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Designing for flood resilience: Challenges and recommendations for flood infrastructure

May 2023

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RESILIENT WATERS

A project of MakeWay

WATERSHED WATCH SALMON SOCIETY

EXECUTIVE SUMMARY

Aging flood control infrastructure along the Lower Fraser has fragmented critical salmon habitat. Additionally, the area is home to important agricultural lands for the entire region. Many communities have been impacted by the situation, most notably First Nations communities along the Lower Fraser whose lands are at a higher risk of flooding due to historically unjust decisions and climate change. Resilient Waters and partner organizations hosted a virtual workshop to discuss perceived barriers to implementing alternatives for flood infrastructure to replace the aging and failing flood structures currently in place. Workshop participants, including municipal employees, First Nations, Provincial staff, academics, private consultants and others, were able to discuss the issues in breakout groups and share notes on a virtual mural board.

While the workshop originally focused on fish-friendly floodgates, the scope of the discussions quickly broadened to cover issues relevant to all kinds of flood infrastructure. Concerning the *planning phase* for new infrastructure, participants highlighted the complicated regulatory process for permitting, the lack of guidelines, the need for collaboration to bring together values and priorities from multiple stakeholders, as well as accessing funding. For the *construction phase*, some of the main barriers mentioned included increased technical complexity due to challenging site conditions, as well as limited options from manufacturers and contractors. *Post-construction*, participants highlighted limited capacity to monitor and maintain infrastructure, the need for specialized training to operate new designs, as well as technical difficulties due to challenging site conditions.

The emerging themes and results from the workshop showed the extent to which some issues are interrelated and how they cut across all phases of the projects (such as insufficient guidance and standards, or the need for effective collaboration between multiple stakeholders). When discussing ways forward, participants highlighted the need to support small scale pilot projects, bring stakeholders together early to be able to integrate all perspectives, and implementing awareness campaigns with the public in order to build support and potentially shift financial priorities in favour of more innovative and fish-friendly designs.

Future workshops will continue to explore additional elements of the current flood control infrastructure along the Lower Fraser.

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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.

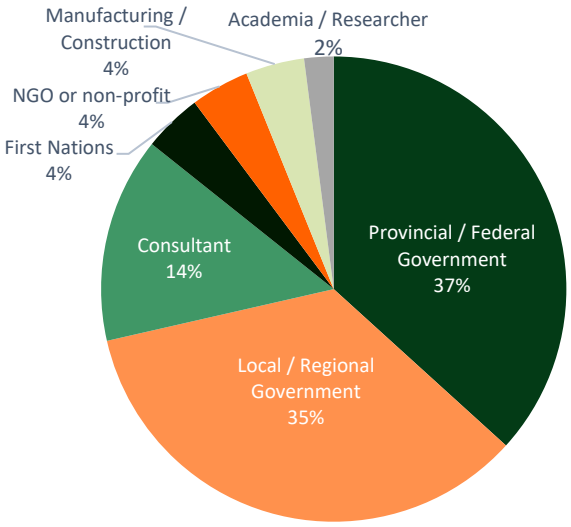


Figure 1: Sectors describing workshop participants.

On April 13th, **Resilient Waters**, along with members from **Partners4Actions**, the **Watershed Watch Salmon Society**, and the **City of Surrey** facilitated a virtual workshop to discuss issues related to implementing more fish-friendly flood infrastructure in the Lower Fraser floodplain. A total of 49 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 workshop opened with a presentation from the City of Surrey, framing the issue of floodgate infrastructure and salmon habitat, and providing context for the Lower Mainland and the Fraser River (Figure 2).

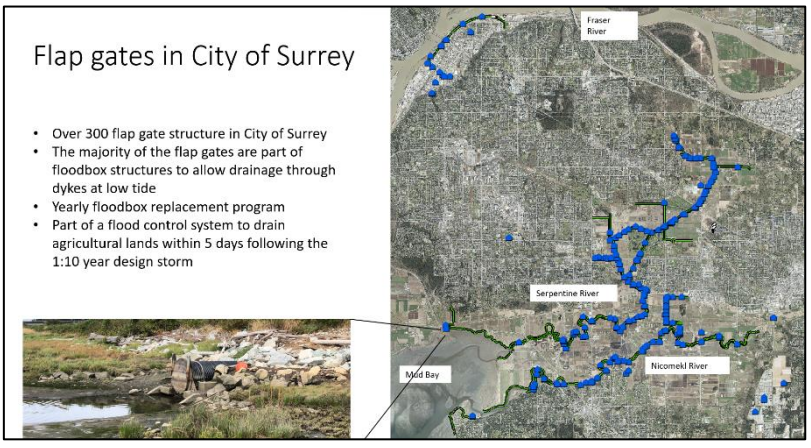


Figure 2: Presentation from the City of Surrey on existing flood infrastructure along water bodies.

[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

BARRIERS TO IMPLEMENTING FLOOD INFRASTRUCTURE

When participants registered for the workshop, they were asked to identify some of the issues concerning the implementation of fish-friendly flood infrastructure that they were most interested in discussing during the workshop (Figure 3).

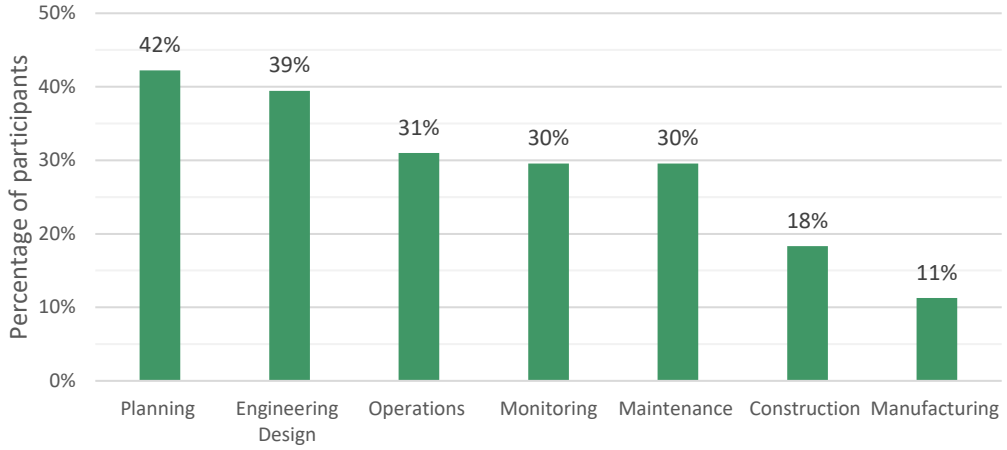


Figure 3: Issues participants were most interested in discussing (registration survey).

Participants were divided into small breakout groups of around 5 people for several rounds of open discussions. Additionally, participants were able to write notes on a virtual mural board (Figure 4). The most common words from the mural notes are summarized in a word cloud shown in Figure 5. Three rounds of discussions took place, each one focusing on a distinct phase of implementing fish-friendly flood infrastructure:

1. Pre-construction and planning: including collaboration between stakeholders, securing funding, obtaining necessary permits and approvals, and overall feasibility of the projects,
2. Construction phase: including engineering and gate design, as well as manufacturing and construction,
3. Post construction: operations, monitoring, and maintenance.

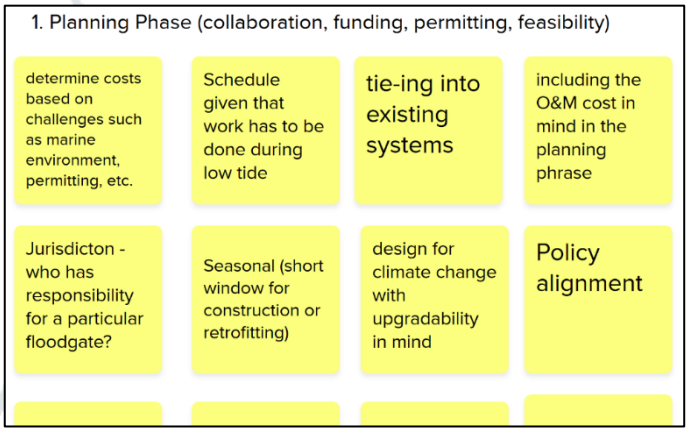


Figure 4: Examples of notes from the virtual mural board.

While the workshop originally sought to focus on issues related to fish-friendly floodgates, the open format of the discussion rounds led participants to address as well some of the challenges associated with implementing flood control infrastructure in general. For instance, some issues mentioned concerned fish-friendly alternatives more directly, such as the lack of standardized designs, or the need for more specialized staff. On the other hand, challenges such as lack of funding or difficult site conditions apply more broadly to most forms of flood control infrastructure.

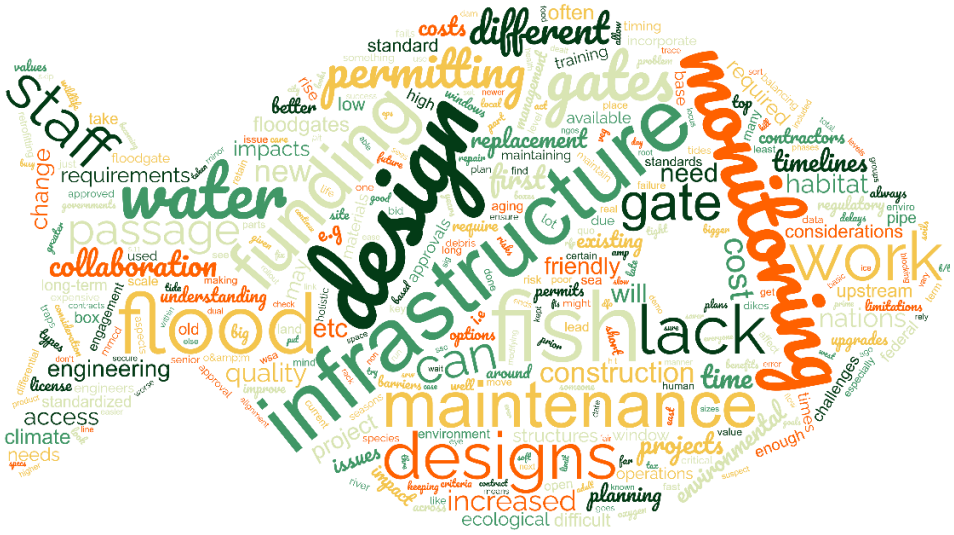


Figure 5: Most common words found in mural board notes.

PHASE 1 – PLANNING

Concerning Phase 1 (Planning), participants in various breakout groups highlighted the following barriers:

- **Challenging site conditions** such as water levels and tidal cycles that restrict potential designs.
- Ensuring **compatibility with existing infrastructure**, making it harder to move away from old systems and designs.
- **Complicated permitting and regulatory processes** involving multiple jurisdictions and lengthy timelines with uncertain outcomes.
- Need for extended and **more meaningful collaboration**, including with First Nations, between jurisdictions, and between disciplines involved in project design and operation.

> "There may be uncertainty of design for fish passable gates. Engineers may want to stick with more familiar designs." Group 8 participant.

- Challenges in **securing funding** since some grant programs may not be well known, could be hard to apply for, or may not provide sufficient financial support.
- Lack of guidance, including availability of data, **standardized guidelines** and tools to assess and compare different alternatives.
- Potential conflicts from **having to balance multiple priorities and values** (for example, protecting agricultural lands while ensuring safe fish passage too).

"Will there be consideration to food security and the ability for our farmers to continue to invest in their land on floodplains?" Group 11 participant.

PHASE 2 – DESIGN AND CONSTRUCTION

The discussion continued to identify issues related to Phase 2 (engineering design, manufacturing, and construction), such as:

- **Supply and manufacturing delays** due to material sourcing and shortages, as well as potential **compatibility issues** as older parts or models get discontinued.
- Challenging site conditions, including difficult terrain and varying water levels that result in very **short windows during which construction can take place** (which can be missed due to delays in permits)
- Seeking to minimize **environmental impacts associated with construction**, such as habitat damage from debris, chemical leeching, and water contamination.
- **Complex project designs** to balance a tight seal and adequate water flow for fish, which often result in higher costs for already stretched budgets and that require highly specialized work that can only be carried out by few contractors.

[There is the] challenge of the timing of receiving approvals for the work from senior government. We need them far in advance of the work in order to go through the RFP process and secure contracts with the contractor. If we don't have enough time, then the good contractors are all busy and don't bid on the work." – Group 10 participant

"… if [a design] is better for fish passage, but worse for salinity coming into a water license holder's access point, hands are tied." – Group 1 participant

PHASE 3 – POST CONSTRUCTION MAINTENANCE AND MONITORING

Finally, concerning Phase 3 (post-construction), the main issues identified by participants related to:

- Need for **continuous monitoring**, which requires significant planning, funding and staff.

- **Challenging site conditions** impacting monitoring and repairs, including limited visibility of submerged gates, site access, sedimentation, and debris accumulation.
- Using new technologies and **complex designs that require specialized staff** that will need to be trained.
- **Insufficient guidelines on operating** new fish-friendly flood infrastructure designs, including clear metrics and ways to evaluate if they are working as intended.
- **Improving management plans in municipalities** to address issues related to record keeping, ensuring regulatory compliance, and determining appropriate maintenance scheduling.
- Need to **include relevant stakeholders in discussions** related to operations and maintenance, such as farmers and landowners, First Nations, water license holders, as well as all government agencies involved.

Following the three rounds of discussions, participants were able to vote on which issues or barriers discussed in the mural board they considered to be most pressing. Each participant was given 5 votes to distribute however they wanted. The results are shown in Figure 6.

Collaboration was the issue most voted for, which is to be expected given how it is needed throughout all the three phases and how it is seen as a vital component to ensure that multiple views, perspectives, and values (notably from First Nations) are considered throughout the entire project.

Figure 7 summarizes the emerging themes and issues that were identified for all three phases based on the mural board notes.

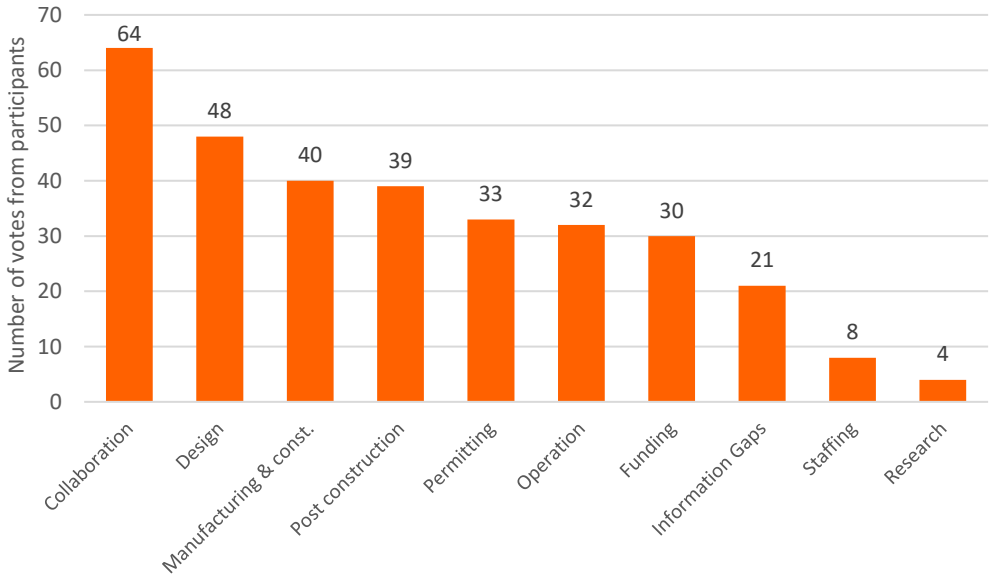


Figure 6: Voting results on most pressing issues to address.

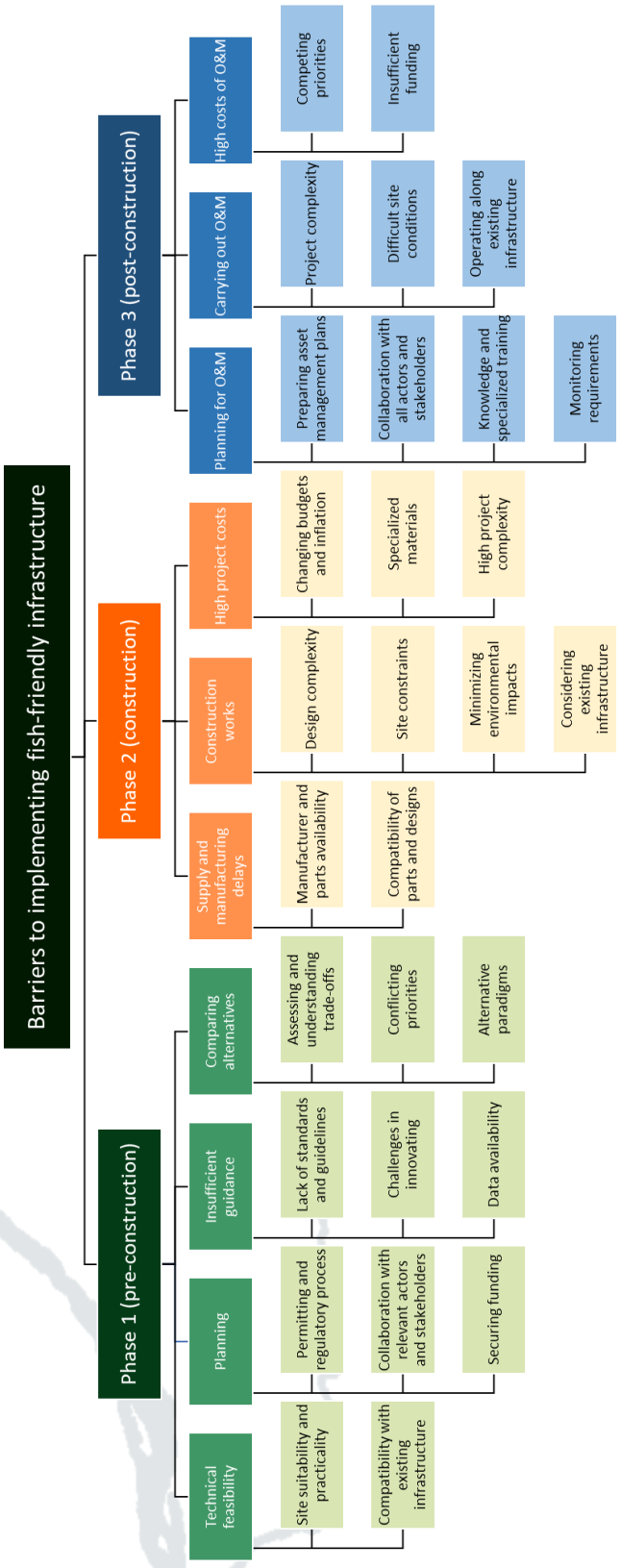


Figure 7: Summary of emerging themes and issues discussed for each phase of implementing fish-friendly infrastructure.

SOLUTIONS AND PATHS FORWARD

The second part of the workshop focused on a more detailed exploration of potential solutions and alternatives. A short presentation explained the functioning and characteristics of existing floodgate designs that allow for better fish passage. Figure 8 shows an example discussed during the workshop that regulates the opening of a side-mounted gate based on the water levels on either side of the gate, which helps maintain a sufficient flow for fish passage while ensuring flood protection when downstream water levels are high.

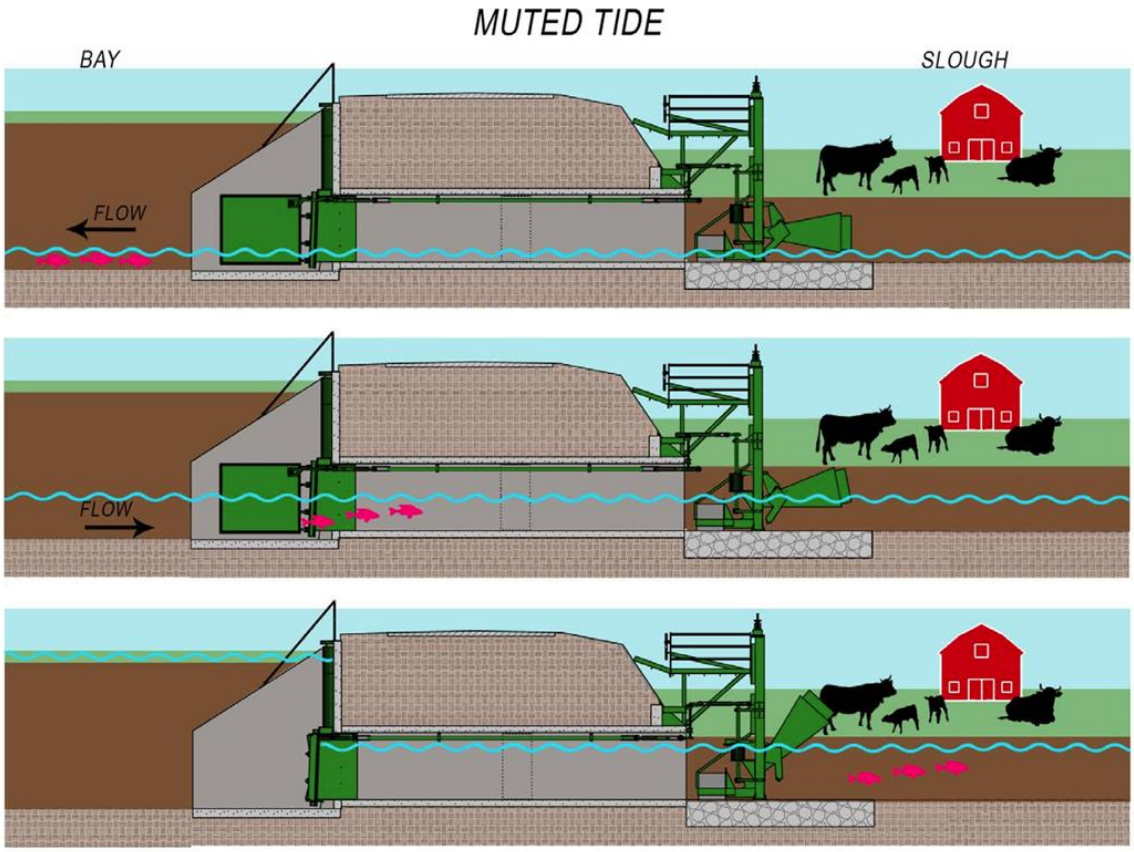


Figure 8: Example of a fish-friendly floodgate design from Nehalem Marine Manufacturing[2]

In a new round of discussions, participants were able to select a breakout room to share ideas on solutions and paths forwards on 6 specific issues:

1) Permitting
2) Operations and maintenance
3) Collaboration and engagement
4) Standardizing design & function
5) Funding

[2] Kuntz, L. (2013) West Coast Salmon Summit, Nehalem Marine Manufacturing, Oregon.

6) Designing for fish needs and ecological values

In the same way as the first round of discussion, some issues related more specifically to fish-friendly alternatives while others applied more broadly to general flood control infrastructure. Examples of suggestions discussed include:

Government aid and regulatory processes

- Having a more **centralized body** to carry out projects at a relevant watershed scale, as seen in some countries like The Netherlands.
- Requesting more collaboration between government bodies and agencies to **streamline permitting process**.
- Pushing for the creation of **national floodgate design standards**, ideally including ecological and biological considerations to help guide the engineering design, and with specific elements for different regions around the country.
- Creating more **flexible financial arrangements** that allow funds for flood infrastructure projects to be more easily shared.
- Taking advantage of other projects and developments in the area as **opportunities to tie-in flood infrastructure interventions.**

Collaboration and communication

- Identifying and **engaging with relevant actors and stakeholders early** to ensure more successful collaboration throughout the entire project, taking more time on pre-design in order to incorporate multiple views and objectives.
- Using the **"Ownership, Control, Access and Possession" (OCAP) principles** for more meaningful collaboration, as presented by the First Nations Information Centre.
- Promoting **exchanges between different communities** and jurisdictions to share knowledge and experience on flood infrastructure projects.
- **Making communication more effective** through visualization tools, ensuring everyone is using the same language, and producing Memorandums of Understanding.

Improving operations and maintenance

- Creating **task forces within municipalities focused on sediment removal** to facilitate maintenance and operations.
- Incorporate technology with more **advanced sensors to facilitate monitoring**, operations and maintenance, and use best materials when available.
- **Recruiting citizen scientists** (such as streamkeepers) to help with monitoring and operations.

Changing perspectives

- Providing **support for small-scale pilot projects** to help demonstrate the benefits of fish-friendly flood infrastructure and for obtaining valuable information that could help develop future standards and guidelines.

- Developing **public awareness campaigns** (including visual aids) to help raise interest and support from residents and stakeholders, which could help influence financial priorities within communities.
- Developing **online courses for professionals** (for example, through Engineers and Geoscientists British Columbia) to help advance training and awareness.
- Exploring **alternative paradigms** such as **removing floodgates** where possible or locating them further inland to extend potential salmon habitat**, reflecting on actual drainage needs**, and even **considering managed retreat** from developments along floodplains.

CONCLUSIONS

The discussion between participants helped highlight how challenges and barriers are interrelated and cut across the different implementation phases. For example, difficult site conditions create barriers in all 3 phases, since projects may only be feasible in some locations, with challenging environmental conditions and limited windows impacting both construction works and maintenance operations. At the same time, these challenges can raise costs for communities that may already be struggling with funding and finding specialized manufacturers and staff. Another example which affects all three phases is the need for more guidelines and standards.

Some key recommendations include keeping dialogue open and collaborations ongoing. Early engagement is vital to ensure all design elements and perspectives (particularly those from First Nations) are taken into account. This engagement should be built into the lifespan of the project, including post construction when discussing operation and maintenance.

Transitions to new systems or technologies always face challenges, and they can be very slow. There clearly remains much to learn about planning and implementing new alternatives for flood infrastructure, including more fish-friendly designs. It is not easy to decide what to implement as multiple stakeholders with different perspectives, values and priorities need to work together and make decisions based on relatively limited information, as there is still little guidance for these kinds of projects.

Moving away from the status quo requires significant resources, which often exceed the capacity of individual communities. Municipalities can benefit from a more coordinated, cooperative approach with neighbouring Nations and governments to improve economies of scales and draw on existing capacities. Pilot projects can help obtain valuable data that could be used to inform future designs, as well as to help demonstrate to stakeholders the potential benefits of alternatives to traditional hard infrastructure. As one of the participants said, “no one knows unless someone tries”. Additional workshops are expected throughout the summer 2023 to continue to explore other issues related to the current flood infrastructure system in place along the Lower Fraser.

APPENDIX A: PARTICIPATING ORGANISATIONS

The workshop included participants from the following groups or organizations

First Nations

Chawathil First Nation
Leq'a:mel First Nation
Sumas First Nation
Tsawwassen First Nation

Local governments

City of Coquitlam
City of Delta
City of Surrey
City of Vancouver
Municipality of North Cowichan

Provincial and federal government

BC Housing
BC Ministry of Agriculture and Food
BC Ministry of Forests
Fisheries and Oceans Canada
National Research Council Canada
Oregon Department of Fish and Wildlife
Province of British Columbia

Other organizations and associations

BC Dairy
Ducks Unlimited Canada
Emergency Planning Secretariat
Engineers and Geoscientists British Columbia
Konscious Foods
Raincoast Conservation Foundation

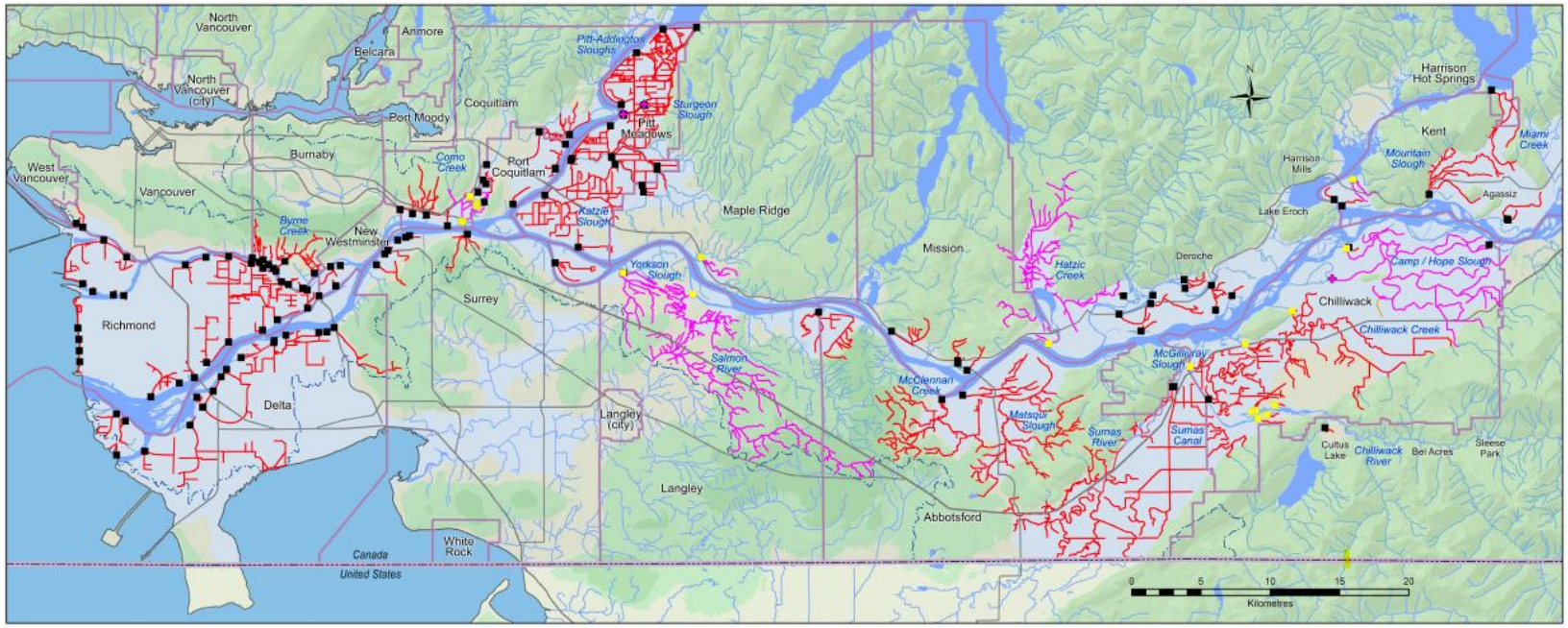
Consulting firms and manufacturing

Blueline Environmental Limited
CBCL Limited
Climate-B Ventures Private Limited Company
CMH Environmental Group Inc.
ISL Engineering
JFSA
Kerr Wood Leidal
Langley Concrete Group
Stantec Consulting Limited
Water Street Engineering
WSP Canada

Academia

British Columbia Institute of Technology
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

Challenges for implementing flood control infrastructure

Designing for flood resilience – Part 1: Challenges and recommendations for flood infrastructure

Phase 1: Planning

- **Technical feasibility**
  - Compatibility with existing infrastructure
  - Site suitability and practicality
- **Project planning**
  - Permitting and regulatory process
  - Collaboration between relevant actors
  - Funding
- **Guidance for communities**
  - Standards and guidelines
  - Challenges in innovating
  - Data availability
- **Comparing alternatives**
  - Assessing and understanding trade-offs
  - Conflicting priorities
  - Alternatives paradigms

Phase 2: Construction

- **Supply and manufacturing delays**
  - Manufacturing and parts availability
  - Compatibility of parts and designs
- **Construction works**
  - Design complexity
  - Site constraints
  - Minimizing environmental impacts
  - Considering existing infrastructure
- **High costs**
  - Changing budgets and inflation
  - Specialized materials
  - More complex projects

Phase 3: Post construction

- **Planning for O&M**
  - Preparing asset management plans
  - Collaboration with stakeholders
  - Knowledge and training
  - Monitoring requirements
- **Carrying out O&M**
  - Project complexity
  - Site conditions and constraints
  - Operating along existing infrastructure
- **High costs of O&M**
  - Competing priorities
  - Insufficient funding

Infographic prepared by Mauricio Carvallo Aceves, based on the results from a cross-sector virtual workshop on flood control infrastructure hosted on April 13th, 2023.

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Scan the code to read the full workshop report and learn more about flood infrastructure in the Lower Fraser.

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Recommendations to address challenges in flood infrastructure

Government aid and regulatory processes

- A more centralized body to carry out projects at a relevant watershed scale.
- Streamline permitting process between jurisdictions and agencies.
- Creation of national floodgate design standards.
- Flexible financial arrangements.

Collaboration and communication

- Identifying and engaging with relevant actors and stakeholders early.
- Using the "Ownership, Control, Access and Possession" principles to guide collaboration.
- Exchanges between communities and jurisdictions to share knowledge and experience.
- Making communication more effective through visualization tools and producing Memorandums of Understanding.

Improving operations and maintenance

- Creating task forces focused on sediment removal within municipalities.
- Creating task forces focused on sediment removal within municipalities.
- Using advanced sensors to facilitate monitoring.
- Recruiting citizen scientists (such as streamkeepers) to help in monitoring and operations

Changing perspectives

- Supporting small-scale pilot projects.
- Developing public awareness campaigns help raise interest and support from residents and stakeholders.
- Developing online courses for professionals to help advance training and awareness.
- Exploring alternative paradigms such as removing floodgates where possible.

Which issues do participants think are most important to address?

Infographic prepared by Mauricio Carvallo Aceves, based on the results from a cross-sector virtual workshop on flood control infrastructure hosted on April 13th, 2023.

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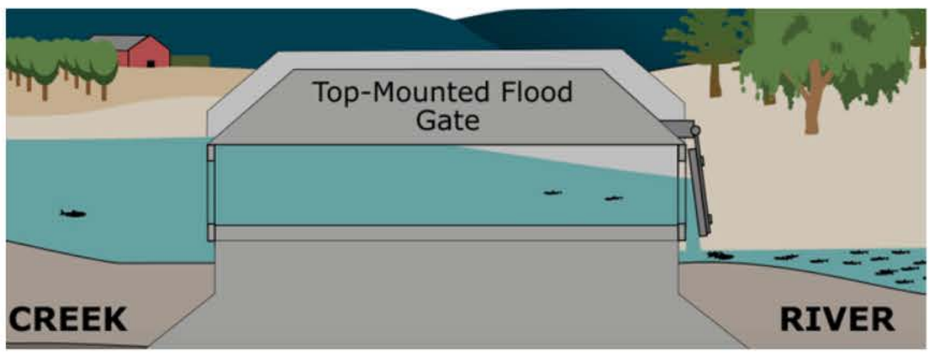
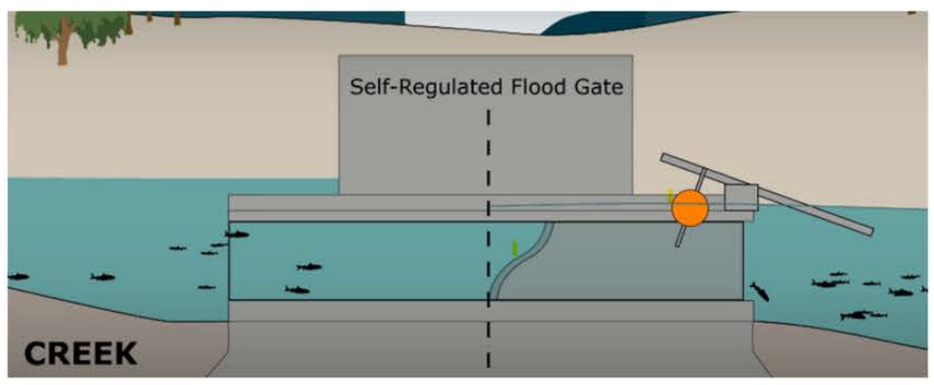
Problems and solutions for floodgates

Conventional top-mounted flood gate



- One of the most commonly used designs.
- Often use heavy gates, with iron flaps that rarely open and often for only short periods of time.
- When open, the water rushing out can be flowing too fast for fish to swim into the gate.
- The opening can be too narrow for larger fish to pass through.

Example of fish-friendly design with self-regulated gate



- Modified version of a top or side mounted gate.
- Inclusion of a counter-balance mechanism, such as a float that results in the gate being open more often, and for longer.
- The gate only closes when the water levels on the river gets high enough to push the float up.
- The default position of the gate is open.
- Designs may include remote sensors, floats, or cables sensitive to resistance to activate gate closure and opening.

Identified barriers to implementation for each life-cycle phase:

Participant comments:

"... if [a design] is better for fish passage, but worse for salinity coming into a water license holder's access point, hands are tied." – Group 1 participant

"There may be uncertainty of design for fish passable gates. Engineers may want to stick with more familiar designs." Group 8 participant.

Phase 1: Planning

- Having to balance multiple priorities and values (e.g., protecting agricultural lands and ensuring safe fish passage too).

Phase 2: Construction

- Difficult site conditions that restrict design and windows for site access
- Highly specialized work that requires additional training.
- Complex projects, which often result in higher costs.

Phase 3: Post construction

- Insufficient standardized guidelines for designing and operations
- Specific monitoring and maintenance needs to ensure adequate performance

Infographic prepared by Mauricio Carvallo Aceves, based on the results from a cross-sector virtual workshop on flood control infrastructure hosted on April 13th, 2023.

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Appendix B Workshop 2 report and infographic

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