Making Room for Wetlands

TransCoastal Adaptations — Centre for Nature-Based Solutions | Saint Mary's University | CBWES CB Wetlands & Environmental Specialists | The Confederacy of Mainland Mi'kmaq | Carleton University

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Ce projet a été réalisé avec l'appui financier de :
Environment and Climate Change Canada / Environnement et Changement climatique Canada
Fisheries and Oceans Canada / Pêches et Océans Canada
Nova Scotia

PROJECT DESCRIPTION

Making Room for Wetlands (*MRFW*) is a climate change adaptation and tidal wetland restoration project focused on improving climate resiliency in dykeland communities, infrastructure, and agricultural lands. *MRFW* builds upon the successful implementation of managed realignment and the restoration of 30.1 ha of tidal wetland habitat in the first iteration of the project (2017-2022).

The projects are a partnership between TransCoastal Adaptations: Centre for Nature-Based Solutions at Saint Mary's University, CB Wetlands & Environmental Specialists, the Confederacy of Mainland Mi'kmaq, Carleton University, and the Province of Nova Scotia. It is funded by:

- DFO's Aquatic Ecosystem Restoration Fund
- ECCC's Nature Smart Climate Solutions Fund, and
- the Province of Nova Scotia.

PROJECT GOALS

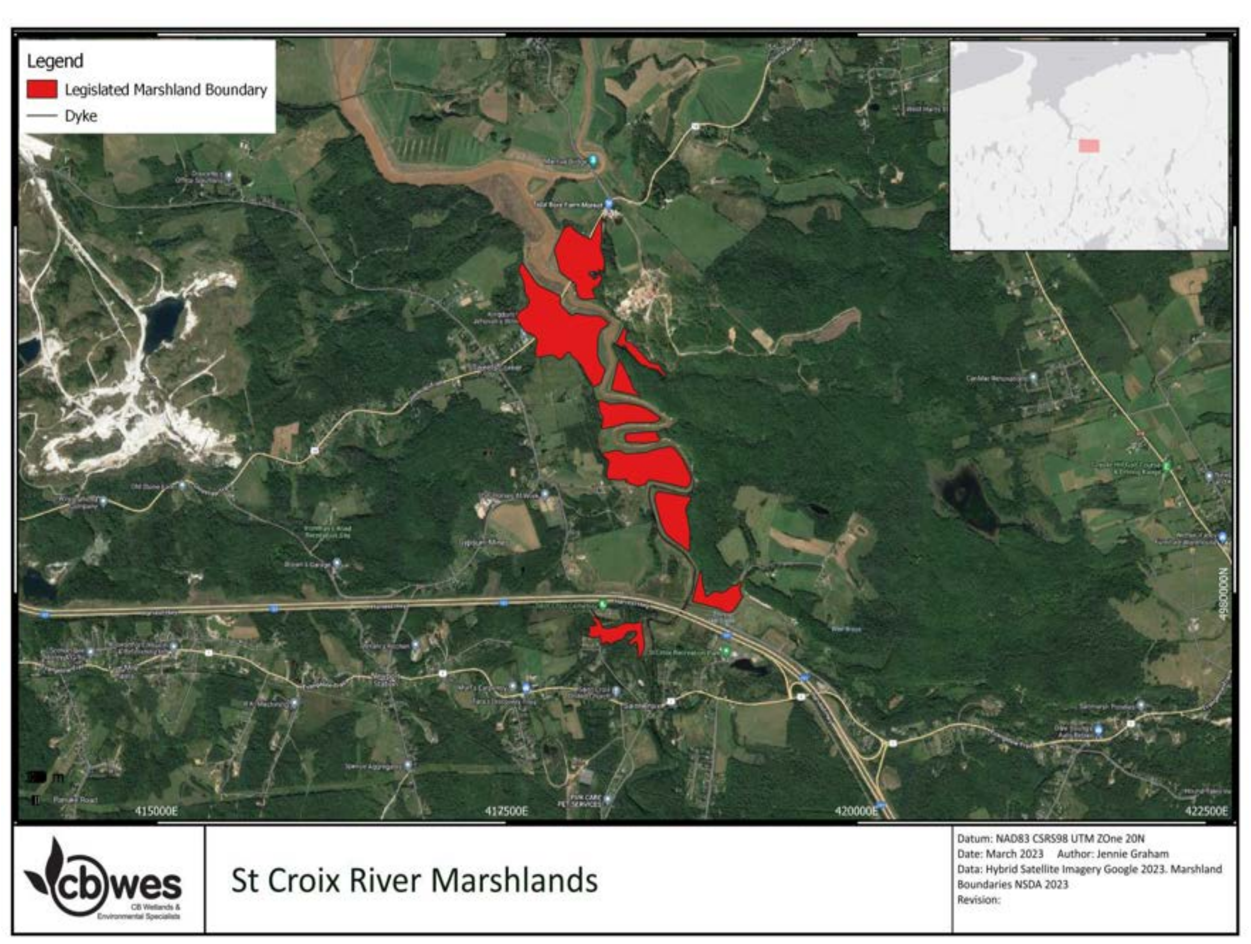
- Improve overall **dykeland climate resilience**, reducing flood and erosion risks;
- **Assess dykeland sites** in the Bay of Fundy;
- Decrease **greenhouse gas emissions**;
- Increase the **permanency of carbon stocks** in restored and foreshore marshes by providing room for natural landward migration;
- Integrate **Mi'kmaq knowledge** and **Two-Eyed Seeing** into the project framework; and
- Increase the total area of tidal wetland for **biodiversity conservation** and various other co-benefits.

The Belcher Street managed dyke realignment site featuring a new dyke (top right) after the tides were reintroduced in May 2018, and the site two years post-breach (bottom right). The top left shows the site pre-breach and the bottom left image shows the site one-year post-breach (CBWES Inc.).

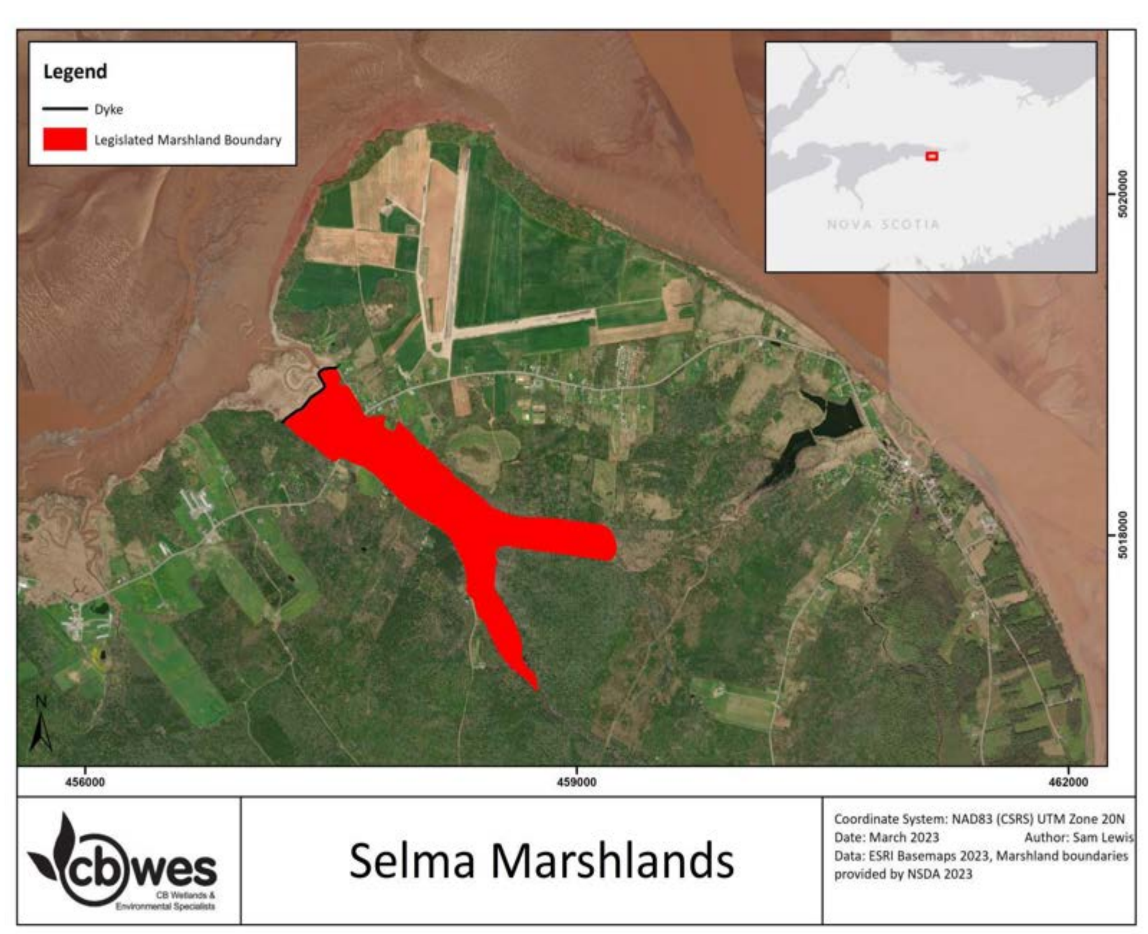
AREAS OF FOCUS

These projects include three main areas of focus:

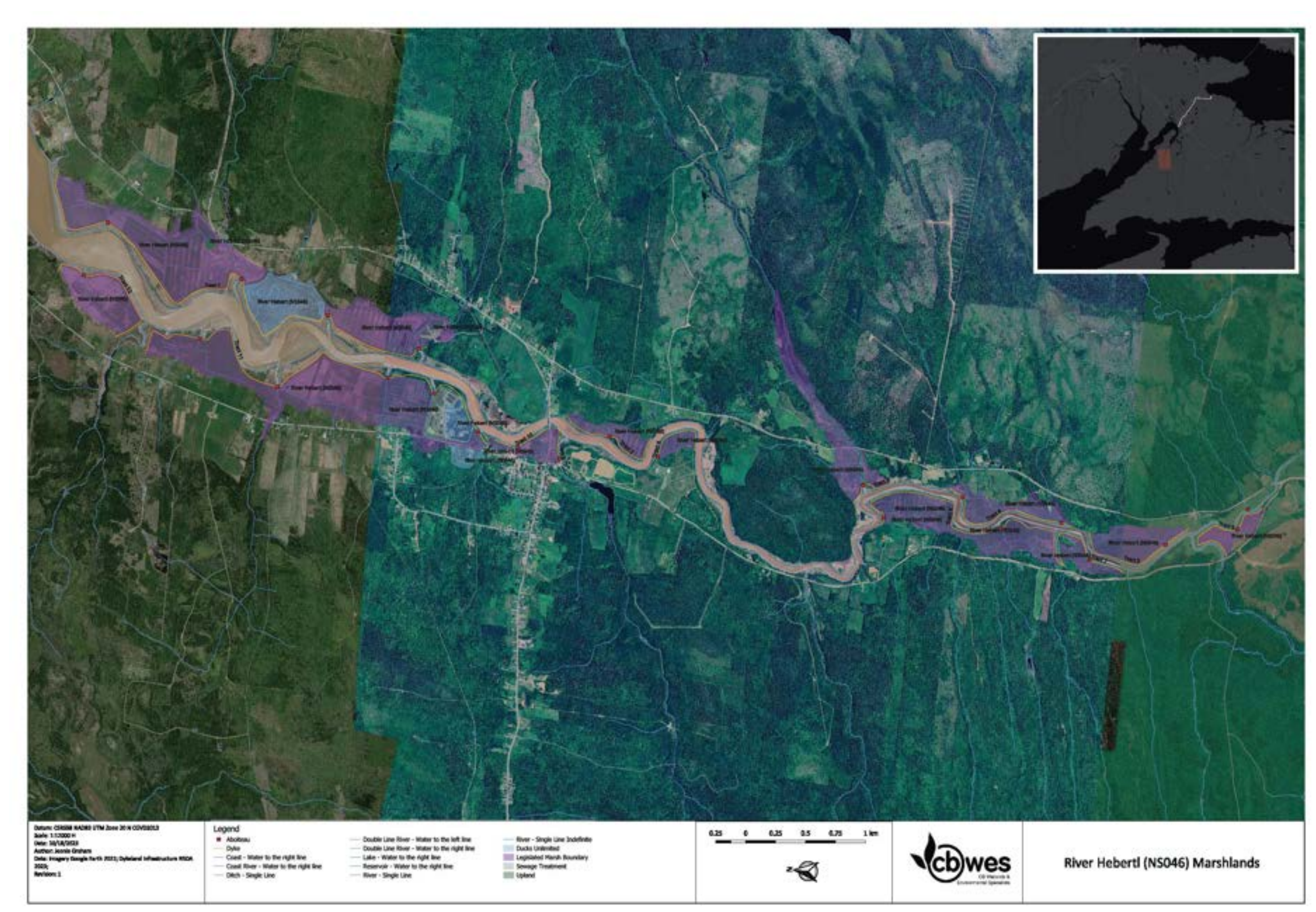
- Tidal wetland restoration in areas currently vulnerable to failure;
- Exploring the removal of vulnerable dyke sections as part of overall managed dyke realignment; and
- Improving agricultural drainage by reshaping fields and upgrading drainage systems.



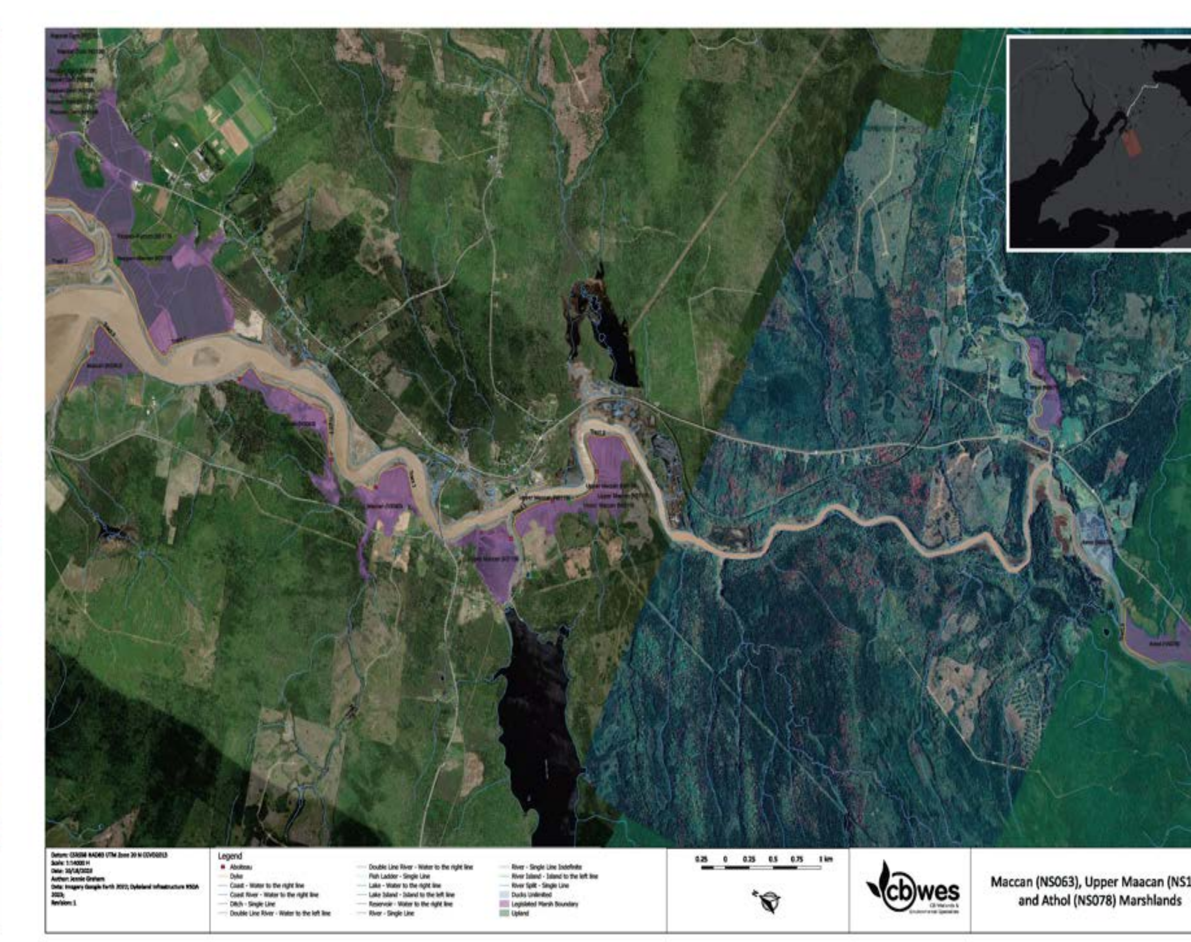
Location map of the legislated marshland boundary of the St Croix river (CBWES Inc.).



Location map of the legislated marshland boundary of the Selma estuary (CBWES Inc.).



Location map of the legislated marshland boundary of the River Hebert estuary (CBWES Inc.).



Location map of the legislated marshland boundaries of Maccan, Upper Maccan, and Athol (CBWES Inc.).

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Making Room for the River

Dykelands and Climate Change

Figure 1: High spring tide in St. Croix River at Trunk 14 on Sept. 29, 2023

- Bay of Fundy dykelands are highly vulnerable to the effects of climate change - subsidence, dyke elevations, aboiteaux.
- Dykeland system in Nova Scotia has 241 km of dykes and 250 aboiteaux – challenge to maintain all in current location with climate change.
- Relative sea level rise projections for Hantsport 0.33 m by 2055 and 0.90 m by 2100 (Daigle, 2016).

Figure 2: Dykelands drained by aboiteaux – one way gate

- Best practices internationally to mitigate the effects of climate change in dyked areas – combine grey with green infrastructure.
  - Provide room for the river to 'breathe' to allow to natural meandering of tidal rivers and increased capacity to absorb storm water.
  - Overall provides increased resiliency of dykeland systems.

Figure 3: Oblique aerial photo of realigned dyke at Belcher St. Marsh, Cornwallis River in Oct. 2022

Flooding

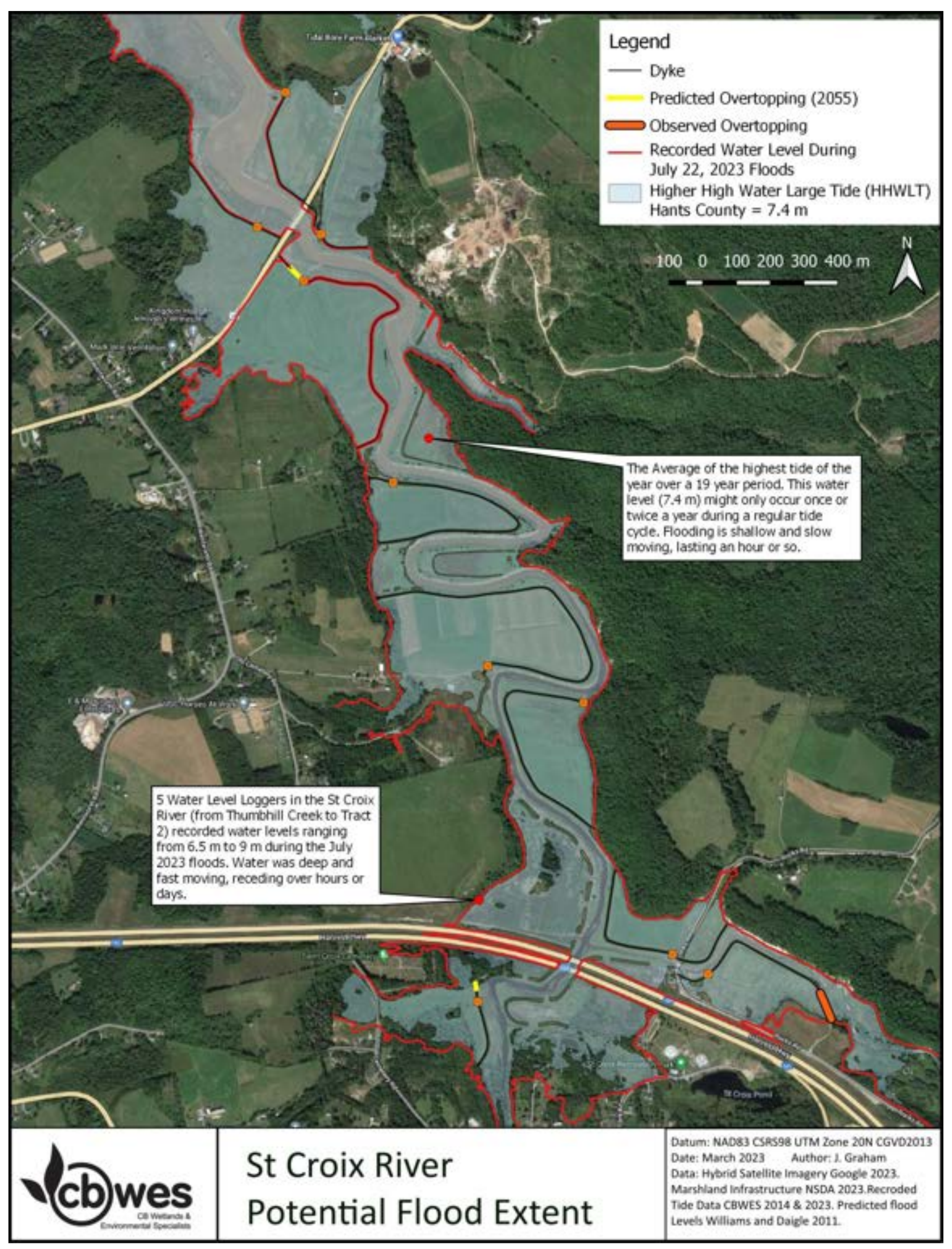

Figure 4: Modelled flood extent of HHWLT (7.4m CGVD2013) and July 22, 2023 flood event.

Figure 5: Freshwater flooding in St. Croix dykeland after tragic flooding on July 22, 2023 (photo taken July 23, 2023 by Graeme Matheson, NSDA)

- Dykelands in tidal river systems are vulnerable to flooding with intense rainfall events, made worse during high tides. They are also susceptible, but less so, to storm surge.
- Average annual precipitation is projected to increase by 14% for the 2051-2080 period (Windsor – www.climatedata.ca), and short duration, high intensity events will likely occur more often.
- Sea level rise increases high tide water levels over time

Erosion

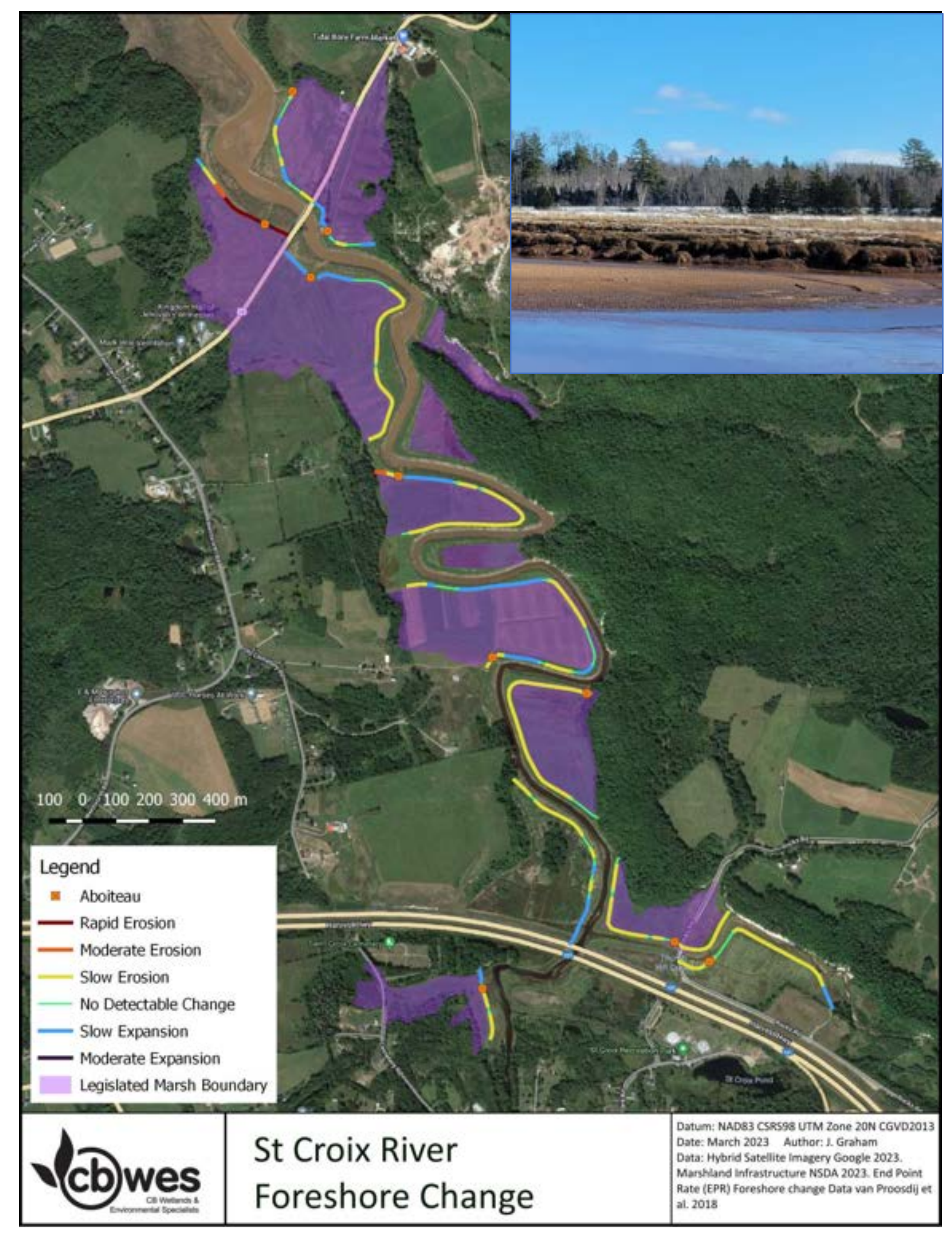

Figure 6: Foreshore marsh change rates based on historical aerial photos in GIS

Figure 7: Eroding foreshore marsh and vulnerable dyke section on Tract 4 (photo taken on July 27,2022 by Graeme Matheson, NSDA).

- Foreshore marsh provides a buffer for wave energy & erosion.
- Eroded material is transported & may form new marsh elsewhere
- Increasing space for marsh development is proven to protect dykes

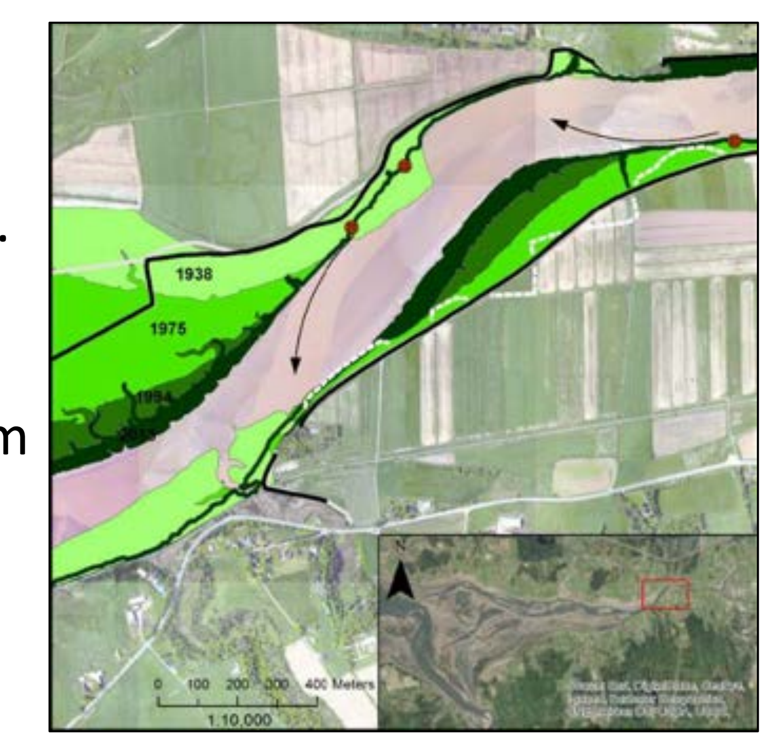

Figure 8: Example of foreshore marsh exhibiting cycles of erosion & growth

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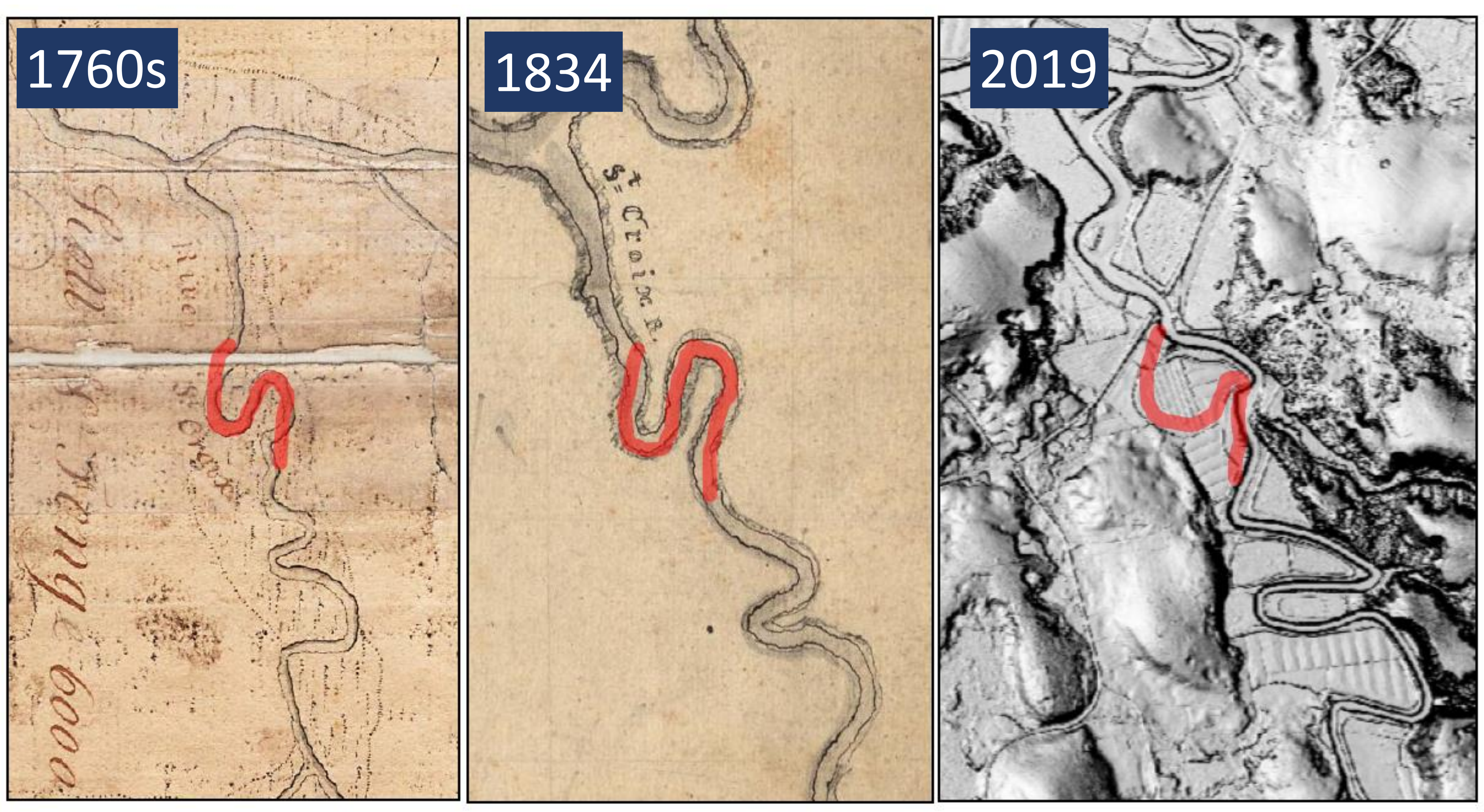
ARCHAEOLOGY

WHY?

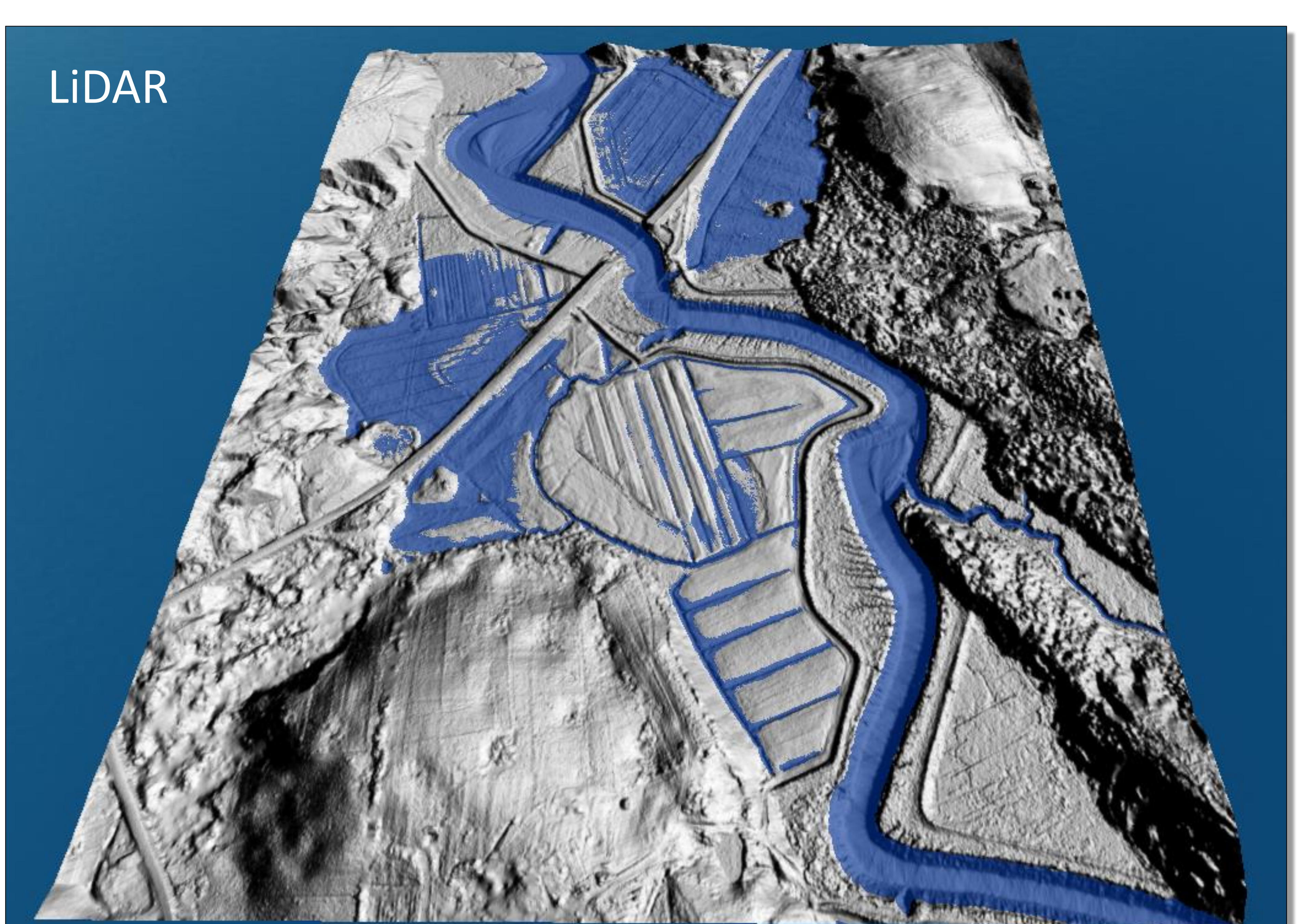
The **Archaeological Record** contains physical evidence of past human activity. It helps us to ***understand*** the past, often contributing information where written records are absent or incomplete. As part of our inheritance from previous generations, it is a valuable and non-renewable ***heritage resource***. We ***manage impacts*** to archaeological resources by studying them before undertaking construction.

UNDERSTANDING THE CHANGING ENVIRONMENT

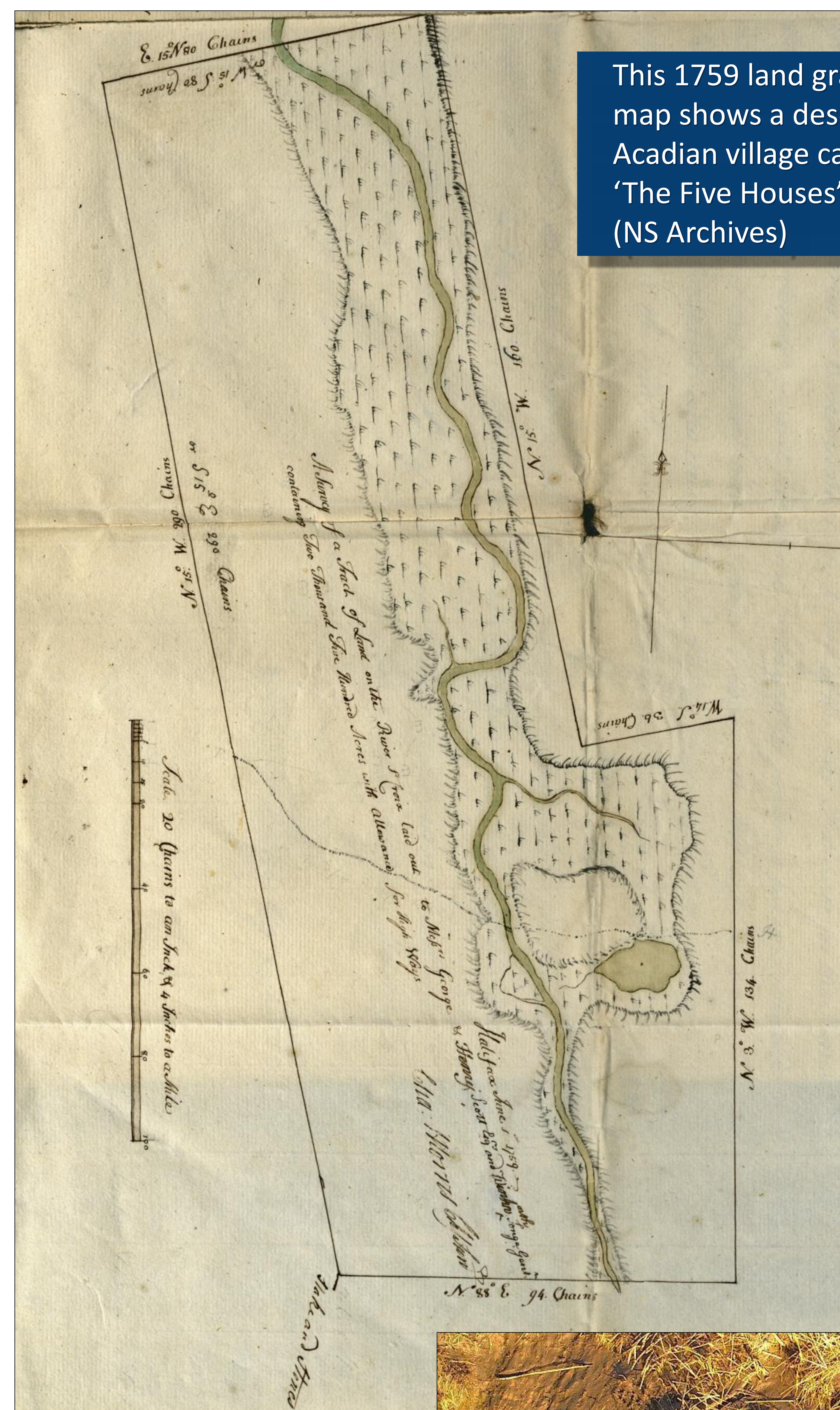


Historical maps indicate that the course of St. Croix River has changed considerably over time. Evidence of old dykes and aboiteaux preserved in the archaeological record show us that previous generations of farmers sometimes repositioned the dykes to respond to natural changes, withdrawing from areas subject to erosion and expanding into new areas of marsh development. (Province of Nova Scotia)

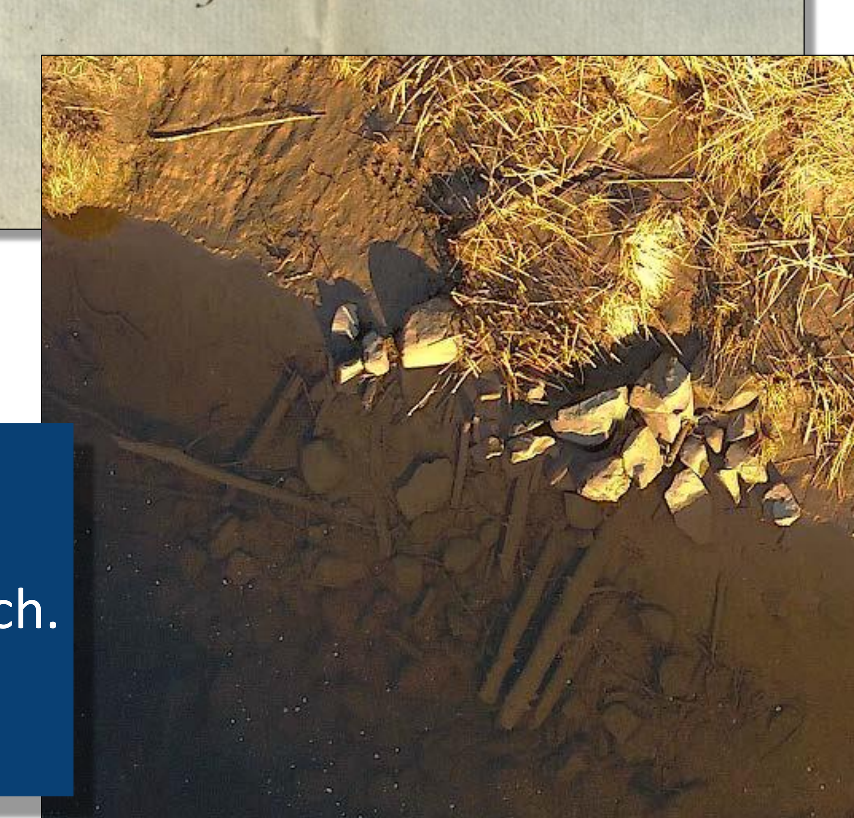
Light Detection and Ranging (**LiDAR**) uses lasers to map the surface of the Earth in great detail, allowing us to digitally remove vegetation, detect subtle landscape features, and measure and visualize elevation.



MAPPING PAST SETTLEMENTS



This 1759 land grant map shows a deserted Acadian village called 'The Five Houses'. (NS Archives)



Field surveys are an important part of archaeological research. We recorded this feature at Tract 11.

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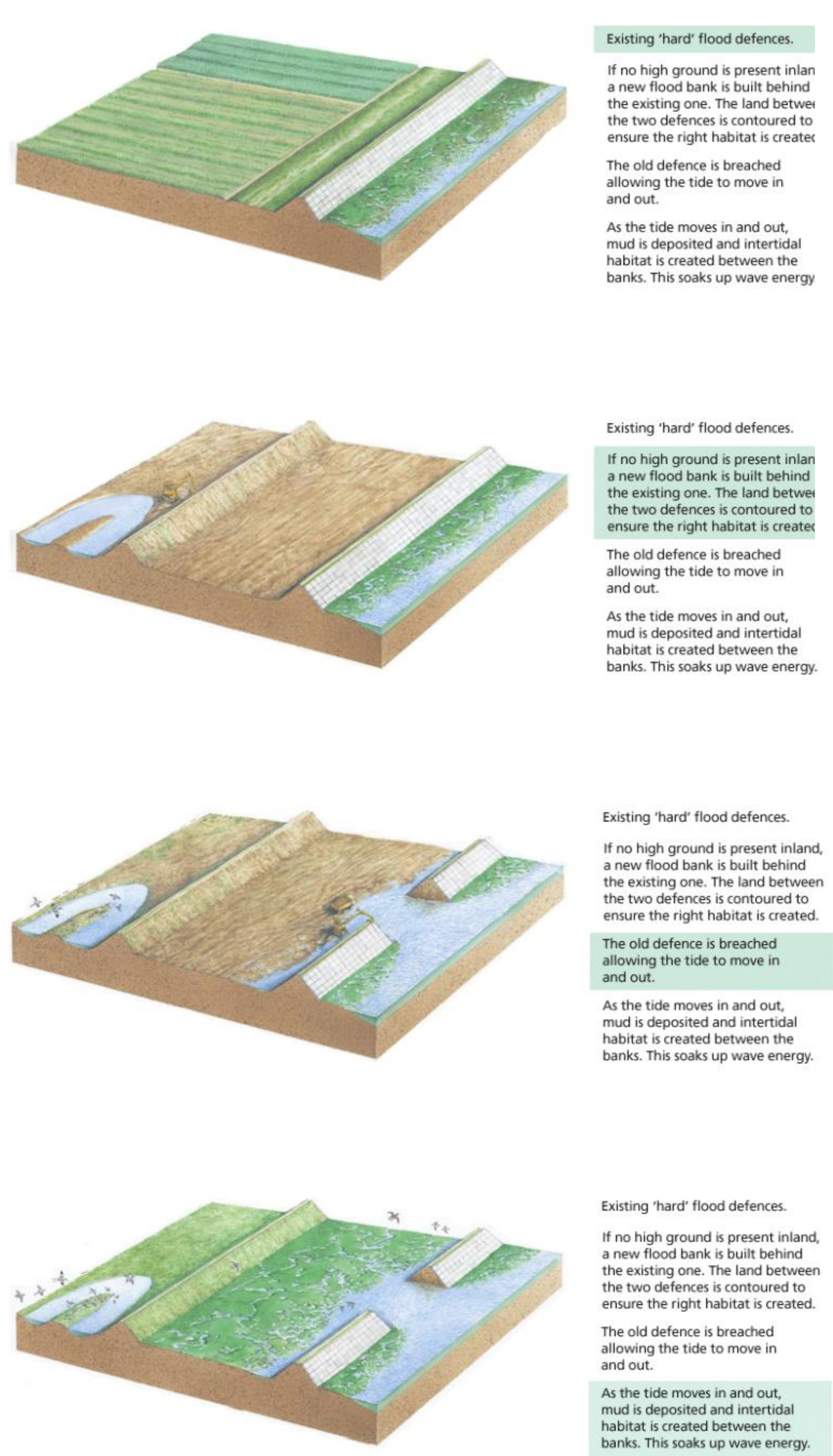
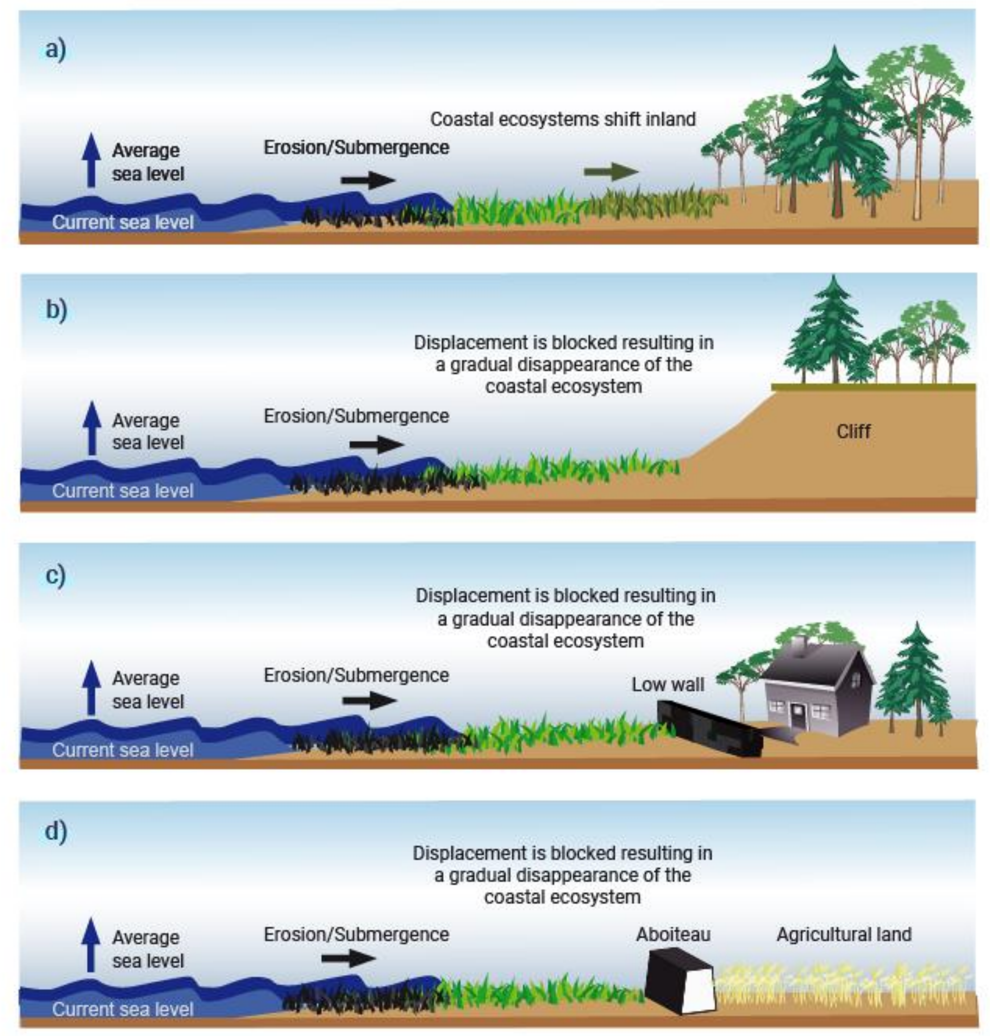
MANAGED DYKE REALIGNMENT (MR) AND TIDAL WETLAND RESTORATION

THE PROCESS OF MANAGED DYKE REALIGNMENT



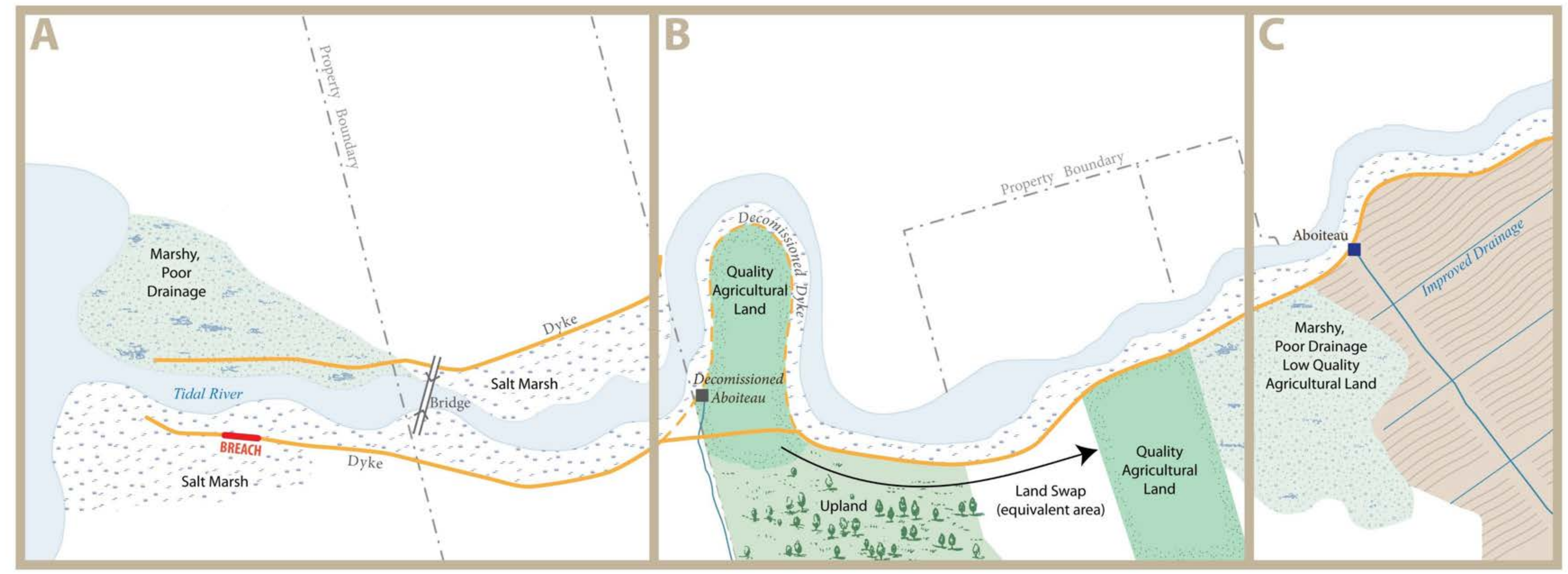
a) Existing agriculture dyke b) A new dyke is built c) The old dyke is breached d) Tides deposit sediment and a new tidal wetland is established (source: http://worldlywise.pbworks.com/w/page/15409213/Unit%201% 20Section%20B%20- %20Managing%20coastal%20areas).

COASTAL SQUEEZE



Bernatchez and Quintin, 2016

MANAGED DYKE REALIGNMENT AND AGRICULTURAL DYKELANDS



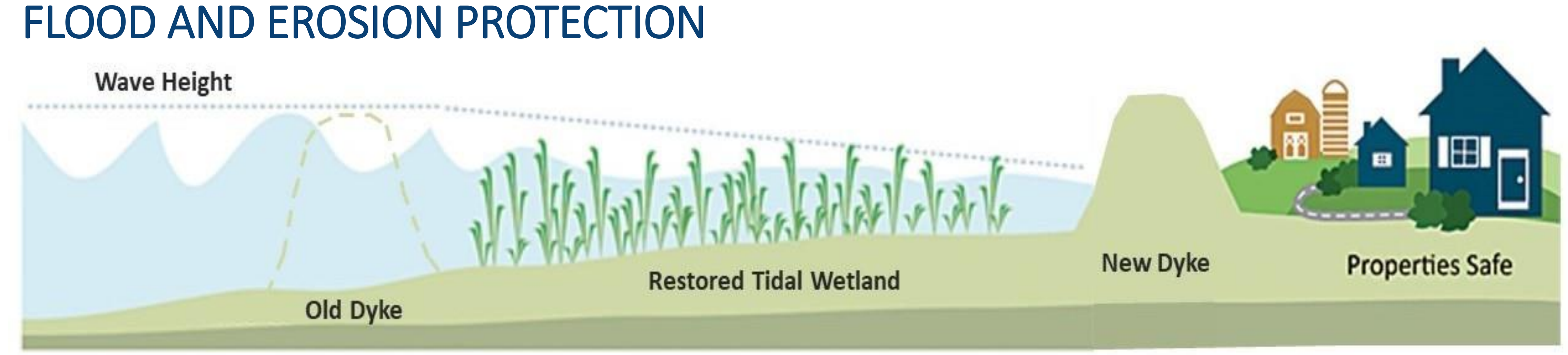
MR IN PRACTICE

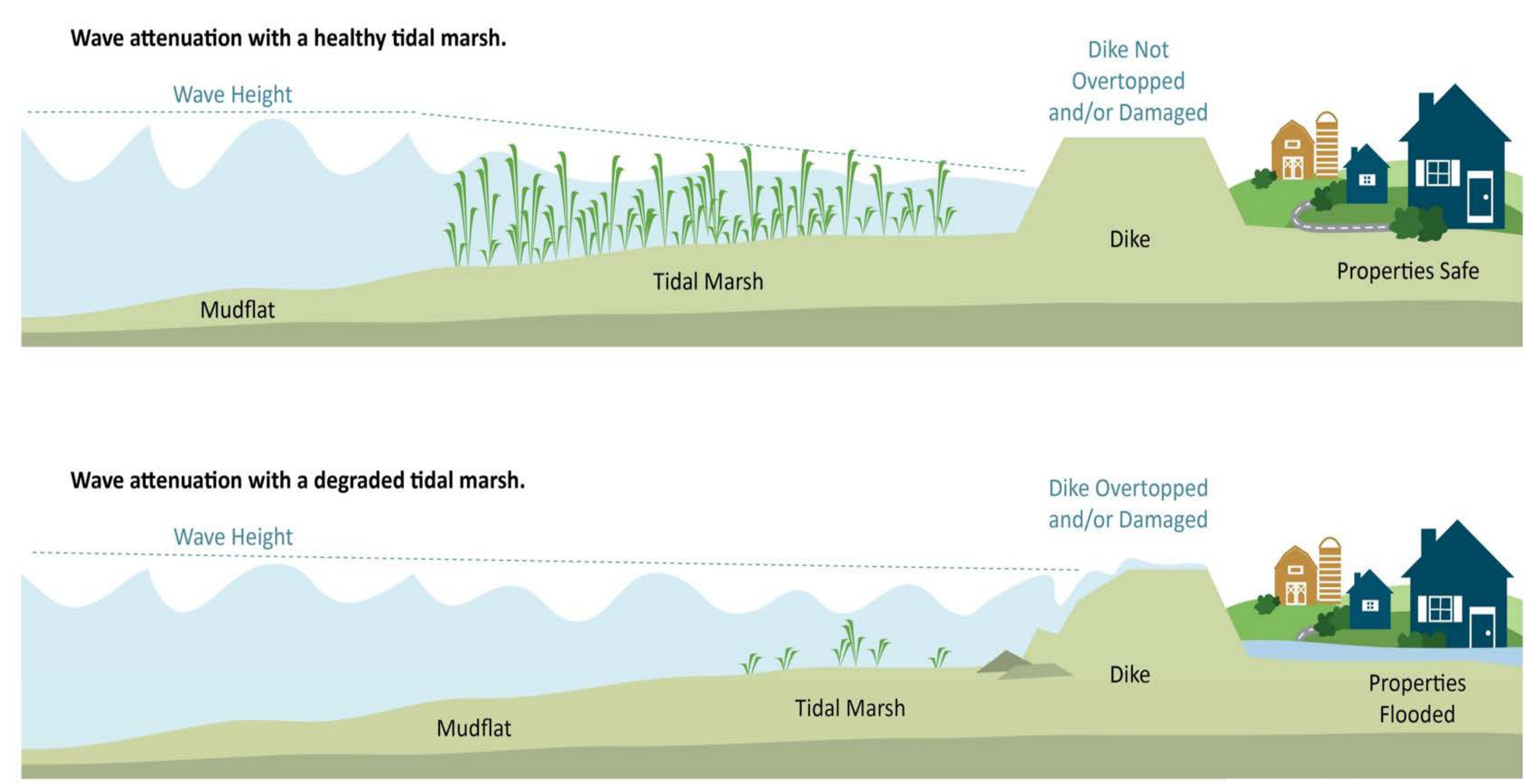

Left) Earthworks at the Belcher Street Marsh Managed Realignment Site, Right restored 2018, CBWES Inc.


Earthworks at the Ksu'ksw Mqoqt/Hemlock Marsh Managed Realignment Site, restored 2022, CBWES Inc.


Earthworks at the Converse Marsh Managed Realignment Site, restored 2019, CBWES Inc.

FLOOD AND EROSION PROTECTION

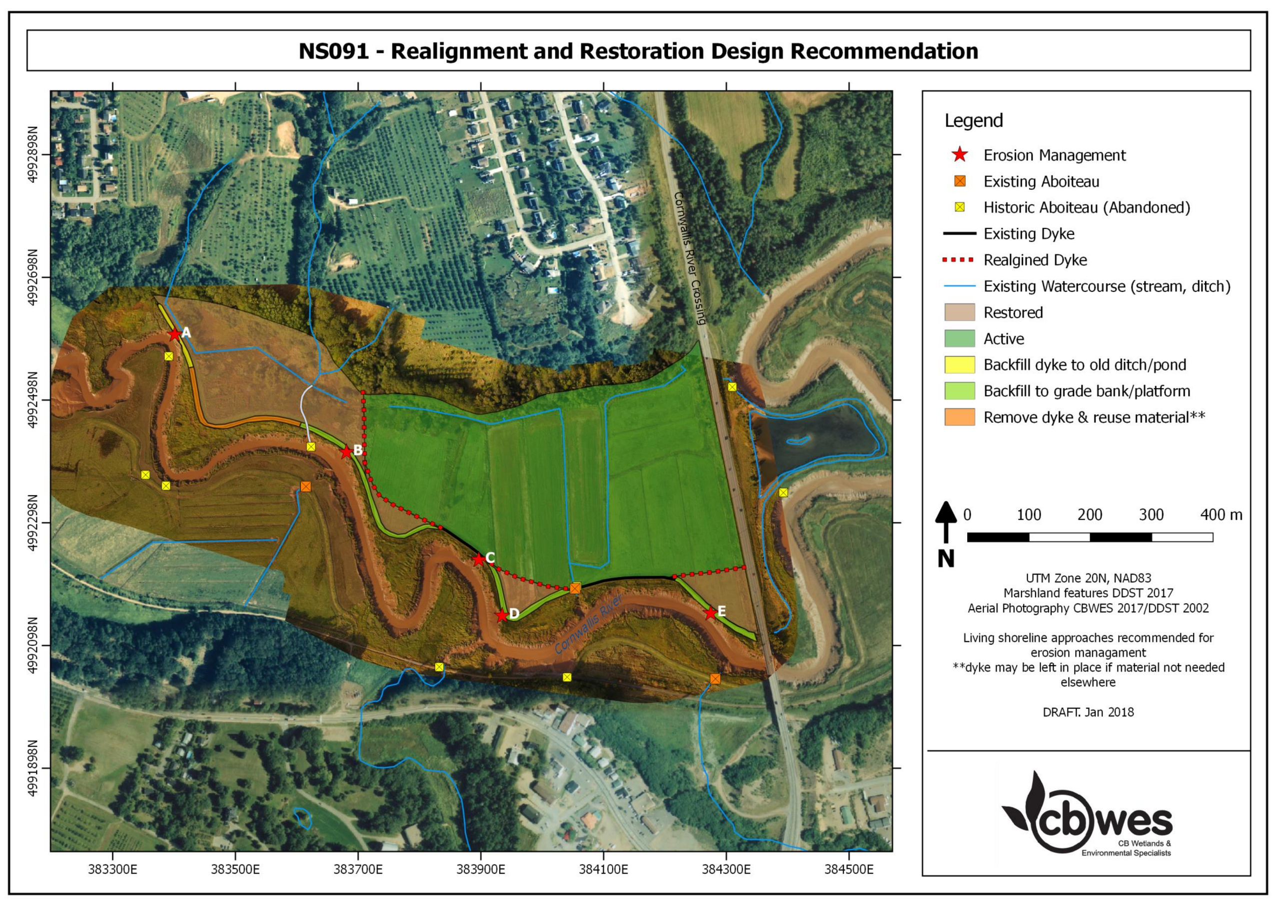




FEATURES AND BENEFITS OF TIDAL WETLANDS

BELCHER STREET MARSH MANAGED REALIGNMENT RESTORED 2018

BELCHER STREET MARSH MANAGED DYKE REALIGNMENT AND TIDAL WETLAND RESTORATION SITE



The Belcher Street Marsh is located on the Jijuktu'kwejk/Cornwallis River in Kentville. The site was realigned and restored in December 2018 to address erosion and loss of foreshore marsh, reduce flood risk to nearby towns, and increase resiliency of the system.

The managed realignment and restoration design also included a living shoreline design, to address areas of significant riverbank erosion.

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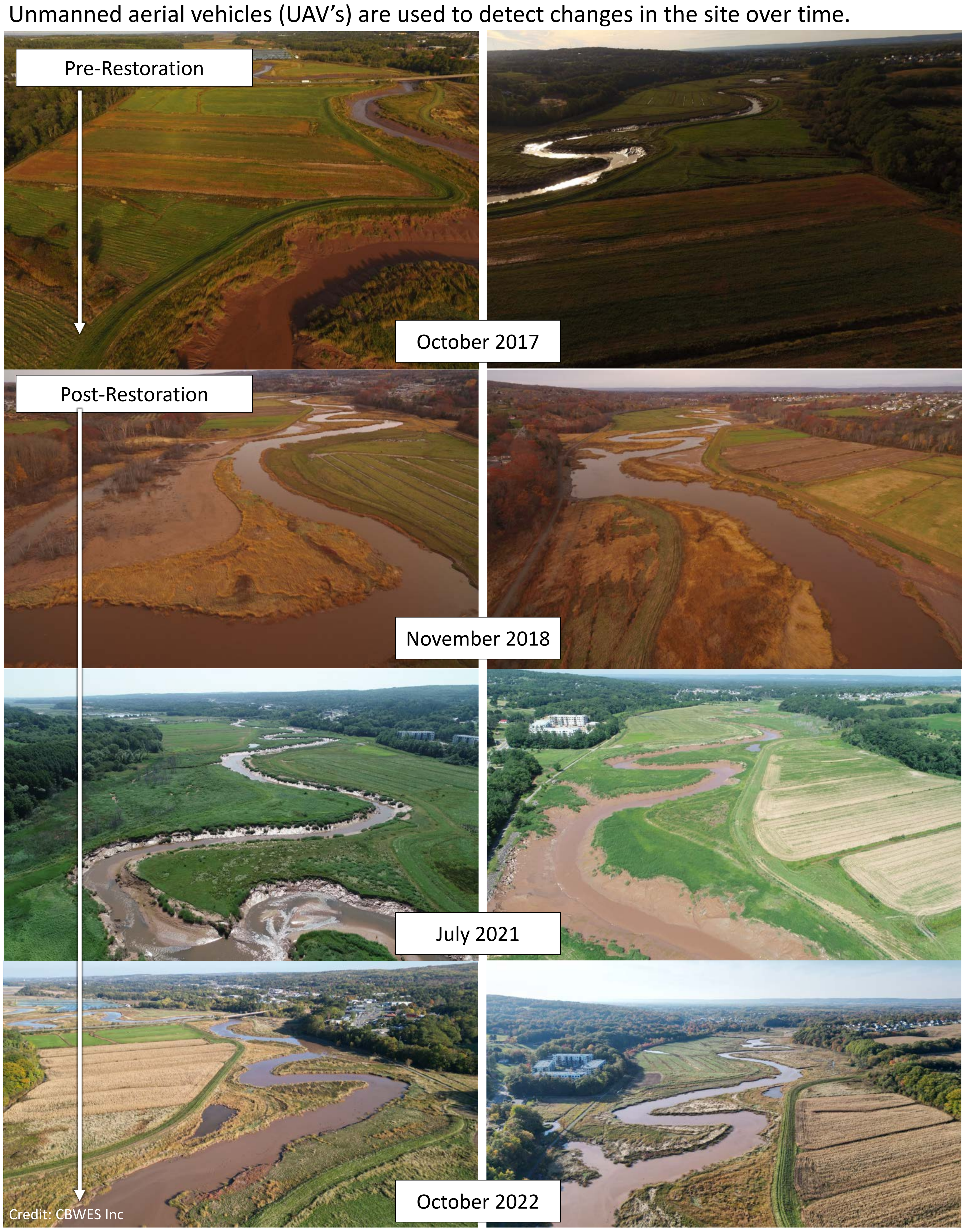
Funding (cash & in-kind) for this project has been provided by: Fisheries and Ocean's Canada's Coastal Restoration Fund, the Nova Scotia Department of Agriculture, CB Wetlands & Environmental Specialists, and Saint Mary's University.

RESTORATION PROGRESS

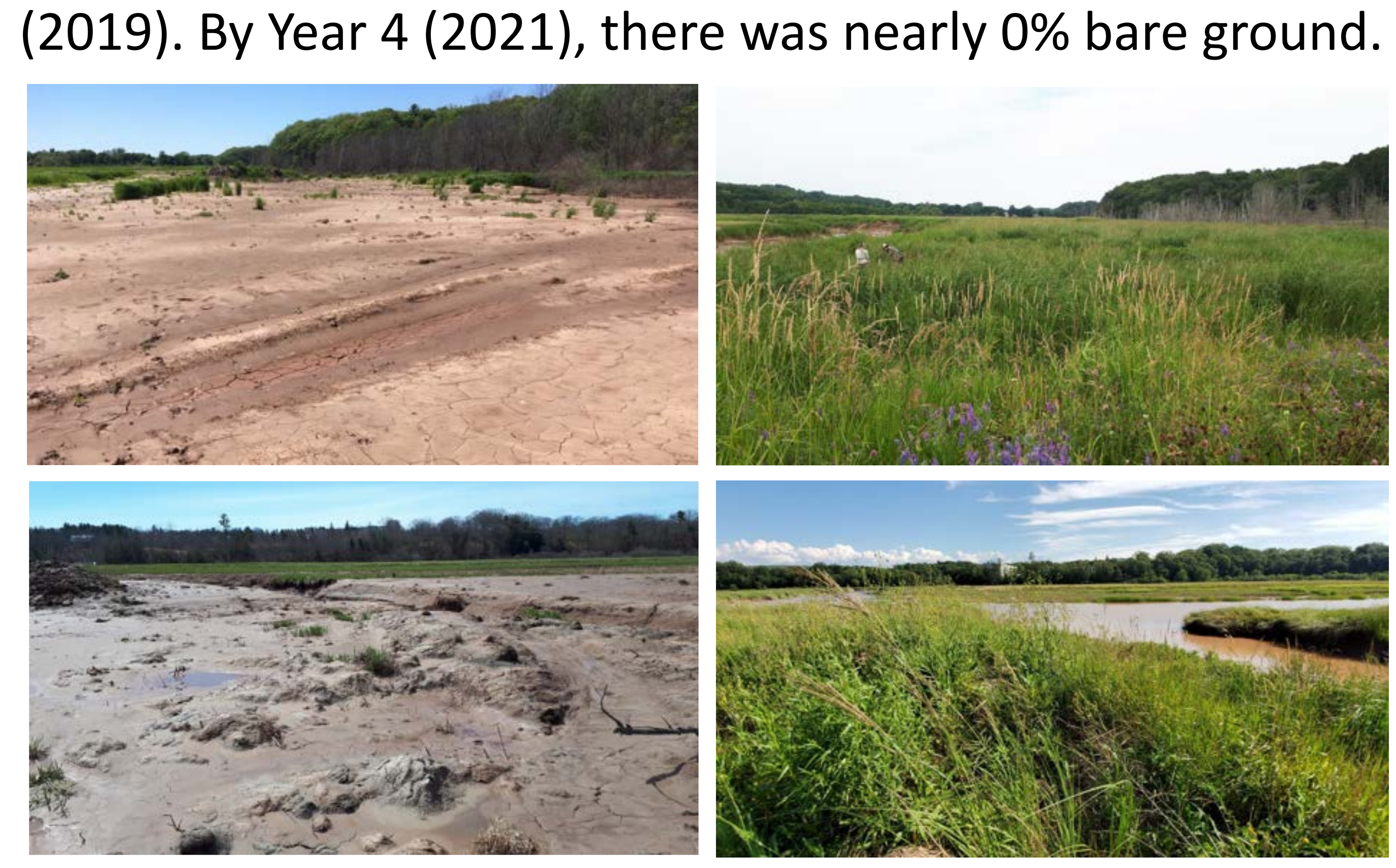
VIEW FROM ABOVE

Unmanned aerial vehicles (UAV's) are used to detect changes in the site over time.



RAPID REVEGETATION

The Belcher Street site went from being a mudflat in 2018 to only having 17% bare ground in Year 2 of restoration (2019). By Year 4 (2021), there was nearly 0% bare ground.



Top: Belcher Marsh platform (left) Year 2 post restoration, June 2019; (right) Belcher Marsh in Year 4 post restoration, July 2021. Bottom: Constructed tidal channel and vegetation (left) Year 2, April 2019; (right) Year 3, July 2020 (CBWES Inc).

LIVING SHORELINE AND ADAPTIVE MANAGEMENT

A hybrid living shoreline was installed at the Belcher Street Marsh to curtail erosion on a stretch of riverbank.

The living shoreline (left) November 2018 with visible root wads; (middle) July 2021 after adaptive management; (right) July 2019 adding evergreen trees to fill holes in root wads, in addition to adding silt and wattle fencing and planting native vegetation.

To address ponding water, a runnel was dug to connect to the larger drainage network.

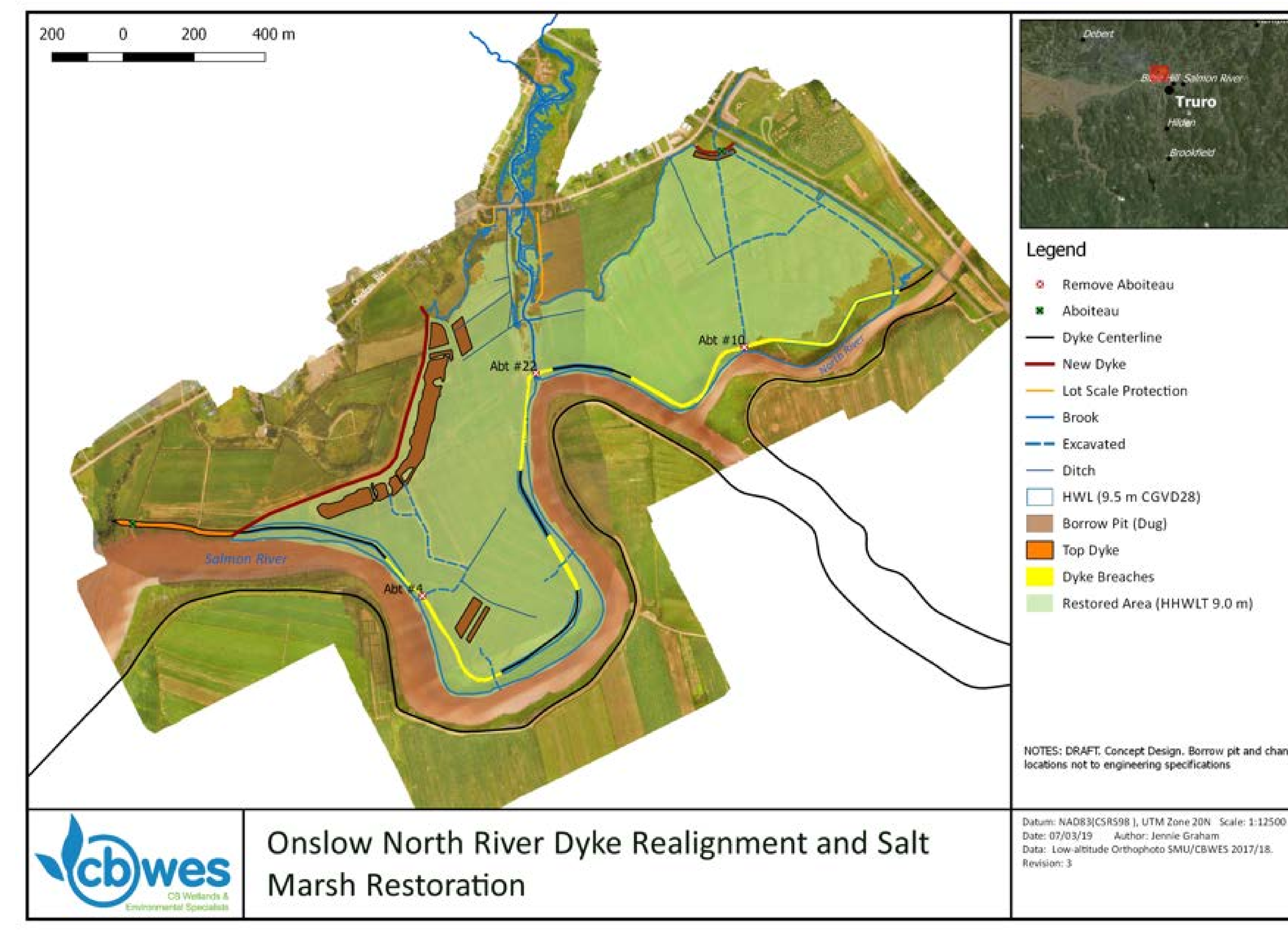
Hand digging a channel, July 2019 (CBWES Inc).

ONSLOW-NORTH PROJECT

MANAGED REALIGNMENT | RESTORED 2019

PROJECT DESCRIPTION

Located at the confluence of the Salmon and North Rivers near the town of Truro, this managed dyke realignment is restoring a 92 ha (227 acre) parcel of land beside the Salmon and North rivers to tidal wetland. This project has three main goals: enhance the protection of both public and private infrastructure; to restore provincially significant tidal wetland habitat; and to reduce the flood risk and enhance climate resiliency for the Town of Truro and Municipality of the County of Colchester. Flooding behind the dyke was an issue at Onslow-North River when river water levels were high or ice jams obstructed the aboiteaux opening. The dyke was additionally prone to overtopping and damage due to its location near the confluence of the Salmon and North rivers. The most cost-effective solution to these issues was managed dyke realignment and tidal wetland restoration. In fact this strategy (restoring natural floodplains) was a key recommendation in a large engineering report completed in 2017 to help reduce flooding in Truro. The restoration involved first building new dykes set back from the original dyke to protect vulnerable infrastructure, creation of natural features such as tidal channels, and decommissioning of the old dyke to allow tidal flooding.



RESTORATION PROGRESS





2019 - Construction

2021 – Post-Breach

2022 – July

2023 - June

MONITORING



FISH


WINTER CONDITIONS

SEDIMENT DEPOSITION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CONVERSE MARSH MANAGED REALIGNMENT SITE: RESTORED 2018

CONVERSE MARSH MANAGED DYKE REALIGNMENT AND TIDAL WETLAND RESTORATION SITE

The Converse Marsh is located on the Missaguash River in the Tantramar marsh system. The site was realigned and restored in December 2018 to address significant erosion, loss of foreshore marsh, and the unsustainability of the existing dyke infrastructure.

The realignment design considered how best to protect adjacent lands, and vital transportation routes and infrastructure, while reducing dyke infrastructure to be maintained, and restoring a tidal wetland environment.

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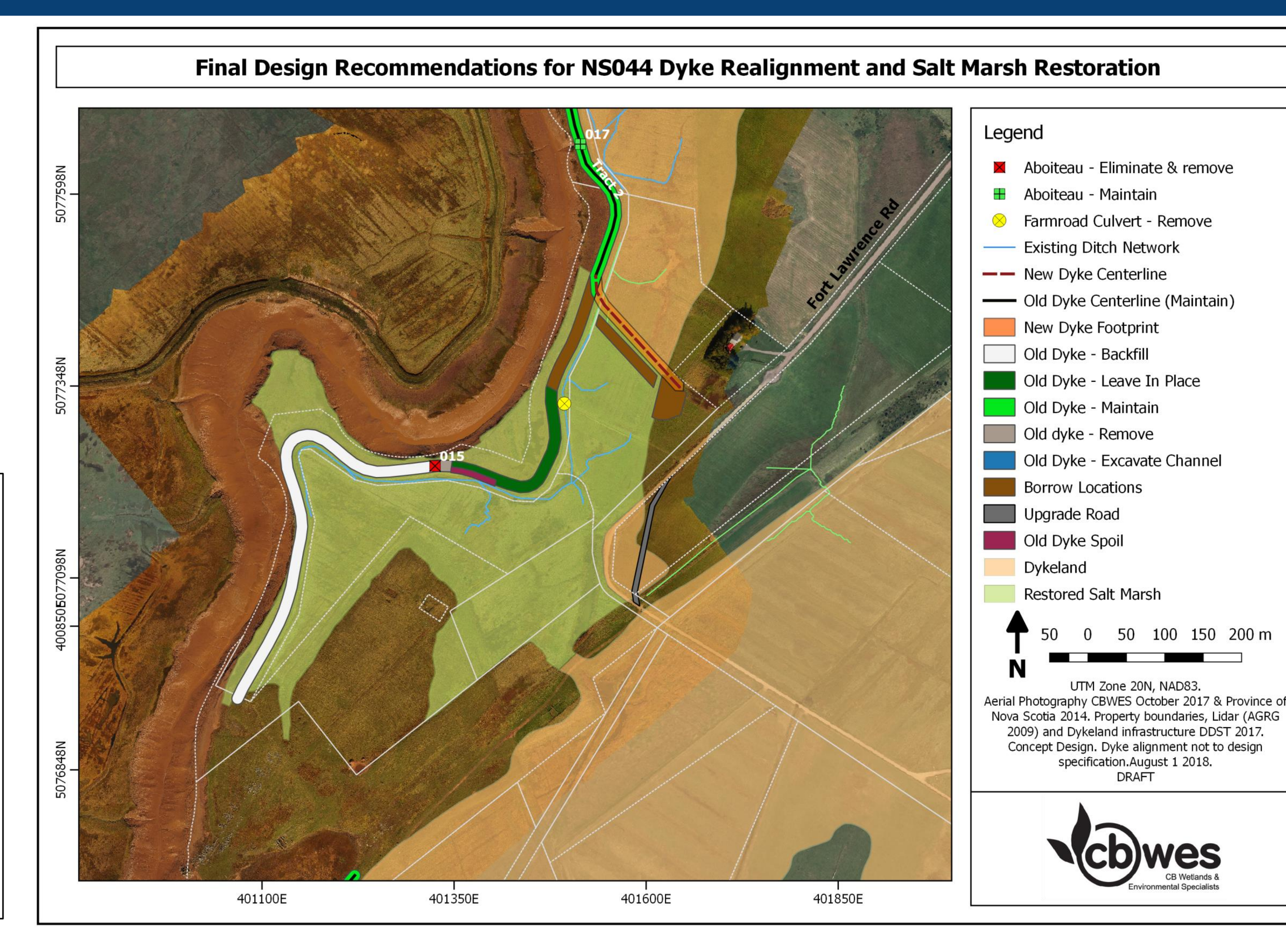
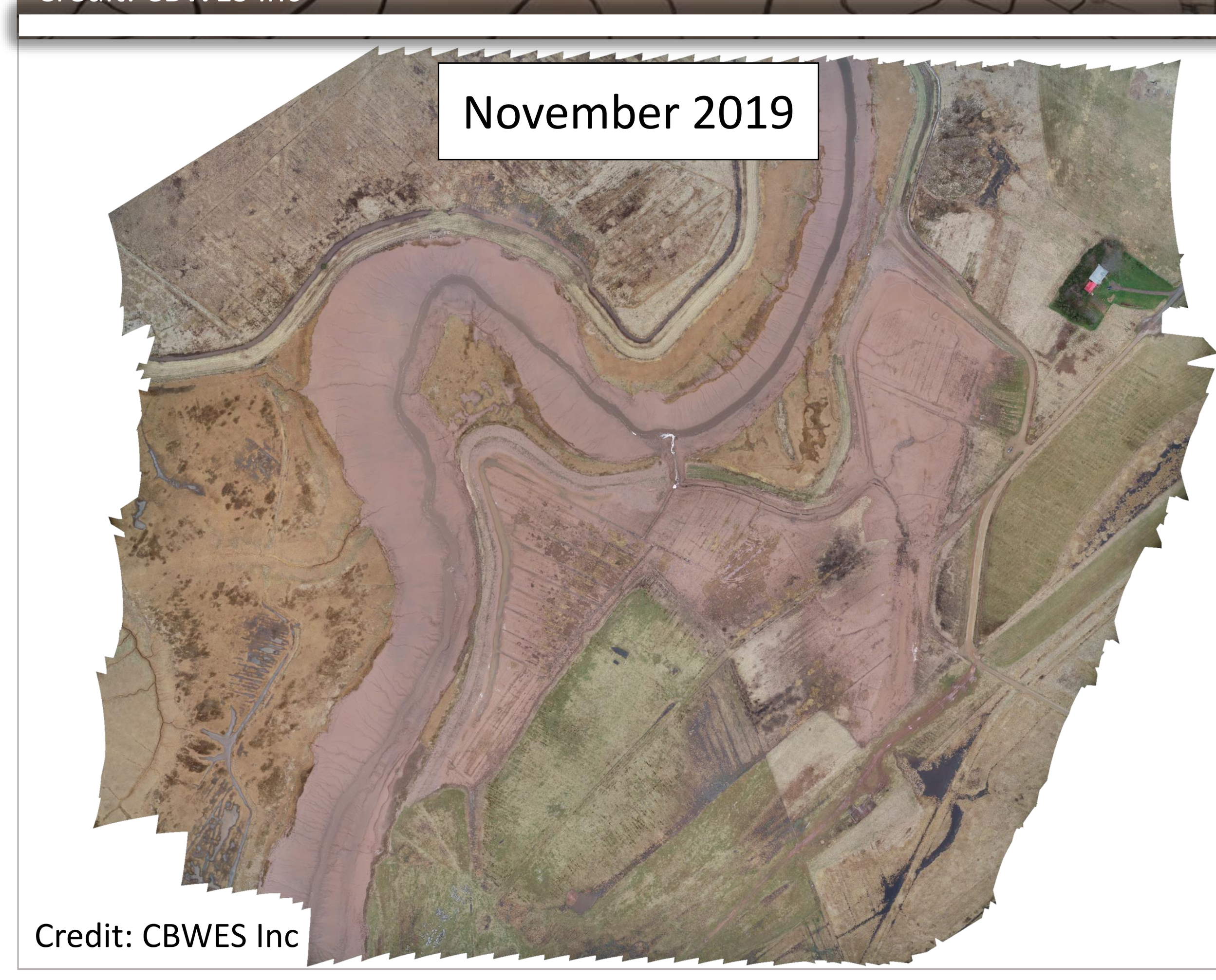
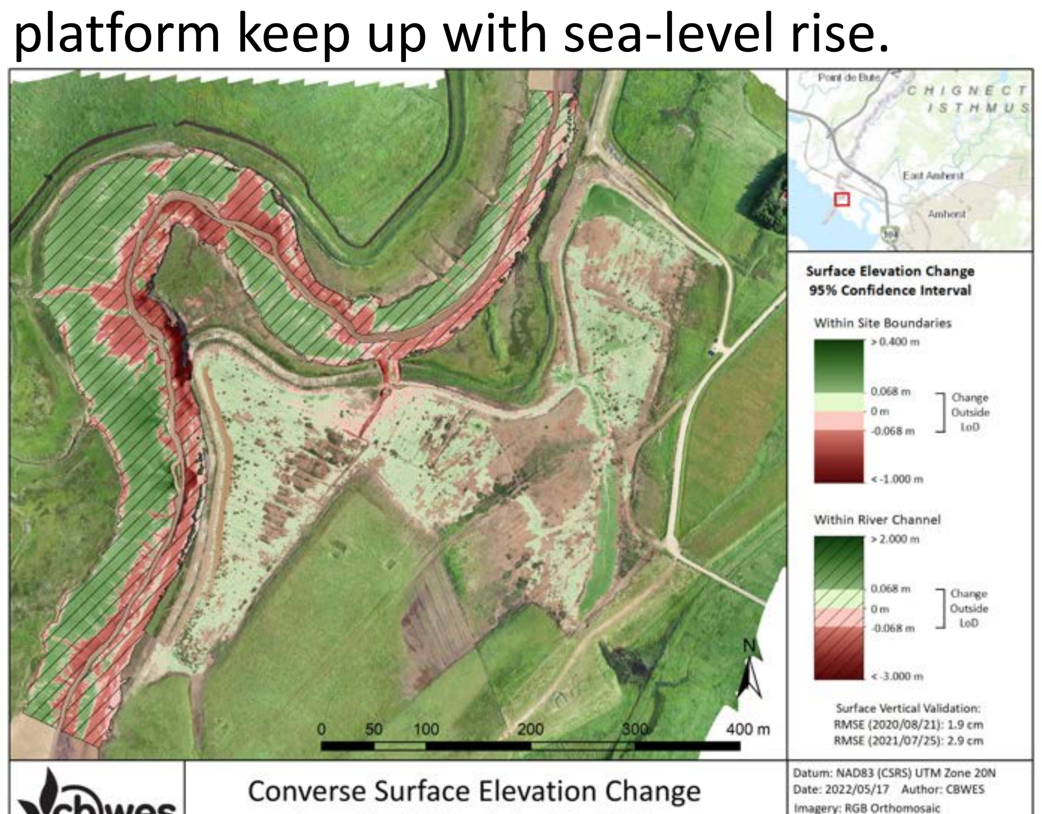


RESTORATION PROGRESS



SEDIMENT DEPOSITION

The Converse Marsh is trapping sediment and gaining elevation, helping the marsh platform keep up with sea-level rise.



Using Rod Surface Elevation Tables (RSET) to monitor elevation.

The Missaguash River continues to shift and erode the now decommissioned dyke.

ADAPTIVE MANAGEMENT

Hay mats, wooden stakes and planted vegetation were used to address erosion at the toe of the new dyke.

WILDLIFE

CHANNEL MOUTH

The developing breach channel is continuing to widen and deepen with restored tidal flow. The remnant aboiteau is now visible.

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FEATURES AND BENEFITS OF TIDAL WETLANDS

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Dykeland System Potential Design Upgrade Options

1 Dyke Reinforcement

★ 2 Dyke Realignment

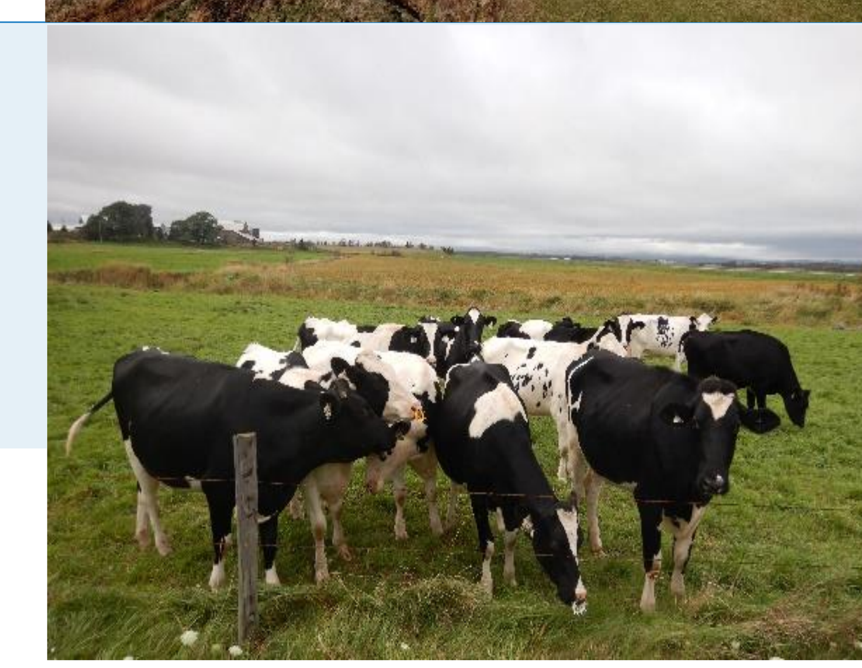
★ 3 Tidal Wetland Restoration

4 Aboiteau/Upgrades Rehabilitation

5 Aboiteau Construction

★ 6 Drainage Improvement

7 Management Plan



https://novascotia.ca/dykeland-system-upgrades/

https://storymaps.arcgis.com/stories/e043dd1df6504f1791eb53ae1e0896ff

Etuaptmumk

two eyed seeing

what is it?

"Two-Eyed Seeing refers to learning to see from one eye with the strengths of Indigenous ways of knowing and from the other eye with the strengths of Western ways of knowing and to using both of these eyes together" – Albert Marshall

Two eyed seeing integrates all knowledge systems, Indigenous, local and academics. Using the strengths of all available knowledge systems to gain a truer and more holistic understanding.

why is it important?

Combining and including all systems reduces and eliminates conflicts. There is a wholistic understanding when multiple perspectives are brought together, accepted and understood. When all these perspectives or knowledge systems are included from the beginning errors can be avoided before they begin.

We are now at a point in time where it's important to keep our traditions but also utilize the benefits of western science through education

what it is

- Contextual
- Co-Learning
- Co-production of knowledge
- Approach for Collaboration
- Empowering Mi'kmaw communities

what it isn't

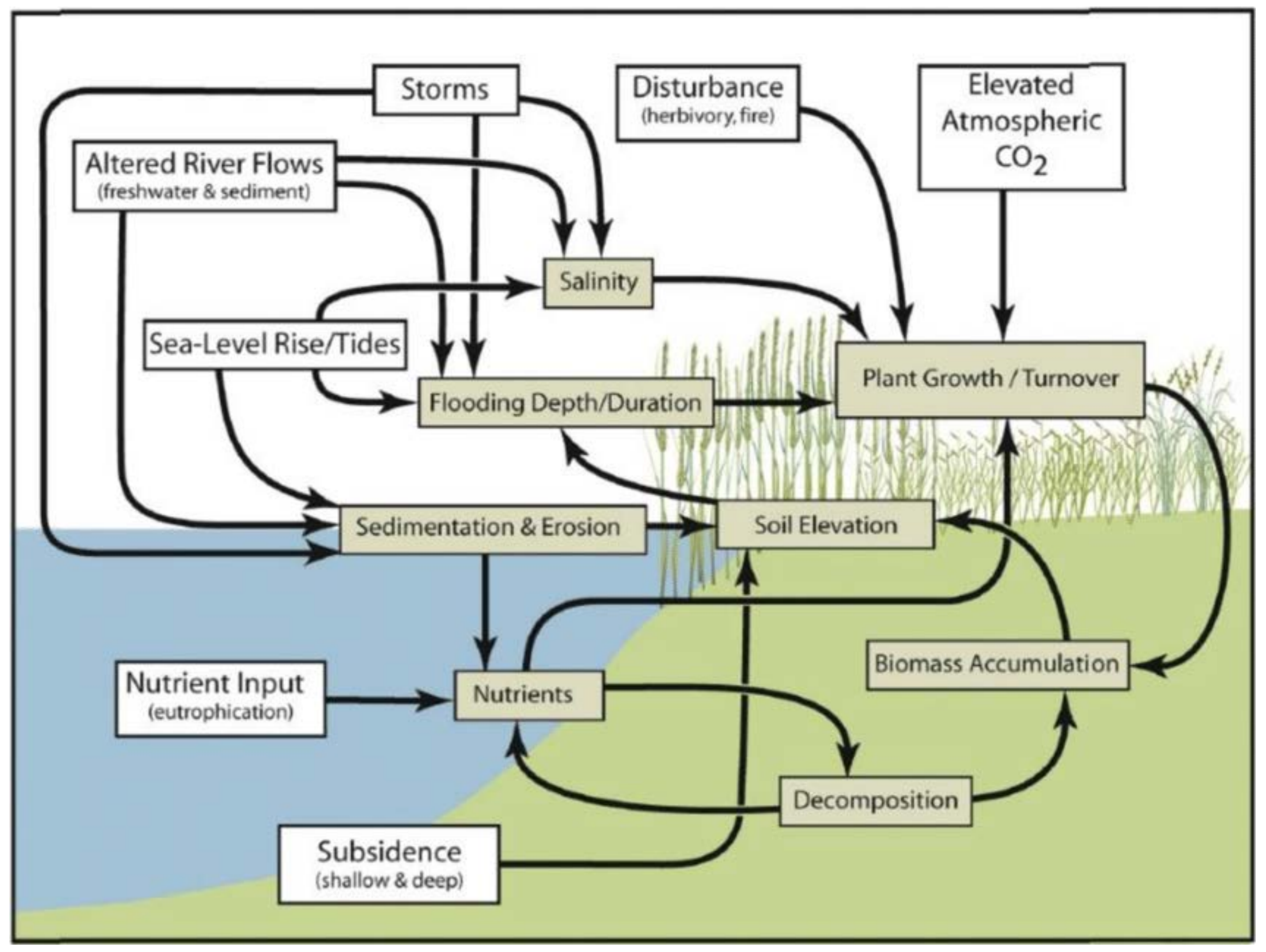
- One size fitsall
- Tokenism
- 'Cherrypicking'
- Choosing one Knowledge System over the other

Making Room for Wetlands

MONITORING & ADAPTIVE MANAGEMENT

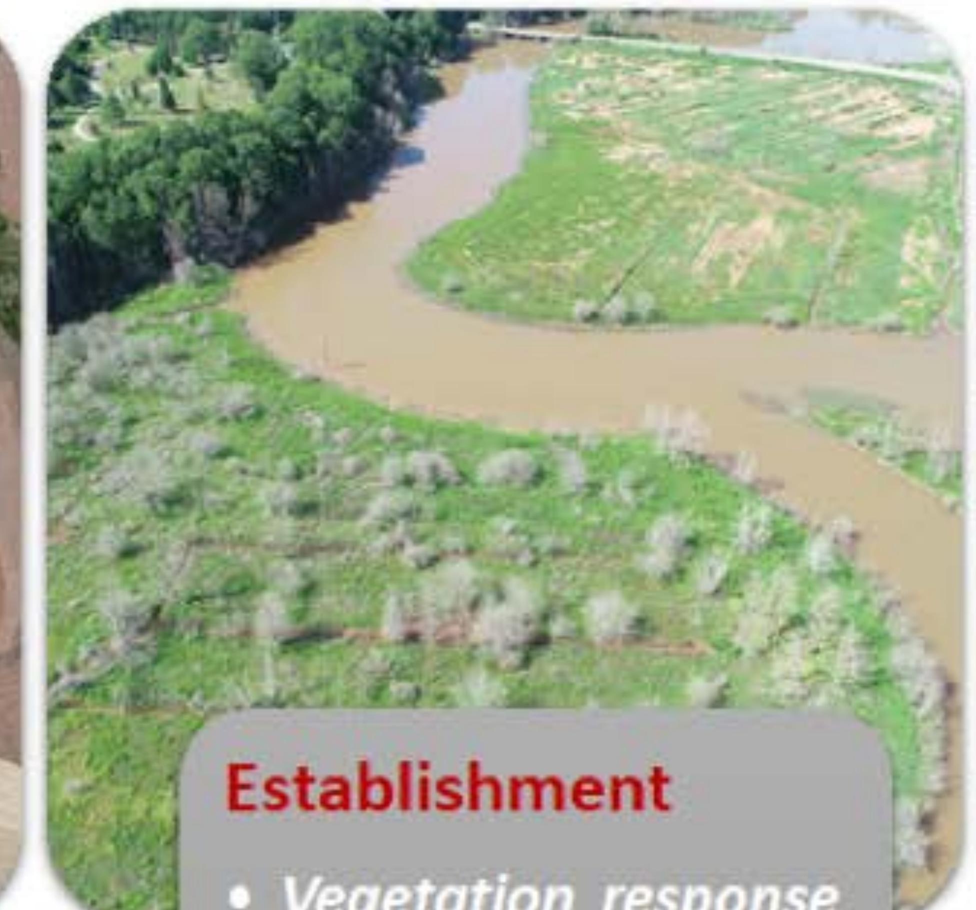
MONITORING

We conduct pre and post-restoration monitoring to understand the current and future condition of tidal wetland function, structure and health. This informs future management and identifies any need for intervention (adaptive management) to ensure the restoration site in reaching expected outcomes.



ADAPTIVE MANAGEMENT

Adaptive management is integrated into monitoring efforts as needed when the health or function of the tidal wetland is not progressing as expected. This may include altering data collection and planting and/or earthworks to ensure the restoration site thrives.



Transition phase

- ***Ecological engineering phase***
- Influx of sediment
- Water very visible
- New plants
- Short term!

Establishment

- ***Vegetation response phase***
- Less sediment
- Plant community establishing
- Species competition
- Water less visible

Equilibrium

- ***Intermittent disturbances & future of site***
- Tidal Wetland zonation
- Stable creek network

Soils & Sediments

Soils and sediments are monitored to understand the underlying processes controlling vegetation type, cover, and growth.

Methods include:

- **Sediment Coring and Analysis**
- **Rod Surface Elevation Tables**
- **Marker Horizons**
- **RBR Turbidity Logger**

Vegetation

Vegetation is monitored to understand vegetation type, cover, and growth.

Methods include:

- **Vegetation Surveys**
- **Habitat Mapping**

Geospatial

Geospatial attributes are collected to understand the form and function of rivers, floodplains and salt marshes and serve as the basis for other analyses.

Methods include:

- **Georeferenced Aerial Photography**
- **Digital Surface Models**
- **Digital Elevation Models**
- **GNSS Elevation Surveys**

Hydrology

Hydrology data is collected to understand the locations of fish habitat, changes in vegetation, and the overall structure and function of the marsh.

Methods include:

- **Automated Water Level Recorders**
- **Sontek M9 River Surveyor**
- **Nortek ADCP**
- **DEM**
- **Tide Signal**

Blue Carbon

Coastal Carbon Accumulation and Greenhouse Gas Fluxes in Tidal Saltmarshes

Background

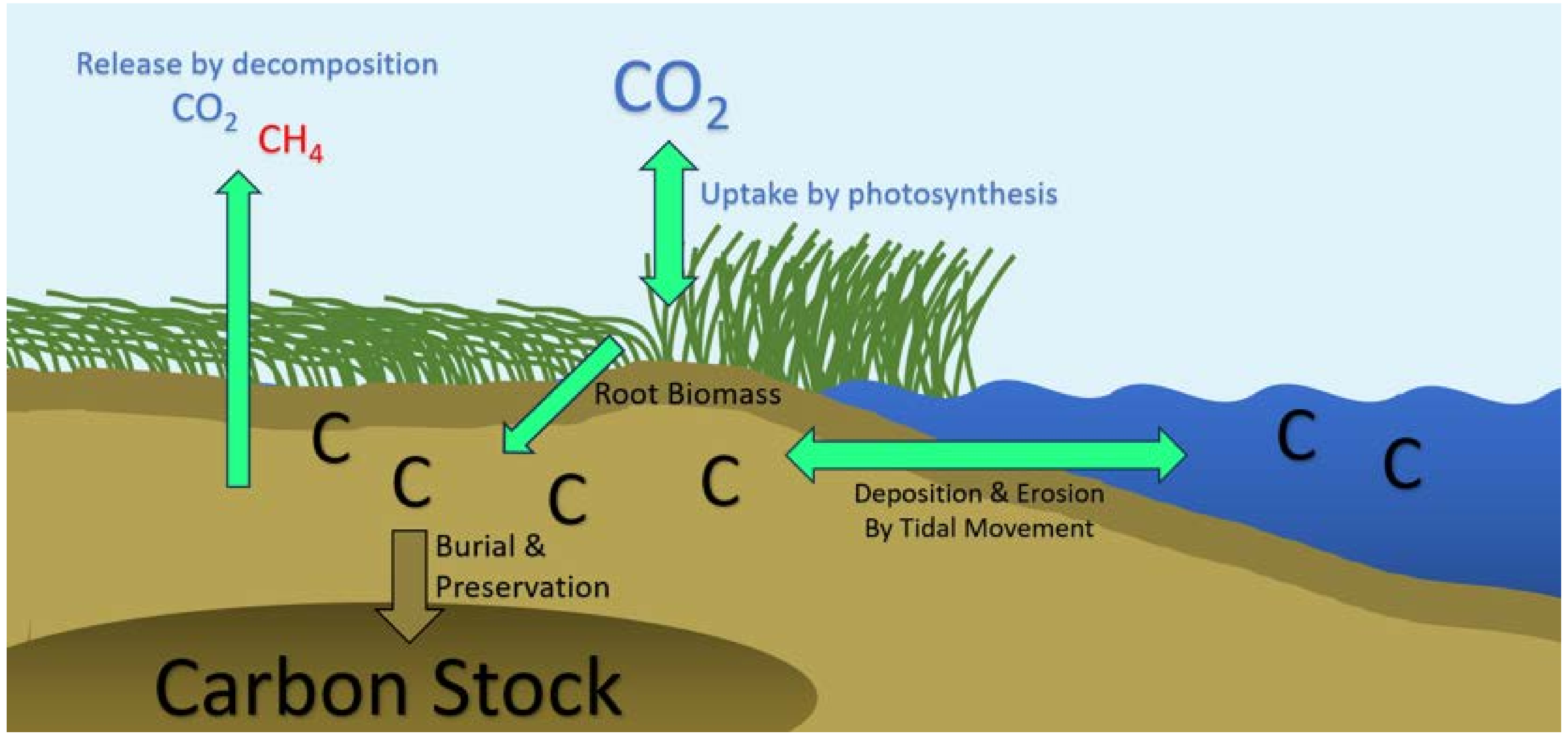


Figure 1: Conceptual diagram showing movement of carbon within a saltmarsh.

Why Saltmarshes?

Salt marshes act as a natural carbon sink, taking up CO_2 through photosynthesis and storing carbon in their soils for long time periods of time, helping to reduce the amount of greenhouse gases in the atmosphere.

- Regular flooding creates a lack of oxygen in the groundwater of saltmarshes, which slows down most microbes from being able to break down the carbon and reintroduce it to the atmosphere.
- Salinity usually prevents the production of other greenhouse gases in salt marshes, like methane (CH_4)

What is Blue Carbon?

Blue Carbon in carbon that is stored in coastal wetlands including saltmarshes, seagrass meadows, and mangroves. As shown below, blue carbon habitats have the potential to store more carbon per area than terrestrial habitats (Howard et al., 2014).

In our study area within the Bay of Fundy, we found very high initial rates of sedimentation leading to high rates of carbon accumulation in the first years after restoration [see Figure 5] (van Proosdij et al., 2023).

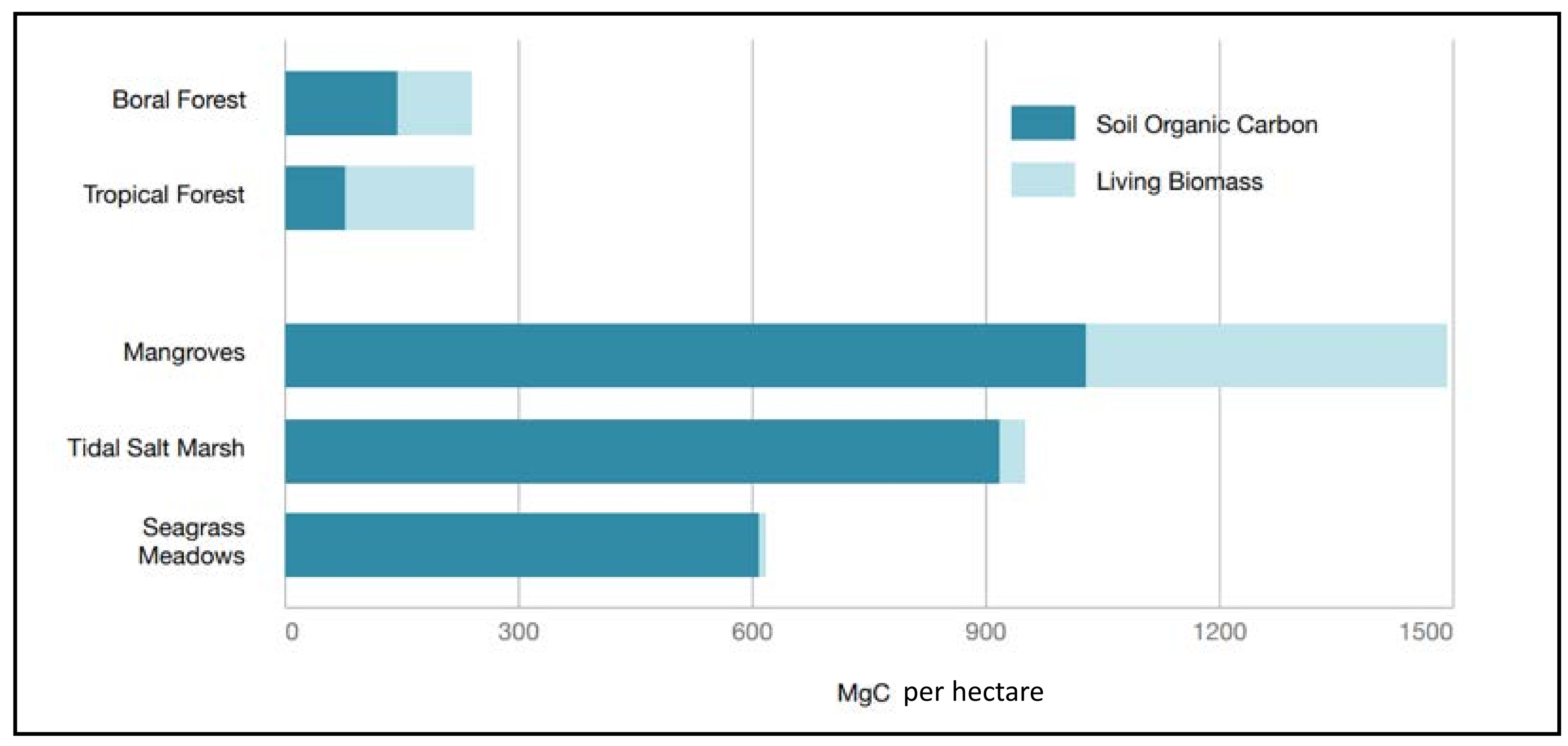


Figure 2: Relative Carbon stores of various ecosystems in megagrams per hectare (1 Mg = 1 metric ton); (from Howard et al., 2014).

Measuring Carbon Accumulation & Storage

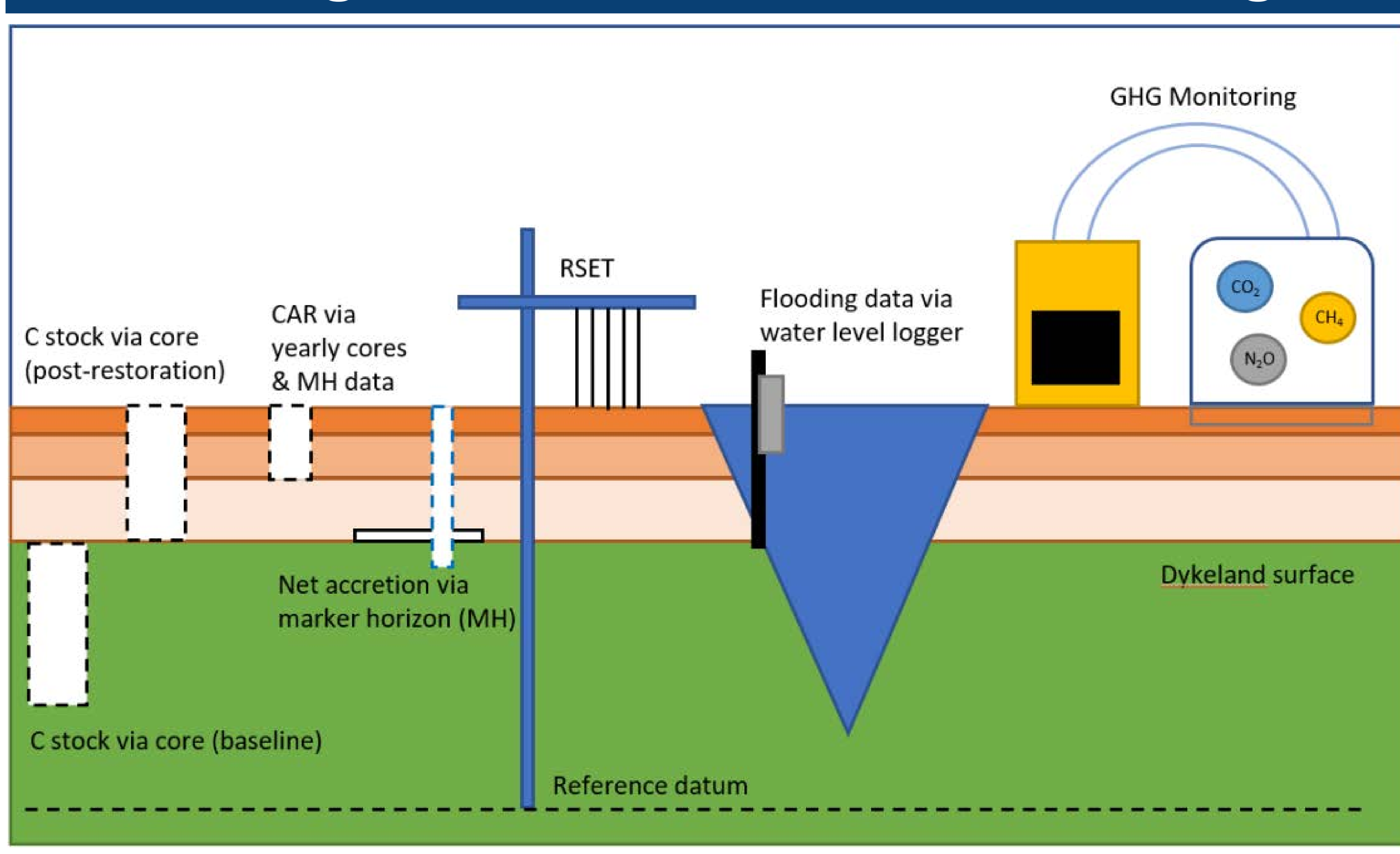


Figure 3: Conceptual Diagram of soil & GHG field measurements (by Brittney Roughan).

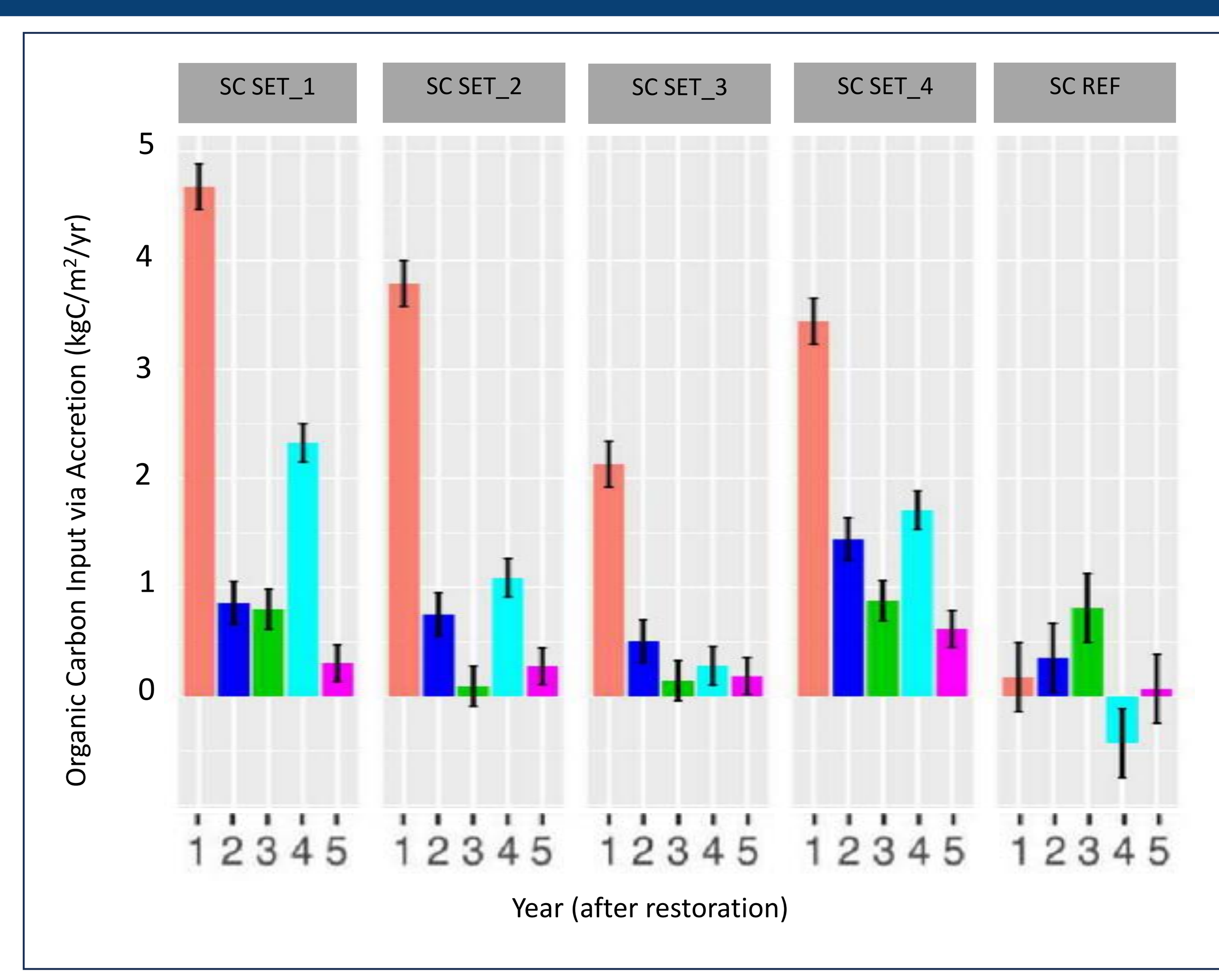


Figure 5: Estimated organic carbon input via sediment accretion over time at St. Croix West restoration site.

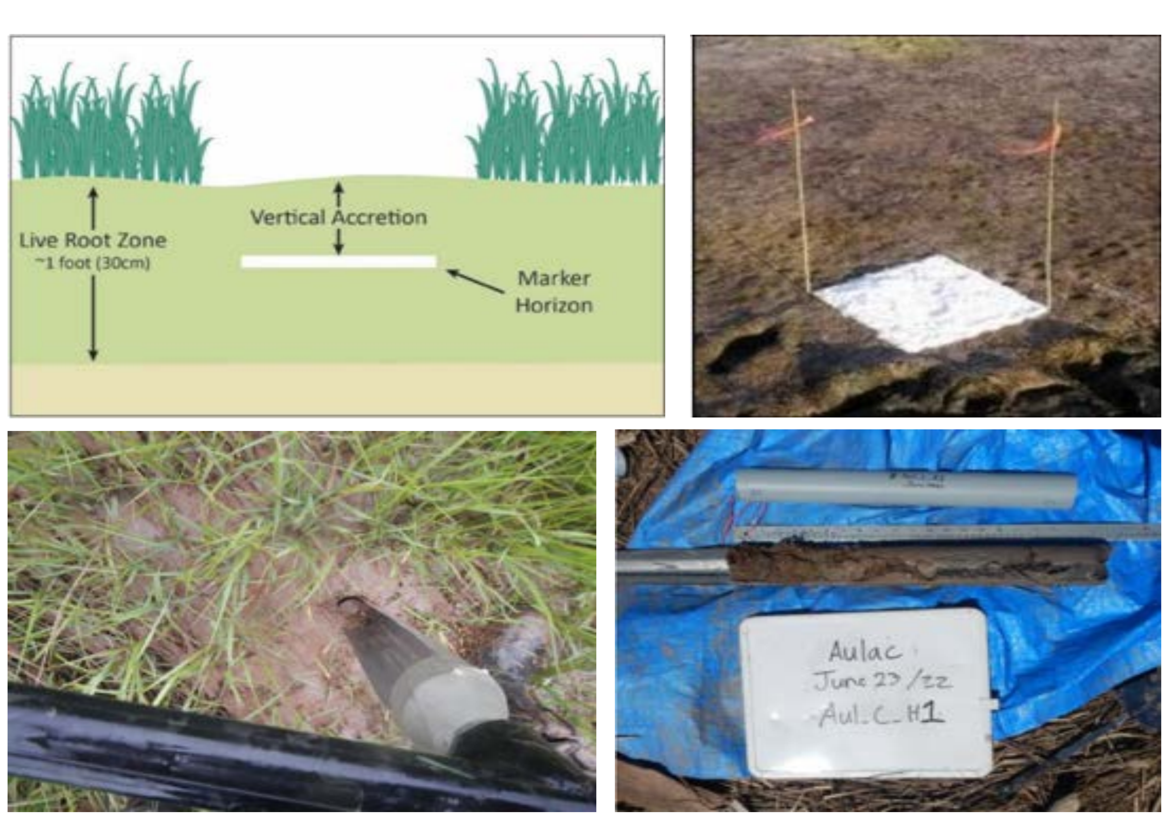


Figure 4: Conceptual diagram of a marker horizon [top left] (from Lynch et al., 2015); Photo of marker horizon installation [top right] (from Graham, 2018); field images of sediment coring [bottom] (photos by Brittney Roughan).

Soil Organic Carbon

Marker Horizon (MH)

A visible layer of clay allows us to measure the depth of any sediment deposited above it.

Soil Cores

Soil cores are taken and processed in the lab to determine the concentration of carbon within the soil.

Rod Surface Elevation Table (RSET)

The RSET (not pictured) accurately measures relative changes in surface elevation.

Figure 6: Eosense auto-chamber [left] (photo by Brittney Roughan); GASMET gas analyzer [right] (photo by Evan Rundle).

Greenhouse Gas Flux

Gas Analyzer - GASMET GT5000

The Gas analyzer [right] and auto-chamber [left] are used to measure the amount of greenhouse gases being emitted or absorbed by the soil.

Making Room for Wetlands

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