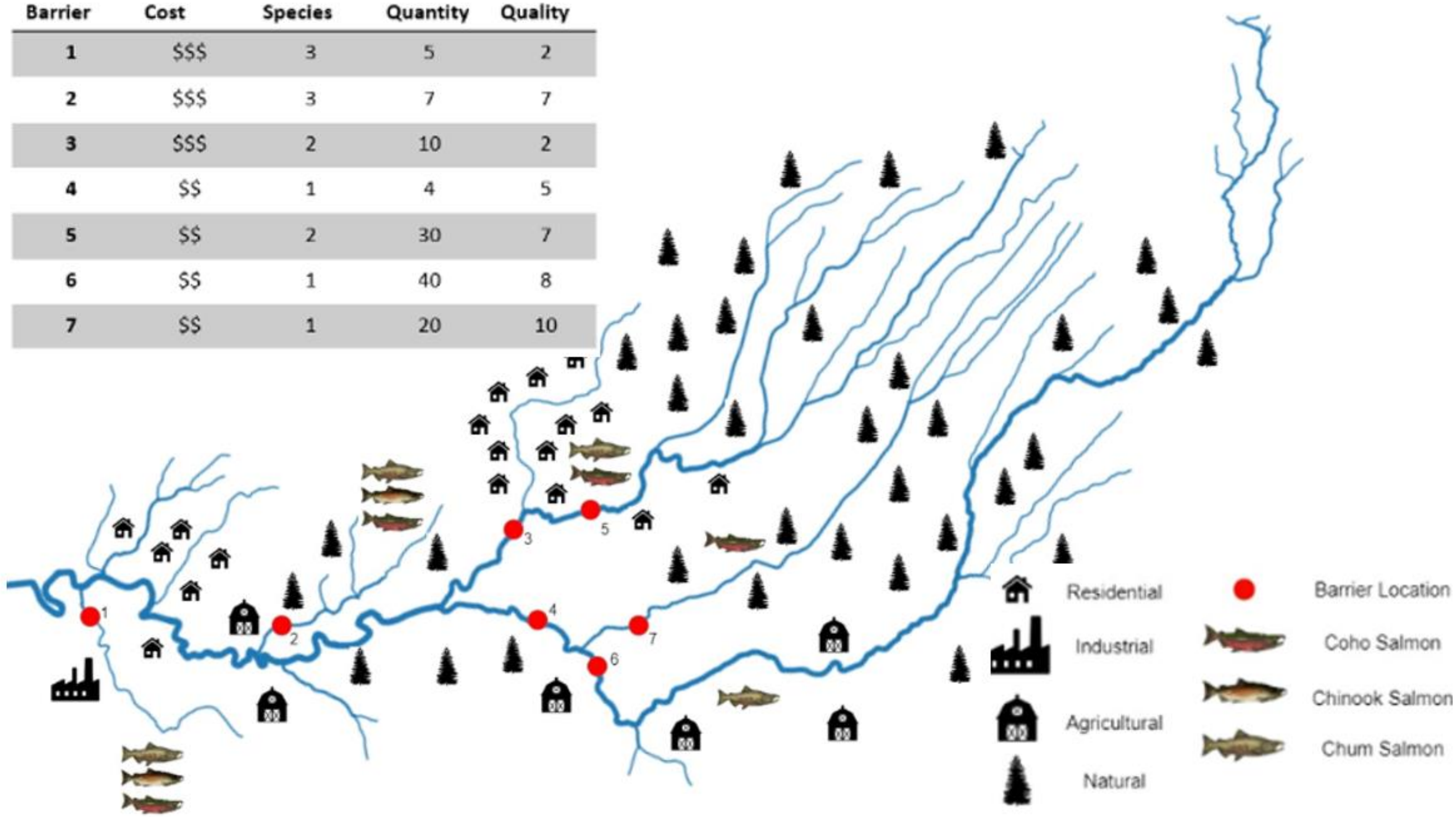
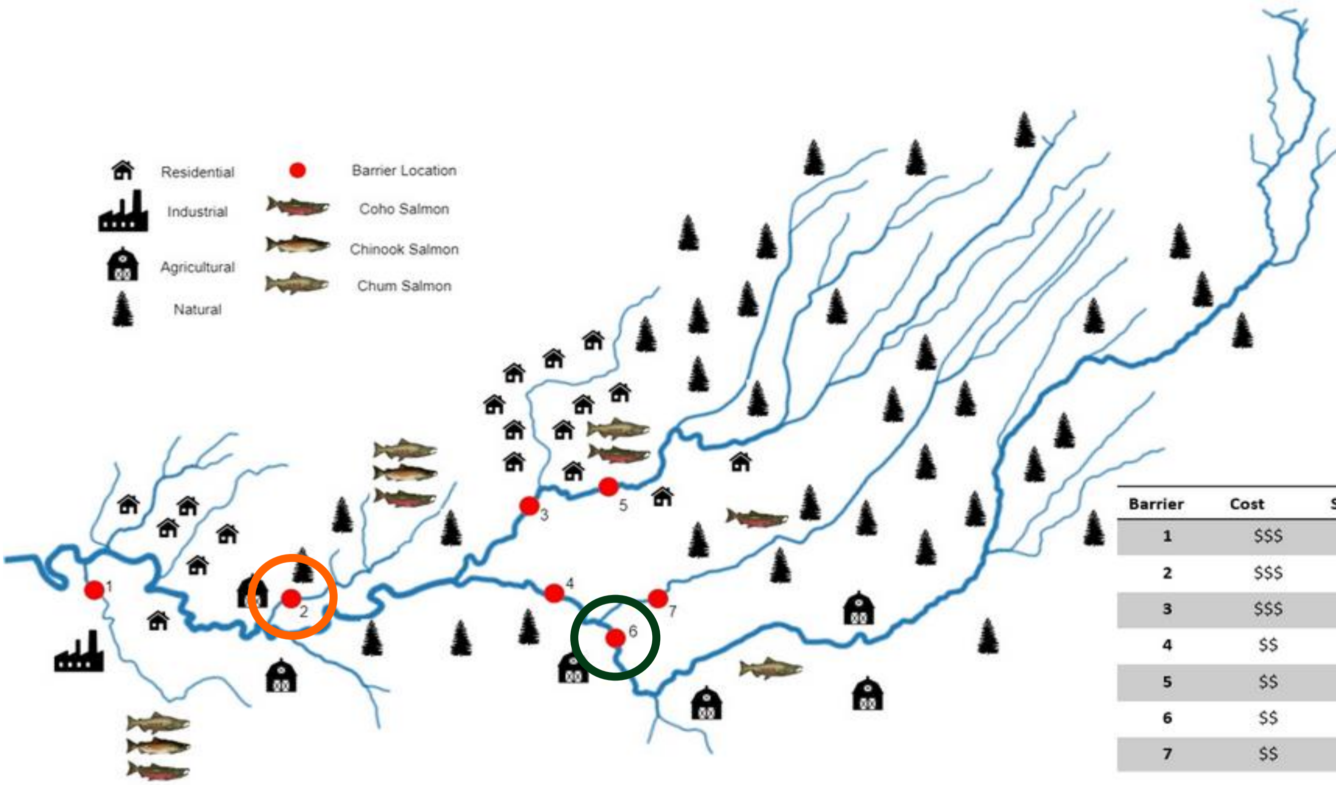


Figure 6: Map and information for team activity (designed by Riley Finn). There are 7 fish barriers in this example system. Each red dot represents a structure that limits the movement of fish upstream. The dark icons characterize the land use of the watershed and can be used to infer the quality of the habitat in the adjacent streams. The fish icons represent the presence of a given species of salmon in the system that might benefit from the restoration of connectivity. The table provides quantified values for the number of species, the quantity of habitat, and the quality of the habitat for each barrier, along with it cost to restore.

ROUND 1 – BUDGET LEVEL - $$$

Barriers chosen for removal (each circle represents a separate answer):

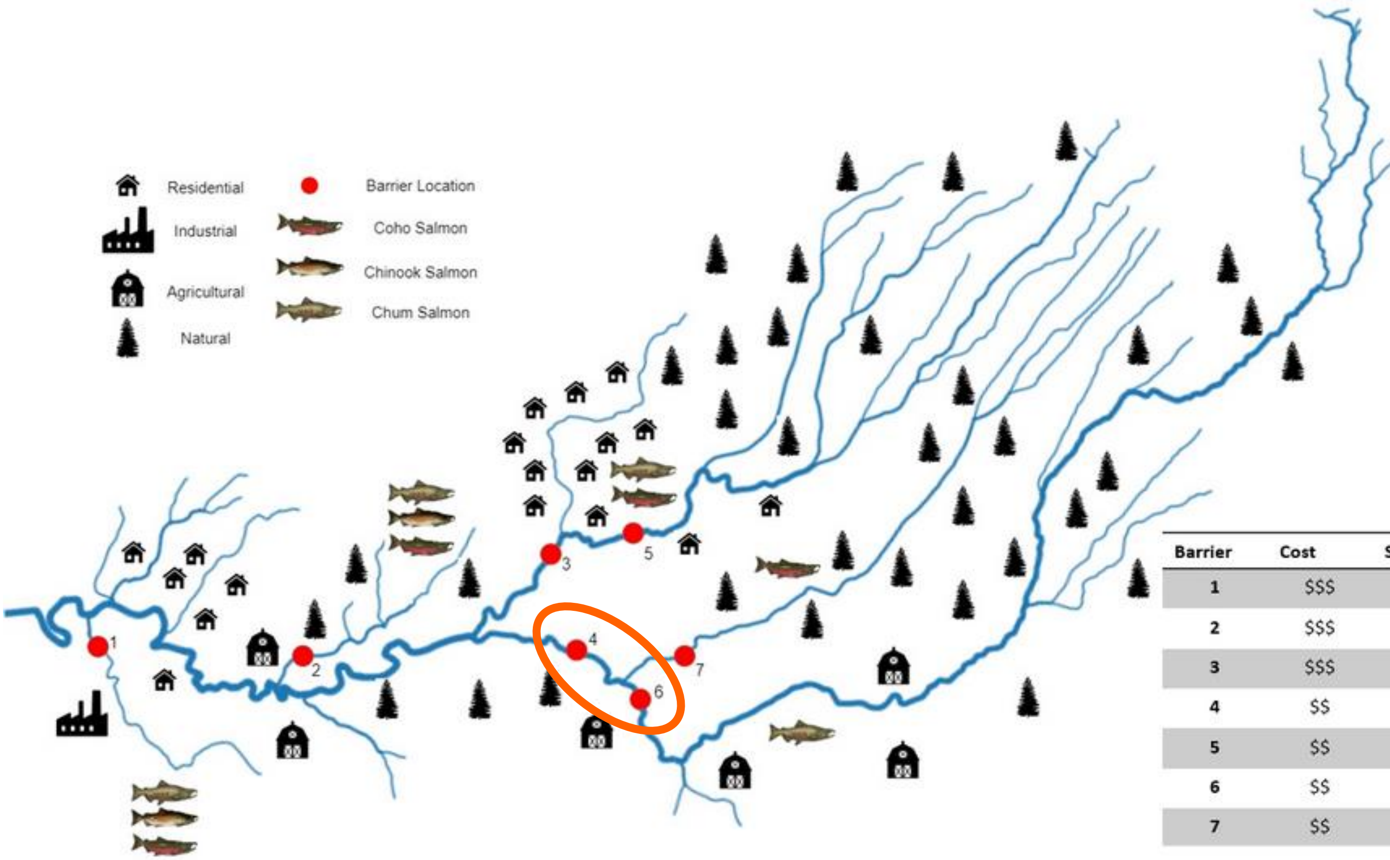


Barrier	Cost	Species	Quantity	Quality
1	$$$	3	5	2
2	$$$	3	7	7
3	$$$	2	10	2
4	$$	1	4	5
5	$$	2	30	7
6	$$	1	40	8
7	$$	1	20	10

Barriers chosen	Reason
No. 1	It seems like a good balance of habitat size and quality, and it impacts 3 species.
No. 6	There is large watershed area upstream, but the benefits of removing that barrier would be limited given the presence of barrier No. 4 downstream.

ROUND 2 – BUDGET LEVEL - $$$$

Barriers chosen for removal (each circle represents a separate answer):

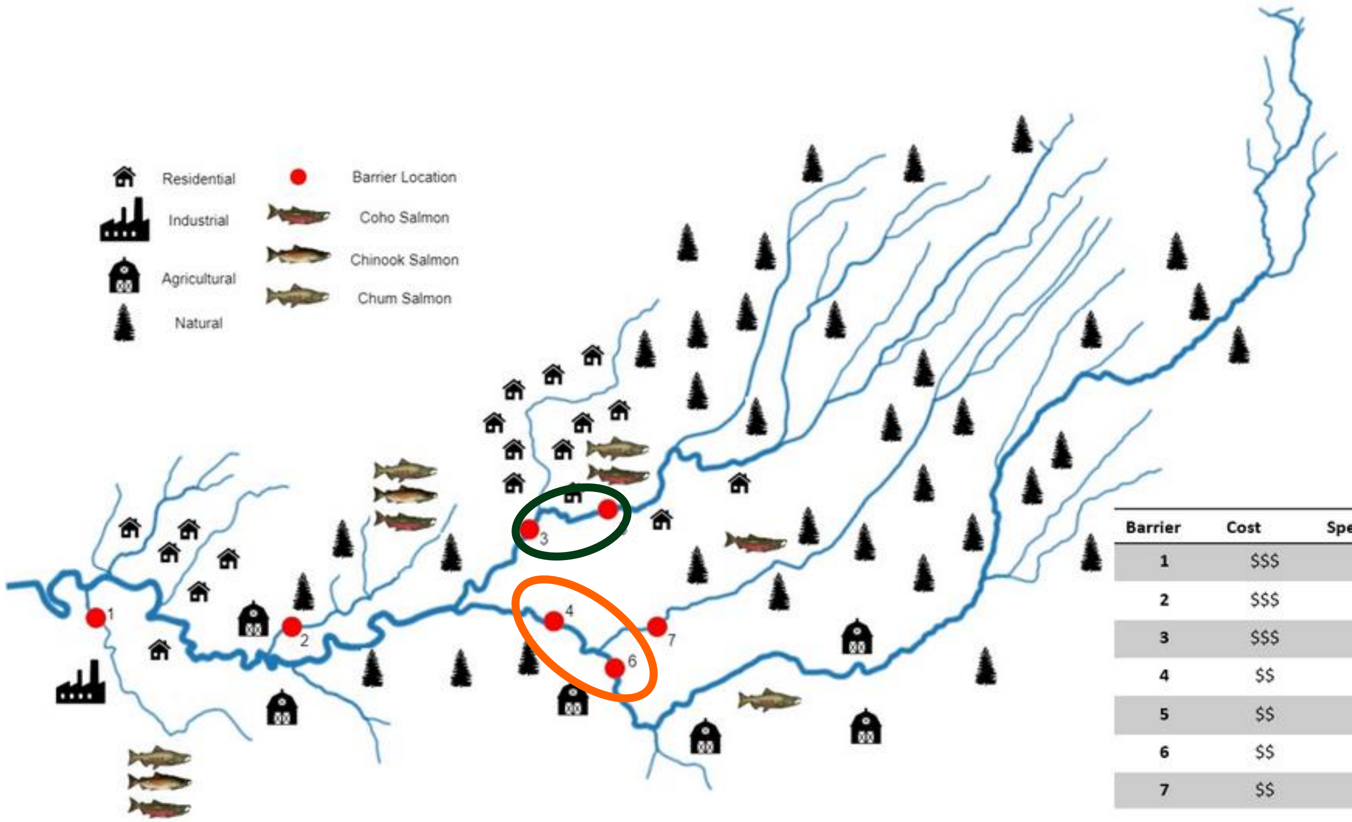


Barrier	Cost	Species	Quantity	Quality
1	$$$	3	5	2
2	$$$	3	7	7
3	$$$	2	10	2
4	$$	1	4	5
5	$$	2	30	7
6	$$	1	40	8
7	$$	1	20	10

Barriers chosen	Reason
No. 4 & 6	It is possible to take advantage of the benefits of removing barrier No. 6 if you also remove No. 4.

ROUND 3 – BUDGET LEVEL - $$$$$

Barriers chosen for removal (each circle represents a separate answer):



Barrier	Cost	Species	Quantity	Quality
1	$$$	3	5	2
2	$$$	3	7	7
3	$$$	2	10	2
4	$$	1	4	5
5	$$	2	30	7
6	$$	1	40	8
7	$$	1	20	10

Barriers chosen	Reason
No. 3 & 5	It may be a shorter reach, and it may not include all 3 species, but it could have a high social impact given the residential land-use upstream from barrier No. 5
No. 4 & 6	It is possible to take advantage of the benefits of removing barrier No. 6 if you also remove No. 4.

EXERCISE - COMMENTS AND DISCUSSION

- Beyond the number of salmon species upstream from a barrier, you also **need to know how each species is doing**. If there is a specific kind of salmon that is struggling, removing barriers that impact it should become a priority.
- There are a number of **invasive species in the Lower Fraser**, and existing barriers might prevent further spread. This should also be considered when choosing what barriers to remove.
- In addition to the information presented in the exercise, prioritization should have a focus **on cultural values, following UNDRIP principles**.
- It would help **knowing if more budget will become available** in the future before choosing which barriers to remove.
- It is possible to start with **a very visual project to address concerns** that residents may have about such projects so as to increase support for the future.
- **Water quality depends on multiple factors**, for instance, channel complexity and land-use components. It would be useful to know how much water quality could be expected to change following the removal of a given barrier.
- It is important to know as well if we are **dealing with a full or partial barrier** to better understand its impact.

KEY TAKEAWAYS AND CONLUSIONS

The prioritization exercise and the workshop presentations helped highlight various issues concerning interventions on existing in-stream barriers:

- Barrier removal **prioritization depends greatly on what the objectives are** (e.g., protecting vulnerable species, unlocking as much habitat as possible, avoiding conflicts with some land-uses, minimizing intervention costs, etc.).
- In other words, the way you frame the problem influences the preferred solutions! **Values play an important role**.
- **Knowing what is upstream and downstream** (including land-uses and other barriers) is vital for choosing where to intervene.
- **Different budget levels** (including potential future budgets) can result in **very different choices of barrier prioritization**. Additionally, budget availability needs to align with the months of the year during which site conditions allow for work to be carried out.
- Promoting **high visibility projects can help with awareness** campaigns, increasing public support, and securing funding.
- In order to decide which barriers to prioritize, it **is important to incorporate information on future stream conditions**, such as land-use developments and climate change scenarios.
- **Optimization tools do not provide the "right" answer,** they are just guides, as the choice ultimately depends on what matters to stakeholders and their objectives (e.g., protect farmland vs. protect vulnerable salmon species).
- The choice of barrier **removal also concerns cultural values.**
- Beyond the habitat area or number of species, **the health of each species should be considered** in the prioritization process.

APPENDIX A: PARTICIPATING ORGANISATIONS

The workshop included participants from the following groups or organizations:

First Nations

Skwah
Stó:lō Nation
Tsleil Waututh Nation
Xʷməθkʷəy̓əm Nation

Local governments

City of Burnaby
City of Delta
City of Port Coquitlam
City of Surrey
City of Vancouver
District of North Vancouver
Metro Vancouver

Provincial and federal government

BC Housing
BC Ministry of Agriculture and Food
BC Ministry of Forests
BC Ministry of Water, Land and Resource Stewardship
Fisheries and Oceans Canada
Province of British Columbia

Other organizations and associations

BC Dairy
British Columbia Landscape and Nursery Association
British Columbia Wildlife Federation
Canadian Wildlife Federation
Community Mapping Network
Ducks Unlimited Canada
Engineers and Geoscientists British Columbia
Investment Agriculture Foundation of BC
Pacific Salmon Foundation
The Nature Conservancy

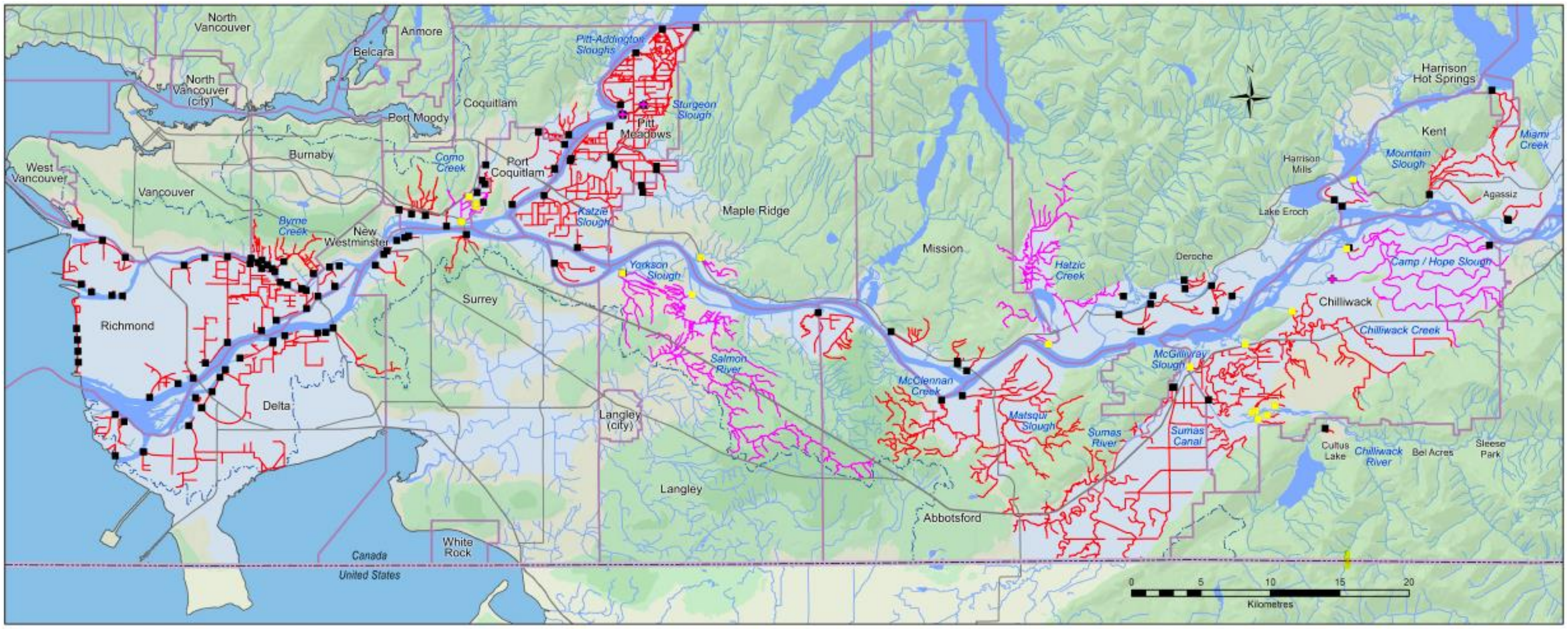
Consulting firms and manufacturing

Kerr Wood Leidal
Northwest Hydraulic Consultants
Urban Systems

Academia

British Columbia Institute of Technology
Oregon State University
University of British Columbia

APPENDIX B : MAP OF FLOOD CONTROL INFRASTRUCTURES ALONG THE LOWER FRASER



Flood control infrastructure impacting potential salmon habitat in the lower Fraser River floodplain

DISCONNECTED WATERS

1,500 km of potential salmon habitat impacted by 156 flood control structures

119 additional structures control farm land, urban or industrial areas

Legend

- Floodbox and/or Pump Station
- Fish-Friendly Flood Control Structure
- Upgrade to Fish-Friendly Structure (2019)
- Disconnected Waterways
- Partially Disconnected Waterways
- Other Waterways
- Highways
- Municipal Boundary
- Fraser River Watershed
- Canada/US Border
- Floodplain
- Lakes and Rivers

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These data are up to date as of March 26, 2018. However, WWSS is continuing to work with municipalities and landowners to confirm types and locations of flood control infrastructure, including whether the infrastructure is fish-friendly.

ACKNOWLEDGEMENTS

WATERSHED WATCH SALMON SOCIETY

PARTNERS FOR ACTION

CHEAM FIRST NATION

SKWAH

The Nature Conservancy Oregon

THE UNIVERSITY OF BRITISH COLUMBIA
Faculty of Forestry

RAINCOAST CONSERVATION FOUNDATION

Fisheries and Oceans Canada
Pêches et Océans Canada