US Army Corps of Engineers®

Engineering With Nature®

Engineering With Nature (EWN) ASBPA Short Course – Engineering Design and Modeling

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U.S. Army Corps Engineer Research and Development Center,
Coastal and Hydraulics Laboratory

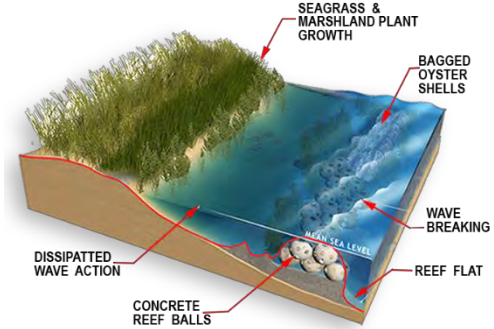
September 13, 2022

Natural and Nature-Based Features

In recent years, there has been an increased emphasis in the coastal engineering community on the use of natural and nature-based features (NNBF's) as a means of protecting and mitigating damage to coastlines affected by storm events.

Some examples of NNBF's include:

- Dunes
- Marshes
- Coral and oyster reefs
- Maritime forests
- Living shorelines
- Barrier islands



https://ewn.el.erdc.dren.mil/nnbf.html

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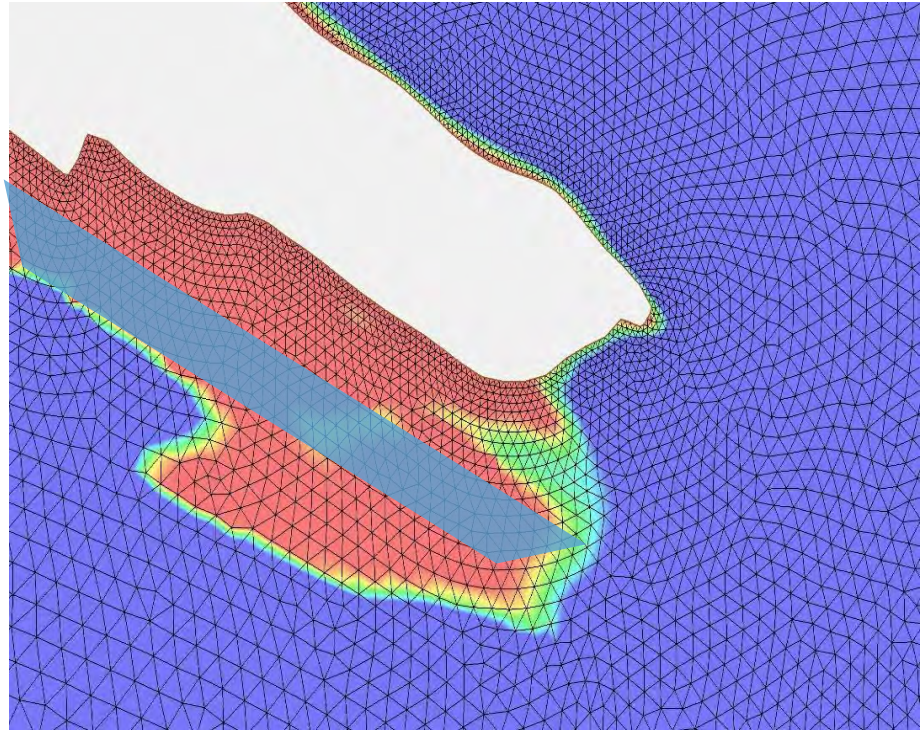
Technical Approach



PROBLEM

- Inclusion of NNBFs into numerical modeling is time consuming, and needs expert level commitment
- Approach has not been standardized, so effort tends to be completed differently per model.

SOLUTION

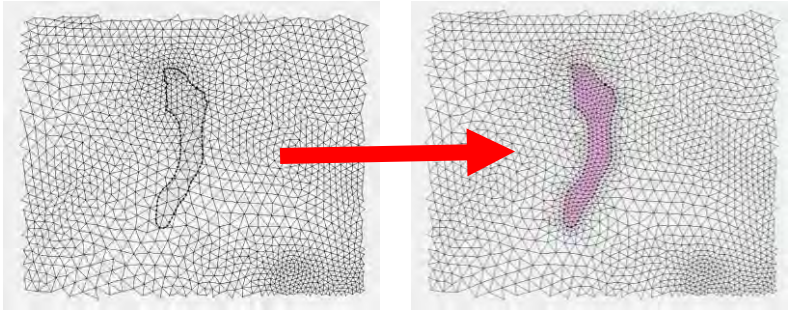
- Develop a semi-automatic GUI that rapidly integrates NNBFs into existing models by;
  - Adjusting topography/bathymetry
  - Enhancing resolution accurately
  - Setting roughness coefficient based on extensive literature review

IMPACT

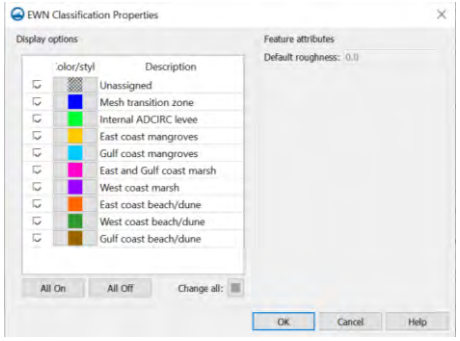
- Time commitment, expert level needed per modeling project
- Allows for MORE designs to be tested
- Allows for more innovation opportunities using NNBFs in flood risk management
- Expands the EWN practice

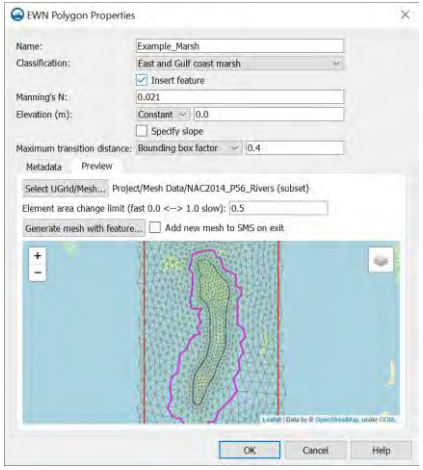
EWN® CSTORM Modeling Toolkit - Summary

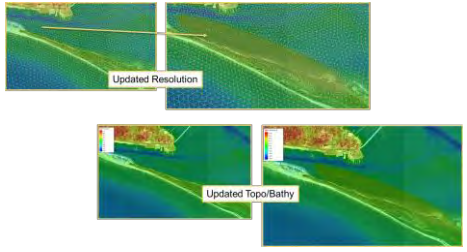
Objective: To develop a workflow and GUI for standardized and rapid representation of Natural and Nature-Based Features (NNBF) in ADCIRC model



- Developed as part of contract with Aquaveo
- Toolkit is included in release of SMS 13.1;
  standalone Python scripts in development
- Resolution-based implementation test cases underway to provide guidance to users
- Funding received to expand Toolkit capabilities to AdH, Wavewatch III, STWAVE, GSSHA, CMS-Flow, and CMS-Wave

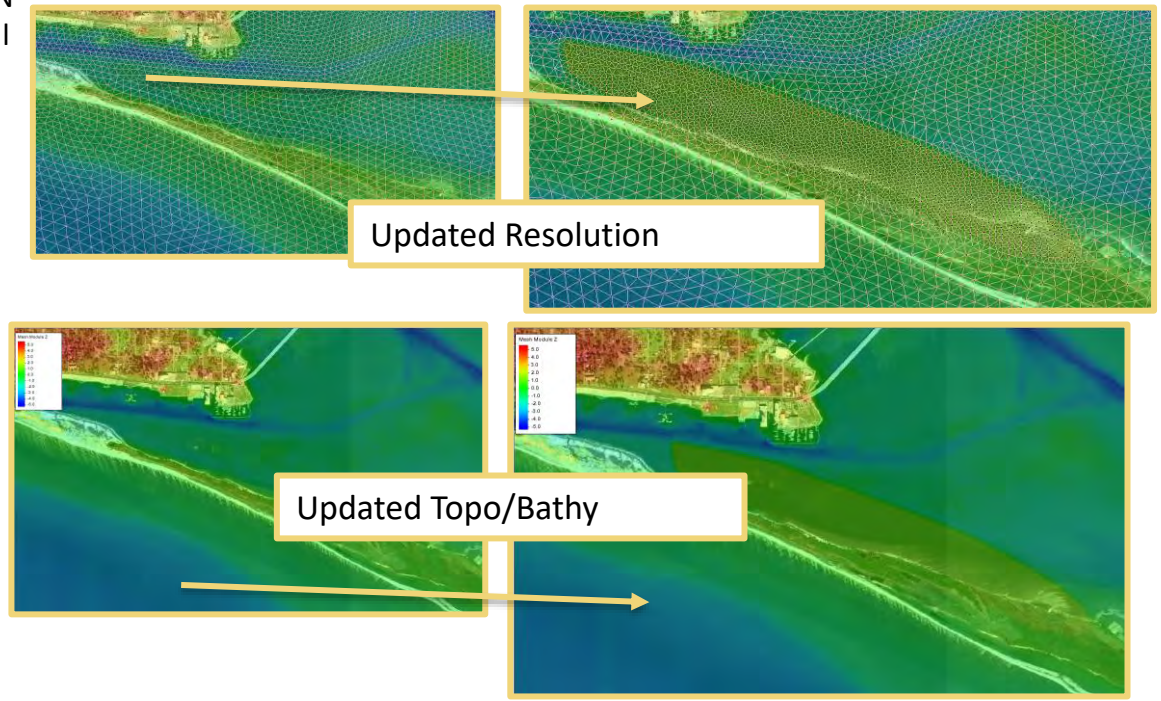






The EWN® Toolkit for ERDC's Coastal Storm (CSTORM) Modeling System

- Toolkit allows for rapid representation of EWN features within a coastal and fluvial numerical model background.
- The user will have a geospatially rectified background image (i.e. from satellite or similar) to reference while working in the mesh editing environment.
- A simple set of tools for creating polygons, and layers of polygons, in which to represent EWN features will be available.
- Each EWN feature will come with an options tab or drop down menu to adjust various parameters for that feature (i.e. density of vegetation, Manning's n values, and bathymetry) that will be stored in a look up table.

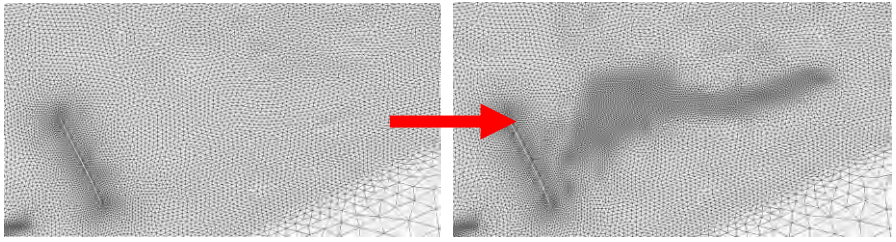


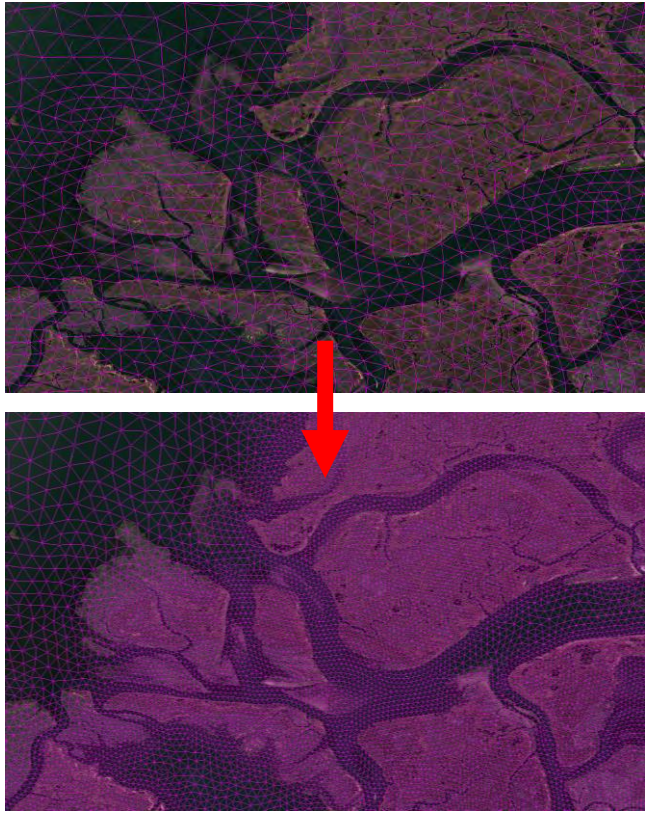
Technical Approach – Model Resolution

To incorporate NNBF into a numerical model, the resolution of the base model grid typically needs to be refined to adequately represent the feature(s).

When setting feature resolution, it's important to take a number of factors into consideration, such as:

1) The needs of the project
2) How to best resolve the feature
3) The model time step and computational cost



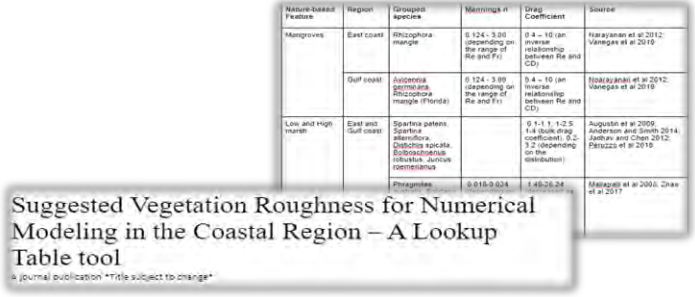


Technical Approach – Feature Attributes

EWN properties will be assigned as the polygons that represent those features are generated. Some properties that may need to be assigned by the modeler to represent the new feature(s) include:

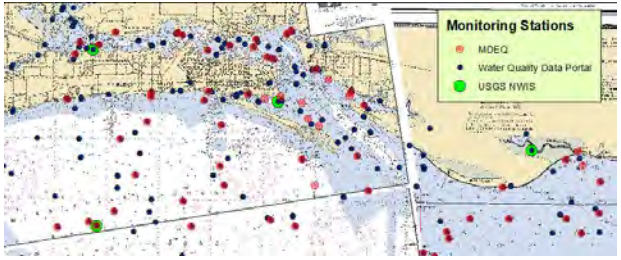
- Topography and bathymetry
- Manning's n roughness coefficient
- Drag coefficient

When using the EWN CSTORM Toolkit, the topographic and bathymetric changes will be assigned by the user and the Manning's n value will be available in a look up table.



Deer Island Restoration Project

- Deer Island is a 3.5-mile long spindle-shaped island located just off the coast of Biloxi, Mississippi.
- The island is owned by the State of Mississippi and is part of the Mississippi Department of Marine Resources Coastal Preserves Program.
- Project being undertaken by the USACE's Mobile District's Mississippi Coastal Improvements Program (MCIP).
- One of the project's goals is to preserve and restore Mississippi's coastal ecosystems to perpetuate their natural characteristics, features, ecological integrity, social, economic, and aesthetic values for future benefit.



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ENGINEER RESEARCH & DEVELOPMENT CENTER

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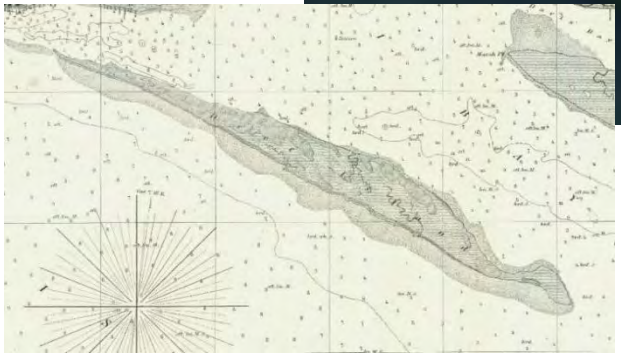
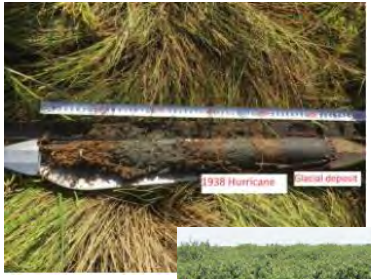
US Army Corps of Engineers
Mobile District

USGS

Deer Island Design Approach

- Use an integrated modeling approach to design and determine performance
- Maximize use of natural and nature based solutions
- Incorporate beneficial reuse
- Component Specific Data Collection and Design Analysis
- Perform design analysis for selected alternative components (Beach, Marsh, Living Breakwaters, Oyster Reefs, etc.)





Existing Conditions Assessment
- Hydrodynamic Modeling (ADCIRC)
- Wave Modeling (STWAVE)

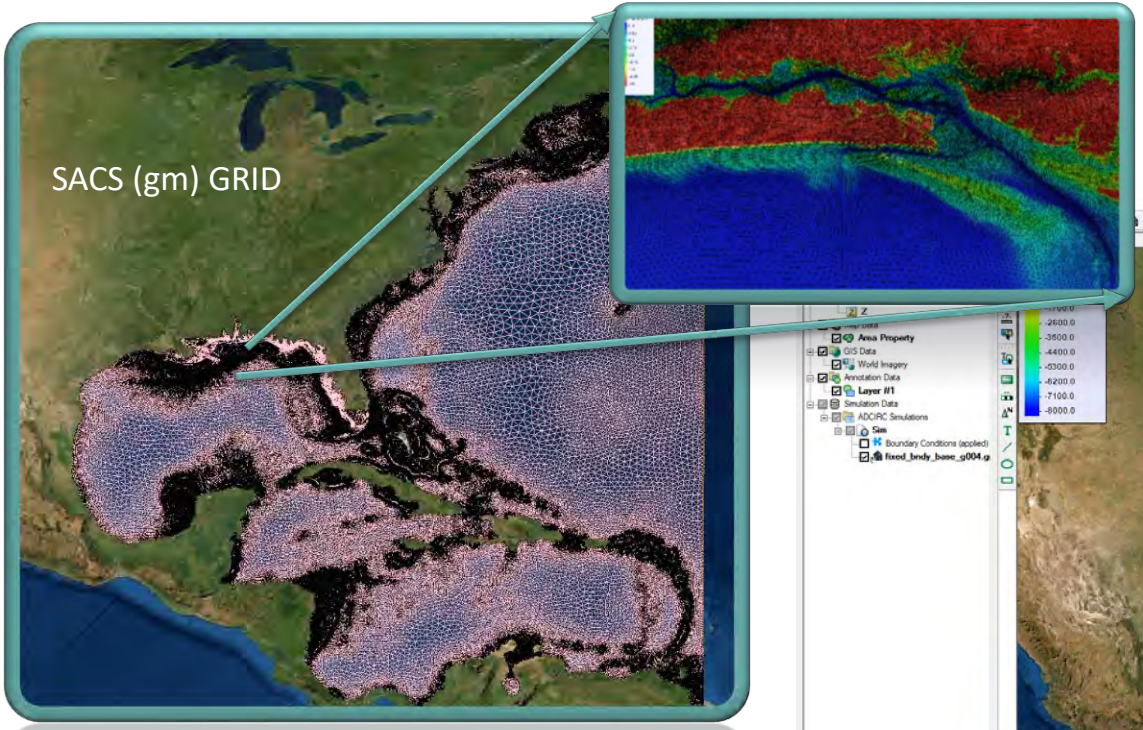
Identification of Design Alternatives
- Identify project components
- EWN Toolkit
- Qualitatively Evaluate Pros and Cons

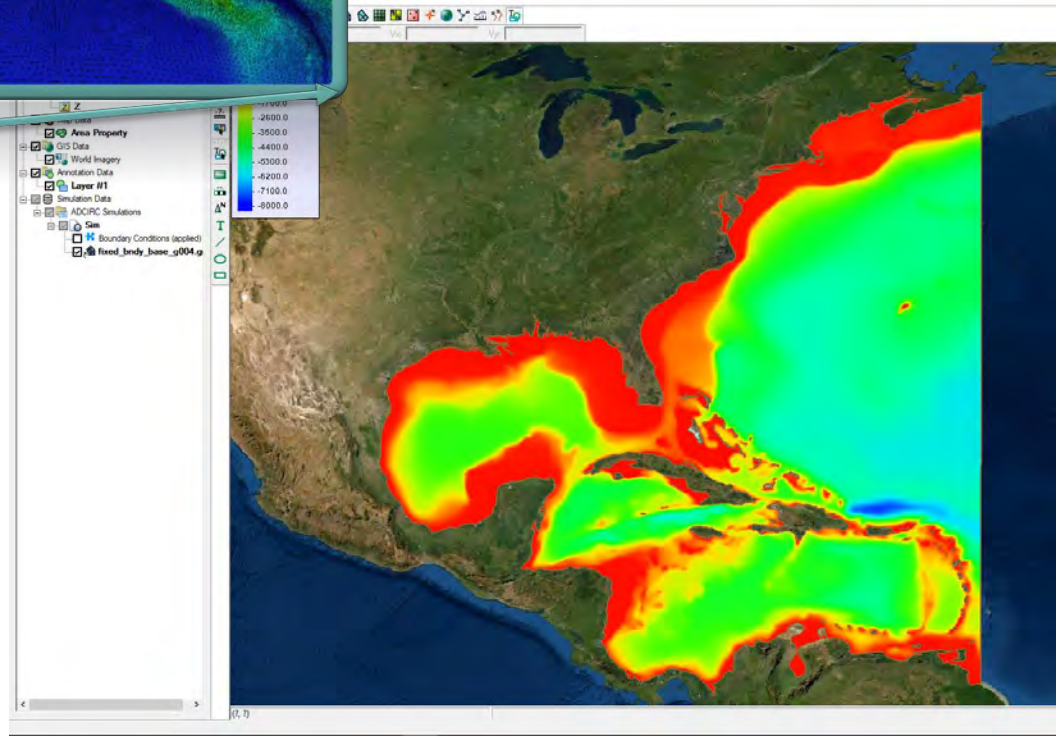
Design Analysis
- Perform design analysis for selected alternative components
- Beach, Marsh, Living Breakwaters, Reefs, Oysters

Performance Analysis
- Evaluate performance under Extreme Events and Sea Level Rise
- Use Numerical models for the analysis

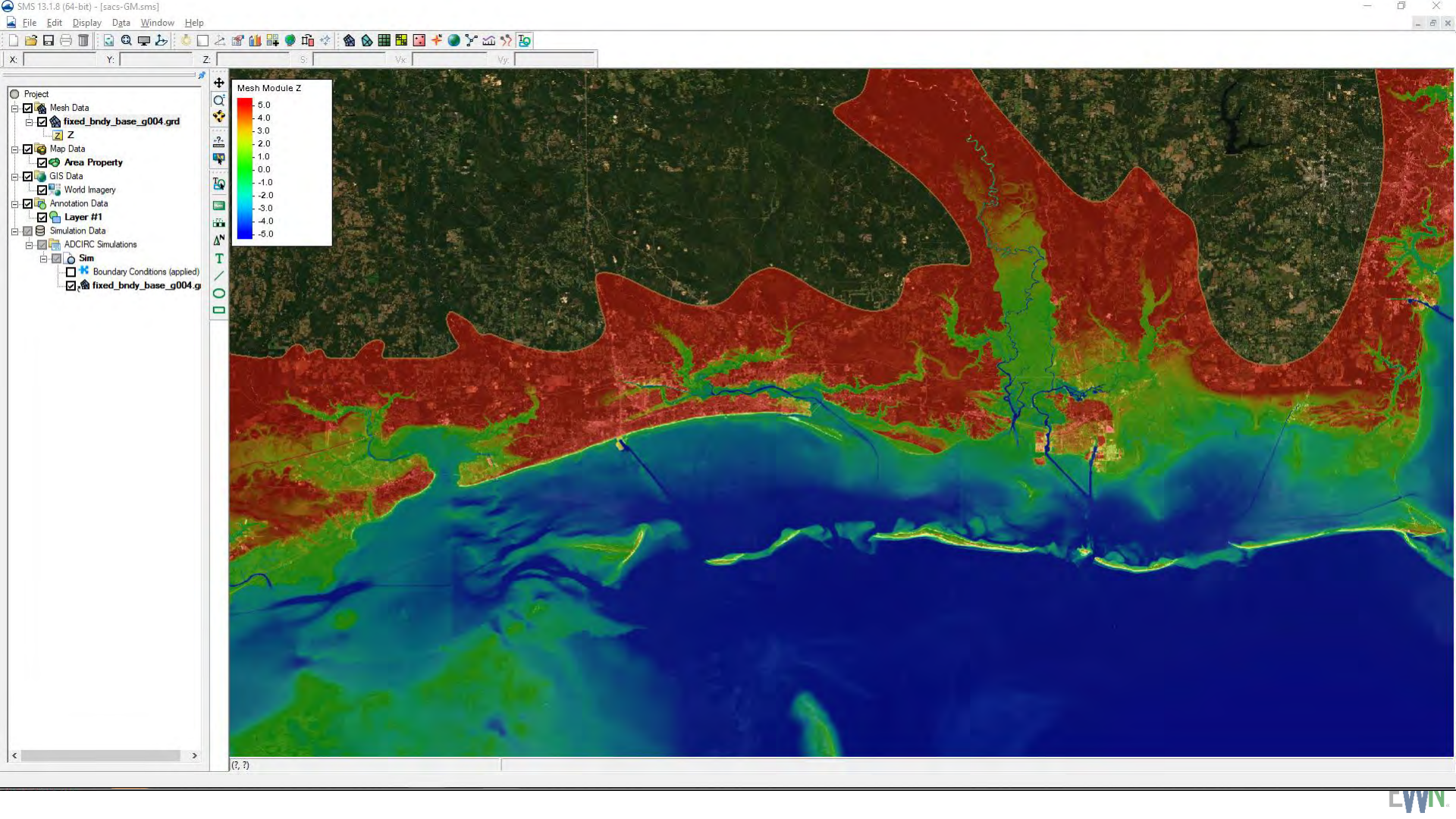
Design Plans and Specs
- Prepare Plans, Sections and Specs

Example EWN Toolkit WORK FLOW (DEMO)





Massey, T.C., Owensby, M., Provost, L., Dillon, C., Hesser, T., Tritinger, A., Bryant, M., and Goertz, J.. (2020). Calibration and Validation of the Gulf of Mexico Domain Model Setup for the South Atlantic Coastal Study (SACS)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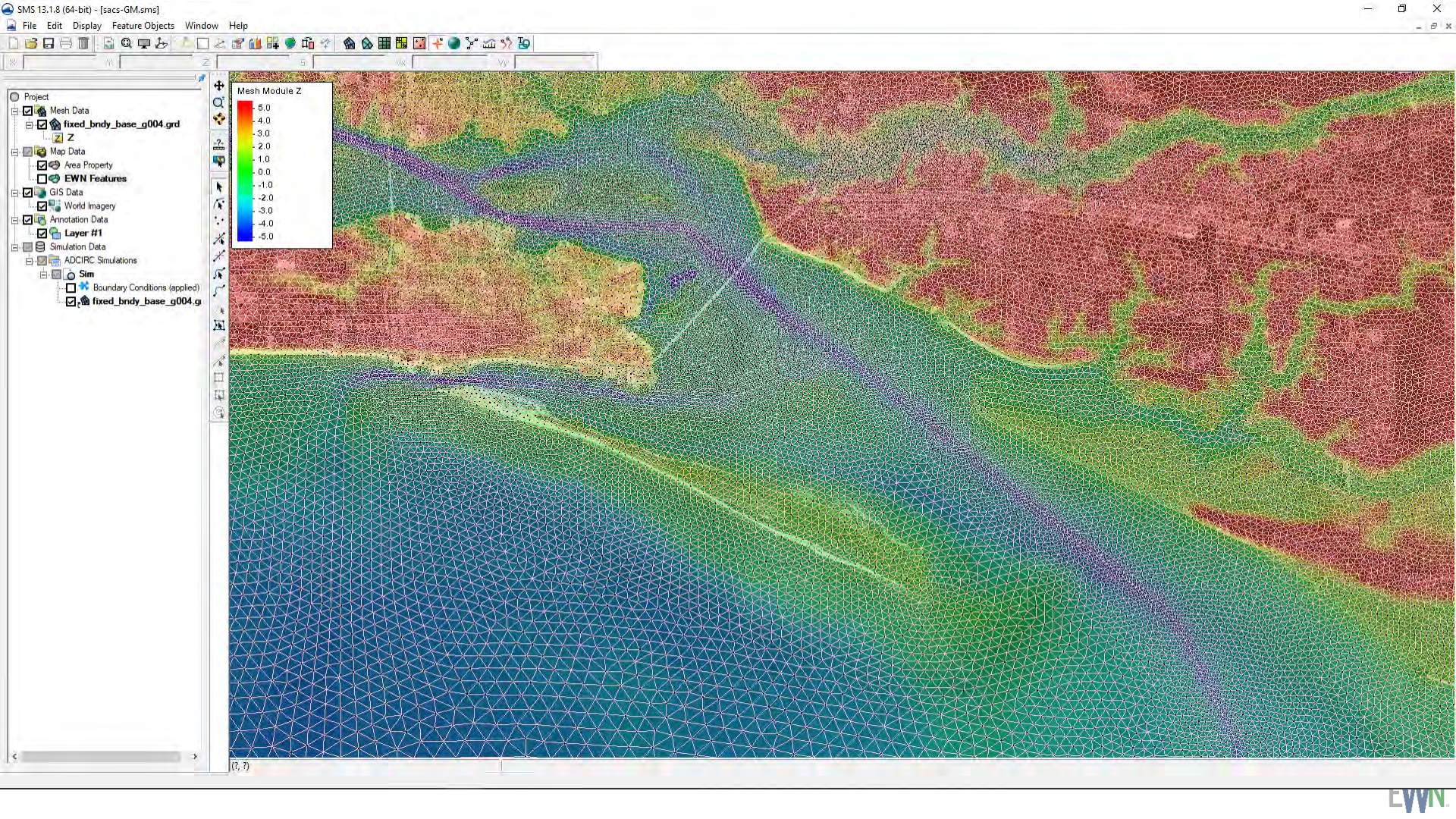
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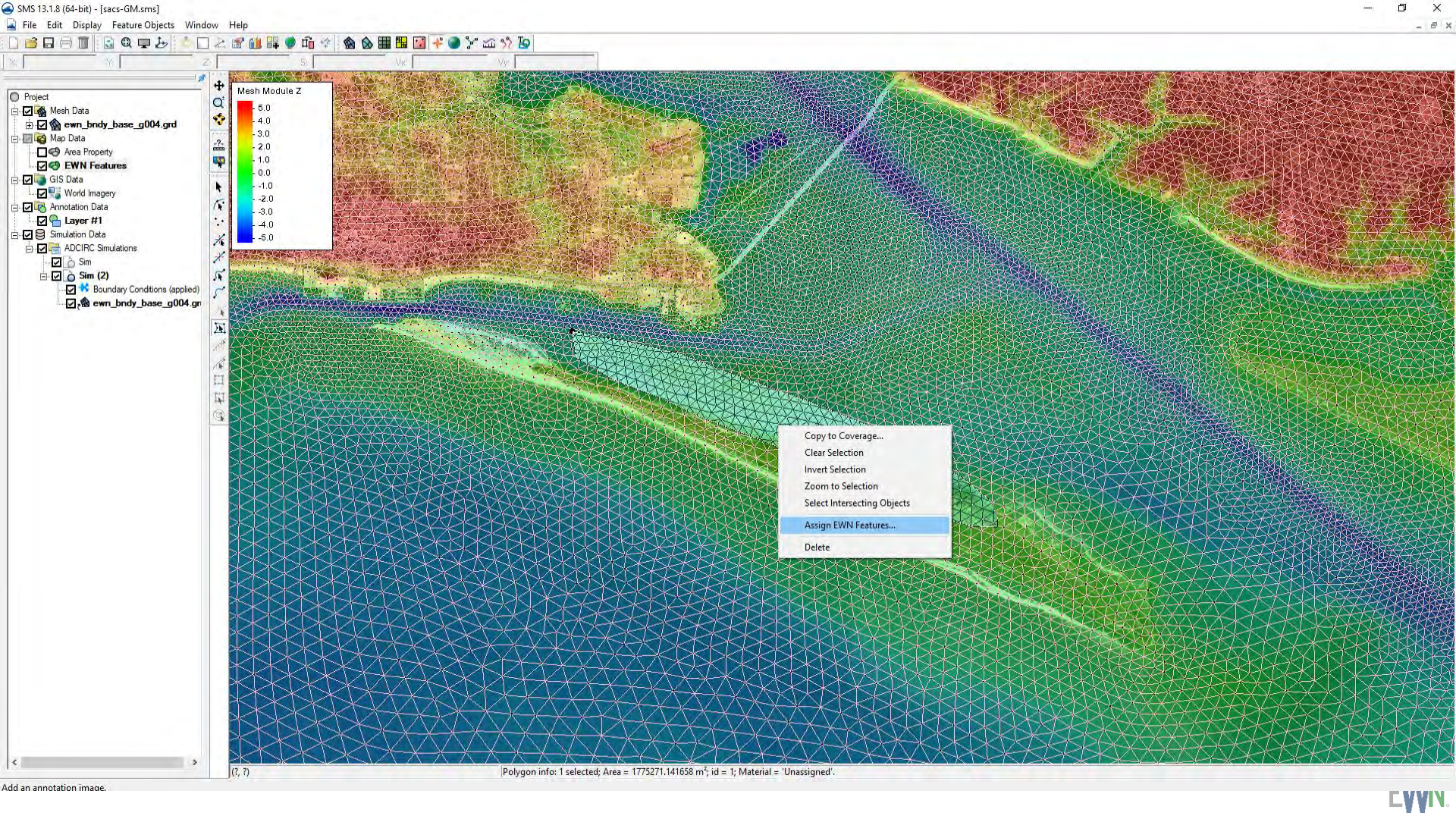
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Copy to Coverage...
Clear Selection
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Zoom to Selection
Select Intersecting Objects
Assign EWN Features...
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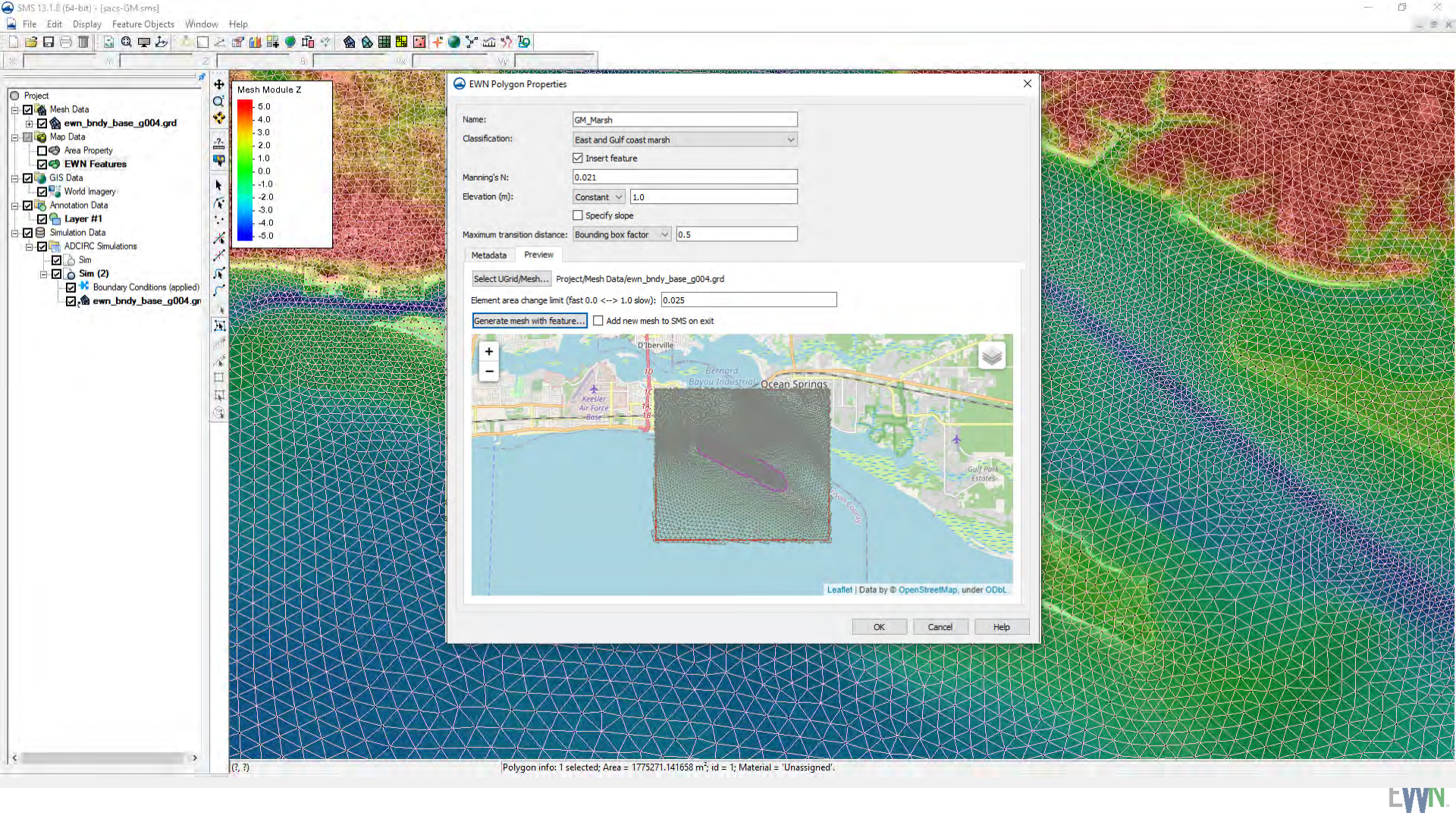
Polygon info: 1 selected; Area = 1775271.141658 m²; id = 1; Material = 'Unassigned'.
Add an annotation image.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EWN Polygon Properties
Name:
GM_Marsh
Classification:
East and Gulf coast marsh
Insert feature
Manning's N:
0.021
Elevation (m):
Constant
1.0
Specify slope
Maximum transition distance:
Bounding box factor
0.5
Metadata
Preview
Select UGrid/Mesh...
Project/Mesh Data/ewn_bndy_base_g004.grd
Element area change limit (fast 0.0 <--> 1.0 slow):
0.025
Generate mesh with feature...
Add new mesh to SMS on exit
D'Iberville
Bernard Bayou Industrial
Ocean Springs
Keesler Air Force Base
Gulf Park Estates
Leaflet | Data by © OpenStreetMap, under ODbL.
OK
Cancel
Help
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Polygon info: 1 selected; Area = 1775271.141658 m²; id = 1; Material = 'Unassigned'.

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File Edit Display Data Nodes Nodestrings Elements Window Help

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  - **EWN Feature Mesh**
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- Map Data
  - Area Property
  - **EWN Features**
- GIS Data
  - World Imagery
- Annotation Data
  - **Layer #1**
- Simulation Data
  - ADCIRC Simulations
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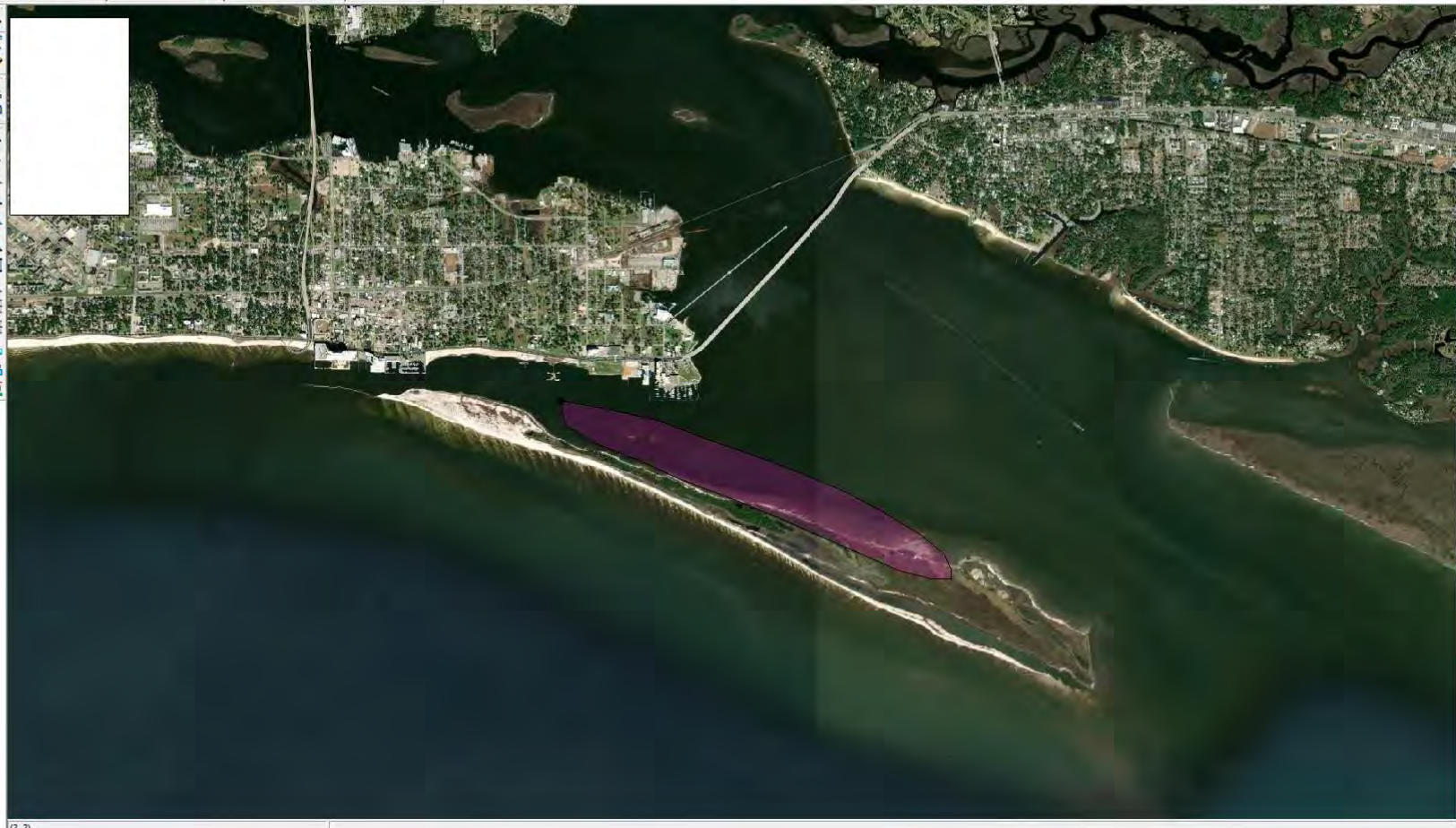

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File Edit Display Data Nodes Nodestrings Elements Window Help

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- Map Data
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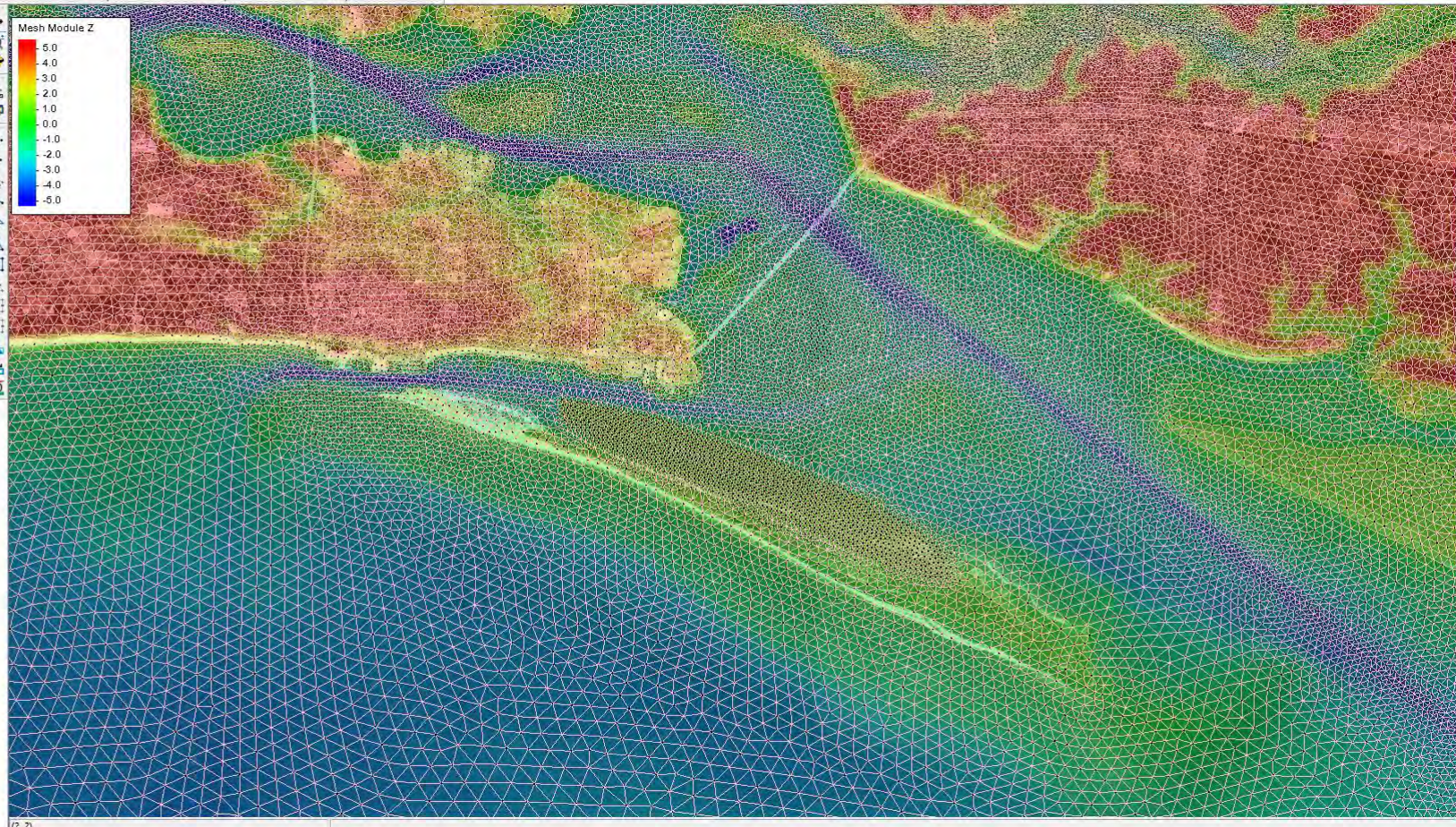

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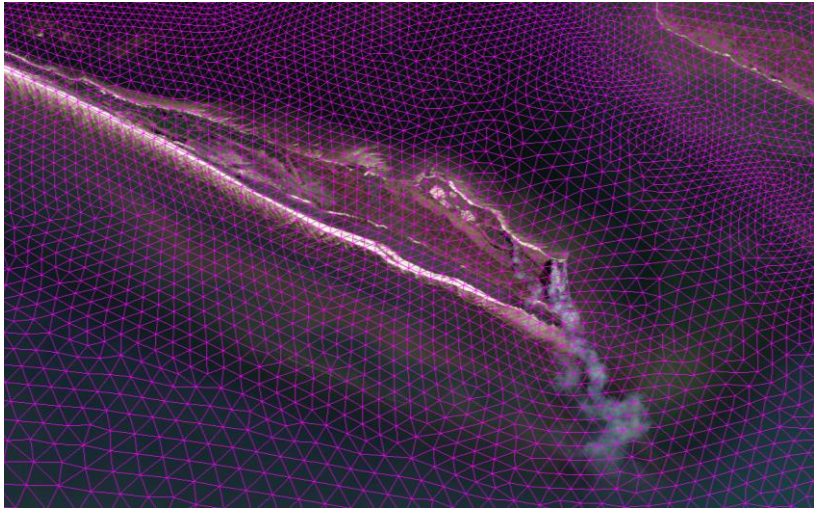
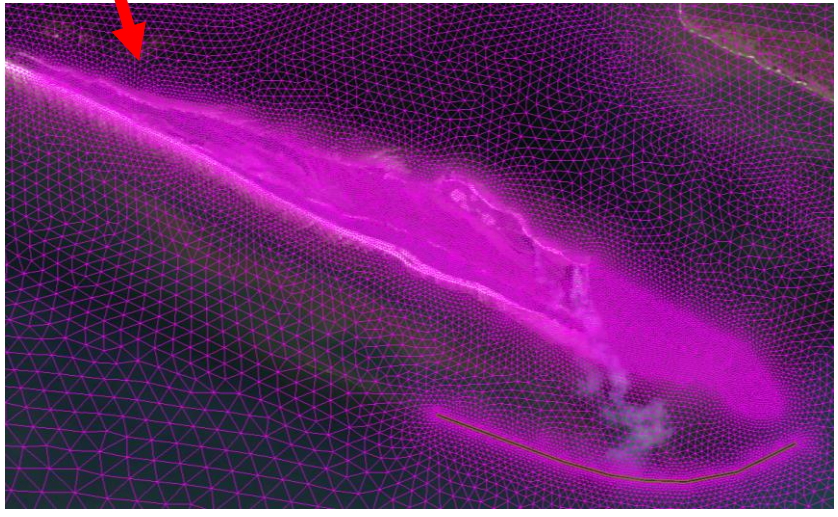
Deer Island Modeling Approach



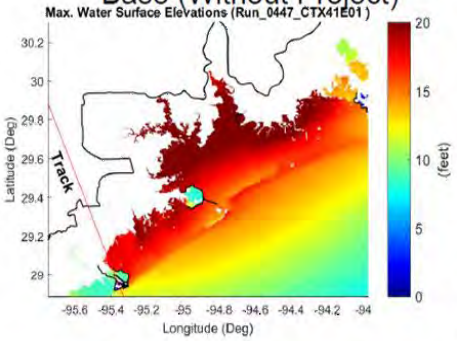
Initial SACS Mesh



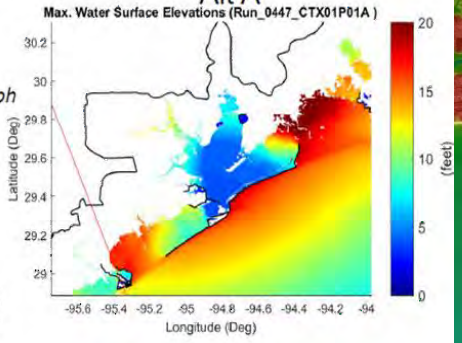
Mesh Refined to Include Proposed Features

COMPARISON

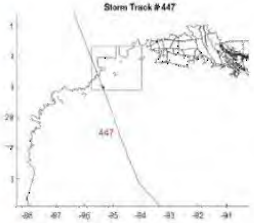
Base (Without Project)



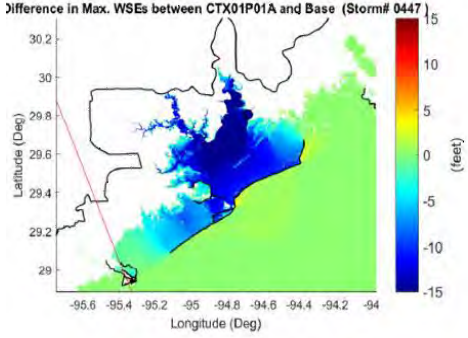
Alt A



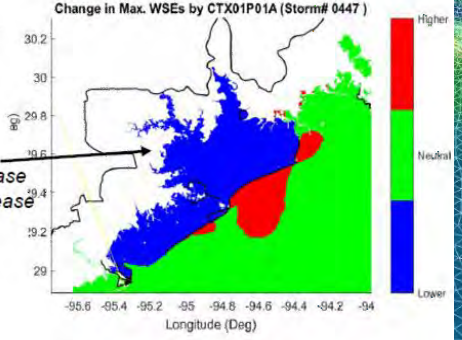
Max. Wind Speed: 105 mph (Cat. 2)
Min. Cp: 905 mb
Rmax: 44.6 nm
Forward Speed: 8.6 kts



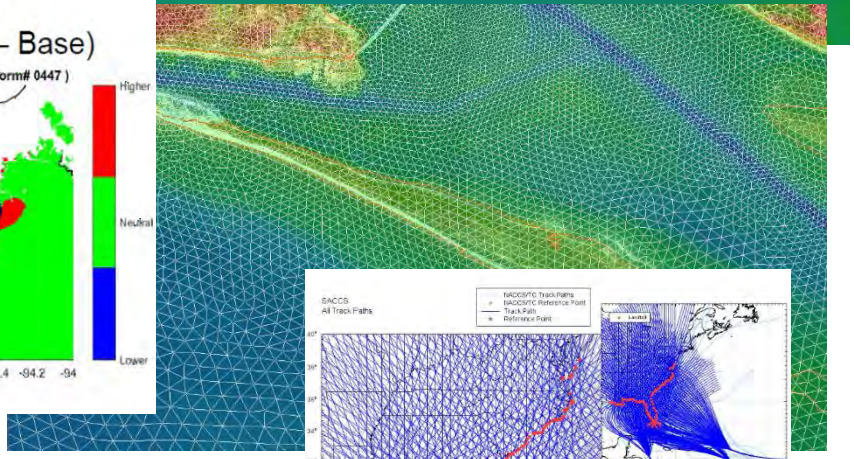
Difference (Alt A – Base)



Difference (Alt A – Base)



Change in WSEs:
Higher: > 1/2 ft increase
Lower: > 1/2 ft decrease
Neutral: in between



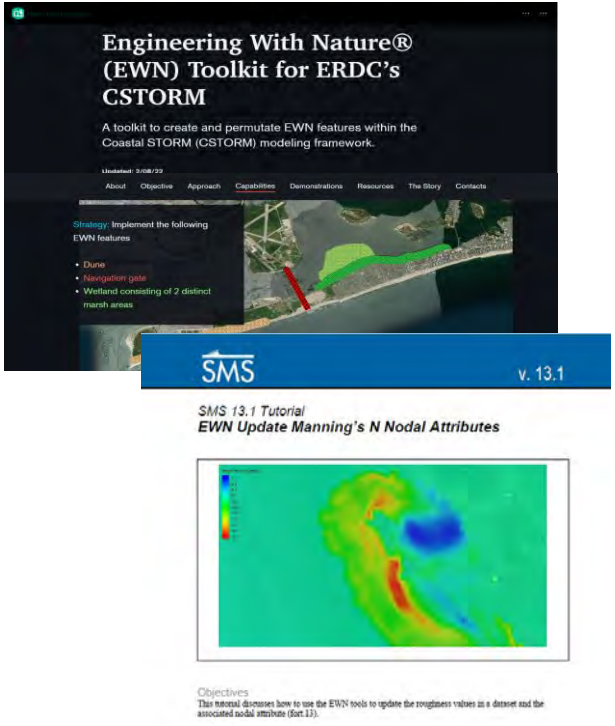
Example results from Coastal Texas Project:

EWN Toolkit Resources

To learn more about the EWN Toolkit, check out the following resources:

- EWN Toolkit Story Map
- SMS Tutorials from Aquaveo
- EWN Toolkit Coastal Storm Risk Management (CSRM) Course
  Lecture Video/Tutorial
- CSRM course being offered at Coastal and Hydraulics Laboratory in Vicksburg, MS in late winter/early spring 2023 – details forthcoming

**** All links included in slide notes! ****



Any Questions?

Please email:

Margaret.B.Owensby@erdc.dren.mil

Amanda.S.Tritinger@erdc.dren.mil

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Coastal and Hydraulics Laboratory

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