Comprehensive Condition Assessments of Navigation Structures and Marine Civil Works

CMANC

January 17-19, 2018

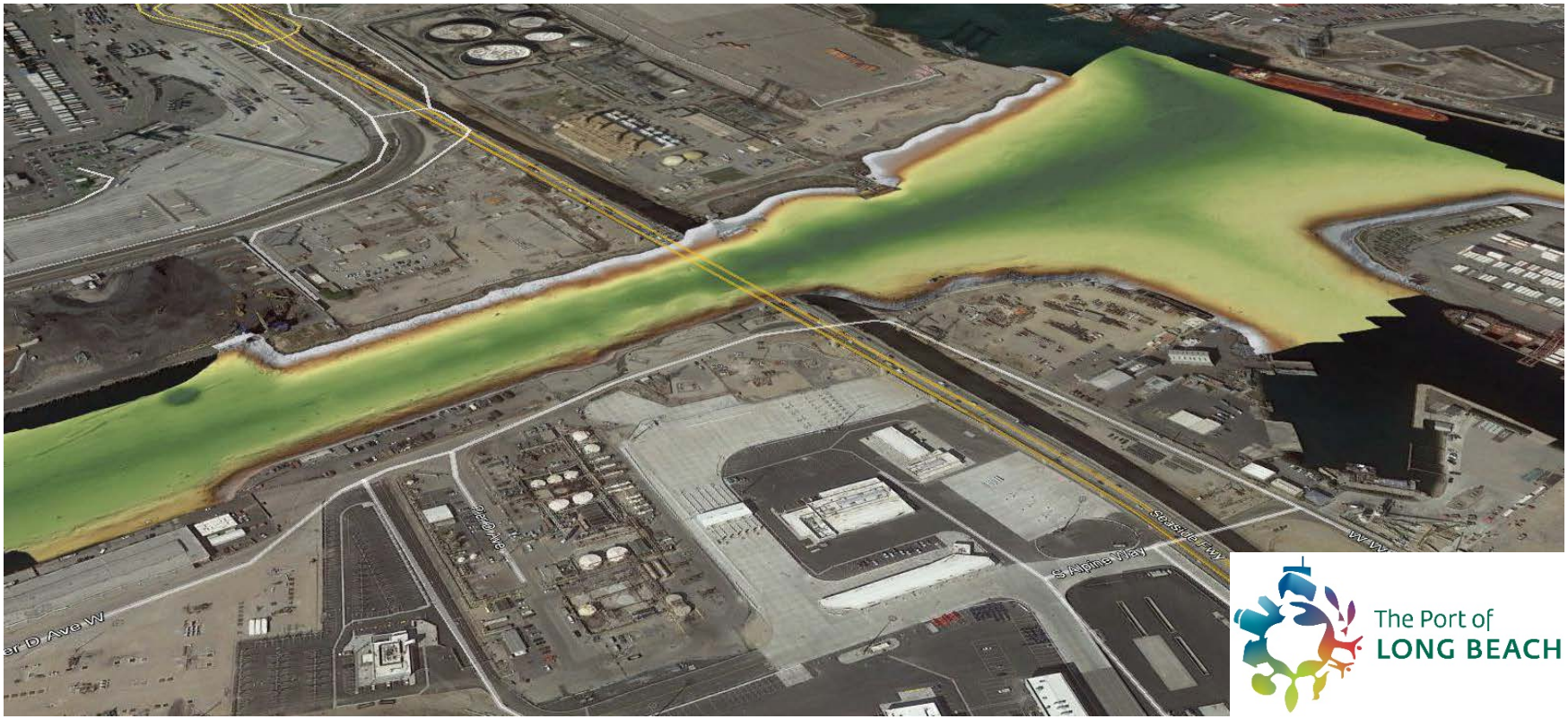
Is Our Navigation and Coastal Infrastructure Up to the Task?

Photos: http://www.vlahovicgroup.com/?p=3232 ; http://angloboerwarmuseum.com/images/boer/scenics/halifax_air_pier21.jpg ; http://www.gen22.net/2012/02/10-jembatan-terpanjang-di-dunia.html ; http://www.kwl.ca/kbase/adapting-vulnerability-metro-vancouver-wastewater-infrastructure-climate-change

Gateway to the Blue Economy

Navigation and marine civil works are the gateway to our participation in local, national and international trade. Our coastal infrastructure is vital for keeping us connected.

It’s performance is vital to trade, safety and the well being of our coastal communities



The ASCE COPRI Approach

Inform

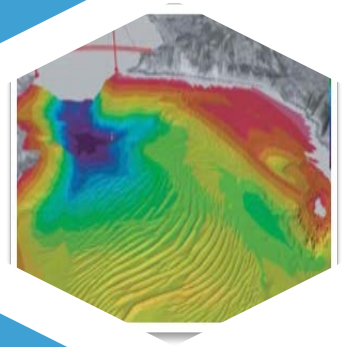
Understand the expectations for performance;

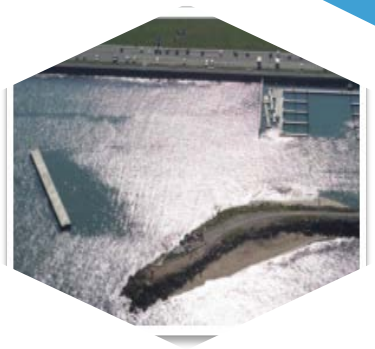
And the drivers threatening failure

Condition Assessment:

Quantify risk, exposure and consequences

Analyze



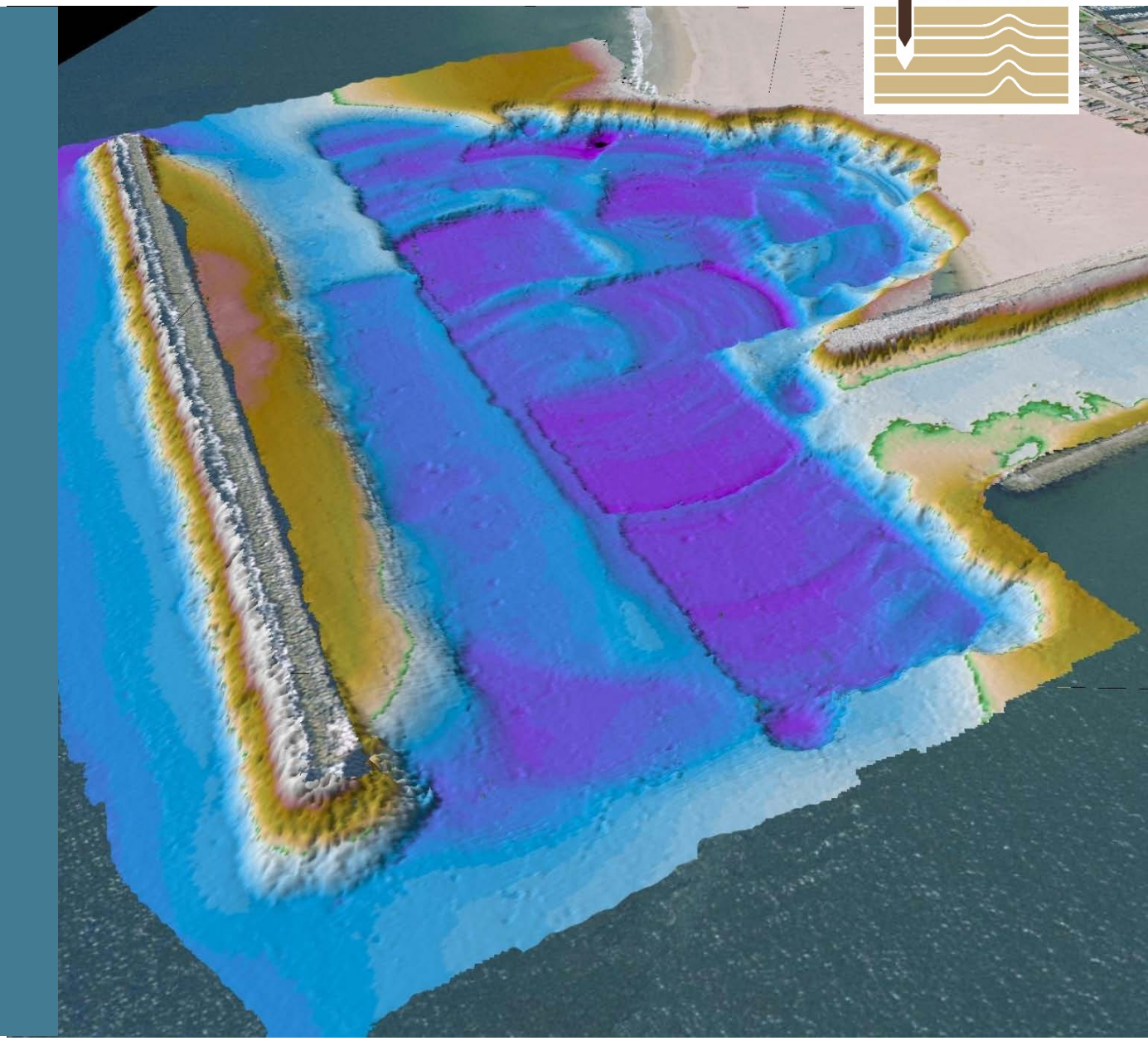


Implement

Implement

Risk-reducing strategies/remediation &/or construction

Defining and Understanding Risk



Risk Identification

Stressor

Primary risk driver (e.g. wave action, flood, debris impact, etc.) that is the root trigger for the chain of events

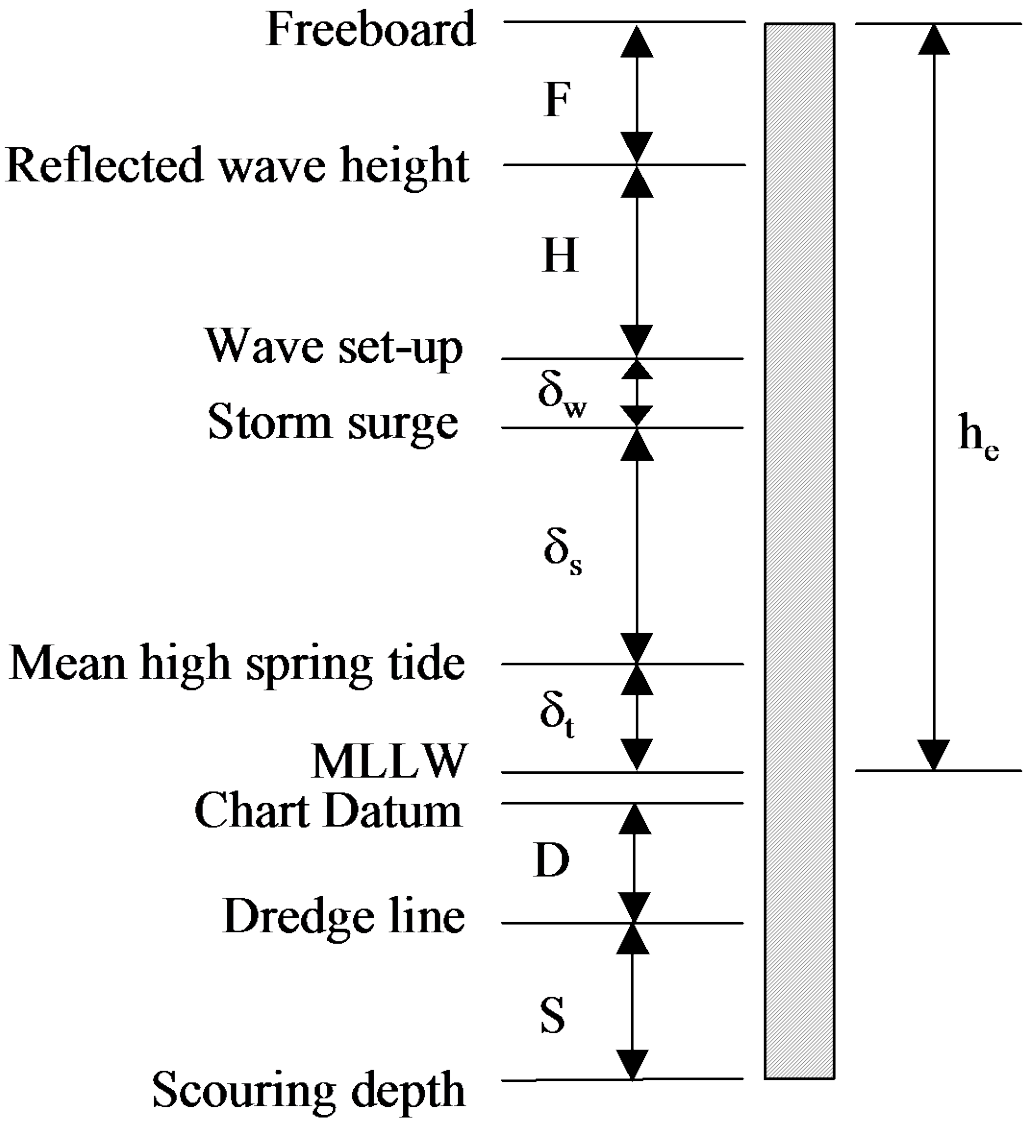
Consequences

As a result of asset failure, consequences follow.

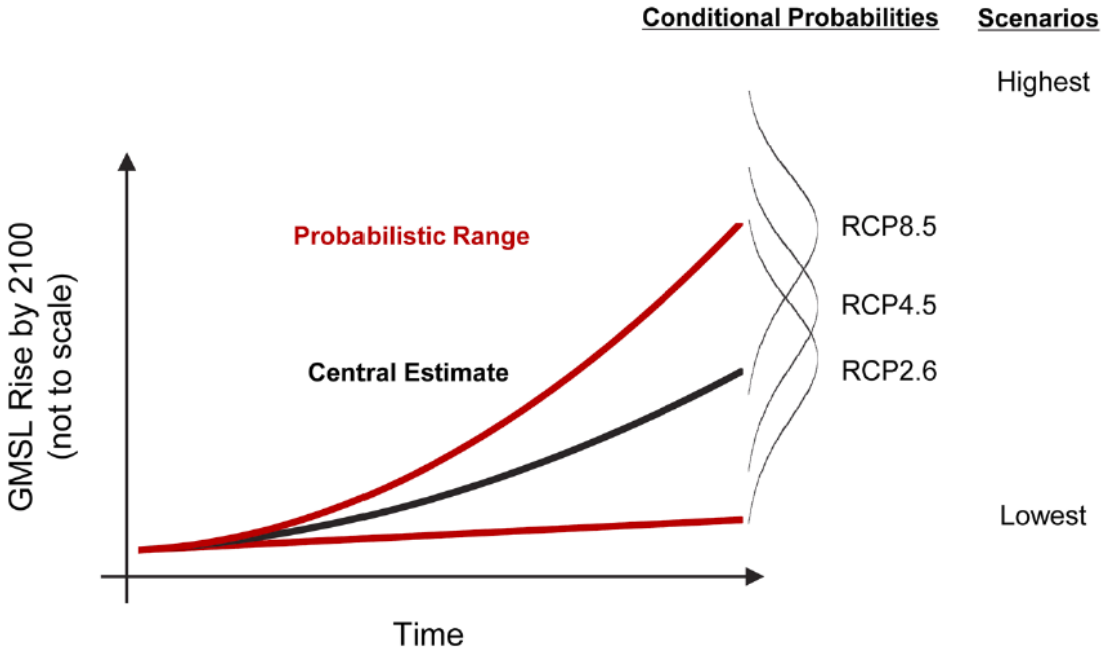
Failure mode

Under action of the stressor, structure, asset, etc. fails to some extent

The Water Column is Not Static



Sea Level Change: Projections and Criticality



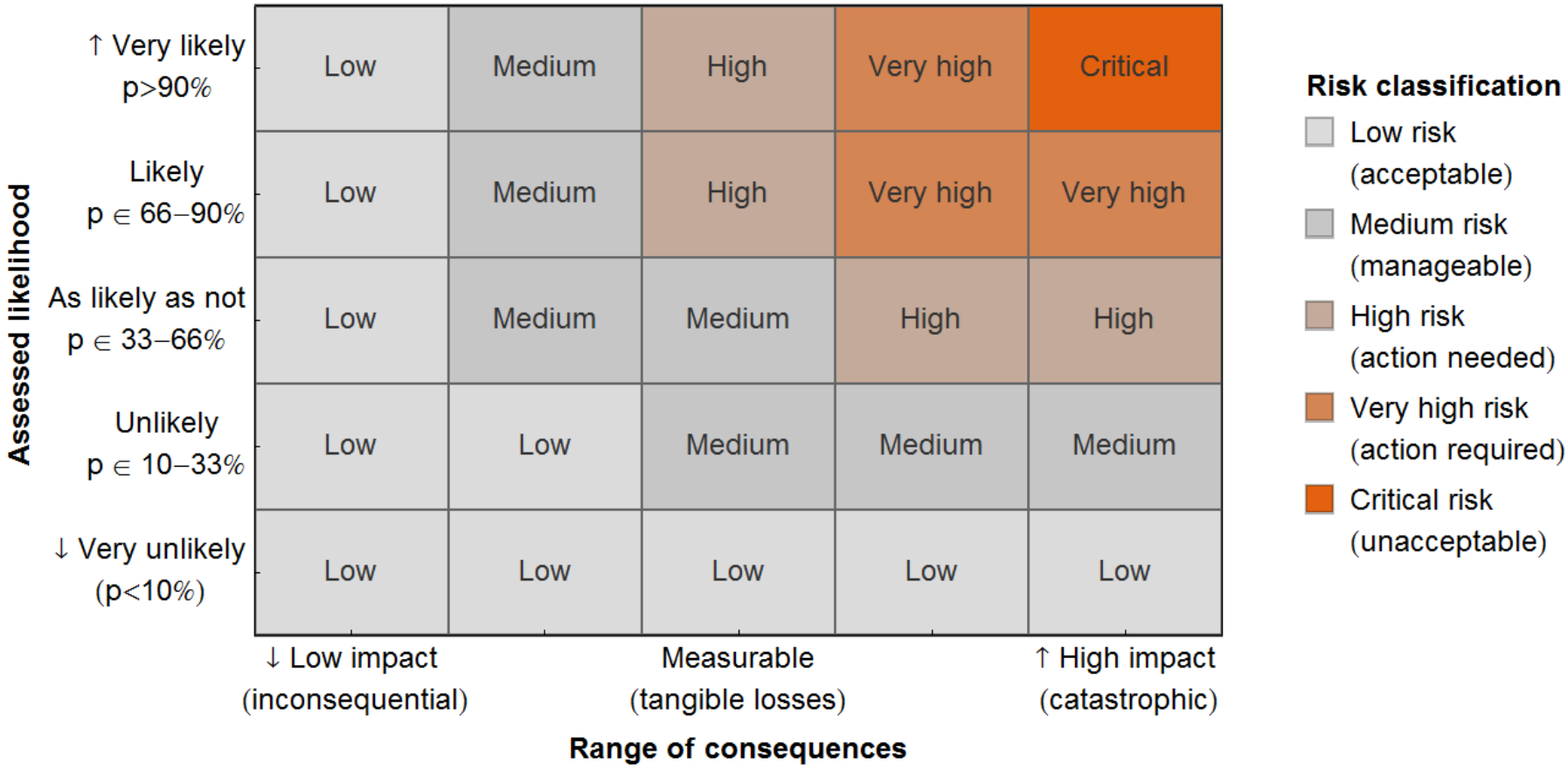
Schematic showing the intersection of scenario approaches with emission-dependent (conditional) probabilistic projections of sea level rise under the climate modeling community's Representative Concentration Pathways (RCP) (van Vuuren et al., 2011).

- Highest Scenario
  - The Highest Scenario should be considered in situations where there is little tolerance for risk
- Intermediate High Scenario
  - Average of the high end of ranges of global mean SLR using semi-empirical approaches
- Intermediate Low Scenario
  - Global mean SLR projection from the IPCC AR4 at 95% confidence interval

NOAA SLR Scenarios for the US:
https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf

Risk Evaluation

Risk Evaluation: Risk Matrix



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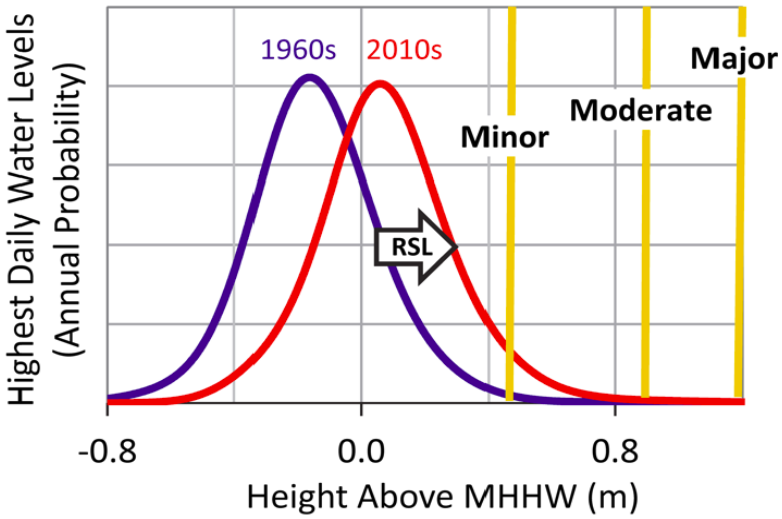
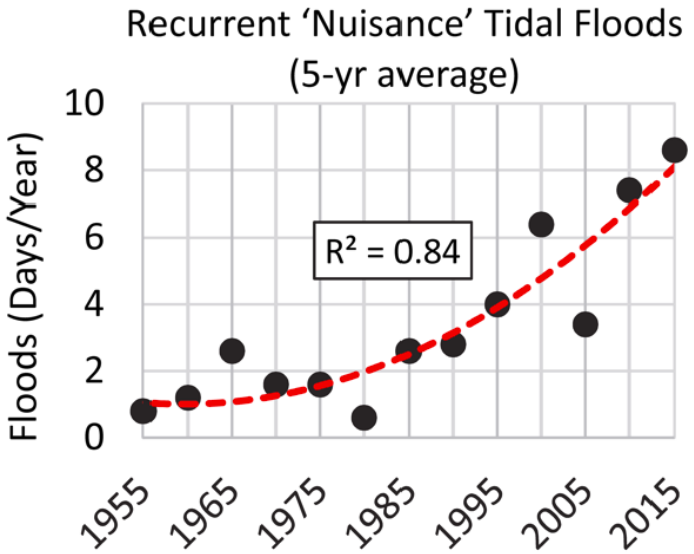




(Sweet and Park 2014)

As baseline water levels go up, the probability of episodic high-water events increases.

Minor events will become moderate; moderate will become major.

Risk is not linear and will increase over the service life of the structure.

NOAA SLR Scenarios for the US:
https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf

Cost Consequences of Failure

Rotten Meat From Katrina Still In Gulfport Neighborhood

We're now just ten days away from the beginning of the 2006 Hurricane Season, and rotting chicken still remains untouched in various pools on abandoned sites throughout a West Gulfport neighborhood surrounding Regnault Avenue.

"It's nine months now. They say, 'Well, you ought to be used to it by now.' You ain't gonna get used to that smell. My gosh," said resident Gary Tatum.

The meat had been stored at the Port of Gulfport. Katrina washed it in to yards covering an eight block span. The meat in the yards has been picked up, but the meat in hard-to-see areas has not.

1 Direct damages
structures, handling equipment, freight, land, etc.

2 Indirect costs
lost wages, business interruptions, cleanup costs

3 Intangible consequences
quality of life, environmental damages, loss of essential services

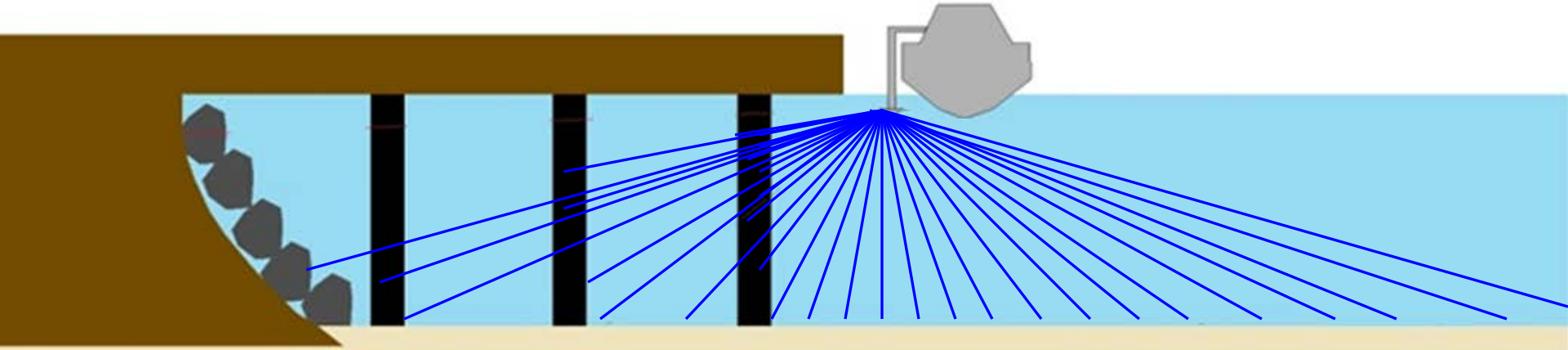
 Story by Karla Redditte, WLOX; http://www.wlox.com/story/4931935/rotten-meat-from-katrina-still-in-gulfport-neighborhood

Bathymetric (Hydrographic) Survey Techniques

Bathymetric (seafloor) terrain surveys

Multibeam bathymetric echosounder (MBES):

- Creates swathes of survey data (not just a single beam)
- Creates continuous seafloor map
- Variable swath width (width vs. detail) and can be rotated

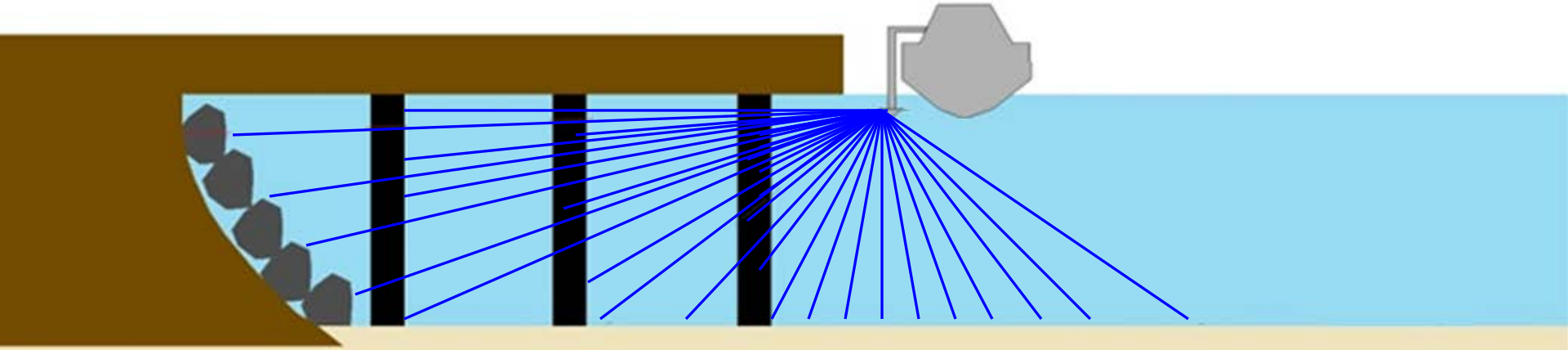


Multibeam Sensor in standard orientation

Bathymetric (seafloor) terrain surveys

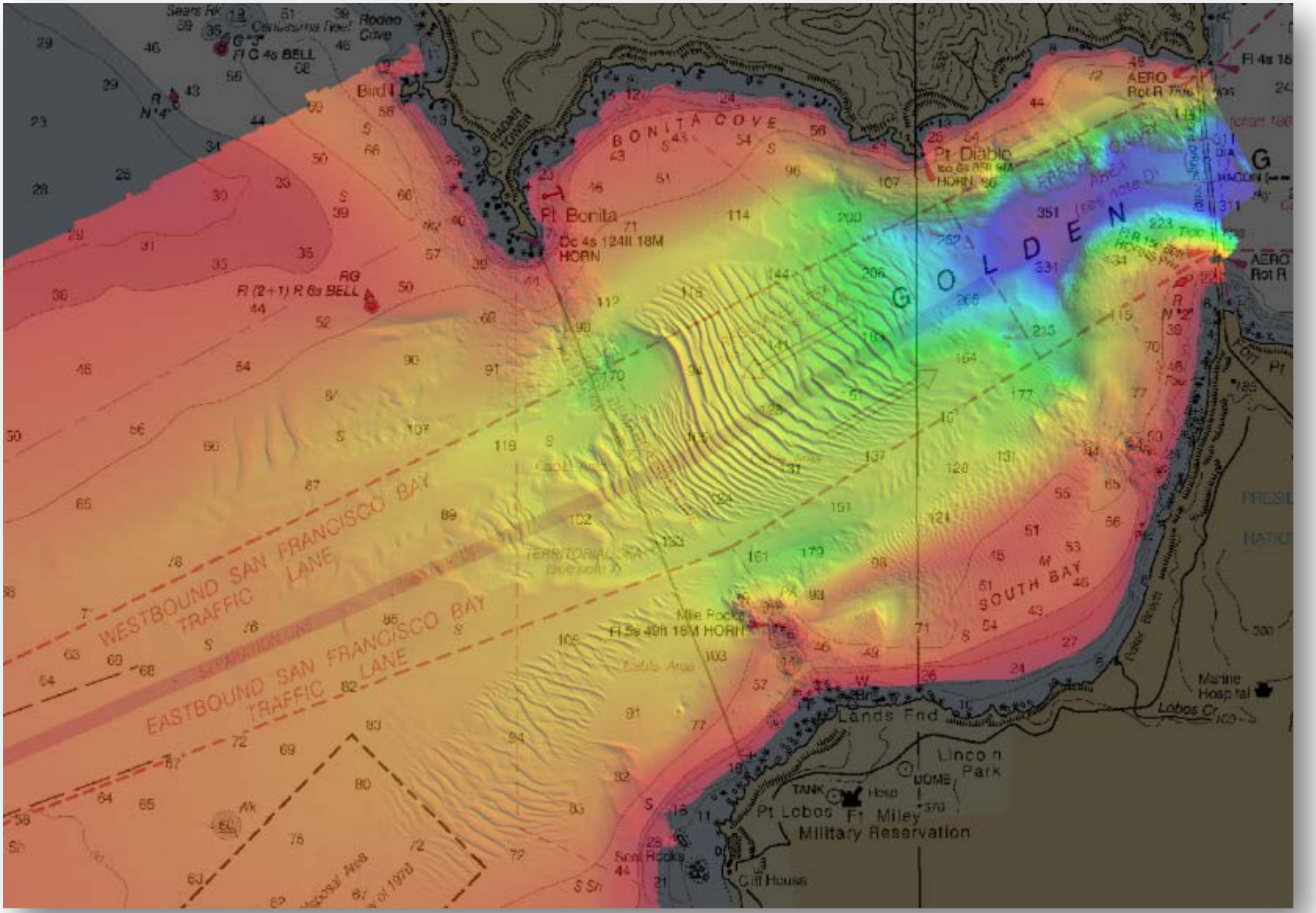
Multibeam bathymetric echosounder (MBES):

- Creates swathes of survey data (not just a single beam)
- Creates continuous seafloor map
- Variable swath width (width vs. detail) and can be rotated
  - Physically or electronically with new sensors!

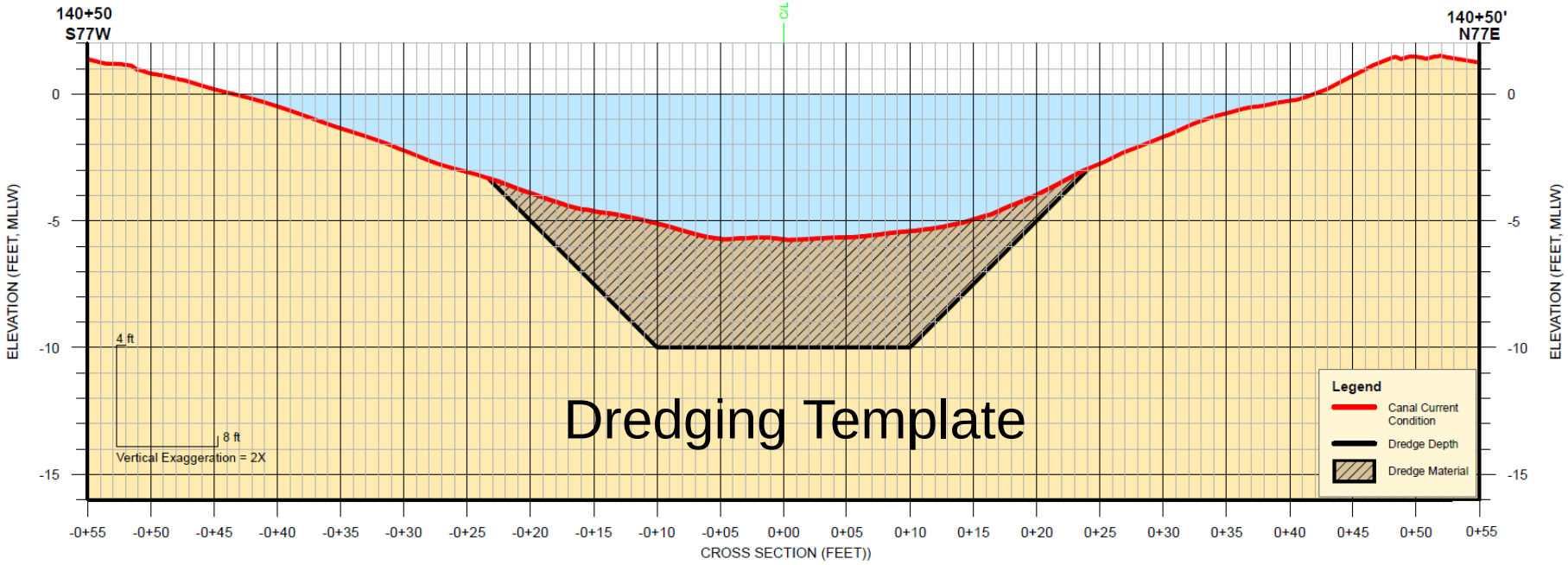


Rotated Multibeam Sensor for surveying laterally to the waterline

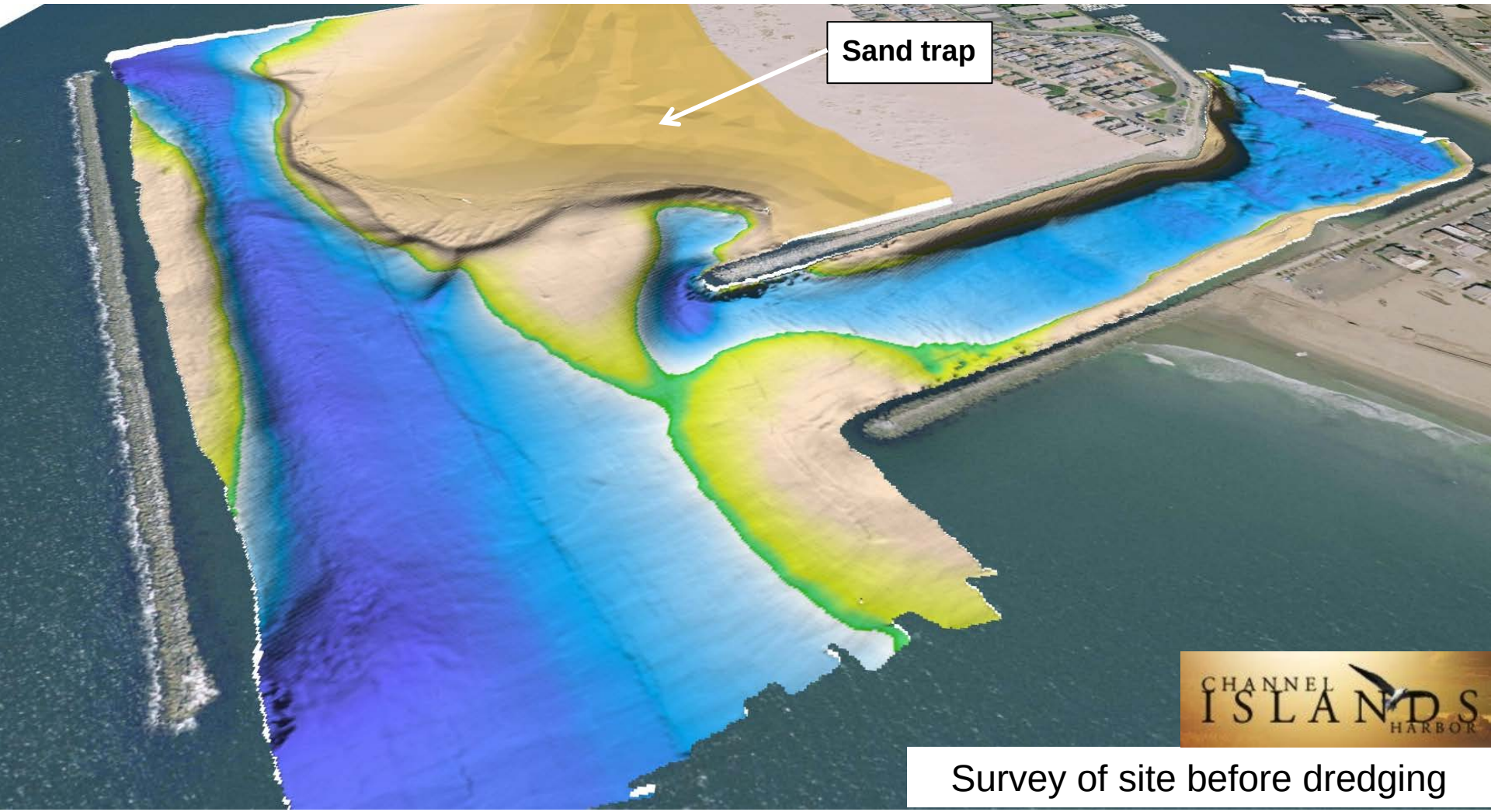
Primary Use for Safe Navigation (Charting)



But Also for Dredging Quantity Measurement

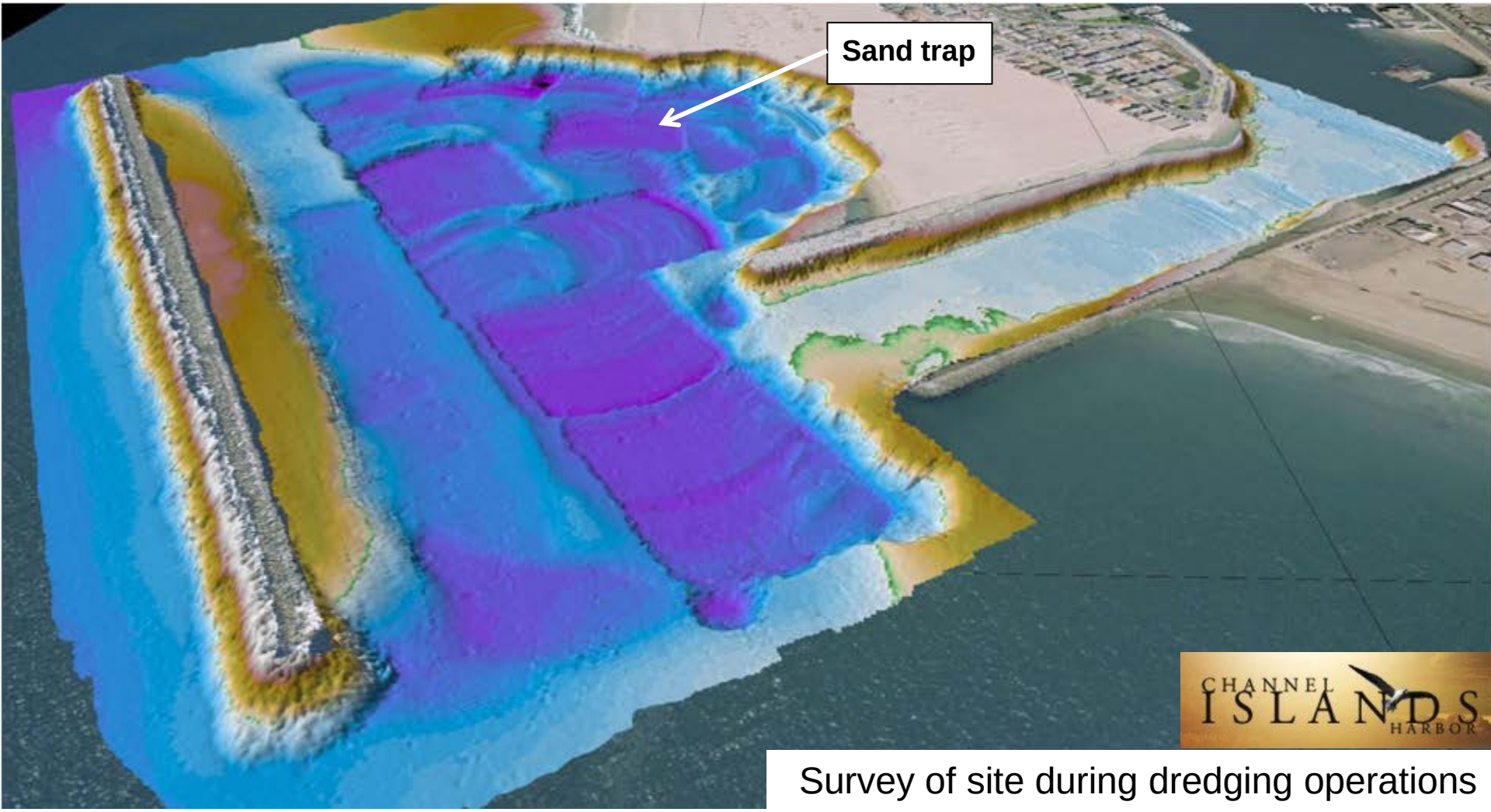


Dredging Example



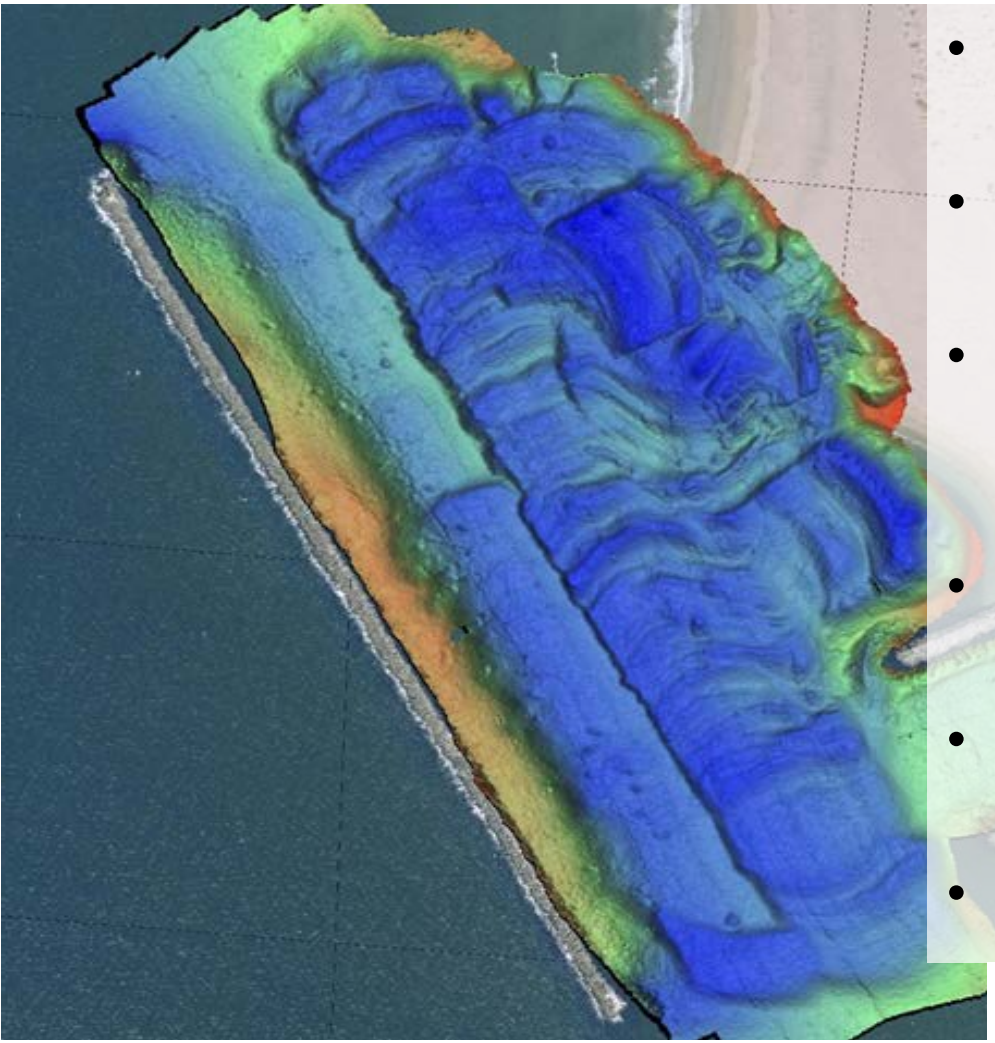
Survey of site before dredging

Dredging Example



Survey of site during dredging operations

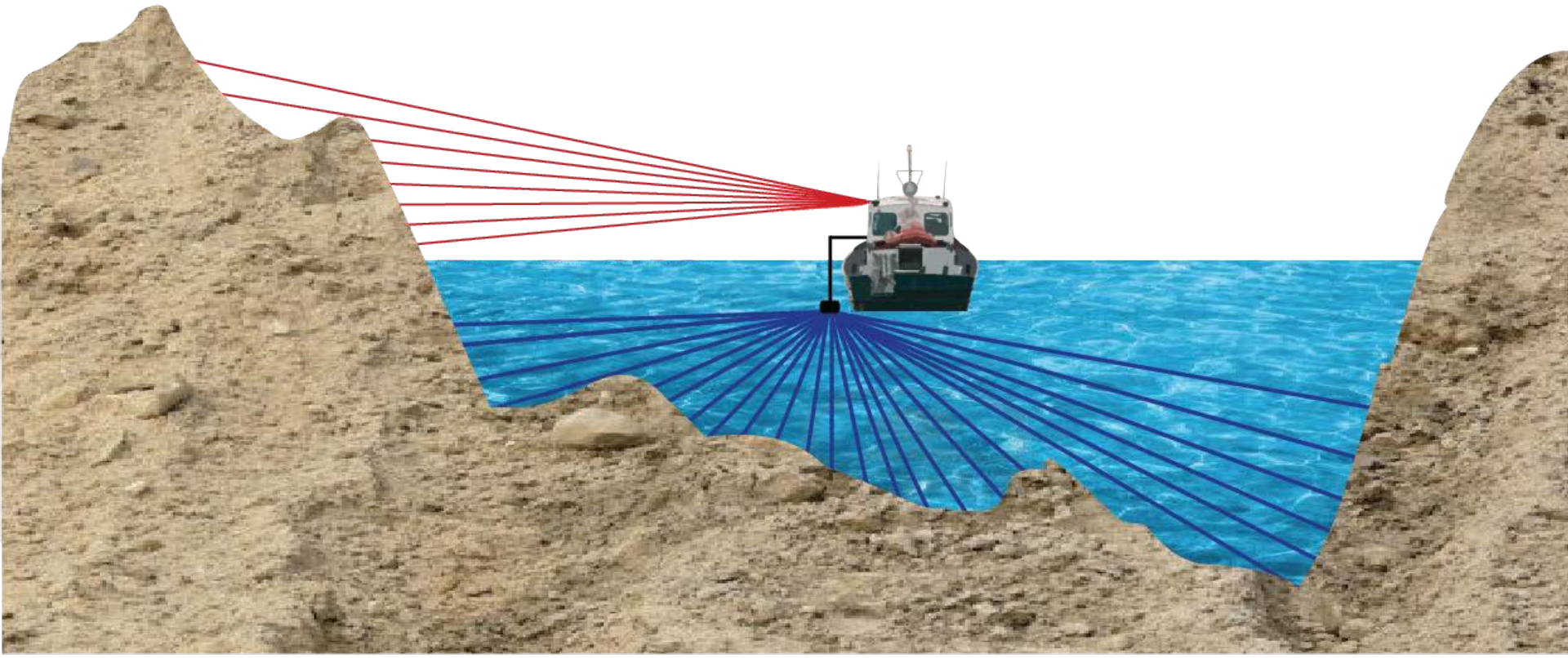
Dredging Example



- Template Design
- Volume Estimates
- Slope stability assessment
  - Key for dredging in front of berths
- Dredge Monitoring
- Material Disposal & Reuse
- Feasibility/Ripability

Survey of site after dredging operations

BOAT-MAP™

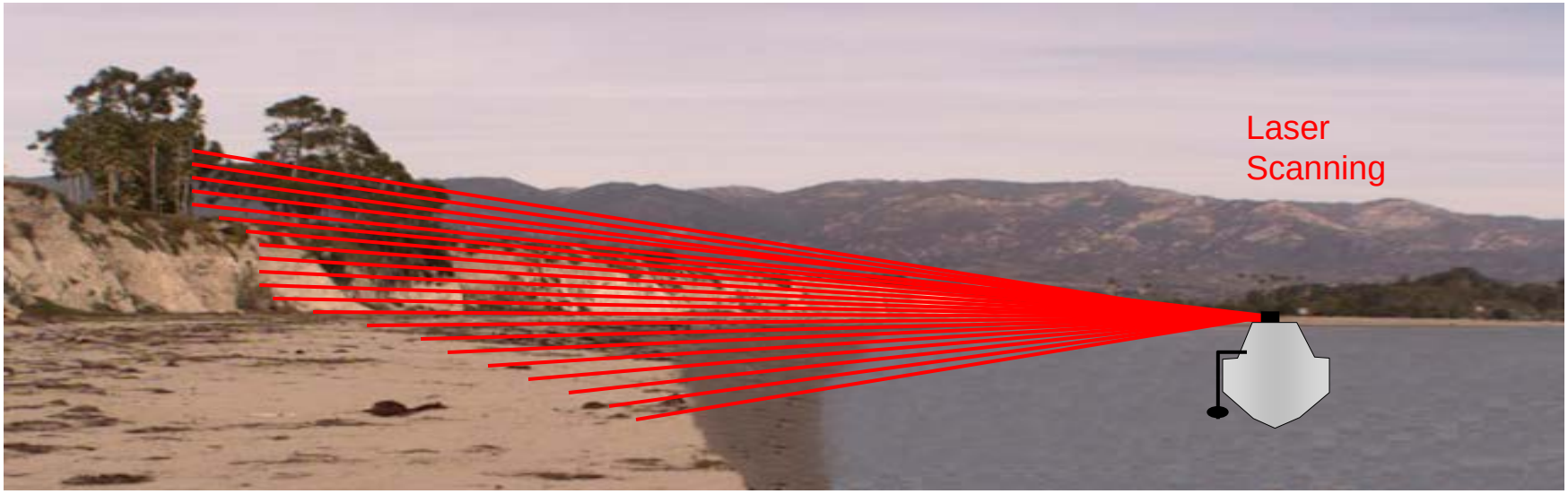


By incorporating mobile laser scanning into our near shore marine surveying services, Fugro brings **BOAT-MAP™** a specialized solution for nearshore marine surveys that need to span the waterline.

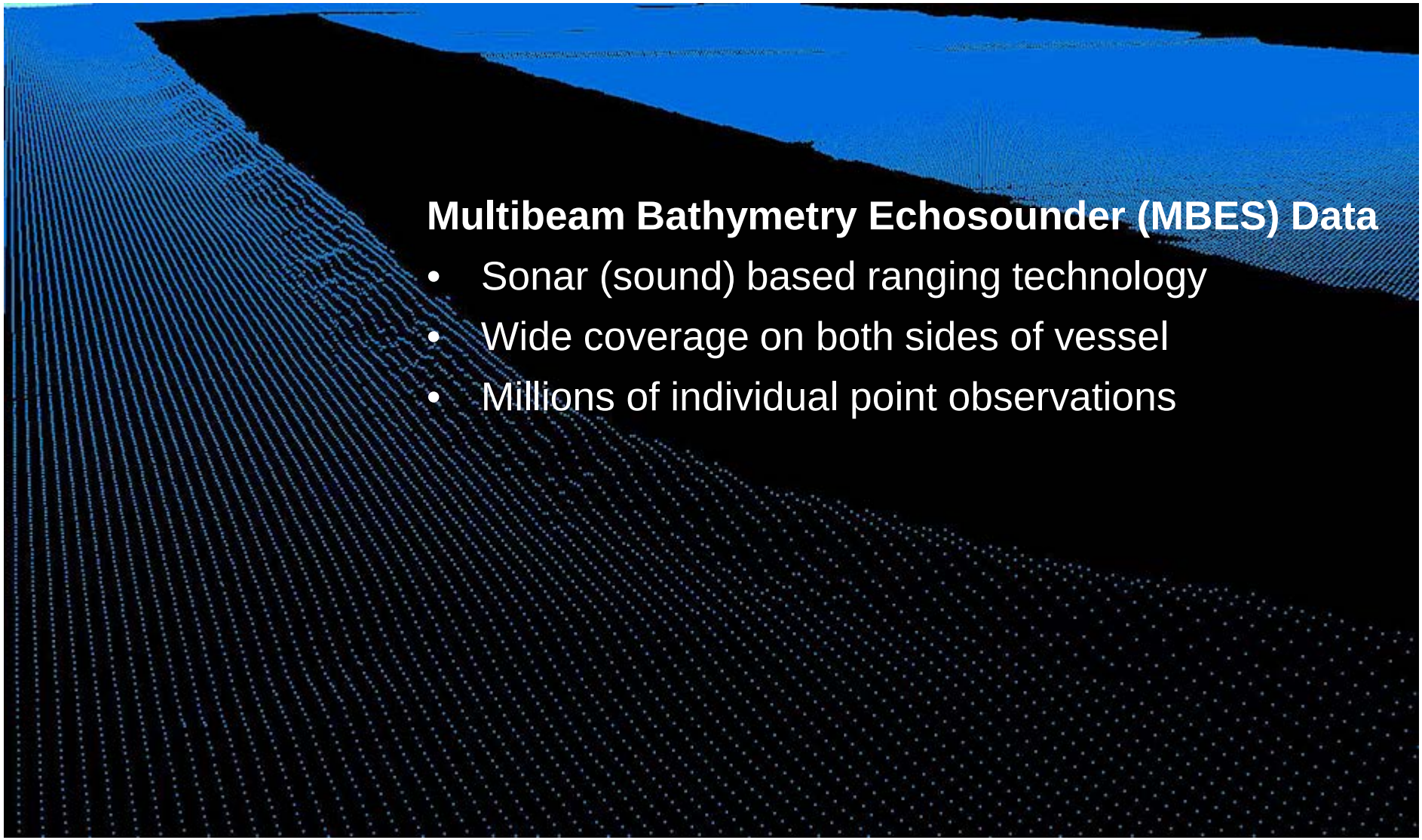
Mobile Laser Scanning (MLS)

A valuable supplement to multibeam when surveying at the waterline

- Uses a laser for surveying above water to capture additional features
- Often longer ranging laser required, especially in dangerous waters
- Some projects benefit from supplemental capture from land



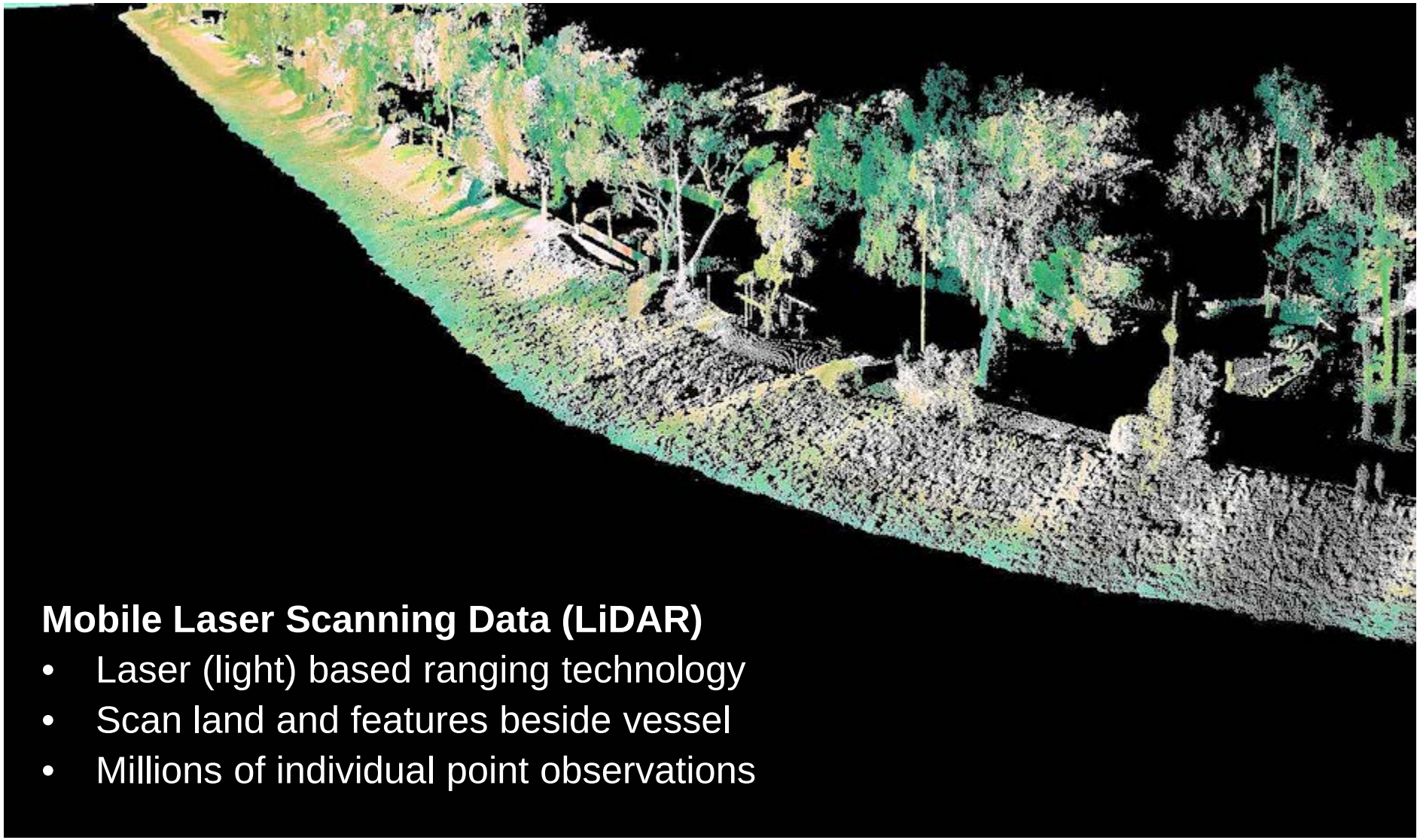
Integrating Bathymetry and Laser Scanning



Multibeam Bathymetry Echosounder (MBES) Data

- Sonar (sound) based ranging technology
- Wide coverage on both sides of vessel
- Millions of individual point observations

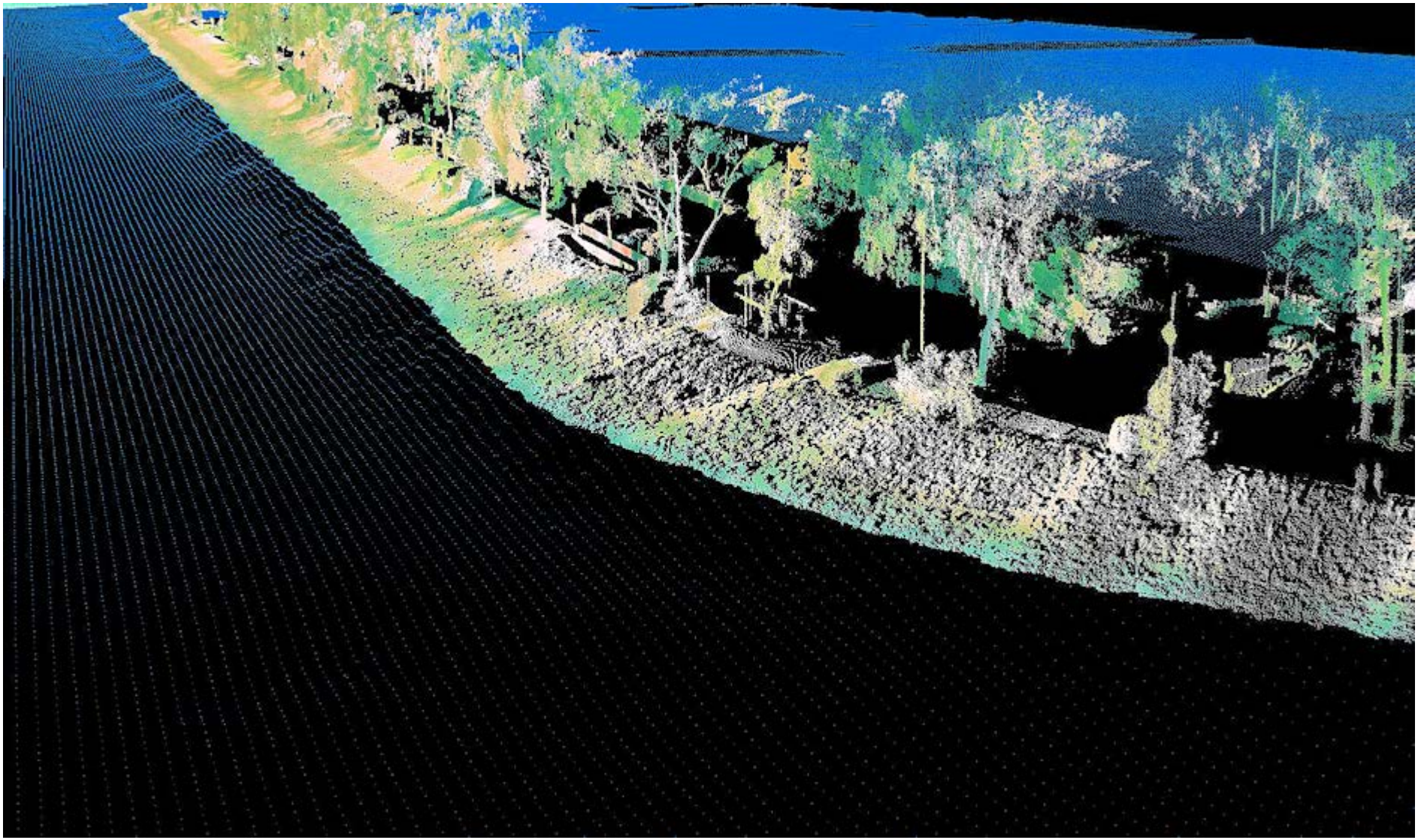
Integrating Bathymetry and Laser Scanning



Mobile Laser Scanning Data (LiDAR)

- Laser (light) based ranging technology
- Scan land and features beside vessel
- Millions of individual point observations

Integrating Bathymetry and Laser Scanning



Applications of the Surveys

Evaluate:

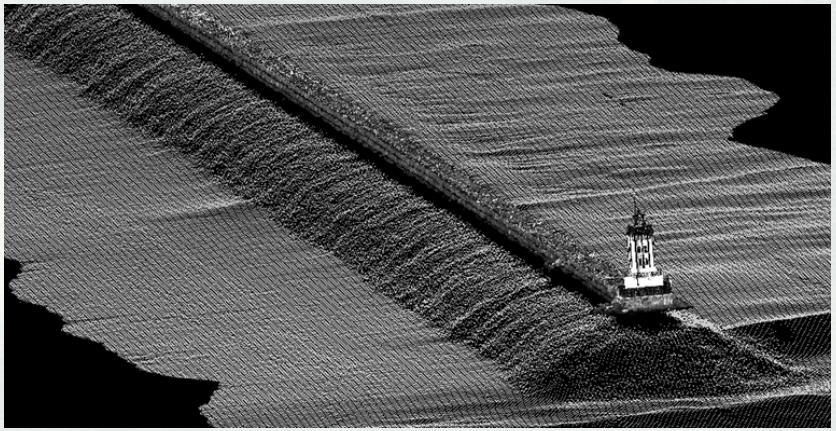
- Channel depth and shoal risks
- Port/Harbor charting
- Breakwater condition
- Sediment scour and deposits
- Hydraulic modeling (storm surge, run-up, etc.)

Fugro has conducted these breakwater surveys at 8 ports and harbors in the Los Angeles District since 2010

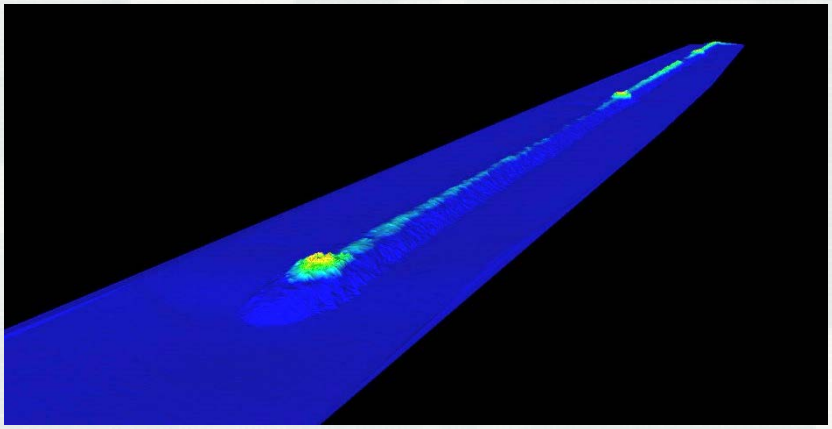
- Ventura
- Dana Point
- Port of Los Angeles
- Port of Long Beach
- San Diego Unified Port District
- Channel Islands
- Port San Luis
- Morro Bay

US Army Corps of Engineers
BUILDING STRONG®

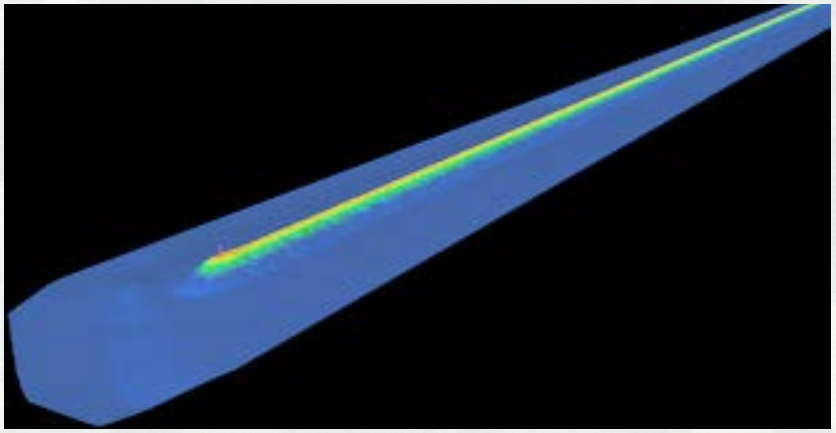
Examples



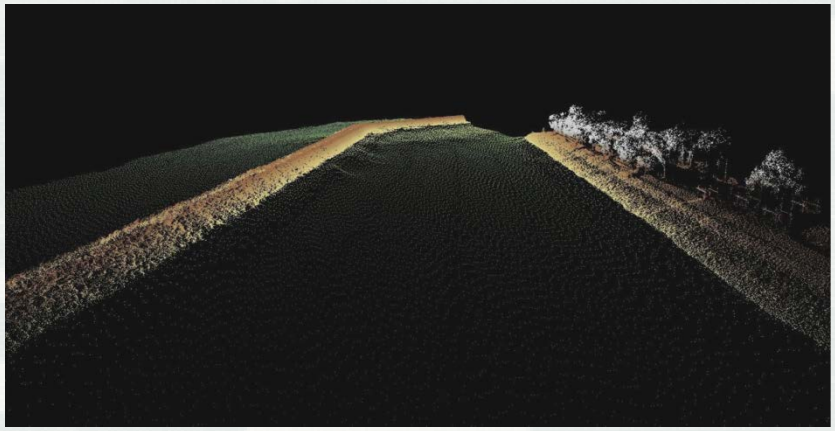
San Pedro Breakwater



Zuniga Jetty



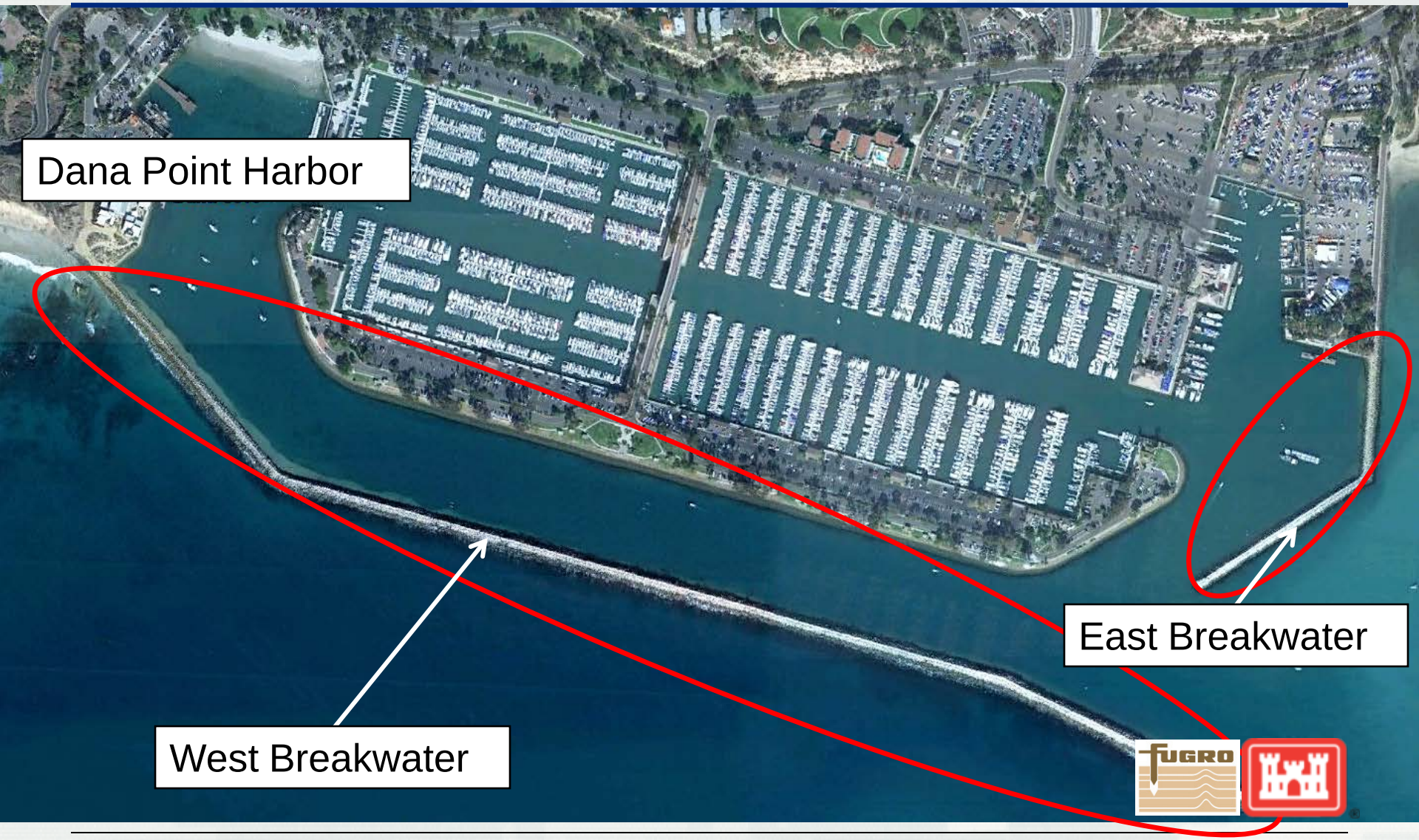
LA/LB Middle Breakwater



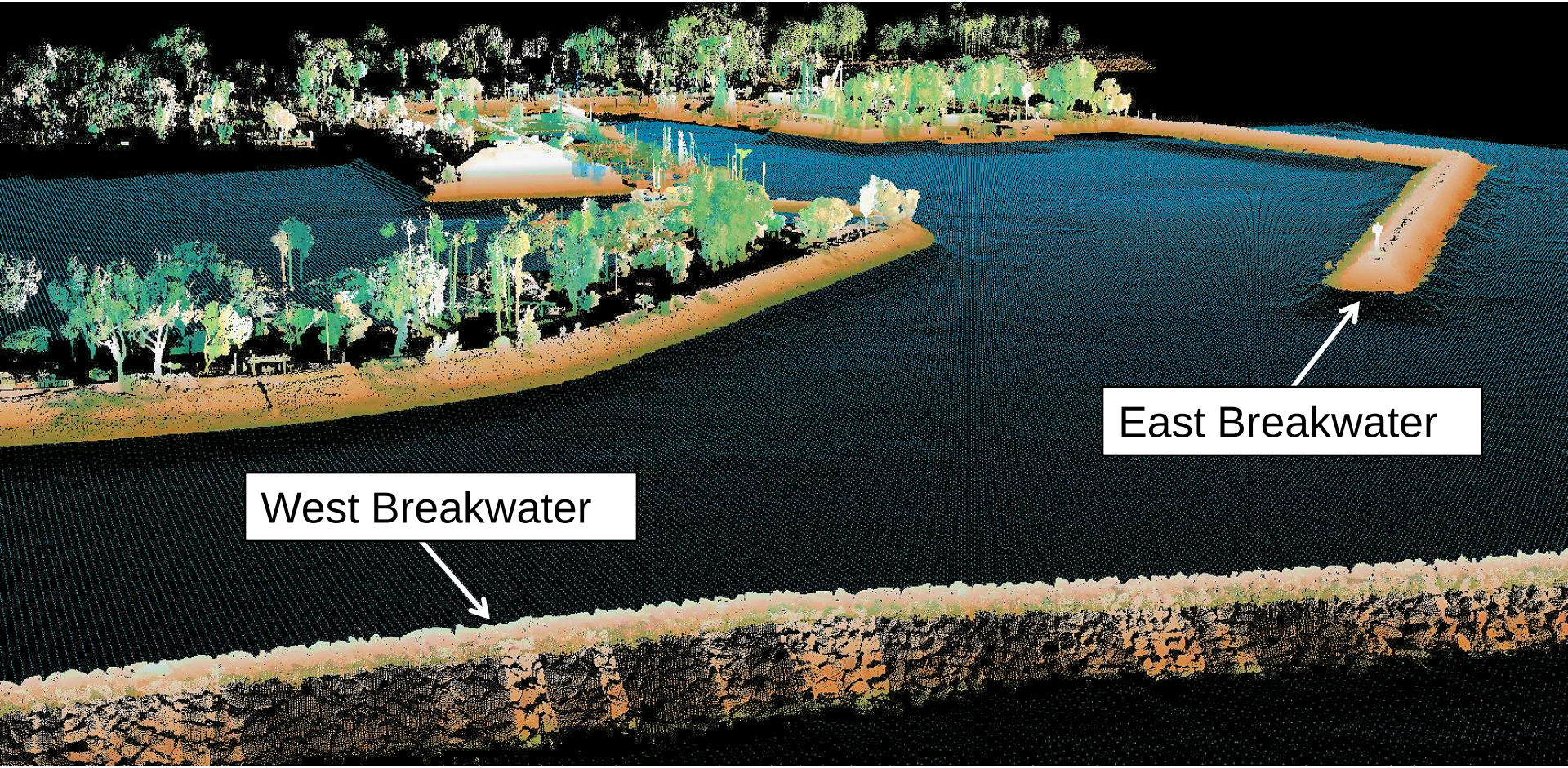
Dana Point

From Mega Port Complexes…

…To Small Craft Harbors



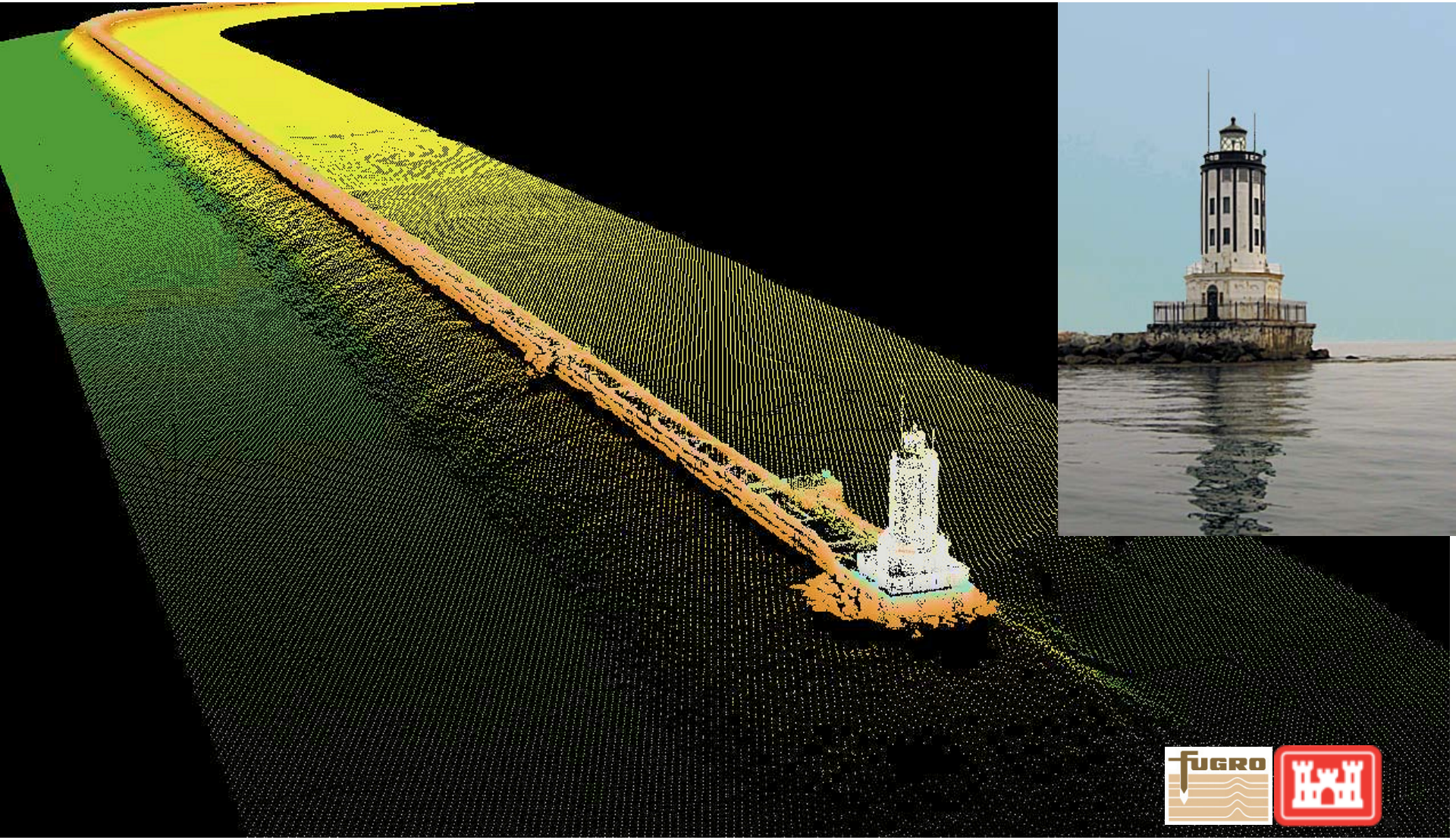
Breakwater (Raw Data “Point Cloud”)



Highly detailed data better informs modeling and assessments.

Remote sensing methods allow mapping to be performed faster and more safely.

Breakwater (Raw Data “Point Cloud”)



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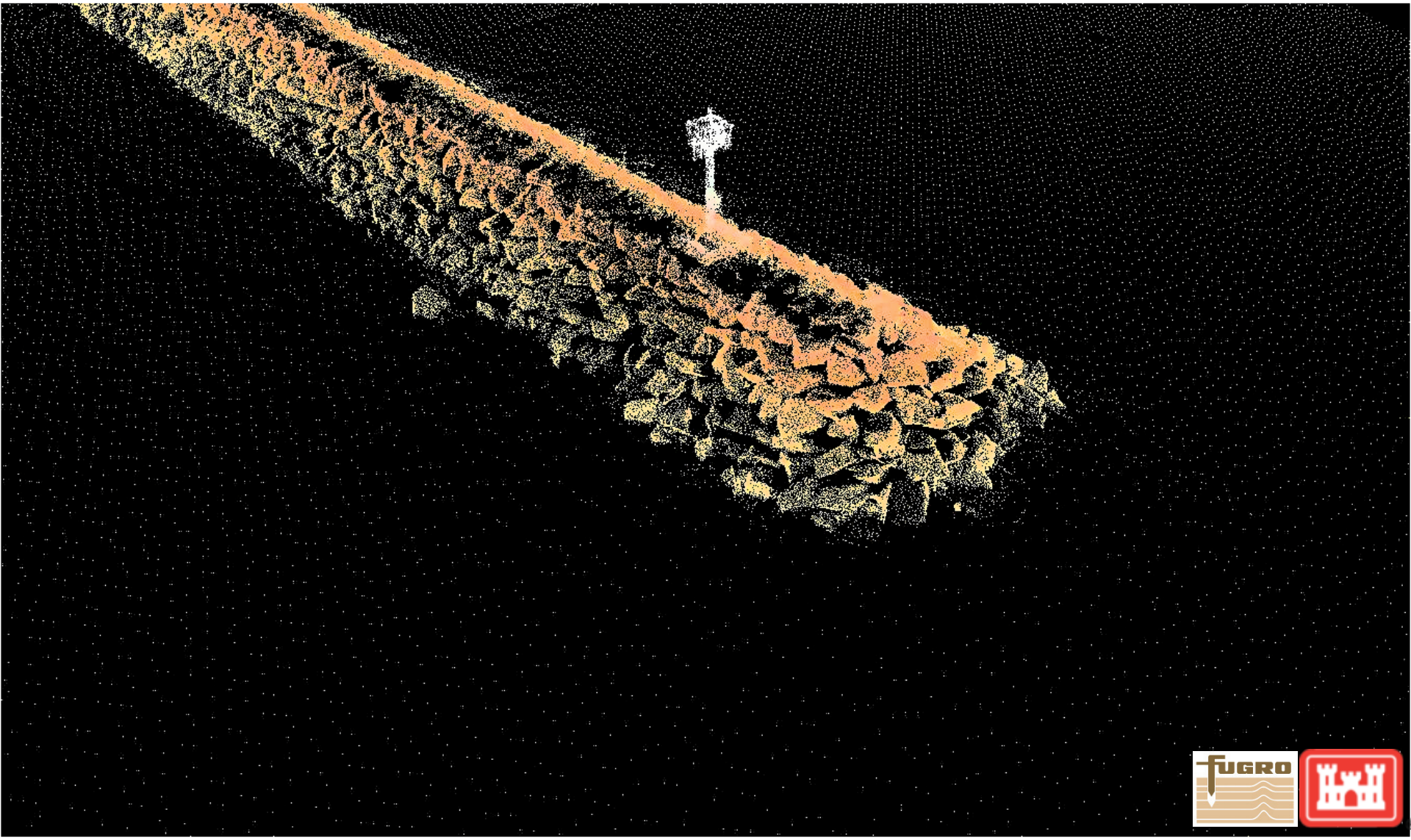
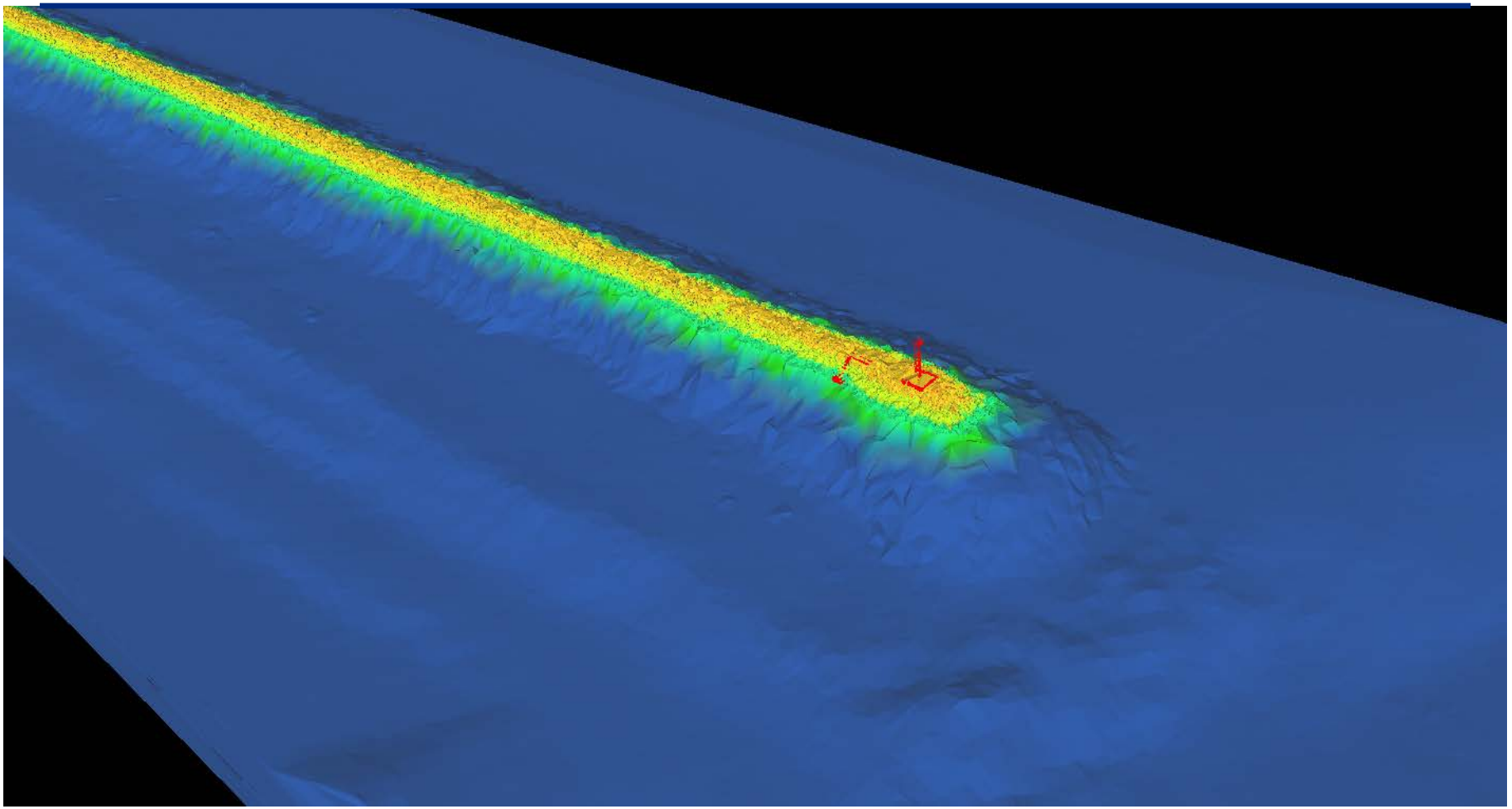
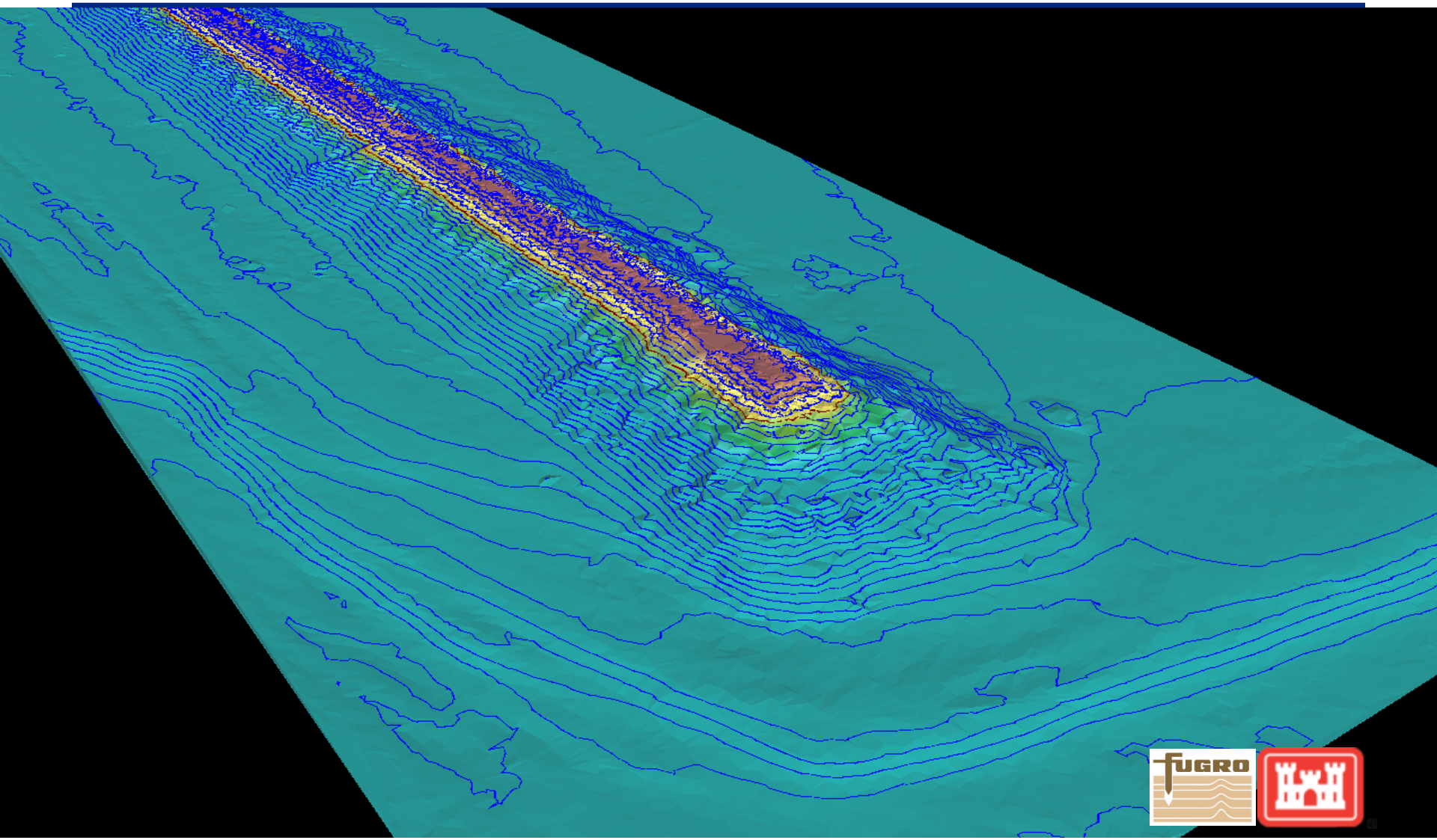


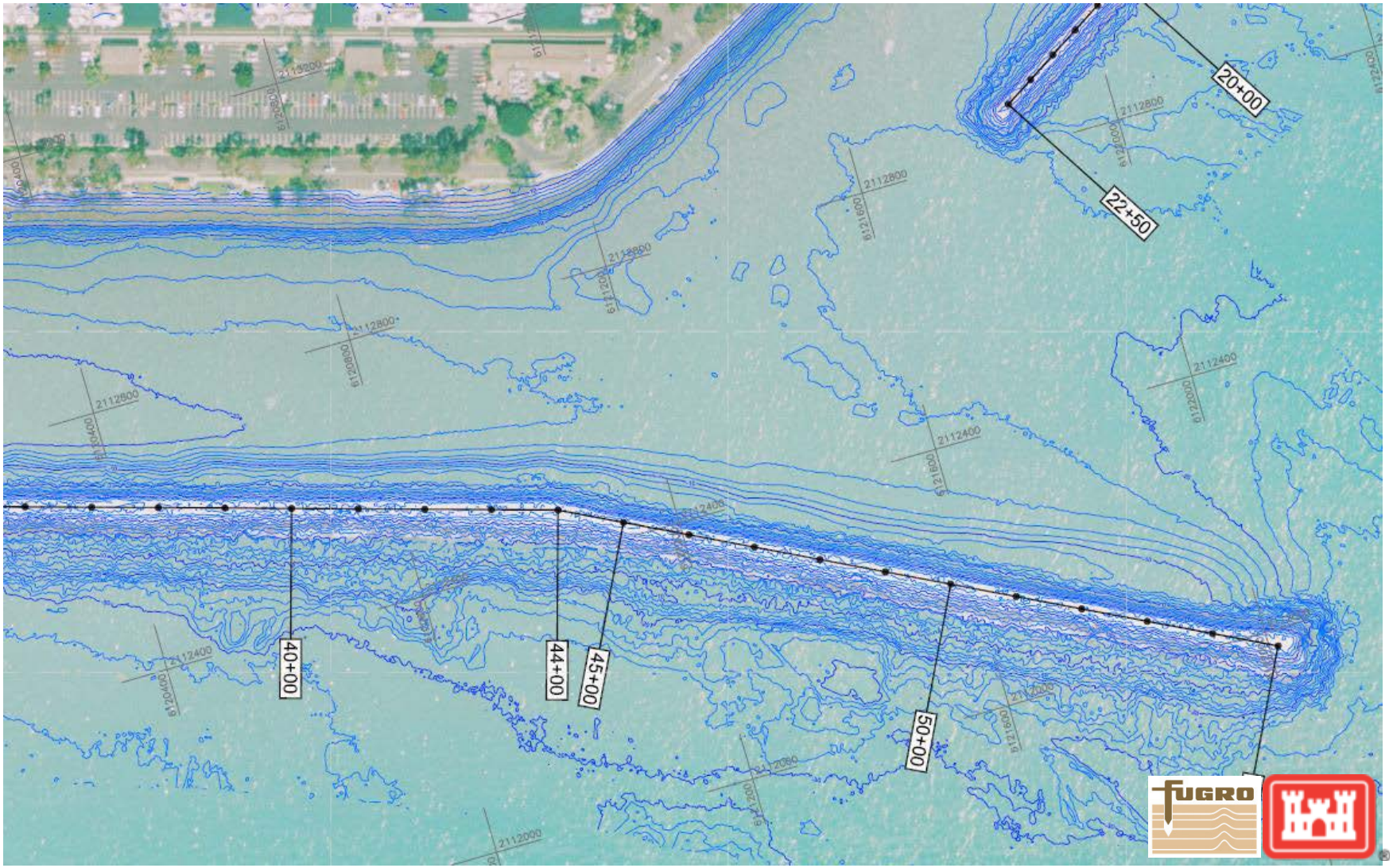
Breakwater (Digital Terrain Model)



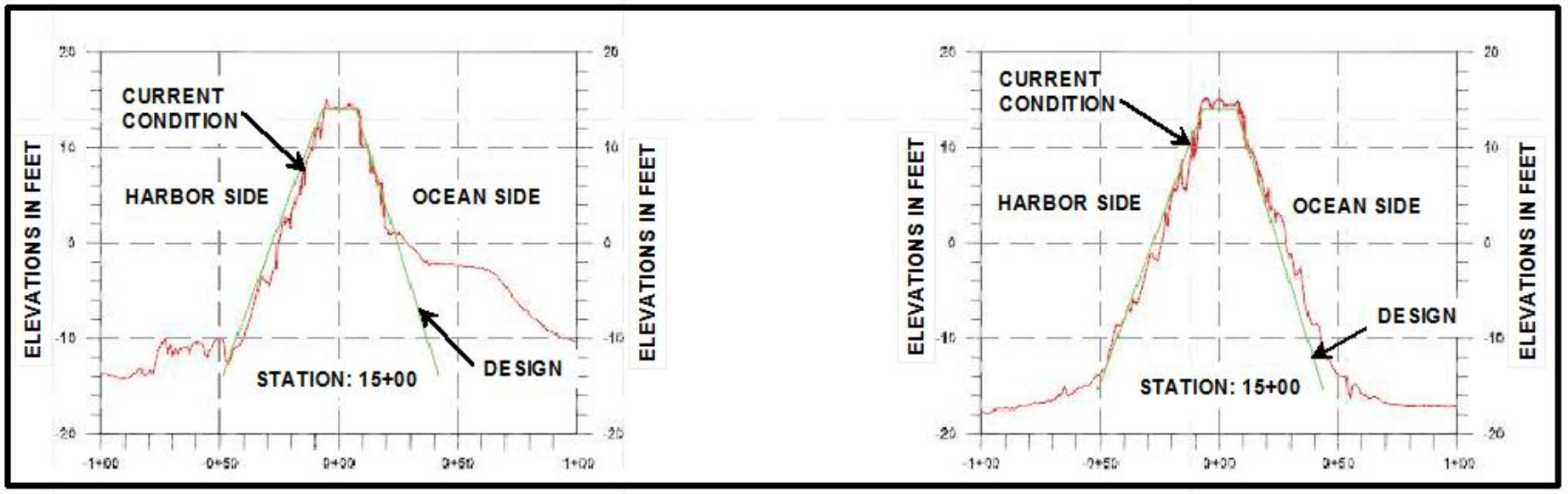
Breakwater (Contour Map – 1')



Nautical Charting Information



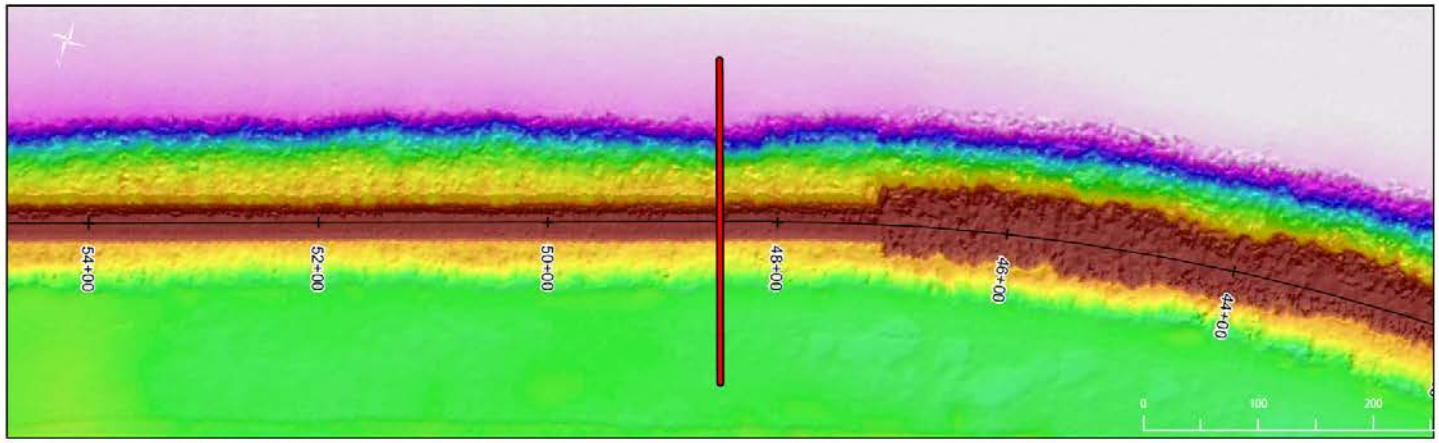
Cross-Section Comparisons: Condition vs. Design

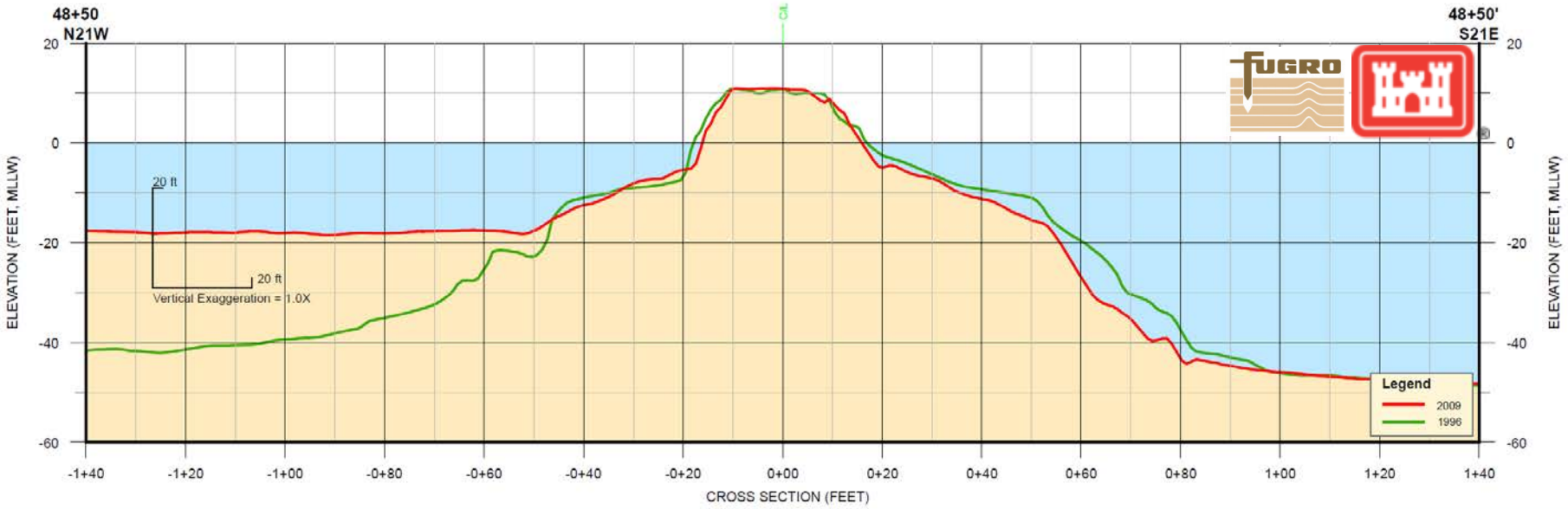


BREAKWATER CROSS SECTION
CURRENT CONDITION AND CONSTRUCTION DESIGN

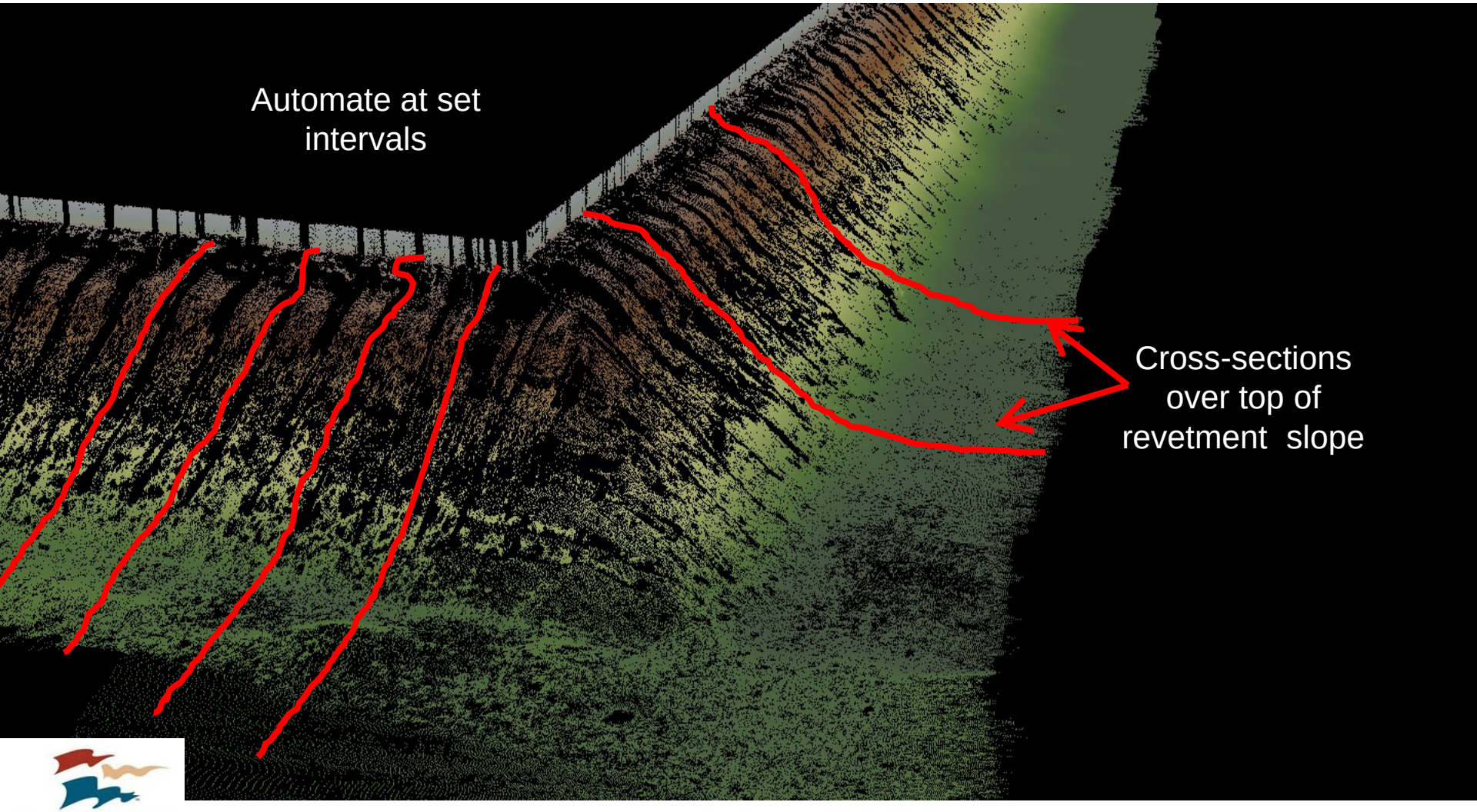
Cross-Section Comparisons: Present vs. Historical

USACE SAN PEDRO BREAKWATER COMPREHENSIVE CONDITION SURVEY
STATION NUMBER 48+50



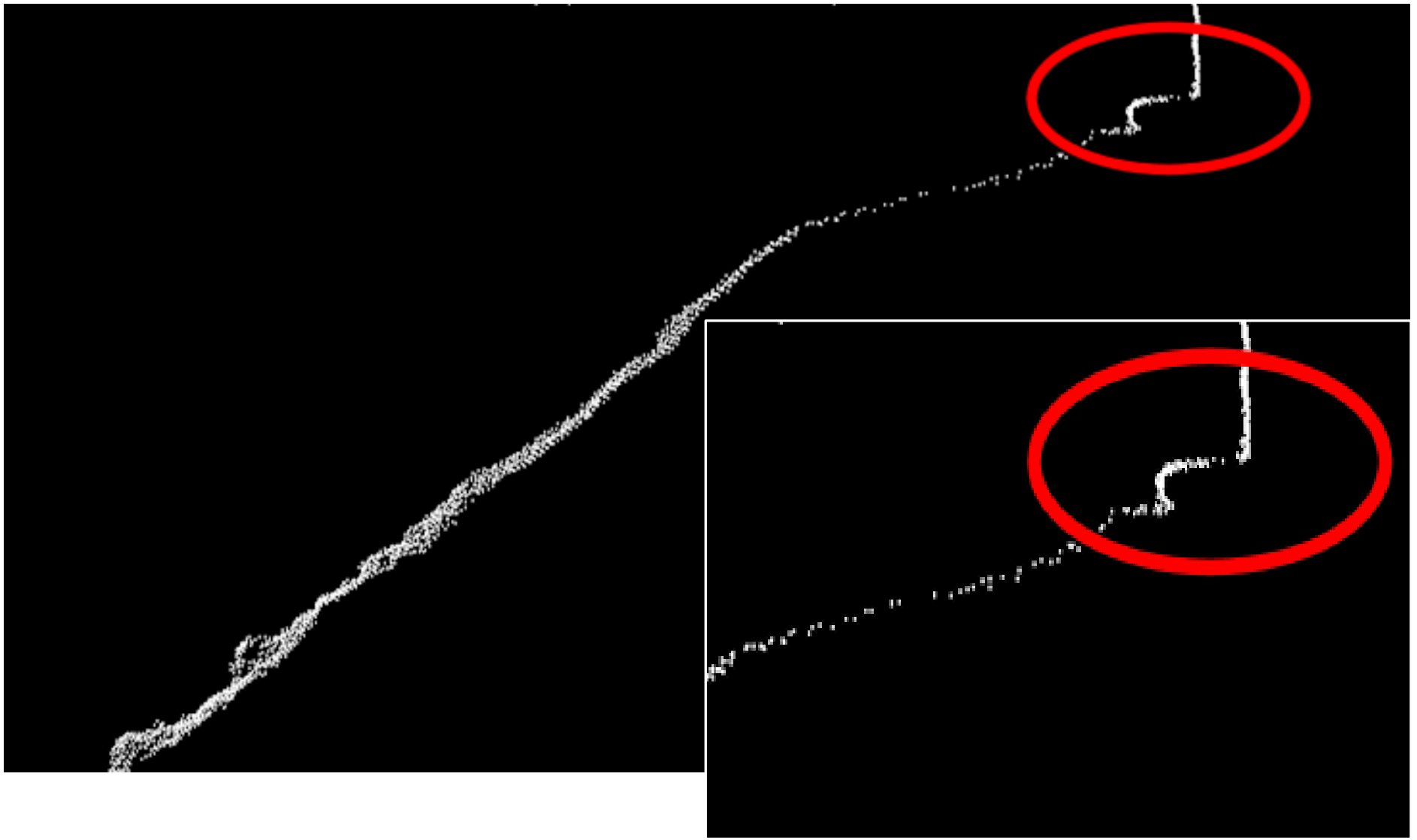


Port Infrastructure: Revetment Condition



Unified Port of San Diego

Single Cross-Section



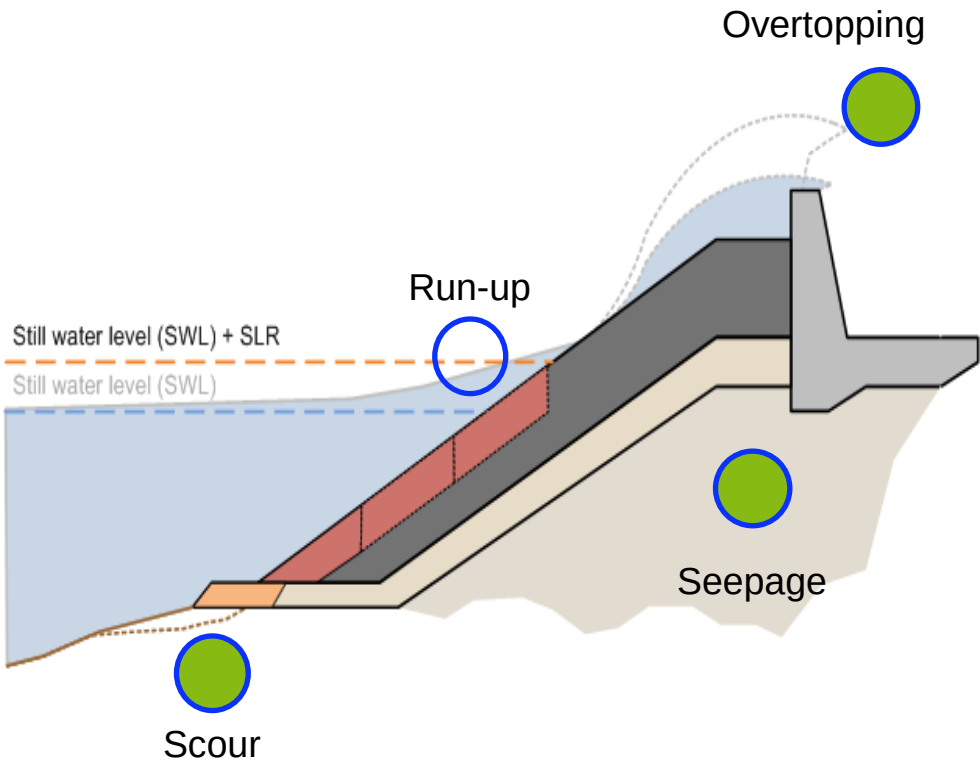
Condition

≠

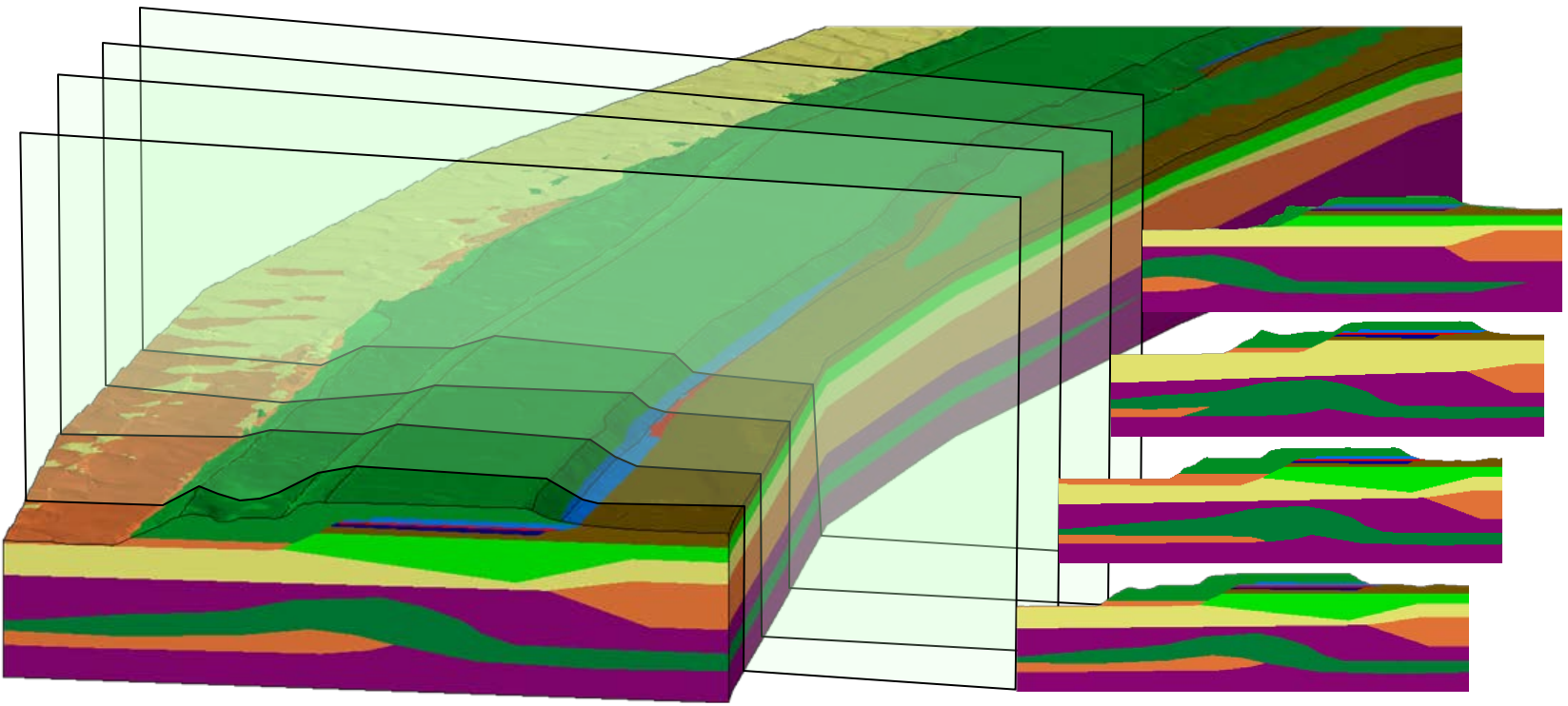
Performance

What Are the Questions?

- Drivers
  - Elevated total-water level
  - Larger waves
- Response
  - Stronger wave action
  - Reduced freeboard
  - More severe overtopping and run-up
  - Foundation and structural instabilities
- Consequences
  - Assets/infrastructure at risk



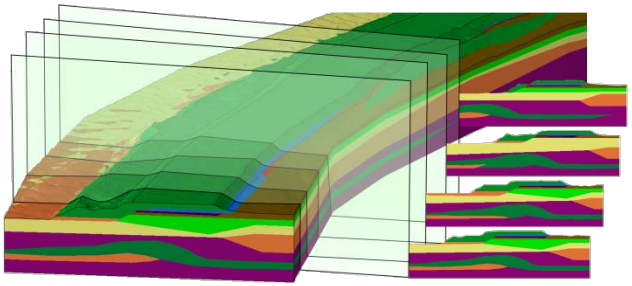
Automated GIS Routines to Evaluate Cross-Sections

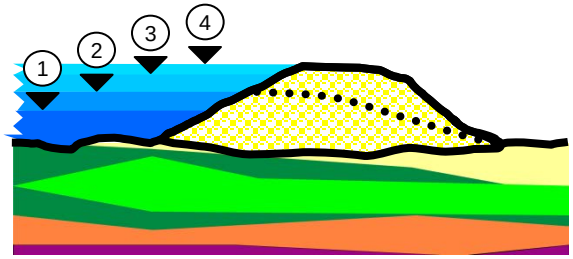


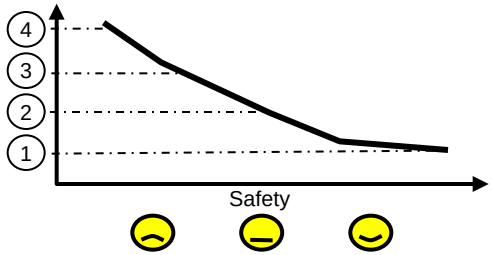
…. for 2D analyses if desired

…or don’t slice and do more complex analyses

Use Automated Routines to Analyze More Scenarios

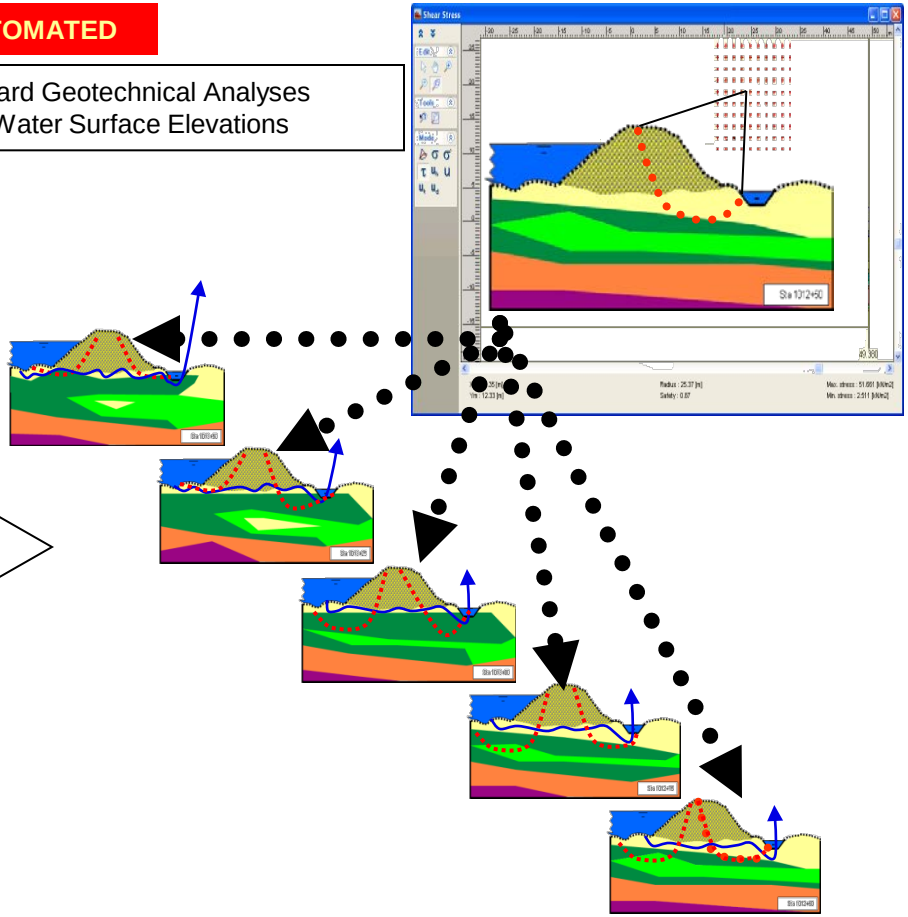






AUTOMATED

Standard Geotechnical Analyses
Multi Water Surface Elevations

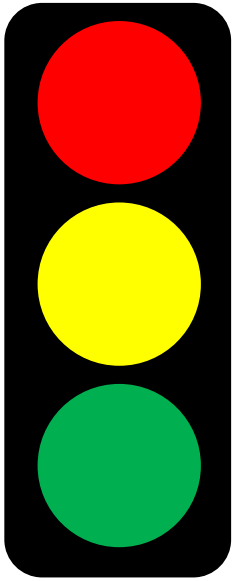


Spacing?

100 ft …..10 ft …… 10 inch ……. 1 inch

Evaluation of Critical Crossings

- Development of Vulnerability/Consequences Rating System
  - Evaluate Level of Threat
  - Factor in Service Life
  - Consider Sea Level Variability & Tolerance
  - Consider Resilience
  - Consider Consequences



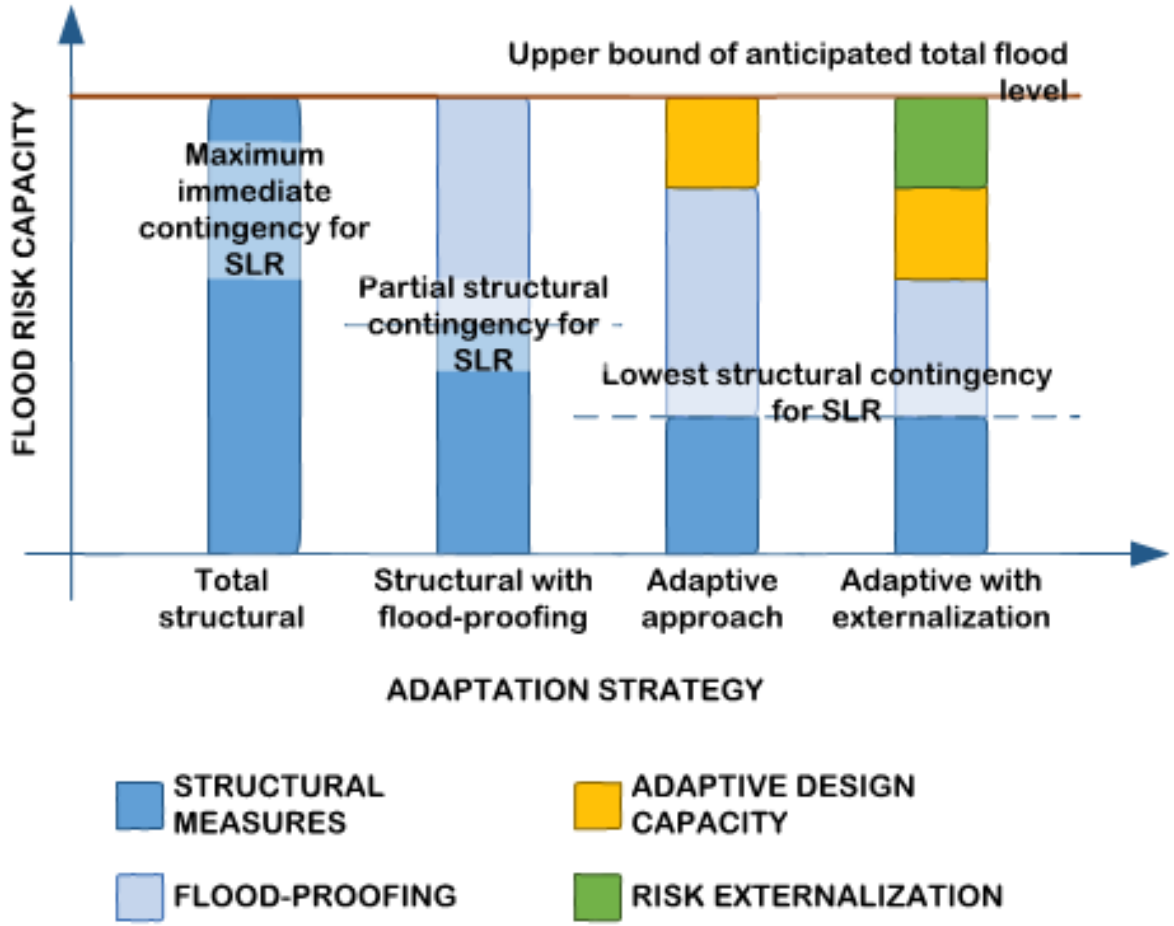
Requires Immediate Attention

Further Evaluation Required

Acceptable Risk

Strategies For Managing SLR Risk

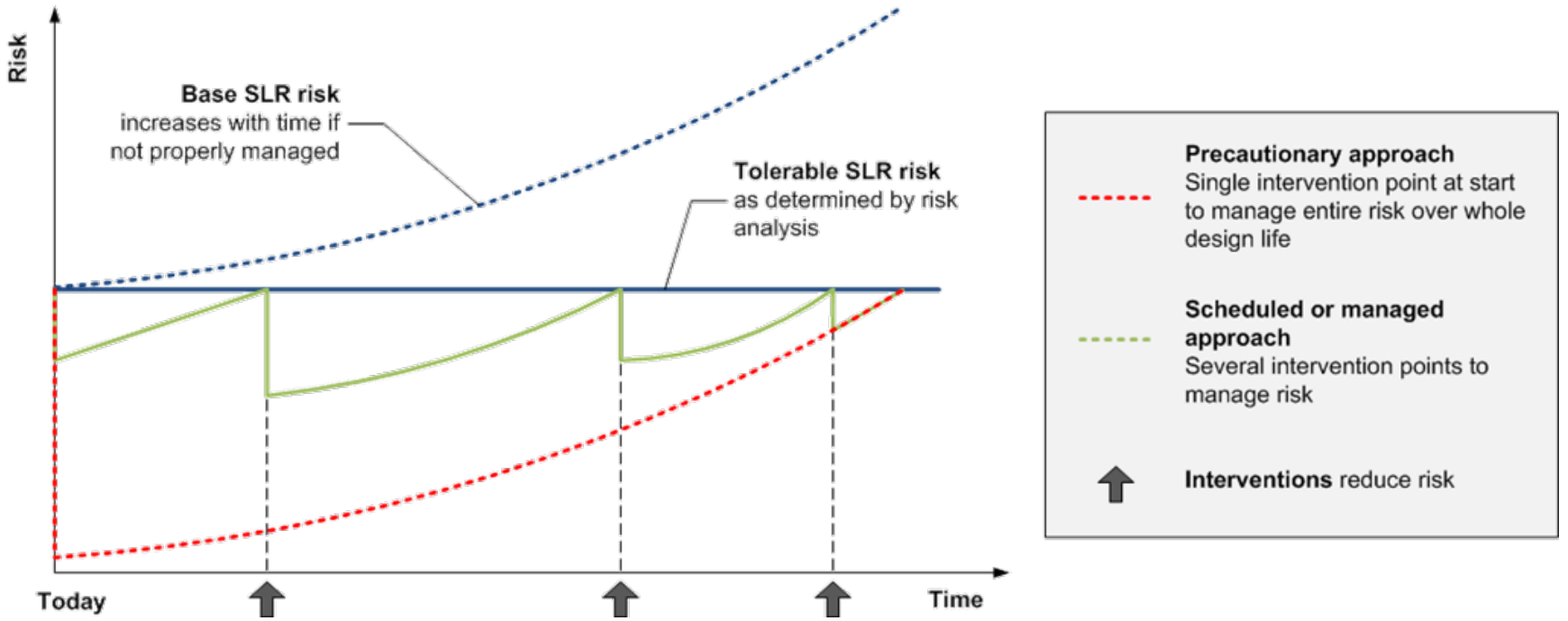
- Flood Risk Capacity Decreases Over Time (Increased Sea Level Rise)
- Risk Management is not always a structural solution.



"Build it now and protect at all costs"

Vs.

"Whenever cost effective, build capacity to accommodate maximum SLR values"



Conclusions

Understanding Risks:

- Criticality of Infrastructure (economic, social, etc.)
- Risk Exposure is Not Linear & Not Static

Consequences of Failure:

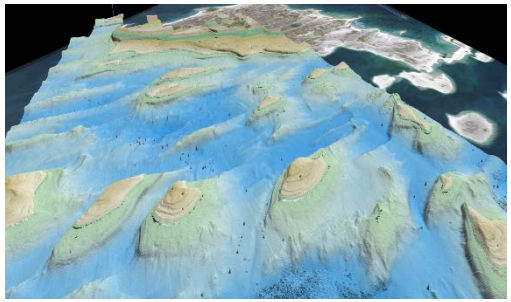
- Direct Impacts
- Indirect Impacts
- Intangible Consequences

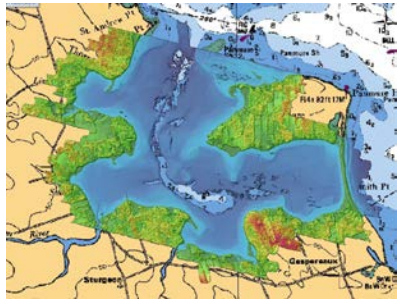
Options:

- Retreat
- Adapt
- Defend

Considerations:

- Condition vs. Performance
- Sustainability
- Precautionary vs. Progressive/ Adaptive Approach





Thank you for your time.

Questions?

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