Healthy Port Futures

Great Lakes Protection Fund

WAYNE COUNTY SOIL & WATER CONSERVATION DISTRICT

PBIA

Healthy Port Futures

PORT BAY SEDIMENT ENGINE

a report summarizing the landscape research, implementation, and monitoring of the Port Bay Sediment Engine

Healthy Port Futures

University of Pennsylvania

Sean Burkholder, Assistant Professor

Tess Ruswick, Research Associate

University of Virginia

Brian Davis, Associate Professor

Participating Partners:

Port Bay Improvement Association

New York Department of Environmental Conservation

Wayne County Soil and Water

NOAA SeaGrant

Cite This Report:

Contact: Sean Burkholder, Assistant Professor, Landscape Architecture Department, Weitzman School for Design, University of Pennsylvania, *sean.burkholder@upenn.edu*

Healthy Port Futures is a collaborative research project funded by Great Lakes Protection Fund to investigate alternative sediment management plans throughout the Great Lakes.

More information can be found at:

http://healthyportfutures.com

EXECUTIVE SUMMARY

This report explains and summarizes the Port Bay Sediment Engine landscape research by the Healthy Port Futures team. This research happened in collaboration with New York State DEC, the Port Bay Improvement Association, and the Wayne County Soil and Water Conservation District, and New York Sea Grant. The PBIA and Wayne County SWCD were able to implement a pilot project during unusually difficult circumstances brought on by the COVID-19 pandemic. The pilot project was executed with Decker Excavation. This pilot project was subsequently monitored and the data analyzed. While the full monitoring plan was not able to be implemented due to travel restrictions brought on by the COVID-19 pandemic, three separate data collection events did occur. The analysis of this data and the lessons learned throughout the project offer some important conclusions for future consideration by stakeholders and communities of the Southeastern Lake Ontario region.

The following conclusions were drawn:

1) The beneficial use of dredged sediment is possible in Port Bay, using a practice that eliminated additional costs and minimizes risk, maximizes shoreline stability and protection, and may provide increased opportunities for recreation and habitat over time.

2) Ongoing monitoring is essential.

3)The study of natural forms and processes provides the best way to develop sediment placement practices in this region.

4)This practice should be considered in the context of the five Wayne County communities, and potentially for the New York Lake Ontario communities that participated in the 2000 Regional Dredge Management Plan.

Looking towards Western Barrier Bar Dredge Pile and Jetty (Tess Ruswick)

TABLE OF CONTENTS

Port Bay Boat Inlet (Tess Ruswick)

1 | Introduction

Background

Port Bay, NY is a small recreational harbor situated along the southwest shores of Lake Ontario, a region characterized by alternating drumlin bluffs and baymouth barriers. Port Bay Barrier bar is a dynamic coastal feature that protects the inner bay from Lake Ontario wave action. This protected bay is an important ecological and recreational feature along the lake, supporting nursery and stop-over habitat as well as residential communities. The inlet that divides the West and East Barrier Bar allows for small boat access and is maintained through a jetty structure and annual dredging. Owned by State of New York, the barrier bar is managed as part of the Lake Shore Marshes Wildlife Management Area through New York State Department of Environmental Conservation (NYSDEC), while the boat channel is maintained by Port Bay Improvement Association (PBIA) (Figure 1.1).

For the past fifty years, owing in part to the construction of a permanent boat channel, a jetty, and hardening of the western bar, Port Bay has witnessed the erosion and thinning of the sediment-starved eastern bar.   Importantly, the practice of placing dredged material from the channel upland, and subsequently, removing important sediment from the nearshore, has further exacerbated the erosion. The dredged sediment was treated as a problem only, instead of a solution. Historically, this baymouth barrier bar, and others like it, were maintained by the sands and gravels from nearby eroding drumlin bluffs traveling eastwards along the lakeshore. However, the aforementioned changes to the barrier bar system have disrupted vital longshore sediment transport and over time, have led to decreased sediment supply and coastal erosion.

While breaching is a natural process, the reduced sediment supply has resulted in an increasingly narrow and disturbance-vulnerable East Barrier Bar. In the past three years, the East Barrier Bar has been breached multiple times. During those times, storm waves have deposited sediment over top the bar, created semi-permanent secondary inlets, and flooded the bay, threatening boats and docks housed along it. The Port Bay community has been working with Wayne County Soil and Water, and the DEC, to reconstruct the bar, using machinery to spread dredge material along the length of it. However, the process is cost-prohibitive and cannot be considered a long-term sustainable solution given the limited resources of the community. Unfortunately, inaction may lead to increased erosion and an inability for the East Bar to stabilize. If a permanent breach was to form, sediment supply and movement, water quality, ecology in the bay would significantly change, and increase the risk for property damage (Bergman 2019).

Purpose

Within this region, DEC manages several other barrier bar spits that are similarly sediment-starved and eroded. DEC + HPF agreed to an MOU for HPF to study and design a more efficient passive sediment approach to utilize dredge material to nourish the bar.

Objectives

Research objectives to explore included (Figure 1.2).

+ How to restore and maintain the disrupted coastal processes including sediment transport?
+ How to maintain associated recreational activities, like fishing and boat access?
+ How to maintain and protect natural habitat areas, including gravel bar, and the nearshore?
+ How to minimize risk to property and infrastructure?
+ How to ensure feasibility of implementation and construction, including maintaining current PBIA dredging budget?.

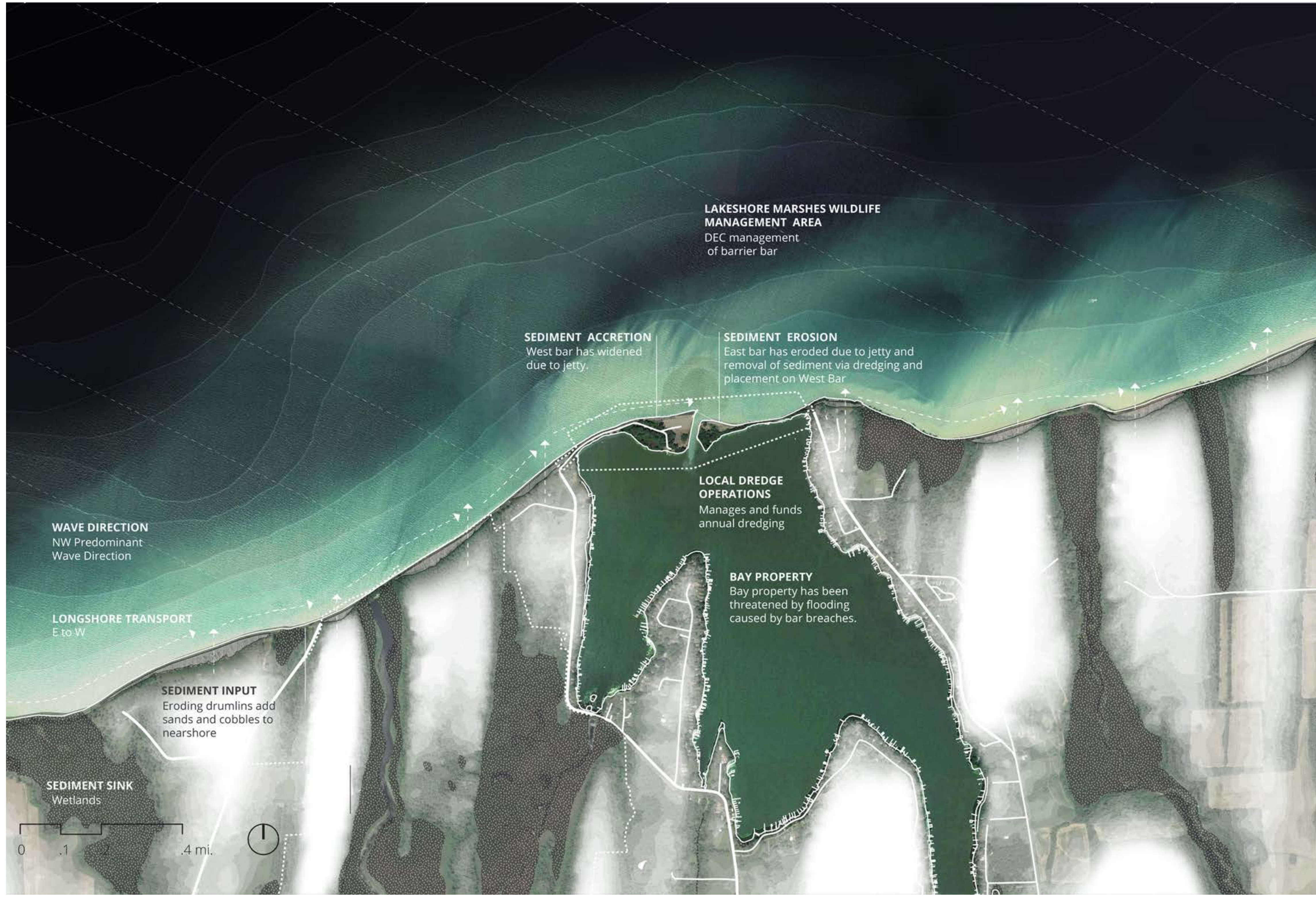


Figure 1.1 *Context*

PARTNER	PBIA	New York State Department of Environmental Conservation	Wayne County Soil & Water Conservation District	Great Lakes Protection Fund
OBJECTIVES	• Eastern bar nourishment • Prevent breaching • Ensure navigation	• Regional Sediment Management • Habitat protection	• Pilot Project that can inform larger REDI project	• Aid in small pilot projects that inform regional sediment management
LIMITATIONS	• Placement same expense/ hours • Within Contractor, Jeff Decker. Slope > 20%, height of pile < 20'	• Placement above LWD (243.3 IGLD 85)	• Monitoring plan that is replicable and accessible	

Figure 1.2 *Project Stakeholder Objectives*

Landscape Research

This project will expand upon some of the recommendations identified in the Port Bay Barrier Bar Assessment (Bergmann 2019), specifically the Sediment Management alternative outlined in the report (Bergmann 2019). HPF will 1) research and analyze of current conditions 2) provide alternatives based on the research outcomes and support local efforts in any efforts to implement new concepts related to the findings and 3) design a maintenance plan through physical modeling iterations.

Construction

HPF's research will include finding related to the following parameters. These parameters are described further on page 40-41 in Research Considerations.

+ Centerline location of placement
+ High point of placement
+ Extent of placement (LP > 243.3 IGLD 85)
+ Type of equipment used.

Monitoring

As a reoccurring maintenance project, this pilot is uniquely positioned to test, observe, and adapt the placement and movement of material via machinery and natural forces. Over time, these maintenance practices will be calibrated and developed into a more elegant and efficient sediment sequencing. This feedback loop will be able to inform the dredging maintenance practiced by nearby bay communities. Moreover, this study can supplement the future REDI (Lake Ontario Resiliency and Economic Development Initiative) funded capital project in Port Bay.

Partners

Project Team + Funding

This research project was funded by Great Lakes Protection Fund as part of the ongoing Healthy Port Futures project. The Healthy Port Futures team is led by Brian Davis, from University of Virginia Landscape Architecture Department, and Sean Burkholder from University of Pennsylvania Landscape Architecture Department.

HPF was connected to Port Bay community through Roy Widrig, a NOAA affiliate, and subsequently went to a community meeting to learn about the issues and ongoing work. Under an agreed MOU between HPF and NYDEC, HPF researched the conditions into a more efficient passive sediment approach utilizing dredge material to nourish the bar.

The project was supported by New York State Department of Environmental Conservation's (NYSDEC) Great Lakes Program through the coordination of any construction or capital costs, community outreach and permitting. Additionally, New York State has been developing a nature-based shoreline monitoring protocol to evaluate the effectiveness of similar coastal resiliency projects. In this way, NYSDEC worked with the Healthy Port Futures team to incorporate any applicable protocols into the project.

Implementation and construction was conducted by Jeff Decker, a contractor who has worked with PBIA.

Healthy Port Futures provided monitoring protocol, but was unable to travel to the site because of Covid-19 travel restrictions. As such, both Ramboll Engineering, and NOAA SeaGrant affiliate, Roy Widrig, conducted drone surveys that were processed and analyzed by Healthy Port Futures. Later surveys were conducted by SeaGrant. Wayne County Soil and Water conducted monitoring (RTK surveys and photo points) and coordination with DEC and PBIA.

SWCD Erosion Control Structures on Eastern Barrier Bar (Tess Ruswick)

Swimming at Eastern Barrier Bar (Tess Ruswick)

2 | Concept Development
Regional Characteristics

Geological and Hydrological Conditions
A large widespread drumlin field stretches throughout a large portion of north-central New York. The north-south orientation of these elongated hills reveal the mechanism that created them: glacial retreat. The northern edge of the drumlins collide into Lake Ontario which result in undulating, alternating pattern of bluffs in various states of erosion. The low spaces between are filled, as direct relation to its distance to the shore, by bays, marshes, and arable farmland. (Figure 2.1).

The drumlin bluffs erode through a process of wave notching, slumping, and gullying. During the bluff erosion, smaller sediment is suspended and moved offshore, while the coarser material, comprised of cobbles and gravel migrates eastwards through the prevailing longshore drift (ACE Sediment Transport Model). This area is unique in that the typical sediment, sourced from the drumlin foreign material is coarser than in other areas across the Great Lakes, as such, can act as a more stable building material.

Sediment accumulates along the baymouth barriers, which in turn, separate the bays and marshes from the lake, protecting the inland waters from wave energy (Pinet + McClennen, 1997). The drumlin bluffs act as a sediment source for the barrier bar, which acts as the sediment sink. These "coastal compartments" have been shown to be effectively closed at the sediment stays within each drumlin- barrier portion for years to decades (See Figure 2.2), so that the neighboring drumlin is the direct feeder of the neighboring bay and barrier bar (Pinet +McClennen, 1997).

Social Characteristics
These unique geological features have shaped the ecological and social uses of the area. The five bays in this region (Sodus, East, Port, Blind Sodus, and Little Sodus Bay) support small communities that rely on water-based recreational activities like boating and fishing. An estimated 2000 boat slips and 20 boat launches are found between the five bays (F-E-S Associates, 2000), and the majority of residents have bayfront access and docks. These communities are reliant on the permanence of certain geomorphological features; a protected bay, a protective barrier bar, and an inlet.

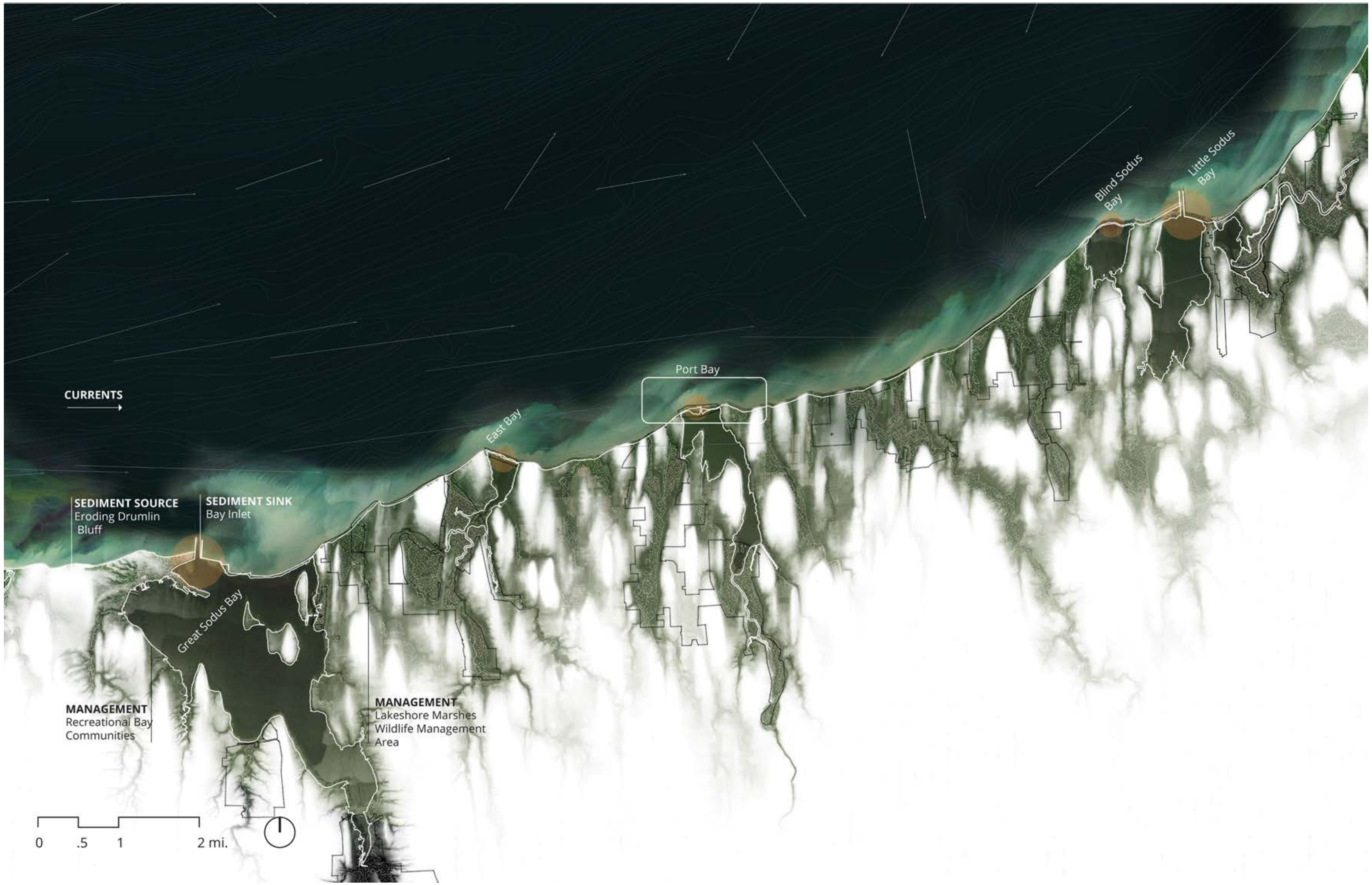


Figure 2.1 *Barrier Bar Context*

Management

New York State Department of Environmental Conservation (DEC) manages large portions of the Southwestern Lake Ontario shoreline as part of the Lake Shore Marshes Wildlife Management Area (WMA). The WMA protects important wildlife habitat existing within the barrier bars, marshlands, and bays. While DEC manages many of the regional barrier bars and marshes, individual communities are responsible for the maintenance and management of the inlets. Considered too small for a federal contract via the Army Corps of Engineers (ACE), these recreational communities self-fund and manage their own local dredging operations. The barrier bar and inlet system are intricately connected, ecologically, hydrologically, and socially, and as such, has necessitated strong coordination in management between local and state agencies. In Port Bay, PBIA, DEC, and Wayne County Soil and Water Conservation District (SWCD) collaborate to oversee the health of the bar, inlet, and bay.

Responsiveness and forward-thinking leadership across all levels, including at PBIA and Wayne County, have created an environment where innovative ideas could developed and pursued. Additionally, Bergmann Engineers' previous work outlining the context and conditions of Port Bay has been an integral foundation for this report.

Breaches + Interventions

About one-fourth, or 1,700 miles, of the Great Lakes shoreline has been modified through armoring, hardening, or artificial shorelines. These measures attempt to stop or reduce erosion. However, these efforts only work in the localized area, and endanger regional sediment management of the larger extent. The eroded shorelines refocus erosional energy elsewhere, while reducing the overall sediment in the system, which endangers the health of the subsequent sediment starved barrier bars and bays.

Naturally, these barrier bars migrate, erode and accrete with fluxes in sediment supply and water levels. Throughout the twentieth century, increased bay development contributed to hardened shorelines and maintained permanent inlets. In Southwestern Lake Ontario, all five bays routinely dredge their inlets, and Sodus, Port, and Little Sodus Bay have hardened portions of the barrier bars. These hardened shorelines led to decreased sediment supply, and increases erosion along unprotected areas.

As a response to the prevailing eastern longshore drift, structures were built to divert the coarser material from entering the boat channel. However, these structures block the nourishment of the downshore barrier bar, threatening its protective, recreational, and ecological attributes. Not only do these jetties and piers disrupt the longshore drift, they also contribute to the shunting of coarse littoral material out of the nearshore. In Sodus Bay, East Bay, Blind Sodus Bay, and Little Sodus Bay, jetties divert between 2,300 and 14,700 cubic yards of coarse material from the nearshore annually. This further removes sediment from the nearshore system, making it unavailable to nourish beaches, protect homes, and provide habitat.

Depending on the practice, maintenance dredging can further acerbate sediment loss, and lead to downshore sediment starvation. During this process, sediment is dredged from the channels, and placed in the most accessible location, often an upland site. Consequently, important sediment is removed from the longshore drift, increasing erosion downshore. Noting this, the 2000 Regional Dredging Management Plan suggests that Port Bay, along with the other two sites, should return the dredged material back into littoral transport system, through placing it in "nearby beach, shoreline or nearshore waters". The report hypothesized that this placement option would allow for continued longshore sediment transport and shoreline stabilization (RDMP, 2000).

In these bay communities, the amount of sediment dredged per event is relatively small (1,000- 5,000 cubic yards). However, dredging occurs with high frequency, at least once per year. These small but high frequency operations can provide opportunities to develop alternate ways to place dredge materials (Figure 2.2).

Over the years, both built and maintenance interventions have significantly changed the longshore transport, and the resiliency of the barrier bars. In Port Bay, the East Bar has become significantly thinner, less vegetated, and more susceptible to breaches. Nearby barrier bars have been similarly impacted; during the spring 2016 storm that breached Port Bay's East Bar, barrier bars along the southern shore of Lake Ontario were also breached, including the bar along Sodus Bay (Bergmann 2018).

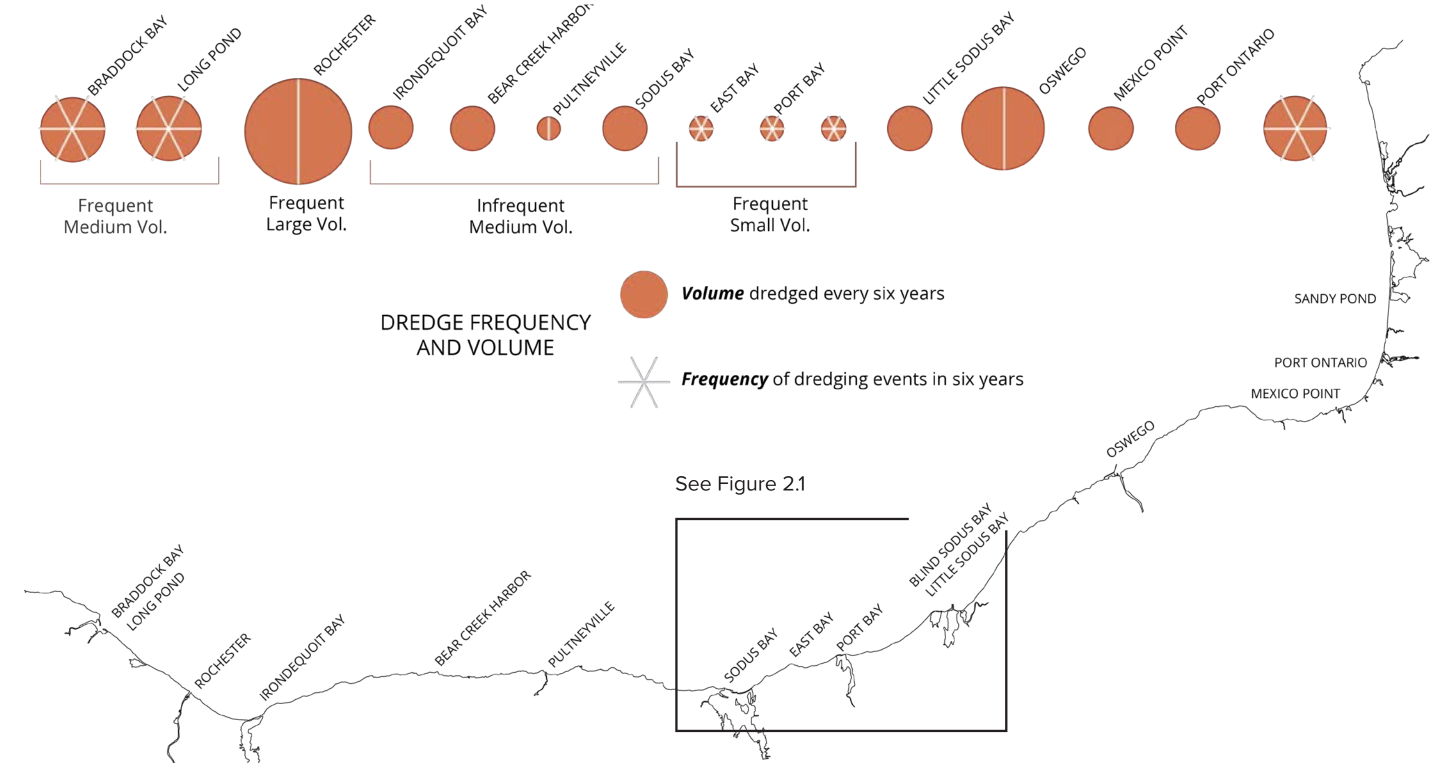


Figure 2.2 *Dredging Regimes in Southwestern Lake Ontario*

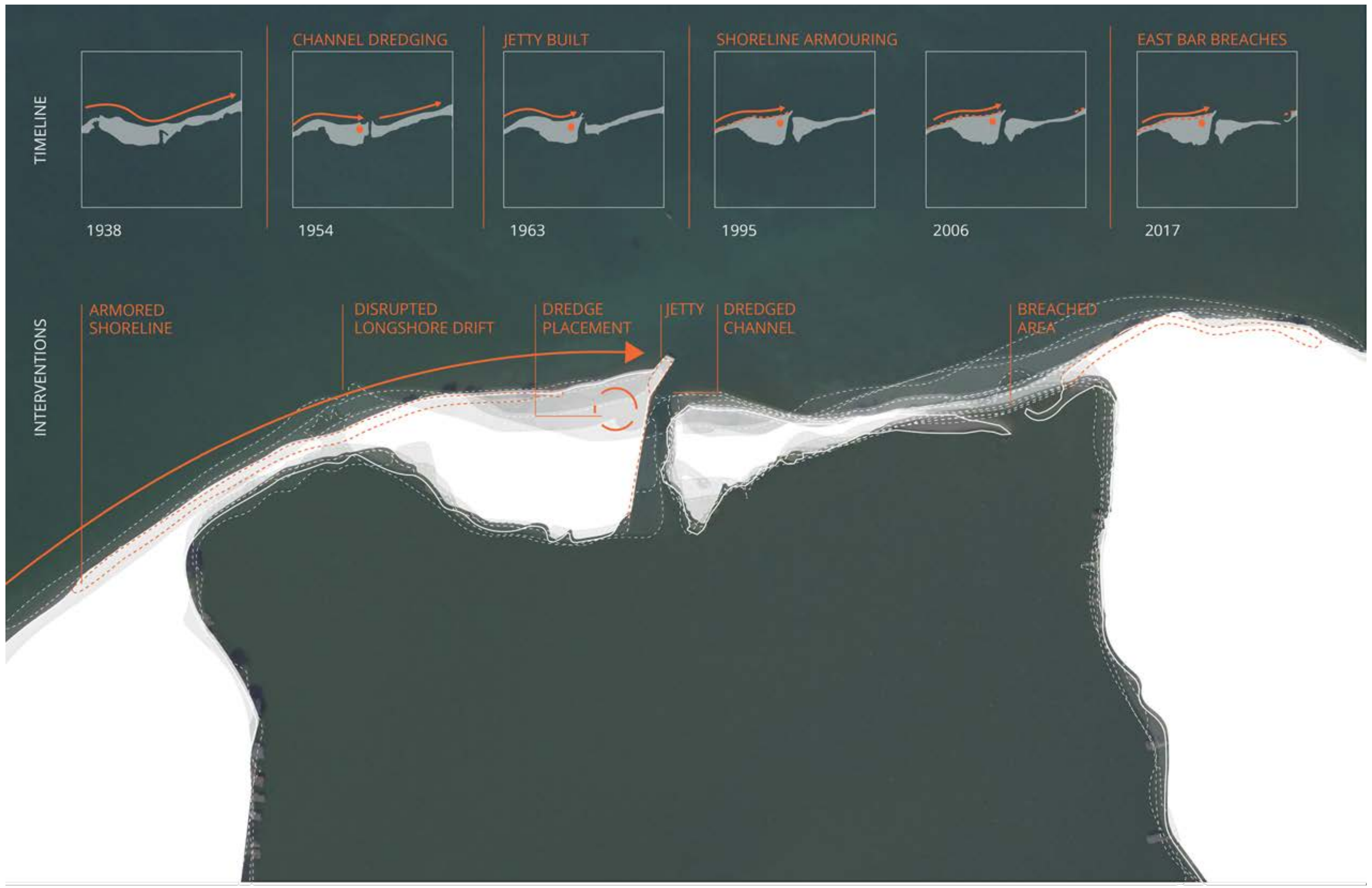


Figure 2.3 *Port Bay Shoreline Change*

Barrier Bar Description

Similar to other bays in Southwestern Ontario, Port Bay is characterized by a large bay protected by a barrier bar and connected to the lake through a maintained inlet channel. The West Bar and East Bar are separated by a ninety-foot wide inlet dredged annually t maintain recreational boat access.

Through the study of historical images and surveys of Port Bay, the barrier bar/ bay complex has altered considerably over time. Naturally, the barrier bar complex shifts, inlets form, move, widen, close, and reform, and bars will thicken and thin, as a result of fluctuating water levels and sediment supply. During periods of high water, coastal erosion increases, leading to increased sediment in the nearshore system which deposits during low water systems. These periods of high and low water predictively occur throughout the season, but also can occur over longer intervals in Lake Ontario. In the short term, storms can cause a massive flux of sediment in the system, and shoreline erosion. This sediment will be later deposited during calm period.

Interventions have changed this dynamic, and the uneven distribution of these measures have led in turn to irregular sediment accretion and starvation, and areas that are either overly fortified or vulnerable.

The majority of the West Bar is protected by large rip rap stones, with the exception of a softer beach shoreline leading into the 120' long jetty that borders the channel. The channel that separates the two barrier bars is dredged on an annual basis. Historical dredging permits indicate that the material was placed upland on the west bar, which effectively removed the material from the longshore drift.

These physical changes and maintenance activities have led to an overall pattern of accretion on the western bar and erosion of the eastern bar. With the exception of the accretion of the sandy beach close to the pier, the western shoreline has remained mostly the same. However, over the past few decades, starved of longshore drift, the natural, unprotected eastern barrier bar has shifted back, and become noticeably thinner (losing almost 70' in shoreline width) (Figure 2.3). Previous breaches have stripped the eastern half of the East Bar of all vegetation, leaving the area more vulnerable to future breaches and further erosion, and making the barrier bar less resilient to storms and future fluctuations in water levels.

Overall Hydrological Conditions

Similar to barrier bars in the area, the Port Bay barrier bar is reliant on the continuous longshore drift and continued erosion of nearby drumlins, and like other port communities, some of the sediment nourishment has been disrupted by built interventions (shoreline hardening, jetties, ect.) and dredging maintenance practices. As mentioned earlier, jetties and other channel structures can serve to divert coarser material from the longshore drift to offshore, as calculated in Regional Sediment Tool (ACE). However, Port Bay differs from the other regional bays in that the jetty does not appear to divert coarse material to the offshore (ACE) (Figure 2.4). While the jetty does accumulate a portion of the longshore transport, storms serve to carry and deposit the materials across the pier into the boat channel (Bergmann 2019).

Consequently, as the jetty does not divert or store coarse material, the material collected in the boat channel should constitute a large portion of the lost longshore material that causes sediment starvation downshore. Indeed, Bergmann estimates the potential gravel sediment transport volume to be around 2,200 CY, close to the overall annual dredging volume, estimated between 1000- 2000 CY (personal comm., Lindsey Gerstenlager). In effect, nourishment of the east barrier bar with annual dredging material has the potential to play a significant role in the stability of the bar (Bergmann 2019).

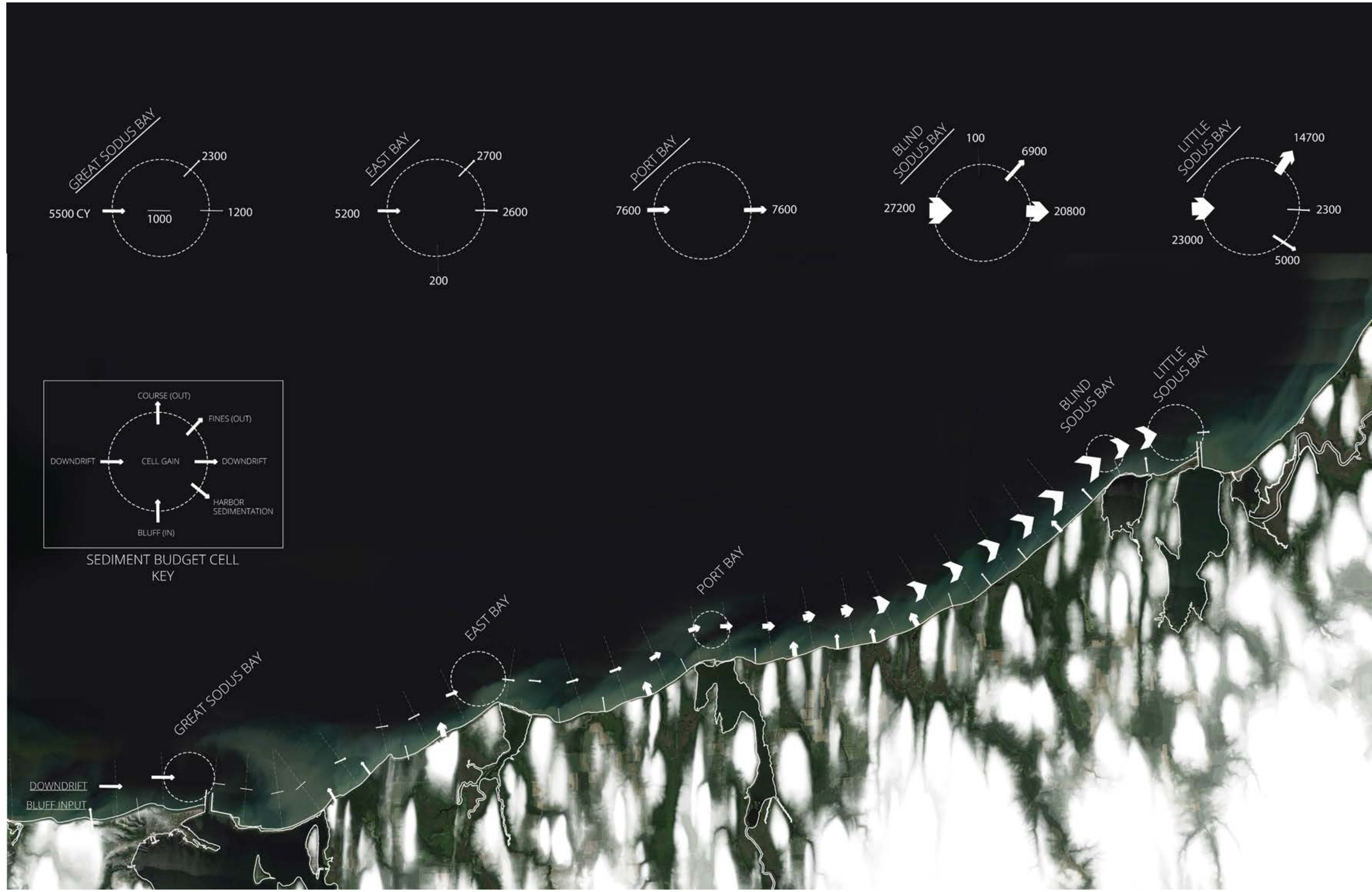


Figure 2.4 *Longshore Drift*

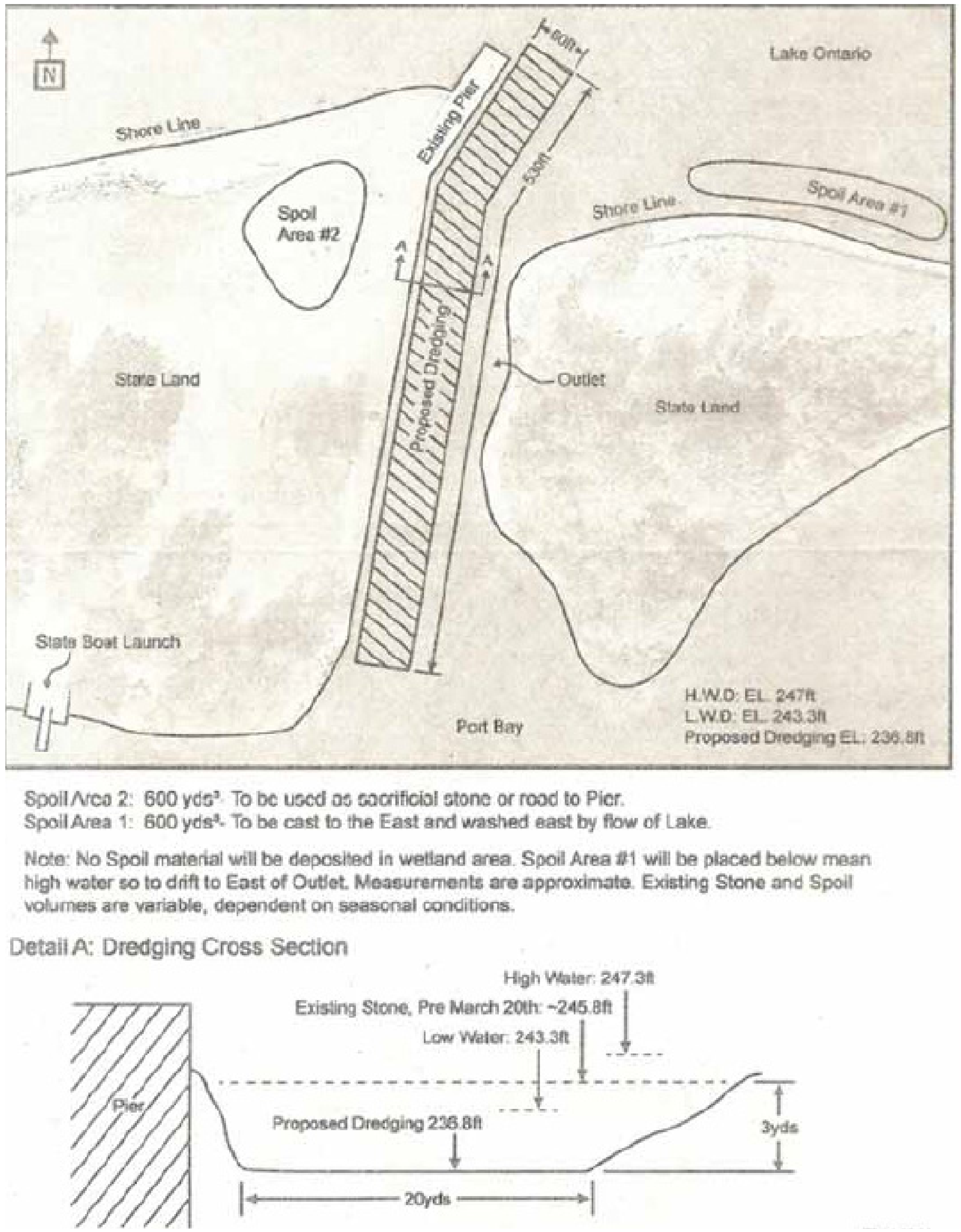


Figure 2.5 *An Example Channel Dredging Proposal from the 2000s (Bergmann, 2019)*

Dredging Operations

Volumes

According to the original dredging permit, Port Bay dredges about 1000 cy/yr. However, based on the available dredging estimates, the actual volume may be greater. In 2018, dredging yielded approximately 2,800 CY, and during the 2019, between 2,500 and 3,000 CY (Bergmann 2019).

Placement

Historically, the dredge materials were piled close to either side of the boat channel. Spoil Area 1, as seen on a typical permit, was placed on the East Bar. While the permit permits for the placement of sediment below High Water Level for the sediment to "drift" along eastwards, typically placement was above typical spring water level (246 IGLD 85). On the West Bar, there is a large coarse sediment pile, approximately 3000 cubic yards, consisting of material dredged from the inlet. Both historical placement sites are above water level during the typical dredging season (around 246.0).

The current permit does not allow for equipment to be in the water. Access to the channel from the East Bar is difficult, especially now that the East Bar is often breached in the early spring. As a result, the channel is most often accessed by the excavator through the West Bar. Accordingly, out of ease and convenience, the dredged material is often placed back on this bar. If enough material is available, the contractor builds a "land bridge" across the inlet with the excess material in order to access and place material on the eastern side. However,the practice can only be done during times of surplus sediment, as the amount of material that can be placed is limited, in both volume and frequency.

Case Studies

Healthy Port Futures researched a series of case studies that related to the passive sediment management. Passive Sediment Management aims to leverage natural coastal and fluvial forces such as winds, waves, and currents to achieve desirable sedimentary outcomes such as shoreline protection, maintenance of navigation, habitat creation, and wetland restoration. In some ways sediment is a resource out of place: while it is often beneficial in nearshore or wetland environments, in the open lake or navigation channels it becomes a problem. PSM workflows and technologies can be developed that can allow for fluvial and coastal conditions to be quickly characterized and appropriately analyzed and modeled, as well as design research that can leverage these insights. This will allow for finely-tuned, simple designs and adaptive approaches that can minimize costs and maximize value creation in sediment projects. In some places, PSM may be deployed for wetland creation, in other places to protect upland habitat and maintain navigation, or several objectives together. Because PSM requires a grounded understanding of the local conditions affecting sedimentary processes, it acknowledges that not all management strategies are deployable at all locations . PSM methods were found to more economically and ecologically beneficial than traditional placement methods.

Case studies like the Sand Motor and Horseshoe Island point to alternative methods to utilize natural forces to move and disperse sediment. While these methods are different in scope and scale to Port Bay, they indicate that these passive sediment management techniques can be successful in providing economic and ecological benefits over traditional methods.

At Port Bay, previous interventions also can provide additional information on the bar. SWCD conducted a one-time mechanical spreading of the material along the beach. While the intervention nourished the bar, the experiment is too cost-prohibitive.

Horseshoe Bend

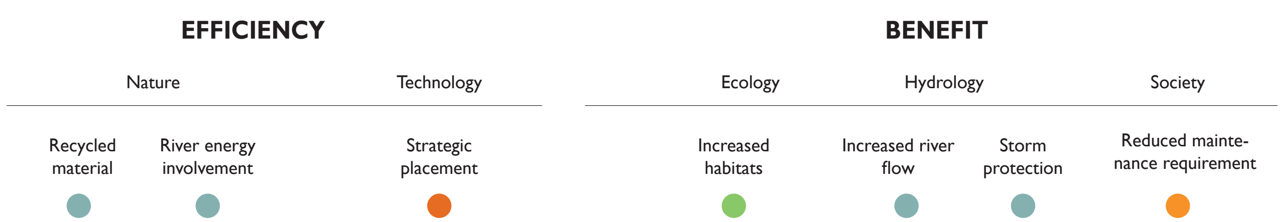
Dredged material was strategically placed in the Atchafalaya River with the intent of utilizing the river currents to disperse the sediment and nourish a downstream island. Every one to three years, half a million to 1. 8 million cubic yards of sediment was placed in mounds in the thalweg of the river (Figure 2.6). Over the course of the twelve year study, the island was monitored to assess the quality of habitat created through this placement method.

During this time, the island grew by 35-ha and formed forest, scrub-shrub, and emergent and submergent wetland habitat. In a study which compared the created habitat to traditionally placed dredge wetland and a naturally occurring wetland, Horseshoe Bend contained the highest plant species richness, and highest number of breeding wading birds. Importantly, Horseshoe Bend also supported the formation of emergent aquatic bed habitats, which resulted in higher infaunal abundance. This innovative passive placement technique was cheaper and easier than more traditional placement practices, and provided additional benefits.

Figure 2.6 Horseshoe Island Experiment

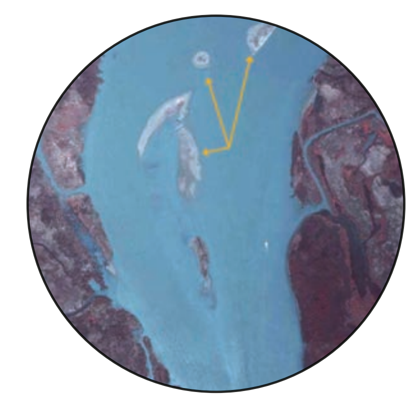
Louisiana, United States
The U.S. Army Corps of Engineers (USACE) New Orleans District (MVN)

Date: 2002 - 2012
Size: 35 ha island
Sediment Type: Shoal material
Environment: Estuary of Atchafalaya Bay
Sediment Amount: 0.4-1.3 million m³, every 1-3 years

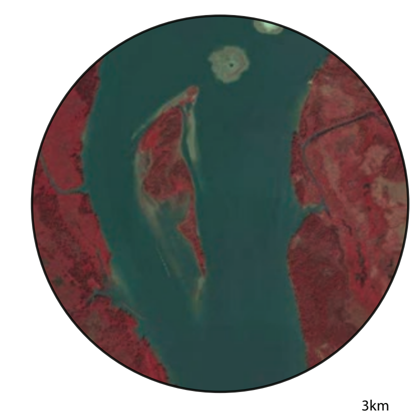


Pre-Disposal
1998

Initial Dredged Mound
2011



Developed Island
2018



Sand Motor

The Sand Motor is massive nourishment project built off the Delfland Coast, The Netherlands. This experiment was intended to test the effects of scaling up the more traditional sand nourishment projects conducted by Rijkswaterstaat (the Dutch Ministry of Infrastructure and Water Management Works), which seek to mitigate shoreline erosion and provide coastal flooding protection. In addition to these objectives, the Sand Motor was designed to add additional social and ecological benefits, which included creating temporary recreational space, and ecological habitat.

Sand Motor was built through the placement of offshore sand into a hook-shaped peninsula along the coast (Figure 2.7). Over a long period of time, coastal forces move and redistribute the large amount of material down-coast. This simpler and more economic nourishment methodology was equivalent to twenty years of annual nourishment.

Based on the initial first four years of monitoring, the sand motor has been successful in providing coastal protection, establishing new habitat for flora and fauna, and creating space for new recreational activities.

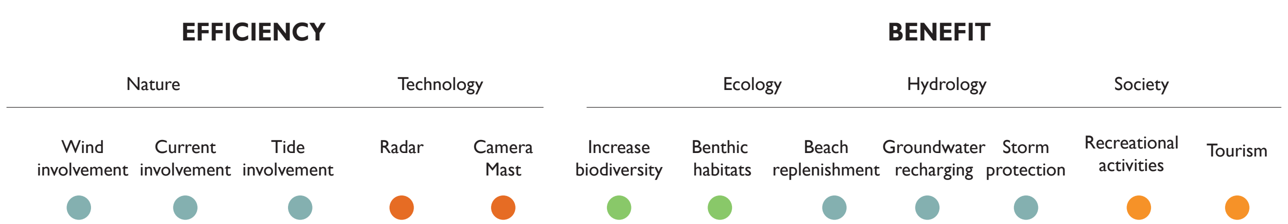
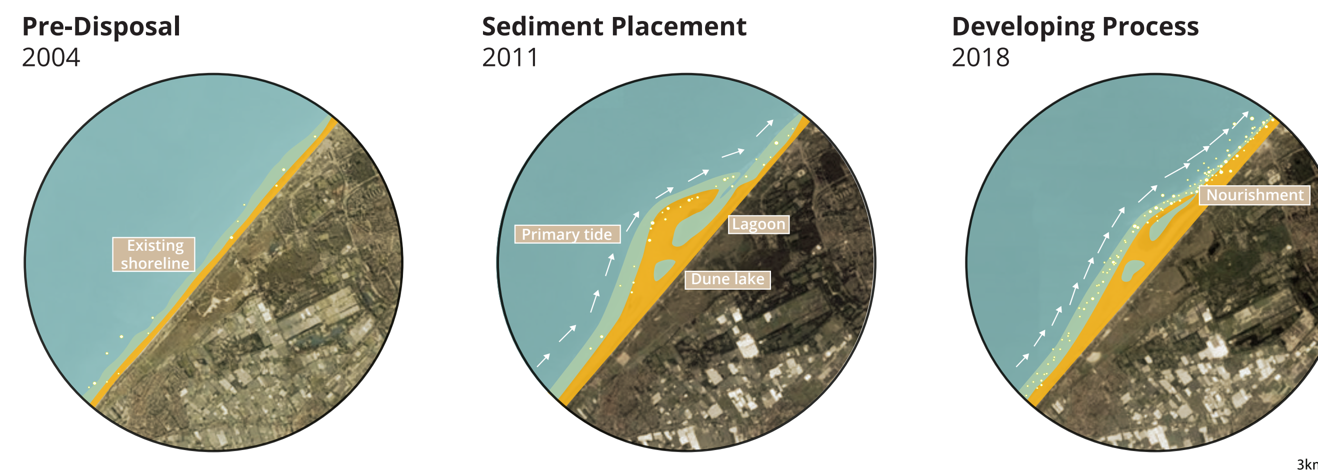


Figure 2.7 Sand Motor Experiment

Hauge, Netherlands
Rijkswaterstaat and the provincial authority of Zuid-Holland

Date: 2011
Size: 128 hectares
Sediment Type: Sand
Environment: Delfland Coast
Sediment Amount: 2-5 million m³



SWCD Beach Building

More recently, specific efforts have been made to re-introduce the material in the nearshore by placing the material on the East Bar's beach. Over the past decade, several breaches have occurred along the non-vegetated eastern portion of the East Bar. The East Bar was breached in 2012, 2015, spring 2016, and spring 2017 (Bergmann 2019). The high frequency of breaching events prompted PBIA, SWCD, and DEC into action, and resulted in the formation of working group, nature-based erosion protection efforts (live stakes, dredge material spread), and a commission of a report (Bergmann 2019).

Following the spring 2016 breach, SWCD permitted and constructed a temporary nature-based shoreline protection, filling the breach and temporarily stabilizing it with logs and root wads (Figure 2.6). In spring 2017, the bar breached, and high water levels prevented any intervention. While the breach closed naturally in the following spring before dredging occurred, SWCD used the secured funding to spread material over the recently-filled in breach area. As an additional fortification measure, SWCD planted live stakes in the location of the 2016 breach.

In 2018, as part of a SWCD- led restoration project, approximately 1,200 cy of material was brought over to the east barrier bar and spread just above the current water level (246 IGLD 85) (Figure 2.8). This effort was expensive, double the annual dredging, and therefore required additional funding. The additional funding paid for the contractor's time and the use and access to a hauler to spread the sediment.

These efforts helped inform our research, and led to a permit change that allowed for dredge material placement along the entirety of the East Bar, thus preparing for future innovation. While there were observed changes to the shoreline as a result of the nourishment, these measures are too cost-prohibitive to be done on an annual basis. Even so, this case study was instrumental in providing a foundational base for the HPF research project to build upon..

Port Bay, NY

Date: 2017
Size:
Sediment Type: Sand, Gravel, Cobbles
Environment: Great Lakes Shoreline
Sediment Amount: 3000 CY

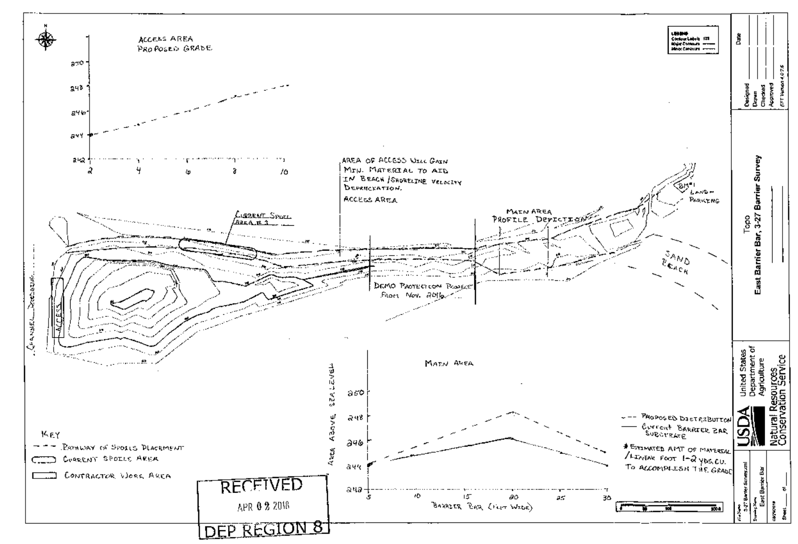


Figure 2.8-2 *2016 SWCD Permit Modification*

Attachment "8"

Figure 2.8-1 *SWCD Efforts*

Concept Summary

HPF developed a concept of dredge placement based on stakeholder objectives, initial preliminary research, and case studies. In particular, Regional Dredging Management Plan, Bergmann report, and the earlier beach nourishment project, provided vital foundational information about the conditions of the bar, that structured HPF's findings . Based on this preliminary research, HPF developed a concept for placement that would utilize the wave energy to disperse the dredge material along the East Bar (Figure 2.9).

Under this plan, machinery would move the sediment from the channel into a pile in the nearshore zone. This process will be less costly, and less disruptive than relying solely on mechanical means to move and spread material, and would move and sort the material, naturally.

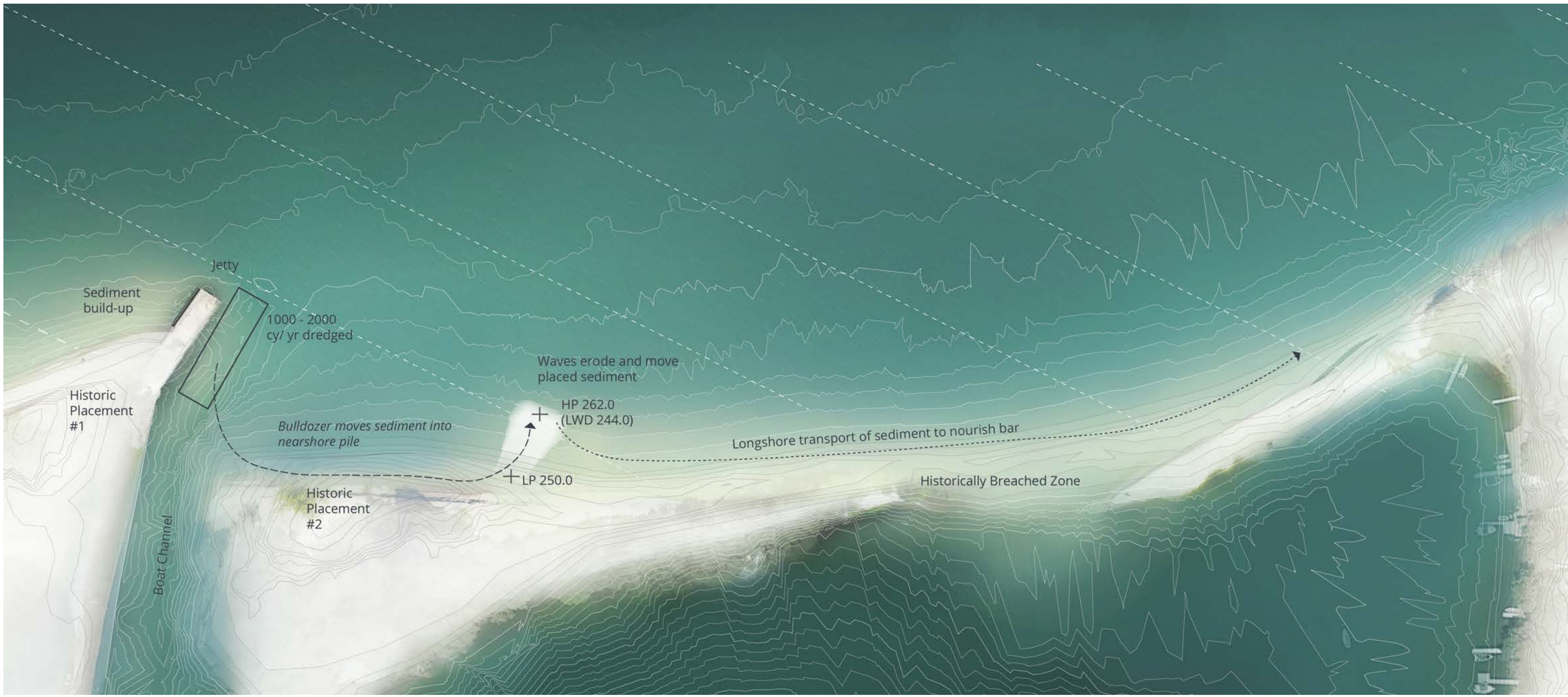


Figure 2.9-1 *Concept Plan*

Sediment Size Gradient (Tess Ruswick)

Research Development

Research Conditions

Sediment

The sediment in Port Bay consists of coarser material, comprised of mostly sand, gravel, and cobbles. During Bergmann's investigation, several sediment samples were taken both from the channel and along the East Bar shoreline. The channel sediments were coarser than the shoreline, and contained a significant amount of cobble material, with a D50 of 20mm. The shoreline materials were well-graded gravel (2mm-64mm) with little sand (< 2mm) and cobbles (64mm).

Wave Energy

Waves significantly shape the Port Bar barrier bar system, and contribute to areas of accretion and erosion, and in the most severe cases, areas that are susceptible to breaching. ACE Wave Information Studies (WIS), scattered throughout Lake Ontario, collected wave measurements from 1974-2014. Healthy Port Futures studied data collected from 1974-2014 at the closest Wave Information Study (WIS) station 91054, to understand the predominate direction of the wave events.

Since these metrics vary seasonally, HPF focused on data from early spring, in particular the month of April, during which dredging and placement would occur. HPF also focused on the larger wave events that would move the coarser dredge material.

The larger waves (>1m) move the coarser gravel and cobble sediment. During April, the larger waves (>1 m at the buoy) were predominantly (72%) from the western- northwestern direction (292.2) (Figure 3.1) While nor'easters do happen, as seen in spring 2016, which led to the major breach, they occur much less frequently. Only eight percent of the larger waves during April come from the northeast. In conclusion, the majority of the waves that would move the coarse dredge material are from the northwest direction. These calculations were considered during the research and placement of the dredge material.

Figure 3.1 *April Wave Classes*

Specific Parameters

PBIA

HPF sought to research possible placement operations that were consistent with PBIA's current annual budget of 15,000. The budget amount accounts for contractor time and equipment. Historically, necessary machinery is limited to a single excavator and bulldozer. While financial assistance through DEC in the past has occasionally enabled beneficial placement of the sediment on the east bar, slip fees collected by the PBIA currently do not allow for the increased equipment and cost necessitated by this practice. To this end, HPF had multiple discussions with the contractor to better understand standard operations and capabilities and develop the concept within those parameters. PBIA cannot pay for annual mechanical spread of material along East Bar as done in 2018 through additional funds. In addition to accounting for PBIA budget-constraints, HPF's research also considered the continuation of fishing and boating access, as well as improving the protection of the East Bar against breaching and floods.

DEC/DOT

DEC is concerned about maintaining and restoring natural coastal processes, including regional sediment transport. As the barrier bar resides within the Wildlife Management Area, DEC's mandate is to protect both bar's own natural habitat, and the habitat which it impacts. This habitat includes the gravel bar itself, prime spiny softshell habitat, the cobble nearshore fish habitat, and the important waterfowl bay habitat. Therefore, any dredging operations cannot impair, and preferably would augment the important existing habitat. For this reason, operations are limited in timing and location. According to the most recent permit modification from 2018, placement below 246.0 cannot occur between May 15th and July 1st. In the current permit, equipment cannot be in the water, and placement cannot occur below current water levels (246.0). However, based on conversations, there is room to change the permit language to allow for placement below current water levels (246.0) but above LWD (243.3 IGLD).

Contractor

HPF talked with Jeff Decker, PBIA's contractor, about potential limitations to equipment. Decker was open to new placement technique with a bulldozer, provided the slope of the placement not exceed 20% with a maximum height of 20'.

Research development Summary

Final Research Concept

Working within this concept, HPF established specific parameters based on wave direction, bathymetry, sediment type, sediment amount, available machinery, contractor and knowledge expertise, and time.

The results of the research suggested that a sediment pile, placed in a drumlin-form perpendicular to the angle of incident waves (Figure 3.2), would allow for the spread of sediment along the bar. The drumlin shape, with its gentle upward grade, its wide-flat ridgeline and its steep, vertical sides, is designed to optimize the machinery and wave forces that construct and erode it. The bulldozer creates the drumlin by repeatedly pushing the material along the wide sloping ridge, higher and farther out into the nearshore, until the drumlin is at the desired length and width. The side slopes will be determined by the dredge material's natural angle of repose. Past channel surveys indicate the dredge material is a mix of coarser material, which should allow it to be stacked high and steep, and consolidated enough to be driven over.

Scaled down, but operating on the same erosive patterns seen in nearby bluffs, the waves will erode the steep sides of the dredge drumlin through notching, slumping, and gullying. The steeper the slopes, the faster the erosive process will occur. In this concept, it is important that the toe of the placement be placed in the active nearshore zone, within the reach of daily waves.

The placement of the feeder drumlin along the bar is designed to minimize the amount of travel distance needed by the bulldozer. It is placed beyond the jetty shadow, to both maximize ability of the incident wave energy to move it westwards, and to reduce the risk of sediment moving eastwards into the navigation channel. The placement location is sited just beyond the current build-up of material located at the western edge of the barrier bar.

HPF investigated several iterations would place material out in the active nearshore zone, effectively re-creating an eroding drumlin bluff (Figure 3.3)

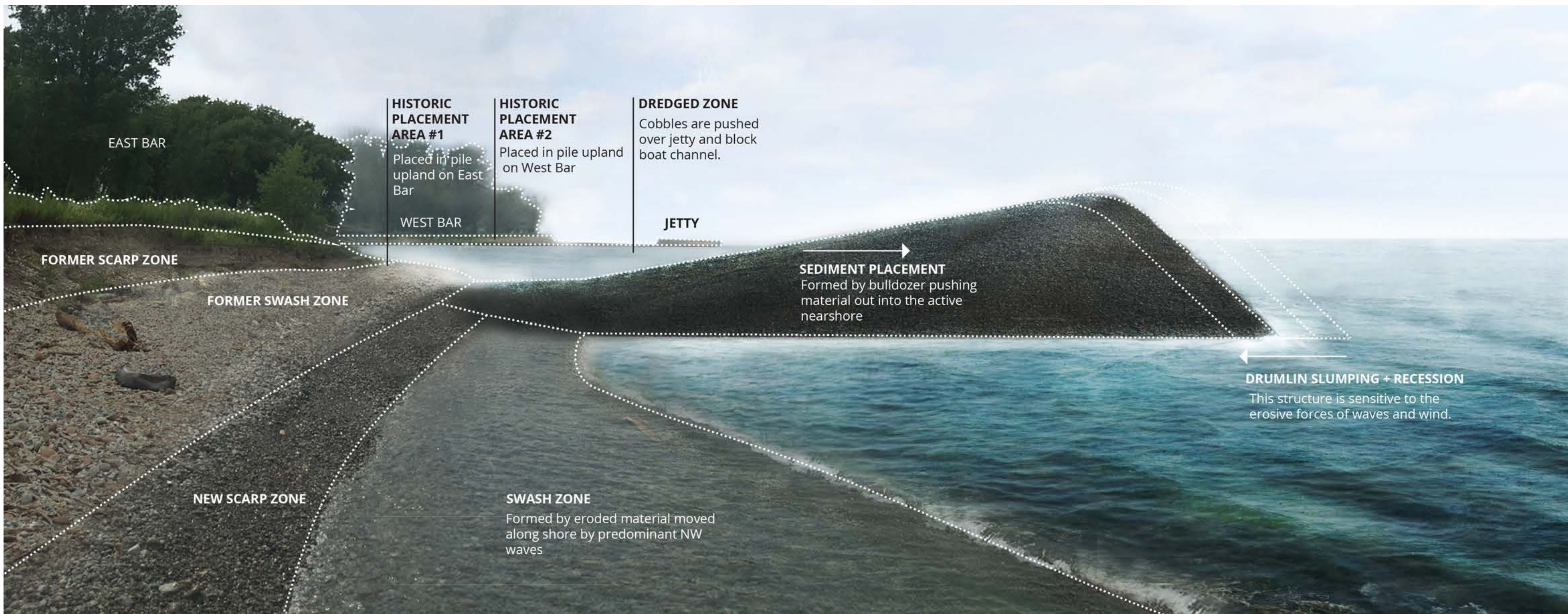


Figure 3.2 *Concept Perspective Drawing*

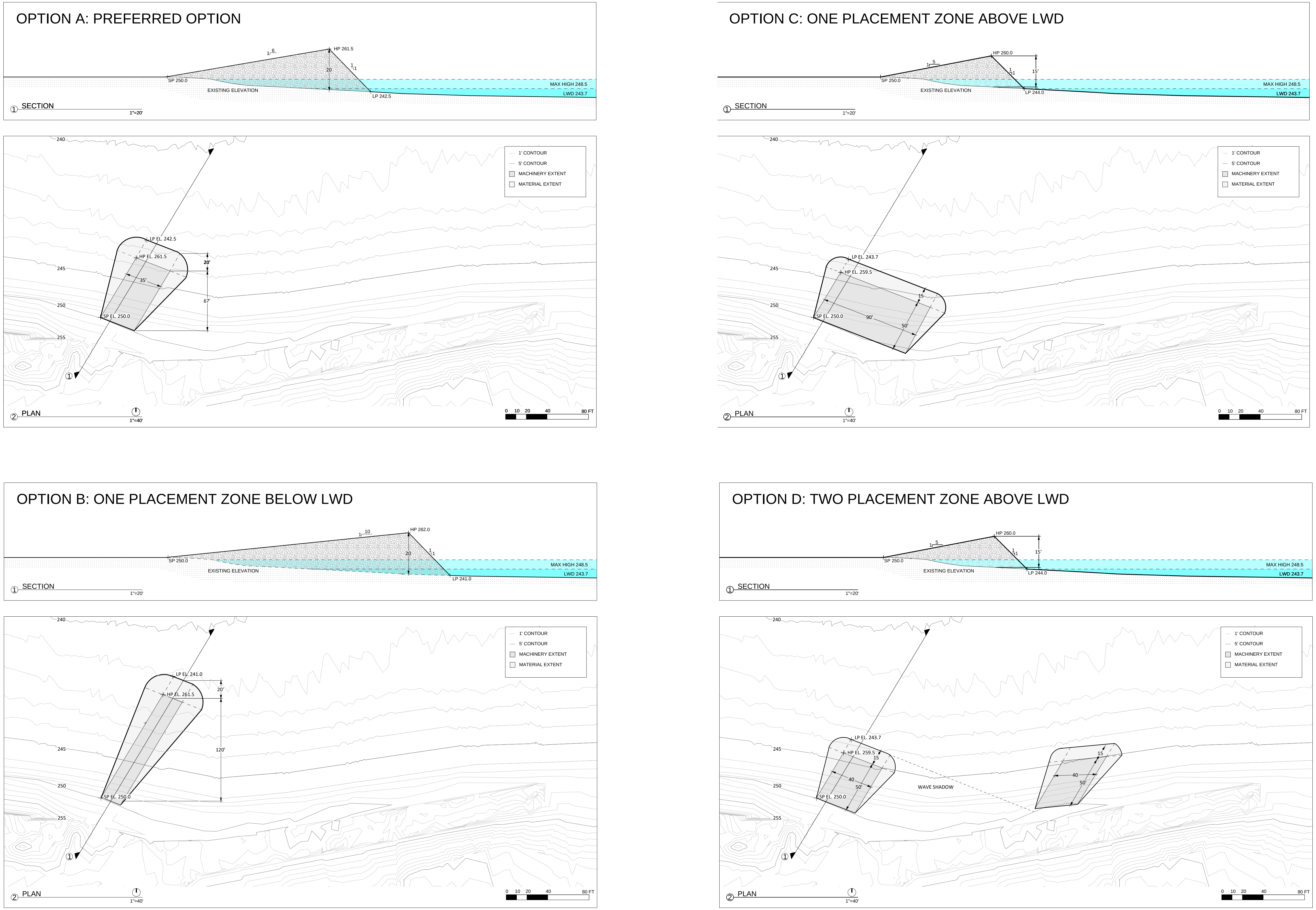


Figure 3.3 *Research Iterations*

Water Table Experiment (Tess Ruswick)

4 | Research Modeling

Water Table Experiments

After conceiving of the general shape and location of the placed material, physical modeling was used to further iterate form specifics and visualize the process of material movement. HPF tested numerous form iterations under a range of wave conditions in order to explore differences in how the material eroded and moved in relation to the wave direction and shoreline morphology.

While the physical modeling was broadly tuned to the conditions at Port Bay, it was not meant as a definitive, and predictive model. Rather, physical modeling was used make general inferences, to illuminate insightful patterns, and to provoke further leading questions. Further tuning in future years will be based on observations and monitoring of the previous ones. Each year, Port Bay is dredged at a similar time by the same contractor; conditions which allow the project to be responsive and adaptive in its approach and support the gradual calibration of placement over time.

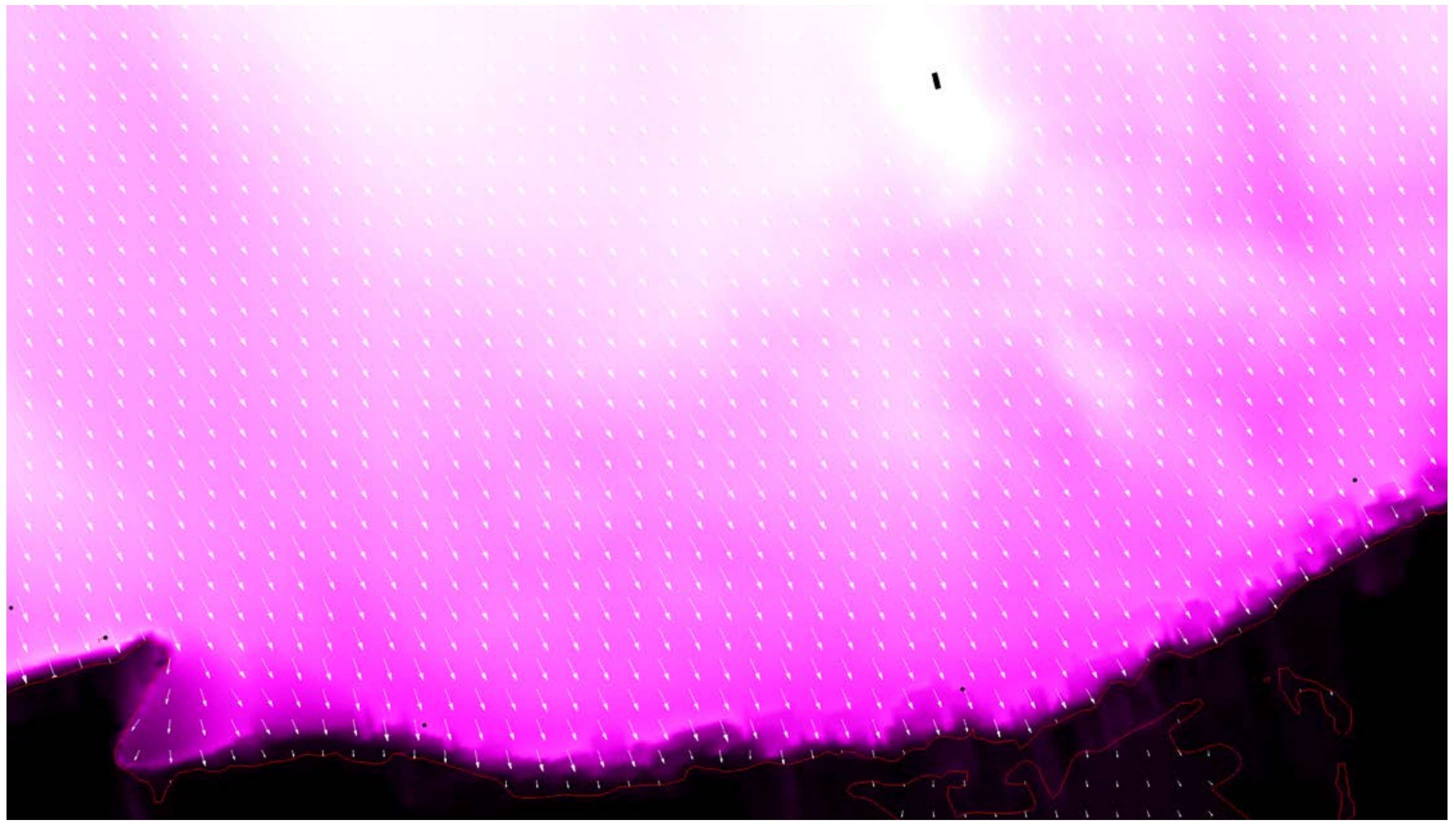


Figure 4.1 CMS Wave Results

Set Up

Computational modeling was done using through CMS-WAVE to model wave refraction and diffraction due to the nearshore and the jetty, respectively. Multiple wave cases were modeled to understand the basic impacts of storm and daily waves in this area. The model was not used to predict sediment movement or shoreline morphology change over time. However, the results helped to locate an effective area for dredge placement within the efficient operating distance of the contractor as well as incident wave angle to shore (Figure 4.1).

Environmental Conditions

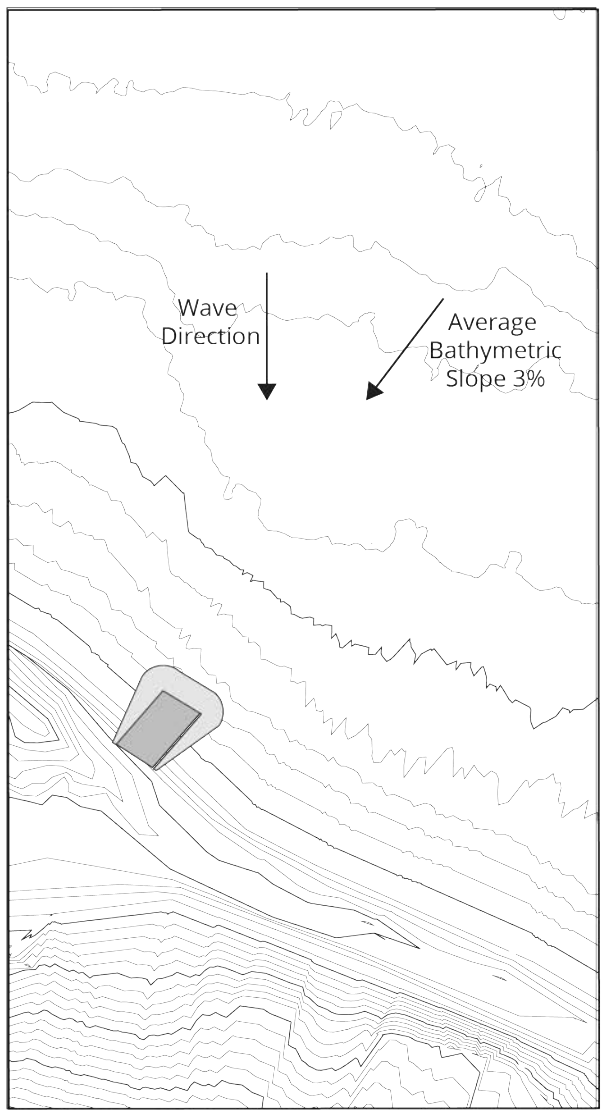


Table Conditions

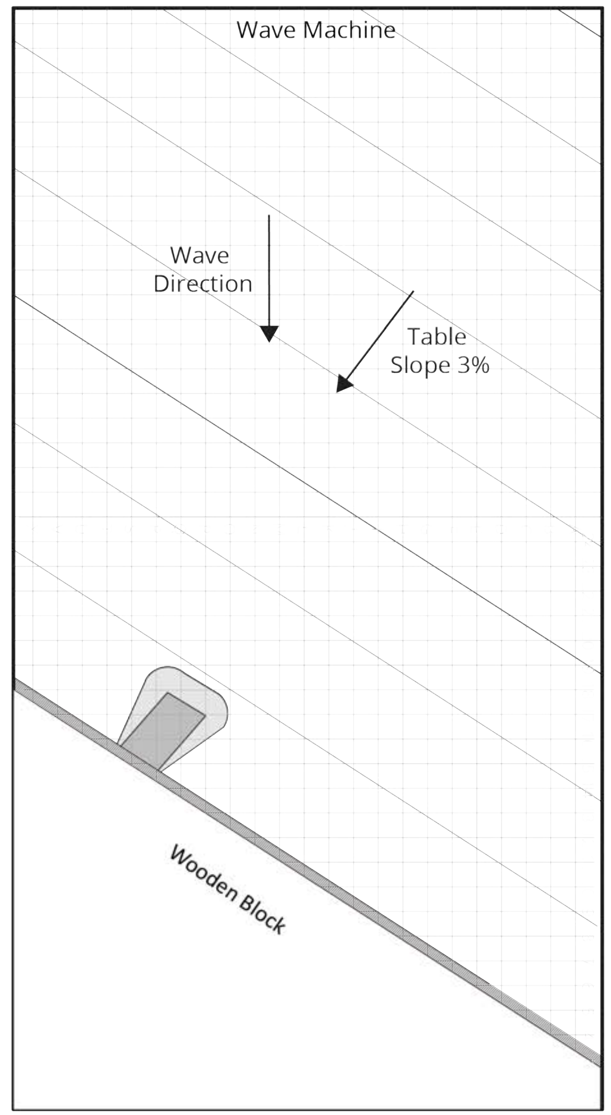


Figure 4.2 *Table Set-up*

The wave table was set up to simulate basic conditions at Port Bay, including predominate wave direction, slope, and sediment size, and scaled at 1 inch: 10 feet (Figure 4.2).

Wave direction relative to shoreline was determined by Aquaveo computational modeling. While the predominate wave direction is from the northwestern direction (292.50) at the USGS wave buoys, as the waves approach the shore, the refracted waves become more shore perpendicular. Several tests were run under different wave directions, but the final run was conducted under 330.0.

Based on the 2018 survey that Bergmann conducted nearshore slope of the East Bar, as defined as within 80 feet of water's edge, is approximately 4%, offshore slope 1%, between 80 and 400 feet of the shoreline, is 1%, and the overall beach slope 2-3%. The water table was adjusted to create an overall 2% slope.

The sediment mix simulated the sediment composition dredged from the boat channel, as cataloged by Bergmann. This composition was recorded to be 2% silt (<.1mm), 38% sand (.1-2), and 60% gravel (2-64mm) sediment. This sediment was simulated by water table sediment of 20% fine red (.5 mm), 20% medium black (?), 60% coarse yellow (2.1 mm). While the sediment is not scaled precisely, the simulations are for pattern recognition and not meant to be a replica of real world conditions.

Iterations

The water table was used to test four placement iterations to explore the performance; specifically, the experiments assessed the pattern and rate of sediment erosion and dispersion along the shoreline as it related to sediment size. Each iteration was set up to experiment with differences in length: width ratio, bathymetric depth, and number of placement sites based on the drumlin design iterations (Figure 4.3).

Option A: Medium length: width ratio, 1 placement

Option B: High length: width ratio, 1 placement

Option C: Low length: width ratio, 1 placement

Option D: Medium length: width ratio, 2 placements

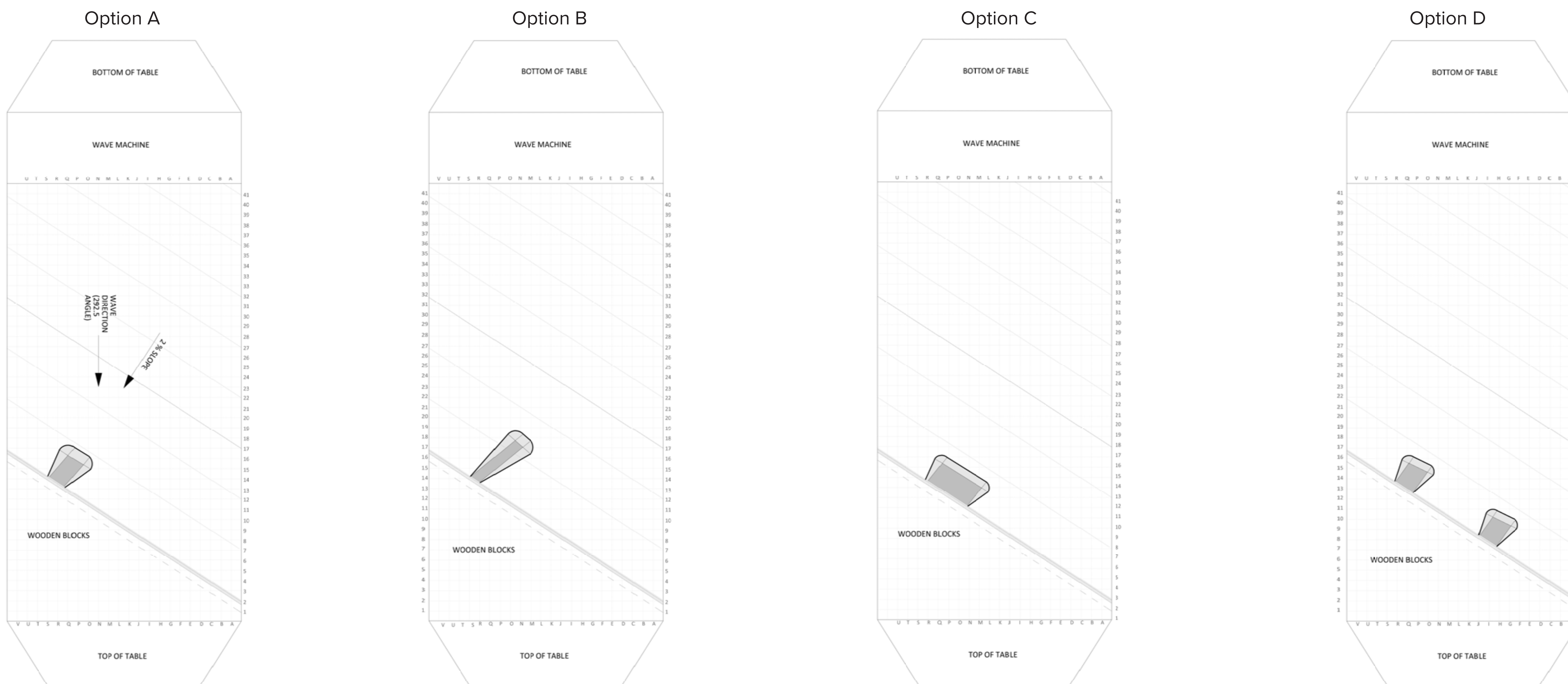


Figure 4.3 *Iterations*

Results

Each iteration was run under the same wave conditions for the same length of time.

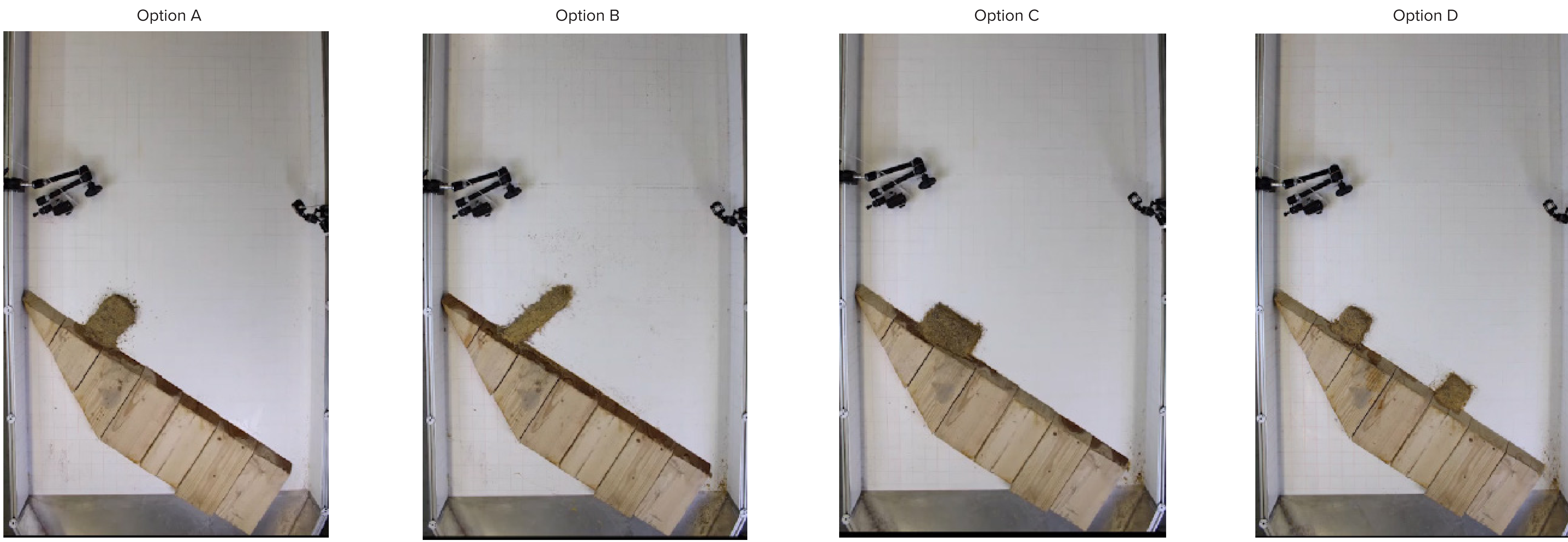


Figure 4.4-1 *Iteration Results (Before)*

Observationally, a few patterns emerged in all of iteration runs (Figure 4.4-1).Fine sediment tended to be pulled further offshore where it dropped out due to lower velocities. This is commonly described as winnowing. This material created a bell-shaped dispersal pattern around the initial placement. Coarse material dispersed along the shore, creating and adding to the initial beach. A swash zone of newly created material formed from some of this coarse material. This swash zone stayed active during the entirety of the iteration run. The majority of the sediment traveled westward, creating a "tail" of sediment. Ideally, the more material that traveled along the shore ("tail") would be greater that the material that remained around the initial placement ("bell")

The placement form influenced the ratio of sediment that dispersed to that which didn't.   Additionally, the form also influenced the rate of dispersal. Based on dispersal pattern and rate, the Option A and D, medium length to width ratio, were most ideal (Figure 4.4-2). This form most efficiently dispersed the sediment into the shore.

Option A | Option B | Option C | Option D

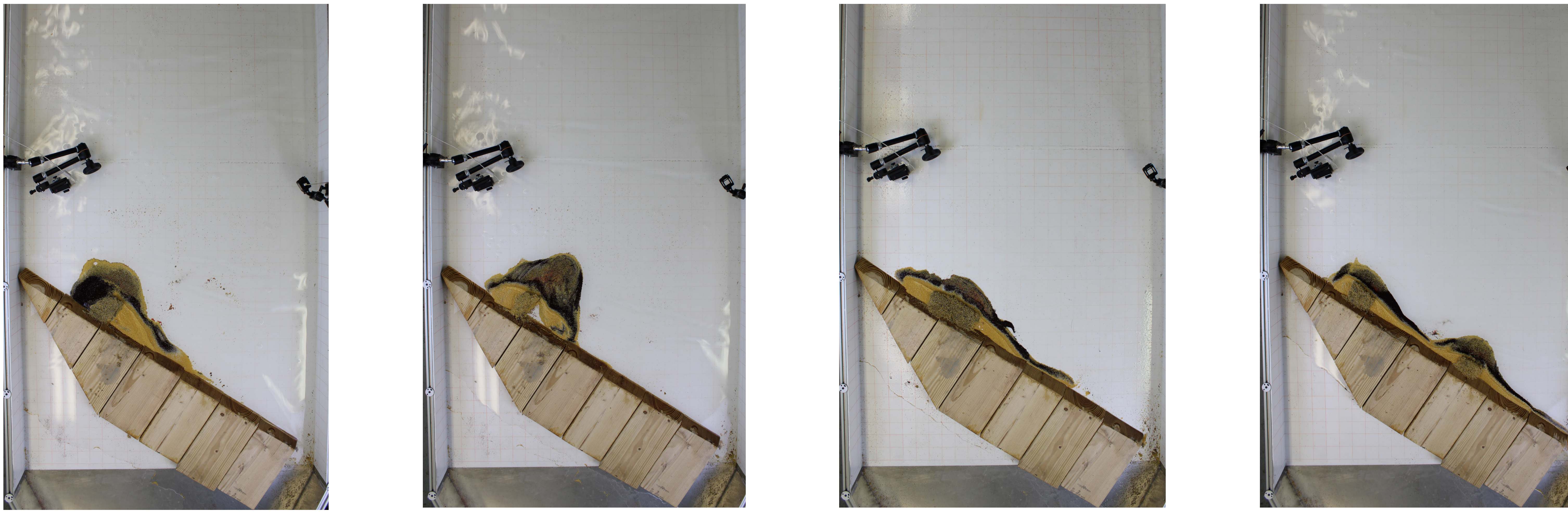
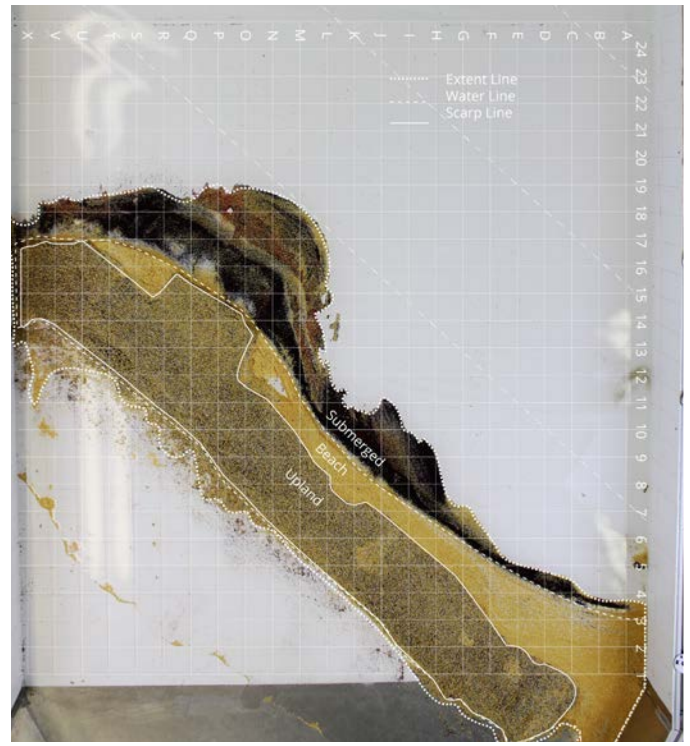


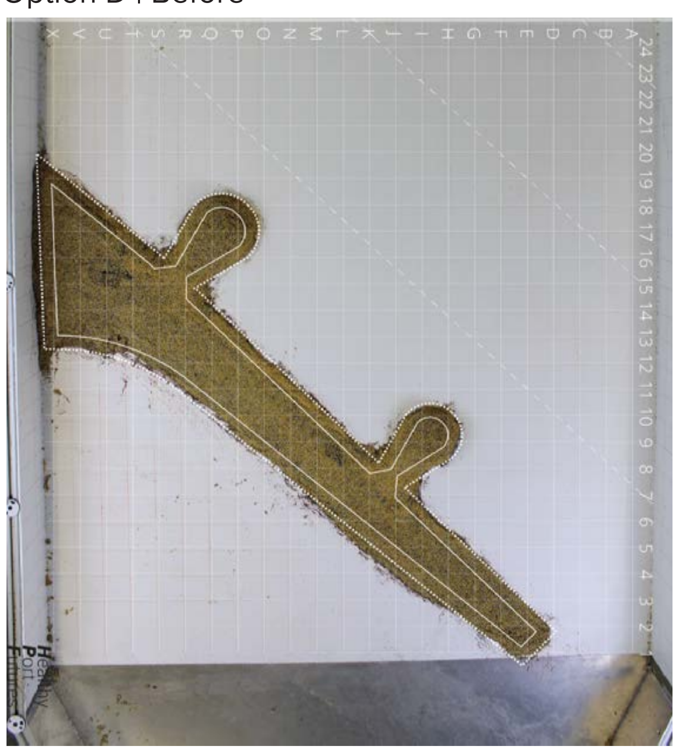
Figure 4.4-2 *Iteration Results (After)*

Option A | Before

Option A | After



Option D | Before



Option D | After

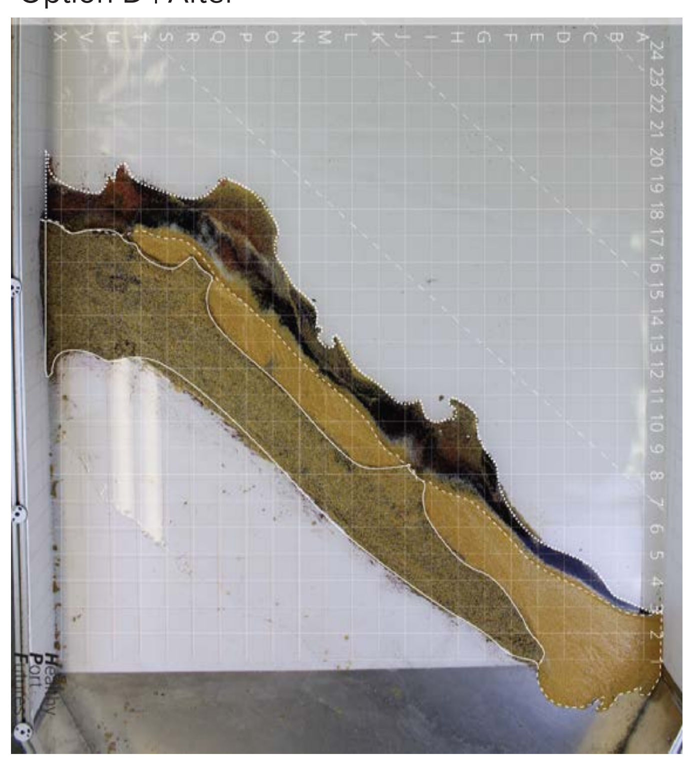


Figure 4.5 *Further Studies (Soft shoreline)*

A second run was conducted to compare Option A and Option D with a soft shore comprised of the same material as the feature. While there was some initial differences in the rate of dispersal between Option A (medium L:W, 1 placement) and Option D (medium L:W, 2 placements), it was not enough to justify the extra labor required for two placement sites, especially since one site would be located an extra distance from the channel, thus exponentially increasing the potential workload (Figure 4.5).

One conclusion, first noted here, and later elaborated in the final conclusion, is that waves can do the work of the hauler and grader (dozer) effectively. This is clearly suggested in the results of the water table. As mentioned earlier, beaches made from natural forces are distinctively different than mechanically graded beaches. As can be clearly seen in the water table experiments by the colored sediments, a waves sort the sediment by size, which can occur along the swash zones, but also along the beach, creating pockets of sand and gravel. These natural beaches have a diversity of microhabitat that mechanically-spread beaches lack.

The drumlin shape increased the erosion rate of the pile. The steep side slopes helped facilitate active sediment erosion. This process mimicked the morphological developmental phases of drumlin bluffs seen along the coast (Figure 4.6). Under these conditions, the drumlin undergoes a faster erosion rate, and more sediment to the system in the preliminary, early stage. In a similar manner, in the water table experiments, the erosion rate and dispersal was high early on, and becomes increasingly slower over time (Figure 4.7). In the field, we might expect to see the same dynamics. This is desirable, because the bar might be quickly nourished and then stay relatively stable over the course of the late spring and summer.

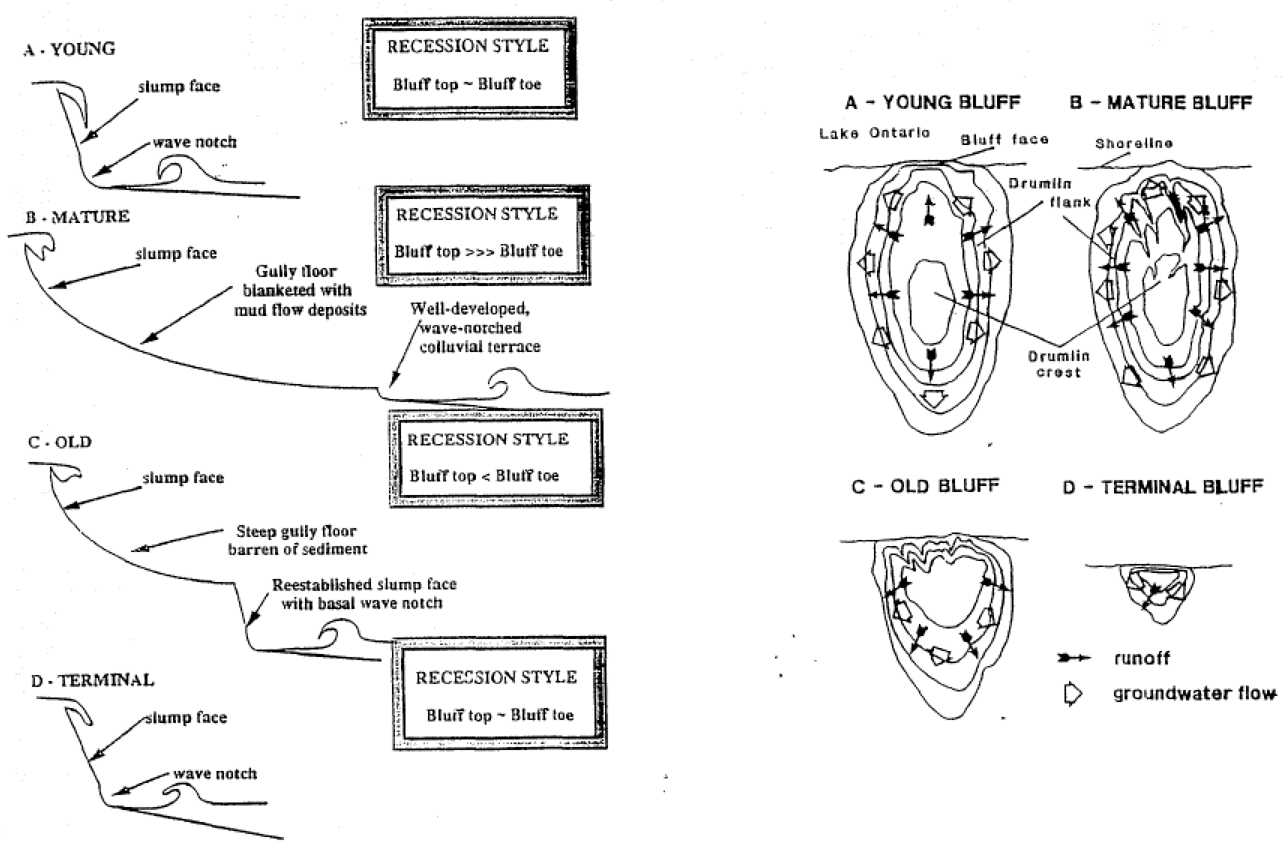


Figure 4.6 *Drumlin Erosion (Pinet + McLennen, 1997)*

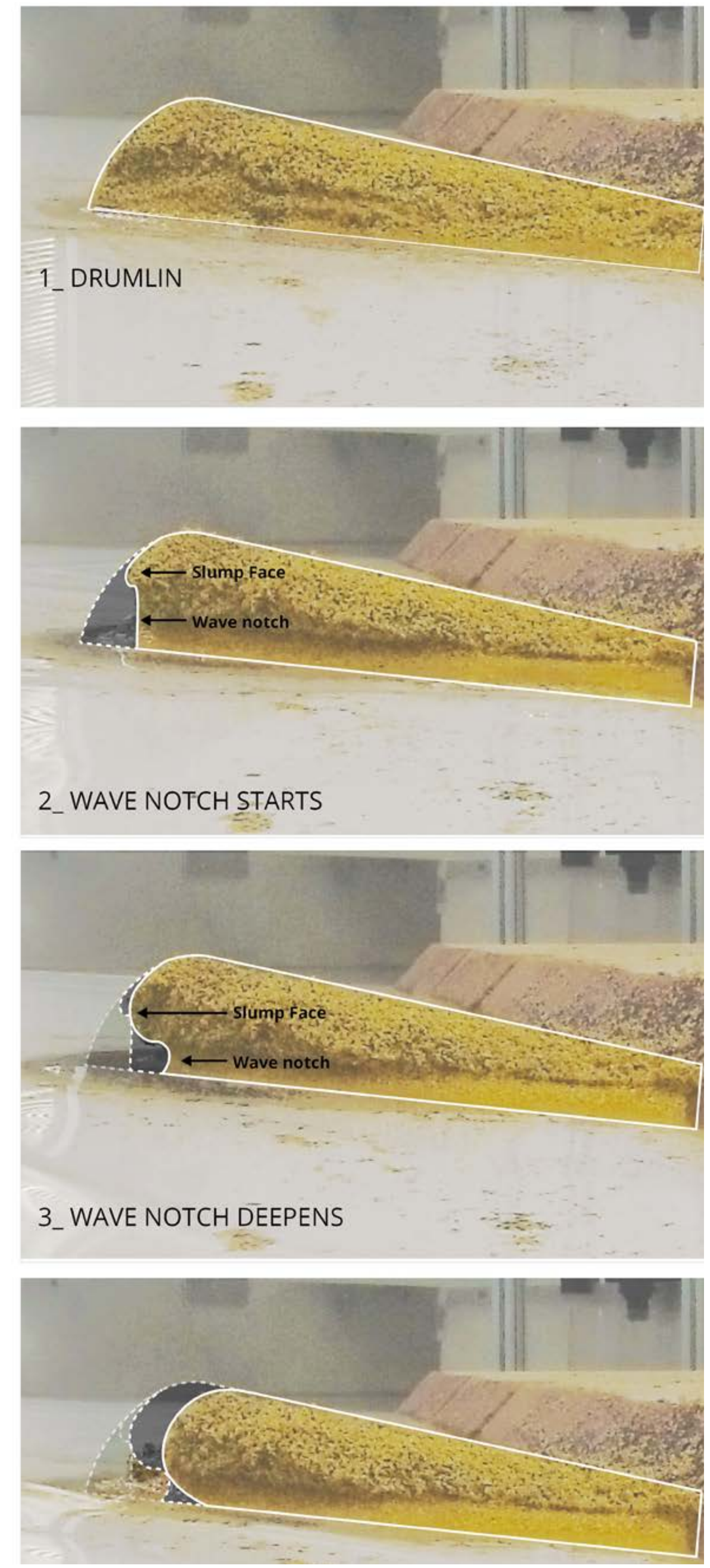


Figure 4.7 *Side Profiles*

Preferred Placement Option

Finding from both physical modeling and discussions with stakeholders suggested a placement practice based on the previously modeled Option A (Figure 4.7). The contractor was given the following guidelines, with the assumption that working slopes drumlin top, and sides might vary in construction. Based on an estimated 2000 cubic yards, Option A had a maximum height of 20', and reached 87' off the shore, with a low point above LWD 243.3 IGLD 85. The constructed slope is 16%, and the natural angle of repose of the sediment is 50%. The feature is angled at 28 degrees.

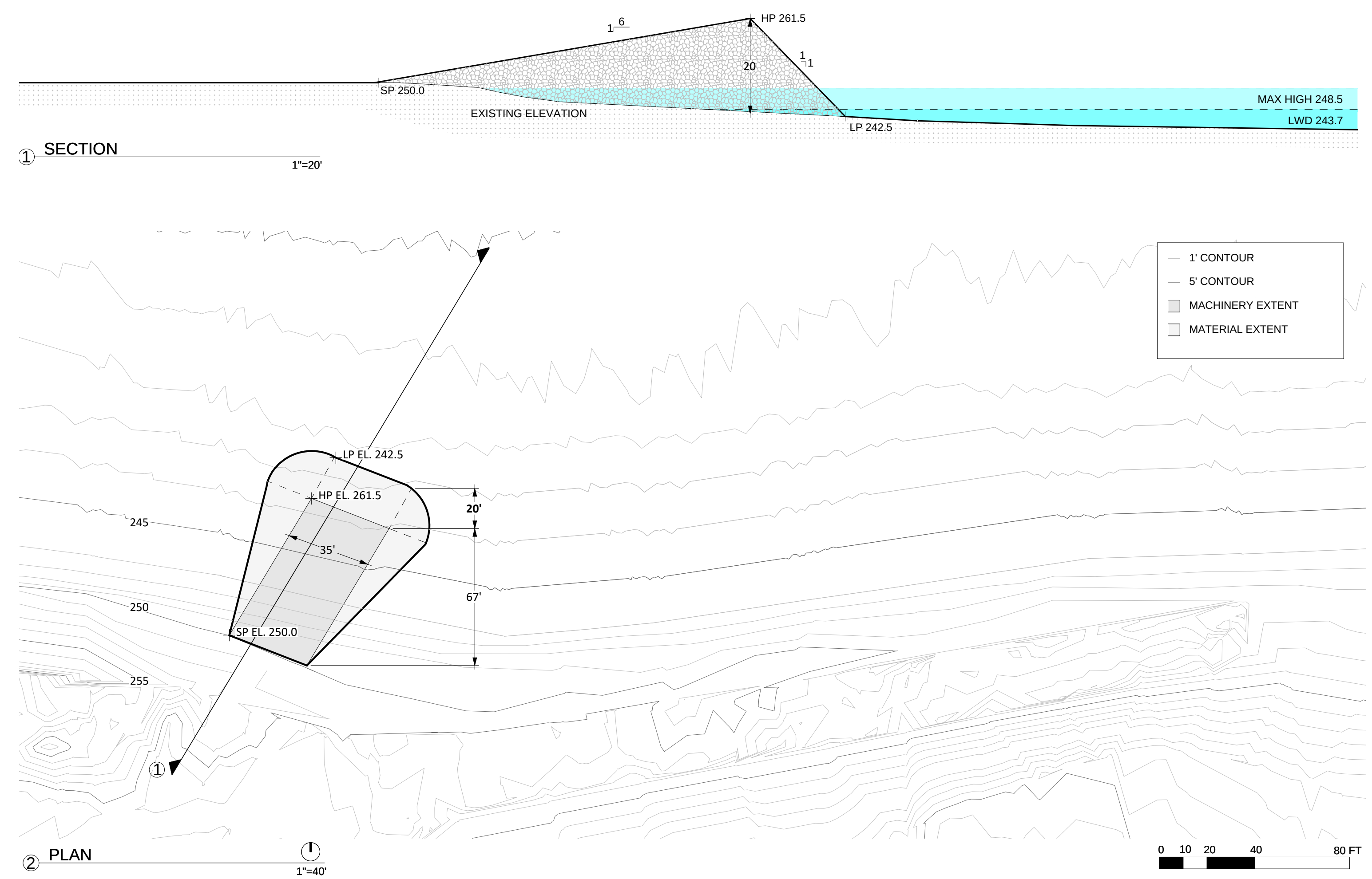


Figure 4.7 *Final Design*

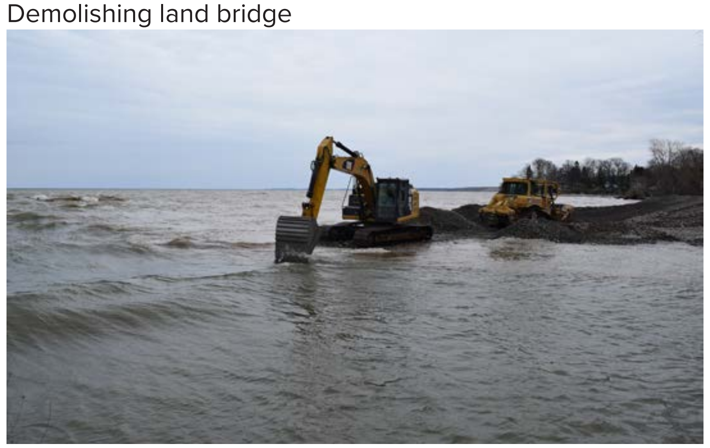
Initial dredge pile from southwest channel

Building land bridge with channel material

Moving material across land bridge

Dredging material from channel

Demolishing land bridge



Spreading material eastwards

Building feature

Continuing to build up feature

Figure 5.1 *Construction Photos*

5 | Implementation

Construction

Conditions

Dredging took place over the course three days, from April 22-25. During that time, the average water level was 247.15 IGLD, and the lake was relatively calm, with waves coming from the northeastern direction. On the first day, the East Bar was still shallowly breached. Over the next few days, the water levels receded to uncover the entire East Bar.

Equipment + Process

The excavator was brought in through West Port Bay Road to the West Bar. Starting on the west side of the boat inlet, the contractor build a land bridge to span the West and East Bar using the excess material dredged from the inlet the previous February, which had been temporarily placed on the West Bar. After the boat channel was dredged and placed on the East Bar using the land bridge, the bulldozer was driven across the East Bar, by way of the East Port Bay Road, in order to be used to push the dredge sediment out into the wave-activated nearshore of the East Bar into a drumlin shape based on the research findings (Figure 5.1).

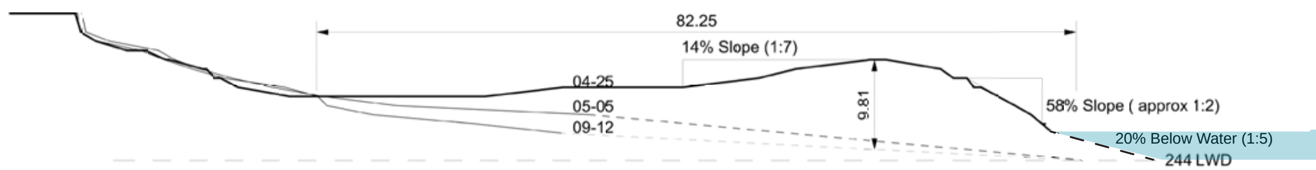


Figure 5.2-1 *Section of built feature*

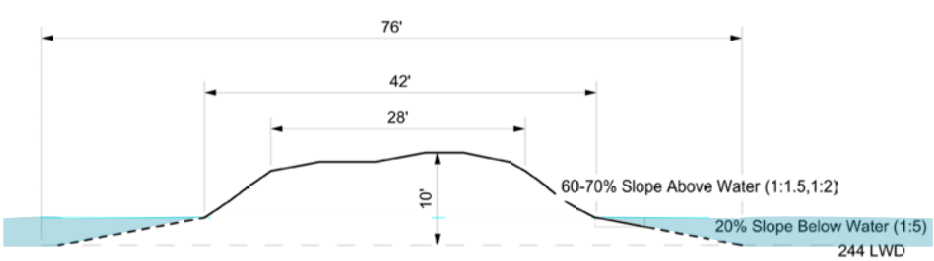


Figure 5.2-2 *Cross-section of built feature*

Amount Placed

Measurements of the feature were derived from the drone-imagery taken that day (Figure 5.2). The built feature was slightly smaller than the 20' tall, 88' long designed feature due to limitations of equipment and amount of sediment. The final feature was ten feet tall at the highest point, and reached 80 feet into the water. The feature hit lake grade at approximately 244.0 LWD. The constructed slope was at its steepest 15%, and the resultant side and front slopes were between 50-66%. Below water, the slopes subsided to 20%. The feature was created to be parallel to the jetty, and was angled at 330 N. The contractor estimated a total of 3000 cubic yards sediment was moved. According to photogrammetry estimates, about 700 cubic yards of that material was placed into the nearshore feature. The remainder of the material was placed along the nearby shoreline.

Construction During Covid

With construction paused across the country, this small-scale pilot project was able to happen largely due to the knowledge and expertise of on-the-ground partners. HPF worked with Jeff Decker, a local contractor, Lindsey Gerstenslager, the District Manager at Wayne County Soil and Water, and Jason Newton, a scientist and UAV pilot from Ramboll, to construct, and monitor the new pilot project.

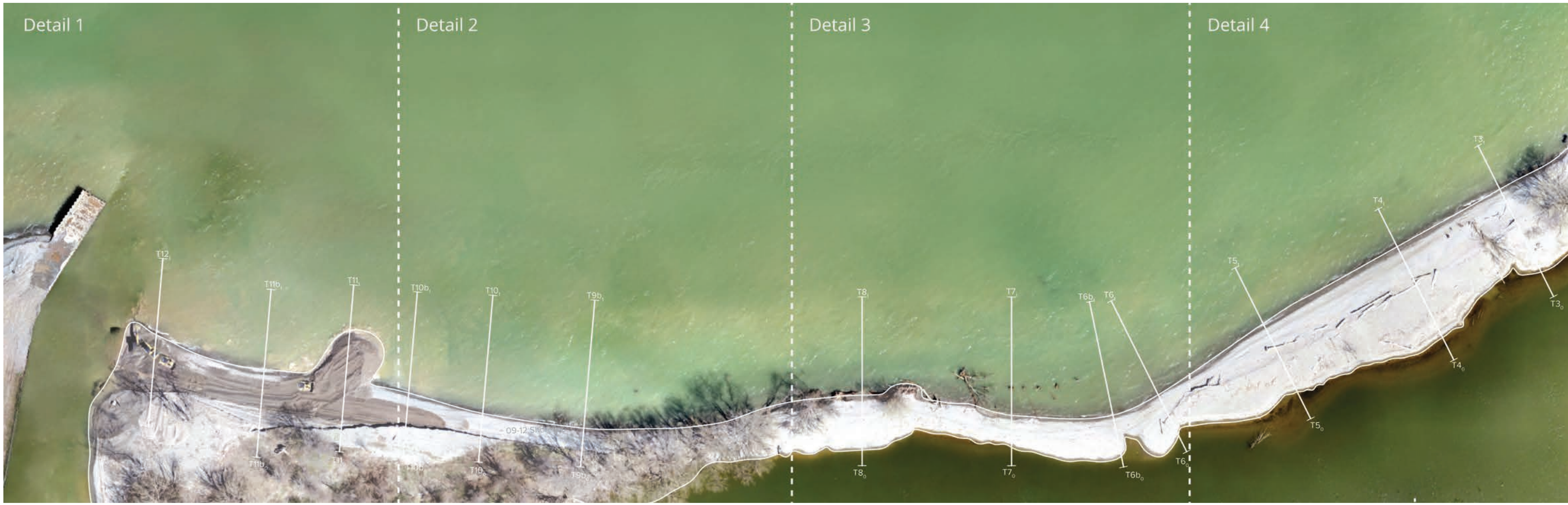


Figure 5.3 | *Orthomosaic_April 25th*

247.15 IGLD85, Calm

Figure 5.4-1 *Detail 1 | April 25*

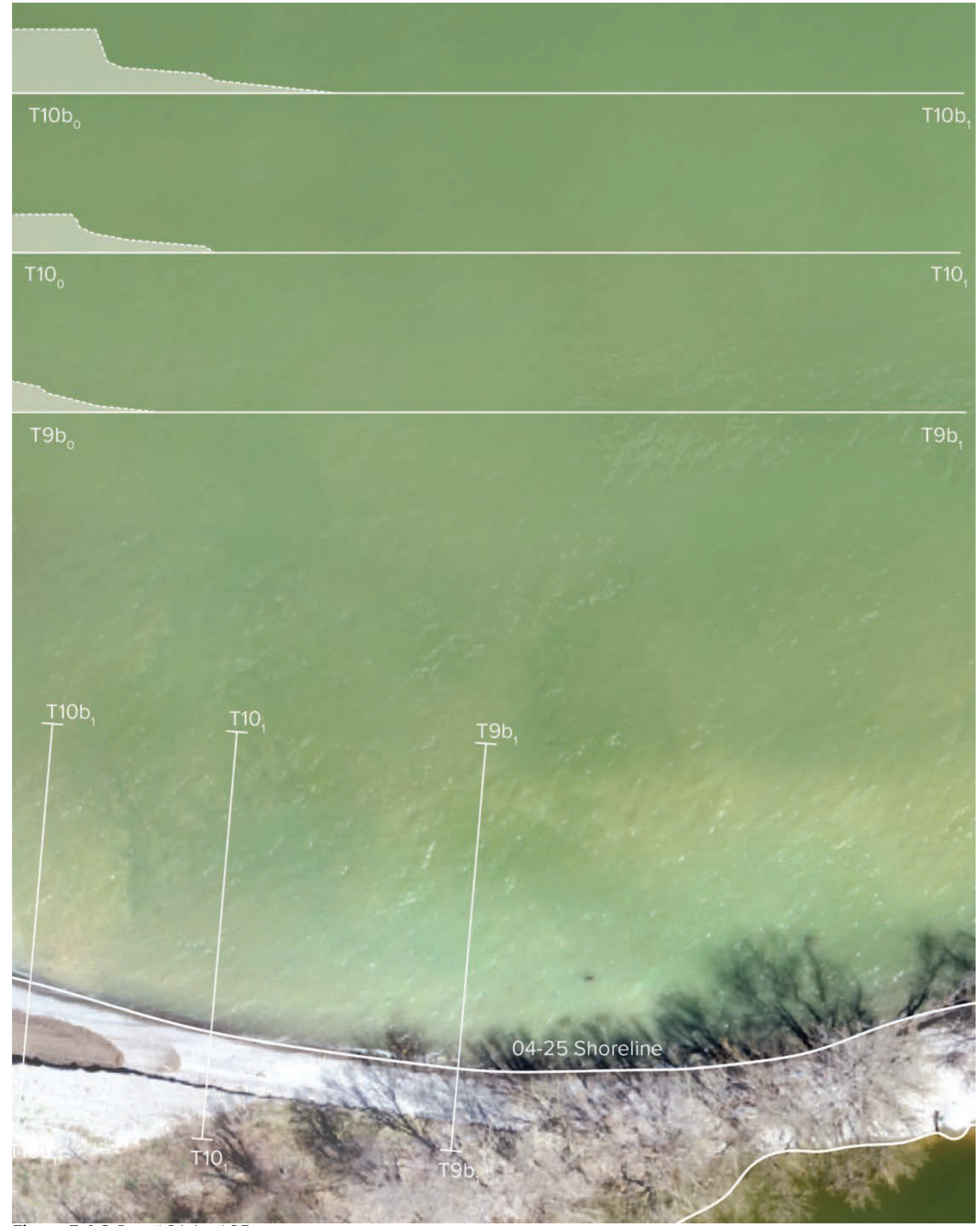


Figure 5.4-2 *Detail 2 | April 25*

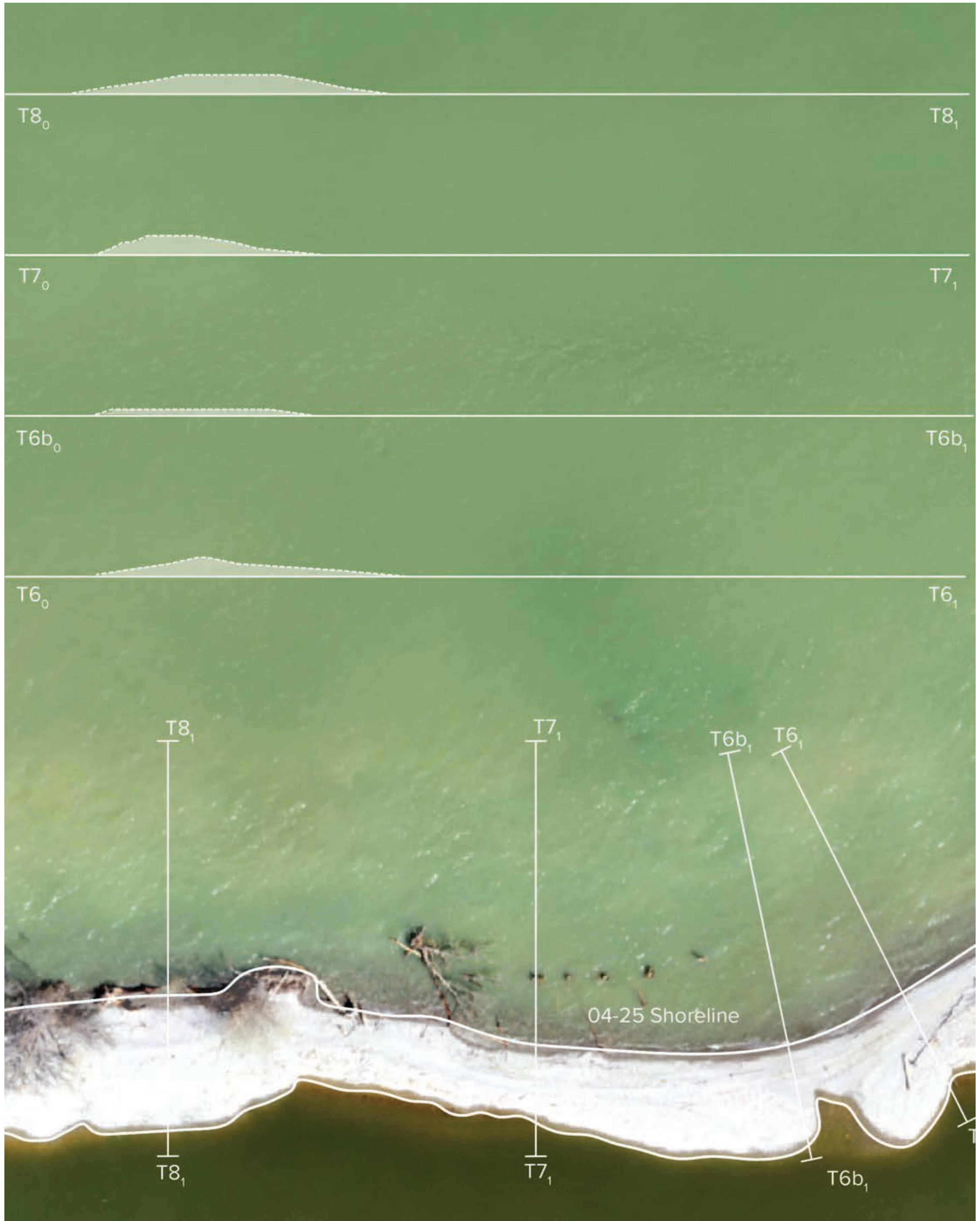


Figure 5.4-3 *Detail 3 | April 25*

Figure 5.4-4 *Detail 4 | April 25*

Surveying Bathymetric Floor (Tess Ruswick)

6 | Monitoring

Overview

As a part of a reoccurring maintenance project, this pilot is uniquely positioned to test, observe, and adapt the placement and movement of material via machinery and natural forces. Over time, these maintenance practices can be calibrated and developed into a more elegant and efficient sediment sequencing. Monitoring is an important component of the study, and supports a better understanding of the sediment dispersal along the bar. In turn, these insights will lead to further adaptation and calibration in future years. The project and subsequent monitoring efforts will provide valuable information into wave- driven dredge placement and movement, and provide a prototype for similar small communities in the region. Additionally, monitoring protocol used technology and programs readily available to state and local agencies with the hope of development methodologies that can be used beyond HPF's involvement.

To that end, the monitoring plan was designed to collect quantitative data on the morphological changes of the East Bar. Monitoring was planned to extend from the day of construction to six months past. This information supplements ongoing anecdotal observations by local residents over the last decade, provide insight into how the material placed in the nearshore environment responds to wave energy, and aid in the calibration of future placements.

Protocol

Questions

Port Futures developed a monitoring plan that will serve to answer the following questions:

+ How quickly did the feature erode?

+ Where was there a measurable effect and when did the measurable effect occur?

Scope

Monitoring will extend from the jetty on the West Bar through the opposite end of the East Bar (Figure 6.1). This monitoring plan was designed to begin at construction on April 25th ice-out in the spring of 2020 in order to establish baseline conditions and will continue into the fall of 2020. However, due to travel restrictions due to Covid-19, monitoring was limited to three main events: April 25th, May 5th, and September 12th. While this limited timeframe will not include all of the events and conditions that could possibly occur during any given year, it will at least provide base information to make decisions for the following year.

NOTES:

SET UP 12-20 GCPs ALONG EASTERN + WESTERN BAR APPROX 80-100' APART.

GCPS SHOULD BE LOCATED WITH UNOBSTRUCTED VISIBILITY TO DRONE + AWAY FROM PROBABLE DISTURBANCE.

IN BREACHED AREA, GCPS SHOULD BE ESTABLISHED IF POSSIBLE.

TRANSECTS SET UP AT GCPS EAST + WEST OF NEARSHORE FEATURE PLACEMENT AND AT GCP CENTER OF ONSHORE PLACEMENT

GCP= GROUND CONTROL POINT T= TRANSECT PP= PHOTO POINT

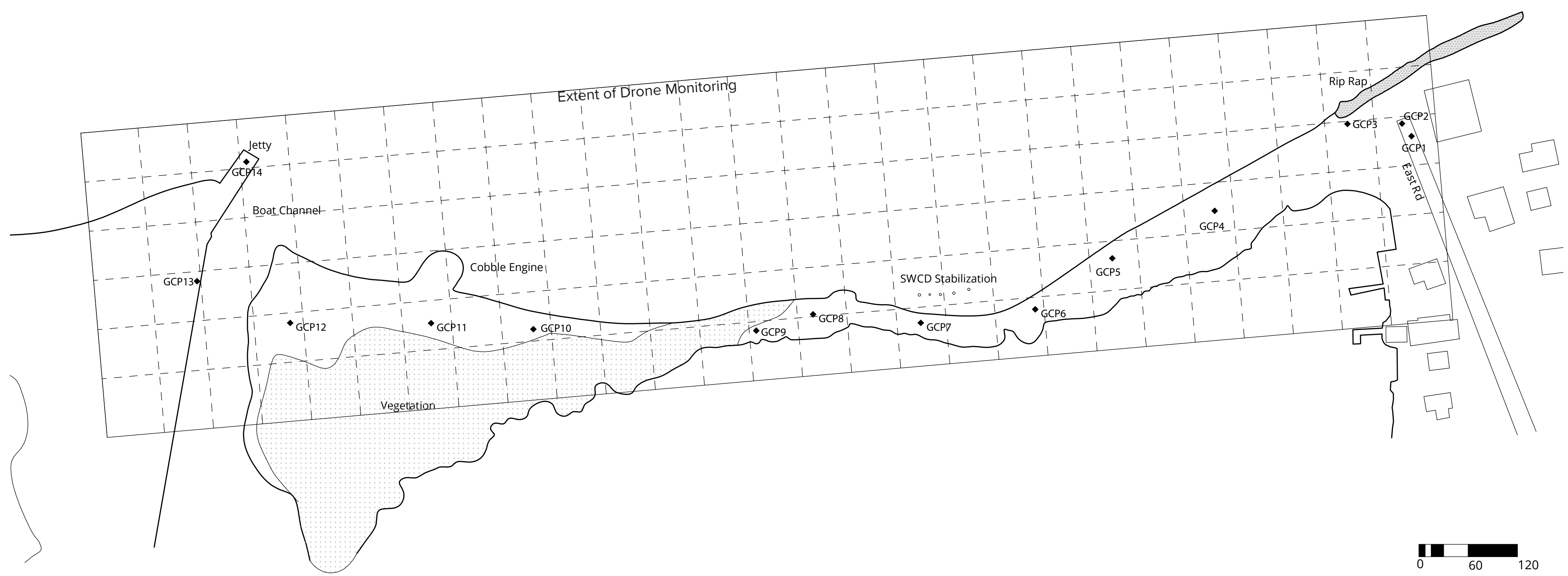


Figure 6.1 | *Monitoring Plan*

Methods

For several months following construction, with the generous help and assistance from our on-the-ground partners and local residents, HPF continued to monitor and track the spread of sediment as the material migrated eastward along the bar.

The primary method of data collection was drone-acquired imagery processed into three-dimensional data. This information included only terrestrial formations and is not able to survey sub-aquatic elevations. However, this data shows the deformation of the dredge bluff feature over time and indicate any changes in beach profile in response to the eroded feature up-system.

Secondarily, survey transects were also collected at particular times, weather permitting, within the nearshore (water less than 3') with RTK survey equipment. This data was used to produce a more accurate shallow water topo-bathy survey, but was not possible to collect during every survey.

Lastly, photo points were established at each ground control point. Photos were taken at eye-level, looking west from the markers. These photos helped capture the qualitative changes of the bar and feature from a ground perspective.

Processing

Drone images were processed using photogrammetry software. HPF used Agisoft-Metashape to compile the images into a rectified orthomosaic and a digital elevation model (DEM). The DEM was processed in ArcGIS to generate contours. Sections through important key spots along the bar were produced in each monitoring section to provide information about sediment accretion and erosion patterns.

For legibility and results sharing, the bar was split into four details. These sections are divided into four details. First detail includes west point of east bar to the feature. The second detail includes directly east of feature to the end of the tree line on the island. The third detail includes the concave section that historically was breached and most eroded portion of the bar. The fourth detail includes the eastern part of the bar until the start of the riprap.

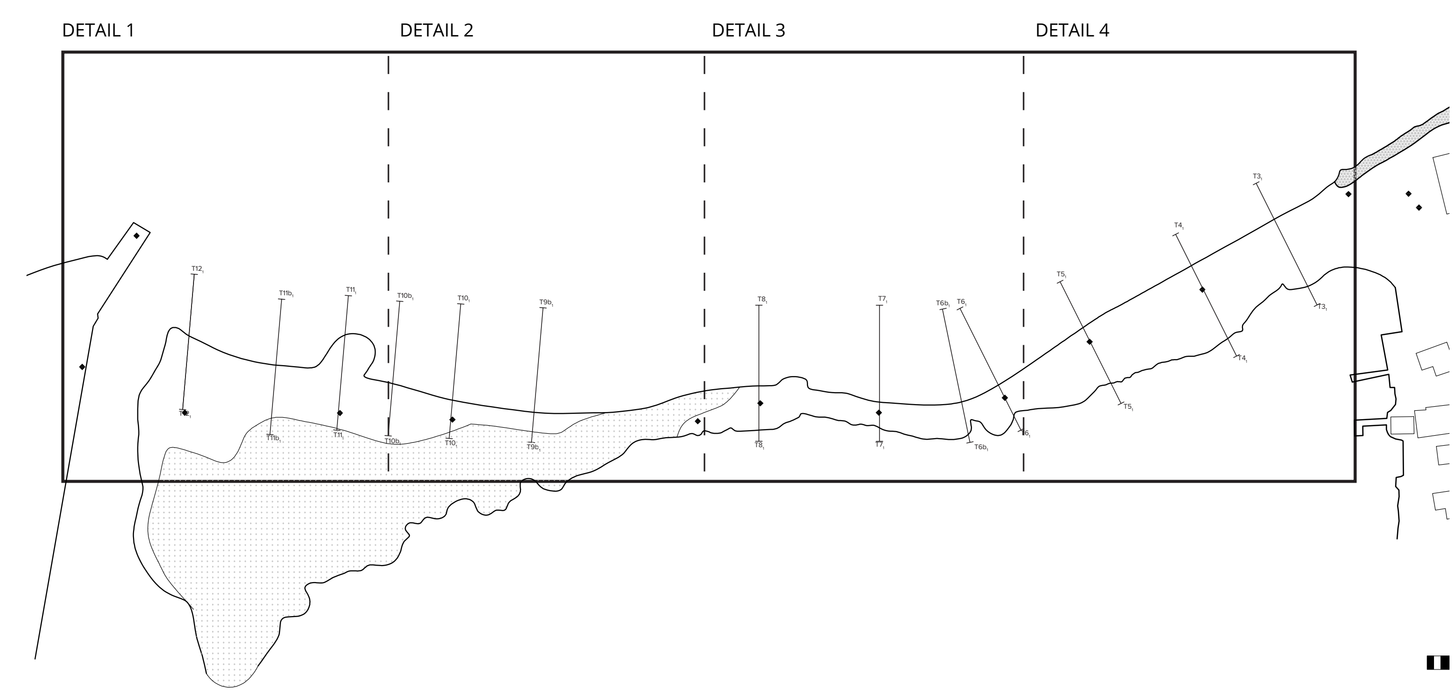
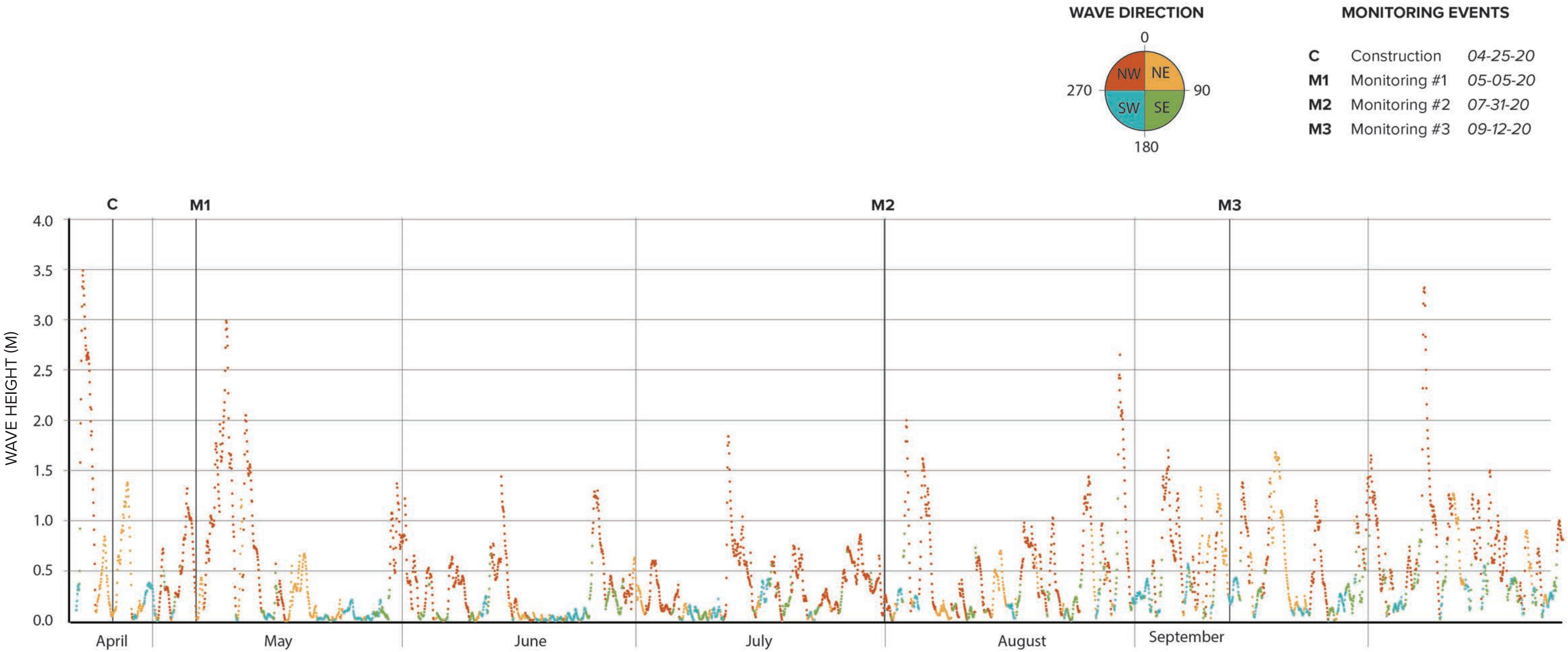


Figure 6.2-1 Wave Events



Data from Great Lakes Observation System- Lake Ontario Forecast. "Virtual buoy" located north of Port Bay @43.3327 °N 76.8411 °W. https://portal.glos.us/#.

Figure 6.2-2 Wave Events-Northeastern

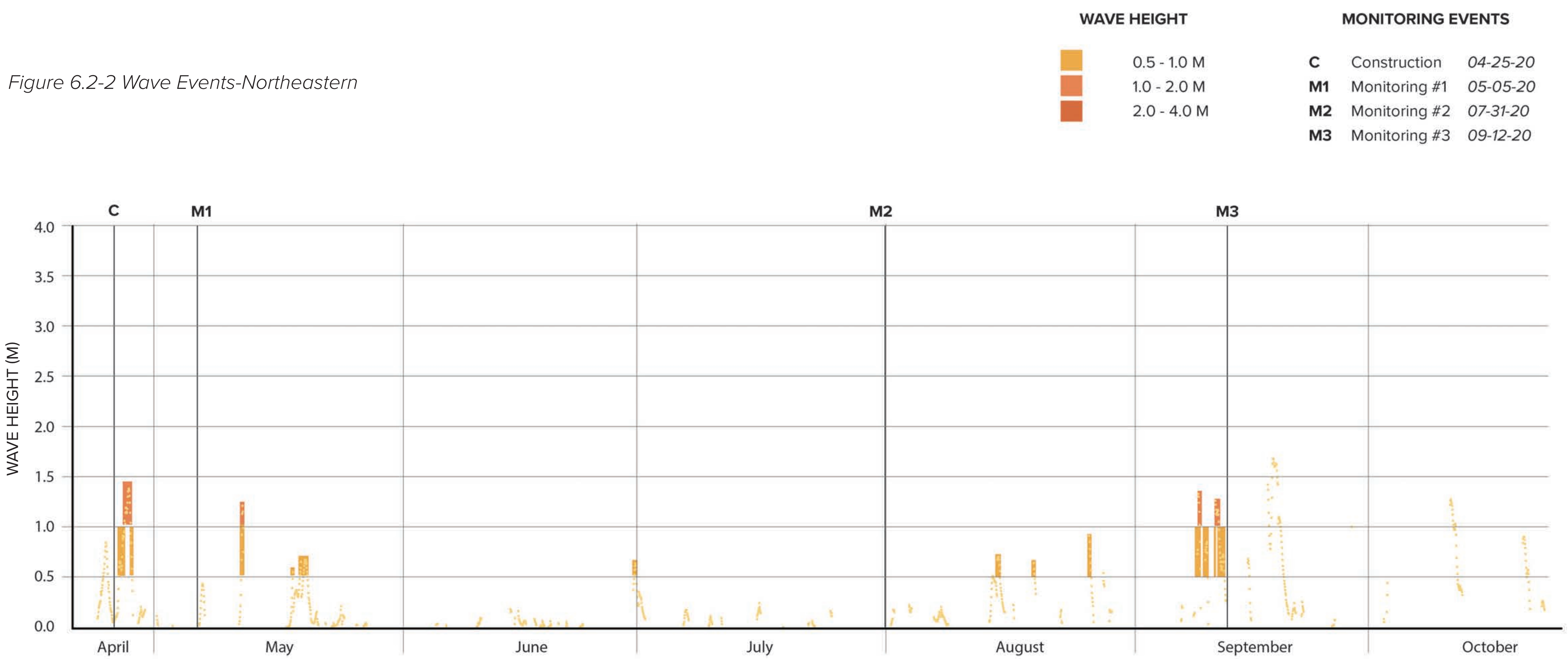
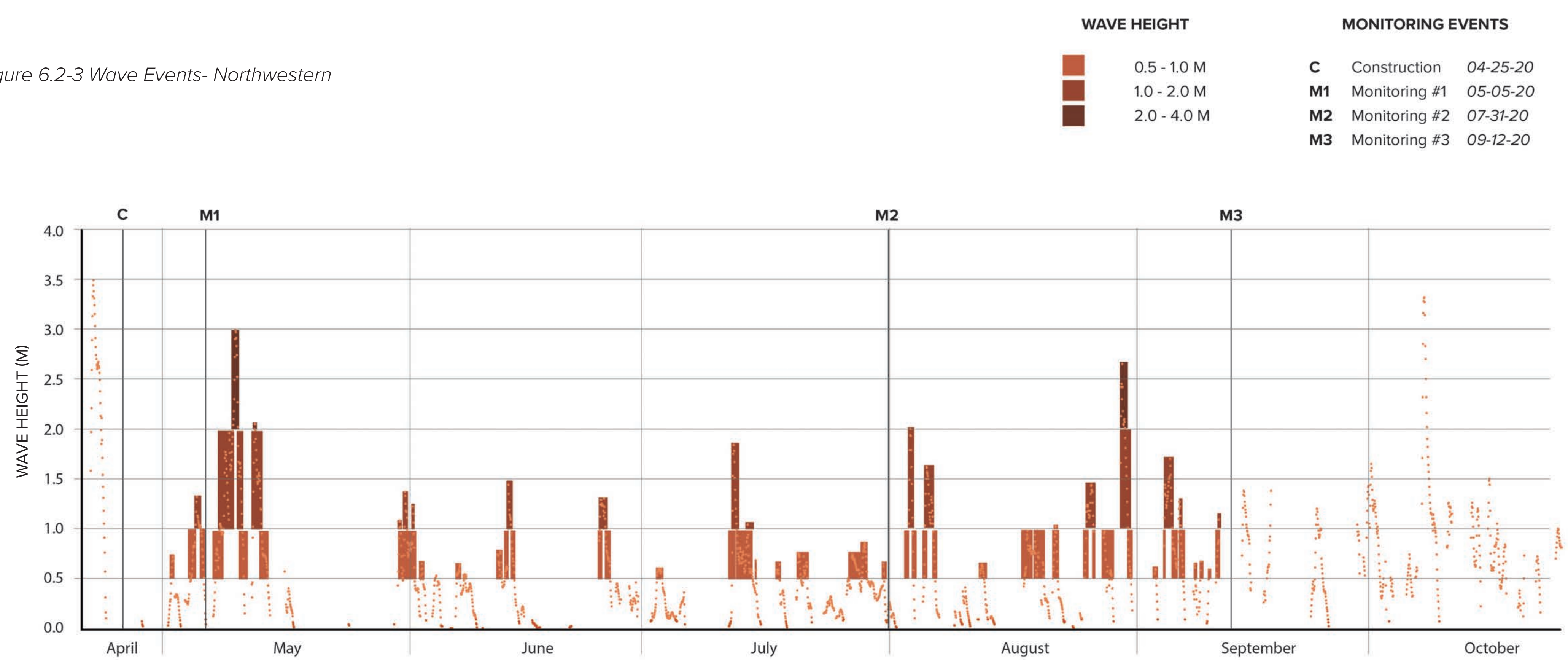


Figure 6.2-3 Wave Events- Northwestern



Results

April 25- May 5

Immediately following construction, large northwestern waves quickly eroded the feature. According to local residents and partners, this process occurred over the course of first few days.

During those ten days, water levels rose by .2' from 247.15 to 247.35 and small storm wave events from the northwest and northeast (Figure 6.2). On May 5th, when data collection occurred, choppy northwestern waves were observed crashing into the beach.

The drone footage and subsequent post-processing photogrammetry and analysis captured the feature erosion and subsequent accretion to the east. Sections taken across East Bar shows sediment accretion the first eight hundred feet east of the feature (Figure 6.3).

Overall, Detail 1 shows erosion, Detail 2 and 3 show accretion, and Detail 4 shows no difference between construction and monitoring. On average, sections in Detail 1 eroded by 1.6 vertical feet and 10.9 horizontal feet, sections in Detail 2 accreted by 1.0 vertical feet and 18.9 horizontal feet, sections in Detail 3, accreted by .7 vertical and 7.5 horizontal feet, and sections in Detail 4, eroded by .3 vertical feet, and 1.8 horizontal feet.

In summary, it appears the feature quickly eroded and sediment began to disperse along the shore, accumulating directly east of the feature, as seen in Detail 2, and filling in the concave, historically breached area, seen in detail 3.

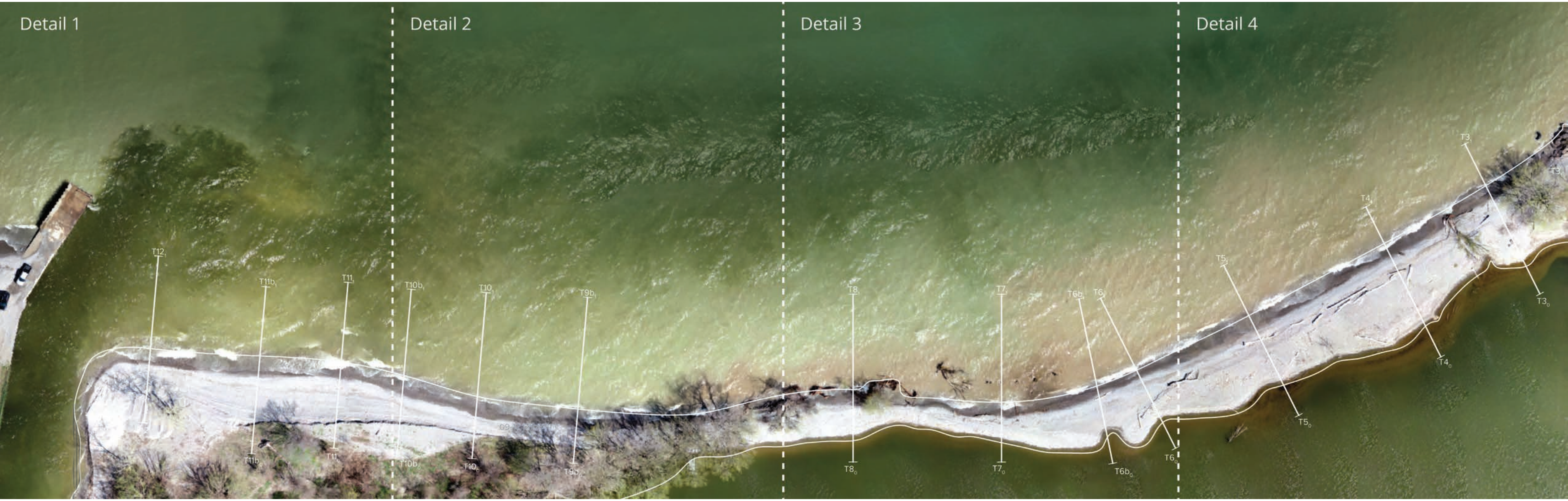


Figure 6.3-1 *Orthomosaic | May 5th*

247.35 IGLD85, Significant Waves

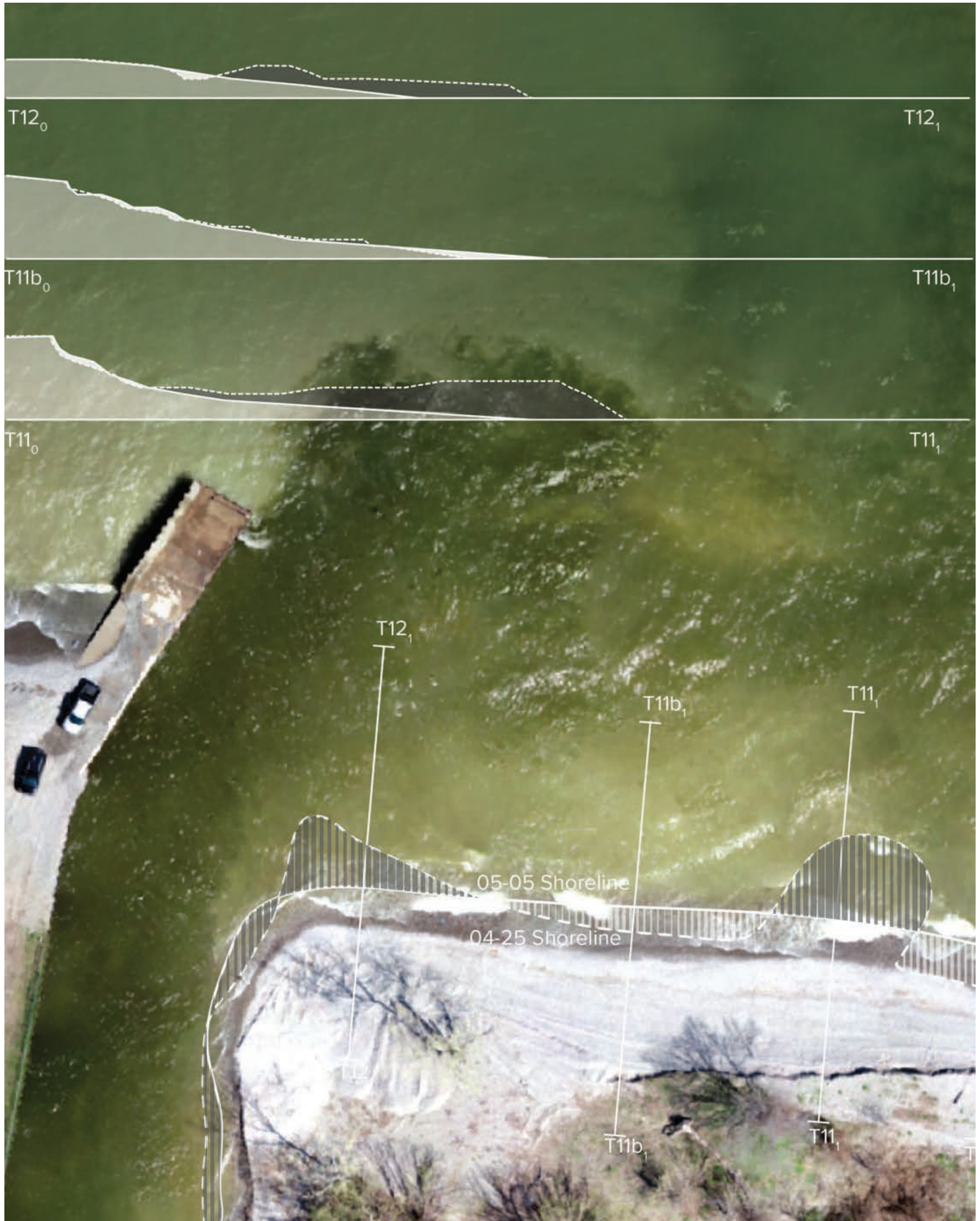


Figure 6.3-2 *Detail 1 | April 25- May 5*

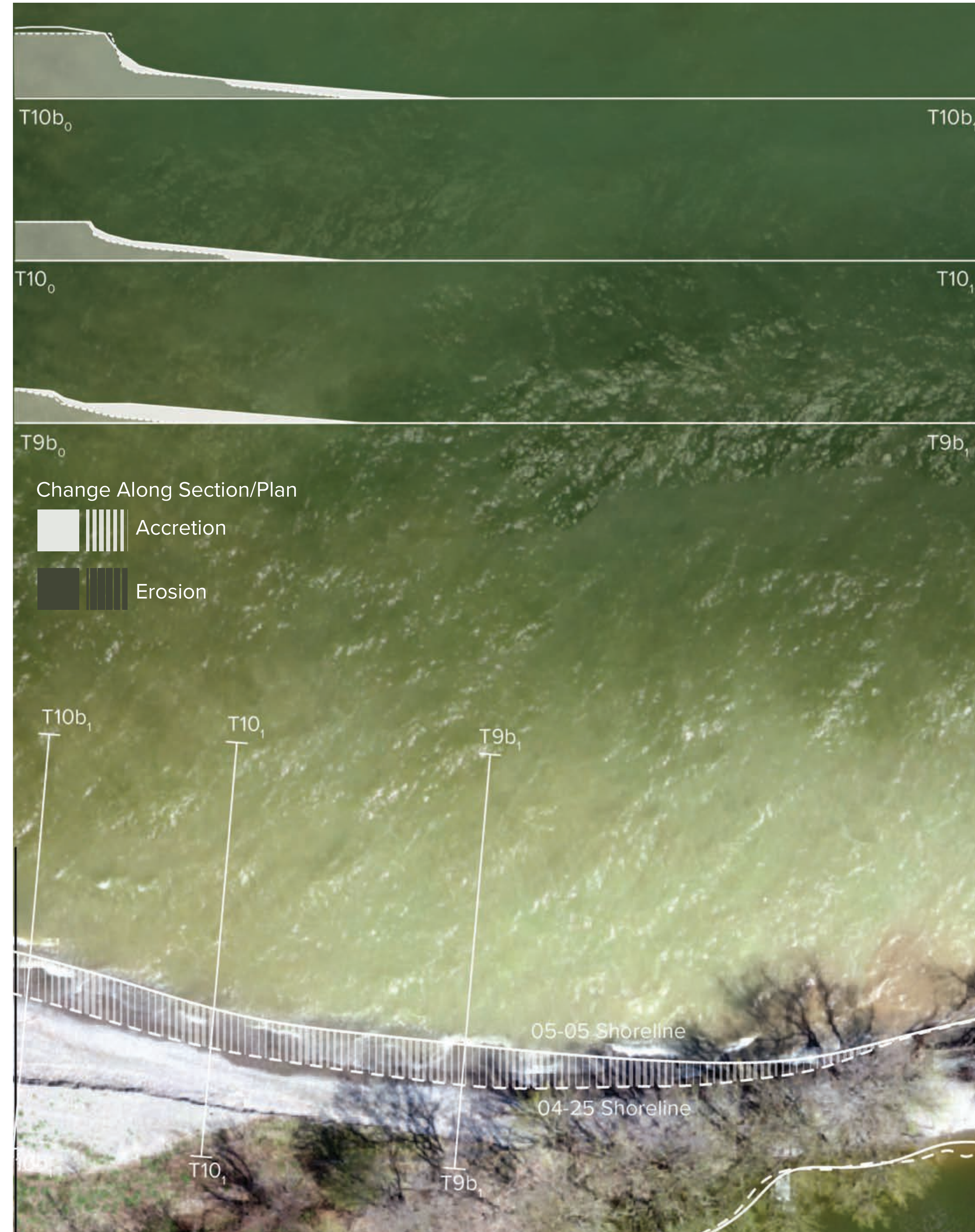


Figure 6.3-3 *Detail 2 | April 25- May 5*

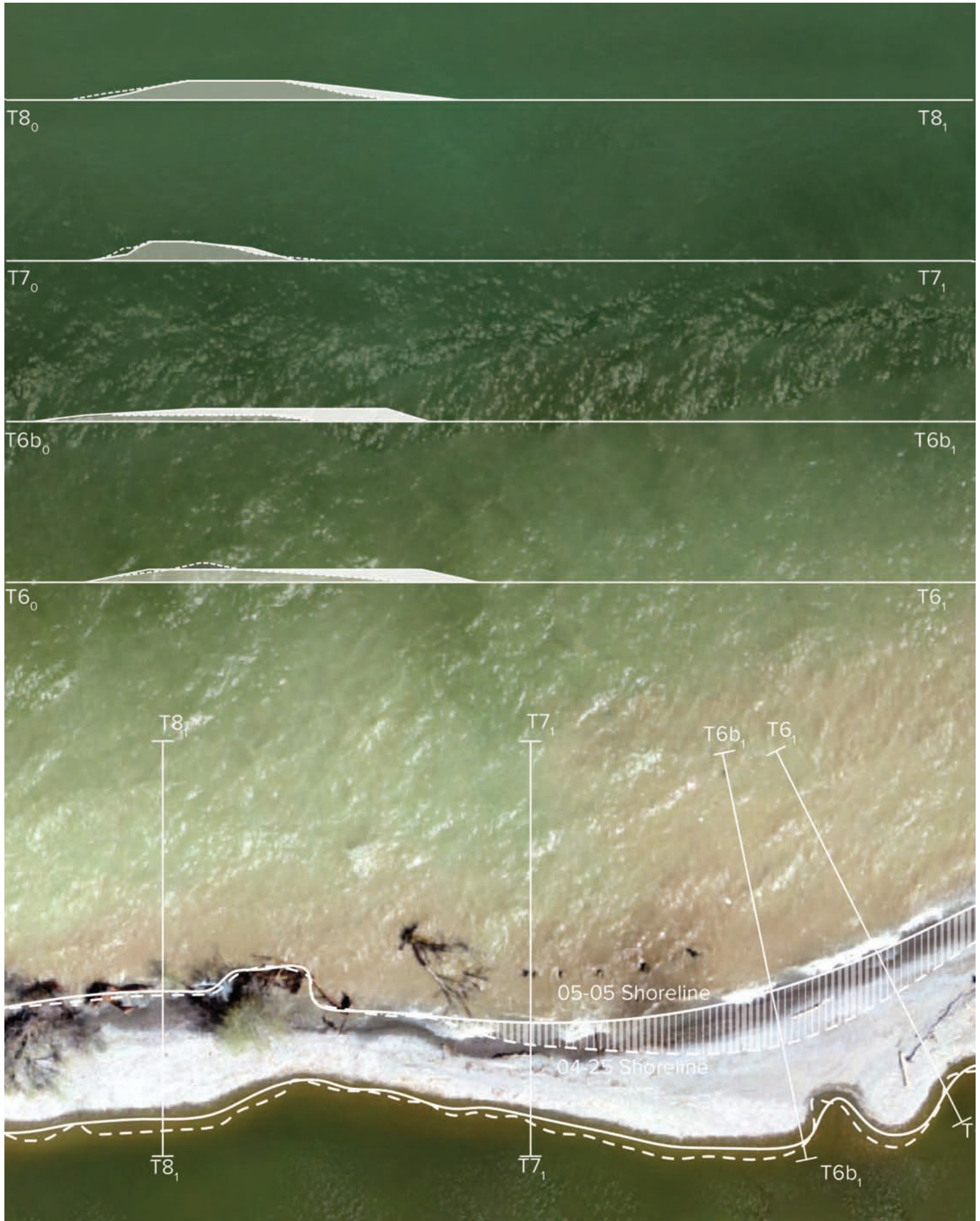


Figure 6.3-4 *Detail 3 | April 25- May 5*

Figure 6.3-5 *Detail 4 | April 25- May 5*

May 5 – September 12

Over the course of the next four months, water levels dropped approximately two feet, from 247.4 to 245.5, revealing significantly more shoreline. The East Bar, especially in Detail 3, significantly increased in width (Figure 6.4). While lower water levels attribute some of this increase, analysis from photogrammetry make clear that significant amount of sediment accretion also occurred. This comparison makes clear another potential benefit of the passive beach and nearshore reconstruction using the small, erodible drumlin feature. Sediment can be expected to deposit not only on the beach to the east but also in the nearshore. This will lead to a reduction in wave height as well as allowing for additional beach width if water levels recede

During this time, Lake Ontario had a series of significant wave events, especially in late July. The majority of larger waves were from the northwest, and while there were some northeastern wave events, they tended to be smaller, and less frequent. These events led to increased erosion along the shoreline, as seen in unnourished, far-west and far-east portions in the bar.

Y

The below average lake levels also might have contributed to increased sediment in the nearshore. The cobble base of the feature can be seen in the aerial photos from July and September. The base does not seem to have shifted, indicating that sediment was not lost from the feature during this time. Meanwhile, the aerial orthomosaic from September shows the movement of sediment around the pier and build up along the western side, suggesting the source of the material necessitating additional dredging originated from the west. Furthermore, as mentioned previously, the majority of wave activity came from the northwest during this time.

According to photogrammetry analysis, the accretion that occurred immediately east of the feature was subsequently eroded over the course of the next four months. The pocket further east continued to accrete. Both west of the feature, and the farther end of the East Bar continued to erode, indicating that any sediment accretion was offset by wave erosion.

Overall, Details 1, 2, and 4 experienced erosion, while Detail 3 continued to experience accretion. On average, sections in Detail 1, eroded by 7 vertical and 17.6 horizontal feet, in detail 2, eroded by .9 vertical and 18.9 horizontal feet, in Detail 3, accreted by .9 vertical and 13.0 horizontal feet, and in Detail 4, eroded by .1 vertical and 5.2 horizontal feet.

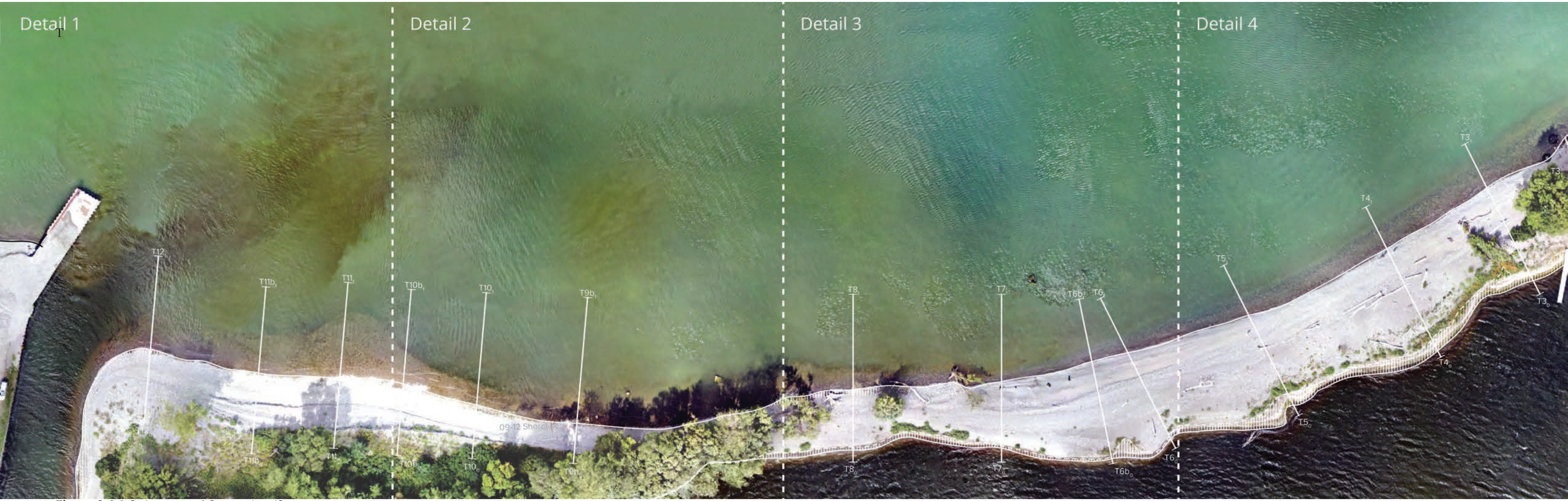


Figure 6.4-1 *Orthomosaic | September 12*

245.5 IGLD85, Significant Waves

Figure 6.4-2 *Detail 1 | May 5- September 12*

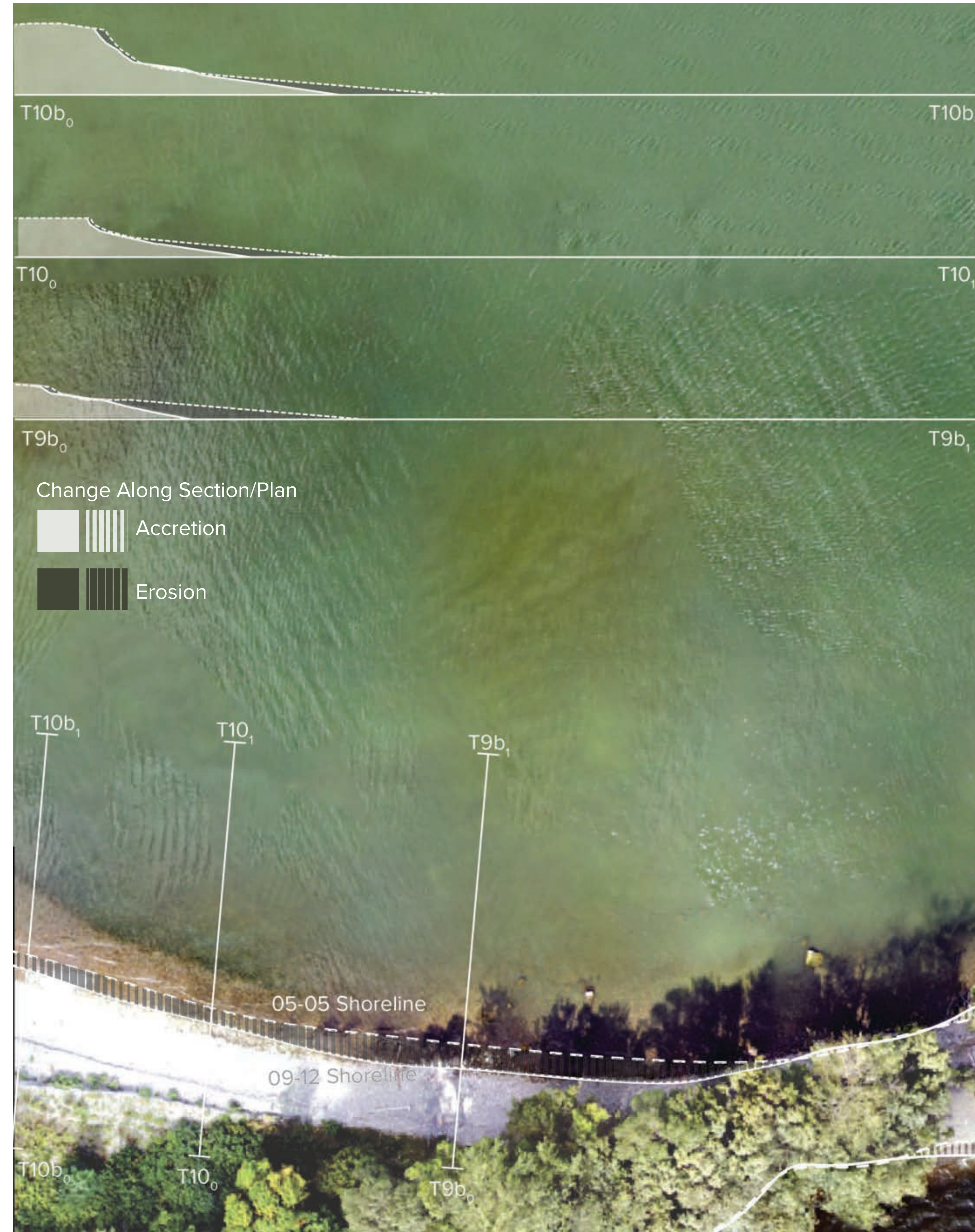


Figure 6.4-3 *Detail 2 | May 5- September 12*

Figure 6.4-4 *Detail 3 | May 5- September 12*

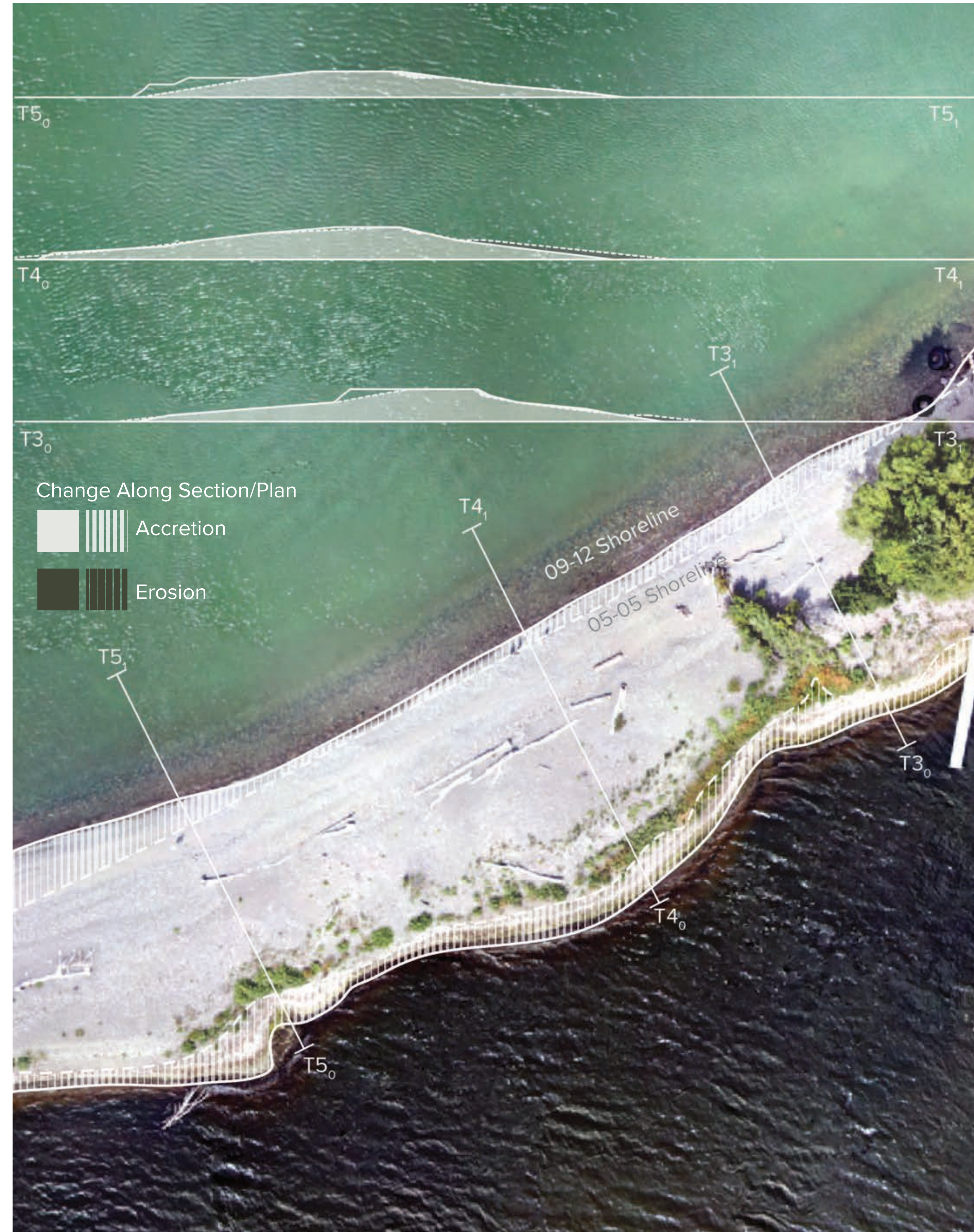


Figure 6.4-5 *Detail 4 | May 5- September 12*

Additionally, photo points, which were located at each of the ground control points (GCPs) tracked on-the-ground experience of the eastern bar growth. Similarly, sediment transects across the bar show the wide variation that occurs, creating pockets of larger and smaller gravel.

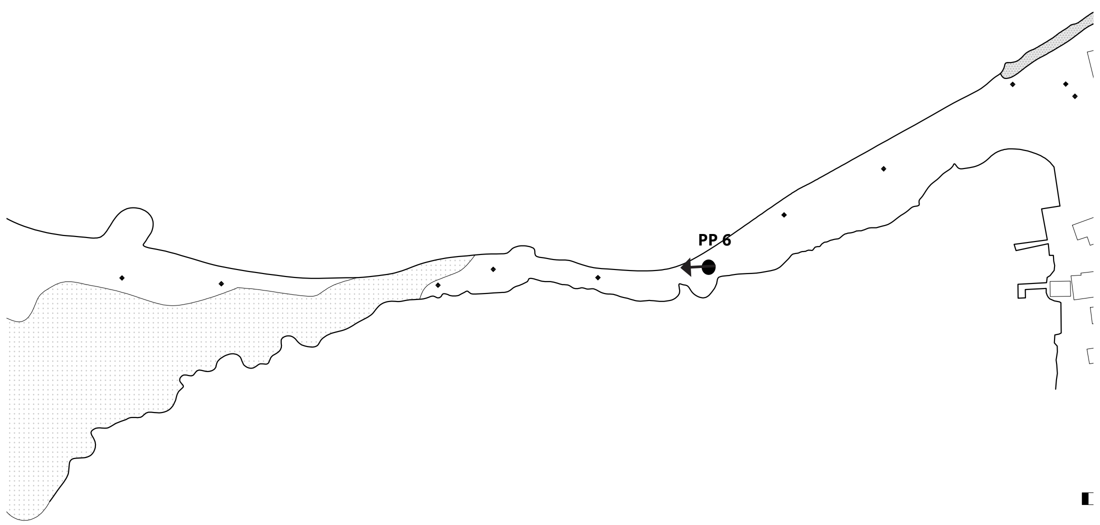


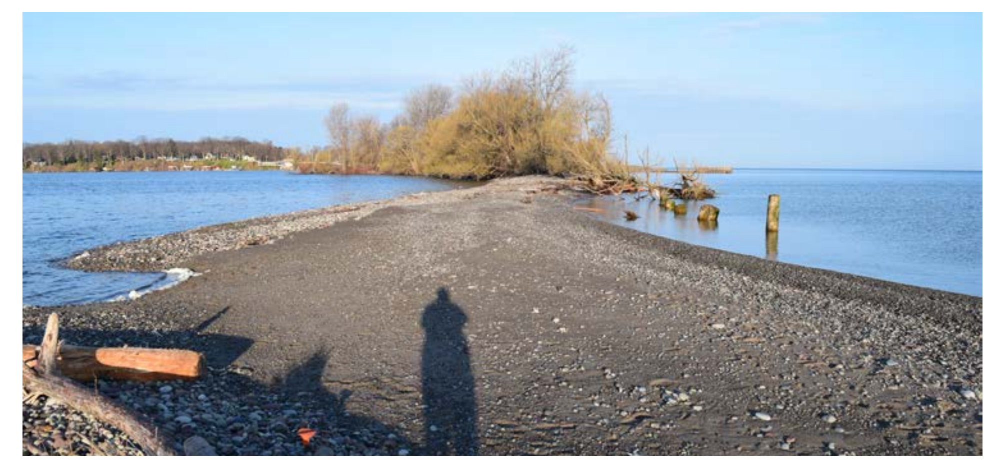
Figure 6.7-1
Sediment Transect 6

Figure 6.7-2 Photo Point 6

04.23.20

04.26.20

05.05.20



09.12.20

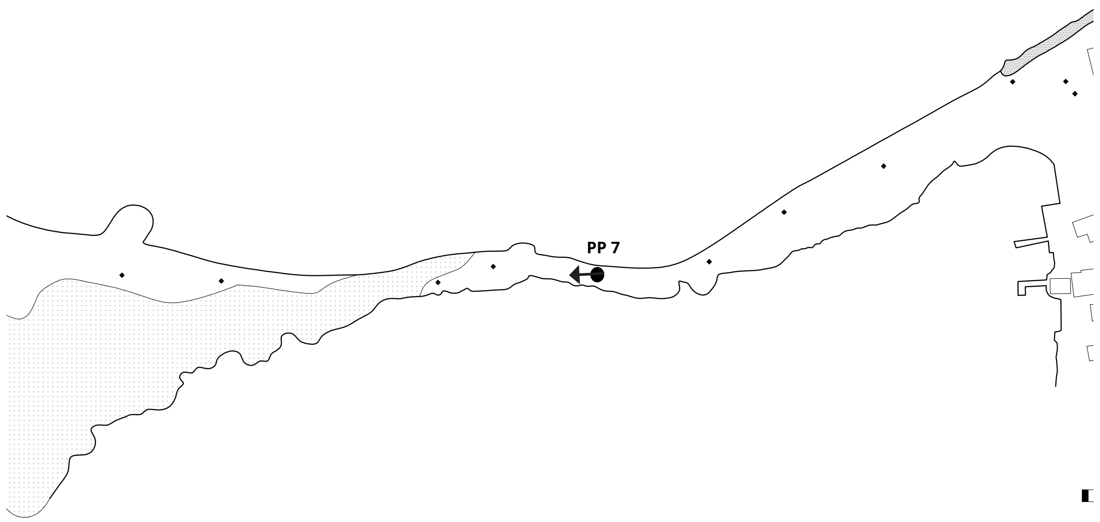


Figure 6.7-3
Sediment Transect 7

Figure 6.7-4 Photo Point 7

04.25.20

05.05.20

09..12.20

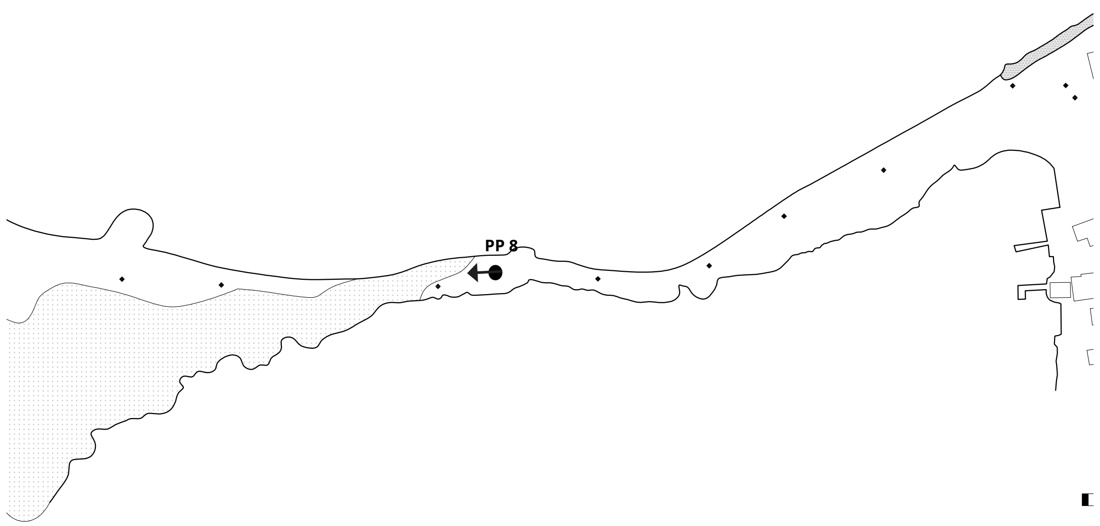


Figure 6.7-5
Sediment Transect 8

Figure 6.7-6 Photo Point 8

04.25.20

05.05.20

09.12.20

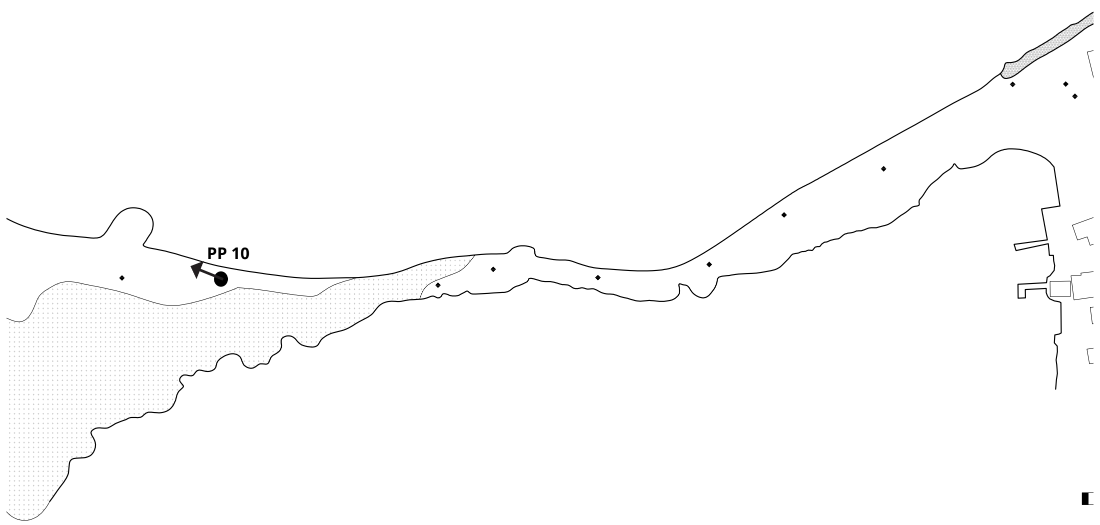


Figure 6.7-7
Sediment Transect 10

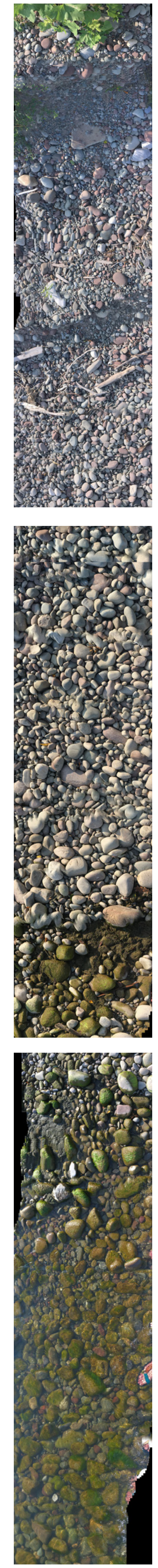


Figure 6.7-8 Photo Point 10

04.25.20

05.05.20

09.12.20

Summary

In summary, between April and September, most of the large wave events occurred from the northwest direction. The westernmost part of the bar eroded since initial placement (Figure 6.5). Much of the initial accretion directly east of the feature eroded four months later, suggesting continued migration across the bar, albeit more slowly. The material continued to migrate eastwards across the bar, filling in concave areas of shoreline. If sediment has travel west of the pocket, the sediment is not enough to offset the erosive wave forces as the area has generally eroded. As can be seen the aerial photography, the base of the feature, thought to mostly be comprised of larger, heavier sediment, has remained. This underground feature is shaped like a bell, and is 97' feet at its widest, and 32 feet past swash zone.

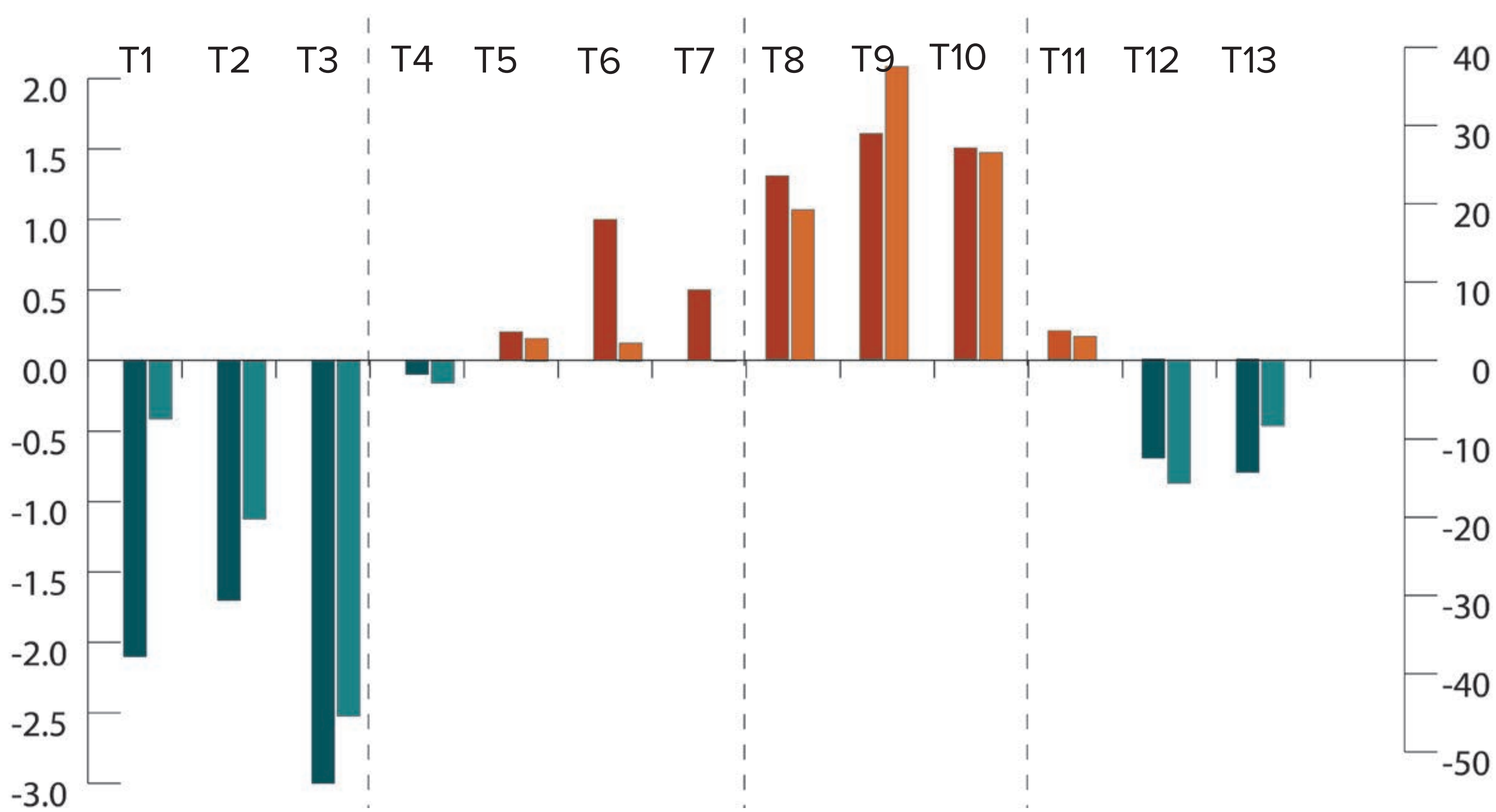


Figure 6.5-1 Transect Graph | April 25- September 12

AVG ELEVATION CHANGE (FT)

Accretion

Erosion

SHORELINE CHANGE (FT)

Addition

Loss

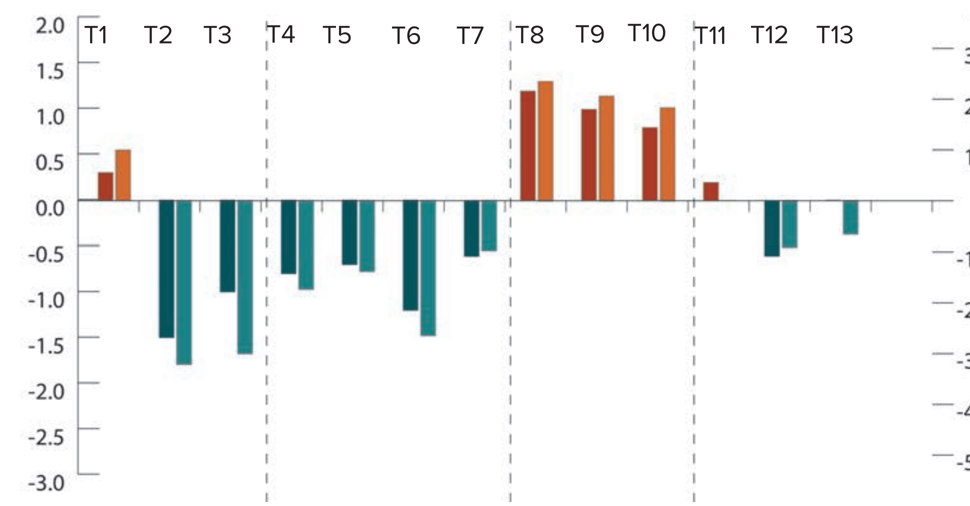


Figure 6.5-2 Transect Graph | April 25- May 5

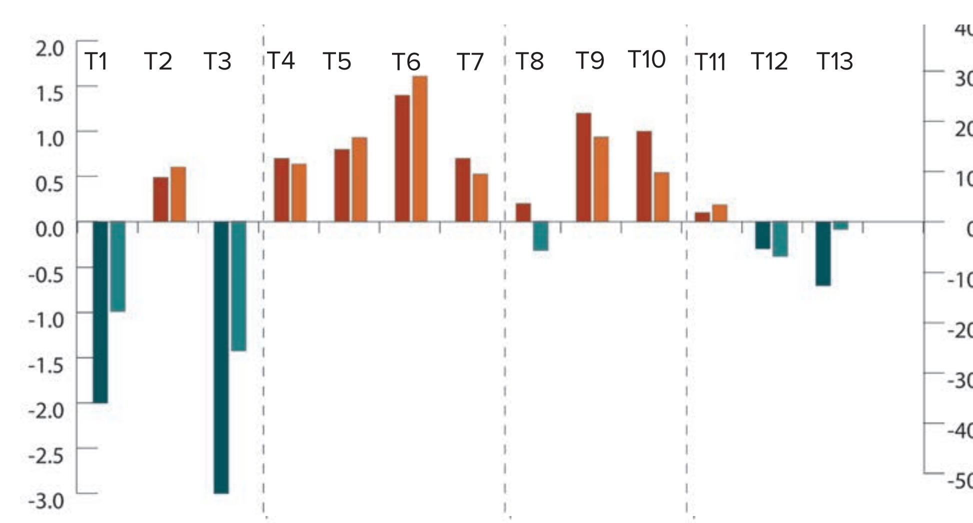
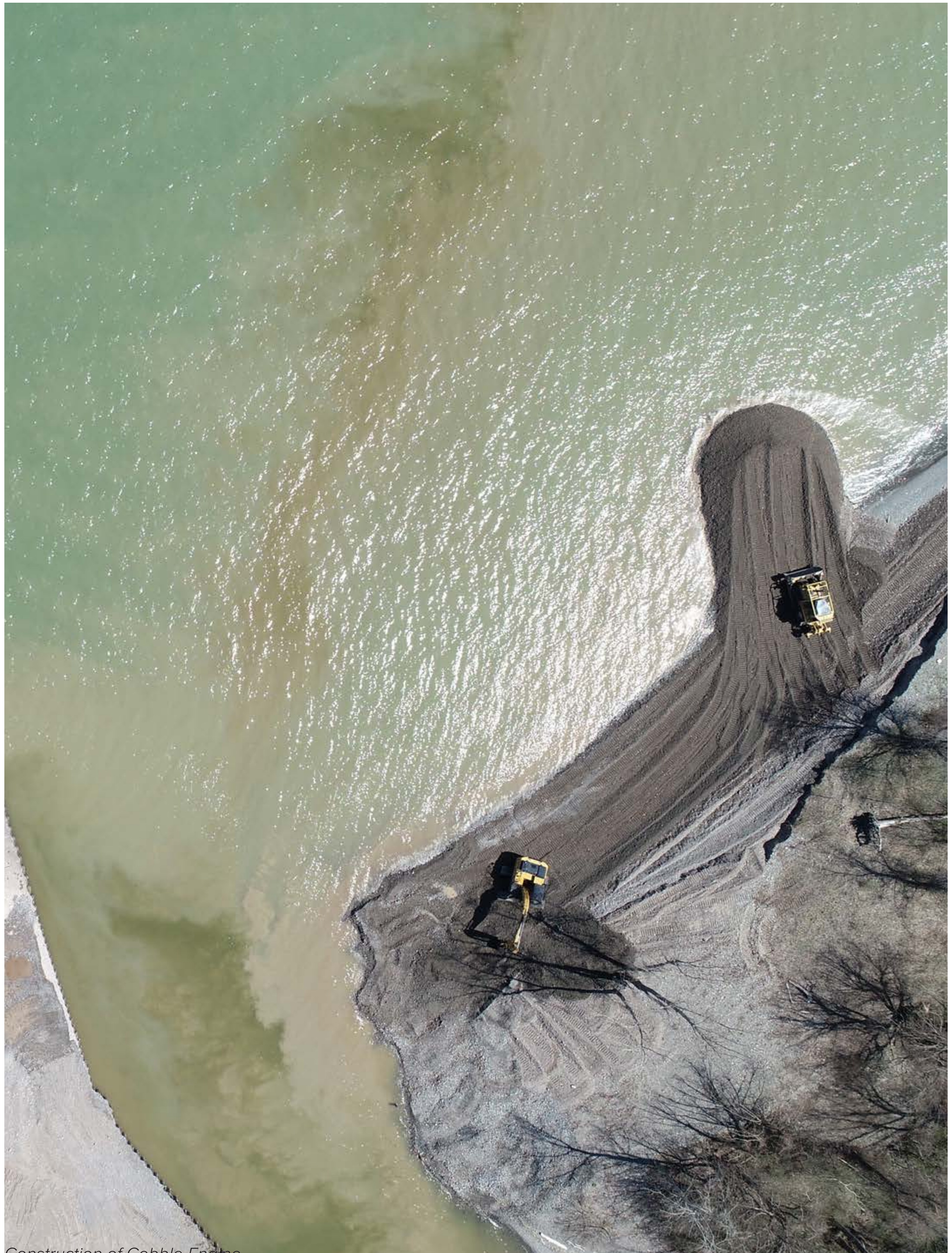


Figure 6.5-3 Transect Graph | May 5- September 12



Construction of Cobble Engine

7 | Conclusion

Results

Observed and Calculated Results

Several of the initial questions posed were readily answered with observed and monitored data. Based on observational data and backed by drone photography, the above-water portion of the feature eroded within the week. Within a week, there was a measurable effect along the sand bar approximately 700' directly east of the feature. Despite extenuating circumstances, initial monitoring data shows that concept worked- material was moved from west to east, resulting in the thickening of the East Bar, and was especially successful in thickening thinning areas of the East Bar that have been historically susceptible to breaching. The sediment that remained- in the bell-shaped curve- is multi-purpose. It can be used as habitat, northeast wave protection for the channel, and a marker for future placement.

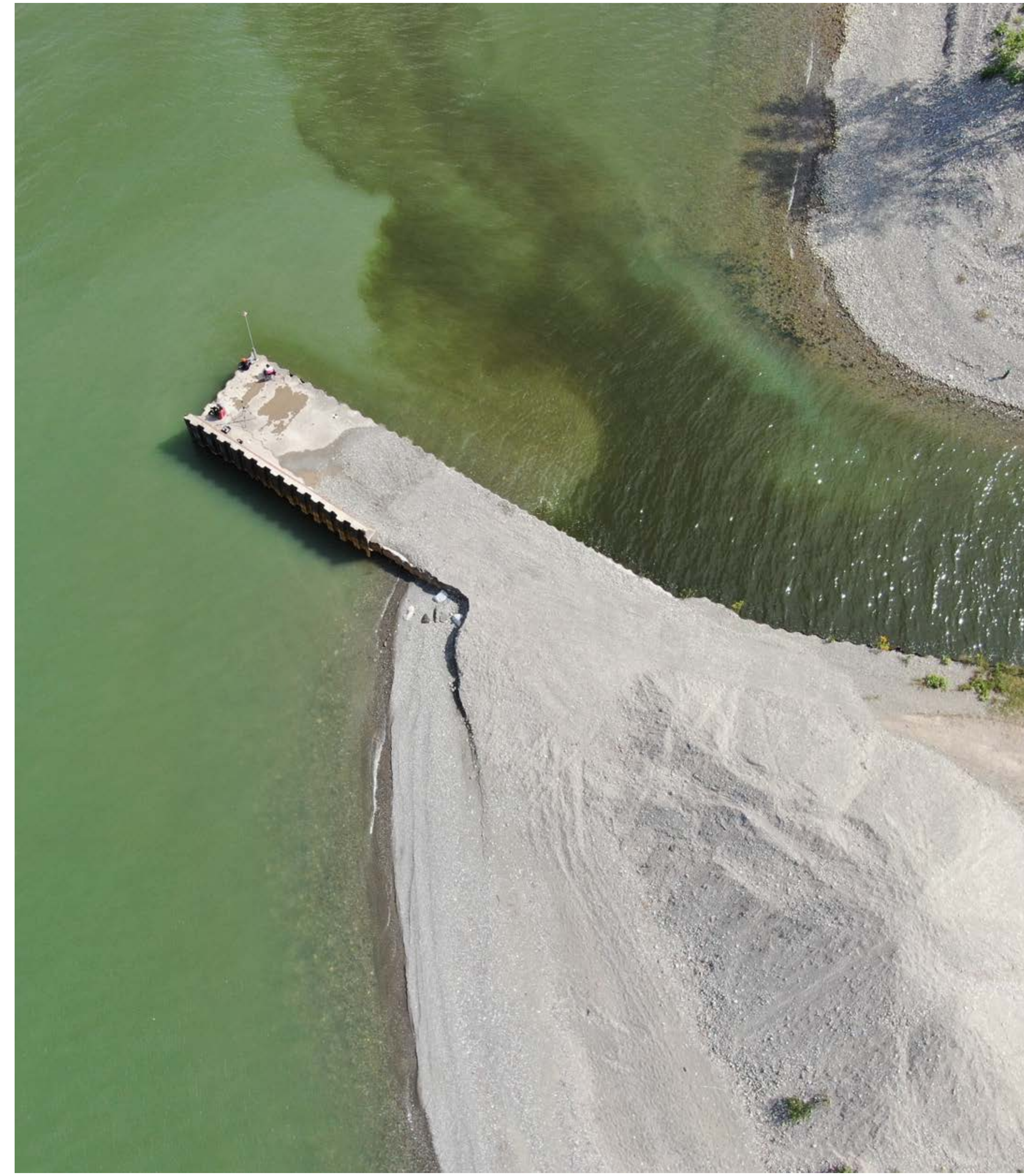
Sediment sorting was seen along the shores, with stretches of larger cobble shores, and pockets of sandy beaches. Cobble and sandy pockets can be observed in GCP 8-9 and GCP6-7, respectively.

Conditions During Study

At time of construction, in April, the water levels were 247.15 and by the last monitoring event in September, the levels were even lower, at 245.5. During the five months of monitoring, there were extended periods of stormy conditions; one of the larger storms took place right after the feature was constructed. Following historic precedent, the large storms mostly were from the northwest.

Impact on Dredging Operations

Just as important as the project's effect on the East Bar is its impact on dredging operations. Over the summer and into fall, multiple dredging events were needed, totaling in an additional 2000 CY of sediment dredged. Aerial drone photos show a "hook" forming around the jetty, and a pile building up on the east side of the jetty. This pattern indicates that the direction of the sediment came from the west, the result of littoral drift, rather than from the east, from erosion of the placed sediment. Water levels were at an historic low during the summer, leading to increased addition of sediment placement along nearshore, which would account for the increased need for supplemental dredging, as encountered in Port Bay. Because of the unusually low water levels, it was difficult to ascertain definitively whether feature placement led to the need for increased dredging in the water channel. However, based on regional trends, and the placement of the sediment in the channel, it remains likely that the low water levels attributed to the increased need for dredging rather than the cobble engine placement.



Process

Physical Modeling

The results from the water table closely projected the field results, in particular, the sorting pattern, the distribution, and the timing. The water table predicted the sediment bell-shaped distribution along the shore. This bell-shaped feature around the initial pile can still be seen in September drone photos, five months after placement. Additionally, the sediment sorting, first seen in the water table, is also visible in the field results. As sand fills in the concave, protected portions of the shoreline, and the cobbles along the straight, wave-battered areas. The small amount of clays and silts found in the dredged material, is either winnowed out, or drops into the broader nearshore shelf. Lastly, the relative timing of the feature eroding was also anticipated by the table experiments. While the feature eroded faster than originally expected, the relatively rapid erosion, especially as it related to the longer distribution time, followed closely the modeled timetable.

Construction

Overall, the construction went smoothly and quickly, with placement taking place over the course of a single day. The feature was constructed very similarly to how it was initially conceived, with several important distinctions. However, these differences are important to note, as they were mostly based on construction ability, and can help inform future placements. In particular, the slopes of the constructed feature was based on the equipment capacity and the sediment angle of repose. The steepest constructed incline was 15%, while the above water angle of repose ranged from 50-66% and 20% underwater. While these built slopes were close to estimated values, the real world measurements can lead to greater precision for future placements.

Monitoring

Covid-related travel restrictions necessitated adaptations in the project's planned monitoring protocol. Due to HPF;s travel restriction, HPF partnered with Wayne County, Ramboll, and Seagrant to supplement the monitoring. Despite monitoring occurring less frequently than initially planned, the monitoring still managed to capture the rapid erosion of the cobble engine, and the slower migration of the sediment.

Recommendations + Future Questions

The first conclusion is that the beneficial use of dredged sediment is possible in Port Bay, using a practice that eliminated additional costs and minimizes risk, maximizes shoreline stability and protection, and may provide increased opportunities for recreation and habitat over time. Moreover, if done carefully, it can be provisionally implemented now with no additional modeling research or other costs, other than monitoring. This conclusion is based on the following observations:

+ the material can be placed out of the jetty shadow at no additional cost

+ the placed material initially moved very quickly, and then moved quite slowly after the initial redistribution by waves. This is a promising sequence for future practice. The drumlin-like feature eroded quickly (between the 4/29 monitoring event and the 5/5 monitoring event), but once it was distributed as part of the beach and nearshore, the movement was slow. Less topographic change was observed in the four months from the 5/5 monitoring event to the 9/12 monitoring than in the 10 days from 4/25-5/5. We expected to see this acceleration and deceleration based on physical modeling done by HPF, and precedent study. However, the difference between the accelerated erosion of the feature and the stability of the beach was more pronounced than we expected. Whether and to what degree this phenomenon repeats itself is an important question going forward. In part, as an examination of the hindcast data as part of the design research suggested was likely, it had to do with the wave climate and weather, with a storm striking immediately after placement, and calmer summer months leading to less movement. We would expect this to be one aspect of the environment that could be leveraged to move sediment in desirable ways-- to rebuild the beach quickly in the spring, and then to have it mostly stabilized in the summer. In addition, precedent research reveals two other important aspects-- forms that protrude into the nearshore as the drumlin-like feature did would normally be expected to erode faster than a beach as wave energy is higher and exposure is greater. This was an intended part of the feature, so that redistribution by the waves would happen quickly, after which, the beach would be stable. Additional research through monitoring, as well as physical and computational modeling, would be important to give greater insight and confidence about this provisional conclusion.

+ This leads to an additional observation: waves did the work that a piece of hauling equipment would typically do in a beach re-nourishment project, thereby saving money. This approach, while affording slightly less control, also likely minimized impacts to the beach ecosystem as driving over barrier bar was minimized. It is also possible that this approach will lead to a better beach, because the sediments had been sorted by the waves as opposed to dumped, thereby directly mimicking natural beach-building processes. Additional research as to the quality of the beach for human use and ecological benefit would be very beneficial to any kind of regional plan for the shoreline.

+ The Port Bay Improvement Association, the Wayne County Soil and Water Conservation District, or other entity involved in contracting and coordinating the work of the dredging contractor should work with directly with the contractor to identify a maximium placement radius each year, for two purposes: 1) to ensure the placement site is far enough east to be out of the jetty shadow and give a buffer in case of a nor'easter storm, and 2) to ensure that no additional cost is necessary. Healthy Port Futures relied on the intelligence and experience of Jeff Decker at Decker Excavation from the beginning, and his feedback and insights all along were critical to the success of the research, and the eventual pilot project implemented by Wayne County SWCD.

+ The dredging and placement window should consider the weather forecast, specifically to ensure that there is no likelihood of waves from the northeast for the first few days after placement. Checking the weather is already a best practice, and nor'easters are often unsuitable as working conditions. Moreover, dredging is already restricted by permit language and practices that account for late-spring ice and potential spawning. Our recommendation is to simply extend this window by three days, to enable the least stable sediment to begin moving farther east to minimize risk. The recommendation may be updated as the practice is implemented, based on experience, or future research.

The second conclusion is the ongoing monitoring is essential. This is a priority identified by NYS DEC at the outset, and the nature of the research and pilot project serves to emphasize monitoring even more. Monitoring the movement of sediment in the implementation of a drumlin-like feature for dredged sediment placement is the best way to understand its performance. In conjunction with the implementation of the pilot, Healthy Port Futures, alongside all project partners, developed and conducted a monitoring protocol. The methodology focused on simple, affordable technology and techniques to be easily adopted if successful. This was only partially implemented in 2020 due to COVID-19 pandemic travel restrictions and relied heavily on local collaborators (NY Sea Grant) and consultants. Nonetheless, important data was gathered, and the methodology proved to be fairly simple. Currently, Healthy Port Futures is developing an agreement with Wayne County SWCD to continue monitoring for the next five years, assuming the pilot project is continued, in order to create a good baseline and a high-resolution image of the practice and its effects. Afterward, a simplified version and protocol may be adopted by local stakeholders. Continually learning from the process and making slight variations and adjustments yearly based on new goals, experiences, and information is important in a landscape project of this type. Moreover, because the improvements are tied to ongoing maintenance dredging and not to a singular capital project, the opportunity to learn and improve performance at no cost other than monitoring is built in. We believe this should be taken advantage of if possible.

The third conclusion is that the study of natural forms and processes provides the best way to develop sediment placement practices in this region. Our research effort began with a review of the scientific literature, an analysis of topography, bathymetry, and wave climate, alongside the geological and human history of the region and the ecological assemblages that rely on the landscape. In addition, we worked to understand the values and use patterns of the community of Port Bay as well as the landowner (NYS DEC) and the limits and insights of the workers responsible for the landscape maintenance (Decker Excavation). While we did not anticipate creating a drumlin-like feature originally, the research pointed in this direction. The form is a significant development, as it works like a smaller, simplified version of a drumlin in a region defined by them. The significance of this observation reinforces the current emphasis on natural and nature-based features (NNBF) and gives a specific case that other communities may be able to draw from. Moreover, because of the support for this approach at the state and federal level (both statutory and through community grants), a focus on developing this practice may provide an opportunity for Port Bay to bring in outside funding to scale up or enrich the practice.

In future placements, further questions can be investigated to determine the efficiency of placement and the quality of habitat created. Such questions might investigate the qualitative differences of material distributed along the beach. Future studies could collect material samples and qualitative observations of the sediment size distribution along the bar. To determine the movement of sediment in the nearshore zone, work could focus on collecting additional bathymetric data, either through LIDAR or more detailed ground surveys. Finally, further experimentation in placement location and geometry can help inform sediment distribution and timing. Refinements to the location and geometry can be slightly altered each year to study the effects on optimal sediment dispersal.

The fourth conclusion is that this practice should be considered in the context of the five Wayne County communities, and potentially for the New York Lake Ontario communities that participated in the 2000 Regional Dredge Management Plan. That study concluded that beneficial use of sediment the best use of the dredge material, and that beach nourishment was the best form of beneficial use. Our design research (based on field observation, a review of the available literature, precedent study, modeling, and drawing) showed how this can be possible within the necessary economic and environmental parameters. Indeed, the pilot project implemented by Wayne County SWCD and PBIA has proven the concept. Partnering with a regional governmental or non-governmental entity to study the feasibility and implications of scaling the practice across the region should be pursued immediately. The Southeastern Lake Ontario shoreline presents one of the last opportunities in the Great Lakes to preserve a natural shoreline largely intact, and to maintain the critical ecological, recreational, and infrastructural processes that a healthy shoreline provides while minimizing risks and cost. This is the most promising avenue for future research identified by our report.

Construction of Cobble Engine (Tess Ruswick)

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This report summarizes findings from the landscape research experiment conducted in Port Bay during Spring 2020. It has been prepared by investigators at University of Pennsylvania and University of Virginia.

Healthy Port Futures is a collaborative research project funded by Great Lakes Protection Fund to investigate alternative sediment management plans throughout the Great Lakes.

More information can be found at:

http://healthyportfutures.com

Healthy Port Futures Great Lakes Protection Fund Department of Environmental Conservation New York State Wayne County Soil & Water Conservation District PBIA Port Bay Improvement Association www.portbayny.org