Southeast Leamington Graduated Risk Floodplain Mapping Project

Prepared for:

Municipality of Leamington

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Pulley Road May 18, 2020





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January 26, 2021

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1.0 INTRODUCTION

Zuzek Inc. and partners, SJL Engineering Inc. and Foresight Management Consulting, were retained by the Municipality of Leamington to complete a Graduated Risk Floodplain Mapping Study. The Southeast Leamington study area is presented in Figure 1.1 and sub-divided into four zones from Wheatley Harbour in the north to the agricultural drains in the south adjacent to Point Pelee National Park.

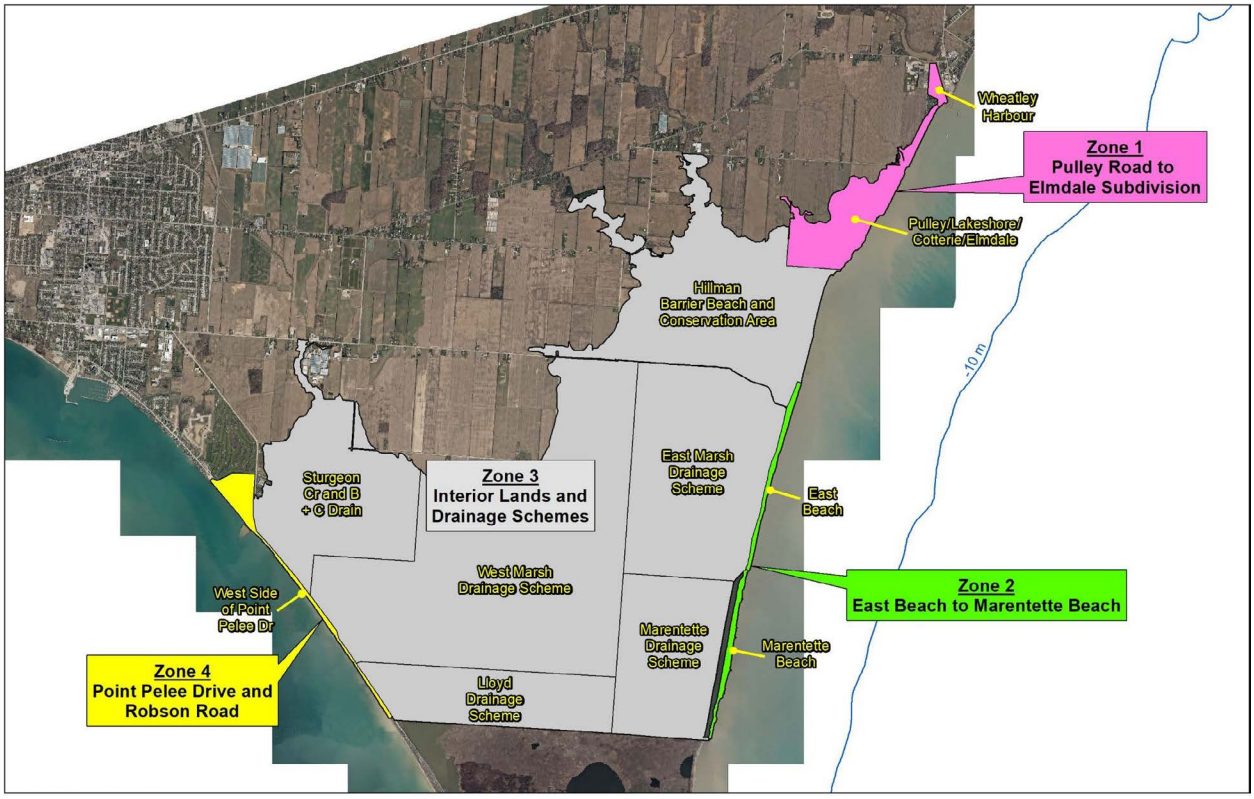


Figure 1.1 Study Area Zones

The study builds off the findings of two reports completed for the National Disaster Mitigation Program (NDMP) including the Southeast Leamington Hazard Identification and Risk Assessment (HIRA) and the Risk Assessment Information Template (RAIT) completed by Zuzek Inc (2018a and 2018b). The total risk score of 400 in the HIRA was eight times the threshold for the hazard to be considered extreme. The RAIT identified primary and secondary hazards, the risk assessment, and vulnerable infrastructure and ecosystems. The RAIT also referenced numerous historical reports on flooding and erosion hazards in Southeast Leamington.

1.1 Land Use History for Southeast Leamington

The land use in Southeast Leamington has changed dramatically in the last 200-years. In the 1850's the lands north of Point Pelee National Park (PPNP) were part of a large marsh complex that extended north to the Hillman Marsh (refer to Figure 1.2). PPNP was a Military Reserve at that time. By the late 1800's, lots and concessions were surveyed and the transition to privately owned lands was underway (Baird, 2007).

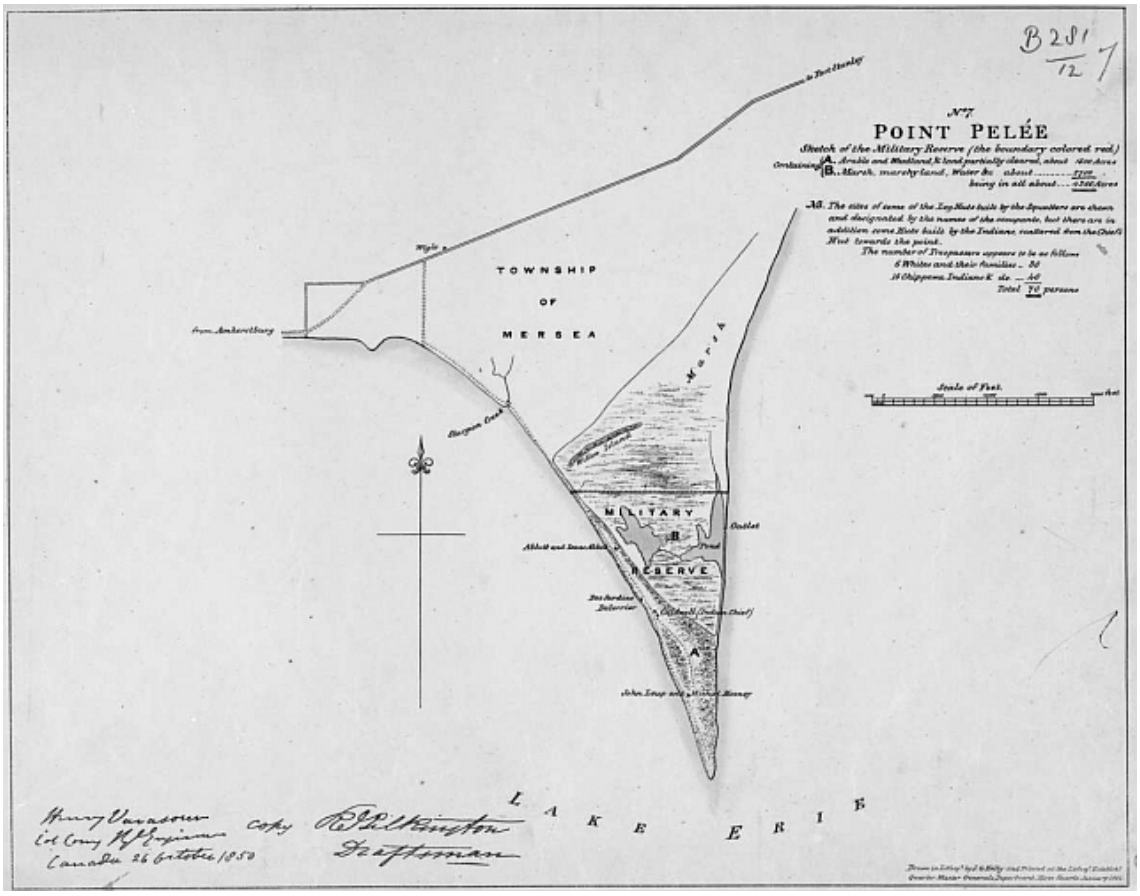


Figure 1.2 Southeast Leamington Land Use in 1850

By the early 1900's, the wetlands between the Hillman Marsh and PPNP were diked and drained for agriculture. Agriculture continues on the former marsh lands today, with rural residential development along the roads. Lakefront development covers the shorelines from Wheatley Harbour to the northeast corner of PPNP and the west shoreline from Sturgeon Creek to the northwest boundary of the national park.

1.2 Existing Site Conditions

The existing shoreline conditions are reviewed with oblique aerial photographs collected in the fall of 2019. Descriptions are provided for the four zones outlined in Figure 1.1.

1.2.1 Zone 1 – Wheatley Harbour to Elmdale Subdivision

Figure 1.3 provides a view of Wheatley Harbour and the offshore breakwater, located at the northern limit of Zone 1. Sand and gravel transported along the shoreline from north to south is trapped in the north fillet beach at Wheatley and in the federal navigation channel. The material is regularly dredged and trucked south to the Hillman Marsh where it is placed on the shoreline.

South of Wheatley Harbour, the shoreline is developed on the east and west side of Pulley Road, Lakeshore Drive, and Cotterie Park. The Elmdale Subdivision is located at the southern end of Zone 1, adjacent to the Hillman Marsh Conservation Area. Refer to Figure 1.4 and Figure 1.5 for images of the shoreline.



Figure 1.3 Oblique Photograph of Wheatley Harbour



Figure 1.4 Pulley Road Shoreline



Figure 1.5 Elmdale and Cotterie Park Looking North

1.2.2 Zone 2 – East Beach and Marentette Beach

Zone 2 is located between the Hillman Marsh and PPNP, along the eastern edge of the study area. The northern limit of East Beach is seen in Figure 1.6. In the fall of 2019, there was no beach lakeward of the rock breakwall that separates the lake from the development. Refer to Figure 1.7 for a typical picture of the East Beach community.

The Marentette Beach community is accessed from East Beach Road or Mersea Road C via a private road, seen in Figure 1.8. The majority of the shoreline is armoured, with the northern limit featuring some beach lakeward of the protection in the fall of 2019. A typical picture of the southern half of Marentette Beach is provided in Figure 1.9.



Figure 1.6 Northern Limit of East Beach



Figure 1.7 East Beach



Figure 1.8 Private Road into Marentette Beach Community



Figure 1.9 Marentette Beach

1.2.3 Zone 3 – Interior Lands and Drainage Schemes

Zone 3 includes the Hillman Marsh and interior lands south to PPNP. A view of the agricultural land looking southwest is provided in Figure 1.10. The conditions at the southeast corner of the Marentette Drain are seen in Figure 1.11. The rock breakwater was under repair in the fall of 2019. Figure 1.12 provides a view of the West Marsh Drainage Scheme looking southeast from Sturgeon Creek.



Figure 1.10 Interior Agricultural Drains South of Hillman Marsh



Figure 1.11 Southeast Corner of Marentette Drainage Scheme



Figure 1.12 West Marsh Drainage Scheme looking East from Sturgeon Creek

1.2.4 Zone 4 – Pelee Drive and Robson Road

The western shoreline of the study area is Zone 4 and includes Pelee Drive and Robson Road north of Sturgeon Creek. A picture of the jetties at the Sturgeon Creek is presented in Figure 1.13. The shoreline north of Sturgeon Creek is seen in Figure 1.14 and is protected with armour stone. Similarly, south of Sturgeon Creek, much of the shoreline consists of quarried armour stone at the waters edge (Figure 1.15). South of Mersea Road 12, the road elevation increases, and the shoreline generally consists of a sand beach. Various forms of backshore protection are used to protect the homes from flood risks, including the sandbags seen in Figure 1.16.



Figure 1.13 Sturgeon Creek Jetties Looking West



Figure 1.14 Shoreline North of Sturgeon Creek



Figure 1.15 West Shoreline North of Mersea Road 12



Figure 1.16 Shoreline South of Mersea Road 12

1.2.5 Point Pelee National Park

PPNP is located south of the study area but is an integral part of the shoreline and future management of the peninsula. The eastern shoreline is actively eroding (Baird, 2007), as seen by the offset in the northeast corner of the park adjacent to the Marentette Drainage Scheme (Figure 1.17). A significant breach formed in PPNP's eastern beach during the April 15, 2018 storm on Lake Erie (Zuzek Inc., 2018c) and remained open more than a year later, as captured by the oblique photograph in Figure 1.18. The sandy western shoreline of PPNP has generally been more stable (Zuzek Inc., 2018c) as seen in Figure 1.19, with the exception of the tip which is heavily armoured (approximately 1 km). Refer to Figure 1.20 taken on October 8, 2019.



Figure 1.17 Northeast Corner of PPNP



Figure 1.18 Breach in East Beach, PPNP



Figure 1.19 Northwest Shoreline of PPNP



Figure 1.20 Armoured Southwestern Tip of PPNP

1.3 Scope of Investigation

The scope of the graduated risk flood study for Southeast Leamington is summarized as follows:

- **Review Background Information:** obtain digital data from the Municipality, review historical reports, and existing data on hazards.
- **Field Investigations:** shoreline reconnaissance, oblique photo collection, shoreline protection database, bathymetric survey.
- **Technical Analysis:** calculate updated shoreline and lake bottom erosion rates, extreme value analysis of water levels, nearshore wave modeling and runup/overtopping calculations, and integrate climate change impacts on hazards.
- **Flood Maps:** prepare flood hazard maps for three scenarios.
- **Mitigation Alternatives:** develop adaptation alternatives for coastal hazards by zone.
- **Communications**: organize and execute three Public Information Centres.
- **Reporting:** draft and final report summarizing study findings.

2.0 FIELD INVESTIGATIONS AND DATA

Section 2.0 of the report summarizes the field investigations and data collected for the study.

2.1 Oblique Aerial Photography

Oblique aerial photography covering the entire 14 km of project shoreline was captured in September 2019 using an unmanned aerial vehicle (UAV). The purpose of capturing the aerial photography was to develop a current, georeferenced photographic library of the entire shoreline. This library was the primary source of information for the development of a high-resolution shoreline protection database (refer to Section 2.2). It also provided the project team with the ability to view and assess portions of the shoreline that would have been logistically difficult to reach by land.

The UAV featured a built-in camera with a 12.7-megapixel sensor, three-axis image stabilization and geotagging capabilities. Photographs were generally taken from an elevation of approximately 35 m, a horizontal distance of approximately 60 m offshore, and with shore-parallel spacing of individual images on the order of 20 – 30 m. This allowed for complete shoreline coverage with sufficient overlap in adjacent photos while producing images with high enough resolution to assess the condition of shoreline structures at the individual private property scale. Where appropriate, images were captured from a higher elevation and further offshore to provide an increased range of view. This included areas such as Hillman Marsh, Point Pelee National Park (PPNP) boundaries, the interior drainage schemes and agricultural lands, and Sturgeon Creek.

Beginning east of Wheatley Harbour on September 23rd, 2019 and finishing west of Sturgeon Creek on September 24th, 2019, a total of 10 flights were carried out covering a cumulative distance of more than 15 km. Sections of photographed shoreline and corresponding flight numbers are provided in Table 2.1. Sample photographs captured using the UAV are provided in Figure 2.1.

Table 2.1 List of UAV flights to capture aerial photos of the shoreline.

Description	Shoreline Length (km)	Flight ID(s)	Flight Date
Wheatley Provincial Park to Wheatley Harbour	2.3	1a / 1b	Sep. 23, 2019
Wheatley Harbour to Fox Run Road	1.0	2	Sep. 23, 2019
Fox Run Road to Hillman Marsh	1.7	3a / 3b	Sep. 23, 2019
Hillman Marsh to Mersea Road B	2.9	4	Sep. 24, 2019
Mersea Road B to Marentette Dyke	3.5	5a / 5b	Sep. 24, 2019
Point Pelee Drive to Robson Road	4.3	6a / 6b	Sep. 24, 2019

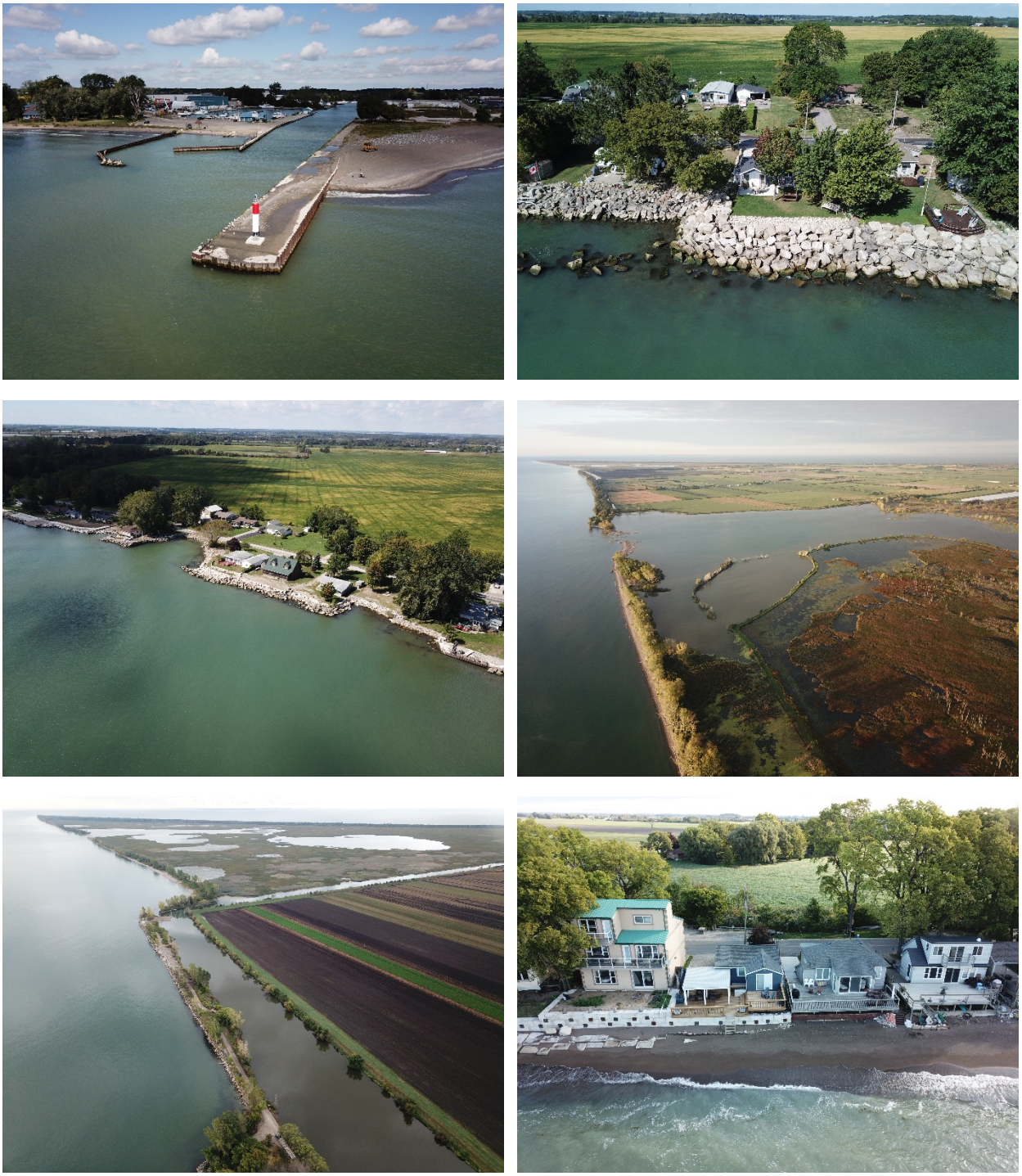


Figure 2.1 Sample photos of project shoreline captured from UAV. Top left to bottom right; Wheatley Harbour, homes on Pulley Road, homes on Cotterie Park Road, Hillman Marsh, Marentette Rock Berm and Point Pelee National Park, and homes on Point Pelee Drive.

2.2 Shoreline Protection Database

A detailed shoreline protection database was developed as a component of the study to document the state of the built-up shoreline as of September 2019. The database was developed primarily from the oblique aerial photography inventory discussed in Section 2.1 and supplemented with

ground observations and measurements where necessary, including for most significant public infrastructure. All major built-up areas and private property shore protection was included in the database. In total, nearly 11 km of shore protection structures were identified in the shoreline protection database, representing approximately 81 % of the project shoreline. Very little shoreline within the project can be considered natural or unaltered, with the following percentages of armoured shoreline being found within each project zone:

- Zone 1 (Wheatley Harbour to Elmdale Subdivision): 95% armoured
- Zone 2 (East Beach and Marentette Beach): 95% armoured
- Zone 3 (Interior Lands and Drainage Schemes): 0% armoured (dykes not considered armoured shoreline)
- Zone 4 (Pelee Drive and Robson Road): 87% armoured

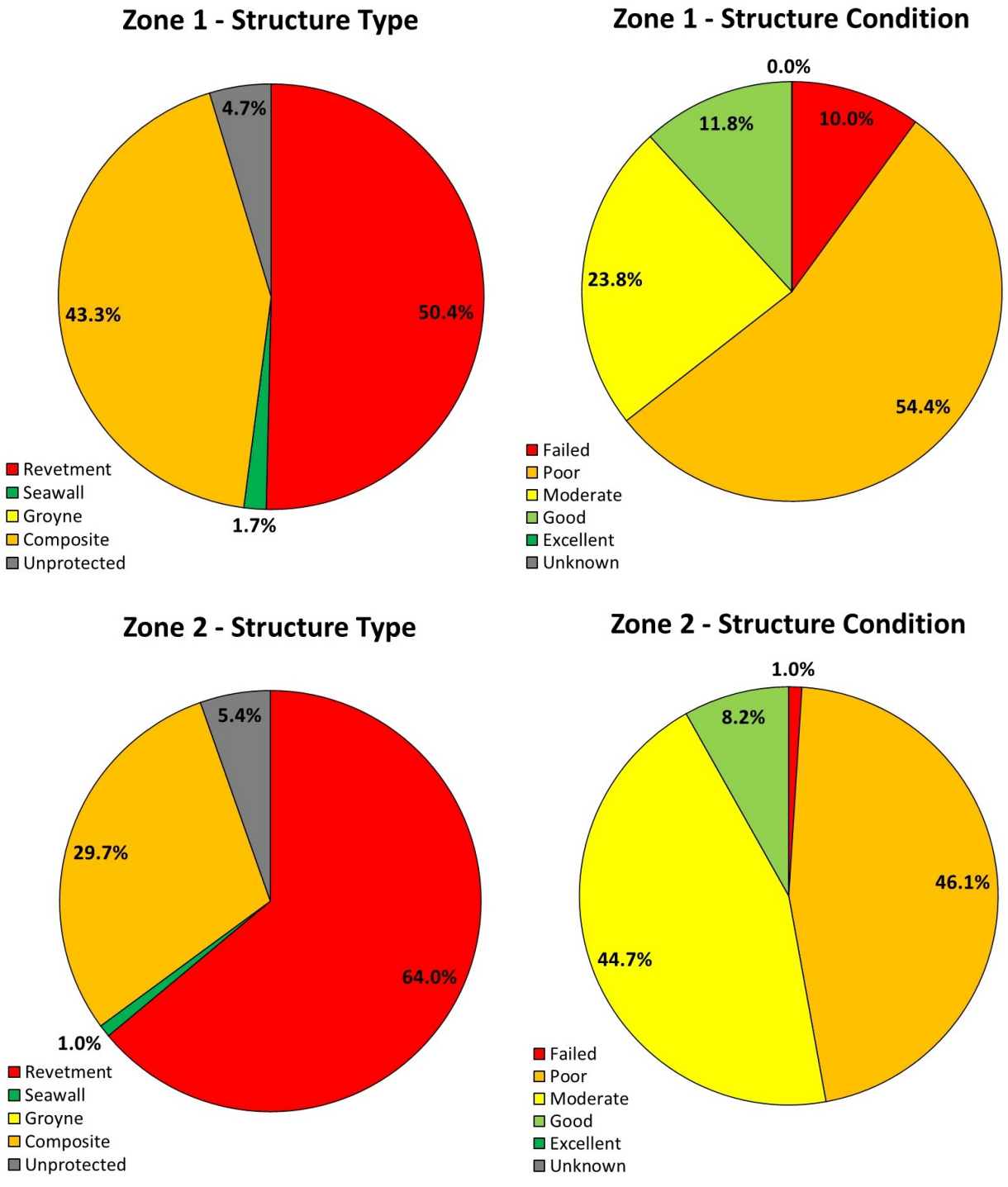
Each shore protection structure added to the database was delineated with start and end coordinates, with neighbouring structures beginning and ending when a significant change in structure type or condition was encountered. Each structure in the database was labelled as public, private or mixed ownership, and assigned information including the following key variables:

1. **Primary Structure Type:** includes both the type of structure (i.e. seawall, revetment, jetty, etc.) and the primary structure material (i.e. rubble, single-layer armour stone, concrete blocks, sheet pile, composite, etc.);
2. **Secondary Structure Type:** secondary information for composite shoreline protection (i.e. groyne backed by a beach curb, concrete block revetment with armour stone crest, etc.);
3. **Level of Design:** well-engineered, moderately engineered, ad-hoc and unknown;
4. **Structure Condition:** excellent, good, moderate, poor, failed, unknown;
5. **Structure Importance:** critical (i.e. protects nuclear power plant), high (protects important public infrastructure), moderate (most private property protection), low (protects undeveloped lands or low energy environments), unknown.

Statistics pertaining to the state of shoreline infrastructure were assessed from the completed shore protection database both for the entire project shoreline and by project zone. Tabulated statistics included (but were not limited to) the following:

- % armoured by structure type
- % armoured by level of design
- % armoured by structure condition
- % armoured by structure importance
- Level of design by structure type
- Structure condition by structure type
- Structure importance by structure type

Sample statistics from the shoreline protection database are provided in Figure 2.2. The entire shoreline protection database including all tabulated statistics have been provided to the municipality in digital form.



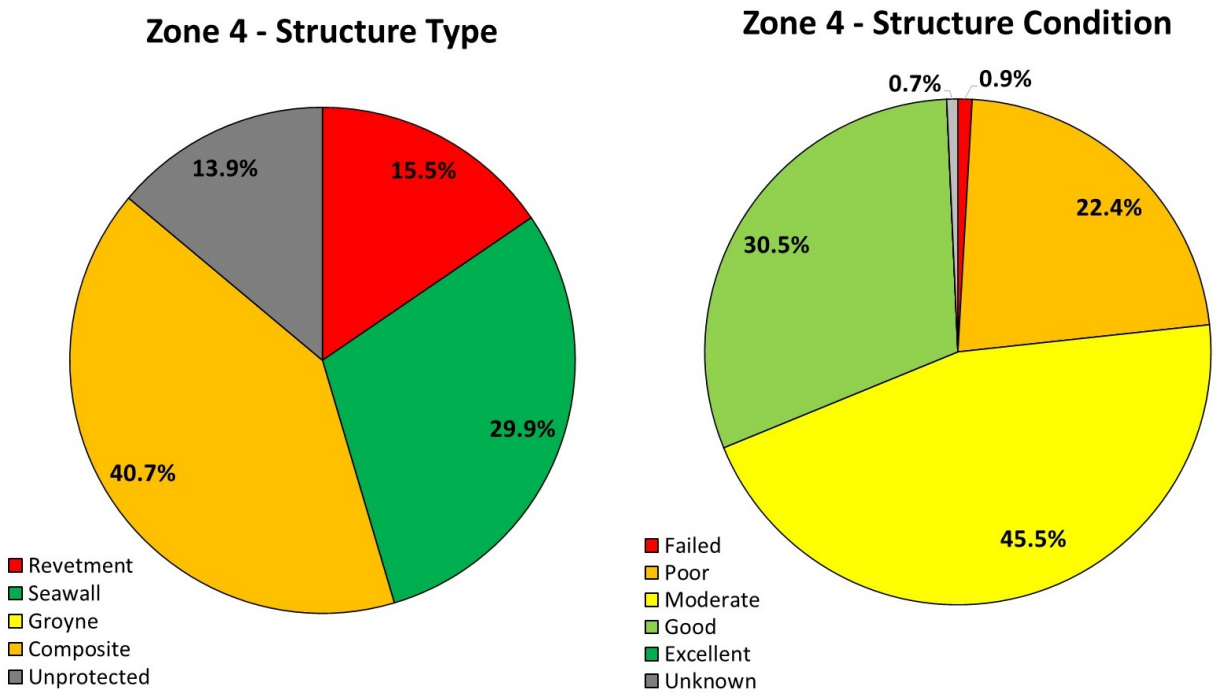


Figure 2.2 Sample shore protection statistics by project zone

2.3 Bathymetric Data and Sonar Collection

The SOLIX is a single-beam bathymetric and sonar system with built-in recording and navigation tools. The transducer was mounted at the back of a boat with a dedicated GPS antenna located directly above the unit. The unit auto-corrects for the depth of the transducer below the lake surface. Depths were recorded every second. A picture of the navigation screen is provided in Figure 2.3. The extent of the data coverage is presented in Figure 2.4.

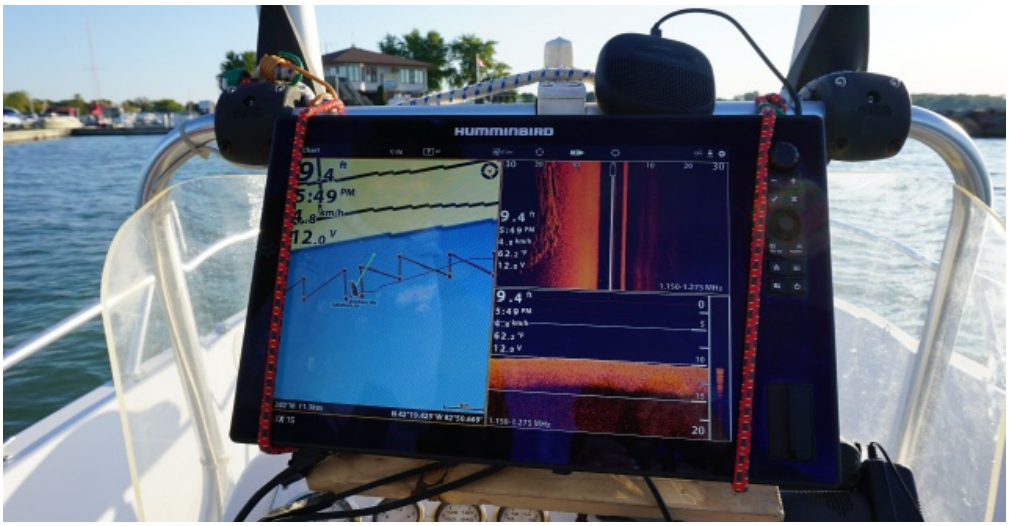


Figure 2.3 SOLIX Navigation Screen

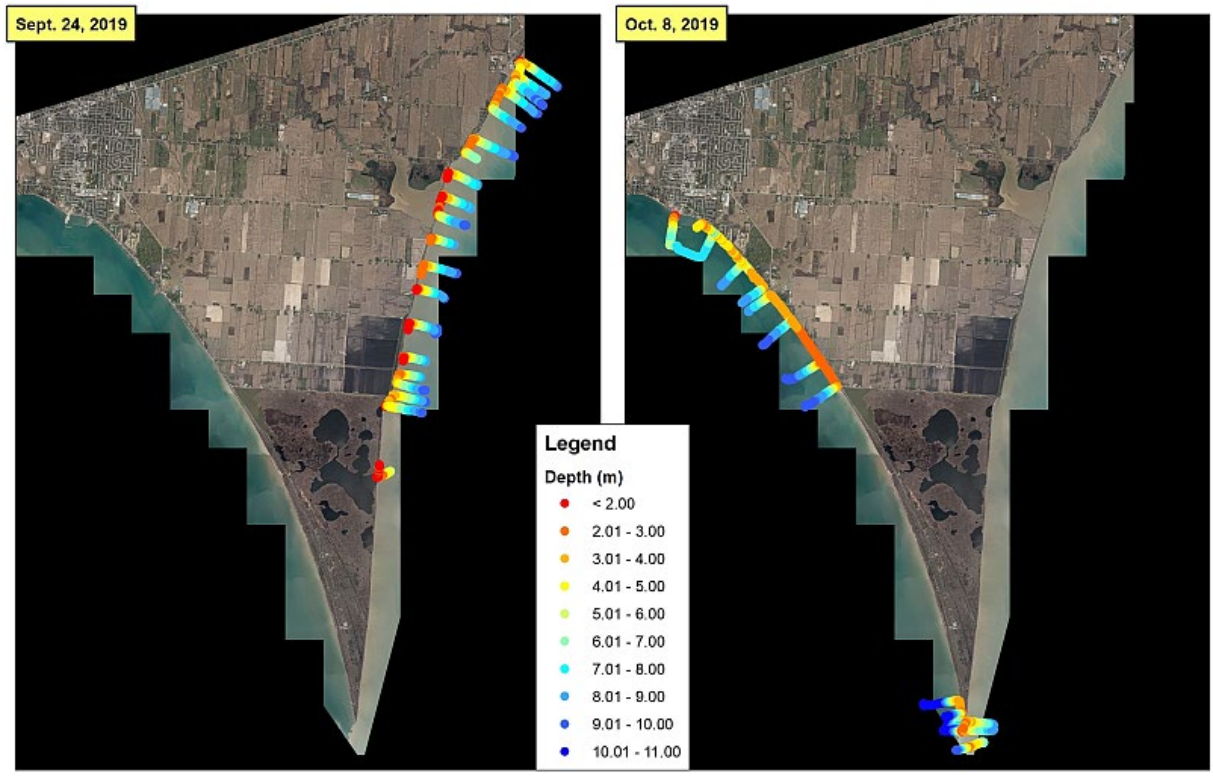


Figure 2.4 Extent of Data Collection with the SOLIX (Sept. 24 and Oct. 8, 2019)

The depth readings were corrected using real-time hydrometric data acquired from the Government of Canada water level website. This real-time data features water level readings taken at hourly intervals. The SOLIX also collects 2D sonar imaging in cross-section and bottom image formats. Figure 2.5 provides an example of the output at the southwestern tip of PPNP. The panel on the left displays the tracks of the bottom. The middle panel provides a cross-sectional view of the sonar output, which is recording the hull of a shipwreck in the provided image. The image on the right shows the downward looking sonar output (lakebed). The individual beams of the ships hull are clearly seen in the provided image.

A sample of the bottom imaging collected with the SOLIX at the north end of Marentette Beach is provided in Figure 2.6. The boat is traveling onshore, as seen in the left panel. The middle pane provides a cross-sectional image of the lake bottom, which features exposures of clay lake bottom covered in peat. The right image highlights the lakebed sonar image looking directly below the boat, is it moves onshore. A swath of 25 m to the left of the boat is recorded. To the right of the boat, the turbulence from the engine propeller hampers the sonar image collection. As is shown in Figure 2.6, the water depth was 4 m extremely close to the shoreline at this location with the lakebed comprised of prominent exposures of clay capped by peat.

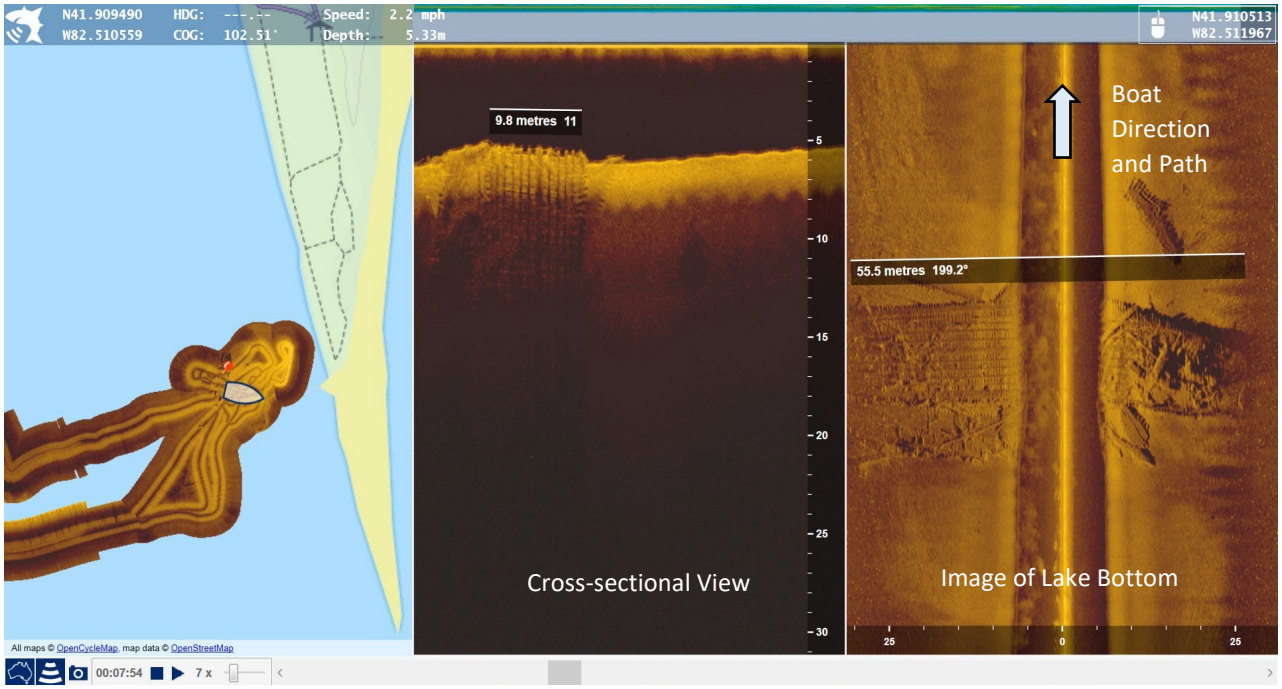


Figure 2.5 Sample of SOLIX Output (left to right, navigation screen, cross-sectional view, bottom image)

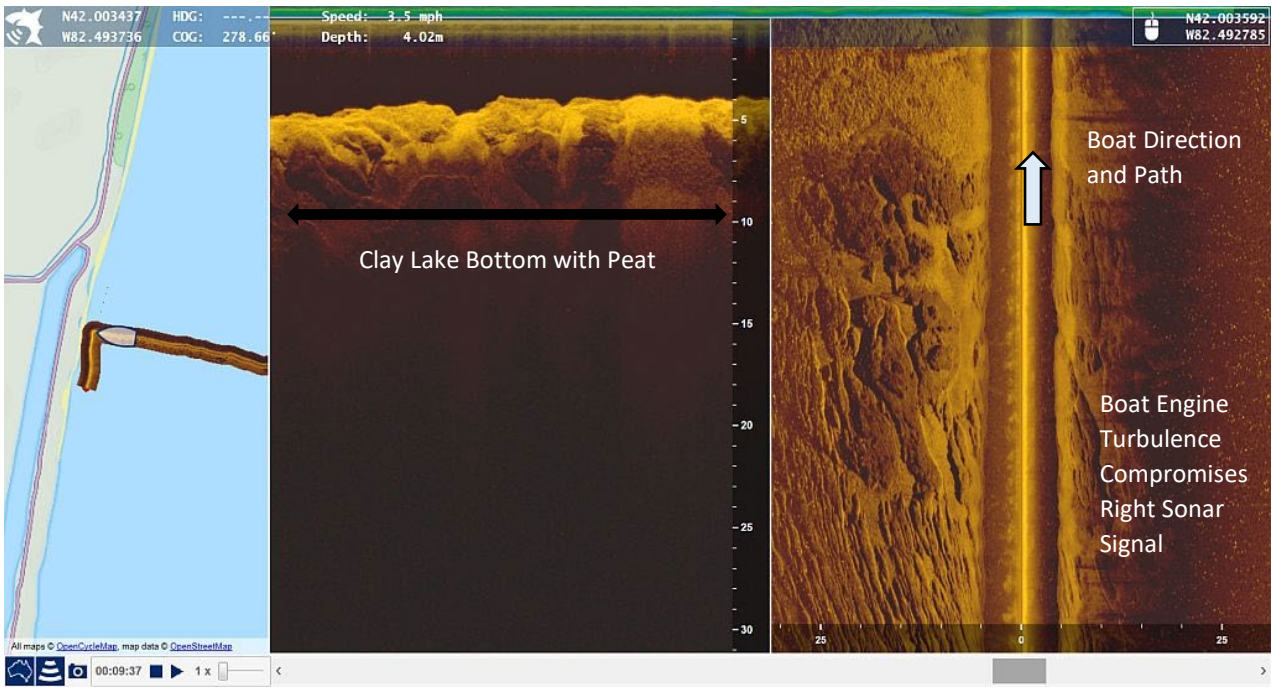


Figure 2.6 SOLIX Sonar Data at the Northern End of Marentette Beach

2.4 Topographic LiDAR for the Study Area

Topographic LiDAR data was collected in the Leamington area in 2017 by the Ontario Ministry of Agriculture, Food, and Rural Affairs. The LiDAR system is mounted on an aircraft and collects dense topographic datapoints on the ground. Objects such as trees and buildings can be removed

from the data to create a 'bare earth' surface. Refer to Figure 2.7 for an example of LiDAR-derived topographic contours for Cotterie Park.

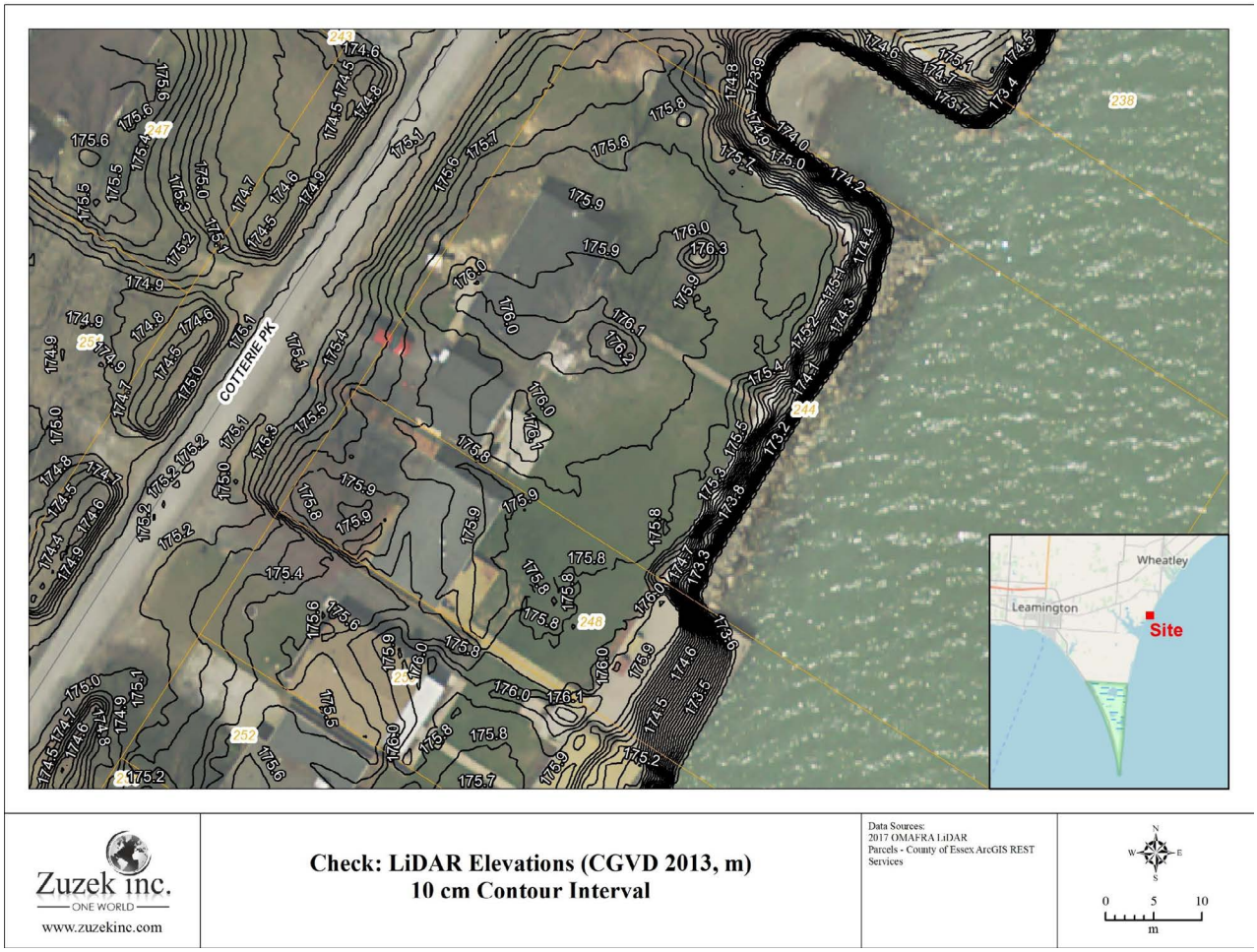


Figure 2.7 Sample of 2017 LiDAR Contours in Cotterie Park

2.5 Property Parcel Database and Buildings

Digital property parcels and assessment data was obtained from the Municipality of Leamington for the study area. A sample of parcel outlines are presented on Figure 2.7. The assessment data for land and buildings was linked to the property parcels and later used in the coastal risk assessment.

Building footprints were also obtained from the Municipality of Leamington and linked to the parcel data so an economic value could be associated with every primary building. The building footprints are used in the flooding assessment described in Section 4.0.

3.0 TECHNICAL ANALYSIS

The technical analysis completed for the graduated risk floodplain mapping assessment is described in the following report sections.

3.1 Shoreline Change Rates

The shoreline change analysis completed for the study is summarized in Section 3.1 for the lake bottom profiles and shoreline.

3.1.1 Changes in Nearshore Lake Bottom

The extent of the lake bottom data collected with the SOLIX was highlighted in Figure 2.4. Seven profiles were selected for comparison against historical lake bottom depths to evaluate long-term trends, such as areas of lakebed downcutting. The location of the profiles is summarized in Figure 3.1.

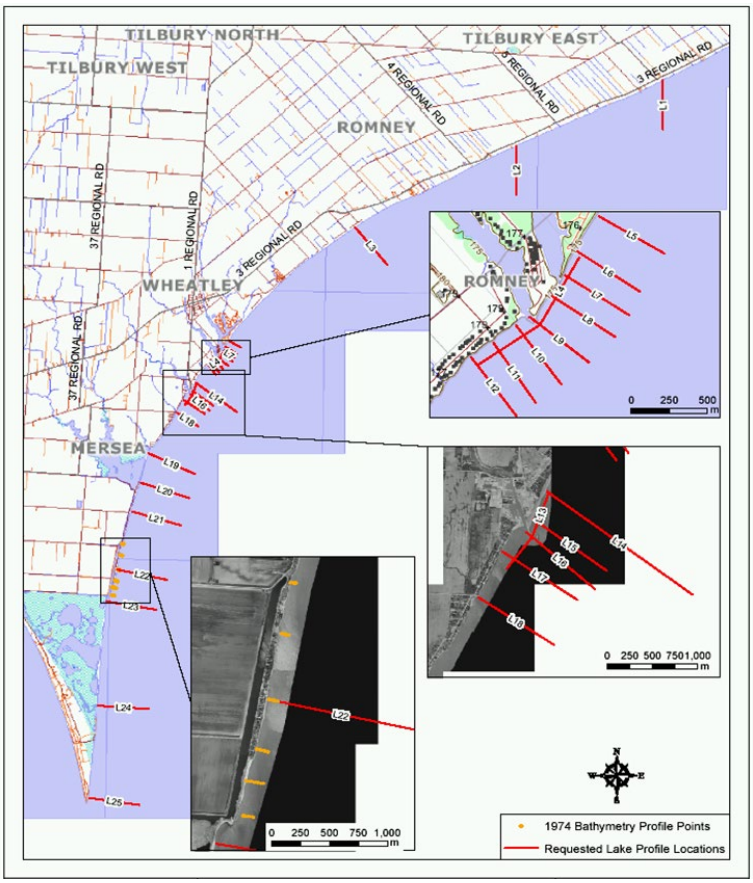


Figure 3.1 Location of Lake Bottom Profiles (two on west side)

The results of the profile comparison and implications for shoreline change are summarized:

- **Line 18 – Fox Run Road**: located between Wheatley and the Hillman Marsh, the results for Line 18 are typical of the shoreline. The shoreline is heavily armoured and the

nearshore is deep and steep. 100 m from the shore protection the lake bottom is 4 m below Chart Datum. However, there has been little change from 2005 to 2019, suggesting the deep nearshore has developed an equilibrium with the shoreline. In other words, while it is deep, the lake bottom erosion has stabilized.

- **Line 19 – North Hillman**: this line records the dramatic erosion of the Hillman Marsh barrier beach from 1964 to 2019, as seen in Figure 3.3. Approximately 200 m offshore, the lake bottom is more than 2 m deeper in 2019 than it was in 1964. In the 14-year period from 2005 to 2019 there was consistent erosion or downcutting of the lake bottom from the shoreline to a distance 500 m offshore. With the erosion of the shallow nearshore at the Hillman Marsh, there is dramatically less wave energy dissipation during storms, which partially explains the breach that now exists in the barrier beach.

- **Line 21 – East Beach:** Between 1964 and 2019, there has been 1.0 to 2.0 m of lakebed downcutting or lowering offshore of the breakwall at East Beach. The shoreline has been artificially stabilized with the breakwall, but the clay lake bottom continues to erode, even between the 2005 and 2019 period. There has also been substantial loss of beach material adjacent to the breakwall, as seen in the red 2005 line versus the blue 2019 line in Figure 3.4 (between 0 and 60 m on the x-axis).

- **Line 22 – Central Marentette Beach**: the erosion trend for the lake bottom at Line 22 between 1964 and 2019 is consistent with the shoreline to the north, as seen in Figure 3.5. The nearshore is 1.0 to 1.5 m deeper in 2019 than 1964. It is interesting to note that the 2019 survey captures a large sand bar, centred at 80 m on the x-axis, that was not present in the 2005 survey. The presence of this sand bar suggests sand and gravel is moving south along the shoreline towards PPNP.

- **Line 23 – Northeast Corner of PPNP**: Line 23 is located just south of the study limits, at the northeast corner of PPNP. This area has eroded dramatically since 1970 when a series of experimental groynes were constructed at the southern tip of Marentette Beach to protect the drainage scheme. This experiment failed and has resulted in accelerated erosion at the northeast corner of the park for the last 50 years (Baird, 2010). There has also been dramatic erosion of the lake bottom, as seen in Figure 3.6.

- **Line 27 – Robson Road (southeast of Leamington Harbour)**: Line 27 records the dramatic erosion of the lake bottom southeast of the Leamington Harbour, as documented in Figure 3.7. Between 1978 and 2019 there has been 2.5 m of nearshore downcutting or lowering of the lake bottom. Lake bottom downcutting has continued in the last 12 years and exceeds 1 m in some locations (between 390 and 510 m on the x-axis in Figure 3.7). The nearshore is deep and steep, which permits large waves to reach the existing shoreline protection.

- **Line 35 – West Side at Road D**: Line 35 is located along Pelee Drive, opposite of Mersea Road D. Unlike Line 27 north of Sturgeon Creek, the lake bottom has been very stable from 2007 to 2019, as seen in Figure 3.8. Close to shore, the lake bottom is shallower in 2019 than it was in 2007. This is the only location in the study area where there has been positive or net accumulation of sand and gravel in the nearshore.

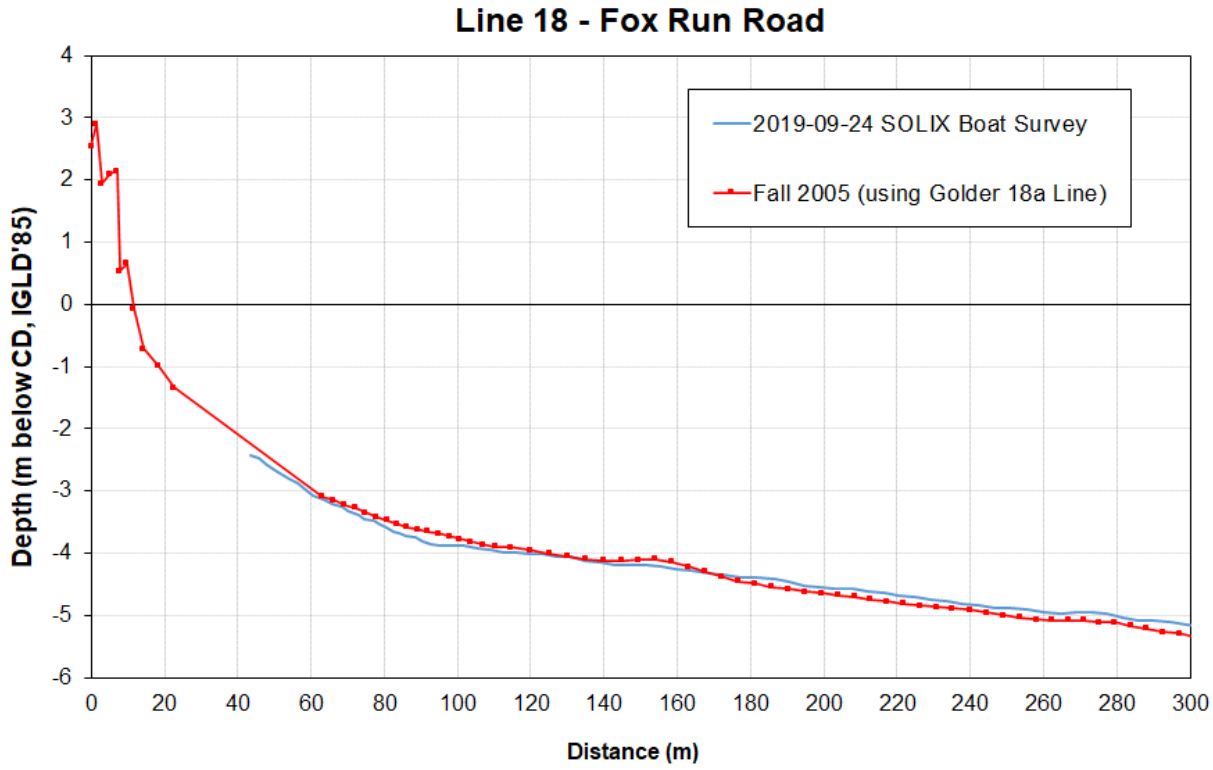


Figure 3.2 Line 18 at Fox Run (between Wheatley and Hillman Marsh)

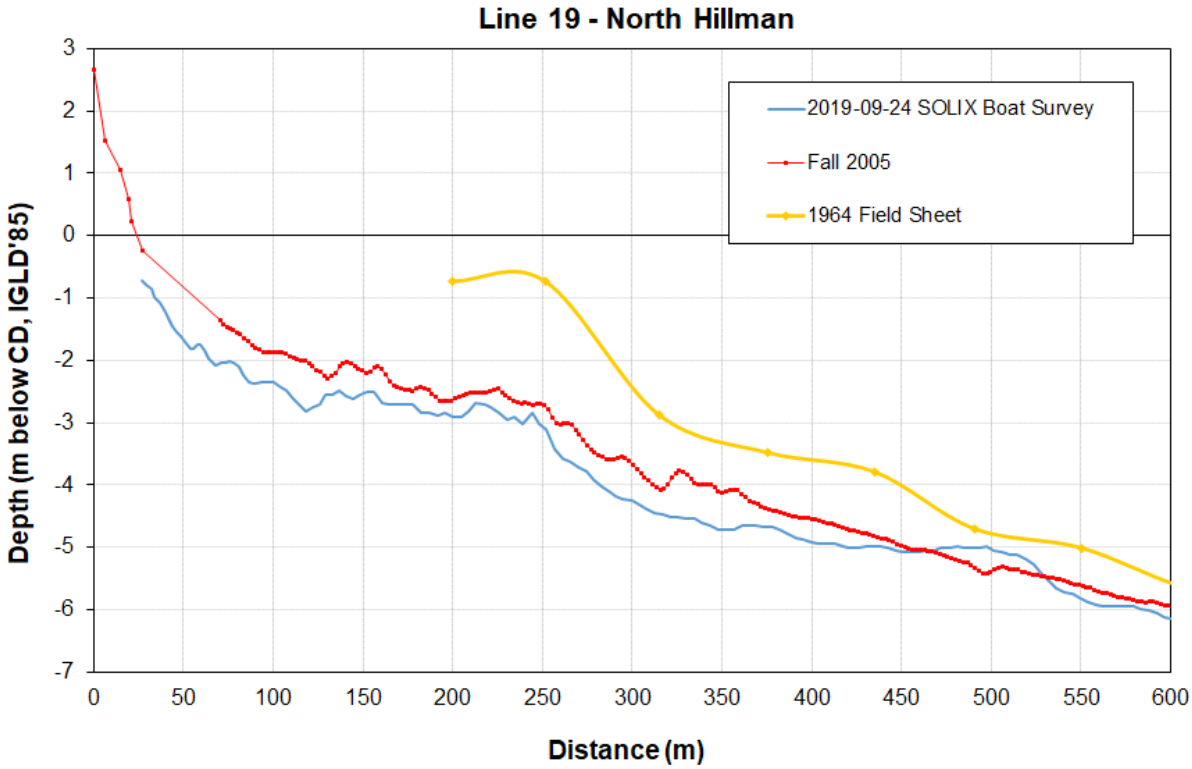


Figure 3.3 Line 19 at the Northern Limit of the Hillman Marsh

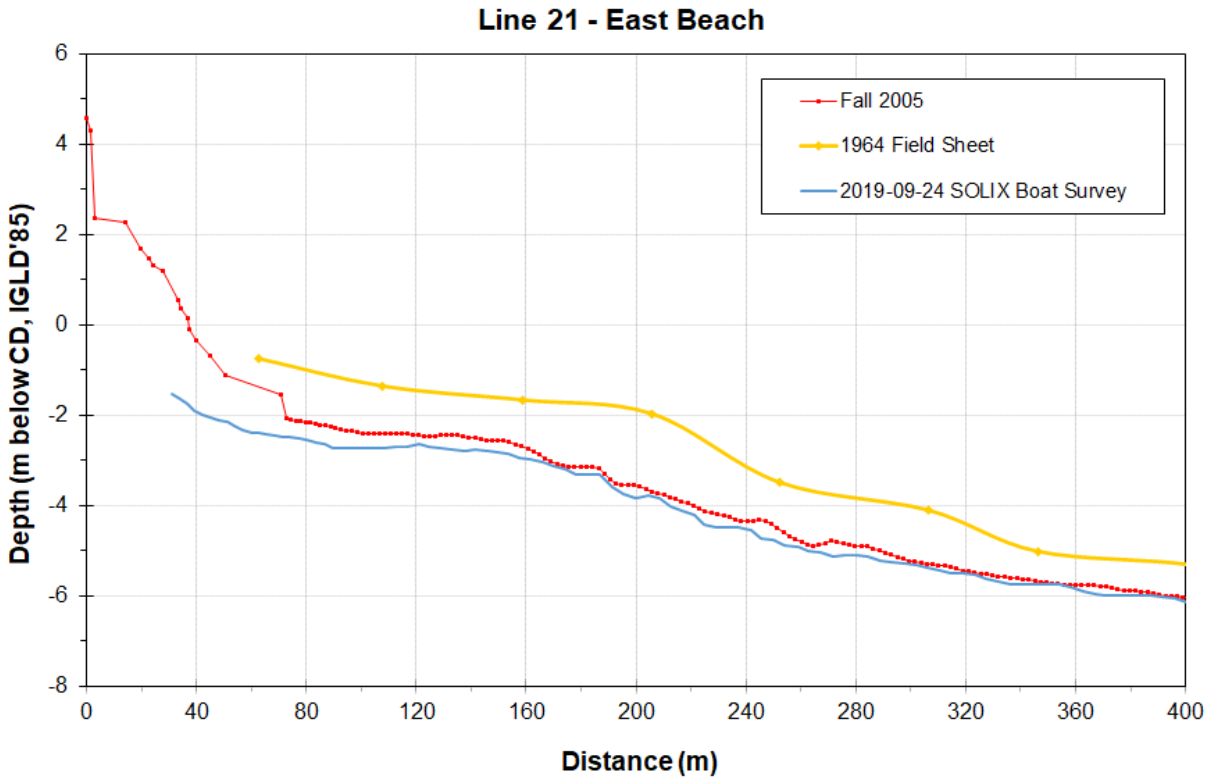


Figure 3.4 Line 21 Located on East Beach

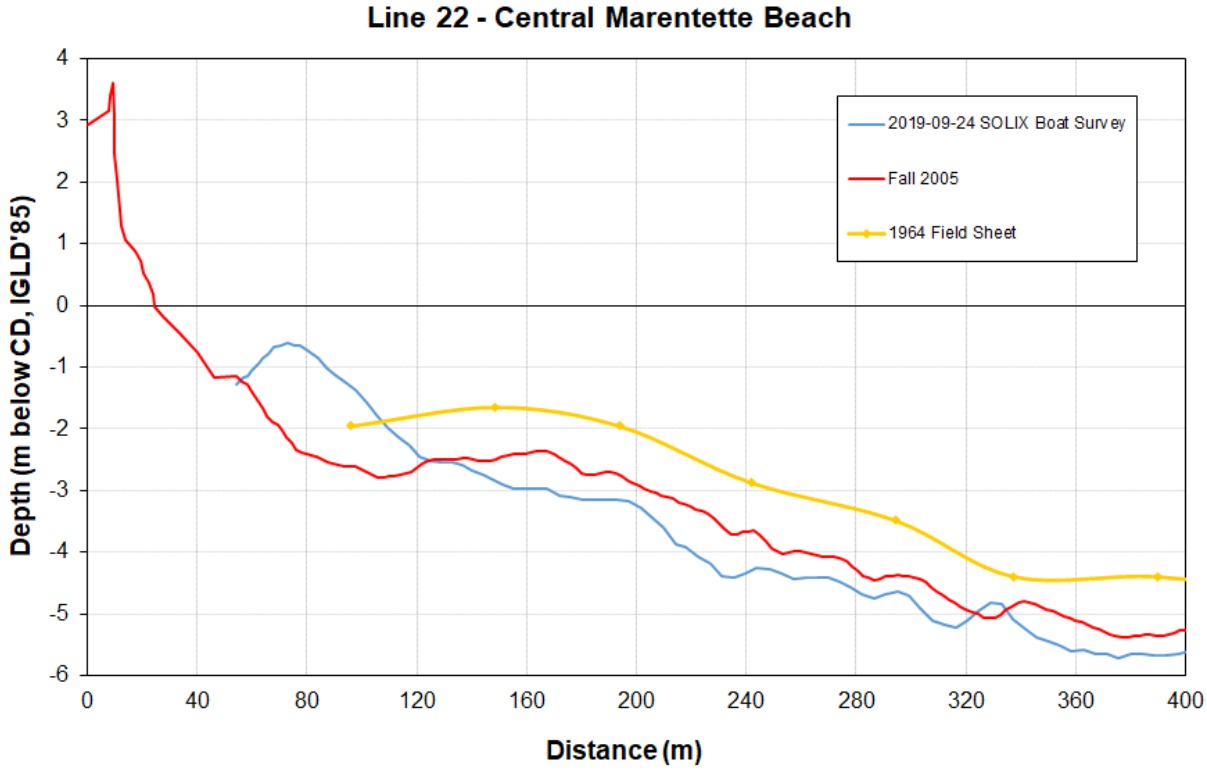


Figure 3.5 Line 22 Located in the Central Portion of Marentette Beach

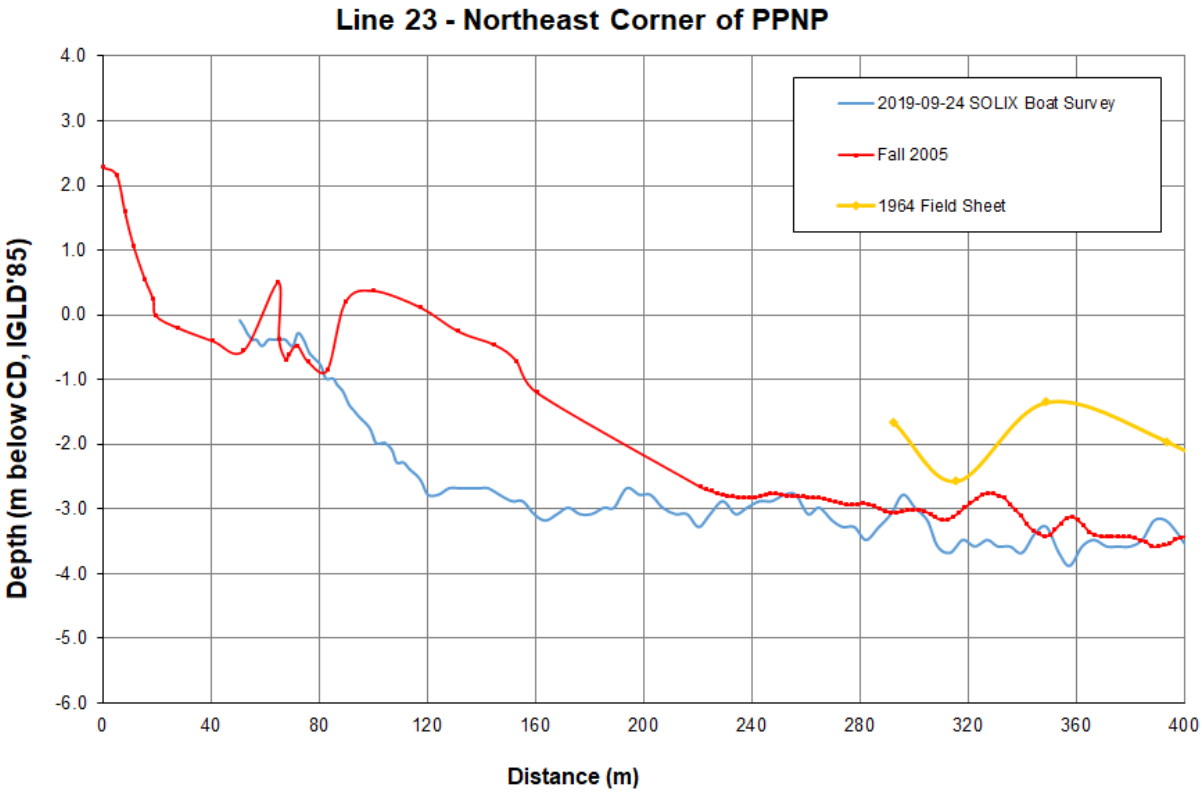


Figure 3.6 Line 23 at the Northeast Corner of PPNP

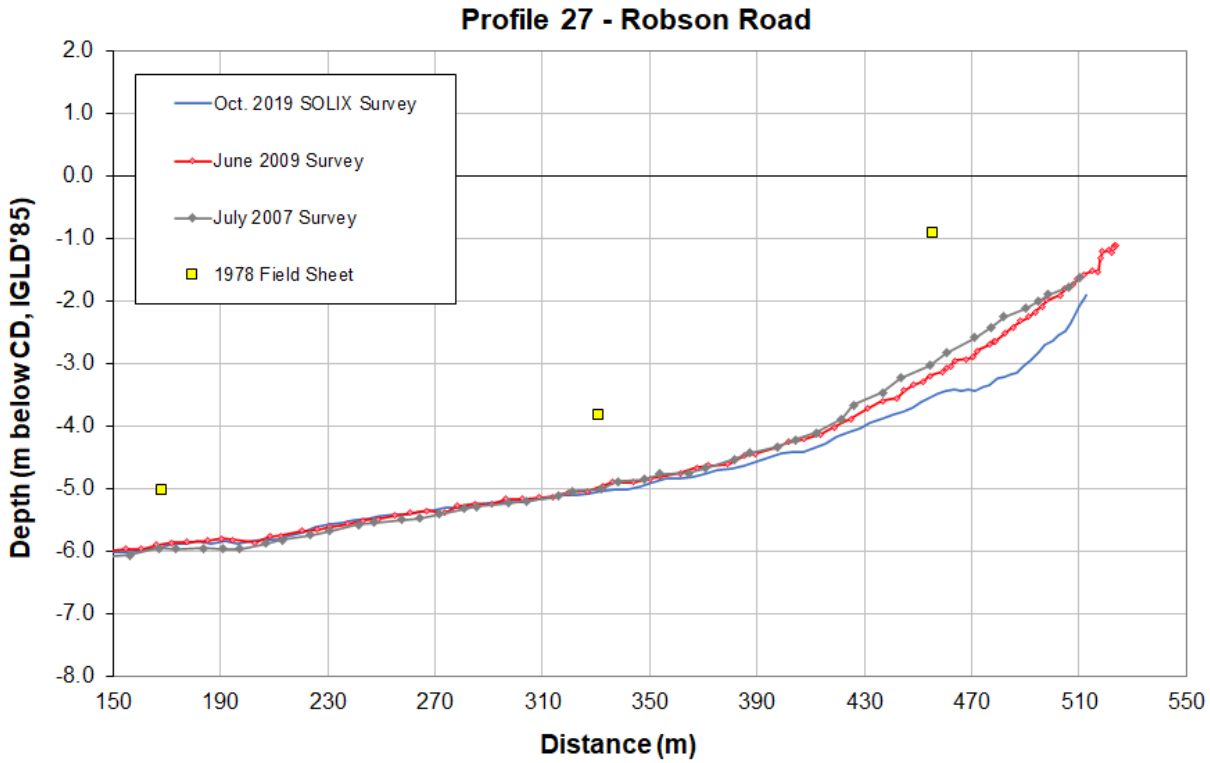


Figure 3.7 Line 27 West Side along Robson Road

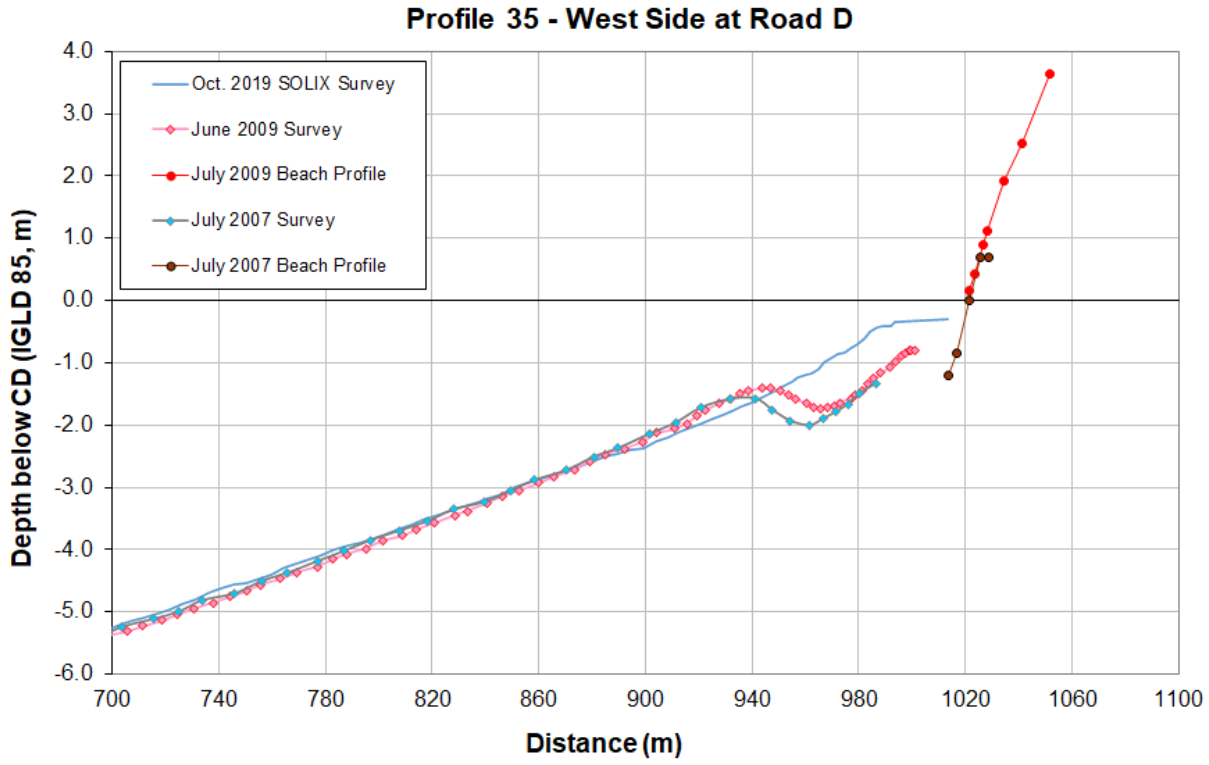


Figure 3.8 Line 35 West Side at Road D

3.1.2 Recent Evolution of the Hillman Marsh

The long-term erosion of the Hillman Marsh barrier beach has been documented in previous reports (Baird, 2007; Baird, 2008b). A map comparing the 1956 and 2017 aerial photographs is provided in Figure 3.9. Over the last 60 years the marsh has undergone a significant transformation, with the extensive emergent vegetation giving way to a sheltered embayment with no emergent vegetation. The treed and stable barrier beach has been migrating steadily inland, as seen in the lower panel of Figure 3.9. In a 2010 (Baird) report focused on erosion mitigation alternatives for the barrier, it was noted that without significant mitigation, the barrier beach would eventually disappear. Ten years later, that prediction has been realized. An oblique photo of the barrier beach in September 2019 is presented in Figure 3.10. A large breach has formed, and a significant portion of the barrier has been reduced to a washover terrace.

Another oblique view of the barrier, roughly five months later, is provided in Figure 3.11. Although ground measurements are not available, it appears the breach is now over 300 m in length. Lake waves are now able to propagate directly into the marsh and approach the East Marsh Dike. During site observations on November 28, 2019, hunks of peat were observed adjacent to the dike. Refer to Figure 3.12. These hunks of peat were likely eroded from the lake bottom in the breach channel and transported to the dike. This is evidence that waves are now propagating into the bay. Figure 3.13 provides a recent photograph of the former parking lot at the end of East Beach Road. During storms the beach is eroded, and beach material is transported to the marsh side of the former parking lot. Without action, this remaining section of the barrier will disappear, and the width of the breach will increase.

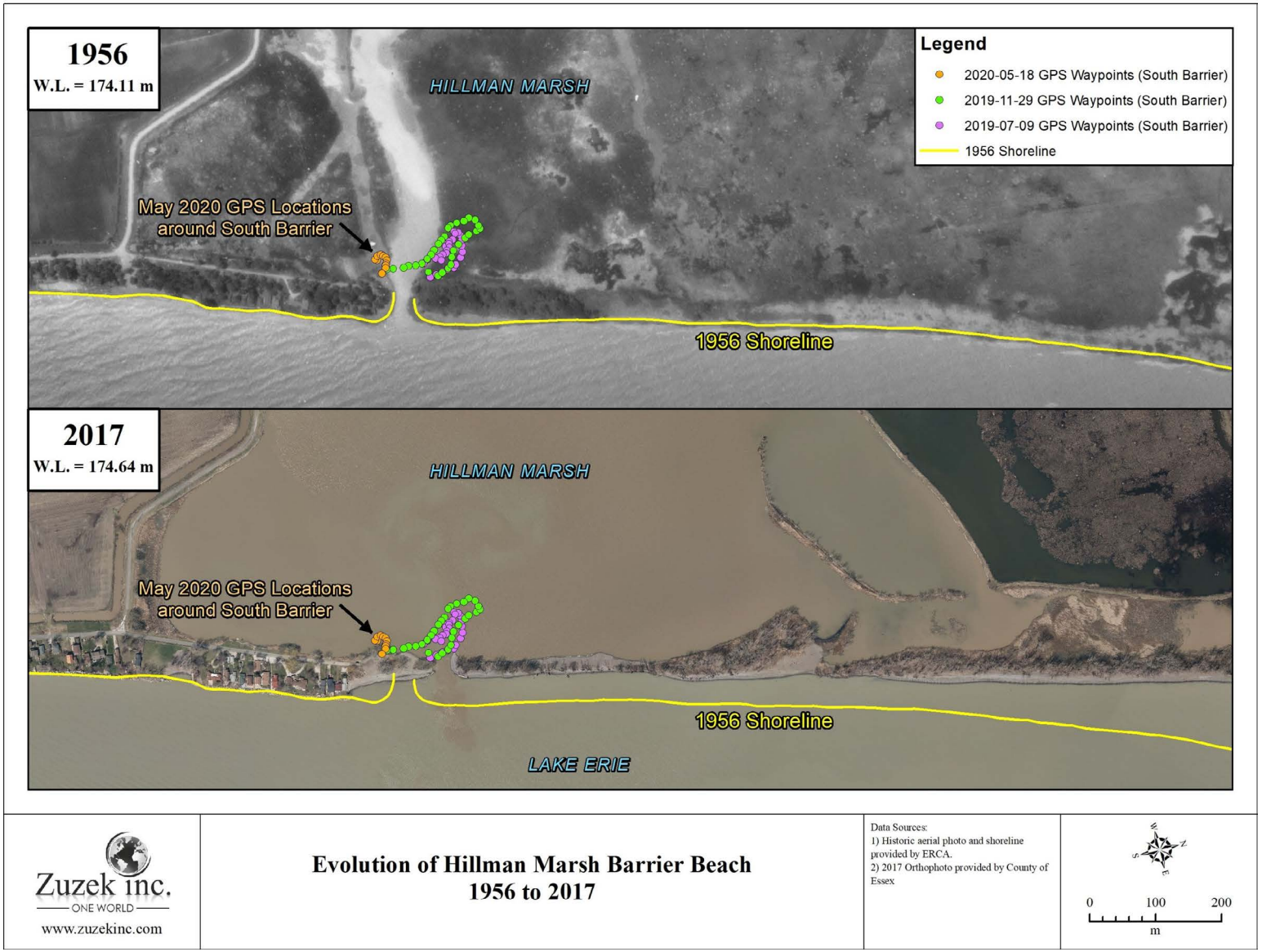


Figure 3.9 Evolution of the Hillman Marsh Barrier Beach from 1956 to 2020



Figure 3.10 Hillman Breach on September 24, 2019



Figure 3.11 Expanded Breach on February 12, 2020 (Photo courtesy of W.King)



Figure 3.12 Hunks of Peat Adjacent to the East Marsh Dike (Nov. 28, 2019)



Figure 3.13 Former Hillman Parking Lot at the end of East Beach Road (Feb. 21, 2020)

3.1.3 Southeast Marentette Drainage Scheme

The Marentette Drainage Scheme was the last drainage system to be constructed and was not completed until 1953. The 1956 aerial photograph in Figure 3.14 captures the shoreline conditions shortly after the drain became operational. The shoreline along the southern limits of Marentette Beach and the northeast corner of the National Park were aligned. Fast forward 60-years and a significant offset between the armoured southern tip of Marentette Beach and PPNP now exists. The shoreline of the National Park has migrated more than 200 m inland in 60-years or roughly 3 m/yr. Refer to the Baird (2010) report for a full summary of the shoreline history, including the construction of an experimental groyne field in 1970 at the tip of Marentette Beach, which is partly responsible for the accelerated erosion rate along the shores of PPNP.

Lakebed downcutting along Marentette Beach is documented above in Figure 3.5 and Figure 3.6. With each passing storm, the lake bottom gets deeper, which in turn allows larger waves to reach the shoreline. For protected shorelines such as the rock berm along the southern portion of Marentette Beach, this process translates into increasingly larger waves impacting the rock structure. Lakebed downcutting also creates instabilities for the structure toe since the very foundation the rocks are resting on is washing away.

Figure 3-15 documents the impacts of lakebed downcutting on the rock berm over the last 22 years, plus recent repairs in the fall of 2019, as follows:

- **Photo A - May 1998:** The rock berm was stable, and the crest of the structure was more than 2 m higher than the land on the backslope.
- **Photo B – May 2004:** The rock berm was stable and providing erosion protection.
- **Photo C – May 9, 2018:** The rock berm had deteriorated to a scattered pile of armour stone.
- **Photo D – July 9, 2019:** With the high lake levels during the summer of 2019, the rock berm had breached, as seen in Figure 3.15.
- **Photo E – October, 2019:** Reconstructed rock berm looking north.
- **Photo F – October, 2019:** Reconstructed rock berm looking south.

A view of the Marentette Beach rock berm, looking south, is provided in Figure 3.16. The deteriorated structure was all that separated Lake Erie waves from reaching the earth dike protecting the interior farmland from flooding. The oblique photograph was taken on September 24, 2019 while repairs to the rock berm were underway. An oblique view of the repaired rock berm on June 29, 2020 is provided in Figure 3.17.

The Municipality is also exploring future dyke improvements such as raising the elevation of the earth dykes, rock protection along the Marentette Canal and rock protection in areas shared with Point Pelee National Park.

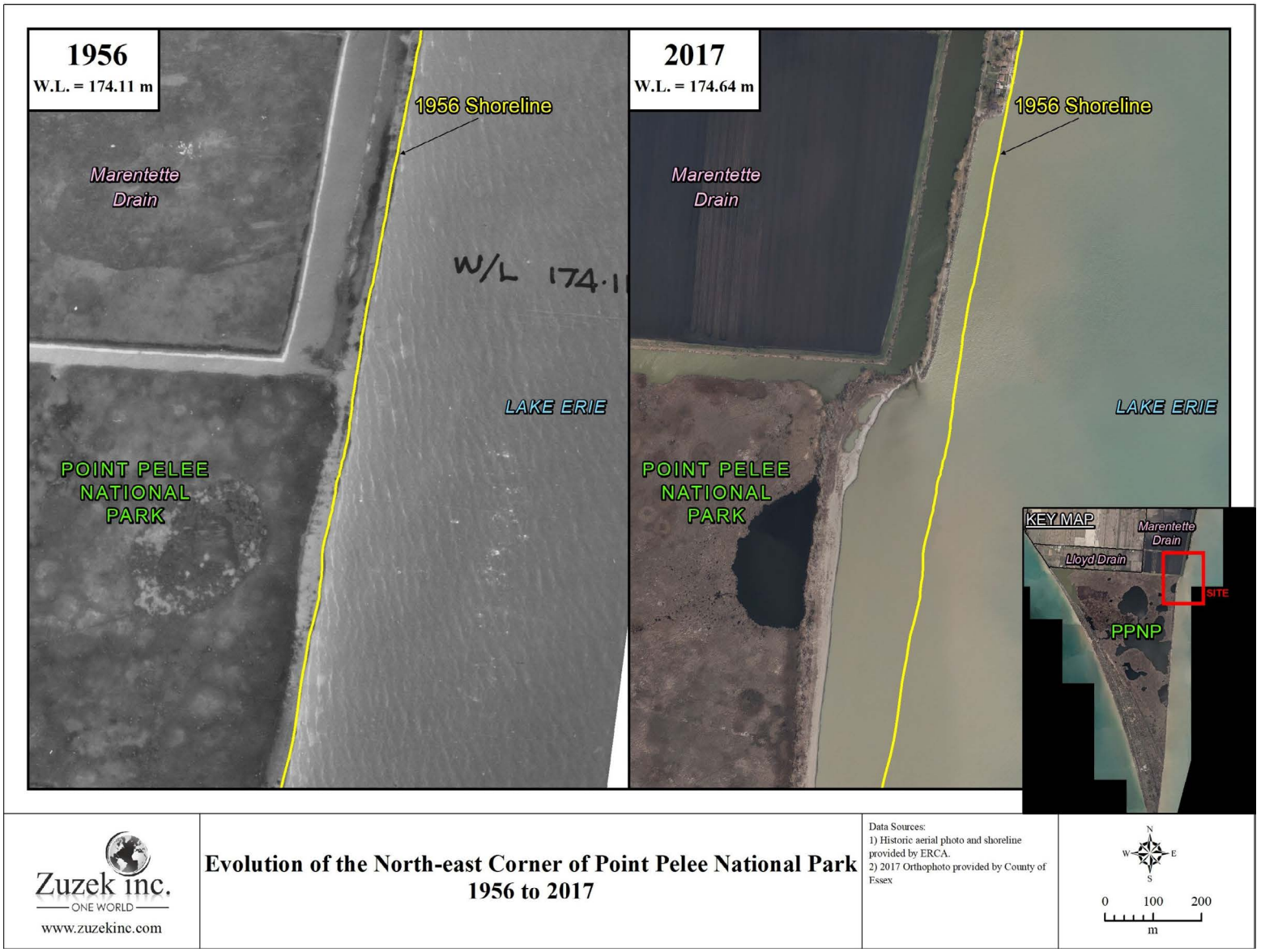


Figure 3.14 1956 to 2017 Comparison of the 1956 to 2017 Shoreline



Photo A: Marentette Rock Berm, South of Last Cottage, May 1998 (note person walking in the picture, the crest of the structure was above their head)



Photo B: Tip of Marentette Beach Rock Berm, May 19, 2004



Photo C: Tip of Marentette Rock Berm after the April 15, 2018 Storm (Photo May 9, 2018)



Photo D: Tip of Marentette Rock Berm on July 9, 2019, from the Marentette Earth Dyke



Photo E: Reconstructed Rock Berm (October 2019, photo courtesy of the Municipality of Leamington)



Photo F: Reconstructed Rock Berm (October 2019, photo courtesy of the Municipality of Leamington)

Figure 3.15 Photo History of the Marentette Beach Rock Berm, 1998 to 2019



Figure 3.16 Offset from Marentette Beach Rock Dike and Northeast Beach, PPNP, September 24, 2019

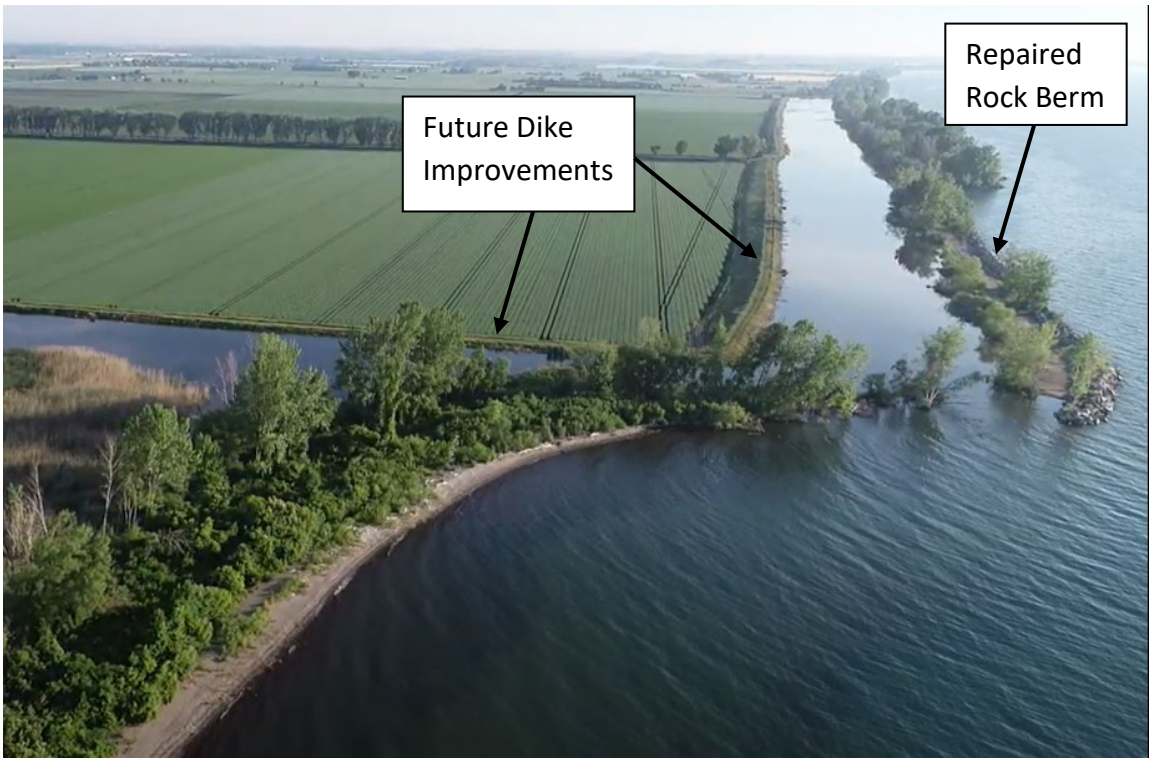


Figure 3.17 Marentette Repaired Rock Berm, June 29, 2020 (image courtesy of PPNP)

3.1.4 Evolution of the Point Pelee Peninsula

The evolution of the Pelee Peninsula is described by Coakley et al (1998) and summarized visually in Figure 3.18. Following the retreat of the last glaciers in Southern Ontario, Lake Erie water levels began to gradually rise to their current levels. Approximately 10,000 years ago, Lake Erie water levels were 10 m lower than present day. By 3,500 years ago water levels were about 4 m lower than present day, and the Pelee Peninsula was located several kilometres east of its present location, as seen in Figure 3.18. As the lake levels rose to the present range, the Pelee Peninsula continued its migration to the west and the size of the land feature decreased as it was inundated by the lake. The original sandy tip of the peninsula evolved into the southeast shoal (the underwater sand deposit south of Point Pelee National Park).

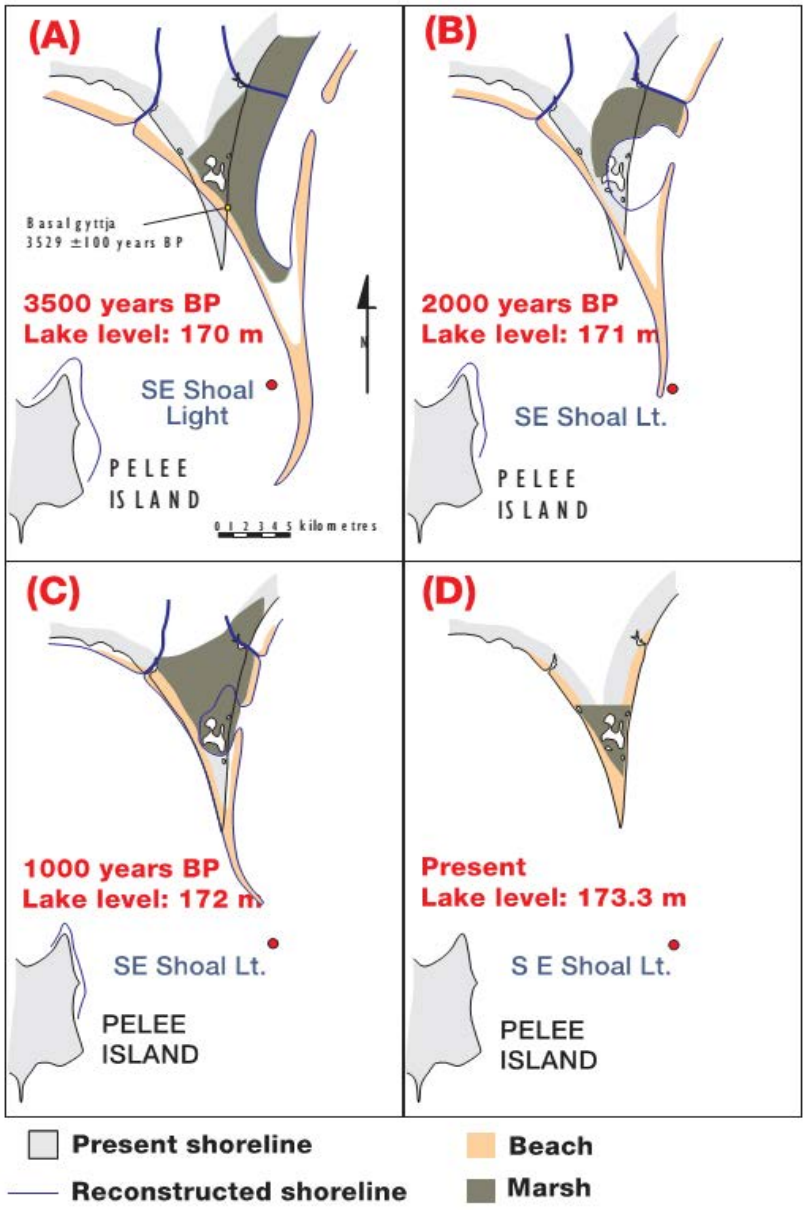


Figure 3.18 Evolution of the Pelee Peninsula, 3500 Years Ago to Present (Coakley et al, 1998)

Additional information from Coakley et al (1998) on the modern geology of Point Pelee is summarized in Figure 3.19 and Figure 3.20. Cross-section B-B' highlights the glacial till foundation under the National Park and the agricultural lands to the north. The interior marsh of the park is only separated from Lake Erie by a narrow ridge of sand as shown above in Figure 1.17 and Figure 1.18. Previous technical studies (Baird, 2007; Baird, 2010) have shown that the glacial till lake bottom is eroding and the eastern shoreline of the park is actively eroding. Shoreline recession at the north east corner of the park from 1956 to 2017 is highlighted above in Figure 3.14.

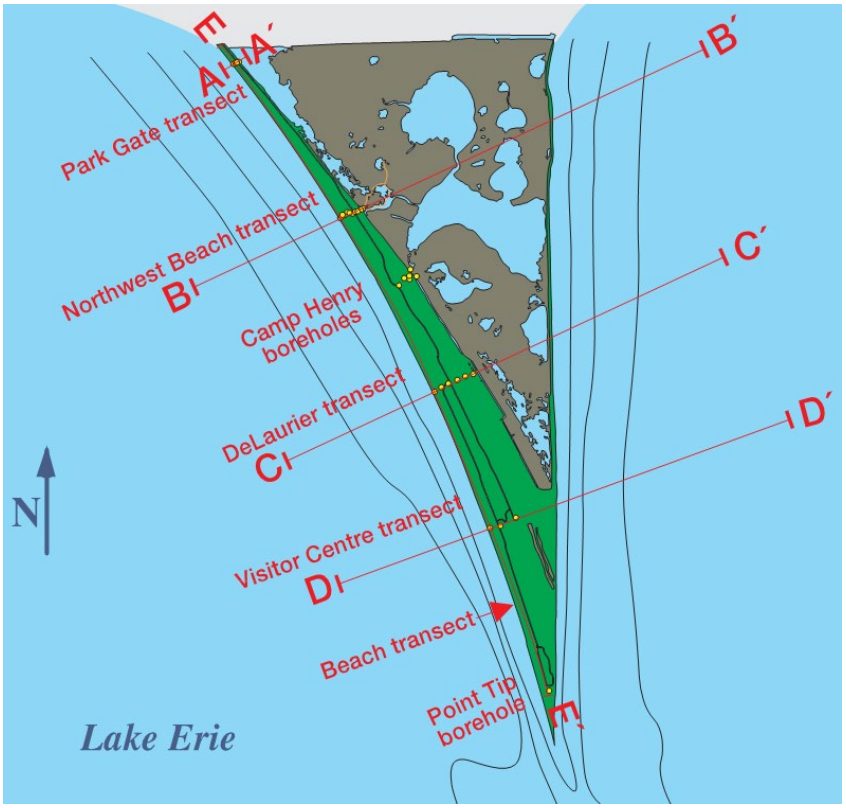


Figure 3.19 Cross-sections of Point Pelee (Coakley et al, 1998)

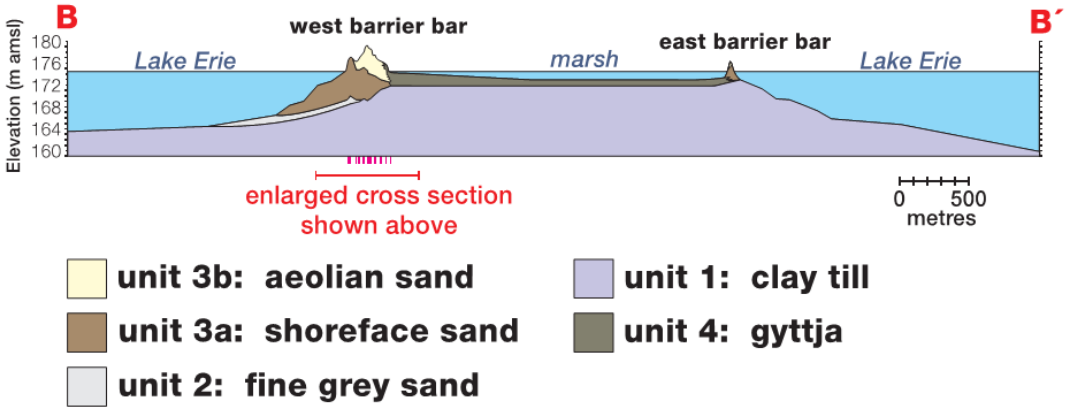


Figure 3.20 Section B-B' at Point Pelee National Park (Coakley et al, 1998)

New information on the evolution of the Southeast Shoal was gathered during the bathymetric surveys in September and October 2019. The results for Profile 42, located 300 m south of the tip of PPNP are presented in Figure 3.21. As of 2019, the crest of the shoal (above 0.0 m on the Y-axis) has migrated approximately 200 m to the west when compared to its 2007 position. Between -2 m and -4 m chart datum (CD), the underwater portion of the shoal has also migrated to the west. A similar trend was observed at Profile 46, located 700 m south of the forested tip of the peninsula. The entire shoal is migrating to the west, as is especially evident when the position of the sand lake bottom is compared to the 1964 survey. In short, the entire eastern shoreline of the Pelee Peninsula is migrating to the west south of Wheatley Harbour. In some locations, private shoreline protection is temporarily slowing the migration at the waterline.

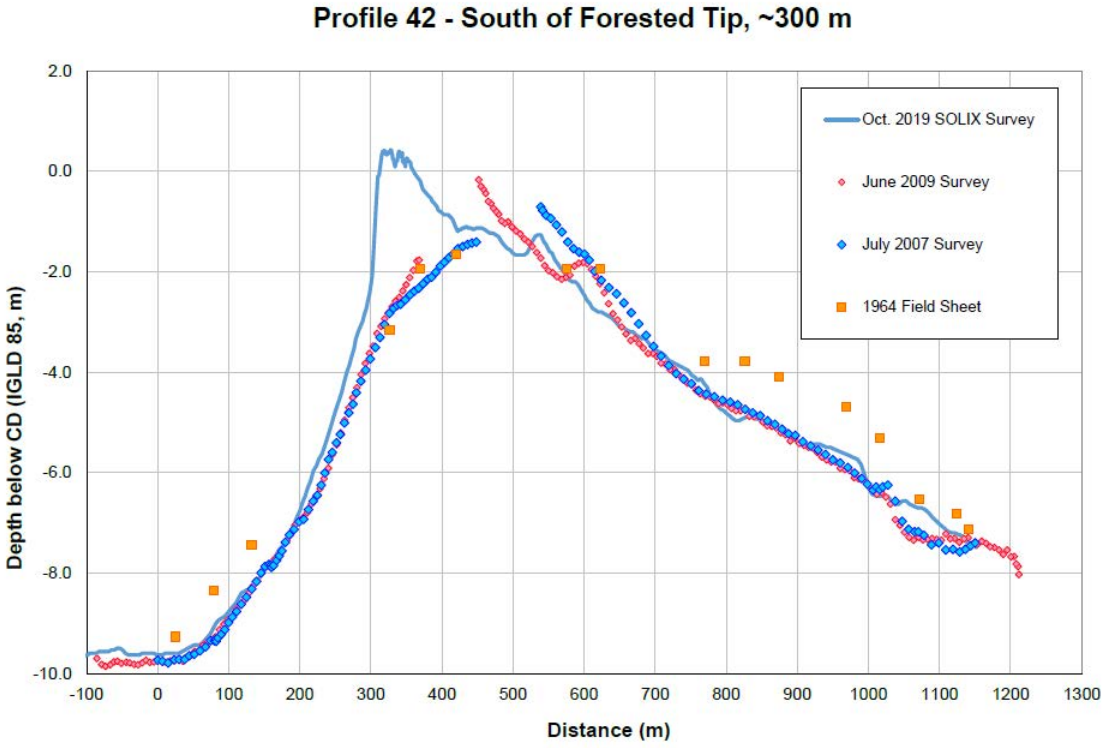


Figure 3.21 Westward Migration of the Southeast Shoal 300 m South of the Forested Tip of Point Pelee National Park

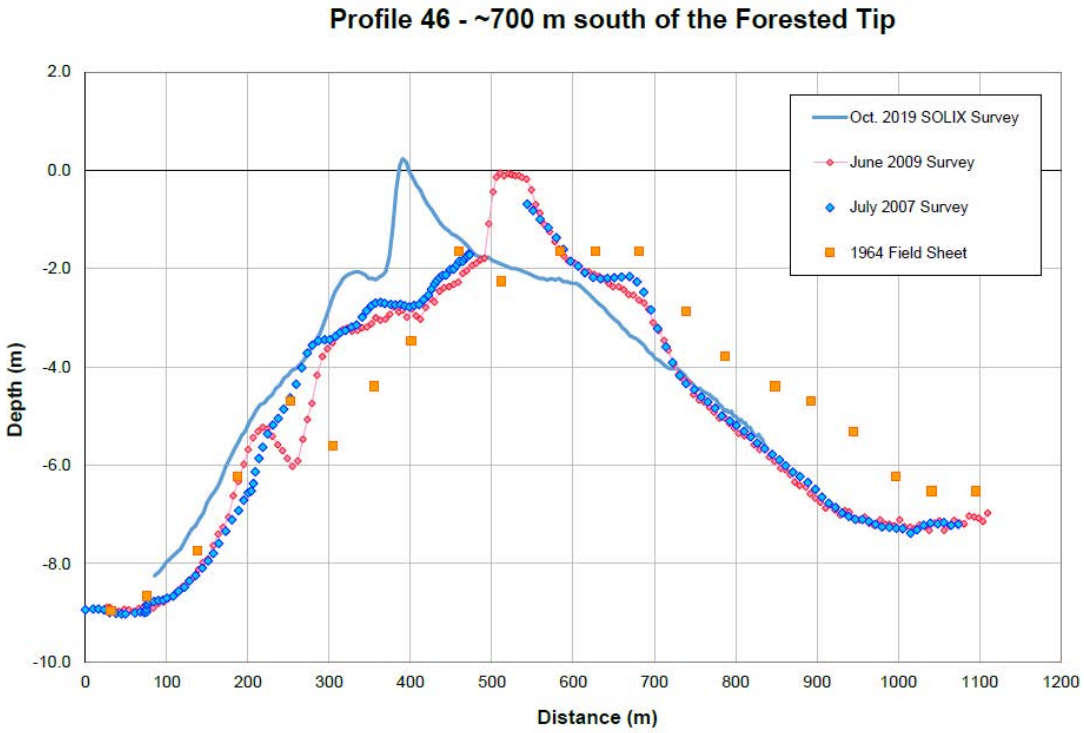


Figure 3.22 Westward Migration of the Southeast Shoal 700 m South of the Forested Tip of Point Pelee National Park

3.2 Lake Level Analysis

Shoreline hazards on the shores of the Great Lakes are defined in part based on the 100-year combined flood level. The 100-year combined flood level is defined as the combination of static water level and wind setup (storm surge) having a combined probability of occurrence of 1 in 100-years (1% in any given year). Combined flood levels used in the regulation of shoreline hazards and provincial planning policies over the past number of decades were largely based on work completed by the Ministry of Natural Resources and Forestry published in a 1989 report titled "Great Lakes System Flood Levels and Water Related Hazards" (MNRF, 1989). Published flood levels were based on a statistical analysis of historical water level data from a coordinated network of gauging stations around the great lakes and supported by numerical storm surge modelling, for the period from early century up to and including 1988. 100-year water levels are provided in MNRF (1989) as +175.6 m IGLD85' and +175.5 m IGLD85' for the west and east sides of the Pelee Peninsula respectively.

Field observations and measurements by ERCA staff following severe storms in April 1986 and April 1998 indicated that localized water levels south of Wheatley Harbour (Cotterie Park Road and East Beach Road) reached approximately +176.0 m IGLD85' (ERCA, 2006). Based on these observations, the adopted 100-year combined flood level for the region has been taken as +176.0 m IGLD85', which is higher than the values provided in MNRF (1989).

Since the publication of MNRF (1989) and the measurements collected by ERCA staff in the 80s and 90s, several decades of high temporal resolution static water level and storm surge data has

been logged at numerous water level gauges around Lake Erie. Furthermore, numerical modelling, data processing and statistical analyses capabilities have improved significantly over those available more than three decades ago. As such, updated 100-year combined flood levels based on the best available data were analysed as a component of the present study and are presented in the sections that follow.

3.2.1 Updated Static Lake Levels

Measured historical static water level data are archived by the Department of Fisheries and Oceans (DFO) for the great lakes dating back to 1918. Measured data is available at 14 gauging stations around Lake Erie, with 6 stations being located on the Canadian side of the lake. Historical static lake level data is also tabulated based on lake averaged levels between the 14 coordinated gauges.

A dataset of maximum monthly static lake level from 1918 to 2019 was generated from the coordinated gauge dataset and separated into 12 monthly datasets to capture the seasonality of static lake levels. Each monthly dataset containing 119 years of maximum monthly static water levels was subsequently ranked from highest to lowest and tested for normalcy using the Chi-Square test. Normalcy was generally found to be weak and so the datasets were fitted to 10 additional cumulative probability distributions with the Weibull and Generalized Extreme Value distributions generally providing the best overall fit based on correlation coefficients. Correlation coefficients of 0.995 or higher were achieved for all monthly datasets. Table 3.1 provides a summary of observed maximum and predicted 100-year static water levels for each month of the year based on the analysis described above.

Table 3.1 – Maximum observed and predicted 100-year monthly static lake levels for Lake Erie (based on data from 1918 – 2019)

	Max. Monthly Lake Level (1918 - 2019)	
Month	Max Observed WL (IGLD85')	100-year WL (IGLD85')
January	174.86	174.79
February	174.78	174.82
March	174.88	174.96
April	174.98	175.05
May	175.05	175.07
June	175.14	175.09
July	175.14	175.05
August	175.02	174.96
September	174.88	174.86
October	174.94	174.74
November	174.85	174.72
December	174.89	174.76
Max =	**175.14**	**175.09**

Based on the extreme value analysis of static lake levels from 1918 to 2019, the maximum 100-year static lake level for Lake Erie is +175.09 m IGLD85' occurring in the month of June. This represents an increase of 0.06 m over the 100-year static lake level published in MNRF (1989).

3.2.2 Storm Surge Analysis

Storm surge is the temporary rise in water levels during a storm resulting from a combination of barometric pressure gradients and wind setup. On large inland lakes the effects of pressure variations are relatively small, while wind setup can be substantial. Wind setup occurs when wind-induced shear stress at the water-air interface pushes water in the direction the wind is blowing. When winds are in an onshore direction this will cause water levels to temporarily increase along the shoreline. For the case of inland lakes, this temporary increase in water level at one side of the lake will be offset by a temporary decrease at the opposite end of the lake. The amplitude of a storm surge event at a given location is dependent on the wind speed, wind direction, fetch (distance over which the wind is blowing), the local shoreline orientation and lakebed bathymetry.

Storm surge events can be analysed from measured water level data at gauging stations around Lake Erie, provided the data is captured at a sufficient temporal resolution to capture a storm surge event, which typically lasts on the order of several hours. The nearest water level gauges to the project shoreline with sufficient temporal resolution are at Kingsville (Station ID 12065) and Erieau (Station ID 12250). Data from each of these stations covering the period from 1962 to 2019 (58 years) were obtained from the Department of Fisheries and Oceans (DFO) for further analysis.

Storm surge events were isolated from static lake levels in each dataset by calculating the difference between the instantaneous water level and a moving average calculated by taking the average water level over the three days prior and three days post-surge event, with the central 24 hours removed (12 hours before and after the peak). The residual between the two values represents the temporary water level increase at the gauge location above (or below) static lake level due to a storm surge event. A minimum duration of 72 hours between independent events was assumed.

The resulting storm surge events at each gauge location were separated into twelve monthly datasets to capture seasonality. In general, storm surge events are more frequent and severe during the fall and winter months than they are during the summer. In order to not preclude a historical event that occurred on the last day of a month as being possible in the subsequent month, the twelve monthly datasets were compiled to include storm surge events measured during the month in question and one month before and after, thus adding a level of conservatism to the analysis. Each monthly dataset was subsequently ranked in order of magnitude, and the top 58 events (one per year) were fitted to several cumulative probability distributions. The distribution for each dataset that resulted in the best overall correlation coefficient was selected. Resulting 100-year storm surge magnitudes at each gauge location and for each month of the year are presented in Table 3.2. Figure 3.23 presents the cumulative distribution plot for the month of January at the Kingsville water level gauge.

Table 3.2 - Seasonal 100-yera storm surge magnitude at DFO water level gauges at Kingsville and Erieau

	100-year Storm Surge Magnitude (m)	
Month	Kingsville (1962 - 2019)	Erieau (1962 - 2019)
January	1.03	0.45
February	0.90	0.42
March	0.75	0.37
April	0.75	0.40
May	0.67	0.33
June	0.60	0.25
July	0.55	0.26
August	0.50	0.21
September	0.77	0.33
October	0.83	0.38
November	1.04	0.41
December	1.04	0.45
Max =	**1.04**	**0.45**

The governing 100-year storm surge at Kingsville and Erieau is 1.04 m and 0.45 m respectively, occurring during the winter months (December – January). These values are 0.10 m higher and 0.04 m lower than those presented in MNRF (1989) for Kingsville and Erieau respectively. This is due in part to the fact that the MNRF analysis was completed using a much shorter temporal period of only 27 years (1962 – 1988). It is also in part due to the limited number of cumulative probability distributions that were evaluated in the 1989 study.

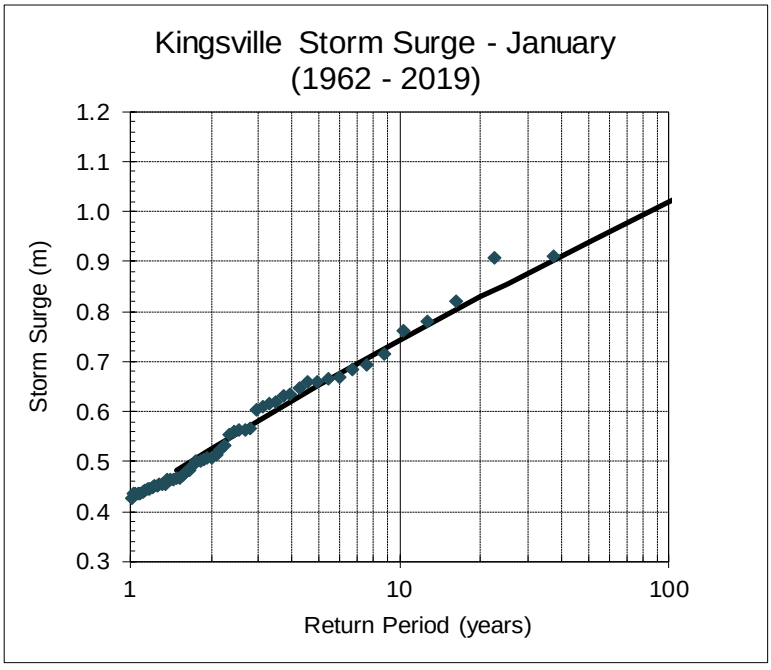


Figure 3.23 - Extreme value analysis plot of storm surge at Kingsville vs. return period (Weibull Distribution).

3.2.3 Joint Probability

The 100-year combined flood level is defined as the combination of static lake level and storm surge with a combined probability of occurrence of 1 in 100-years. In order to assess the 100-year combined flood level, a seasonal joint probability analysis must be performed on the static lake level and storm surge datasets.

In the seasonal joint probability analysis, static lake level and storm surge are treated as independent variables X and Y. An extreme value analysis is first completed for each independent variable and for each month of the year, as was discussed above. Once cumulative probability distributions are fitted to each independent dataset, multi-variate discretization is performed, and the convolution formula is used to determine the joint probability of combined water levels "Z" (where Z = X + Y). The resulting joint probability equation can be expressed as:

$$P(Z) = \sum_{Rx} P(X) \cdot P(Z - X)$$

Assessing the above formulation for a range of possible combined flood elevations (Z) at each water level gauge location and for each month of the year results in series of cumulative joint probability distributions of static water levels and storm surge. Figure 3.24 shows one such joint probability distribution for the month of June at the Kingsville water level gauge. The 100-year combined flood level is the value that corresponds to a cumulative probability of occurrence of 1% (0.01).

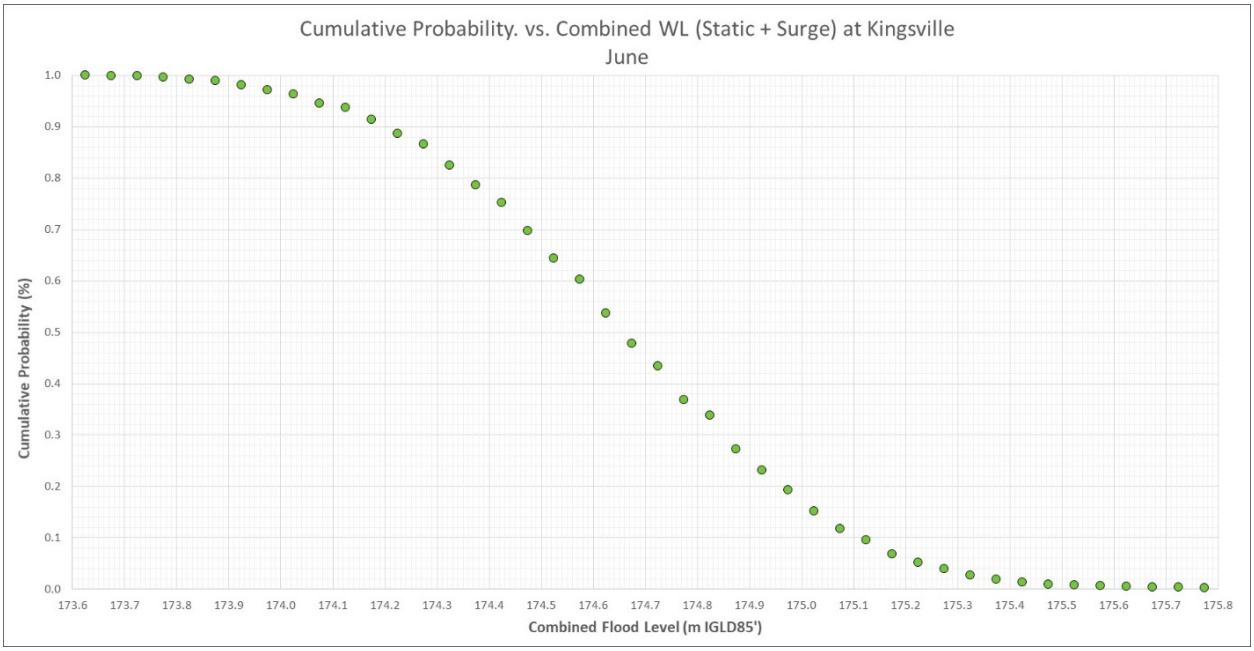


Figure 3.24 - Cumulative joint probability distribution plot of combined flood level (static water level and storm surge) at Kingsville for the month of June

Table 3.3 presents summary results of the joint probability analysis of combined flood levels for the 100-year average recurrence interval at each water level gauge location.

Table 3.3 - Seasonal 100-year combined flood levels at Kingsville and Erieau

	100-year Combined Flood Level	
Month	**Kingsville**	**Erieau**
January	175.46	175.05
February	175.44	175.09
March	175.55	175.23
April	175.62	175.32
May	175.59	175.31
June	175.47	175.27
July	175.39	175.21
August	175.28	175.09
September	175.34	175.06
October	175.29	174.97
November	175.40	174.99
December	175.44	175.03
Max =	**175.62**	**175.32**

Based on the results of the updated joint probability analysis presented in Table 3.3, the assessed 100-year combined flood levels at Kingsville and Erieau are +175.62 m and +175.32 m IGLD85' respectively, occurring in the month of April. These results are 0.05 m lower and 0.03 m higher than those published in MNRF (1989) respectively.

3.2.4 Water Level Gradients and Local Observations

In addition to assessing return period water levels at gauge locations, the MNRF (1989) report included numerical modeling of storm surge events throughout Lake Erie in order to determine appropriate combined flood levels for additional locations around the lake that did not feature water level gauges. The numerical model was calibrated to gauge locations and remains an appropriate tool for interpolating between gauge locations.

100-year peak instantaneous still water levels (i.e. the combined flood level) were provided at three locations between the Kingsville and Erieau gauges in MNRF (1989) and are summarized as follows alongside the Kingsville and Erieau values (published values have been converted from IGLD55' to IGLD85'):

- Kingsville = +175.67 m IGLD85'
- Pelee West (west project shoreline) = +175.56 m IGLD85'
- Wheatley (east project shoreline) = +175.47 m IGLD85'
- Port Crew = +175.34 m IGLD85'
- Erieau = +175.29 m IGLD85'

Based on the MNRF (1989) results, the delta between Kingsville and Erieau is 0.38 m. The delta from Kingsville to the west and east project shorelines is 0.11 m and 0.20 m respectively. As such, it can be assumed that the same relative delta can be applied to the updated joint probability results for the Kingsville and Erieau water level gauges presented above. This results in the following updated 100-year combined flood levels for the project shoreline (Kingsville and Erieau also shown):

- Kingsville = +175.62 m IGLD85'
- **West Project Shoreline (Pelee West) = +175.53 m IGLD85'**
- **East Project Shoreline (Wheatley) = +175.46 m IGLD85'**
- Erieau = +175.32 m IGLD85'

As was discussed at the outset of this section, field observations and measurements by ERCA staff following severe storms in April 1986 and April 1998 indicate that localized water levels south of Wheatley Harbour reached approximately +176.0 m IGLD85' (ERCA, 2006). Based on these observations, the adopted 100-year combined flood level for the region has been taken as +176.0 m IGLD85' over the MNRF (1989) values for the past two decades. The accuracy and validity of these observations is unknown. It is also unknown if the measurements were influenced by local effects such as ponding, storm water runoff, wave setup, or localized increases in surge due to shoreline orientation or the presence of coastal structures. However, based on the historical adoption of +176.0 m IGLD85' as the 100-year water level for the region, and given that the updated analysis of water level gauge data at Kingsville and Erieau has not shown a dramatic change from the values published in the MNRF (1989), it is recommended that a 100-year combined flood level of +176.0 m IGLD85' be maintained for both the west and east project shorelines.

3.3 Wave Climate

The deep-water wave climate and the numerical modeling completed to transform these waves into shallow water is described in Section 3.3.

3.3.1 Offshore Waves

The offshore wave climate affecting the SE Leamington region was assessed from the Wave Information Study (WIS) database. The WIS is a United States Army Corps of Engineers (USACE) sponsored project led by the Coastal and Hydraulics Laboratory Engineering Research and Development Center providing hourly wave climatologies for all major shorelines throughout the United States. Included in this study was a 55-year wave hindcast for Lake Erie covering the period from 1960 to 2014. In a wave hindcast, historical wind fields are used to drive a wave generation and propagation model to produce a timeseries of historical waves. The model is then calibrated to measured wave buoy data where available. The WAVAD numerical model was used for the Lake Erie wave hindcast and is a second-order wave propagation model. The WIS database is the most accurate and complete wind-wave dataset available for Lake Erie.

Offshore waves were taken from two WIS stations, one to the west of Point Pelee Peninsula (Station 92132) and one to the east (Station 92138). The stations are 7 – 8 km offshore and located in 10 m and 15 m respectively (below CD). A statistical analysis of extreme events, commonly referred to as an extreme value analysis (EVA), was conducted on offshore wave data at both locations covering the period from 1960 to 2014 inclusive (55 years). The results of this EVA were used as offshore wave targets for the numerical wave model, and are summarized as follows:

Table 3.4 – Offshore wave statistics at WIS offshore output points west and east of Point Pelee Peninsula

ARI (years)	WIS Station 92132 (west model)			WIS Station 92138 (east model)		
	Lat: 41.92^0, Lon: -82.60^0			Lat: 42.00^0, Lon: -82.40^0		
	Depth: 10 m below chart datum			Depth: 15 m below chart datum		
	H_s (m)	T_p (s)	DIR (deg)	H_s (m)	T_p (s)	DIR (deg)
1	2.54	6.5	245	3.00	8.5	75
10	3.24	7.0	245	3.92	9.0	75
25	3.49	7.5	245	4.28	9.0	75
50	3.67	7.5	245	4.55	9.5	75
100	3.85	7.5	245	4.82	9.5	75

3.3.2 Nearshore Waves

The numerical wave module Delft3D-WAVE was used to transform the offshore WIS storm waves to the project shoreline. Delft3D-WAVE utilizes the third-generation, phase-averaged spectral wave model SWAN (Delft University of Technology, 2018). SWAN has been widely used throughout the Great Lakes and accounts for all significant nearshore wave transformations including shoaling, refraction, bottom friction and depth-induced breaking.

Two offshore wave models were setup using the Delft3D-WAVE module. The first model covered the entire west side of Point Pelee Peninsula from west of the Leamington Marina to the southern tip of Point Pelee, a total shoreline length of approximately 20km. The second model covered the entire east side of Point Pelee Peninsula from north of Wheatley Provincial Park to the southern tip of Point Pelee, a total shoreline length of approximately 23km. Offshore model boundaries extended well beyond the WIS station locations to permit model calibration.

Bathymetry used in the creation of the model domains was provided by NOAA (2018) as 1 m bathymetric contours. The NOAA bathy was however updated to account for changes in local bathymetry identified in the bathymetric surveys discussed in Section 2.3. This survey indicated that while lakebed elevations on the west side of the peninsula have remained reasonably stable over the last several decades, the east side of the peninsula has suffered from nearshore lakebed downcutting of up to 2 m versus the NOAA bathy. As such, nearshore lakebed elevations were adjusted accordingly to approximate the present-day profiles collected in the field.

The model was first run by inputting offshore storm waves at the model boundaries and adjusting their input height until the 100-year offshore wave conditions described above were matched at each of the WIS output points.

Three wave and water level scenarios were subsequently simulated using the calibrated numerical wave model, and are summarized as follows:

- **Scenario A:** 100-year offshore waves and 100-year water levels (+176.0 m IGLD85') assuming present day conditions (no future lakebed downcutting or climate change influences).

- **Scenario B:** 100-year offshore waves and 100-year water levels plus an additional 0.5 m water level increase representative of mid-century climate change predictions (+176.5 m IGLD85'). The influence of climate change is discussed in Section 3.4.4.

- **Scenario C:** 100-year offshore waves and 100-year water levels including climate change (+176.5 m IGLD85'), plus an additional 1.0 m of lakebed downcutting on both sides of the peninsula. This represents approximately 25 years of downcutting on the east side based on historical measured downcutting rates. The timeline is unknown for the west side of Point Pelee as the collected bathymetric profiles show little to no downcutting along this shoreline as of 2019.

Nearshore wave conditions were output every kilometre along the project shoreline, resulting in 14 output points for the west model and 21 for the east model. The resulting 100-year nearshore wave conditions for each of the three scenarios described above were subsequently used in the determination of wave runup, overtopping, and ultimately in the determination of wave impacts on private and public infrastructure and associated economic implications (discussed in Section 4.2.2). Nearshore wave conditions were also used in the development of recommendations for shoreline protection structures featured in the risk adaptation and mitigation concepts discussed in Section 6.0. Figure 3.25 presents contour maps of 100-year significant wave height for both model domains and for Scenario A.

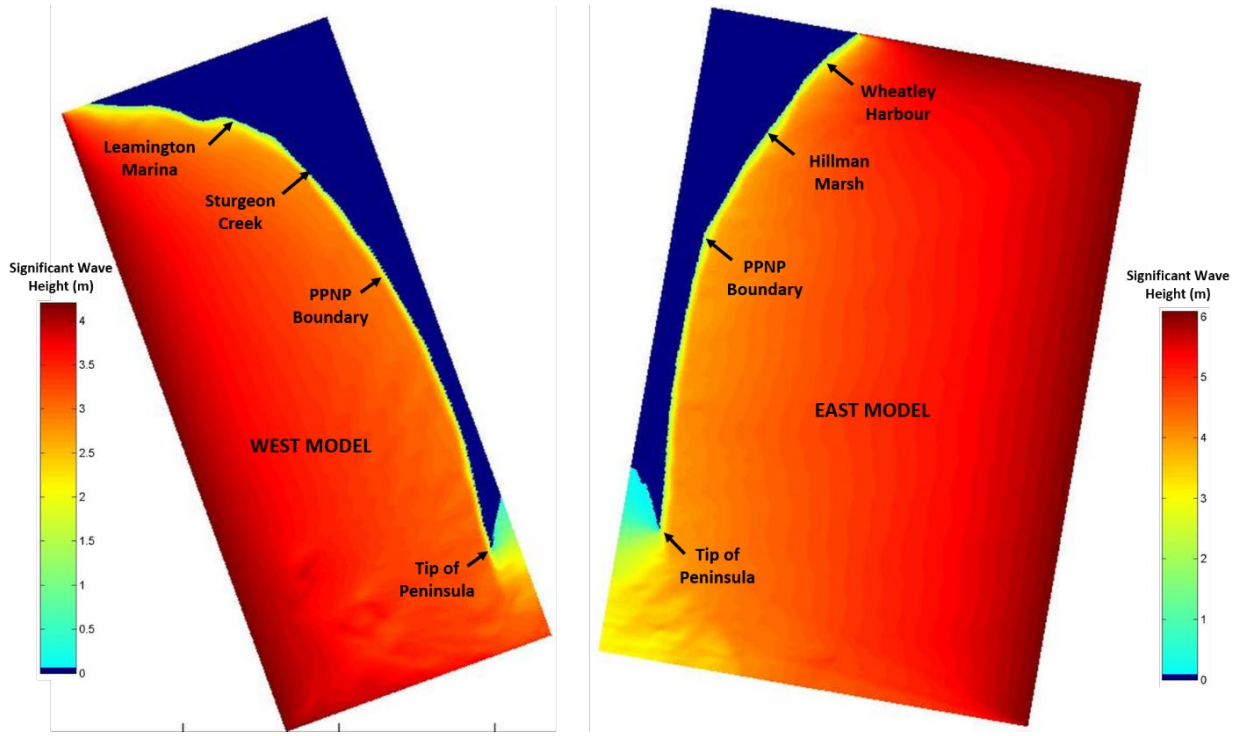


Figure 3.25 West and east model domains showing colour contours of 100-year significant wave height for Scenario A.

3.4 Influence of Climate Change

A recent technical study supported by Natural Resources Canada (Zuzek Inc., 2019) investigated the impacts of climate change on future storms and ice cover in the Great Lakes Basin. This investigation was the first of its kind to focus solely on storm impacts to wave heights and storm surges in the basin. To evaluate projected changes to our climate in the future, scientists have developed representative concentration pathways (RCPs) that correspond to different future emission scenarios for greenhouse gases. RCP2.6 is a low emission scenario needed to keep global temperature increases to roughly 2 degrees Celsius, while RCP8.5 assumes no changes to current greenhouse gas emissions (Bush and Lemmen, 2019). Recent physical evidence from the melting of global ice-sheets suggests our climate is tracking the worst-case RCP8.5 emission scenario (Slater et al, 2020). The key findings are summarized in the following report sections.

3.4.1 Warming Due to Climate Change

The projected winter warning in Canada for RCP2.6 and RCP8.5 were recently summarized by Bush and Lemmen (2019). Refer to information for 2031-2050 and 2081-2100 in Figure 3.26. Significant winter warming is projected, especially for RCP8.5. By late century, winter temperatures for this scenario are projected to be 5 to 7 degrees Celsius warmer.

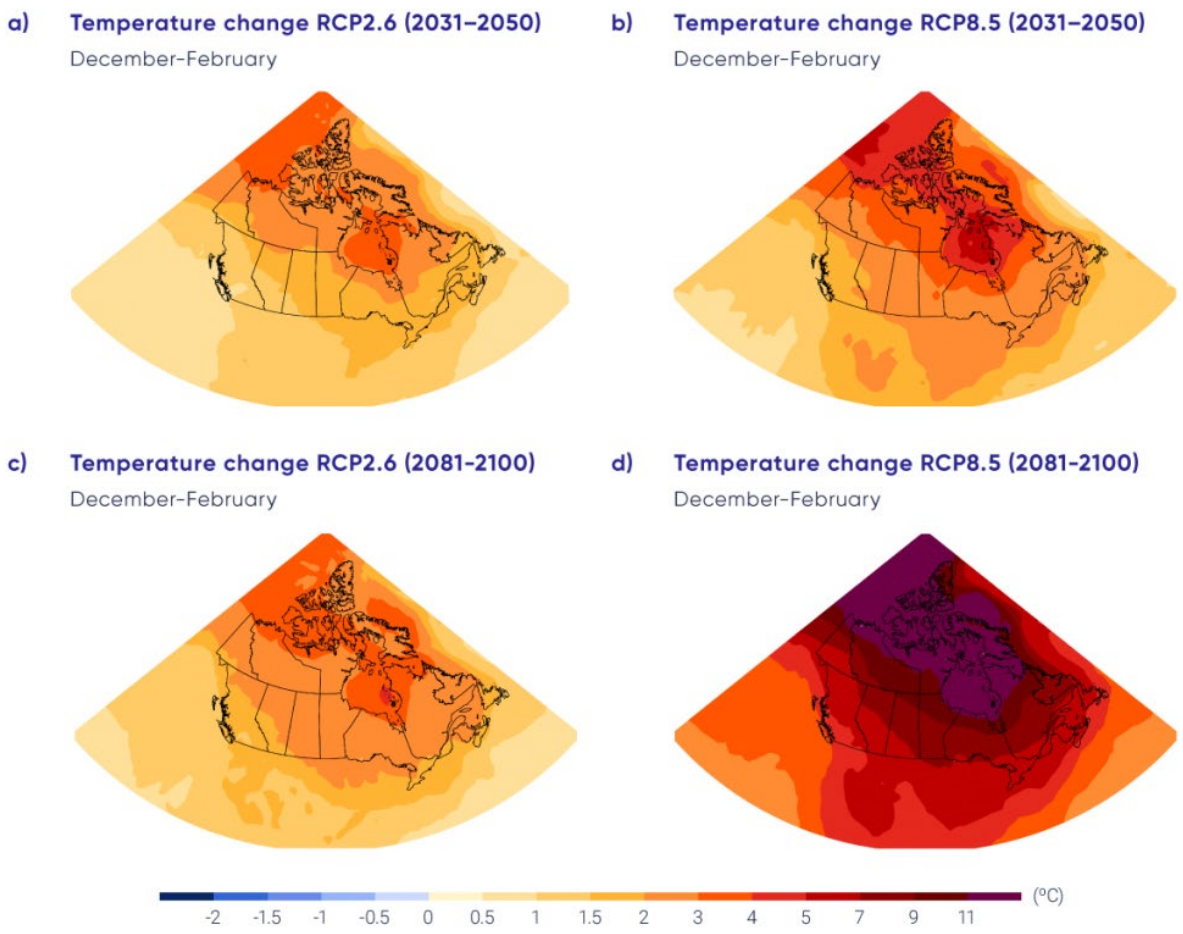


Figure 3.26 Winter Warming for Mid- and Late-Century (from Bush and Lemmen, 2019)

3.4.2 Ice Cover Projections Due to Warming

Ice cover in the Great Lakes has been decreasing since 1973 (Wang et al, 2012) and across the northern hemisphere (Sharma et al, 2019). The projected winter warming will continue to increase land and lake temperatures, resulting in further reductions in ice cover in the future. Figure 3.27 provides a conceptual diagram of these changes on ice cover, with near full lake ice coverage in the left-hand panel, partial coverage in the middle satellite image, and limited coverage in the right-hand panel. As the winter temperatures continue to warm in Southern Ontario, the duration of lake ice coverage will continue to decrease and could approach zero coverage by late century (e.g., 2080).

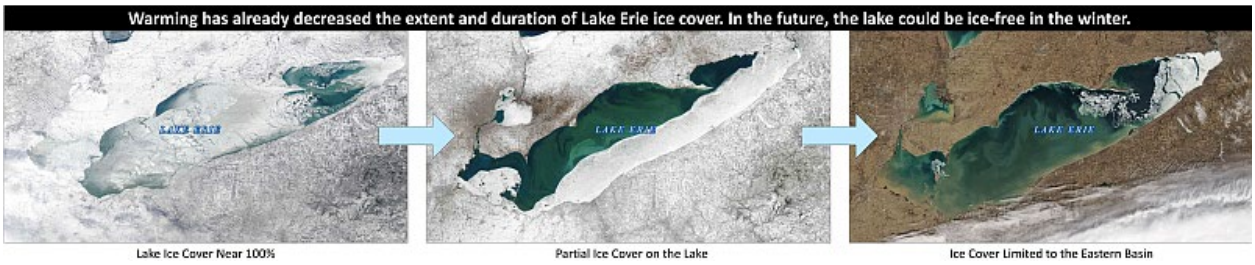


Figure 3.27 Schematic Diagram of Reduced Lake Erie Ice Coverage

Similar conclusions were reached by RWDI (2020) based on a study of future land and lake temperatures for a late century RCP8.5 emission scenario, in which it was identified that Lake Erie and Lake Ontario could be ice free in the future. This conclusion was also recently validated by an ongoing ECCC study for the Great Lakes (ECCC, Internal File 2020).

3.4.3 Changes in Wave Climate and Storm Surge

The impacts of climate change on future coastal storms, wave heights, and storm surges was recently evaluated for Lake Erie and Lake Ontario (Baird, 2019). The wave height analysis was completed by selecting the top 15 wave height storms on Lake Erie from 2000 to 2013, then comparing the predicted wave heights for the same storms for a late-century RCP8.5 scenario. The results did not produce any consistent trends on the potential impacts of climate change on future wave heights (e.g., larger or smaller wave heights in the future). The analysis did however highlight the importance of lake ice cover on the generation of deep-water waves and propagation of those waves into the shoreline.

In the second part of the analysis (Baird, 2019), an hourly wind-wave hindcast was completed using spatially varying winds across Lake Erie for the historical baseline period (2000 to 2013) with actual ice-cover and then the same weather simulated for late-century with the RCP8.5 scenario with zero ice-cover (assumes no lake ice in the future).

For each grid cell in the wave model, hourly wave energy density was calculated for the entire 13-year wave hindcast. The results from the future hindcast were subtracted from the historical simulation to estimate the potential increase in future wave energy due to climate change. The results are summarized in Figure 3.28. In the shallow western basin of Lake Erie, the elimination of winter ice cover resulted in a 120% increase in the amount of wave energy reaching the shoreline during the winter months. For the open bluff shorelines of the study area, the increase in winter wave energy is predicted to be 70% to 80%, which is a significant increase.

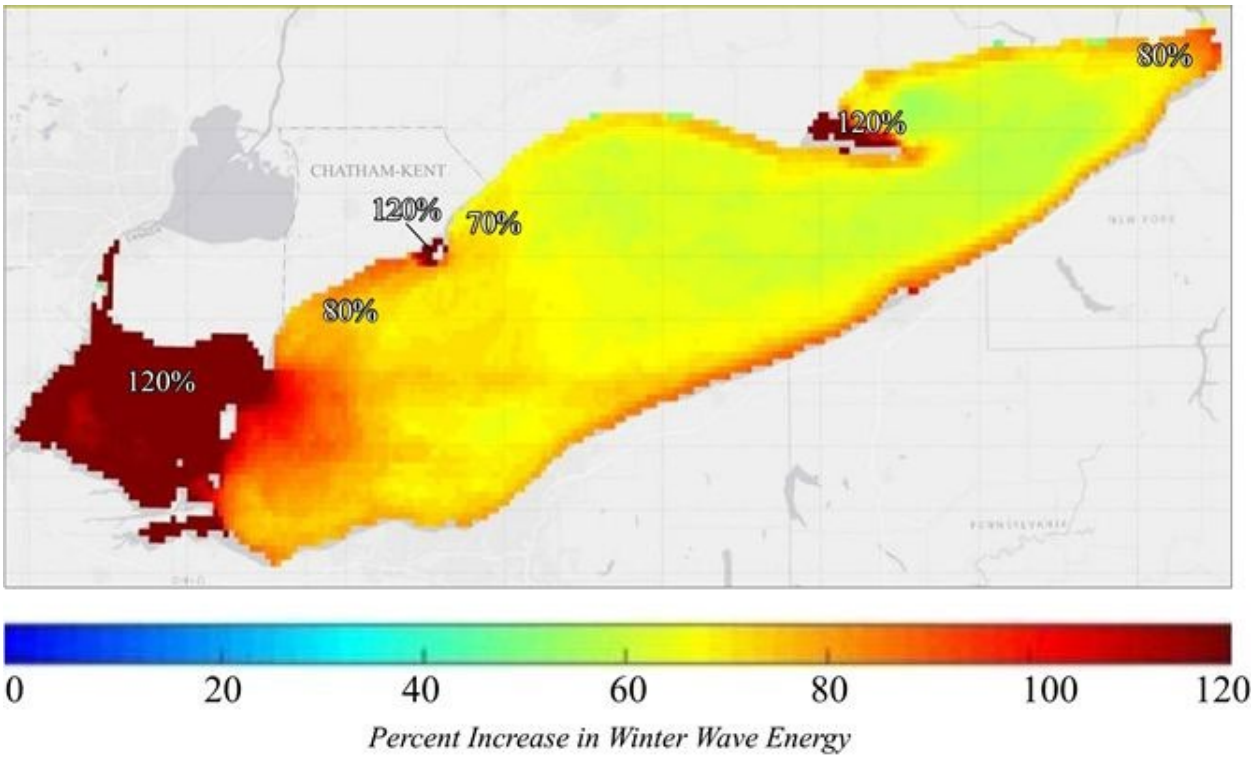


Figure 3.28 Projected Increase in Winter Wave Energy for RCP8.5 (late century)

3.4.4 Historical Lake Levels and Future Projections

The monthly mean water levels for Lake Erie, from 1918 to 2019, are plotted in Figure 3.29 in metres relative to the International Great Lakes Datum (IGLD). Throughout the last 100 years, the lake has fluctuated between periods of high, average, and low water levels. The record low was recorded in 1934 during the drought associated with the Great Depression. The record high was established in June 2019.

Figure 3.29 also includes the existing 100-year flood level (+176.0 m, IGLD'85) based on historical data and a recommended future level that accounts for climate change (i.e., 0.5 m higher or 176.5 m, IGLD'85). The coastal risk assessment will be completed with both elevations.

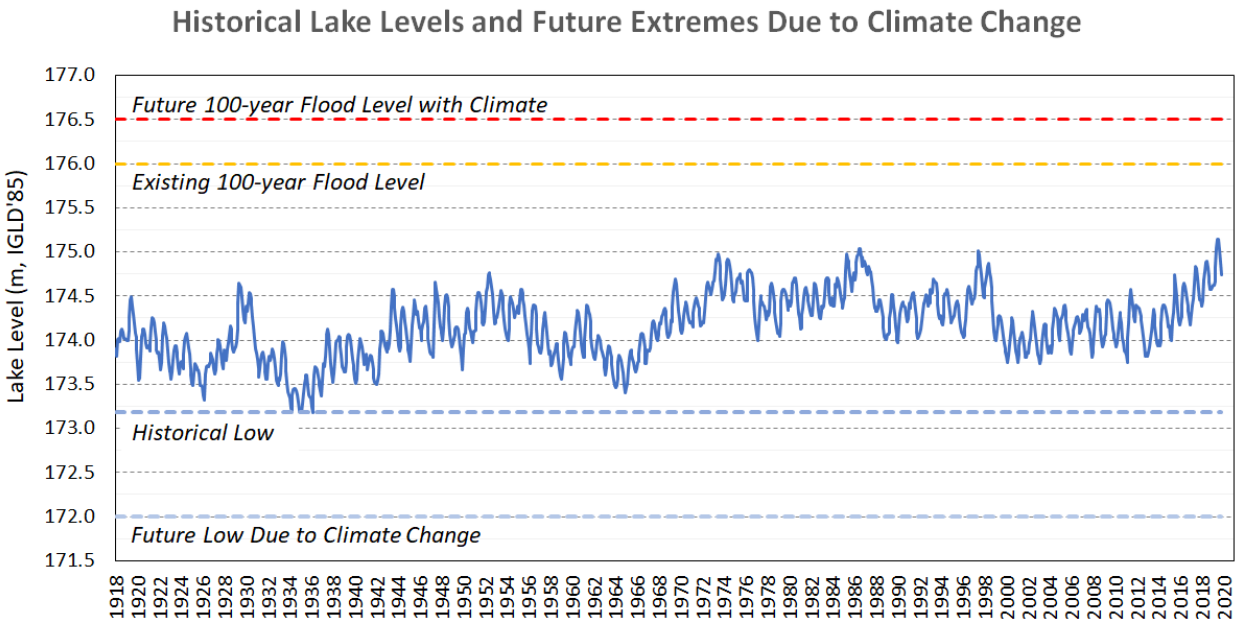


Figure 3.29 Historical 100-year Flood Level and Projected Climate Change Impacts

4.0 GRADUATED RISK ASSESSMENT

Section 4.0 summarizes the results of the coastal risk assessment for Southeast Leamington, including the flood scenarios, methodology for calculating potential economic damages, and the results.

4.1 Flood Scenarios

Three potential flood scenarios with progressively higher hazard exposure were selected for the graduated risk assessment, including:

- **Scenario A**: 100-year lake level of 176.0 m IGLD'85.
- **Scenario B**: 100-year climate change lake level of 176.5 m IGLD'85.
- **Scenario C**: 100-year climate change lake level of 176.5 m IGLD'85 plus 1.0 m of additional lakebed downcutting assumed.

A storm could generate the Scenario A lake level at any time. Scenario B could happen in the near-term if the Great Lakes basin continues to receive above-average precipitation or some time in the future due to climate change. Scenario C is a medium to long-term projection as it factors in additional lakebed downcutting at the base of the existing shoreline protection structures. This additional downcutting would take several decades.

4.2 Methodology for Estimating Economic Damages

There is a large body of literature linking flood inundation depths with economic damages to buildings, contents, and other community infrastructure. The basic premise of the relationship is the greater the depth of flooding relative to the first-floor elevation, the greater the economic damages. These methods have been applied previously in the Great Lakes to evaluate flood risk (Baird, 2005; Baird, 2012; Baird, 2015).

4.2.1 Potential Damages to Buildings and Contents for Direct Inundation

Following our literature review, the depth-damage relationships developed for the State of Louisiana by GEC (2006) were selected for use in this study. This work was completed for the US Army Corps of Engineers and was selected for the following reasons: 1) the depth-damage curves included relationships for freshwater and saltwater (many studies only provide information for saltwater), 2) curves were available for a wide range of buildings types (e.g., residential, commercial, single storey, two storey, etc.), 3) curves were available for short- and long-duration floods, and 4) the results are based on field data and expert opinion (i.e., multiple lines of evidence).

The structural damage information, as a percentage of the building value, is presented visually in Figure 4.1. With flooding of 1 ft above the main floor elevation, structural damage to the building is 32%. The relationships are expressed in fourth order polynomials for the analysis. Damages to building contents were calculated with a similar expression and the depth-damage

relationships are presented visually in Figure 4.2. With 1 ft of flooding above the main floor, damage to the contents is estimated at 29%.

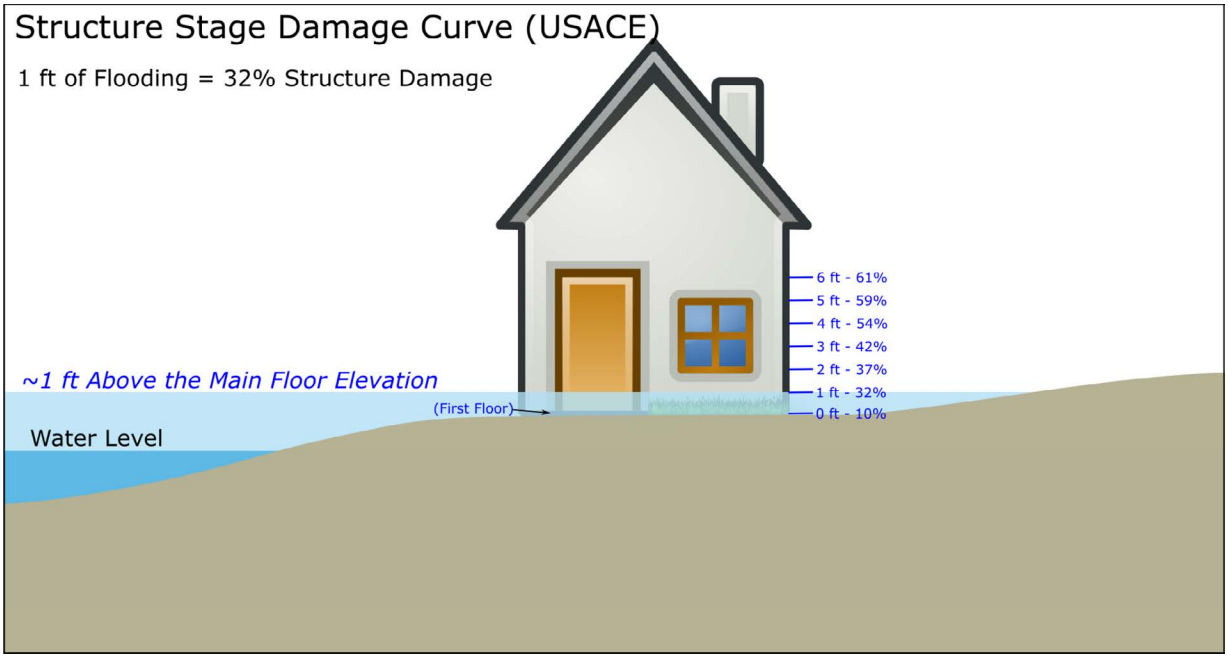


Figure 4.1 Stage Damage Relationship a Slab on Grade Single Storey Residence

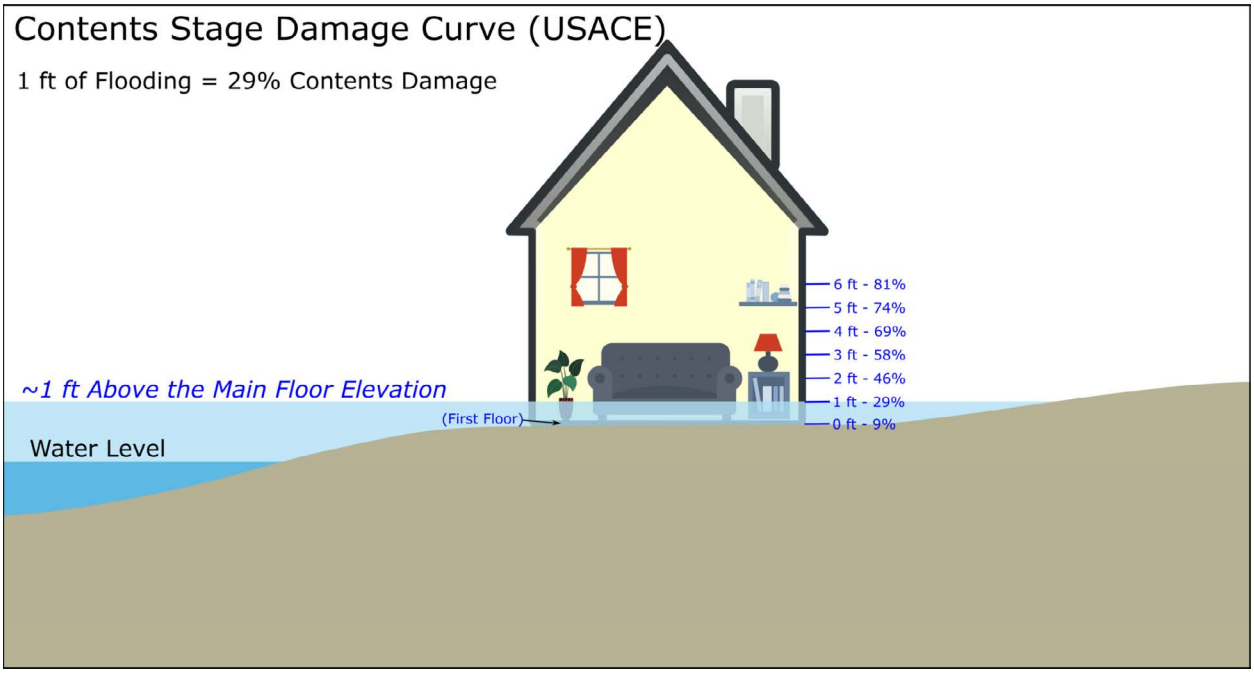


Figure 4.2 Stage Damage Relationship for Contents in a Single Story Slab of Grade

4.2.2 Potential Damages Due to Wave Forces

The methodology described in Section 4.2.1 is applicable for buildings not exposed to waves, such as second row structures or those located in the agricultural drains. However, for some low-lying front-row buildings, potential damages during a storm can be significantly greater due to wave impacts on the structure. Refer to Figure 4.3, which captures structural damages to a waterfront home on Marentette Beach following the April 2018 storm.



Figure 4.3 Wave Forces Destroy Cottage on Marentette Beach Road, April 15, 2018

Potential damages on structures due to wave forces were calculated based on the methodology outlined in the 1973 Canada-Ontario Great Lakes Shore Damages Survey, which developed a relationship between wave power or wave energy flux striking a building and the amount of structural damages. While this is an older reference, it was based on actual field damages collected during high water storms at five sites on Lake Erie (Kingsville, Erieau, Long Point, Port Ryerse, Port Maitland). It was integrated into the methodology to account for realistic damages to buildings exposed to direct wave attack. An example of a building in close proximity to the shoreline and on low-lying land is presented in Figure 4.4



Figure 4.4 Home on Low-lying Lands Close to the Shore, East Beach Road

4.2.3 Potential Damages to Shoreline Protection Structures

Economic damage potential to shoreline protection structures was estimated for all four project zones based on the shoreline protection database developed for the project and discussed in Section 2.2. In Scenario A all structures identified as "failed" in the shore protection database were assumed to require a complete rebuild at a cost of $4,000 per metre. All structures presently in "poor" condition were assumed to require repairs at a cost of $1,000 per metre. Note that actual costs for rebuilding or repairing shoreline protection structures can vary and may exceed the values assumed herein.

For Scenario B (100-year water level plus climate change) all "failed" and "poor" structures were assumed to require a complete rebuild while 50% of structures in "moderate" condition are assumed to require repairs.

For Scenario C (Scenario B plus 1.0 m of future lakebed downcutting), in addition to the costs calculated for Scenario B, the remaining 50% of structures in "moderate" condition are deemed to require a complete rebuild, while 50% and 10% of structures in "good" and "excellent" condition, respectively, are assumed to require repairs.

Assumed rebuild and repair costs for shoreline protection structures are based on past experience and unit rates for shoreline protection projects throughout southern Ontario, indexed to 2020.

4.2.4 Other Damages Not Integrated in the Analysis

Flooding damages are not limited to structural impacts to buildings and contents. Impacts are far-reaching and can include the following additional direct and indirect damages and impacts:

- Ecosystem impacts, such as eroded coastal wetlands
- Lost crops if the flood occurs during the growing season
- Damage to private septic systems
- Structural damage to dikes (e.g., breach/failures), drainage ditches, and pump houses
- Road surfaces on the dikes
- Vehicles and farm equipment (e.g., tractors, harvesters, sprayers)
- Mental and physical trauma, lost employment, or lost income

While these are important factors and potentially devasting to the impacted landowners, they are not presently included and are outside the scope of this study. The potential damage results due to inundation, wave forces, and contents will highlight the magnitude of the vulnerability to flooding in Southeast Leamington.

4.3 Potential Extent of Flooding and Economic Damages

The height of the existing dikes relative to the 100-year flood level for Scenario A is presented visually in Figure 4.5 (left panel). In three locations, the existing dike crest is below the 100-year flood level, including the southern Marentette Dike, the intersection of Mersea Road C and East Beach Road, and the central portion of East Beach Road. Therefore, during a storm at the 100-year flood level, interior flooding could occur even if the dikes do not breach. However, for Scenario A we assume that the East Marsh and Marentette drainage scheme dikes breach, leading to interior flooding to the same elevation as the lake surface during the storm.

When the extent of the inundation above the dike crest is evaluated for the 100-year flood level accounting for climate change, almost the entire dike system along the east shore is under water (right panel of Figure 4.5). In other words, even without a dike failure and breach, water would be flowing into the interior drainage schemes. Scenario B also assumes that the dikes will breach during the 100-year storm and the interior will flood to the same elevation as the lake. The same dike breach assumption is applied for Scenario C.

Figure 4.6 to Figure 4.8 summarizes the spatial extent of the flooding for Scenarios A to C, along with the depth of inundation. The different shades of blue represent different depths of water. The potential economic damages associated with building and content damage, plus shore protection maintenance by zone is also summarized.

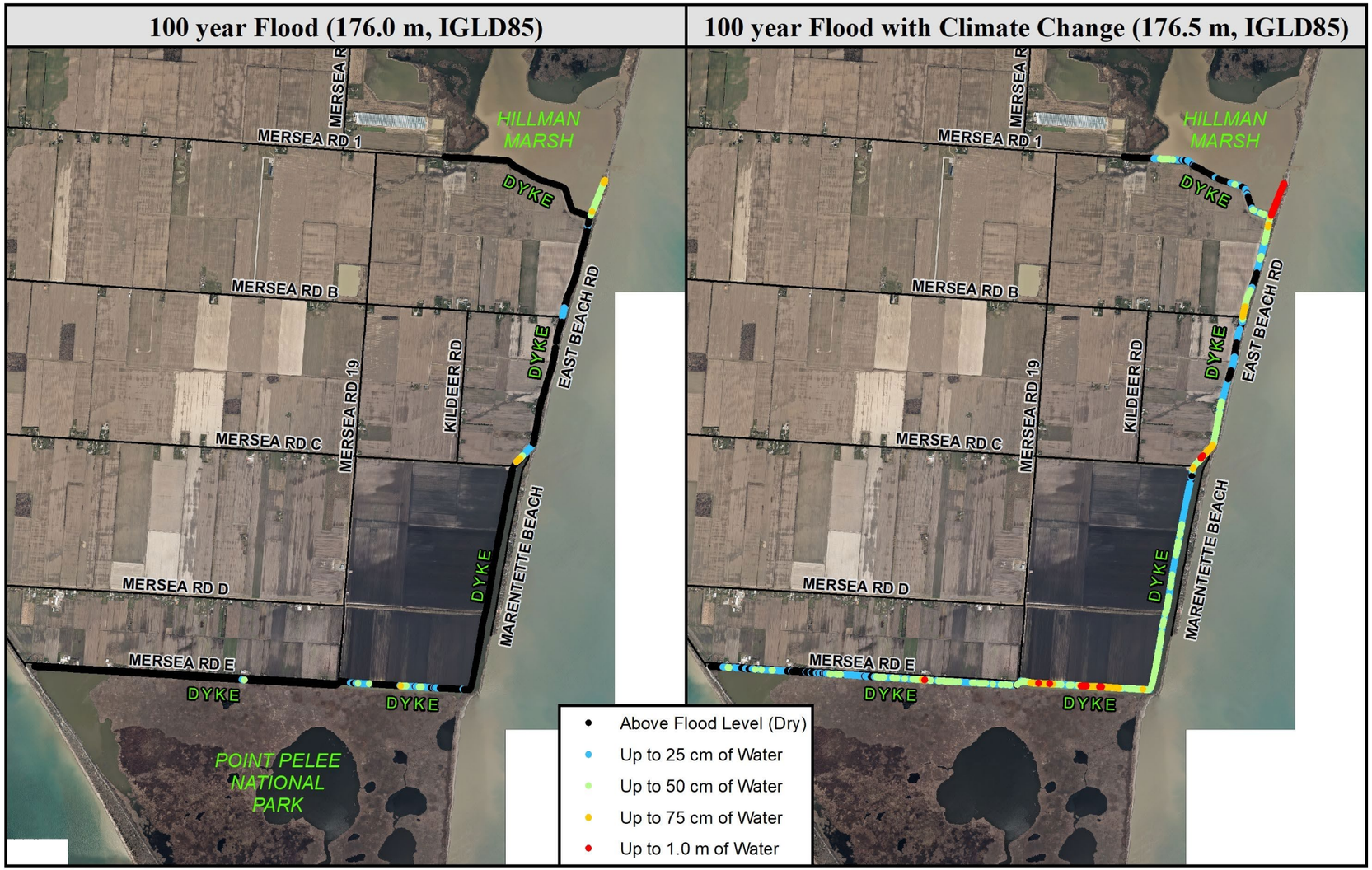


Figure 4.5 Dike Crest Inundation during the 100-year Flood Event

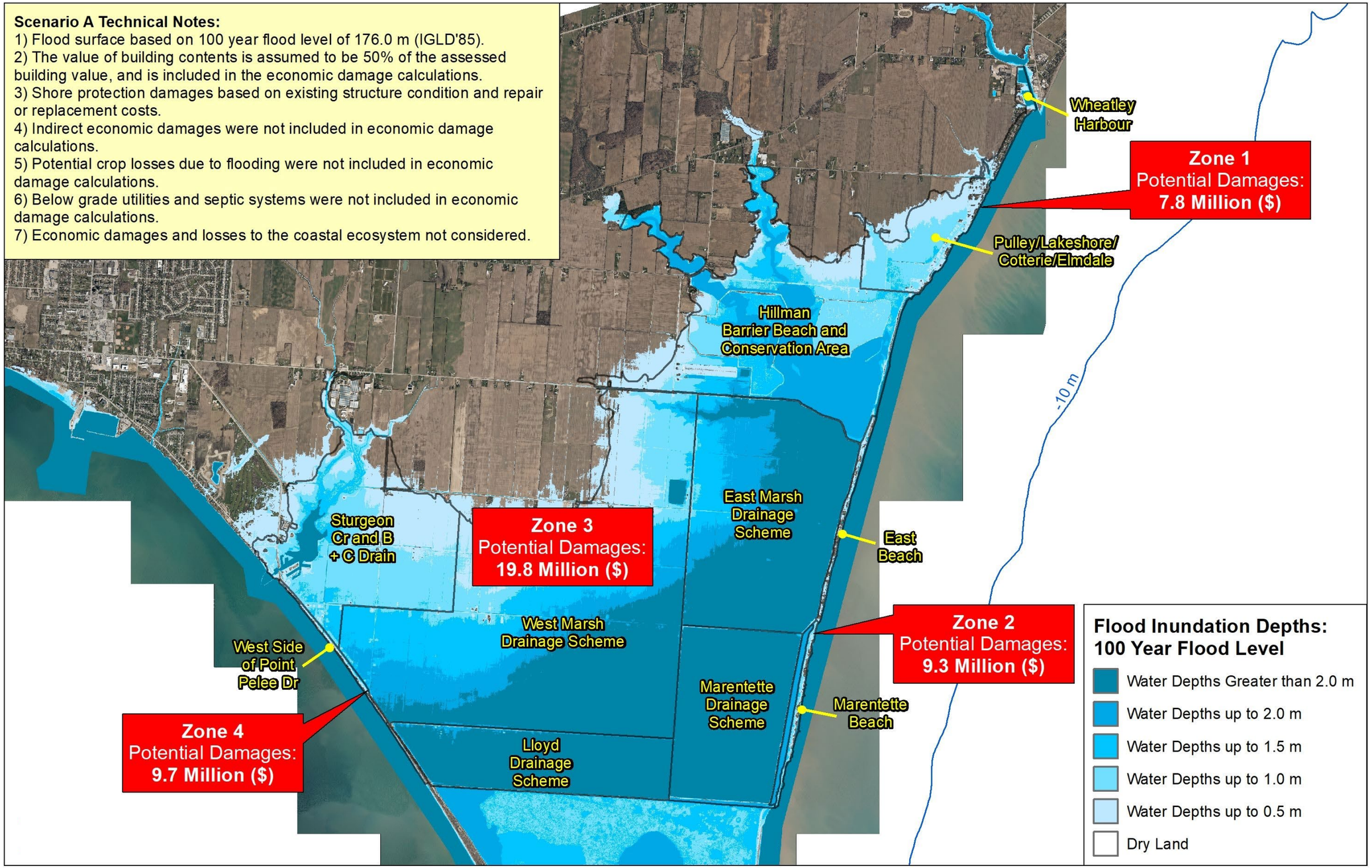


Figure 4.6 Scenario A Flood Extent and Projected Economic Damages to Buildings

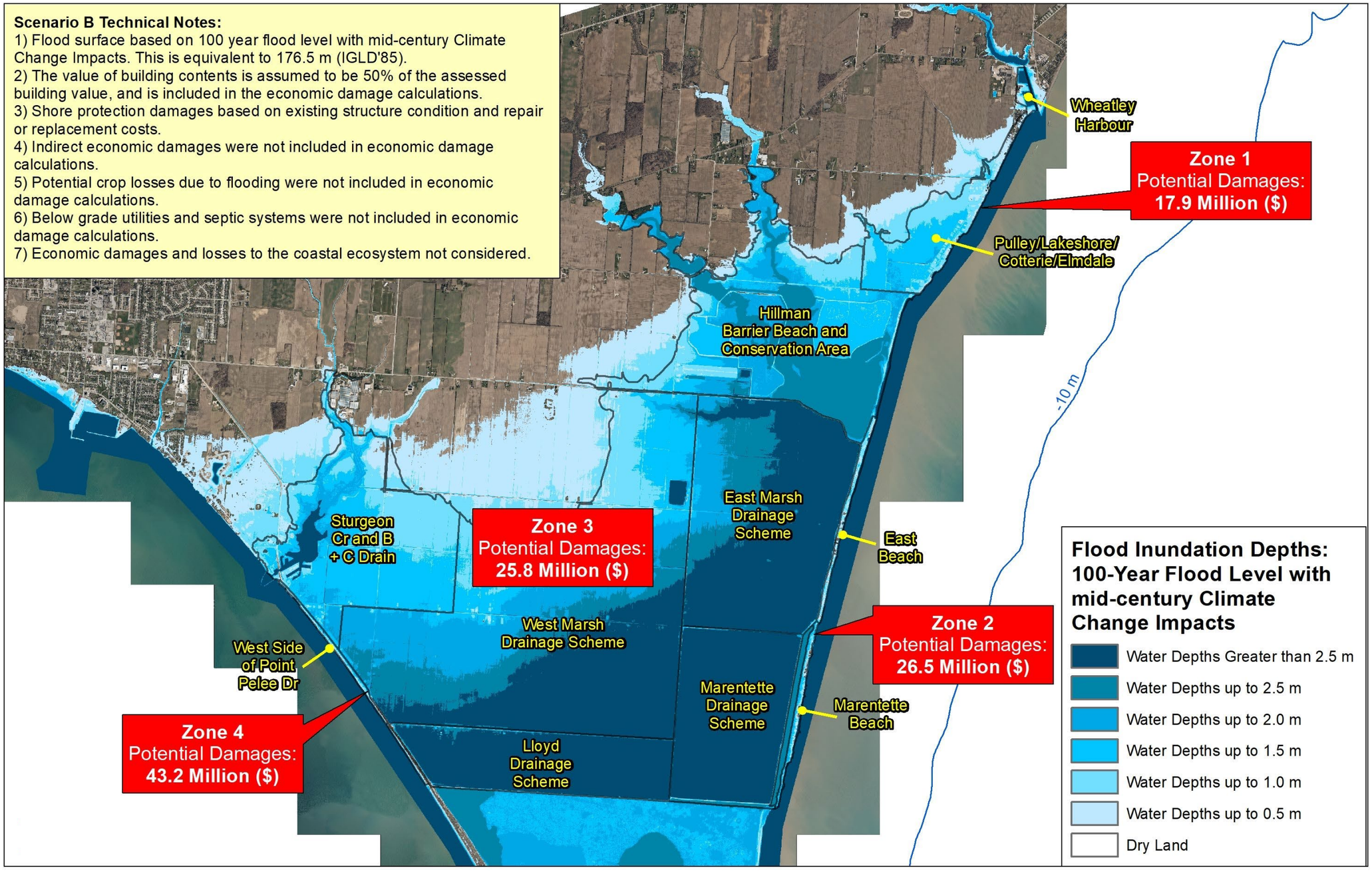


Figure 4.7 Scenario B Flood Extent and Projected Economic Damages to Buildings

Scenario C Technical Notes:
1) Flood surface based on 100 year flood level with mid-century Climate Change Impacts. This is equivalent to 176.5 m (IGLD'85).
2) The value of building contents is assumed to be 50% of the assessed building value, and is included in the economic damage calculations.
3) Shore protection damages based on existing structure condition but assumes 1.0 m of future downcutting when estimating repair and replacement costs.
4) Indirect economic damages were not included in economic damage calculations.
5) Potential crop losses due to flooding were not included in economic damage calculations.
6) Below grade utilities and septic systems were not included in economic damage calculations.
7) Economic damages and losses to the coastal ecosystem not considered.

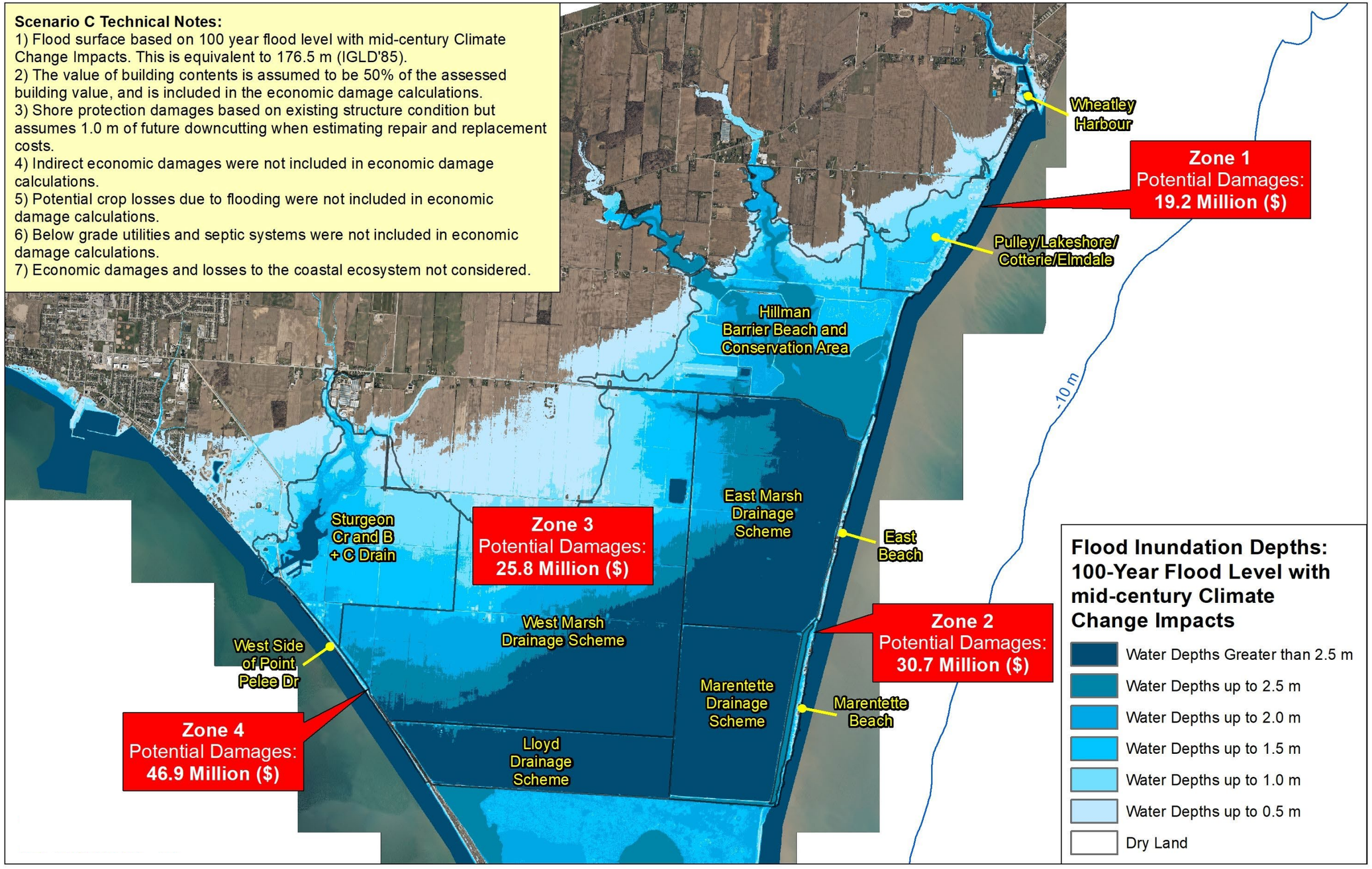


Figure 4.8 Scenario C Flood Extent and Projected Economic Damages to Buildings

The potential economic damages are further summarized in Table 4.1. Zone 1, from Wheatley to Elmdale Subdivision, features the lowest potential damages for Scenario A ($7.8 million), while the greatest damages are in the interior drainage schemes, as $19.8 million. The total damages for the Scenario A flood are $46.5 million.

Table 4.1 Summary of Potential Economic Damages

	Zone 1: Wheatley to Elmdale	East Beach to Marentette Beach	Zone 3: Interior Drainage Schemes	Zone 4: Point Pelee Drive
Total Primary Buildings	177	108	221	256
SCENARIO A FLOOD DAMAGES: $46,474,000				
# of Flooded Buildings	33	45	143	82
Damage to Buildings and Contents	$3,281,000	$3,937,000	$19,759,000	7,577,000
Shore Protect Damage	$4,482,000	$5,342,000		$2,096,000
Total Damages	$7,763,000	$9,279,000	$19,759,000	$9,673,000
SCENARIO B FLOOD DAMAGES: $113,283,000				
# of Flooded Buildings	104	86	170	206
Damage to Buildings and Contents	$11,010,000	$17,029,000	$25,770,000	$39,094,000
Shore Protect Damage	$6,862,000	$9,440,000		$4,078,000
Total Damages	$17,872,000	$26,469,000	$25,770,000	$43,172,000
Damage Increase for Scenario A versus B	2.3	2.8	1.3	4.5
SCENARIO C FLOOD DAMAGES: $122,564,000				
# of Flooded Buildings	104	86	170	206
Damage to Buildings and Contents	$11,010,000	$17,029,000	$25,770,000	$39,094,000
Shore Protect Damage	$8,222,000	$13,622,000		$7,817,000
Total Damages	$19,232,000	$30,651,000	$25,770,000	$46,911,000

When the additional 0.5 m is added to the 100-year lake level to account for climate change, the total potential damages across all four zones increases dramatically to $113.3 million. The potential damages in Zones 1 and 2 increase by a factor of 2.3 and 2.8 respectively. For the interior lands in Zone 3, the damages only increase by a factor of 1.3. The greatest increase is in Zone 4 which includes Point Pelee Drive and Robson Road, where damages increase by a factor of 4.5 for a total of $43.2 million. Much of this zone has been rebuilt and floodproofed to the existing 100-year lake level. However, due to the low-lying nature of the shoreline, the additional 0.5 m in water associated with Scenario B results in a dramatic increase in the potential economic damages.

Scenario C uses the same water level for the flooding analysis as Scenario B, so the potential economic damages to buildings and contents are the same. However, the damage to existing shoreline protection structures is greater since more lakebed downcutting and impacts from larger waves are assumed for this scenario. The total damages for the Scenario C flood are $122.6 million.

4.4 Emergency Ingress and Egress during the 100-year Flood

A critical aspect of hazard planning is emergency ingress and egress. The extensive area of potential flooding for Scenarios A and B highlight the critical importance of emergency access evaluation for Southeast Leamington. The extent of the flood waters above the local road network is presented in Figure 4.9. For Scenario A, there are numerous roads that would be inundated with more than 2.0 m of water during the peak of the flood. The entire length of the private road for Marentette Beach would be covered by more than 1.0 m of water. For the residents of Marentette Beach or East Beach, the only evacuation route is west along Mersea Road C. However, the eastern portion of Road C would be covered by 1.0 m of water during the flood. Moreover, there exists a significant risk that under these circumstances this entire dike could fail completely.

With Scenario B, the ability to safely evacuate is even more challenging, given the additional 0.5 m of water during the peak of the storm. The low spot in Road C when leaving East Beach and Marentette Beach would be covered by 1.5 m of water at the peak of the storm. And Sections of Mersea Road B, C, D, and E are covered by more then 2.0 m of water.

4.5 3D Renderings of Flood Scenarios

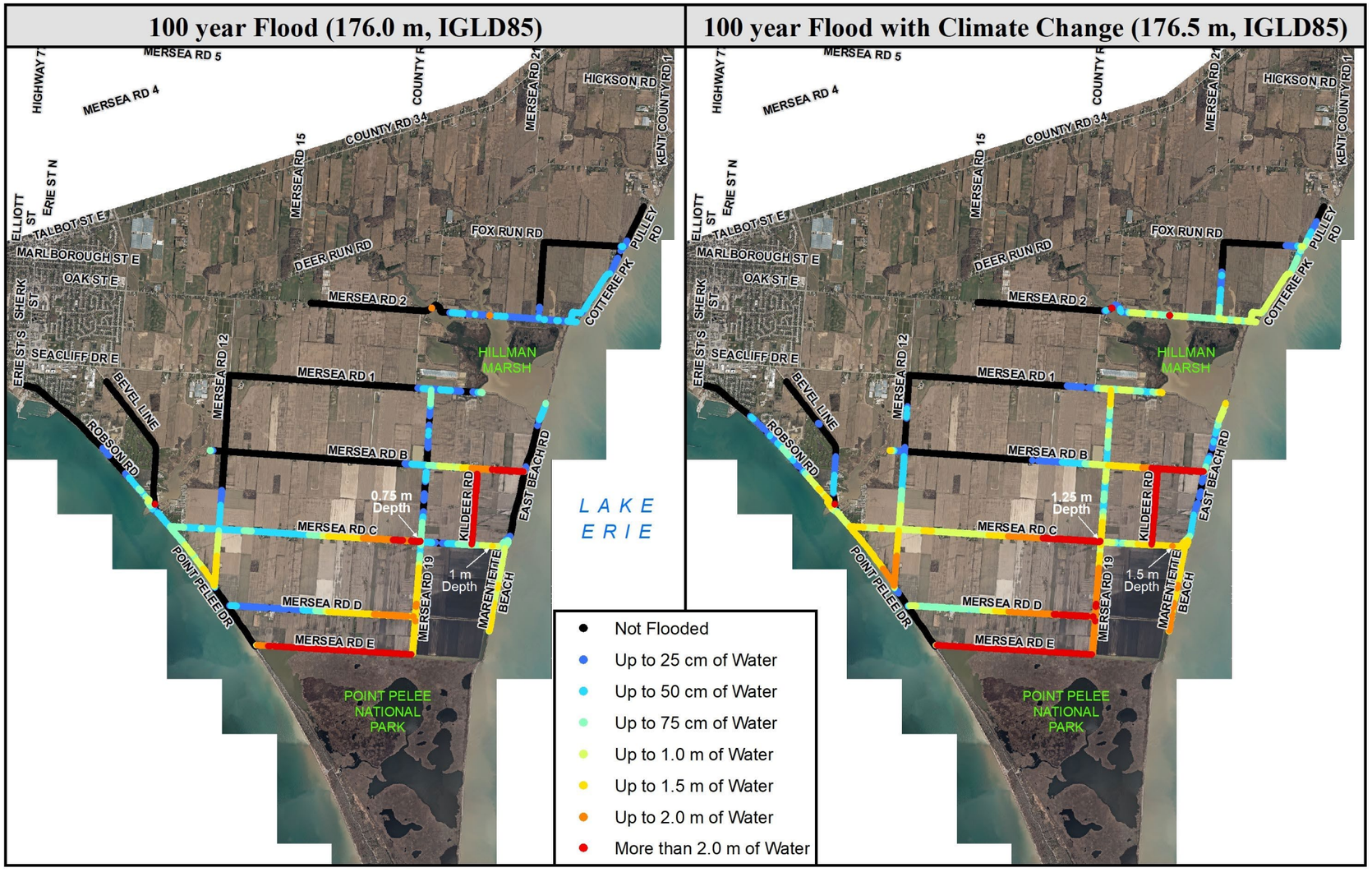
Three dimensional (3D) renderings were generated for non-flood conditions and the Scenario A and B floods in Southeast Leamington to produce realistic images of the flood threat. The renderings were generated using sophisticated, technical software that incorporated high-resolution topographic data to represent actual land and water level elevations. Satellite imagery is draped over the land elevations and supplemented with 3D features such as trees and buildings. The extent and spatial distribution of flooding is commensurate with that which is shown in the flood maps featured in in Section 4.3. The first sequence of images was generated looking southwest and is presented in the following figures:

- Figure 4.10: Non-storm conditions with a lake level of 174.0 m IGLD'85.

- Figure 4.11: Scenario A flooding at 176.0 m IGLD'85 (100-year lake level) with a breach of the interior dikes. The interior flooding is extensive and extends from Lakeshore Drive south to the tip of Marentette Beach Road. The East Marsh, Marentette, and Lloyd Drains are completely inundated, as is a significant portion of the West Marsh. The majority of Point Pelee National Park is under water, with the exception of the treed western shoreline.

- Figure 4.12: The Scenario B flooding at 176.5 m IGLD'85 (100-year climate change lake level) is presented in Figure 4.12. The flooding is even more extensive, stretching north of the Hillman Marsh and west to Sturgeon Creek. The interior agricultural lands are complete inundated, as is the majority of PPNP, including the forested tip.

- Figure 4.13: The flooding associated with Scenarios A and B includes the influence of storm surge associated with powerful storm events. When the storm subsides, the lake waters will recede to their pre-storm level (i.e., the static lake level). In Figure 4.13 the 3D rendering simulates the extent of flooding for the post-storm condition of 175.2 m IGLD'85 and a breached dike system. The visualization assumes the dike breaches can not be readily repaired and the interior lands become connected to the lake (i.e., the water level in the drains develops an equilibrium with the lake). This is a devasting scenario, as recovery would require a marine operation to re-build the damaged dikes and the duration of the inundation could be many months or longer. Structural and contents damage would be 100%. It is worth noting that the potential flood damage calculations in Section 4.3 assume the flood duration is short, such as 24- to 48-hours, and the buildings can be dried and repaired. There is no recovery from the prolonged interior flood at 175.2 m depicted in Figure 4.13. If the dikes are not repaired, the new shoreline for the Pelee Peninsula would extend east-west from the Hillman Marsh to Sturgeon Creek.



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Potential Road Inundation During Flood Events

Data Sources:
1) Elevations taken from 2017 LiDAR (OMAFRA).
2) 2017 Orthophoto Mosaic (County of Essex)

N W E S
0 1,000 2,000
m

Figure 4.9 Depth of Flood Water above the Road Surface



Figure 4.10 Southeast Leamington Looking Southwest with a Lake Level of 174.0 m IGLD'85



Figure 4.11 Scenario A Flooding with a 100-year Lake Level of 176.0 m IGLD85, Looking Southwest



Figure 4.12 Scenario B Flooding with a 100-year Climate Change Lake Level of 176.5 m IGLD85, Looking Southwest



Figure 4.13 Post-flood Scenario with a Static Lake Level of 175.2 m and a Breached Dike System, Looking Southwest

The second set of images provide an oblique 3D perspective of the background conditions (non-flood) and the Scenario A and B inundation looking east as follows:

- Figure 4.14: Non-flood conditions for the Pelee Peninsula with a lake level of 174.0 m IGLD'85, looking east from the western basin above the Leamington Harbour. Sturgeon Creek and Hillman Marsh are represented, along with the forested western shoreline of PPNP and the interior marsh.

- Figure 4.15: The Scenario A flood inundation for the 100-year lake level of 176.0 m IGLD'85 which extends across the entire Pelee Peninsula, from Pelee Drive along the western shoreline, across the Lloyd and West Marsh, plus the Marentette and East Marsh. The majority of PPNP is also under water.

- Figure 4.16: The extent of the shoreline and interior flooding increases dramatically for the 100-year lake level accounting for climate change. Only the northern half of the west shoreline of PPNP remains above water for Scenario B.

- Figure 4.17: Once the storm surge is over, some of the interior flood waters would drain back to the lake, but with a breached dike system, a significant portion of the interior lands from the Hillman Marsh to Sturgeon Creek remain under water.



Figure 4.14 Southeast Leamington Looking East with a Lake Level of 174.0 m IGLD'85



Figure 4.15 Southeast Leamington Flooding with a 100-year Lake Level of 176.0 m IGLD85, Looking East

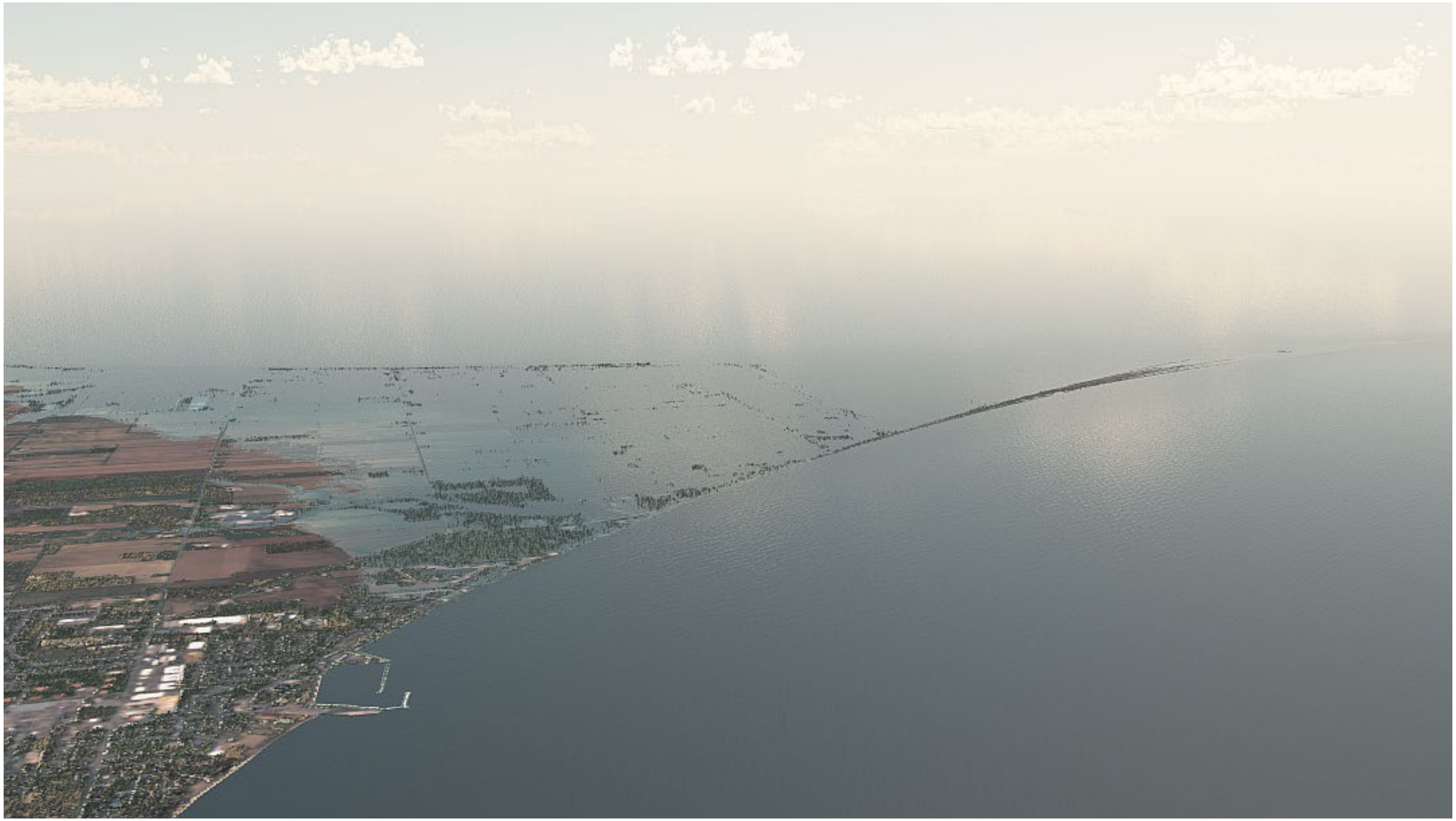


Figure 4.16 Southeast Leamington Flooding with a 100-year Climate Change Lake Level of 176.5 m IGLD85, Looking East

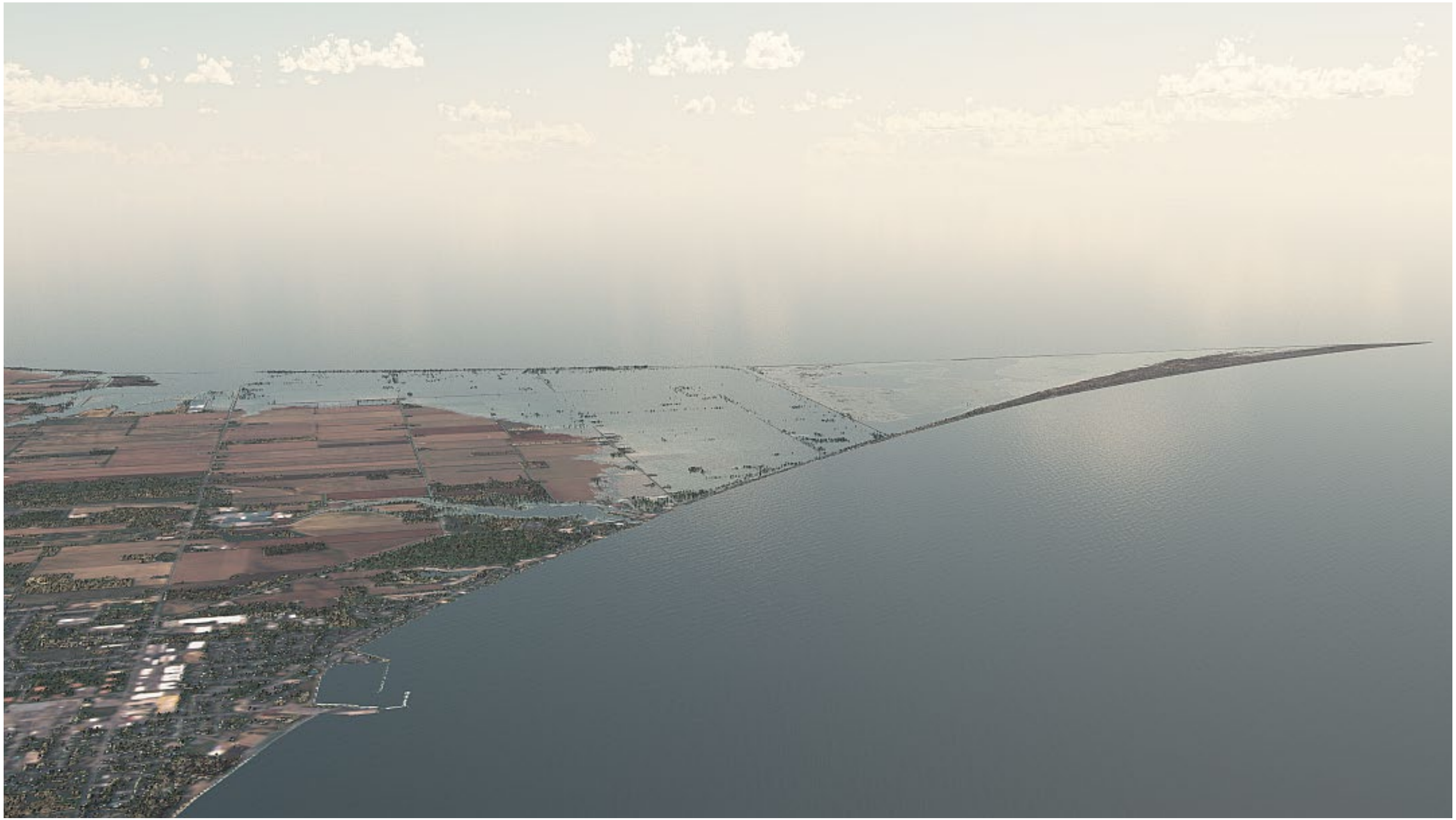


Figure 4.17 Post-flood Scenario with a Static Lake Level of 175.2 m and a Breached Dike System, Looking East

5.0 COMMUNITY ENGAGEMENT

The community engagements completed for the Southeast Leamington study is summarized.

5.1 Leamington Website and Direct Mailouts

Community engagement was a vital component of the Southeast Leamington Graduated Risk Floodplain Mapping Project. Community engagement was facilitated through written communication and face to face interaction during two Public Information Centres (PIC).

Written communication included both the Municipality of Leamington website and direct mailouts. Both methods are described below.

Municipality of Leamington Website: Residents have access to the Municipality of Leamington website (link below). The website contains public notices, the study area map, comment sheets and the PIC presentations. Comment sheets were provided after each PIC to allow for residents and stakeholders to provide input regarding the study.

https://www.leamington.ca/en/our-community/projectsandstudies.aspx#Southeast-Leamington-Graduated-Risk-Floodplain-Mapping-Project-

Direct Mailouts: Residents were contacted through public notices that were sent via direct mail five to six weeks in advance of the PIC. The public notice included the background of the study, the process, PIC goals, and the date, time, and location of the PIC. Notices for PIC1 and PIC2 can be found in Appendix A.

5.2 Public Information Centre #1 (PIC1)

PIC#1 was held on November 27, 2019 at the Best Western Plus Leamington Hotel and Conference Centre on 566 Bevel Line Road. Attendees were asked to register for the meeting in advance such that adequate space could be arranged for the event. The afternoon session ran from 2:00 to 4:00 p.m. with 111 attendees, followed by an evening session from 6:30 to 8:30 p.m. with 105 attendees.

The goals for PIC#1 were to:

- Provide an overview of the project and workplan.
- Share the preliminary findings from the field work.
- Present examples of flood hazard mitigation, climate change adaptation, and emergency response.

Gather feedback from attendees about local conditions and evaluation criteria**.**

The format of PIC#1 included a formal presentation, a short question and answer period; followed by breakout groups. The breakout groups were facilitated by staff from the Municipality of Leamington and the Project Team. A “dry run” orientation session was held one

week prior to PIC#1 to review the agenda, the presentation and the role of the table facilitators which was to guide discussion and take notes.

The following questions were discussed in the breakout groups:

1. What is the most important aspect of the project?
2. With respect to flooding and erosion hazards, what are the most vulnerable areas in Southeast Leamington?
3. What are your priorities when evaluating long term solutions to the coastal hazards in Southeast Leamington?

While signing in at the event, all attendees were provided a comment sheet that included the breakout questions. Attendees were given the opportunity to submit their comment sheets at the end of the PIC, or to do so following the PIC during a 2-week comment period.

The comment sheet for PIC#1 can be found in Appendix A.

Notes from both the breakout groups and the comment sheets were summarized, and the themes are presented in priority order as follows:

Question	Themes in Priority Order
1. What is the most important aspect of the project?	• Develop innovative shoreline and dyke protection solutions • Cost and financial assistance • Short- and long-term solutions • Everyone working together • Engage all levels of government to pursue solutions • Neglected or vacant lots • Studies that don't lead to action
2. With respect to flooding and erosion hazards, what are the most vulnerable areas in Southeast Leamington?	• Cotterie Park • East Beach (south of Hillman) • Hillman Marsh and the East Marsh Dyke and farmland • Marentette Beach • Lots without protection on Point Pelee Drive • Agricultural Dykes
3. What are your priorities when evaluating long term solutions to the coastal hazards in Southeast Leamington?	• Overall cost and determining who pays • Ensuring sustainable long-term solutions • Receiving financial assistance from government • Remaining on land without retreat • Receiving fair compensation for a property buyout • Unified approach for community solutions

Overall, the feedback received during and after PIC#1 was positive. The Project Team utilized the feedback and insights about the project to inform the project and plan the agenda for PIC#2.

5.3 Public Information Centre #2 (PIC2)

PIC#2 was held on January 15, 2020 at the Best Western Plus Leamington Hotel and Conference Centre on 566 Bevel Line Road. Attendees were asked to register for the meeting in advance such that adequate space could be arranged for the event. The afternoon session ran from 2:00 to 4:00 p.m. with 93 attendees, followed by an evening session from 6:30 to 8:30 p.m. with 60 attendees.

The goals for PIC#2 were to:

- Provide an overview of the project and workplan.
- Share results from PIC#1 breakout groups.
- Review vulnerability assessment that considers climate change.
- Discuss draft economic damages for various flooding scenarios.
- Show case studies of adaptation options to mitigate flood and erosion hazards.
- Gain feedback on evaluation criteria, options and funding scenarios.

The format of PIC#2 included a formal presentation, a short question and answer period; followed by breakout groups that were facilitated by staff from the Municipality of Leamington and the Project Team. The role of the table facilitator was to guide discussion and take notes.

Breakout Groups were divided into Zones based on geographical location as follows:

- ZONE 1: Pulley Road to Elmdale Subdivision
- ZONE 2: East Beach to Marentette Beach
- ZONE 3: Interior Lands and Drainage Schemes
- ZONE 4: Point Pelee Drive and Robson Road

The breakout groups discussed the following questions:

1. Do you agree with the top priorities for evaluating the long-term infrastructure solutions for Southeast Leamington from the first Public Meeting (Nov. 27, 2019)?
    - Calculating overall costs and determining who pays
    - Ensuring sustainability of the long-term solution(s)
    - Receiving financial Assistance from government
    - Remaining on our land without retreat/re-location

- Receiving compensation for property buyouts (fair market value)

2. Please share your ideas for long-term sustainable solutions to reduce coastal hazards in Southeast Leamington (avoid, retreat, accommodate, and protect).
3. How much would you be willing to pay to protect your private property in Southeast Leamington with a long-term (50-year) infrastructure and/or shoreline protection solution (nothing, 10-25k, 50-100k, 100-200k, not sure)?

While signing into the event, all attendees were provided a comment sheet that included the breakout questions. Attendees were given the opportunity to submit their comment sheets at the end of the PIC, or to do so following the PIC during a 2-week comment period.

The comment sheet for PIC#2 can be found in Appendix A.

Notes from the breakout groups and comment sheets were summarized and the themes are presented as follows:

Zone	#am	#pm	Response	Comments
1	20	13	33 = yes	• Concern with timelines and climate change • Financial assistance is a priority • Some felt that Ensuring sustainability of the long-term solution(s) should be the first priority • Some felt staying on the land was not a priority • Identify areas of greatest risk
2	19	6	25 = yes	• Not much different from 2008/09 report • Some felt staying on land is highest priority • Stop studies and get something done • Unified approach • Drains need more maintenance • Re-instate dyke on Mersea 1 - Seacliff
3	27	13	40 = yes	• Some felt financial assistance is highest priority • Two tables felt that Ensuring sustainability of the long-term solution(s) should be the first priority and second both calculating cost and financial assistance • Current real estate market is poor • Some felt staying on the land was not a priority • Ok with being bought out
4	27	23	50 = yes	• Look at design of break wall – limestone vs. granite • Some felt staying on land is highest priority • Protecting own property means also protecting neighbour's property • Bring all levels of government together • Improve storm system on Pt. Pelee Drive

				• Why doesn't disaster assistance apply to these cases • Define from engineering point of view what is acceptable for shoreline protection • Vacant properties need to have property standards
Comments sheets			30 = yes 1 = no	• Comments integrated into feedback above
Total Comments			**179**	

5.4 Future Information Sharing

The third Public Information Centre (PIC#3) was scheduled for March 30, 2020. The Municipality of Leamington has taken precautionary measures and cancelled PIC#3 due to concerns surrounding COVID-19 and public gatherings.

The goals of PIC#3 were to provide:

- an overview of the project.
- an update on the technical analysis.
- an update on floodplain mapping, economic damage potential, and emergency access during storms.
- an overview of draft adaptation options to increase community resilience to coastal hazards.
- a group discussion to provide feedback on adaptation options.

The Municipality and Project Team are discussing options for PIC#3 including video conferencing or a webinar format. Notifications will be sent once the format has been determined.

6.0 ADAPTATION OPTIONS

Section 6.0 describes the adaptation options developed for the study area. Options have been organized by community and project zone. There is no "Do Nothing" alternative given the severity of the risks, the potential for loss of life and building damage, and the possibility of permanent inundation of the interior agricultural lands as illustrated by the 3D renderings presented in Section 4.5. Recovery from the 100-year storm is no longer about repairing the roads or pumping out the flooded interior drainage schemes, it is potentially about the very existence of the Pelee Peninsula in the future.

The adaptation options were developed with the assumption that Pelee Peninsula will be saved, through significant capital investments to maintain the status quo land uses or with a large-scale nature-based solution to re-align the land use. All of the options presented herein will require significant financial investment and a long-term commitment to future maintenance.

Adaptation options are grouped into four principal strategies as follows:

- **Avoid:** reduce future exposure to risk by planning for and locating new developments away from hazardous lands.

- **Retreat / Re-Naturalize:** a strategic decision to withdraw or relocate public and private assets exposed to significant coastal hazards, typically accompanied by re-naturalization of the shoreline to reinstate nature-based resilience and habitat.

- **Accommodate:** an adaptive strategy that allows for continued occupation of hazardous lands while making changes to human activities and infrastructure to better accommodate the hazards and reduce the overall risk.

- **Protect:** a reactive strategy to protect people, property and infrastructure using traditional coastal engineering approaches to erosion and flood protection.

A summary of adaptation options by project zone and community is presented as Table 6.1 and described in the following report sections. It is important to note that the strategies provided herein are concept-level options for planning purposes and are not suitable for construction. Site-specific engineering investigations, analyses, and detailed designs are required prior to implementation. All concepts should be designed by a qualified individual.

Table 6.1 Summary of adaptation option strategies by project zone and community including key strategy components

Zone	Location	Adaptation Strategy	Components
1	Wheatley Harbour	Accommodate & Protect	Hydraulic Sediment Bypassing / Strategic Use of Deposited Sand / Extend South Jetty / New Boat Launch
	Pulley Road	Avoid	Land Use Planning
		Accommodate & Protect	Upgrade Shore Protection / Road Upgrades / Raise Land & Floodproof Homes / Raise Underground Utilities
	Lakeshore Cotterie Elmdale	Avoid	Land Use Planning
		Accommodate & Protect	Upgrade Shore Protection / Road Upgrades / Raise Land & Floodproof Homes / Raise Underground Utilities
		Retreat & Re-Naturalize	Minor Shore Protection Upgrades / Purchase Properties / Decommission Roads, Buildings, Utilities, Re-Naturalize Land
2 & 3	Hillman East Beach Marentette Beach Interior Drains	Avoid	Land Use Planning
		Accommodate & Protect	Armoured Headlands / Artificial Islands / Dyke Upgrades / Lakebed Armouring / Shore Protection Upgrades / Termination Structure at Park Boundary / Road Upgrades / Raise Land & Floodproof Homes / Raise or Replace Underground Utilities
		Retreat & Re-Naturalize	Minor Shore Protection Upgrades / Hillman Marsh Upgrades / Purchase Properties / Decommission Roads, Buildings, Utilities / Regrade and Re-Naturalize Land / Upgrade Mersea Road 19 / Provide Hydraulic Connection to Lake
4	Point Pelee Drive Robson Road	Accommodate & Protect	Upgrade Shore Protection /Raise Land & Floodproof Homes / Road Upgrades
All	Region	Accommodate & Protect	Regional Sediment Management Plan

The following approach was followed for the development of the adaptation concepts by zone:

- The concepts focus on community-scale solutions to increase resilience. Lot-by-lot recommendations were not generated.
- The concepts developed for the regions have not be optimized for an individual lot, since this is a planning study. In other words, the concepts could be further refined based on local site conditions resulting in local variations within the community-scale solutions.
- The provided concept sketches are not suitable for construction.
- The 100-year design water level was +176.0 m IGLD'85 (refer to Section 3.2). It is possible that climate change will lead to higher extremes in the future, as discussed in this report.
- Recent (2019) depth surveys completed for the east and west shores were used to capture the existing site conditions.
- The "Protect" options were prepared for a 50-year planning horizon. Acceptable levels of damage requiring occasional maintenance would be expected during that period.

The data collected and costing strategy developed to prepare the concept level opinion of cost for the various adaptation options included:

- Unit costs for materials, such as quarried armour stone, were based on our internal database and more than ten recent local construction projects in Southwestern Ontario. The cost for municipal works, such as waterlines, new roads, or road decommissioning was provided by the Municipality of Leamington.
- All historical construction costs were updated for inflation to present value (2020).
- 20% was added to the capital costs for engineering design, permits, tender, and construction services.
- Since all projects would require at least two years to design, permit and construct, all costs were indexed by 4%.
- Where possible, a range of costs was provided. The low range was the actual cost minus 15% to account for the fact that no optimization was completed for the concept-level designs and lot by lot information was not integrated. For the high range, 15% was added to the actual cost, which represents a contingency.
- The financial estimates were focused on initial capital costs, including land/building acquisition based on the 2019 assessment values from the Municipal Property Assessment Corporation (MPAC) and material/construction costs. All expenditures were assumed to be present value costs.

Future maintenance for the adaptation strategies was not included in the capital cost estimates. However, for planning purposes future maintenance of all shoreline protection structures should be assumed.

6.1 Wheatley Harbour (Zone 1)

Wheatley Harbour represents the northeastern boundary of the project region. Although shoreline hazard risks are not significant at Wheatley Harbour due to the land elevations and development setbacks, there are a number of strategies that could be implemented to improve the resilience and function of the harbour, while continuing to bypass sediment to the south. To date, only preliminary conversations have been held with the Wheatley Harbour Authority and they have not endorsed these concepts. Based on these initial discussions, the following considerations are provided for Wheatley Harbour, many of which are illustrated in Figure 6.1.:

- **Hydraulic Sediment Bypassing:** A significant amount of sediment is deposited on the north fillet beach at Wheatley Harbour during periods of wave action from the east and northeast. This sediment arrives from the north due to the net littoral drift (sediment moving laterally along the shoreline). The sand deposited on the north fillet beach and in the navigation channel has historically been excavated and trucked to the Hillman barrier beach. To harness this sediment source in a more efficient manner and restore a more natural sediment pathway, a hydraulic dredge could be used to pump sediment from the north fillet beach to the downdrift shoreline, immediately south of the harbour. This sediment could then resume its natural longshore transport pathway, increasing the sediment supply to the eastern shoreline of Point Pelee Peninsula. Hydraulic dredging operations can be setup with key infrastructure (pipes, pumps, valves, etc.) remaining in place and operated at regular intervals or setup and decommissioned per project. This

option would have to be combined with an extension of the south jetty, described in the next bullet.

- **Extend South Jetty:** The south jetty at Wheatley Harbour could be extended to mirror the length of the north jetty, which is the typical design in the Great Lakes for a jettied navigation channel. This would provide improved shelter in the navigation channel during storm events and should reduce the need for regular dredging of the navigation channel. The extended south jetty would be required if hydraulic bypassing was adopted at the harbour, as it will prevent the bypassed sediment from being transported back into the navigation channel during periods of southerly waves.

- **Strategic Use of Excavated Sediment:** Instead of or in addition to hydraulic sediment bypassing, excess sand excavated from the north fillet beach could be used in more strategic ways. For example, the sand could be used to create beach cells in front of the Mersea Road 1 dyke, within Hillman Marsh. These beaches would increase the habitat diversity in the marsh while reducing the wave exposure of the dyke. Another example would be using the sediment to create artificial islands within Hillman Marsh near the breached section of the barrier beach. These islands would create important habitat while dissipating destructive wave energy that enters through the breach before it can impact the environmentally sensitive marsh habitat or pose a threat to the dykes. These options are discussed further below in Section 6.4.

- **New Boat Launch (South or North Side):** If the south jetty were to be extended, a public boat launch could be installed on the south side of the navigation channel at the southeast corner of the public parking area as shown in Figure 6.1 or the north side. This new location would be sheltered from waves and would not suffer the same sedimentation problems that impact the current launch.

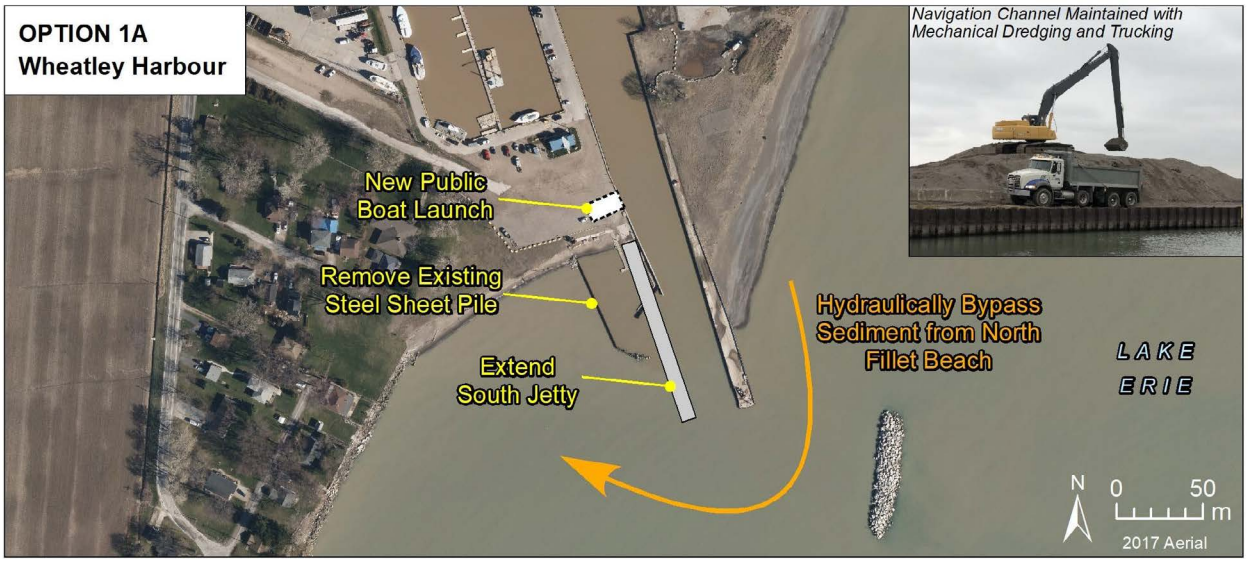


Figure 6.1 Adaptation Concepts for Wheatley Harbour to Increase Coastal Resilience and Improve Sediment Management

6.2 Pulley Road (Zone 1)

For the Pulley Road section of Zone 1, immediately south of Wheatley Harbour, avoid, accommodate, and protect concepts were generated.

6.2.1 Avoid

Most of the properties on Pulley Road are above the 100-year water level (Scenario A), except those along the southern third of the road near the intersection with Fox Run Road. Future development should not be permitted in these areas.

6.2.2 Accommodate and Protect

In order to mitigate risk and allow for continued long-term occupation and land use along Pulley Road, the following actions are recommended and are illustrated in Figure 6.2 and Figure 6.3 below:

- **Upgrade Shore Protection:** Existing private property shore protection should be upgraded to reduce wave overtopping, reduce erosion, and slow the downcutting rates. A berm-type structure with a wide footprint, mid-slope bench, and wide stone gradation is recommended. This type of design allows for smaller stone sizes, is easier to maintain, and is less susceptible to failure due to downcutting of the lakebed due to its wide footprint, increased capacity for settlement and superior wave dissipation when compared to a conventional, single-slope revetment. Given the depth and wave exposure along the Zone 1 shoreline, shore protection structures should have minimum crest elevations of +178.0 m IGLD85' to limit overtopping during the 100-year event. The structure should be founded on a bedding stone layer at least 0.5 m below the existing lakebed profile. Finally, armouring the lakebed in front of the structure with a thin layer of rip rap is recommended to slow the downcutting rates and extend the overall life of the shore protection scheme. Upgrades to shore protection should be properly designed by a qualified professional engineer.

- **Road Upgrades:** The southern portion of Pulley Road and the end of Fox Run Road are presently below the 100-year water level. To provide safe ingress/egress during storm events, these low-lying portions of road would have to be raised and the culvert at the south end of Pulley Road upgraded. The exposed, south-facing section of Pulley Road near the intersection with Fox Run Road and Lakeshore Drive should be protected by an engineered erosion protection structure with a sufficient crest elevation, as was described above. If this section of road is not engineered to withstand direct impact from lake waves, it could be compromised during a major storm event resulting in the Pulley Road community being flanked by erosion from the south.

- **Raise Land Elevations and Floodproof Homes:** In order to reduce risk associated with flooding, low-lying properties, particularly those at the south end of Pulley Road and immediately adjacent to Wheatley Harbour would have to be raised above the Scenario B flood level (100-year event plus mid-century climate change) and homes should be floodproofed. These properties can be identified in the flood maps provided in Section 4.0. Floodproofing of homes can include such measures as raising foundations,

placing the home on stilts, ensuring all openings (doors, windows, etc.) are sealed or above the flood level and increasing the capacity of sump-pumps.

- **Raise or Upgrade Underground Utilities:** Underground utilities including municipal water supply and private septic systems should be raised or otherwise upgraded to remain functional at the Scenario B flood level. A qualified individual should be consulted so that underground utilities are not compromised and remain functional during the 100-year flood event.

A concept level cost estimate is provided in Table 6.2 for the accommodate and protect measures presented above for the Pulley Road community. The cost range is $6.8M to $9.1M. For comparison, the 2019 MPAC assessed value of the land and buildings in the area is $9.1M.

Table 6.2 Concept Level Cost Estimates for Pulley Road (Zone 1) – Accommodate and Protect Strategy

	Measure	Units	$/unit	Cost
ROAD UPGRADES				
Upgrade Road at Fox Run/Pulley	410	m	1890	$774,900
Creek Culvert at Fox Run/Pulley	1	m	100000	$100,000
SHORE PROTECTION				
Upgrade Shore Protection	850	m	5071	$4,310,350
Flanking Protection for Fox Run	70	m	5071	$354,970
FLOODPROOF BUILDINGS				
Raise Grade Around Foundation	0	#	18000	$0
Raise Building and then Raise Grade	0	#	68000	$0
Replace Septic Systems (tank and field)	22		30000	$660,000
MUNICIPAL UTILITIES				
New Waterline at Fox Run/Pulley	350	m	491	$171,850
			Capital Costs for Shoreline Protection and Restoration	$6,372,070
			20% for Engineering Design, Permits, Tender, Construction Observation	$7,646,484
			4% for Future Indexing	$7,952,343
			Low Range (-15%)	**$6,759,492**
			High Range (+15%)	**$9,145,195**

NOTES		
Number of Parcels and Assessed Value	*87*	*$9,315,285*

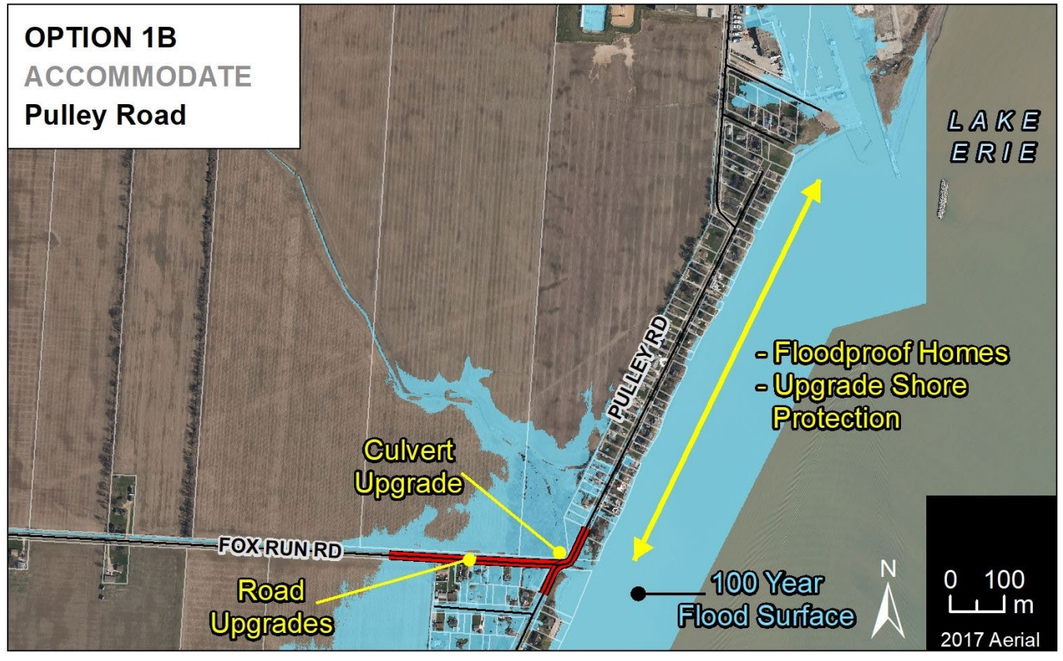


Figure 6.2 100-year Flood Surface (blue) and Accommodate/Protect Strategies for Pulley Road

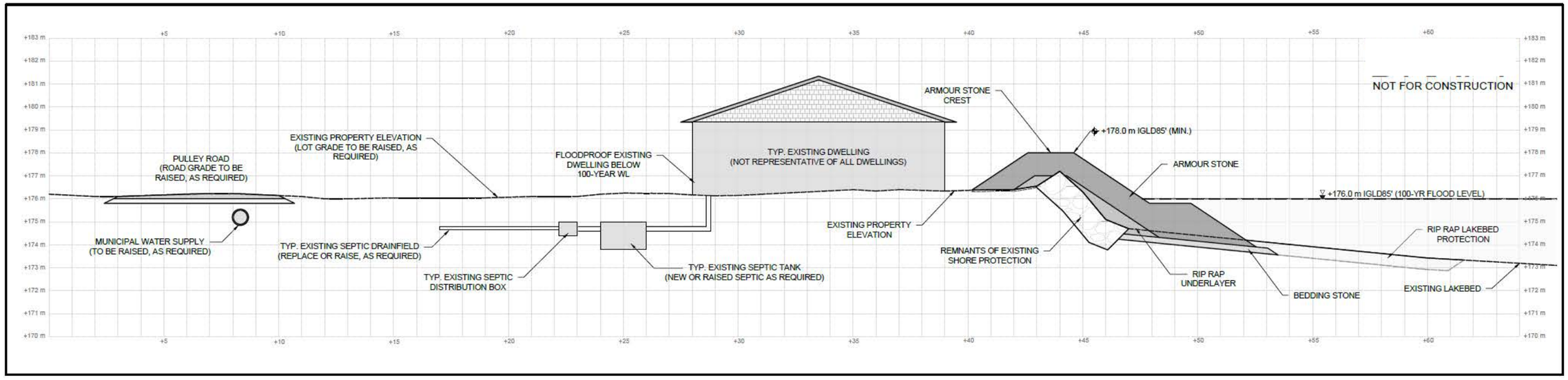


Figure 6.3 Cross-section of a Typical Waterfront Property on Pulley Road with Shore Protection Upgrades and Floodproofing

6.3 Lakeshore, Cotterie, Elmdale (Zone 1)

The adaptation concepts generated for the Lakeshore, Cotterie, and Elmdale portion of Zone 1 are outlined below, including avoid, accommodate, protect, and retreat and naturalize.

6.3.1 Avoid

The majority of the communities of Lakeshore, Cotterie Park and Elmdale are under water with no ingress/egress for vehicles for the Scenario A flood (100-year lake level), as presented in Figure 4.6. When the climate change 100-year lake level is considered, the entire community is inundated (Figure 4.7). As such, it is recommended that no new development be permitted in these communities unless the accommodate and protect strategies outlined in Section 6.3.2 are implemented.

6.3.2 Accommodate and Protect

Given the entire communities of Lakeshore Drive, Cotterie Park and Elmdale are in the floodplain for Scenario A, there is no safe ingress/egress during a major storm event, and considering the poor condition for much of the shore protection structures along this shoreline, the Accommodate and Protect Option is an all-in approach to accommodate the hazards and protect this community. In order for the land to remain occupied while mitigating risk to acceptable levels, all of the following strategies are required and are shown in Figure 6.4 and Figure 6.5 below:

- **Upgrade shore protection:** As is evident in the shoreline protection database presented in Section 2.2, the vast majority of this shoreline is protected by aging infrastructure in poor or failed condition. Many structures have been abandoned and rebuilt landward at least once throughout their lifetime. As such, significant shore protection upgrades would be required for the majority of private property shore protection in this region. The recommended approach is the same as presented for Pulley Road in Section 6.2.2 above, albeit with a higher crest elevation of +178.5 m IGLD85'. The higher crest is recommended for this region due to the increased depths in front of most properties and corresponding increase in wave exposure when compared to the properties along Pulley Road.

- **Road Upgrades:** The entirety of Lakeshore Drive, Cotterie Park Road and roads within the Elmdale subdivision are presently below the 100-year water level. To provide safe ingress/egress during storm events, these roads would have to be raised. Furthermore, Mersea Road 2 should be raised from Elmdale all the way to Mersea Road 19 to provide access to the region from the south during the 100-year flooding event.

- **Raise Land Elevations and Floodproof Homes:** Nearly all properties in these communities are partially or fully below the Scenario A and B floodplains, meaning that widespread flooding would occur under either scenario. All properties should be regraded above the Scenario B flood level, at least in the vicinity of access routes (driveways) and primary buildings. In addition, the majority of homes require some form of floodproofing to mitigate significant damage during the 100-year event. As discussed in Section 6.2.2 above, floodproofing may include raising foundations, raising the home

on piles, ensuring all openings are sealed or above the flood level, and increasing the capacity of sump-pumps (where present).

- **Raise or Upgrade Underground Utilities:** Underground utilities including municipal water supply and private septic systems should be upgraded or raised above the Scenario B flood level. A qualified individual should be consulted to ensure that underground utilities are not compromised and remain functional during the 100-year flood event.

A concept level cost estimate is provided in Table 6.3 for the accommodate and protect measures presented above for the Lakeshore, Cotterie and Elmdale communities. The cost range is $31.3M to $42.4M. The MPAC assessed value of the lands in 2019 was $15.6M.

Table 6.3 Concept Level Cost Estimates for Lakeshore, Cotterie, Elmdale (Zone 1) – Accommodate and Protect Strategy

	Measure	Units	$/unit	Cost
ROAD UPGRADES				
Upgrade Mersea Road 2	2400	m	1890	$4,536,000
Upgrade Elmdale Subdivision	590	m	1890	$1,115,100
Upgrade Cotterie/Lakeshore	1480	m	1890	$2,797,200
Upgrade Fox Run/Pulley Road Intersection	100	m	1890	$189,000
SHORE PROTECTION				
Upgrade Shore Protection	1630	m	8405	$13,700,150
Flanking Protection (Mersea Road 2)	100	m	8405	$840,500
FLOODPROOF BUILDINGS				
Raise Grade Around Foundation	60	#	18000	$1,080,000
Raise Building and then Raise Grade	15	#	68000	$1,020,000
Replace Septic Systems (tank and field)	90	#	30000	$2,700,000
MUNICIPAL UTILITIES				
Replace Waterline for Road Upgrade	3170	m	491	$1,556,470
			Capital Costs for Shoreline Protection and Restoration	$29,534,420
			20% for Engineering Design, Permits, Tender, Construction Observation	$35,441,304
			4% for Future Indexing	$36,858,956
			Low Range (-15%)	**$31,330,113**
			High Range (+15%)	**$42,387,800**

NOTES		
Number of Parcels and Assessed Value	*163*	*$15,608,824*

6.3.3 Retreat and Re-Naturalize

If the option to accommodate and protect the Lakeshore, Cotterie Park and Elmdale communities is not feasible, the remaining option for the region is to retreat and re-naturalize. This strategy is illustrated in Figure 6.6 and Figure 6.7 and would require the following aspects to be successful:

- **Minor Shore Protection Upgrades:** Even with no roads or dwellings, some level of protection for the shoreline is required to fix its location or at least slow the long-term recession rate. If this component is not included in the retreat and re-naturalize strategy, the shoreline recession rates would increase over time as aging shore protection structures fail. Eventually, the lands and roads to the west of Lakeshore, Cotterie Park and Elmdale including Mersea Road 21 and Fox Run Road, would be threatened. Shore protection for a retreat and re-naturalize strategy can be minimal, as overtopping during storm events and gradual settlement are less of a concern. Figure 6.7 presents a concept-level cross-section of a low-crested (crest elevation of +177.0 m IGLD85') berm type structure comprised of a single, wide gradation of armour stone placed over the existing shoreline infrastructure and directly on the lakebed. Deposition of sand behind the low-crested structure would be encouraged, along with the development of dune grasses and other native shoreline vegetation.

- **Purchase Properties and Decommission Homes:** If a property buy-out program existed, it would be initiated to purchase the homes. All buildings and other private infrastructure would subsequently be decommissioned and removed. At this time, we are not aware of any buy-out program funded by senior levels of government.

- **Decommission Roads and Public/Private Utilities:** All public and private underground utilities including water supply and septic systems would be decommissioned and removed.

- **Re-Naturalize Land:** Lands would be returned to a natural state and native coastal vegetation would be encouraged to help stabilize the lands behind the minor shore protection upgrades.

A concept level cost estimate is provided in Table 6.4 for the retreat and re-naturalize strategy for the Lakeshore, Cotterie and Elmdale communities. The costs to retreat and re-naturalize Lakeshore, Cotterie Park, and Elmdale ranges from $28.6M to $31.5M.

Table 6.4 Concept Level Cost Estimate for Lakeshore, Cotterie, Elmdale (Zone 1) – Retreat and Re-Naturalize Strategy

	Measure	Units	$/unit	Cost
PURCHASE BUILDINGS				
Purchase Property Parcels	163	#		$15,608,824
Decommission Buildings	163	#	25000	$4,075,000
Sub-total				$19,683,824
5% Administration Costs				$984,191
Total Property Acquisition Costs				**$20,668,015**
DECOMMISSION ROADS				
Mersea Road 2	2400	m	400	$960,000
Elmdale Subdivision	590	m	400	$236,000
Cotterie/Lakeshore	1480	m	400	$592,000
SHORE PROTECTION				
Upgrade Shore Protection (low-crested)	1630	m	3317	$5,406,710
Flanking Protection (Mersea Road 2)	100	m	3317	$331,700
			Capital Costs for Shoreline Protection and Restoration	$7,526,410
			20% for Engineering Design, Permits, Tender, Construction Observation	$9,031,692
			4% for Future Indexing	$9,392,960
			Low Range (-15%)	**$7,984,016**
			High Range (+15%)	**$10,801,904**
OVERALL OPTION 1D COST RANGE				
			Low Range	**$28,652,031**
			High Range	**$31,469,919**

NOTES

Number of Parcels in zone and MPAC Assessed Value	*163*	*$15,608,824*

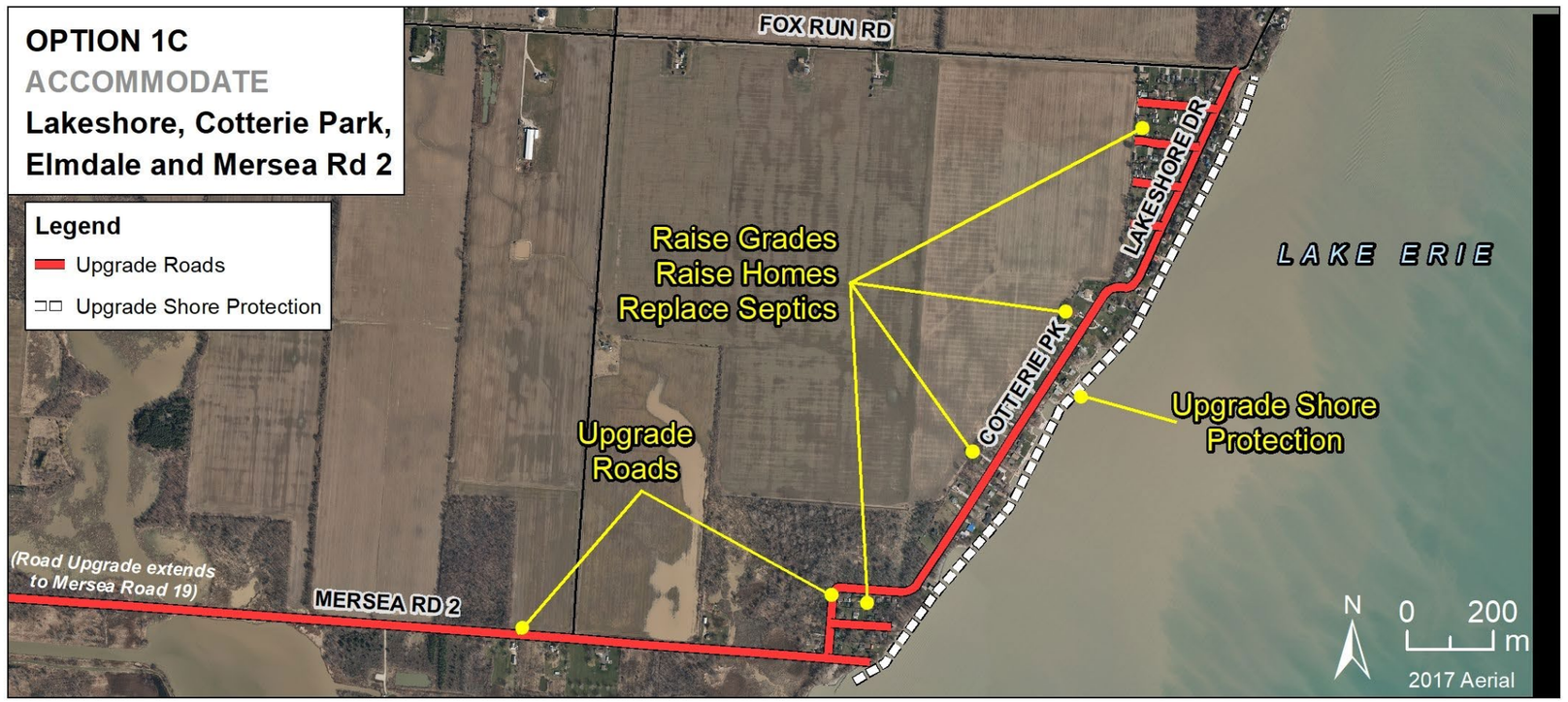


Figure 6.4 Recommended Accommodation and Protection Strategies for Lakeshore, Cotterie, Elmdale and Mersea Road 2

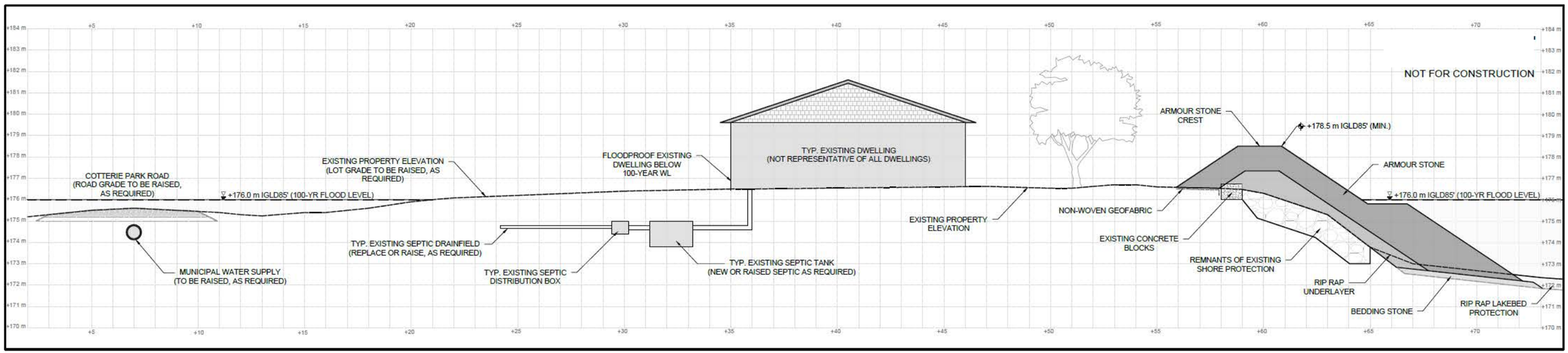


Figure 6.5 Cross-section of Typical Waterfront Property on Cotterie Park Road with Concept-level Shore Protection Upgrades and Flood Proofing Measures

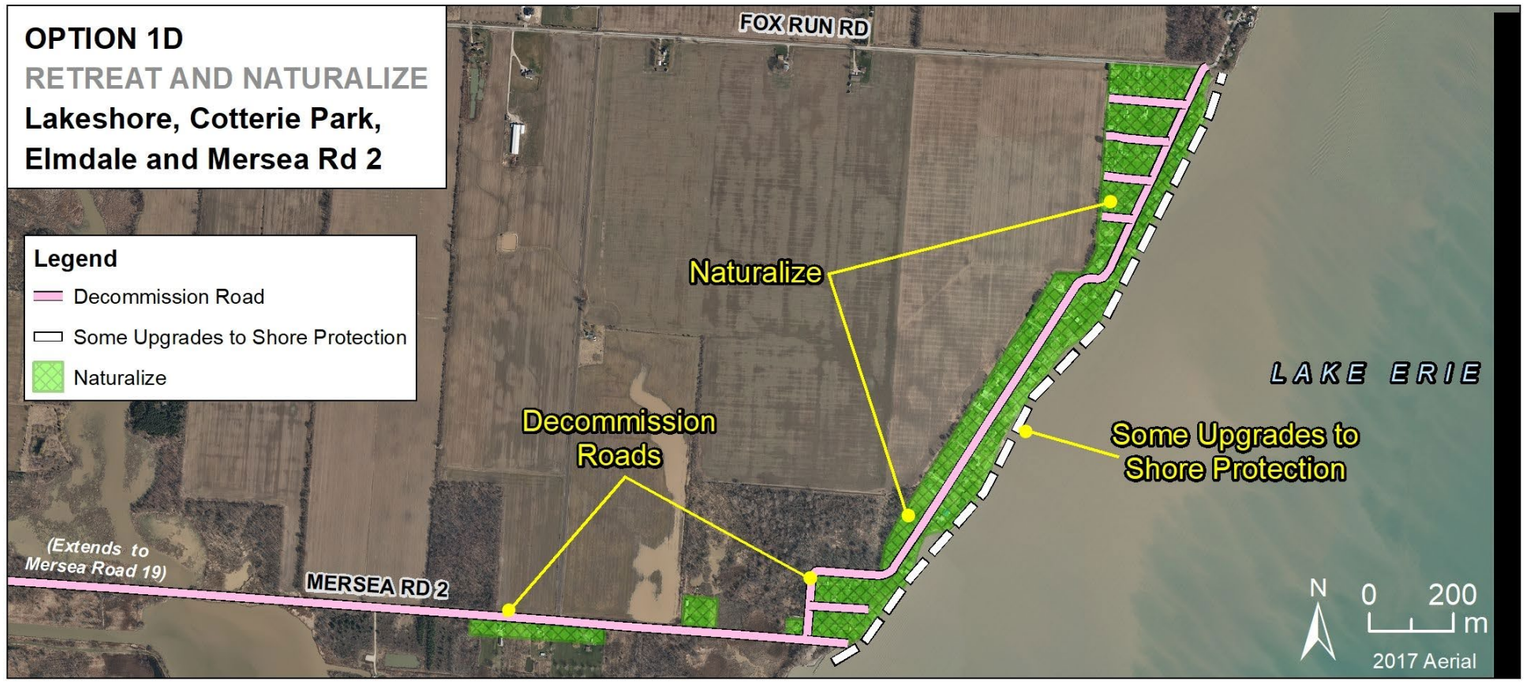


Figure 6.6 Recommended Retreat and Re-naturalize Strategies for Lakeshore, Cotterie, Elmdale and Mersea Road 2.

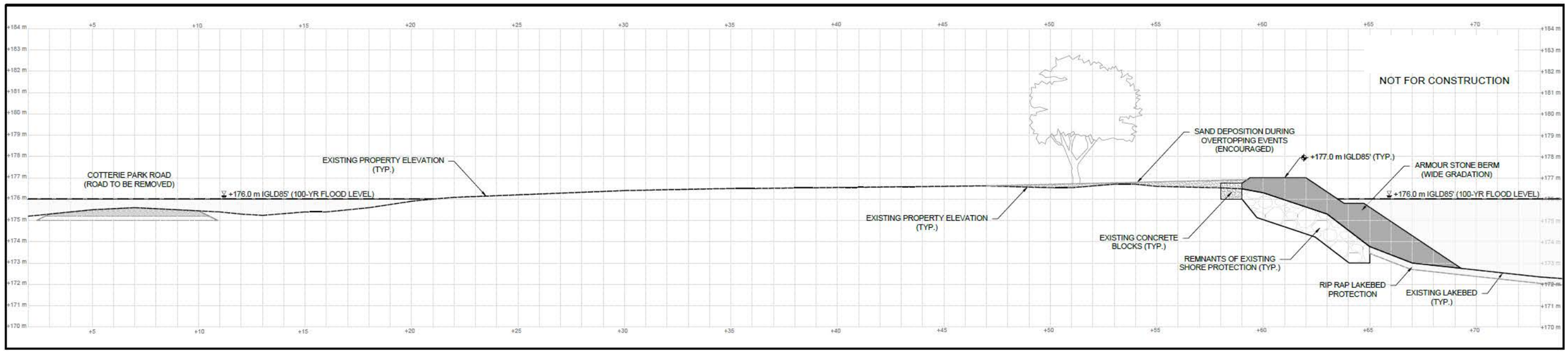


Figure 6.7 Typical Cross-section in Cotterie Park Road with Recommended Retreat and Re-naturalize Concepts

6.4 Hillman Marsh, East Beach, Marentette Beach, Interior Drainage Schemes (Zones 2 and 3)

Zones 2 and 3 are grouped together for the development of the adaptation strategies given the inter-related nature and magnitude of the flood risk. Lot by lot approaches or small-scale mitigation efforts are no longer feasible.

6.4.1 Avoid

The communities of East Beach and Marentette Beach as well as a significant portion of the interior agricultural lands including East Marsh Drain, Marentette Drain and Lloyd Drain are under water with no safe ingress/egress during Scenarios A (100-year event) and Scenario B (100-year event plus mid-century climate change). As such, it is recommended that no new development be permitted in these communities unless the Accommodate and Protect Everything strategy outlined in Section 6.4.2 is implemented. This will ensure the high level of risk exposure for the existing development ($29M for Scenario A and $52.2M for Scenario B) does not increase with new construction.

6.4.2 Accommodate and Protect Everything

The regions grouped together in this section are interconnected and share significant boundaries marked by roads or dykes. If any portion of this system is left vulnerable to shoreline hazards, the entire region will be irreversibly flooded due to the extremely low land elevations throughout Zones 2 and 3. Flood depths in some locations are in excess of 3 metres under the Scenario B flooding event. As such, the only approach in which continued land occupation would be safe is to protect the entire region from the hazards and to upgrade all properties, buildings and access routes to accommodate the significant flooding potential throughout the region. A strategy of this magnitude would require the following components, all of which are illustrated in Figure 6.8 through Figure 6.13 below:

- **Armoured Headlands North and South of Hillman:** The Hillman barrier beach has suffered a significant and likely permanent breach in recent years with portions of beach on either side of the breach receding away from the breach and towards the marsh at a high rate. In time this recession will result in the exposure of the southeast corner of the Elmdale subdivision and the north end of East Beach, the latter of which has already begun to occur. In order to protect these communities at either end of the barrier beach, armoured headlands should be constructed to fix the position of the shoreline on either side of Hillman Marsh (refer to Figure 6.9). These structures would be similar in cross-section to the shore protection upgrades described in Section 6.2.2, albeit likely with larger stone and potentially higher crest elevations due to the rounded structure alignment and increased depths and wave exposure.

- **Hillman Artificial Islands:** As the Hillman Barrier Beach breach continues to increase in both width and depth, the ecologically sensitive marsh and critical dyke system along Mersea Road 1 and Mersea Road 2 become increasingly exposed to waves propagating through the breach from Lake Erie. In order to mitigate the propagation of wave energy into the marsh and to provide additional habitat, a series of artificial islands behind the

breach are proposed (refer to Figure 6.9 and Figure 6.11). These islands would be crescent shaped with the convex, lake-facing sections being armoured with a low-crested armour stone or rip rap berm. Behind the berm the islands would be filled with imported sediment; potentially sand trucked from the Wheatley Harbour east fillet beach. Deposition of silts and organic materials on the west facing side of the islands would be encouraged, as would overtopping of the structures from the lake side during storm events. Native marsh vegetation (submerged and emergent) would be encouraged on the islands. This nature-based solution is an efficient way to restore protection to the marsh and the Mersea Road 1 dike while creating valuable wetland habitat.

- **Mersea Road 1 Dike Repairs:** Traditional repairs would include upgrading the dyke to an appropriate crest elevation above the Scenario A flood level, and armouring the lake-facing slope with a rip rap underlayer and primary armour stone layer to protect against lake-waves in the event that the Hillman barrier beach breaches entirely and the dyke becomes directly exposed to the lake. It is recommended that this approach be taken, but in conjunction with creating a headland-beach cell system along the lake facing side of the dyke (refer to Figure 6.9 and Figure 6.10). Low-crested headlands would be constructed and protected in a similar manner to the dyke, and sand would be imported from the Wheatley Harbour east fillet beach to nourish the beach cells. Native marsh vegetation would be encouraged within the beach cells, providing an additional level of protection to the dyke while significantly increasing the habitat potential for the marsh. The increased wave dissipation potential provided by the headland-beach cell system would also result in the dike requiring a lower crest elevation and smaller armour stone to be effective.

- **Lakebed Armouring:** The clay and peat lakebed fronting the Hillman barrier beach, East Beach and Marentette Beach has shown significant downcutting (vertical erosion) over the past several decades. This has resulted in increased wave exposure to the shoreline and destabilization and settlement of existing coastal structures. A simple strategy to mitigate or slow the vertical downcutting process is to armour the lakebed in front of the shoreline with a thin layer of quarried rip rap. This additional protection was included in the protect concepts and shown in Figure 6.12 and Figure 6.13.

- **Upgrade Shore Protection:** Much of the shore protection infrastructure fronting East Beach and Marentette Beach is in poor condition and will not provide adequate protection during 100-year wave and water level conditions. As such, significant upgrades to existing shore protection along all private and public properties is required to protect the communities and interior drainage schemes behind. These upgrades must include higher crest elevations to prevent significant overtopping and flooding during the 100-year event. A description of the recommended protection approach is provided in Section 6.2.2 above for Pulley Road. Typical concept-level cross-sections are provided in Figure 6.12 and Figure 6.13.

- **Shore Protection for the Northeast Corner of PPNP:** In order to prevent waves from breaching the barrier beach at the northeast corner of PPNP, shore protection is required to shelter the earth dike from direct wave attack and stabilize the northeast corner of PPNP. This concept was originally developed and proposed in Baird (2010).

- **Road Upgrades:** Many of the roads in the drainage schemes lie partially or fully below the Scenario A flood level and will not provide safe ingress/egress to the community in the case of a dike breach. East Beach and Marentette Beach are particularly vulnerable, since the area would be the first to be inundated during a flood and is the furthest from high ground to the northwest above the Scenario A flood. The following road upgrades are included to provide an evacuation route for the residents of East Beach and Marentette Beach during the Scenario A flood (via Road C, north of Road 19, and west on Road B):

    - Sections of East Beach Road (910m).
    - Marentette Beach Road (1,700 m).
    - Mersea Road C between Road 19 and East Beach (1,700 m).
    - Mersea Road 19 between Road B and C (1,400 m).
    - Mersea Road B west of Road 19 (500 m).

    The full 1,900 m of Road E in the Lloyd Drain is below water during the Scenario A flood, as is a significant portion of Road C west of Road 19. However, with a sufficient warning system, the residents in these areas would have adequate time to evacuate in the case of a dike breach, since the East Marsh and Marentette Drains would have to fill with water first before the water spills west over Road 19. Therefore, Road E and Road C west of Road 19 upgrades are not included at this time.

- **Dyke Upgrades:** Portions of the dyke along the park boundary, near the intersection between East Beach Road and Marentette Beach and at the north end of East Beach are presently below the 100-year flood elevation and must be raised. Moreover, nearly all dykes protecting the interior drainage schemes are below the Scenario B flood level (+176.5 m IGLD85'). If the region is to be adequately protected from flooding all dykes would need to be raised and reinforced to some degree, in the event that the primary shore protection along Marentette and East Beach were to fail and the dyke were to become exposed to lake waves.

- **Raise Land Elevations and Floodproof Homes:** The majority of properties along East Beach and Marentette are below the Scenario B flood level. These properties should be raised or and buildings raised or floodproofed to the Scenario B flood level, as discussed in Section 6.2.2 above.

- **Raise or Upgrade Underground Utilities:** Underground utilities including municipal water supply and private septic systems throughout East Beach and Marentette Beach would have to be raised or otherwise upgraded to conform to the Scenario B flood level. A qualified individual should be consulted to ensure that underground utilities are not compromised and remain functional during the 100-year event.

In the 2010 Point Pelee Eastern Shoreline Erosion Mitigation Study (Baird, 2010), the cost to upgrade and repair the flood protection for the interior drainage schemes and the Hillman Marsh was estimated at $32.8M. These repairs today are estimated at $46.5M. However, when repairs to the shoreline protection and road upgrades to provide safe ingress and egress are included, the overall cost for the accommodate and protect concept is $83.4 to $112.9M (refer to Table 6.5). By way of comparison, the 2019 MPAC assessed value of the land and buildings in Zone 2 and Zone 3 was $64M.

Table 6.5 Concept level cost estimates for Hillman Marsh, East Beach, Marentette Beach, Interior Drainage Schemes (Zones 2/3) – Accommodate and Protect Everything strategy.

	Estimate	Year	Measure	Units	$/unit	Cost
Hilman Marsh						
Lakebed Armouring			1500	m	835	$1,252,500
Habitat Islands			500	m	4679	$2,339,500
Mersea Road 1 Dyke Headland Beach System			1500	m	3192	$4,788,000
Hard Points for North and South Corners			800	m	7215	$5,772,000
East Beach						
Upgrade Shore Protection			2600	m	7215	$18,759,000
Raise Sections of East Beach Road			910	m	1980	$1,801,800
Raise Grade Around Foundations			18	#	18000	$324,000
Raise Building and then Raise Grade			8	#	68000	$544,000
New Septic Systems			43	#	30000	$1,290,000
Marentette Beach						
Upgrade Shore Protection			1700	m	7974	$13,555,800
Raise Marentette Beach Road			1700	m	2835	$4,819,500
Raise Grade Around Foundations			8	#	18000	$144,000
Raise Building and then Raise Grade			21	#	68000	$1,428,000
New Septic Systems			38	#	30000	$1,140,000
Drainage Schemes (East, Marentette, Lloyd)						
Mersea Road 1 Dyke Repairs, South Slope (2130 m)	1,475,000	2013	12.80%			$1,663,800
Raise Elevation of Road C	3,700,000	2007	25.10%			$4,628,700
Road 19 bwn Road B and C	(use Road C unit cost)		1400		2800	$3,920,000
Road B Small Section	(use Road C unit cost)		500		2800	$1,400,000
Marentette South Dyke South Slope Protection	500,000	2009	21.10%			$605,500
Marentette South Dyke North Slope Clay Plug	350,000	2009	21.10%			$423,850
Marentette South Dyke Crest Repairs to >176.0 m	n/a		1			$180,000
East Marsh Pump Replacement	300,000	2009	21.10%			$363,300
Marentette Pump Replacement	300,000	2009	21.10%			$363,300
Rock Berm South of Marentette Beach (toe)	n/a		570		2473	$1,409,610
Road 19 / Road D Bridge Replacement	215,000	2009	21.10%			$260,365
Road E Upgrade	815,000	2009	21.10%			$986,965
Lloyd South Dyke Slope and Erosion Protection	2,000,000	2009	21.10%			$2,422,000
Shore Protection for the NE Corner of PPNP	1,700,000	2009	21.10%			$2,058,700
					Capital Costs for Shoreline Protection and Restoration	$78,644,190
					20% for Engineering Design, Permits, Tender, Construction Observation	$94,373,028
					4% for Future Indexing	$98,147,949
					Low Range (-15%)	**$83,425,757**
					High Range (+15%)	**$112,870,141**

NOTES

Value of beach and interior property	*$53,968,295*

6.4.3 Retreat and Re-Naturalize

If the community-scale Protect Everything option outlined in Section 6.4.2 is not feasible, then the only remaining option is to pursue a large-scale nature-based adaptation solution. This concept includes retreat or re-location of buildings and re-naturalization of the shoreline and interior lands south of the Hillman Marsh. This concept was explored extensively during the Southeast Leamington Sustainable Management Strategy (Baird, 2007; Baird, 2009b). The spatial extent of the re-naturalization strategy is illustrated in Figure 6.14. A sketch of the shore protection upgrades along East Beach and Marentette Beach is provided in Figure 6.15. This nature-based adaptation concept would include the following aspects to be successful:

- **Minor Shore Protection Upgrades:** Even with no occupied lands or buildings to protect, some level of protection for the shoreline is required to fix its location or at least significantly slow its recession. Shore protection for a retreat and re-naturalize strategy can be minimal, as overtopping during storm events and gradual settlement are less of a concern. Figure 6.15 presents a concept-level cross-section of a low-crested, berm type structure comprised of a single, wide gradation of armour stone placed over the existing shoreline infrastructure and directly on the lakebed. Deposition of sand behind the low-crested structure would be encouraged, along with the development of dune grasses and other native shoreline vegetation. Placement of a rip rap layer on the nearshore lakebed is also included to mitigate or slow the vertical downcutting of the lake bottom.

- **Hillman Marsh Upgrades:** Several concept level upgrades for Hillman Marsh were presented in Section 6.4.2., including armoured headlands at the north and south ends of the barrier beach, artificial islands and Mersea Road 1 dyke improvements and beach cells. These concepts or similarly effective alternatives (designed by qualified individuals) would still be required under the retreat and re-naturalization concept. However, the costs are lower than for the Accommodate and Protect option since the thresholds for wave overtopping, for example, increase significantly (the protection is for nature not the protection of human lives).

- **Purchase Properties and Decommission Homes:** A property buy-back program would be required for lands in the East Beach, Marentette Beach, and the Lloyd, Marentette and East Marsh Drainage Schemes provided a program funded by senior levels of government exists. All buildings and other private infrastructure would subsequently be decommissioned and removed.

- **Decommission Roads and Public/Private Utilities:** All public and private underground utilities including water supply and septic systems would be decommissioned and removed.

- **Regrade and Re-Naturalize Land:** Agricultural lands within the East Marsh Drain, Lloyd Drain and Marentette Drain would be regraded to create deeper open water areas, gently sloping emergent vegetation zones, coastal wetlands, and dry uplands that would protect the remaining agricultural lands in the West Marsh. For example, earth would also be pushed west against Mersea Road 19 to create a large berm of upland forest to

protect the road from flooding using a nature-based design. The regraded coastal wetlands and upland forest would be re-vegetated with native plants, shrubs, and trees.

A concept level cost estimate is provided in Table 6.6 to purchase the properties in Zone 2 and 3, remove buildings, and decommission utilities. When administrative costs are included, the total cost of the buy-out is $62.1M. It should be emphasized that no such buy-out program exists at this time. The cost estimate for the protection of the shoreline and re-naturalization of the interior agricultural lands is $42.8M to $58.0M. The overall cost for this retreat and re-naturalize option is $104.9 to $120.0M.

Table 6.6 Concept Level Cost Estimates Zones 2 and 3 Nature-based Adaptation

	Measure	Units	$/unit	Cost
Purchase Property / Risk Reduction				
East Beach		70		$11,300,806
Marentette Beach		94		$10,377,462
East Marsh Drain		70		$12,327,895
Marentette Drain		22		$7,463,899
Lloyd Drain		92		$12,498,233
Remove Buildings		207	25000	$5,175,000
Sub-total				$59,143,295
5% Administration Costs				$2,957,165
Total Property Acquisition Costs				**$62,100,460**
East Beach and Marentette Beach Stabilization				
Lakebed Armouring	4300	m	835	$3,590,500
Shore Protection for East and Marentette Beach	4300	m	1898.5	$8,163,550
Protection of the Hillman Marsh				
Habitat Islands for the Hillman Marsh	500	m	4679	$2,339,500
Mersea Road 1 Dyke Headland Beach System	1500	m	1596	$2,394,000
Hard Points for North and South Corners of Hillman	800	m	3607.5	$2,886,000
Re-naturalize Interior Agricultural Lands				
Regrade Earth in East Marsh Drain	1200	acres	5700	$6,840,000
Regrade Earth in Lloyd Drain	540	acres	5700	$3,078,000
Regarde Earth in Marentette Drain	675	acres	5700	$3,847,500
Restore Native Vegetation	2415	acres	3000	$7,245,000
			Capital Costs for Shoreline Protection and Restoration	$40,384,050
			20% for Engineering Design, Permits, Tender, Construction Observation	$48,460,860
			4% for Future Indexing	$50,399,294
Total Restoration Costs			***Low Range (-15%)***	**$42,839,400**
			High Range (+15%)	**$57,959,189**
OVERALL OPTION 3 COST RANGE				
			Low Range	**$104,939,860**
			High Range	**$120,059,648**

NOTES

Value of beach and interior property	*$53,968,295*

It is interesting to note that due in large part to the costs associated with a property buy-back program, the total costs for Protect Everything and Retreat/Re-naturalize are very similar. It should also be noted that with the Retreat/Re-naturalize strategy, future liability and risk associated with flooding and erosion are eliminated and coastal resilience is restored with nature.



Figure 6.8 All Existing Land Uses Remain for East Beach, Marentette Beach and the Interior Drains

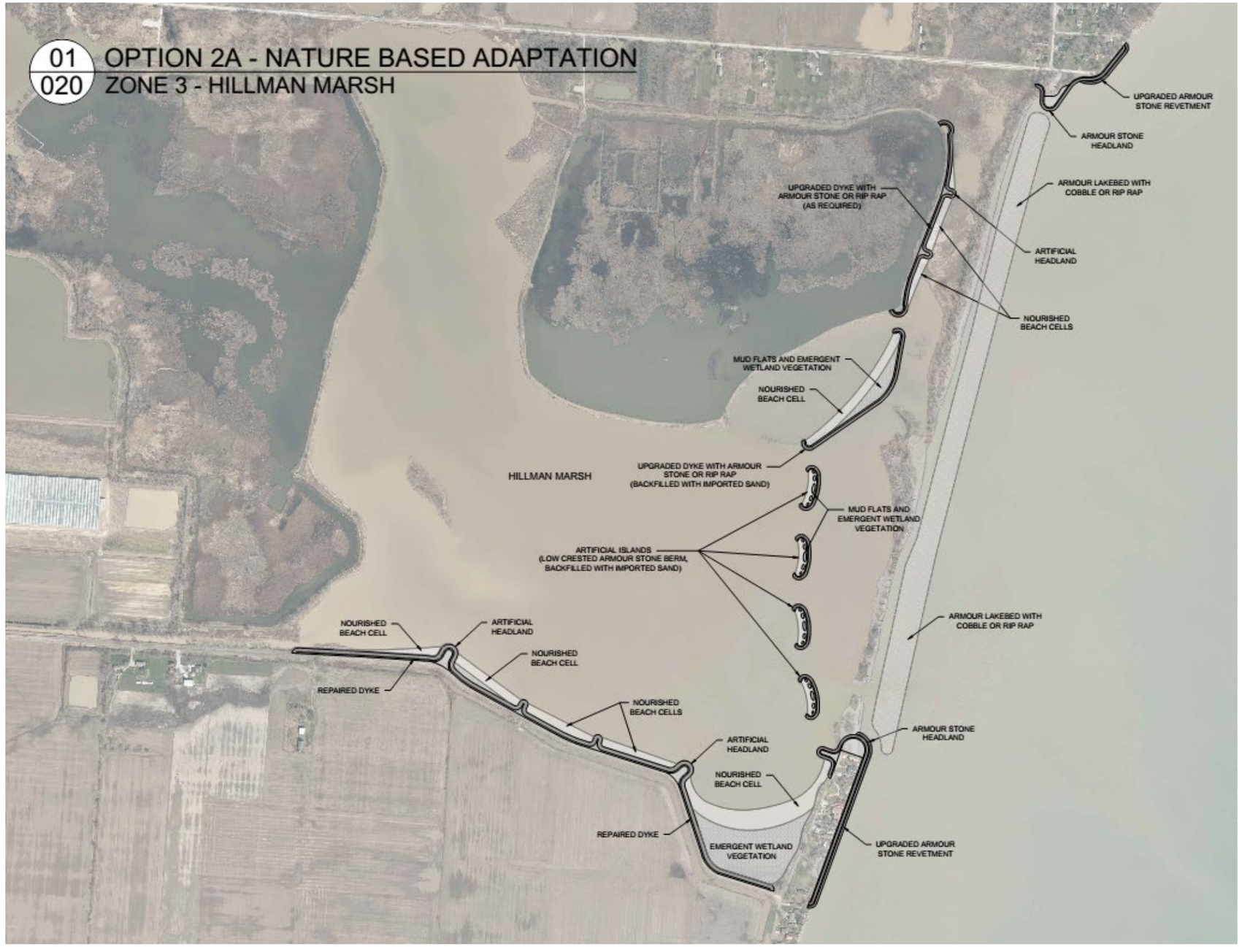


Figure 6.9 Restoration Concept for the Hillman Marsh with Traditional Coastal Engineering Approaches and Nature-based Solutions (FOR ILLUSTRATION PURPOSES ONLY)

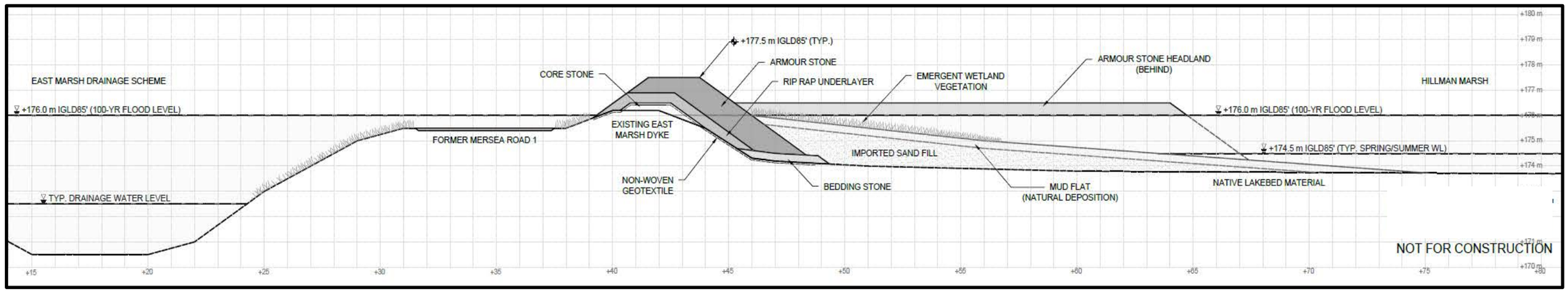


Figure 6.10 Typical Cross-section through the Mersea Road 1 Dike with New Slope Protection and Headland-Beach Cell System

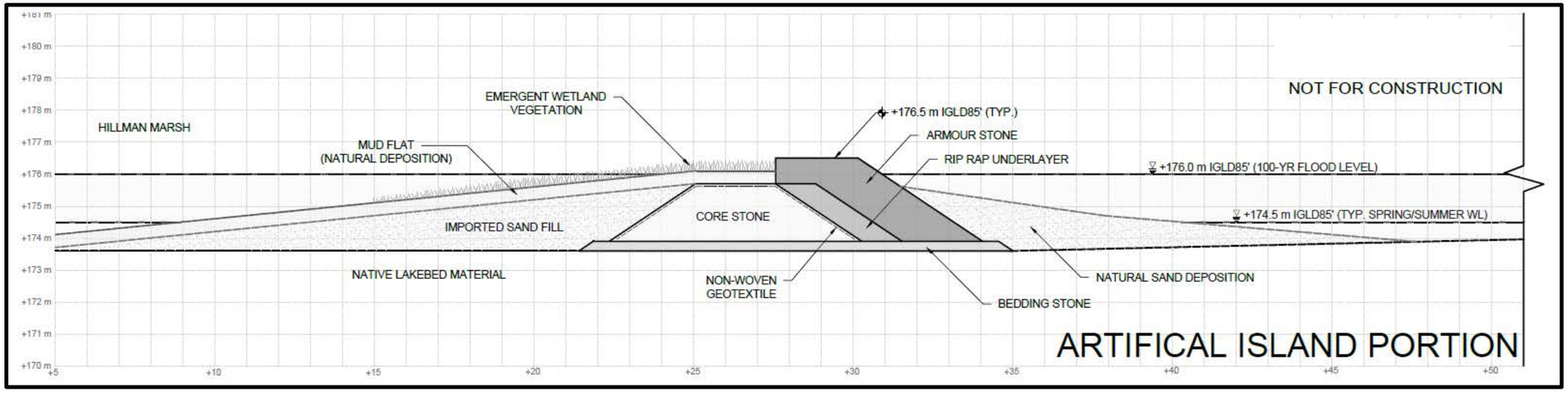


Figure 6.11 Typical Cross-section through New Artificial Island in the Hillman Marsh

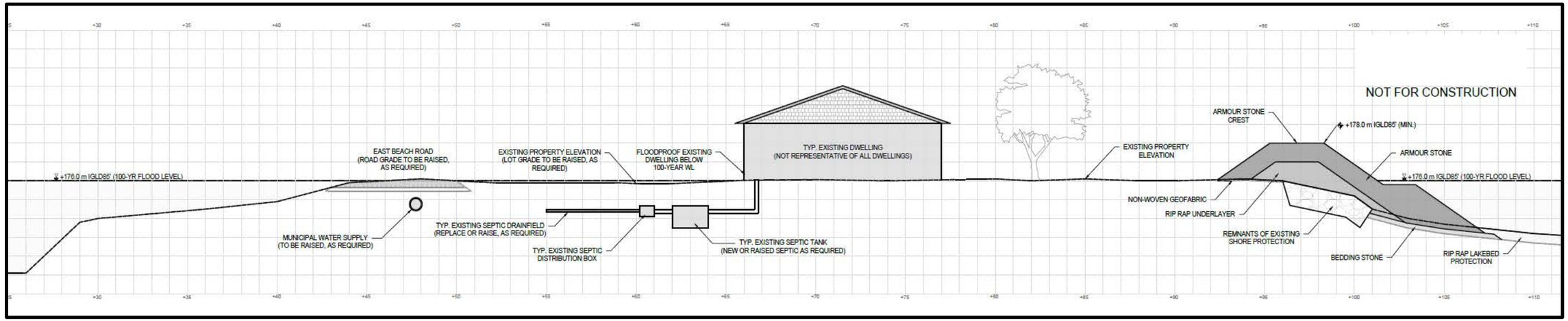
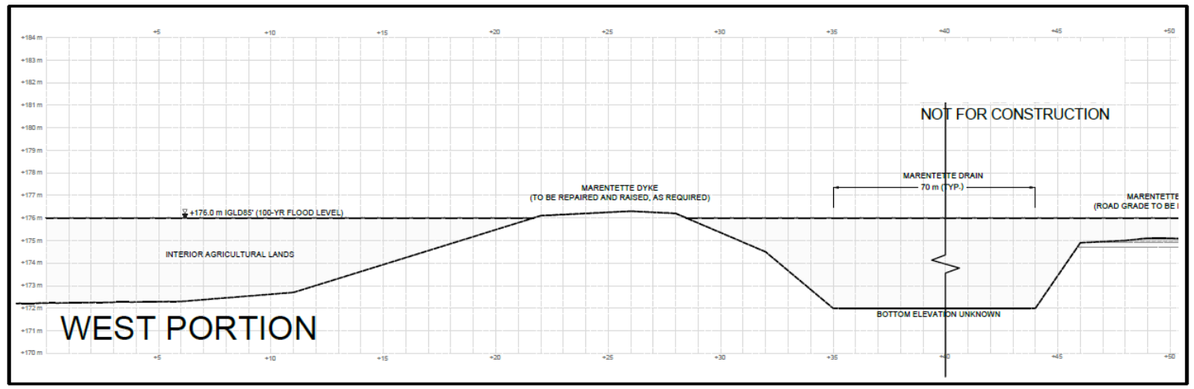


Figure 6.12 Typical East Beach Cross-section with Concept-level Shore Protection Upgrades and Other Accommodate Strategies



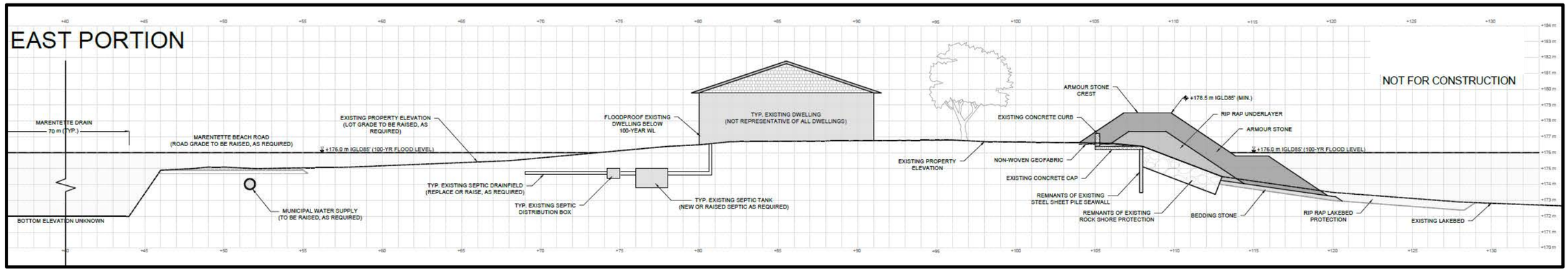


Figure 6.13 Typical Marentette Beach Cross-section with Concept-level Shore Protection Upgrades and Other Accommodate Strategies



Figure 6.14 Spatial Extent of the Retreat and Re-naturalize Strategy for Zones 2 and 3

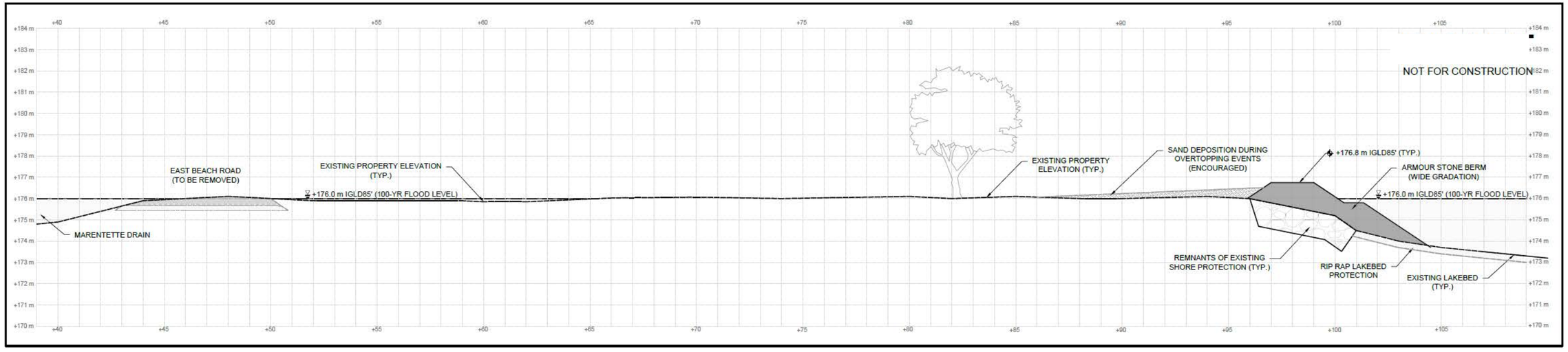


Figure 6.15 Cross-section at East Beach Road with Re-naturalized Dike and Upgraded Shore Protection

6.5 Point Pelee Drive, Robson Road (Zone 4)

The majority of Zone 4 is fully armoured with armour stone revetments and seawalls. The primary risk to buildings and road infrastructure is flooding, primarily north of the Mersea Road 12 and Point Pelee Drive intersection. Roughly 1,800 m of Point Pelee Drive and 800 m of Robson Road are flooded during Scenario A. Erosion of the clay lake bottom north of Sturgeon Creek will result in ongoing maintenance of the private shoreline protection. Section 6.5.1 describes the accommodate and protect strategy for these communities.

6.5.1 Accommodate and Protect

To mitigate the existing flood and erosion risk along Robson Road and Point Pelee Drive, the following components were integrated into the accommodate and protect strategy:

- **Upgrade Shore Protection:** Existing private property shore protection should be upgraded to reduce wave overtopping and provided improved structural longevity. In most cases this can be accomplished by adding additional properly sized armour stone to existing shore protection structures. Crest elevations should be raised to +178.0 m IGLD85' or higher to mitigate overtopping during severe storm events. Refer to Figure 6.16 for a concept sketch of the shore protection upgrade.

- **Raise Land Elevations and Floodproof Homes:** Low-lying properties, particularly those between Mersea Roads C and D, should be regraded above the Scenario B flood level (100-year climate change lake level) and homes should be floodproofed. These properties can be identified in the flood maps provided in Section 4.0. Floodproofing of homes can include such measures as raising foundations, placing the home on piles, ensuring all openings (doors, windows, etc.) are sealed or above the flood level and increasing the capacity of sump-pumps.

- **Road Upgrades:** Roughly 2.6 km if Robson Road and Point Pelee Drive are located below the 100-year flood level. The elevation of the road should be raised to ensure safe ingress/egress routes during the 100-year storm event. How this is accomplished and the potential implications to local drainage are beyond the scope of this study.

A concept level cost estimate was generated for the shore protection upgrades, flood proofing, and road improvements. Table 6.7 summarizes the results north of Mersea Road 12, with a cost range of $18.2M to 24.6M. South of Mersea Road 12, only shore protection upgrades are required, with a cost range of $7.4M to $10.0M. Refer to Table 6.8

Table 6.7 Cost Estimate to Flood Proof Buildings, Upgrade Shore Protection, and Raise Road Elevations in North of Mersea Road 12

North of Mersea Road 12	Measure	Units	$/unit	Cost
SHORE PROTECTION				
Upgrade Shore Protection	1800	m	5464	$9,835,200
FLOODPROOF BUILDINGS				
Raise Grade Around Foundation	42	#	18000	$756,000
Raise Building and then Raise Grade	24	#	68000	$1,632,000
RAISE ROAD ELEVATION				
Raise Grade of Robson Road and Point Pelee Drive	2600	m	1890	$4,914,000
			Capital Costs for Shoreline Protection and Floodproofing	$17,137,200
			20% for Engineering Design, Permits, Tender, Construction Observation	$20,564,640
			4% for Future Indexing	$21,387,226
			Low Range (-15%)	**$18,179,142**
			High Range (+15%)	**$24,595,309**

NOTES

Number of Parcels and Assessed Value	*91*	*$19,068,180*

Table 6.8 Cost Estimate to Upgrade Shore Protection South of Mersea Road 12

South of Mersea Road 12	Measure	Units	$/unit	Cost
SHORE PROTECTION				
Upgrade Shore Protection	1270	m	5464	$6,939,280
FLOODPROOF BUILDINGS				
Raise Grade Around Foundation	0	#	18000	$0
Raise Building and then Raise Grade	0	#	68000	$0
			Capital Costs for Shoreline Protection and Floodproofing	$6,939,280
			20% for Engineering Design, Permits, Tender, Construction Observation	$8,327,136
			4% for Future Indexing	$8,660,221
			Low Range (-15%)	**$7,361,188**
			High Range (+15%)	**$9,959,255**

NOTES

Number of Parcels and Assessed Value	*78*	*$15,922,408*

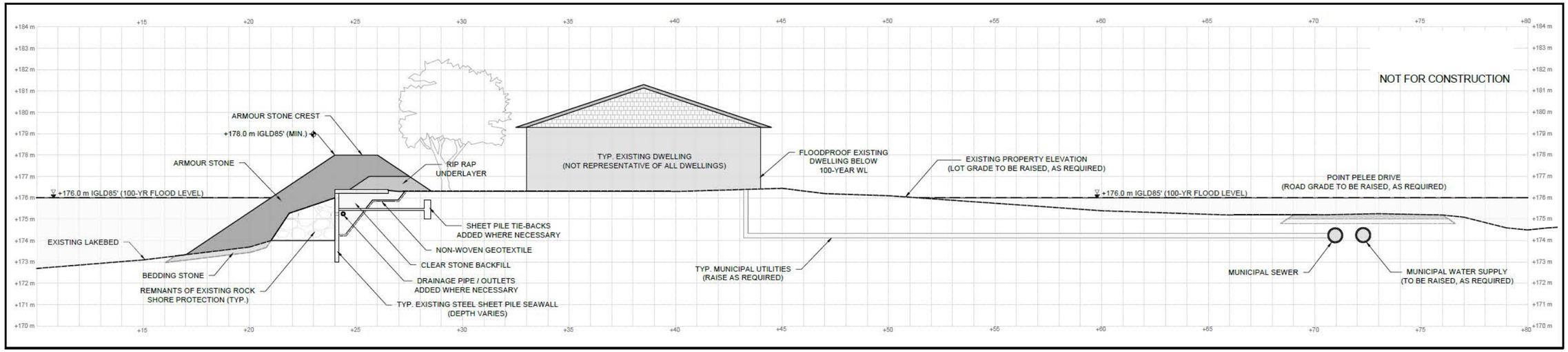


Figure 6.16 Cross-section for Point Pelee Shore Protection Upgrades, Flood Proofing, and Road Upgrades

6.6 Western Basin Regional Sediment Management

A final adaptation concept was generated for the western basin shoreline from Colchester to Point Pelee Park to address the need for a Regional Sediment Management Strategy. As highlighted in Baird (2008a; 2009a), the harbours west of Southeast Leamington have trapped a significant volume of littoral sediment in their west fillet beaches. Recommendations for sediment bypassing at these harbours were provided and several meetings of a Regional Sediment Management Committee were held.

For additional context, the western shoreline of the Pelee Peninsula is part of a littoral cell that starts in the west at the Colchester Harbour and extends east and south to the tip of the Southeast Shoal. Refer to Figure 6.17.

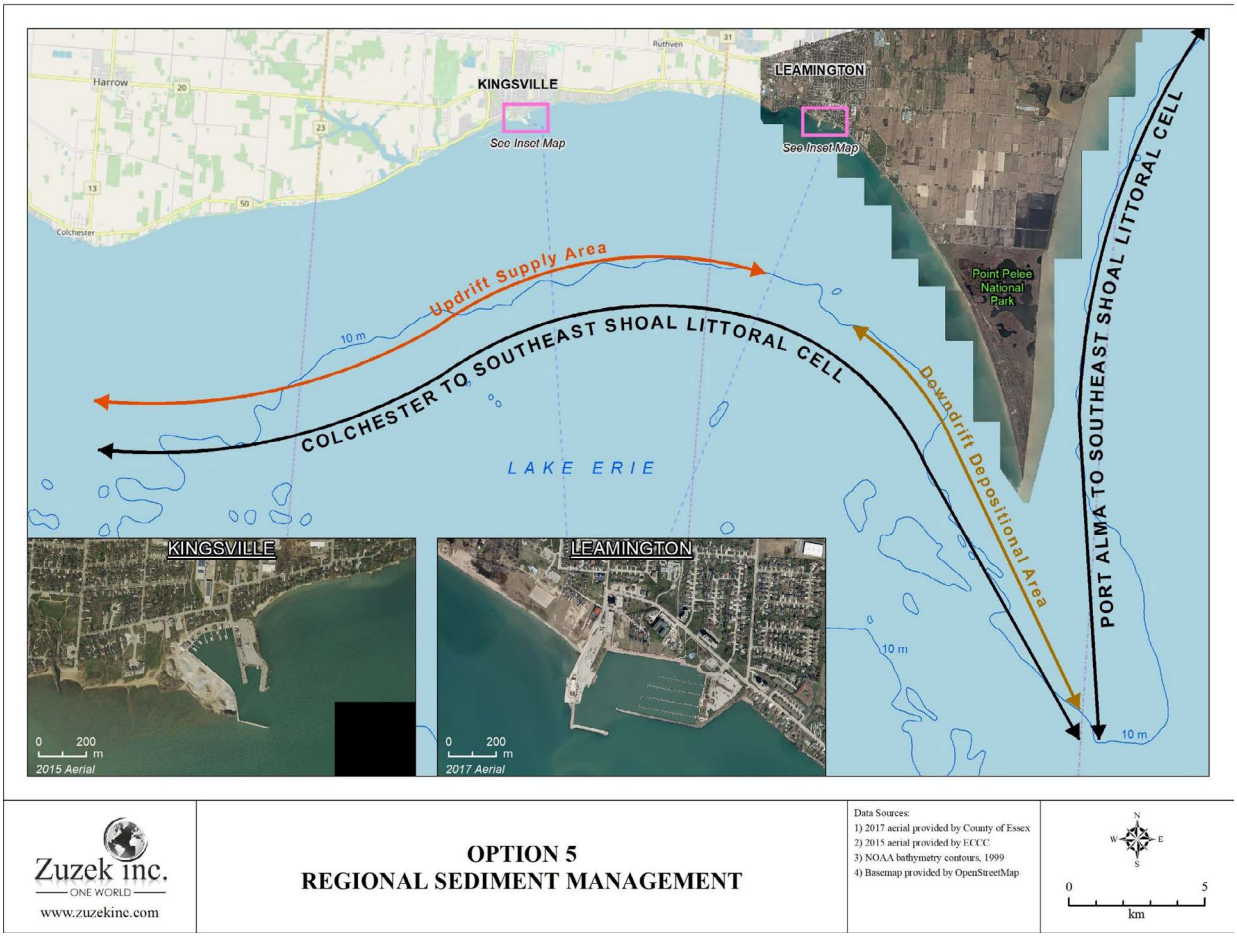


Figure 6.17 Spatial Limits of the Colchester to Southeast Shoal Littoral Cell

Sand that eroded from the shoreline in the littoral cell was historically transported to the east and deposited along the western shoreline of PPNP and in the Southeast Shoal, which is located at the tip of the park and extends roughly 10 km to the south. The Southeast Shoal contains approximately 48M to 74M cubic metres of sand. To put this enormous volume of sand in context, it is enough material to fill the Rogers Centre, with the roof closed, 30 to 45 times.

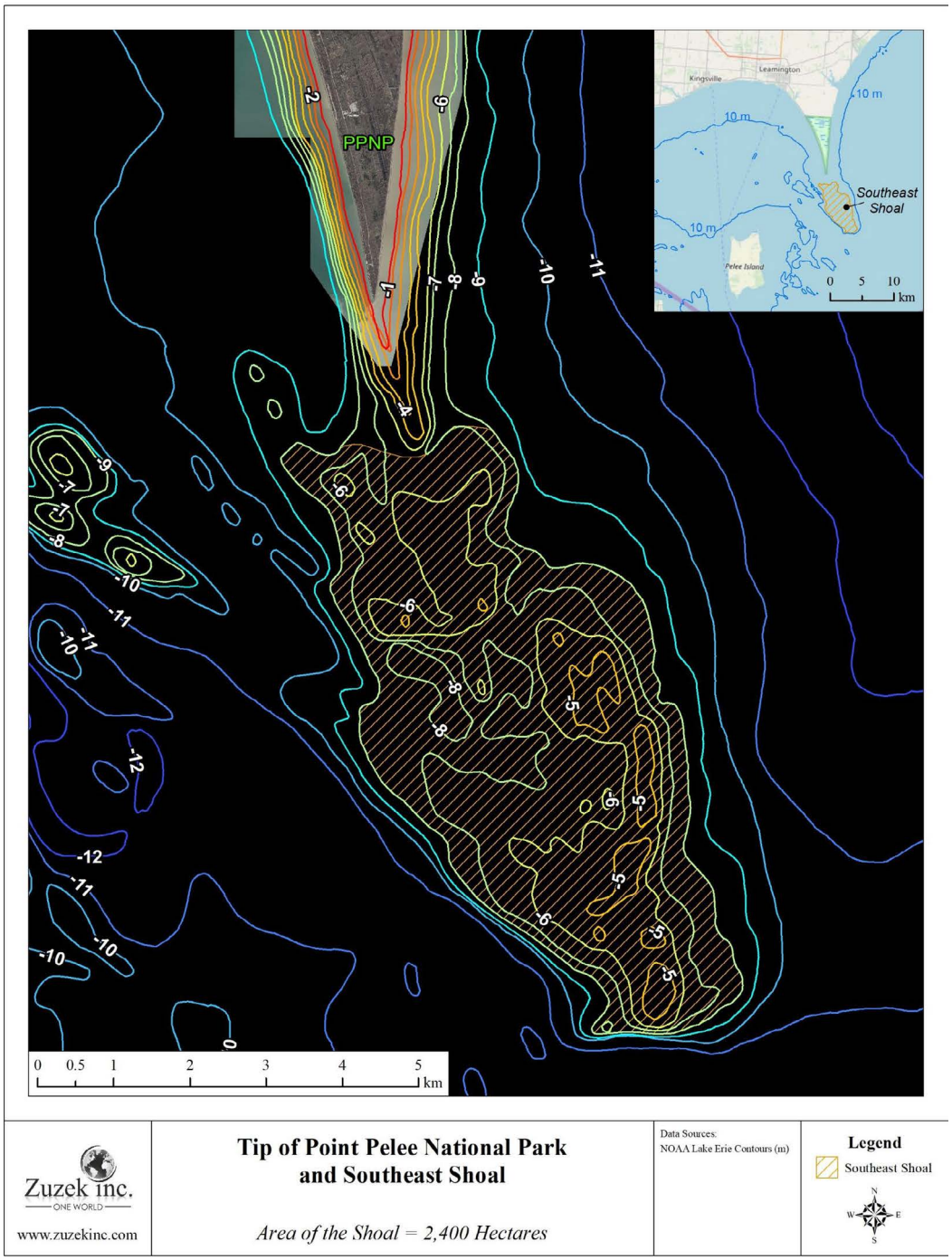


Figure 6.18 Approximate Spatial Extent of the Southeast Shoal

With appropriate technical studies to evaluate potential impacts and benefits, it may be possible to use a small portion of this large sand resource to nourish the beaches of Point Pelee National Park. The sand would be excavated with a hydraulic dredge and pumped to appropriately located feeder beaches in the north. Refer to Figure 6.19 and Figure 6.20 for graphics depicting a hydraulic dredge and beach nourishment program.



Figure 6.19 Conceptual Diagram of a Small-scale Hydraulic Dredge



Figure 6.20 Dredged Sand Pumped and Graded in Place on a Beach

7.0 STUDY FINDINGS

The overall study findings are summarized in Section 7.0, including major conclusions and recommendations for next steps.

7.1 Major Conclusions

The primary conclusions related to coastal hazards, vulnerability, and adaptation options are summarized:

- The east side of the Pelee Peninsula is an eroding cohesive shoreline. The long-term natural trend for the shoreline is erosion, even prior to European settlement.

- Most of the shoreline south of Wheatley has been armoured with shore parallel protection to slow the shoreline erosion rate. These protection structures are generally in poor shape, with only 10% in good condition (the remaining were classified as failed, poor, or moderate condition), and will require continuous maintenance.

- Monitoring has shown the lake bottom along the east shore has been continually eroding from 1964 to present, despite the construction of shore parallel protection structures, which do nothing to stop lakebed downcutting.

- The Hillman Marsh barrier beach breached during the April 2018 ice-storm and the size of the breach continuous to grow with each passing storm. Lake waves are now able to propagate into the marsh and reach the north slope of the Mersea Road 1 dike. The threat of a dike breach, due to wave attack and general deterioration of the dike, increases with each passing storm.

- The southeast corner of the Marentette Drainage scheme is vulnerable to wave attack and a dike breach, given the deep nearshore conditions along the breakwall, unprotected dike slopes, overall deterioration of the dike, low crest elevation, and continued erosion of the adjacent PPNP northeast beach.

- The west shoreline, including Pelee Drive and Robson Road, is mostly protected with shore parallel structures such as walls and armour stone. From the shore protection database, 30% is in good condition. The remaining structures will require continuous maintenance.

- North of Sturgeon Creek, the lake bottom has eroded dramatically since 1978. South of Sturgeon Creek, the lake bottom has generally been stable since 2009.

- Over 11,000 acres of the interior farmland is located below the 100-year lake level and kept artificially dry with the dikes, drainage works, and pump houses. The infrastructure in these drainage schemes, including dikes, drainage ditches, and pump houses require significant maintenance. For example, in the East Marsh the required maintenance for the Mersea Road 1 dyke outlined in the Dillon (2013) report, $5.9M in 2013, was identified as unaffordable by the landowners in the drain. The Leamington Council

declared the area unsustainable and directed Leamington Administration to evaluate short- and long-term solutions. This report is part of the process to generate updated technical information and identify options. To date, no repairs have been completed.

- In June 2019 the Lake Erie monthly mean water level reached a new all-time high (175.14 m IGLD'85). During the spring of 2020, the monthly means in March and April have also established new record highs for these months. Climate change projections suggest future highs will be even higher than the June 2019 level.

- The projected warming due to climate change will continue to result in shorter winter ice cover seasons. By late century, for the RCP8.5 emission scenario, Lake Erie could be largely ice free. For an ice-free scenario, the amount of energy that impacts the east shoreline could increase by 80% in the winter and by 120% for west shoreline. The risk of winter flooding will increase steadily into the future due to reduced ice cover and increased exposure to storms. The ice-free winter of 2019-2020 and storm impacts is a prelude to the future.

- The East Beach and Marentette perimeter dikes can be overtopped during the 100-year storm, even without a dike failure. With the 100-year climate change lake level, water would overtop all the perimeter dikes without a failure. For the flood inundation scenarios evaluated in this study (A to C), a dike breach is assumed.

- For the 100-year storm, the potential economic damages to building and contents from flooding and shoreline protection maintenance due to failures was estimated at $46.5M. When the potential impact of climate change on future lake levels is considered (an increase in 0.5 m), the potential economic damages to primary buildings, contents, and shore protection more than doubles to $113.3M. A third flood scenario (C) assumes continued downcutting in front of the shoreline protection structures and the climate change 100-year lake level (from Scenario B). The potential damages increase to $122.6M.

  These damages do not consider impacts to crops if the flood happens during the growing season, farm equipment, vehicles, ecosystem impacts, damage to septic systems and underground utilities, damages to the roads and dikes, and secondary impacts such as lost employment or lost income. Most importantly, the potential for mental and physical trauma was not estimated or included, however, it would be significant if one of these flood scenarios materialized.

- The spatial extent of the coastal floodplain mapped for this study using a 100-year flood level of 176.0 m IGLD'85 is generally consistent with the existing flood mapping available from the Essex Region Conservation Authority. Minor changes were identified in the interior drainage schemes due to the availability of new high-resolution topographic data. Plus, this study developed spatially varying flood-depth data, which had not previously been generated.

- The spatial extent of the flood inundation projected for Scenarios A and B is significant, with 30 km of shoreline flooded and more than 11,000 acres of interior farmland and

rural residential property under water. There is no guarantee the community could recover from such a massive flood. Point Pelee National Park could become an island and the new Lake Erie shoreline might extend from Sturgeon Creek and the Hillman Marsh. The extent of the post-flood inundation following a dike breach was shown graphically in Figure 4.13 and Figure 4.17.

- Due to the elevation of the existing road network in Southeast Leamington, safe ingress and egress during the 100-year flood is not possible in many locations, including Marentette Beach, East Beach, Cotterie Park, sections of Point Pelee Drive, and all the interior roads in the East Marsh, Marentette, and Lloyd Drains.

- Two rounds of community engagement were completed with over 400 people attending a total of four meetings. Valuable feedback was received from the community, which contributed greatly to the development of adaptation options and the overall content of this report. Due to the COVID-19 pandemic, additional input was sought based on Draft version of the study but no further in-person community engagement session was held. The meetings to date provided useful information to establish key priorities for the project (innovative solutions, cost-sharing, financial assistance, collaboration, etc.) and priorities for evaluating long-term solutions (e.g., overall cost and who pays, sustainable long-term solutions, financial assistance from government, etc.).

- A wide range of adaptation options were developed to address the coastal hazards and associated risks for Southeast Leamington. They were organized by Zone (1 to 4) and followed four principal adaptation themes: Avoid, Accommodate, Retreat, and Protect. In many cases, the costs for the adaptation options exceeded the assessed value of the assets to be protected.

- This updated risk assessment is step one in establishing priorities and pursuing solutions to the severe flood and erosion hazards in Southeast Leamington. Implementing adaptation solutions will require many more steps supported with a united community, stakeholders, and all levels of government. A fractured community and government will not be successful in moving forward beyond this technical study.

7.2 Recommendations:

- The study findings should be shared with senior levels of government in appropriate knowledge sharing forums to explore potential collaborations.

- Continue regular monitoring of critical infrastructure, including dykes, shore protection, and roads.

- Pursue necessary short-term measures to address high vulnerability areas, such as the exposure of the Mersea Road 1 Dike to lake waves.

- Prioritize actions and explore funding opportunities to implement solutions.

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APPENDIX A

Materials from the Public Meetings

Notice of Public Information Centre

Southeast Leamington Graduated Risk Floodplain Mapping Project

Background

The Municipality of Leamington has retained Zuzek Inc., and their sub-consultants SJL Engineering Inc. and Foresight Management Consulting, to complete a Floodplain Study for Southeast Leamington that accounts for the influence coastal storms and climate change. The study area includes the flood prone lands between Wheatley Harbour to the northern border of Point Pelee National Park, and the west shore to Sturgeon Creek. Refer to **Figure 1.**

The Process

This investigation will study the influence of climate change on future coastal hazards due to changes in storms and ice cover and the associated challenges for the coastal communities of Leamington. Updated floodplain mapping will be generated, along with adaptation options to address the coastal hazards. The ultimate goal is to increase the resilience of the Southeast Leamington community to coastal hazards through the development of short-term and long-term solutions.

How to Get Involved

As part of the process, a Public Information Centre (PIC) is scheduled to provide information to homeowners and community members on the overall project, schedule, work completed to date, and to provide an opportunity for questions and feedback.

PIC Information

When: November 27, 2019.
Session 1: 2:00 PM to 4:00 PM (registration at 1:30 PM); **or**
Session 2: 6:30 PM to 8:30 PM (registration at 6:00 PM)

Where: Best Western Plus Leamington Hotel and Conference Centre
566 Bevel Line Road, Leamington, ON

Attendees are asked to register for the meeting in advance to reserve a spot. This will ensure adequate room for all attendees. Please register at www.leamington.ca/projects or by calling (519) 326-5761 ext. 1444.

The goals of this PIC will be to provide an overview of the project and work plan, share the preliminary findings from the fieldwork, present examples of flood hazard mitigation, climate change adaptation and emergency response, and to gather feedback from the attendees about local conditions and the evaluation criteria.

A short presentation followed by questions and answers will be held at the times noted above. Small breakout groups will also be used to gather information on vulnerable areas and priorities for solutions.

Should you have any questions or concerns, please contact Gaspare Graziano, Engineering Project Manager at 519-326-5761 ext. 1303.

This notice issued on Oct. 24, 2019

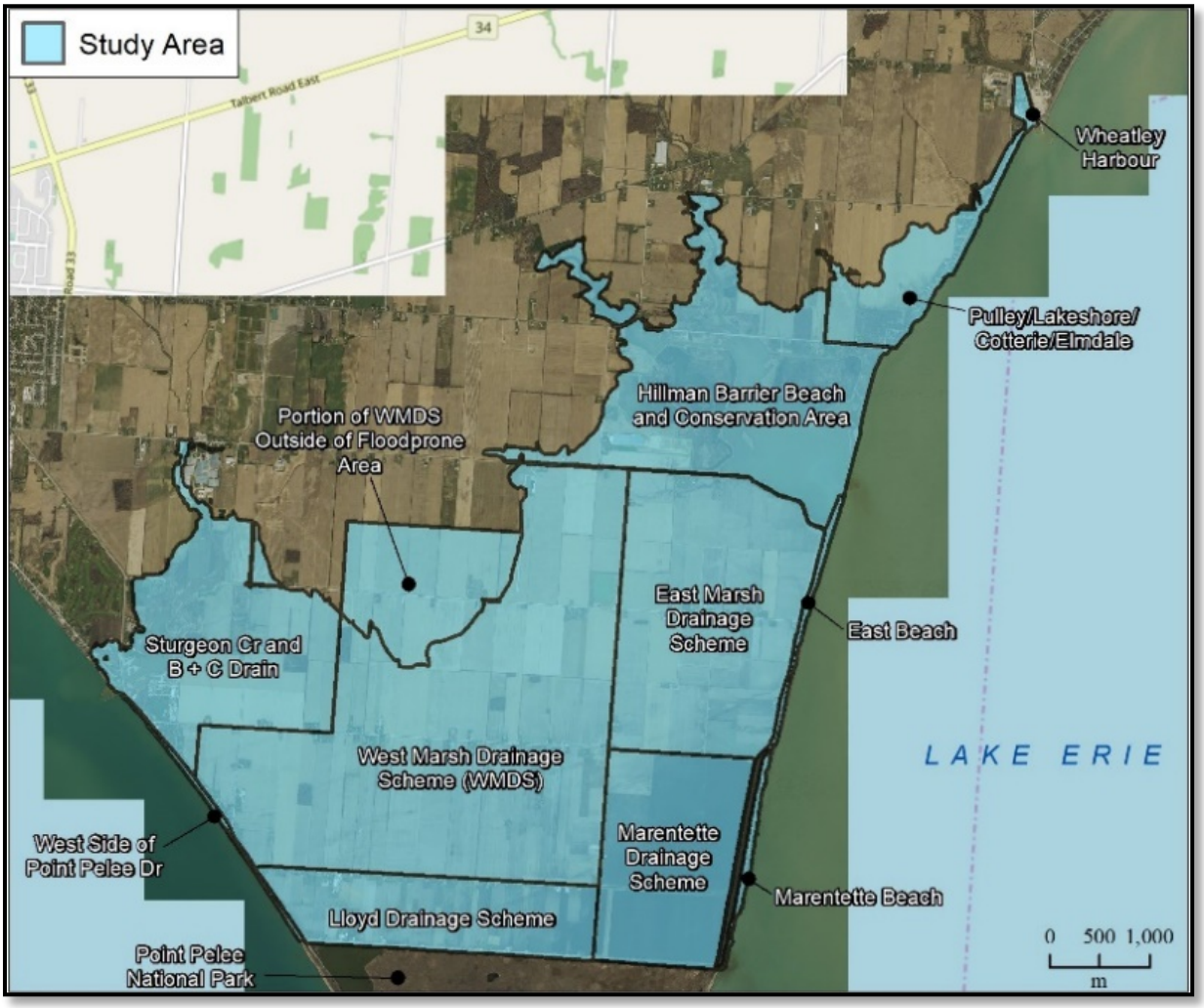

Figure 1: Study Area

Comment Sheet

Southeast Leamington Graduated Risk Floodplain Mapping Project

We want to hear from you! We value your feedback. By completing this comment sheet, your feedback and insights about the project will be considered as the project moves forward.

Please Print Your Name and Contact Information Below

Name: _____ Telephone: _____

Address: _____ E-mail: _____

1. What is the most important aspect of the project?

_____

_____

_____

2. With respect to flooding and erosion hazards, what are the most vulnerable areas in Southeast Leamington?

_____

_____

_____

3. What are your priorities when evaluating long-term solutions to the coastal hazards in Southeast Leamington (overall cost, cost to landowners, sustainability of the solution, staying on the land, protection and enhancement of the coastal ecosystem)?

_____

_____

_____

Please submit your written comments before leaving the meeting or mail / email them by December 20, 2019.

- email to ggraziano@leamington.ca or
- return in person or by mail to the Municipality of Leamington, 111 Erie Street North, Leamington, ON, N8H 2Z9 Attention: Engineering Services

1. Do you have any additional questions or comments for the study team?

Notice of Public Information Centre #2

Southeast Leamington Graduated Risk Floodplain Mapping Project

Background

The Municipality of Leamington has retained Zuzek Inc., and their sub-consultants SJL Engineering Inc. and Foresight Management Consulting, to complete a Floodplain Study for Southeast Leamington that accounts for the influence coastal storms and climate change. The study area includes the flood prone lands between Wheatley Harbour to the northern border of Point Pelee National Park, and the west shore to Sturgeon Creek. Refer to **Figure 1.**

The Process

This investigation will study the influence of climate change on future coastal hazards due to changes in storms and ice cover and the associated challenges for the coastal communities of Leamington. Updated floodplain mapping will be generated, along with adaptation options to address the coastal hazards. The ultimate goal is to increase the resilience of the Southeast Leamington community to coastal hazards through the development of short-term and long-term solutions.

Goals of PIC #2

As part of the process, another Public Information Centre (PIC) is scheduled. The goals of this PIC will be to provide:

- an overview of the project;
- an update on the technical analysis;
- updated floodplain mapping (draft) that accounts for climate change;
- draft economic damage calculations for various flooding scenarios; and
- a breakout session to review the results and provide feedback.

PIC #2 Information:

When: **Wednesday,** January 15, 2020
Session 1: 2:00 PM to 4:00 PM (registration at 1:30 PM); **or**
Session 2: 6:30 PM to 8:30 PM (registration at 6:00 PM)

Where: Best Western Plus Leamington Hotel and Conference Centre
566 Bevel Line Road, Leamington, ON

Attendees are asked to register for the meeting in advance to reserve a spot. This will ensure adequate room for all attendees. We request that you register by Tuesday, January 14, 2020. Please register for PIC #2 on our website at www.leamington.ca/projects or by calling (519) 326-5761 ext. 1444.

Should you have any questions or concerns, please contact Gaspare Graziano, Engineering Project Manager at 519-326-5761 ext. 1303.

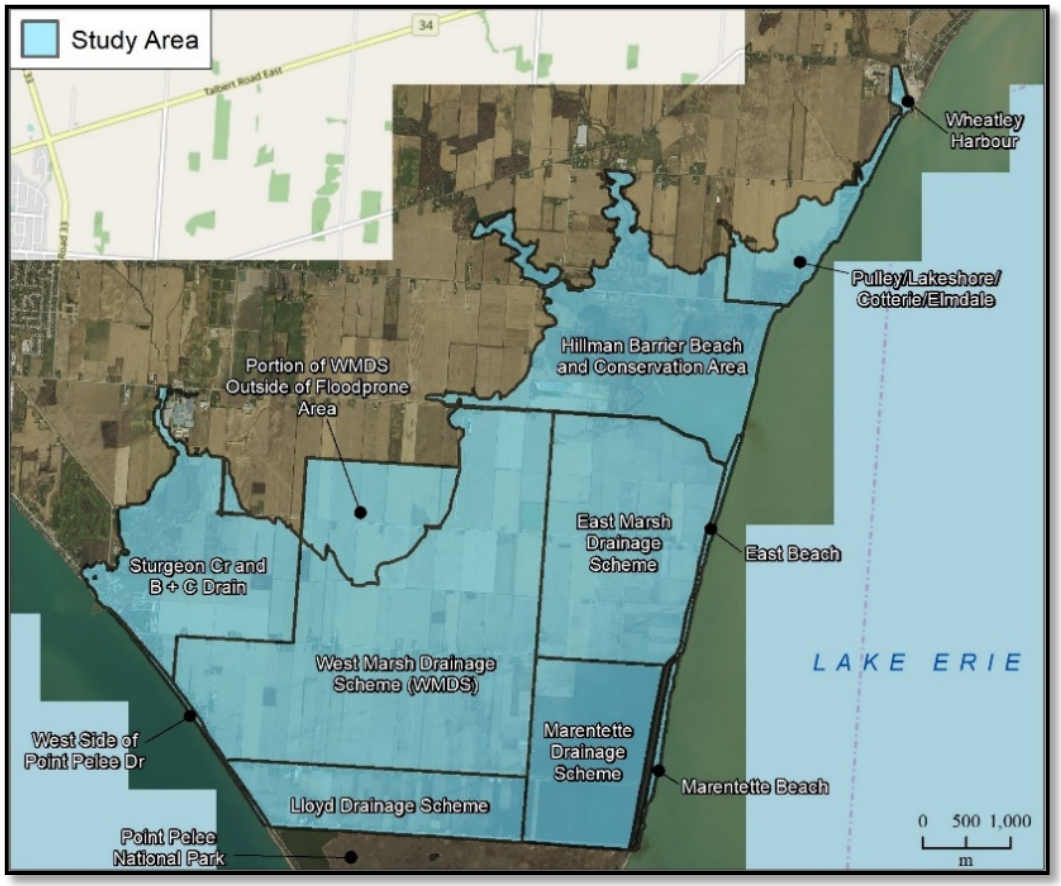

Figure 1: Study Area

This notice issued on December 4, 2019

Comment Sheet

Southeast Leamington Graduated Risk Floodplain Mapping Project

We want to hear from you! We value your feedback. By completing this comment sheet, your feedback and insights about the project will be considered as the project moves forward.

Please Print Your Name and Contact Information Below (OPTIONAL)

Name: _____ Telephone: _____

Address: _____ E-mail: _____

1. Do you agree with the top priorities for evaluating the long-term infrastructure solutions for Southeast Leamington from the first Public Meeting (November 27, 2019):

I. Overall costs and who pays,
II. Sustainability of the long-term solution(s),
III. Financial assistance from government,
IV. Remaining on our land without retreat/re-location,
V. Compensation for loss of property

_____

_____

_____

2. Please share your ideas for long-term sustainable solutions to reduce coastal hazards in Southeast Leamington (avoid, retreat, accommodate, and protect).

_____

_____

_____

_____

Please submit your written comments before leaving the meeting or mail / email them by January 31, 2020.

- email to ggraziano@leamington.ca or
- return in person or by mail to the Municipality of Leamington, 111 Erie Street North, Leamington, ON, N8H 2Z9 Attention: Engineering Services

3. How much would you be willing to pay to protect your private property in Southeast Leamington with a long-term (50-year) infrastructure and/or shoreline protection solution (select one option)?

- ☐ Nothing
- ☐ $10,000 to $25,000
- ☐ $25,000 to $50,000
- ☐ $50,000 to $100,000
- ☐ $100,000 to $200,000
- ☐ Not sure

4. Additional comments: