NATURE-BASED INFRASTUCTURE MODELLING IN AN INTERTIDAL ENVIRONMENT EXPOSED TO STORM SURGES

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INTRODUCTION AND SITE DESCRIPTION
Boundary Bay is an intertidal embayment on the eastern coast of the Salish Sea in British Columbia, Canada. Topographically steered winds result in the focusing of storm surges and wind-driven surface waves into this bay, across the mud flats, and into tidal channels and salt marshes. The bay is rimmed by a network of coastal dykes, which provide some coastal flood protection to communities, infrastructure, and agricultural land. However, the rapidly changing climate is driving rising sea and groundwater levels and coastal erosion. Without intervention, these climate-driven processes are expected to result in coastal squeeze, overtopping, and eventual dyke failure in Boundary Bay. Rather than continually reinforce the existing dykes, a local government and First Nation partnership has initiated the construction of a nature-based solution pilot, which aims to stimulate wave attenuation and prevent landward flooding. (City of Surrey 2022)

NATURE-BASED INFRASTRUCTURE
Nature-based Infrastructure and Solutions (NbI/NbS) integrate sustainable materials and techniques into coastline management, such as the living dyke pilot in Boundary Bay. The living dyke uses brushwood dams, oyster shell bags, vegetation, and thin layering of sediments to stabilize and raise the elevation of existing marshes and promote wave attenuation. This concept leverages the natural salt marsh's ability to sequester carbon and drive biodiversity while also preventing flooding and erosion. While the benefits of salt marshes have been widely studied, human-constructed nature-based designs, such as living dykes, are still novel and the long-term capabilities, especially when considering their response to the impacts of climate change, are not yet well understood. This is a key example of nature-based design explained in the Canadian Design Guide for NbI (Mulligan et al. 2023).

MODEL DESCRIPTION
This study implements a high-resolution two-way coupled flow-wave numerical model of Boundary Bay using Delft3D (Lesser et al. 2004) and SWAN to simulate water levels, storm surges, and waves. A high-resolution flexible mesh (FM) grid (1 km to 30 m) was developed, incorporating bathymetry derived from multibeam and Lidar surveys. The model is forced with a high-resolution spatially varied atmospheric model that incorporates the topographic steering of the surrounding landscape. At its offshore boundaries, the Boundary Bay model is forced with water levels and wave conditions output from a larger FM flow-wave model of the Salish Sea. Calibration of the hydrodynamic conditions is guided by in-situ data collected by sensors across the flat in two transects, including nearshore measurements at the dyke to observe the attenuation and wave breaking driven by the new infrastructure. After validation, the model is used to simulate potential future scenarios, including sea-level rise, infrastructure breach, and extreme storm events.

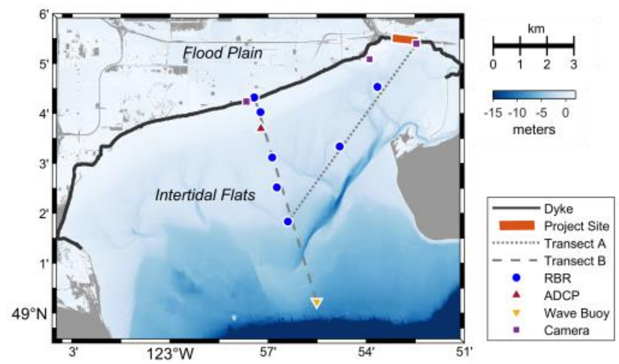

Figure 1 – Map of offshore hydrodynamic sensor locations in Boundary Bay, including pressure sensors (RBRs), acoustic Doppler current profilers (ADCPs), floating wave buoys, and digital cameras.

RESULTS
This study evaluates changing hydrodynamic conditions in an intertidal bay in response to a nature-based coastal dyke. The impacts of a variety of components of a 'living' vegetated dyke on wave attenuation are quantified. The impacts of sea-level rise and potential future extreme storm events on the performance of a living dyke design are simulated and discussed. Design recommendations for nature-based infrastructure and solutions in intertidal environments are presented.

REFERENCES
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