

Impacts of Hurricane Ian along Southwest Florida Coast:

Lessons (to be) Learned

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Outline

Introduction

Data Collection (by numerous entities)

Observations and Reflections

Introduction: The Storm

Wind:

Generate storm waves & storm surge
Cause structural damage directly

Storm Waves:

Cause beach/dune erosion
Move sediment landward & seaward
Cause structural damage directly

Storm Surge:

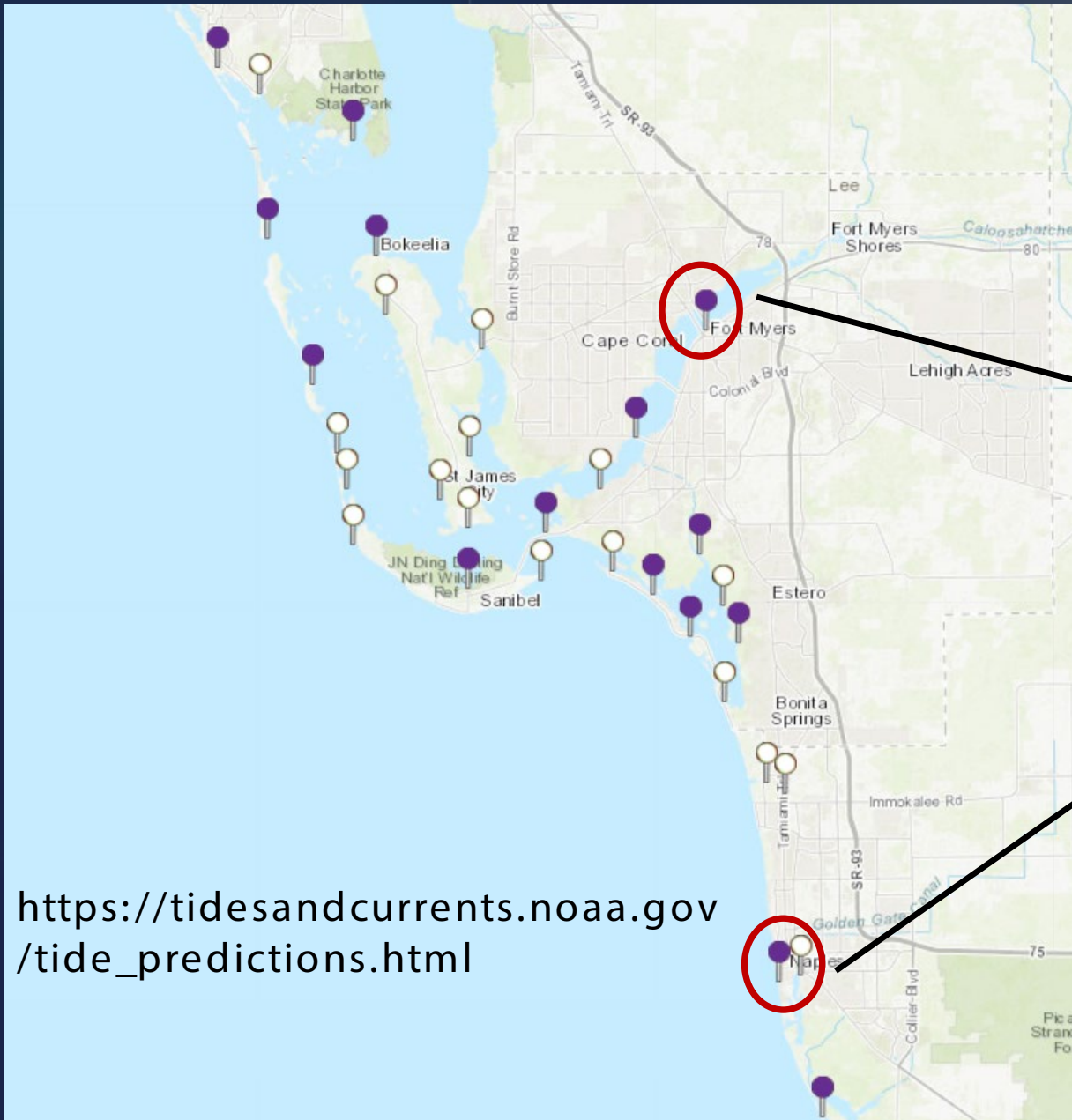
Elevate the water level for wave forcing
Cause structural damage directly
Distribute debris (floatation) & toxic chemicals (dissolution)

Rainfall:

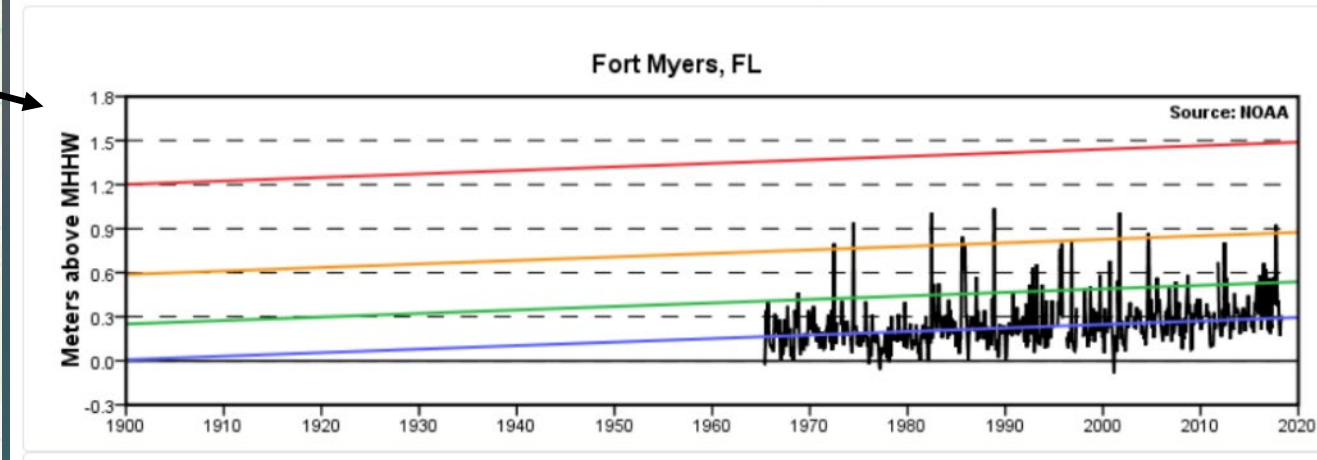
Contribute to compound flooding
Cause structural damage directly

Introduction: The Storm: Ian's storm surge

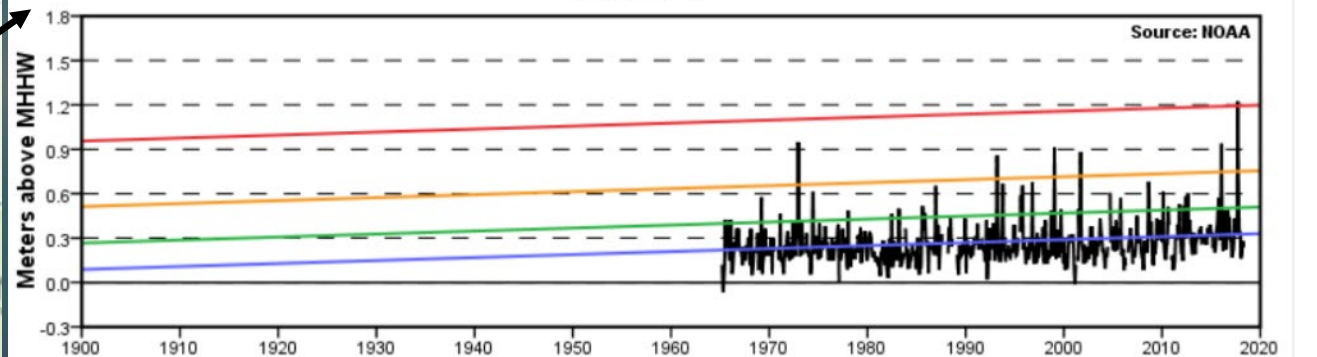
Two relatively long-term NOAA tide stations at the study area



Extreme Water Levels
8725520 Fort Myers, FL

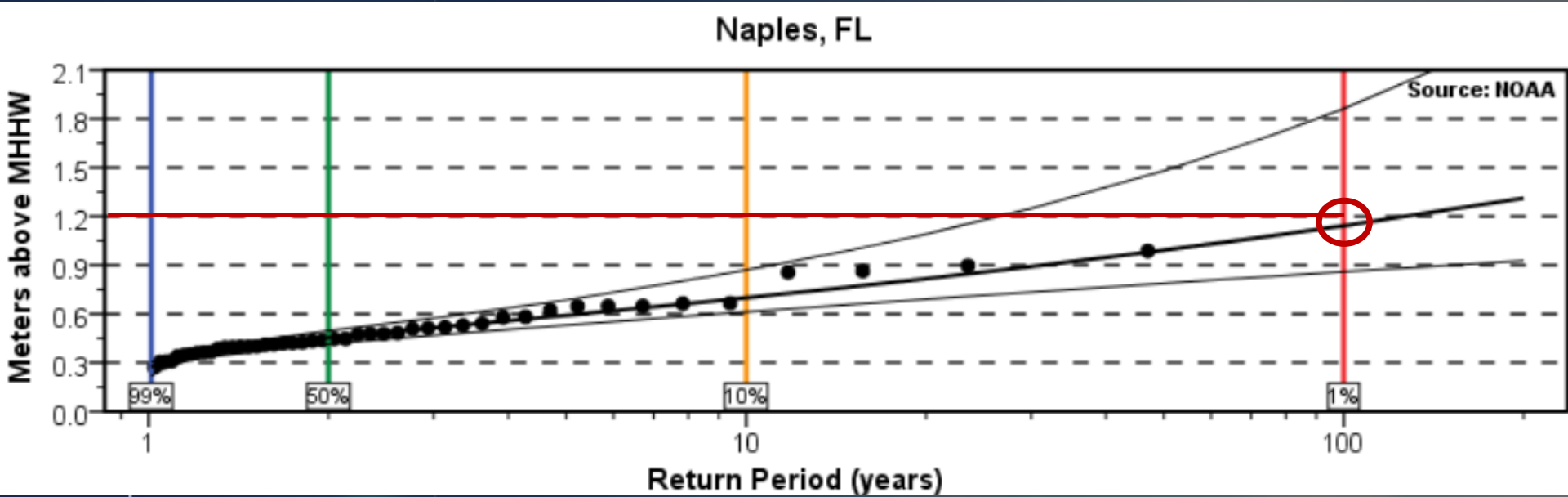


Naples, FL

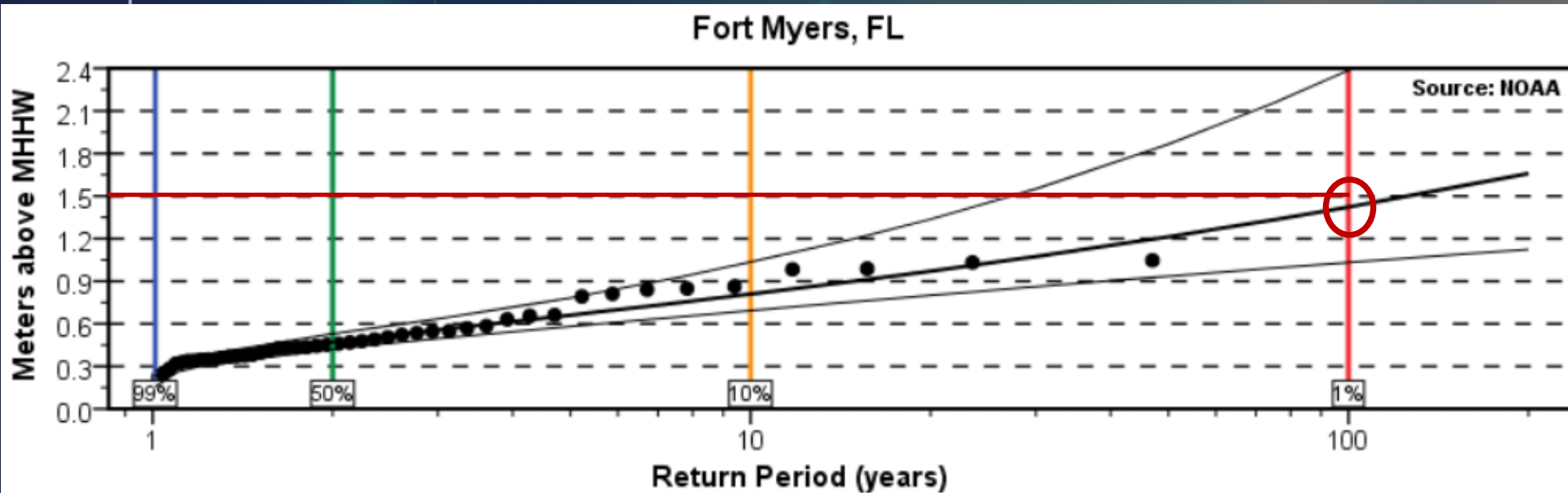


https://tidesandcurrents.noaa.gov/tide_predictions.html

Introduction: The Storm: Ian's storm surge



Naples: 100-year storm surge level is estimated by NOAA to be **~1.3 m NAVD88**.
MHHW 0 = **~0.18 m** above NAVD88

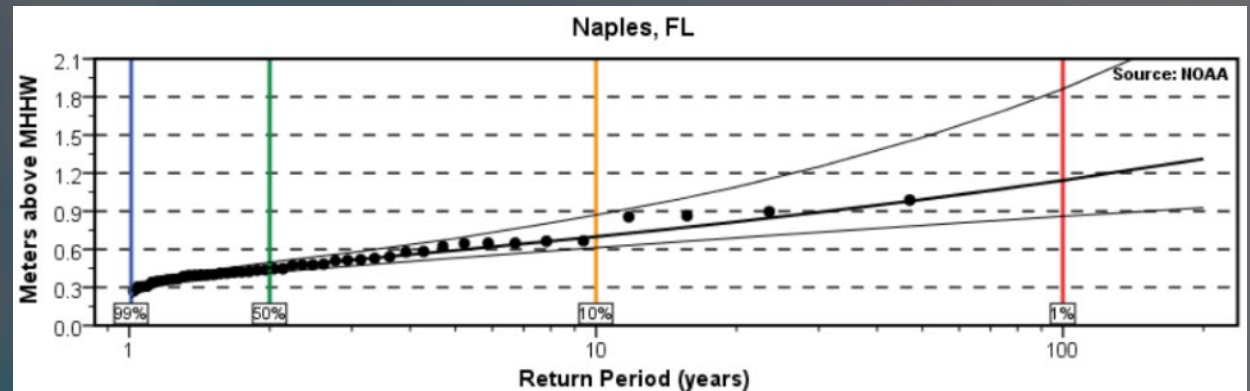


Ft. Myers on the River: **~1.6 m NAVD88**.
MHHW 0 = **~0.15 m** above NAVD88

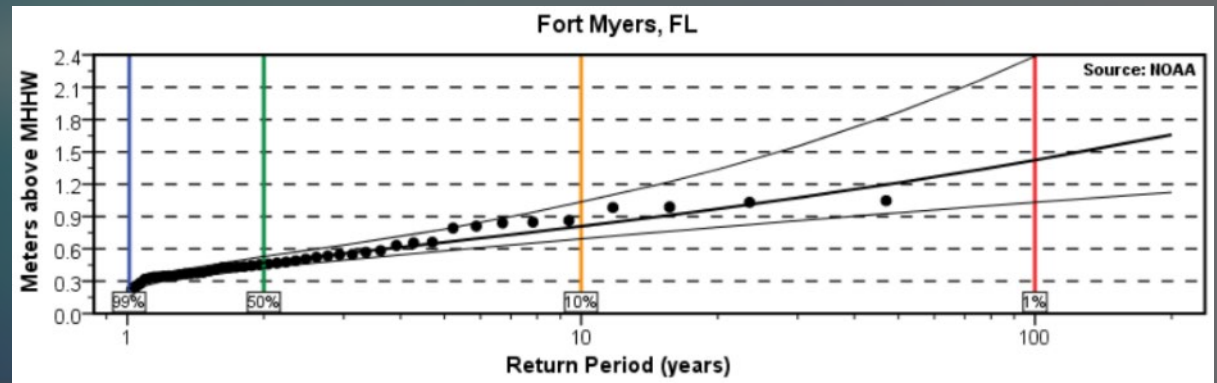
Introduction: The Storm: Ian's storm surge



Bonita Beach: measured by USF based on the wreck line: **3.8 m NAVD88 vs ~1.3 m 100-year** surge level (or 2.5 m higher, off the chart): or 2.4 m above ground at 1.4 m NAVD88



Ft. Myers: **2.6 m NAVD88 vs ~1.6 m 100-yr** survey level (or 1.0 m higher, off the chart again): or ~ 1.2 m above ground at 1.4 m NAVD88.



Reflection: The Storm: Ian's storm surge

Statistically, Hurricane Ian should be very rare

But can we assume that it will NOT happen again in, e.g., 50-100 years?

Statistics may not be on our side

Introduction: The Environment: SW Florida Coast

VERY gentle and wide continental shelf:

Favorable for developing high storm surge

A long and complex barrier-island chain (or 3 shorelines):

Varying length, width, and orientation

Low-lying with no real dunes, for ALL the barrier islands

Can have dense vegetation landward of the sandy beach

A large estuary with three major SW FL rivers:

Compound flooding: water from ocean and land

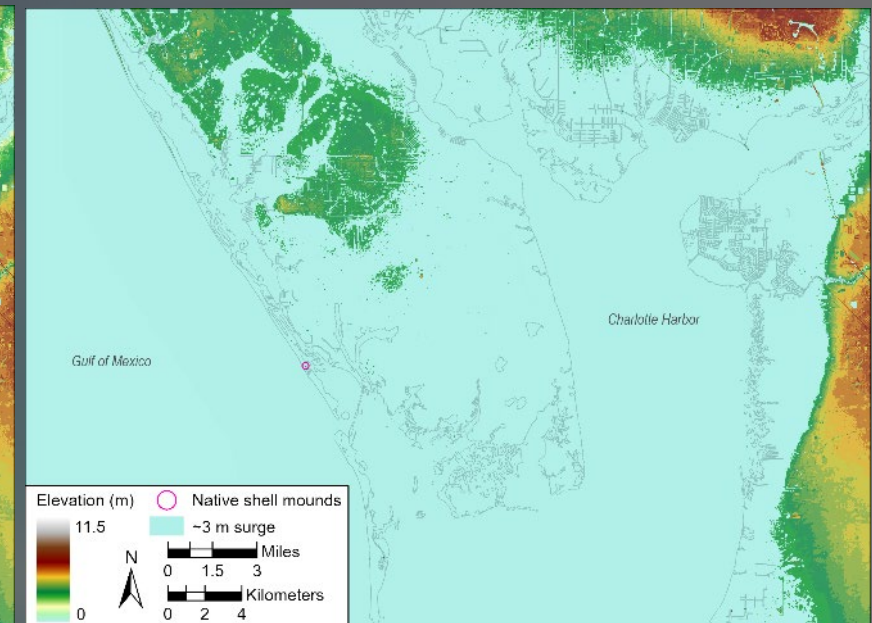
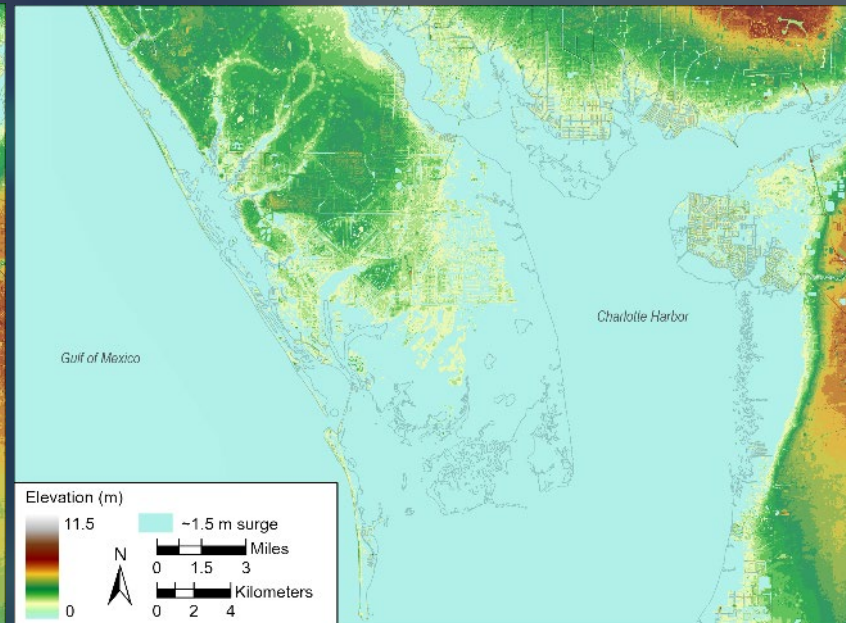
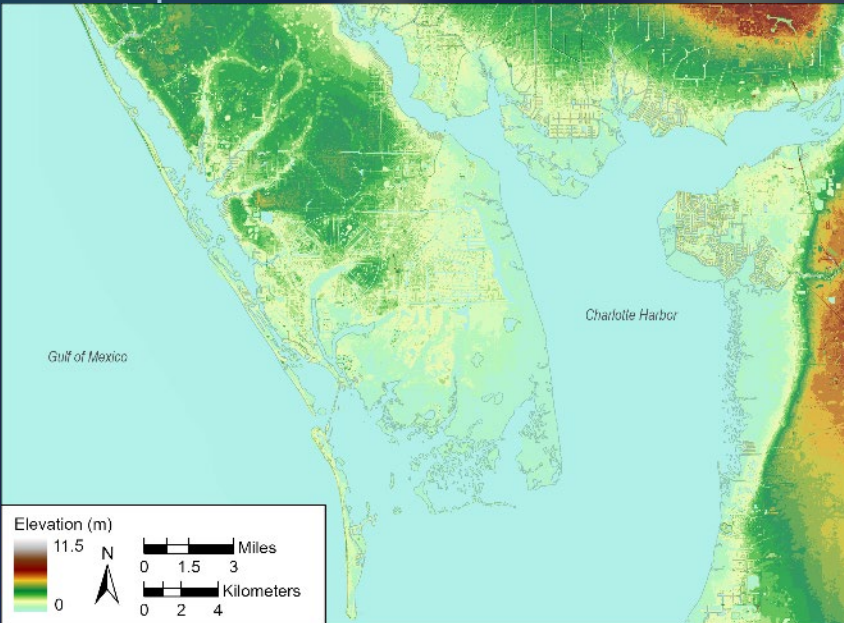
May “take” the storm surge far inland

VERY dense population and growing fast:

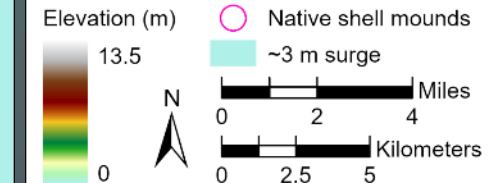
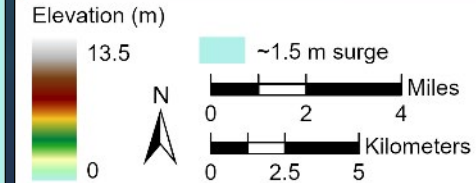
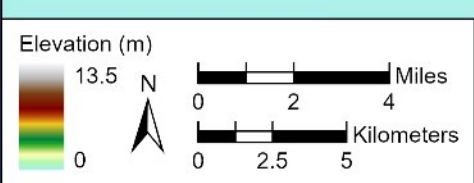
Dense development, old and new, along the waterfront

Introduction: The Environment: SW Florida Coast

Upper Charlotte Harbor

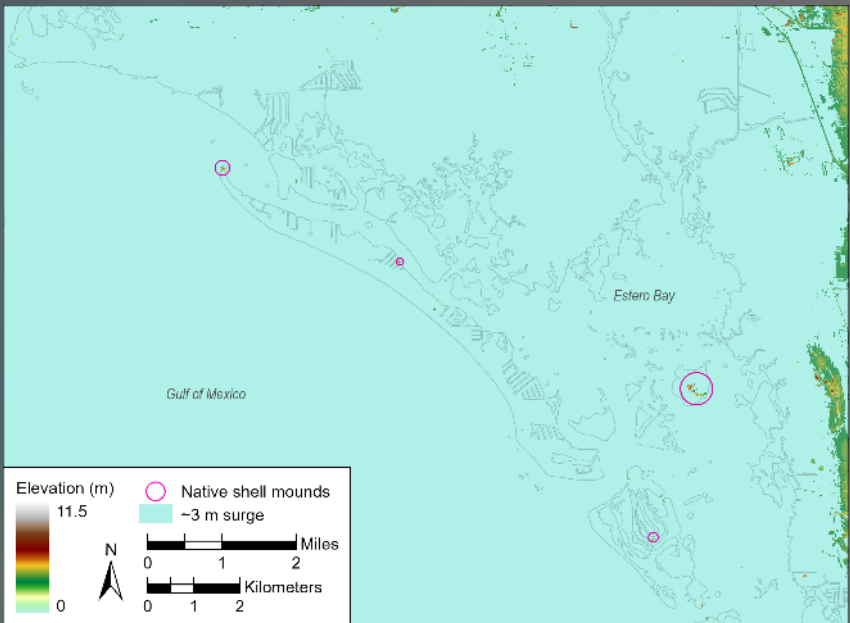
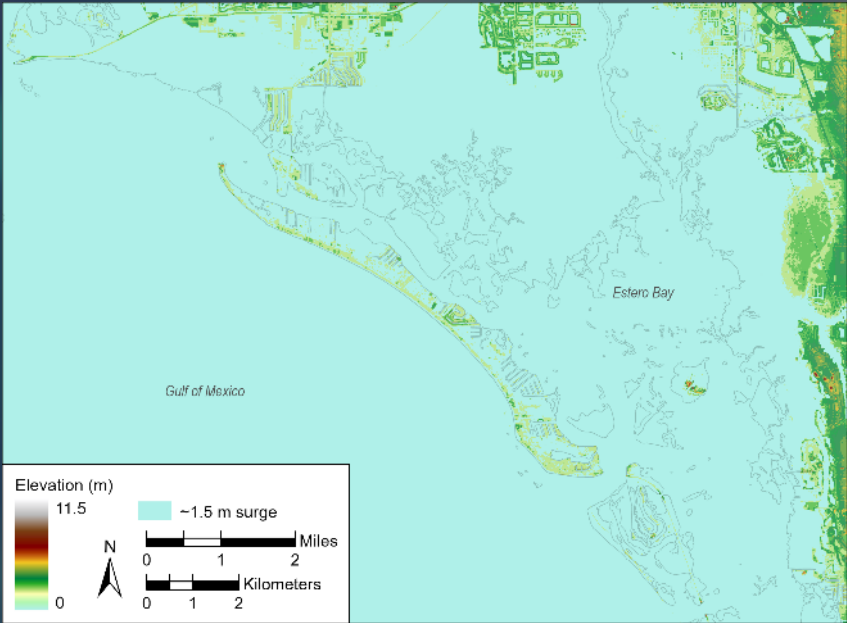
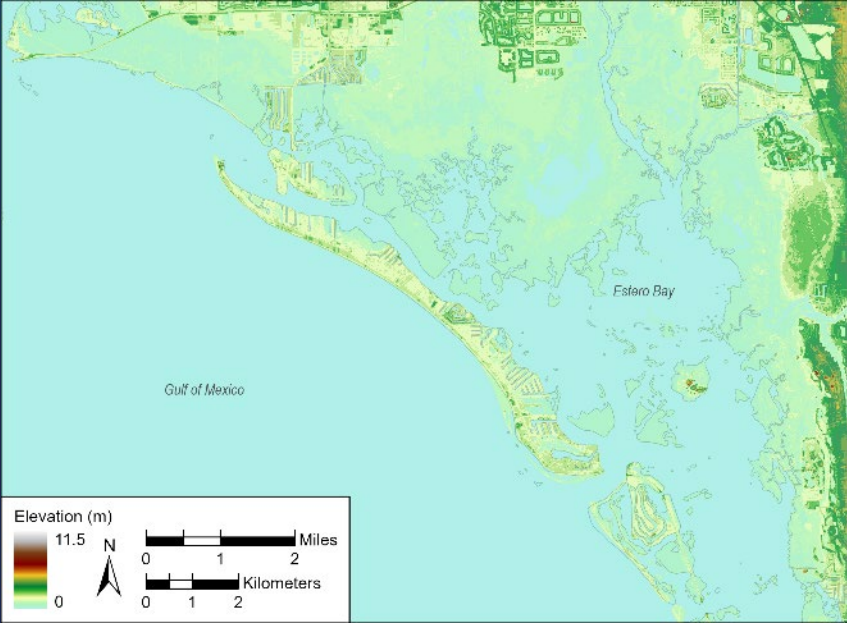


Introduction: The Environment: SW Florida Coast Lower Charlotte Harbor

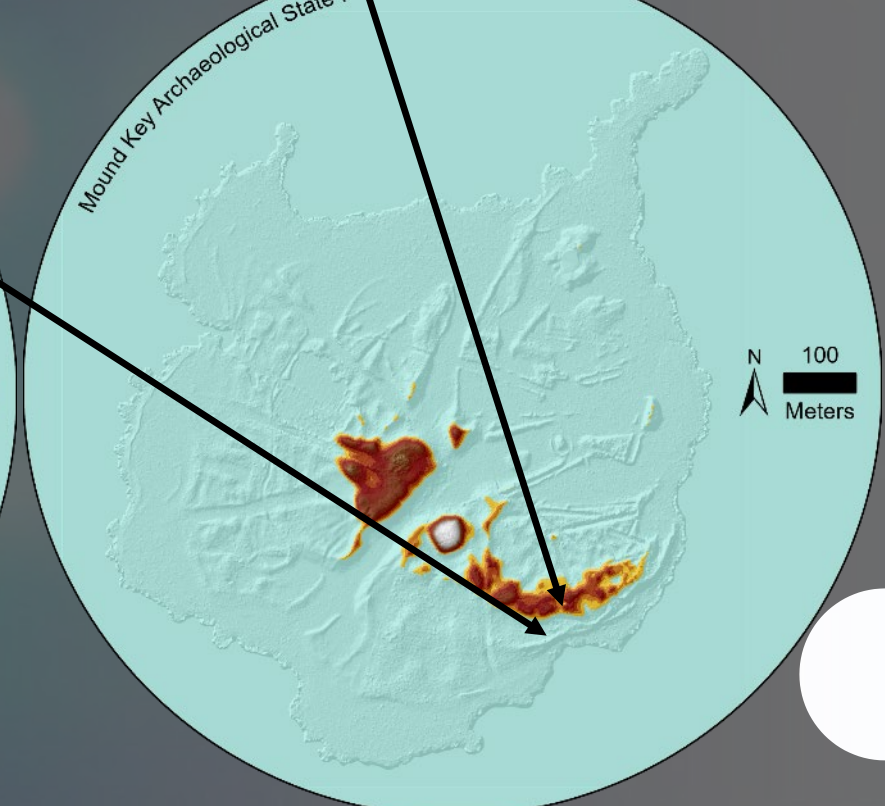
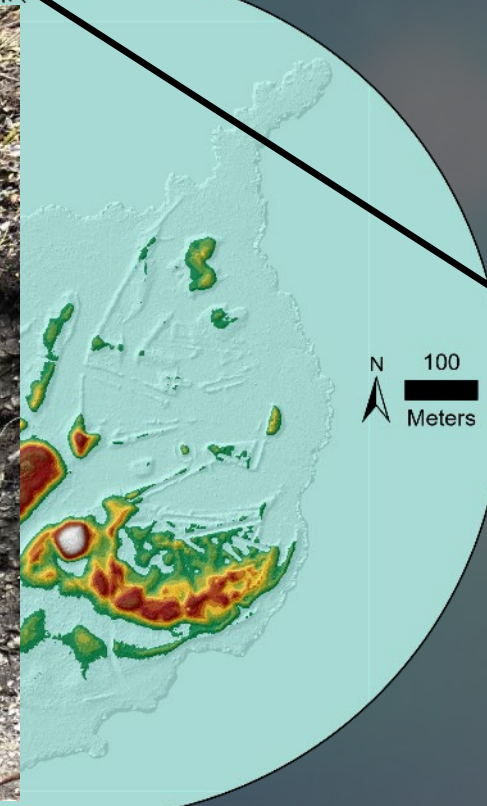
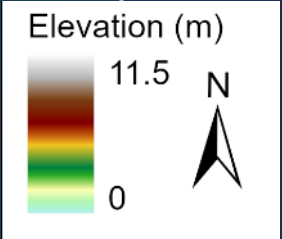


Introduction: The Environment: SW Florida Coast

Estero Bay



Introduction:



Reflection: The Environment: SW Florida Coast

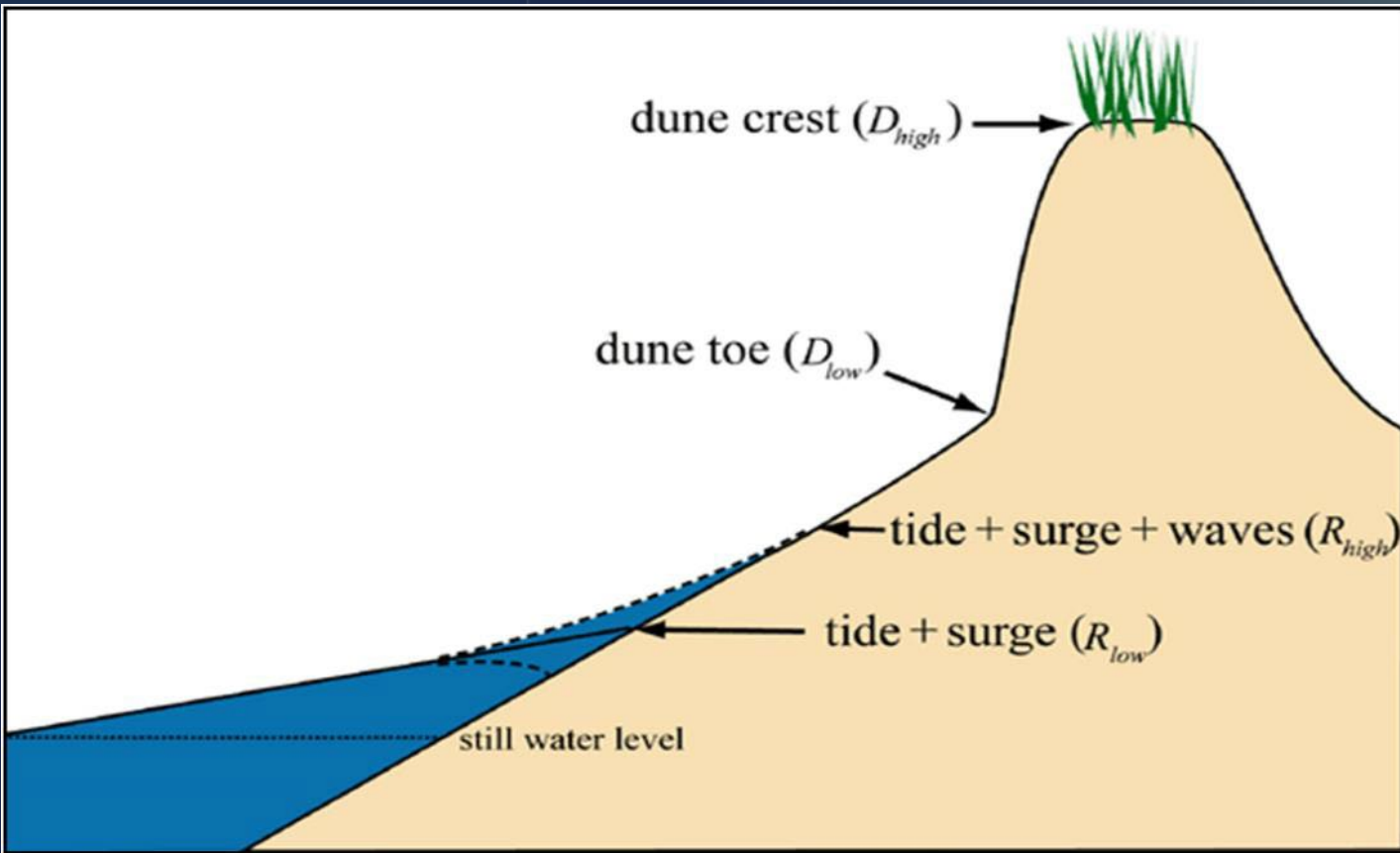
The natural SW Florida coast appears to “survive” this type of extreme storm by “going under”

Will the developed environment have to do the same, at “reasonable cost”, with “optimal preparation”, for a “reasonably rapid” recovery?

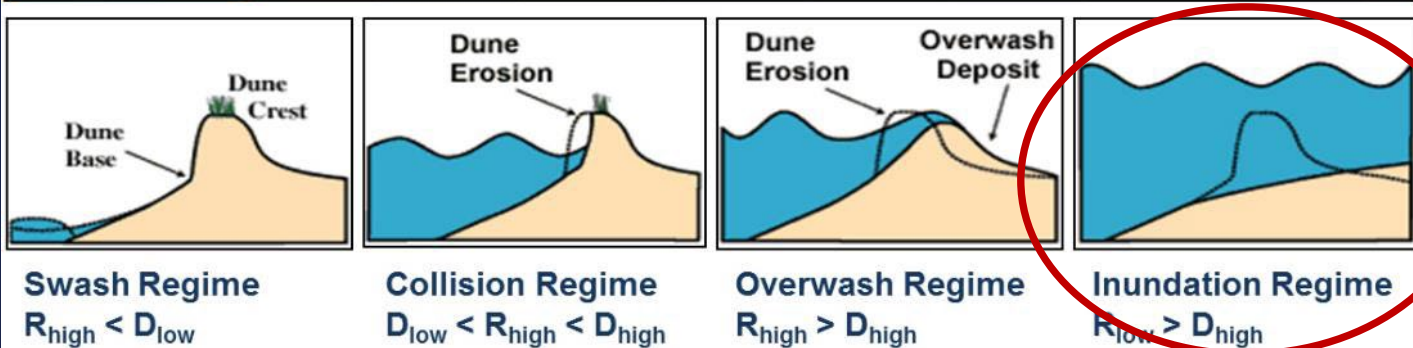
Do we have other options?

Introduction: The Sallenger Storm Impact Regime

Considering both the storm and the receiving coast



Hurricane Ian induced wide-spread Inundation Regime in SW Florida

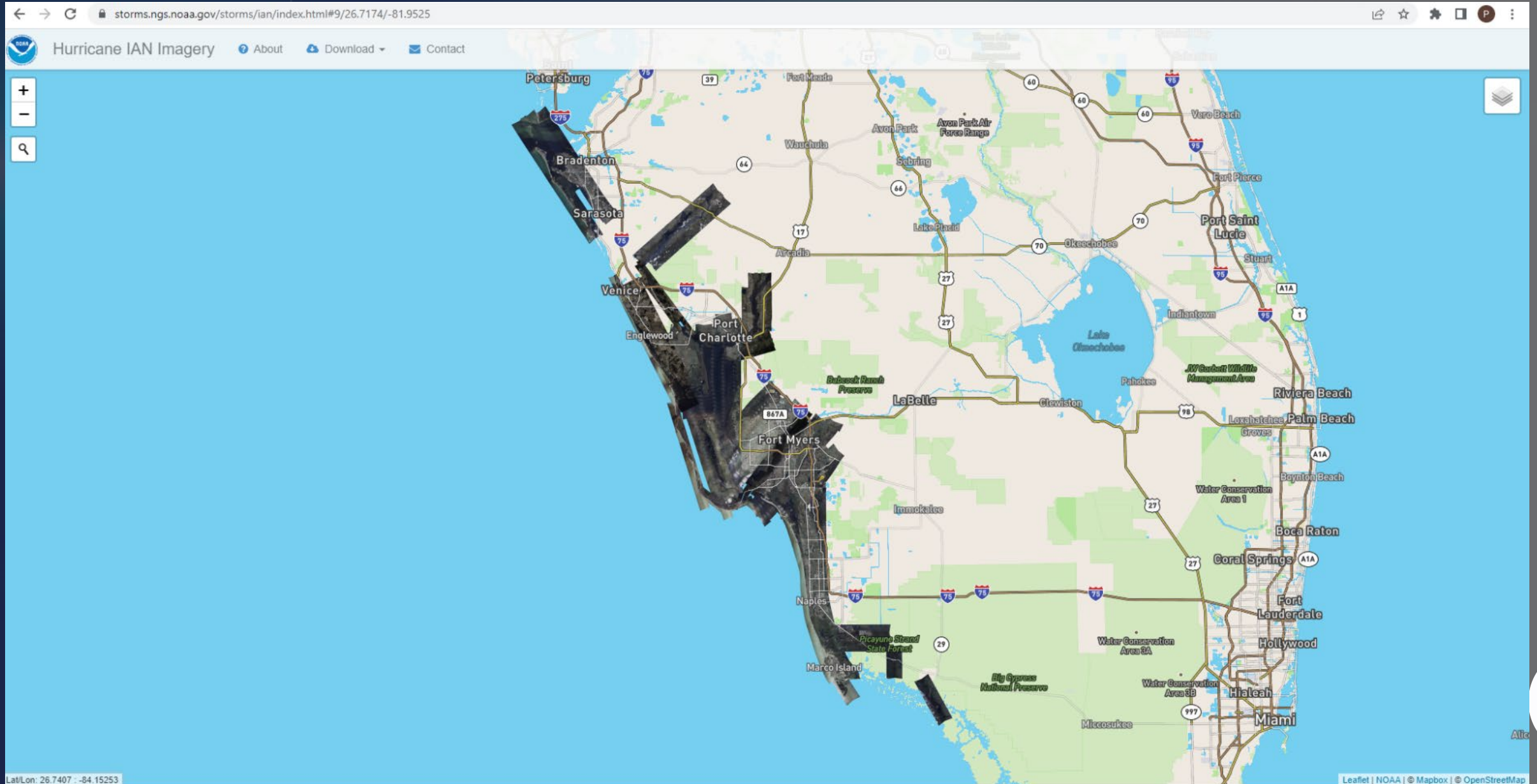


Data Collection (by numerous entities)

Ian may be the best documented Hurricane, providing tremendous opportunities for learning new knowledge and testing new tools.

Data Collection: aerial photos

<https://storms.ngs.noaa.gov/storms/ian/index.html#9/26.4200/-81.9700>



Data Collection: Post-storm video - FDEP

https://www.floridagio.gov/pages/video_hurricaneian



Florida Geographic Information Office

Community

Initiatives

GeoResources

Geospatial Open Data Portal

FDEP's Office of Resilience and Coastal Protection Videography

In response to Hurricane Ian, videography of the beach-dune system along the Gulf front coast was collected and is a State of Florida product; the flight lines may be shared, and deliverables will be hosted at FDEP and available to the public without vendor limitations. [Contact](#).

Data collection notes:

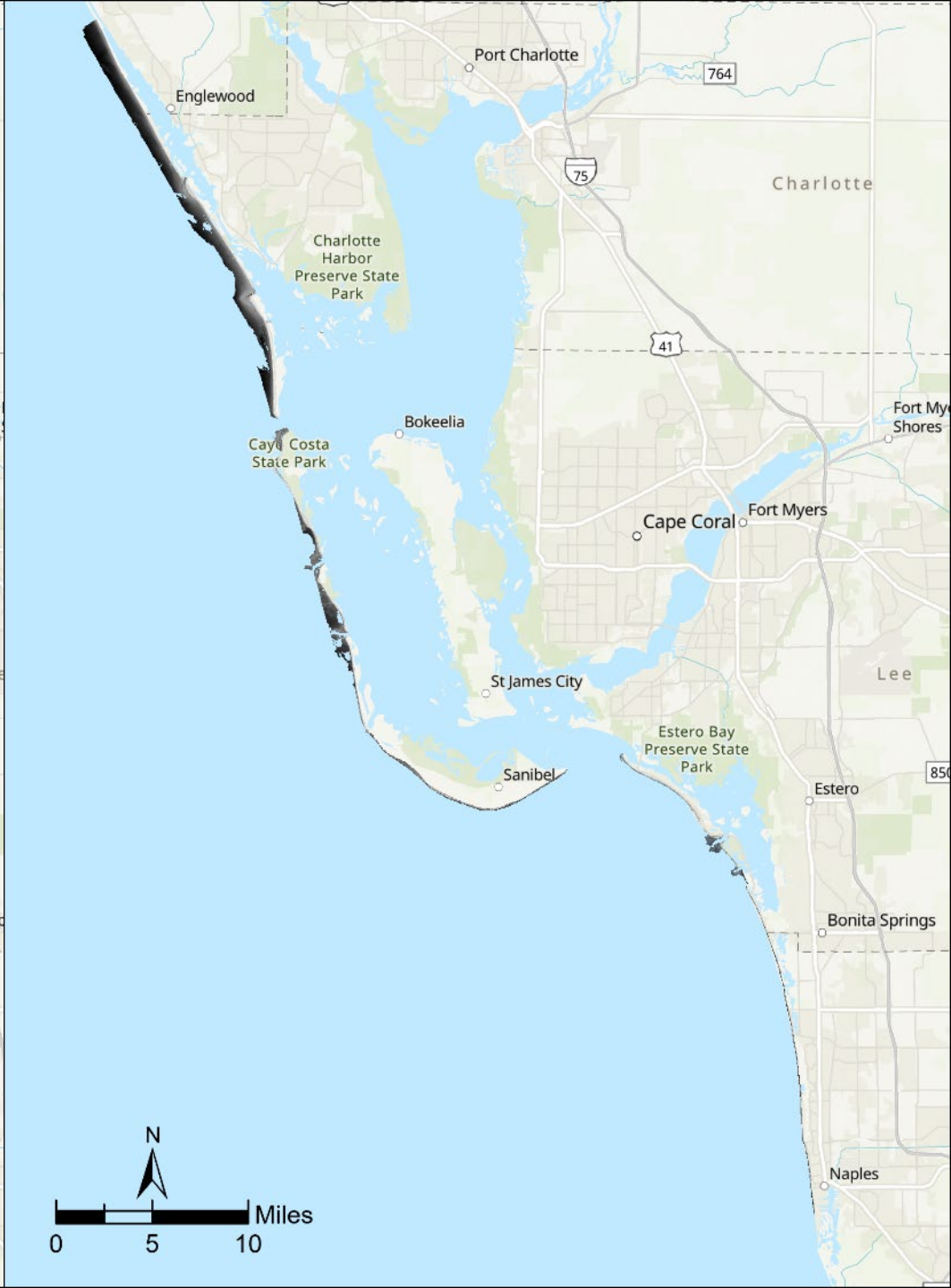
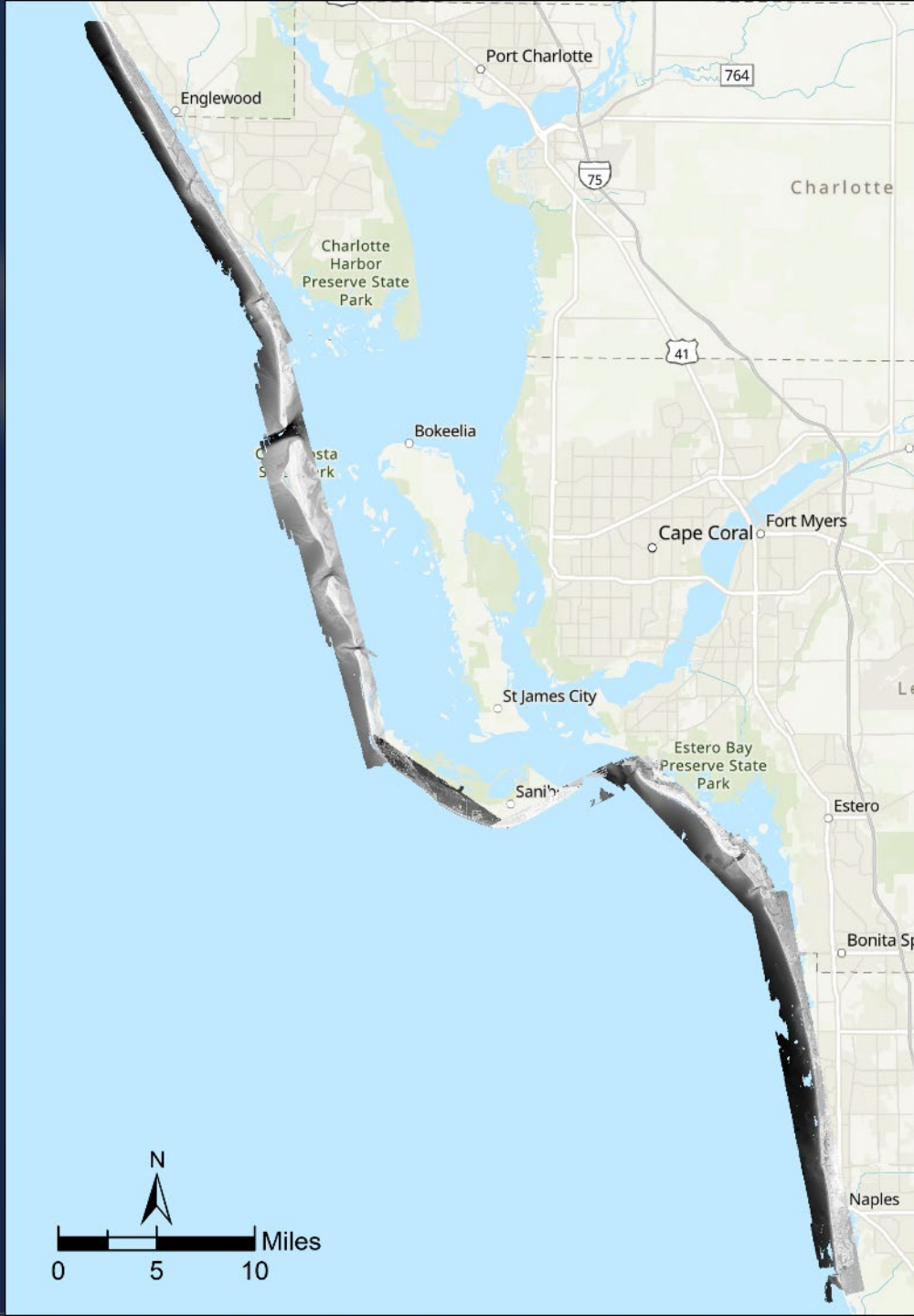
- Saturday October 1 - Anclote Key to Venice
- Sunday October 2 - Venice to Cape Romano
- Georeferenced with time stamps

LAT: 25.891408
LNG: -81.709598
UTC: 2022-10-02 21:27:58

FROM: Begin (24151.6 m)
TO: V-324 (69.9 m)



Data Collection: Airborne LIDAR



Data Collection: Water level measurements – USGS and others

<https://stn.wim.usgs.gov/FEV/#2022lan>

USGS science for a changing world **Flood Event Viewer** ABOUT GEOSEARCH

EVENT: **2022 Ian**
24 Sep 2022 thru 8 Oct 2022

BASEMAPS > FILTERS > CHANGE FILTERS

Current Filters
EVENT 2022 Ian
GET DATA > POWERED BY WIM

MAP LAYERS

Real-time Event Data
Tidal gages and real-time stream and rain gage layers only available at zoom level 9 and above. Please zoom in to view.

- Real-time Streamgage
- Real-time Rain Gage
- Tidal Gage
- SOFAR Buoy
- NOAA National Buoy
- Rapid Deployment Gage
- NOAA Tides and Currents Stations

Observed Event Data

- Barometric Pressure Sensor
- Water Level Sensor
- Meteorological Sensor
- Wave Height Sensor
- High Water Mark

Interpreted Event Data

- Peak Summary

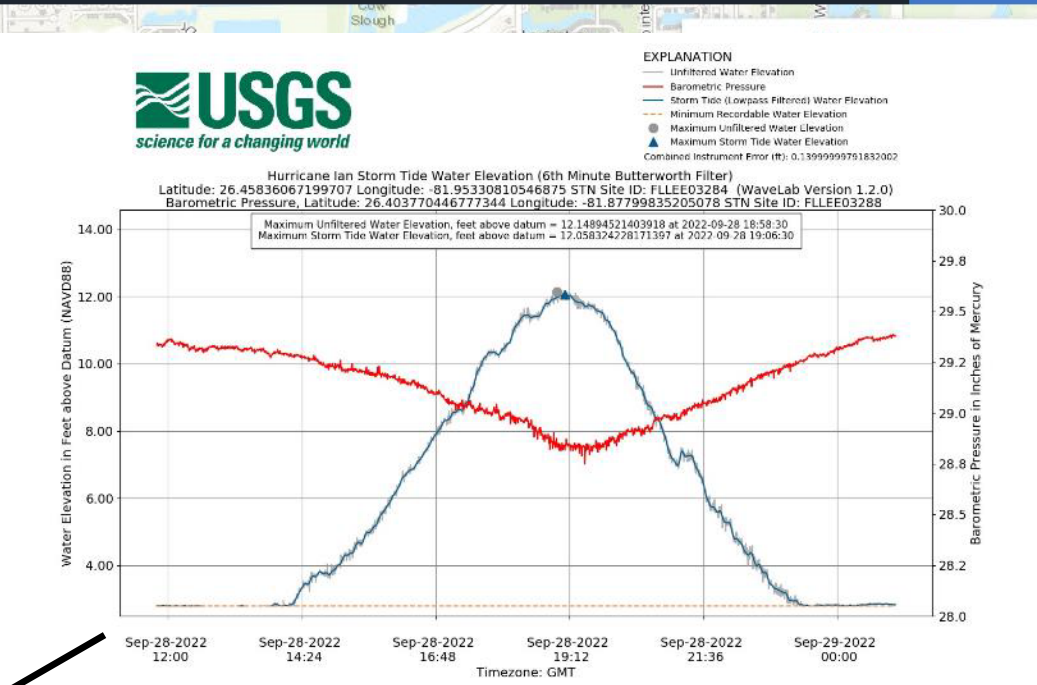
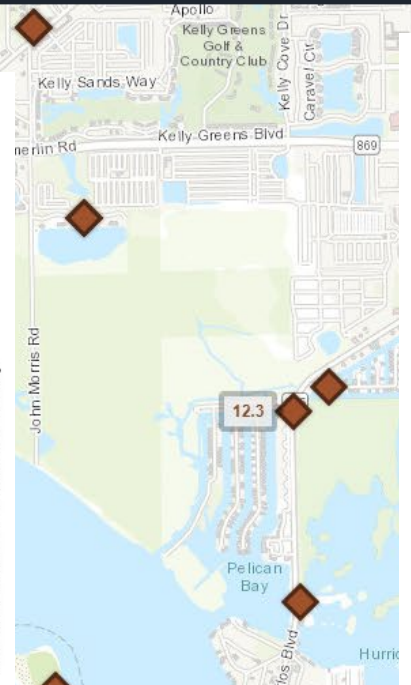
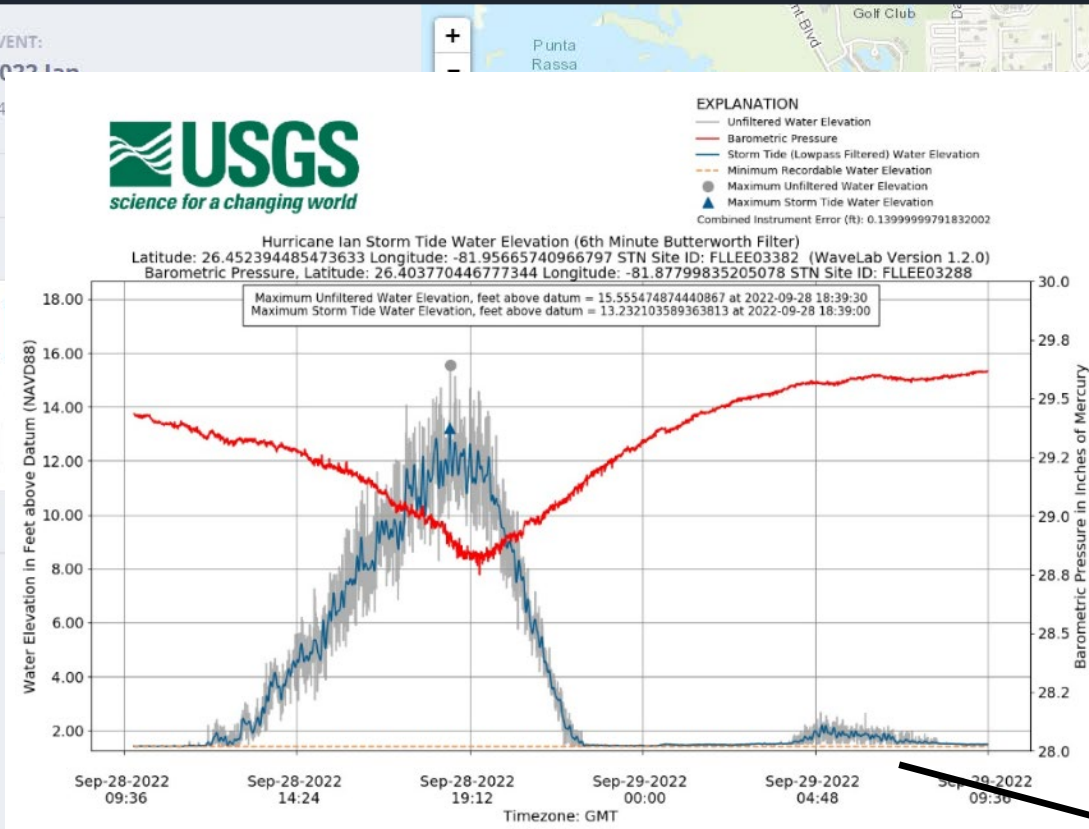
Supporting Layers

- Watersheds

1:9,244,649 | 6
27.1569 | -91.3180

Data Collection: Water level measurements – USGS

<https://stn.wim.usgs.gov/FEV/#2022Ian>



Data Collection: Water level measurements – USGS

<https://stn.wim.usgs.gov/FEV/#2022lan>

USGS Flood Event Viewer

EVENT: 2022 lan
24 Sep 2022 thru 8 Oct 2022

BASEMAPS >
FILTERS >
CHANGE FILTERS

Current Filters
EVENT 2022 lan
GET DATA >

POWERED BY WIM

1:72,223 | 13
26.4197 | -82.0032

MAP LAYERS

- Real-time Event Data
 - Real-time Streamgauge
 - Real-time Rain Gage
 - Tidal Gage
 - SOFAR Buoy
 - NOAA National Buoy
 - Rapid Deployment Gage
 - NOAA Tides and Currents Stations
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- Interpreted Event Data
 - Peak Summary
- Supporting Layers
 - Watersheds
 - NOAA Tropical Cyclone Forecast Track

Data Collection: Water level mo

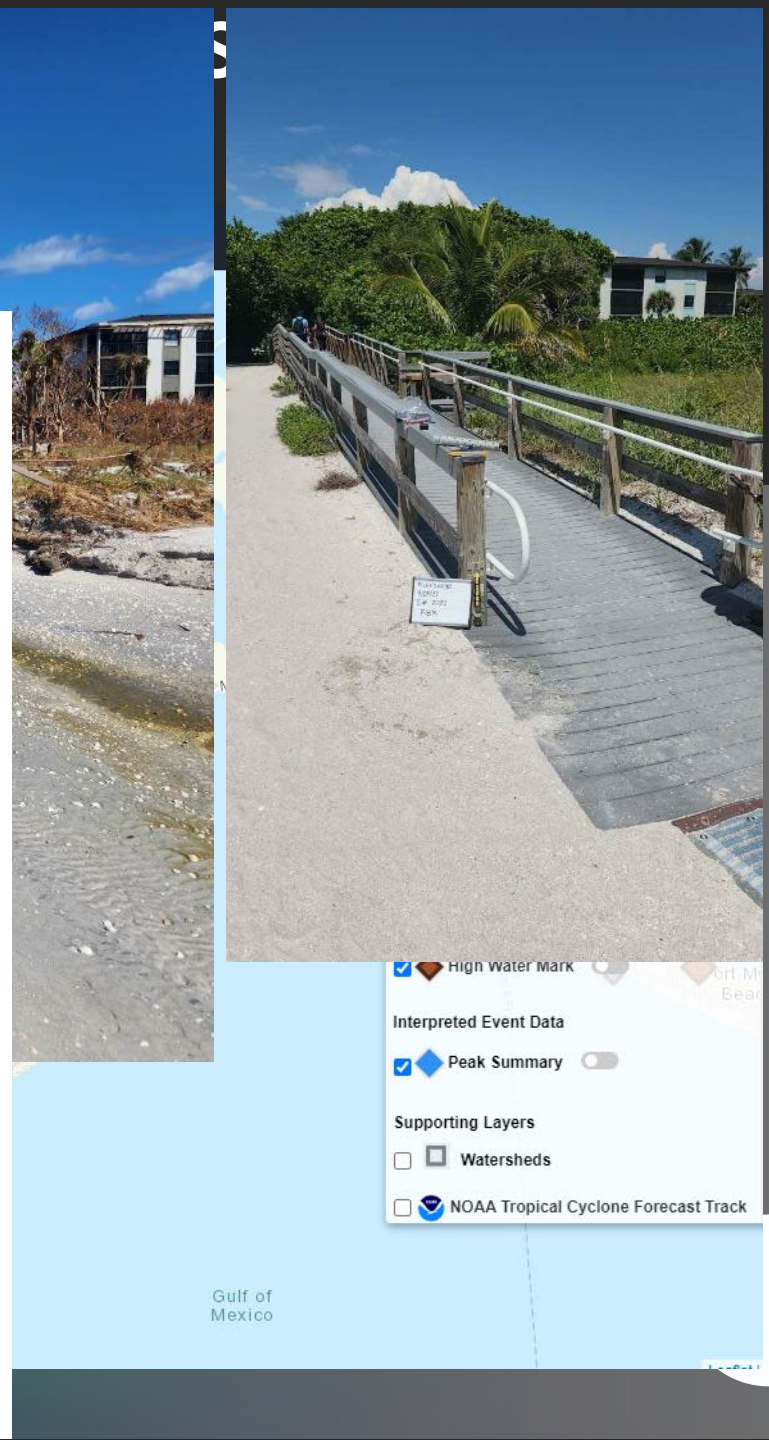
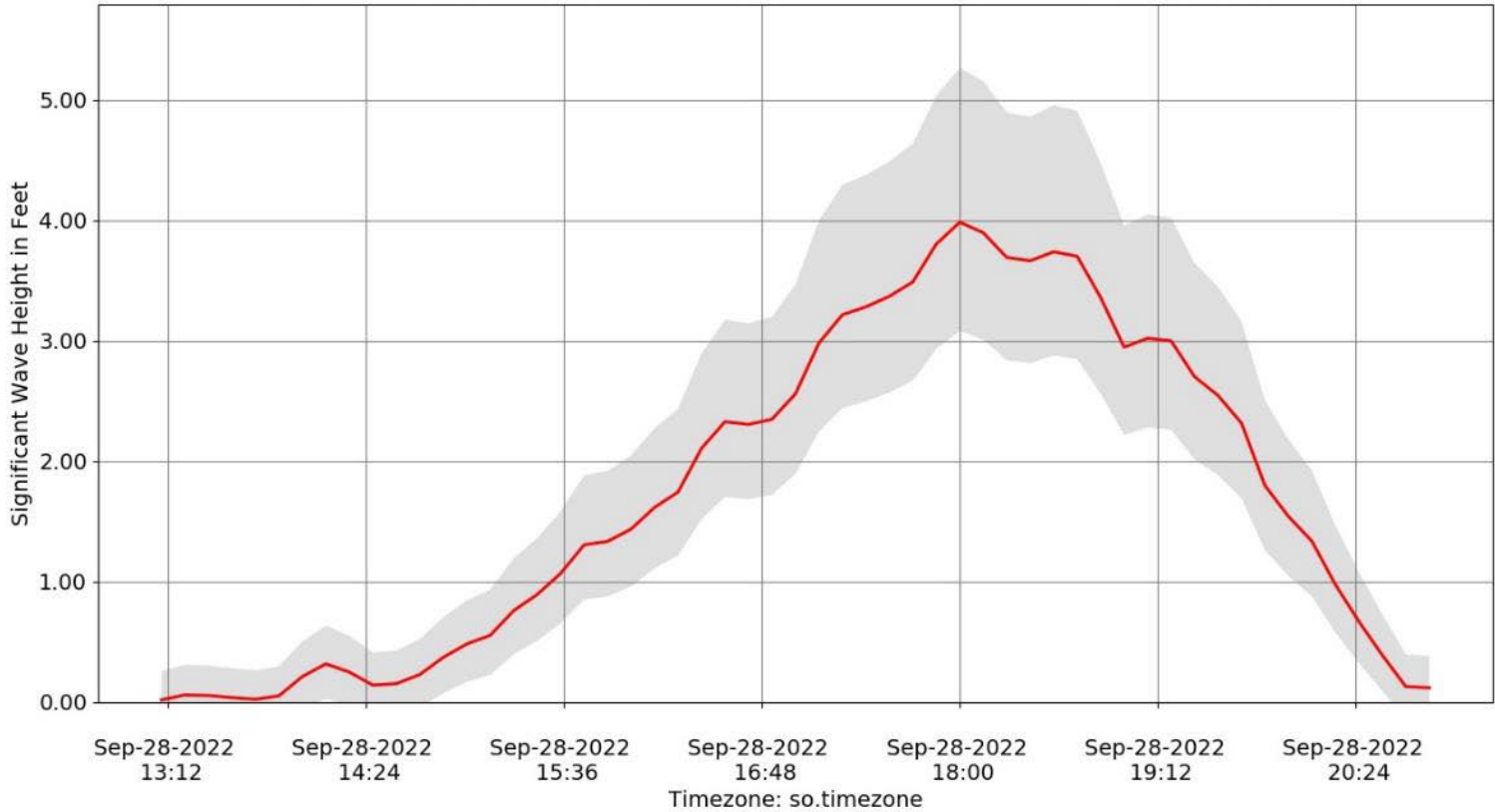
<https://stn.wim.usgs.gov/FEV/>

USGS Flood Event Viewer



EXPLANATION
— Original Estimate
— 90% Confidence Bound

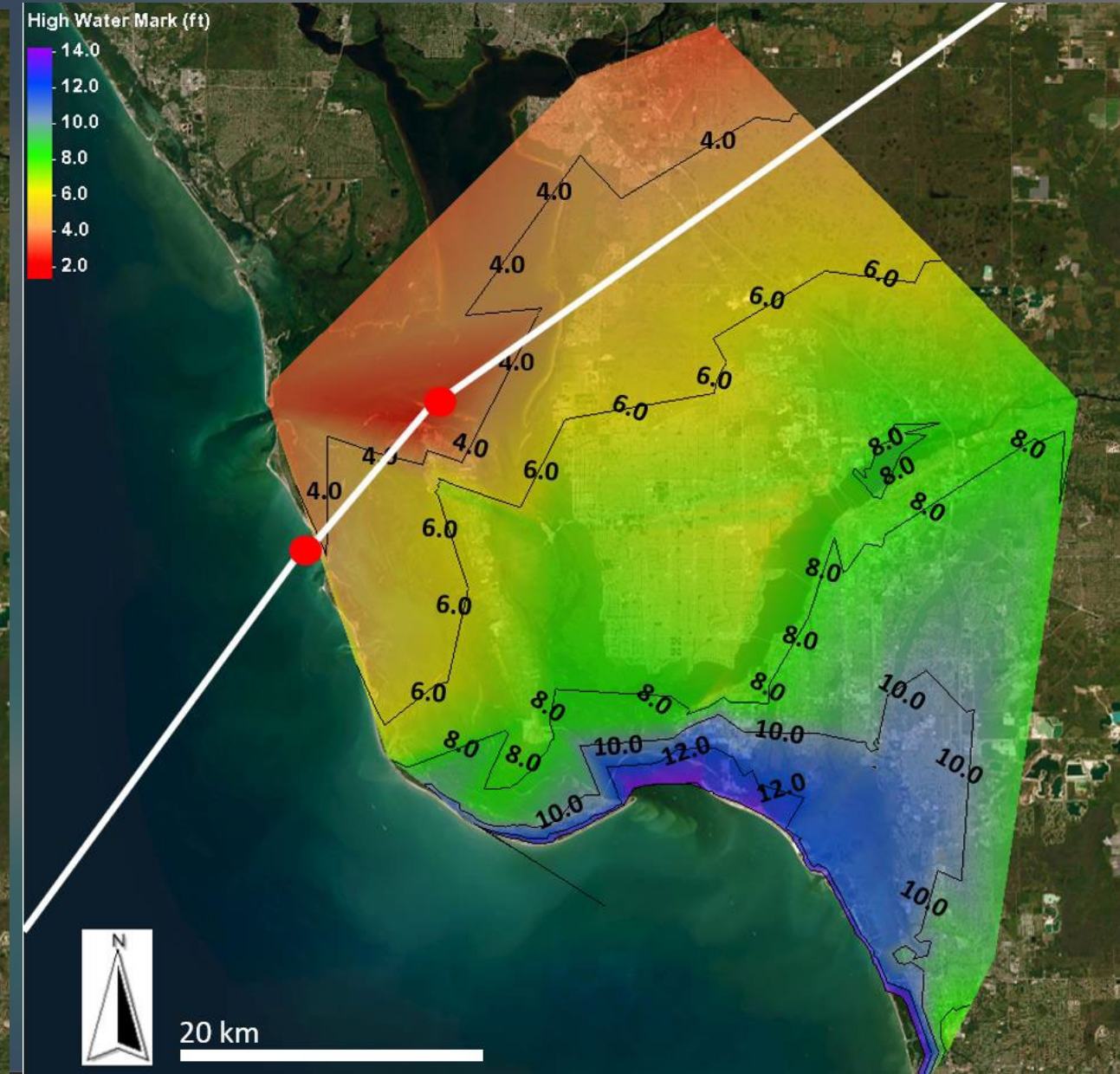
Hurricane Ian 90 Percent Confidence Intervals for Significant Wave Height (WaveLab Version 1.2.0)
Latitude: 26.42198944091797 Longitude: -82.08009338378906 STN Site ID: FLLEE26290



- High Water Mark
- Interpreted Event Data
 - Peak Summary
- Supporting Layers
 - Watersheds
 - NOAA Tropical Cyclone Forecast Track

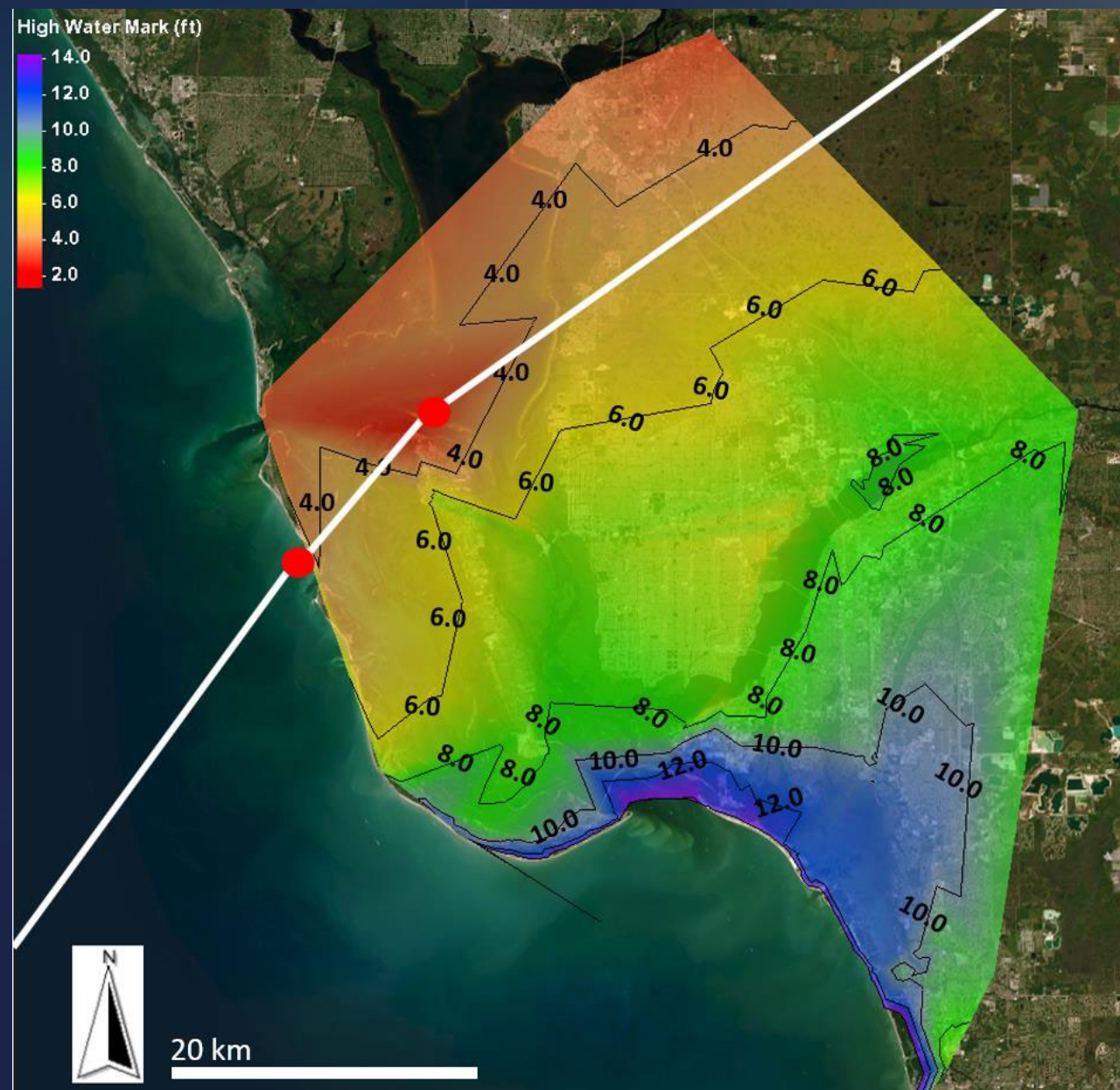
Data Collection: Water level measurements – USGS

<https://stn.wim.usgs.gov/FEV/#2022lan>



Data Collection: Water level measurements – USGS

<https://stn.wim.usgs.gov/FEV/#2022lan>



Area with 10+ ft surge:
264 km² (101 mi²)

Area with 8+ ft surge:
718 km² (277 mi²)

Area with 6+ ft surge:
1540 km² (595 mi²)

For Comparison:
Manhattan Island: 23 mi²



Data Collection: NSF funded Hazard Networks, mostly academia

<https://www.steer.network/>



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- StEER releases PVRR for Hurricane Merbok ([Access Here](#))
- StEER/EEFIT Collaborative wins Ground Engineering Award in UK: [Read More](#)
- **ONGOING RESPONSES:**
 - 23 November 2022 Earthquake, Turkey: [Access Duzce, Turkey Earthquake Response Page](#)
 - 21 November 2022 Earthquake, Indonesia: [Access Indonesia Earthquake Response Page](#)
 - 28 September 2022 Hurricane Ian, Florida: [PVRR Released](#) | [Access Hurricane Ian Response Page](#)
 - 18 September 2022 Hurricane Fiona, Puerto Rico: [Access Hurricane Fiona Response Page](#)
 - 14 August 2021 Earthquake in Nippes, Haiti: [PVRR Released](#) | [Access Haiti Response Page for Resources &Dat](#)



StEER
STRUCTURAL
EXTREME EVENTS
RECONNAISSANCE

Building Resilience through Reconnaissance

Join Now >

Data Collection: NSF funded Hazard Networks, mostly academia

<https://neerassociation.org/>



Nearshore Extreme
Events Reconnaissance
NEER

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NEER ENABLES RAPID ADVANCES IN
UNDERSTANDING THE NEARSHORE
SYSTEM.

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Nearshore Extreme Events Reconnaissance (NEER)

The goal of NEER is to conduct rapid, pre-storm site characterization, and instrument deployments by interdisciplinary teams to collect perishable data needed to address key hypotheses about storm impacts on coastal areas, including interactions and feedbacks between the natural and built environments and human actions and reactions.

Extreme storms have significant impacts on the nearshore water-land interface (where ocean, sound,



Data Collection: NSF funded Hazard Networks, mostly academia

<https://geerassociation.org/>



Geotechnical Extreme Events Reconnaissance
Turning Disaster into Knowledge
Sponsored by the National Science Foundation

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GEER
Turning Disaster into Knowledge

**GEOTECHNICAL
EXTREME EVENTS
RECONNAISSANCE**

Extreme events engineering is an experience-driven field. Thus, it is critically important to systematically collect perishable post-disaster data that can be useful in advancing our understanding of extreme events when they happen. Detailed mapping and systematic surveys of damaged areas provide the core data of well-documented case histories that drive the development of many of the empirical procedures used in geoen지니어ing practice.

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Select Event Type

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- Earthquake
- Flood
- Hurricane
- Landslide
- Storm
- Tsunami
- Typhoon
- Fire
- Explosion

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- [Upcoming Activities](#)

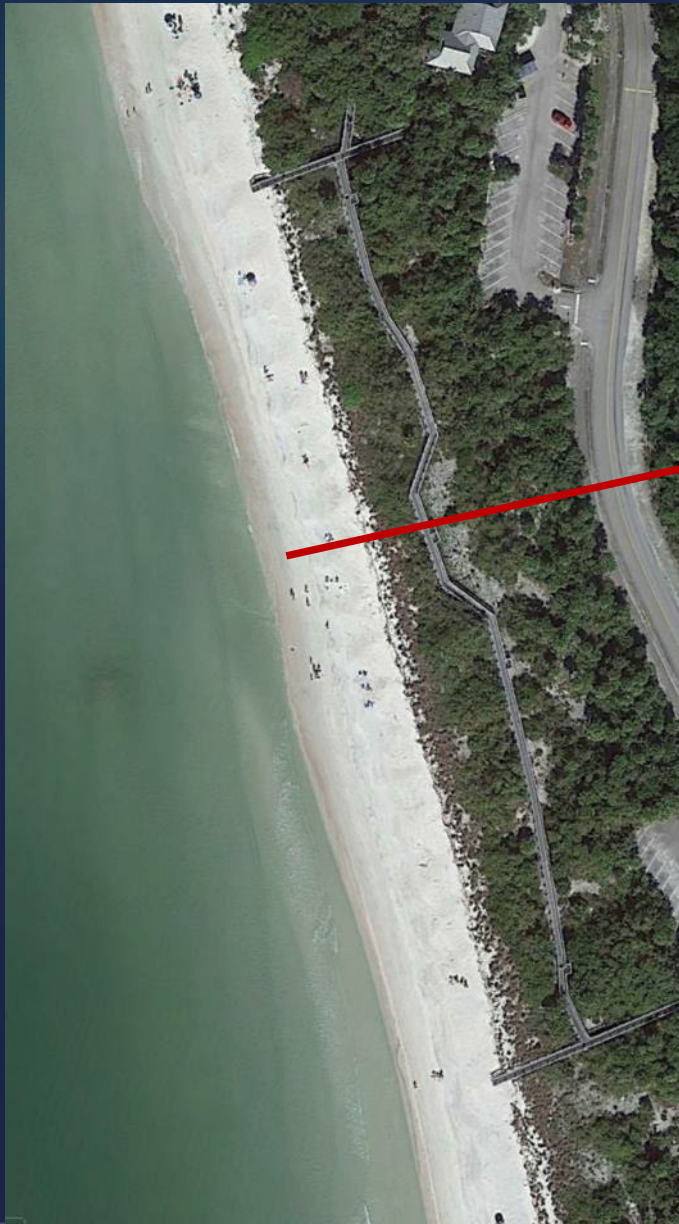
GEER NEWS

- [New GEER Member Portal](#)
2022-03-02 21:25:55

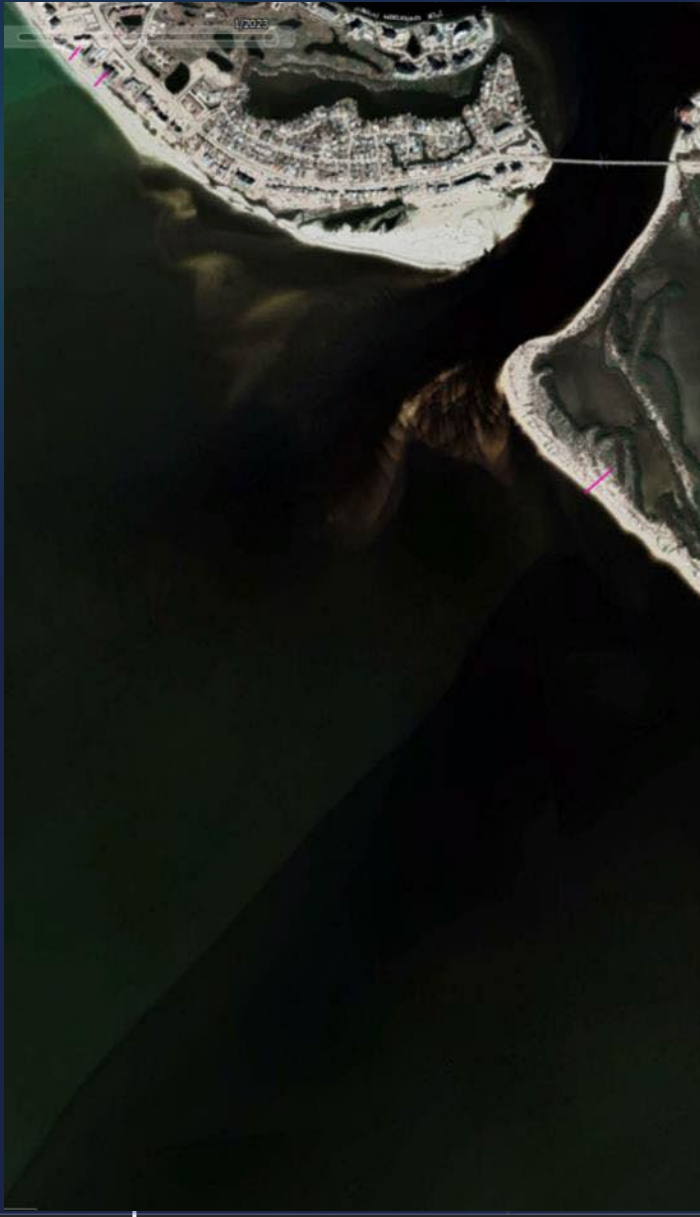
Observations: Overwash into “cat’s eye” pond within the barrier island interior and in the back bay



Observations: Overwash into dense vegetation



Observations: Overwash/storm deposits in the back-barrier bay – a mangrove island



Reflection: overwash and landward sand transport

Storm overwash provides a mechanism for elevation gain on:

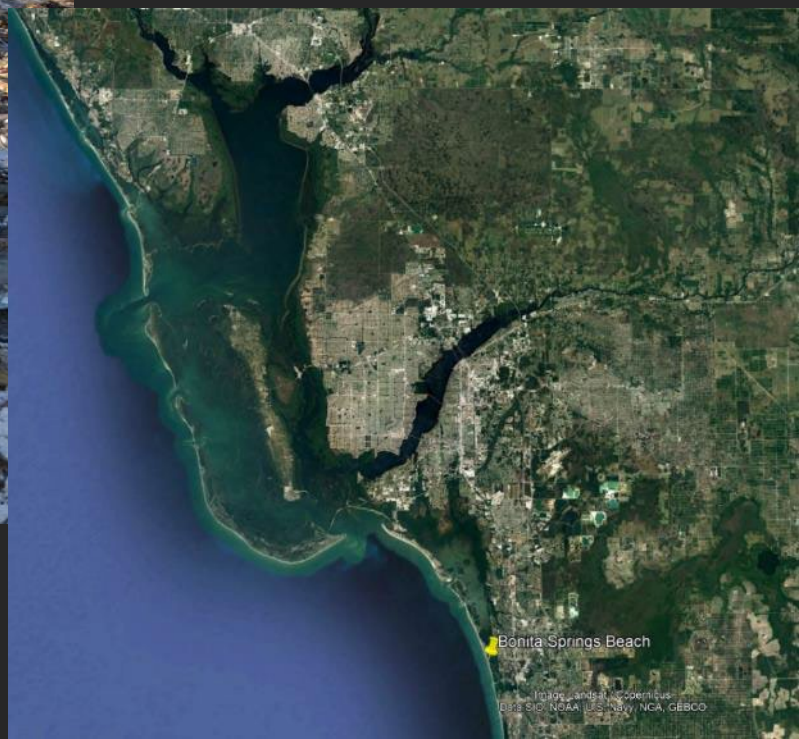
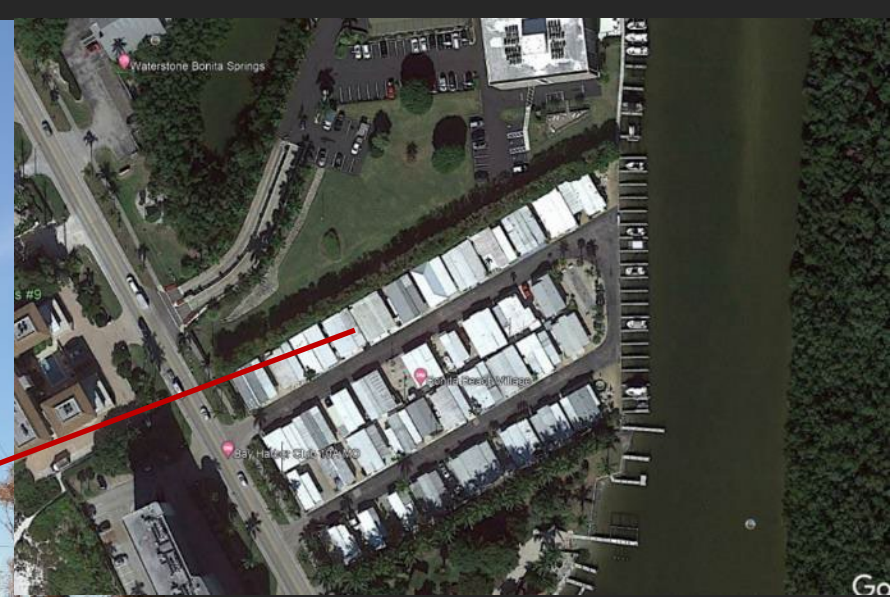
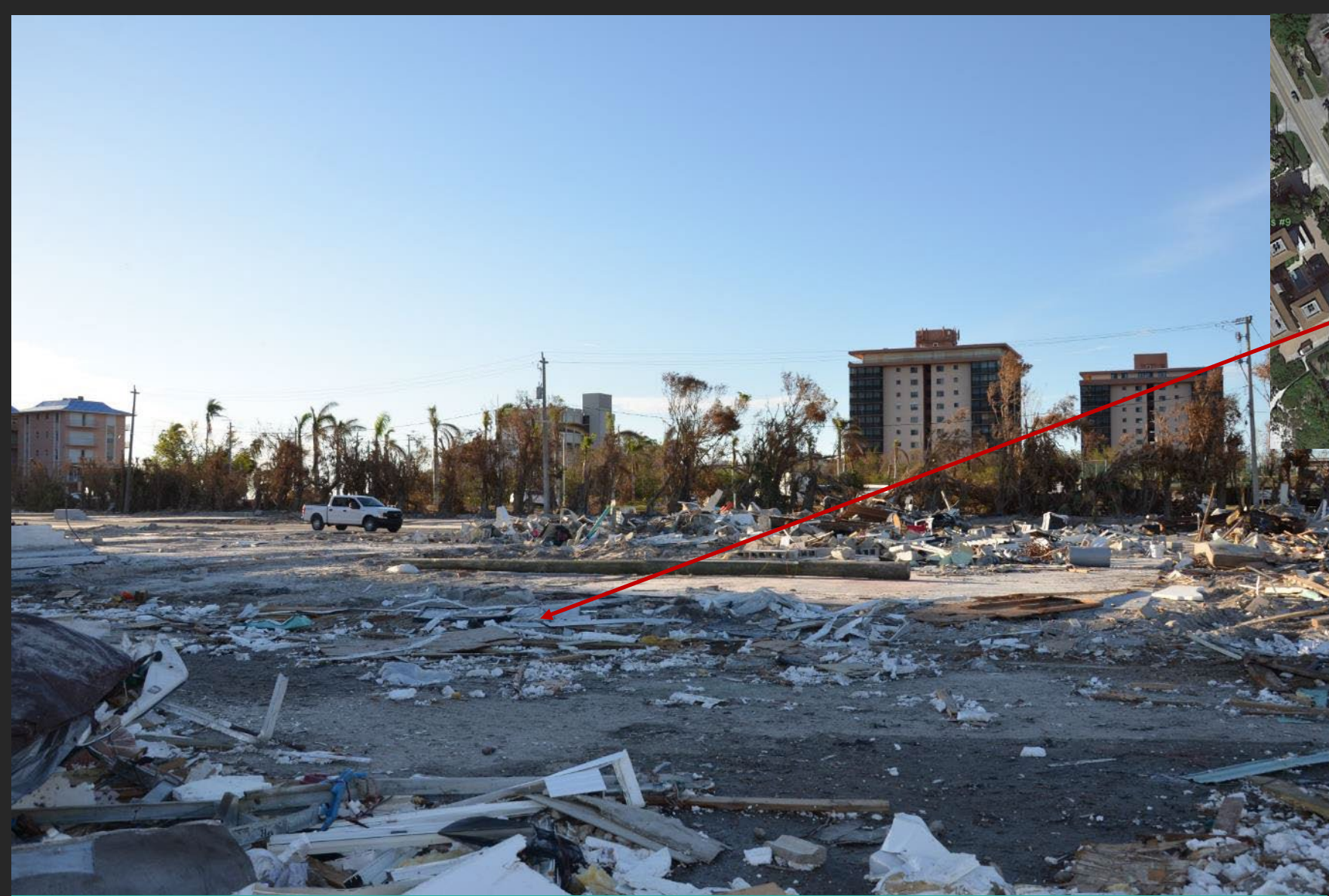
mangrove islands

beach ridges under certain circumstances

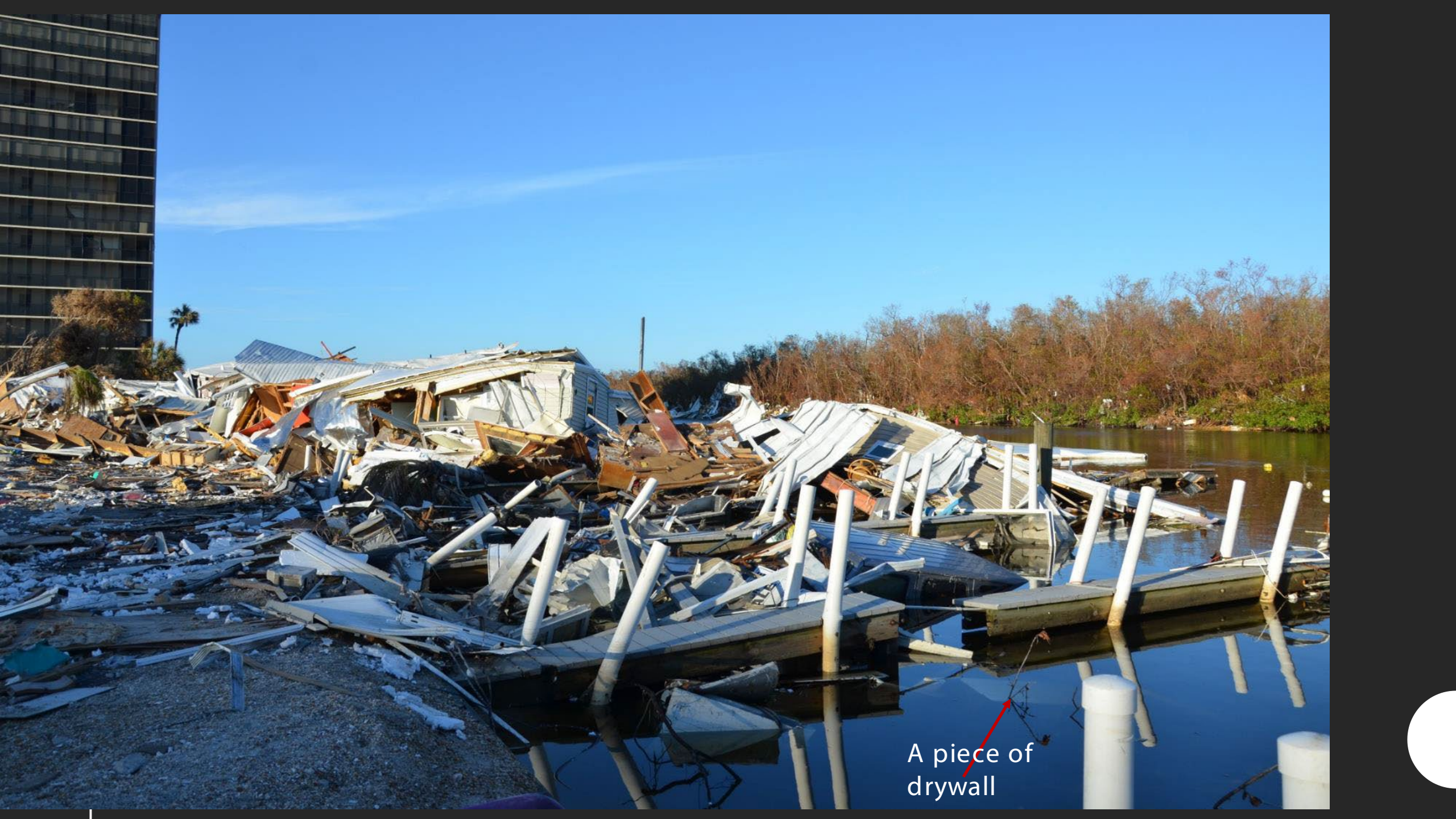
Landward penetration of storm overwash was limited by dense vegetation.

Observations: widespread overwash of everything





An entire mobile home (38) community was washed into the back bay (dredged channels in this case). Enroute from Bonita Beach to Estero Island



A piece of
drywall

Reflections:

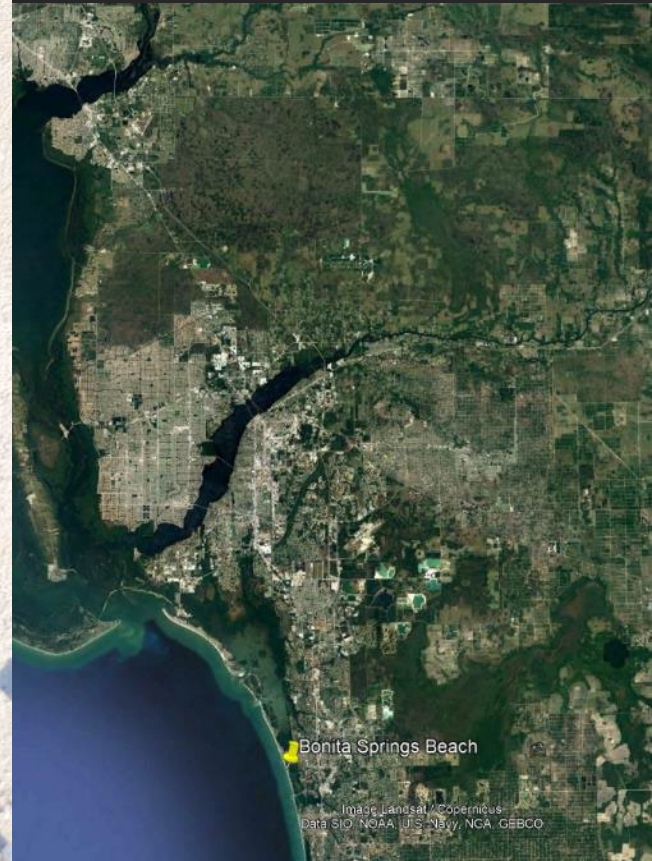
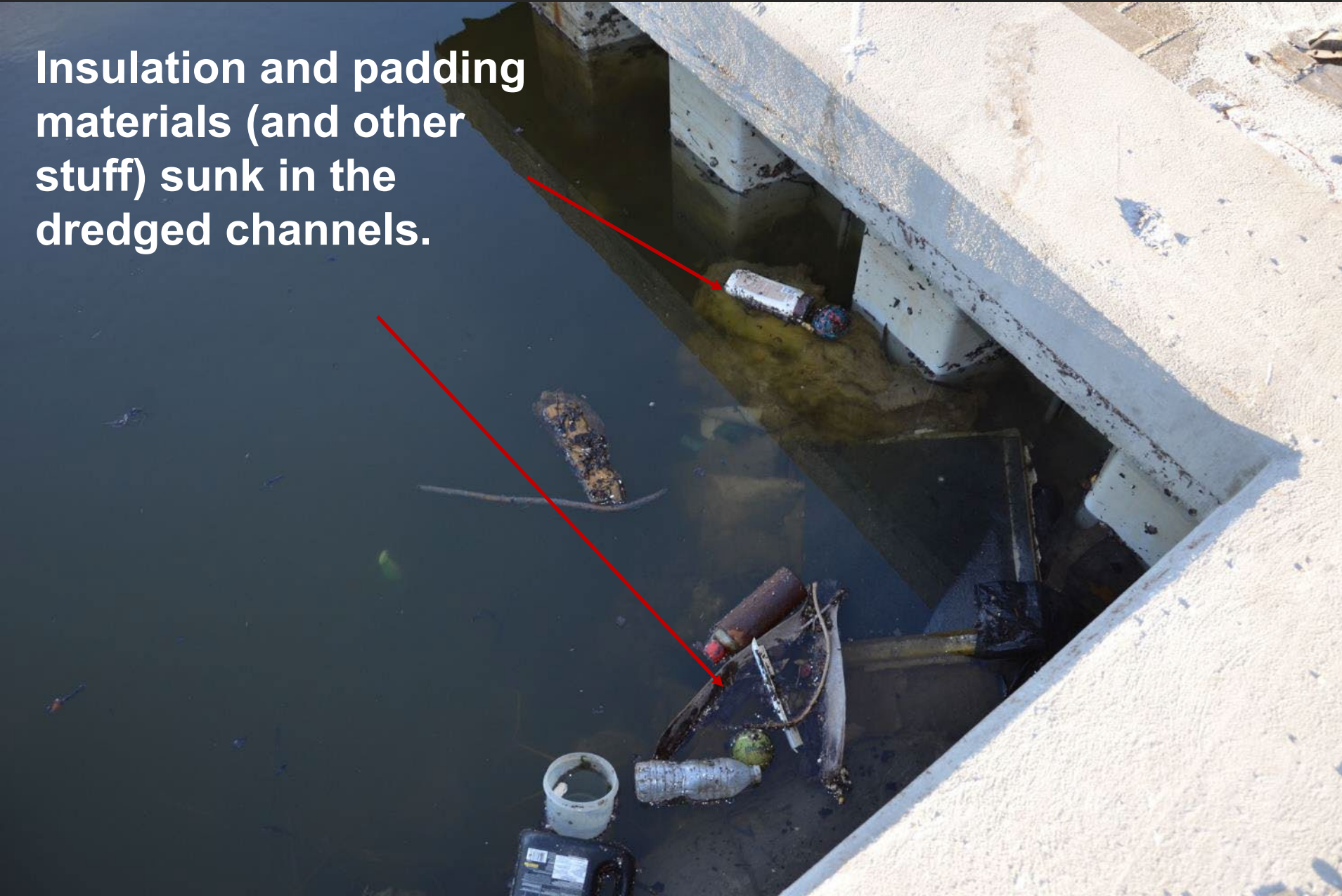
Waterfront mobile home is not a resilient practice

They are not strong enough for hurricane strength wind

They can be washed into the water body, at a considerable quantity.

Observations: widespread overwash of everything

Insulation and padding materials (and other stuff) sunk in the dredged channels.



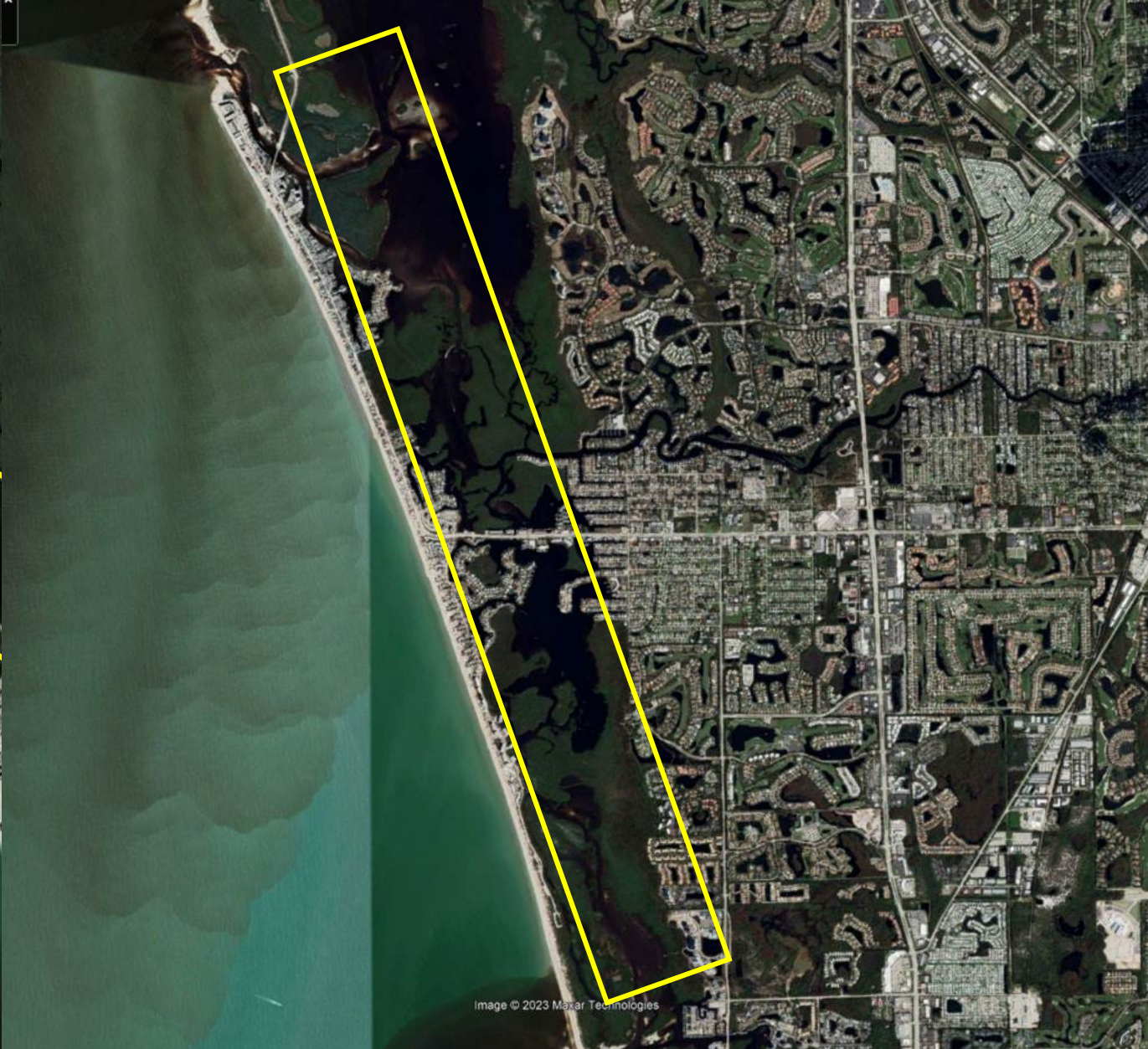
Observations: widespread overwash of everything



Observations: widespread overwash of everything



Observations: widespread overwash of everything



Reflections:

A large amount of “environmentally unfriendly” debris were washed into the sensitive wetlands (visible), and in the estuary (un-visible).

Debris concentration appears to be proportional to the proximity to the development and its density

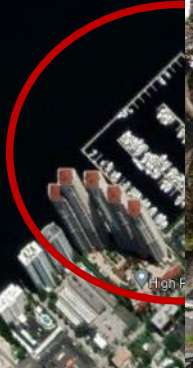
What is the long-term impact to habitats?

Measures to prevent debris from washing into the estuaries?

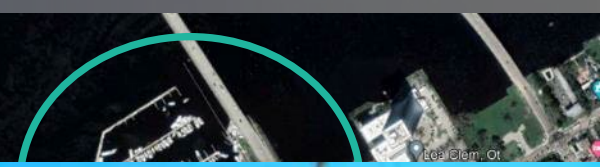
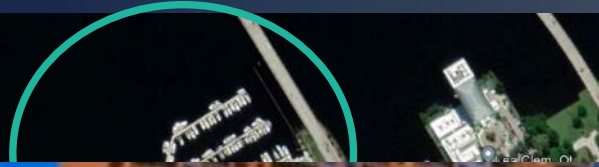
Observations: widespread overwash of everything



Observ



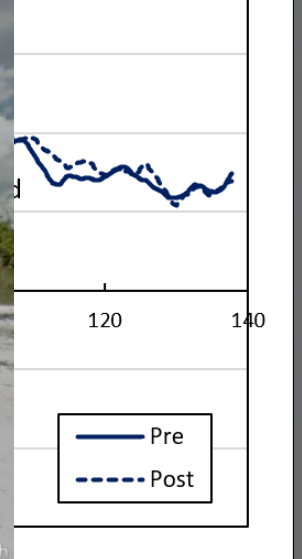
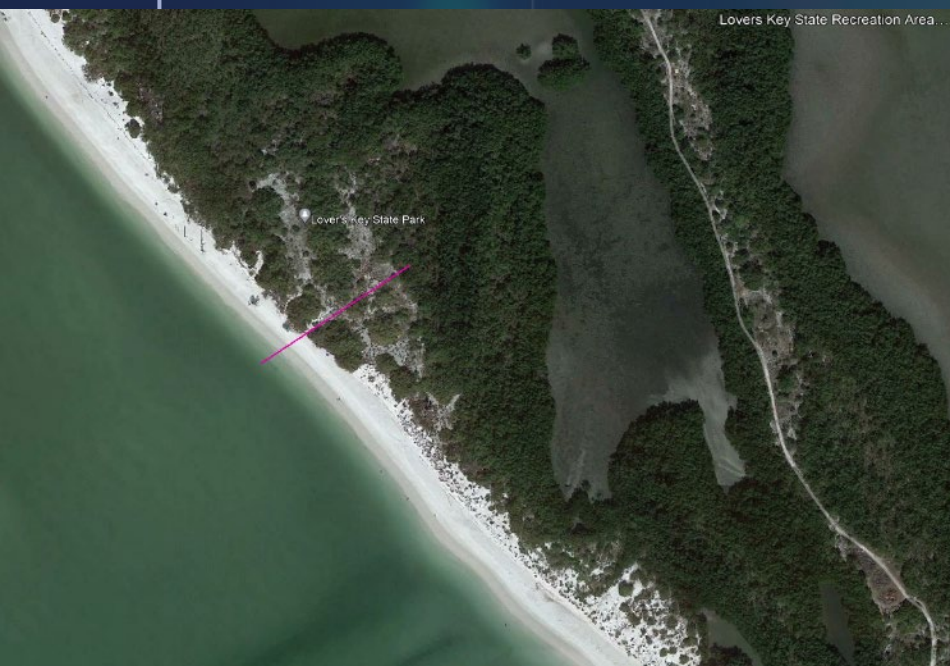
Observations: widespread overwash of everything



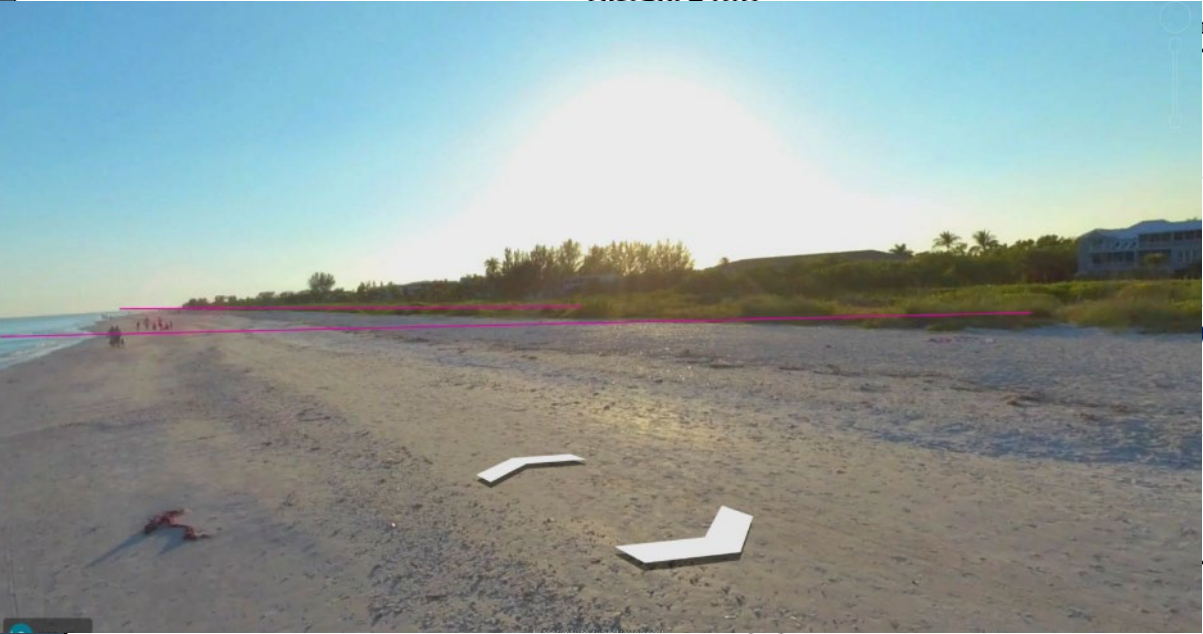
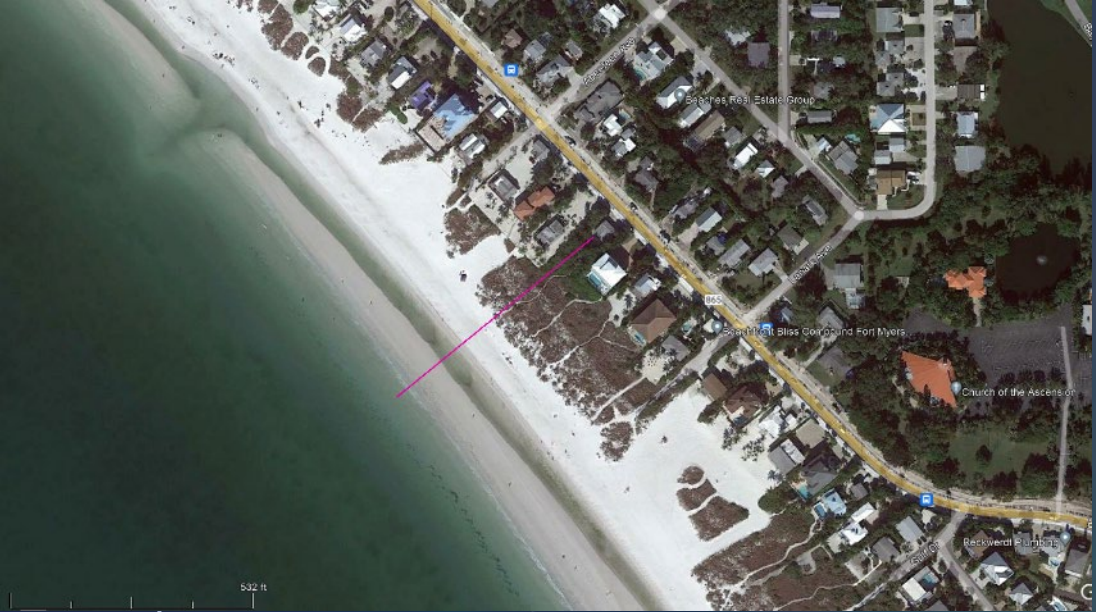
Reflection



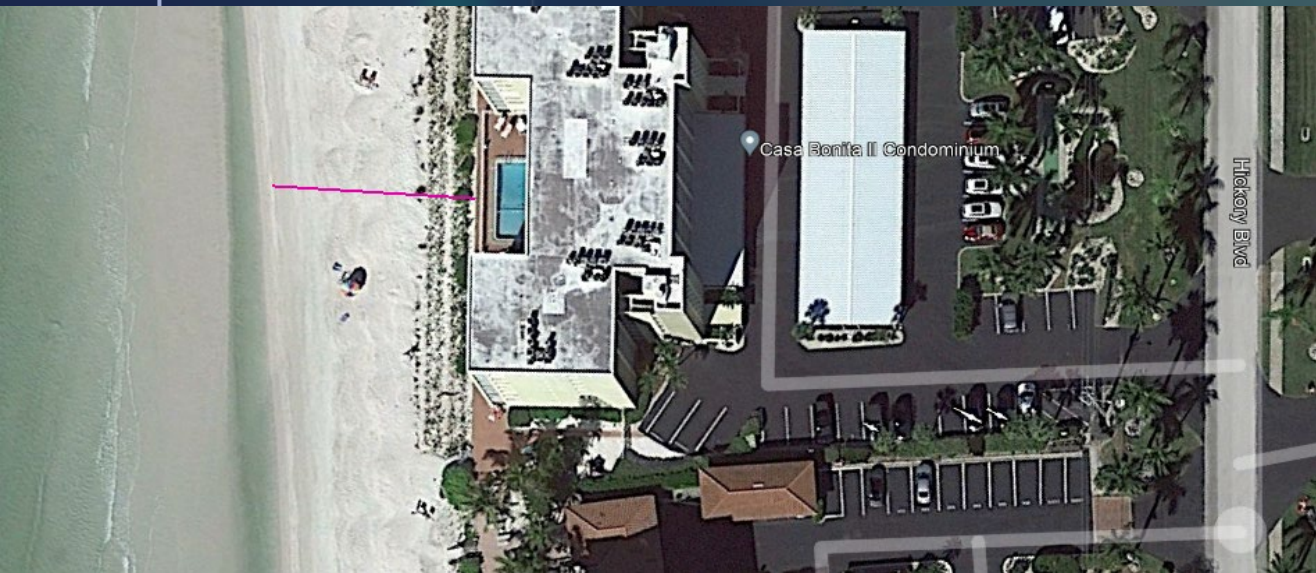
Observations: beach profile changes: un-developed beach backed by dense vegetation



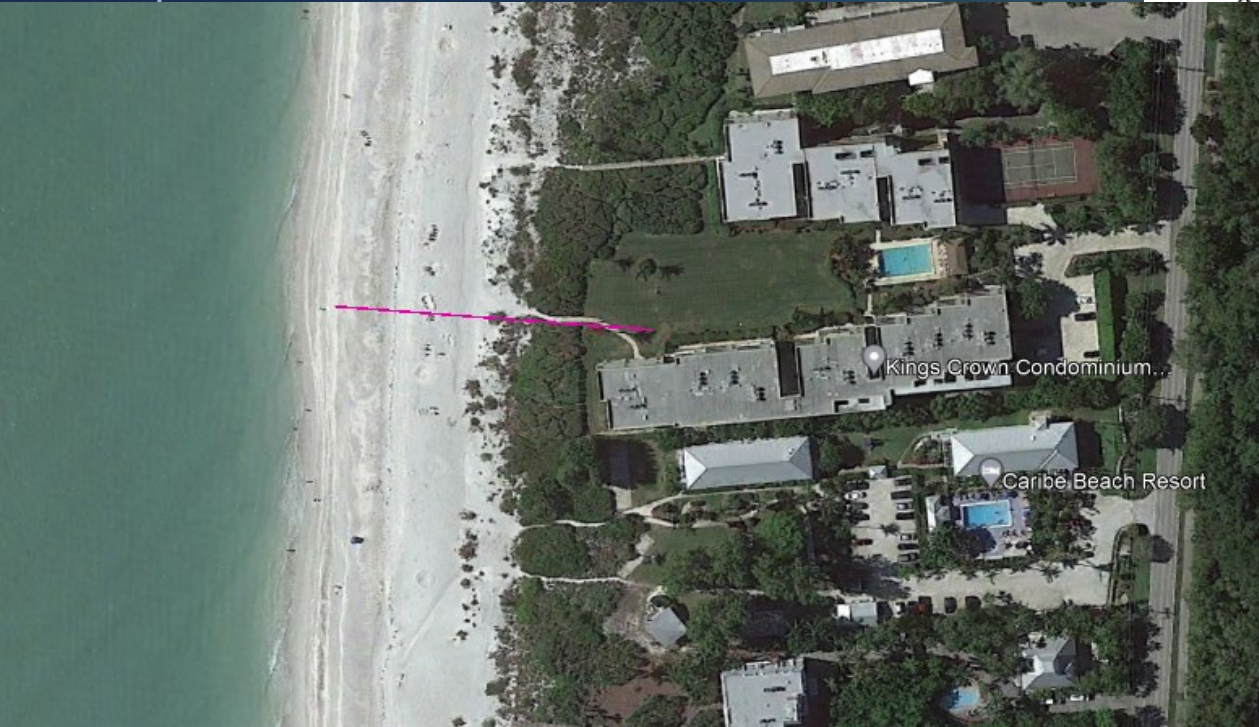
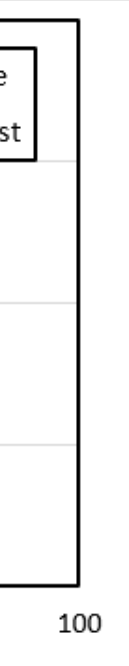
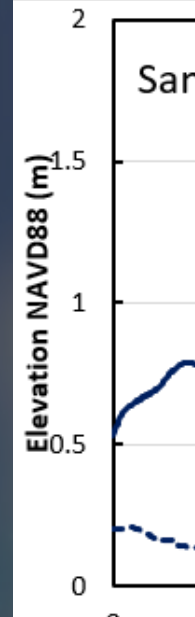
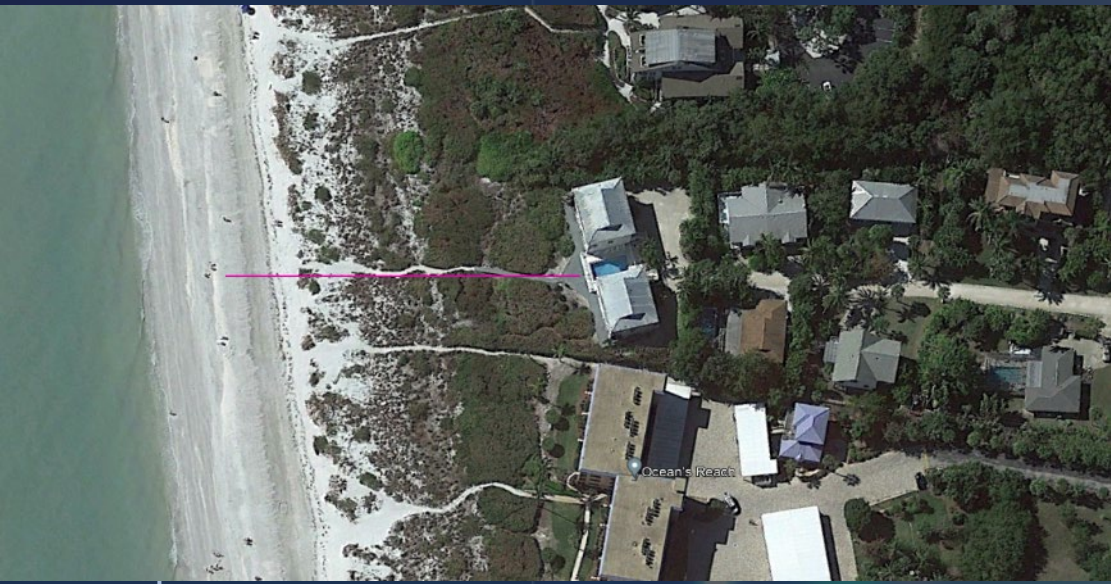
Observations: beach profile changes: typical developed coast



Observations: beach changes: developed beach with a seawall



Observations: beach profile changes: typical developed beach



Reflections:

The beach system was typically lower than 2.5 m NAVD88

Beach above 0.5 m NAVD88 experienced erosion with elevation loss of 0.5 – 1.5 m

Landward sand transport and elevation gain was limited by dense vegetation or buildings.

Shoreline (0 m NAVD88) or HTL contour (~0.3 m NAVD88) are not good indicator of beach changes

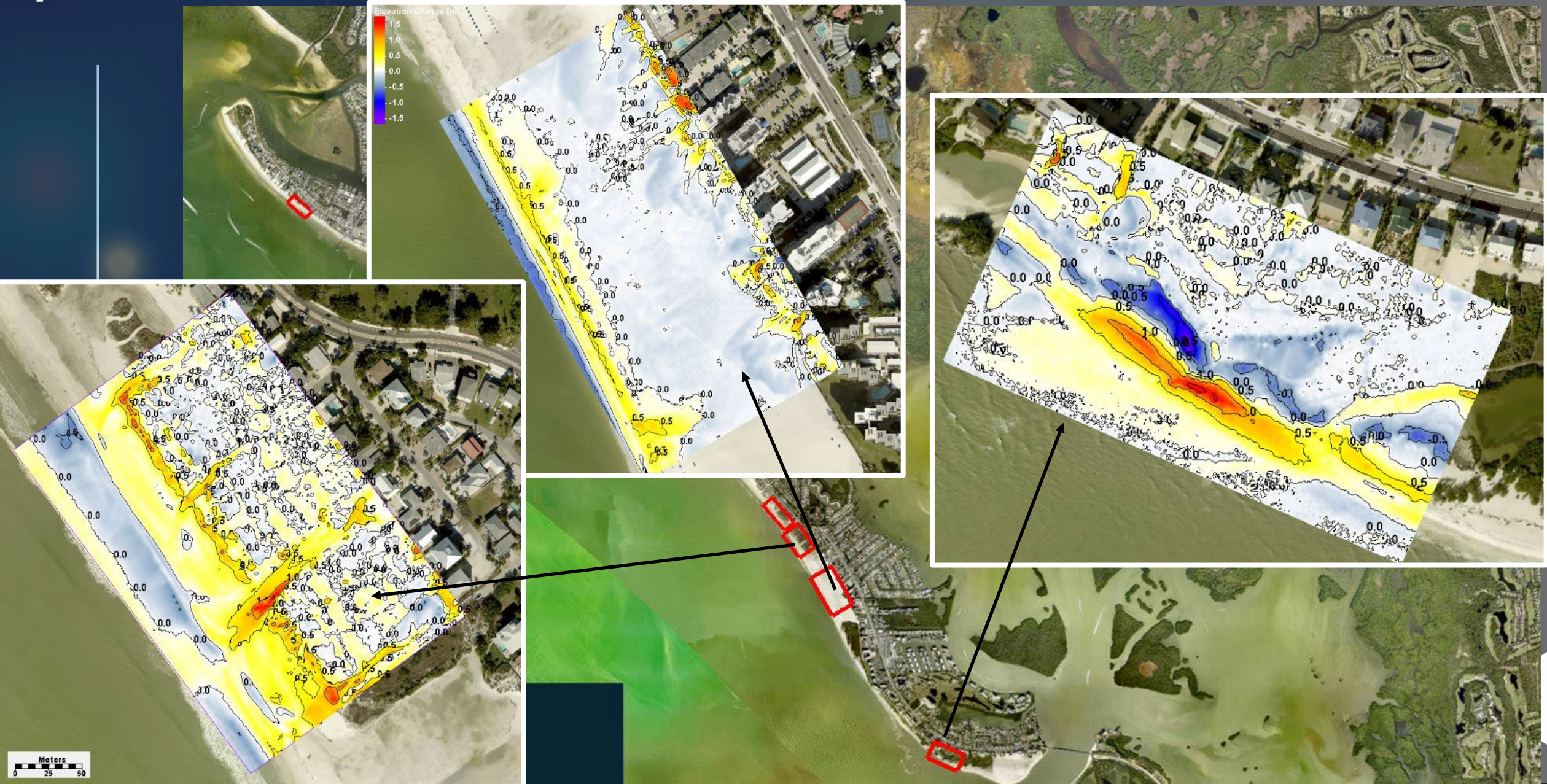
Observations: beach changes and overwash based on pre- and post-storm LIDAR data: influence of pre-storm conditions

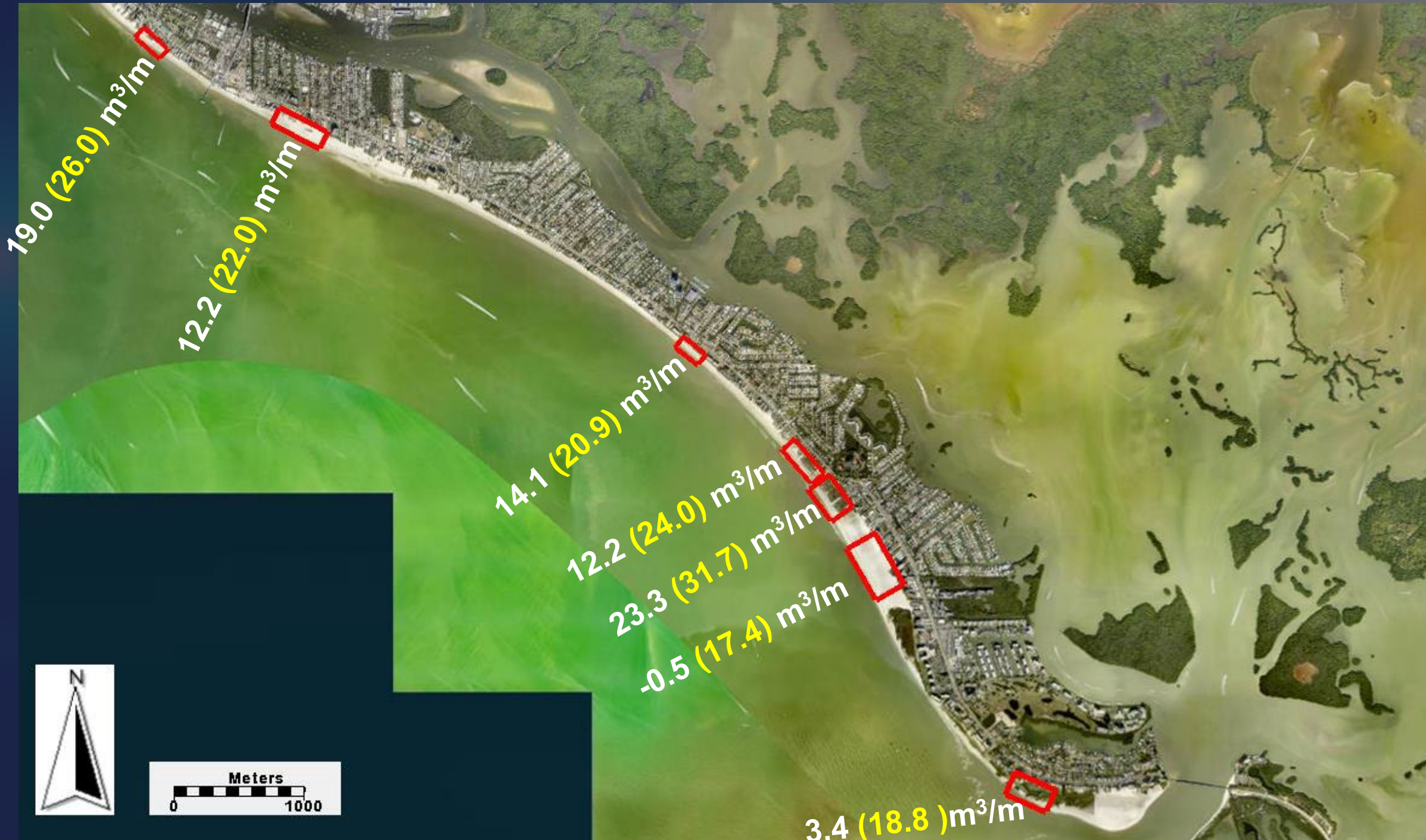


Observations: beach changes and overwash based on pre- and post-storm LIDAR data: influence of pre-storm conditions

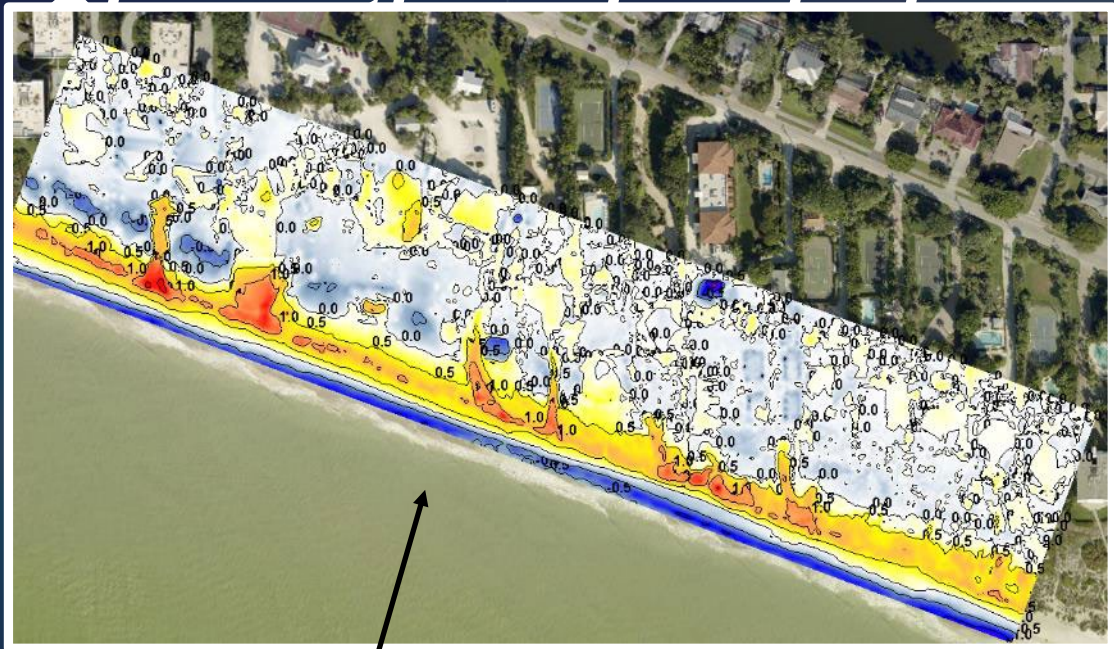


Observations: beach changes and overwash based on pre- and post-storm LIDAR data: influence of pre-storm conditions:

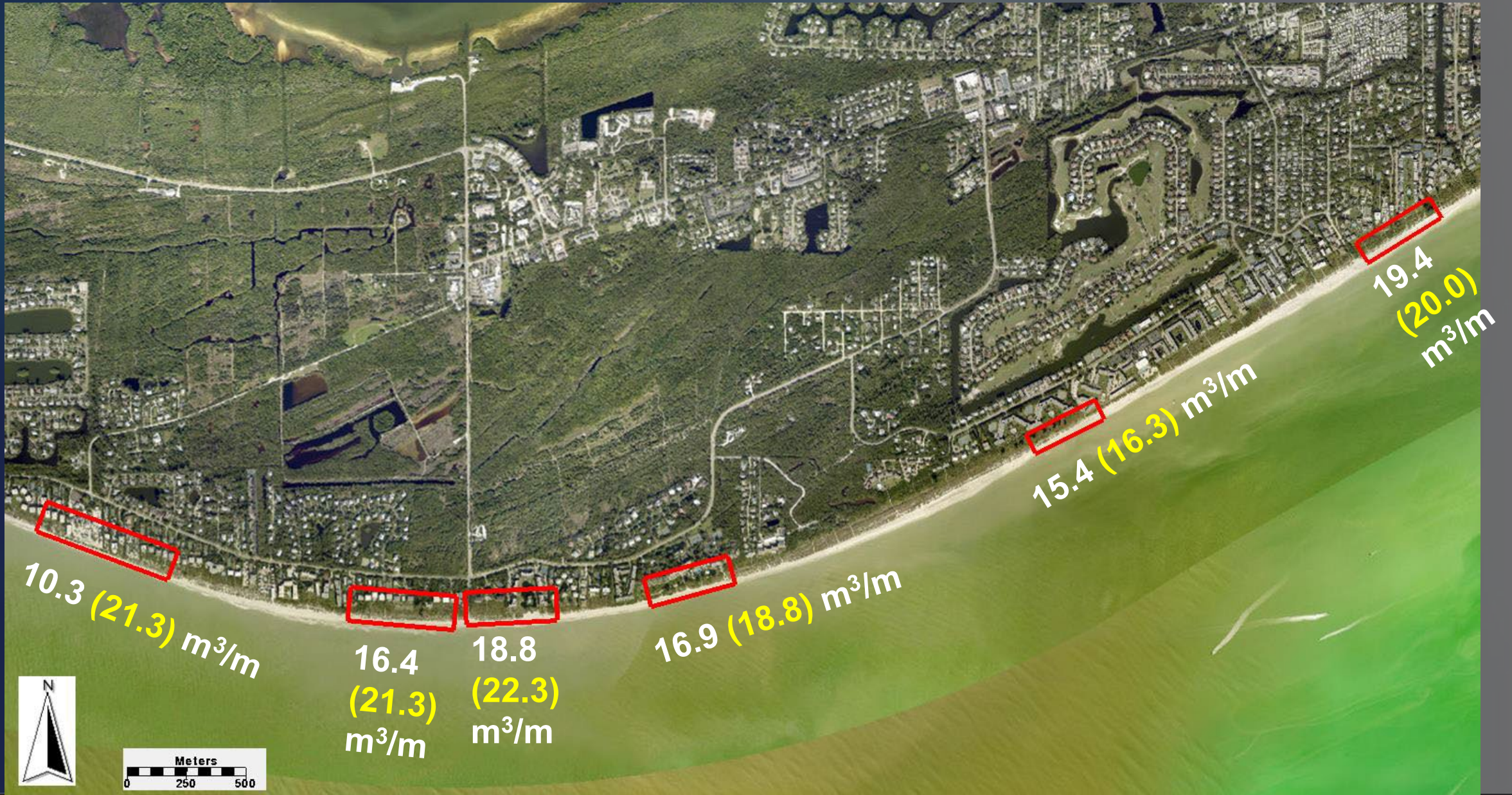




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Observations: beach changes and overwash based on pre- and post-storm LIDAR data: influence of pre-storm conditions



Reflections:

Considerable alongshore variation in beach volume change, ranging ~10 to 30 m³/m, or 15 to 45 m³/m net erosion

Buildings (close to beach) had influence on local beach changes

Dense vegetation or building/vegetation limited landward extents of overwash

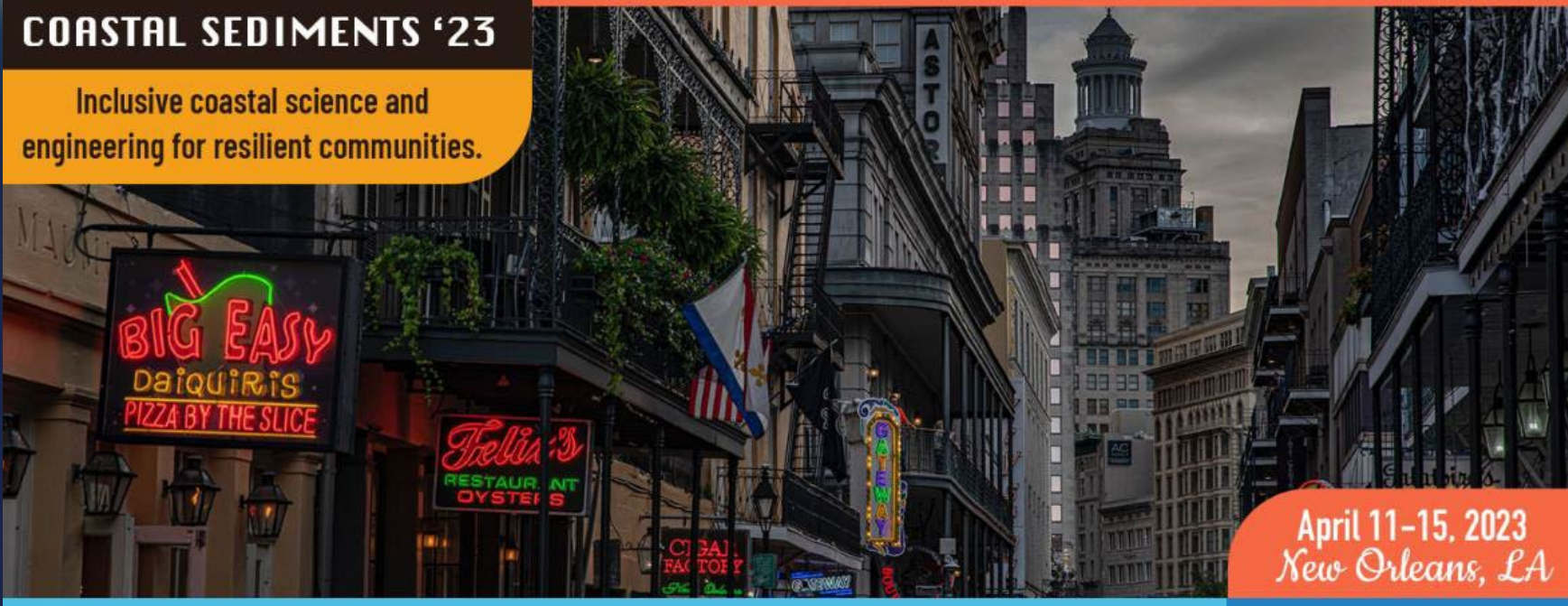
Sanibel headland has more concentrated gullies than other beaches, gullies did not contribute to alongshore variation

Thank you!

Questions/Comments?

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