Managing Flood and Erosion Risk in Canadian River Systems using Nature-Based Infrastructure:

A Canadian Guideline for Design and Implementation

Contributing to a

Climate Resilient Built Environment

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Sean.Ferguson@nrc-cnrc.gc.ca

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National Research Council Canada
Conseil national de recherches Canada
Canada

Nature-Based Infrastructure – Background and Research Needs

Strategies or measures that depend on, or mimic, natural system processes to provide flood and erosion risk management functions, while delivering environmental and other societal co-benefits (Vouk et al., 2021)

Common Functions

- Provide buffer zones between hazards and valued assets
- Store, slow, or disperse floodwater
- Preserve or restore sediment balance
- Attract or support stabilizing flora and fauna

Potential Benefits

- Manage flood and erosion risk
- Improve water quality
- Enhance biodiversity and habitat
- Improve aesthetics
- Provide recreational opportunities

Motivation and Research Needs

Despite growing popularity, there are still research gaps preventing broader uptake of NBI, including a need for **authoritative, national guidance, informed by scientific evidence**, to support design and implementation (Bridges et al., 2021; Vouk et al., 2021)

These research gaps inspired two projects at NRC-OCRE:

Coastal NBI

- Emerging technique
- Gaining popularity

Riverine NBI

- Nature-based approaches have been popular for some time
- No authoritative national guidance

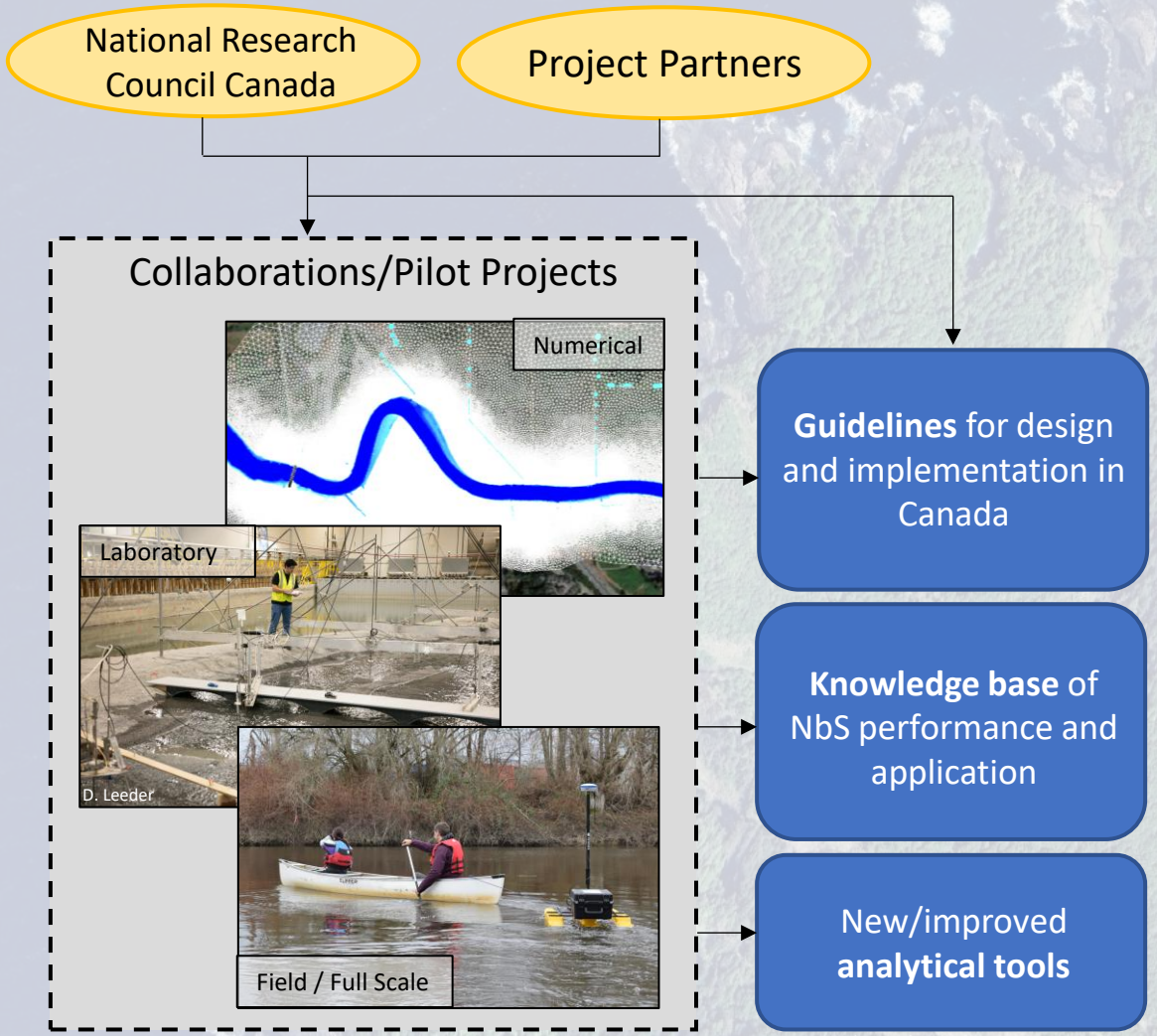
Project Overviews: Coastal and Riverine NBI

Objectives:

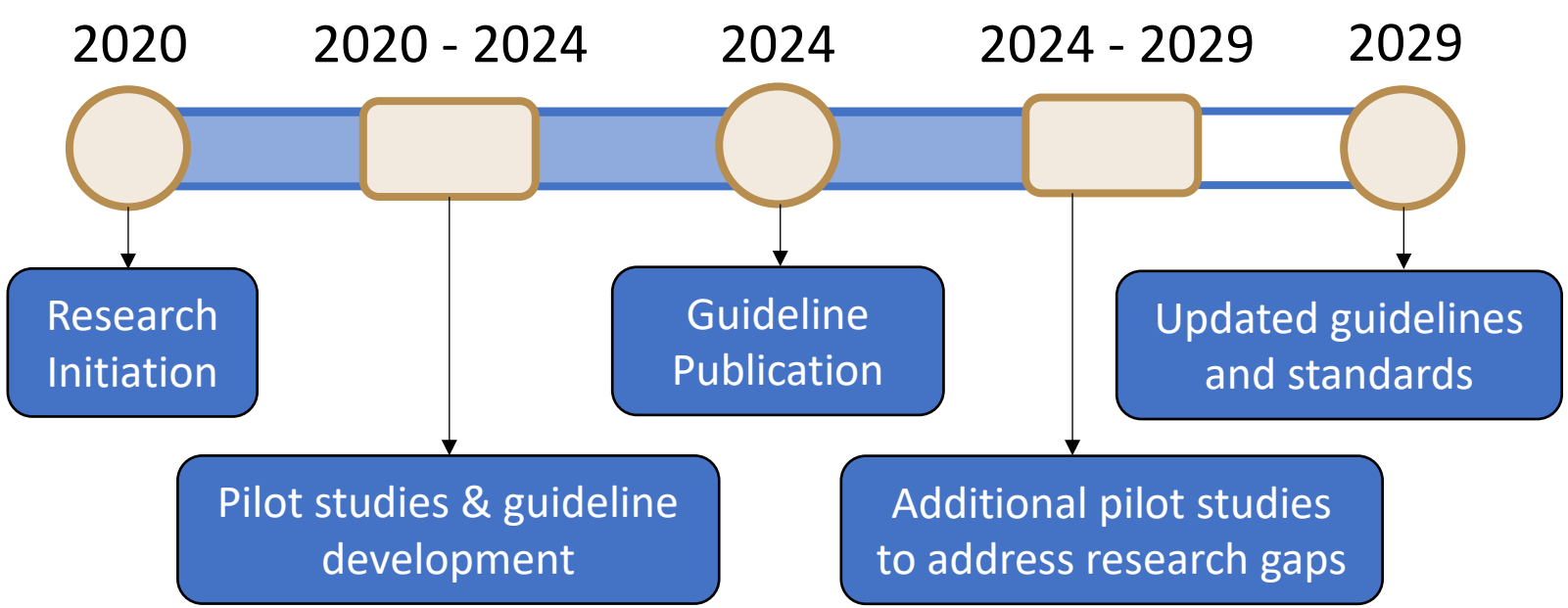
- **Address knowledge gaps** that prevent broader uptake of NBI for flood and erosion risk management in Canada
- Develop **design guidance** for engineers and practitioners

Impact:

- **Reduced uncertainties** regarding performance and suitability
- Enhanced ability to **demonstrate flood/erosion management**
- Broader **uptake, implementation, and success** of NBI



Coastal NBI Project



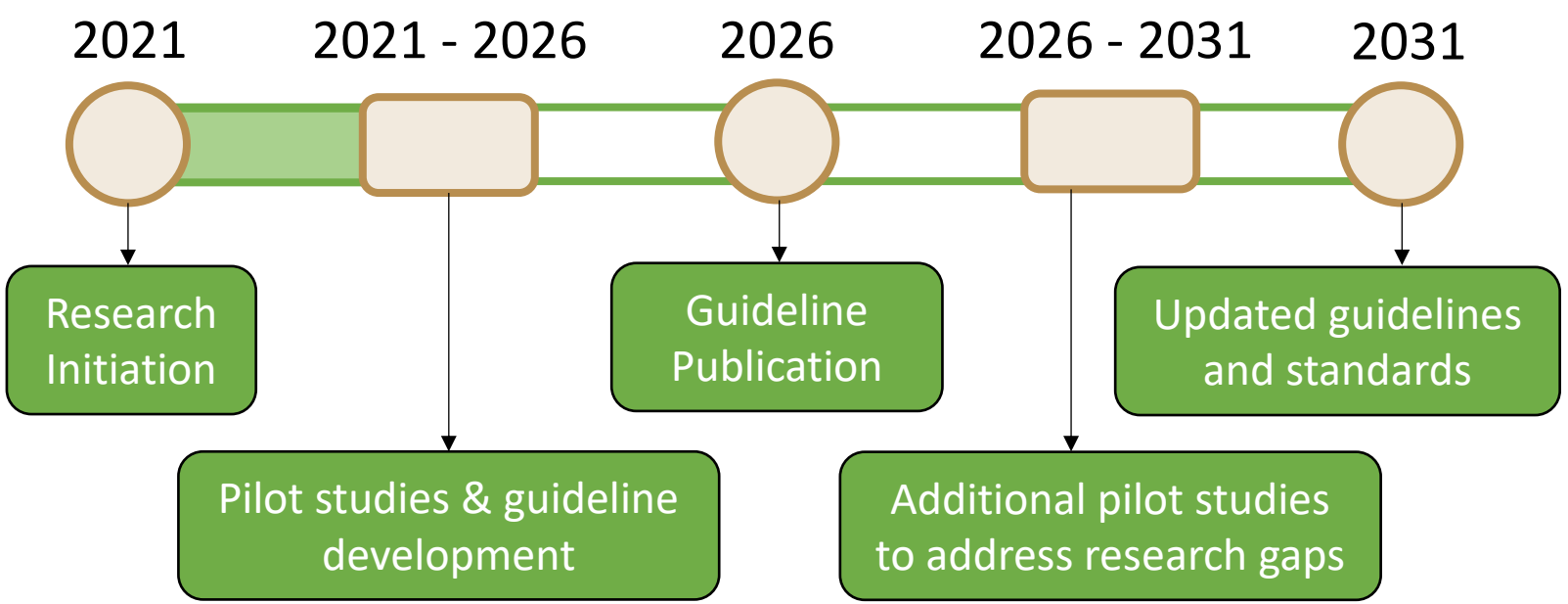
Partners & Contributors

Baird. Climate Change Engineered.
CBCL Solutions today Tomorrow mind
Credit Valley Conservation Inspired by nature
cbwes
CLIMAtlantic
The Confederacy of Mainland Mi'kmaq
Dalhousie University
DHI
Conserving Canada's Wetlands
Emergency Planning Secretariat EPS
EWN
GL Williams & Associates Ltd. Coastal and Estuarine H
Government of Canada / Gouvernement du Canada
INRS Institut national de la recherche scientifique
INTACT CENTRE ON CLIMATE ADAPTATION
nhc northwest hydraulic consultants
PICS Pacific Institute for Climate Solutions
Queen's University
Semiahmoo First Nation
SJL Engineering
City of Surrey the future lives here.
TransCoastal Adaptations
Saint Mary's University
UBC
uOttawa
VALORĒS
West Coast Environmental Law
Canadian Safety and Security Program

Nature-based infrastructure for coastal flood and erosion risk management: a Canadian design guide

Murphy et al., 2024

Riverine NBI Project



Partners & Contributors

Writing in Progress:

Guideline for natural and nature-based infrastructure for flood and erosion risk management in Canadian river systems

Pilot Projects and Case Studies

Reconnecting Floodplains, *Surrey, BC*

A new park is being developed. In addition to enhanced recreational opportunities, the design will alleviate flood risk by increasing capacity for flood water storage.

Sediment Management Strategies *Calgary, AB*

A large gravel bar is constricting flow and elevating flood risk. Gravel bar realignment strategies are being considered to address the blockage while minimizing impacts to habitat and the sediment balance.

River Corridor Management, *Calgary, AB*

An investigation of meander belt width and the impacts of constricting river corridors. This work will inform construction setbacks that consider both flooding and channel migration.

Nature-based Shoreline Protection, *Ottawa, ON*

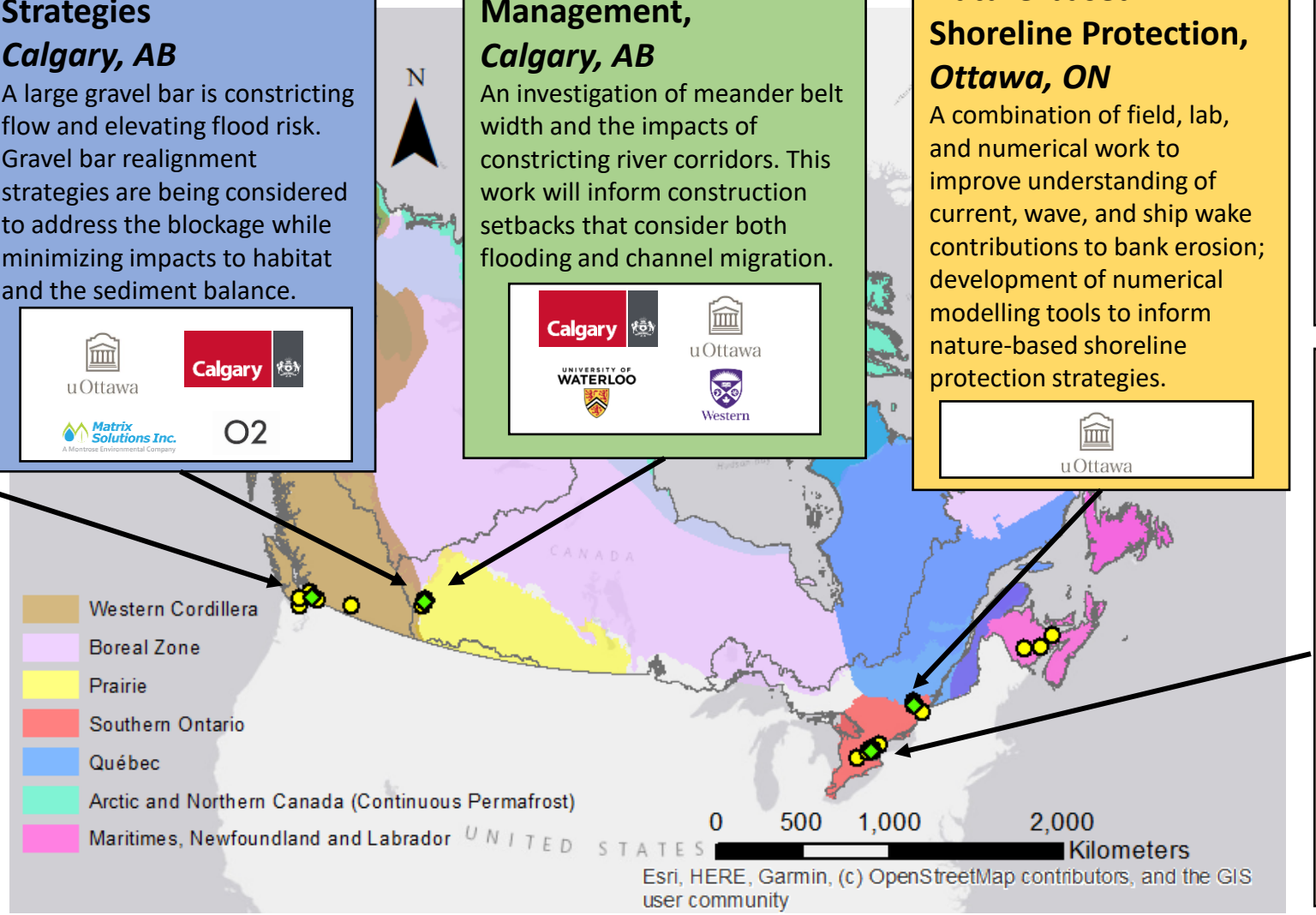
A combination of field, lab, and numerical work to improve understanding of current, wave, and ship wake contributions to bank erosion; development of numerical modelling tools to inform nature-based shoreline protection strategies.

Representing Vegetation in Physical Models

Investigation of strategies to better represent erosion protection provided by live plants in a laboratory setting; improved laboratory techniques for NBI assessment.

Practical Tools for Decision Support *GTA, ON*

Development of improved decision support systems for sustainable watershed management and erosion risk assessment (SPIN Tool).



- Guideline is supported by evidence from approximately 25 pilot projects and case studies
- NRC-OCRE provided support and contributions for 6 pilot projects

Pilot Projects and Case Studies

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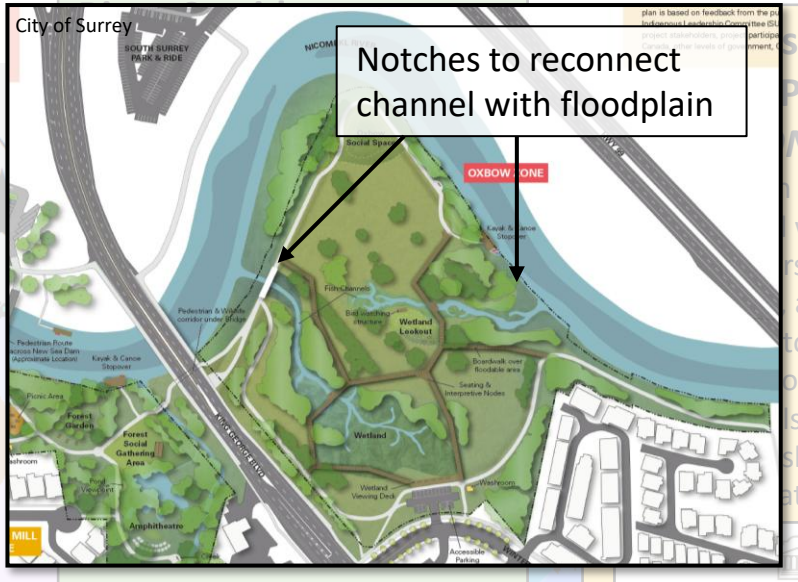

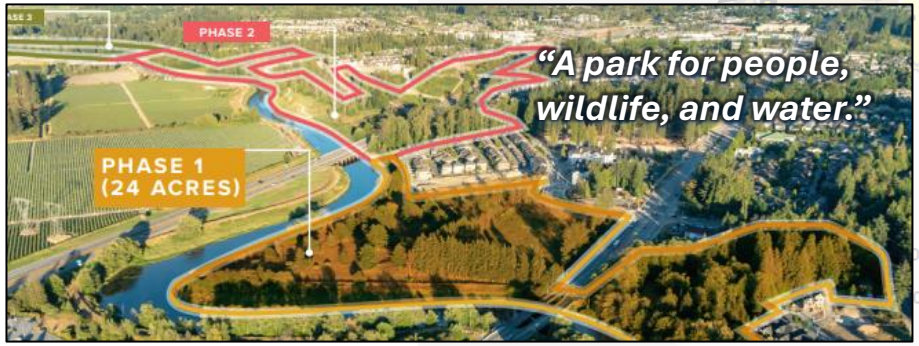

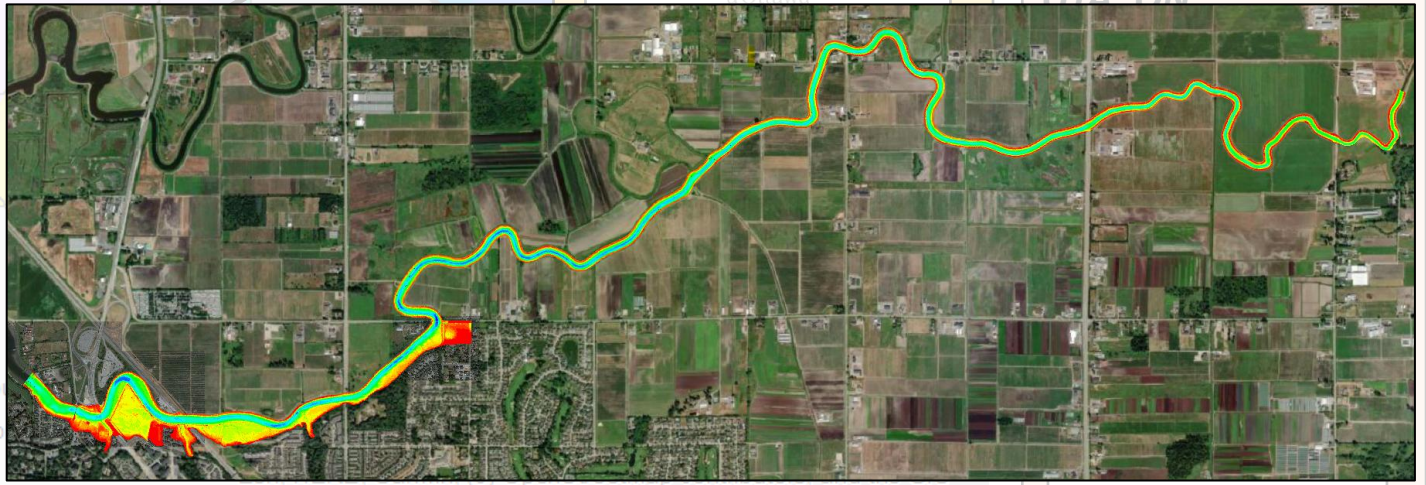

user community

Pilot Projects and Case Studies

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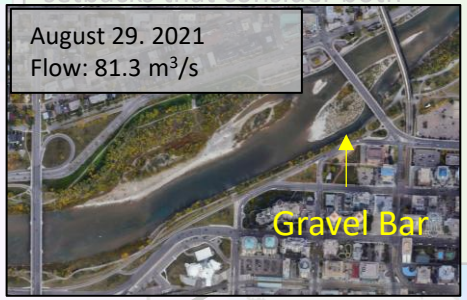
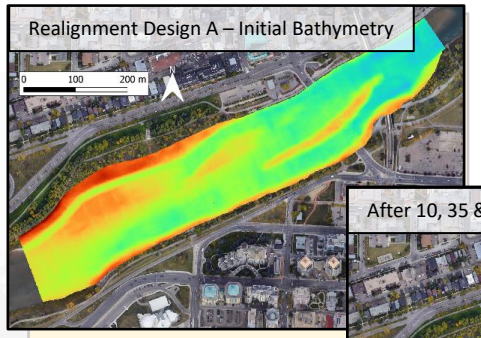
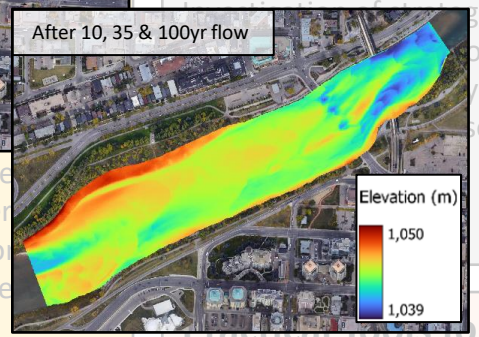
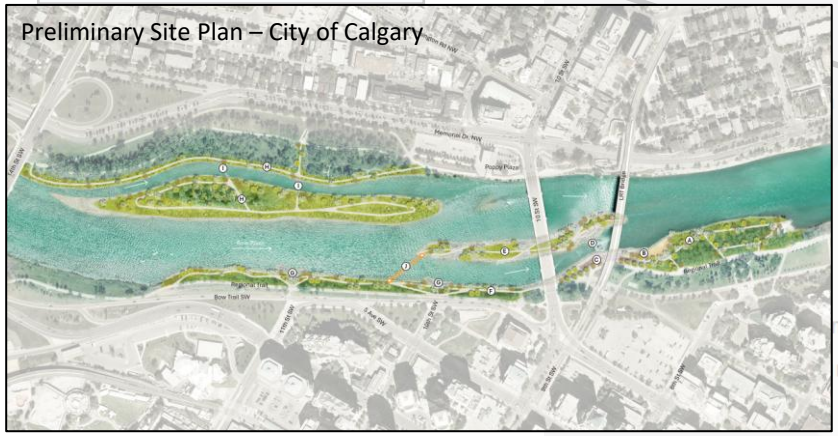






Representing Vegetation in Physical Models

Practical tools for Decision Support



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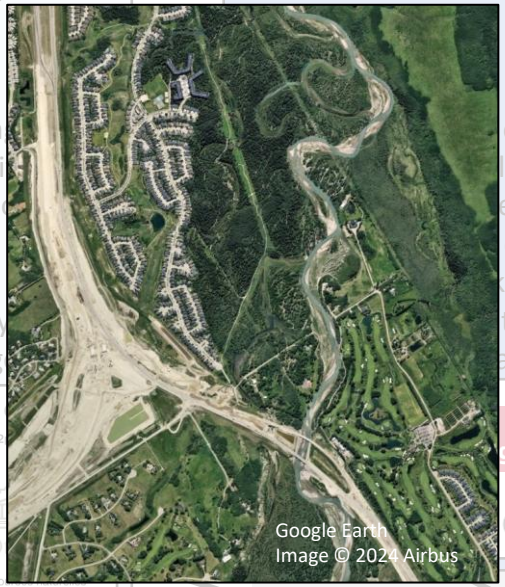

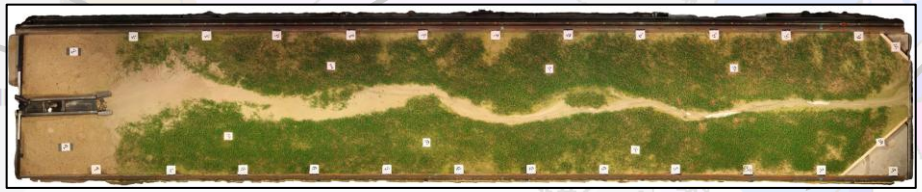

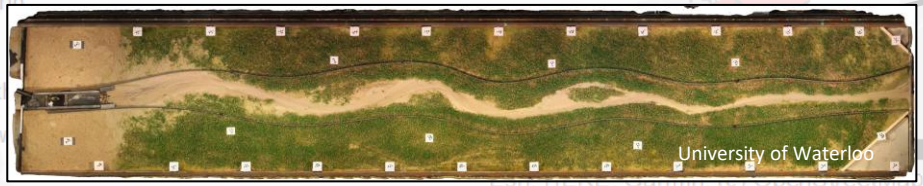

Pilot Projects and Case Studies

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uOttawa

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Credit Valley Conservation

Toronto and Region Conservation Authority

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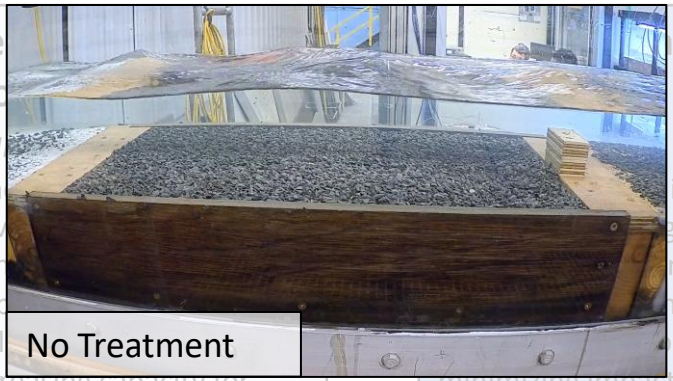
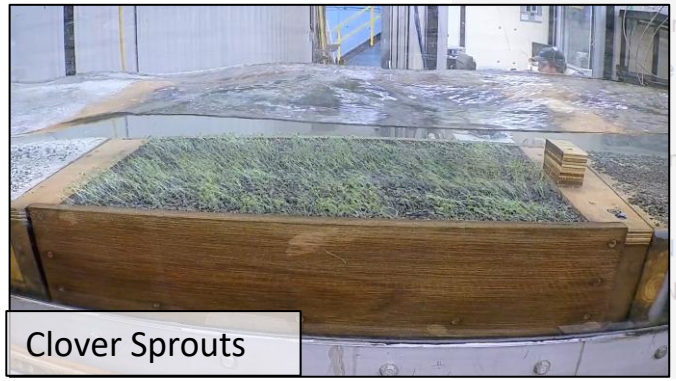
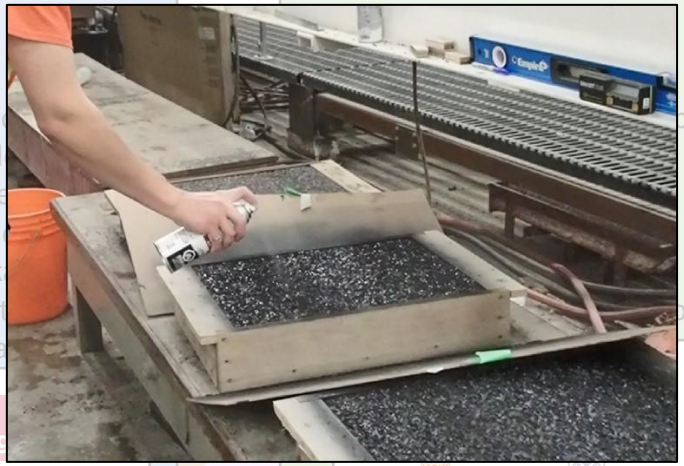


No Treatment

Spray Paint



Clover Sprouts



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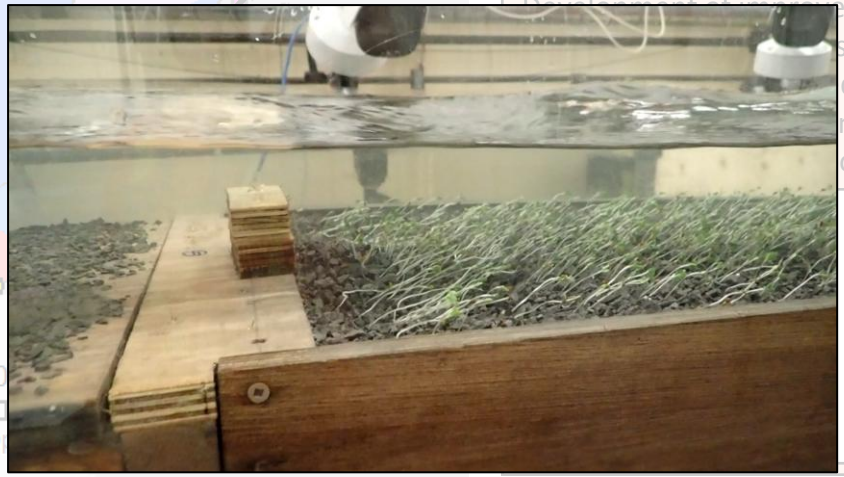

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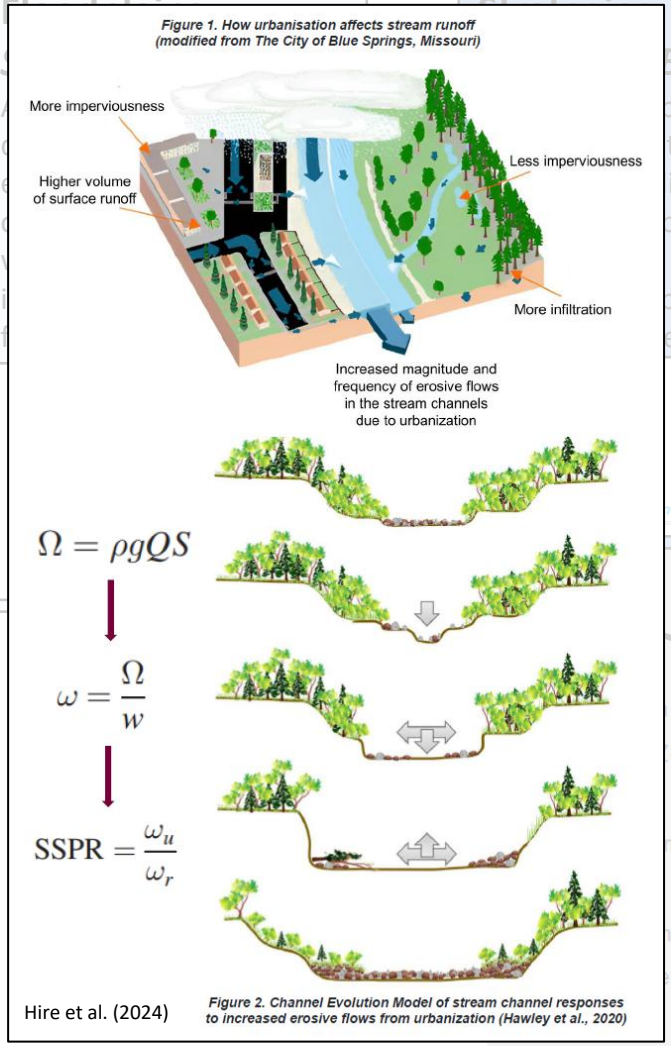
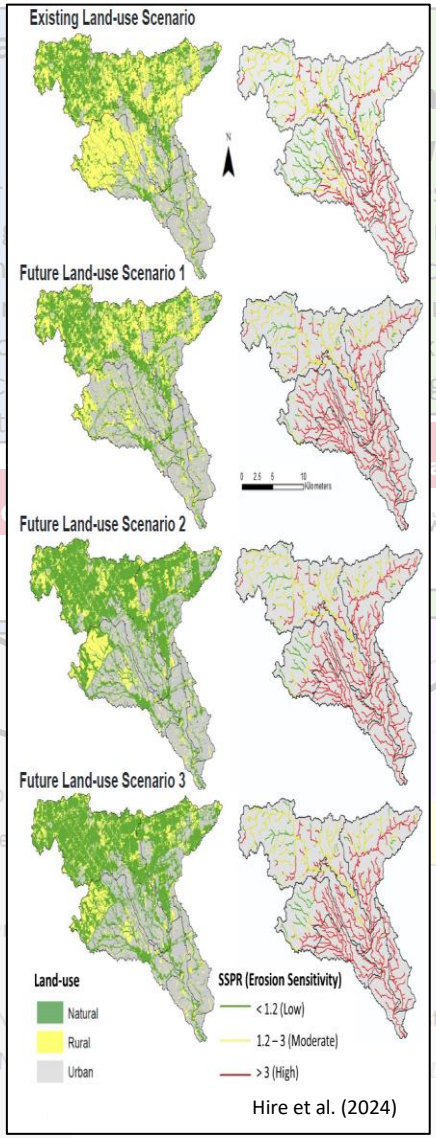


Hire et al. (2024)



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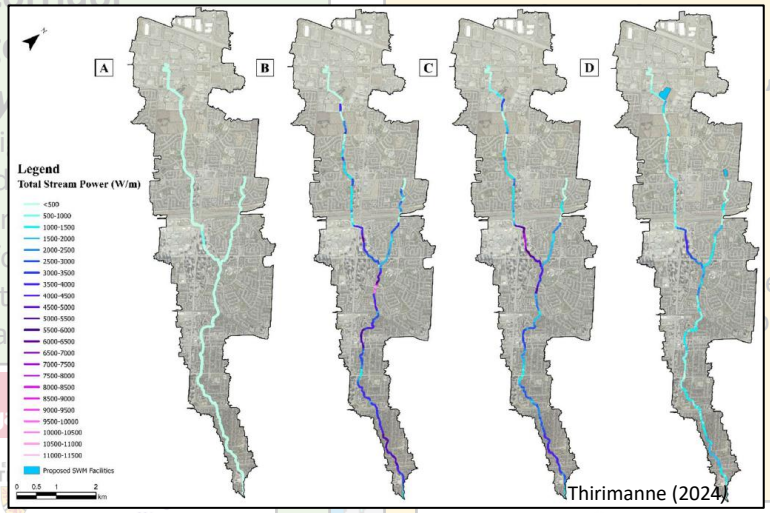

Thirimanne (2024)

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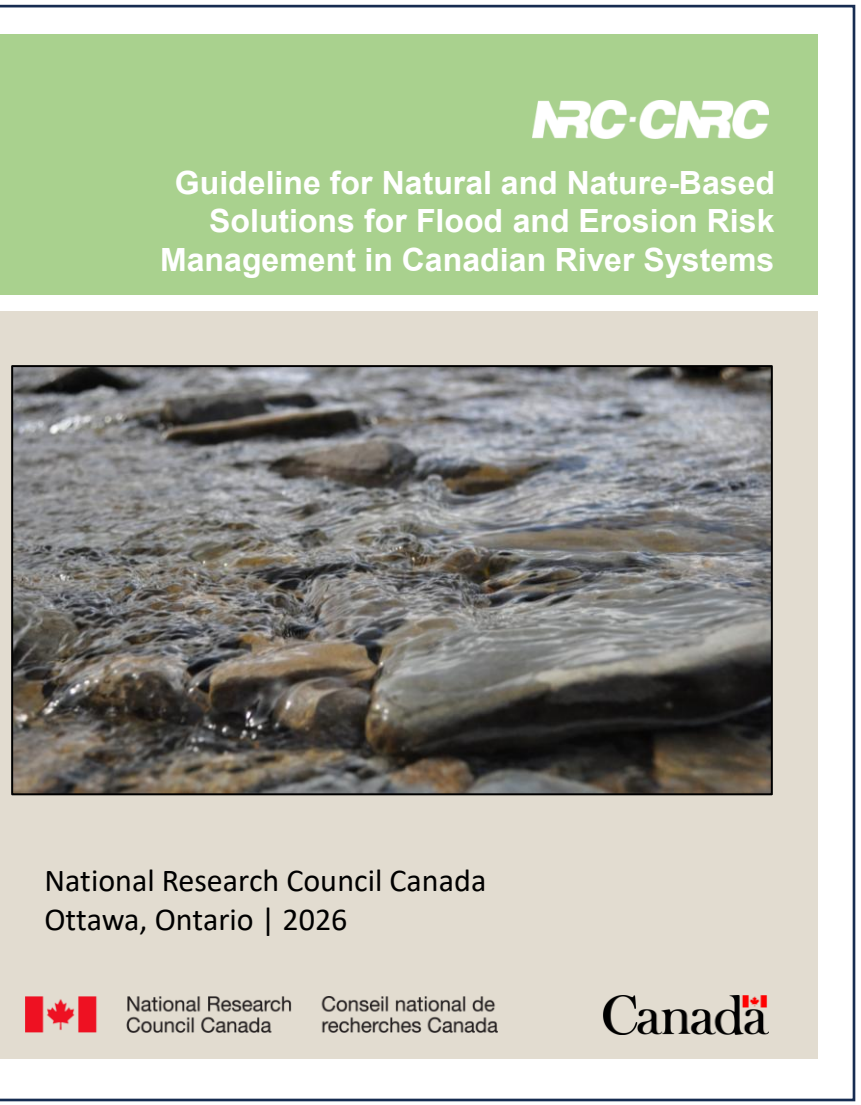
Guideline Development

- 1 Introduction — NRC·CNRC
- 2 Principles & Concepts — NRC·CNRC
- 3 Existing Guidance — NATURE-ADAPT
- 4 Governance — NATURE-ADAPT
- 5 Implementation Framework — KERR WOOD LEIDAL consulting engineers
- 6 Engagement — DALHOUSIE UNIVERSITY
- 7 Management & Valuation of Assets — NATURE-ADAPT
- 8 Adaptive Management — Applied Ecohydraulics



- NRC·CNRC — 9 Physiographic Considerations
- Credit Valley Conservation — 10 Watershed Considerations & Approaches
- University of Waterloo — 11 Floodplain Considerations & Approaches
- McMaster University — 12 Channel Considerations & Approaches
- KERR WOOD LEIDAL consulting engineers — 13 Design & Construction
- uOttawa — 14 Modelling
- Toronto and Region Conservation Authority — 15 Monitoring
- Many Contributors — 16 Case Studies

Guideline Development

1. Introduction
2. Principles & Concepts
3. Existing Guidance
4. Governance
5. Implementation Framework
6. Engagement
7. Management & Valuation of Assets
8. Adaptive Management

Introduction | Principles & Concepts

Chapter Leads: Ivana Vouk & Sean Ferguson

NRC·CNRC

Chapter Content and Guidance:

- Objectives of the guideline
- Scope, limitations, and target audience
- Key risk management concepts
- Guiding principles for NBI

Existing Guidance | Governance

Chapter Lead: Joanna Eyquem

NATURE-ADAPT

Chapter Content and Guidance:

Existing Guidance

- Key resources and publications pertaining to: international frameworks, climate change, Canadian policy, strategic river management, and technical methods

Governance

- Watershed and watercourse governance in Canada
- Governance approaches & challenges

9. Physiographic Considerations
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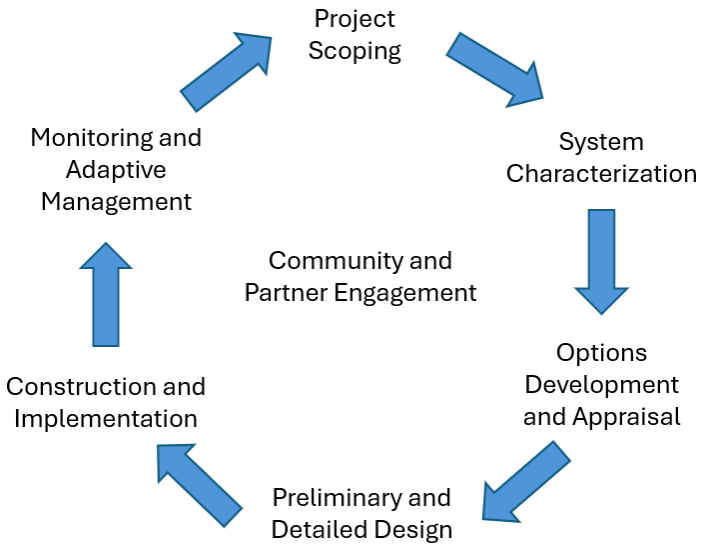
Chapter Leads: Allison Matfin & Mike Gallant

KERR WOOD LEIDAL consulting engineers

Chapter Content and Guidance:

- Framework for development and implementation of NBI in river systems
- Practical guidance for each step of the framework
- i.e. practitioners tasked with designing or implementing NBI can go to this chapter to help them formulate a project plan



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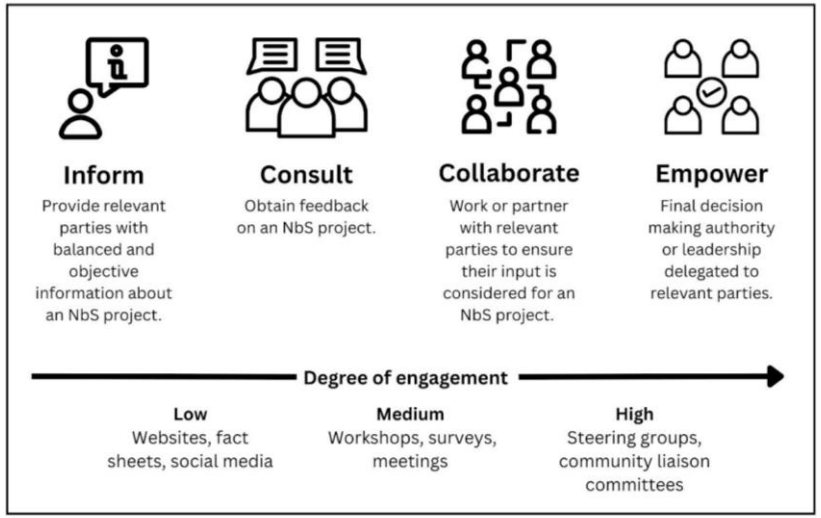
Chapter Leads: Keahna Margeson

DALHOUSIE UNIVERSITY

Chapter Content and Guidance:

- Guidance on including interested and affected people in NBI projects
- The importance of ethical engagement
- Understanding who should be engaged
- Methods, tools, and resources



adapted from IAP2, n.d and Ibrahim et al. 2025

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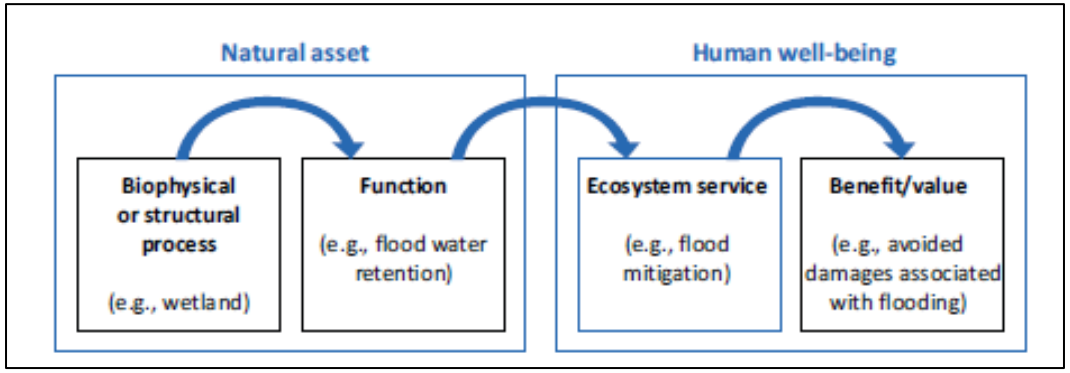
Chapter Leads: Joanna Eyquem

NATURE-ADAPT

Chapter Content and Guidance:

- Guidance on assessing value of natural assets
- Integrating natural assets into planning, design, management, and reporting



CSA Group (2023)

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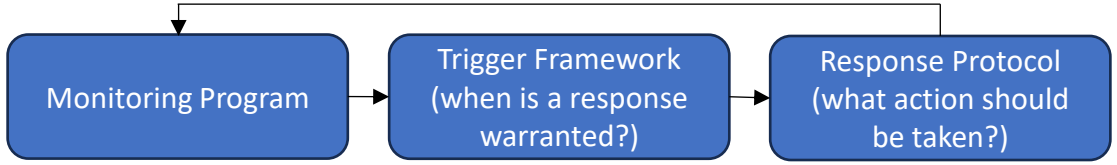
Chapter Leads: Greg Courtice

Applied Ecohydraulics

Chapter Content and Guidance:

- The benefits of adaptive management
- The importance of embracing uncertainty of natural systems in NBI initiatives
- Guidance on designing and implementing an adaptive management approach



Failure caused by challenging construction conditions

Reconstructed bank protection with design modifications

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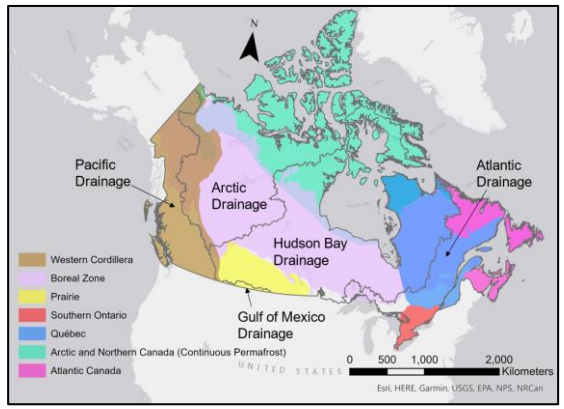
Chapter Leads: Ivana Vouk & Sean Ferguson

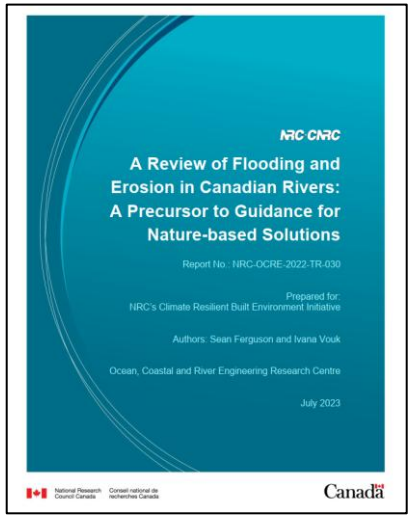
NRC·CNRC

Chapter Content and Guidance:

- Description of different physiographic regions in Canada
- General description of factors affecting flooding and erosion
  - Climate (precipitation, temperature, etc.)
  - Channel Morphology
  - Vegetation
  - Urbanization



Ferguson & Vouk (2023)



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Chapter Leads:
Sally Betts, Bruce MacVicar & Elli Papangelakis

Credit Valley Conservation

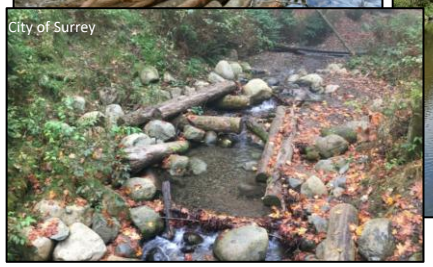
University of Waterloo

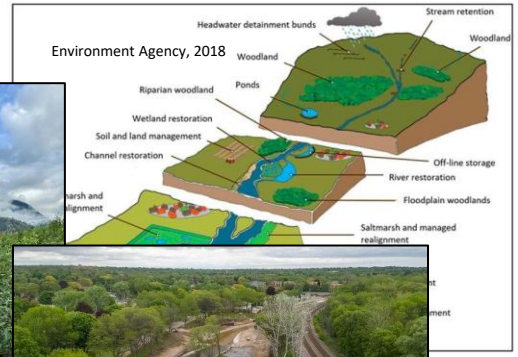
McMaster University

Chapter Content and Guidance:

- Technical chapters describing, at each scale:
  - What should be considered?
  - What can be done to manage flooding and erosion?

- System connectivity
- Stressors and impacts
- Hydraulic and geomorphic processes
- NBI approaches
- Best practice





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Chapter Leads: Allison Matfin & Mike Gallant

KERR WOOD LEIDAL consulting engineers

Chapter Content and Guidance:

- Practical and logistical guidance related to the design and construction of NBI including, but not limited to:

Design

- Establishing risk tolerance
- Regulatory requirements
- Long term management and maintenance
- Design tools and techniques

Construction

- Contractor selection
- Budgeting considerations
- Sourcing and installing materials and vegetation
- Construction equipment and methods

Figure: Importance of Following the Recommended Planting Schedule (KWL, 2024)

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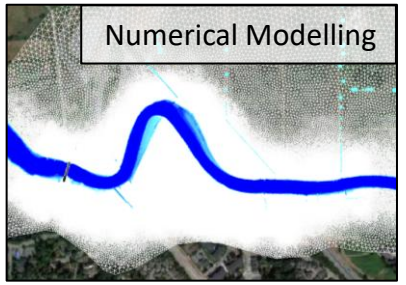
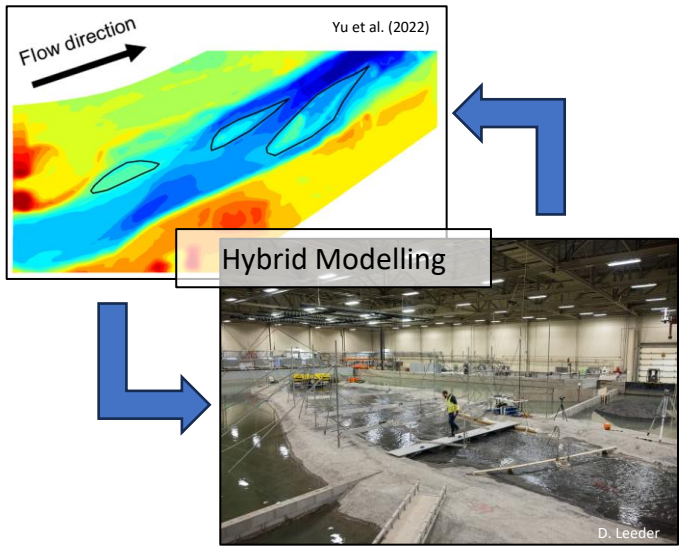
Chapter Leads: Colin Rennie

uOttawa

Chapter Content and Guidance:

- Modelling tools and techniques to support design and assess performance of NBI
- Modelling complexity required
- Specific considerations for NBI:
  - Morphodynamic models
  - Habitat suitability models
  - Representing vegetation





9. Physiographic Considerations
10. Watershed Considerations & Approaches
11. Floodplain Considerations & Approaches
12. Channel Considerations & Approaches
13. Design & Construction
14. Modelling
15. Monitoring
16. Case Studies

Guideline Development

1. Introduction
2. Principles & Concepts
3. Existing Guidance
4. Governance
5. Implementation Framework
6. Engagement
7. Management & Valuation of Assets
8. Adaptive Management

Chapter Leads: Christina Bright

Toronto and Region Conservation Authority

Chapter Content and Guidance:

- Monitoring purposes
  - Establishing baseline conditions
  - Monitor post-construction performance
- Monitoring tools and techniques at different scales
  - Watershed
  - Floodplain
  - River reach
  - Point

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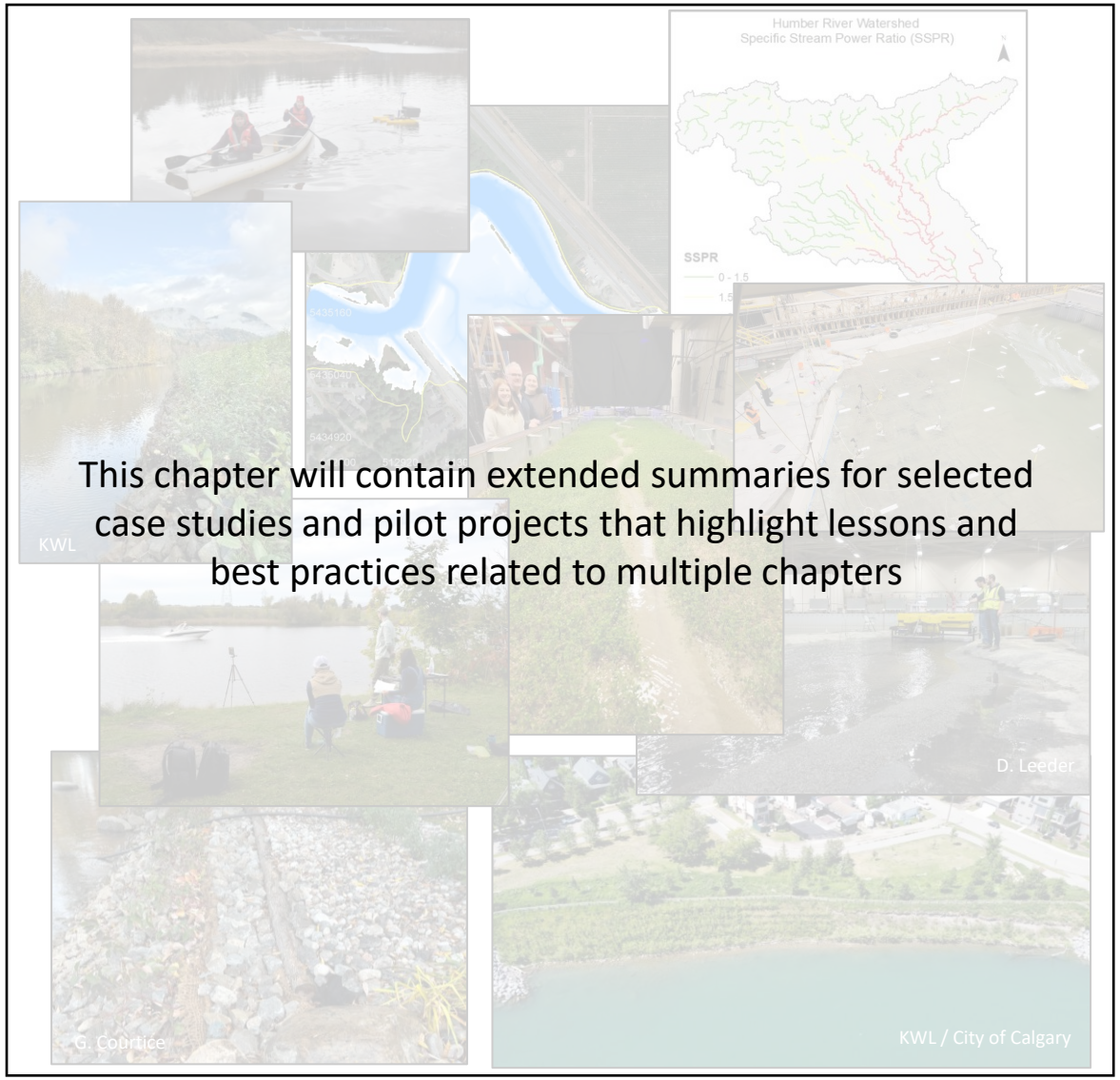

This chapter will contain extended summaries for selected case studies and pilot projects that highlight lessons and best practices related to multiple chapters

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Conclusions

Guideline

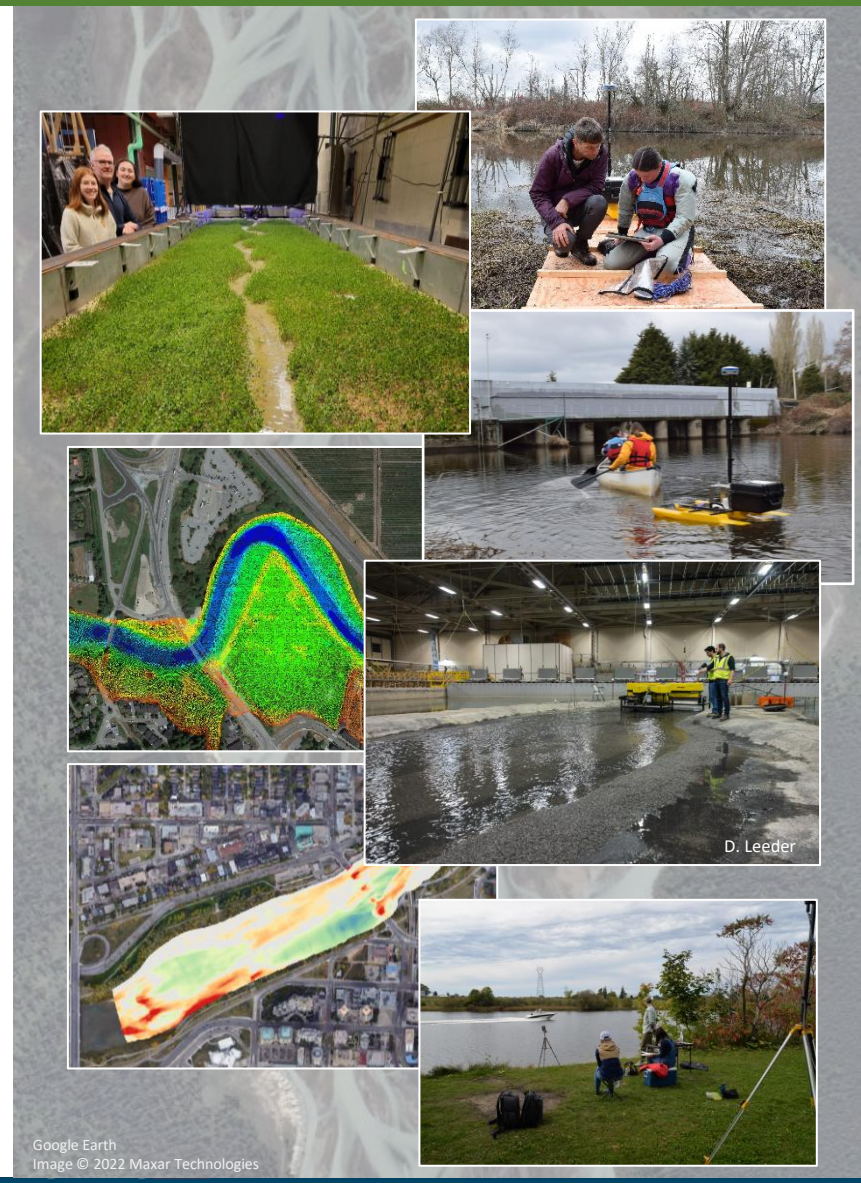
- Guideline development well underway in collaboration with project partners and collaborators
- Leadership from 10 different organizations
- Contributions from approximately 40 contributors from 23 different organizations

Pilot Projects and Case Studies

- Guideline content is based, in part, on knowledge and lessons learned from approximately 25 pilot projects and case studies
- Six projects were supported by NRC-OCRE through this initiative on NBI
  - 19 conference materials
  - 2 graduate theses
  - 2 technical reports
  - 1 journal paper
  - More publications underway

Future Work

- Finalize guideline (copyediting, translation, publication)
- Pursue additional pilot project collaborations to address remaining gaps (e.g. NBI applications and considerations in cold regions)



Managing Flood and Erosion Risk in Canadian River Systems using Nature-Based Infrastructure:

A Canadian Guideline for Design and Implementation

Thank You

Contributing to a

Climate Resilient Built Environment

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National Research Council Canada
Ocean, Coastal and River Engineering

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