DRAFT

May 2019

Port Bay Barrier Bar Assessment

Prepared for New York State Office of General Services and New York State Department of Environmental Conservation

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NYS Office of General Services
NYS Department of Environmental Conservation

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Project Number: OGS SC286

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ABBREVIATIONS

CRESS	Coastal and River Engineering Support System
EBM	Ecosystem-Based Management
EL	Elevation
FAS	Fishing Access Site
FEMA	Federal Emergency Management Agency
FHWA	US Federal Highway Administration
IGLD	International Great Lakes Datum
IJC	International Joint Commission
LST	Longshore Sediment Transport
NAVD	North American Vertical Datum
NOAA	National Oceanic and Atmospheric Administration
NYNHP	New York Natural Heritage Program
NYSDEC	New York State Department of Environmental Conservation
NYSDOS	New York State Department of State
NYSOGS	New York State Office of General Services
OHW	Ordinary High Water
PAC	Project Advisory Committee
PBIA	Port Bay Improvement Association
SEQRA	State Environmental Quality Review Act
SWCD	Soil & Water Conservation District
TMDL	Total Maximum Daily Load
USACE	United States Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
WI/PWL	Waterbody Inventory/Priority Waterbodies List
WL	Water level
WMA	Wildlife Management Area

1 Introduction

1.1 Project Purpose and Objectives

The Port Bay Barrier Bar is a narrow strip of land that forms a natural divide between Port Bay and Lake Ontario in the towns of Wolcott and Huron in Wayne County, New York. This barrier bar is a highly dynamic coastal feature that keeps the waters of Lake Ontario from entering Port Bay, which is bordered by seasonal and year-round homes and serves as habitat to aquatic species. A small, man-made channel in the barrier bar provides boaters with access to and from Port Bay (**Figure 1.1-1**). The barrier bar is owned by the State of New York (acquired in 1960) and is managed by the New York State Department of Environmental Conservation (NYSDEC) as part of the Lake Shore Marshes Wildlife Management Area (WMA).

Over the past several years, two breaches have occurred on the barrier bar: in 2016, a breach in the east barrier bar was repaired by Wayne County Soil & Water Conservation District (SWCD) using stumps, logs, gravel material, and supplemental plantings. This breach repair held during the 2017 record high lake levels, but in April 2017 a larger breach formed in a new area to the east of the repaired section.

Figure 1.1-1 Port Bay Barrier Bar Aerial View

Source: Google Earth, 2016

Periodic breaching of barrier bars on Lake Ontario is a natural process, with some breaches tending toward closure because of littoral sediment supply from up-drift. Over the past century, however, human development and activity along the shoreline (including armoring of the west barrier bar during the mid-1980s and in 1999, installation of a pier in the early 1960s, and regular maintenance dredging of the Port Bay outlet) has altered natural processes and interrupted sediment transport in portions of the lake's shoreline. A reduced sediment supply generally decreases the chance that the barrier bar would rebuild itself naturally. The 2016 Port Bay east barrier bar breach was closed as a result of the Wayne County SWCD project, and the 2017 breach closed naturally. It is unclear whether future breaches in the east barrier bar would stabilize, trend toward natural closure, or grow over time if no action is taken, nor is there a clear understanding of the timeframe and frequency over which these changes would take place. Moreover, the long-term effects of allowing the breach to stay open are not well known in terms of sediment supply and transport, water quality, and ecology in the bay. Local concerns have been raised that increased wave action, as well as ice and debris transport within the bay, could cause property damage. Given the highly dynamic nature of the barrier bar, NYSDEC is seeking a comprehensive evaluation of the Port Bay barrier bar system and potential management alternatives to make a science-informed decision on how best to manage the bar and respond to these types of events in the future.

The overarching goal of this study is to *use the best available science to identify and assess management alternatives for the Port Bay barrier bar, including the east barrier bar, west barrier bar, channel and surrounding nearshore areas, while considering the variety of complex ecological, social, economic, and environmental factors that are supported by this unique embayment community.*

Evaluations were conducted to attempt to determine the effects of the breaches on the surrounding area. Where possible, record data, anecdotal information, reports, and photographs were reviewed to establish the impacts that the breaches—as well as the long-term changes within the coastal area—have on the local environment and nearby properties. The lack of existing or historical data often led to general conclusions based on similar environmental scenarios.

Management alternatives were developed and evaluated with respect to achieving a balance of key project goals identified by project stakeholders:

- Maintain natural/dynamic coastal features in the nearshore area, beach, and barrier bar.
- Maintain and restore natural coastal processes, including sediment transport.
- Maintain and protect natural habitat areas.
- Minimize damage to property and infrastructure, both public (NYSDEC WMA) and private (shoreline residents).
- Ensure human health and safety.
- Ensure continued fishing and boat access.
- Ensure feasibility of implementation.

As a result of this study, project leaders and stakeholders seek the following outcomes:

- To better understand the factors that formed and sustained the barrier bar, the causes of erosion and breaching, and the risks (to property, habitat, water quality, etc.) posed by the east barrier bar breach.
- To understand any positive or negative consequences associated with the east barrier bar breach.
- To evaluate the possible management alternatives that address anthropogenic impairments, restore healthy barrier forms and processes and more effectively manage the entire barrier bar into the future.

To address the goals and desired outcomes of this study, this report assesses current and recent conditions, drawing on previous reports and analyses (**Appendix A**) as well as new research, and analyses. The report then describes and evaluates eight management alternatives for responding to breaches in the east barrier bar. These alternatives are initially evaluated based on their compatibility with the project goals; a select subset of these alternatives is then evaluated based on a life-cycle cost analysis. Finally, this report recommends an alternative that is most likely to effectively manage the Port Bay East Barrier Bar into the future.

It is important to note, that this document is not a design document, but a decision-making document designed to assist NYSDEC in determining the best course of action. The management alternatives provided in the report are schematic level only and would need to be fully fleshed out and designed during the design process.

1.2 Project Team/Sponsors

This project is sponsored by three New York State agencies:

- NYS Office of General Services (NYSOGS)
- NYS Department of Environmental Conservation (Great Lakes and Region 8), which manages the state-owned land at the Port Bay Barrier Bar as a Wildlife Management Area (WMA) and Fishing Access Site (FAS)
- NYS Department of State (NYSDOS), which has responsibility for evaluating proposed actions in New York's coastal zones.

The consultant team is led by Bergmann, an engineering/architecture/planning firm that managed the project, conducted the sediment analysis, assessed coastline conditions and damage, performed coastal engineering analyses and concept design, developed and evaluated alternatives, and recommended a course of action for addressing the breach. EcoLogic was responsible for assessing Port Bay's biota, habitat, and water quality conditions, and for coordinating preparation of this report. Bathymetric and topographic surveys were conducted by Prudent Engineering.

1.3 Stakeholder Coordination and Outreach

Local stakeholders and State agency representatives are an integral part of this project and have been engaged in studying, assessing, and identifying alternatives to address breaches of the Port Bay Barrier Bar. An overview of stakeholder coordination for this project is described below; Appendix B provides additional details about survey responses and public comments received.

Project Advisory Committee. A Project Advisory Committee (PAC) was established to support this study and consult with the consultant team throughout the duration of the project. PAC members include staff from the project sponsors (NYSDEC Great Lakes Watershed Program, Main Office, and Region 8, NYSOGS, NYSDOS) and key stakeholder organizations, including the Port Bay Working Group, local municipalities, New York Sea Grant, and the Wayne County Soil & Water Conservation District. The PAC assisted the consultant team in accessing State and local data, provided input on the study methodology, and reviewed and provided input on the draft report. PAC members participated in biweekly phone calls during which they reviewed plans for public participation, discussed management alternatives, and helped to develop criteria and priorities for evaluation.

Port Bay Working Group. The Port Bay Working Group, formed in 2015, serves as a liaison between the local Port Bay community and New York State agencies and partners that are involved in the east barrier bar management decisions. This group has been working toward identifying a manageable and acceptable solution for shoreline protection that meets all needs of the residents and wildlife. Members include leadership of the Port Bay Improvement Association (PBIA) (a group of homeowners in the area), the Town of Wolcott, the Town of Huron, New York Sea Grant, the Wayne County Soil & Water Conservation District, and representatives of NYSDEC. Several members of the working group also served on the PAC for this study.

Coordination with Outside Agencies. In addition to involving and seeking input from agencies directly involved in the PAC and Port Bay Working Group, the project team used sediment budget and sediment transport data from the US Army Corps of Engineers (USACE) and drew upon studies and data by the Federal Emergency Management Agency (FEMA), US Geological Survey (USGS), the National Oceanic and Atmospheric Administration (NOAA), the NYSDEC Division of Fish and Wildlife, NYSDEC Coastal Erosion Management Program, and NYSDOS Division of Coastal Resources.

Public Outreach. In addition to connecting with local stakeholders through the PAC and Port Bay Working Group, the project team engaged in the following public outreach:

- *Survey of Port Bay Residents.* Consultants worked with the PAC to develop a survey that was issued to residents who live on or have infrastructure located along the perimeter of Port Bay. This survey, which focused on economic damage incurred as a result of 2016 and 2017 breaches of the east barrier bar, was distributed via the PBIA Facebook page and email listing. The survey was made available electronically due to the short analysis period and the temporary residency of respondents. The survey received 181 responses from all around Port Bay. Results of this survey are discussed in **Section 2.2** and presented in **Appendix B**.

- *Public Meeting.* The project team held a public meeting at which they presented preliminary findings and provided an opportunity for people to pose questions and comments. This meeting, held Saturday, September 8, 2018, was attended by at least 37 Port Bay residents and other stakeholders.
- *Draft Report Review.* The draft assessment report was made available online for public review. **Appendix B** includes a summary of public comments received.

2 Existing Conditions

This section of the report assesses coastal conditions and the causes of erosion, as well as the risks and consequences that breaches pose to Port Bay's coastal features and processes, local property and infrastructure, and wildlife habitat. The assessment of existing conditions draws on a wide array of existing data and information that has been compiled and published (see **Appendix A** for a full list of previous reports and analyses used), as well as new research and analyses conducted for this study (bathymetric/topographic survey, sediment sampling analysis, a coastline damage survey, coastal engineering and biota and habitat assessments).

This study was conducted using information obtained from previous studies, reports, and publicly available information. The available funding and limited timeframe for study completion did not allow for the necessary long-term data accumulation necessary to perform detailed longshore and transverse sediment transport studies for the limited coastal area within the project vicinity. It was assumed that review of previous generalized studies, past dredging records, and existing topography and bathymetric survey, etc., would be sufficient for estimating the general conditions at Port Bay. The following sections describe the data reviewed and analyses conducted.

2.1 Physical/Geological Conditions

This section contains an overview of the shoreline physical conditions, recent breaches in the east barrier bar, dredging practices, beach and channel geometry, and sediment transport. It also derives design values for water level, wind-driven current, offshore waves, storm surge, and sediment size.

2.1.1 Data Sources

To assess existing physical and geological conditions in the project area, the project team drew on numerous past reports and data sources, which are referenced in **Appendix A**. The team also conducted a topographic and bathymetric survey of the project area, visual assessments, and sediment sampling analysis.

A note is worthy of mention on the adopted vertical datum for water level (WL) data from various sources. While the North American Vertical Datum (NAVD88) has been affirmed as the official vertical datum for the United States (by a notice in the Federal Register, Vol. 58, No. 120, page 34325, on June 24, 1993), most data obtained from various sources such as the National Oceanic and Atmospheric Administration (NOAA) and USACE are expressed in terms of IGLD85; that is, the International Great Lakes Datum (IGLD) 1985 as the dynamic height. IGLD85 is the mean WL at a set of master WL stations on the Great Lakes. Due to various observational, dynamic, and steric effects, there is a slight location-dependent difference between NAV88 and IGLD85 (see https://www.ngs.noaa.gov/TOOLS/IGLD85/igld85.shtml) known as hydraulic corrector. For our project site (Port Bay with North Latitude of 43.2975935°N and West Longitude of -76.8317758°W), this correction factor is given in **Table 2.1-1** for a typical WL of 246 ft = 74.98 m (see https://www.ngs.noaa.gov/cgi-bin/IGLD85/IGLD85.prl).

Table 2.1-1 Conversion from IGLD85 to NAVD88 for Port Bay

North Latitude	West Longitude	Gravity (gals)	NAVD88 Height (m)	Dynamic Height (m)	IGLD85 Height (m)
43° 17′ 52.80000″	76° 49′ 55.20000″	980.40640	74.9976	74.9815	74.9800

This means that for our project site: NAVD88 = IGLD85 + 0.058 ft (or 0.017 m).

2.1.2 Condition of the Shoreline

2.1.2.1 *Overall Evolution*

The Port Bay Barrier Bar is divided into two parts—west barrier bar and east barrier bar—by the Port Bay Outlet Channel, which is a roughly 90 ft wide (as measured from 2015 aerial imagery) dredged channel for recreational boat access between the bay and the lake. The west barrier bar has boat access, a parking lot, and an access road with riprap protection. The majority of the west barrier bar is lined with large jetty stone on the lake side, and a roughly 120 ft long pier extends into the lake at the eastern end of the west barrier bar. Approximately 210 ft of natural beach and nearshore area remain undisturbed immediately west of the pier. The shoreline of the west barrier bar has remained fairly constant since the installation of the shoreline protection in the 1999. The east barrier bar is roughly 1,300 linear ft of natural beach and nearshore area. The east barrier bar has shifted location and has become thinner and less vegetated over the past several decades. As recently as the 1960s, cottages stood on the east barrier bar. Remnants of the stone foundations can still be seen in the waters north of the bar today. The bar has been anecdotally reported to have been as much as 100 feet wide at one time; however, it is now only 30 feet wide in some spots. Currently, there is little to no vegetation on the east half of the east barrier bar, as all the woody vegetation that once supported the bar was lost in the previous breaches.

Historically, the Port Bay Barrier Bar was likely one solid bar with variations in width and breach locations dependent on natural conditions. Historical USGS topographical mapping and aerial imagery from 1938 show the barrier bar without the outlet channel as seen today. The earliest documentation received from NYSDEC Regulatory Permits indicates that an extension of an expired dredging permit for the outlet channel was requested in 1976. The permit describes the dredged channel width as approximately 20 yards or 50 ft. Documentation also indicates that the original dredging practices consisted of selling the dredged material or placing it on the west bar.

Figure 1.1-1 shows aerial views of the shoreline in the early spring of 2012. The overall recession and erosion pattern on the lake side of the east barrier bar over the past 13 years is depicted in **Figure**

2.1-2. Figure 2.1-3 provides an overview of the evolution of the east barrier bar from 1995 to 2015. A historical overview of the Port Bay shoreline is presented in **Figure 2.1-4.**

2.1.2.2 *Recent Breaches*

The east barrier bar has been breached or weakened in recent years by wave impact near its middle in the early spring. A pictorial description of the breaches and the east barrier bar during 2012–2018 is presented in **Figure 2.1-5** through **Figure 2.1-15**. An approximate timeline of the pertinent events related to these recent breaches is shown in **Figure 2.1-16**.

A breach occurred in the early spring of 2012. Another 50-ft wide breach was formed in 2015 (**Figure 2.1-5)**. Little documentation about these two breaches was found. It is assumed that the breaches repaired themselves naturally; however, the timeframe, size, conditions and impacts are not well documented. In 2014 and throughout 2015, the PBIA began working with the SWCD on a partnership for public outreach and Port Bay water quality protection. The Port Bay Working Group was formed and began discussing the erosion concerns along the east barrier bar.

On April 3, 2016, during a spring storm with northeasterly winds, another breach took place that was 100-ft wide (**Figure 2.1-5** and **Figure 2.1-6**). A few other barrier bars along the south shore of Lake Ontario were also broken by the storms on April 3, 2016, including Charles Point/Crescent Beach connection on Sodus Bay. The 2016 break in the east barrier bar resulted in as much as a couple of feet of sediment moving into the bay and depositing just inside the breach. Upon inspection of the breach, the Port Bay Working Group found it to be larger and deeper than expected. The SWCD began preparing a permittable plan for short-term erosion control and shoreline protection. The SWCD sought grant money to help fund a temporary stabilization project for the barrier bar using nature-based methods. The breach was filled and temporarily stabilized in November 2016 using logs and root wads (**Figure 2.1-6**). The nature-based stabilization project included burial of large tree stumps and woody debris in the breach area and placement of supplemental gravel/cobble-sized material (dredged material).

In early March 2017, another breach occurred east of the 2016 breach. In 2017, record high lake levels were recorded for Lake Ontario. The average lake level in March was 246.06 ft, which was already 1-foot higher than the long-term average levels for March. As the lake levels continued to rise, the breach became deeper and wider until it was roughly 400-ft wide (**Figure 2.1-7** through **Figure 2.1-14**). The breach depth was about 6–7 ft during high water (quoted from PBIA, PAC call, Aug. 9, 2018). Water levels peaked in June 2017 at an elevation of roughly 248.7 ft, indicating that ground elevations within the breach could have been as low as 241–242 ft, which is 2–3 ft below average low water levels. The high water levels that continued through 2017 and early 2018 prevented any natural or manmade repairs.

Figure 2.1-15 shows the status of the breach during a site visit on February 17, 2018, when the breach was still visibly open. Sometime in late February to early March 2018, the breach was closed naturally through sediment transport along the shoreline. This same figure also shows a drone view of the east barrier bar on March 27, 2018, following the breach closure. At this time, the annual channel dredging had not been performed, and transported sediment had been deposited within the outlet channel such that roughly 90% of the channel was closed.

Since the SWCD still had money within their grant funding for erosion protection on the east barrier bar, they contracted with the dredging firm hired by PBIA to dredge the outlet channel each year, to take the spoil material from the dredging and spread the material along the east barrier bar. As access to the east end of the east barrier bar (closest to the breach) is very difficult, access was made from the west end and the material spread primarily on the west end of the east bar. Additionally, in the summer of 2018, the SWCD teamed with local volunteers to plant additional live stake plantings on the nature-based protection area from 2016.

2.1.2.3 *Channel Deposition and Dredging*

Winter storms usually pound Port Bay and fill in the outlet channel, making navigation impossible. Because the outlet channel is used for recreational purposes only, the funding for dredging the channel comes from the users. The PBIA uses the organization's dues to hire a contractor to perform dredging and give safe and easy access to Lake Ontario for all boaters. The dredging permit allows for removal of sediment of a roughly 50 ft wide channel bottom with a bottom elevation of 236.8 (IGLD85). No in-water work is permitted between April 1 and July 15 of any year; therefore, the dredging typically occurs at the end of March each year. The amount of annual dredging varies each year but is estimated at approximately 1,000 CY (per the original dredging permit application); however, accurate records are not typically retained each year. Only two years of dredging estimates are recorded: 2018 and 2019. The 2018 dredging yielded approximately 2,800 CY. The PBIA verbally indicated that the 2018 dredging quantity appeared to be more than the average quantity. During the most recent 2019 dredging, the contractor estimated a yield of approximately 2,500 to 3,000 CY. **Figure 2.1-17** and **Figure 2.1-18** give an overview of the process and extent of the dredging. **Figure 2.1-19** shows the sediment deposit around the channel outlet on March 24, 2019, two days prior to the annual dredging. Further description of the dredging from 2018 and 2019 is provided in **Section 2.1.9**. Since only two years of records for dredging quantities currently exist, for the purposes of this report, the estimated average value of 1,000 CY is used in all subsequent dredged material estimations.

The dredged materials are typically piled on the sides of the channel outlet: Spoil Area #1 is located on the east barrier bar, and Spoil Area #2 is located near the pier (as shown in **Figure 2.1-18**). Currently, the permit does not allow for equipment to be in the water, and access from East Port Bay Road across the east barrier bar is difficult and requires water access; therefore, the dredging equipment is typically situated on the west barrier bar and reaches across the channel to excavate material. This results in a larger quantity of dredged material remaining on the west barrier bar in Spoil Area #2. During years when enough sediment is available, a "land bridge" is created from the sediment deposited in the channel that allows the dredging equipment to drive over the sheet pile walls, across the channel and to the east barrier bar to conduct some of the dredging. When this is practical, some dredged material is deposited on the east barrier bar at Spoil Area #1. The amount of material and access varies from year to year. When possible, the practice is to place as much dredged material on the east barrier bar to aid in bar nourishment; however, this is sometimes not possible based on the constrictions of the existing permit. Investigations have been made into securing a barge for additional material placement; however, the cost has been estimated at roughly twice that of the current dredging operations. Since the dredging is funded by the PBIA, the cost is out of reach for the organization and not considered further. On March 26, 2018, SWCD wrote to NYSDEC asking to amend the dredging permit to spread all the dredged material spoils along the entire east barrier bar. The material dredged during 2018 was not enough to spread over the entire bar; however, the modification to the permit allows for continued spreading with future dredged spoils.

2.1.2.4 *West Barrier Bar Riprap*

In 1999, a riprap revetment was constructed along 1,700 ft of the shoreline at the west barrier bar. The revetment was installed as part of a larger fishing access project including construction of a 40 car and trailer boat access site with a parking lot, turn around, boat ramp, and access road. The access road was protected by the riprap revetment. The revetment is comprised of large quarried rock (roughly 2-3 ft in diameter) that extends from elevation 241.5 at the toe to roughly 251-252 at the top of the access road. This revetment was continuing to prevent significant erosion of the west bar as of Spring 2018 (**Figure 2.1-20**). The access road is sometimes known to have been affected by waves crashing on the bar. The access road, which is comprised of fine grain sediments and gravels, has been replenished in the past (such as in 2018) with some of the spoil materials from the dredging operation. No other maintenance records were located.

2.1.2.5 *Beach Geometry*

A topographic and bathymetric survey was conducted on July 16, 2018. The topographic survey was limited to the east barrier bar in the vicinity of the previous breaches. Higher elevations on the east barrier bar and west barrier bar were not surveyed. The bathymetric survey extended roughly 400 ft from the water's edge along both the east and west bars. The lake water level variation near Oswego that day is shown in **Figure 2.1-21**; the average water level was ~246.25 ft. The results of the survey are depicted in **Figure 2.1-22**.

The bank slopes on the north side of the bay as well as the beach slopes for the west and east barrier bars are extracted as shown in **Figure 2.1-23**. This figure also shows the estimated nearshore slope (within ~80 ft of the water's edge) and offshore slope (between ~80 ft and 300–400 ft from the water's edge). The following describes representative slopes for the lake side of the east and west barrier bars:

East barrier bar: Nearshore slope = 4%; Offshore slope = 1%; Overall beach slope = 2–3%

West barrier bar: Nearshore slope = 7%; Offshore slope = 1%; Overall beach slope = 4–5%

The approach to the channel in the bay lies on upward slopes of 10% and 15%.

2.1.2.6 *Channel Geometry*

As depicted in the typical dredging plan for the Port Bay channel (**Figure 2.1-18**), the navigable length of the channel is 530 ft, which extends from the northern end of the existing pier, south to the southern end of the east bar. The permit allows for dredging of a 60-ft wide channel to a depth of 9 ft (EL 236.8), which is typically located against the sheet pile wall on the west. The actual waterway width varies between 80–110 ft, as shown in **Figure 2.1-24**. Per conversations with PBIA members, dredging is typically completed at the northern end of the channel near the middle of the existing pier, and typically does not extend farther south than the bend in the sheet pile wall. The southern portion of the channel tends to remain clear.

2.1.3 Lake Level History and Projections

NOAA monitors and forecasts water levels (among other meteorological parameters such as temperature and current) for several stations in Lake Ontario, including a station in Oswego that is the closest to Port Bay (**Figure 2.1-25**). USACE has also collected, presented, and predicated water level data in Lake Ontario for the past 100 years (**Figure 2.1-26**, **Table 2.1-2**, and **Figure 2.1-27**). The average lake elevation for the entire period of record is 245.28 IGLD85. The federal regulatory boundary for Lake Ontario is the Ordinary High Water (OHW) established as 247.3 IDLG85.

Table 2.1-2 Monthly Variation of Water Levels in Lake Ontario, 1918-2017

DETROIT DISTRICT

US Army Corps of Engineers

ABOUT BUSINESS WITH US MISSIONS MEDIA LIBRARY CONTACT LOCATIONS CAREERS

HOME » MISSIONS » GREAT LAKES INFORMATION » GREAT LAKES WATER LEVELS » HISTORICAL DATA

Historical Data

Long Term Average, Maximum, and Minimum Great Lakes Water Levels

FINAL 2017
and Long-Term (1918-2017) Mean, Max & Min
Monthly Mean Water Levels (Based on Gage Networks)
(Feet, IGLD85)

3-Apr-2018

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
LAKE ONTARIO													
2017	*244.82*	*245.47*	*246.06*	*247.21*	*248.69*	*248.72*	*248.33*	*247.47*	*246.33*	*245.60*	*245.64*	*245.31*	*246.65*
Mean	**244.62**	**244.75**	**245.01**	**245.67**	**246.13**	**246.23**	**246.06**	**245.70**	**245.21**	**244.78**	**244.55**	**244.49**	**245.28**
Max	246.59	246.95	247.28	248.20	248.69	248.72	248.33	247.97	247.41	246.78	246.65	246.72	
	1946	1952	1952	1973	2017	2017	2017	1947	1947	1945	1945	1945	
Min	242.16	242.06	242.59	242.88	243.14	243.41	243.24	242.78	242.49	242.19	241.96	241.93	
	1935	1936	1935	1935	1935	1935	1934	1934	1934	1934	1934	1934	

The storms of Sunday and Monday, April 3-4, 2016, which caused the breach of 2016, occurred when the lake water level was higher than normal, roughly 246.3 ft, approximately 0.7 ft above the average of 245.01 ft. Likewise, the 2017 breach occurred in early March when water levels averaged 246.0 ft, 1 ft above the long-term average. Water levels on the days the 2016 and 2017 breaches occurred are shown in **Figure 2.1-28** and **Figure 2.1-29**. **Figure 2.1-30** presents Oswego water level variations in April 2016, 2017, and 2018. Water levels in April 2017 were visibly higher than in the other two years. Water levels in 2017 reached record highs.

In 2014, the International Joint Commission (IJC) of Canada and United States published a new policy for regulating Lake Ontario–St. Lawrence River water levels and flows, known as *Plan 2014*. The policy "would relax the compressed Lake Ontario levels of Plan 1958-DD, but with the upper levels still substantially controlled to protect Lake Ontario riparians. The maximum level simulated under Plan 2014 is only 6 cm (a little more than 2 in) higher than the maximum level under Plan 1958DD" (IJC 2014, vi). **Figure 2.1-31** and **Figure 2.1-32** reflect the data and a comparison of the new and old policies.

Plan 2014 became effective in January 2017. The IJC website holds that "The International St. Lawrence River Board of Control is now the International Lake Ontario–St. Lawrence River Board. The Board implemented *Plan 2014* to ensure that releases at the Moses-Saunders Dam comply with the International Joint Commission's 8 December 2016 Supplementary Order effective January 2017" (http://ijc.org/en_/islrbc; retrieved Aug. 26, 2018). *Plan 2014* was the water level control during the 2017 breach; the prior breaches occurred while under the Plan 1958-DD water level controls.

According to the December 2016 order, the regulated monthly mean level of Lake Ontario shall not exceed the following high and low elevations "in the corresponding months with the supplies of the past as adjusted." **Table 2.1-3** contains the respective values in which 248.46 ft (75.73 m) is the maximum mean water level, which would occur in May and 241.34 ft (73.56 m) would be the minimum mean water level, which would occur in January.

Table 2.1-3 Maximum and Minimum Allowable Monthly Mean Water Level of Lake Ontario Based on an Order by IJC Effective Jan. 2017

Lake Ontario Level IGLD1985				
	Low Level Limits		High Level Limits	
Month	Meters	Feet	Meters	Feet
January	73.56	241.34	75.26	246.92
February	73.62	241.54	75.37	247.28
March	73.78	242.06	75.33	247.15
April	73.97	242.68	75.60	248.03
May	74.22	243.50	75.73	248.46
June	74.27	243.67	75.69	248.33

Lake Ontario Level IGLD1985				
	Low Level Limits		High Level Limits	
Month	Meters	Feet	Meters	Feet
July	74.26	243.64	75.63	248.13
August	74.14	243.27	75.49	247.67
September	74.04	242.91	75.24	246.85
October	73.83	242.22	75.25	246.88
November	73.67	241.70	75.18	246.65
December	73.57	241.37	75.23	246.82

Source: Lake Ontario St. Lawrence River Plan 2014, Supplementary Order of Approval 2016, http://www.ijc.org/en_/Plan2014/Supplementary_Order_of_Approval_2016.

Figure 2.1-32 shows a comparison of the anticipated extremes between the Plan 2014 and Plan 1958DDD water level controls. The "historic extremes" represent actual water levels based on 101 years of record. The "stochastic" values represent modeled scenarios where additional water supply datasets were analyzed, some of which included much wetter and drier periods than any experienced during the 101 years of historic records. The average water levels in May and June 2017 were 248.69 ft and 248.72 ft, respectively, both of which exceeded the Plan 1958DD historic water levels and historical peaks of those simulated under Plan 2014.

2.1.4 Typical Current Velocities

There are no long-term monitoring gages measuring current (velocity), water level or other types of data located in Port Bay. Visual assessments and measurements within the outlet channel were taken during site visits; however, this only provides single data points during certain fair-weather conditions and would not be representative of the conditions during the past breaches or during storm events. In order to estimate current velocities within the lake near the project site, NOAA data for two of the lake stations were explored. Sample data are presented in **Figure 2.1-33**. A value of 0.4 knots (~0.2 m/s, 0.65 ft/s) for current velocity is assumed typical for the project site.

2.1.5 Wind Generated Waves

Visual evidence of considerable wave action on the beach has been noted and is depicted in **Figure 2.1-34**, which shows where the shoreline of the west barrier bar between the pier and the beginning of the riprap protection is eroded. **Figure 2.1-35** shows waves in fairly rough lake water near the east barrier bar going through the breach of early March 2017. Several pictures in **Figure 2.1-36** show the lake waves acting on the shoreline or entering the bay.

Several USACE wave measurement stations in Lake Ontario are located north of Port Bay (**Figure 2.1-37**). The stations and data were obtained from the "Wave Information Studies" database of USACE (http://wis.usace.army.mil/). Typical data on large waves (greater than 2 m or 6.6 ft) at each of Stations

91055 (water depth 70 ft), 91054 (water depth 100 ft), and 91053 (water depth 56 ft) during 1970–2014 was reviewed. The stations recorded approximately 9,000 wave observations. These three offshore stations are 2–3 miles from the project site. **Figure 2.1-38**, **Figure 2.1-39**, and **Figure 2.1-40** show the wave statistics and prediction (1970-2014), wave rose (2014), and wave parameters (amplitude and period; 2014), respectively, for Station 91055. The wave roses for the other two stations are fairly similar to that for Station 91055. The roses clearly show that, in this area, waves predominantly arrive from the west-northwest, and the majority of the significant wave heights range from 0–2 m. Occurrences of waves greater than 2 m are much less frequent, but the area has been shown to have 2–3 m high significant waves approaching from the north-northeast, as would be expected with nor'easter storm events.

Table 2.1-4 contains data on the three largest observed waves at these stations during 1970–2014, the largest of these being 7.08 m (23.2 ft) at Station 91055, 7.13 m (23.4 ft) at Station 91054, and 6.56 m (21.5 ft) at Station 91053. As the wave roses show, all these large waves attack from almost the same angle. Interestingly, the predominant wave direction is almost normal to the pier, which indicates the proper choice for the pier orientation in the design of this structure more than half a century ago. As well, historical Google Earth images for the project site in 1995 and 2002 (the only two Google Earth images with visible wave fronts) show wave fronts coming from the same angle (**Figure 2.1-41**).

Table 2.1-4 Largest Three Observed Waves at Three Stations North of Port Bay, 1970-2014

Extreme Deep Water Wave Heights for Lake Ontario				
Rank	**Date**	**Peak Wave Height**	**Period**	**Direction Waves Are Arriving From**
Station 91055				
1	4/6/1979	23.23 ft (7.08 m)	11.48	292.0 (W/NW)
2	11/13/2003	23.19 ft (7.07 m)	11.48	293.0 (W/NW)
3	10/15/2003	20.87 ft (6.36 m)	10.28	297.0 (NW)
Station 91054				
1	4/6/1979	23.39 ft (7.13 m)	11.37	289.0 (W/NW)
2	11/13/2003	23.33 ft (7.11 m)	11.39	290.0 (W/NW)
3	12/18/2000	21.13 ft (6.44 m)	10.70	289.0 (W/NW)
Station 91053				
1	4/6/1979	21.52 ft (6.56 m)	11.43	290.0 (W/NW)
2	11/13/2003	21.49 ft (6.55 m)	11.46	291.0 (W/NW)
3	12/18/2000	20.54 ft (6.26 m)	10.90	291.0 (W/NW)

According to the Coastal Engineering Manual (USACE 2002), in a swell event $H_{max} = 1.86 \times H_s$, where H_s is the significant wave height defined as the average of the largest one-third of wave heights. This relation is based on Rayleigh Distribution for random wind-generated waves. The maximum observed offshore wave height during 1970-2014 for Station 91055 was 23.23 ft (7.08 m), and the predicted offshore wave height with 50 and 100 years of return period is 24.6 ft (7.5 m) and 25.9 ft (7.9 m), respectively (see **Figure 2.1-38**). Since the wave records for the project site only cover 44 years, it seems reasonable to assume H_{max} is greater than the 100-year wave height statistically determined from the 44 years of record, namely 26 ft. An approximation was made to assume H_{max} = 28 ft, which yields an offshore significant wave height H_s of 28/1.86 = 15 ft, where the water depth is 70 ft.

2.1.6 Storm Surge

Storm surge is the rise of the lake surface that occurs in response to barometric pressure variations (the inverse barometer effect) and to the stress of the wind acting over the water surface (the wind setup component). **Table 2.1-5** lists the top ten storm surges in Oswego, Lake Ontario, during 1976–2006.

Table 2.1-5 Top 10 Surges in Oswego, 1976-2006

Rank	Maximum Time	Maximum Surge (ft)	Duration (hrs)	Total Water Level (ft, IGLD85)
1	1979/04/06 15:00	1.18	31	247.12
2	2006/02/17 09:00	1.16	43	246.76
3	1992/11/13 01:00	1.10	12	246.55
4	1991/12/14 18:00	0.97	18	245.03
5	1980/01/12 09:00	0.88	15	245.67
6	2005/09/29 09:00	0.83	13	245.74
7	2003/11/13 17:00	0.82	27	245.72
8	1974/01/31 17:00	0.81	8	246.67
9	1996/01/28 02:00	0.81	23	245.83
10	1976/03/05 12:00	0.80	17	246.65

Source: Baird, Pete Zuzek, undated presentation: "Update on Great Lakes Coastal Methodology—Event versus Response Approach."

2.1.7 Coastal Sediment Transport

Erosion along shorelines and barrier bars is a natural progression. Coastal areas are built and eroded by movement of sediment lengthwise along the coast, termed longshore sediment transport (LST) and perpendicular to the shoreline, termed cross-shore transport. This material moves from lakes and rivers to the coastline along shorelines in a continuous fashion. The dynamic nature of beaches and barrier bars means that they will perpetually be changing, altering their shape, size and location. When these natural features are the basis of protection or placement of permanent structures, the natural process becomes a problem. Permanent structures such as seawalls, harbors, revetments, groins, jetties, and other protective features change the dynamics of sediment transport. The conditions at Port Bay are likely a result of changes that have been going on in the area and all around Lake Ontario. Because of this, it is important to understand the sediment transport conditions and how this project may affect or be affected by longshore transport.

2.1.7.1 *Evidence of Actual Sediment Transport*

There are several sources that show there is actual active sediment transport at Port Bay as follows.

Overall beach recession. **Figure 2.1-2** presented the evolution of the lake side edge of the east barrier bar since 2005. The same pattern is visible in the historical images of **Figure 2.1-4** where the middle of the east barrier bar shifted dramatically between 1954 and 2015. **Figure 2.1-42** shows a closer view at the southward shift of the bar from late April 2015 to July 2018. The edge of water along the bar has moved between 6 ft and 30 ft to the south due to erosion, with an average of ~13 ft in the last eight years. Erosion has been more evident in the eastern half of the bar, with an average of 18 ft. However, a fairly continuous supply of the eastward LST from the up-coast regions, coupled with fairly mild cross-shore movement of sediment, do not allow excessive erosion of the bar and loss of its width.

Aerial images. The images in **Figure 2.1-43** provide visual evidence of active sediment transport along the shoreline from 1995 to 2015.

Erosion west of the pier. The gap between the pier and the existing rock revetment on the west barrier bar, approximately 200 ft long, is exposed to natural, fairly cyclic erosion and deposition as depicted in **Figure 2.1-44**.

Annual dredging. The images in **Figure 2.1-45** present evidence of both longshore and cross-shore sediment transport. Approximately 1,000 CY of material is dredged from the navigation channel each spring. The material is mostly dredged from the outlet channel near the bend of the pier and further north, as described in **Section 2.1.2.3**. This volume is the minimum sediment transport that can be attributed to both these types of sediment transport.

2.1.7.2 *Shoreline Sediment Composition*

Pictures contained in **Figure 2.1-46** provide a good representation of the shoreline sediment at the east barrier bar. Views of the east barrier bar beach and sediment are shown in **Figure 2.1-47**.

Six samples of sediment were taken during a site investigation on April 11, 2018, as shown in **Figure 2.1-48**. Samples #1 and #2 were taken on the west side of the pier, at the sheet pile wall below and above the water line, respectively. This area is reportedly not modified during the annual dredging and spoil placement. These should be native materials being transported along the west barrier bar. Sample #3 is taken from the sediment recently deposited in the former breach area. This material arrived here naturally. Sample #4 comes from the recently spread spoils material along the western end of the east bar. Samples #5 and #6 are also from the east bar, along the outlet channel. These materials should be naturally placed. As part of the revised dredging permit, a sediment sample, including gradation of the dredged material, must be provided to NYSDEC. This is the first year (2018) this rule has been enacted. There are no other sediment samples of the previous dredged material. The results from the sieve analysis for these collected samples and the sample from dredging of the channel are given in **Figure 2.1-49**, **Figure 2.1-50**, and **Figure 2.1-51**.

The results suggest that the shoreline materials of the east barrier bar can be described in general as "well-graded gravel (2 mm–64 mm)" with little sand (<2 mm) and cobbles (>64 mm). Also called a shingle beach, the Port Bay beach has the following typical sediment sizes representing:

D50[1] = 12 mm; D10 = 2.5 mm; D30 = 6 mm; D60 = 14 mm; D90 = 40 mm

This overall shoreline description can be compared to other beaches along the lake near Port Bay. An investigation into the sediment along Lake Ontario shorelines entitled *Lake Ontario Ecological Sediment Budget* (Baird 2011) classifies beaches on the west and east of Port Bay as "cobble beach" and "sandy beach" respectively (**Figure 2.1-52**).

Looking at the results individually, it can be noted that the samples have very similar gradations. Samples #2, #3, and #4 (west side above the waterline, east side material filling former breach, and east side dredge material placed on shore, respectively) each show a slightly higher D50 than Samples #1, #5, and #6, indicating the presence of larger material. Sample #4 has the largest D50 of 50 mm and is the only sample to have a significant percentage of cobble-sized material. Samples #1, #5, and #6 have a higher percentage of sand materials than the others, with Sample #1 having the smallest D50 at 3.7 mm.

2.1.7.3 *Review of Existing Baird Analysis*

Baird (2011) numerically simulated the potential LST along the south shore of Lake Ontario and conducted limited field investigations to support the simulations. "*Two sets of model runs were undertaken: a 'potential' sediment transport run, where sediment supply was not limited, so the rate of transport is governed by the available wave energy, and a 'supply-limited' run, where sediment transport is limited by the amount of sand in the nearshore zone*" (Baird 2011, 14). Noting Port Bay is located between Sodus Bay (on the west) and Little Sodus (on the east), the results of the simulations are presented in **Figure 2.1-53**, **Table 2.1-6**, and **Figure 2.1-54**. The simulations can be summarized as follows:

- Bluff recession may feed a large portion of the supply-limited LST upcoast of Port Bay;
- A large portion of the LST comes from the west leading to a net eastward LST; and

[1] Typically, particle size distributions, as a result of a sieve analysis, are presented in the form of an S-curve of cumulative mass retained on each sieve. The D values (D10, D50, D60, etc.) are commonly used metrics referring to the diameter corresponding to the percentage of mass retained on each sieve (e.g., D50 = 12 mm, means 50% of the material is finer than 12 mm, 50% of the material is larger than 12 mm. D50 is often referred to as the median diameter and typically used to classify sediments.

- Near Port Bay, the potential LST (~300,000 m^3/yr) is more than 10 times (~13 times) the supply-limited LST (~22,000 m^3/yr).

Table 2.1-6 Lake Ontario Annual Sediment Budget

Existing		Sources		Sinks		All values in 1,000 m^3/yr	
Sub-Cell	Input from Updrift Sub-Cell**	Bluff Recession	Lakebed Downcutting	Fillet Beaches	Harbor Sedimentation	Output to Downdrift Sub-Cell**	Δ
Bay	0.0	4.2	0.1	0.7	0.0	3.7	3.7
Sodus Bay–Little Sodus	3.7	18.8	0.1	0.6	0.1	21.9	18.3
Little Sodus–Oswego	21.9	7.9	0.1	0.0	1.6	28.3	6.4
Oswego–Eastern Lake Ontario	28.3	10.5	0.1	0.0	0.0	38.9	10.5

Source: From Baird (2011)

* Unknown input required to balance budget

** Assumes sediment bypassing at harbors (no numerical modeling completed to confirm this assumption)

*** Potential inputs from shoreline west of the Niagara River not quantified in this study

Quantitative applicability of these findings to the present study of the east barrier bar is limited because the simulations have not incorporated the following local factors:

- Actual sediment properties (size, shape, etc.) at the project site (this alone can limit the validity of the findings to a large extent);
- Cross-shore sediment transport at Port Bay, which, according to observations from recent breaches in 2016 and 2017, has a significant role for the stability of the east barrier bar;
- Local wave and current data as derived in **Sections 2.1.4** and **2.1.5** of this study;
- Impact of annual dredging and the resulting reintroduction of the dredged materials to the shoreline on the morphology of the east barrier bar; and
- Interaction between the channel/bay and the lake.

Although the volume of the dredged materials (1,000 CY; fourth bullet above, see also **Section 2.1.2.3**) may be small compared to the potential sediment transport at the site, this volume may have an impact on the temporary sediment deprivation around the channel outlet. Removal or later distribution of this volume is in fact a disturbance of a possible equilibrium condition in the shoreline. The importance of the interaction between the channel/bay and the lake (fifth bullet above) is mentioned in **Section 2.1.7.6**.

2.1.7.4 *Sediment Transport Analysis*

Waves. The shoreline at Port Bay is subject to waves, as described in **Section 2.1**. **Figure 2.1-55**shows examples of these waves and a typical wave rose at a nearby offshore station 2.5 miles from the site. While the structures such as rock revetments are designed to withstand extreme waves, sediment transport is determined by actual waves represented by the wave rose, which includes a range of waves from small to large.

The angle of the dominant wave is 22.5 degrees with the W-E line but given a slight overall east-northern inclination of the east barrier bar as well as a 45-degree direction (denoted by 315 on the wave rose) for a portion of large north-westerly wave, a 30-degree angle is assumed for the LST purposes. The longshore impact of the 22.5-degree waves is counteracted by a great portion of the 315-degree waves. Approximately 15% of large waves approach the shoreline at a right angle. These, plus the normal component of the predominant waves, generate cross-shore movement of water particles and sediment grains, leading to cross-shore sediment transport.

To facilitate the sediment transport calculations, offshore waves are summarized by five wave classes of W1: 0.5 m (1.7 ft) high, W2: 1.5 (4.9 ft) high, W3: 2.5 m (8.2 ft) high, W4: 3.5 m (11.5 ft) high, W5: 4.5 m (14.8 ft) high. These represent the mid-range of five major wave types denoted by dark blue, orange, yellow, purple, and green colors, respectively, in the wave rose. The impact of a very small percentage (~0.1%; light blue) belonging to very large wave height of 6.25 m (20.5 ft) is assumed to be incorporated in W5. **Table 2.1-7** summarizes the waves. The wave crests are at 30^{o} with the shore, which means the rays have a 60^{o} angle with the shore-normal.

Table 2.1-7 Representative Waves of Sediment Transport Calculations

Wave Class	Offshore Wave Height	Nearshore Wave Breaker Height*	Wave Period (sec)	Frequency of Occurrence in a Typical Year
W1	0.5 m (1.7 ft)	0.4 m (1.4 ft)	5	20%
W2	1.5 m (4.9 ft)	1.34 m (4.4 ft)	5	8%
W3	2.5 m (8.2 ft)	1.34 m (4.4 ft)	7	4%
W4	3.5 m (11.5 ft)	1.34 m (4.4 ft)	9	2%
W5	4.5 m (14.8 ft)	1.34 m (4.4 ft)	9	1%

* Note: See the procedure to compute HD for the rock revetment.

Longshore current. In addition to the wind-driven currents discussed in **Section 2.1.5** (0.2 m/s or 0.6 ft/s), waves generate longshore currents. Komar's (1975) equation (USACE 2002) is used to estimate the average longshore current velocity across the surf zone due to waves.

$$Vmean = 0.50\sqrt{gH_b}.\sin 2\theta_b$$ (Equation 4; SI units)

where

H_b = where $(H_b)_{1/3}$ breaking wave height,
θ_b = angle between breaker crest and shoreline, and
g = acceleration due to gravity

Equation 4 yields V_{mean} = 0.5 × (9.8 × 4.4 × 0.305) ^ 0.5 × 0.86 = 1.5 m/s = 5 ft/s.

With a typical nearshore water depth of 5 ft (1.7 m) and the equivalent Manning's roughness coefficient of 0.022 for the gravel bed of the beach, an average shear stress of 10 N/m^2 (0.2 lbf/ft^2) will result. Based on the Shields' criterion for the incipient motion, this shear stress is capable of moving 12 mm particles. Half of the sediment grains at the beach are smaller than this size

Sediment classification. The beach at Port Bay was previously described as a shingle beach with some sand and little cobble. Owing to a wide range of sediment sizes, calculation of LST should not be based on a single representative size such as D_{50}. Therefore, the range is divided into three classes as contained in **Table 2.1-8**; this table also identifies the proper LST estimation method for each sediment class.

Table 2.1-8 Sediment Fractions for Calculation of Longshore Sediment Transport

Size class	D (mm)	Porosity	Fraction of shoreline sediment	Designation	Estimation method
D1	2	40%	20%	Coarse sand	CERC as described in "Coastal Engineering Manual" by USACE (2002) [or by Van Rijn (2013)] as incorporated in CRESS (1990-2018)
D2	20	45%	50%	Coarse gravel	Estimator by Tomasicchio et al. (2015) as used in CRESS (1990-2018)
D3	35	50%	30%	Very coarse gravel	Estimator by Tomasicchio et al. (2015) as used in CRESS (1990-2018)

2.1.7.5 *Potential Longshore Sediment Transport*

Potential LST reflects the combined capacity of waves and currents to transport sediment alongshore under unlimited supply. With data summarized in **Table 2.1-7**, **Table 2.1-8** and **Section 2.1.2.5**, potential LST is calculated as summarized in **Table 2.1-9**.

Table 2.1-9 Potential Longshore Sediment Transport Along East Barrier Bar

		D1 (Coarse sand); 40% porosity	D2 (Coarse gravel); 45% porosity	D3 (Very coarse gravel) 50% porosity	Total potential sediment transport per year; bulk volume (*i.e.*, porosity included)		
					m^3	1,000 ft^3	**$yard^3$**
LST for wave class **W1** (*i.e.*, for 20% of yr)	m^3/s	0.00029	≈0	≈0	1,800	64	2,400
	m^3	1,800	≈0	≈0			
LST for wave class **W2** (*i.e.*, for 8% of yr)	m^3/s	0.004100	0.000245	0.000084	11,280	400	14,650
	m^3	10,400	640	240			
LST for wave class **W3** (*i.e.*, for 4% of yr)	m^3/s	0.004100	0.000250	0.000088	5,640	200	7,380
	m^3	5,200	320	120			
LST for wave class **W4** (*i.e.*, for 2% of yr)	m^3/s	0.004100	0.000255	0.000088	2,825	100	3,700
	m^3	2,600	165	60			
LST for wave class **W5** (*i.e.*, for 1% of yr)	m^3/s	0.004100	0.000255	0.000088	1,412	50	1,850
	m^3	1,300	82	30			
				Sum	≈23,000	≈810	**≈30,000**

The numbers are in good agreement with observations and previous findings as follows:

Previous high-level investigation. The present estimate of 23,000 m^3/yr for potential annual LST is based on local wave and sediment data and lies between the high-level estimates by Baird (2011) for potential LST (300,000 m^3/yr) and supply-limited LST (~22,000 m^3/yr).

Active annual LST. Given the size classes and percentages in **Table 2.1-8**, gravels are in active movement along the shoreline at Port Bay 10%~15% of times while sands move 20%~25% of times each year. The pier stops part of the eastward LST for a few months only, before new storms pick up and carry the deposited materials across the pier, both around the pier and over the pier.

Dredging in the context of LST. Calculation shows that the LST capacity for the gravel portion of the beach materials equals approximately 2,200 CY. This number is derived from the sum of the values for D2 and D3 grain class sizes (coarse gravel and very coarse gravel, as defined in **Table 2.1-8**) for all of the wave classes, as shown in **Table 2.1-9**.

$$(640 + 320 + 165 + 82) + (240 + 120 + 60 + 30) = 1{,}660\ m^3 \approx 2{,}200\ CY$$

The annual volume of the dredged materials (~1,000 CY, see **Section 2.1.2.3**) which reportedly contain little sand (see gradation curve in **Figure 2.1-51**) is close enough to the estimated potential gravel sediment transport volume (~2,200 CY). This shows that the actual sediment transport is not too far from the potential LST. The sources of up-coast sediment supply from the west are bluff erosion and stream flows (Baird 2011). Less than half of the potential gravel LST passes the pier to remain in the navigation channel outlet area while the remaining LST materials bypass the pier and move along the east barrier bar to leave Port Bay towards the east. Therefore, the nourishment of the east barrier bar with the materials from the annual dredging plays a significant role in the stability of the bar.

Cross-shore sediment movement. Those large waves that are almost normal to the shoreline (~ 8% of all large waves), and the shore-normal component of the predominant waves are capable of moving grains smaller than 12 mm (D_{50}).

- At the channel outlet: These waves are responsible for pushing the materials normal to the shore into the navigation channel forming eventually a gravel bar across the channel near the south end of the pier. The bar may break by the force of the flow from the bay into the lake, but the bar essentially stops the cross-shore gravel motion into the channel. This explains why dredging is not needed south of the bend in the navigation channel. A preceding section on the impacts of the channel provided a quantitative view on the role of flow from the bay into the lake.
- Across the east barrier bar: As discussed in standard coastal engineering literature such as that by USACE (2008) on waves attacking shorelines, "*a second constructive force originates within the bottom boundary layer, causing a net mean velocity in the direction of propagating water waves*" (p. III-3-4; see the definition sketch in **Figure 2.1-56**). With the known parameters near the east barrier bar, this velocity is estimated to be V=2.2 ft/s ~ 2.4 ft/s which is quite adequate to push sand (including very fine sands that are suspended) and fine gravels (rolling and sliding on the bed) through any break that may take place like those occurred in 2016 and 2017. This has been demonstrated in several pictures of the intruded "mud plume" in previous sections as well as in the survey of the sediment deposit in the bay south of the break.

Unprotected shoreline gap west of the pier. The cyclic erosion of the unprotected gap between the pier and the existing rock revetment on the west of the pier seems to be regularly and naturally filled up by LST during storm seasons. No repair of this gap using hard structures seems to be necessary.

2.1.7.6 *Impacts of the Channel*

The flow from the bay into the lake alters the velocity field near the outlet, which in turn impacts the sediment transport around the shoreline discontinuity near the channel outlet. Again, as no velocity or other types of long-term data logging gages are present in Port Bay, it is difficult to interpret how the velocity in the channel fluctuates and how those fluctuations may impact or be impacted by other outside sources.

Simple field measurements of the water velocity at the surface were taken around 9:00 am on November 6, 2018, using a floating object along 100 ft of the channel downstream of the pier where the channel width is approximately 90 ft. The lake water level was 244.5 ft, and temperature was 50°F with southeasterly wind of 5-10 mph. The velocity measurement was repeated 10 times leading to results between 1.7 ft/s and 2.6 ft/s with a mean of 2.1 ft/s.

Assuming an average velocity of 1.7 ft/s (80% of the surface average velocity), a typical water depth of 10 ft in the channel, and a Manning's roughness coefficient of 0.022 (course gravel bed), the following estimates are made:

Typical friction slope, S_f = 0.0004
Average bed shear stress = 10 N/m^2 = 0.02 lbf/ft^2

This channel flow would be able to carry sand and fine gravel particles along the channel bed. This capability limits the intrusion of sand and fine gravel from the lake into the channel by waves. That is why channel dredging is not needed south of the pier.

As well, the channel flow can impact the hydrodynamics and sediment transport along the shoreline near the pier and at the outlet. Visual evidence for the impact of the channel and pier on hydrodynamics and sediment transport along the shoreline are presented in **Figure 2.1-57**. The effects of the discharge out of the channel can be seen in several of these aerial photographs. At times, sediment plumes can be seen and the images, such as the 2008 and 2016 images, show how the current could deflect the LST away from the east barrier bar temporarily. Conversely, the 2002 image shows wave action along the lake shore with only minor disruptions visible in the wave patterns at the channel outlet and 2015 seems to show a transfer of sediments into the channel rather than into the lake.

2.1.8 Coastal Sediment Trapped During 2016 and 2017 Breaches

Calculating the amount of sediment transported into the bay during the breaches of 2016 and 2017 is not strictly possible due to a lack of baseline data. The east barrier bar is a dynamic system that changes shape and elevation almost daily. In addition to the detailed topographic and bathymetric survey conducted in July 2018 specifically for this project, the SWCD had taken topographic surveys of the east barrier bar, or portions of it, in 2015 and 2016. Outlines of the barrier bar (at current water surface elevation) were taken by SWCD at various other points to show the progressive shifting of the bar. Some of these outlines are depicted in **Figure 2.1-2** and **Figure 2.1-14.** However, none of these surveys included bathymetrical data. The only source of historical bathymetrical data comes from a 2007 study of the entire Port Bay. The data from the 2007 bathymetry appears to be at a coarser scale than the 2018 survey.

The two datasets were converted into raster surfaces. A comparison of the 2018 and 2007 bathymetry data was conducted to estimate a volumetric quantity of material deposited in the bay as a result of the breaches (subtraction of raster surfaces). Due to the nature of the datasets, a wholesale comparison of the large area was not feasible; however, isolating the comparison area to that directly surrounding the breach area resulted in roughly 12,500 CY of additional material in the bay. **Figure 2.1-58** shows the changes seen in the bathymetry.

2.1.9 2018 - 2019 Dredged Material Placement

Typically, PBIA does not keep detailed records of the dredging quantities from the outlet channel. During 2018, some information was recorded as a result of the combined east barrier bar restoration project carried out in conjunction with the SWCD and the revised permit conditions. Based on verbal descriptions from PBIA and SWCD, roughly 2,800 CY was dredged from the channel in 2018, which is considered more than is typically dredged. The reported average dredging quantity from the dredging permit is 1,000 CY. An additional 1,000 CY of older dredged material was located on the west barrier bar in Spoil Area #2. Roughly 300-600 CY of the material was used to help fortify and repair the surface of the west barrier bar access road. The remainder of the newly dredged material and the old dredged material were brought over to the east barrier bar and spread along the western beach area, above the water level at the time, ~246 IGLD85, and below mean high water of 247.3 IGLD85 as part of the sponsored project. The intent of the project was to allow this sediment to return to the littoral sediment transportation zone and be drifted downshore to aid in stabilization of the east barrier bar.

During the development of this report, the PBIA conducted the annual channel outlet dredging on March 28, 2019. The estimated quantity of dredging in 2019 was 2,500 to 3,000 CY. **Figure 2.1-19** shows the condition of the channel just prior to dredging.

Figure 2.1-1 Aerial Views of Port Bay Shoreline, Early Spring 2012 (looking south)

#1 (starting from east)

#2 (east end of the bay)

#3 (east barrier bar)

#4 (channel dredged)

#5 (riprap revetment of the west barrier bar)

#6 (west end of the bay)

Photo credit: FEMA

Note: Channel dredging is usually accomplished at the end of March before April 1st. Spoil materials are placed on the east (Spoil #1) and west (Spoil #2) sides of the channel outlet.

Figure 2.1-2 Overall Erosion and Recession of the Lake Side of the East Barrier Bar, 2005-2018

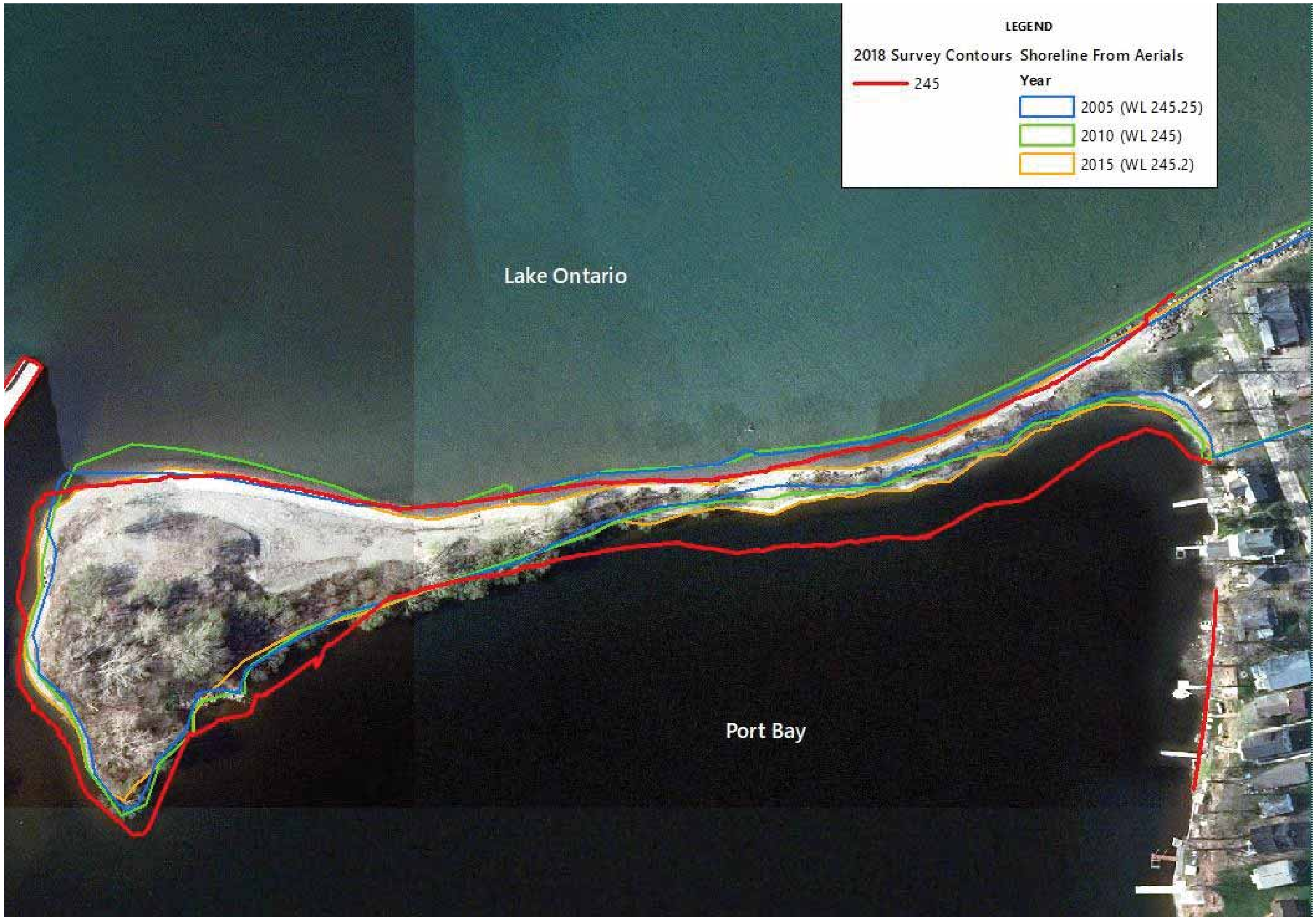


Figure 2.1-3 Evolution of the West and East Barrier Bars, 1995-2015

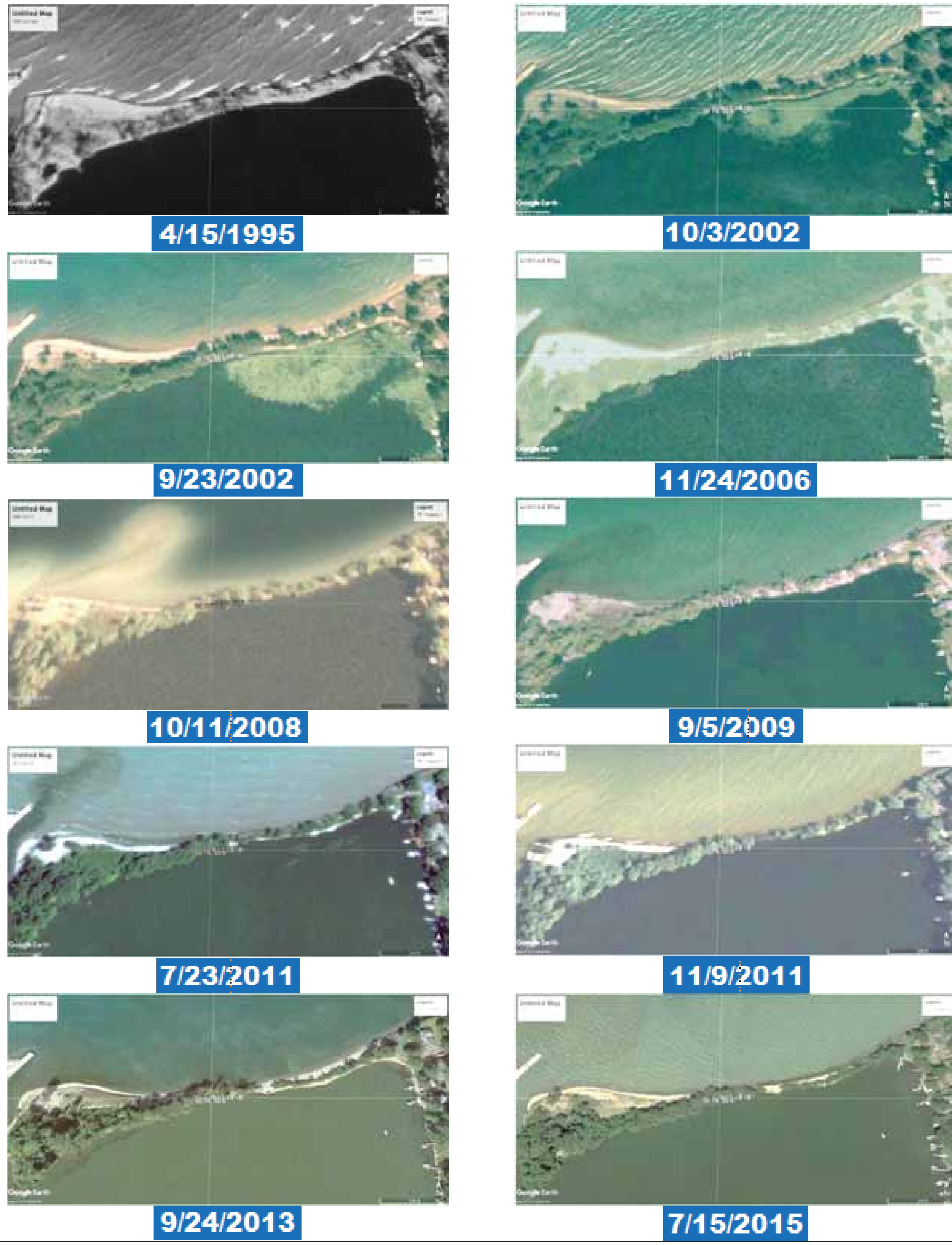
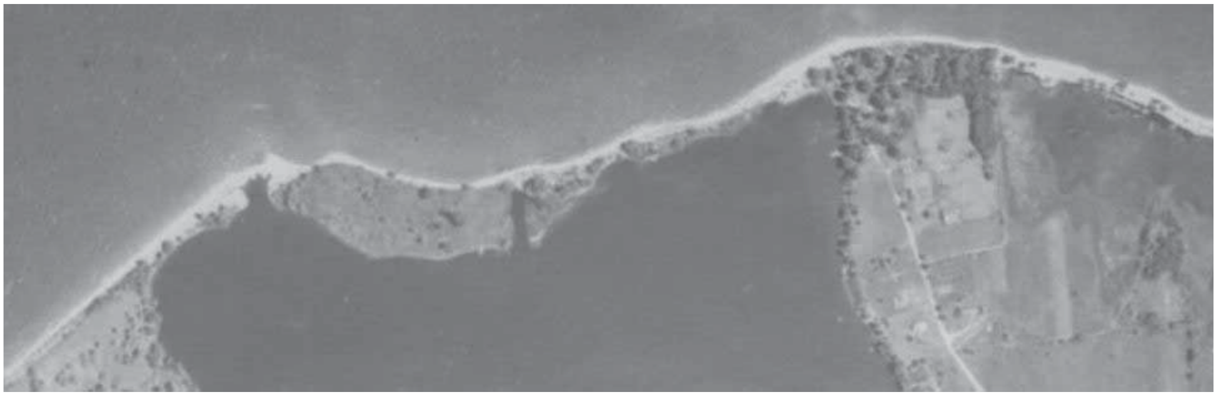
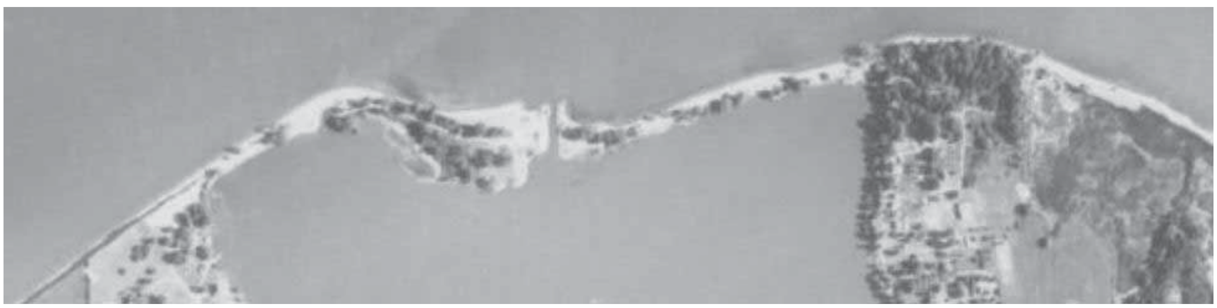


Figure 2.1-4 Historical Overview of Port Bay Shorelines



6/3/1938



7/26/1954

6/26/1963

7/15/2015

Figure 2.1-5 East Barrier Bar Breaches, 2012 and 2016

Breach in early spring of 2012 (exact date unknown)

Location of the breach in Nov. 2015 (~WL 244.5 IGLD85)

Breach of Apr. 3, 2016 (~WL 246.4 IGLD85)

Figure 2.1-6 East Barrier Bar Breach, April 2016

Port Bay before Apr. 2016 breach in east barrier bar

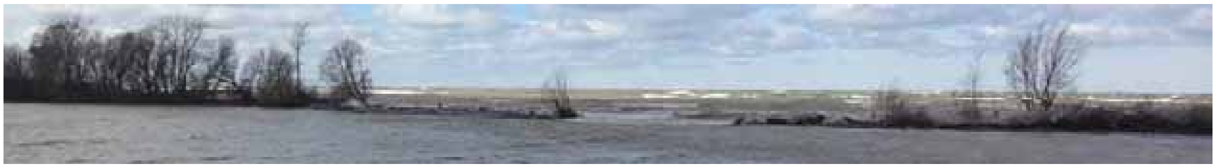
Trees washed into the bay (~WL 246.4 IGLD85)

Trees washed into the bay (~WL 246.4 IGLD85)

Apr. 10, 2016; WL=246.4 ft; Normal average WL=245.7 ft

Repair completed in Nov. 2016 (~WL 244.4 IGLD85)

Figure 2.1-7 East Barrier Bar Breach 2017 (viewed Mar. – May 2017)



Breach of Mar. 2-4, 2017 (~WL 246.0)

Breach widened in Apr. 2017 (~WL 247)

Breach as of May 2017 (~WL 248.5)

From bay looking toward bars (note the large east bar breach); May 10, 2017 (WL~248.6 ft)

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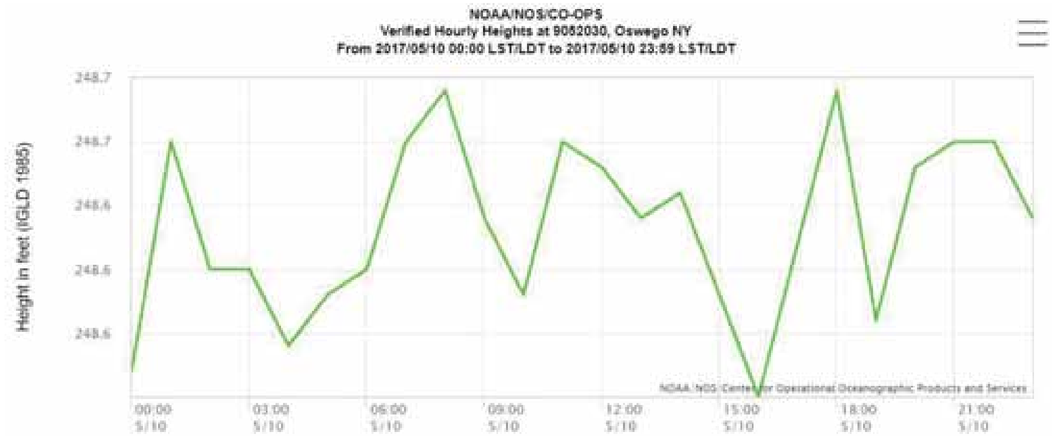
Figure 2.1-8 East Barrier Bar Breach, 2017



Water level plot for May 10, 2017; Average WL ~248.64 ft

Intrusion of sediment ('mud plume') from the lake into the bay; May 10, 2017 (WL~248.6 ft)

Breach as of Oct. 18, 2017 (~WL 245.7)

Figure 2.1-9 East Barrier Bar Breach under High Water Level (~248.6 ft), May 10, 2017 (drone view)

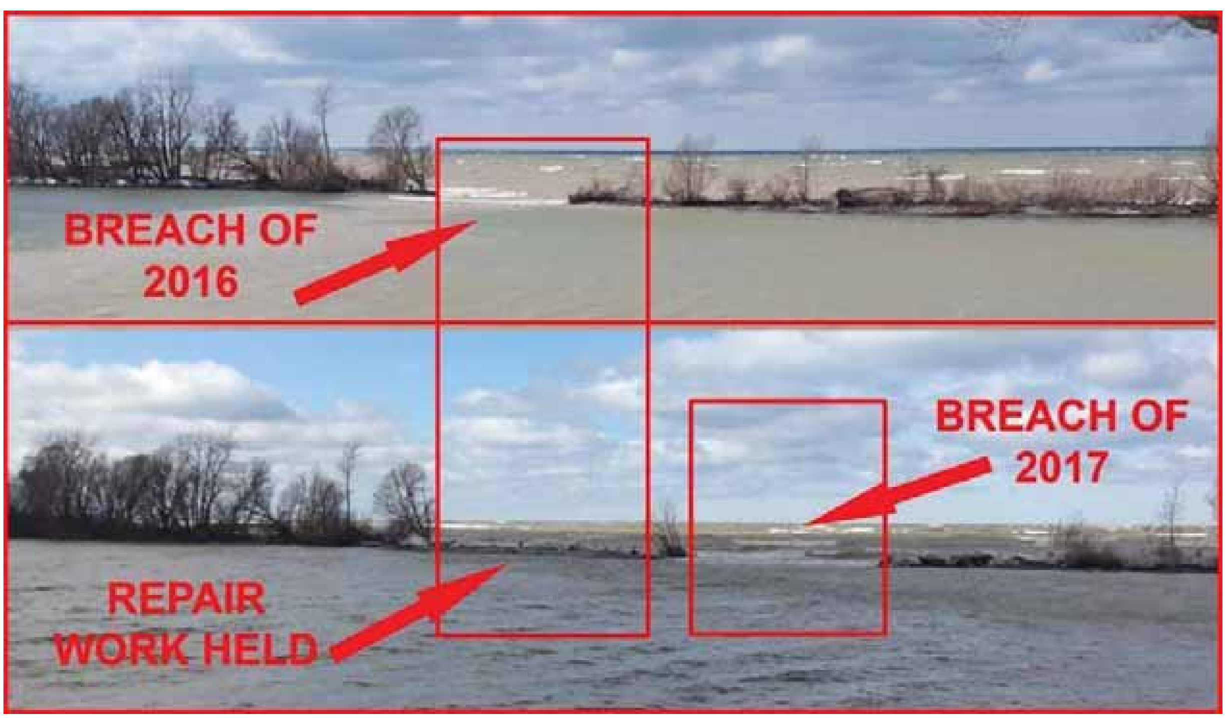
East barrier bar breach wide open because of high water level

Part of the east barrier bar (repair of 2016, west of the breach) inundated because of high water level

Pier, spoil area (dredged materials), and head of the east barrier bar

Figure 2.1-10 East Barrier Bar Breaches of 2017 and 2016 Compared

Breach of Apr. 3, 2017; channel outlet is filled in; WL=247.21 ft; Normal average WL=245.67 ft



Comparison of breaches in Apr. 2016 and Mar. 2017; photo on Apr. 6, 2017 (~WL 246.6)

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Figure 2.1-11 East Barrier Bar Breach, Sep. – Oct. 2017

On the east barrier bar looking west, Sep. 19, 2017 (~WL 246.2)

Closer look at the bar from the bay looking west, Oct. 18, 2017 (~WL 245.6)

Location of the 2016-repair as of Sep. 19, 2017 9 (~WL 246.2)

Figure 2.1-12 Port Bay and East Barrier Bar Breach, April 2017 (aerial view)

Apr. 2 (~WL 246.4)

Apr. 23 (~WL 247.6)

Figure 2.1-13 Damage During Breach of March 2017

May 3, 2017; WL=248.69 ft (normal average WL=246.10 ft)

May 3, 2017; WL=248.69 ft (normal average WL=246.10 ft)

Logs & debris swept into the bay; May 29, 2017; WL=248.72 ft (normal average WL=246.23 ft)

Figure 2.1-14 Survey Comparison of Bar Changes During 2017 Breach

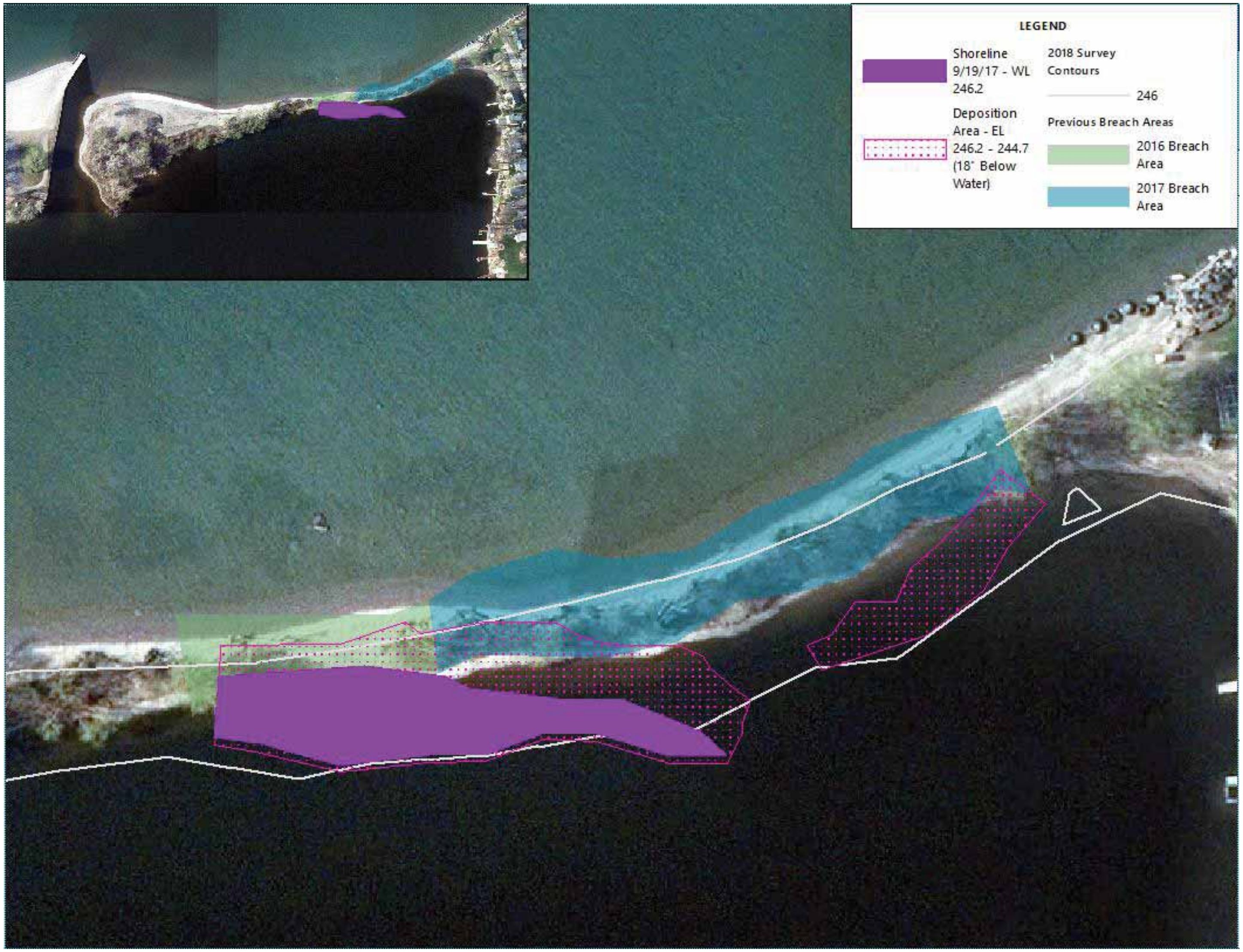

Figure 2.1-15 East Barrier Bar Breach of 2017 and Its Natural Repair (viewed Feb. – Apr. 2018)

Looking east (some flow from the bay to the lake; left to right)

Looking west (notice the pier and Spoil #2)

Above: Views of the breach of 2017 on the site visit of Feb. 17, 2018 (~WL 245.6)

Drone view of the east barrier bar on Mar. 27, 2018; Natural repair of the breach; photo credit: David Aldrich, PBIA (~WL 245.5)

Looking west to the east barrier bar on Apr. 11, 2018 (site visit); Breach is naturally closed (~WL 245.8)

Figure 2.1-16 Timeline of Recent Breaches

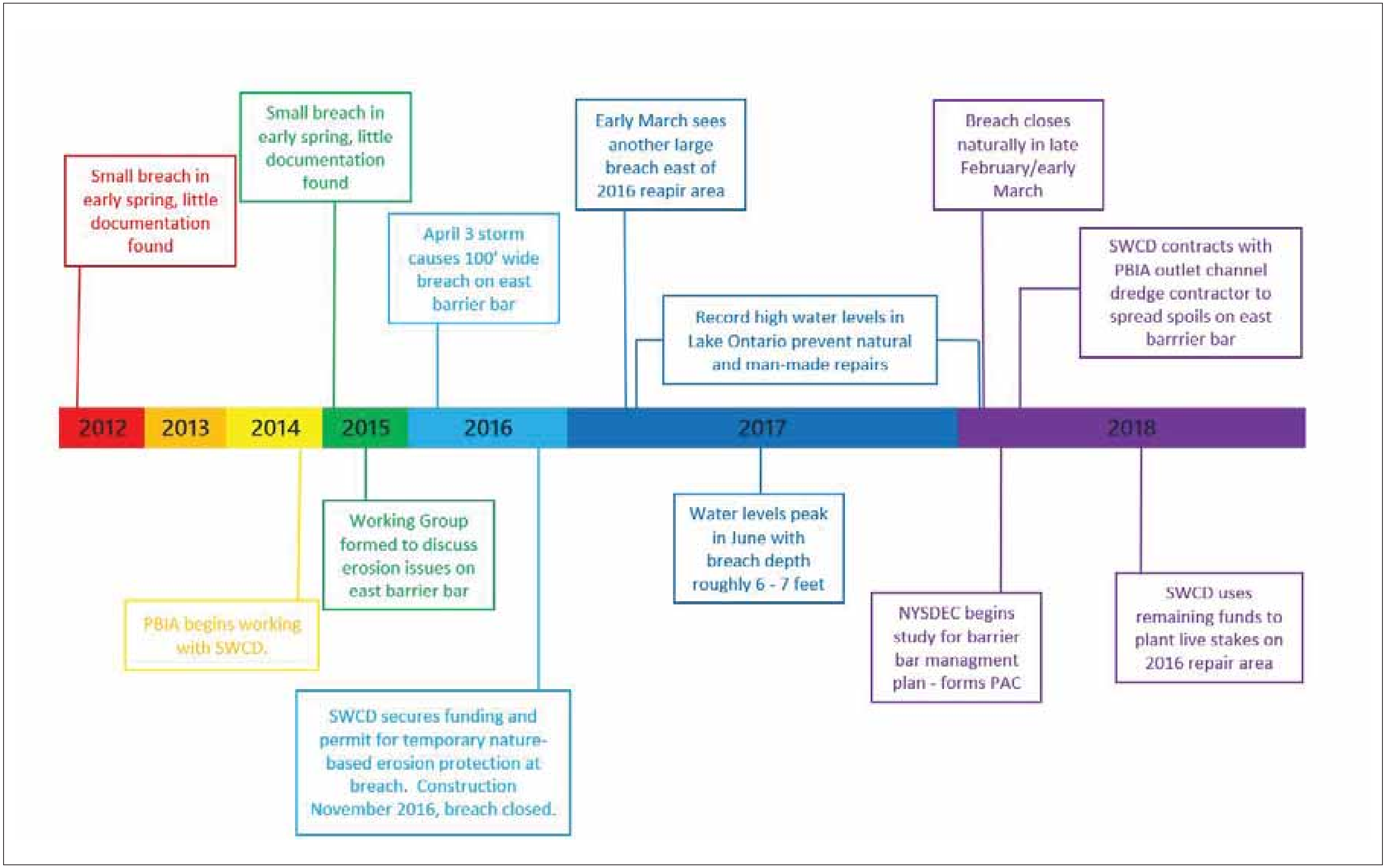

Figure 2.1-17 Annual Dredging of the Channel

Fill in navigation channel outlet

Dredging

An obstructed channel allows the water levels in the Bay to rise to higher than lake levels. Eventually the channel/bay flow forces an opening to relieve water (Spoil #2 in the background)

Looking north on the Pier during a winter strom; A portion of the materials that fill in the channel come over the top

Part of dredged materials (spoil #1) near the pier; looking north

Deposition at the channel outlet to be dredged; looking east

Above: Drone view, Mar. 27, 2018; Photo credit: David Aldrich, PBIA

Dredging on Apr. 6, 2016; looking south

Access to the east side of the channel is critical for proper dredging and placement of materials on east bar

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Figure 2.1-18 A Typical Channel Dredging Proposal in the 2000s

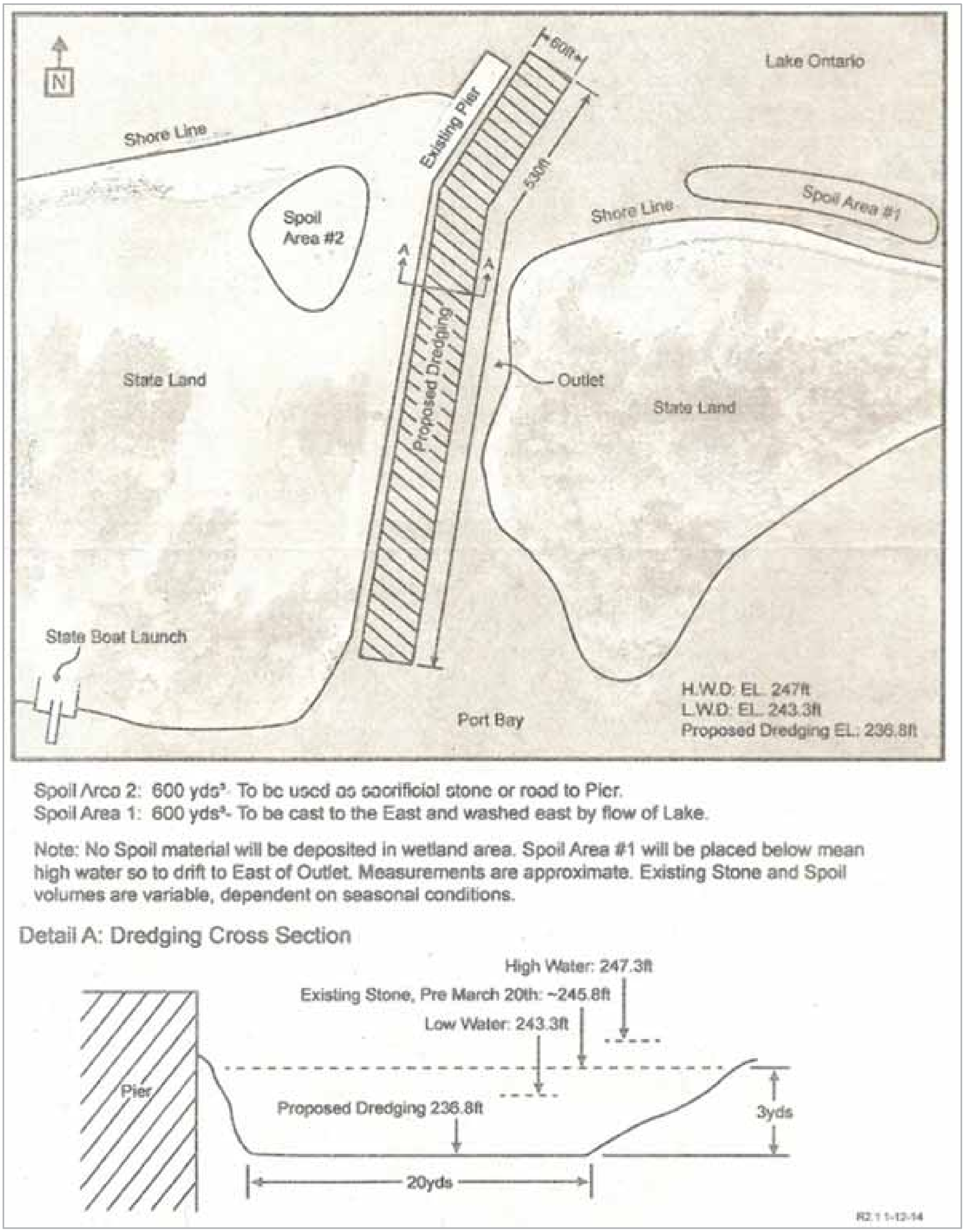

Figure 2.1-19 Sediment Deposition at the Channel Outlet as Viewed on March 24, 2019

(a) Looking north towards the lake through the channel outlet

(b) Sediment deposit on and near the eastern edge of the pier

Note: The deposition patter in (b) shows large accumulation of gravel immediately south of the concrete wall, an indication of gravel moving across and over the pier.

Photo Credit: Dave Aldrich, PBIA

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Figure 2.1-20 Riprap Protection of the West Barrier Bar; 1,700 ft of Rock Revetment

May 2015 (~WL 245.5)

May 2015; Google Earth image

Apr. 11, 2018, site visit (~WL 245.8)

Apr. 11, 2018, site visit

Apr. 11, 2018, site visit

May 10, 2017, drone view (~WL 248.6)

May 10, 2017, drone view

Figure 2.1-21 Hourly Water Level Variation in Lake Ontario, July 16, 2018, near Oswego (WL ~246.25 ft)

FIGURE 2.1-22

EXISTING CONDITIONS SITE PLAN

Date: SEPTEMBER 2018

Legend:

- EDGE OF WATER
- MAJOR CONTOUR
- MINOR CONTOUR

NOTES:
DATE OF SURVEY:
7/16/2018
(WSEL = 246.0 NAVD88)

DATE OF AERIAL PHOTO:
SOMEWHERE BETWEEN 4/15/2015 AND 5/9/2015
(WSEL = 244.82 IGLD85)

N

200' 100' 0 200'
1" = 200'

Port Bay Barrier Bar Assessment

OGS Project No. SC286

NEW YORK STATE OF OPPORTUNITY. Office of General Services

NEW YORK STATE OF OPPORTUNITY. Department of Environmental Conservation

BERGMANN ARCHITECTS ENGINEERS PLANNERS

PRUDENT ENGINEERING

Figure 2.1-23 Beach Slopes Estimated from Survey of Port Bay and Shorelines, July 16, 2018

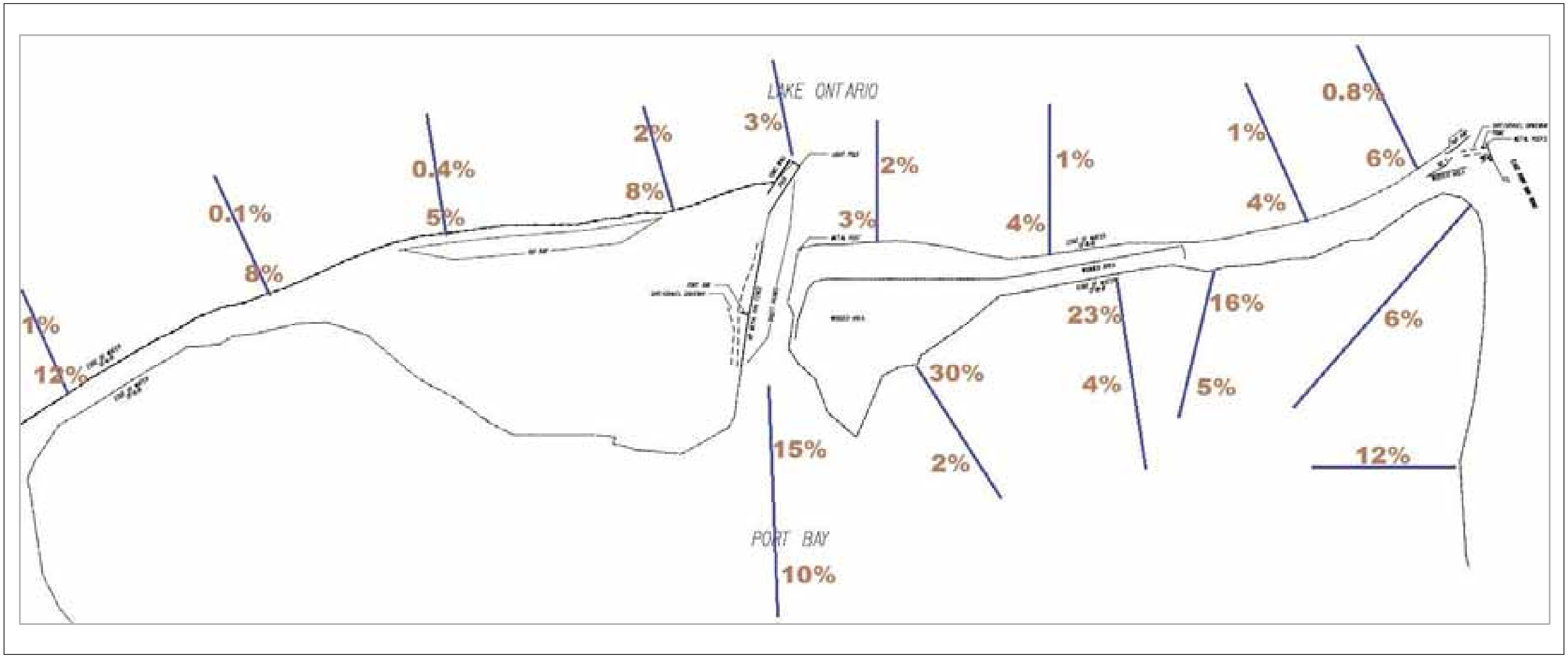


Figure 2.1-24 Channel Widths as of 1988

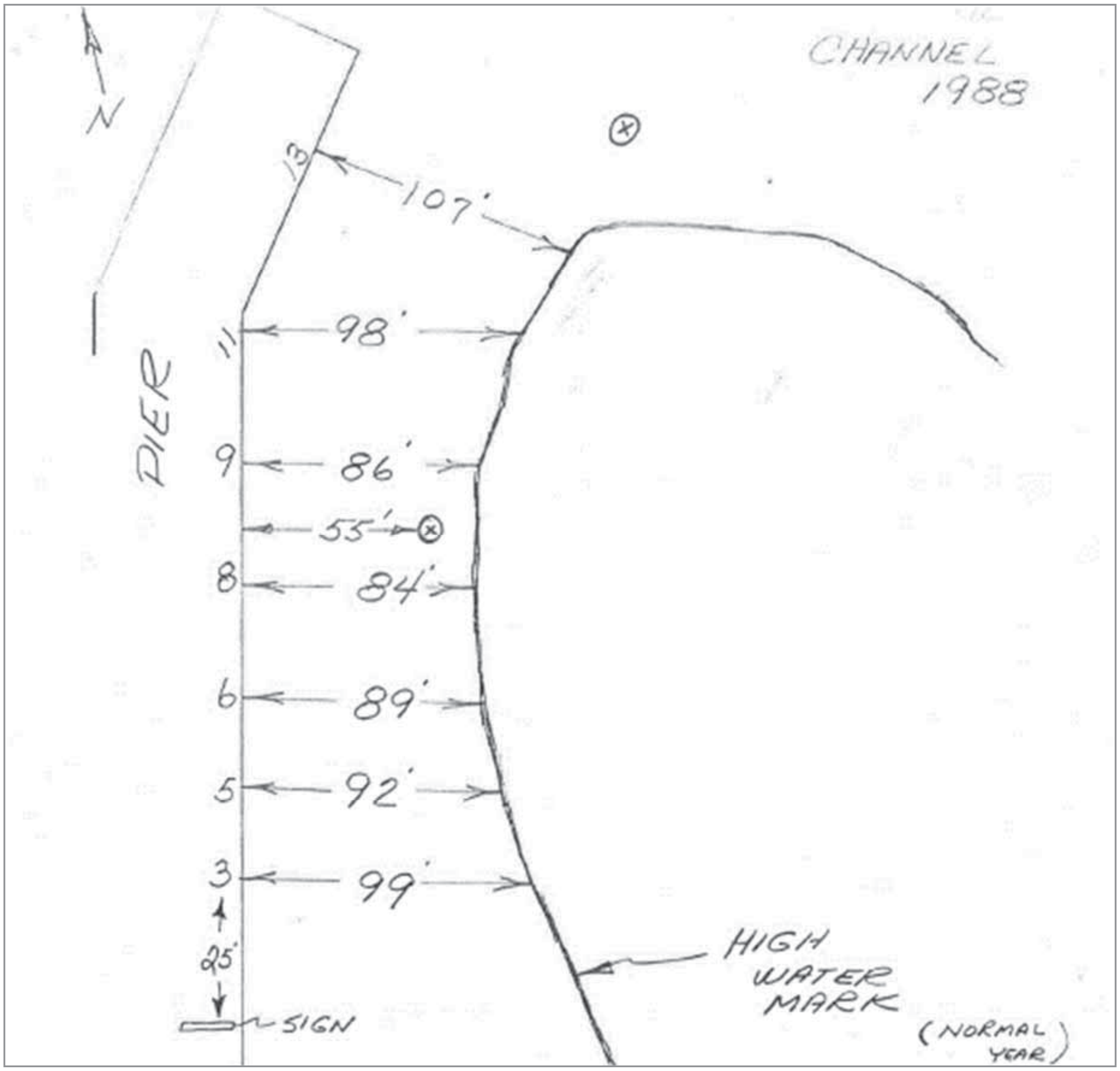


Figure 2.1-25 NOAA Measurement Stations in Lake Ontario

Figure 2.1-26 Daily Water Level Variation in Lake Ontario, 2017-2018

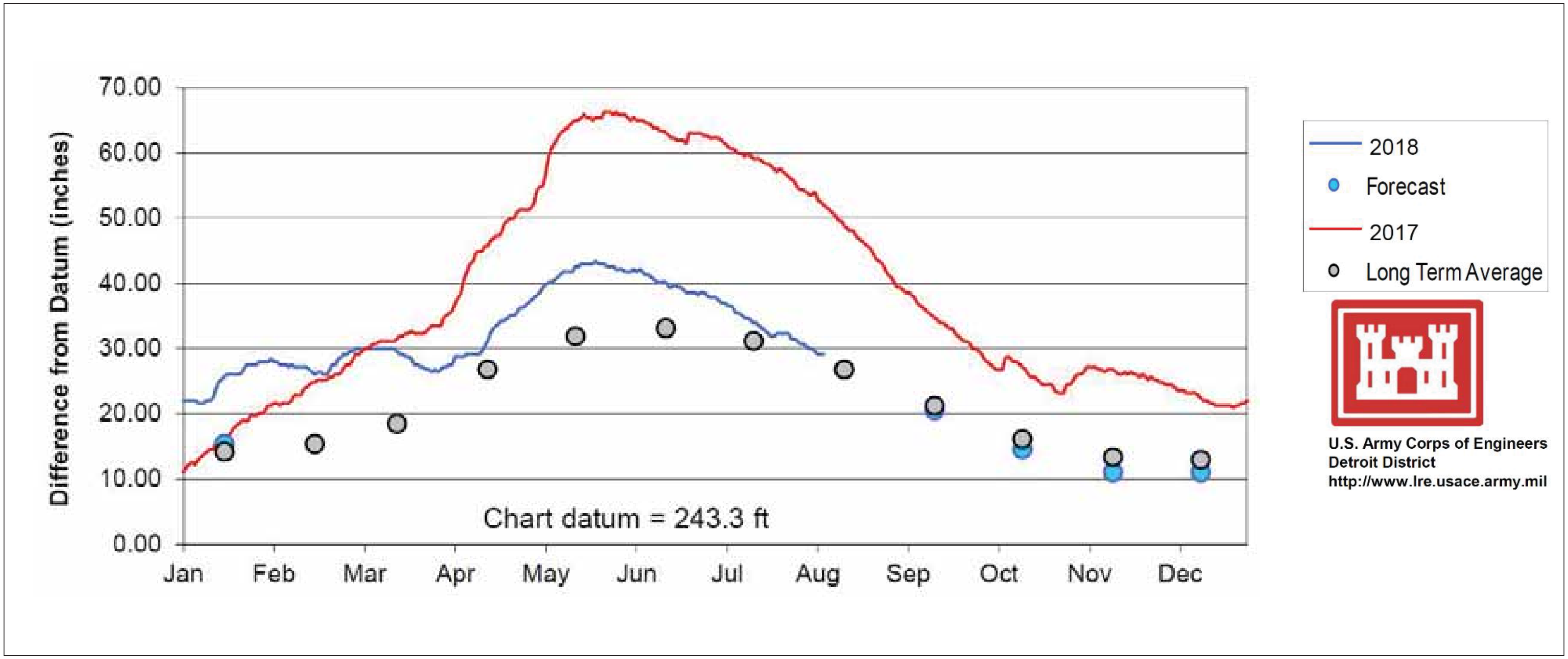


Figure 2.1-27 Monthly and Long-Term Water Levels in Lake Ontario, 1918-2018

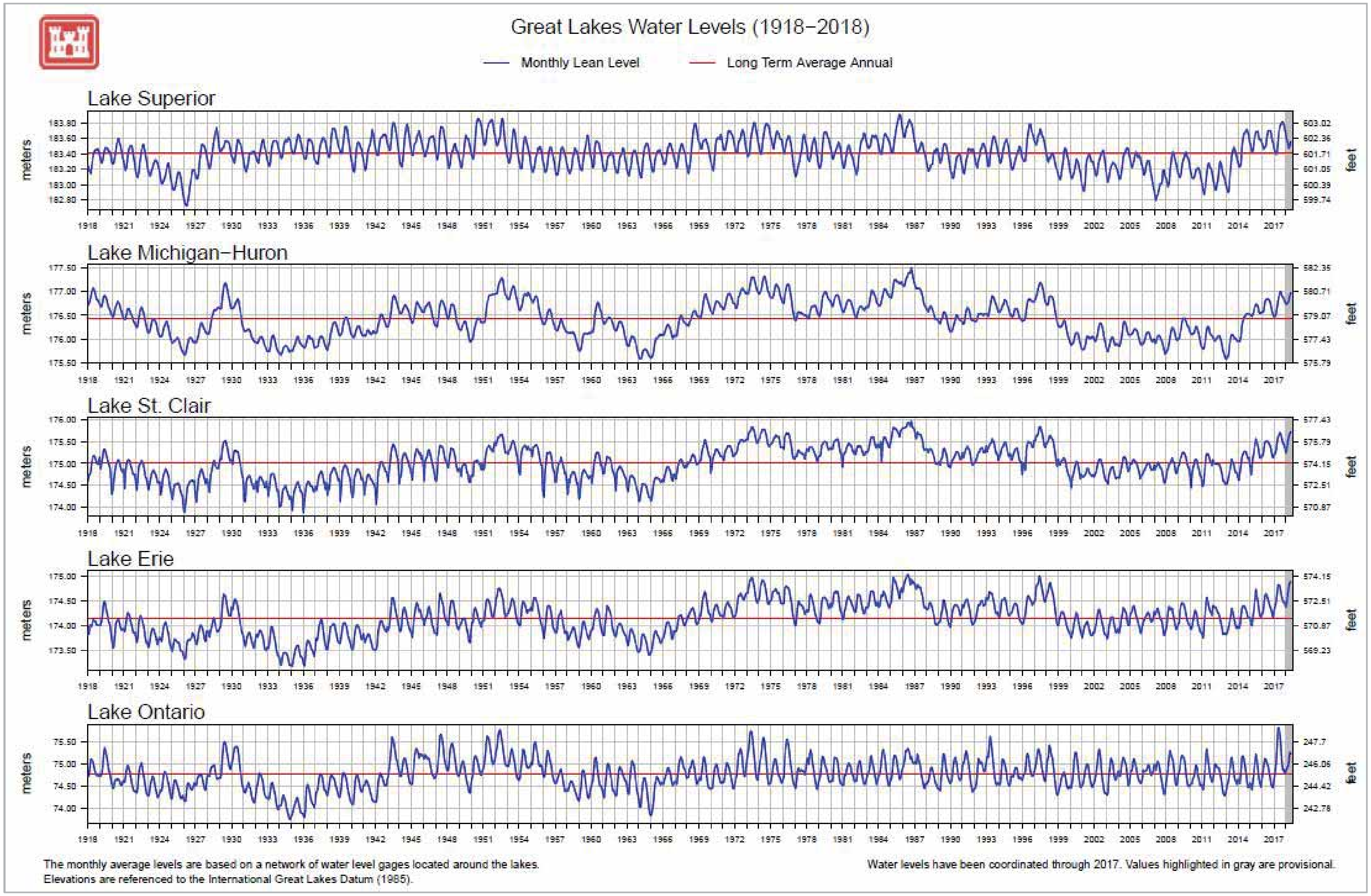
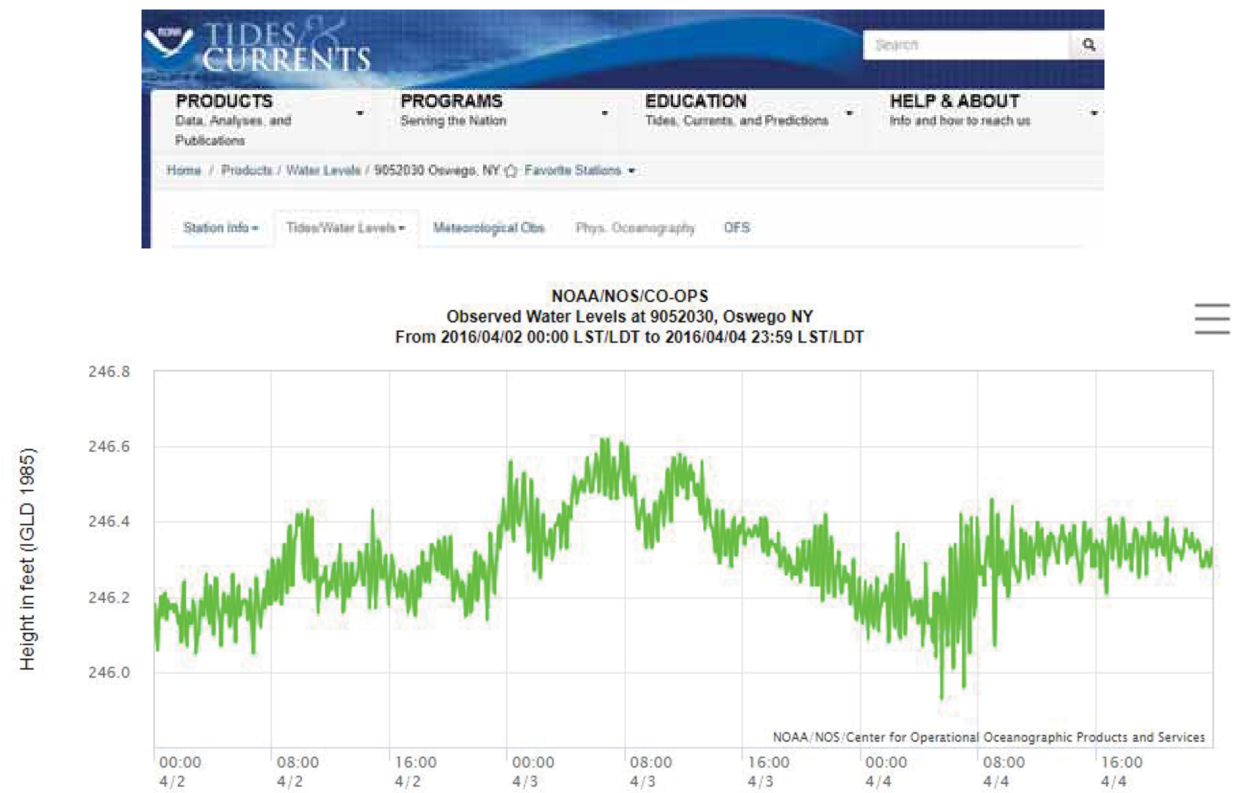


Figure 2.1-28 6-min Water Level Variations in Lake Ontario near Oswego, April 2-4, 2016



Note: Port Bay east barrier bar breach occurred on Apr. 3, 2016

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Figure 2.1-29 Hourly Water Level Variation in Lake Ontario near Oswego, March 2017

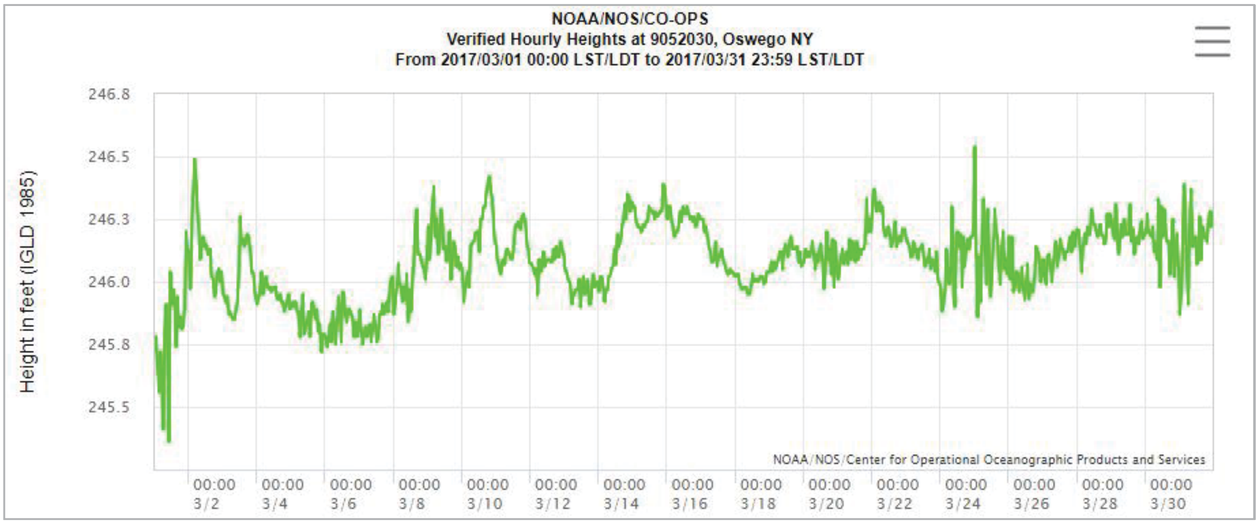

Figure 2.1-30 Water Level Variation in Lake Ontario near Oswego, April 2016, 2017, and 2018

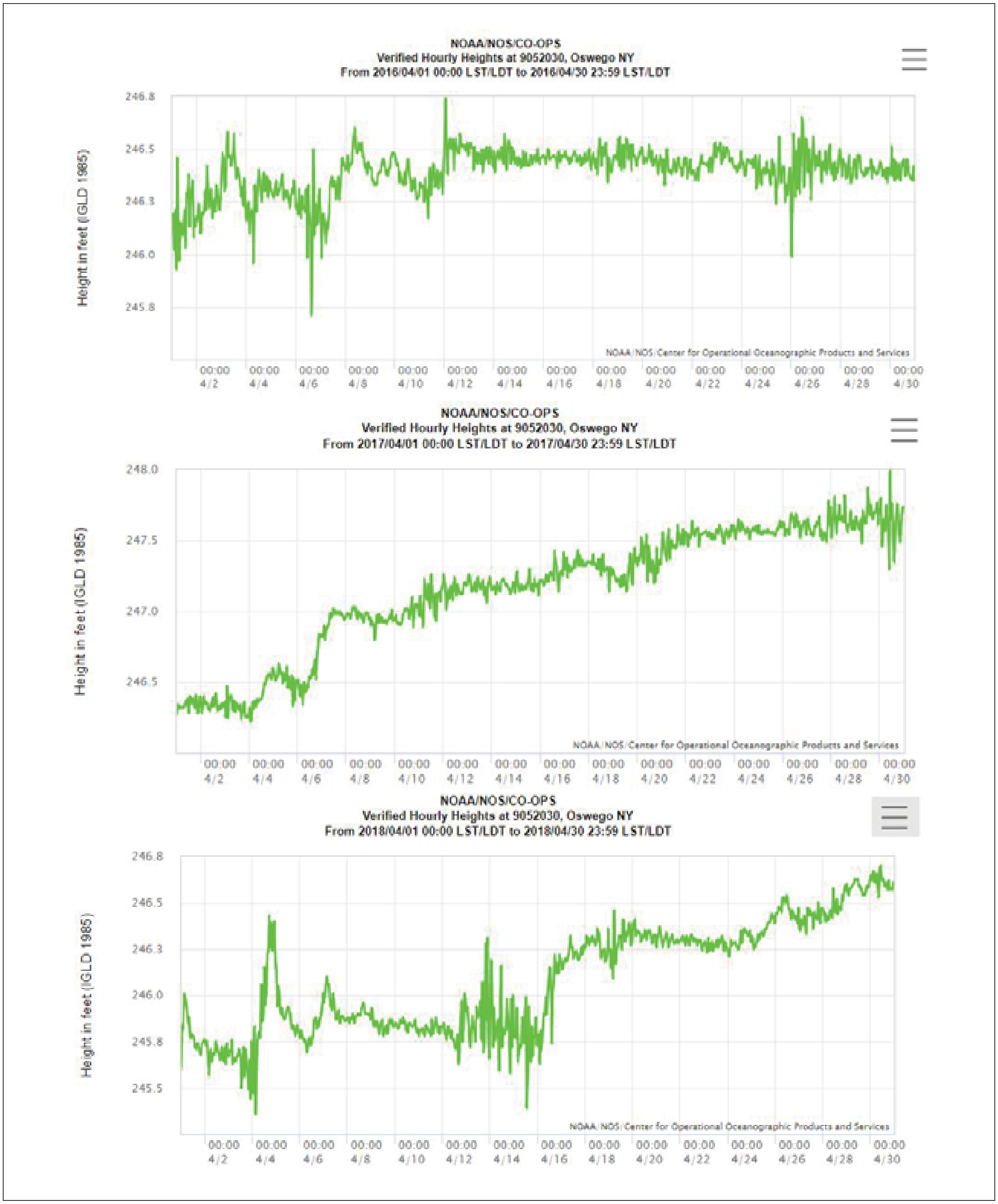

Figure 2.1-31 Historical Data Used in IJC *Plan 2014* for Lake Ontario Water Levels

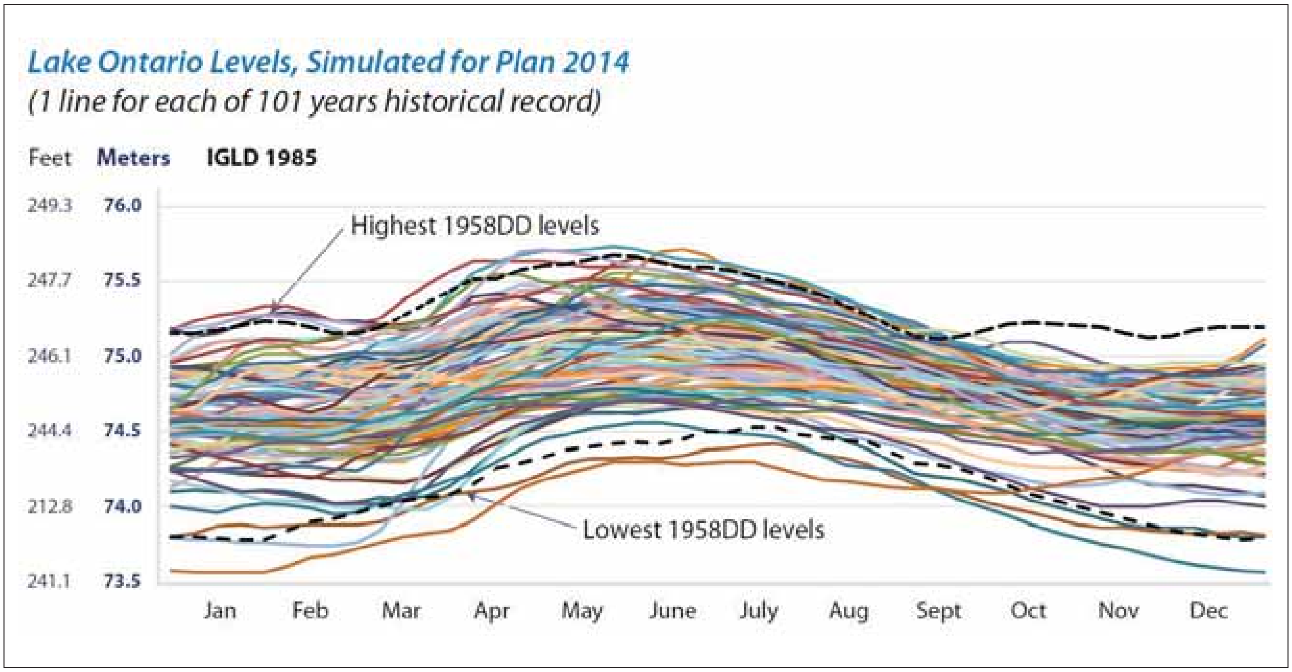

Figure 2.1-32 Comparison of Potential Water Level Extremes in IJC *Plan 2014* and plan 1958DD

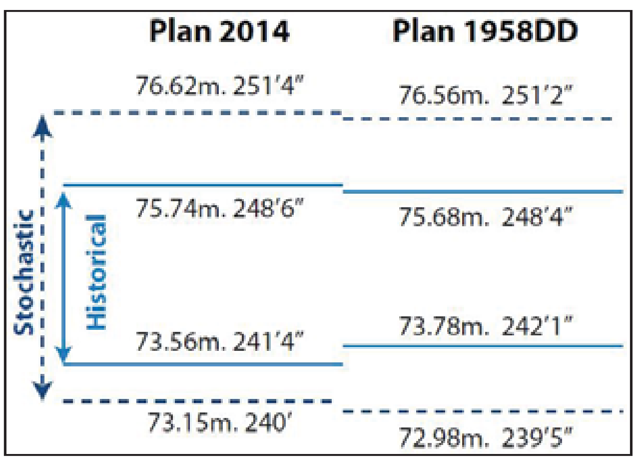

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Figure 2.1-33 Current (Velocity) in Lake Ontario, Aug. 20-24, 2018

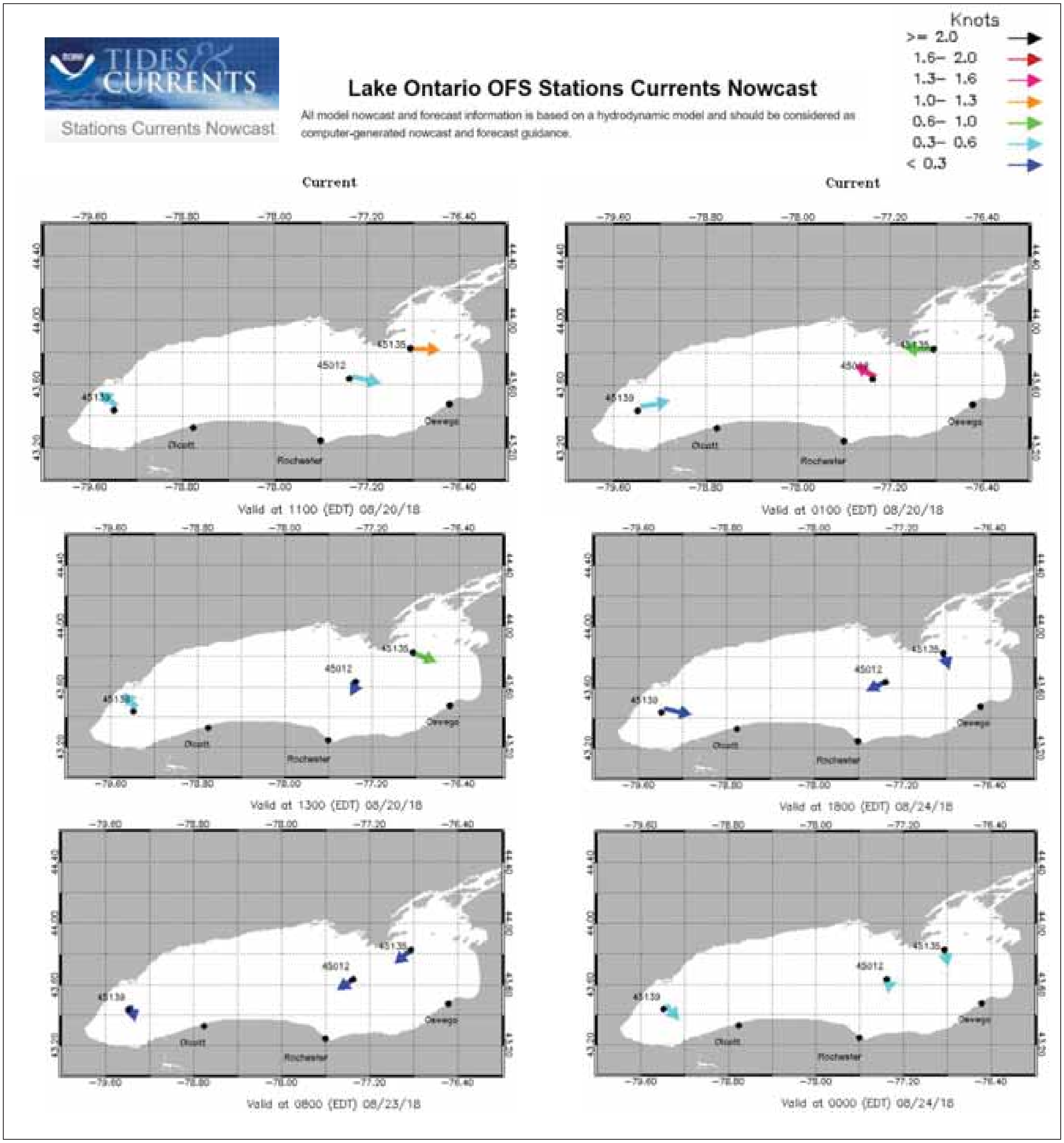

Figure 2.1-34 Wave-Induced Bank Erosion West of the Pier, May 10, 2017 (drone view)

Figure 2.1-35 Wave Field in a Fairly Rough Lake Near East Barrier Bar Breach, Mar. 4, 2017

Note: Photo taken at 10:52 a.m., Mar. 4, 2017

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Figure 2.1-36 Waves on Port Bay Shorelines, Apr. 2016 and Aug. 2017

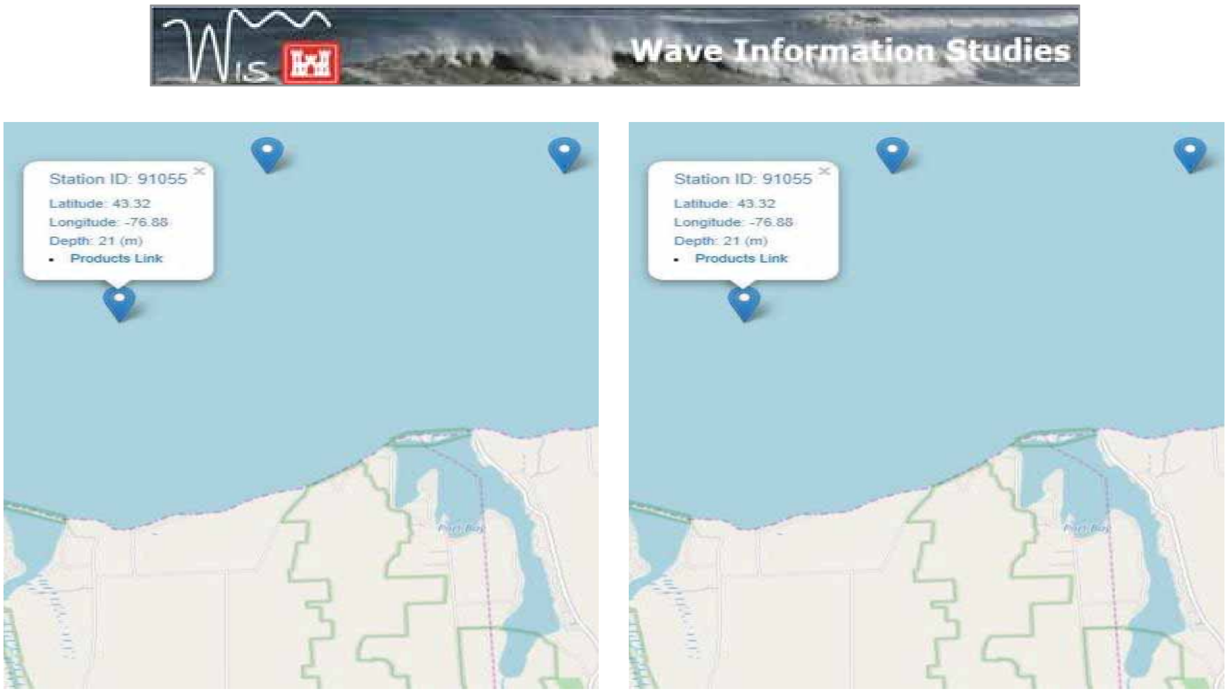
Waves in the lake hours after the breach of Apr. 3, 2016; looking north through the east barrier bar (~WL 246.4)

Waves entering the channel (looking south)

Waves from the lake to the bay through the 70-ft opening in the east barrier bar on Sunday Apr. 3, 2016

Wave action on the west barrier bar in early Aug. 2017; looking east; bay is on the right (~WL 247.8)

Figure 2.1-37 USACE Wave Stations North of Port Bay



Source: "Wave Information Studies" database of USACE (http://wis.usace.army.mil/)

Figure 2.1-38 Wave Statistics and Prediction for USACE Station 91055 (northwest of project site), 1970 - 2014

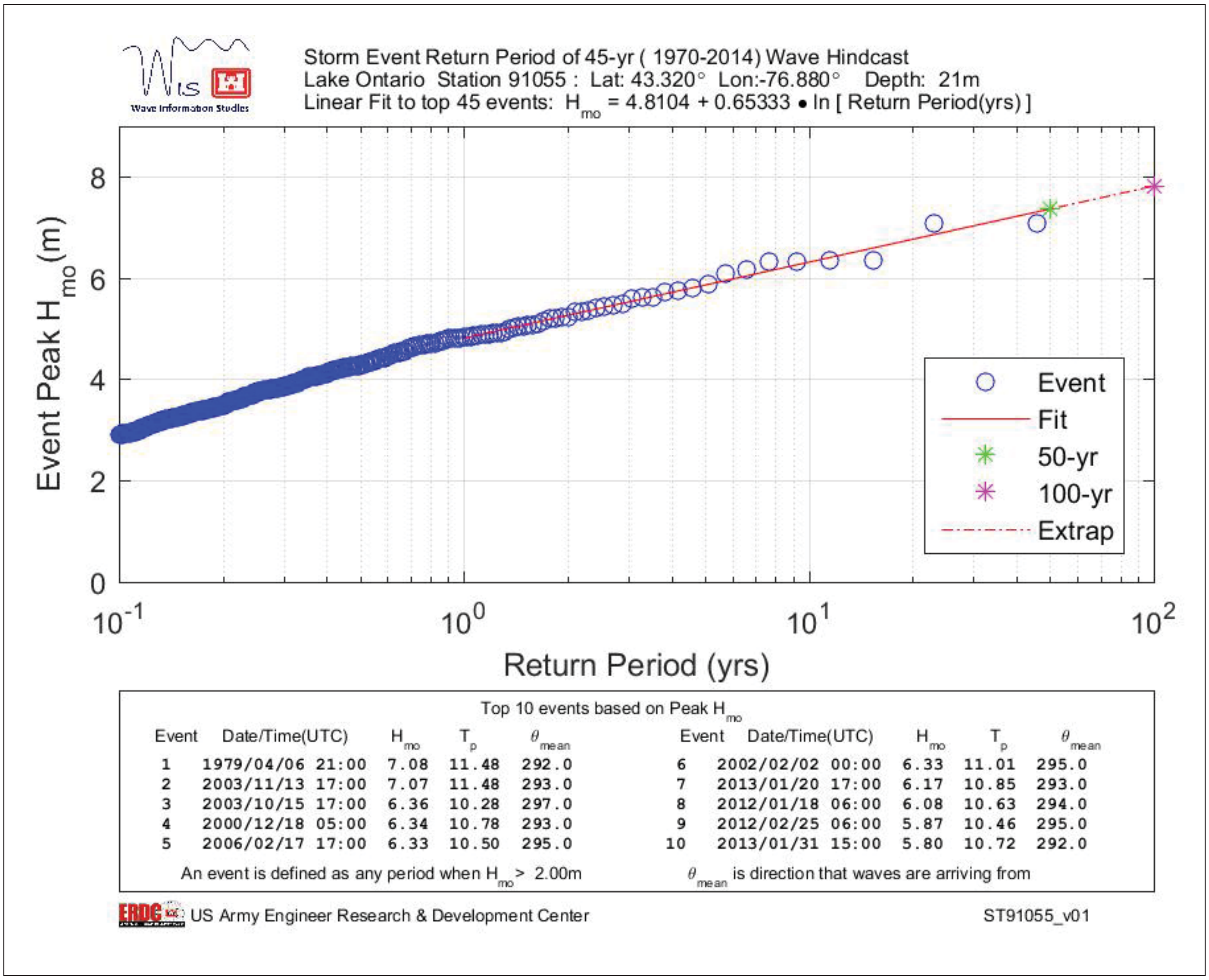


Figure 2.1-39 Wave Rose for USACE Station 91055 (northwest of project site), 2014

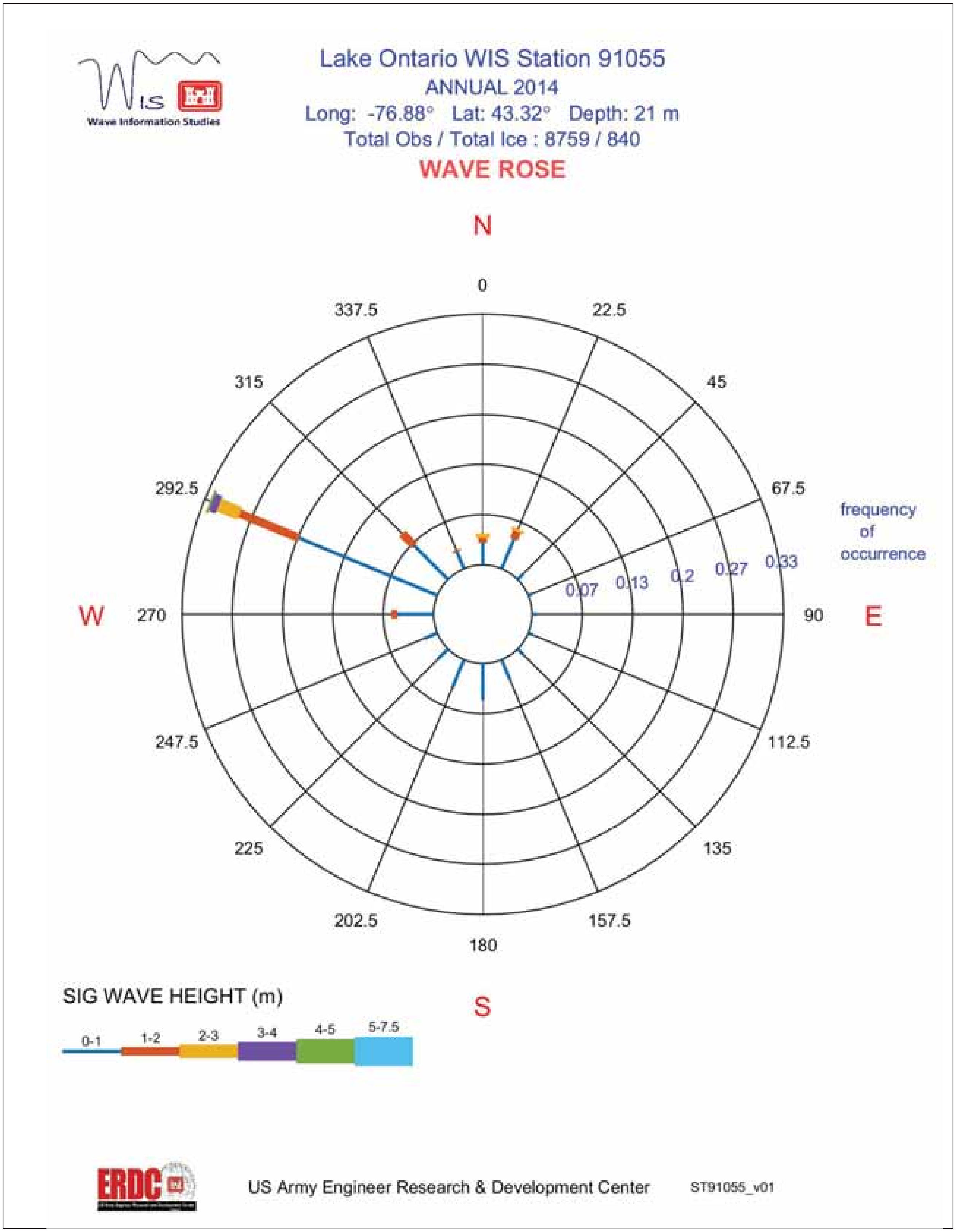


Figure 2.1-40 Wave Parameters for USACE Station 91055 (northwest of project site), 2014

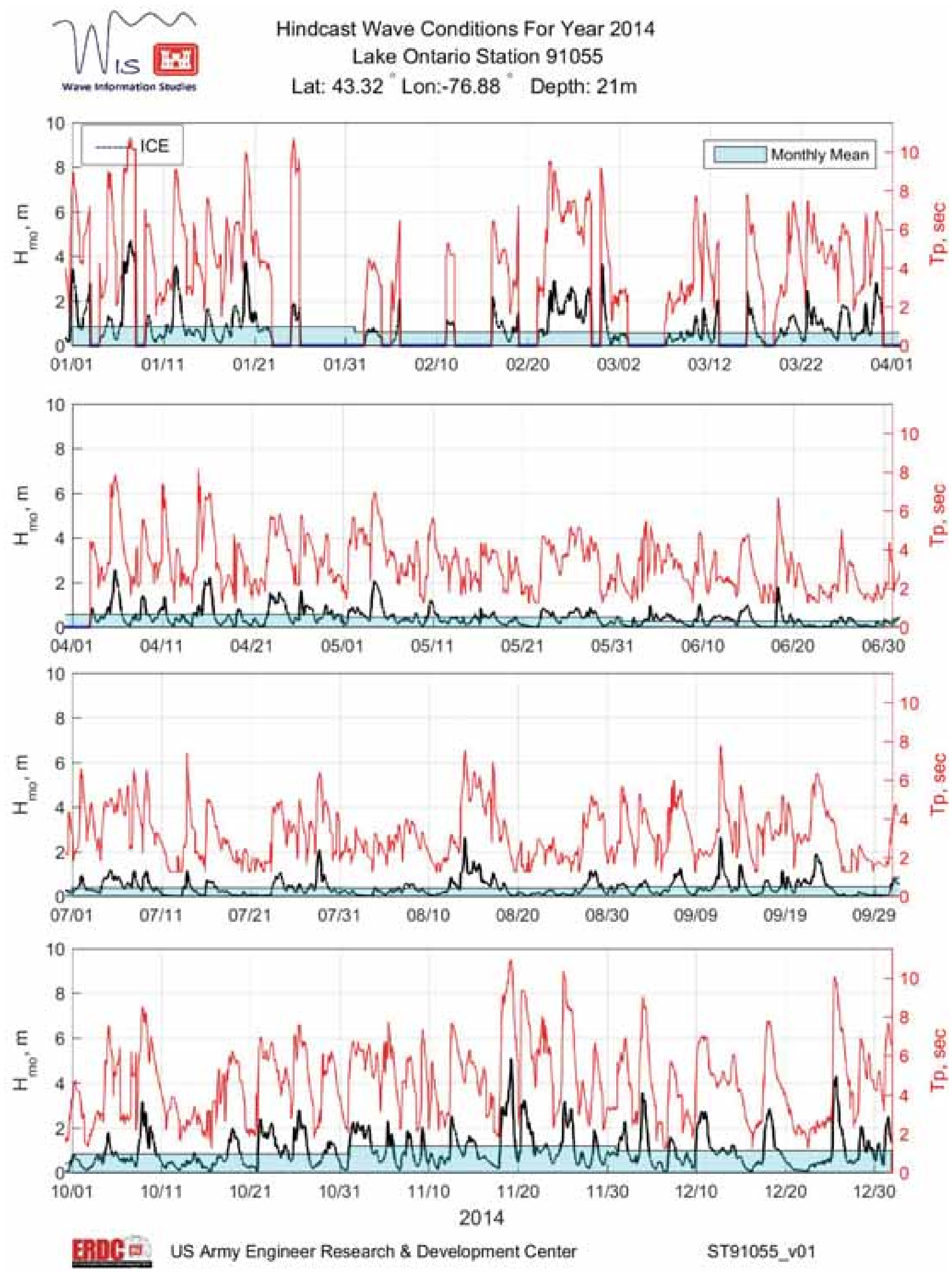
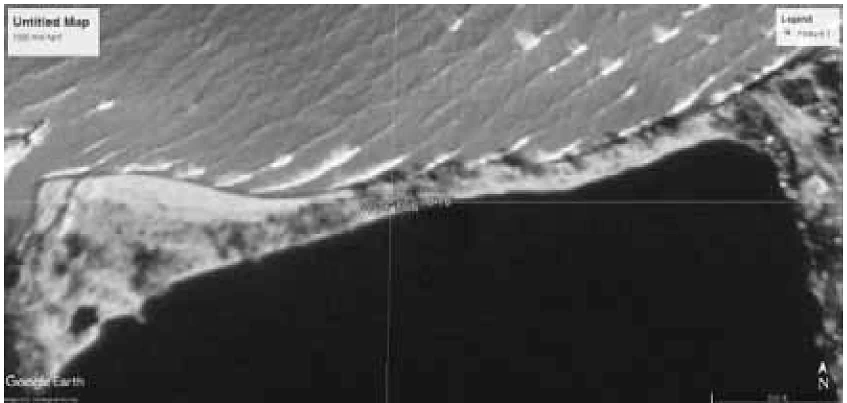
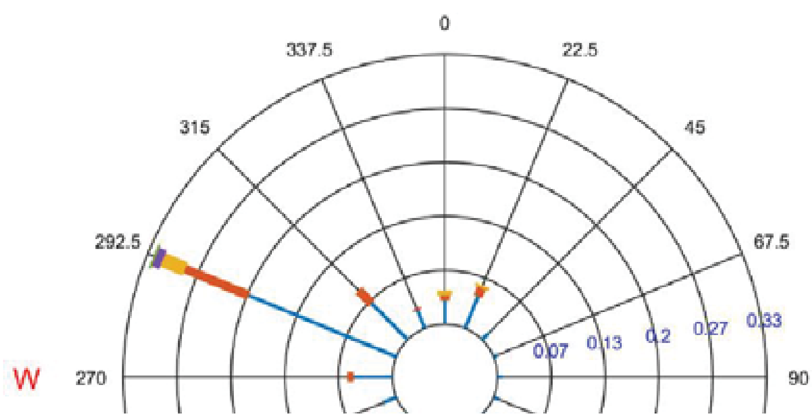


Figure 2.1-41 Predominant Wave Direction is Close to Normal to the Pier



4/15/1995 Note the northwesterly wave fronts

10/3/2002 Note the northwesterly wave fronts



Part of the wave rose for station 91055

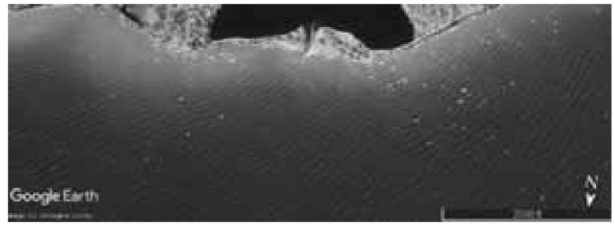
Pier at ~30 degrees with north

Figure 2.1-42 Southward Bar Erosion from 2015 to 2018

Figure 2.1-43 Indications of Active Sediment Transport Along the West Shoreline

Note an overall eastward movement of the sediment masses and plumes, in line with the predominant north-westerly wave direction.

April 15, 1995



April 15, 1995

May 23, 2008

May 23, 2008

May 26, 2011

July 15, 2015

May 26, 2011

July 15, 2015

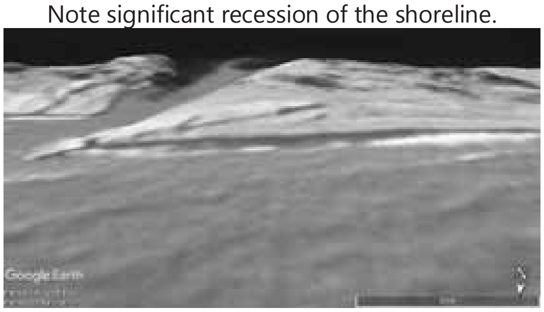
May 26, 2011

July 15, 2015

Figure 2.1-44 Natural Erosion and Deposition Along the Unprotected Shoreline West of the Pier

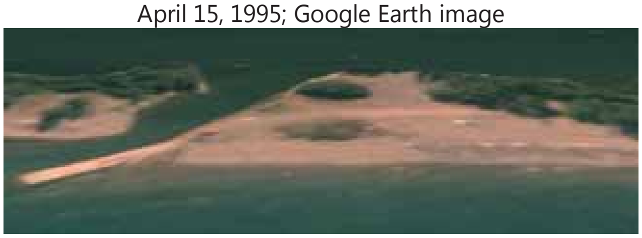
(a) West of pier, May 10, 2017, Drone view
(Average WL = 248.65 ft)
Note significant recession of the shoreline.

(b) West of pier, July 15, 2015, Google Earth image;
(Average WL = 246.75 ft)
Note the natural "repair of the eroded gap.



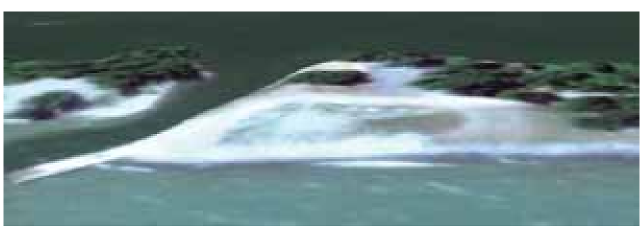
April 15, 1995; Google Earth image

Oct 3, 2002; Google Earth image



Sept 29, 2002; Google Earth image

(c) May 3, 2009; Google Earth image
Note accretion of shore at gap extending to the pier top.



July 23, 2011; Google Earth image

May 26, 2011; Google Earth image

(d) Sep 24, 2013; Google Earth image
The eroded gap seems to be repaired.

(e) July 15, 2015; Google Earth image
The eroded gap seems to be repaired.

Figure 2.1-45 Sediment Transport and Deposition Along and Across the Outlet of the Navigation Channel

Filled-in navigation channel outlet; looking northwest.
Note gravel on the pier.

Dredging on April 6, 2016; looking south.
Note gravel bar across the entire outlet.

Gravel on pier, even at the toe of the concrete wall from the top of the wall; looking northeast

(a) Pile of gravel on the pier next to concrete wall from longshore sediment transport (LST); looking northeast

(Drone view, Mar. 27, 2018; Photo credit: David Aldrich, PBIA)

Gravel bar across the outlet; a narrow gap has been created by flow from the bay into the lake; Looking east from pier bend
(Drone view, March 27, 2018; Photo credit: David Aldrich, PBIA)

Figure 2.1-46 Sediment Near the Breach (gap) in the East Barrier Bar, Mar. 7, 2018

~WL 245.9

Figure 2.1-47 Shoreline Sediment along the East Barrier Bar

Looking west; Site visit of Apr. 11, 2018 (~WL 245.8)

Looking east the pier/channel outlet before dredging, Mar. 27, 2018 (drone view) (~WL 245.5)

West side of the breach looking south, May 10, 2017 (drone view) (WL~248.6)

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Figure 2.1-48 Locations of Sediment Samples Along the Beach (Site Investigation, Apr. 11, 2018)

Near #3 looking west towards the pier

Near #4 looking east

#1

#2

#3

#4

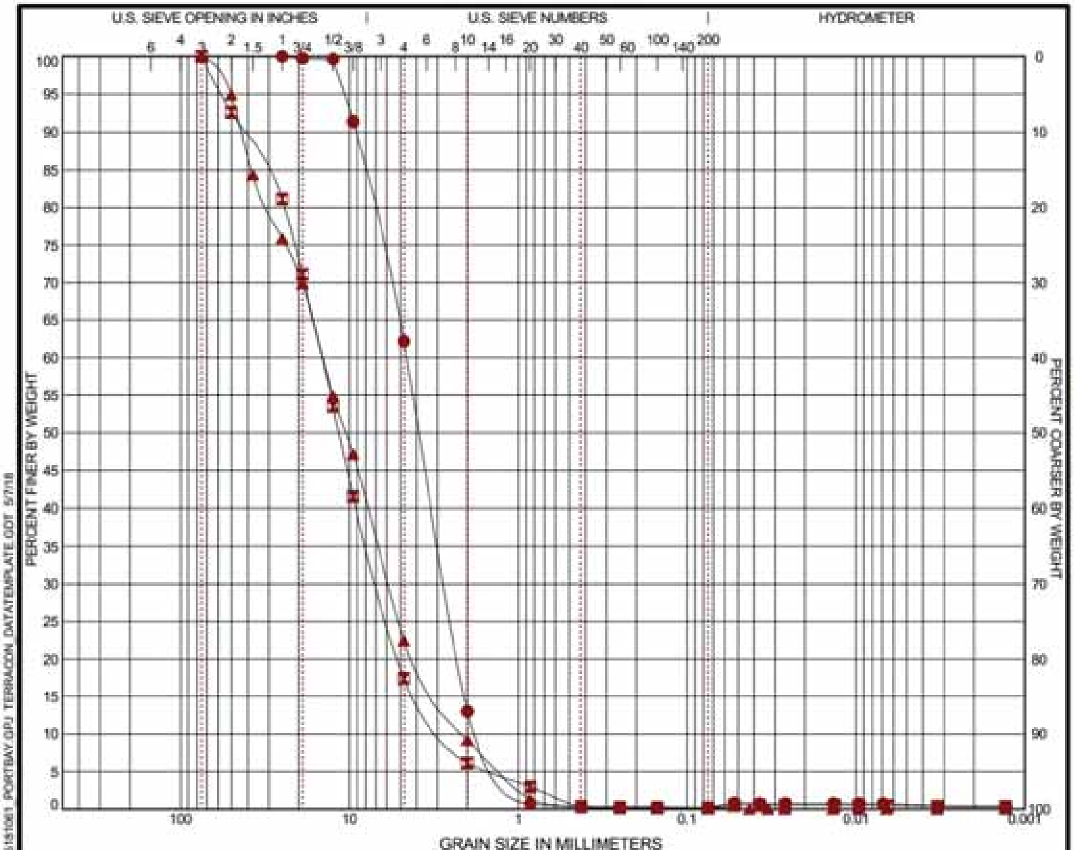
#5

#6

Figure 2.1-49 Gradation Curves for Sediment Samples #1, #2, and #3

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	W#1 - shoreline	0	0.0	37.8	61.9	-0.4		0.6	SP
⌶	W#2 - shoreline @ wall	0	0.0	82.6	17.2	-0.3		0.4	GW
▲	E-3	0	0.0	77.6	22.2	0.2		0.0	GW

	GRAIN SIZE		
	●	⌶	▲
D_{60}	4.571	14.58	14.401
D_{30}	2.697	6.824	5.872
D_{10}	0.813	2.69	2.112
	COEFFICIENTS		
C_C	1.96	1.19	1.13
C_U	5.62	5.42	6.82

●		⌶		▲	
Sieve	% Finer	Sieve	% Finer	Sieve	% Finer
3/4"	99.72	2"	92.56	2"	94.85
1/2"	99.63	1"	81.15	1 1/2"	84.35
3/8"	91.38	3/4"	71.13	1"	75.93
#4	62.18	1/2"	53.53	3/4"	69.87
#10	13.01	3/8"	41.52	1/2"	54.96
#20	0.7	#4	17.38	3/8"	47.14
#40	0.32	#10	6.15	#4	22.44
#60	0.28	#20	2.99	#10	9.16
#100	0.25	#40	0.35	#20	1.32
#200	0.23	#60	0.22	#40	0.3
	100.0	#100	0.2	#60	0.25
		#200	0.16	#100	0.21
			100.0	#200	0.19
					100.0

SOIL DESCRIPTION
- ● POORLY GRADED SAND with GRAVEL (SP)
- ⌶ WELL-GRADED GRAVEL with SAND (GW)
- ▲ WELL-GRADED GRAVEL with SAND (GW)

REMARKS
- ●
- ⌶
- ▲

PROJECT: Port Bay Improvements

SITE: Port Bay

Terracon
15 Marway Cir Ste 2B
Rochester, NY

PROJECT NUMBER: J5181061

CLIENT: Bergman Associates

EXHIBIT: B-1

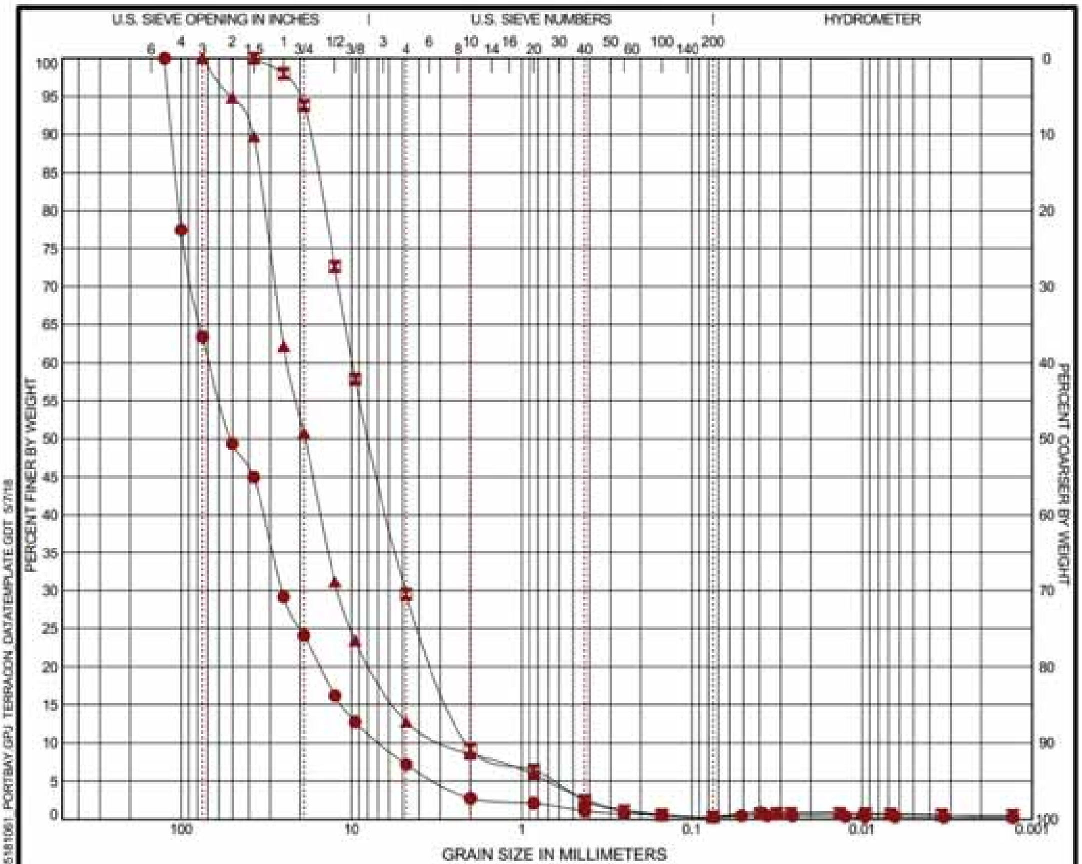
LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS 1 J5181061 PORTBAY.GPJ TERRACON_DATATEMPLATE.GDT 5/7/18

DRAFT

Figure 2.1-50 Gradation Curves for Sediment Samples #4, #5, and #6

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	E-4	0	36.6	56.2	6.9	0.0		0.3	GW
⌶	E-5	0	0.0	70.5	29.2	-0.3		0.6	GW
▲	E-6	0	0.0	87.2	12.4	-0.3		0.7	GW

	GRAIN SIZE		
	●	⌶	▲
D_{60}	67.994	9.886	23.744
D_{30}	25.547	4.808	12.009
D_{10}	6.738	2.068	2.674
	COEFFICIENTS		
C_c	1.42	1.13	2.27
C_u	10.09	4.78	8.88

● Sieve	● % Finer	⌶ Sieve	⌶ % Finer	▲ Sieve	▲ % Finer
4"	77.44	1 1/2"	100.0	3"	100.0
3"	63.39	1"	98.0	2"	94.8
2"	49.37	3/4"	93.85	1 1/2"	89.71
1 1/2"	44.96	1/2"	72.63	1"	62.15
1"	29.16	3/8"	57.85	3/4"	50.71
3/4"	24.09	#4	29.5	1/2"	31.12
1/2"	16.18	#10	9.22	3/8"	23.42
3/8"	12.76	#20	6.45	#4	12.77
#4	7.19	#40	2.45	#10	8.6
#10	2.75	#60	1.11	#20	5.87
#20	2.13	#100	0.58	#40	2.6
#40	1.1	#200	0.31	#60	1.22
#60	0.75			#100	0.66
#100	0.51			#200	0.37
#200	0.25				
	100.0				

SOIL DESCRIPTION
- ● WELL-GRADED GRAVEL (GW)
- ⌶ WELL-GRADED GRAVEL with SAND (GW)
- ▲ WELL-GRADED GRAVEL (GW)

REMARKS
- ●
- ⌶
- ▲

PROJECT: Port Bay Improvements

SITE: Port Bay

Terracon
15 Marway Cir Ste 2B
Rochester, NY

PROJECT NUMBER: J5181061

CLIENT: Bergman Associates

EXHIBIT: B-2

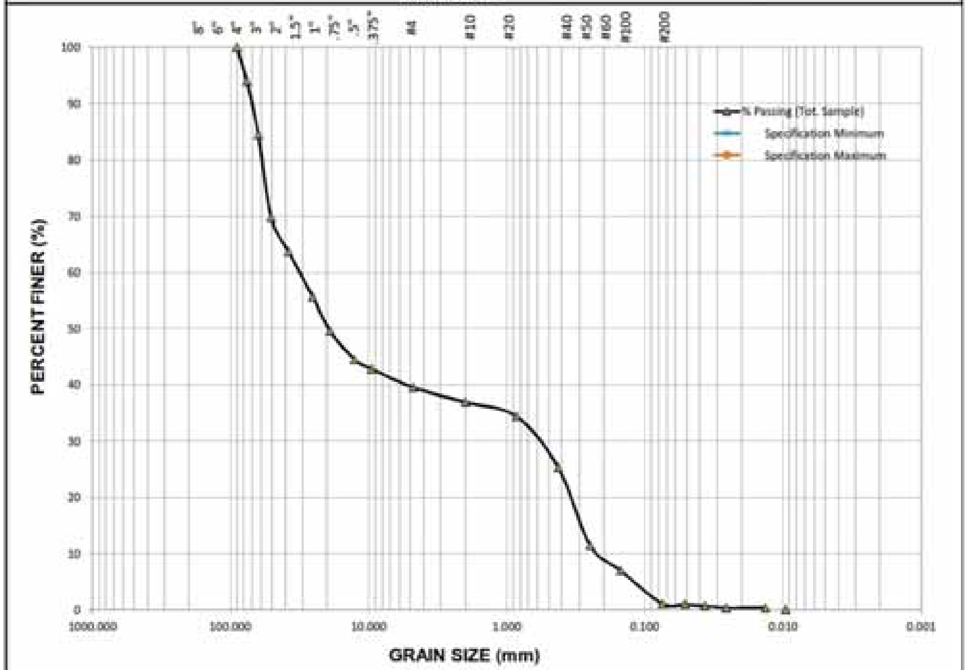
LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS 1 J5181061 PORTBAY.GPJ TERRACON_DATATEMPLATE.GDT 5/7/18

DRAFT

Figure 2.1-51 Gradation Curve for Sample from 2018 Channel Dredge Material

GRAIN SIZE DISTRIBUTION TEST REPORT

ASTM D-422



% Cobbles	% Gravel	Crs	Med	Fine	% Fines: Silt	% Fines: Clay
		7	30	63		
0	60.5	% Sand		38.4	1.1	0.0

Classification: *

Sieve Size (mm.)	Sieve Size (in./no.)	Cumulative Wt. Retnd	% Passing (Tot. Sample)	% Passing (Sand Port.)	Specification Minimum	Specification Maximum
80.000	5"	0	100.0			
76.200	4"	3696.00	94.0			
63.000	3"	9520.00	84.4			
50.800	2"	18446.00	69.8			
38.100	1.5"	22177.00	63.7			
25.400	1"	27090.00	55.7			
19.050	3/4"	30824.00	49.6			
12.700	1/2"	33931.00	44.5			
9.525	3/8"	34958.00	42.8			
4.750	#4	36950.00	39.5			
2.000	#10	60.86	36.8			
0.850	#20	117.85	34.3			
0.425	#40	323.35	25.3			
0.300	#50					
0.250	#60	636.90	11.4			
0.150	#100	738.40	7.0			
0.075	#200	872.30	1.1			
0.052			1.0			
0.037			0.7			
0.026			0.4			
0.013			0.4			
0.010			0.1			
0.000			0.0			

Total Dry Wt. 61104.13 g.
Split Wt. 896.31 g.

Project: **Port Bay Improvements**	Project No.: **J5181061**	Report #:
Location:	Specification:	Date: **04/02/18**
Source: Dredge Material	Sampled from: On-site Stockpile	

Terracon
77 Sundial Avenue
Manchester, NH 03103
(603) 647-9700 fax: (603) 647-44
www.terracon.com

Remarks:

Tested By: D. Savage Date: 04/17/18
Reviewed By: A.Suprunenko Date: 04/20/18

ASTM D422 - Rev. 3

Figure 2.1-52 Beach Classification by Baird (2011) for Two Near Sites: Chimney Bluffs and Little Sodus Bay

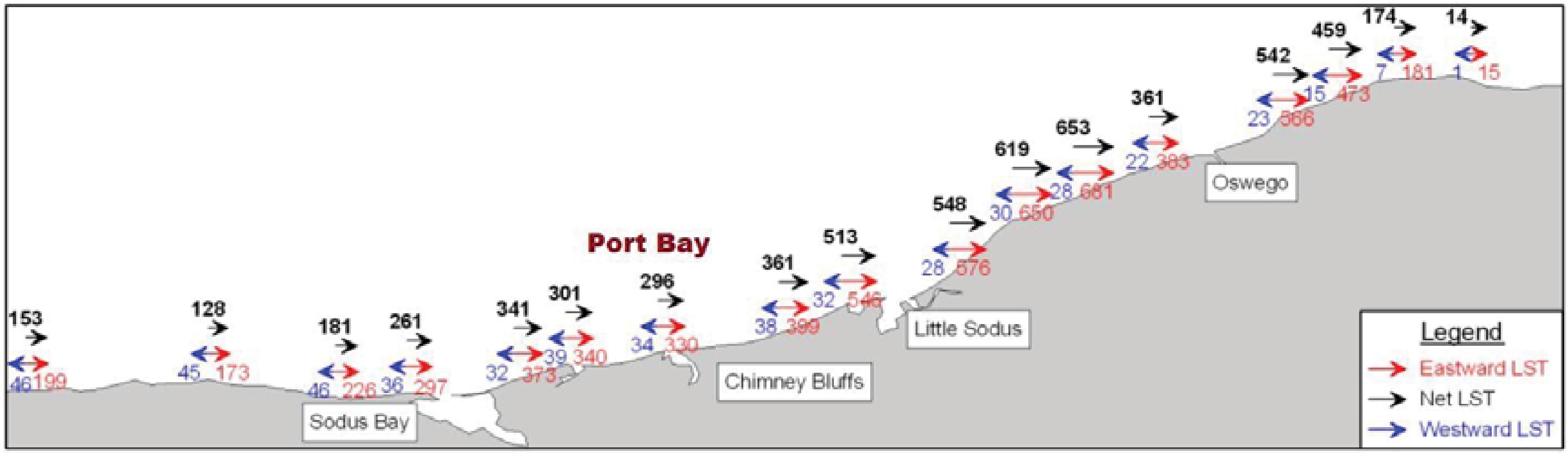
Project sites in Baird (2011)

"Chimney Bluffs" project site classified as cobble beach

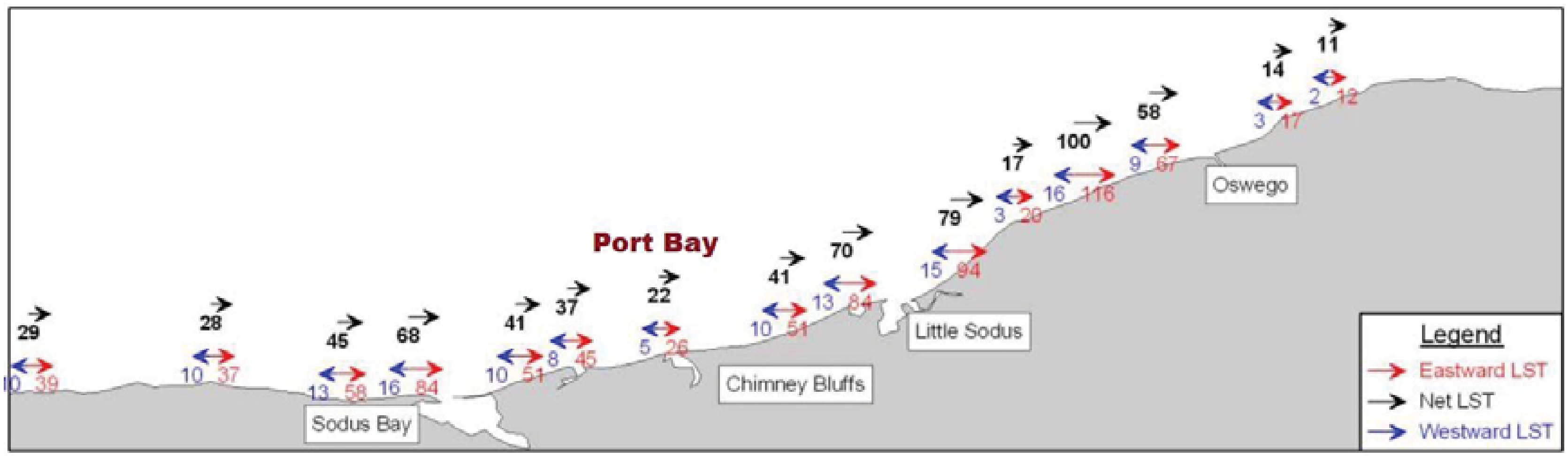
Little Sodus Bay" project site classified as "sandy beach"

DRAFT

Figure 2.1-53 Lake Ontario Annual Longshore Sediment Transport (LST)



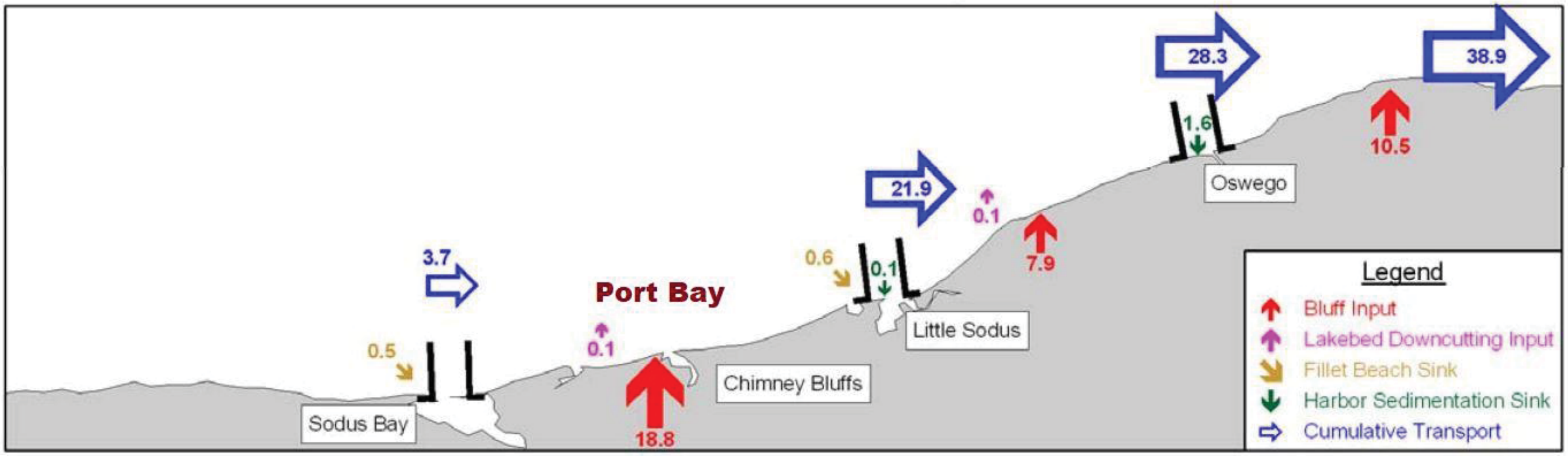
Unlimited supply (in thousands of m^3)



Supply-limited (in thousands of m^3)

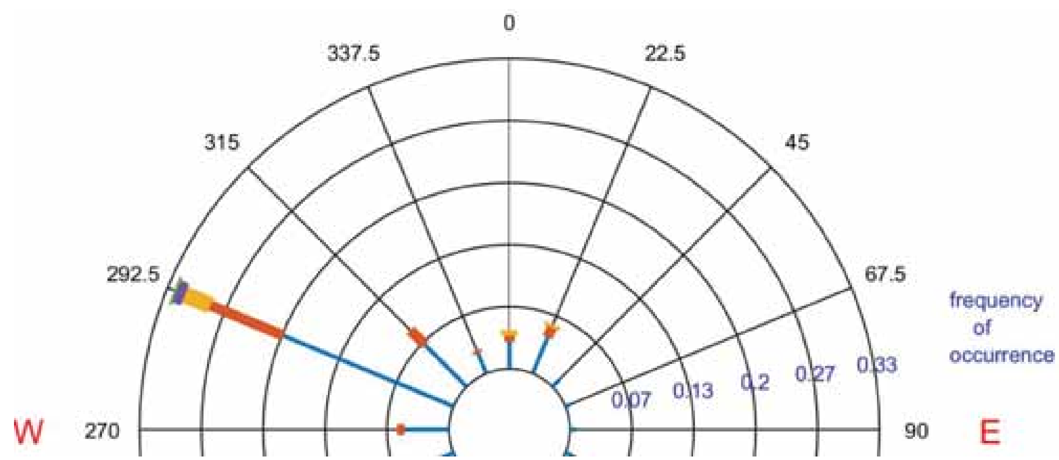
Source: Adapted from Baird (2011)

Figure 2.1-54 Lake Ontario Annual Sediment Budget for Existing Conditions

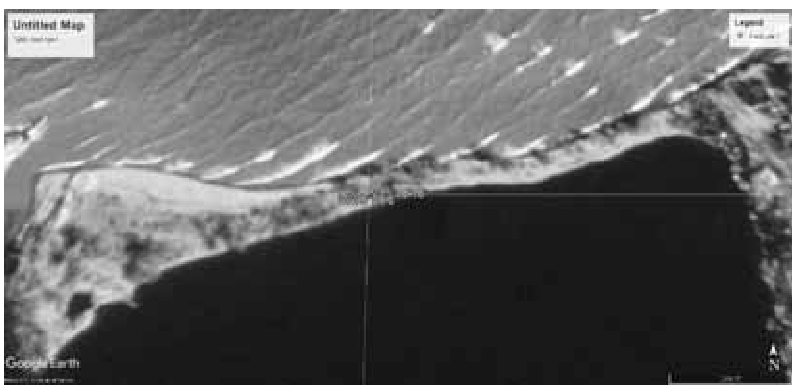


Source: Adapted from Baird (2011)
Note: Harbor bypassing estimates derived from GIS-based analysis only; no numerical modeling.

Figure 2.1-55 Waves and Direction of Dominant Waves



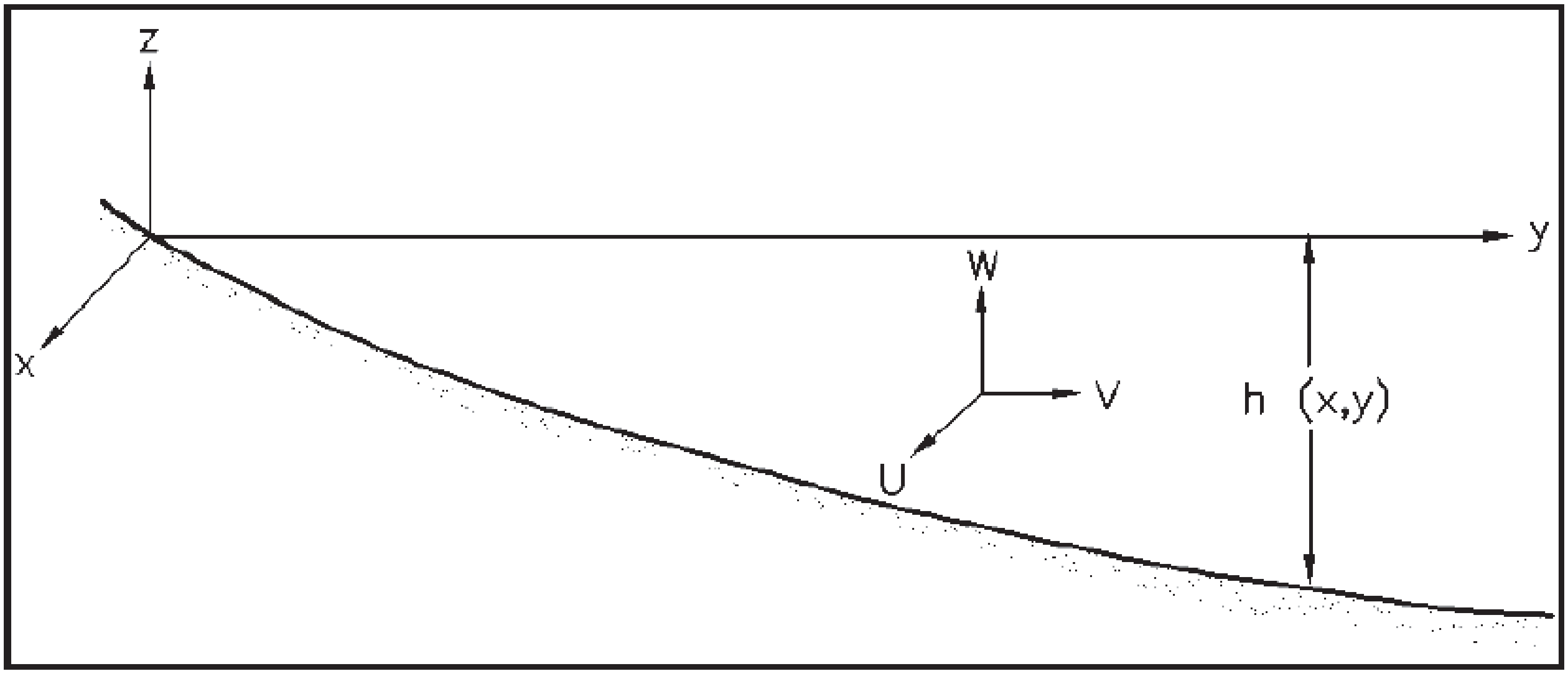
(See Figure 2.1-38 in a previous section for more details)



From Google Earth images, April 14, 1995

From Google Earth images, Oct. 3, 2002

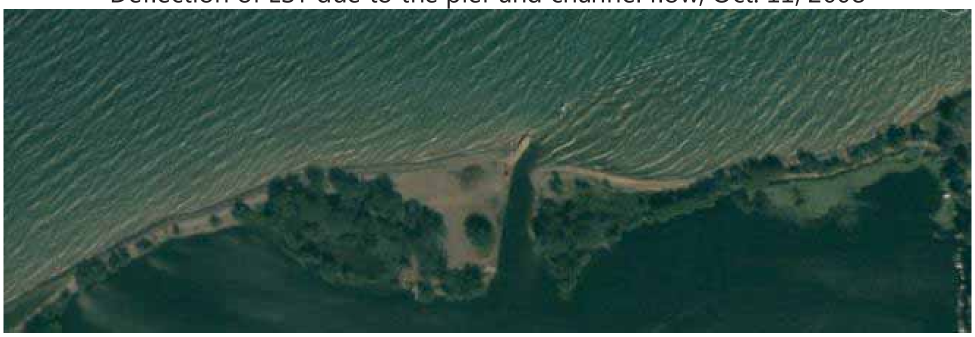
Figure 2.1-56 Definition Sketch for the Wave Generated Water Particle Velocities as Related to Cross-shore Sediment Transport



Source: Adapted from Figure III-3-3 of USACE 2008]

Figure 2.1-57 Impact of the Channel on Shoreline Hydrodynamics and Sediment Transport

Deflection of LST due to the pier and channel flow, Oct. 11, 2008



Wave fronts influenced by the pier, Oct. 3, 2002

Impact of flow from the bay on the flow pattern;
2016 before east barrier bar breach

"Mud plume" into channel and near outlet,
Jul. 15, 2015

Images adapted from Google Earth

Figure 2.1-58 Elevation Difference Between 2018 and 2007 Bathymetry

2.2 Economic Conditions

2.2.1 Data Sources

Port Bay has roughly 8 miles of shoreline, the majority of which is developed with small, residential structures on the roughly 400 parcels adjacent to the bay. In order to assess economic damage, the project team conducted a survey of Port Bay residents (included in **Appendix B**). According to the public survey, roughly 80% of the residents are part-time residents who use their homes as a vacation or weekend retreat rather than a full-time residence. The survey was conducted online and distributed via Facebook and direct email. The short time frame for analysis and the temporary residency of the property owners were concerns that precluded direct mail surveys. The intent of the survey was to determine the types of shoreline protection around the bay and to determine damage from 2016 (breach only), 2017 (record high water and breach), and 2018 (breach only), which would hopefully lead to a means of estimating the type, quantity, and cost of damage associated with the breach condition.

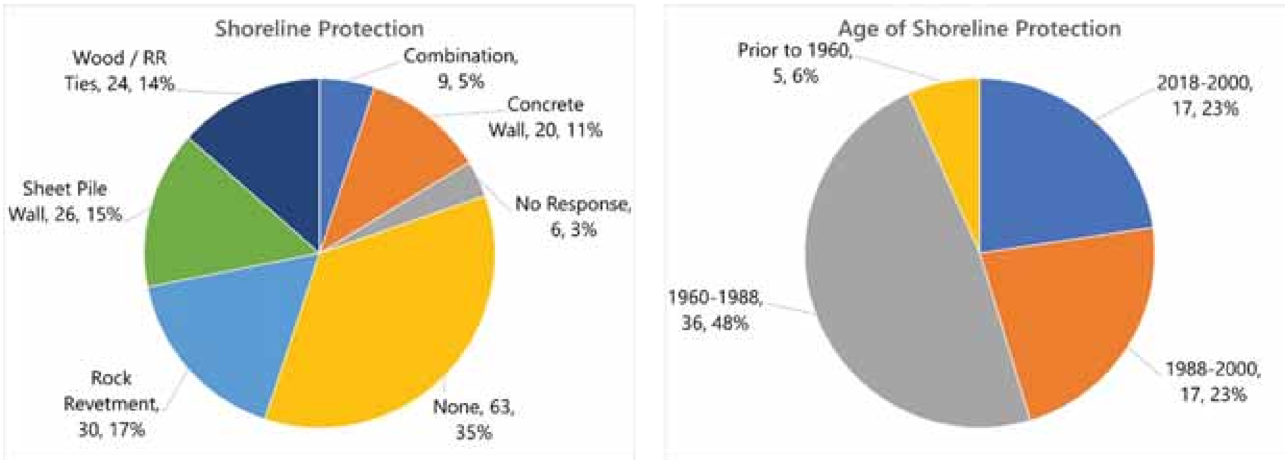
The survey resulted in 181 total respondents. It should be noted that not all respondents answered all the questions within the survey; therefore, different questions have different numbers of respondents.

2.2.2 Private Property Damage Costs from 2017 Breach Event

Many of the homes along Port Bay were originally built between 1920 and 1980. Fewer homes were built more recently than 1980. As such, the shoreline protection of these homes is also dated. Of the 181 survey respondents, 63 (35%) state they have no shoreline protection at all and only 34 thought their shoreline protection was installed after 1988. The remaining 54% have shoreline protection measures over 30 years old, the life span standard for today’s permitting issuance.

Figure 2.2-1 shows a breakdown of the types of shoreline protection features and their approximate age, as described by the survey respondents. Of the 112 respondents who reported having shoreline protection, 83 (74%) reported to have some type of vertical breakwall made of either concrete (25%), stone (1%), wood/timber/rail road ties (31%), sheet piling (31%), or combination thereof (11%). As it is NYSDEC’s policy to not allow vertical protection unless absolutely necessary or as a replacement of an existing functional vertical structure, all of these walls are assumed to be originally installed prior to NYSDEC permitting requirements. **Figure 2.2-2** shows the geographic locations of the various types of shoreline protection.

Figure 2.2-1 Types and Age of Shoreline Protection Measures Around Port Bay

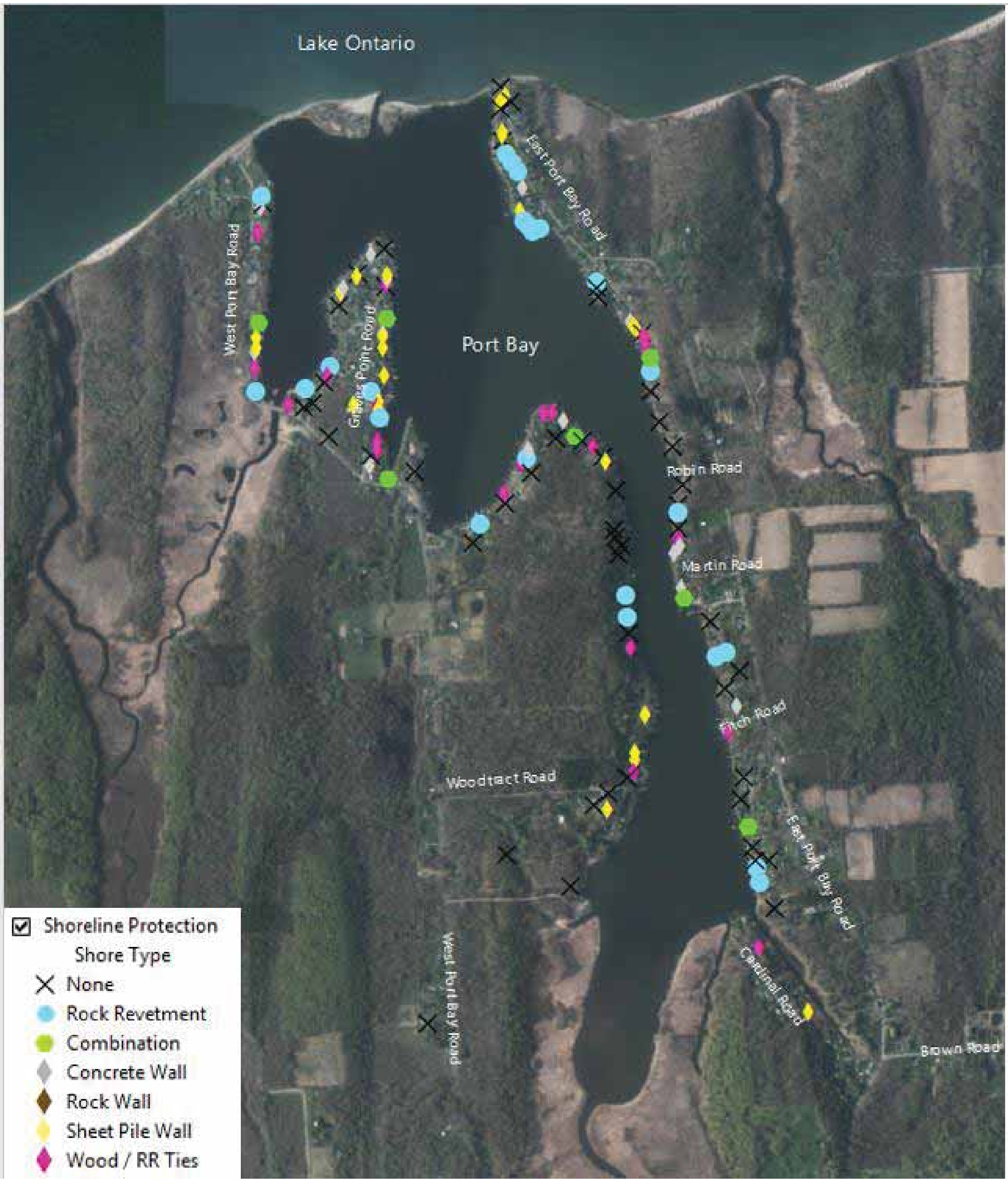


Public Survey Analysis

The survey then focused on determining the condition of the shoreline protection and whether it was damaged in previous years, during 2017, or during 2018. When asked how frequently their property was damaged prior to 2016, the vast majority of respondents said there was seldom or never any damage except that of normal wear and tear and aging or anticipated erosion during high water events or from wave action above their shoreline protection. When asked if their shoreline, dock or home was damaged in 2017, 82% of respondents said yes. Descriptions of damage included minor damage such as limited erosion, cosmetic damage to docks requiring cleaning, staining or board replacement due to being under water for long periods of time, loss of grass or other vegetation due to flooded lawns, to extensive erosion issues including failing breakwalls and erosion behind breakwalls, to structural flooding issues such as mold, settlement, or general damage to homes, sheds, garages, and boat houses. **Figure 2.2-3** shows survey respondents' perceived causes of damage in 2017. Of the 147 respondents who gave an opinion of what the major causes of the damage were, 97% indicated high water, 39% indicated wave/wake action, 15% indicated debris, and 4% indicated other reasons, such as the breach.

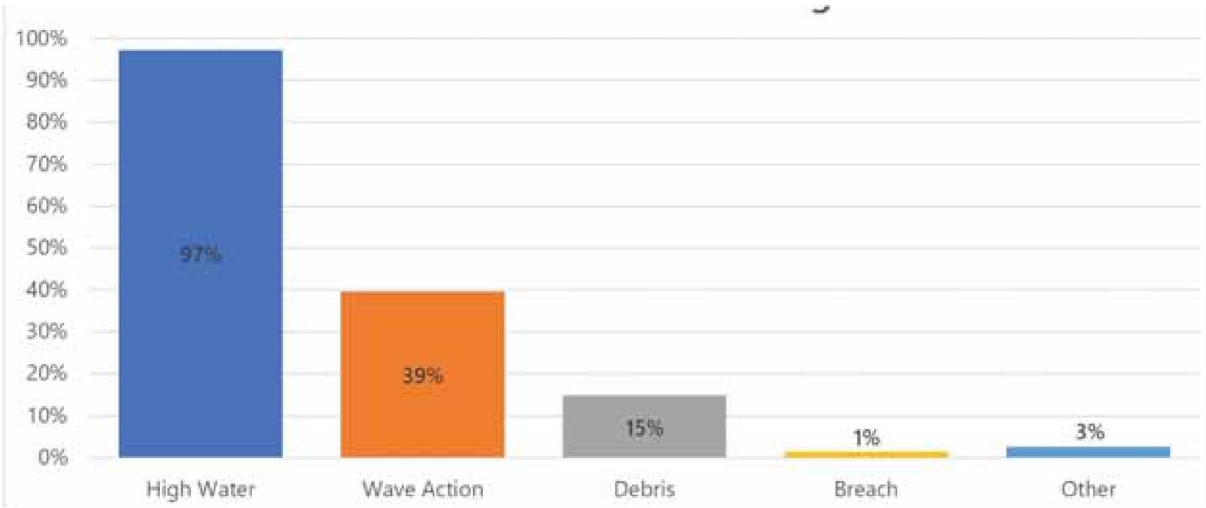
Figure 2.2-4 shows the geographical locations of perceived damage, indicating that respondents thought wave action was a cause of damage throughout the embayment. Debris was also strongly indicated as a source of damage to those properties on the upper east and upper west shorelines that would be in the direct pathway through the breach during normal westerly winds or the strong northeast storm winds. High water damage is not included in **Figure 2.2-4** since nearly all respondents indicated it as a cause.

Figure 2.2-2 Types of Shoreline Protection Measures Around Port Bay



Public Survey Analysis

Figure 2.2-3 Perceived Caused of Damage during 2017 from Survey Respondents

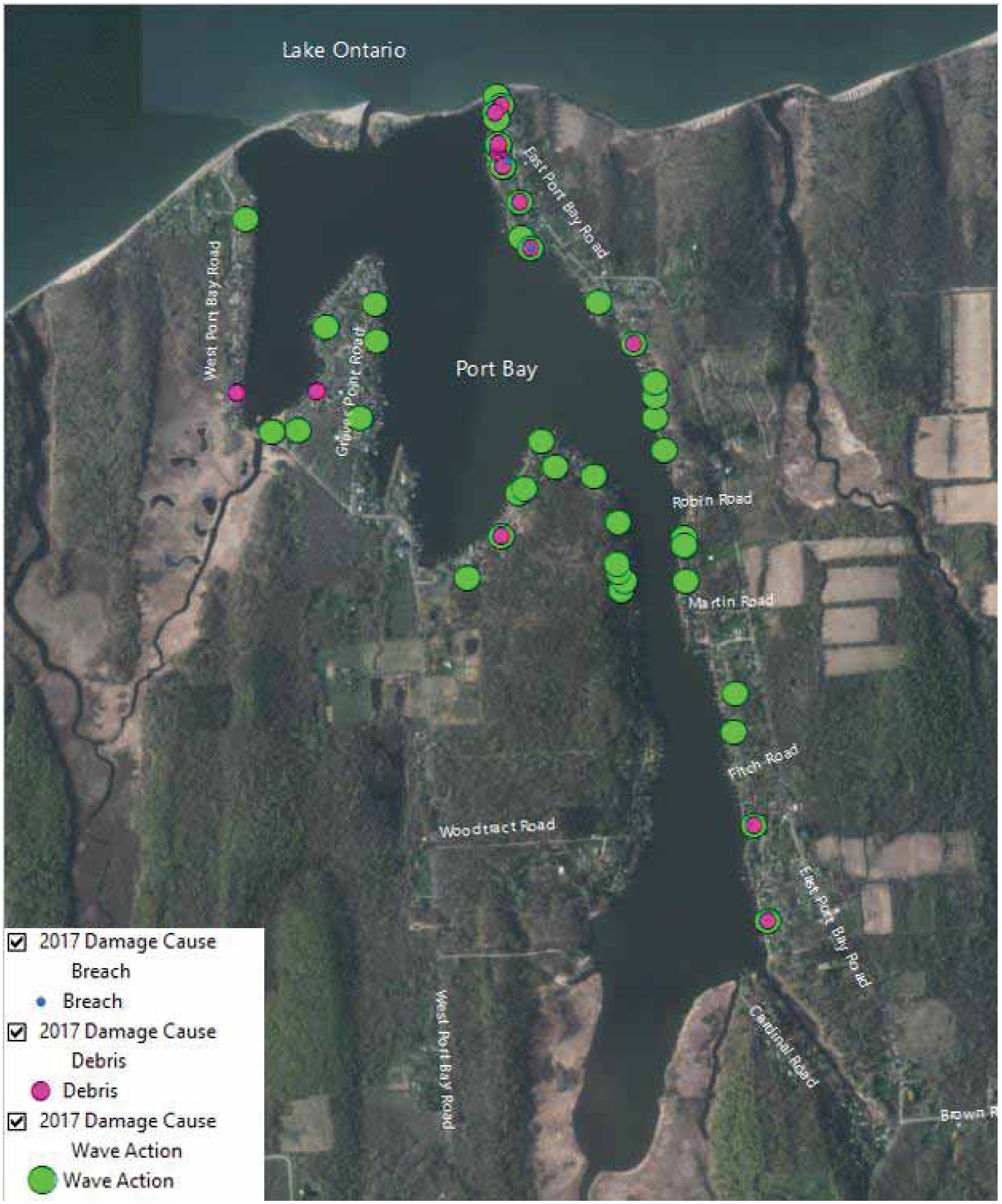


Public Survey Analysis

In addition to the survey, NYSDEC Regulatory Permits provided the permit files for all environmental permit applications in Port Bay between March 2016 and March 2018 and some older historical permits. Based on a review of all of these permits, **Table 2.2-1** shows the address of the permit applicant, general reason for the permit, and approximate date of initial application of those after March 2016.

Most of the permit documents reference the high water as the source of damage or the reason for the modification. Many of the permits are related to repairs, replacement, or refacing of an existing vertical breakwall; however, many of these walls were also originally constructed using timber or railroad ties and were likely in poor condition prior to 2017. The impression from reviewing the permit applications was that the high water levels and aging infrastructure were the primary source drivers for the damage that occurred in 2017. An increased level of debris and wave action, primarily in the uppermost sections of the embankment may have been an added stressor, but unlikely the primary cause of damage. Additionally, as the residents that reported wave action and debris as the perceived sources of damage are dispersed throughout the bay, as shown in Error! Unknown switch argument., not just in the area that would be directly effected by the breach, this indicates that the height of the east barrier bar would also play a critically important role in the protection of the bay residents. The low height of the bar during the 2017 event was not sufficient to protect the bay from increased wave action and debris.

Figure 2.2-4 Perceived Causes of Damage During 2017



Public Survey Analysis

Many residents along Port Bay did not have significant enough damage to warrant repairs that would trigger an environmental permit application or have not completed repairs at this time. Of the 148 respondents who reported 2017 damage, only 38% stated that they had made repairs. Additionally, most permit applications do not specify the cost of the repairs. The public survey allowed people to estimate the cost of repairs following the 2017 flooding and breach. **Table 2.2-2** shows the responses from the survey respondents regarding the cost to repair damage incurred during 2017. These values are not a true representation because of several key factors:

- Costs cannot always differentiate between damage from flooding and damage from a breach of the barrier bar, as the two actions were too intertwined in the 2017 season and many of the survey respondents reported damage from both;
- Costs may include normal maintenance or hazard costs that should be associated with high risk area (i.e., dock washing, re-staining, clean-up of debris);
- Costs may reflect what property owner spent, but may include upgrades from existing condition or replacement of aging infrastructure (i.e., railroad ties replaced with sheet pile walls, increased height of walls, larger decks);
- Many repairs and a great deal of cleanup were performed by homeowners, which would not include fair market costs of labor and materials and would not capture the "sweat equity" put into repairs.

Figure 2.2-5 shows the geographical distribution of the ranges of repair costs experienced around the bay following the 2017 breach.

Table 2.2-1 NYSDEC Environmental Permits Within Port Bay

Address	Reason	Date
7807 Eagle Rd	Repair riprap, increase height of riprap revetment	5/25/2017
8279 E Port Bay Rd	Replace timber wall with sheet pile	6/10/2017
7638 Cardinal Rd	Replace timber wall with sheet pile	7/6/2017
7946 N Maple Rd	Rebuild dock, damage due to flooding	9/17/2017
8123 Robin Rd	New sheet pile wall	9/27/2017
11349 Leone Dr	Repair timber breakwall	10/2/2017
8170 Graves Point Rd	Reface with sheet pile wall	10/3/2017
8341 Graves Point Rd	Replace timber wall with sheet pile	11/8/2017
8333 E Port Bay Rd	Repair / install riprap	12/17/2017
*8355 Graves Point Rd**	*Replace existing dock – No damage mentioned*	*12/18/2017*
7720 Cardinal Rd	Breakwall replacement	1/5/2018
8327 E Port Bay Rd	Replace timber wall with sheet pile	1/16/2018
8128 W Port Bay Rd	Reface timber/concrete breakwall with sheet pile	1/22/2018
7770 W Port Bay Rd	*Replace existing dock – No damage mentioned*	*2/4/2018*

Address	Reason	Date
7760 W Port Bay Rd	*Replace existing dock – No damage mentioned*	*2/9/2018*
8047 Martin Rd	Reface concrete wall with sheet pile	2/19/2018
8552 Brown Rd	Stone revetment, grade bluff, veg, access ramp	2/26/2018
8503 E Port Bay Rd	Sheeting, stone, docks and hoist	3/6/2018
8491 E Port Bay Rd	40' long sheet pile wall, stone revetment, dock, boat hoist	3/26/2018
Port Bay Barrier Bar	Spoil placement	4/1/2018
8164 Graves Point Rd	Permit extension, replace wooden rail tile wall with sheet pile wall	6/14/2018
11745 Tompkins Point Rd	Replace timber breakwall, dock, boat hoist	6/25/2018
8335 Graves Point Rd	Replace railroad tie wall with sheet pile wall. Higher to reduce flooding	1/31/2018

* Italicized permit applications appear to be normal maintenance/upgrading requests and do not appear to be due to damage from 2017.

Table 2.2-2 Survey Responses for Damage Incurred During 2017

Address	Description of Damage In 2017	Respondent Perceived Cause of Damage	Repair Work Preformed	Estimate of Cost
8341 Graves Point Rd	Dock and retaining wall washed away	High Water	New dock and break wall	$50,000
11685 Tompkins Point Rd	Severe shoreline erosion and coming apart of wood break wall.	High Water	New pile driven steel break wall being installed to replace pre-existing wood break wall.	$45,000
8463 E Port Bay Rd	Boat house knocked down	Wave Action; High Water; Debris	Fixed boat house	$40,000
8509 E Port Bay Rd	Erosion where there was no sheet piling. The entire property and dock were under water for several months	Wave Action; High Water; Debris	Repairs are scheduled. Waiting on permits for additional sheet piling and raising height of existing wall.	$40,000
8385 Thrush Rd	*Shoreline was damaged, under cut our break wall. It also knockdown our rocks on our break wall some of the rocks were swept away. Damage to of pier foundations on our garage and under our cottage.	*Wave Action; Debris; The breech allowed more material into the bay and caused issues	*Personally replaced some of the stone on our break wall. Removed a lot of logs, trees and other debris	$20,000
8252 W Port Bay Rd	Dock needed power wash and stained. Break wall had damage due to wash out of backfill behind it.	High Water; Debris	New metal break wall was installed. Dock was power washed and re-coated with 3 coats of stain	$17,000
E Port Bay Rd	Ruined the dock & cracked the cement	Wave Action; High Water; Debris; Ice	New dock & cement patch	$12,000
8018 N Maple St	Erosion, dock damage	High Water	Restrained dock, need to replace boards, fixed break wall, fix electrical on dock	$10,000
8216 Graves Point Rd	Deteriorating breakwall and submerged docks caused cosmetic damage to docks	High Water; Ice	Docks were sanded and refinished. New breakwall to be installed during 8/2018	$10,000
11735 Tompkins Point Rd		High Water	Stone wall	$5,000
7876 N Maple St	lawn brake wall	High Water	25 yards topsoil and seed	$5,000
8459 E Port Bay Rd	Dock, breakwall, and boathouse damaged due to high water, float trees, Lifted dock boards off, eroded breakwall	Wave Action; High Water; Debris	Replaced missing dock boards, boathouse doors. Filled in soil that eroded behind breakwall. Pulled out 25+ trees from dock/boathouse area	$5,000
11700 Tompkins Point Rd		Wave Action; High Water		$4,000

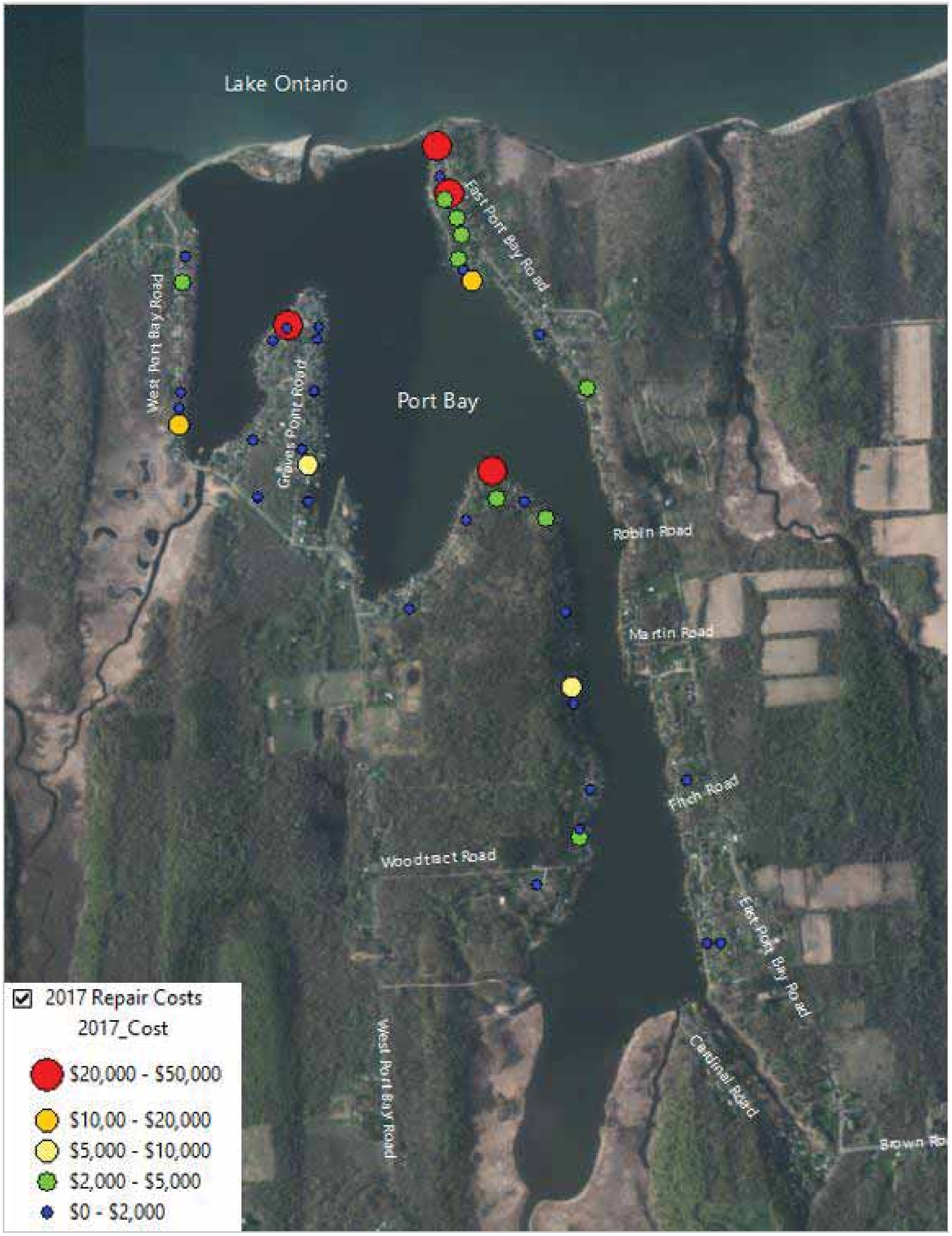
Address	Description of Damage In 2017	Respondent Perceived Cause of Damage	Repair Work Preformed	Estimate of Cost
8285 E Port Bay Rd	All the new landscaping from the newly installed wall was destroyed; Brand new Dock decking was damaged from being underwater most of 2017	High Water	Replaced all new lawn work, replaced topsoil, reseeded; manually cleaned deck, re treated deck, scrubbed and re-conditioned. Not yet fixed is new stone landscape wall that sank b/c of high water	$4,000
8382 W Port Bay Rd		High Water	Replacement	$4,000
8405 Thrush Rd	*Dock damage. Carpet. Sidewalk. Shed flooded. This caused mold and mildew and warping. Lawn was underwater and needed topsoil and to be reseeded.	High Water	*We pressure washed dock. Cleaned the shed with bleach and resealed the floor and Coated and sealed wooden sidewalk. Topsoil and grass seed. Rewired electric to dock. More repairs needed	$3,000
8427 E Port Bay Rd	*Dock damage from debris. Lots of debris removal	Wave Action; High Water; Debris	Boards were replaced on the dock. Electric had to be redone. Debris and logs had to be transported away.	$3,000
8010 N Maple Rd	*Boathouse turned shed with a surrounding dock flooded. Lost quite a bit inside, had to replace floor and interior walls. Corner totally rotted causing boathouse to sag dramatically out of alignment.	Wave Action; High Water	Replaced floor and walls. Removed damaged contents. Had to realign entire boathouse with wench and secure	$2,800
8451 E Port Bay Rd	Rock wall washed out due to soil behind it washed out, first time the water level has gone over the rock wall since installed	High Water	Completely rebuilt stone wall and raised it 12" higher and had truck loads off soil brought in to reinforce rock wall	$2,500
7920 N Maple St	*Highwater went over the wall and wash the hill away also destroyed the grass and lower area. Loss of use.	High Water		$2,000
8002 N Maple St		High Water	Boat house floor restoration, mildewed furniture cushions, rusted wrought iron furniture and ruined dock stain requiring new staining. Temporary dock fastening, which floated away.	$1,500
8479 E Port Bay Rd	Major land erosion, damaged stairs	Wave Action; High Water; Debris	New stairs and cleanup of debris	$1,200
11608 Tompkins Point Rd	Erosion of shoreline due to high water and waves.	Wave Action; High Water	Added sandbags for temporary repair. Had soil and rock brought in in spring of 2018 for more permanent repair.	$1,000
7927 Jay Rd	Parts of the dock wood broke away.	High Water	Plank replacement	$1,000
8404 W Port Bay Rd	Some boards on dock raised- soil washed out under deck	High Water	Deck boards replaced	$1,000

Address	Description of Damage In 2017	Respondent Perceived Cause of Damage	Repair Work Preformed	Estimate of Cost
11659 Tompkins Point Rd	Permanent dock under water for 3 months resulted in damage to finish and quality of permanent dock boards. Erosion to shoreline due to high water and wave action.	Wave Action; High Water	Professional power wash and re-staining done to address cosmetic damage to permanent dock.	$800
11715 Tompkins Point Rd	Dock under water 2,5 months: visible damage minimally but waterlogged etc.	High Water	Power washed. Left to dry and stained this year	$800
8043 Martin Rd	Water 'Back Cut' the break wall washing away a lot of our front lawn.	Wave Action; High Water	Hauled in loads of dirt to back fill between the breakwall and the cottage	$800
8346 Graves Point Rd	Being dock is fairly new I had to power wash and re-stain the dock. Some boards had to be re-screwed down as they had lifted	High Water	Restrained dock and repaired boards that popped up	$750
7787 Dove Rd	Dock was broken	High Water	New wood and posts for dock	$600
	Dock under water	High Water; Debris	replace wood	$500
11730 Woodtract Rd	Dock washed away	High Water	Retrieve and rest dock list two adjustable legs	$500
7781 Dove Rd	Water over the dock lifting up boards and dislodging some floating devices	High Water	Replaced the boards and repaired the hose line	$500
7826 S Maple Rd	Erosion, deck and shed damage	High Water	replace flooring in shed, deck structure, fill dirt and seed	$500
8268 W Port Bay Rd	Dock and front yard	High Water	Topsoil and seed repair dock and re stained	$500
8282 Graves Point Rd	Dock and lawn both underwater until mid-July. Some dock boards needed to be replaced. Lawn needed to be entirely reseeded.	High Water	Dock boards replaced, dock power washed and painted, lawn reseeded.	$500
8393 Thrush Rd	boat hoist damage, stone steps eroded, rocks fell to water	Wave Action; High Water; Debris; Ice	replaced parts, stones pulled out of eater and put back up onto rip app	$500
8182 Graves Point Rd	EROSION BEHIND BREAKWALL	High Water	BACK FILL WITH TOPSOIL	$400
8325 Ash Rd	flooded boat house erosion behind the wall	High Water	placed stone behind wall cleaned out boat house and threw out things that were destroyed	$400
8334 Graves Point Rd	damaged boards, rotting boards and loss of grass	High Water	new boards, new grass	$400

Address	Description of Damage In 2017	Respondent Perceived Cause of Damage	Repair Work Preformed	Estimate of Cost
6174 Graves Point Rd	I lost $ 300.00 worth of treads from my dock.	High Water	Replaced all the lost deck treads.	$300
8180 W Port Bay Rd	Dock washed away	High Water		$200
8239 Dogwood Rd	Under water for 3 months, needed cleaning, re-staining, left some boards with creaks and splinters.	High Water	Did it myself.	$200
7884 N Maple St	slight settling of patio pavers due to water erosion	High Water	releveling of the patio pavers	$100
8305 Ash Road	20' x 40' of submerged lawn needed to be reseeded	High Water	Lawn reseeded	$100
8339 Graves Point Rd	Minor damage to dock and minor erosion to breakwall top plate from sandbags.	High Water	Replaced a couple of beams to the dock.	$75
11777 Tompkins Point Rd	A number of dock boards needed to be repaired	Wave Action; High Water	reattach damaged dock boards	$50
8280 W Port Bay Rd		High Water	Dock was under water and could not use our boat.	$50
8339 E Port Bay Rd		Wave Action; High Water	Trying to regrow vegetation and added more cobble rock to washout areas	$50
8230 Graves Point Rd	Lost ground and stone along shoreline shifting base of dock.	Wave Action; High Water; Ice	Added rocks to raise breakwall and backfilled eroded ground with stone.	$0
8415 E Port Bay Rd	We lost some dirt		Filled it in with dirt	$0

* Indicates table entries that were modified to fit the table. See **Appendix B** for the full responses from the public survey.

Figure 2.2-5 Repair Costs for 2017 Damage



Public Survey Analysis

2.2.3 Private Property Damage Costs from 2018 Breach Event

Because the 2017 damages are so intertwined between the high water and the breach, it is nearly impossible to differentiate costs related to the breach alone based on damage from 2017. In order to better estimate what repair costs and damage would be associated with a breach condition in a normal year (i.e., not extreme high water), the final questions of the public survey were related to damage experienced in the spring of 2018. The barrier bar was breached in February and March of 2018. The water levels within the lake and the embayment were seasonally normal. High water was experienced in the embayment earlier in the year; however, this was due to the natural filling of the embayment while the outlet channel was partially closed, which could be anticipated to occur annually depending on conditions in the outlet channel. The breach actually led to the reduction of water levels as a conduit to the lake was created. Only 11% of respondents reported damage in 2018; however, the description of the 2018 damage reports tend to cover longer periods of time than the 2018 breach occurred or indicate that high water and ice were more of the causes of the 2018 damage. Some of the descriptions were also inconsistent with the conditions (i.e., high water as the source of damage occurring in May–August; however, the survey was distributed in July and the water was not significantly high), which indicates that there may have been some confusion or mislabeling of responses in the survey. This all indicates that the actual damage reported should likely be less than 11% and that the 2018 breach was not a major source of damage. The 2018 damage reports are shown in **Table 2.2-3**. **Figure 2.2-6** shows the ranges of repair costs experienced around the bay for damage incurred during 2018.

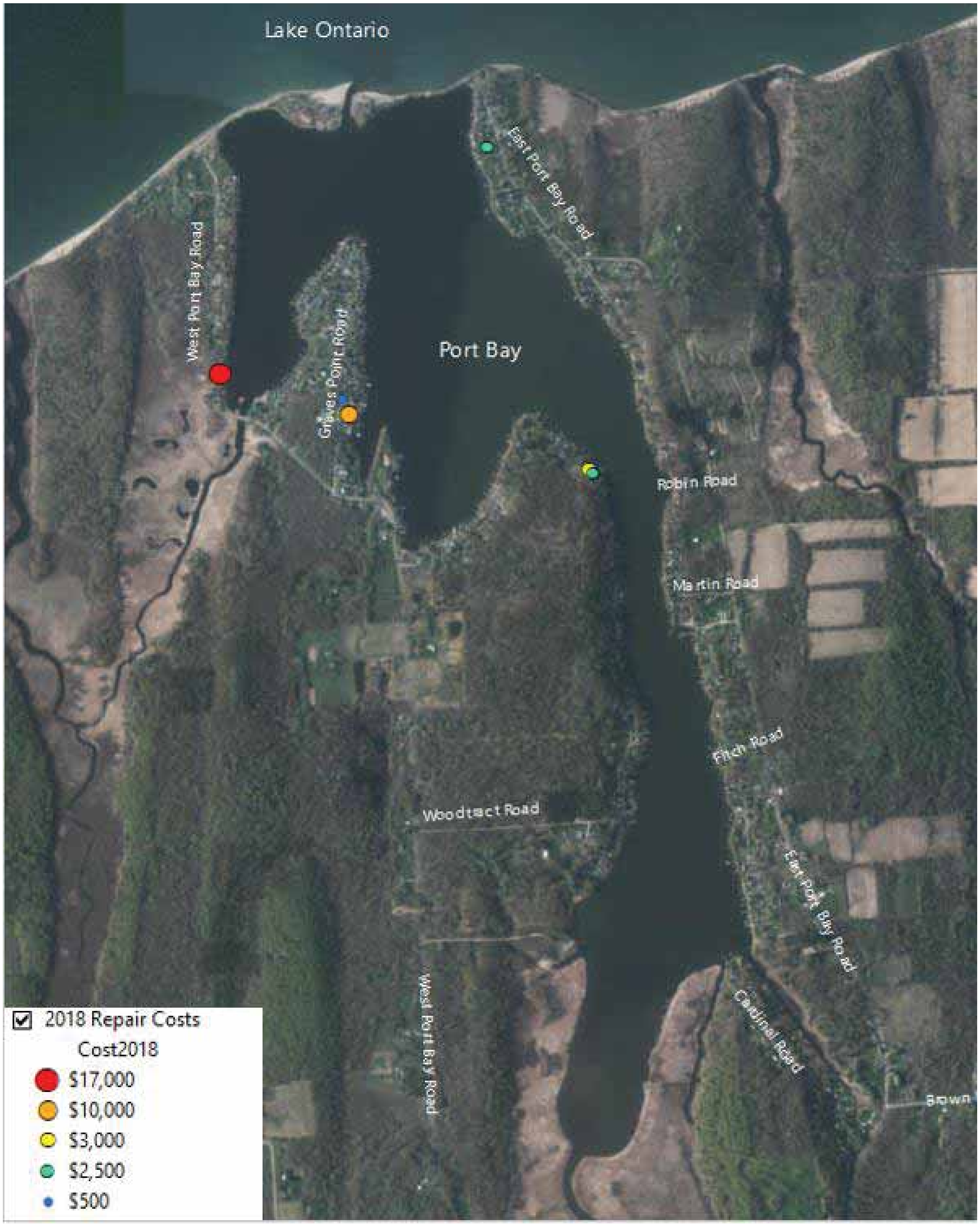
Table 2.2-3 Description of Damage Incurred During 2018

Address	Description of Damage in 2018	Respondent Perceived Cause	Timeframe of Damage Occurrence	Repair	Cost of Repair
	Continued shoreline erosion and wave action destroying property	Wave Action; High Water; Debris	Spring–Early Summer		
Eagle Rd	Ice further impacted rock face and dock structure due to higher water levels	Ice	January–March		
11617 Tompkins Point Rd	More erosion of foundation	Wave Action; High Water	Winter–Spring 2018		
11657 Tompkins Point Rd	Dock lifted, boards weakened by water, sealer dissolved	Wave Action; High Water	March–July		
11735 Tompkins Point Rd		Wave Action	May		$3,000
11737 Tompkins Point Rd	Breakwall	High Water	April–May	Backfill needed	$2,500

Address	Description of Damage in 2018	Respondent Perceived Cause	Timeframe of Damage Occurrence	Repair	Cost of Repair
7899 Finch Rd	Eroded the soil behind the railroad ties, allowing the ties to fall into the water	Wave Action; High Water	March–April–May 2018		
7945 Jay Rd		Wave Action; High Water; Boats going too fast!	Spring		
7965 Lark Rd	Break wall and dock damaged	Wave Action; High Water	May–August		
8034 N Maple St	Dock	High Water	May		
8043 Martin Rd	Wave action from initial high water, boats further eroded cracks in breakwall	Wave Action; High Water; Ice	Winter–Spring		
8043 Martin Rd	Settling and cracking of dock and breakwall	High Water	Slowly over the summer of 2017 to summer 2018		
8123 Robin Rd	Erosion from high waters and waves	Wave Action; High Water; Debris	March to now		
8215 Graves Point Rd	High water in spring	Wave Action; High Water	April		
8216 Graves Point Rd	Cosmetic damage to docks + structural damage to breakwall.	High Water; Ice	April–May 2018	Dock sanded and refinished, New breakwall to be installed 8/2018	$10,000*
8230 Graves Point Rd	Dock split and ended up in the water.	Wave Action; High Water; Ice	April around the ice breakage on the bay.	Raised dock adding new temp supports	$500
8252 W Port Bay Rd	Dock needed power wash and re-staining. Breakwall weakened by erosion behind wall caused by washout of back fill	High Water	June-July	New steel breakwall, power wash and re-stain dock	$17,000*
8294 W Port Bay Rd	Dock and poles corrosion	High Water	July		
8325 Ash Rd	Dock lifted on right side	Ice	Winter I was not here when it occurred		
8459 E Port Bay Rd	Dock boards torn off and remaining PVC decking permanently stained	Wave Action; High Water; Debris	May-July	Replace missing boards	$2,500

*Indicates costs also reported in 2017 damage assessment

Figure 2.2-6 Repair Costs for Damage Incurred During 2018



Public Survey Analysis

Based on the 2018 damage descriptions provided by the respondents, the majority of properties were undamaged or received only normal or anticipated damage associated with typical erosion on shoreline features during the barrier bar breach under normal water levels in 2018. Over 50 respondents reported damage and repair costs in 2017, whereas less than half that reported damage in 2018 and only 6 reported costs. Roughly half of the 2018 damage reports were for dock damage. The two highest reported costs of $10,000 and $17,000 were for dock repairs and new breakwalls. However, these costs and repairs were also reported in the 2017 repair costs question. Both of these walls are also reported to originally be railroad ties walls. So even if damage was done in 2018, the walls were previously damaged in 2017 and well past their lifespan. The other reported repair costs in 2018 were related to backfill and dock repairs, with a maximum of $3,000.

These significant differences in damage reports from a high water year (2017) and a normal water level year (2018) lend to the conclusion that the breach alone may not be a significant source of damage. Similarly, the prior 2012 and 2015 breaches appeared to not have been a significant source of damage, as most respondents reported little to no damage prior to 2017. However, the breach clearly accentuated damage incurred during the high water and vice versa. This shows that there are other factors to consider when evaluating a breach scenario, such as time of breach opening, storm events and high wind events occurring during the breach period, and general seasonal water level variations, which are clearly not able to be compared based on this limited analysis. The length of time the breach was open during 2017 and the high water levels created a much more dangerous and damaging event than the shorter duration and lower water level breach condition in early 2018. The majority of property owners reporting issues (e.g., permit applications) reported that their shoreline protection was overtopped by high water levels in 2017, thereby rendering it ineffective against the additional wave action or debris from the breach.

2.2.4 Determination of Anticipated Damage Cost Per Breach

Based on the survey responses, it is clear that not every property was damaged during the 2017 and 2018 breaches, and thus applying damage assessments to all 400+ residents of the bay would be inappropriate. Residents have indicated that the wave action and debris are the most damaging effects of the breaches. Wave action and accumulation of debris will be most severe for those first dozen or so homes along the northern end of East Port Bay Road, which are in line with the breach and wave direction for the predominant west/northwest winds, as well as for a select few homes along West Port Bay Road and at Graves Point where waves may pass through the breach during nor'easter storm events. As such, it is recommended that damage costs associated with a breach condition, for the purpose of this report, be limited to roughly 30 homes along the northern limits of East and West Port Bay Roads and Graves Point (see **Figure 2.2-7**). This is not to say that other homes along Port Bay have not been impacted by the breaches, but their impacts have likely been significantly less or more manageable through routine maintenance (i.e., maintaining shoreline protection, debris removal, protection/removal of dock, boat, etc., during storm events).

Figure 2.2-7 Estimate of Homes With Highest Likelihood of Damage During Breach Event

The yellow shaded area shows the approximate area of former breaches. The red shaded area shows the roughly 11 homes on the northwest side of the bay most likely to be impacted from a breach and the predominant west/northwest winds. The orange shaded areas show the roughly 19 homes most likely to be impacted by a breach and the less frequent nor'easter winds.

Looking at the damage reported in these areas, the 2017 damage costs ranged from $50,000 reported for a new retaining wall and dock to $1,000 for backfill of an existing wall. The shoreline management technique in this select 30 home area includes unprotected shores, sheet pile walls, timber walls, concrete walls, and rock revetments. The most northern areas are bluffs where the homes are situated well above the normal water levels. The bluff lowers towards the southern limits. The west side properties are predominantly protected with rock revetments at the water level, transitioning into low walls at the southern limits. The east side has more vertical walls (sheet pile or concrete) with low lying boat houses and patios built into the water's edge. The point is a low bluff with low vertical walls at most homes. A number of breakwalls were replaced in these areas, particularly the red area, following the damage of 2017.

While the $50,000 for a refaced/replacement breakwall is a significant expense, it is not appropriate to use as the damage assessment value. Several of the breakwalls replaced following the 2017 damage were reported to be timber or railroad tie walls, which were past their expected life expectancy, and others were damaged due to the washout from behind the wall due to overtopping. While the wave action and debris of the breach played a role in the wash out, the high water had bigger role in damage as the walls were not high enough to protect the area from a normal wave action at that height. Therefore, part of that cost should be considered as anticipated replacement costs of aging infrastructure that would not be required after each breaching event or solely because of a breach. Similar to car insurance, totaling a 10 year old vehicle does not result in the payment for a current model year new car. Vertical walls in water, particularly those made of timber or railroad ties, have a limited life expectancy; therefore, a large portion of the replacement cost of refacing/replacing with a steel sheet pile wall would be inappropriate as a method of assigning a damage cost to each property from the breach. Similarly, replacing these structures with a more substantial material and more appropriate design height would then reduce the anticipated damage costs as the result of future breaches; therefore, the replacement/refacing cost cannot be attributed as a "per breach" potential cost.

A more appropriate "per breach" damage cost attributable to the increased wave action and debris due to the breaches may be closer to the value provided by those who replaced stones or backfilled their walls. Additionally, some dock repair may be required due to damage from debris; however, not entire dock replacements. These costs would be more in line with the repair costs reported from the 2018 breach. These repairs may be of a continual basis that may be assumed to be required following every breach, unless a more expensive, long term protection were installed (e.g., replace fixed dock with floating dock, install rock revetment, reface old breakwall, etc.). Spread over time, these repair costs would likely also reach the cost of a more substantial repair option. The highest repair cost reported in 2018 (excluding the duplicate 2017 costs) was $3,000. Two other reports of $2,500 for backfill or dock repair were also reported. Based on these reports, it is recommended that a value of $5,000 of damage (assuming $2,500 for backfill + $2,500 for dock repair) be assigned to each property in the higher risk areas per breach. Since there is no way to predict how often breaches would occur, when or how long they would last, a long-term value is difficult to assess. However, if the value of $5,000 of damage per breach is applied for each of the 30 properties in the higher risk areas, it could be assumed each breach would have the potential of $150,000 damage.

2.3 Biota, Habitat, and Water Quality Conditions

2.3.1 Data Sources

To assess existing biota, habitat, and water quality conditions in the project area, the project team drew on numerous reports and data sources, which are referenced in **Appendix A**. In addition to these past studies, the team conducted a field assessment in June 2018, which included:

- visual assessment of Port Bay in the vicinity of the coastal barrier to characterize habitat within the littoral zone along the bay side of the barrier bar, particularly in the breach area but also both east and west of the navigation channel;
- identification of individual habitat units within the littoral zone based on substrate type; the presence, type, and abundance of aquatic macrophytes; other cover types; and bottom slope; and
- observations of fish and wildlife use of the littoral zone and adjacent areas, including observed negative and/or positive impacts that occurred as a result of the 2017 barrier bar breach.

2.3.2 Fisheries

The NYSDEC conducted warm-water fishery assessments of Port Bay in 1992, 1993, and 2012 (Sanderson 2015). Additional surveys targeting only specific gamefishes were conducted in 1994 (for largemouth bass, walleye, and northern pike; Sanderson 2015) and 2017 (for walleye, bass, and yellow perch). The summary report for the 2017 survey was not available at the time this report was prepared. Twenty-two species of fish have been reported during these surveys (**Table 2.3-1**). All 22 reported species were collected during the 2012 survey, including four which were not collected in previous surveys (white sucker, grass pickerel, white perch, and round goby). Round goby is an invasive species that was first reported in Lake Ontario in 1998 and colonized Port Bay subsequent to the 1993 survey. The most abundant species in the 2012 survey was bluegill, followed by alewife and then largemouth bass. Other warm-water gamefish found in the bay include northern pike, brown bullhead, rock bass, pumpkinseed, black crappie, yellow perch, smallmouth bass (*Micropterus dolomieu*), channel catfish (*Ictalurus punctatus*), and chain pickerel (*Exos niger*), the last three of which were not collected during formal surveys (Sanderson 2015). In addition, four cold-water species— Chinook salmon, brown trout, coho salmon (*Onchorynchus kisutch*), and rainbow trout (*Onchorynchus mykiss*)—are seasonally available to anglers when they migrate through the bay during spawning runs to and from tributaries.

Table 2.3-1 Number and Relative Abundance of Fish Species Captured by Gill Netting and Board Electrofishing from Port Bay During NYSDEC Fisheries Survey, Sept. 2012

Common Name	Scientific Name	Gill netting		Electrofishing		Combined	
		No.	%	No.	%	No.	%
Bowfin	*Amia calva*	1	0.1%	7	0.6%	8	0.4%
Alewife	*Alosa pseudoharengus*	429	52.3%			429	21.3%
Gizzard Shad	*Dorosoma cepedianum*	200	24.4%	14	1.2%	214	10.6%
Chinook Salmon	*Oncorhynchus tshawytscha*	1	0.1%			1	0.0%
Brown Trout	*Salmo trutta*	2	0.2%			2	0.1%
Grass Pickerel	*Exox americanus*			5	0.4%	5	0.2%
Northern Pike	*Esox Lucius*			9	0.8%	9	0.4%
Common Carp	*Cyprinus carpio*	4	0.5%			4	0.2%
Golden Shiner	*Notemigonus crysoleucas*			7	0.6%	7	0.3%
Spottail Shiner	*Notropis hudsonius*	31	3.8%	14	1.2%	45	2.2%
White Sucker	*Catostomus commersoni*	5	0.6%	1	0.1%	6	0.3%
Brown Bullhead	*Ameiurus nebulosus*	7	0.9%	5	0.4%	12	0.6%
Brook Silverside	*Labidesthes sicculus*	14	1.7%	15	1.3%	29	1.4%
White Perch	*Morone americana*	30	3.7%	1	0.1%	31	1.5%
Rock Bass	*Ambloplites rupestris*			4	0.3%	4	0.2%
Pumpkinseed	*Lepomis gibbosus*			27	2.3%	27	1.3%
Bluegill	*Lepomis macrochirus*	9	1.1%	659	55.3%	668	33.2%
Largemouth Bass	*Micropterus salmoides*	4	0.5%	333	28.0%	337	16.8%
Black Crappie	*Pomoxis nigromaculatus*	3	0.4%	11	0.9%	14	0.7%
Yellow Perch	*Perca flavescens*	76	9.3%	75	6.3%	151	7.5%
Walleye	*Sander vitreus*	2	0.2%	3	0.3%	5	0.2%
Round Goby	*Neogobius melanostomus*	2	0.2%	1	0.1%	3	0.1%
Totals		820	100.0%	1,191	100%	2,011	100%

Source: Sanderson 2015

The shallow-water (water 2 m deep or less) fish community was dominated by bluegill and largemouth bass, which composed 55% and 28% of the 1,191 fish collected by boat electrofishing. Both of these species thrive in vegetated habitats such as those found in the nearshore areas of the bay. The open-water (4–8 m deep) fish community was dominated by alewife and gizzard shad, which composed 52% and 24% of the 820 fish collected by gill netting. These two species are planktivorous and typically occupy unvegetated offshore waters.

Fish species observed during the assessment of littoral zone habitat conducted in June 2018 included largemouth bass, bluegill, pumpkinseed, round goby, unidentified minnows, and unidentified fry (recently hatched fish). Largemouth bass, bluegill, and pumpkinseed were seen nesting in the littoral zone along the bay side of the east barrier bar. Many schools of fry and minnows were observed among beds of aquatic macrophytes in shallow, nearshore areas.

2.3.3 Rare, Threatened, and Endangered Species and Significant Habitats

The U.S. Fish and Wildlife Service (USFWS) was contacted to determine if any federally listed threatened or endangered species occur in the immediate vicinity of the Port Bay east barrier bar. The USFWS provided an Official Species List identifying species that are listed or proposed to be listed that may be present in the area of a proposed action. The northern long-eared bat (*Myotis septentrionalis*), a federally threatened species, may occur within the boundary of the proposed project and/or may be affected by the proposed project. Northern long-eared bats roost singly or in colonies underneath bark, in cavities, or in crevices of both live and dead trees (https://ecos.fws.gov/ecp/species/9045). Potential habitat for this species occurs in the wooded area of the western two-thirds of the east barrier bar. A targeted survey would be necessary to determine if this species is actually present on the barrier bar.

The New York Natural Heritage Program (NYNHP) was contacted for records of rare or state-listed animals and plants and significant natural communities that occur on or adjacent to the Port Bay Barrier Bar. The spiny softshell turtle is listed as an S2S3 Species of Greatest Conservation Need (High Priority) and a Species of Concern by the NYNHP. Occurrence of this species in the vicinity of Port Bay was documented through the New York State Amphibian and Reptile Atlas Project during surveys conducted from 1990 to 1999 (https://www.dec.ny.gov/animals/7140.html). This species was known to nest near the east end of the barrier bar prior to the 2017 breach. Nesting was again observed at the east end of the barrier bar in 2018 (personal communication from Port Bay resident B. Coon, 8/23/18) despite apparent impacts to the nesting area from the 2017 breach. This species prefers to nest on open, elevated sand or gravel banks or sandbars as close to the water as possible (Harding and Mifsud 2017). This type of habitat occurs along the bay side of the east barrier bar but was reduced in area following the 2017 breach.

The NYNHP also identified the occurrence of a significant natural community (Great Lakes aquatic bed) adjacent to the Port Bay Barrier Bar. This community consists of 395 acres of aquatic beds in excellent condition in Port Bay and is classified as a *High Quality Occurrence of Uncommon Community Type* by the NYNHP.

Port Bay is classified by NYSDOS as a Significant Coastal Fish and Wildlife Habitat (https://www.dos.ny.gov/opd/programs/consistency/Habitats/GreatLakes/Port_Bay.pdf). Such habitats receive this designation when the NYSDEC determines the habitat meets the following functions:

- is essential to the survival of a large portion of a particular fish or wildlife population
- supports populations of species which are endangered, threatened or of special concern
- supports populations having significant commercial, recreational, or educational value
- exemplifies a habitat type which is not commonly found in the State or in a coastal region

As per the Coastal Fish & Wildlife Habitat Rating Form for Port Bay (see above link), Port Bay is one of several large, sheltered, coastal bays on Lake Ontario. Extensive littoral areas, such as those found in Port Bay, are uncommon in the lake, and the bay serves as a very productive area for many fish and wildlife species. Port Bay has outstanding habitat values for resident and lake-based fisheries resources, including dense beds of aquatic vegetation, high water quality, sandy substrates, and freshwater inflow, that create highly favorable spawning and nursery habitat for many species. Port Bay also is a major concentration area for yellow perch in Lake Ontario. The diverse and productive fisheries in Port Bay, along with good public access, provide excellent opportunities for recreational fishing. Thus, Port Bay meets multiple criteria for designation as a Significant Coastal Fish and Wildlife Habitat.

2.3.4 Regulated Wetlands

The Port Bay Barrier Bar overlaps four federally designated National Wetlands Inventory wetlands classified as L1UBH, L2UBH, L2USJ, and R4SBC. The L1UBH wetland is a lacustrine (lake-like), limnetic (>2.5 m deep) habitat with an unconsolidated bottom (≥25% of substrate is <6 cm diameter, and vegetated cover is <30%) that is permanently flooded. Wetland type L2UBH is a lacustrine, littoral (≤2.5 m deep) habitat with an unconsolidated bottom that is intermittently flooded. The L2USJ wetland is lacustrine, littoral habitat with an unconsolidated shore (<75% cover of stones, boulders or bedrock) that is intermittently flooded. Wetland type R4SBC is a riverine (contained within a channel), intermittent streambed that is seasonally flooded.

No New York State regulated wetlands overlap the barrier bar, but there is one such wetland that is in close proximity to the barrier bar and two others that have boundaries or check zones that overlap the bay (**Figure 2.3-1**) New York State Wetland NW-9 is a Class 2 wetland of approximately 21.7 acres located immediately east of the barrier bar. Wetland NW-5 is a Class 1 wetland of approximately 347.2 acres located at the southern end of the western lobe of Port Bay. Wetland NW-8 is a Class 1 wetland of approximately 451 acres located at the southern end of Port Bay.

2.3.5 Aquatic Macrophytes

Aquatic macrophytes are a prominent feature of the Port Bay ecosystem. Macrophyte growth has become so dense in portions of the bay that mechanical harvesters are used to control the growth of problematic invasive species. **Table 2.3-2** provides a list of aquatic macrophytes known to occur in Port Bay and their status as native or invasive species. Much of the littoral zone of the bay (the area in which light penetrates to the bottom) supports dense beds of Eurasian watermilfoil, curlyleaf pondweed, broad waterweed, eel-grass, water stargrass, Richardson's pondweed, and coontail

(Sanderson 2015). A large proportion of the shoreline of Port Bay has been developed for residential use, so there is relatively little emergent vegetation growing along the shoreline. Where residential development has not occurred, dense stands of emergent vegetation like cattail, purple loosestrife, sedges, and water-willow may occur. White waterlily can also be found in nearshore areas lacking adjacent development.

Table 2.3-2 Species and Native/Invasive Status of Aquatic Macrophytes Known to Occur in Port Bay

Common Name	Scientific Name	Native/Invasive Status
American lotus	*Nelumbo lutea*	Native
Broad waterweed*	*Elodea canadensis*	Native
Cattail (unidentified)	*Typha sp.*	Native
Common frogbit	*Hydrocharis morsus-ranae*	Invasive
Coontail*	*Ceratophyllum demersum*	Native
Curlyleaf pondweed*	*Potamogeton crispus*	Invasive
Eel-grass*	*Vallisneria americana*	Native
Eurasian watermilfoil*	*Myriophyllum spicata*	Invasive
Flatstem pondweed	*Potamogeton zosteriformes*	Native
Floating pondweed	*Potamogeton natans*	Native
Greater duckweed*	*Spirodela polyrrhiza*	Native
Longleaf pondweed	*Potamogeton nodosus*	Native
Narrowleaf cattail*	*Typha angustifolia*	Native
Pondweed (unidentified)*	*Potamogeton sp.*	Native
Purple loosestrife	*Lythrum salicaria*	Invasive
Richardson's pondweed	*Potamogeton richardsonii*	Native
Sedge*	*Carex sp.*	Native
Slender naiad*	*Najas flexilis*	Native
Southern naiad	*Najas guadalupensis*	Native
Star duckweed	*Lemna trisulca*	Native
Stonewort*	*Chara sp.*	Native
Water buttercup	*Ranunculus aquatilis*	Native
Water chestnut*	*Trapa natans*	Invasive
Watermeal*	*Wolffia sp.*	Native
Water stargrass*	*Heteranthera dubia*	Native
Water-willow*	*Justicia sp.*	Native
White waterlily*	*Nymphaea odorata*	Native

Source: Unpublished data, K. Des Jardin, Finger Lakes Institute and EcoLogic, LLC.
* Denotes found in close proximity to the barrier bar.

The dominant submergent aquatic macrophyte species along the bay side of the barrier bar are the invasive Eurasian water milfoil and curlyleaf pondweed. Native submergent species that are relatively abundant in the vicinity of the barrier bar are coontail, broad waterweed, and stonewort. Narrowleaf cattail is the dominant emergent macrophyte along the barrier bar, but it occurs primarily along the bayside of the western portion of the bar.

2.3.6 Invasive Species

The Port Bay Barrier Bar has undergone significant physical change from its natural state. Physical disturbance, coupled with its direct connection to Lake Ontario and high human use of the bay, makes the Port Bay Barrier Bar and its littoral zone highly susceptible to colonization by invasive species. Aquatic invasive species known to regularly occur in the vicinity of the barrier bar include round goby, alewife, zebra mussel, Eurasian watermilfoil, curlyleaf pondweed, and water chestnut. Invasive terrestrial plant species reported growing on the barrier bar include bristly locust (*Robinia hispida*), Japanese honeysuckle (*Lonicera japonica*), swallow-wort (*Cynanchum sp.*), mugwort (*Artemisia vulgaris*), multiflora rose (*Rosa multiflora*), and reed canary grass (*Phalaris arundinacea*).

2.3.7 Water Quality

Port Bay is identified by New York State as a Class B waterbody. Port Bay is required to support and protect the best uses of primary and secondary contact recreation, and fishing use. The bay is relatively shallow, with a maximum depth of 8.2 m and a mean depth of 4.0 m (Cadmus Group 2011). However, it is deep enough that thermal and dissolved oxygen stratification occurs from late June through late August, with strong temperature and dissolved oxygen differences throughout the water column (Sanderson 2015). By mid-July, dissolved oxygen concentrations are anoxic at depths of 5 m and below.

The trophic status of the bay ranges from eutrophic to hypereutrophic (Sanderson 2015). Excessive nutrient loading, primarily phosphorus, has been an issue for Port Bay in the recent past. During the 2000s, summer mean epilimnetic total phosphorus concentrations were above 120 µg/L, several times higher than the New York State guidance value of 20 µg/L (Makarewicz and Nowak 2010). Port Bay was added to Part 1 of the New York State Clean Water Act Section 303(d) List of Impaired Waters 2006, as a waterbody requiring a Total Maximum Daily Load (TMDL) for Phosphorus. The Phosphorus TMDL for Port Bay was completed and approved by the United States Environmental Protection Agency (EPA) and Port Bay was removed from the list in 2010.

The TMDL for phosphorus was developed for the bay with the goal of reducing inputs of phosphorus in order to restore and protect the designated uses of the bay (Cadmus Group 2011). The TMDL identified the sources of phosphorus entering the bay, determined the phosphorus load capacity of the bay, identified target load allocations for each source of phosphorus, and developed implementation strategies for meeting the target allocations.

2.3.8 Littoral Zone Habitat

The littoral zone habitat of the bay side of the barrier bar was characterized during a field visit by a pair of biologists from EcoLogic, LLC on June 22, 2018. Individual habitat units within the littoral zone were delineated based on substrate type; the presence, type, and abundance of aquatic macrophytes; other cover types; and bottom slope. Aquatic macrophytes present and observations of fish and wildlife were recorded, and representative habitat features were photo documented. Eight distinct habitat segments were identified along the bay side of the barrier bar (**Figure 2.3-2**).

Habitat Segment 1. Habitat Segment 1 was approximately 40 m long and located at the far western end of the barrier bar (**Figure 2.3-3**). The littoral zone in this area was relatively narrow, extending offshore approximately 16-18 m, with the outer limit of aquatic macrophytes at approximately 5 m deep. Bottom substrate near shore was primarily sand with cobble and boulder along the water's edge. Substrate was primarily silt/mud offshore. The littoral zone was densely vegetated, with macrophytes occupying nearly the entire water column out to the vegetated limit (**Figure 2.3-4**). The dominant macrophyte was Eurasian watermilfoil. Other noted macrophyte species were curlyleaf pondweed, coontail, and white waterlily. The bank was lined with boulder and large cobble. Several schools of fish fry and minnows were observed. Zebra mussels (*Dreissena polymorpha*) were found clinging to macrophyte stems.

Habitat Segment 2. Habitat Segment 2 occupied a relatively long section of the western barrier bar, extending approximately 200 m along the narrowest portion of the western bar (**Figure 2.3-5** and **Figure 2.3-6**). The width of the littoral zone (16-18 m) and outer limit of aquatic macrophytes (approximately 5 m deep) was similar to that of Segment 1. Gravel was the dominant substrate near shore (**Figure 2.3-7**), with sand being sub-dominant toward the western end. Substrate was primarily silt/mud offshore. The littoral zone was densely vegetated, with macrophytes occupying much of the water column out to the vegetated limit. The dominant submergent macrophyte was Eurasian watermilfoil. Other submergent species noted included curlyleaf pondweed, slender naiad, and broad waterweed. The dominant emergent macrophyte was narrowleaf cattail. Other emergent or floating-leaf macrophytes observed were white waterlily, sedge, and one rosette of the invasive water chestnut. Much of the macrophyte growth was coated with filamentous algae, which formed small mats in some nearshore areas. Most of the bank was lined cattails, but there were small patches of exposed gravel beach in places. Schools of fish fry were observed, as were round goby and zebra mussels.

Habitat Segment 3. Habitat Segment 3 was a relatively short (approximately 45 m), broad (18-35 m wide) reach of littoral habitat (**Figure 2.3-8**). The outer limit of macrophyte growth was approximately 4.5 m deep. Eurasian watermilfoil was again the dominant submergent macrophyte, with curlyleaf pondweed, water stargrass, and broad waterweed also present. Narrowleaf cattail was abundant and formed a dense stand along the water's edge along the length of the segment. White waterlily occurred sporadically. Bottom substrate was primarily organic material immediately adjacent to the cattails and gravel adjacent to that. Offshore substrate was primarily silt/mud. Filamentous algae was abundant and formed dense mats along the outer edge of the cattails. Beaver (*Castor canadensis*) cuttings were observed at one location near shore.

Habitat Segment 4. Habitat Segment 4 was relatively large, extending along approximately 140 m of shoreline (**Figure 2.3-9** and **Figure 2.3-10**). This segment extended approximately 18 m offshore, with dense macrophyte growth out to the 3 m depth and macrophyte growth disappearing beyond the 4 m depth. Eurasian watermilfoil was the dominant submergent macrophyte, with curlyleaf pondweed, slender naiad, and an unidentified pondweed also present. Tall trees lined the bank in the western half of the segment. Narrowleaf cattail was abundant and formed a dense stand along the water's edge in the eastern half of the segment. White waterlily occurred sporadically. Similar to Habitat Segment 3, bottom substrate was primarily organic material immediately adjacent to the cattails or shore, gravel adjacent to that, and primarily silt/mud offshore.

Habitat Segment 5. Habitat Segment 5 was approximately 95 m long and located at the east end of the western portion of the barrier bar (**Figure 2.3-11** and **Figure 2.3-12**). It is adjacent to the area of the west barrier bar that has been developed for boating and recreational access. The littoral zone in this area broadened, extending offshore approximately 33 m, with the outer limit of aquatic macrophytes at approximately 4-5 m deep. Bottom substrate was primarily gravel and sand near shore and silt/mud offshore. Submergent macrophyte density was lower than in Segments 1-4, with percent coverage ranging from 10-25%. Eurasian watermilfoil and curlyleaf pondweed were the predominant submergent macrophytes. Small stands of emergent water-willow and sedge were present near shore. Portions of the shoreline and riparian zone were unvegetated gravel/soil, serving as parking lot, boat launch, and shoreline access points. Two floating, removable dock structures were located at the west end of the segment. Public use of this segment for boat launching and angling was relatively high. Anglers were observed catching largemouth bass and sunfish.

Habitat Segment 6. Habitat Segment 6, the largest habitat segment identified, was approximately 265 m long and located immediately east of the navigation channel that bisects the barrier bar (**Figure 2.3-13**, **Figure 2.3-14** and **Figure 2.3-15**). The littoral zone in this segment was relatively broad (20-30 m wide), with the outer vegetated limit at approximately 5 m deep. Bottom substrate was primarily a mix of gravel, old zebra mussel shell, and sand near shore and silt/mud offshore. Submergent macrophyte density was relatively high and extended to just below the surface until well offshore. Submergent macrophytes included curlyleaf pondweed, Eurasian watermilfoil, broad waterweed, coontail, and eel-grass. There was a small pocket of emergent vegetation on the east side of the point extending off of the west end of the segment. Emergent macrophytes noted in this area included narrowleaf cattail, water-willow, and sedge. Filamentous algal growth was prominent on much of the submergent vegetation and around the emergent vegetation. The riparian zone along this segment consisted of dense growth of mature trees and shrubs, including willow (*Salix* sp.), cottonwood, and box elder. The trees along the shoreline provided substantial cover in the form of overhanging limbs and shade. Large woody debris in the form of logs and large branches provided additional cover and habitat complexity for fish and wildlife. Many fish were observed in this segment, including nest-guarding largemouth bass, bluegill, and pumpkinseed. Schools of unidentified fish fry were also seen, as were a female mallard with a brood of chicks and turtles basking on logs extending out of the water.

Habitat Segment 7. Habitat Segment 7 was located in the mid-section of the eastern barrier bar, just west of the area that breached in 2017 (**Figure 2.3-16** and **Figure 2.3-17**). This segment was approximately 75 m long and approximately 25 m wide, with the outer vegetated limit at approximately 4 m deep. Submergent macrophyte density was lower than in Segment 6, and growth of macrophytes was not as close to the surface in the nearshore area. Eurasian watermilfoil and curlyleaf pondweed were the dominant submergent macrophytes near shore, but coontail and stonewort were dominant offshore (>2 m deep). No emergent vegetation was observed, but a single rosette of water chestnut was found in this segment. Filamentous algae coated much of the submergent vegetation. Substrate was primarily gravel with some sand near shore and silt/mud with some organic material offshore. Similar to Segment 6, the riparian zone along Segment 7 consisted of dense growth of mature trees (primarily willow) that provided substantial cover in the form of overhanging limbs and shade. Logs and roots provided additional in-water cover.

Habitat Segment 8. Habitat Segment 8 consisted of the eastern approximately 150 m of the barrier bar and included the section of the bar that breached in 2017 (**Figure 2.3-18**, **Figure 2.3-19**, and **Figure 2.3-20**). The littoral zone in this segment broadened from west to east, ranging approximately from 35 m to 70 m wide. Aquatic macrophytes were scarce or absent from shore out to approximately 1.6 m, were abundant out to the 3-m depth, and then became sparse, disappearing at about the 4-m depth. Curlyleaf pondweed was the dominant macrophyte out to the 3-m depth, where coontail and stonewort were more prominent. Eurasian watermilfoil was present but not dominant. The only emergent vegetation in this segment was a small patch of cattail that appeared to have been recently placed along the barrier bar (**Figure 2.3-21**). Filamentous algae was abundant on the macrophytes and the nearshore bottom substrate **Figure 2.3-22**). Nearshore (out to 2 m deep) bottom substrate was primarily gravel with lesser amounts of cobble along much of the segment's length (**Figure 2.3-18**), but sand increased in prominence near the east end of the segment. The offshore substrate was primarily silt/mud. Other than macrophytes, the only notable cover was a cluster of trees that had been pushed off shore during the breaching and protruded above the water's surface (**Figure 2.3-23**). Bluegill and pumpkinseed were observed guarding nests at the east end of the segment. Round gobies were also seen in this area. A large flock of gulls and terns was observed resting on the barrier bar in this segment as well.

Summary. Littoral zone habitat along the bay side of the Port Bay Barrier Bar varies by substrate, aquatic macrophyte abundance and composition, and bottom slope. Nearly the entire littoral zone supports submergent macrophytes, and this growth is often dense. Emergent macrophytes, primarily cattails, are prominent primarily along the western portion of the bar. The riparian zone along the majority of the barrier bar is also vegetated, primarily with large trees or shrubs. Of the eight habitat segments identified, seven (numbers 1-7) of them can be characterized as well-established habitats. These segments are not necessarily undisturbed, but their physical and biological features are relatively stable. The remaining habitat segment, Habitat Segment 8, is the one containing the area of the 2017 breach. The habitat in this segment is highly disturbed. This is evident from the lack of vegetation in the riparian zone; the reduced abundance, species richness, and density of aquatic macrophytes; and the clean, coarse nature of much of the nearshore substrate. The wave action and substrate mobilization associated with the breach restructured much of this area. This habitat segment is currently in a state of transition. The degree and timing of stabilization of the habitat in this area will be dependent on future levels of physical disturbance, such as that caused by breaching.

2.3.9 Summary of Impacts of the 2017 Breach on Biota, Habitat, and Water Quality

The breach and associated large-scale movement of sediment/substrate across the eastern end of the barrier bar that occurred in 2017 had significant impacts to the riparian and near-shore littoral zone of Port Bay in the vicinity of the breach. Riparian vegetation and soil on the barrier bar were eliminated in the vicinity of the breach and replaced with bare, unstable cobble/gravel substrate. This drastically reduced habitat complexity and eliminated an array of microhabitats capable of supporting a broad assortment of riparian wildlife along more than 100 m of the eastern barrier bar. The deposition of cobble/gravel on the bay side of the eastern barrier bar during this event buried existing near-shore aquatic macrophyte beds. It also replaced finer substrate materials such as silt and sand capable of supporting aquatic macrophytes and fish spawning with coarser mineral substrates incapable of supporting macrophytes and of considerably lower quality as fish spawning habitat.

The transport of coarse sediment across the eastern barrier bar during the 2017 breach also buried or otherwise altered the finer substrate at the east end of the bar that has supported nesting of spiny softshell turtles. Turtles were seen nesting in this location in 2018, but the area containing suitable nesting substrate and elevation was reduced by an undetermined amount following the breach in 2017.

The 2017 breach undoubtedly affected water quality in Port Bay, but the extent of this effect is unknown due to a lack of monitoring before, during, and after the breach. In addition, the extremely high water during 2017 following the breach also would have affected water quality, further complicating any ability to attribute water quality changes specifically to the breached condition. Speculatively, the breach would have increased mixing of the water column in Port Bay, potentially reducing the extent and duration of stratification and associated anoxic conditions in the deeper portions of the bay during summer 2017. There would have been greater exchange of water between the lake and the bay, which could have resulted in reduced levels of phosphorus in areas of the bay affected by lake inflow. This effect, if it did occur, was likely localized in the vicinity of the barrier bar and northeast portion of the bay.

The 2017 breach also provided increased connectivity between the bay and the lake for aquatic organisms. Fish making seasonal migrations for spawning or foraging purposes had a secondary passage route between the lake and the bay. This increased connectivity also increased the potential for genetic exchange between lake and bay populations of aquatic organisms. A potential negative aspect of this increased connectivity was the creation of an additional route through which invasive species could enter the bay.

Figure 2.3-1 New York State Regulated Wetlands in the Vicinity of Port Bay, NY

Image source: http://www.dec.ny.gov/gis/erm/

Figure 2.3-2 Littoral Zone Habitat Segments Identified along the Bay Side of the Port Bay Barrier Bar during the Littoral Zone Characterization, Jun. 22, 2018

Image source: Google Earth

Figure 2.3-3 Littoral Zone Habitat Segment 1 (looking north from south end)

Photo: K. Jirka, 6/22/18

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Figure 2.3-4 Littoral Zone Habitat Segment 1 Dense Macrophyte Growth

Photo: K. Jirka, 6/22/18

Figure 2.3-5 Littoral Zone Habitat Segment 2 (looking east-northeast from west end)

Photo: K. Jirka, 6/22/18

Figure 2.3-6 Littoral Zone Habitat Segment 2 (looking west-southwest from east end)

Photo: K. Jirka, 6/22/18

Figure 2.3-7 Littoral Zone Habitat Segment 2 Nearshore Gravel Substrate

Photo: K. Jirka, 6/22/18

Figure 2.3-8 Littoral Zone Habitat Segment 3 (looking northwest from east end)

Photo: K. Jirka, 6/22/18

Figure 2.3-9 Littoral Zone Habitat Segment 4 (looking east form west end)

Photo: K. Jirka, 6/22/18

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Figure 2.3-10 Littoral Zone Habitat Segment 4 (looking west from east end)

Photo: K. Jirka, 6/22/18

Figure 2.3-11 Littoral Zone Habitat Segment 5 (looking east from west end)

Photo: K. Jirka, 6/22/18

Figure 2.3-12 Littoral Zone Habitat Segment 5 (view toward west end from near midpoint)

Photo: K. Jirka, 6/22/18

Figure 2.3-13 Littoral Zone Habitat Segment 6 (looking north-northwest at west end)

Photo: K. Jirka, 6/22/18

Figure 2.3-14 Littoral Zone Habitat Segment 6 (looking north-northeast at west end)

Photo: K. Jirka, 6/22/18

Figure 2.3-15 Littoral Zone Habitat Segment 6 (looking east from midpoint)

Photo: K. Jirka, 6/22/18

Figure 2.3-16 Littoral Zone Habitat Segment 7 (looking west from midpoint)

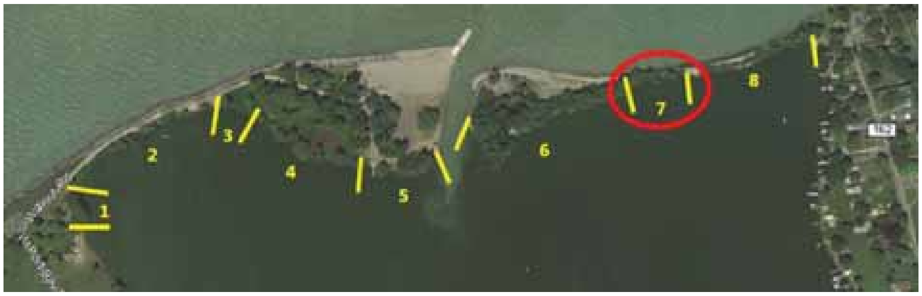

Photo: K. Jirka, 6/22/18

Figure 2.3-17 Littoral Zone Habitat Segment 7 (view toward east end from midpoint)

Photo: K. Jirka, 6/22/18

Figure 2.3-18 Littoral Zone Habitat Segment 8 (looking west from near midpoint)

Photo: K. Jirka, 6/22/18

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Figure 2.3-19 Littoral Zone Habitat Segment 8 (looking east from near midpoint)

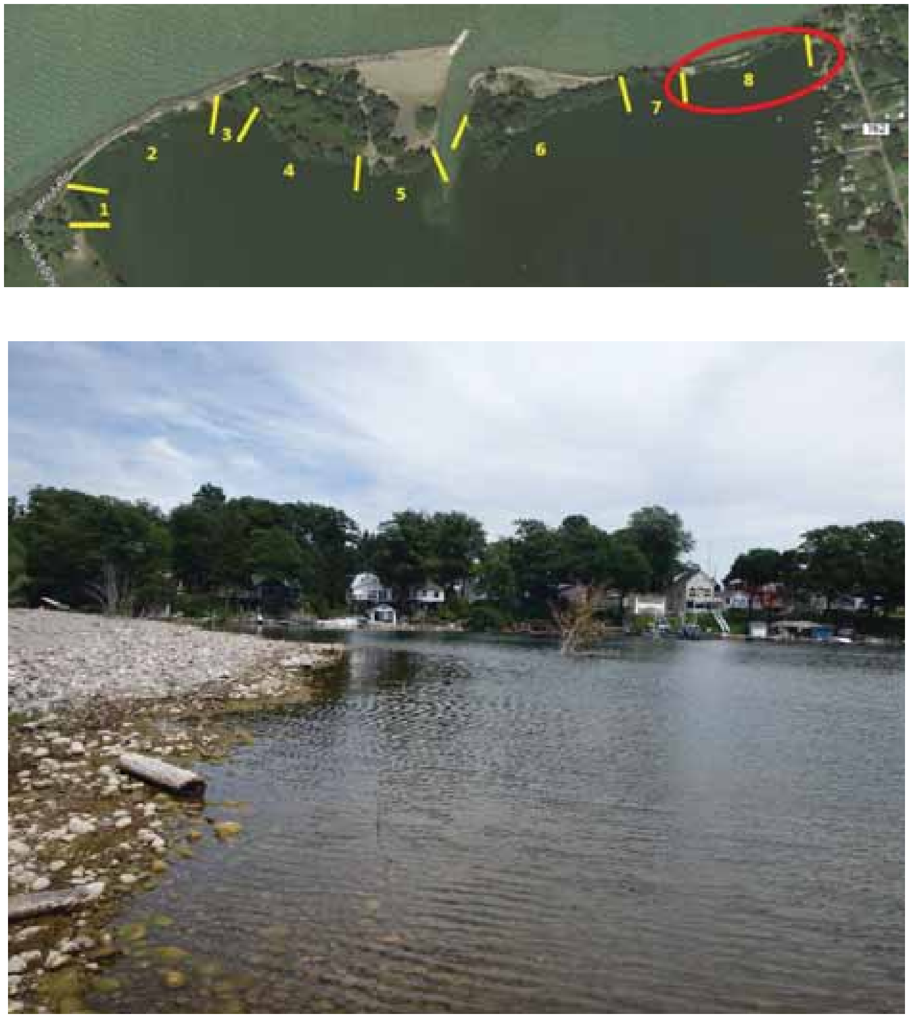

Photo: K. Jirka, 6/22/18

Figure 2.3-20 Littoral Zone Habitat Segment 8 (looking west from east end)

Photo: K. Jirka, 6/22/18

Figure 2.3-21 Littoral Zone Habitat Segment 8 Isolated Cattail Stand

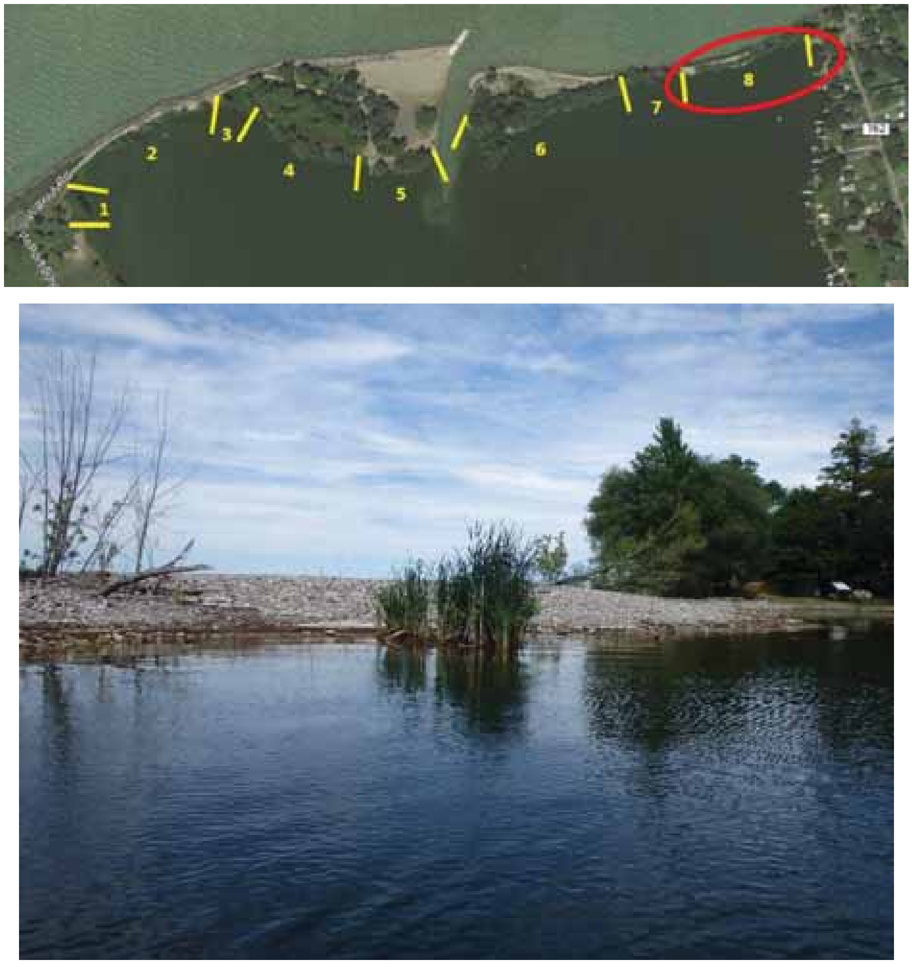

Photo: K. Jirka, 6/22/18

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Figure 2.3-22 Littoral Zone Habitat Segment 8 Filamentous Algae in Nearshore Area

Photo: K. Jirka, 6/22/18

Figure 2.3-23 Littoral Zone Habitat Segment 8 Offshore Cluster of Displaced Trees

Photo: K. Jirka, 6/22/18

3 Management Alternatives and Design Requirements

This section of the report describes the eight management alternatives developed during project scoping and provides conceptual layouts of the alternatives. As discussed in **Section 1.1**, NYSDEC is looking to evaluate management alternatives to achieve the best balance of the key project goals identified by the project stake holders, namely:

- Maintain natural/dynamic coastal features in the nearshore area, beach, and barrier bar.
- Maintain and restore natural coastal processes, including sediment transport.
- Maintain and protect natural habitat areas.
- Minimize damage to property and infrastructure, both public (NYSDEC WMA) and private (shoreline residents).
- Ensure human health and safety.
- Ensure continued fishing and boat access.
- Ensure feasibility of implementation.

As a result of discussions among the PAC, the eight management alternatives considered for managing the Port Bay barrier bar include:

- (A) no action,
- (B) limited sediment management,
- (C) nature-based barrier bar,
- (D) adaptive management,
- (E) infrastructure protection measures,
- (F) fortification using rock revetment,
- (G) fortification using rock revetment with armored overflow, or
- (H) fortification using rock revetment with culverts.

In the following alternative descriptions, note that aspects of some alternatives are incorporated into other alternatives, either in part or in their entirety. For example, early on in the review process it was determined that providing enhanced sediment management at the bar was considered a beneficial and feasible technique (see **Section 4**); therefore, it is included as a stand-alone alternative (Alternative B) as well as included as a part all the other alternatives.

It is important to note that the management alternatives described are at a schematic level of detail. The initial designs focus on providing protection on the east barrier bar between East Port Bay Road and the previously installed demonstration repair project at the site of the 2016 breach. Potential designs were advanced to a point to achieve general material and scale details in order to estimate a potential construction cost. Concept level sizing and design parameters are described further in

Appendix D (if applicable). Any management alternative selected would have to be fully detailed under final design/implementation, modifications such as protective length, elevation, and detailed design parameters would need to be detailed further. An evaluation of the management alternatives is reported in **Section 4**.

3.1 Management Alternatives

3.1.1 Permanent Equipment Access

During discussions with the PAC, it was determined that in order to facilitate sediment movement and maintenance of the east barrier bar, each of the design alternatives (not including Alternative A: No Action) would require the inclusion of some sort of reliable equipment access from East Port Bay Road to the east barrier bar, for maintenance and equipment access only. It should also be noted that a full evaluation of the dredging equipment access approach was not included as part of the scope of this study and should be further evaluated separately.

The adjacent property line, topography, and nearby shoreline present some challenges in establishing equipment access. If equipment access were configured to be located solely on NYSDEC property extending from East Port Bay Road, a large quantity of fill material may be needed lake side to accommodate equipment use. A preliminary estimate to construct a permanent equipment access of this nature was estimated to be cost prohibitive. However, it is expected that less-intrusive and more-affordable options could be evaluated. The final design would require the detailed design and evaluation of potential equipment access options. Possible options could include: a permanent access ramp, seasonal ramp, potential barge access, maintaining equipment access on existing NYSDEC property, or obtaining additional NYSDEC easements to utilize adjacent private property. Any final design of the equipment access would need to go through detailed analysis, design, and permitting. For the purposes of this report, a simplistic equipment access was assumed, with a potential construction cost of $200,000 and assumed to be same for each of the alternatives.

3.1.2 Alternative A: No Action

Alternative A, the no action or null alternative, is presented in **Figure 3.1-1.** This alternative represents a baseline condition under which no additional measures are taken, and management of the bar continues as it has previously. No future reactive measures, maintenance measures or modifications would be made by NYSDEC. The PBIA dredging activities would continue as they have previously, with placement of dredged materials in either Spoil Area #1 or #2, depending on access for the year. The alternative would include only the following already planned and/or constructed measures:

- 2016 nature-based stabilization measures (tree stumps, woody material and beach nourishment) previously constructed by SWCD;

- additional nature-based measures that were to be implemented by SWCD before the end of 2018 (plantings); and
- placement and spreading along the east barrier bar of sediments dredged from the navigation channel during 2017.

Under this alternative, the east barrier bar's longitudinal profile and plan form would respond to future wave, current, water level, and LST conditions under natural conditions. The existing dredging practices, placement, and permit conditions would remain unchanged. While it is not possible to determine if and when breaches would occur again on the east barrier bar, the recent trends of breaches in 2012, 2015, 2017, and 2018, the continued narrowing of the bar, and the general trend towards lower and lower levels of LST within Lake Ontario support the conclusion that breaches will continue to form, periodically, within the east barrier bar if left to natural conditions.

This alternative provides no additional protection to minimize the occurrence of future breaches, the shifting of the east barrier bar, or impacts to surrounding bay shoreline properties, bay users and turtle habit. The alternative leaves the east barrier bar to erode and repair itself naturally over time. There would be no additional construction related impacts beyond the dredging equipment access.

3.1.3 Alternative B: Limited Sediment Management

Alternative B, presented in **Figure 3.1-2**, would implement several sediment management measures, each of which would provide improvements to increase the amount of sediment deposited on the east barrier bar by managing LST based on modern coastal engineering principles. These measures are as follows:

<u>Base Alternative B</u>

- Provide reliable equipment access from East Port Bay Road to the east barrier bar, as described in **Section 3.1.1**. Periodic maintenance of the equipment access may be required; however, it is assumed that it should be able to be replenished as necessary with dredged materials.
- Modify the existing dredging permit by requesting that NYSDEC permanently waive the permit condition that restricts equipment from being transported through water. This will allow dredging equipment to traverse the east barrier bar to reach the channel and to place the dredged material at the shoreline using excavators.
- Place all seasonally dredged material (typically averages 1,000 CY, refer to **Section 2.1.9**), on the lake side of the east barrier bar or in shallow waters of the lake (where existing dredging equipment can operate) between the east edge of the navigation channel and a point just west of the rip-rap at the end of East Port Bay Road.

Additional Optional Measures for Alternative B (not included in the evaluation):

- Reduction of west pier: reduce the length of the west pier to allow a greater quantity of sediment to be naturally moved past the west pier.
- Sediment bypass: Add a sediment bypass as part of the dredging activities to move material from the west side of the pier to the east barrier bar to maximize the natural LST from west to east.

This alternative focuses on maintaining the natural conditions along the east barrier bar but aiding in the repair process by making dredging practices easier to move sediment trapped on the west side and within the navigation channel over to the east barrier bar to be reinstituted in the LST process. This option offers no direct protection against breaches; however, the additional sediment available to be moved each year would allow for more substantial material quantities available for influx into the natural repair and establishment system each spring. The placement of all the dredged materials along the lakeshore on the east barrier bar, would maximize the available sediment supply and reduce coastal erosion. This alternative would have temporary construction impacts each year and would be limited to the sediment supply within the navigation channel (i.e., no imported sediment).

3.1.4 Alternative C: Nature-Based Barrier Bar

Alternative C, presented in **Figure 3.1-3**, would follow the approach used after the 2016 breach, when Wayne County SWCD repaired the breach in the east barrier bar using nature-based methods, including buried live stumps, buried logs, placement of additional gravel material, and supplemental plantings. This November 2016 demonstration project raised the grade on the east barrier bar along an approximately 75 LF section of the bar to roughly elevation 248 in order fortify the location of the 2016 breach. These measures were effective in protecting the previous breach location in 2017 (the 2017 breach was east of the repair area). Under Alternative C, the following measures would be implemented:

- Use methods similar to those used in 2016 to provide added protection to the barrier bar. Buried wood logs and stumps, additional gravel material, and plantings would be installed across the east barrier bar, east of the demonstration project eastward to East Port Bay Road (approximately 350 ft). Nature-based techniques are generally preferable to hardened structures according to the State’s coastal management policies.
- The bar elevation would be raised to elevation 252 ft (which exceeds the 2016 repair elevation).
- Additional sediment material would likely need to be imported to build the barrier bar. The materials would be cobbles and gravels with an overall D50 similar to or larger than the D50 of the cobble material presently located on the bar.
- Incorporate the base elements of Alternative B, including equipment access.

Additional Optional Measures for Alternative C (not included in the evaluation):

- Incorporate the hardened overflow zone from Alternative G.
- Additional protection may include environmentally enhanced structural measures (such as rock toe protection).

This alternative increases the level of protection on the east barrier bar to reduce the potential for future breaches. Nature-based solutions are typically weakest when initially constructed but strengthen over time as vegetation is established. They require more maintenance in the early years and potentially following extreme events to ensure continued protection. The nature-based alternative allows the bar to maintain its natural features and processes and adjust naturally with additional internal fortification and plant-life with root systems that will aid in strengthening the bar. The height of the bar will aid in wave protection within the bay. Sediment will build and erode from the lakeside of the bar naturally. The bayside of the bar will maintain its natural condition providing bayside habitat. The increased sediment transport measures described in Alternative B will aid in annual replenishment of gravel material on the east barrier bar.

Temporary construction impacts are required for the construction as well as for the maintenance of spreading of dredged materials annually and other periodic maintenance. The buildup of the bar would require permanent fill within Lake Ontario. Efforts should be made minimize the impacts to the bay side of the bar to protect the existing habitat areas.

3.1.5 Alternative D: Adaptive Management

Alternative D, presented in **Figure 3.1-4**, would:

- Leave the east barrier bar in a natural state, but
- Define conditions that, when met, would act as triggers for actions such as repairs or maintenance activities to escalate the level of protection of the barrier bar and provide a long-term management plan. The management plan would be a formal document outlining the intended strategy and adopted by NYSDEC.
  - Example triggers: Anticipated periods of greater than normal high water, lower than normal barrier bar crest elevations, repeated breach conditions
  - Example actions: Sandbag/jersey barrier protection, provide gravel nourishment and bar reshaping, spot repair with nature-based solutions, full length nature-based repair, rock revetment protection
- Incorporate the base elements of Alternative B, including equipment access.

Plans similar to this have been referred to as “breach contingency plans”, and they have been developed for other coastal areas of New York State. The details of the triggers would need to be defined in advance and a monitoring plan developed to identify when the triggers are met. For example, if a trigger is based on estimates of predicted water surface elevations, then it would be possible to respond in advance to a predicted exceedance of the trigger with protective measures. Narrowing of the east barrier bar due to high water and/or erosion or breaching could be used as another trigger that would require monitoring and reactive post-trigger maintenance/repair.

This alternative allows for a long-term progressive management of the bar allowing for the natural condition of the bar to remain until a potential breach presents unacceptable risks. Stepping the protection measures allows NYSDEC to attempt to maintain the natural condition or implement small-scale solutions while maintaining the natural function of the bar before resorting to hardened measures.

Several of the actions in the management plan would have to be pre-permitted to allow for emergency response. Other more substantial actions would be permitted individually. This option requires a significant amount of time, pre-allocated funds and manpower on NYSDEC's part to monitor the conditions, establish emergency responses, and evaluate the needs of the area for escalation to a different strategy of the management plan.

This alternative would have the same temporary annual maintenance impacts as the previous alternatives. Other construction impacts are not fully able to be determined until a management strategy is devised; however, is assumed to be minimal or temporary as the initial intent would be to conduct the least invasive measures first.

3.1.6 Alternative E: Infrastructure Protection Measures

Alternative E, presented in **Figure 3.1-5**, focuses on protecting infrastructure (homes, docks, walls, shoreline of the bay) from damage by ice and woody debris that could be carried through any future breaches. To accomplish this, the alternative would:

- Leave the barrier bar and any potential breach in a natural state.
- Construct a long debris boom on the Port Bay side of the east barrier bar. A challenge of this alternative is that since the location of any future breach cannot be precisely known in advance, the debris boom itself would need to protect the narrow portion of the east barrier bar beginning at the eastern end of the 2016 demonstration project and extending to East Port Bay Road. The eastern anchorage would be located near East Port Bay Road and the equipment access location, and the west anchorage would be near where the bar begins to widen again. Optimized locations for the anchorages would be determined during design. The anchorages would likely be concrete structures buried into the east barrier bar to provide adequate strength against wave and debris loads. The boom would be designed to float vertically from low water to the 30-year anticipated water level.
- Incorporate the base elements of Alternative B, including equipment access.

This alternative allows the bar to remain in a completely natural state which will erode and repair, breach and move continuously. This alternative does not provide any additional protection from high wave conditions or prevent breaches from occurring. The sole purpose of this alternative would be to capture and minimize the amount of debris that would make its way through a potential breach or over the low barrier bar. This capturing of debris would aid in minimizing damage to bay property owners that stated debris was a significant source of damage during the 2017 breach. As a side effect, the boom may encourage settlement of material within the protected area as a result of the accumulated debris and lower velocities.

The boom will require on-going maintenance from NYSDEC for installation and removal of the boom (unlikely needed during low water / winter months), removal and disposal of accumulated debris, storage of the boom, as well as general boom repair and maintenance. The boom would also limit or minimize boat access to the bayside of the east barrier bar. It would need to be designed to minimize the navigational impacts.

3.1.7 Alternative F: Fortification Using Rock Revetment

Alternative F, presented in **Figure 3.1-6**, would have the primary outcome of ceasing migration and erosion of the east barrier bar. This alternative would:

- Implement a conventional rock revetment fortification along the narrow portion of the east barrier bar shoreline incorporating a minimal amount of vegetation beginning at the easterly end of the 2016 demonstration project and extending to East Port Bay Road.
- Incorporate the base elements of Alternative B, including equipment access.

Taking elements of the rock revetment designs from the PBIA / SWCD conceptual design and the west barrier bar design, the rock revetment proposes complete hardening of the east barrier bar. The core of the barrier bar would be reconstructed using sand/gravel geotextile blocks to form a sturdy foundation. The lake side of the revetment would be constructed of layers of quarried rock of varying dimensions. The varied gradation allows for a “chinking” of the rocks. A base layer of smaller diameter stone will be placed before the heavier armor stone. This minimizes the suction of smaller grained materials through the rock void spaces which can undermine rock revetments. The armor stone will be sized to withstand movement during the peak wave events of the design storm, allowing for a 30-year life span. Revetment design parameters and stone sizing calculations are provided in **Appendix D**. The remainder of the bar will be formed with imported gravel/cobble sized material, similar to or slightly greater in size than the existing bar material.

The top elevation of the revetment will be set at 252, similar to that of the west barrier bar and the higher points on the east barrier bar. The elevation of the bar is set to protect the bay from breaking waves during high water events (see **Appendix D**). The concept design shows a 2H:1V side slope for the revetment. Variations in side slope would be considered if the alternative proceeds to a design phase. Lessening the slope would increase cost (increase quantities) and fill within the lake and/or bay. The bay side of the barrier bar would be planted to provide some bayside habitat, with attempts to keep the existing slope.

The rock revetment alternative is designed to ultimately negate or substantially reduce the likelihood of a future breach, movement/shifting of the barrier bar, and reduce the vast majority of wave impacts into the bay from the lake. The alternative does destroy the nearshore habitat and removes any natural condition of the east barrier bar. The temporary construction impacts would have a significant impact on the bay side habitat; however, the bay side would be revegetated and shaped to return to a condition similar to existing. The revetment would minimize the amount of sediment being pushed over the bar and into the bay side area and turtle habitat.

Hardening of the shoreline also removes additional sediment from the LST process. The base elements of Alternative B would allow for the maintenance practices of placing dredged material on the east barrier bar; however, placement would be limited to the western end of the bar which would remain natural. The sediment movement may help minimize the downgrade in LST to downstream shorelines, but no more than the other alternatives.

3.1.8 Alternative G: Fortification Using Rock Revetment with Armored Overflow

Alternative G, presented in **Figure 3.1-7**, is a variation on the rock revetment fortification (Alternative F) that would allow for water exchange between the lake and bay during high water conditions, which could in turn improve fish and wildlife habitat. Similar to Alternative F, Alternative G would begin at the easterly end of the 2016 demonstration project and extend to East Port Bay Road. This alternative would:

- Include an armored depression in the east barrier bar with an elevation set at a point that allows exchange of lake and bay waters when either the bay or lake water levels reach a predetermined elevation based primarily on aquatic habitat considerations (assumed for purposes of this report as elevation 246.0). While the crest of Alternative F is 252, this alternative would descend from 252 to 246 at a 10% slope, remain flat at 246 for a short distance and the ascend to elevation 252 at a 10% slope. The 10% slope would be required to allow for equipment to traverse the crest of the bar.
- Includes a debris boom, similar to that described in Alternative E, but a smaller scale. The boom would only cover the overflow area that would be more frequently overtopped. The boom would be anchored using concrete, similar to Alternative E. The boom would likely remain resting on the back side of the revetment during lower water levels but would be designed to rise with higher water levels.
- Incorporate the base elements of Alternative B, including equipment access.

The revetment would be designed similar to Alternative F. This top of the crest would need to be protected using the armor stone as described in Alternative F as this area would be subject to wave action. A covering of smaller material (alternatives include concrete, articulated mattresses, etc.) would be placed to allow for the equipment to more easily traverse. The lowering of the crest elevation allows for limited water exchange between the lake and the bay. During periods of high water in the lake, flow and waves would enter the bay and allow for minor flushing. Additionally, some fish and other aquatic creature access between the bay and lake would be possible, depending on the elevation of the crest. During the winter months when bay levels tend to rise, the lowered crest would provide a permanent outflow location to keep water levels reasonable until the navigation channel is dredged.

This alternative hardens the shoreline with the intention of completely reducing the likelihood of future breaching. The depression attempts to provide some aquatic benefits; however, decreases the level of protection to the property owners from wave action and debris. Regular maintenance from NYSDEC would be required to remove sediment and debris build up from the crest. The intent would be to design the crest to be traversable yet sustainable to wave action; however, potential repair to the revetment crest would also be a possibility (assumed similar to replenishment of access road on west barrier bar).

Hardening of the shoreline also removes additional sediment form the LST process. The base elements of Alternative B would allow for the maintenance practices of placing dredged material on the east barrier bar; however, placement would be limited to the western end of the bar which would remain natural. The sediment movement may help minimize the downgrade in LST to downstream shorelines, but no more than the other alternatives.

3.1.9 Alternative H: Fortification Using Rock Revetment with Culvert(s)

Alternative H, presented in **Figure 3.1-8**, is another variation on the rock revetment fortification that provides for water exchange between the lake and bay (Alternative G), but in Alternative H the overflow section is replaced with one or more box culverts that would maintain the revetment crest but still allow for water exchange. Similar to Alternative F, Alternative H would begin at the easterly end of the 2016 demonstration project and extend to East Port Bay Road. This alternative would:

- Include box culverts with their inverts set at an elevation that allows exchange of lake and bay waters when either the bay or lake water levels reach a predetermined elevation based primarily on aquatic habitat considerations.
  - For the purposes of this report, two 8′ x 8′ box culverts have been assumed. The invert of the culverts is set at 242 with 3′ of natural fill material within the box to an elevation of 245 (roughly lake bottom elevation near the shore).
  - Box culverts are assumed to meet H-20 loading with sufficient coverage and maintaining the 252 crest elevation.

  - Box culverts are assumed to have sloped end sections to aid in material placement.
- Incorporate the base elements of Alternative B, including equipment access.

This alternative would be designed similar to Alternative F with the intent of preventing or minimizing the likelihood of future breaches. The elevation of the crest also reduces the effects of wave action and debris on the residents of Port Bay.

The box culverts allow for exchange of lake and bay water as well as providing a means for aquatic life movement between the bay and the lake; however, the height and stability of the revetment allow for waves to break on the revetment rather than enter the bay. The culvert openings, depending on the size and inverts, would open up the possibility of debris movement into the bay as well. Similar to Alternative H, the culvert openings would aid in maintaining safe water elevations in the bay during late winter/early spring months when the bay levels tend to rise.

This alternative hardens the shoreline with the intention of completely reducing the likelihood of future breaching. The culverts attempt to provide some aquatic benefits; however, decreases the level of protection to the property owners from wave action and debris. Regular maintenance from NYSDEC would be required to remove sediment and debris build up from within the culverts to maintain the design inverts.

Hardening of the shoreline also removes additional sediment form the LST process. The base elements of Alternative B would allow for the maintenance practices of placing dredged material on the east barrier bar; however, placement would be limited to the western end of the bar which would remain natural. The sediment movement may help minimize the downgrade in LST to downstream shorelines, but no more than the other alternatives.

FIGURE 3.1-1

ALTERNATIVE A
DO NOTHING / NULL

Date: May 2019

Legend:

- Dredged Material Spoil Area to Remain
- Zone of Dredged Material Placement in 2017
- 2016 Demo Project Area To Remain
- Approximate Parcels
- DEC Lands

100 50 0 100 Feet

1 inch = 150 feet

Port Bay Barrier Bar Assessment

OGS Project No. SC286

FIGURE 3.1-2

ALTERNATIVE B LIMITED SEDIMENT MANAGEMENT

Date: May 2019

Legend:

- Area of Potential Dredging
- Zone of Proposed Dredged Material
- Equipment Access to East Barrier Bar
- 2016 Demo Project Area To Remain
- Zone of Dredged Material Placement in 2017
- Approximate Parcels
- DEC Lands

100 50 0 100 Feet

1 inch = 150 feet

Port Bay Barrier Bar Assessment

OGS Project No. SC286

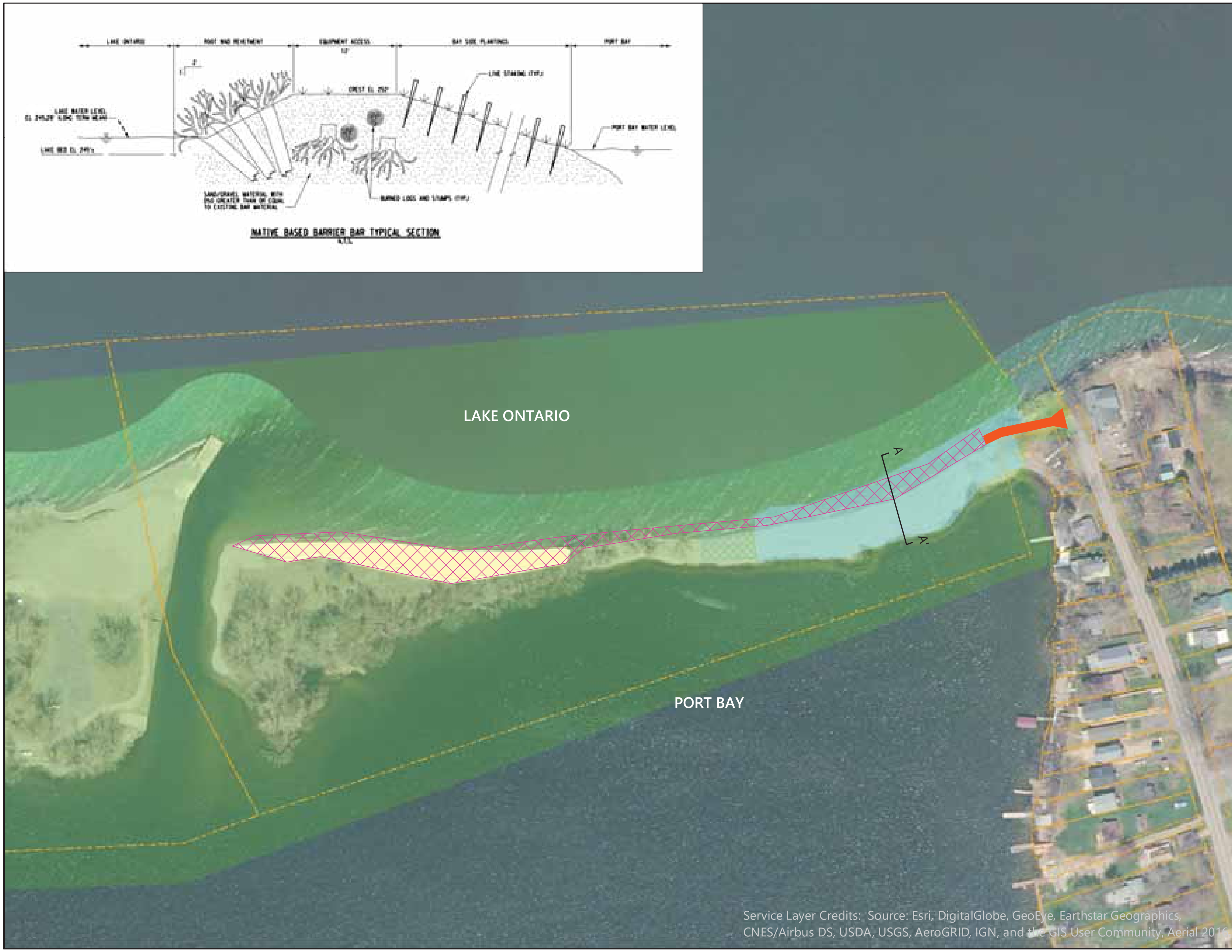

FIGURE 3.1-3

ALTERNATIVE C NATURE-BASED BARRIER BAR

Date: May 2019

Legend:

- Equipment Access to East Barrrier Bar
- Zone of Proposed Dredged Material
- Nature-Based Barrier Bar Measures
- Zone of Dredged Material Placement in 2017
- 2016 Demo Project Area To Remain
- Approximate Parcels
- DEC Lands

100 50 0 100 Feet

1 inch = 150 feet

Port Bay Barrier Bar Assessment

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New York State Department of Environmental Conservation

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FIGURE 3.1-4

ALTERNATIVE D ADAPTIVE MANAGEMENT

Date: May 2019

Legend:

- Equipment Access to East Barrier Bar
- Zone of Proposed Dredged Material Placement
- Zone of Dredged Material Placement in 2017
- 2016 Demo Project Area To Remain
- Approximate Parcels
- DEC Lands

100 50 0 100 Feet

1 inch = 150 feet

Port Bay Barrier Bar Assessment

OGS Project No. SC286

FIGURE 3.1-5

ALTERNATIVE E INFRASTRUCTURE PROTECTION MEASURES

Date: May 2019

Legend:

- Debris Boom
- Equipment Access to East Barrier Bar
- Zone of Proposed Dredged Material Placement
- Zone of Dredged Material Placement in 2017
- 2016 Demo Project Area to Remain
- Approximate Parcels
- DEC Lands

100 50 0 100 Feet

1 inch = 150 feet

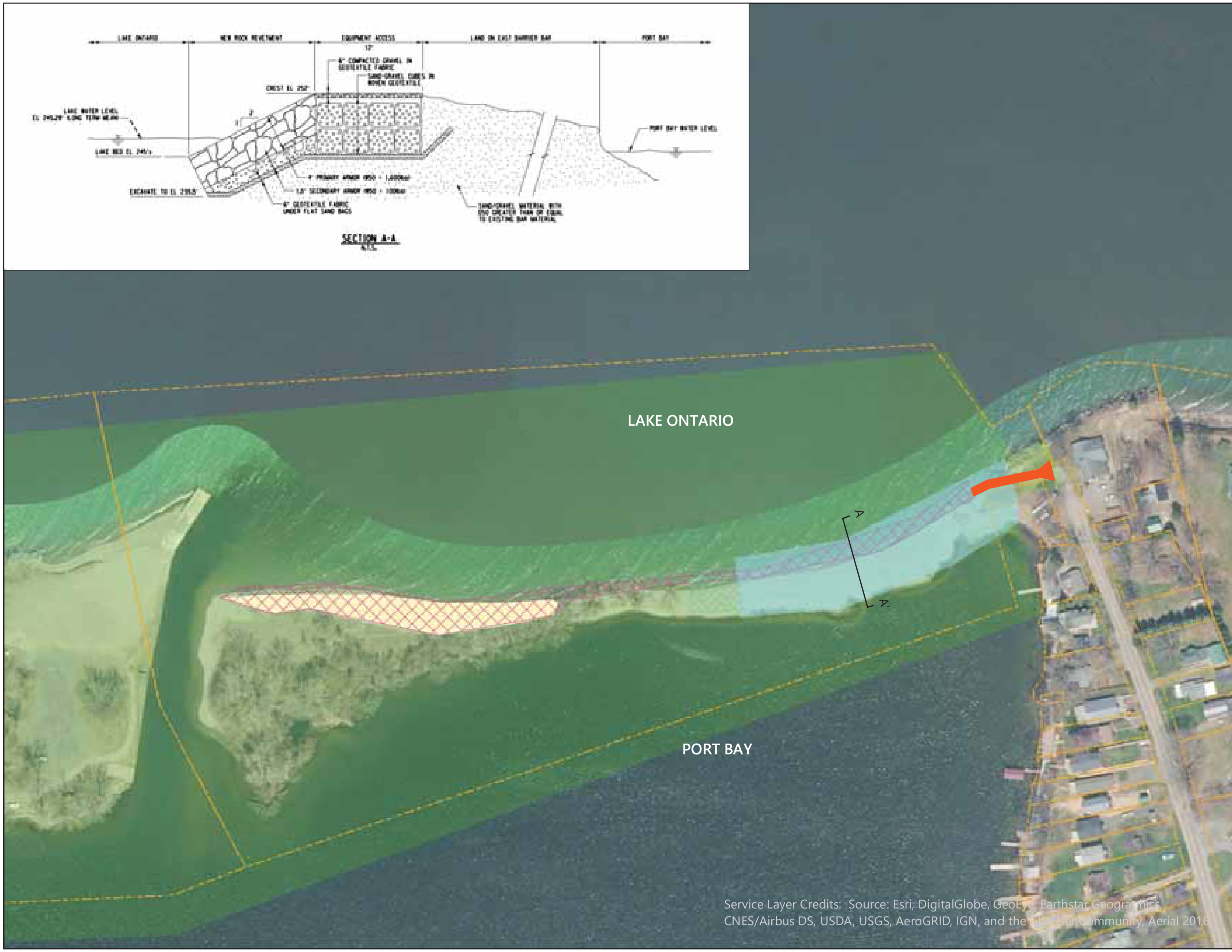
Port Bay Barrier Bar Assessment

OGS Project No. SC286

FIGURE 3.1-6

ALTERNATIVE F FORTIFICATION USING ROCK REVETMENT

Date: May 2019



Legend:

- Equipment Access to East Barrier Bar
- Rock Revetment
- 2016 Demo Project Area To Remain
- Zone of Proposed Dredged Material Place ment
- Zone of Dredged Material Placement in 2017
- Approximate Parcels
- DEC Lands

100 50 0 100 Feet

1 inch = 150 feet

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OGS Project No. SC286

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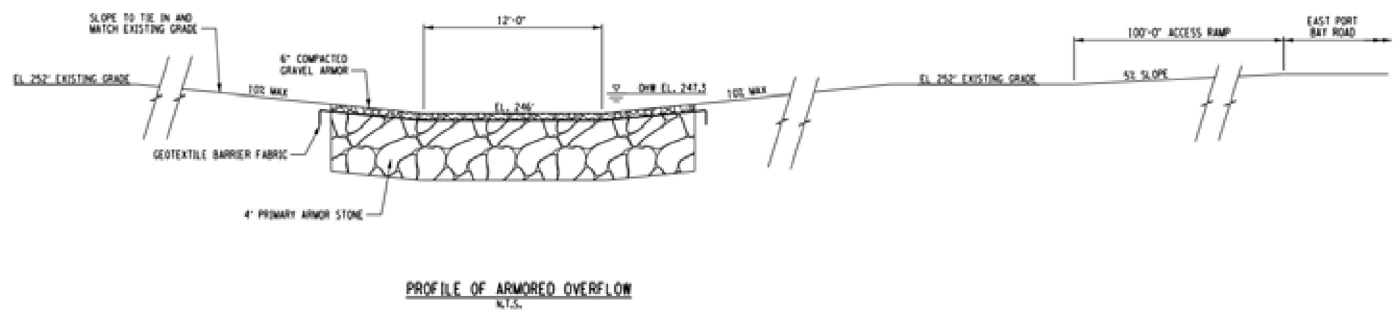
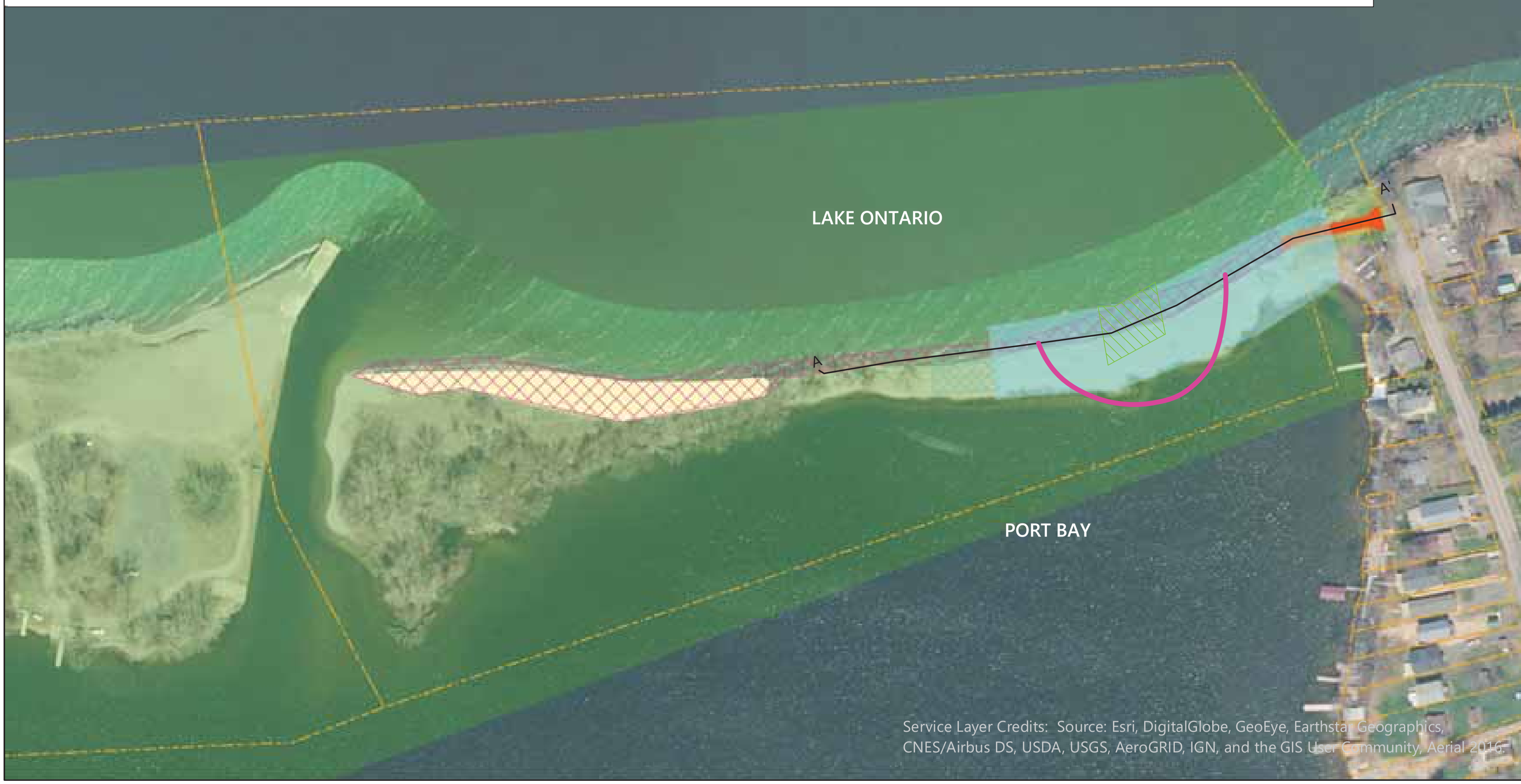
FIGURE 3.1-7

ALTERNATIVE G ROCK REVETMENT WITH ARMORED OVERFLOW

Date: May 2019





Legend:
- Debris Boom
- Overflow Area
- Rock Revetment
- Equipment Access to East Barrier Bar
- Zone of Proposed Dredged Material Placement
- Zone of Dredged Material Placement in 2017
- 2016 Demo Project To Remain
- Approximate Parcels
- DEC Lands

100 50 0 100 Feet

1 inch = 150 feet

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OGS Project No. SC286

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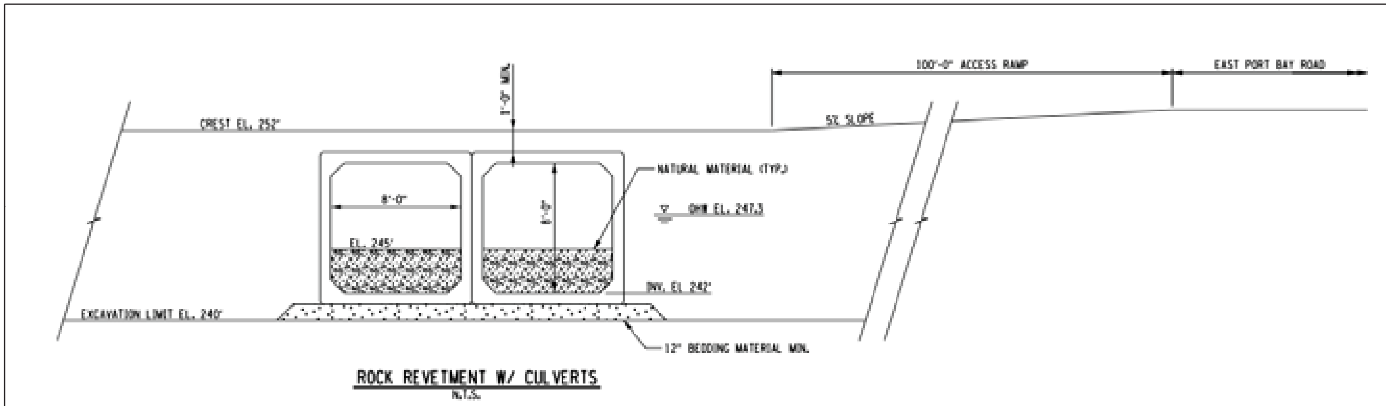
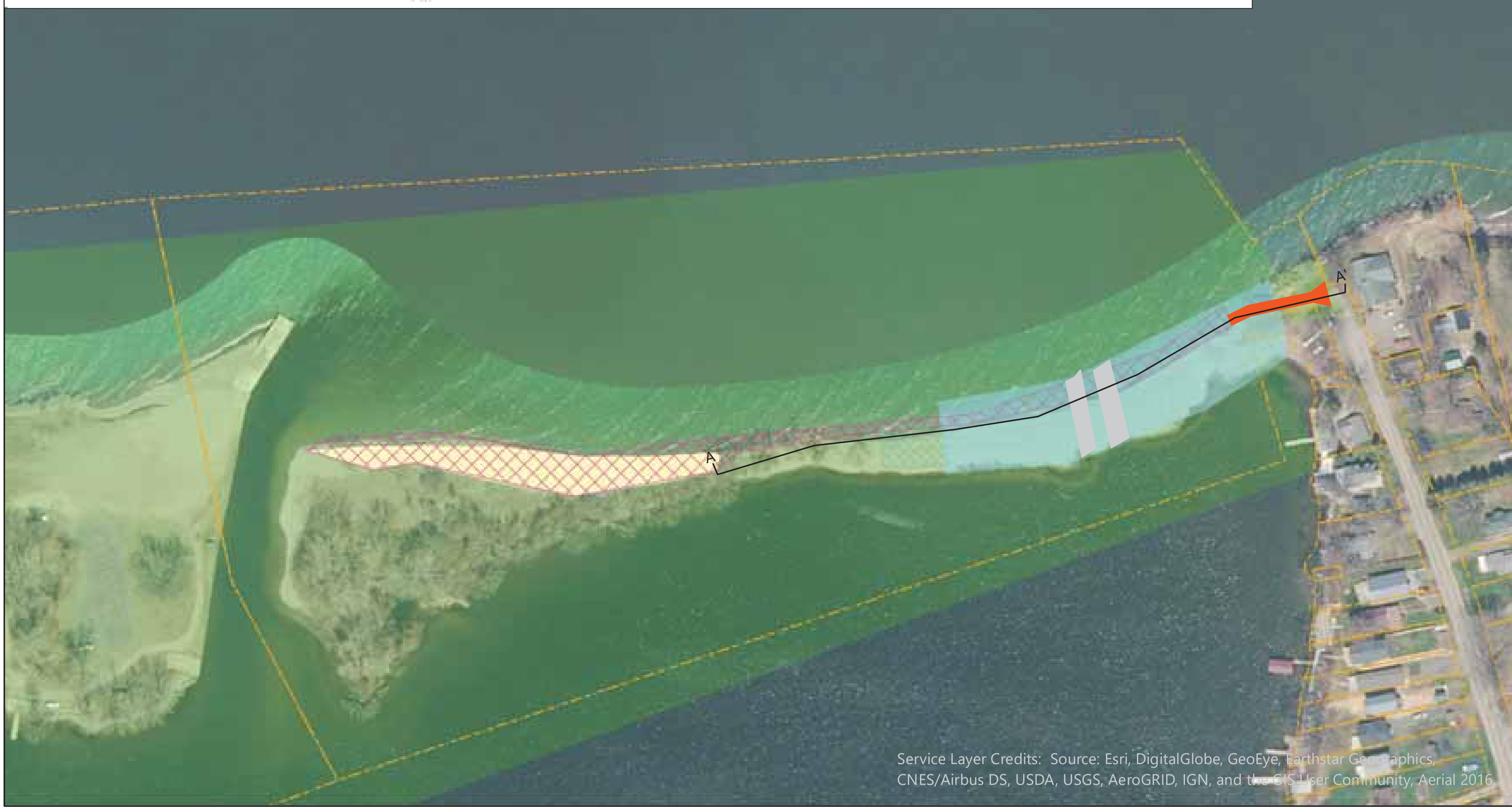
New York State of Opportunity Department of Environmental Conservation
BERGMANN Architects Engineers Planners
EcoLogic LLC

FIGURE 3.1-8

ALTERNATIVE H ROCK REVETMENT WITH CULVERT(S)

Date: May 2019





Legend:

- Debris Boom
- Culverts
- Equipment Access to East Barrier Bar
- Rock Revetment
- Zone of Proposed Dredged Material Placement
- 2016 Demo Project To Remain
- Zone of Dredged Material Placement in 2017
- Approximate Parcels
- DEC Lands

100 50 0 100 Feet

1 inch = 150 feet

Port Bay Barrier Bar Assessment

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4 Evaluation and Recommendations

4.1 Overview of the Alternatives Evaluation Process

The management alternatives were evaluated in stages using a multi-step process that screened the options based on selected evaluation criteria. A preliminary screening of alternatives based on conformance with the State Coastal Management Policies and the policies outlined in the Town of Huron Local Waterfront Revitalization Program (LWRP) was attempted by the PAC. This screening process was determined to be premature due to the early conceptual stage of the alternatives and lack of information regarding the need and goals for the project. As such, the coastal management policy screening method of evaluation was abandoned as a formal screening process and the project goals were developed to act as the measurement tool for analysis of each alternative. Additional preliminary screening was conducted during the public meeting held on September 8, 2018 at the Elks Lodge in Wolcott, NY. The meeting presented the preliminary management alternatives to the community for review and comment. This information was used to modify the alternatives and considered during the final evaluation.

The final evaluation was conducted in two phases. First, all eight alternatives were evaluated against the overarching project goals and the anticipated coastal processes within the project area. A detailed description of the coastal processes analysis is provided in **Appendix E**. Based on these evaluations, considerations from the PAC, and comments from the public input, three alternatives were removed from further analysis. The remaining five alternatives were then advanced to provide conceptual construction costs and life cycle costs to aid in determining the feasibility of each of the five alternatives. Based on all of these evaluations, the alternative that best met the multiple project goals and indicators was identified as the recommended alternative.

The evaluations are based on the conceptual designs described in **Section 3**. It is important to note that these designs only reflect a schematic level of design to represent varying types of management activities. Any implemented project would still require detailed design prior to permitting by NYSDEC, NYSDOS, NYSOGS, USACE and any other local regulatory agencies to ensure all applicable requirements are met.

The eight alternatives evaluated (described in **Section 3**) are:

- Alternative A: No Action
- Alternative B: Limited Sediment Management
- Alternative C: Nature-Based Barrier Bar
- Alternative D: Adaptive Management
- Alternative E: Infrastructure Protection Measures
- Alternative F: Fortification Using Rock Revetment

- Alternative G: Fortification Using Rock Revetment with Armored Overflow
- Alternative H: Fortification Using Rock Revetment with Culvert(s)

For the purpose of the evaluation, each of the design alternatives (not including Alternative A – No Action) are assumed to be the base condition, as described in **Section 3**, which includes providing reliable equipment access and the limited sediment management outlined as base conditions of Alternative B.

The project goals that were used as the first phase of screening criteria were identified by the PAC; whose input was based on discussions of the Port Bay Working Group. These overarching project goals considered an array of factors—coastal processes, ecological and habitat-related concerns, human priorities and socioeconomic factors—reflecting an ecosystem-based management approach to alternative evaluation and selection, rather than a strictly cost-benefit ratio evaluation. Each of the goals was more specifically defined using a set of indicators that helped to assess how well each alternative supported the broader goal, as outlined in **Table 4.1-1**.

Table 4.1-1 Project Goals and Indicators Used to Screen Management Alternatives

Goals	Indicators
Maintain natural/dynamic coastal features in the nearshore area, beach, and barrier bar.	• Minimizes disturbance to east barrier bar • Minimizes disturbance to nearshore area • Reduces long-term breaching or loss of east barrier bar
Maintain and restore natural coastal processes, including sediment transport.	• Maintains natural shoreline • Promotes longshore transport (LST) • Maintains low gradient shoreline slopes • Minimizes impacts to downdrift neighbors
Maintain and protect natural habitat areas.	• Protects turtle habitat • Protects shorebird habitat / nearshore habitat in lake • Protects fisheries habitat in bay • Protects wildlife habitat in bay • Minimizes impacts to bat habitat
Minimize damage to property and infrastructure, both public (NYSDEC WMA) and private (shoreline residents).	• Maintains a continuous east barrier bar • Minimizes potential damage to shoreline properties from debris • Protects against wave action
Ensure human health and safety.	• Improves water quality circulation in bay • Minimizes risks to recreational users (boaters, anglers, hikers, beachgoers) • Ensures boaters and other users continued shielding from extreme lake conditions in the bay (i.e., storm events)
Ensure continued fishing and boat access.	• Minimizes impacts to boaters in the bay • Maintains shoreline access across east barrier bar

Goals	Indicators
Ensure feasibility of implementation.	• Grant funding availability • Minimizes management time commitment • Minimizes risk of emergency responders and maintenance personnel • Maintains equipment access to east barrier bar for dredging / maintenance purposes • Construction Cost *(From Phase 2 of evaluation)* • Operation and Maintenance Cost *(From Phase 2 of evaluation)*

4.2 Evaluation of Alternatives Against Project Goals and Indicators

Each of the eight potential alternatives were evaluated against the project goals and indicators as outlined above. Each of the alternatives were evaluated as to how well they met the conditions of each of the indicators. One of six different categories was then assigned to each alternative for a particular indicator: High, Moderate to High, Moderate, Low to Moderate, Low or None. If an alternative could be described to perform well for a particular indicator, it was given a High value, those that performed poorly or would not meet the objective of the indicator, were rated as Low or None (would not meet at all). The following section further describes each of these goals and indicators and how they were evaluated for the purpose of this report. Each evaluation assumed continued implementation over the 30-year design life.

Goal: Maintain natural/dynamic coastal features in the nearshore area, beach, and barrier bar.

Beaches, nearshore areas, barrier islands and other natural protective features help safeguard coastal lands and property from damage. These areas are naturally dynamic and create sensitive habitats and natural ecosystems that function based on the natural fluctuations and processes that occur in these areas. NYS Coastal Management policies dictate that the State must protect and maintain these natural areas to the maximum extent practical.

Minimize disturbance to east barrier bar.

This indicator was based on the level of disturbance associated with construction activities or on-going maintenance. Those activities that involved heavy construction and disturbance to the east barrier bar scored lower.

Minimize disturbance to nearshore area.

This indicator was based on the level of disturbance associated with construction activities or on-going maintenance. Those activities that involved heavy construction and disturbance to the nearshore area scored lower.

Reduces long term breaching or loss of east barrier bar.

A variety of conditions play into the formation of barrier bars: sediment supply, LST, wave conditions, water levels, human impact, etc. The history of this bar indicates, based on historic aerial photos, that the eastern end of the east barrier bar has been progressively narrowing for several decades. Management alternatives that mitigate progressive shoreline erosion and secured the continued existence of the east barrier bar were scored higher, those that provided less assistance to maintain the integrity of the bar scored lower.

Goal: Maintain and restore natural coastal processes, including sediment transport

Long-term integrity of the coast in general and the shoreline at the east barrier bar in particular depend on a fairly stable interplay of major factors including the following:

- Continuity of the LST;
- Undisturbed flow from the Bay into the lake by proper dredging near the channel outlet;
- Mitigation of progressive erosion of the east barrier bar that has taken place in the last few years as manifested in three breaches of 2012, 2016 and 2017;
- Preserving the existing natural low beach slope;
- Preparation for the increased lake water level fluctuations resulting from implementation of IJC Plan 2014; and
- Protecting the downcoast neighbors from shoreline erosion following future potential east barrier bar breaches and the associated eastward LST deficit.

Management activities that incorporate these major factors scored higher.

Maintains natural shoreline.

Hard structures such as groins or detached breakwaters would significantly alter the balance of natural coastal processes and are associated with high economic and environmental costs. Even structures such as rock revetments are associated with a milder degree of the same implications. Therefore, management alternatives associated with hard structures using artificial (e.g., concrete) or non-native (e.g., large rock) materials were given lower values.

Promotes longshore transport (LST).

Previous sediment transport investigations showed that the dominant eastward LST originates from up-coast (westerly) regions. A significant amount of LST is trapped by the pier. The LST that bypasses the pier coupled with the cross-shore sediment movement and placement of the material annually dredged from near the channel outlet play an important role in the integrity of the natural coastal processes occurring along the east barrier bar. It was also noted that previous breaches in the east barrier bar acted as sinks for the eastward LST leading to intrusion of sediment in the bay and discontinuity of LST for the downcoast regions. While it is true that typically, hardened shorelines are considered to provide negative impacts on LST, for the alternatives evaluated, it was determined that the long-term impacts to LST based on the development of a sink as the result of a breach or the loss of the bar would provide a greater detriment than the short term LST loss due to the hardened structure. Those management alternatives that provide the greatest protection against the development of future breach-induced sinks in terms of LST deficit were given the highest ratings.

Maintains low gradient shoreline slopes.

It was shown that large offshore wave heights are significantly attenuated when waves approach the nearshore over very mild beach slopes in the Port Bay region. Low beach slopes give rise to breakers with smaller wave heights and lower energy when they attack the shore. Steep slopes allow for crashing waves with higher energy, which results in more erosion at the toe. Alternatives that entail rehabilitation measures associated with structures on steep slopes across the shoreline were considered less desirable and scored lower.

Minimizes impacts to downdrift neighbors.

Given the predominant eastward longshore current and sediment transport, alternatives that introduce discontinuity or considerable disturbance for alongshore currents and sediment movement may result in increased erosion downdrift. Potential impacts to downdrift neighbors associated with east barrier bar hardening, wave refraction, and sediment transport were incorporated in the determination of risk of exposure resulting in excessive erosion from the implementation of each of the management alternatives. Those management alternatives that provide the greatest risk for long-term sediment deficit to be cast downstream scored the lowest.

Goal: Maintains and protects natural habitat areas.

The Port Bay barrier bar, as well as the bay area it protects, are part of the Lake Shore Marshes Wildlife Management Area (WMA). The WMA provides a unique combination of lake and bay marshes that provide habitat for many species of fish, mammals, songbirds, and waterfowl. Any proposed management alternative would be required to protect and/or promote the wildlife habitats known to be within the project area.

Protects turtle habitat.

The spiny softshell turtle is listed as an S2S3 Species of Greatest Conservation Need (High Priority) and a Species of Concern by the New York Natural Heritage Program. This species prefers to nest on open, elevated sand or gravel banks or sandbars as close to the water as possible. This type of habitat occurs along the bay side of the east barrier bar. Management alternatives expected to either protect or expand the amount of turtle nesting habitat along the bay side of the bar were scored high. Alternatives expected to reduce or eliminate available turtle spawning habitat were scored low or none, respectively.

Protects shorebird habitat / nearshore habitat in lake.

The nature of shorebird habitat can vary considerably depending on the shorebird species and the function of the habitat (e.g., nesting, foraging, roosting). Management alternatives were evaluated with these differences in mind, and the score was often contingent on the species or function of the habitat. Some alternatives could thus score high for some species or functions and low or none for others. Nearshore habitat was generally scored in relation to the degree of long-term disturbance or elimination of structural complexity, with higher scores given to alternatives that minimized disturbance of or reduction in structural complexity and poorer scores allotted to alternatives that resulted in long-term homogenization of nearshore habitat.

Protects fisheries habitat in bay.

Fish habitat in the bay that is affected by the east barrier bar management is primarily limited to the vegetated littoral zone. This is an area of relatively high productivity and provides fish spawning and nursery habitat. Management alternatives that minimized or eliminated disturbance to bay-side vegetated nearshore areas were scored higher than alternatives that resulted in significant or ongoing disturbance to such areas. In addition, alternatives that provided increased opportunity for fish passage into and out of the bay were scored favorably.

Protects wildlife habitat in bay.

A wide variety of wildlife, including softshell and other turtles, woodland birds, wading birds, waterfowl, birds of prey, furbearers, and others use the various habitats of the east barrier bar and bay. Management alternatives can differentially affect these different species by protecting, enhancing, or reducing available habitat, so a management alternative score was often contingent on the species or function of the habitat considered. Alternatives that tend to protect or minimize disturbance to vegetated terrestrial and/or aquatic habitats were scored higher than those that reduced or eliminated vegetated habitat or reduced habitat structural complexity. In some cases, a management alternative could score high for protection of wildlife habitat in the bay while at the same time score low for disturbance or reduction in wildlife habitat on the east barrier bar itself.

Minimizes impacts to bat habitat.

Northern long-eared bats roost singly or in colonies underneath bark, in cavities, or in crevices of both live and dead trees. Potential habitat for this species occurs in the wooded area of the western two-thirds of the east barrier bar. Management alternatives were scored with regard to impacts to bat habitat based on the expected degree of disturbance to or removal of large diameter trees that may serve as bat roosting sites. Alternatives that protected such habitat were scored higher than those that would likely result in loss of large diameter trees on the east barrier bar.

Goal: Minimize damage to public (DEC WMA) and private (shoreline residents) property / infrastructure

While there is no longer any infrastructure located on the east barrier bar itself, the remaining land area of the bar is valuable to the people of New York State as a place for public recreation. Additionally, the barrier bar provides protection to the bay and shoreline structures from wave action, ice, and debris that would otherwise enter from the lake.

Maintains a continuous east barrier bar.

Those alternatives that provide the greatest protection against loss of the east barrier bar and resistance to long term damage scored highest. Those with the potential for continued breaching scored lowest.

Minimizes potential damage to shoreline properties from debris.

During previous breaches, it was noted that a significant amount of debris (including trees, shrubs, etc.) was seen to wash through the breach and be carried into the bay. These debris items were caught in docks, repeatedly washed against shorelines exacerbating erosion and acting as deterrents to navigation. The east barrier bar, when fully intact, provides protection against debris washing in from the lake. During winter months, the potential for ice sheets to be conveyed through a breach on the east barrier bar also exists. Alternatives that provide the greatest protection against future breaching and minimize the ability for debris and ice to wash over or through the east barrier bar were given highest scores.

Protects against wave action.

The east barrier bar, when fully intact, allows waves to break on the bar, rather that entering the bay area. During previous breaches, it was noted that waves traveled into the bay creating choppy conditions in the bay. Should the east barrier bar be completely lost, the bay would be subject to an increased fetch, leading to waves within the bay being significantly larger. Alternatives that provided the greatest protection against future breaching, provided greater resistance to wave crashing, and minimized the ability for waves to crash over or roll through the bar were given the highest scores.

<u>Goal: Ensure human health and safety</u>

The east barrier bar and the adjoining waterways are public lands and should be kept in such a condition where continued public use of the public lands is safe and accessible. As such, the management of the east barrier bar must take into account the safety of all potential users as well as the health and safety of those adjacent to the bar.

Improves water quality circulation in the bay.

While no site-specific water quality circulation analysis was conducted, it has been shown in other areas, such as at Fire Island downstate, that breaching of barrier bars can provide some increase in water quality benefit by increasing the circulation and exchange of water between the bay and lake (USACE 1999). However, the size and depth of the breaches in comparison to the size and depth of the bay indicates that breaches would likely only have a limited impact on water quality. Management alternatives that effectively prevented breaches from occurring scored low. Those that allowed or provided for increased conveyance and water exchange scored higher.

Minimizes risks to recreational users (boaters, anglers, hikers, beachgoers).

As public land, the east barrier bar is available for recreational use, be it fishing access, dog walking, sunbathing or other forms of activities. In the past, the breaches have made it dangerous for users to cross the east barrier bar due to the current and waves; therefore, those alternatives with the highest breach potential scored low. However, there are a variety of other potential hazards considered including steep slopes, walkability (i.e., gravel vs. riprap), and debris build up potential.

Ensuring continued shielding of boaters and other users from extreme lake conditions in the bay.

While Port Bay is not a designated “safe harbor”, the inlet channel and bay area still provide refuge for recreational users in the event of storm conditions on Lake Ontario. The bar allows an area for lake waves to break on and creates a calmer water surface within the bay. Alternatives that minimized the potential for breaching, overtopping, or permanent conveyance of flows through the east barrier bar were given higher ratings that those that encouraged or did not prevent lake inflows and breaching.

Minimizes risk of internal bay flooding during winter/spring.

Dredging of the inlet channel is typically done in late March due to weather and permitting restrictions. During winter and spring storms, the sediment transported along the lake shoreline ends up depositing in the inlet channel; often times this elevation can be high – above lake elevations. In these instances, as the early spring snowmelt and runoff conditions increases the inflow into the bay, the bay levels can rise as the conveyance area for equalizing water surface elevations with the lake is diminished. Under these conditions, the flooding in the bay can become a problem until a point that a break in the inlet channel, dredging, or, as in the past, a breach, allowed water levels to equalize. Management alternatives that provided some permanent connection with the lake or allowed for continued breaching scored higher for this indicator.

Goal: Ensure continued fishing and boat access

Port Bay is widely used for fishing and boating recreation. The vast majority of the homeowners on the bay have boat/dock access along the shoreline. Users of the bay include both motorized and non-motorized boaters. In addition, the east barrier bar itself is often used as a fishing access point.

Minimizes impacts to boaters in the bay.

As many boaters use the bay for fishing and recreational use, calm conditions are ideal. Alternatives where wave or debris intrusion would be encouraged or protection against breaches was limited were scored lower. Alternatives where wave or debris intrusion would be discouraged, or protection against breaches was provided, scoured higher.

Maintains shoreline access across east barrier bar.

It is assumed that fishing access would come from walking across the east barrier bar from East Port Bay Road. In the past, walking across breach areas has been dangerous. Therefore, alternatives where protection against breaches was the greatest, scored highest. Alternatives where protection against breaches was limited or not provided, scored lowest.

Goal: Implementation and Feasibility

As with any project, the implementation ability and feasibility of the project can be driving factors. No matter the benefits, if a project is not permittable or fundable, it has no chance of being constructed. NYSDEC has a variety of environmental regulations, budgetary and staffing constraints, and logistical concerns that should be considered when evaluating alternatives.

Grant funding availability.

Typically, grant funding is the easiest way to provide payment for a project such as this. Grant funds such as FEMA or storm recovery are unlikely to be applicable due to the nature of the proposed work and the rules associated with the grants. The most applicable grants will come from green infrastructure improvement funding. Therefore, the alternatives that provide the greenest solutions scored high.

Minimize management time commitment.

NYSDEC has large and far reaching areas of the state under its jurisdiction. It is assumed that all of the build alternatives would require annual maintenance / inspection and coordination with the PBIA; however, other alternatives would require additional levels of oversight, increased maintenance / repair, and evaluation that would require an increased time commitment from NYSDEC staff and other partners. Those alternatives thought to have the largest on-going time commitment scored low.

Minimize risk of emergency responders and maintenance personnel.

Each of the build alternatives includes access across the east barrier bar for channel dredging and sediment management purposes. Those alternatives where potential breaching or damage to this cross-bar access is a risk scored the lowest, and those that provided for continued access scored highest.

Provides equipment access across east barrier bar for dredging / maintenance purposes.

Each of the build alternatives requires access across the bar for channel dredging and sediment management purposes. Those alternatives where the potential for this cross-bar access is at risk due to breaching scored the lowest, and those that provided for continued access scored the highest.

Construction Cost.

Schematic level construction costs were developed for each alternative. These values (described further in **Section 4.3**) take into account potential construction costs.

Operation and Maintenance Cost.

Also described further in **Section 4.3**, each build alternative is assumed to have on-going annual maintenance, inspections and other work that would be required over the assumed 30-year life span of the project. These life cycle costs help to rationalize future money that must be considered for the up-keep and continued protection provided by each of the management alternatives.

Table 4.2-1 provides a visual representation of the evaluations using a red to green color ramp (see **Figure 4.2-1**) representing the evaluation scores. A more detailed summary of the evaluations and the reasoning behind the conclusions are provided in **Table 4.2-2**.

Figure 4.2-1 Color Ramp for Project Goal Evaluation

High	Moderate to High	Moderate	Moderate to Low	Low	None

Table 4.2-1 Visual Summary of Project Goals Evaluation

PROJECT GOALS EVALUATION									
		Alternatives							
		A	B	C	D	E	F	G	H
Goals	Indicators	Do Nothing	Sediment Management	Nature-Based Protection	Adaptive Management	Infrastructure Protection	Rock Revetment	Rock Revetment with Overflow	Rock Revetment with Culverts
Maintain natural/dynamic coastal features (nearshore area, beach, barrier bar)	Minimize disturbance to east barrier bar	High	Moderate to High	Moderate	Moderate	High	None	None	None
	Minimize disturbance to nearshore area	High	Moderate to High	High	Moderate	High	Low	Low	Low
	Reduces long-term breaching or loss of east barrier bar	None	Moderate	Moderate to High	Moderate	Moderate	High	High	High
Maintain and restore natural coastal processes, including sediment transport	Maintains natural shoreline	High	High	High	High	High	Low	Low	Low
	Promotes long-shore transport (LST)	Low	Moderate to High	High	Low	Low	High	High	High
	Maintains low gradient shoreline slopes	High	High	Moderate to High	High	High	Low	Low	Low
	Minimizes impacts to downdrift neighbors	Low	Moderate	Moderate to High	Moderate	Low	High	High	High
Maintains and protects natural habitat areas	Protects turtle habitat	Low	Low	Moderate	Low	Low	None	None	None
	Protects shorebird habitat / nearshore habitat in lake	Low to Moderate	Low to Moderate	High	Moderate	Low to Moderate	Low	Low	Low
	Protects fisheries habitat in bay	Low to Moderate	Low to Moderate	High	Moderate	Low	High	High	High
	Protects wildlife habitat in bay	Low to Moderate	Low to Moderate	High	Low	Low	Moderate	Moderate	Moderate
	Minimizes impacts to bat habitat	Moderate to High	Moderate to High	High	Moderate	Moderate to High	None	None	None
Minimize damage to public (DEC WMA) and private (shoreline residents) property / infrastructure	Maintains a continuous barrier bar	Low	Low to Moderate	Moderate to High	Low to Moderate	Low to Moderate	High	High	High
	Minimizes potential damage to shoreline properties from debris	Low	Low to Moderate	Moderate to High	Low to Moderate	High	High	High	Moderate to High
	Protects against wave action	Low	Low to Moderate	Moderate to High	Low to Moderate	Low to Moderate	High	Moderate to High	High
Ensure human health and safety	Improves water quality circulation in bay	Moderate to High	Low	Low	Low	Moderate to High	None	Moderate	Moderate
	Minimizes risks to recreational users (boaters, anglers, hikers, beachgoers)	Low to Moderate	Moderate	Moderate to High	Low to Moderate	Low	Moderate to High	Moderate to High	Moderate to High
	Ensuring continued shielding of boaters and other users from extreme lake conditions in the bay (i.e., storm events)	None	Moderate	High	Low	Moderate	High	High	High
	Minimizes risk of internal bay flooding during winter/spring	Moderate to High	Moderate	None	Moderate	Moderate to High	None	High	Moderate to High
Ensure continued fishing & boat access	Minimizes impacts to boaters in the bay	None	Moderate	High	Low	Moderate	High	Moderate to High	High
	Maintains shoreline access across east barrier bar	Low	Moderate	High	Moderate	Low to Moderate	Moderate to High	Moderate to High	Moderate to High
Ensure feasibility of implementation	Grant funding availability	High	Low	High	Low	Low	Low	Low	Low
	Minimize management time commitment	High	Moderate to High	Moderate to High	Low	Moderate	High	Moderate to High	Low
	Minimize risk of emergency responders and maintenance personnel	Low	Low to Moderate	High	Low	Low	High	Moderate to High	Low to Moderate
	Maintains equipment access across east barrier bar for dredging / maintenance purposes	None	Moderate	Moderate to High	Moderate	Moderate	High	High	High
	Construction Cost	High	High	Moderate	N/A	Moderate to High	None	N/A	N/A
	Operation and Maintenance Cost	High	High	Low to Moderate	N/A	Low to Moderate	High	N/A	N/A

TABLE 4.2-2: PROJECT GOALS EVALUATION

Goals	Indicators	A – Do Nothing	B – Sediment Management	C – Nature-Based Protection	D – Adaptive Management	E – Infrastructure Protection	F – Rock Revetment	G – Rock Revetment with Overflow	H – Rock Revetment with Culverts
Maintain natural/dynamic coastal features (nearshore area, beach, barrier bar)	Minimize disturbance to east barrier bar	High - No human-induced alteration of physical habitat	Moderate to High - Minimal, seasonal modifications to portion of barrier bar. Annual maintenance to encourage natural erosion and repair.	Moderate - Some short-term disturbance to natural shoreline and barrier bar to enhance natural protective benefits and place gravel to design elevation.	Moderate - Some short-term disturbance to natural shoreline and barrier bar will eventually occur when management is required to enhance natural protective benefits but upper elevations not disturbed.	High - No human-induced alteration of physical habitat.	None - Involves large-scale modification of habitat. Lake-side habitat will be permanently altered and "artificial." Bay-side habitat will also be altered but in the long-term may revert to a "natural" condition.	None - Involves large-scale modification of habitat. Lake-side habitat will be permanently altered and "artificial." Bay-side habitat will also be altered but in the long-term may revert to a "natural" condition.	None - Involves large-scale modification of habitat. Lake-side habitat will be permanently altered and "artificial." Bay-side habitat will also be altered but in the long-term may revert to a "natural" condition.
	Minimize disturbance to nearshore area	High - No human-induced alteration of physical habitat.	Moderate to High - Minimal, seasonal modifications to portion of nearshore area. Annual maintenance to encourage natural erosion and repair.	High - Gravel placement will create a bar similar to the existing conditions with enhanced vegetation for stabilization. Nearshore conditions to remain virtually unchanged.	Moderate - Some short-term disturbance to natural shoreline and barrier bar will eventually occur when management is required to enhance natural protective benefits but upper elevations not disturbed.	High - No human-induced alteration of physical habitat.	None to Low- Involves large-scale modification of lake-side near-shore habitat. Lake-side habitat will be permanently altered and "artificial." Bay-side habitat will also likely be altered but to a lesser degree and in the long-term should revert to a natural condition.	None to Low- Involves large-scale modification of lake-side near-shore habitat. Lake-side habitat will be permanently altered and "artificial." Bay-side habitat will also likely be altered but to a lesser degree and in the long-term should revert to a natural condition.	None to Low- Involves large-scale modification of lake-side near-shore habitat. Lake-side habitat will be permanently altered and "artificial." Bay-side habitat will also likely be altered but to a lesser degree and in the long-term should revert to a natural condition.
	Reduces long-term breaching or loss of east barrier bar	None - Pattern of breaches and reduced LST indicates breaches will likely continue.	Moderate - Approximately half of potential gravel LST is deposited around channel outlet. Annual dredging and redistribution of this volume will increase the sediment supply to aid in repair and replenishment of material for east barrier bar.	Moderate - Base elements of Alt. B coupled with increased protection. Most vulnerable immediately following construction. Dependent on vegetation establishment.	Moderate - Base elements of Alt. B. Depends on implementation strategy. Reactive to future breaches.	Moderate - Base elements of Alt. B. No additional protection against long-term breaching.	High - Design intended to minimize potential for breaching.	High - Design intended to minimize potential for breaching.	High - Design intended to minimize potential for breaching.
Maintain and restore natural coastal processes, including sediment transport	Maintains natural shoreline	High - No modifications to natural conditions. Erosion and repair naturally.	High - Minimal modifications to natural shoreline. Annual maintenance to encourage natural erosion and repair.	High - Enhances natural shoreline to increase natural protective benefits. Enlarges barrier bar footprint.	High - Minimal modifications to natural shoreline. Annual maintenance to encourage natural erosion and repair.	High - Minimal modifications to natural shoreline. Annual maintenance to encourage natural erosion and repair.	None to Low- Involves large-scale modification of lake-side shoreline. Lake-side shoreline will be permanently altered and "artificial." Bay-side shoreline will also be altered but to a lesser degree and in the long-term should revert to a natural condition.	None to Low- Involves large-scale modification of lake-side shoreline. Lake-side shoreline will be permanently altered and "artificial." Bay-side shoreline will also be altered but to a lesser degree and in the long-term should revert to a natural condition.	None to Low- Involves large-scale modification of lake-side shoreline. Lake-side shoreline will be permanently altered and "artificial." Bay-side shoreline will also be altered but to a lesser degree and in the long-term should revert to a natural condition.
	Promotes long-shore transport (LST)	None to Low- Gaps due to breaches may act as sink for LST as they may draw part of the LST and cross-shore sediment transport into the bay.	Moderate to High - Exposes the spread spoil to wave attack and LST	High - Mitigates the risk of breaches similar to those in 2012, 2016, and 2017 which could act as sink and discontinuity for LST while maintaining natural sediment and shoreline.	None to Low- Gaps due to breaches may act as sink for LST as they may draw part of the LST and cross-shore sediment transport into the bay.	None to Low- Gaps due to potential breaches may act as sink for LST as they may draw part of the LST and cross-shore sediment transport into the bay.	High - Minimizes the risk of breaches similar to those in 2012, 2016, and 2017 which could act as sink and discontinuity for LST.	High - Minimizes the risk of breaches similar to those in 2012, 2016, and 2017 which could act as sink and discontinuity for LST.	High - Minimizes the risk of breaches similar to those in 2012, 2016, and 2017 which could act as sink and discontinuity for LST.
	Maintains low gradient shoreline slopes	High - existing low slope nearshore to remain.	High - existing low slope nearshore to remain.	Moderate to high - Sediment management combined with vegetative protection will reduce erosion and allow for transported sediment to continue to build and repair shoreline natural slopes. Transition to built protective slope could reduce gradient.	High - existing low slope nearshore to remain.	High - existing low slope nearshore to remain.	Low - Large scale revetment will create steep slope at shoreline. Erosion potential at toe.	Low - Large scale revetment will create steep slope at shoreline. Erosion potential at toe.	Low - Large scale revetment will create steep slope at shoreline. Erosion potential at toe.
	Minimizes impacts to downdrift neighbors	None to Low - On the one hand, to the extent the unrepaired breaches may act as sinks for LST to move part of sediment into the bay, slightly less sediment may move downcoast. On the other hand, any future breach would cause short-term downcoast inequilibrium condition in the downcoast shoreline should breaks similar to those in 2012, 2016 and 2017 take place.	Moderate - Spoil materials partly compensate for sediment deficit needed for LST. This slightly mitigates the overall erosion and recession of the east bar, beneficial for downcoast neighbors.	Moderate to high - Any stabilization of the east bar minimizes the risk of breaches and therefore, helps stability of downcoast shorelines.	Moderate - Fairly deals with the risk of east bar breaches similar to those of 2012, 2016, and 2017. Any stabilization of the east bar minimizes the risk of breaches and therefore, helps stability of downcoast shorelines.	None to Low - Does not pro-actively deal with the risk of east bar breaches similar to those of 2012, 2016, and 2017. Any stabilization of the east bar minimizes the risk of breaches and therefore, helps stability of downcoast shorelines.	High - Any stabilization of the east bar minimizes the risk of breaches and therefore, helps stability of downcoast shorelines. The sediment deficit resulting from shore hardening at the revetment and lack of local contribution to LST will be short-term and a one-off event until a new equlibrium condition is established. The source of LST is up-coast shorline erosion along many tens of miles in the region. The short-term sediment deficit can be compensated for by a one-off beach nourishment using spoil from dredging.	High - Any stabilization of the east bar minimizes the risk of breaches and therefore, helps stability of downcoast shorelines. The sediment deficit resulting from shore hardening at the revetment and lack of local contribution to LST will be short-term and a one-off event until a new equlibrium condition is established. The source of LST is up-coast shorline erosion along many tens of miles in the region. The short-term sediment deficit can be compensated for by a one-off beach nourishment using spoil from dredging.	High - Any stabilization of the east bar minimizes the risk of breaches and therefore, helps stability of downcoast shorelines. The sediment deficit resulting from shore hardening at the revetment and lack of local contribution to LST will be short-term and a one-off event until a new equlibrium condition is established. The source of LST is up-coast shorline erosion along many tens of miles in the region. The short-term sediment deficit can be compensated for by a one-off beach nourishment using spoil from dredging.

TABLE 4.2-2: PROJECT GOALS EVALUATION

Goals	Indicators	Alternatives A: Do Nothing	B: Sediment Management	C: Nature-Based Protection	D: Adaptive Management	E: Infrastructure Protection	F: Rock Revetment	G: Rock Revetment with Overflow	H: Rock Revetment with Culverts
Maintains and protects natural habitat areas	Protects turtle habitat	Low - recent breach has reduced the area of suitable turtle nesting habitat. Future breaches are likely to reduce it further.	Low - recent breach has reduced the area of suitable turtle nesting habitat. Future breaches are still possible and likely to reduce it further.	Low to High - Depends on project design. If current nesting area is protected and nature-based protections result in increased stability of bay-side east end then turtle habitat will be protected. If barrier stabilization features encroach on turtle habitat, it will not be protected.	Low - recent breach has reduced the area of suitable turtle nesting habitat. Future breaches are likely to reduce it further. Effect of adaptive management will depend on condition of turtle habitat following next breach and chosen management alternative.	Low - recent breach has reduced the area of suitable turtle nesting habitat. Future breaches are likely to reduce it further.	None - There will likely be complete elimination of existing turtle nesting habitat.	None - There will likely be complete elimination of existing turtle nesting habitat.	None - There will likely be complete elimination of existing turtle nesting habitat.
	Protects shorebird habitat / nearshore habitat in lake	Low to Moderate - Habitat for shore birds preferring cobble/gravel bars may not be appreciably affected but those preferring shallow, vegetated foraging areas or wooded shoreline habitat may see a reduction in available habitat.	Low to Moderate - Habitat for shore birds preferring cobble/gravel bars may not be appreciably affected but those preferring shallow, vegetated foraging areas or wooded shoreline habitat may see a reduction in available habitat.	High for shorebird habitat; Low for nearshore lake habitat. Stabilizing the barrier bar should benefit shoreline bird habitat but some nearshore lake habitat will be disturbed/altered by stone protection placement.	Low to high depending on impacts that occur prior to adaptive management action. Once adaptive management alternative is implemented, shoreline bird habitat should be protected but nearshore lake habitat will be disturbed at least short-term.	Low to Moderate - Habitat for shore birds preferring cobble/gravel bars may not be appreciably affected but those preferring shallow, vegetated foraging areas or wooded shoreline habitat may see a reduction in available habitat.	None to Moderate - Permanent large-scale modification of lake-side nearshore habitat. Shorebird habitat will also be heavily modified but may recover in the long-term.	None to Moderate - Permanent large-scale modification of lake-side nearshore habitat. Shorebird habitat will also be heavily modified but may recover in the long-term.	None to Moderate - Permanent large-scale modification of lake-side nearshore habitat. Shorebird habitat will also be heavily modified but may recover in the long-term.
	Protects fisheries habitat in bay	Low to Moderate - May be some loss or continued suppression of spawning/nursery habitat in vicinity of barrier bar.	Low to Moderate - May be some loss or continued suppression of spawning/nursery habitat in vicinity of barrier bar if breaches continue to occur but likelihood of breaches should be somewhat reduced.	High - Stabilizing the barrier bar should benefit bay-side fish habitat by removing major disturbances caused by breaching.	Low to high depending on impacts that occur prior to adaptive management action. Once adaptive management alternative is implemented, bay-side fisheries habitat should be protected.	Low - May be some loss or continued suppression of spawning/nursery habitat in vicinity of barrier bar. Fishery habitat may be reduced depending on nature of infrastructure protection measures along the shoreline within the bay.	High - May be some short-term impacts to near-shore bay-side fisheries habitat but habitat should be protected long-term.	High - May be some short-term impacts to near-shore bay-side fisheries habitat but habitat should be protected long-term. Occasional improved passage conditions for fish into and out of the bay.	High - May be some short-term impacts to near-shore bay-side fisheries habitat but habitat should be protected long-term. Improved passage conditions for fish into and out of the bay.
	Protects wildlife habitat in bay	Low to Moderate - May be some loss or continued suppression of habitat for species like spiny softshell turtle, woodland birds other wildlife but other species may be unaffected.	Low to Moderate - May be some loss or continued suppression of habitat for species like spiny softshell turtle, woodland birds other wildlife but likelihood of breaches should be somewhat reduced.	High - Stabilizing the barrier bar should benefit bay-side wildlife habitat by removing major disturbances caused by breaching.	Low to high depending on impacts that occur prior to adaptive management action. Once adaptive management alternative is implemented, bay-side wildlife habitat should be protected.	Low - May be some loss or continued suppression of habitat for species like spiny softshell turtle, woodland birds other wildlife but other species may be unaffected. Wildlife habitat may be reduced depending on nature of infrastructure protection measures along the shoreline within the bay.	None to High -Large-scale modification of barrier bar wildlife habitat. Wildlife habitat elsewhere in the bay will be protected.	None to High -Large-scale modification of barrier bar wildlife habitat. Wildlife habitat elsewhere in the bay will be protected.	None to High -Large-scale modification of barrier bar wildlife habitat. Wildlife habitat elsewhere in the bay will be protected.
	Minimizes impacts to bat habitat	Moderate to High - Bat habitat should be unaffected unless future breaches remove large trees favored as roosting or nesting sites.	Moderate to High - Bat habitat should be unaffected unless future breaches remove large trees favored as roosting or nesting sites. Extending the area receiving dredged material should help protect existing trees.	High - Stabilizing the barrier bar should reduce the likelihood of erosion removing large trees favored by bats for roosting or nesting.	Low to high depending on impacts that occur prior to adaptive management action. Once adaptive management alternative is implemented, bat habitat should be protected.	Moderate to High - Bat habitat should be unaffected unless future breaches or selected infrastructure protection measures remove large trees favored as roosting or nesting sites.	None - Any existing bat habitat (i.e., large trees) would be removed from the barrier bar.	None - Any existing bat habitat (i.e., large trees) would be removed from the barrier bar.	None - Any existing bat habitat (i.e., large trees) would be removed from the barrier bar.
Minimize damage to public (DEC WMA) and private (shoreline residents) property / infrastructure	Maintains a continuous barrier bar	Low - Trends indicate barrier bar will continue to erode, narrow, and shift location	Low to Moderate - Increased sediment supply should slow erosion.	Moderate to High - Increased size and stability should slow erosion. Smaller material size does allow for erosion and potential shifting	Low to Moderate - Depends on impacts that occur prior to implementing adaptive management alternative.	Low to Moderate - Increased sediment supply should slow erosion.	High - Design intended to minimize erosion and maintain bar location and size	High - Design intended to minimize erosion and maintain bar location and size	High - Design intended to minimize erosion and maintain bar location and size
	Minimizes potential damage to shoreline properties from debris	Low - Trends for continued breaching indicates debris may continue to enter bay through breach	Low to Moderate - Additional sediment supply should decrease potential for breaching; and thereby debris access	Moderate to High - Provides increased protection against breaching; and thereby reduces debris access	Low to Moderate - Additional sediment supply should decrease potential for breaching; and thereby debris access	High - Boom designed to capture debris entering through breach or over bar	High - Design intended to minimize potential for breaching; and thereby debris access	High - Design height and additional boom designed to minimize debris access	Moderate to High - Design height intended to minimize debris access over bar. Culverts may continue to allow some debris access.
	Protects against wave action	Low - Trends for continued breaching indicates waves may continue to enter bay. Low height allows for wave overtopping.	Low to Moderate - Additional sediment supply should decrease potential for breaching; and thereby wave action through to bay.	Moderate to High - Provides increased protection against breaching; and thereby reduces wave action in bay.	Low to Moderate - Additional sediment supply should decrease potential for breaching; and thereby wave action through to bay.	Low to Moderate - Additional sediment supply should decrease potential for breaching; and thereby wave action through to bay.	High - Design intended to minimize potential for breaching; and thereby wave action in bay	Moderate to High - Design intended to minimize potential for breaching; however low flow may allow wave action into bay during high water events.	High - Design intended to minimize potential for breaching; and thereby wave action in bay

TABLE 4.2-2: PROJECT GOALS EVALUATION

		Alternatives							
		A	B	C	D	E	F	G	H
Goals	Indicators	Do Nothing	Sediment Management	Nature-Based Protection	Adaptive Management	Infrastructure Protection	Rock Revetment	Rock Revetment with Overflow	Rock Revetment with Culverts
Ensure human health and safety	Improves water quality circulation in bay	Moderate to High - Occasional breaches may temporarily increase circulation and improve water quality. If breaches form more permanently, likely to have greater improvement to circulation. Improvement likely to only be located near the breach.	Low - Occasional breaches may temporarily increase circulation and improve water quality but unless breaching is permanent water quality will likely not improve substantially.	Low - If effective, breaching would be eliminated and no increased circulation of bay waters would occur.	Low - If effective, breaching would be eliminated and over the long-term no increased circulation of bay waters would occur.	Moderate to High- Depends on the nature of the breach, including depth, width, and permanency. The larger and more permanent the breach, the greater the improvement to circulation.	None - Would effectively remove potential for breaching, so no increase in water circulation would occur.	Moderate - Occasional overtopping of barrier in overflow area would increase water circulation for limited periods and likely only isolated area near the overflow	Moderate - Degree of increase in circulation will depend on the effective elevation of the culverts. Increase circulation likely to only be near culverts.
	Minimizes risks to recreational users (boaters, anglers, hikers, beachgoers)	Moderate to Low - Potential for breach remains high; however, during non-breach periods, bar is walkable and easily navigated.	Moderate - Potential for breach remains, but reduced. Influx of gravel material is easily walkable and navigated.	Moderate to High - Reduced potential for breaches. Gravel material easily walkable and navigable.	Moderate to Low - Potential for breach remains high; however, during non-breach periods, bar is walkable and easily navigated.	Low - Potential for breach remains high; however, during non-breach periods, bar is walkable. Debris build up at the bar could be a danger. Boom could be a navigational hazard.	Moderate to High - Significantly reduced potential for breach and easily walkable top of revetment. However, large stone material on lake side is difficult to walk on an may pose a hazard.	Moderate to High - Significantly reduced potential for breach and easily walkable top of revetment. However, large stone material on lake side is difficult to walk on an may pose a hazard.	Moderate to High - Significantly reduced potential for breach and easily walkable top of revetment. However, large stone material on lake side is difficult to walk on an may pose a hazard.
	Ensuring continued shielding of boaters and other users from extreme lake conditions in the bay (i.e., storm events)	None - Potential for breaches remain with intrusion of waves and debris to the bay.	Moderate - Potential for breach remains, but reduced.	High - Minimized potential for breaches. Minimizes potential for intrusion of waves and debris to the bay.	Low - Potential for breaches remain with intrusion of waves and debris to the bay.	Moderate - Does not protect against breaches, but provides means of capturing debris prior to entering bay. May reduce waves, but not designed to break waves.	High - Minimized potential for breaches. Minimizes potential for intrusion of waves and debris to the bay.	High - Minimized potential for breaches. Minimizes potential for intrusion of waves and debris to the bay.	High - Minimized potential for breaches. Minimizes potential for intrusion of waves and debris to the bay.
	Minimizes risk of internal bay flooding during winter/spring	Moderate to High - Ability f or bar to breach allows for potential internal flood relief.	Moderate - Ability for bar to breach allows for potential internal flood relief.	None - High design elevation prohibits outflow of internal flood relief.	Moderate - Ability for bar to breach allows for potential internal flood relief.	Moderate to High - Ability f or bar to breach allows for potential internal flood relief.	None - High design elevation prohibits outflow of internal flood relief.	High - Overflow would be designed to provide relief for internal flooding	Moderate to High - Culverts allow relief of internal flooding, however have the potential to clog with transported material
Ensure continued fishing & boat access	Minimizes impacts to boaters in the bay	None - Potential for breaches remain with intrusion of waves and debris to the bay, including boating hazards.	Moderate - Potential for breach remains, but reduced.	High - Minimized potential for breaches, protecting against waves and debris in the bay.	Low - Potential for breaches remain with intrusion of waves and debris to the bay, including boating hazards.	Moderate - Minimizes debris intrusion; however, boom could provide a navigation obstacle.	High - Minimized potential for breaches, protecting against waves and debris in the bay.	Moderate to High - Minimized potential for breaches, protecting against waves and debris in the bay. Overflow could allow some wave and debris intrusion during storm events.	High - Minimized potential for breaches, protecting against waves and debris in the bay.
	Maintains shoreline access across east barrier bar	Low - Potential for breaches remain. Poor access from East Bay Road.	Moderate - Improved access from East Bay Road; potential for breach remains.	High - Improved access from East Bay Road; top line of protection accessible; shorelines walkable.	Moderate - Improved access from East Bay Road; potential for breach remains.	Low to Moderate - Improved access from East Bay Road; potential for breach remains; build up of debris could hinder access across bar.	Moderate to High - Improved access from East Bay Road; top line of protection accessible; lake side shore revetment with large stone can be difficult to walk/access	Moderate to High - Improved access from East Bay Road; top line of protection accessible; lake side shore revetment with large stone can be difficult to walk/access	Moderate to High - Improved access from East Bay Road; top line of protection accessible; lake side shore revetment with large stone can be difficult to walk/access
Ensure feasibility of implementation	Grant funding availability	N/A	Low - Likely need to be considered as on-going allocation of funds.	High - Funds for green techniques typically available	Low - Likely need to be funded through permanent allocation of funds.	Low - Unknown grant funding source	Low - Hardening shoreline funds typically not provided.	Low - Hardening shoreline funds typically not provided.	Low - Hardening shoreline funds typically not provided.
	Minimize management time commitment	None	• Annual maintenance coordination with PBIA	• Annual maintenance coordination with PBIA; • Bi-Annual Inspections; • Routine maintenance (vegetation management, potential for imported sediment required)	• Annual maintenance coordination with PBIA; • Annual and following large storm event monitoring (e.g. survey); • Funding budget management; • Emergency preparedness response; • Post event emergency repair response	• Annual maintenance coordination with PBIA; • Annual deployment and removal; • Removal of debris (multiple times per deployment), chipping or dumping of debris.	• Annual maintenance coordination with PBIA; • Bi-Annual Inspections; • Routine maintenance (periodic stone replacement)	• Annual maintenance coordination with PBIA; • Bi-Annual Inspections; • Routine maintenance (periodic stone replacement, removal of debris from overflow)	• Annual maintenance coordination with PBIA; • Bi-Annual Inspections; • Continued maintenance of clearing culverts from built up sediment and debris; • Routine maintenance (periodic stone replacement)
	Minimize risk of emergency responders and maintenance personnel	Low - Potential for breaches remain. Poor access from East Bay Road.	Low to Moderate - Improved access from East Port Bay Road; potential for breach remains.	High - Improved access, minimized risk of breach, low maintenance once established.	Low - Improved access from East Port Bay Road; potential for breach remains. Continued maintenance; potentially during breach events.	Low - Improved access; maintenance required to remove debris ; potential for breach remains.	High - Improved access, minimized risk of breach, low maintenance.	Moderate to High - Improved access, minimized risk of breach, some maintenance may be required to remove debris from overflow.	Low to Moderate - Improved access, minimized risk of breach; culverts will likely block frequently with sediment and debris causing a work and access issues for maintenance personnel.
	Maintains equipment access across east barrier bar for dredging / maintenance purposes	None - No access	Moderate - Improved access from East Bay Road; potential for breach remains; travel across bar most likely at water's edge or in water.	Moderate to High - Improved access from East Port Bay Road; travel path across top of bar; vegetation may be a hinderance	Moderate - Improved access from East Bay Road; potential for breach remains; travel across bar most likely at water's edge or in water.	Moderate - Improved access from East Bay Road; potential for breach remains; travel across bar most likely at water's edge or in water.	High - Improved access from East Port Bay Road with vehicle access across top of revetment.	High - Improved access from East Port Bay Road with vehicle access across top of revetment.	High - Improved access from East Port Bay Road with vehicle access across top of revetment.
	Construction Cost	N/A $0	$200,000	$600,000	--	$400,000	$2,100,000	--	--
	Operation and Maintenance Cost	N/A $0	$340,000	$550,000	--	$560,000	$340,000	--	--

4.3 Project Costs and Life-Cycle Cost Analysis of Most Feasible Alternatives

As a result of the previous evaluation, and discussions between the PAC members, the following four alternatives (in addition to Alternative A: No Action) were selected to advance to the second phase of the evaluation, a concept level construction cost and life-cycle analysis:

- Alternative B: Limited Sediment Management
- Alternative C: Nature-Based Barrier Bar
- Alternative E: Infrastructure Protection Measures
- Alternative F: Fortification Using Rock Revetment

4.3.1 Conceptual Project Construction Costs

Project construction costs were estimated for the alternatives based on conceptualized designs. Rough order of magnitude quantities have been developed and unit costs have been derived from similar NYSDOT item costs, recommended manufacturer costs and other similar project known costs. The costs are assumed to represent scale differences between the alternatives but are by no means considered accurate for detailed construction estimates. No engineering costs or permitting costs have been included. Alternatives B, C, E, and F each also include the construction costs associated with providing reliable equipment access (**Section 3.1.1**). An assumed cost of $200,000 was included as part of the initial construction cost of each of these build alternatives to account for the equipment access.

The following summarizes the concept level initial construction cost estimates for each of the evaluated alternatives:

- Alternative A: No Action $0
- Alternative B: Limited Sediment Management $200,000
- Alternative C: Nature-Based Barrier Bar $600,000
- Alternative E: Infrastructure Protection Measures $400,000
- Alternative F: Fortification Using Rock Revetment $2,100,000

Details of the conceptual cost estimates are included in **Appendix C**. These values are also included in **Table 4.2-2**.

4.3.2 Life Cycle Analysis

The life-cycle cost analysis is based on the 30-year design lifespan required for coastal structures by New York State. Some of the factors that are accounted for in the analysis include:

- Annual limited sediment management for all alternatives, with varying values for normal years and difficult years for access and maintenance. PBIA would still be providing funds for dredging; however, it is assumed NYSDEC would provide additional funds for spreading of the material and placement of material across the east barrier bar would be required.

- Annual maintenance for all alternatives (e.g., debris removal, re-plantings, nourishment of equipment access, replacement of isolated stones)
- Biennial inspections by NYSDEC staff to report on condition, perhaps perform topographic survey and/or sample vegetation, water quality, etc.
- Assumed more substantial maintenance for nature-based barrier bar immediately following construction, assumed to minimize over time as vegetation established (Alternative C only)
- Assumed 15-year life span of boom; no improvements to anchors needed (Alternative E only)
- Assumed 30-year life span for rock revetments with only routine maintenance required

Table 4.3-1 provides a summary of the assumed maintenance activities for each alternative.

Table 4.3-1 Maintenance Activities Summary

Maintenance Activity	Recurrence Interval	Alternative				
		A	B	C	E	F
Employ limited sediment management to east barrier bar (typical year)	1 year		X	X	X	X
Employ limited sediment management to each barrier bar (difficult year)	10 years		X		X	
Initial maintenance of Nature-Based Barrier Bar	5 years for 2 cycles			X		
Remaining maintenance of Nature-Based Barrier Bar	10 years for 2 cycles			X		
Installation / removal of boom	2X per year				X	
Replacement of boom	15 years				X	
Debris removal from boom	2X per year				X	
Revetment crest maintenance	1 year					X
Biennial inspection	2 years		X	X	X	X

Additional assumptions included in the analysis are:

- PBIA to maintain continued dredging within navigation channel (not included in NYSDEC budget)
- Assumed 4% discount rate
- Assumed 30 year life cycle

Table 4.3-2 provides the summary of the life cycle cost analysis over 30 years including construction, operation and maintenance are anticipated for each alternative:

Table 4.3-2 Life Cycle Analysis Costs

	Initial Construction Cost	Life Cycle Cost (Present Value)	Total
Alternative A: No Action	$0	--	--
Alternative B: Limited Sediment Management	$200,000	$340,000	$940,000
Alternative C: Nature-Based Barrier Bar	$600,000	$550,000	$1,550,000
Alternative E: Infrastructure Protection Measures	$400,000	$560,000	$1,320,000
Alternative F: Fortification Using Rock Revetment	$2,100,000	$340,000	$2,440,000

Details of the life cycle cost analysis are included in **Appendix C**. These values are also included in the project goals evaluation shown in **Table 4.2-2**.

4.4 Recommended Alternative

Should the NYSDEC identify the need to select an alternative other than Alternative A (No Action), this section provides a recommendation for selection of a project alternative. Based on the evaluations outlined in this section and indicators considered, it is recommended that Alternative C: Nature-Based Barrier Bar be selected as the proposed project alternative. This alternative is shown to provide the best blend of positive impacts on the project site, while still achieving the project goals at a reasonable initial construction plus life-cycle cost.

As described in **Section 2.1.2**, the east barrier bar has clearly been diminishing in size for the past several decades. The cottages that were formerly located on the east barrier bar are no longer present, nor would there even be enough land width on the bar to situate such structures today. The pattern of breaches that has occurred over the past six years indicates that this could be the new normal pattern. It is impossible to predict breaches, but the combination of present narrow width, reduced LST throughout the lake, increased occurrences of high water, and increasingly large storm events would indicate that this pattern has a high probability of continuing. While breaches are a natural occurrence of barrier bars, the adverse effects resulting from breaching at this location are thought to outweigh the desire to leave the east barrier bar alone completely. **Section 2.3** describes the diverse natural community that is present on, around and adjacent to the bar. The bar is actively used for recreational purposes and provides a unique natural feature that itself warrants protection. As described in **Section 1.1**, this bar provides an array of beneficial functions. NYSDEC is looking to provide a management alternative that best considers all of these beneficial functions. Based on the evaluations described herein, the nature-based barrier bar alternative provides the best balance of meeting all of the project goals and indicators.

Section 2.2 discussed some of the property damages associated with the breaches of 2016, 2017 and 2018. This section discussed the results of the survey that was distributed to the residents of Port Bay (also provided in **Appendix B**). While the survey was inconclusive as to damage that occurred during the 2017 season and the differentiation between high water caused damage and breach caused damage, what was plainly evident was that the breach, at minimum, played a role in some of the damage. In 2017 the two sides of the event (high water and breach) were too intertwined to purely blame one or the other, but intuitively it can be seen that each exacerbated the other. Debris was a widely reported issue during 2017 (**Figure 2.1-13**). Some of this debris was reported to have washed through the breach and into the bay. The debris may not have been as significant an issue once inside the bay if the water levels were lower; however, it would remain an issue. The breach also allowed for wave action from the lake to enter the bay. During normal years when the east barrier bar is intact, the water surface within the bay is relatively calm as most waves are broken on the east barrier bar. With a breach, fully developed waves are able to pass into the bay and break on the bay shoreline (**Figure 2.1-35** and **Figure 2.1-36**). While the water level was high, these waves were more damaging since many shoreline protection features were under water; however, even a lower water conditions, large, breaking waves in the bay would be an issue. In order to maintain the protective nature of the barrier bar, some management technique would need to be adopted to either minimize/prevent breaches from occurring or reduce their impacts. For this reason, Alternative A – No Action was not recommended as the recommended alternative.

Alternative B – Limited Sediment Management provides a strong candidate for a management alternative. **Section 2.1.7** delves into the coastal sediment transport conditions at the east barrier bar. The pier on the west side of the outlet channel acts as a disruption to the active LST. As shown in the photos in **Figure 2.1-17** and **Figure 2.1-19**, at times the LST can wash up and over the pier and continue downshore. Also discovered through this study, is that the gravel dredged from the outlet channel each year constitutes a high percentage of the total gravel based LST anticipated each year. This indicates that appropriate management of the dredged materials would play a significant role in maintaining the integrity of the east barrier bar. The typical dredging practices allow for placement of dredged material in spoil areas designated on the west end of the east barrier bar and west of the pier. While the desire has always been to deposit as much material as possible on the east barrier bar, the implementation of this is difficult due to the restrictions of the dredging permit, the cost/available funds for dredging, and the accessibility of the east barrier bar from East Port Bay Road. While a full evaluation of the dredging access and approaches is not part of the scope of this study, this study has been able to show that this may need to be investigated further. Even with diminishing LST within Lake Ontario as a whole, providing limited sediment management in the form of ensuring dredged material is consistently placed and spread on the east barrier bar, additional sediment bypassing, supplementing materials, etc. could have a significant impact on the reformation of the east barrier bar. While this is a strong candidate for a management alternative and should definitely be considered as an add-on to all alternatives and implemented in the near future, it was shown during the evaluation that it may not go far enough to provide additional protection against breaching, based on the project goals and indicators.

Alternative D – Adaptive Management was a difficult alternative to evaluate. Without a thoroughly designed adaptive management plan, it was difficult to determine all of the benefits a solution like this could provide. The major drawback to this type of solution is the time commitment and funding allocation. Without having permits in place, sources of funding allocated and available for use, this type of reactive management plan would be difficult to implement.

Alternative E – Infrastructure Protection, similar to Alternative A, provides no added protection to minimize the potential for breaching. This alternative requires the installation of a debris boom that would capture debris and potentially reduce waves that may enter through a breach. While this alternative has a lot of positive aspects, as shown in the evaluation, the cost, time commitment and remaining potential for breaching were the leading factors as to why this alternative was not selected.

Alternatives F, G, and H each represent variations of the rock revetment alternative. While rock revetments can provide substantial protection against breaching and the damages incurred therefrom, the impacts they have on the natural condition, ecosystems and habitats, downdrift neighbors, and LST all seem to outweigh the needed protection. While **Section 2.2** describes the damages that were incurred during the breaches of 2017 and 2018, it also continues to conclude that the damages from the breach alone were not substantial enough to justify the cost from this type of feature. Taking the high water condition out of the equation, the damages reported from the breaches of 2012, 2016 and 2018 were relatively minor. While it is impossible to know what would happen with the breaches in the future, the damage costs, at this point, do not justify the significant construction cost expenditures for a revetment alternative. Similarly, at this point in time, the damage reports do not support the permanent alteration and potential loss of the sensitive nature of the ecosystem, the habitats, and the nearshore coastal features along the east barrier bar that revetment alternatives would require. As such, none of the revetment alternatives were proposed as the recommended alternative.

Alternative C – Nature-Based Barrier Bar was shown through the evaluation to provide the best blend and balance of achieving the project goals. This alternative would employ the limited sediment management outlined in Alternative B that would provide a means of promoting more LST past the pier and onto the east barrier bar. The additional gravel and vegetation proposed to build up the east barrier bar would provide a more substantial feature to resist and break the waves from Lake Ontario, while maintaining the natural features of a barrier bar. The ecosystems, habitats, and nearshore coastal features would remain intact. The small section of nature-based barrier bar that was installed in 2016, closing the 2016 breach, remained intact during the 2017 high water season and adjacent breach. This supports the fact that the nature-based alternative would be able to provide added protection to the east barrier bar and the bay shoreline residents.

Based on the discussions above and the evaluations described in **Table 4.2-2**, the nature-based alternative appears to provide the best balance of meeting the project goals. The alternative described is a conceptual outline and would need to be evaluated further for detailed design and analysis. It is recommended that steps (i.e., permit modification, equipment access, barge consideration, etc.) be taken to evaluate and institute sediment management measures, such as those described in Alternative B, prior to the implementation of the nature-based barrier bar or any proposed build alternative. The design, analysis, permitting, and construction phases will take time, and the sediment management measures can be started quickly. Election of this alternative also allows for a limited "adaptive management" solution, in that, at this time, a more substantial solution does not seem to be supported; however, with time, if this alternative does not meet management goals, there is room to elevate the level of protection and provide added justification for doing so.

4.5 Regulatory Requirements for the Recommended Alternative

The recommended alternative is not a final design. Further consideration is needed for detailed design and analysis of elements that could be provided to maximize the benefits of the design within the available budget and regulatory requirements. Additional consideration must also be provided for the assumed equipment access from East Port Bay Road.

The recommended alternative, or any potential build alternative, must be designed to meet all federal, state and local requirements. Regulatory requirements for each agency may vary. **Table 4.5-1** provides a summary of the potential regulatory reviews and/or authorizations that may be required for the final project. This table is for reference only and should not be considered final. Permits and authorizations will ultimately depend on the final proposed design. Reliance upon the contents of this document in the selection of a preferred alternative should not be considered a pre-approval of the design and does not obviate the need to acquire the necessary permits and authorizations, whose requirements will ultimately depend on the final proposed design.

Table 4.5-1 Potential Regulatory Reviews and Authorizations

Regulatory Agency	Permit / Approval	Authority
US Army Corps of Engineers	Section 404 / Section 10 Permit	Regulates fill and/or discharge of dredged material in Waters of U.S.
U.S. Fish and Wildlife Services	Consultation	Threatened and endangered species review under Endangered Species Act
NOAA / National Marine Fisheries Service	Consultation	Essential Fish Habitat review

Regulatory Agency	Permit / Approval	Authority
NYSDEC	SEQRA	Environmental assessment as presumed lead agency
	Article 15 – Protection of Waters	Disturbance to bed or banks of Port Bay, a Class B waterbody and Lake Ontario, a Class A waterbody
	Article 34 – Coastal Erosion Hazard Area Permit	Disturbance within a designated CEHA area
	Section 401 Water Quality Certification	Individual Water Quality Certificate may need to be obtained depending on Section 404 permit authorization and general/regional conditions
	SPDES General Permit for Stormwater Discharges from Construction Activities (GP-0-15-002)	If project disturbs more than 1 acre, then a SWPPP will need to be prepared for coverage under General Permit
NYS Natural Heritage Program	Consultation	State listed threatened and endangered species and Significant Natural Communities
NYS Department of State	Federal Consistency Review	Conformance with NYS Coastal Management Program
NYS Office of General Services	Authorization	State Lands Underwater
NYS Office of Parks, Recreation and Historical Preservation	Consultation	Review under Section 106 of Historical Preservation Act
Town of Huron	Consultation	Review in accordance with Local Waterfront Revitalization Program (LWRP)

5 References

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CRESS. 1990-2018. "Coastal and River Engineering Support System." An initiative of the Netherlands Ministry of Infrastructure and Environment, Delft University of Technology, and UNESCO-IHE.

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F-E-S Associates. Dec. 2014. *Regional Dredging Management Plan Update, Final Report* (includes Wayne County). Prepared for NYSDOS Division of Coastal Resources.

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NYSDOS (New York State Department of State). 2017. "State Coastal Policies." Excerpted from the *State of New York Coastal Management Program and Final Environmental Impact Statement*, Section 6, August 1982; with changes made to incorporate routine program changes approved in 1983, 2001, and 2017.

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Appendix A
Previous Reports and Analyses Used

Published Reports

Title	Date	Author	URL/Doc. ID
Barrier Beaches and Dunes Performance Indicator Summary	2005?	Baird & Assoc., and Coastal Technical Workgroup	
Discovery Report: Lake Ontario Irondequoit-Ninemile Watershed, HUC 04140101	Mar. 2014	FEMA	Report # 01
Great Lakes Region National Shoreline Management Study (Draft)	Oct. 2017	USACE	
Habitat Management Plan for Lake Shore Marshes Wildlife Management Area, 2017–26	Aug. 2017	NYSDEC Division of Fish and Wildlife	
Implementing a Lake Ontario LaMP Biodiversity Strategy	Apr. 2011	Lake Ontario LaMP Work Group and Technical Staff	002987_IE10_03-B3278
Lake Ontario Lakewide Action and Management Plans (LaMPs)	Apr. 2006 status report; 2012 annual report; 2017 annual report	USEPA Region 2, Environment Canada, NYSDEC, Ontario Ministry of the Environment.	https://www.epa.gov/greatlakes/lake-ontario
Lake Ontario Ecological Sediment Budget.	Nov. 2011	Baird and Assoc. for US Army Corps of Engineers	
Lake Ontario–St. Lawrence River Plan 2014	Jun. 2014	International Joint Commission	ISBN: E95-2/18-2014E-PDF
Lake Ontario WAVAD Hindcast for IJC Study	Oct. 2003	Baird & Assoc. for IJC and USACE	10389.02
Port Bay, Wayne County, New York (Technical Report, Studies on Water Resources of New York State and the Great Lakes)	Jan. 2010	Joseph C. Makarewicz and Matthew J. Novak, SUNY College at Brockport	Tech Report 43. http://digitalcommons.brockport.edu/tech_rep/43
Regional Dredging Management Plan Update, Final Report (includes Wayne County)	Dec. 2014	F-E-S Assoc. for NYSDOS Div. of Coastal Resources	
High Water Level Survey	2017, 2018	NYS Sea Grant/Cornell Univ.	https://seagrant.sunysb.edu/articles/t/new-york-sea-grant-posts-high-water-level-survey-results-resources-coastal-community-development-program-news

Title	Date	Author	URL/Doc. ID
Fire Island to Montauk Point Adaptive Management Program	July 2016	USACE	http://www.nan.usace.army.mil/Portals/37/docs/civilworks/projects/ny/coast/fimp/FIMP%20GRR/HSGRRAppendix%20KAdaptiveManagement.pdf?ver=2016-07-19-185728-237
Atlantic Coast of Long Island, Fire Island inlet to Montauk Point, New York. Storm Damage Reduction Reformulation Study – Water Quality Modeling. DRAFT Report	September 1999	USACE	https://www.nan.usace.army.mil/Portals/37/docs/civilworks/projects/ny/coast/fimp/water.pdf

Maps, Permits, and Other Data Sources

Title	Date	Author	URL/Doc. ID
Coastal Erosion Hazard Area (CEHA) Maps - Town of Huron, NY - Town of Wolcott, NY	Dec. 27, 1988	NYSDEC Coastal Erosion Management Program	#350-796-79 #351-796-79
Dredging Permit for Port Bay Outlet, issued to Port Bay Improvement Assoc. and subsequent modifications	1976-2018	NYSDEC	Permit #8-5426-00010
Facebook – PBIA - Record photos	July – October 2018	PBIA	https://www.facebook.com/PBIA75/?ref=br_rs
Great Lakes Coastal Flood Study - LiDAR (topo/bathy) - Oblique Imagery - Shoreline classifications	2012	NOAA, FEMA, USACE	http://www.greatlakescoast.org/great-lakes-coastal-analysis-and-mapping/technical-resources/
Great Lakes Dashboard (Water Level)	2018	NOAA, USACE, Great Lakes Commission	https://www.glerl.noaa.gov/data/dashboard/GLD_HTML5.html
Port Bay FAS / West Bar	1983	NYSDEC	Permit #80-82-0010
Port Bay FAS / East Bar	1984	NYSDEC	Permit #80-84-1095
Pier Modification Permit USACE / NYSDEC	1989	NYSDEC/USACE	Permit #8-5426-00010 (NYSDEC) and 89-740-4 (USACE)
Federal Emergency Management Agency (FEMA) Maps: - T. Huron, Flood Insurance Rate Map - T. Wolcott, NY, Flood Insurance Boundary Map - Coastal Work Maps for Lake Erie and Lake Ontario – New York	Jan. 1996 Jun 1992 2018	FEMA	360892 0010- C 360901-C http://fema.maps.arcgis.com/home/webmap/viewer.html?webmap=e8c229a3c01448ebb75b7fde702f72e0
NYSGIS Clearing House - Wayne County Municipal GIS Data - Aerial Imagery (2015, 2010, 2005, 2002, 1994)	July 2018	NYSDEC	https://gis.ny.gov/gisdata/inventories/member.cfm?organizationID=529

Title	Date	Author	URL/Doc. ID
Port Bay Improvement Association - Historical recollections - Previous photo logs, area descriptions, presentation		PBIA	The Port Bay East Barrier Bar; Port Bay Channel
USGS National Water Information System: USGS 04232133 Sterling Creek at Mouth at North Fair Haven NY	Jul. 2017-18	USGS	https://waterdata.usgs.gov/ny/nwis/uv/?site_no=04232133&PARAmeter_cd=72214
USGS National Water Information System: USGS 0423207760 Lake Ontario at Sodus Point NY	Jul. 2017-18	USGS	https://waterdata.usgs.gov/ny/nwis/uv/?site_no=0423207760&PARAmeter_cd=72214
USGS Flood Event Viewer: STN Site No.: NYWAY20102	Jul. 2018-18	USGS	https://stn.wim.usgs.gov/fev/#LakeOntario2017
USGS Historical Topographic Map Explorer	July 2018	USGS	http://historicalmaps.arcgis.com/usgs/
"Wave Information Studies" database		USACE	http://wis.usace.army.mil/
Wayne County Soil and Water Conservation District - Topographic and Bathymetric Surveys - Conceptual Designs - Photos - Other supplemental data	2015-2018	WCSWCD	

Appendix B
Summary of Stakeholder Outreach

Port Bay Damage Assessment Questionnaire

181 responses

Port Bay Resident Information

Address:

181 responses

11753 Tompkins Point Road, Wolcott, NY, 14590

8282 Graves Pt. Rd

11677 Tompkins Pt. RD.

8229 east port bay

8123 Robin rd.

11700 Tompkins put rd

East port bay road

8160 Graves Point Road

Graves Pt.Rd.

7884 North Maple Ave

8182 GRAVES POINT

7625 W Port Bay Rd.

8034 North Maple Rd

8391 Thrush rd Wolcott NY

7876 north maple rd

7771 Dove Road

8099 Martin road

8206 Graves point

8346 Graves Point Rd

11617 thompkins pt. Rd

7920 north maple wolcott

8506 E Port Bay

8283 E. Port Bay Road

11642 Tompkins Point Road

8324 West Port Bay Rd 14590

8081 martin rd

8451 East Port Bay Road

11727 Tompkins Point Road

11715 Tompkins Point Rd., Wolcott, NY

7866 N Maple Rd

11735 Tompkins Point Rd Wolcott NY

7899 Finch Road

11773 Tompkins Point

8382 west port bay rd

8215 graves point

8503 east Port Bay Rd , Wolcott NY 14590

8294 W Port Bay Rd

8228 West Port Bay Rd.

8033 and 8047 martin rd

11730 woodtract rd

8174 Graves Point Rd

8405 Thrush rd

8285 East Port Bay Rd -Wolcott

Eagle Road

8081 Martin Road

8119 Martin Rd

8509 East Port Bay Rd

8300 Graves Pt Rd

8002 north maple rd

11645 Tompkins point road

7863 n maple

8333 East Port Bay Rd.

11742 Woodtract Wolcott 14590

7737 east port bay rd

7927 Jay rd, Wolcott, ny 14590

8123 Robin Road

8018 north maple

8339 East Port Bay Road

8203 Starling

8459 East Port Bay Rd.

8247 east port bay rd

Graves Point Rd.

8325 ash rd

8477 east port bay rd. Wolcott ny

8215 walnut rd

8280 West Port Bay Road

7787 Dove Road

11777 Tompkins Pt Rd

11658 Tompkins or rd

8305 Ash Rd. Wolcott NY 14590

7780 West Port Bay Road

8043 Martin Road

8251 E Port Bay Rd

8463 East Port Bay rd

8341 graves pt

8455 E Port Bay Rd Wolcott, NY

8368 Graves point

6174 Graves Pt. rd.

7705 Cardinal Dr

8087 Martin Road, Wolcott, NY

8471 East Port Bay Road, Wolcott, NY

11697 Tompkins Point Rd

7992 N Maple

11608 Tompkins Point Road

7761 Dove rd

8239 Dogwood Rd. Wolcott, NY 14590

7839 eagle rd

8233 walnut rd Wolcott ny

8509 E Portbay Rd

8305 Ash Rd Wolcott NY 14590

8385 Thrush Road

11659 Tompkins Point Road

7908 North Maple Road

7945 Jay Rd., Wolcott

8367 East Port Bay Road

11746 Woodtract Road Wolcott, N.Y.

6214 W Port Bay Road

7760 W Port Bay Rd

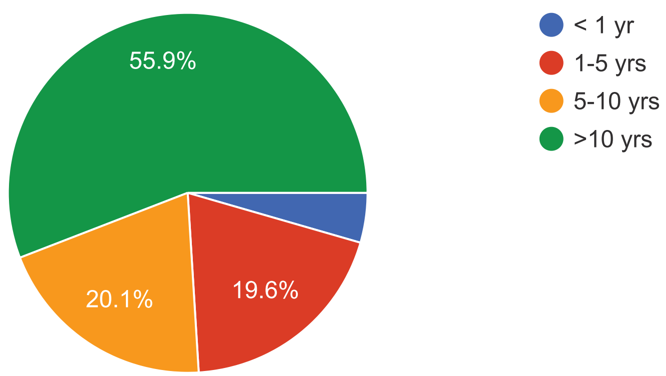
8488 East Port Bay Rd

11657 Tompkins Point Rd

Other (81)

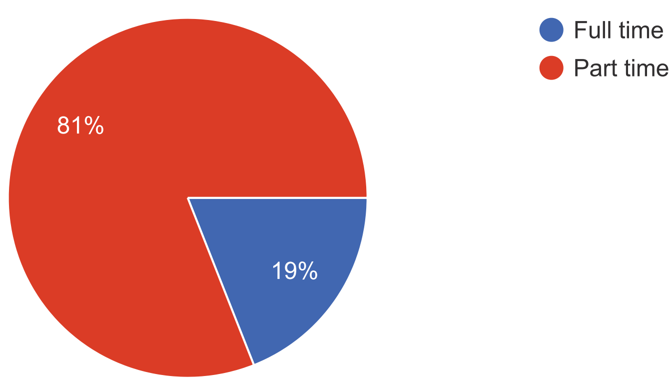
How long hove you lived at this property?

179 responses



Are you a full time or part time resident of Port Bay?

179 responses



If Part Time, what date range are you typically in residence?

147 responses

May - October (4)

April-November (4)

Summer (3)

May-October (2)

April thru November (2)

May to October (2)

May-September (2)

April to october (2)

May - September (2)

May through October (2)

May-Sept (2)

March - November (2)

weekends (2)

May - Sept (2)

April-October (2)

May thru October (2)

May-Oct (2)

Part time during all 12 months. All weekends from May through mid November

June - September

Florida

March to October

April to October

5/1-9/30 weekends & holidays

Weekends year round

YEAR ROUND BUT PART TIME

4/30 - 10/30

6/1---12/1

April to November

March to November

Most of the summer weekends and selected weekends the remainder of the year

Memorial to Labor Day weekends

April 15 to oct 31

Every weekend

6 months

Weekends but all year

Weekends and summertime

Spring/Summer/Fall...Thursday thru Sunday

O5/01-10/31

12 months

every weekend all year

June- October

May through October but I

5-1 to 11-1

May 1 to oct 30

Year around on weekends and some weekdays.

April-September

May -Nov

April -October

May till October

5/1 - 11/1

various days, May through October

Weekends

April - early November

June 23 thru September 3rd

Weekend from April to October then full time summer

Year round

March-Nov

May - Nov

early may until the last week in sept

Throughout the whole year

May through middle of November

Memorial Day to Labor Day

May-Sept, also December

varies

visit all year

5/15-10/1

Four months

April - Oct

Not our primary residence, but utilize Port Bay all year on weekends.

May-Nov

May to September

4/1- 11/25

4days week from april to october

Mar-Nov

weekends only, but year round and a few months during the spring, summer, and fall

April - November

May to October

Mostly summer

April _October

May to September

Throughout the year, mainly May to October

2-4 days per week

April through October

4/1-11/1

May-December

Summers

April through December

Mar - nov

4/20-10/25

april through november

Off and on all 12 months as it is a year round house.

Basically used for rv and boat storage. Only there for one or two weeks annually.

April 1 to October 30

45 weekends a year

April -november

april through october

summer

May 1st - Oct. 1st

April thru october

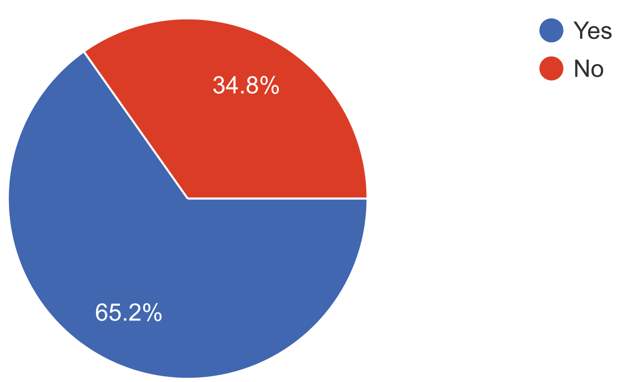
July

Other (25)

Shoreline Protection

Does your property have shoreline protection? (i.e., rock, breakwall)

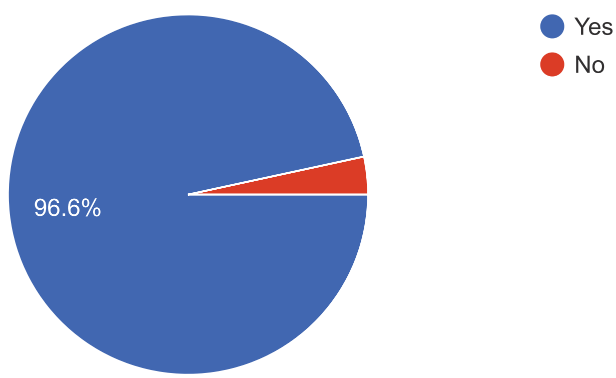
181 responses



Property having shoreline protection

Was it installed prior to 2016?

118 responses



Shoreline protection installed prior to 2016

Approximately what year was your shoreline protection installed?

109 responses

1973 (7)

1990 (5)

2000 (5)

1985 (5)

2013 (4)

Unknown (4)

Not sure (4)

1993 (3)

1980 (3)

1998 (2)

unknown (2)

1960 (2)

2005 (2)

2014 (2)

1972 (2)

unsure (2)

Unsure

1950

Don,t know. Loose rocks placed over the years.

na

Unknown- previous owner

Natural rock date unknown

Over many years and only patial

Over the years

1977

1955

1970

I do not know exact date, but judging by the materials used I woul say early 80's

1988

don't know

1940 looks original

Pre 2000

Mid 1930 upgraded in 1981

1960 ???

Previous owner but only a portion is wall. Did not help at all last year. We were completely under water all last season

unknown. Installed before we bought the property in 1990

1980’s

Existed when purchased

The 80's or before

1970's

?

no idea

NA

late 1950's

Previous owner but believe sometime around 2010

2008

unkown

Don’t know maybe 93

1989

Not sure - but quite old in spots

2009 approx.

1960’s

Before 1977, not sure when!

not sure

2003

1949

1970s

Will have to look it up

Not sure guessing 40 years ago

in the 1950"s then redone in early 70's after Hurricane Agnes

I don’t know, it was before us

1976

Don't know

Not sure, probably in 1960’s ?

Before we purchased

Not sure - previous owner installed

Not sure. Previous owner installed it.

1995

Over 20years

1972. Agnes

1984

Describe what kind of protection (i.e., rock, wall, sheet piling, vegetation, etc.)

112 responses

Rock (11)

Wall (7)

Sheet piling (7)

Railroad ties (3)

Wood (3)

Steel wall (3)

sheet piling (2)

Rocks (2)

rock (2)

Steel (2)

wood (2)

Steel breakwall (2)

Concrete (2)

Steel sheet piling (2)

Wood wall with rock behind.

Cement wall & rock

WOODEN WALL

Some rocks

loose rock

Large stoned

8x8 timbers

Concrete & rock

Railroad Tie's

Part rock and part concrete

Rock shoerline

8033 rock wall, 8047 cement wall

Wall. (Timbers)

Sheet piling

Concrete breakwall and stacked rock wall

Rock and. Vegetation

Part wall steel

Concrete block and rock

rail road ties

Concrete

Existing small rock cobble and vegetation

wall

Sheet Piling

Stone and mortar breakwall

Concrete and RR ties

Rock Wall Put up after hurricane Agnes

rocks

Wood break wall

wood walls with rocks behind

basically rock and earth

Steel sheet piling - some. The rest is rock and vegitation

lake rock

At immediate water's edge we have only rock, however we have a steel breakwall further up the hill

6X6 wood posts

Wooden breakwall with piled lake rock in front

Sheet pile

wooden wall

concrete breakwall

Concrete/stone

Steel break wall

wood wall rock behind

Wood Piling

Sheet piling backfilled with concrete

wall on one side, rocks and vegetation on the other

concrete

Concrete wall

Cement breakwall

concrete walkway - railroad style wood pillings

Sheet piling but only on about 1/3 of the shoreline

Wood veneer supported by Rail Road ties

Wood planks

Just rock at hill bottom

Loose rocks mostly

Cement wall

Natural rock

Block solid filled with concrete

Rock & wall

Rock, wood wall, and vegetation

rip rapp rock

Cement wall. Railroad ties

pressure treated wood wall

rr ties

Prior to 2016, how often did your shoreline, dock or home experience damage? Describe the damage.

110 responses

Never (18)

None (12)

none (9)

never (4)

once (3)

Unsure (2)

Unknown (2)

Normal wear and tear (2)

In 1972 the break wall was destroyed.

None before 2016

Almost Never

NEVER

Never. No damage. Had to sandbag to keep junk from yard.

Erosion to land

6 times since 1973 - 5 times with minor dock damage and 1 time tore dock and cribbing away due to high waters in early spring.

N/A

the bank is falling into the bay, and high water waves have eroded the top tie's

don't know

1 time in ?1991?

never

Every year. Rocks fall in and we have to put what we can back.

Not to my knowledge

Seldom

whenever the lake level went above 248'

Consistent small erosion

Erosion behind the break wall, water in boathouse, damage to boathouse doors from spring high water level and floating debris

Prior to installing break wall, the ground was eroding.

hard to tell, possibly every winter, there are cracks in the wall which seem to be getting bigger

Only had damage when water was high. Shore line soil was washed away.

Wash out behind wall

periodic high water levels would cause some damage

?

Rare - some erosion

1997 high water.2011 or 2012 first small breech on PB, before that till the 1950's nothing

NA. Purchased property in Dec 2016.

Don't know

None, Normal wear and tear

With high water (20-year cycle)

normal

no damage

Minimal if any

None that I know of

unsure, purchased 2013

Zero

Displacement of wood timbers

minor damage

next to NONE!

shoreline eroding

Never had damage prior

Once

concrete walkway sank/listed during the prior high water in 1993

Not often

None

Wood veneer wall shows weakening, bowing and partial detachment each year.

Boards knocked from dock as a result of debris from breach and wave action.

None

Didn't own it then

Yes erosion of the water front shoreline

Dock under water. Wall a few cracks

Not sure- purchased 2018

0

seldom

seldom-some sink holes behind wall caused from spring high waters

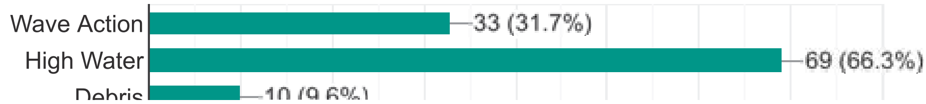
Mebrr

no

Not very often. Deterioration of old railroad tie breakwall.

What would you attribute the majority of the damage to?

104 responses



Shoreline protection installed after 2016

When was it installed?

4 responses

2017

August 2016

december 2017

2016

Damage caused in 2017

Was your shoreline, dock or home damaged in 2017?

181 responses

Yes to damage in 2017

Describe the damage caused

120 responses

Dock under water so damage to finish and shoreline erosion

Dock and lawn both underwater until mid July. Some dock boards needed to be replaced. Lawn needed to be entirely reseeded.

Washed out dirt where we didn't get sandbags installed

Ruined the dock & cracked the cement

slight settling of patio pavers due to water erosion

EROSION BEHIND BREAKWALL

Dock under water, raised and rotted 2 center posts

lawn brake wall

Dock flooded

Damage to Dick boards and shoreline erosion

Brand new dock wook is damaged along with shoreline and land erosion

Being dock is fairly new I had to power wash and restain the dock . Some boards had to be rescrewed down as they had lifted

Flooded basement ruined entire basement. Erosion took out footings. Foundation which sits in water was broken and eroded. Dock damaged. Have to take out entire floor and repour. Utility damage. All basement drywall.

Highwater went over the wall and wash the hill away also destroyed the grass and lower area The most ridiculous part was the loss of the use of the water for a whole year why do I pay taxes

Breakwall timber deterioration. Excessive peeling to deck stain

Dock wood damage

Dock damage tree erosion

water damage to shed ,rocks,and wash out behind wall

rock wall washed out due to soil behind it washed out , first time the water level has gone over the rock wall since installed

some railroad ties washed away

Dock under water 2,5 months: visible damage minimally but water logged etc.

Docks and boat house were under water and flooded boat house

Flooding caused massage cleaning several times

8047 cement breakwall compromished due to errosion..soil washed out under footers. 8033 west wall and north wall home foundation partial collaspe...8033 some sink holes near rock breakwall as soil washed out...dock under water requires cleaning and repainting

Dock washed away

Dock boards are warped and split. Screws are all rusted. Cleats are all corroded. Electrical needed to be replaced being underwater. Deck needed to be pressure washed to remove seaweed growth covering everything . Carpet covered in mold from being underwater. Side walk warped from being underwater . Shed had about 6 inches of sitting water most of the summer. This caused mold and mildew and boards warping. Lawn was underwater and needed topsoil and to be reseeded.

All the new landscaping from the newly installed wall was destroyed; Brand new Dock decking was damaged from being underwater most of 2017

Water 2 feet over top of breakwall , took out lawn decorative gardens and caused collapse of portions of the rock face

Wash out behind breakwall and rocks; flooded shed

Dock boards needed to be replaced, restaining of dock. Lost quite a bit of the shoreline due to high water and wave action. Keeping sandbags until new breakwall can be replaced.

Our entire dock and lower deck area was completely under water for the entire season. Water damage to our wood. Degree everywhere including giant tree parts and trunks We lost a huge chunk of hill not protected by the steel wall. Which by the way did absolutely nothing to protect us from damage. Who knows what damage the steel has. Massive erosion under the slightly higher deck area. Couldn't use our water craft for the entire season

Damage to rock wall and loss of soil

erosion behind break wall, missing railroad ties, lost all grass, topsoil, plants and trees on the ground level of our property

3 large timbers that hold up our large deck were encased in high water.

Parts of the dock wood broke away.

Bank eroded

Erosion, dock damage

Dock, breakwall, and boathouse damaged due to high water, float trees,
Lifted dock boards off, eroded breakwall

Toe of slope washed away, most of protective rock gone

flooded boat house erosion behind the wall

Erosion, boat shed damage

Dock was broken

A number of dock boards needed to be repaired

Dock cover board loosened from high water and wave action

water 'Back Cut' the break wall washing away a lot of our front lawn.

Break away of RR ties, boathouse shifting.

Boat House & interior components were damaged

dock and retaining wall washed away

Docks damaged, lost boards, moved docks, hoist motor, rock gabion baskets ruined, most grass and fill dirt erroded away

I lost $ 300.00 worth of treads from my dock.

Severe wash out behind wall and water damage to wood which will require repair or replacement once water recedes in fall, which did not happen in 2017.

The garage door of our boathouse was smashed in and some of the shoreline was washed away.

Erosion of shoreline due to high water and waves.

Under water for 3 months, needed cleaning, re-staining, left some boards with creaks and splinters.

we lost 7 feet of land to the water

erosion from high water to shoreline

Erosion where there was no sheet piling. The entire property and dock were under water for several months

20' x 40' of submerged lawn needed to be reseeded

shoreline was damaged do to the high water and wave action. Specifically the wave action. it under cut our break wall. It also knockdown our rocks on our break wall some of the rocks were swept away by logs and wave action hitting them. Also with the higher water it did some damage to of pier foundations on our garage and under our cottage.

Permanent dock under water for 3 months resulted in damage to finish and quality of permanent dock boards. Erosion to shoreline due to high water and wave action.

Shore Erosion, lost 3’

water went over the breakwall allowing water to come up onto property, this hurt the stabilization of the breakwall and caused us to have to refill the dirt behind the breakwall to hold it up

Dock separated, twisted and under water

rock barrier washed away, seasonal dock destroyed

Wooden ties and stones completely washed out; loss of shoreline partially ameliorated by sandbags (>400)

Retaining wall compromised and eroded on shore side, flood damage to guesthouse

Major Shoreline errosion

Water laden ground behind wall forced it to bow out

dock deterioated

erosion, dock mold, dock boards needed repair, garbage & debris

Dock and front yard

Underwater almost till August...boards warped and concrete pad cracked..beaver moved onto boathouse and chewed 3/4 thru support beam

Wood on dock

Rock break wall was displaced dock was under water and dock foundation damaged boards removed and structure changed

Water damage to boat house and shore erosion

Shoreline erosion, electrical issues, dock damage

Minor errosion. Dock under water much of summer. Wood damage.

Docks and break wall underwater and grass yard wash away

Dock under water

Erosion, Delamination of composite decking.

damaged boards, rotting boards and loss of grass

Severe shoreline erosion and coming apart of wood break wall.

Some boards on dock raised- soil washed out under deck

Paint gone, wood damaged and splintered, mildew present

paint peeled on dock due to being submerged

The wave action eroded the concrete along the edge of the steel panels.

High level waters

erosion, deck and shed damage

Dock washed away

Boathouse, which had been turned into storage with a floor with a surrounding dock was a foot under water all summer 2017. Lost quite a bit inside, had to replace floor and interior walls. Corner totally rotted causing boathouse to say dramatically out of alignment. we

degradation of wall, erosion of vegetation erosion

shore line wash away

Wooden boards on the dock were damaged

more settling of the walkway

Major land erosion, damaged stairs

Water over the dock lifting up boards and dislodging some floating devices

We lost some dirt

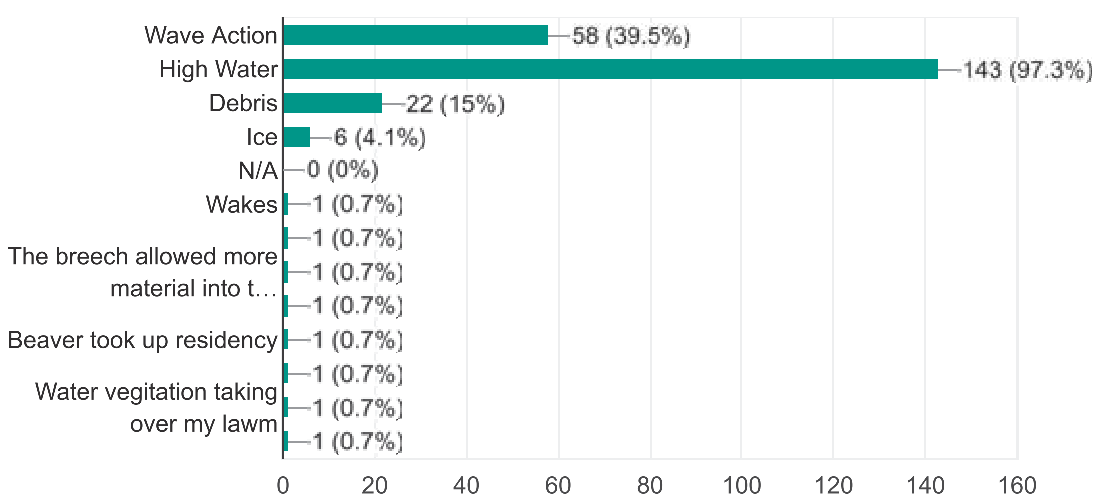
Deteriorating breakwall and submerged docks caused cosmetic damage to docks

Dock boards were knocked off by logs and debris impacting the dock. All electrical had to be redone. Large amount of driftwood/plastics/garbage had to be removed from dock creating a pile about 8' x 4' x 4'. Dock poles had to be sand blasted and repainted. Additional debris had to be removed from stairways.
As a result of the breach, many huge logs and trees came into the bay. Many people put there own safety in jeopardy by swimming out to tie ropes on the logs so they could be brought to shore before causing far more damage to docks and boat hoists. Neighbors with large equipment dragged to logs from the bay to a central pile that became huge. The county, town or state offered no assistance even when asked. Establishing a total cost is difficult because much of this was done by neighbor helping neighbor.

Other (20)

What would you attribute the majority of the damage to?

147 responses



What was the approximate month or timeframe the majority of damage occurred?

148 responses

May (8)

April (4)

Summer 2017 (4)

May and June (3)

June (3)

July (3)

May - August 2017 (2)

June - August (2)

May through August (2)

May through July (2)

Spring 2017 (2)

May through end of August

May - July

April to July

May till August

April

3/2017-7/2017

april thru July

FEB. - JULY

April-August

April to Sept

May - June 2017

During high water first half of 2017

All summer

Winter spring 2017

May 2017

Don't know but during the summer

June 2017

June&july '17

May- June 2017

June, July , August 2017

Mid May to Augusr

Spring summer

March

April-september

June July

2017 high water spring till late august

April-late August

May-Aug 2017

April through Sept

June, July, August

summer months od the high lake levels.

All season. April till well after October

End of May through early July

april to august 2017

3/17 - 9/17

May thru august

Last spring and summer

May to August

May-August

April-July

Last spring and summer

april

April to september

May-June

May, June

all spring and summer 2017

May-July

March - April - May 2017

april - july

May - Aug

May-Aug

Spring thru end of summer

May, June, July

4/1/2017 - 11/30/2017

probably the month of July

May - June

late March thru late May

April - Aug 2017

Apr - Aug

Spring through Summer

April & May

March through July

March-November

At thaw through july

june/july

March - end of July

April through August

Spring tbru early August

March through July

May they July or august

May to sept 17

June thru September

May-aug 2017

spring

May -July ?

may-july

Spring,summer 2017

Spring- summer

March 2017-August 2017

Stormy weather when waves were raging!

May thru September

May-Aug.

june

April - June

summer

Spring & Summer 2017

April through August

June-july

My wife suffered strokes last year / anything was irrelevent to me

Other (24)

Did you have the damage repaired?

148 responses

Repair of damage 2017

Describe the repair

53 responses

Dock boards replaced, dock power washed and painted, lawn reseeded.

New dock & cement patch

releveling of the patio pavers

BACK FILL WITH TOPSOIL

25 yards top soil and seed

Restrained dock and repaired boards that popped up

completely rebuilt stone wall and raised it 12" higher and had truck loads off soil brought in to reinforce rock wall

Power washed. Left to dry and stained this year

Stone wall

Replacement

Retrieve and rest dock list two adjustable legs

Not everything was repaired yet . We did what we could and will continue to finish as we can afford. Dock still needs new boards and screws. We pressure washed dock .Cleaned the shed with bleach and resealed the floor and Coated and sealed wooden sidewalk . Topsoil and grass seed . Rewired electric to dock.

Replaced all new lawn work, replaced top soil, reseeded; manually cleaned decking, re treated decking, scrubbed and re-conditioned. Not yet fixed is new stone landscape wall that sank because of high waters

We had to completely redo the dock
We cannot get back the eroded hill which we pay property tax on. We have yet to repair the lower deck area or the slightly higher deck area. $
All of our rocks were pushed up against the back wall. We had to painstakingly respread all the rocks. Our entire log pile was taken away by the water. We had just purchased an entire load just prior to the water issues. We have no idea of the damage to the steel from sitting inder the gross water for the season as well as no idea how bad the erosion is under our decks and the small cement wall at the end of one of our decks

Boat house floor restoration, mildewed furniture cushions, rusted wrought iron furniture and ruined dock stain requiring new staining. Temporary dock fastening, which floated away.

Plank replacement

Restrained dock, need to replace boards, fixed break wall , fix electrical on dock

Trying to regrow vegetation and added more cobble rock to washout areas

Replaced missing dock boards, boathouse doors. Filled in soil that eroded behind breakwall. Pulled out 25+ trees from dock/boathouse area

placed stone behind wall cleaned out boat house and threw out things that were destroyed

Dock was under water and could not use our boat.

New wood and posts for dock

reattach damaged dock boards

Hauled in loads of dirt to back fill between the breakwall and the cottage

Walls of Boat House were rebuilt

new dock and break wall

Replaced all the lost deck treads.

Added sandbags for temporary repair. Had soil and rock brought in in spring of 2018 for more permanent repair.

Did it myself.

Repairs are scheduled. Waiting on permits for additional sheet piling and raising height of existing wall.

Lawn reseeded

we personally replaced some of the stone on our break wall. we also removed a lot of log's tree's and other debris and either cut up the trees and moved out of the water so it would not be someone else's problem. 8-12 hours on a weekend were lost to protecting and cleaning up our shoreline, so others did have to. I would also assume other had similar experiences.

Professional power wash and re-staining done to address cosmetic damage to permanent dock.

A break wall needs to be installed

Top soil and seed repair dock and re stained

replace wood

new boards, new grass

New pile driven steel break wall being installed to replace pre-existing wood break wall.9

Deck boards replaced

replace flooring in shed, deck structure, fill dirt and seed

Replaced floor and walls. Removed damaged contents. Had to realign entire boathouse with wench and secure

fill in the parts that eroded

New stairs and cleanup of debris

Replaced the boards and repaired the hose line

Filled it in with dirt

Docks were sanded and refinished. New breakwall to be installed during 8/2018

Boards were replace on the dock. The electrical had to be redone. Debris and logs had to transportes away.

Added rocks to raise breakwall and backfilled eroded ground with stone.

Power wash and patch cement floor, replaced damaged wood planks/ties

Replaced a couple of beams to the dock.

replaced parts, stones pulled out of eater and put back up onto rip app

new metal break wall was installed.dock was power washed and re-coated with 3 coats of stain

Fixed boat house

Provide an estimate for the cost of repair

56 responses

4000 (2)

$800 (2)

$500 (2)

minimal (2)

$500.00 (2)

$300 - $500 plus lots of sweat equity from myself, wife, son son-in-law

$12,000

< $100.00

$400.00

app 5000

$750

2000

did the work myself about 3weeks 120 hrs plus of hard work and three loads of soil estimate of material and my labor $2000-2500

5000

Spent about 600 dollars and 100 hours of time. Amount needed for dock repair approximately 2500.

$4,000

No clue. Haven't added it up yet because we still aren't done
Probably going to be upwards of $40,000.

$1500

1000 dollars

$10,000

minimal put not a permanent fix

$5000

400.00

$600

If we used a contractor, perhaps between 400 to 800 dollars? Brought the dirt from our farm and did the work ourselves, so no cost was incurred.

40,000 + boat damage + Winch Damage Etc. Can you put a price on loosing your Place to entertain grand kids for a summer ?

$50,000.00

$300.00

$1000 in materials and 2 days of labor for 2 people.

$200

$40k

$100 plus own labor

$20,000 in personal time and labor

???

500.00

$300-400

$45,000

Not sure as had stairs replaced at same time

200.00

$2800

dont have one

1200.00

$0

Approx. $10,000.

Family and friends helped with repairs but if done professionally the cost would have amounted to between $2000 and $3000.

0 did it ourselves using stone from dredged channel pile.

Unsure- completed by previous owner

Approximately $75 for materials. More time than money.

hoist $100, $500+ for erosion

$17,000

40k

Damage caused in 2018

Was your shoreline, dock or home damaged in 2018?

181 responses

Yes to damage in 2018

Describe the damage caused

23 responses

Destroyed dock

Dock

More erosion of foundation

eroded the soil behind the railroad ties, allowing the ties to fall into the water

High water in spring

Dock and poles corrosion

Ice further impacted rock face and dock structure due to higher water levels

Erosion from high waters and waves

Dock boards torn off and remaining pvc decking permanently stained

dock lifted on right side

Erosion

settling and cracking of dock and breakwall

Dock lifted, boards weakened by water, sealer dissolved

Wave action from initial high water from boats further eroded cracks in breakwall

Break wall and dock damaged

More shoreline erosion

Shoreline eroded, finish lifted off dock, lost 2 sections of dock that floated away!

Cosmetic damage to docks + structural damage to breakwall.

Dock split and ended up in the water.

Breakwall

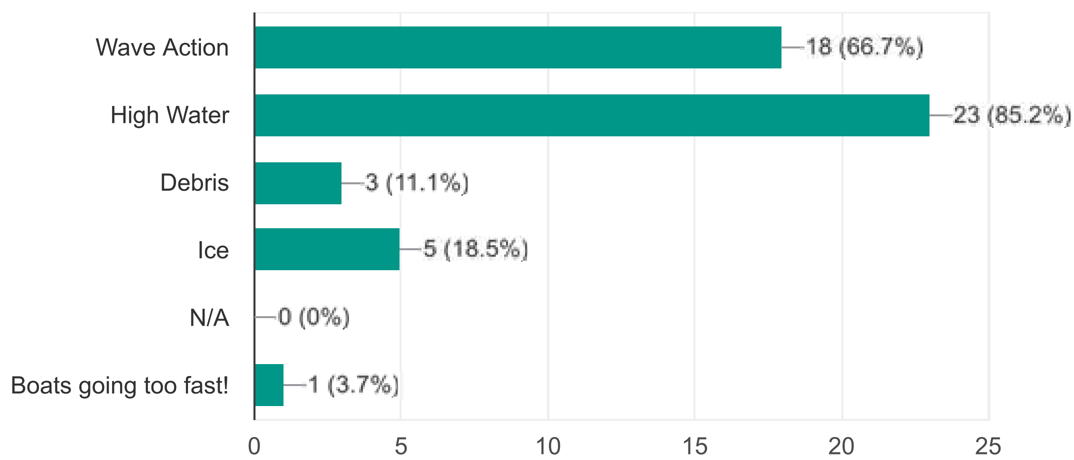
dock needed power wash and re-staining.breakwall weakened by erotion behind wall caused by washout of back fill

Continued shoreline erosion and wave action destroying property

Dock underwater. Yard damage.

What would you attribute the majority of the damage to?

27 responses

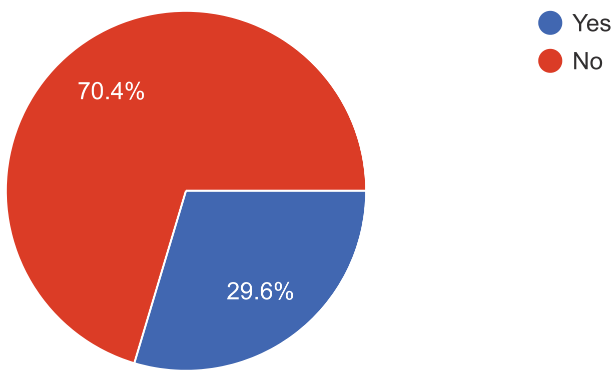


What is the approximate month or timeframe the majority of the damage occurred?

27 responses

Did you have the damage repaired?

27 responses



Repair of damage 2018

Describe the repair

7 responses

Rebuilt dock$4000

Replaced missing boards

New break wall being installed

Docks sanded and refinished. Breakwall to be replaced during 8/2018

Raised dock adding new support to keep it out of water and piece it back together. This is only a temporary fix that will require replacement of entire dock since 2 of 6 posts snapped.

Backfill needed

new steel break wall.power washed dock and re-stained

Provide an estimate for the cost of repair

7 responses

3000

$2500

$45,000

Approx. $10,000.

$500 so far, I have an estimate to replace for $18,000.

2500

$17,000

Further Contact

Name

113 responses

Ron Woodcock

Richard Cavallaro

Russ welkley

Scott

Chris loveless

Richard Paradiso

David Grantham

Maryellen

Harry DeKing

William Clifford

Jeff auser

Paul Ferruzza

Kevin Lochner

Beth malone

Edward allen

GARY PENNER

Frank St. George

Roger Pritchard

William DeWispelaere

George Satter

Robert and Linda Kammer

Bob Kimmel

Janet Pontera

Tim Clark

Herb Besaw

Nicholas e decausemaker

Wayne Legacy

Terry Palis

Tartaglia

Matt harper

Shawn Blackburn

Beth and Todd Galloway

Stephen Cataldi

Don Stevens

Lynn Pritchard

Jennifer Pulver

Tony Leone

Michel Neracker

Thomas Anderson

Mike van allen

Richard Switzer

Michael Young

Tom Interlichia

Richard Neubauer

Maureen Giroux

Glenn Saile

Fran mackaravitz

Amy hughes

David Michels

Jean Melino

robert pedzich

Cathy Hurwitch

William F Embrey

Bruce Johnson

Paul Marone

BARBARA THOMPSON

Michele

Lou Rotunno

Dave DeZutter

Tom Noll

R Sturn

Andrew Lacy

Michael Keeney

Carl Hurwitch

David Aldrich

Jay Woychick

Ralph A. Gravelle

Brittany

Jim McDonald

Joseph Izzo

Mike DePuyt

Hal Smith

John McClellan

Lori Furguson

Susan Reiber

Margaret Embrey

Olaf Lieberg

Susan mcbride

Terrence Cahill. Why does it matter if we are full or part time resdience. I find that question offensive

Al Borrino

Craig and Fran Miller

David Nersinger

Dawn DeRoo

Jeff Hamelinck

Chanda Vincent

Robert Maier

Gerald DeCausemaker

Lynn Cataldi

Robert

no

Dan Boas

Graham Dickson

Keith Mrzywka

Douglas Kinney

Bruce and Carol Coon

Pat and Dan Finn

Colleen & Steven Hill

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Appendix C
Details of the Concept Cost Estimates

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Albany, New York 12242
Phone: (518) 474-6604

Alternative B	To:	Bergmann	Project No.:	-
	Trade:	Construction	Date:	4/1/19
Port Bay Barrier Bar	New/Rehab:	Rehab	Phase:	Design
Huron, NY			Client Agency:	NYSDEC
Wayne County			Prepared By:	Bergmann

Budgetary Order of Magnitude Construction Cost Estimate

Work Item				Qty	UoM		Unit Rate			Extended Cost
0	Permanent Equipment Access			1	LS		$200,000	/LS	$	200,000
	Mobilization and Access	subtotal	$	-	at		10%			
	Contingency	subtotal	$	-	at		30%			
	Contractor Supervision			0	Days	$	550.00	/Day		
								Total	$	200,000
								Rounded Construction Total	**$**	**200,000**

Life Cycle (LC) Cost Estimate

Maintenance Activity	Reccurrence Interval (Years)	2018 Cost Estimate Per Occurance
Employ sediment bypass to east bar (typical year)	1	$15,000
Employ sediment bypass to east bar (difficult year)	10	$40,000
Biennial Inspection	2	$3,000

Discount Rate	4%	
Duration	30	years
Present Value of LC Costs	$340,000	

Key Assumptions

- Permanent equipment access included as part of original construction cost
- Sediment bypass to east bar employed annually, and assumes once every ten years a difficult year is encountered where additonal effort is required due to poor site access

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Alternative C	To:	Bergmann	Project No.:	-
	Trade:	Construction	Date:	4/1/19
Port Bay Barrier Bar	New/Rehab:	Rehab	Phase:	Design
Huron, NY			Client Agency:	NYSDEC
Wayne County			Prepared By:	Bergmann

Budgetary Order of Magnitude Construction Cost Estimate

Work Item			Qty UoM	Unit Rate		Extended Cost
0 Permanent equipment access			1 LS	$200,000 /LS	$	200,000
1 Nature-Based Barrier Bar			450 LF	$500 /LF	$	225,000
Mobilization and Access	subtotal	$ 225,000	at	10%	$	23,000
Contingency	subtotal	$ 248,000	at	30%	$	74,000
Contractor Supervision			60 Days	$ 550.00 /Day	$	33,000
				Total	$	555,000
				Rounded Construction Total	**$**	**600,000**

Life Cycle (LC) Cost Estimate

Maintenance Activity	Reccurrence Interval (Years)	2018 Cost Estimate Per Occurance
Employ sediment bypass to east bar (typical year)	1	$15,000
Initial maintenance of nature-based bar	@ year 5 & 10	$120,000
Remaining maintenance of nature-based bar	@ year 20 & 30	$80,000
Biennial Inspection	2	$3,000

Discount Rate	4%
Duration	30
Present Value of LC Costs	$550,000

Key Assumptions
- Permanent equipment access included as part of original construction cost
- Sediment bypass to east bar employed annually
- Assumes substantial maintenance every 5-10 years, with initial maintenance occuring every 5 years for 2 cycles, and remaining maintenance to occur every 10 years

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Alternative E	To:	Bergmann	Project No.:	-
	Trade:	Construction	Date:	4/1/19
Port Bay Barrier Bar	New/Rehab:	Rehab	Phase:	Design
Huron, NY			Client Agency:	NYSDEC
Wayne County			Prepared By:	Bergmann

Budgetary Order of Magnitude Construction Cost Estimate

Work Item				Qty UoM		Unit Rate		Extended Cost
0 Permanent equipment access				1 LS		$200,000	/LS	$ 200,000
1 Debris Boom and Anchorages				1 LS		$107,500	/LS	$ 107,500
Mobilization and Access	subtotal	$	107,500		at	10%		$ 11,000
Contingency	subtotal	$	118,500		at	30%		$ 36,000
Contractor Supervision				5 Days	$	550.00	/Day	$ 2,750
							Total	$ 357,250
							Rounded Construction Total	**$ 400,000**

Life Cycle (LC) Cost Estimate

Maintenance Activity	Reccurrence Interval (Years)	2018 Cost Estimate Per Occurance
Employ sediment bypass to east bar (typical year)	1	$15,000
Employ sediment bypass to east bar (difficult year)	10	$40,000
Installation / Removal of Boom	0.5	$600
Replacement of Boom	15	$135,000
Debris Removal from Boom	0.5	$2,200
Biennial Inspection	2	$3,000

Discount Rate	4%
Duration	30
Present Value of LC Costs	$560,000

Key Assumptions

- Permanent equipment access included as part of original construction cost
- Sediment bypass to east bar employed annually, and assumes once every ten years a difficult year is encountered where additonl effort is required due to poor site access
- Installation and Removal of Boom occurs twice a year @ approx. $600/EA, assuimng a two man crew for 1 day
- Replacement of Boom at 15 years assumes full replacement of the boom, excluding the anchorages which are assumed to have 30 year service
- Debris Removal from Boom occurs twice a year @ approx. $2200/EA, assuimng a two man crew for 2 days + disposal costs

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Alternative F	To:	Bergmann		Project No.:	-
	Trade:	Construction		Date:	4/1/19
Port Bay Barrier Bar	New/Rehab:	Rehab		Phase:	Design
Huron, NY				Client Agency:	NYSDEC
Wayne County				Prepared By:	Bergmann

Budgetary Order of Magnitude Construction Cost Estimate

Work Item		Qty	UoM	Unit Rate		Extended Cost
0 Permanent equipment access		1	LS			$ 200,000
1 Structure Excavation + Placement of Exc. Mat'l		3320	CY	$20	/CY	$ 66,400
2 Geotextile Fabric		4800	SY	$8	/SY	$ 38,400
3 Sandbags		65000	EA	$7	/EA	$ 455,000
4 Secondary Stone Armor		700	CY	$80	/CY	$ 56,000
5 Primary Stone Armor		2150	CY	$100	/CY	$ 215,000
6 Sand-Gravel Cubes in Woven Geotextile		2700	CY	$200	/CY	$ 540,000
7 Compacted Gravel		220	CY	$60	/CY	$ 13,200
Mobilization and Access	subtotal	$ 1,384,000	at	10%		$ 138,000
Contingency	subtotal	$ 1,522,000	at	30%		$ 457,000
Contractor Supervision		90	Days	$ 550.00	/Day	$ 49,500
					Total	$ 2,028,500
					Rounded Construction Total	**$ 2,100,000**

Life Cycle (LC) Cost Estimate

Maintenance Activity	Reccurrence Interval (Years)	2018 Cost Estimate Per Occurance
Employ sediment bypass to east bar (typical year)	1	$15,000
Revetment Crest Maintenance	1	$2,000
Biennial Inspection	2	$3,000

Discount Rate	4%
Duration	30
Present Value of LC Costs	$340,000

Key Assumptions

- Permanent equipment access included as part of original construction cost
- Sediment bypass to east bar employed annually
- Assume an annual allowance for minor revetment crest maintenance

Cost Summary

Alternative		Initial Construction Costs	Life Cycle Costs	
			Total Life Cycle Cost (Present Value)	Annualized Cost (Over 30 Years)
A	No Action	$0	$0	$0
B	Limited Sediment Management	$200,000	$340,000	$11,333
C	Nature-Based Barrier Bar	$600,000	$550,000	$18,333
E	Infrastructure Protection Measures	$400,000	$560,000	$18,667
F	Fortification Using Rock Revetment	$2,100,000	$340,000	$11,333

Maintenance Activities Breakdown

Maintenance Activity	Reccurrence Interval	Alternative					2018 Cost Estimate per Occurrence
		A	B	C	E	F	
Employ sediment bypass to east bar (typical year)	1 year		X	X	X	X	$15,000
Employ sediment bypass to east bar (difficult year)	10 years		X		X		$40,000
Initial Maintenance of Nature-Based Bar	5 years for 2 cycles			X			$120,000
Remaining Maintenance of Nature-Based Bar	10 years for 2 cycles			X			$80,000
Installation/removal of boom	2X per year				X		$600
Replacement of Boom	15 years				X		$135,000
Debris removal from boom	2X per year				X		$2,200
Revetment crest maintenance	1 year					X	$2,000
Biennial Inspection	2 years		X	X	X	X	$3,000

Appendix D
Design of Rock Revetment

Design Requirements

Design of Rock Revetment

Several of the alternatives involve maintaining the natural condition or enhancing the natural condition of the barrier bar. These types of solutions typically do not have hard design parameters but are based on mimicking the conditions noted in the field with natural enhancements. These alternatives also assume that the life expectancy of the practice will be limited and will need to be replaced, repaired, adjusted or completely rethought in the future. Alternatives F, G and H each propose the implementation of a rock revetment system with the intent of providing long-lasting fortification of the bar. These revetments are designed with a life expectancy of 30 years. While maintenance is required for hardened revetments, it should be less than would be required for nature-based solutions. The preliminary evaluation of the coastal data in **Section 2.1** provided for the following design information, parameters, and conclusions with respect to the management alternatives that include fortification with rock revetment:

a. The coastal dynamic of the east barrier bar involves an overall recession and erosion of its lake side.
b. Combination of high water level and large storms led to breaches near the middle of the bar in early spring of 2012, 2016, and 2017.
c. Winter storms have transported sediment over the pier and across the navigation channel (**Figure 2.1-19**). The sediment transported into the channel and the need for a deepened navigation channel has necessitated an annual dredging of the channel (≈1,000 CY) in early spring. The dredged material is placed into two spoil areas on either side of the channel. The navigable length of the channel is 530 ft with a width of 60 ft within 80 ft ~110 ft waterway.
d. The west barrier bar riprap revetment along 1,700 ft of the shoreline has performed adequately at preventing bar erosion and maintaining bar location since its construction in 1985. Periodic maintenance of the access road at the top of the revetment is required. This is typically done with the dredged material.
e. The following typical beach slopes are extracted from a coastal and land survey in mid-July 2018:

    East barrier bar: Nearshore slope = 4%; overall beach slope = 2~3%
    West barrier bar: Nearshore slope = 7%; overall beach slope = 4~5%

f. Based on an analysis of the historical variations of the water level in Lake Ontario and conforming to the IJC *Plan 2014*, a maximum lake WL of 249 ft (75.9 m) is adopted for design of hard structures such as revetment. This is slightly greater than the recommended maximum allowable mean WL in the months of April (248.03 ft), May (248.46 ft), June (248.33 ft) and July (248.13 ft). In May 2017, the maximum water level was close to 249 ft (e.g., WL = 248.72 ft on May 29 and WL = 248.6 ft on May 10).

g. At Port Bay: NAVD88 = IGLD85 + 0.058 ft (or 0.017 m)
h. A design value of 0.4 knots (~0.2 m/s, 0.65 ft/s) for wind-driven current velocity is adopted for the project site.
i. Significant wind-generated wave height, H_s is 15 ft at a water depth of 70 ft at stations 2~3 miles offshore of the site where H_{max} =28 ft. The waves are predominantly northwesterly, at the angle of 30 degrees with the shoreline (*i.e.*, 60 degrees with the shore normal) and nearly normal to the pier.
j. Sediment sampling from the site suggests that the east barrier bar can be described in general as "well-graded gravel (2 mm- 64 mm)" with little sand (<2 mm) and cobbles (>64 mm). Also called a shingle beach, the Port Bay beach has the following typical sediment sizes:

D_{50} = 12 mm; D_{10} = 2.5 mm; D_{30} = 6 mm; D_{60} = 14 mm; D_{90} = 40 mm

k. A high level sediment transport investigation for the neighboring regions along the south shoreline of Lake Ontario in 2011 suggested that the potential longshore sediment transport (LST) (~300,000 m^3/yr) is more than 10 times (~13 times) the supply-limited LST (~22,000 m^3/yr). No local wave and sediment data were incorporated in this previous investigation.

Design Wave Height, H_D

Return period. According to Policy 13 of the NYS coastal policies: "*The construction or reconstruction of erosion protection structures shall be undertaken only if they have a reasonable probability of controlling erosion for at least thirty years as demonstrated in design and construction standards and/or assured maintenance or replacement programs*" (NYSDOS 2017). Therefore, the 30-year wave height for the project site will be of interest when designing management alternatives that involve fortification with rock revetment.

Thirty-year wave height. The heights of random wind-generated waves in open waters can be described by Rayleigh probability distribution (USACE 2002) as follows:

$$P(H) = 1 - e^{-\left(\frac{H}{H_{rms}}\right)^2} \quad \text{(Equation 1)}$$

$$1 - P(H) = e^{-\left(\frac{H}{H_{rms}}\right)^2} \quad \text{(Equation 2)}$$

where H is the wave height, "1–$P(H)$" is the exceedance probability (i.e., percentage of waves with a height greater than H), and H_{rms} is the root-mean-square height of the waves in the data series. It can be shown that $H_{rms} = H_s /1.416$ in which the significant wave height, H_s, is the average of the highest 1/3 of the waves in the record. This yields H_{rms} = 15 / 1.416 = 10.6 ft at the depth of 70 ft where the offshore H_{max} and H_s were calculated in **Section 2.1.5**.

The 30-year wave height is associated with the exceedance probability of 1/30 = 0.33 per year. With "1- *P(H)*" = 0.33 and Equation 2, the corresponding offshore wave height *H* is computed as follows:

$$0.33 = e^{-\left(\frac{H}{10.6}\right)^2} \quad \text{which yields} \quad H = 11.2 \text{ ft}$$

As mentioned in **Section 2.1.5**, the wave height for structures such as coastal revetment design is either the depth-limited maximum wave height (H_b) or the average of the highest 10% of all wave heights in the design sea-state (H_{10}), whichever is less (USACE 1984, FHWA 2008). These two values are estimated in the following sections.

Estimation of H_b. Coastal revetments are often located where the design sea-state is depth-limited, i.e., the depths are so shallow immediately offshore of the location of the revetment that the storm waves have broken and the largest waves are on flat offshore slopes, where $H_b = 0.8 \times d_s$ in which H_b is maximum breaking wave height and d_s is design depth at the toe of the structure.

From the design WL of 249 ft, an average revetment slope of 1V:2~3H, and maximum nearshore slope for the east barrier bar, and the contours in **Figure 2.1-22**, the maximum water depth at the toe of the prospective revetment will be $d_s \approx 5.5$ ft. Therefore, $H_b = 0.8 \times 5.5 \approx 4.4$ ft.

Estimation of H_{10}. It follows from the Rayleigh probability distribution for wave heights that $H_{10} = 1.27 \times H_s = 1.27 \times 11.2 = 14.2$ ft. This offshore wave height will be transformed to a smaller value as it approaches the shore. The procedure introduced by Kamphuis (2000) as described in the European software CRESS (1990–2018) is used to compute the nearshore wave height. With the breaker index of 0.78, refraction and shoaling coefficients of 1, and the wave angle with the shore normal of 60 degrees, the deep-water H_{10} of 14.2 ft yields a nearshore H_{10} of 11.4 ft.

Choice of H_D. For calculation of the size of rock armors in the revetment, the lesser of the above values (i.e., 4.4 and 11.4) is chosen as the design wave height, namely $H_D = 4.4$ ft (1.34 m).

Rock Size

The rock revetment consists of primary armor units on top of underlayer (secondary) armor units.

Primary Armor: Median Size (D_{50}). Hudson equation as described in USACE (2002, 1984) is employed to estimate the median size of the rock armor units in the first layer of the rock revetment. The equation is

$$W_{50} = \frac{\gamma_a H_D{}^3}{K_D (SG - 1)^3 \cot\alpha} \qquad \text{(Equation 3)}$$

in which W_{50} is the median weight of the rocks, H_D is the design wave height, γ_a is the weight density of the armor units, K_D is a nondimensional stability factor, SG is the specific gravity of the armor units (≈2.65 for quartz), and $\cot\alpha$ is the revetment slope when expressed as 1V:($\cot\alpha$)H.

The following parameters are used:

Design wave height, H_D	= 4.4 ft (1.34 m)
Wave period	= 9 Sec
Revetment slope, $\cot\alpha$	= 1V:2H
Relative rock density, SG	= 2.65
Empirical stability factor, K_D	= 2.0 (rough angular quarry stone; breaking waves)

Calculations yield:

W_{50} = 800 lb (360 kg)
D_{50} ≈ 2 ft (0.6 m)

This first armor layer consists of angular rocks with median size of 2 ft (0.6 m) with an overall thickness of ~4 ft (1.2 m).

Primary Armor: Gradation. Most rocks within the cover (primary) layer can range from 0.75 to 1.25 W_{50} as long as 50 percent weigh at least W_{50} and the gradation is fairly uniform across the structure's surface. Additionally, based on USACE (1985, 4) and USACE (1995, 2-10):

- The maximum rock size is limited to 4 × W_{50} which corresponds to 3,200 lb (1.6 ton) and approximately 1.6 × D_{50} (i.e., maximum size is ~3.2 ft or ~1 m).
- The minimum rock size is limited to 0.125 × W_{50} which corresponds to ~100 lb and approximately 0.5 × D_{50} (i.e., minimum size is 1 ft or 0.3 m).

Secondary Armor. The median weight of the underlayer units is chosen as W_{50} / 15. This yields a weight of 53 lb (24 kg) and a size of 0.4 × D_{50}, namely 0.8 ft (10 in; 0.25 m). The layer thickness is 1.5 ft (18 in, 0.45 m). Gradation follows the same rules as for the primary layer. This means a minimum rock size of 0.4 ft (5 inches; 0.12 m) and maximum rock size of 1.3 ft (15 in; 0.38 m). The secondary armor units will sit on a layer of geotextile fabric, which is in turn placed under fairly flat sandbags (6 in thick). The overall thickness of the secondary armor layer will be approximately 2 ft.

Wave Run-Up

The method introduced by Van der Meer and Stam (1992) is employed to estimate wave run-up over sloping surface of the ruble revetment. The method is also adopted by USACE (2002) and FEMA (2005) and computerized in the European software CRESS (1990–2018). With wave height of 4.4 ft, wave period of 9 sec, revetment slope of 1V:2H, and surface permeability of 0.5, the vertical height of wave run-up estimated as R_u (2%) = 8.8 ft (2.6 m) and R_u (50%) = 3.6 ft (1.1 m) for two extreme run-up levels of 2% (very conservative) and 50% for the "run-up value, n" which means n% of waves exceed the run-up tongue.

Even the smallest of these values would impose an excessive burden on the design in terms of elevation of the top of the revetment and construction cost. Therefore, it is decided to incorporate only some freeboard (0.8 ft vertical; 2 ft of inclined run-up on the rubble surface) and instead provide for a fairly erosion-resistant abutment or platform behind the revetment. The abutment would laterally support the revetment, resist against occasional overtopping during large storms, and act as a service road along the revetment. It is described in the following section.

Erosion-Resistant Abutment

At points along the east barrier bar with elevation significantly below the required top elevation of the revetment, an abutment will be constructed to take the lateral loads from the revetment. The abutment consists of a 6-inch service road on layers of 1-cubic-yard sand-gravel cubes contained in woven geotextile with lifting loops. Where the bar is high enough (near the eastern end) to take the lateral loads from the revetment, the cubes will not be needed, and the gravel service road will sit on the compacted natural land in a cut. The revetment limits are as follows:

- Upper limit is at 249 + 0.5 × 4.4 + 0.8 = EL 252 ft, which includes the design high WL plus wave amplitude plus a small freeboard.
- Lower limit (i.e., top of the toe) is at EL 245 ft. However, the lakebed at the toe will be excavated to EL ≈ 239.5 ft to incorporate the full depth of the revetment.
- Western and eastern limits adequately cover the breach areas of 2012, 2016, and 2017.

As indicated in **Table 2.1-2** (**Section 2.1**), the lower elevation of the revetment (245 ft) is above the long-term (i.e., in the last 100 years) mean WL during six months of the year, close to the long-term annual mean WL (i.e., 245.28 ft), and approximately 1.3 ft below the mean WL in May, June, and July. This means that construction of the revetment will not require significant wet excavation and rock placement.

Design Features

The design wave height selected for the above mentioned calculations is based on transformation of waves from wave stations that are far from the project location. To account for the resulting uncertainty due to lack of local wave data from the project site, it is recommended to increase the average size of the primary armor units by 25%. This yields an average rock size of 2.5 ft (1,600 lbs) and a rock size range of 1.25 ft to 4.0 ft (200 lb to 3.2 ton) for the first armor layer.

The typical section of the proposed east barrier bar rock revetment is depicted in **Figure D-1** while **Figure D-2** shows the longitudinal extent of the revetment (Alternative F). **Figure D-3** contains views of the existing revetment along the west barrier bar and its rock sizes.

The proposed rock revetment has the following features:

<u>Geometry</u>

Side slope:	1H : 2V
Height:	10 ft
Length:	900 ft
Overall depth:	6 ft (normal to revetment surface)

<u>Primary armor</u>

Average rock size:	2.5 ft (1,600 lb)
Range of rock sizes:	1.25 ft to 4.0 ft (200 lb to 3.2 ton)
Depth:	4 ft (normal to revetment surface)

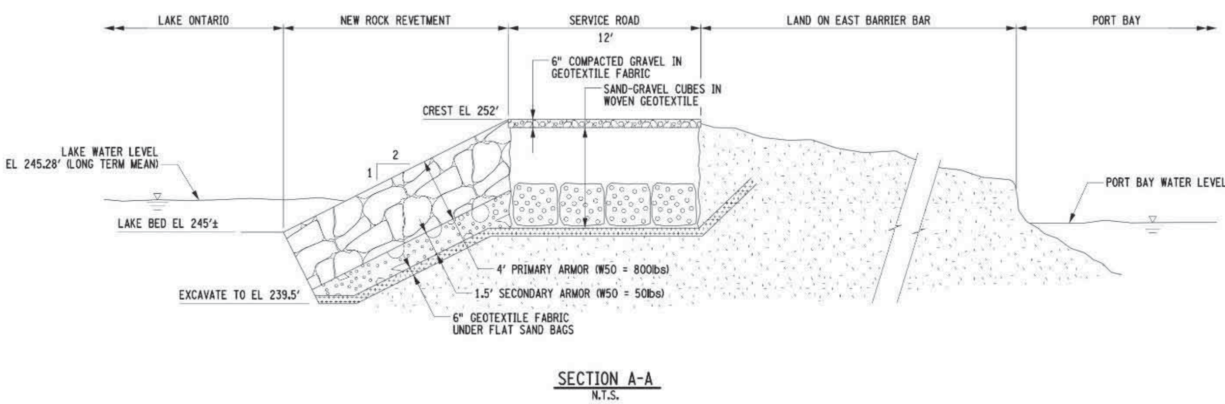
<u>Secondary (underlayer) armor</u>

Average rock size:	1 ft (100 lb)
Bedding:	Geotextile fabric under fairly flat sandbags
Depth:	2 ft (normal to revetment surface)

<u>Abutment (where fill needed)</u>

Width:	12 ft (also width of the service road)
Height:	≈7 ft
Material:	Cubes in woven geotextile containing local sand-gravel

Figure D-1
Typical Section of the Rock Revetment, Alternatives F, G, H, for the East Barrier Bar



Note: Where the bar EL > 252 ft, the cubes may not be needed, and the road is built on natural land in cut.

Figure D-2
Longitudinal Extent of the Rock Revetment, Alternatives F, G, H, Along the East Barrier Bar

Figure D-3
Views of the Existing Revetment and Its Rocks Along the West Barrier Bar



From drone views on May 10, 2017 (consider the diameter of the large logs in the left and lower pictures ≈ 6–8 in)

From site visit of April 11, 2018 (consider the fisherman as a 6-ft tall man)

Appendix E
Coastal Processes Evaluation

Coastal Processes Evaluation of Proposed Alternatives

This section further describes the coastal processes evaluation of the eight alternatives.

Alternatives and Lake-Bay Interaction

In terms of the lake-bay interaction through the east barrier bar, the management alternatives discussed in **Section 3** can be divided into three categories:

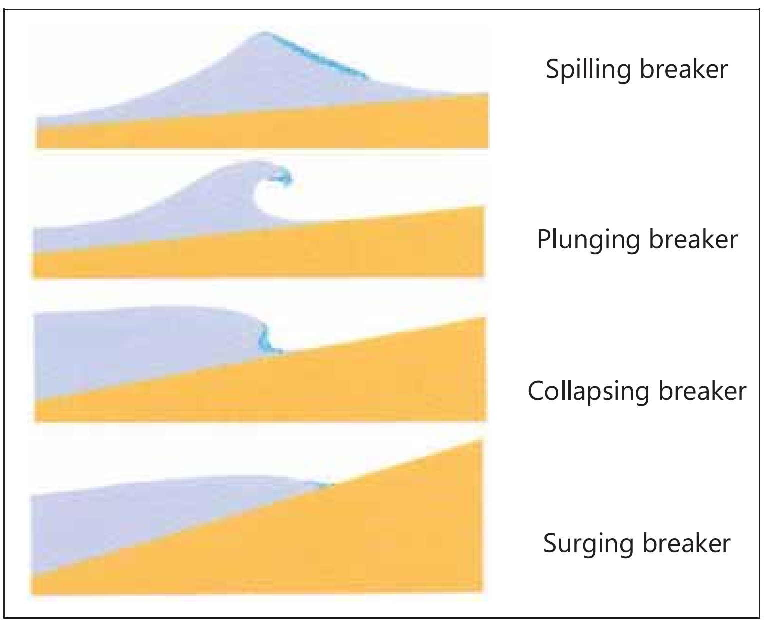
- Open-interaction through existing or future breaches (Alternatives A, B, D, E);
- Limited-interaction (Alternatives G and H), and
- No-interaction (Alternatives C and F).

The sediment transport impact of such interaction deserves special attention as discussed below.

Breaker Type and Sediment Load

The beach at the east barrier bar has a very mild slope (< 1/25) leading to spilling breaker waves, as opposed to the other three types of breaker waves depicted in **Figure E-1**; see USACE (2002, Part II-4). Each breaker type is associated with a special geometry, breaking mechanism, and vertical turbulence distribution—factors that collectively impact the ability of the waves to stir sediment from the bed to move along the bed or to get suspended. For example, when a plunging wave breaks, it dissipates its energy over a short distance near the bed, leading to significant suspended sediment for fine grains. A spilling wave, however, is characterized by foam and turbulence near its crest. Therefore, most of the sediment transport (if any) due to spilling waves occurs near the bed with relatively little suspended sediment.

Figure E-1
Four Types of Breaking Waves



The predominant mode of sediment transport due to large waves pounding the east barrier bar is expected to be bed load. However, most of the fine contents of the beach materials get suspended in large storms due to the combined impact of large waves and associated currents. Several figures in **Section 2.1** presented evidence for noticeable suspension of fines in the murky water and "mud plumes" near the beach and in the bay, including **Figure 2.1-6** (photo on April 10, 2016), **Figure 2.1-8** and **Figure 2.1-9** (photos on May 10, 2017), **Figure 2.1-12** (photos on April 2, 2017), and **Figure 2.1-13** (photos on May 3 and 29, 2017).

Post-Breach Sediment Deposit in the Bay

While the intruded suspended sediment may give rise to water quality and environmental issues for the bay, the significant bed load movement can deposit considerable sand and gravel in the bay near the shoreline; however, these transported materials are submerged and do not provide any significant built up or support to the barrier for some time. As reflected in **Figure 2.1-58** (**Section 2.1.8**), a comparison of data from two surveys in 2007 and July 2018 shows deposition of 12,500 CY of sediment in the bay carried through the breached bar. The first breach in early spring 2012 was small (50-ft wide in 2015); the breach of April 2016 (70-ft wide) was repaired in November 2016; and the larger breach of March 2017 (~400-ft wide) was naturally repaired by late March 2018. The volume of deposit is more than 10 times the volume of annual dredging of the navigation channel outlet. The deposit includes a portion of longshore sediment transport (LST) attracted into the bay through the breaches, augmented by the cross-shore sediment transport and overwashing of the bar.

In the absence of sufficient pre- and post-breach surveying data, sediment samples from the sediment deposit in the bay, and field data on water-sediment mixtures, it would not be feasible to quantify the evolution of the deposition in the bay or lateral and vertical expansion the breaches or the relative contribution of bed load and suspended load in the sediment intruded from the lake into the bay. However, some qualitative statements can be safely made with respect to this intrusion and stability of the bar against breaching and overwashing risks.

Open-Interaction Alternatives (A, B, D, E)

The three recent breaches of 2012, 2016, and 2017 can be regarded as an equivalent breach width of 250 ft exposed for two years. This has resulted in an average rate of 50 CY (≈ 12,500 CY / 250 ft) of annual sediment intrusion per 1-ft gap, concurrent with a southward beach recession rate of over 2 ft/yr (≈ 18 ft / 8 yr; see **Section 2.1.7.1**) due to erosion of the bar. Moreover, the hitherto post-breach period is not long enough so far to see if an equilibrium shape of the breached bar will be naturally reached.

Assuming a useful life span of 30 years for any rehabilitation measure resulting from the present investigation, the expected erosion and sediment intrusion outlook for these four alternatives with respect to the bar stability and the bay's environmental integrity should be taken into account.

Limited-Interaction Alternatives (G, H)

The invert of the overflow section (15~20 ft wide) in Alternative G will be set above the natural bed of the lake to allow water exchange between the lake and the bay only during the high water season. The invert elevation is estimated to be at 246.0 to allow annual summertime high waters into the bay. The elevation also allows for only a limited amount of bed load materials expected to enter the bay during the usual storms and high water. Small amounts of sediment, mostly fine to medium size gravel, would be anticipated to deposit on the overflow during high water and storm events. This may require occasional clearing of the overflow to maintain the functionality of the overflow and accessibility of the crest.

Alternative H dictates the use of box culverts to accommodate water interchange at the bar. Based on permitting requirements and ecological benefits, it is assumed that the actual invert of the box would be buried and a portion of the box pre-filled with natural sediment. The predetermined invert of the natural sediment within the culvert in Alternative H will be set near or just above the long-term mean water level in the lake (245 ~ 246 ft) for the water exchange to take place annually during the high water season. However, given the fact that during major storms, some medium to coarse gravels reach the pier (with top elevation 249.5 ft) and even the top of the concrete wall extension (at elevation 254.4 ft), deposition of gravel within the culvert box (~ 40 ft long) is likely. This may call for routine cleaning of the opening if the deposit grows and reduces the functionality of the culvert. Although not a major limiting design factor, the required accessibility to the culvert opening from either the lake or the bay side will be taken into account as a factor in determining the size of the box.

A small amount of suspended sediment is expected to come into the bay with large waves and high water through the overflow section (Alternative G) or the culvert (Alternative H). The resulting deposit on the bay side of these structures over the life span of the present rehabilitation project is not expected to be large.

With the protection of the lake side of the east barrier bar by rock revetment, no major stability risk to the bar would be anticipated with either of these alternatives.

No-Interaction Alternatives (C & F)

The southward recession and breach of the east barrier bar would be prevented in Alternative F by installation of a rock revetment. The satisfactory performance of the existing revetment at the west barrier bar provides realistic evidence for the technical feasibility of this alternative. Continuity of the eastward LST and the annual nourishment of the bar with the dredged materials will help the stability of the revetment toe as a portion of the moving gravel will be held in between and in front of the toe rocks, providing a natural buffer for the toe erosion by wave action and longshore current.

Adequate design and execution of Alternative C can provide for a faster and less expensive rehabilitation solution compared to Alternative F. However, two potential risks of this alternative should be closely monitored and managed: one relates to the erosion of the lake side and the other is associated with waves breaking at and near the crest. These are discussed as follows.

Lake-side erosion near the toe. Observations indicate that the actual LST of gravel at Port Bay is considerably less than the potential LST, which was estimated to be greater than 30,000 CY per year (see **Table 2.1-9**). The first observation is the limited volume of annual dredging (~1,000 CY). If the actual LST was larger, greater dredging volume would result because the navigation channel outlet region (namely, the focus of dredging) is not highly protected by the existing modest pier structure (120 ft long and approximately 4~5 ft high), which allows bypass and overtopping of gravel in several seasonal storms every year; see **Figure 2.1-45**. The second observation is the fact that the size of the scour and deposition at the unprotected shoreline behind the pier seems to have always been limited. For example, at no time did the deposit grow to the tip of the pier or did the scour encroach into the access road near the pier (see pictures in **Figure 2.1-44**). The third observation pertains to the gradual southward recession of the east barrier bar as previously discussed in **Section 2.1.7.1**. Unless the lower part of the lake-side face of the breached bar is protected by structures such as rock revetment, the considerable sediment supply deficit (i.e., potential LST minus actual LST) will remain a source of continuous erosion of the bar.

Crest and lake-side slope erosion. With the crest elevation of 252 ft for Alternative C, the natured-based barrier bar, the crest would be protected against any sustained submergence because the IJC mandated allowable monthly maximum values for April to July are all below 249 ft. The resulting safety margin of more than 3 ft is fairly adequate even against the wave setup associated with any unbroken design wave amplitude of 2.2 ft, namely half of the design wave height of 4.4 ft. Moreover, given the fairly shallow water dept near the shore, the effective wave amplitude will be a break amplitude of approximately 1.5 ft which equals the water depth multiplied by the breaker index of 0.78. The difference between the 252 ft crest and the design storm water level (i.e., 249 + 1.5 = 250.5 ft) will also incorporate a fairly sizeable wind set up in the lake.

As the waves approach the bar crest on their way toward the bay, they will break. Given the steep lake-side slope of the rehabilitated bar, the breaker wave will be of plunging or collapsing or surging type as referred to in **Figure E-1**—all associated with significant release of the wave energy near or at the bar crest. This calls for adequate implementation of the buried live stumps and dense vegetation establishment to absorb the wave energy on the slope and protect against slope erosion. Additional maintenance costs may need to be considered for long-term sustainability.

The rock revetment of Alternative F is protected against these potential risks owing to the large rock toe protection and the placement of large rocks on the slope.