Lake Ontario
Shoreline Management Plan

Central Lake Ontario Conservation Authority

Pete Zuzek, Zuzek Inc. and Seth Logan, SJL Engineering Inc.

November 5, 2019

Presentation Outline

I. Project Overview - PZ
II. Shoreline Observations - SL
III. Technical Analysis – SL & PZ
IV. Hazard Mapping for Erosion, Flooding, and Dynamic Beaches - SL
V. Management Recommendations for Reaches - PZ
VI. Guidance for Shoreline Protection Structures - SL
VII. Questions and Discussion

I – PROJECT OVERVIEW

Principles and Objectives for the Shoreline Management Plan (SMP)

- Principles
  - Sustainable coastal development (balance between environment, society, economy)
  - Integrated coastal zone management (systems approach – everything is connected)

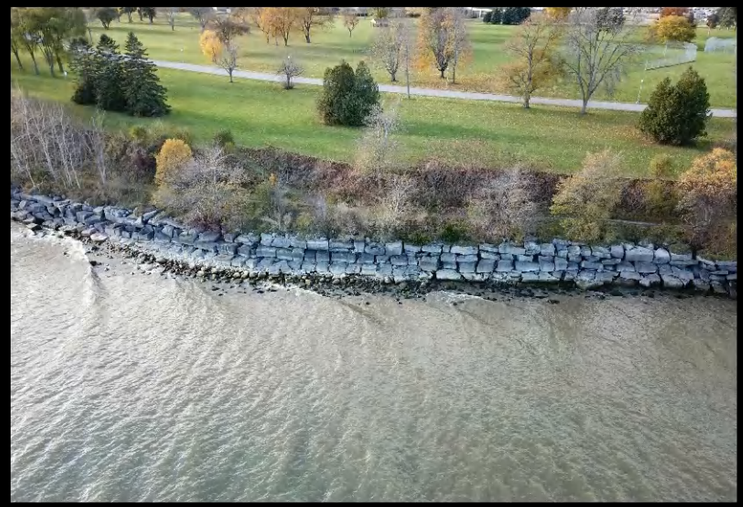
- Objectives
  - Protect new development from coastal hazards
  - Increase the resilience of coastal communities
  - Integrate climate change impacts when estimating future coastal hazards
  - Maintain sediment supply to local beaches and barrier beach ecosystems
  - Incorporate nature-based options to reduce coastal hazards
  - Maintain existing public open spaces

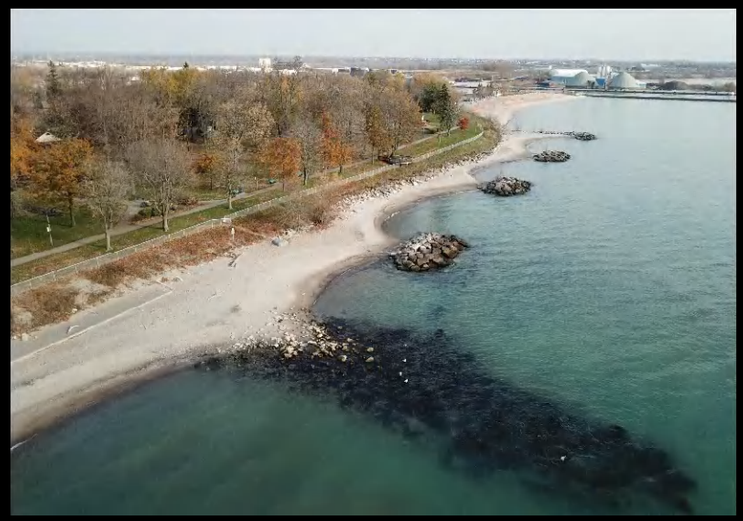
Major Components of the SMP

- Field Work in the Fall of 2018
- Technical Analysis in the Fall 2018 and Winter 2019
- Emergency field visits in May 2019
- Hazard Mapping (Erosion, Flooding, Dynamic Beaches)
- Coastal Management recommendations
  - Must consider regulations, policy, and legislation
  - Focus on increasing resilience to high lake levels, flooding, and erosion
- Public Feedback in the Fall 2019
- Draft Shoreline Management Plan report (Winter 2020)

II – SHORELINE OBSERVATIONS

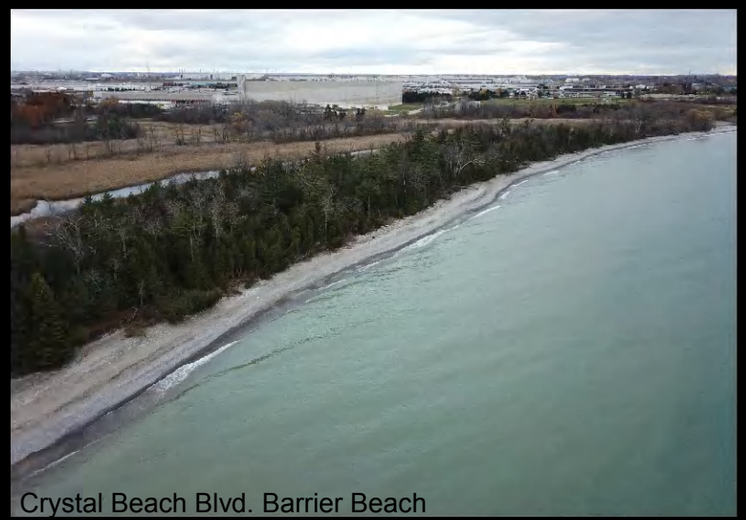
CLOCA – Developed Areas





CLOCA – Natural Areas

Lakeside Park – West Boundary


Crystal Beach Blvd. Barrier Beach

Pumphouse Marsh - Oshawa

Lakewoods Park - Oshawa

Oshawa West Fillet Beach

Port Darlington West Barrier Beach

CLOCA – High Risk Areas

Ontoro Blvd., Ajax
Erosion
Structural

Barrier Beach / Wetlands (several)
Erosion
Flooding
Environmental/Ecological

Crystal Beach Blvd.
Erosion
Flooding
Structural

CLOCA – High Risk Areas

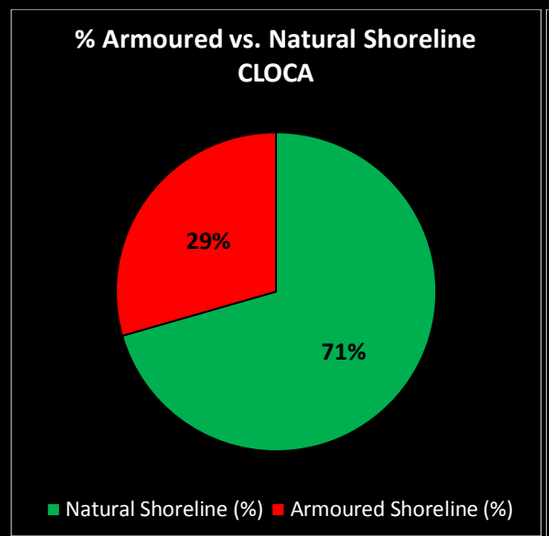
Stone Street, Oshawa
Erosion
Structural

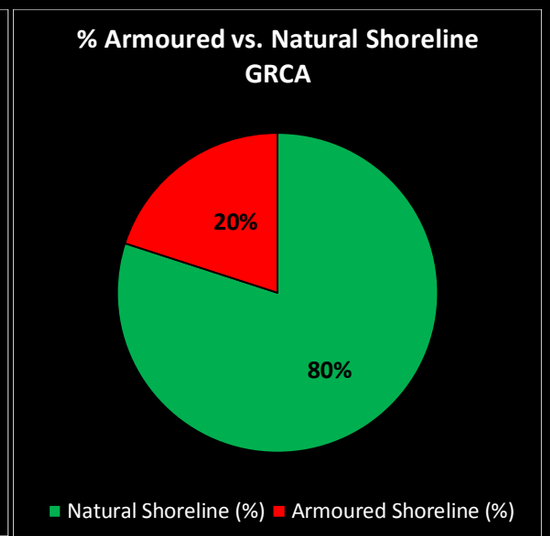
Cedar Crest Beach Blvd., Darlington
Erosion
Flooding
Structural

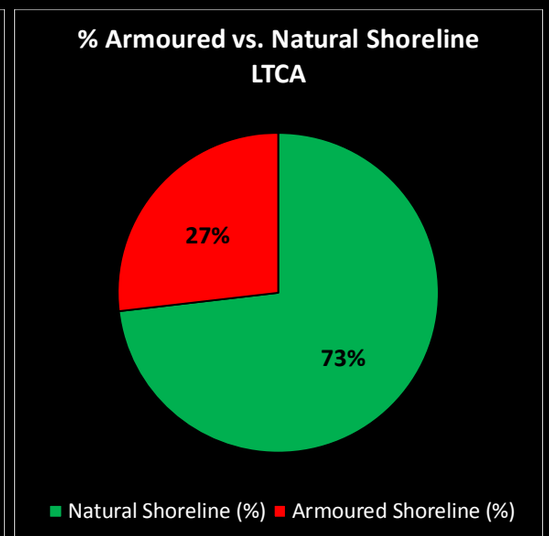
East Darlington
Erosion
Structural

Coastal Structures Database

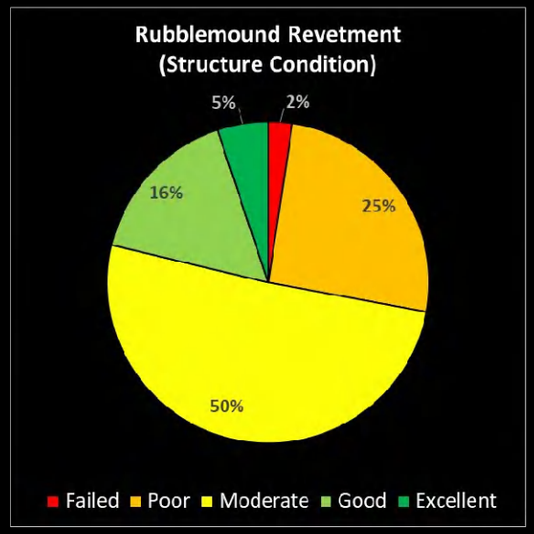
- Shoreline protection database was assembled for entire project shoreline
- Statistics summarize by project reach and Conservation Authority for:
  - Armoured vs. natural shoreline
  - Structure type
  - Structure condition
  - Level of design
  - Structure importance

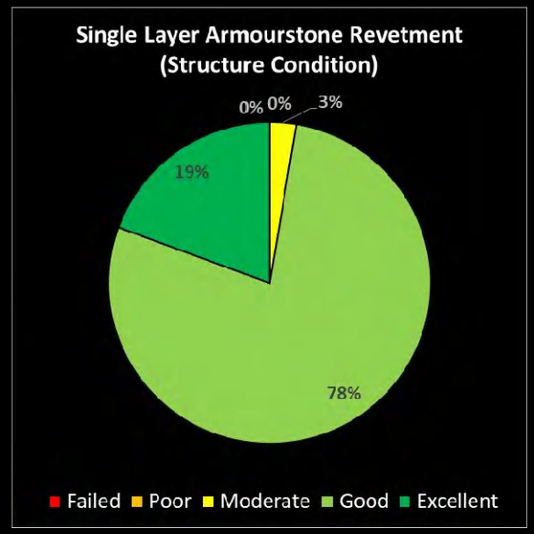


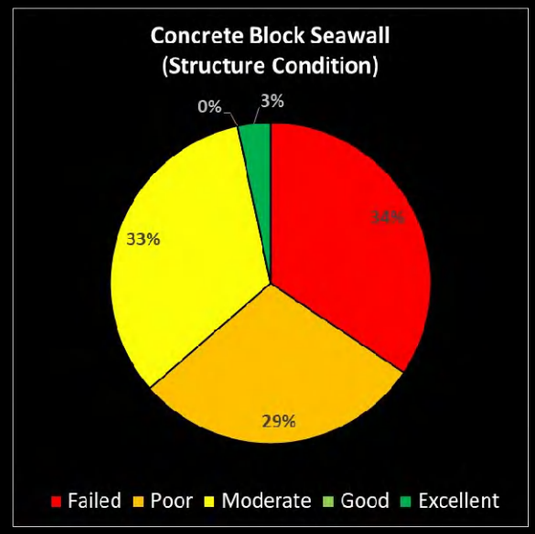




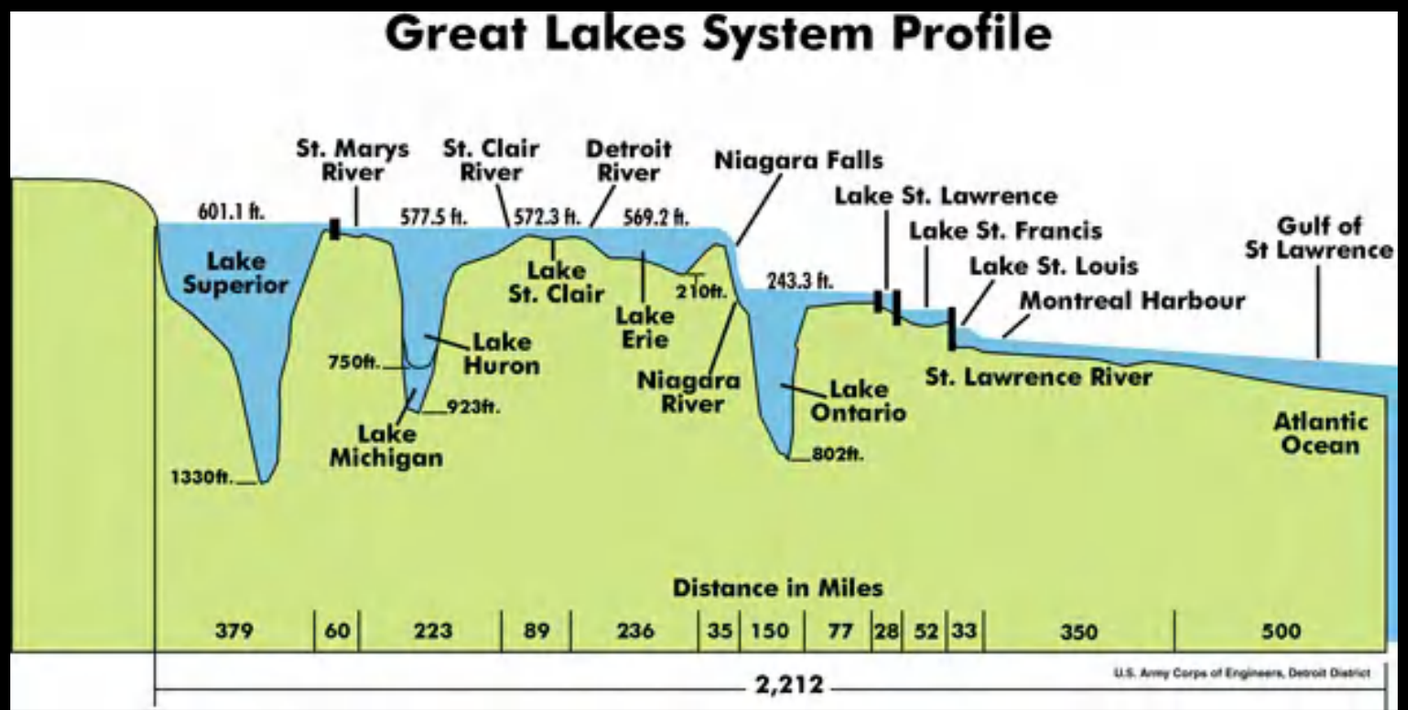
Coastal Structures Database – Stats by Structure Type







III – TECHNICAL ANALYSIS



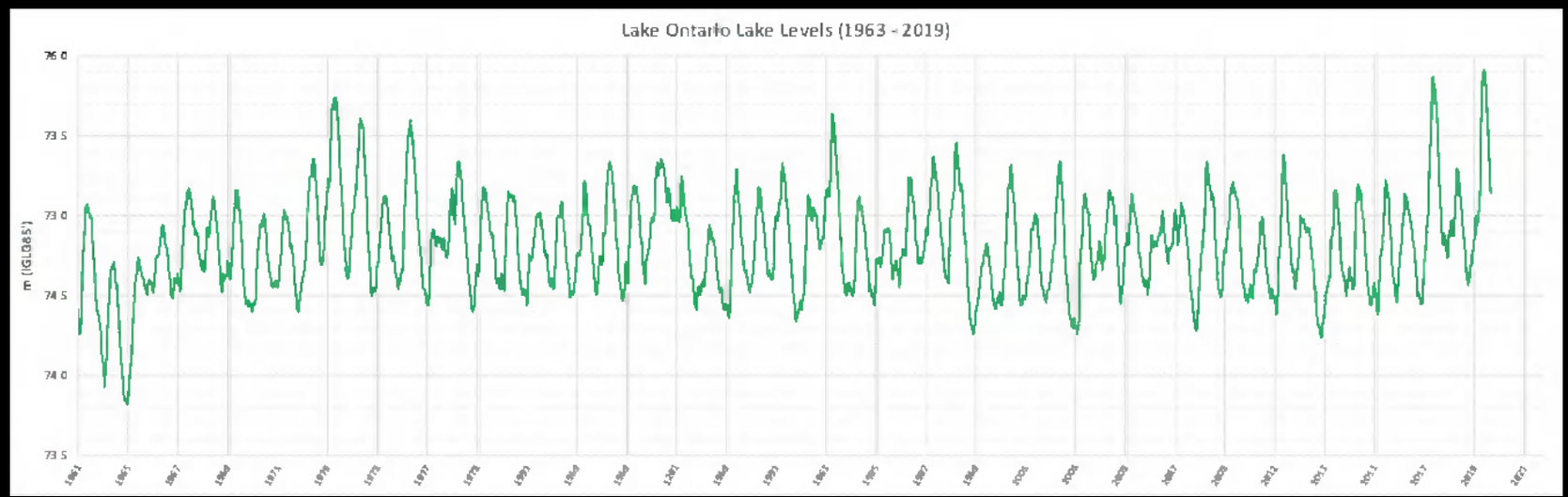
Lake Ontario Water Levels

- Only Lake Ontario and Lake Superior are “regulated”
- All five Great Lakes, Lake St. Clair, Ottawa River and St. Lawrence River met or exceeded record levels in 2019
- Net Supply to Lake Ontario (500,000 km^2 drainage basin):
  - Lake Erie 85%, local supply 15% (precipitation, now melt, runoff, rivers/streams)
  - Record net supply Jan – Jun, 2019
- Net Outflow:
  - Combination of evaporation and outflow to St. Lawrence
  - Record outflows Jun – Aug, 2019
- Timing of inputs and outputs is critical

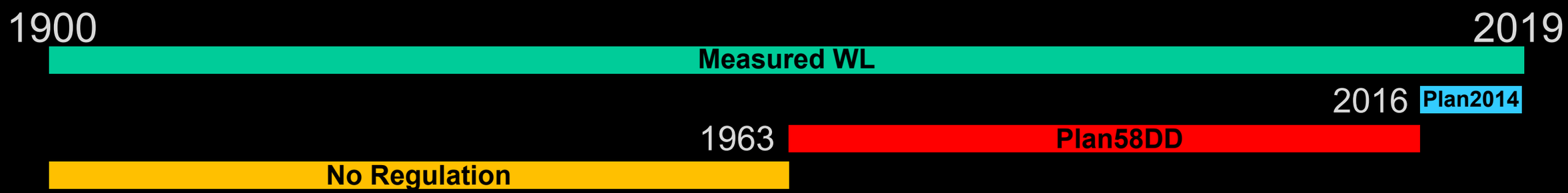
- Water levels are highly variable and impossible to predict due to variability in net supply
- Focus must be on improving community resilience to water level fluctuations and future extremes

Water Levels – 100-year Flood Level

- 100-year Flood Level defined as:
  - “Maximum instantaneous still water level with a probability of occurrence of 1% in any given year”
- Combination of static lake level and storm surge
  - Independent variables
  - Requires a joint probability analysis

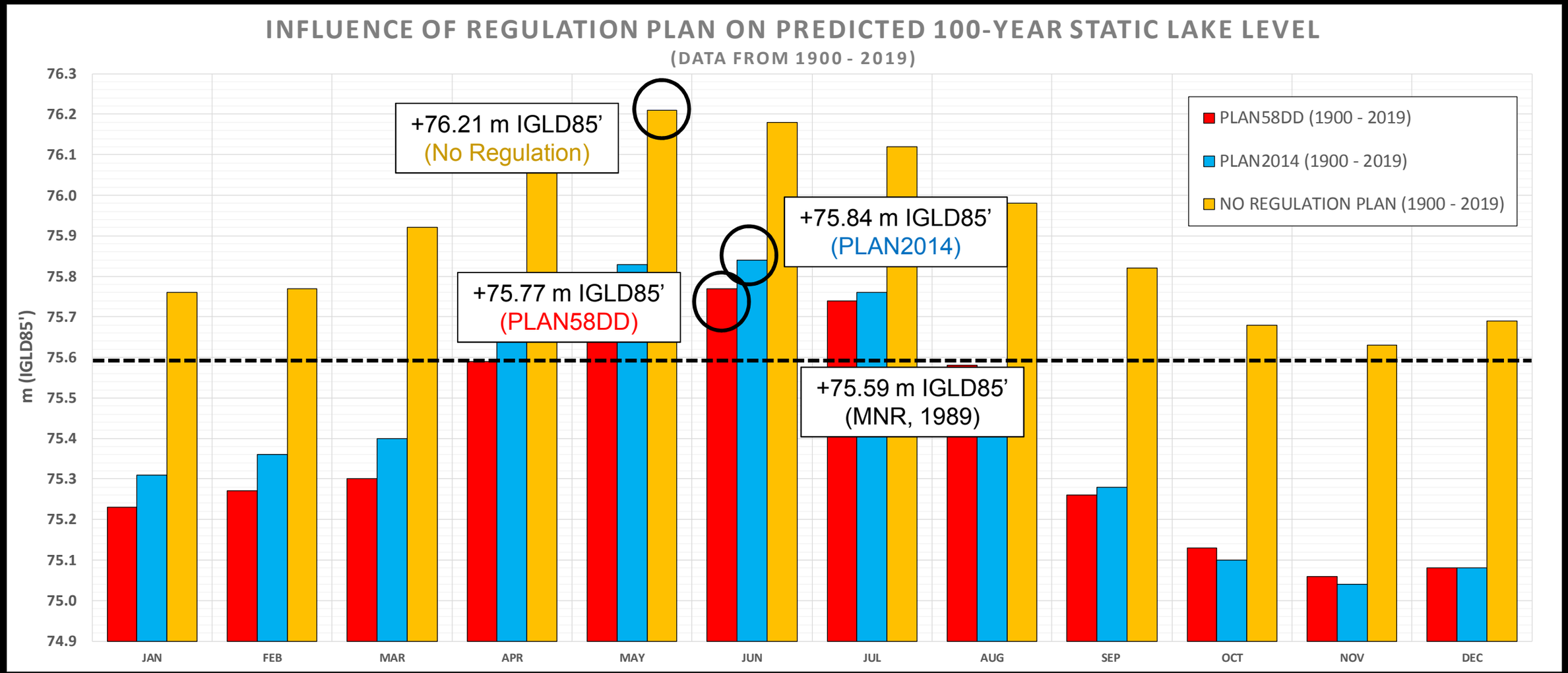


Lake Ontario Static Lake Level



- Statistical analysis of modelled WL datasets (courtesy of ECCC):
  - Modelled Pre-Regulation Plan (1900 – 2008)
  - Modelled Plan58DD (1900 – 2008)
  - Modelled Plan2014 (1900 – 2008)
- Each dataset has the same historical inflows, different outflows based on regulation plan
- Measured data from 2009 to 2017 added to each modelled dataset
- Monthly Extreme Value Analysis (EVA) completed for each dataset

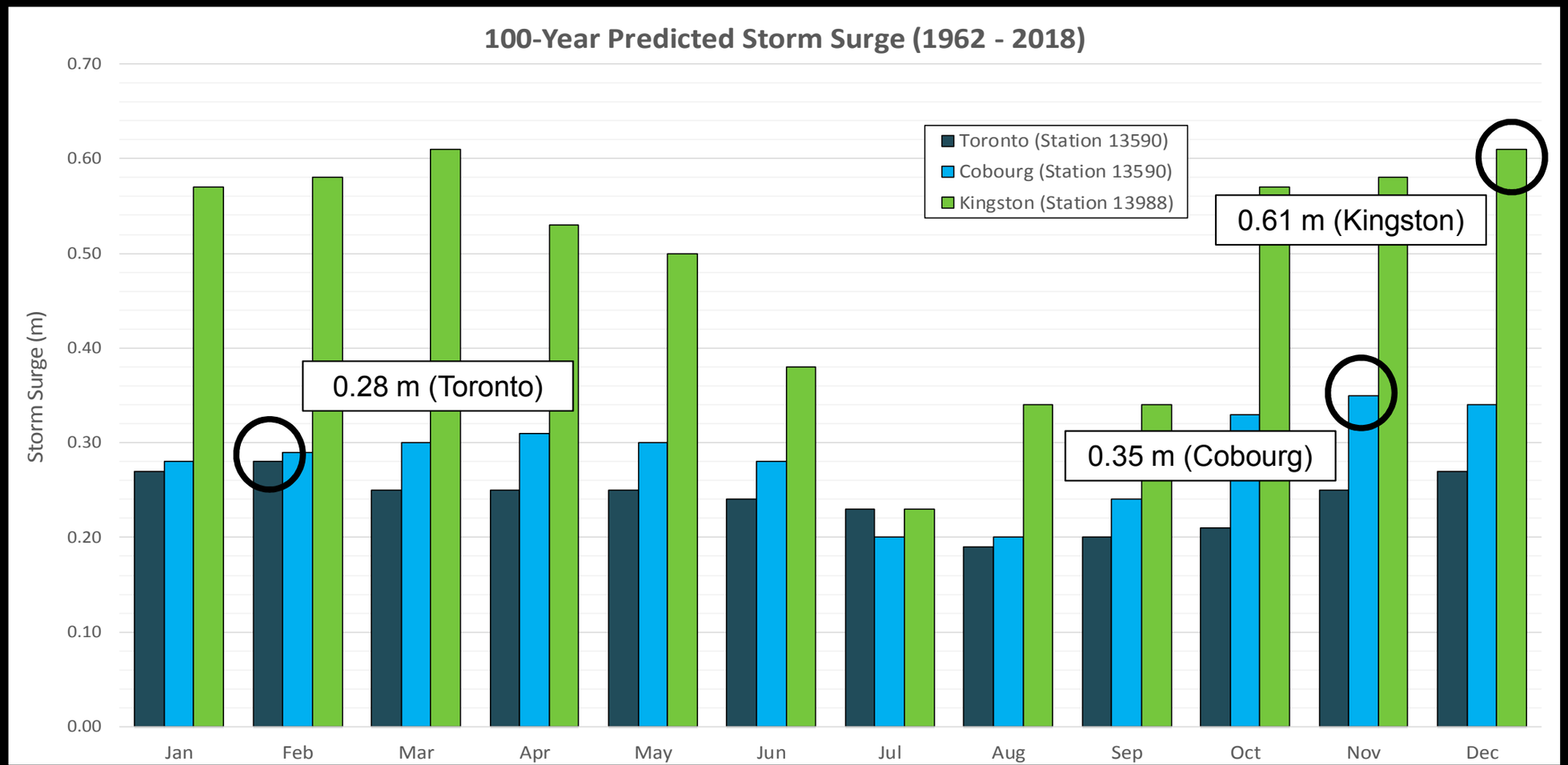
Influence of WL Regulation on 100-yr Static Lake Level



SL1

Lake Ontario Storm Surge

- Measured storm surge analysed at Toronto, Cobourg and Kingston (1962 – 2018)

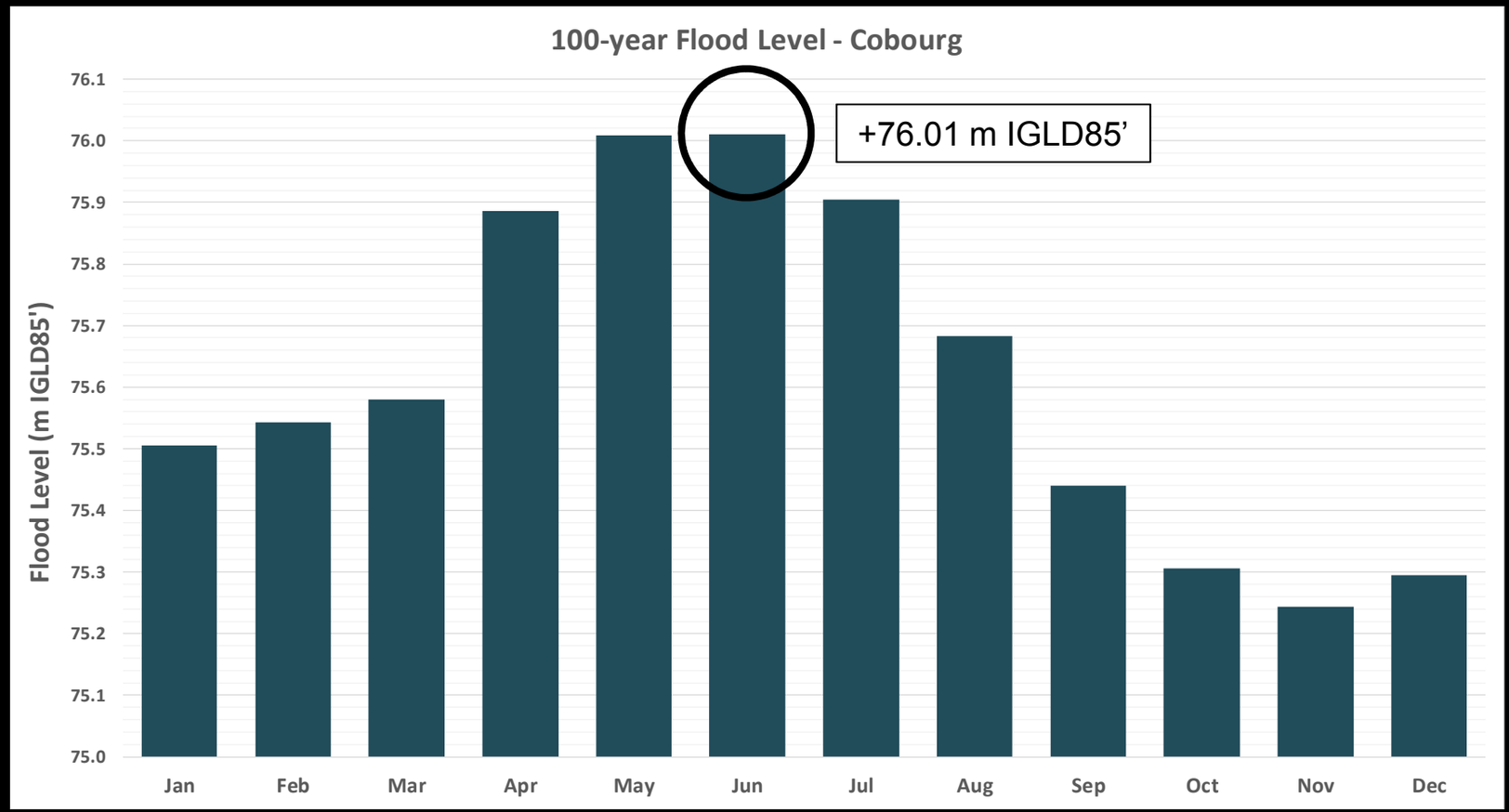


Slide 18

SL1 Seth Logan, 26/03/2019

100-year Combined Flood Level

- Combination of static lake level and storm surge
- Joint probability assessment of static WL + storm surge (Toronto, Cobourg, Kingston)



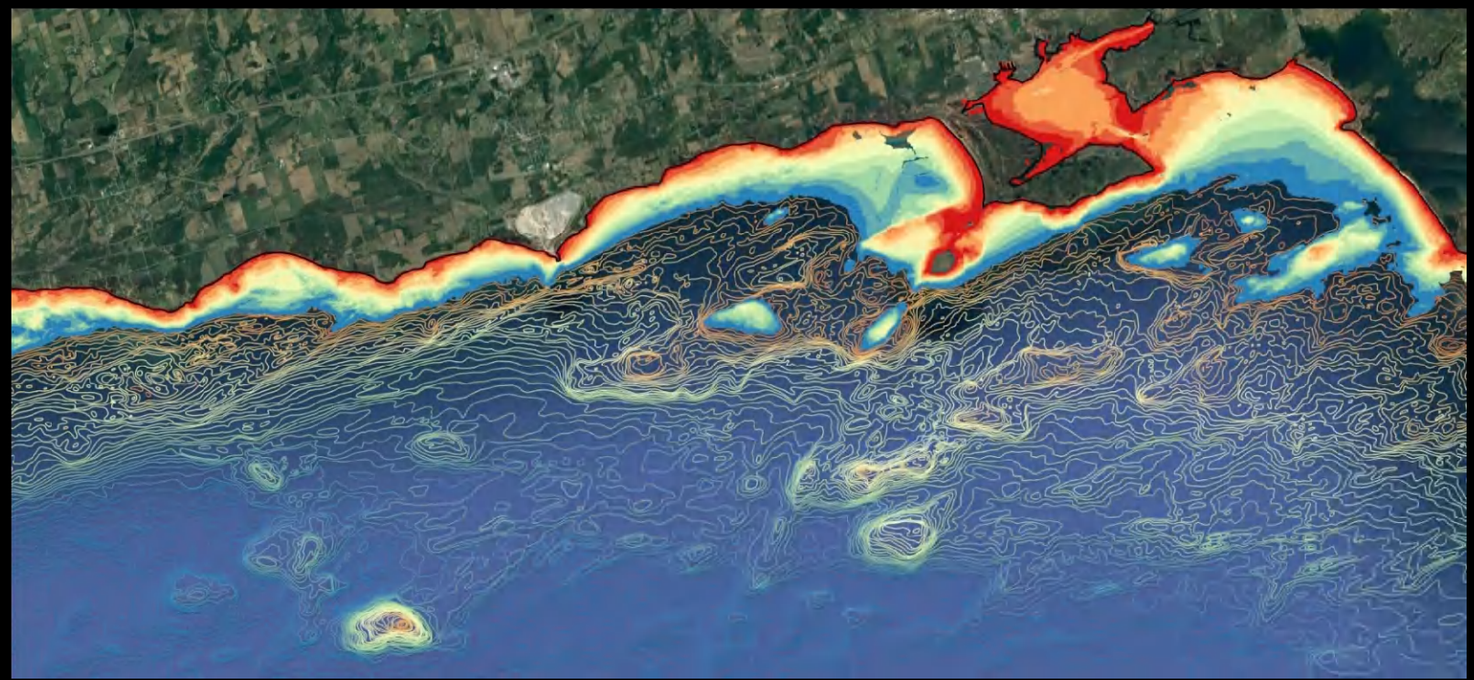
Water Levels – 100-year Combined Flood Level

Gauge Location	MNR (1989)	Updated (2019)	
Toronto	+75.74	+76.01	+0.27
Cobourg	+75.80	+76.01	+0.21
Kingston	+75.99	+76.08	+0.09

*Datum is IGLD85'

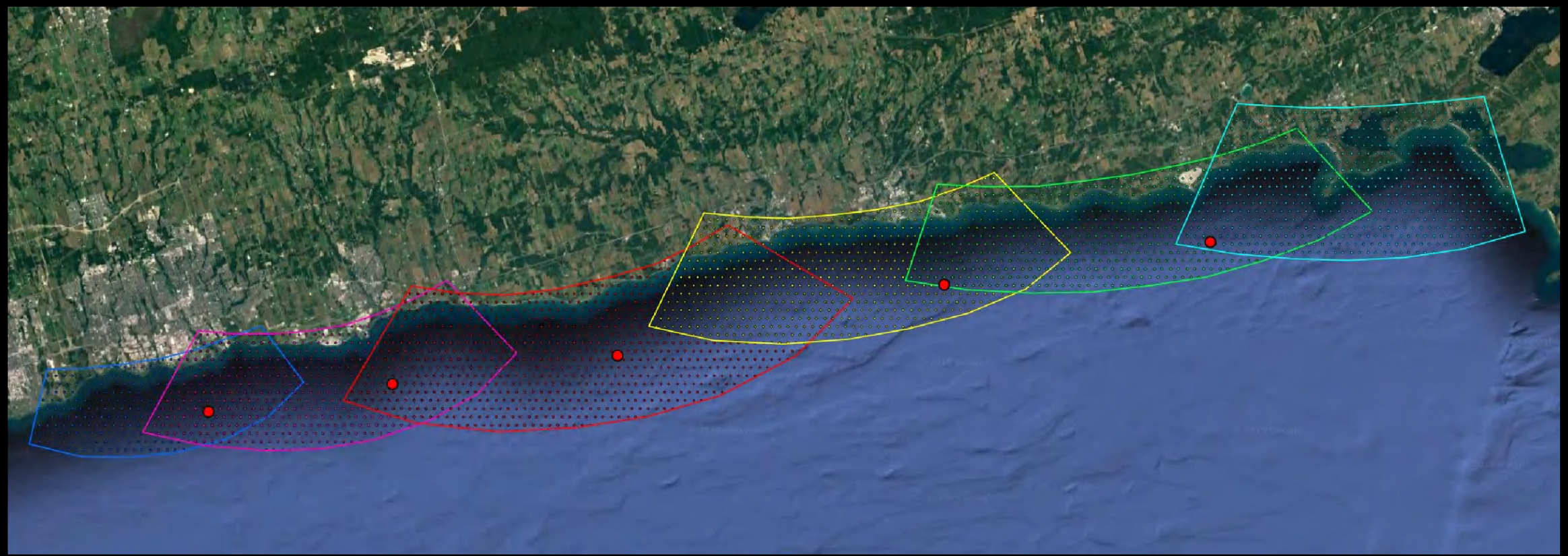
- Interpolating to Conservation Authority boundaries gives:
  - CLOCA = +76.01 m IGLD85'
  - GRCA = +76.01 m IGLD85'
  - LTRA = +76.03 m IGLD85'

WAVE MODELLING & SEDIMENT TRANSPORT

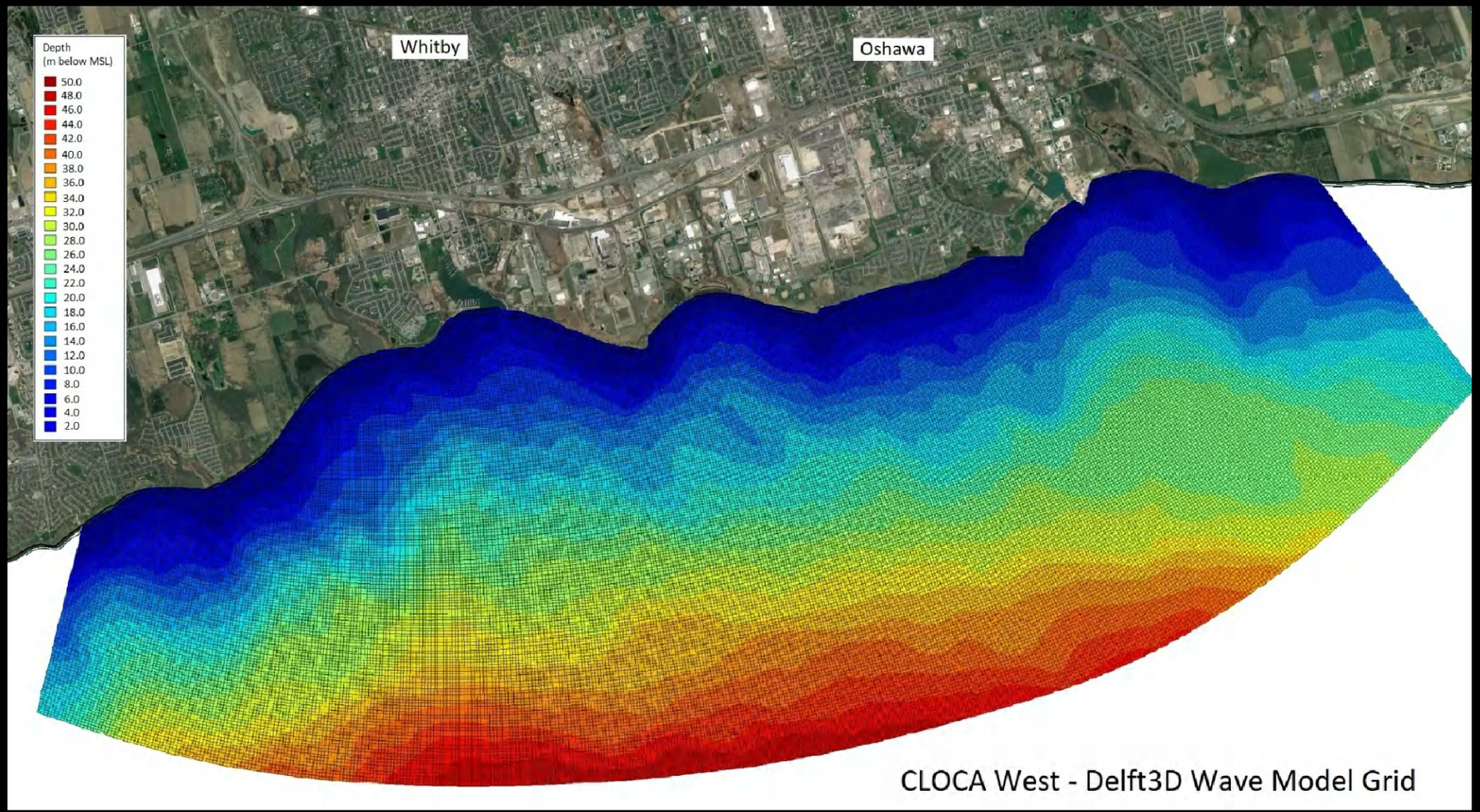


Wave Modelling – Delft3D

- Offshore wave statistics were analysed from WIS hindcast data (USACE)
- 6 nearshore wave models setup using Delft3D Wave

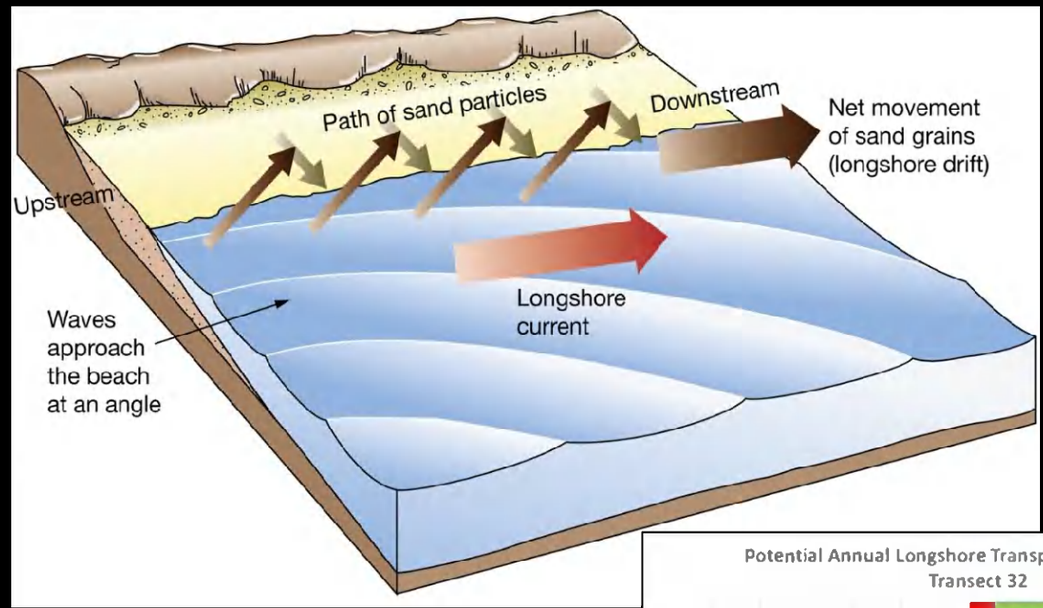


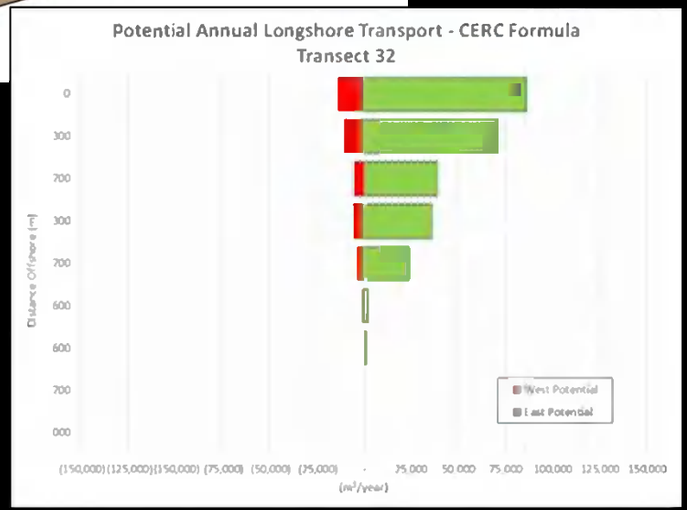
Wave Modelling – Delft3D



Longshore Sediment Transport

- What is “Longshore Sediment Transport”?
  - Sediment transported laterally along the coastline due to wave action or currents
  - “Potential” longshore sediment transport is the volume of sediment that would be moved if sufficient sediment is available
  - “Actual” longshore sediment transport may be considerably less due to lack of sediment supply

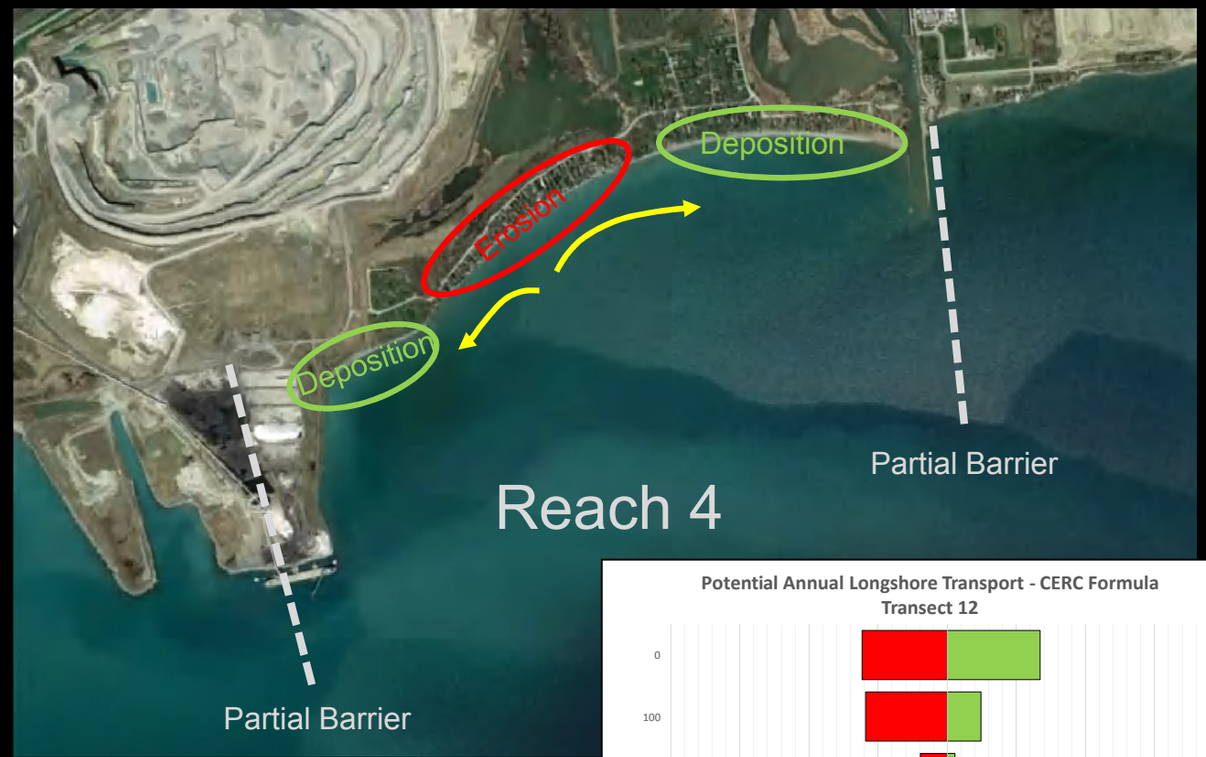


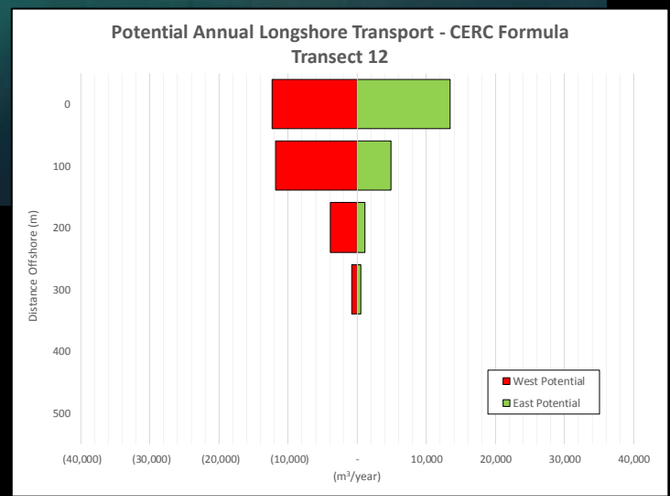


SHORELINE REACHES FOR STUDY AREA

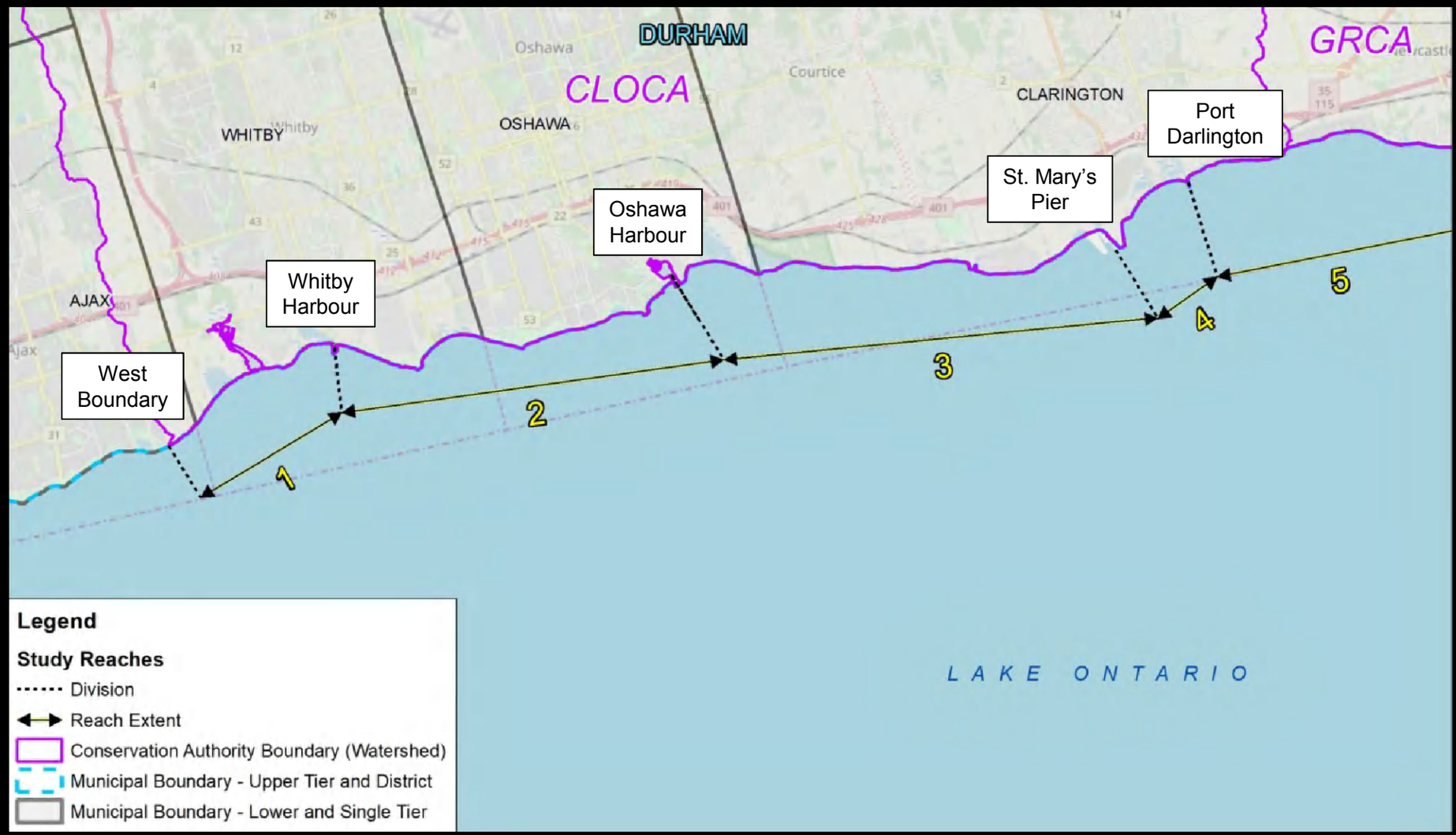
Shoreline Reaches

- Shoreline reaches delineated primarily based on littoral sub-cells:
  - Littoral sub-cell boundaries are defined by natural features or man-made structures that act as partial barriers to the alongshore movement of sediment
  - Divides the shoreline into partially self-contained systems of erosion/deposition
- 13 distinct shoreline reaches identified (down from 66 in 1990 SMP)





Shoreline Reaches - CLOCA



Erosion Rate Approach

BLUFF

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REACH 5
1954 to 2018 Transect Summary - Top of Bluff

Lake Ontario SMP

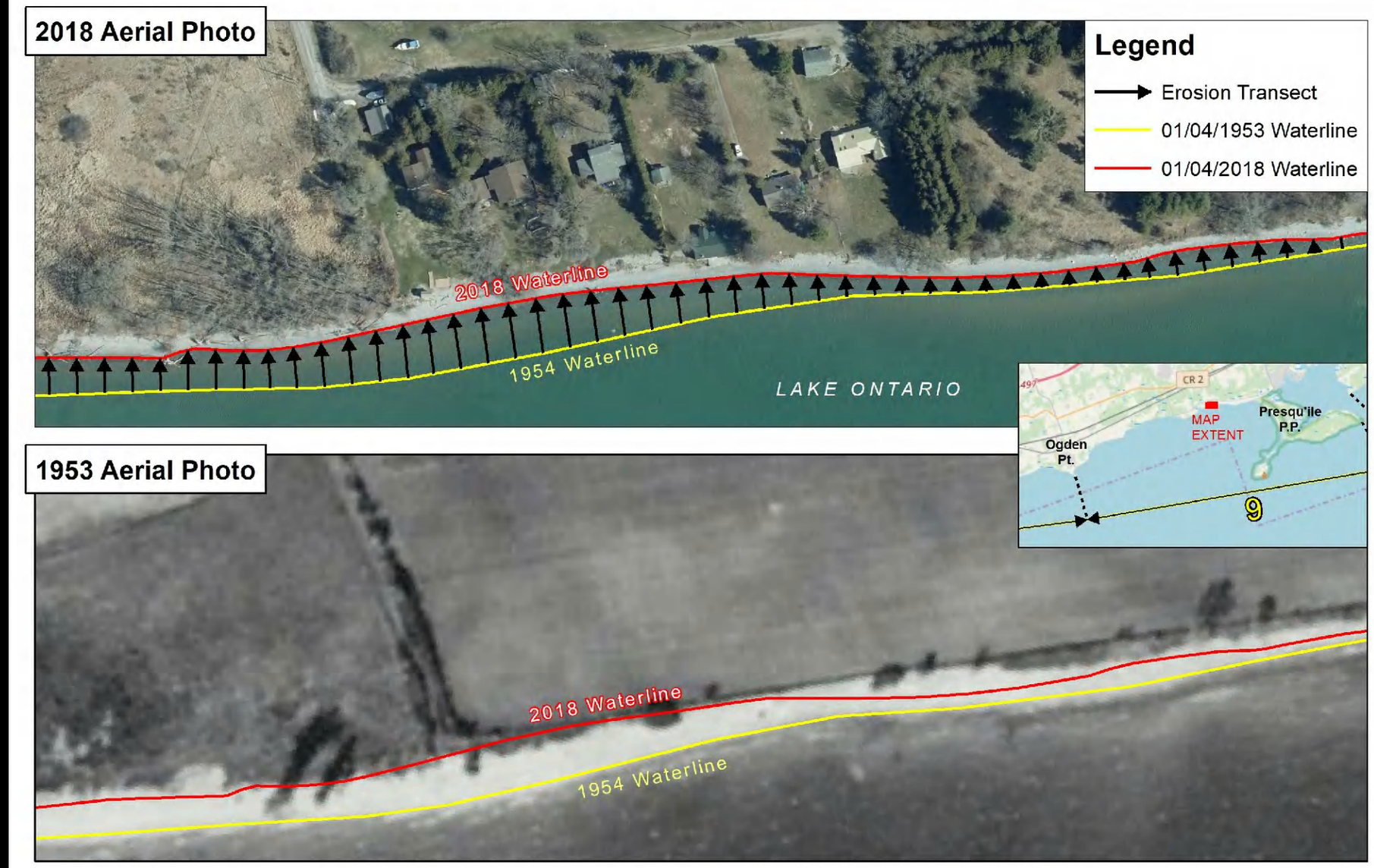
2018 Orthophotography provided by © First Base Solutions

DRAFT

0 10 20 30 40 50
m

Erosion Rate Approach

BEACH



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REACH 9
1954 to 2018 Transect Summary - Eroding Waterline

Lake Ontario SMP

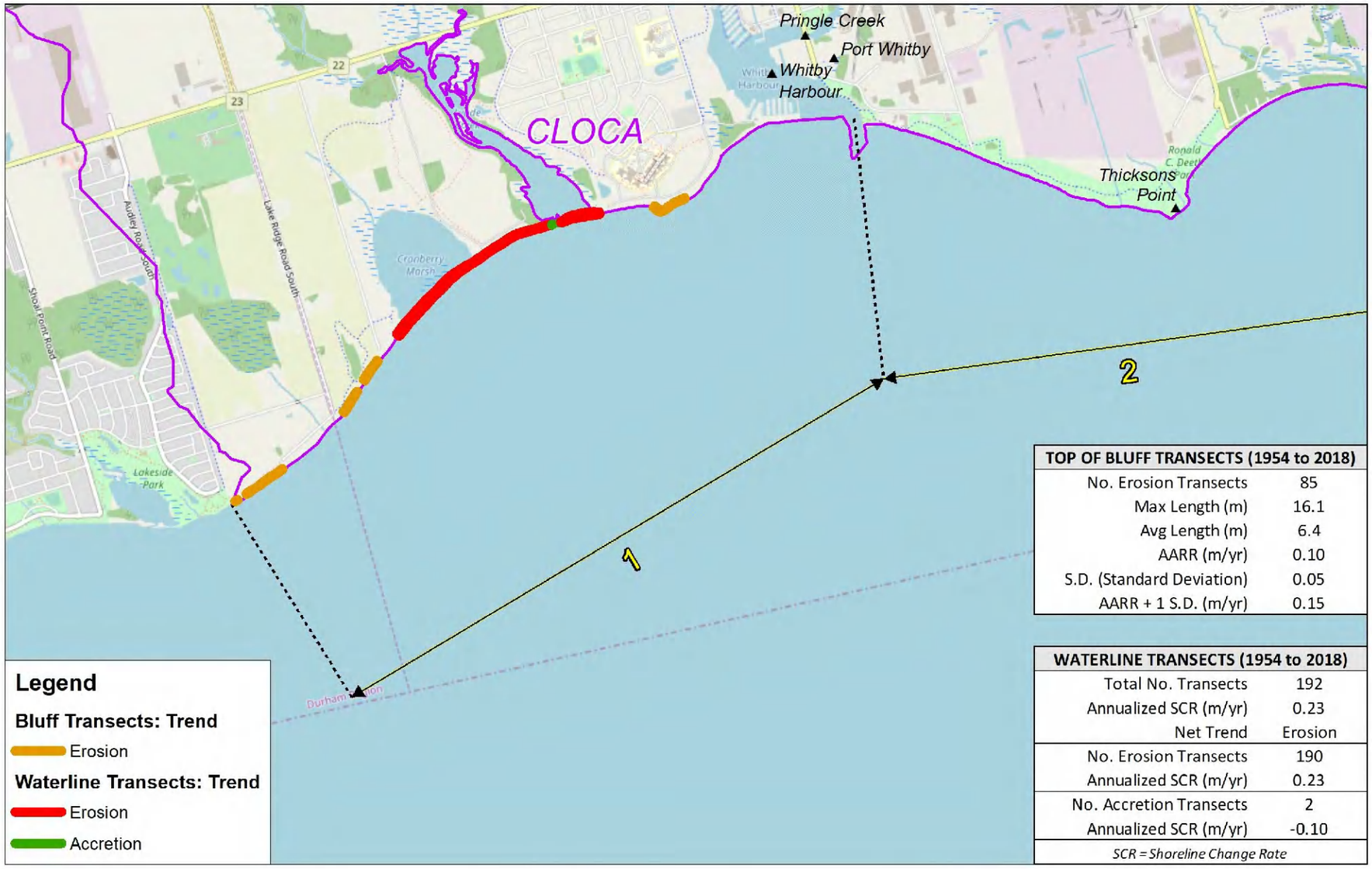
Note:

DRAFT

N W E S

0 50
m

Reach 1



TOP OF BLUFF TRANSECTS (1954 to 2018)	
No. Erosion Transects	85
Max Length (m)	16.1
Avg Length (m)	6.4
AARR (m/yr)	0.10
S.D. (Standard Deviation)	0.05
AARR + 1 S.D. (m/yr)	0.15

WATERLINE TRANSECTS (1954 to 2018)	
Total No. Transects	192
Annualized SCR (m/yr)	0.23
Net Trend	Erosion
No. Erosion Transects	190
Annualized SCR (m/yr)	0.23
No. Accretion Transects	2
Annualized SCR (m/yr)	-0.10
SCR = Shoreline Change Rate	

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REACH 1
1954 to 2018 Transect Summary (Top of Bluff + Waterline)

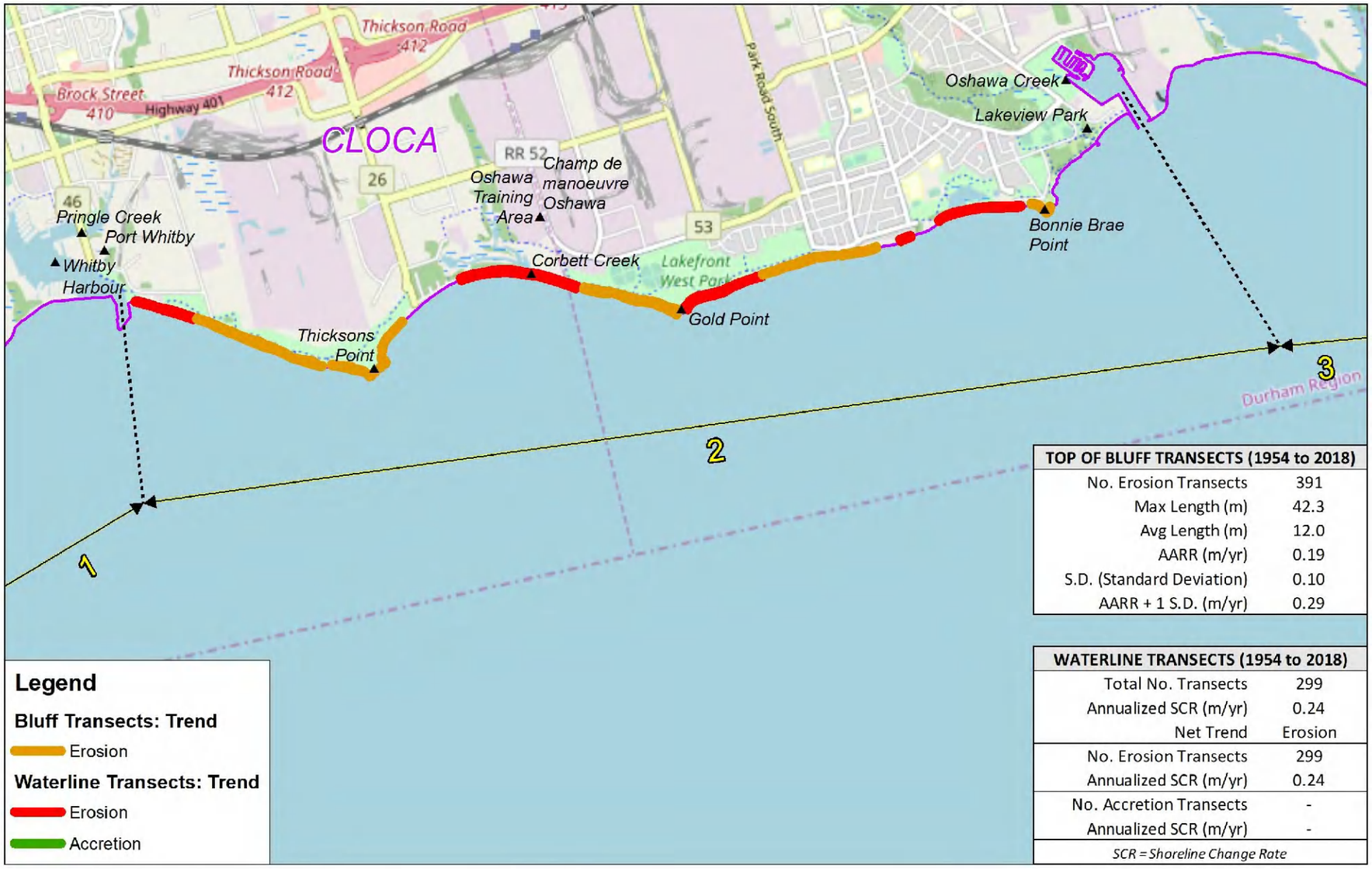
Lake Ontario SMP

Note:
1) Dynamic beaches were excluded from the waterline analysis
2) Areas with engineered shore protection were excluded from the analysis

DRAFT

N W E S
0 1 km

Reach 2



TOP OF BLUFF TRANSECTS (1954 to 2018)	
No. Erosion Transects	391
Max Length (m)	42.3
Avg Length (m)	12.0
AARR (m/yr)	0.19
S.D. (Standard Deviation)	0.10
AARR + 1 S.D. (m/yr)	0.29

WATERLINE TRANSECTS (1954 to 2018)	
Total No. Transects	299
Annualized SCR (m/yr)	0.24
Net Trend	Erosion
No. Erosion Transects	299
Annualized SCR (m/yr)	0.24
No. Accretion Transects	-
Annualized SCR (m/yr)	-
SCR = Shoreline Change Rate	

Legend

Bluff Transects: Trend

Erosion

Waterline Transects: Trend

Erosion

Accretion

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REACH 2
1954 to 2018 Transect Summary (Top of Bluff + Waterline)

Lake Ontario SMP

Note:
1) Dynamic beaches were excluded from the waterline analysis
2) Areas with engineered shore protection were excluded from the analysis

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N W E S

0 1 2
km

Reach 3

TOP OF BLUFF TRANSECTS (1954 to 2018)	
No. Erosion Transects	348
Max Length (m)	30.4
Avg Length (m)	9.9
AARR (m/yr)	0.16
S.D. (Standard Deviation)	0.09
AARR + 1 S.D. (m/yr)	0.25

WATERLINE TRANSECTS (1954 to 2018)	
Total No. Transects	335
Annualized SCR (m/yr)	0.32
Net Trend	Erosion
No. Erosion Transects	308
Annualized SCR (m/yr)	0.36
No. Accretion Transects	27
Annualized SCR (m/yr)	-0.11
SCR = Shoreline Change Rate	

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REACH 3
1954 to 2018 Transect Summary (Top of Bluff + Waterline)

Lake Ontario SMP

Note:
1) Dynamic beaches were excluded from the waterline analysis
2) Areas with engineered shore protection were excluded from the analysis

DRAFT

N W E S
0 1 2
km

Reach 4

TOP OF BLUFF TRANSECTS (1954 to 2018)	
No. Erosion Transects	20
Max Length (m)	23.6
Avg Length (m)	18.0
AARR (m/yr)	0.28
S.D. (Standard Deviation)	0.05
AARR + 1 S.D. (m/yr)	0.33

WATERLINE TRANSECTS (1954 to 2018)	
Total No. Transects	97
Annualized SCR (m/yr)	-0.10
Net Trend	Accretion
No. Erosion Transects	33
Annualized SCR (m/yr)	0.17
No. Accretion Transects	64
Annualized SCR (m/yr)	-0.24
SCR = Shoreline Change Rate	

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REACH 4
1954 to 2018 Transect Summary (Top of Bluff + Waterline)

Lake Ontario SMP

Note:
1) Dynamic beaches were excluded from the waterline analysis
2) Areas with engineered shore protection were excluded from the analysis

DRAFT

N W E S
0 1
km

Reach 5

TOP OF BLUFF TRANSECTS (1954 to 2018)	
No. Erosion Transects	420
Max Length (m)	24.2
Avg Length (m)	11.0
AARR (m/yr)	0.17
S.D. (Standard Deviation)	0.07
AARR + 1 S.D. (m/yr)	0.24

WATERLINE TRANSECTS (1954 to 2018)	
Total No. Transects	36
Annualized SCR (m/yr)	0.13
Net Trend	Erosion
No. Erosion Transects	36
Annualized SCR (m/yr)	0.13
No. Accretion Transects	-
Annualized SCR (m/yr)	-
SCR = Shoreline Change Rate	

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REACH 5
1954 to 2018 Transect Summary (Top of Bluff + Waterline)

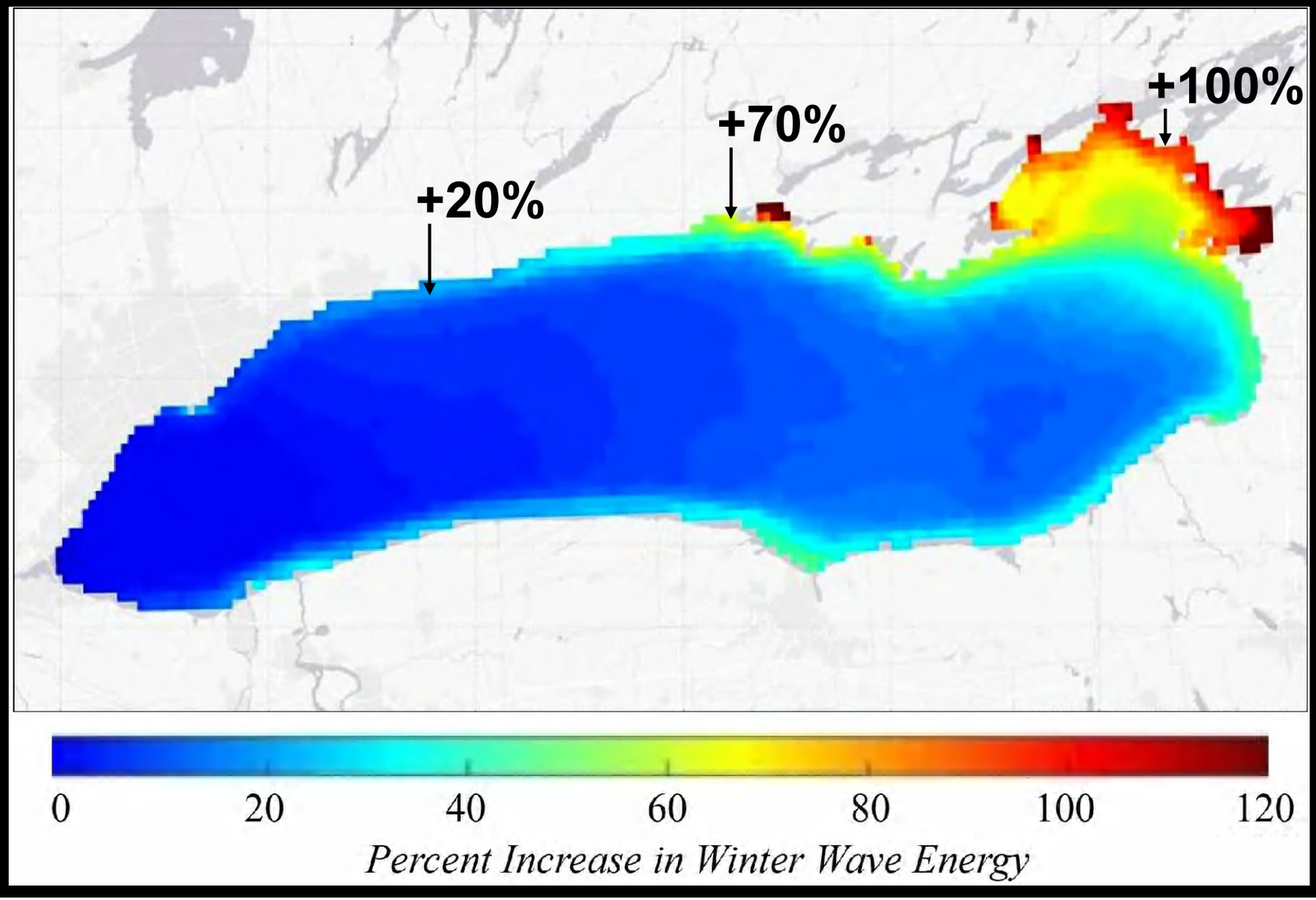
Lake Ontario SMP

Note:
1) Dynamic beaches were excluded from the waterline analysis
2) Areas with engineered shore protection were excluded from the analysis

DRAFT

N W E S
0 1 2
km

Change in 2000 to 2013 Winter Wave Energy versus RCP8.5 Late Century Wave Energy



IV – HAZARD MAPPING FOR EROSION, FLOODING & DYNAMIC BEACHES

Shoreline Hazards – Lake Ontario

- Shoreline hazards are defined in the Conservation Authorities Act & MNRF Technical Guide (2001)
- Regulation of hazards became law for CAs in 2006
- Specific Regulations:
  - CLOCA – Ontario Reg. 42/06
  - GRCA – Ontario Reg. 168/06
  - LTCA – Ontario Reg. 163/06
- Governing hazard setback is furthest landward extend of:
  - Erosion Hazard
  - Flooding Hazard
  - Dynamic Beach Hazard
- Regulated setback may include additional allowances

Shoreline Hazards – Lake Ontario

- Erosion Hazard is defined as:
  - "The predicted long term stable slope projected from the existing stable toe of the slope or from the predicted location of the toe of the slope as that location may have shifted as a result of shoreline erosion over a 100-year period"

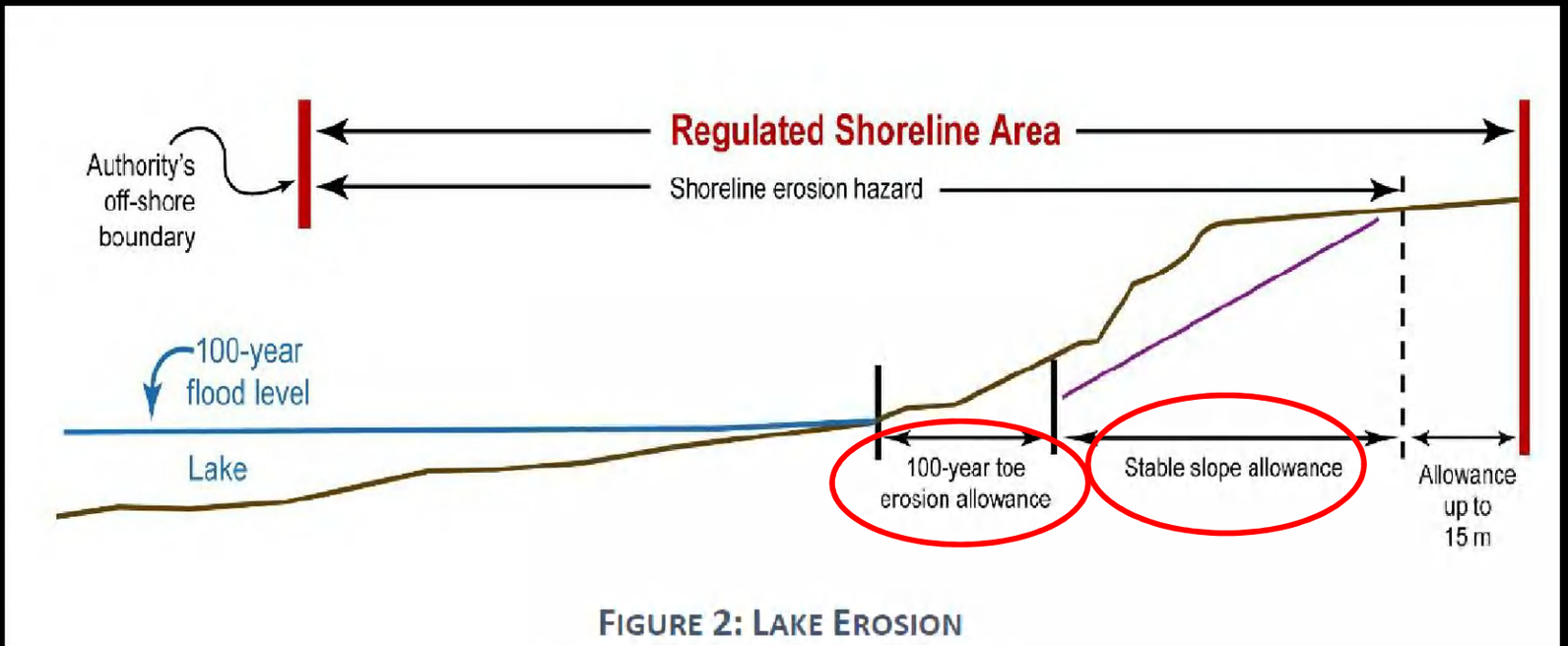


FIGURE 2: LAKE EROSION

Figure taken from LTCA Policy Manual – Ontario Reg. 163/06

Shoreline Hazards – Lake Ontario

- Flooding Hazard is defined as:
  - "The 100-year flood level plus an appropriate allowance for wave uprush (and other water-related hazards)"

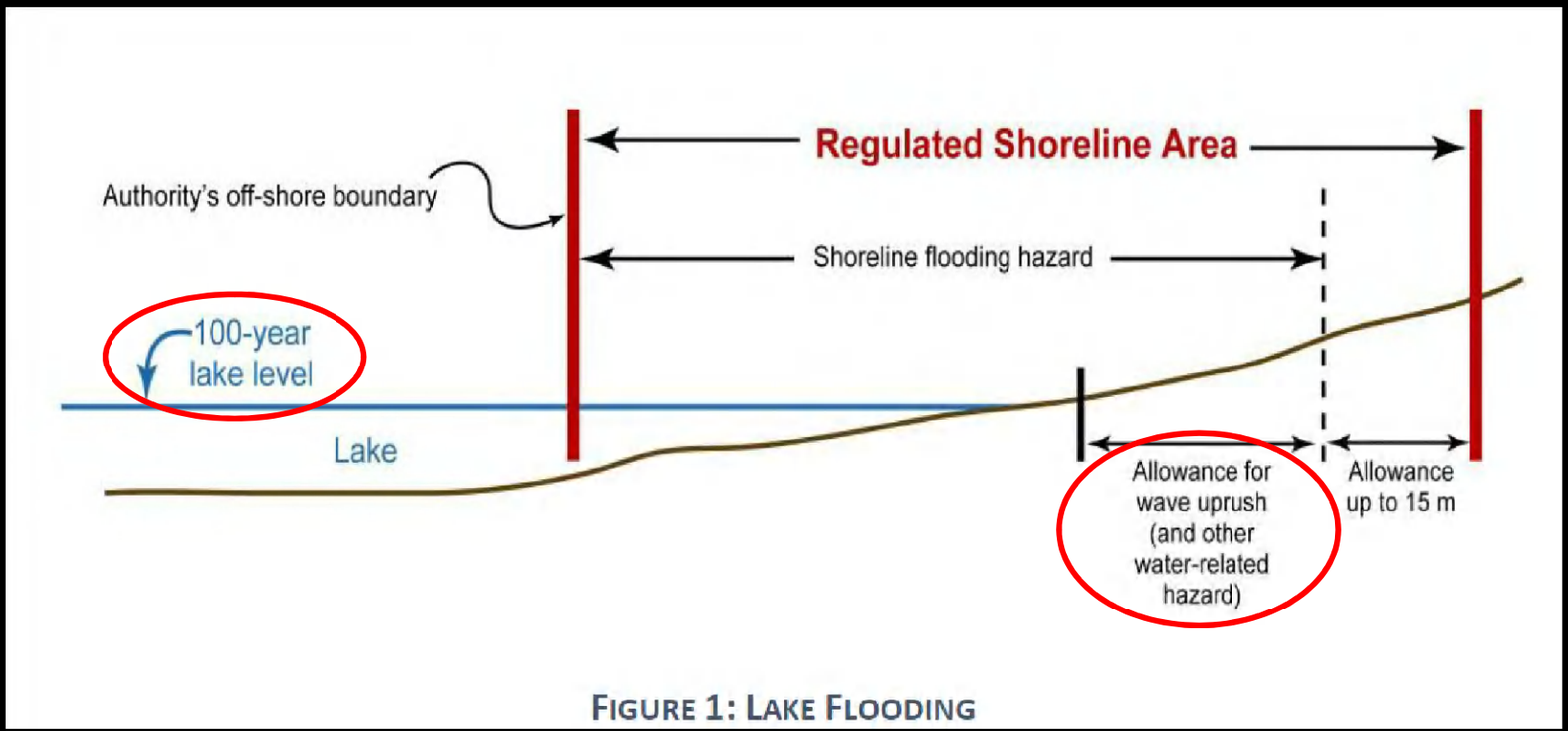


FIGURE 1: LAKE FLOODING

Figure taken from LTCA Policy Manual – Ontario Reg. 163/06

Shoreline Hazards – Lake Ontario

- Dynamic Beach Hazard is defined as:
  - "Where a dynamic beach is associated with the waterfront lands, the appropriate allowance inland to accommodate dynamic beach movement"

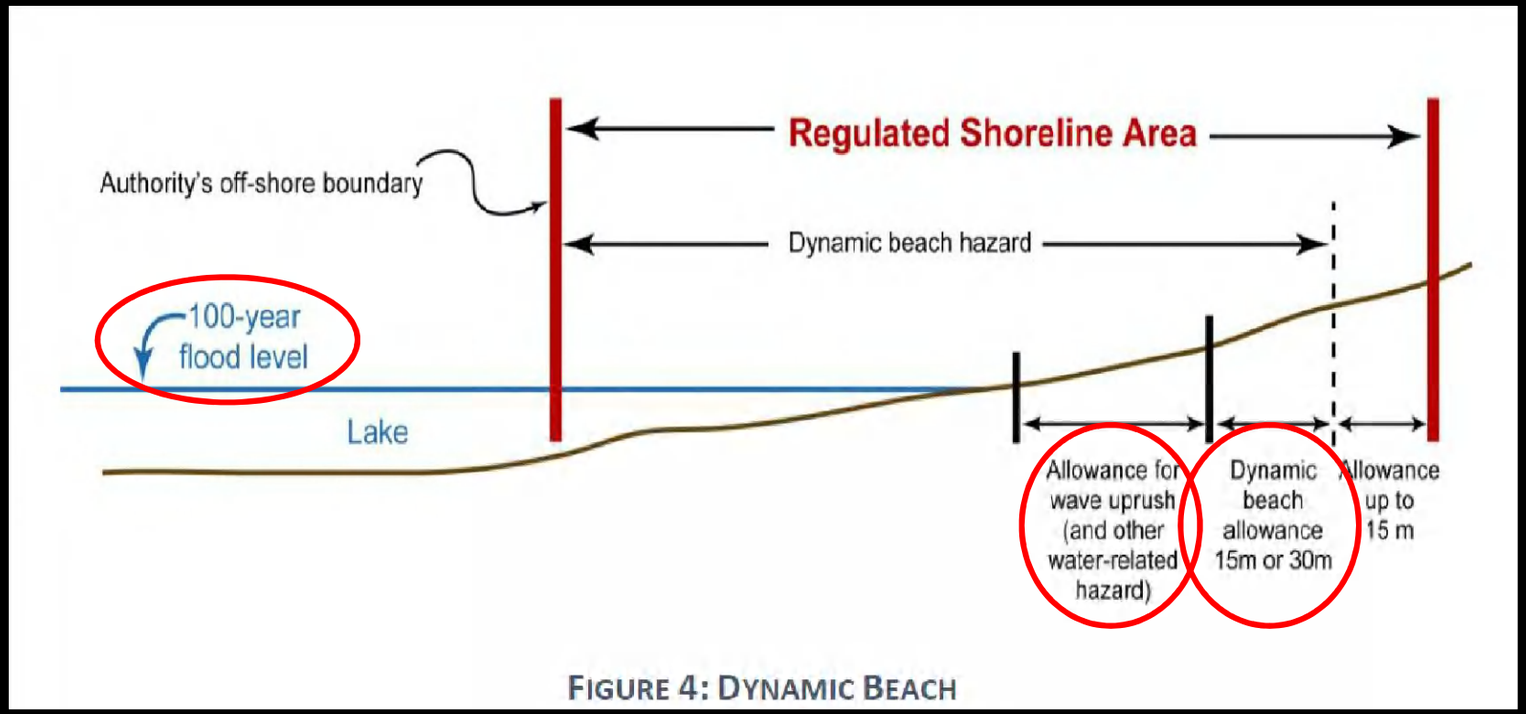


FIGURE 4: DYNAMIC BEACH

Figure taken from LTCA Policy Manual – Ontario Reg. 163/06

Shoreline Hazards – Lake Ontario

Lake Ontario Shoreline Management Plan Hazard Maps

Central Lake Ontario Conservation Authority (CLOCA)

LEGEND:

Hazard Mapping:

- Toe of Bluff
- Erosion Hazard Limit
- Flood Hazard Limit
- Dynamic Beach Setback

Base Mapping:

- Geographical Names
- Road Network
- CLOCA Administrative Boundary

INTERPRETATION OF THE HAZARD MAPS:

The hazard maps were prepared to support the Lake Ontario Shoreline Management Plan. The hazard limits are not the official regulatory limits of the Conservation Authority. Please contact the Conservation Authority for additional details on the regulatory limit and implications for new development.

DEFINITIONS:

100 Year Flood Level
The 100 Year Combined Flood Level considers both static lake level and storm surge, having a combined probability of being equalled or exceeded during any year of 1% (i.e., probability, P =0.01). The 100 Year Combined Flood Level elevation for CLOCA is +76.01 m IGLD85 (+75.59 m CGVD2013).

Flood Hazard Limit
The Flood Hazard Limit is defined as the 100-Year Flood Level plus an allowance for wave runup and uprush.

Dynamic Beach Hazard Limit
The Dynamic Beach Hazard Limit is defined as the sum of the Flood Hazard plus 30 metres measured horizontally. Local conditions may require a modified mapping approach if the beach is eroding or a barrier beach. Refer to the Lake Ontario Shoreline Management Plan report for additional details.

Toe of Bluff
The Toe of Bluff is the transition from the gently sloping beach to the steep portion of the bank or bluff slope.

Stable Slope Allowance
The Stable Slope Allowance is defined as a horizontal setback equivalent to 3.0 times the height of the bank or bluff.

Erosion Hazard Limit
The landward extent of the Erosion Hazard is the sum of the 100 year erosion rate plus the Stable Slope Allowance, measured horizontally from the toe of the bank or bluff.

DATA SOURCES:

2018 Orthophotography provided by © First Base Solutions

2018 Digital Terrain Model provided by © First Base Solutions
2016 LiDAR Digital Terrain Model obtained from the Ministry of Natural Resources and Forestry. Contains information licensed under the Open Government Licence – Ontario.

Bathymetry TBD

Geographical Names obtained from Natural Resources Canada
Road Network File, 2016 Census. Statistics Canada Catalogue no. 92-500-X

Inset Map © OpenStreetMap contributors

Datums:
Horizontal: UTM 17N NAD1983, metres.
Vertical: CGVD2013, metres

Datum Conversion:
IGLD1985 - CGVD2013 = 0.46 m (average)
To convert from IGLD85 to CGVD2013, subtract 0.46 m.
Note: There are local variations along the reaches within CLOCA. Refer to the Lake Ontario SMP for additional details.

0 50 100 200 m

N W E S

PREPARED BY:

Zuzek inc. ONE WORLD

SJL ENGINEERING

This map was published November 2019 for the Central Lake Ontario Conservation Authority (CLOCA). The mapping of hazardous lands, including erosion, flooding, and dynamic beach areas, is subject to change. The proponent of a proposed development on or adjacent to the hazardous lands should contact CLOCA to discuss permit requirements.

Every reasonable effort has been made to ensure the accuracy of this map. However, neither CLOCA, Zuzek Inc., SJL Engineering, or any other affiliated party assume any liability arising from its use. This map is provided without warranty of any kind, either expressed or implied.

Mapping prepared by Zuzek Inc. for the Central Lake Ontario Conservation Authority, with support from Durham Region.

MAP PUBLISHED NOVEMBER 2019

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CLOCA Map 1 of 30

Example of Erosion and Flood Hazard Limit

Example of Erosion and Flood Hazard Limit

V – MANAGEMENT RECOMMENDATIONS

Adaptation Strategies for Coastal Hazard

(https://www2.gov.bc.ca/assets/gov/environment/climate-change/adaptation/resources/slr-primer.pdf)

- **Avoid**: reduce exposure by ensuring new development doesn't occur on hazardous land
- **Accommodate**: allows for continued occupation while changes to human activities or infrastructure are made to deal with hazards
- **Protect**: protect people, property, and infrastructure. Traditional approach and often the first considered
- **Retreat**: a strategic decision to withdraw or relocate public and private assets exposed to coastal hazards

AVOID: Naturalized Shorelines, Public Open Space, and Erosion Buffers

Lakeside Neighbourhood Park

Lakefront Park West

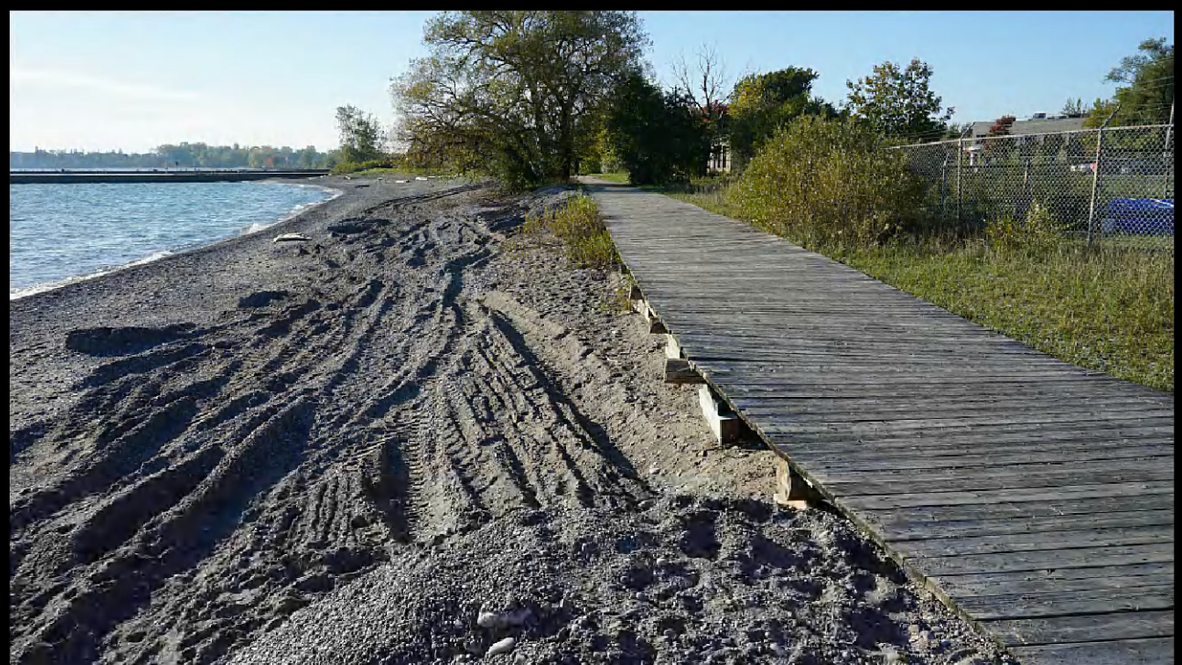
ACCOMMO-DATE

Raise Building Foundation

(Lake St. Clair)

PROTECT: Beach Nourishment to Protect Shoreline Infrastructure

- Rotary Sunrise Lake Park, Whitby



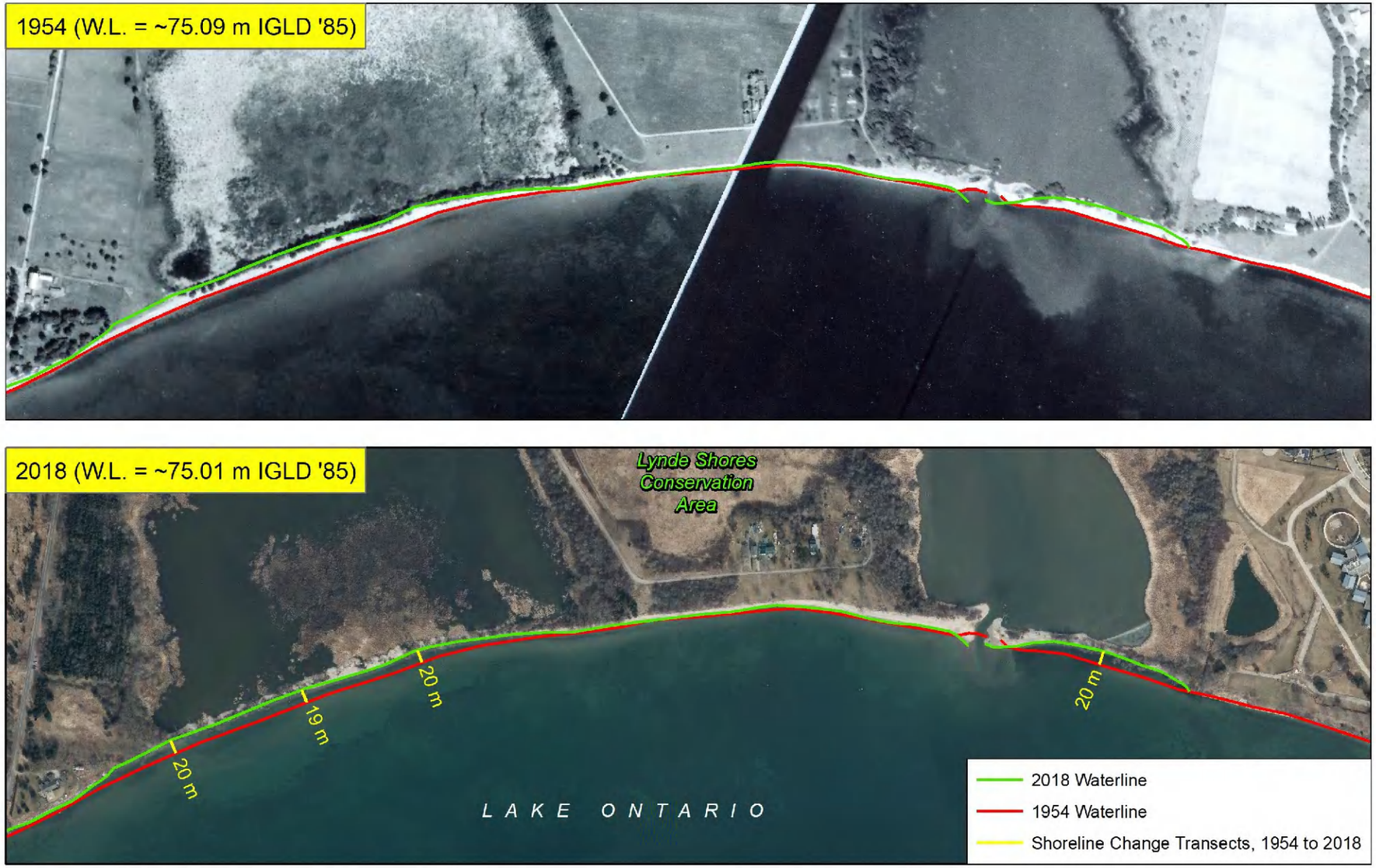
Linkages Between Shoreline Erosion and Sediment Supply for Beaches

- The bluffs consists of erodible glacial sediment
- Bluff erosion is natural process
- Shoreline armouring decreases sediment supply to local beaches

Future Approaches to Maintain Sediment Supply

- Maintain eroding shorelines
- Implement a large scale artificial beach nourishment program (truck sand to the shoreline)
- Placed dredged material on beaches

Cranberry Marsh Shoreline Erosion



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www.zuzekinc.com

Shoreline Comparison at Lynde Shores

CLOCA

Data Sources:
1954 and 2018 aerial imagery provided by CLOCA.

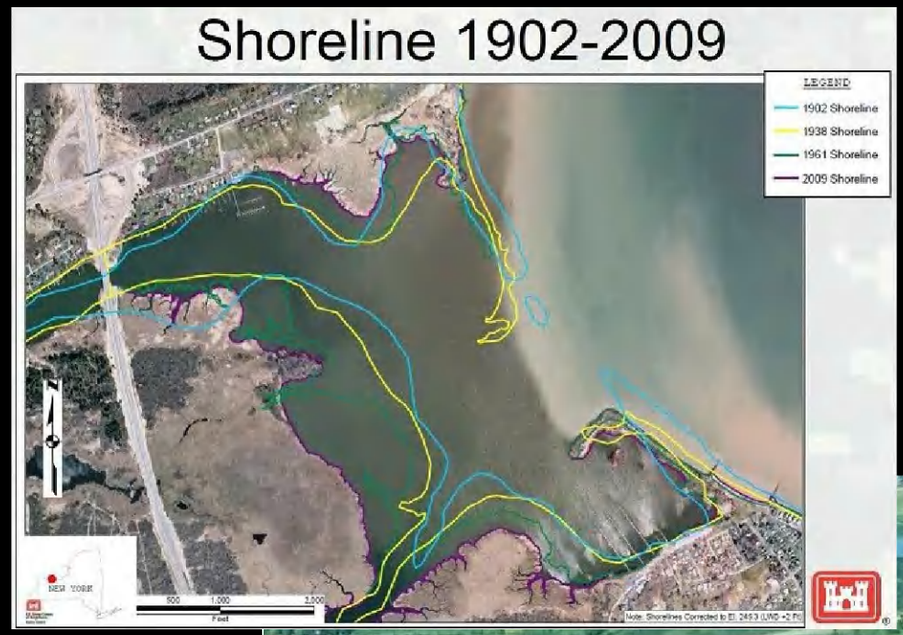
Water levels shown are the Lake Ontario monthly means for April.

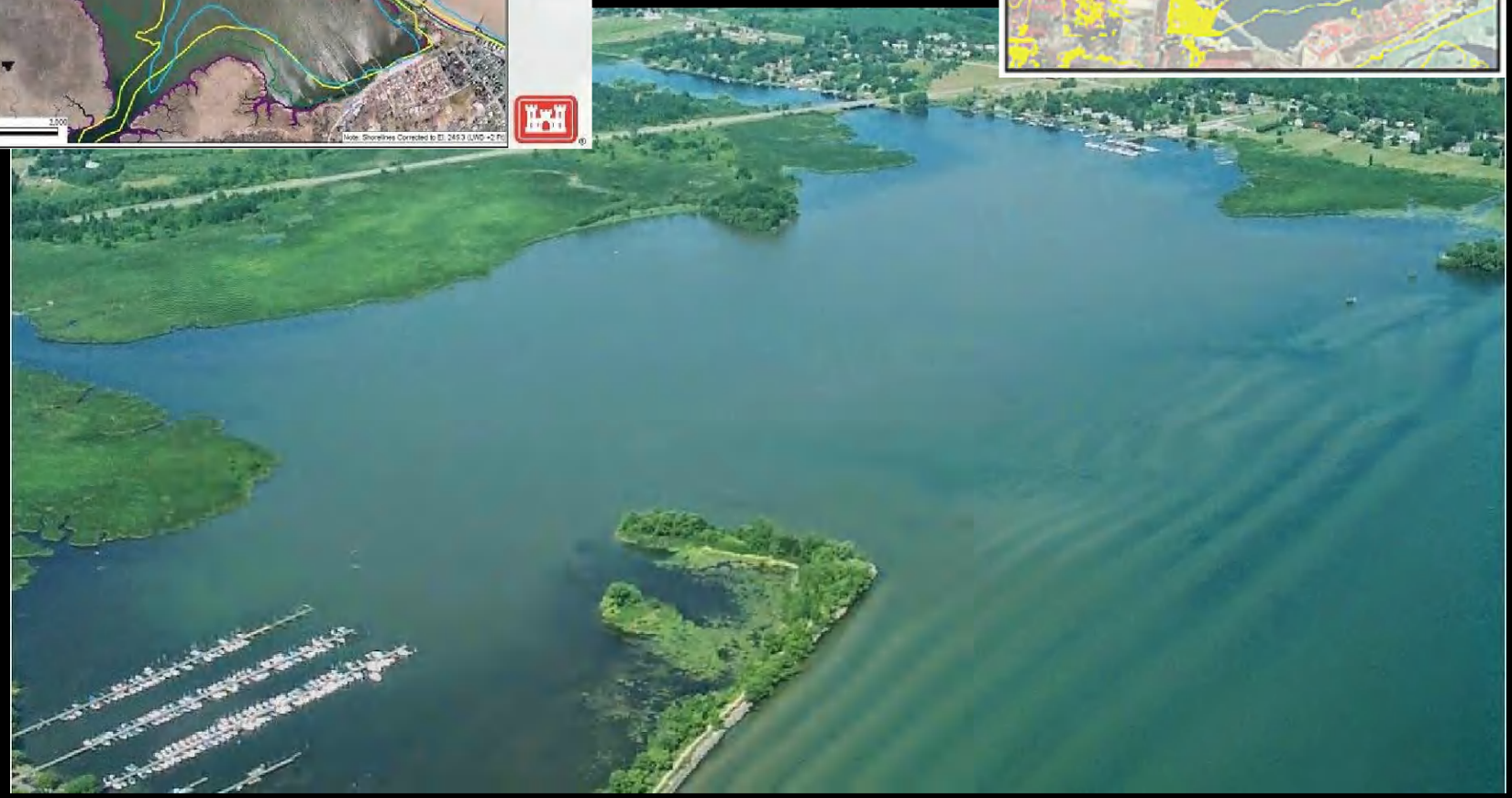
0 50 100 200
m

Cranberry Marsh May 28, 2019

Cranberry Marsh May 28, 2019

Braddock Bay Barrier Beach Eroded and Never Recovered





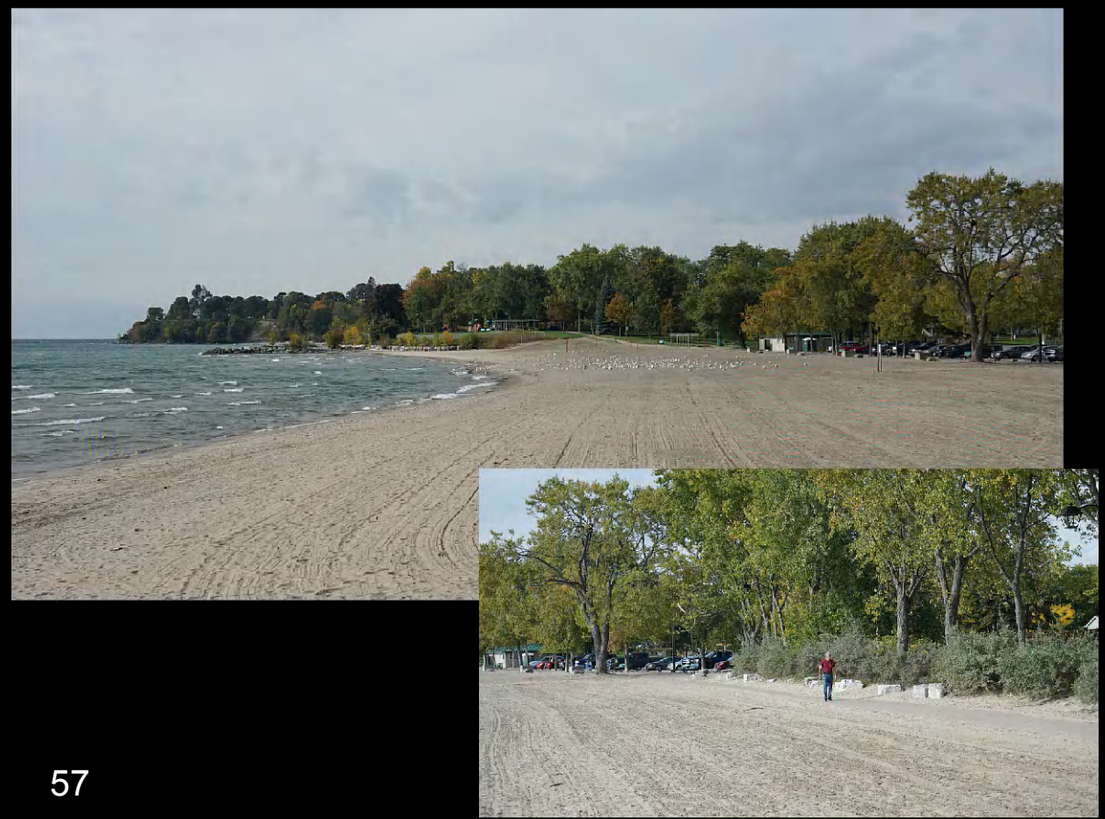
Barrier Beach Replaced with an Armour Stone Structure

Hillman Marsh, Lake Erie

Sometimes the Beaches don’t Recover

PROTECT: Sand Dunes Increase Beach Resilience

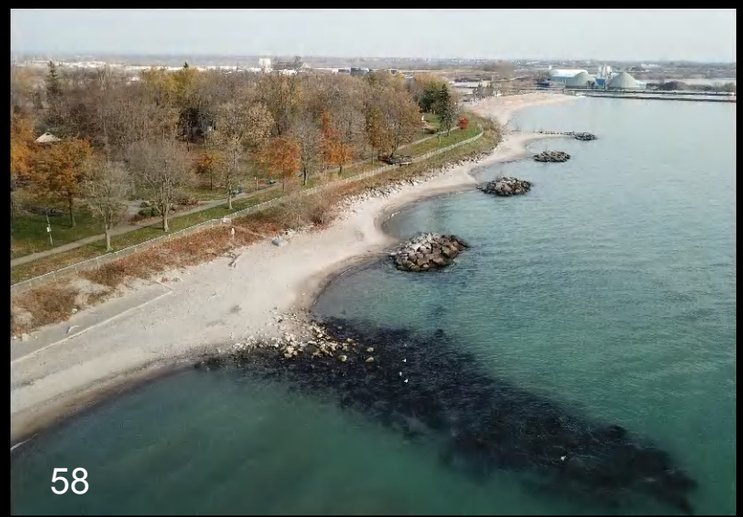
Lakeview Park, Oshawa
-No Dunes



Darlington Provincial Park
-Healthy Dune Ecosystem

PROTECT: Traditional Engineered Protection

(there will always be a need for well engineered structures)



RETREAT

C-K Building Relocation Example

Build Back Better

- Bluff failure in early 1990s threatens home
- Building successfully relocated with Provincial funding
- Currently ~30 m from the bluff edge (adjacent image)

Imagery courtesy of LTVCA

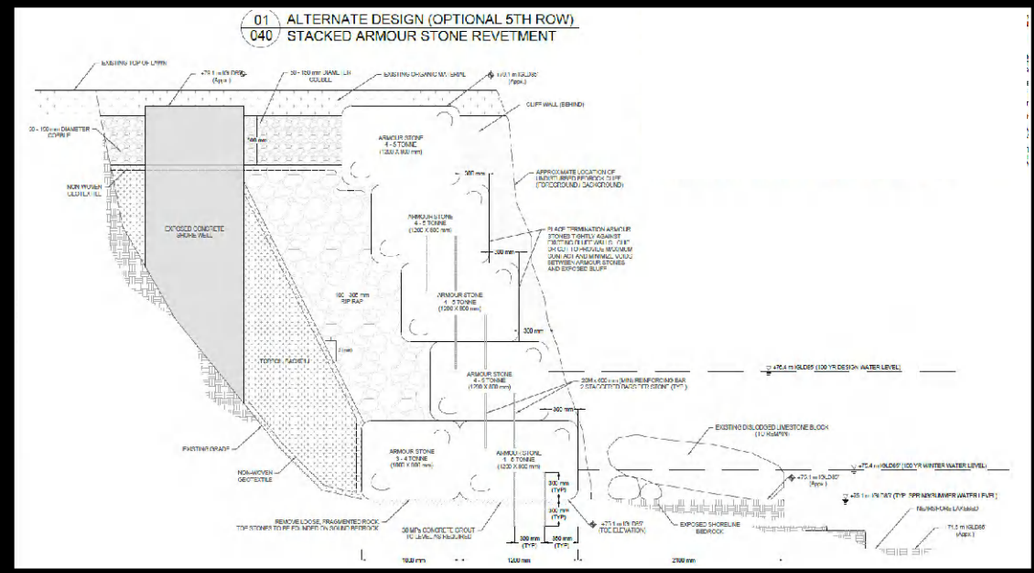
RETREAT – PROPERTY BUY-OUT EXAMPLES

- High up-front costs but effective at reducing risk when vulnerability is high
- 2013 Alberta Flood impacted the Community of High River
  - High River Council voted for the relocation of the Wallaceville Community
  - Land and buildings purchased by the province at pre-flood assessment value
  - Lands returned to a natural state
- 2019 Montreal Area Floods
  - Provincial government offered up to $100k (cumulative) for flood damage restoration
  - Or a $200k buyout
  - If damage was greater than 50%, not able to re-build

VI – GUIDANCE FOR SHORELINE PROTECTION STRUCTURES

Shore Protection Guidance

- What does “properly engineered” mean?
- Analysis of site specific design conditions
  - Waves
  - Water Levels
  - Currents
  - Ice
  - Slope stability
  - Drainage
  - Substrate
- Alternatives assessment
- Coastal processes study to assess downdrift impacts
- Environmental impacts assessment
- Detailed design work including sizing of all structural elements
- Construction drawings and specifications



Shore Protection – NOT Recommended

- Pre-cast concrete block seawalls
- Cast-in-place concrete seawalls
- Sheet-pile seawalls
- Groyne-type structures
- Ad-Hoc Shore Protection:
  - Concrete rubble
  - Gabion baskets
  - Railway ties
  - Timber
  - Tires
  - Steel drums
  - Poured concrete

Shore Protection – Engineered Examples

- Stacked/Stepped Armour Stone Revetment
  - Good for low shorelines with limited space
  - Very large, blocky, quarried stone (natural)
- Rubble Mound Revetment
  - Good for all types of shorelines
  - Field stone OR quarried stone (natural)
- Single-Layer Armour Stone Revetment
  - Good for all types of shorelines
  - Large, flat quarried stone (natural)
  - Special stone placement in single layer
- ALL MUST BE PROPERLY ENGINEERED

VII – QUESTIONS