Navigating Dynamics: Sediment Transport Modeling at Sturgeon Point Marina

Introduction

Project/Site:
- Marina in northeast Lake Erie, ~16 miles southwest of Buffalo
- Services 4000 boaters annually
- 1988 construction of outer jetty and groin
- **Sedimentation problems** blocking **navigation** and **marina access** since construction
- Annual dredging needed to keep marina operational (average 10,000 CY annually)
- Client goal is to **reduce maintenance dredging** with more permanent solutions.

Site / Lake Erie
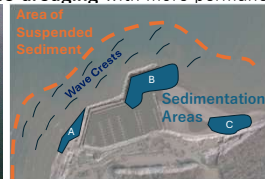
Objectives:
- ✓ Reduce sedimentation/accretion in marina and navigable channel.
- ✓ Reduce sediment flow from the West around the outer jetty and from the East toward the mouth of the marina.
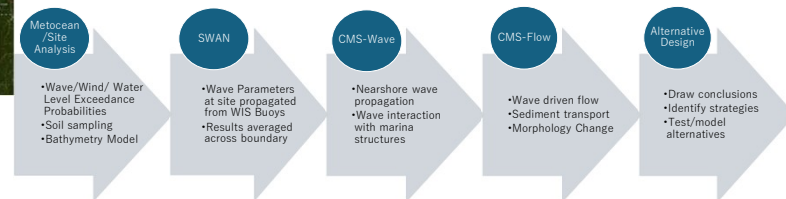
Other considerations:
- ✓ Marina expansion (increased boat slips)
- ✓ Cost
- ✓ Navigation
- ✓ Permitting

GZA Subcontracted to:
1. Develop meteorologic, oceanographic, and bathymetric conditions
2. Use numerical modeling to understand sediment transport in and around the marina
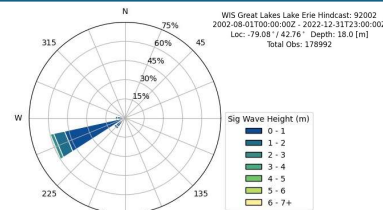3. Identify and model marina structure alternatives to mitigate navigation issues

Metocean/Site Analysis
- Wave/Wind/Water Level Exceedance Probabilities
- Soil sampling
- Bathymetry Model

SWAN
- Wave Parameters at site propagated from WIS Buoys
- Results averaged across boundary

CMS-Wave
- Nearshore wave propagation
- Wave interaction with marina structures

CMS-Flow
- Wave driven flow
- Sediment transport
- Morphology Change

Alternative Design
- Draw conclusions
- Identify strategies
- Test/model alternatives

Methods

Metocean Data Analysis

10 and 20-Year Exceedance Probability Per USACE Great Lakes Guidance

Recurrence Event Probability	NOAA Water Level Gauge Sturgeon Point 9063028 (feet, NAVD 88)	ASCE-7 10-Min Wind Speed (mph)	USACE WIS Point 09002 Significant Wave Height (Offshore SWAN Input) (feet)
Low Water Datum	569.3	-	-
Average (2022)	572.3	-	-
10-Year	578.4	53.5	15.4
20-Year	578.9	58.4	17.0

- **Sediment Sampling Conducted:** – Average $D_{50} = 0.5mm$, $D_{90} = 0.9mm$
- **Digital Elevation Model:**
  - USACE Lake Erie USACE Digital Elevation Model (DEM) and Fisher Associates 2023 Bathymetric and Topographic Survey

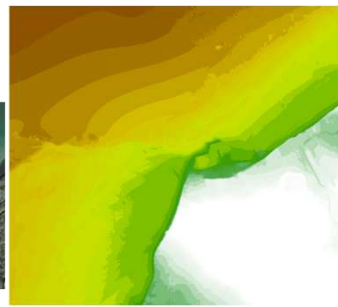### SWAN 2D (Simulating Waves Nearshore) Model
- Unstructured Grid; WIS - JONSWAP Wave Input, Default Wave Growth Functions

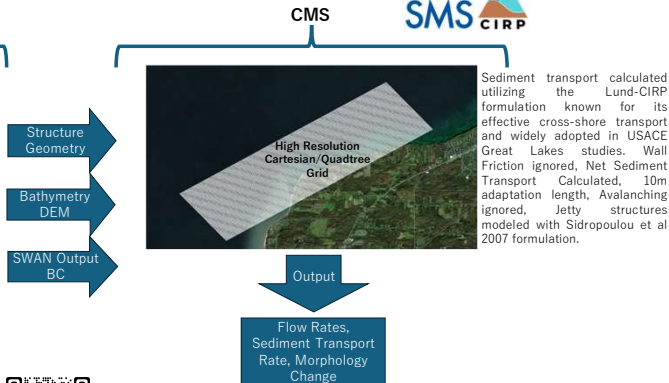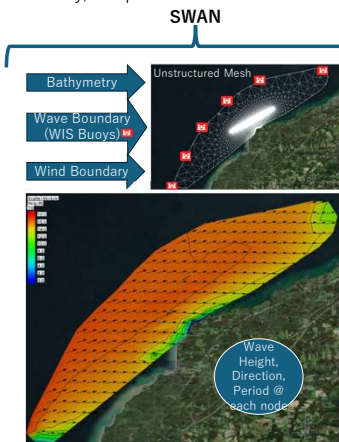### CMS (Coastal Modeling System)-Wave/Flow
- USACE Developed Tool
- CMS-Wave: -Spectral wave transformation model utilizing finite difference method
- CMS-Flow: -Uses conservative shallow water equations and advective diffusion models to simulate circulation, sediment transport, and salinity/temperature variations.

WIS Great Lakes Lake Erie Hindcast: 92002
2002-08-01T00:00:00Z - 2022-12-31T23:00:00Z
Loc: -79.08°/ 42.76° Depth: 18.0 [m]
Total Obs: 178992

Sig Wave Height (m)
0 - 1, 1 - 2, 2 - 3, 3 - 4, 4 - 5, 5 - 6, 6 - 7+

Fisher Sediment Sampling Location

Digital Elevation Model

SWAN

- Bathymetry
- Wave Boundary (WIS Buoys)
- Wind Boundary
- Unstructured Mesh
- Wave Height, Direction, Period @ each node

CMS

- Structure Geometry
- Bathymetry DEM
- SWAN Output BC
- High Resolution Cartesian/Quadtree Grid
- Output
- Flow Rates, Sediment Transport Rate, Morphology Change

SMS CIRP

Sediment transport calculated utilizing the Lund-CIRP formulation known for its effective cross-shore transport and widely adopted in USACE Great Lakes studies. Wall Friction ignored, Net Sediment Transport Calculated, 10m adaptation length, Avalanching ignored, Jetty structures modeled with Sidropoulou et al 2007 formulation.

Results/ Discussion

- 20-year wave/20-year water level conditions caused most sedimentation in dredge Area B
- Slightly more sedimentation from NE direction with high water, however these events are not as likely

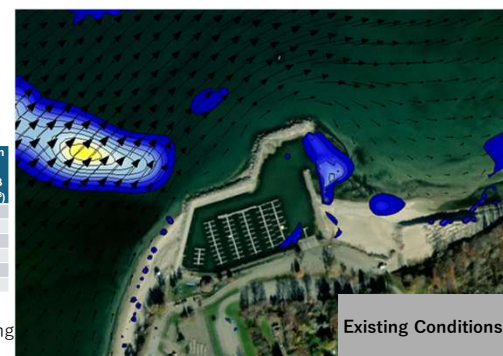| Case No.	Harbor Layout	Recurrence Interval (Year) Wave/ Water Level	Wave/Wind Direction	Wave Height (Input to SWAN) (feet)	Water Level (feet, NAVD 88)	Sedimentation in Dredge Area B (5 Storms) (yd³)
1	Current	20/20	SW	17.0	578.9	+634
2	Current	20/20	NE	4.6	578.9	+663
3	Current	20/10	SW	17.0	578.9	+615
4	Current	10/10	SW	15.4	578.4	+570
5	Current	20/AVG	SW	17.0	578.9	+470
6	Current	20/AVG	NE	4.6	572.3	+226

- Southwest high water and wave events:
  - Sediment wrapping around end of outer jetty and settling outside of marina opening, extending past lower groin.
- Northeast high water and wave events:
  - Sediment pushing from the East and settling in between the end of the outer jetty and the lower groin.

Initial Proposed Alternatives
1. Breakwater Leg 4 Spur
2. Curved Breakwater with Spur
3. Leg 4 Breakwater Extension
4. Spur on Entrance Breakwater
5. Spur on Breakwater Leg 4 and Detached Breakwater
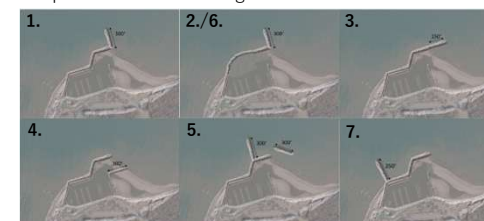
- Varying wave directions for sediment transport analyses
- Numerous iterations/sensitivity analyses for sediment transport/wave parameters
- Sediment transport dynamics simulated
- Multiple alternatives that reduced sedimentation in the desired area were analyzed for economic benefit
- Findings still being processed and are a part of Sturgeon Point Marina and Bluffs Master Plan and Revitalization Strategy, which will be presented in a Report and in Public Workshops

Existing Conditions

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7.