#### **NCCNC**

## Applied Research to Guide Engineering With Nature on the Great Lakes

Presentation for Engineering with Nature Great Lakes Playbook Workshop Enda Murphy & Scott Baker Ocean, Coastal & River Engineering 24 January 2023



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## Coastal Flood & Erosion Risk on Great Lakes

#### Canada's disaster aid system is overwhelmed, leaving victims to rebuild on their own

For more than 50 years, homeowners and businesses hit by fires, floods or storms have had a federal program to help governments decide who pays for the cleanup. Climate change is exposing its weaknesses and renewing talk of big changes to come

Globe & Mail (2022)

#### Canada: Top 10 Natural Disasters for Insurance Payouts









Source: IBC Facts Book, PCS, CatrQ, Swiss Re, Munich Re & Deforme Values in 2021\$ CAN

## **Engineering With Nature Approaches (or NbS)**

Simultaneously address multiple government policy priorities, e.g.:

- ✓ Climate mitigation
- ✓ Climate adaptation
- ✓ Disaster risk reduction
- ✓ Biodiversity

Accepted and proven internationally (NNBF Guidelines)

Canada's National Adaptation Strategy objectives (Jan 2023):

The use of nature-based solutions is accelerated to increase resilience, reduce reliance and stress on grey infrastructure, increase social benefits of nature.

Underutilized in Canada



## Knowledge Gaps and Research Needs



https://www.csagroup.org/article/research/na ture-based-solutions-for-coastal-andriverine-flood-and-erosion-risk-management/



#### STANDARDS RESEARCH

Nature-Based Solutions for Coastal and Riverine Flood and Erosion Risk Management

October 2021

# Nature-based Infrastructure for Coastal Resilience and Risk Reduction





#### **Growing Technical Communities of Practice and Guidance**

Symposium and workshop in Halifax, June 2022: https://www.transcoastaladaptations.com/news/workshop-series-2022

Cold Regions Living Shorelines Community of Practice – Great Lakes Chapter:

 First chapter meeting 13<sup>th</sup> February (<u>rachael.f.taylor@noaa.gov</u> or <u>glcoldregions@gmail.com</u>)

Design guide under development:

- Build on existing guidance, adding detail, Canadian context, and case studies
- Special session at Coastal Zone Canada Conference















#### **Transferable Concepts, Knowledge, and Solutions**







# Transferable Concepts, Knowledge and Solutions





### RESEARCH SUPPORTING EWN PROJECTS ON THE GREAT LAKES

#### **Lakeview Waterfront**

- Shoreline rehabilitation and flood protection
- Restore habitat and improve public linkages
- Use of clean fill from regional infrastructure projects







#### **Lakeview Waterfront - Concept**

- 1.5M m<sup>3</sup> fill
- Habitat features with stabilizing control structures, coastal wetlands
- Headland with armored revetment
- Cobble beaches
- 3 offshore island



#### Lakeview Waterfront – Physical Modelling

- 1:35 scale physical model
- NRC's 50m x 30m Large Area Basin (Ottawa, Canada)
- Tested range of storm wave conditions (moderate to extreme)
- Verify and optimize stability of beaches and control structures
- Reduce design uncertainty and risk



#### **Lakeview Waterfront - Observations**

- Verification of beach material size distribution, steep berm formation in exposed areas
- Beach alignments adjusted to achieve better equilibrium





#### **Lakeview Waterfront - Observations**

- Optimization of armor stone sizing, reduced crest elevation
- Identification of areas prone to scour and erosion





#### **Lakeview Waterfront – Benefits**

- Estimated project cost savings of \$3 million compared to EA costing (more than 10x modelling costs)
- Identification of potentially problematic aspects to be addressed through final design
- Cost savings + design optimization = reduced project risk



#### **Scarborough Waterfront**

- Scarborough Bluffs, ~11km of shoreline along Lake Ontario
- SWP headlands, sand and cobble beaches, wetlands, naturalized coastal features to promote shoreline stability and provide recreational opportunities to the public



#### **Scarborough Waterfront**

- Optimized South Headland design to:
- Prevent siltation of the harbor entrance
- Improve the design elements in terms of flood resilience, overtopping, stability performance, and cost under a range of storm conditions and lake levels





#### **Scarborough Waterfront**

- Optimized North Shoreline design to:
- Provide a buffer of beach at the toe of the bluffs (maintain shore stability)
- Improve the layout and design of the rubblemound features and the planform of the beach to provide a stable yet natural appearance under a range of storm conditions and lake levels



#### **Concluding Thoughts**

- EWN approaches can play a much greater role in managing coastal flood and erosion risk on Great Lakes shorelines, while delivering multiple co-benefits
- System-based decision-making frameworks (e.g. Shoreline Management Plans) needed to guide strategic deployment and identify opportunities for hybrid (green-grey) solutions
- Leverage concepts and lessons learned from projects in comparable settings to facilitate technology transfer – benefits of bi-national collaboration
- Effective EWN solutions require **multi-disciplinary teams** opportunities to collaborate
- Targeted, applied research can inform and **de-risk** EWN solutions on the Great Lakes
- **Technical guidance** has an important role to play mainstreaming, promoting confidence in solutions, and supporting effective decision-making



#### THANK YOU!

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## References

- Baker, S., Murphy, E., Cornett, A., & Knox, P. (2022). Experimental study of wave attenuation across an artificial salt marsh. *Frontiers in Built Environment*, 8.
- Baker, S., Murphy, E., & Cornett, A. (Accepted). Experimental investigation of wave interactions with hybrid dyke-marsh systems. *ICE Breakwaters 2023*, UK.
- Caldera, G., Stolle, J., Pham Van Bang, D., Cornett, A., Murphy, E., & Nistor, I. (2022). Wave attenuation of saltmarsh vegetation under storm conditions. *International Conference on Coastal Engineering*, Sydney, December 2022.
- Ghodoosipour, B., Rahman, A., Knox, P., Cornett, A., & Murphy, E. (2022). Experimental investigation of wave and current interactions with immature *Spartina alterniflora* salt marsh canopies. *39<sup>th</sup> IAHR World Congress*, Granada, June 2022.
- Henteleff, R., Markov, A., Nistor, I., & Mohammadian, A. (2022). Flexible fluid-structure interacton model of a plant for nature-based solutions. *International Conference on Coastal Engineering*, Sydney, December 2022.
- Markov, A., Henteleff, R., Stolle, J., Nistor, I., Murphy, E., & Cornett, A. (2022a). Characterizing Live Vegetation Response to Wave Forcing: A Prototype-scale Flume Experimental Program. *39<sup>th</sup> IAHR World Congress*, Granada, June 2022.
- Markov, A., Muller, M., Baker, S., Nistor, I., Murphy, E., Stolle, J., & Cornett, A. (2022b). New insights on using scaled marsh plant surrogates for wave attenuation. *International Conference on Coastal Engineering*, Sydney, December 2022.
- Provan, M., Murphy, E., Rahman, A., Morris, E., & Matfin, A. (Accepted) Experimental study of edge stabilization features and interactions with sediments and debris on a Living Dyke. *Coastal Sediments* 2023, New Orleans.
- Rahman, A., & Murphy, E. (2022). Modelling storm wave impacts and interactions with nature-based features at Metlakatla. *Natural and Nature-based Infrastructure for Coastal Resilience Symposium*, Halifax, 27 June 2022.
- Sirianni, D., Nistor, I., Rennie, C., Cornett, A., Murphy, E., Baker, S., & Hnatiw, D. (2022). Effect of gravel particle size on the reshaping of dynamic revetments. *International Conference on Coastal Engineering*, Sydney, December 2022.
- van Proosdij, D., Murphy, E., Cornett, A., Nistor, I., Mulligan, R., Côté, M., Stolle, J., Knox, P., Baker, S. (2022). Collaborative Living Laboratories to inform Canadian Design Guidance for Nature-based Solutions. *International Conference on Coastal Engineering*, Sydney, December 2022.
- Vouk, I., Pilechi, V., Provan, M., & Murphy, E. (2021). *Nature-Based Solutions for Coastal and Riverine Flood and Erosion Risk Management.* Canadian Standards Association.