Predictive Modeling and Design Solutions for Beneficial Use of Dredged Material

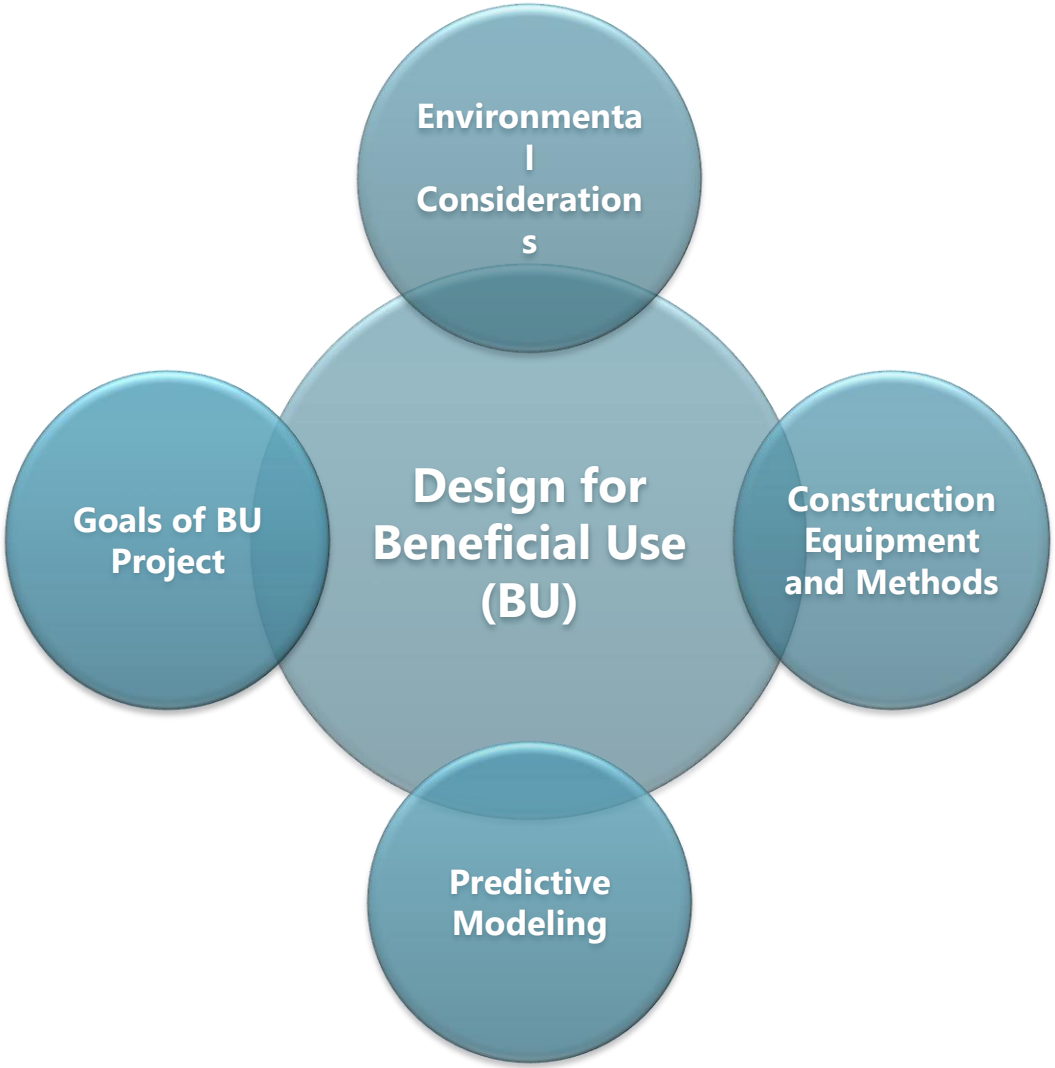
ANCHOR QEA

Presented by Tom Wang, P.E.
April 10, 2018

Overview of Presentation

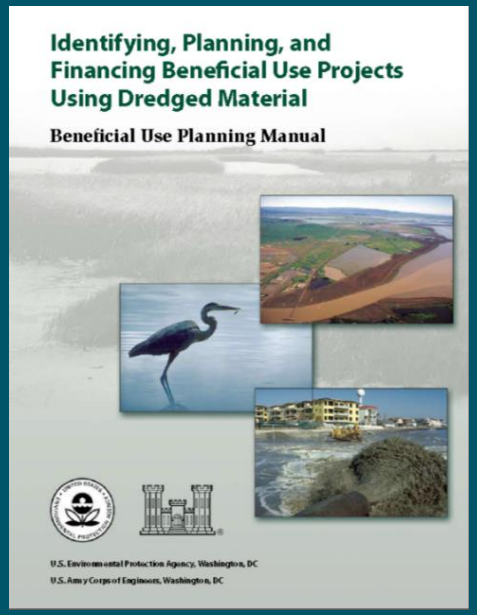
- Examples of dredged material beneficial use (BU) opportunities
- Predictive modeling for BU
- Dredging, transport, and placement methods for BU
- Example dredged material BU Sites
- Questions

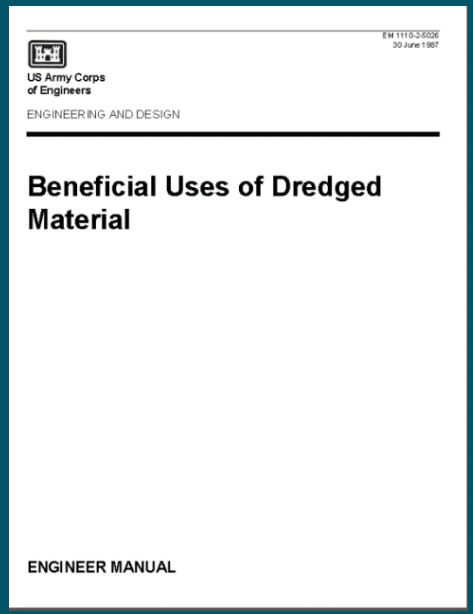
Integrated Approach is Key to Success



Beneficial Use Design Guidance

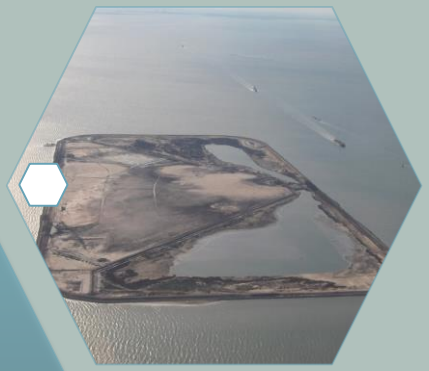
- USACE publications
  - EM 1110-2-5026 Dredged Material Beneficial Uses
  - DRP and DOER papers and case studies
- USEPA
  - EPA842-B-07-001 Beneficial Use Planning Manual





Beneficial Use (BU) Opportunities

Beneficial Use Opportunities



Confined Aquatic Disposal (CAD)

Remediation Caps

Confined Disposal Facility (CDF)– Shoreline Development

Beneficial Use Opportunities, continued

Habitat Restoration - Mitigation

Beach Nourishment

Predictive Modeling for BU Projects

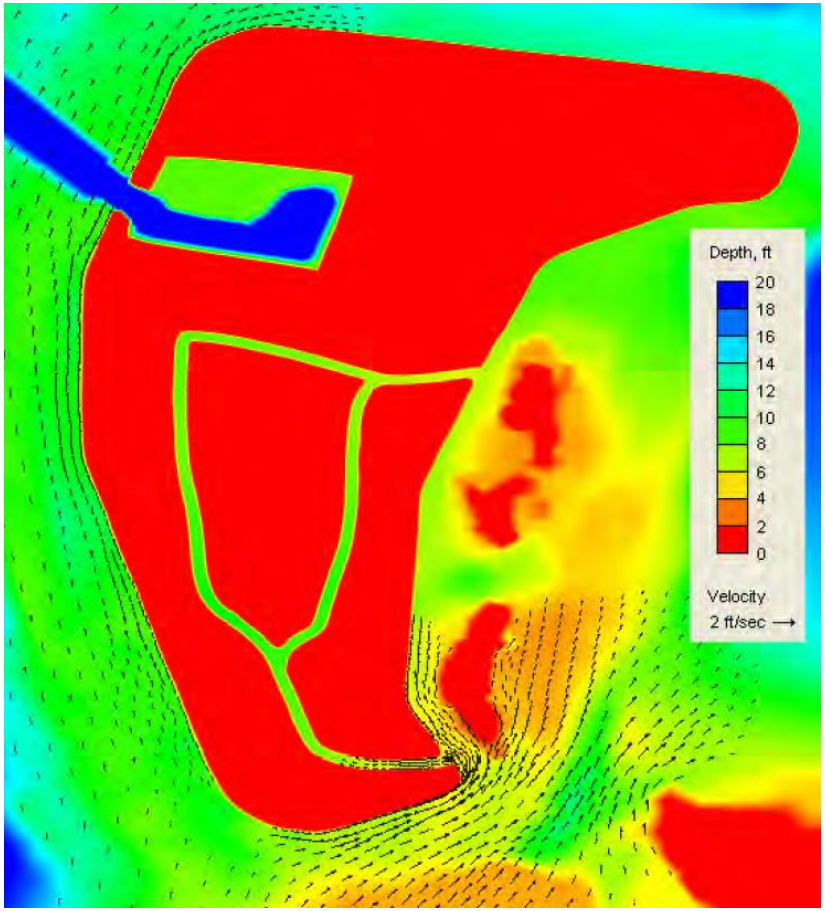
Summary of Predictive Modeling for BU

Beneficial Use Options	Physical Stability	Sustain-ability	Contaminant Mobility (Benthic)	Contaminant Mobility (suspended)	Geotechnical Considerations
Confined Disposal Facility/ Shoreline Development	+++	+	+++	+++	+++
Confined Aquatic Disposal	+++	++	+++	+++	+++
Beach Nourishment	+++	+			+
Habitat Restoration/Mitigation	+++	+++			+++
Sediment Remediation Cap	+++		+++	+++	+++

\+ Considered
++ Important
+++ Critical for Design

Physical Stability of Placed Sediment

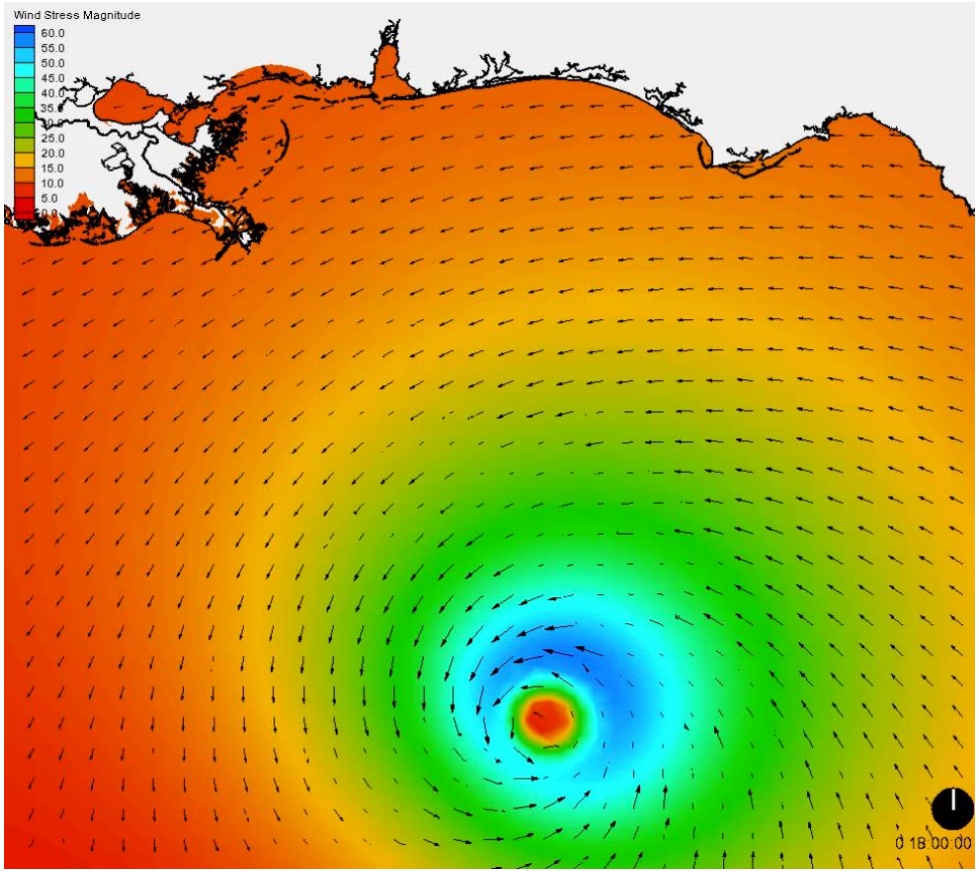
- Objective: Evaluate short- and long-term physical stability of placed material due to hydrodynamic forcing
- Tools: ADCIRC, STWAVE, Delft-3d, SWAN, M2D and others
- Data needs
  - Site conditions
  - Design conditions
  - Sediment characteristics



Maximum Predicted Current Field Around BU Island (M2D Model

Physical Stability of Placed Sediment

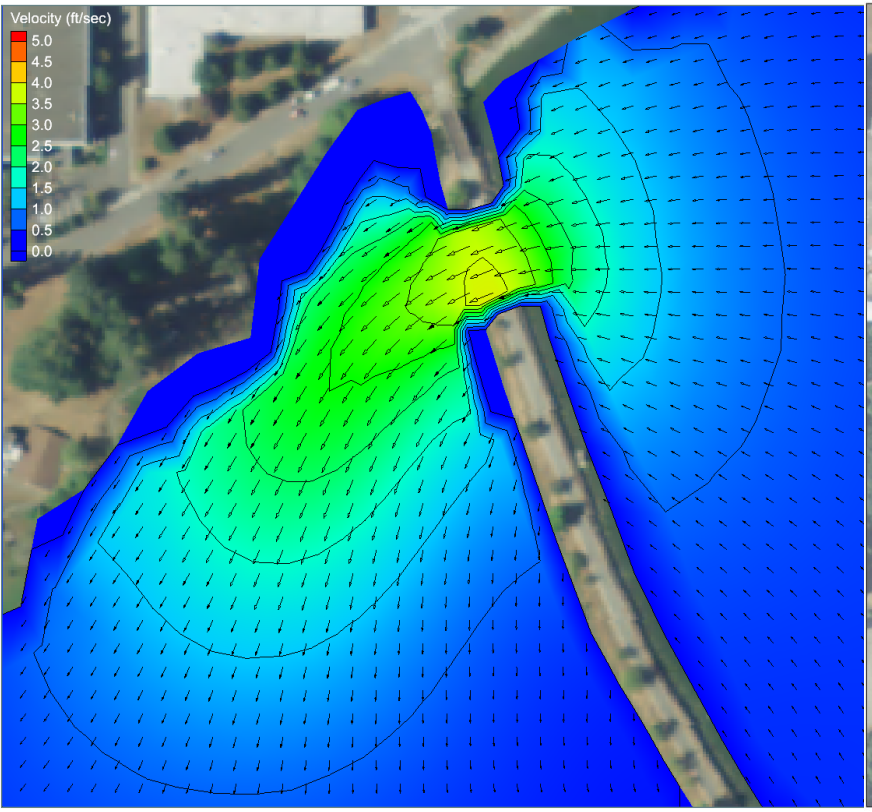
- Tidal currents
- Wind-waves
- Vessel wakes
- Propeller wash
- Riverine currents
- Outfalls/stormdrains
- Storms/hurricanes

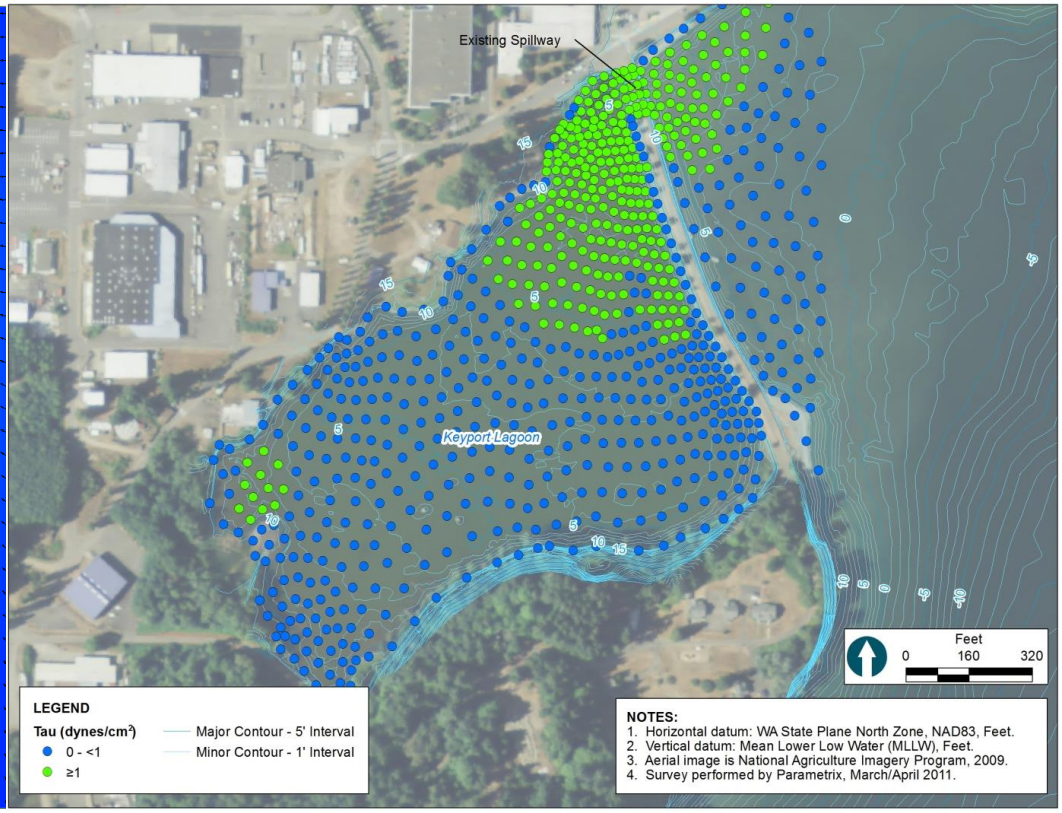


Simulation of Hurricane Katrina for Port of Gulfport (wind stres

Keyport Lagoon, U.S. Navy

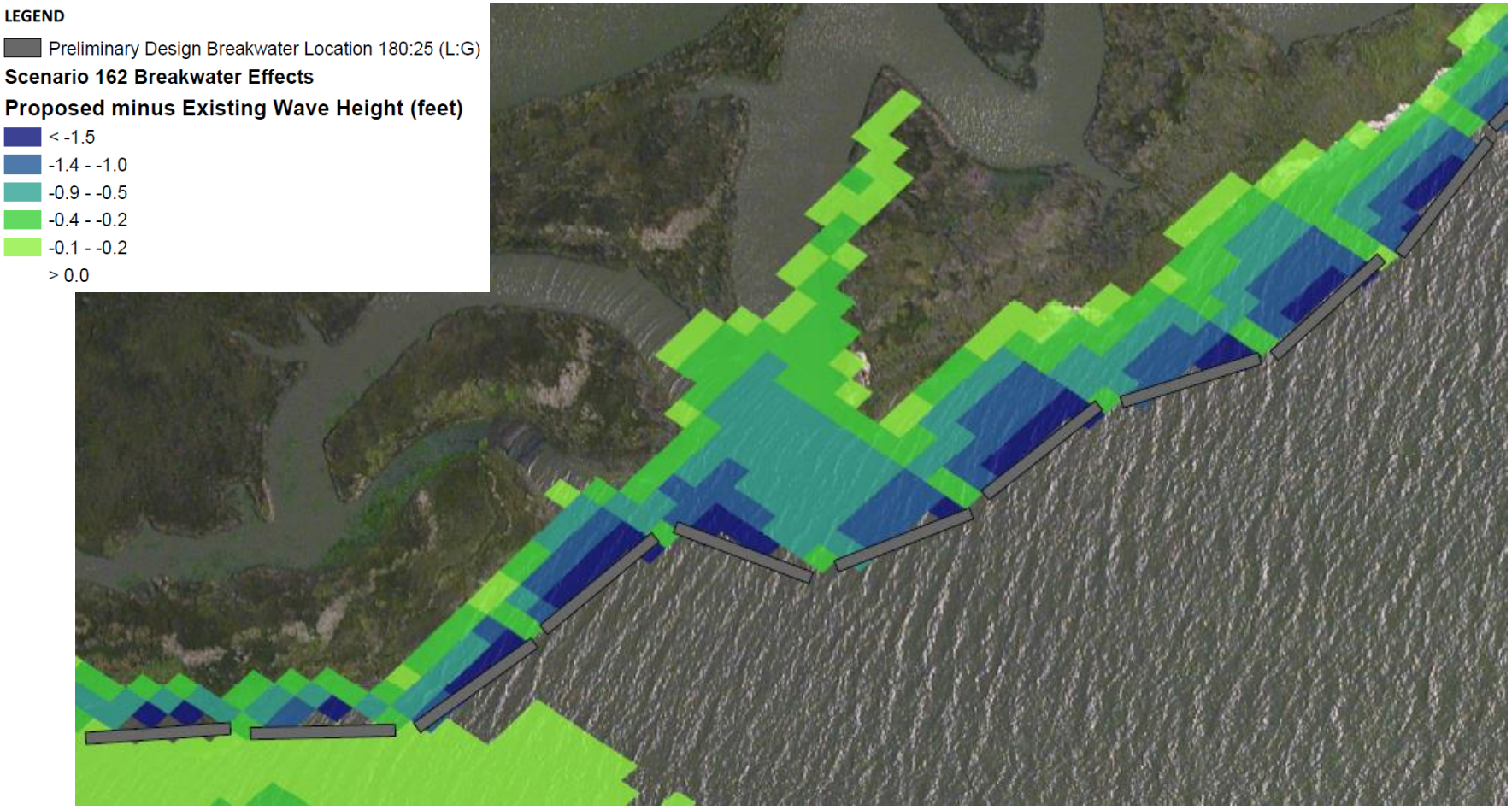
Tidal Currents (ADCIRC) and Excess Shear Stress





Hancock County Living Shorelines, Mississippi Sound

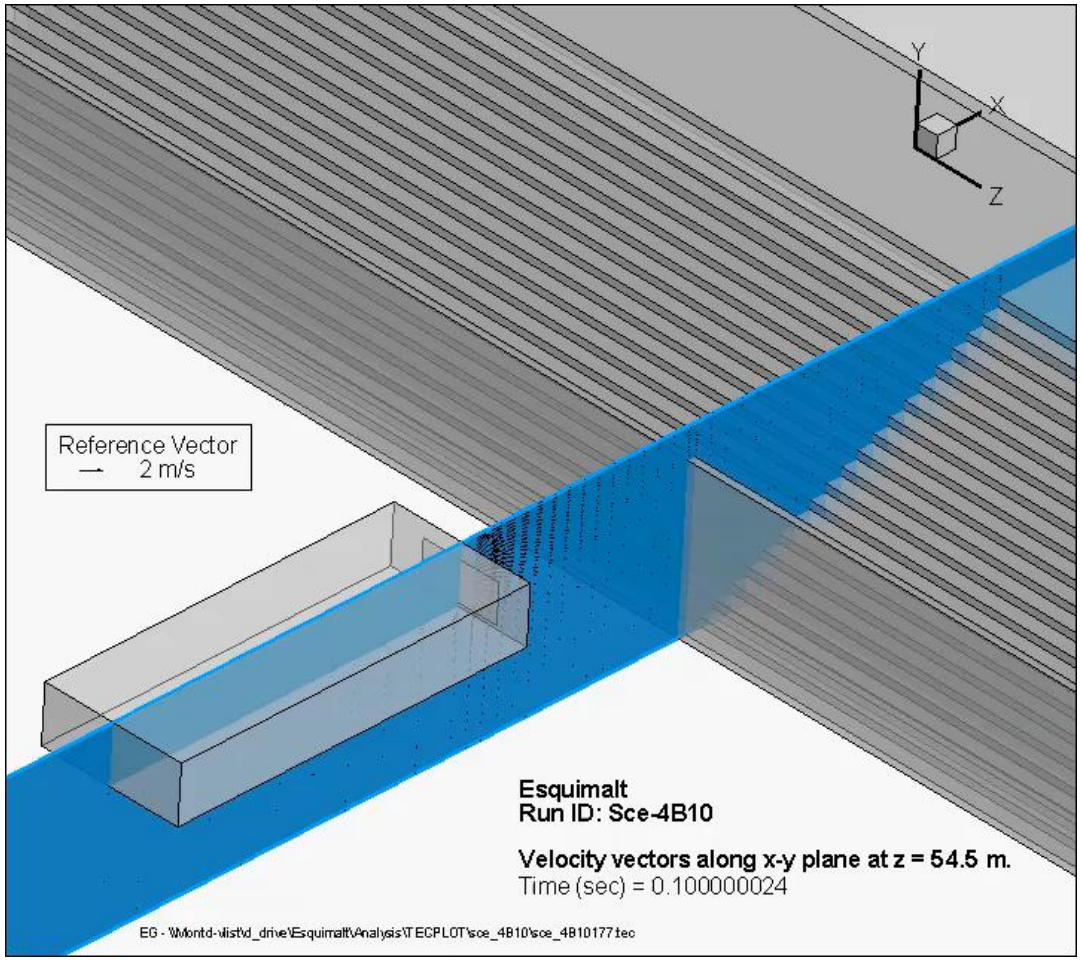
Wave Energy along Shoreline (SWAN)



Esquimalt Harbour, British Columbia, Canada

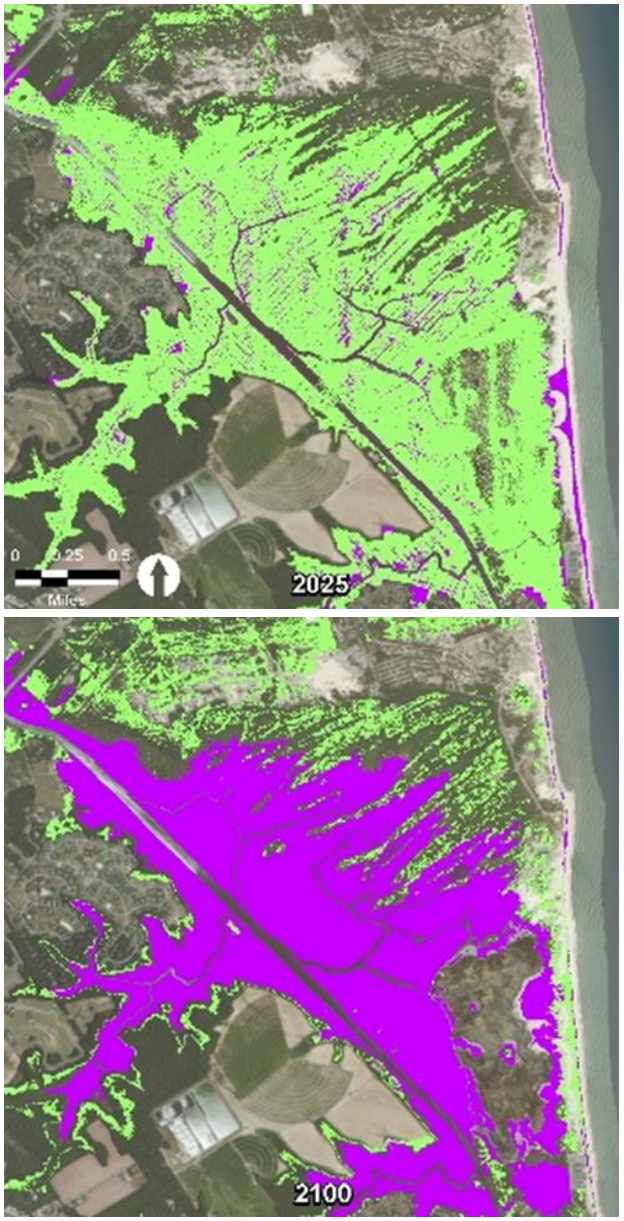
Prop Wash Evaluation

- CFD Code
- Need to predict specific velocity field behind the prop
- Evaluate scour potential based on predicted velocity field
- Example shows velocity field around constructed containment wall



Sustainability (SLR)

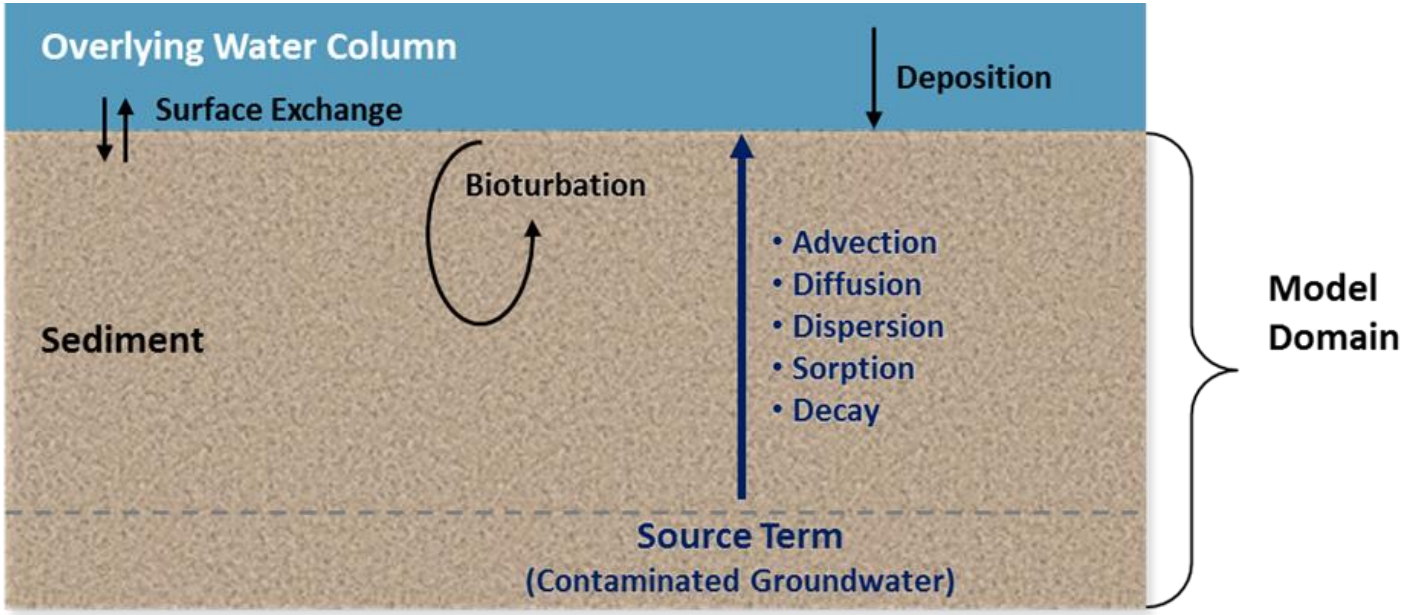
- Objective: Evaluate impacts to project over design life based on predictions of sea level rise
- Tools: Hydrodynamic models and GIS spatial modeling tools
- Data needs
  - Site conditions
  - Design conditions
  - Habitat conditions and characteristics
  - Sea level rise estimates (typically through 2100)



Transformation of Tidal Wetlands in DE

Contaminant Mobility (Benthic)

- Mobility of contaminants through the placed sediments
- Groundwater pathways
- Reible Model (1998 EPA Cap Guidance document)
- AQFATE



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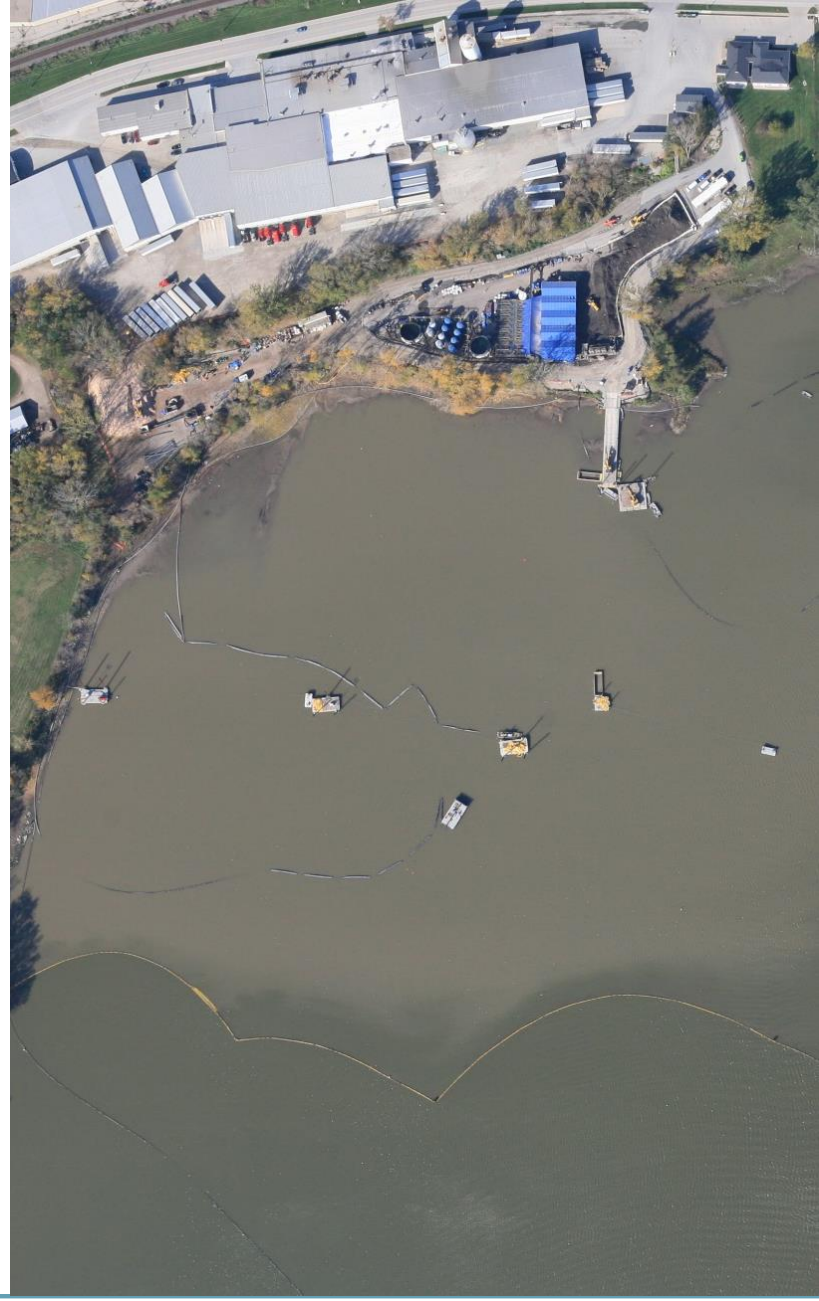
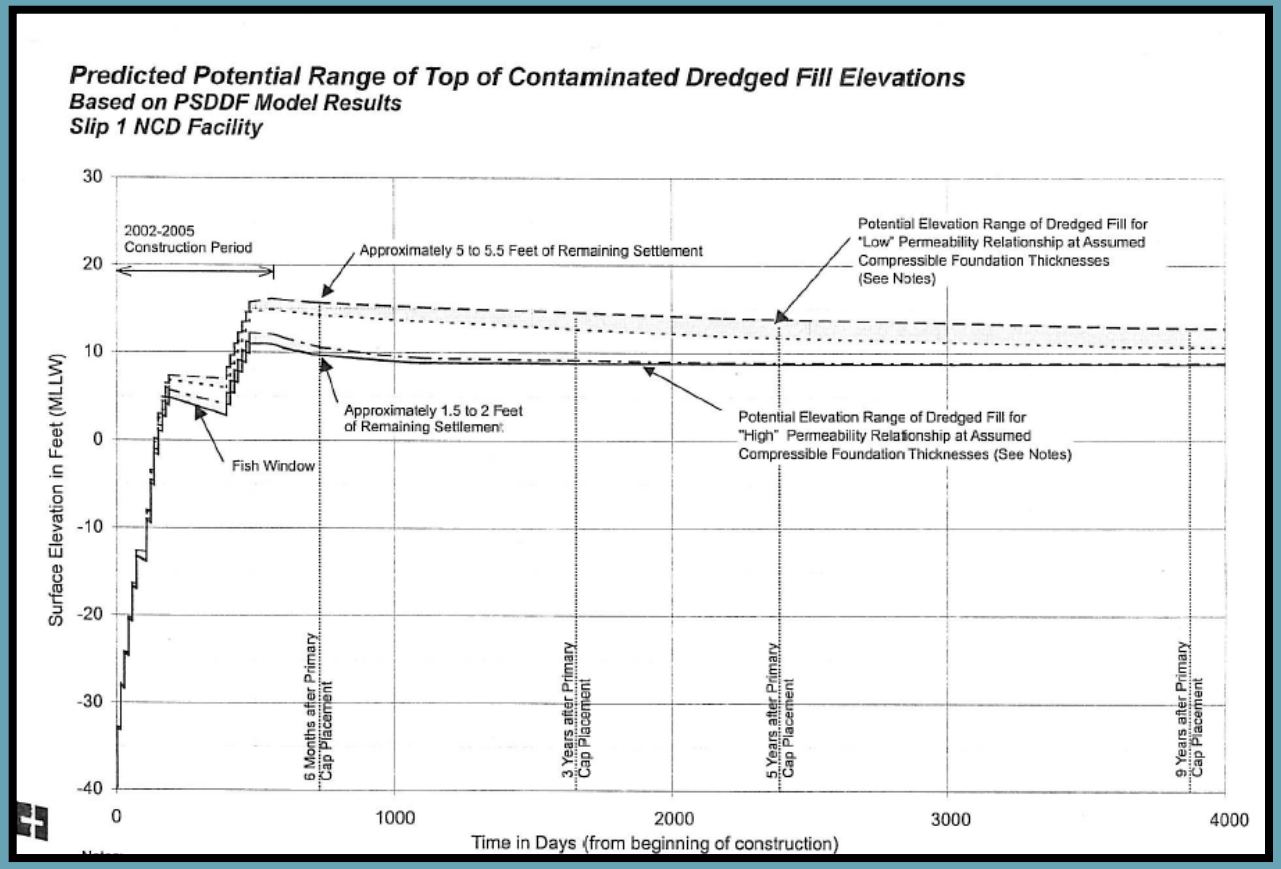
Contaminant Mobility (Suspended)

- Objective: Assess water quality impacts resulting from dredging
  - Turbidity
  - Dissolved contaminants
- Tools: ADDAMS, DREDGE and STFATE modules; EPA Plumes
- Data needs
  - Site conditions
  - Sediment characteristics
  - Dredge characteristics and operations
  - Disposal operations



Geotechnical Modeling

- Dredged material bulking and settlement (short-term)
- Foundation consolidation (long-term)
- PSDDF Model
  - Settlement during construction
  - Long-term consolidation



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Sediment Remediation Cap	+++		+++	+++	+++

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Dredging, Transport and Placement Considerations

Dredging, Transport, and Placement

- Key considerations in equipment and method selection
  - Intended beneficial use of dredged materials at placement site
  - Distance between dredge and placement sites
  - Dredging vs. placement production rates
  - Substrate suitability of dredged material for beneficial use
  - Sediment contamination
  - Placement site timeframe to achieve functionality
    - Short-term dredge material bulking and settlement
    - Long-term consolidation (sediment and foundation)
  - Dewatering or treatment needs

Dredging, Transport, and Placement (cont.)

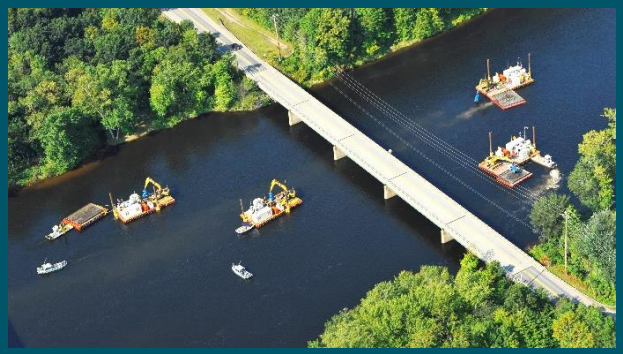
- Key considerations in equipment and method selection
  - Predictive modeling results
  - Empirical laboratory or bench-scale testing results
  - Environmental impacts
    - Water quality impacts at dredge and placement sites
    - Habitat impacts
    - Ability to employ construction BMPs to mitigate impacts

Dredging, Transport, and Placement (cont.)

Beneficial Use Options	Dredging Method (Mechanical, Hydraulic)	Transport Method (Barge, Pipeline)	Clean or Contam. Sediment	Active Dewatering Typically Used	Treatment Typically Used
Confined Disposal Facility/ Shoreline Development	Both	Both	Both	Yes	Sometimes
Confined Aquatic Disposal	Mechanical	Barge	Both	No	No
Beach Nourishment	Hydraulic	Pipeline	Clean	No	No
Habitat Restoration/Mitigation	Both	Both	Clean	No	No
Sediment Remediation Cap	Mechanical	Barge	Clean	No	Sometimes

Dredging and Transport Technologies

- Mechanical
  - Barge transport
  - Unlimited transport distance
  - Low bulking (i.e., near in-situ)
  - Intermittent placement
  - Debris is relatively easy
  - Lower production rate
- Hydraulic
  - Pipeline transport
  - Restricted transport distance
  - High bulking (i.e., hydraulic slurry)
  - Continuous placement
  - Debris is challenging
  - Higher production rate



Barge placement

Telebelt placement

Thin layer placement with rehandling bucket

Mechanical Placement

- Barge transport for dredged material
- Capable of placing wide variety of material
- Multiple placement methods: barge, rehandling, conveyor, tremie
- GPS enabled for documentation of area coverage

Hydraulic Placement

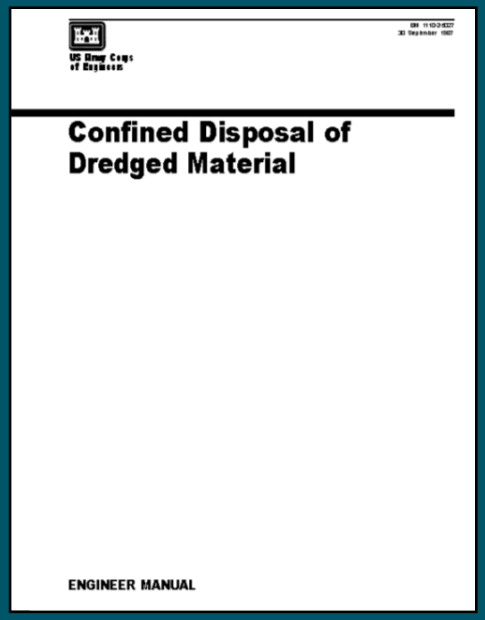
- Slurry transport via hydraulic pumps and pipeline
- Barges equipped with anchoring system and GPS
- Ideal for sand and finer material up to 1 inch in diameter
- Thin layer cover combines dredging and precision placement, restores marsh elevation

Hydraulic with diffuser screen

Hydraulic diffuser

Thin layer capping over marsh

Confined Disposal Facilities



CDF Design Guidance

- U.S. Army Corps of Engineers publications
  - EM 1110-2-5025 Dredging and Dredged Material Disposal
  - EM 1110-2-5027 Confined Disposal of Dredged Material
  - Dredging Research Program (DRP)
  - Dredging Operations and Environmental Research (DOER)
  - EM 1110-2-1902 Slope Stability

Source: http://www.publications.usace.army.mil/USACEPublications/EngineerManuals.aspx

CDF Design Considerations

- Containment design
  - Static and seismic stability
  - Contaminant mobility
- Size and capacity
  - Short-term bulking and settlement
  - Long-term consolidation
  - Ponding area to meet water quality criteria
- Pumping distance
  - Water content
- Site final use
  - Habitat
  - Shoreline development
  - Recreation

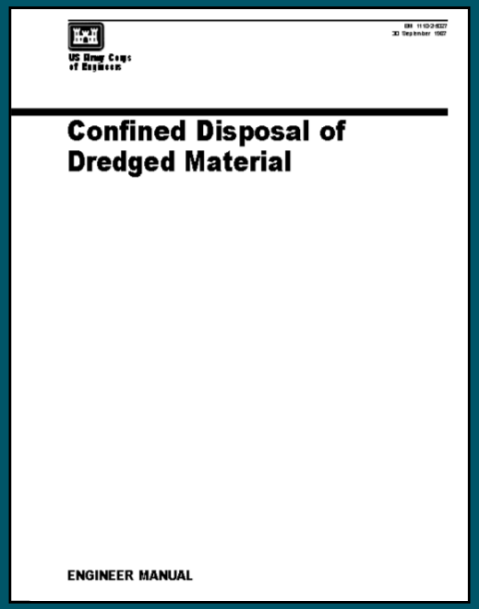
Milwaukee Waterway NCDF and Habitat

Milwaukee Waterway NCDF and Habitat

Confined Aquatic Disposal

Confined Aquatic Sites

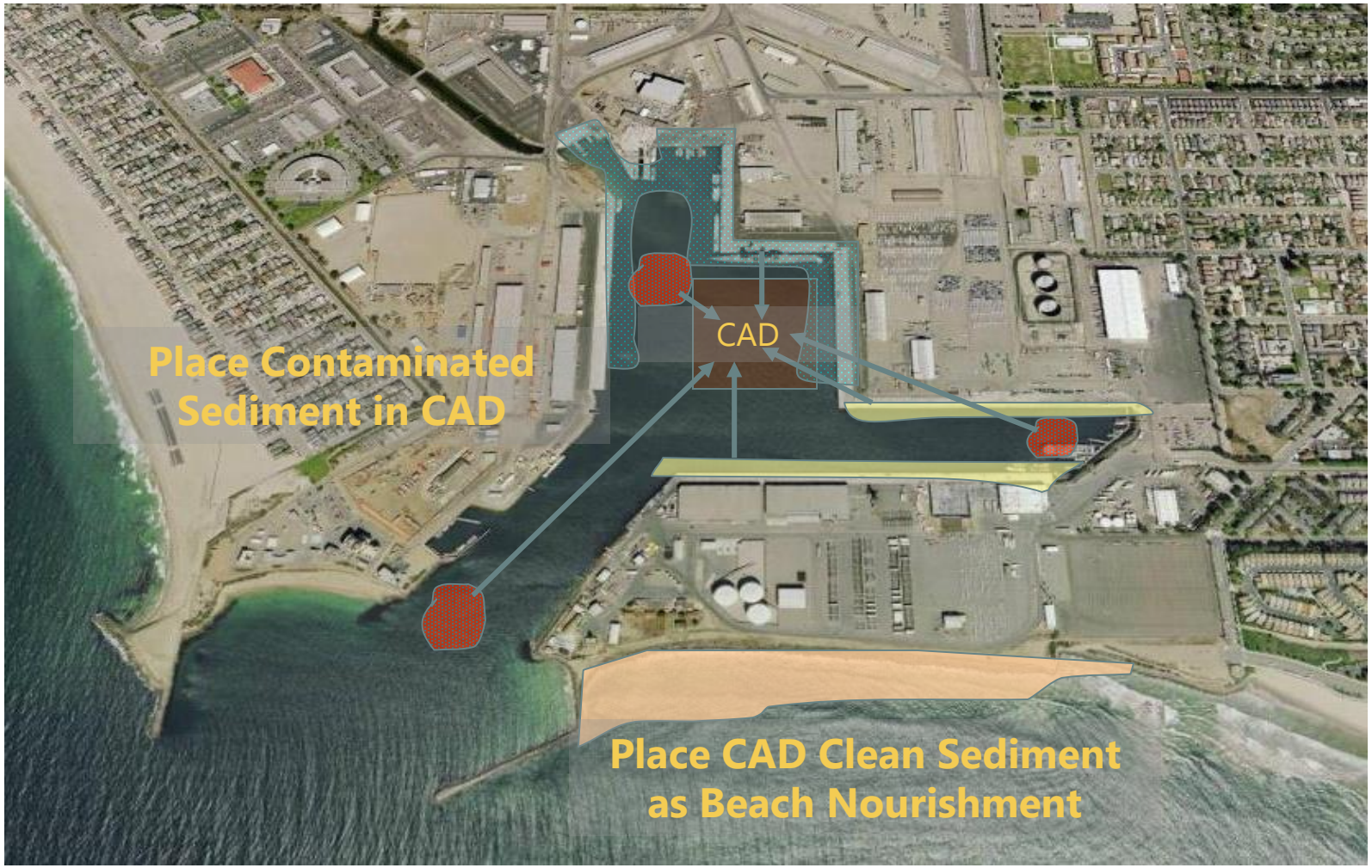
- USACE Publications
  - EM 1110-2-5025 Dredging and Dredged Material Disposal
  - EM 1110-2-5027 Confined Disposal of Dredged Material
  - DRP and DOER Reports
- USEPA
  - Ocean Disposal Manual
  - CAD designs



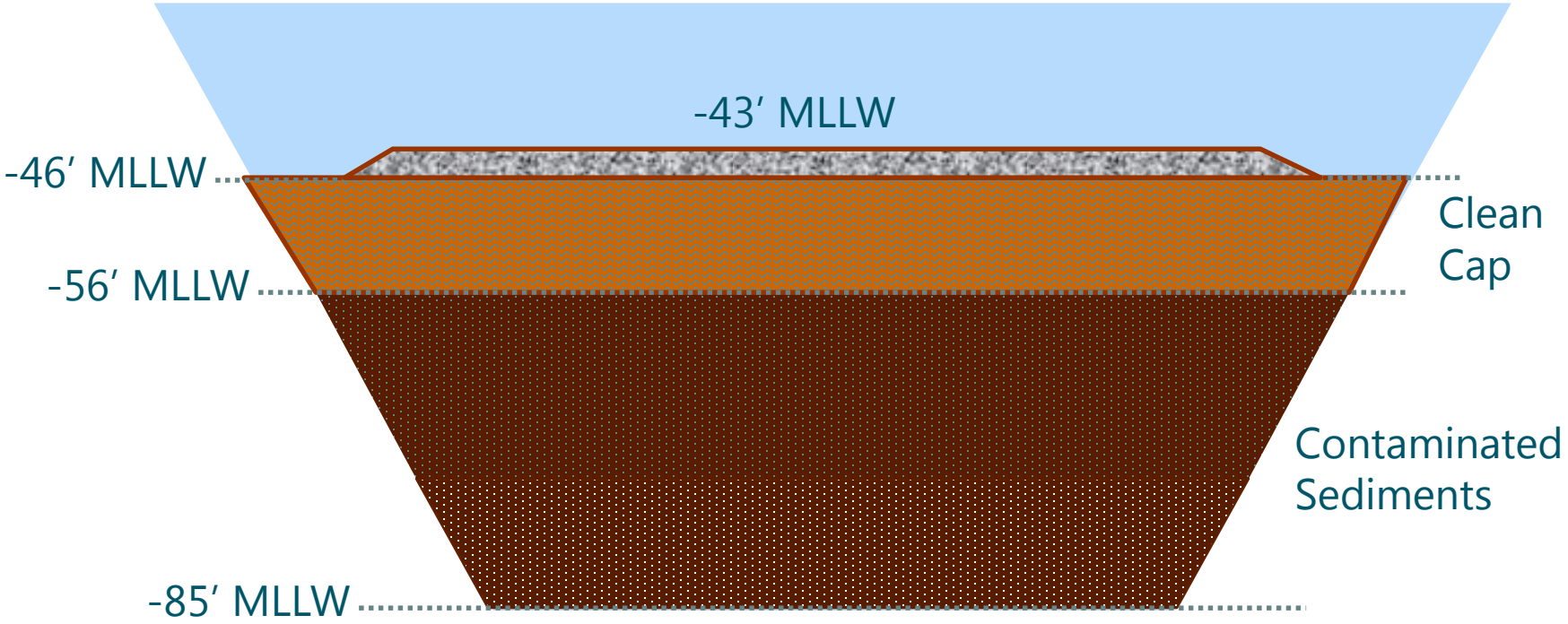
CAD Design Considerations

- Submerged or emergent
- Containment design
  - Static and seismic stability
  - Erosion protection
  - Contaminant mobility
- Size and capacity
  - Short-term bulking and settlement
  - Long-term consolidation
- Sustainability
- Pumping distance
  - Water content
- Site final use
  - Typically habitat function
  - Navigation and anchoring restrictions

Port Hueneme Beneficial Use

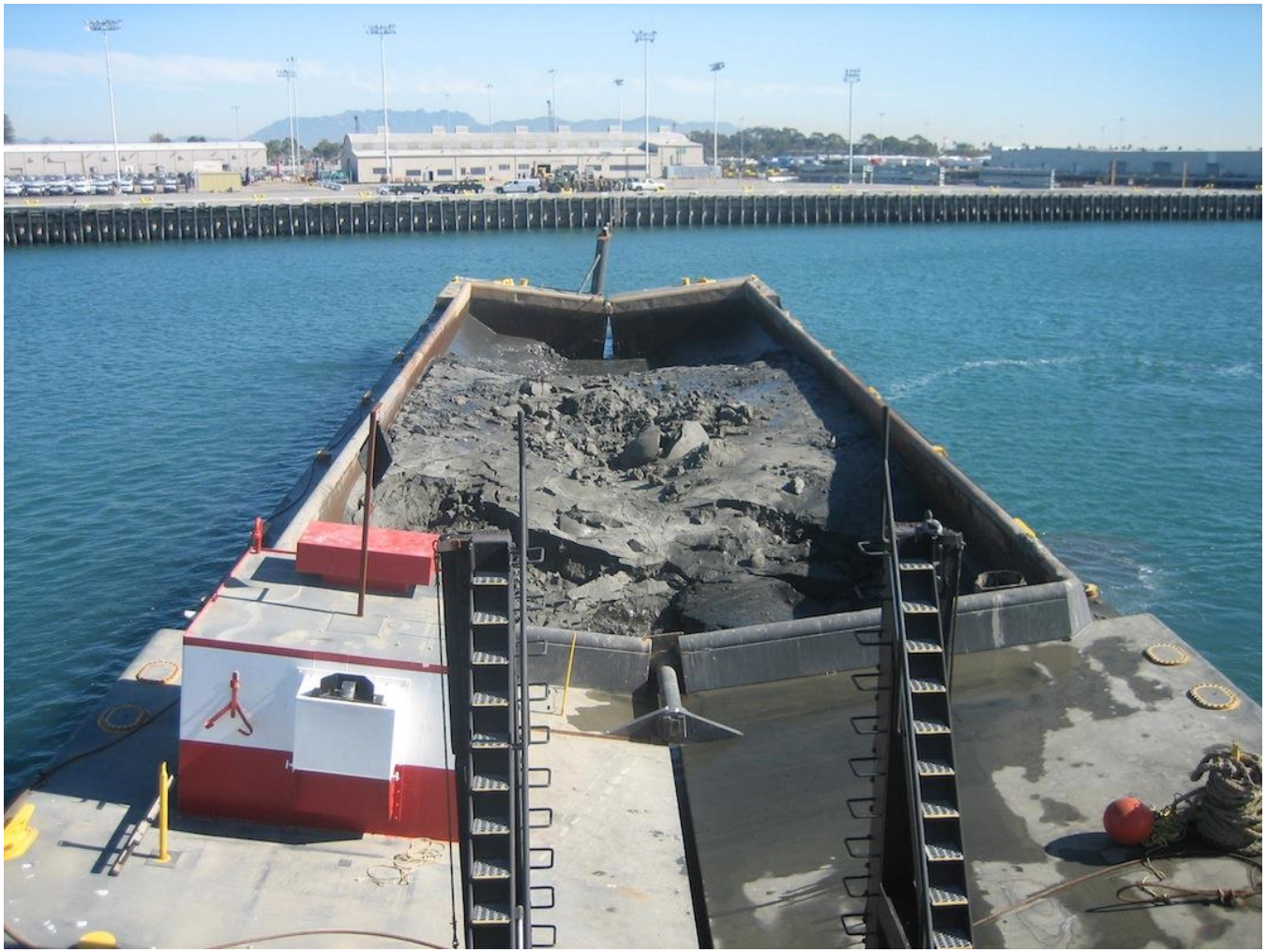


Port Hueneme CAD Cross-section



Note:
MLLW = mean lower low water

Port Hueneme – Barge Placement



Port Hueneme, USACE, U.S. Navy

Port Hueneme – Barge Placement

Port Hueneme, USACE, U.S. Navy

Beach Nourishment and Habitat Restoration

Other Beneficial Uses

- Beach nourishment
- Agriculture and products
  - Topsoil
  - Aquaculture
- Berms
  - Stable and feeder
- Habitat restoration
- Land improvement
- Marsh and intertidal habitat

Deer Island Marsh Creation

- Design elements
  - 7- to 8-foot-high dike
  - Easterly wing dike
  - Flash board riser weirs
  - Offset to provide bayou
- Dredged material from Biloxi Lateral Channel
- Approximately 40 acres were filled with 365,000 cy of sediment

Enhancing Existing Marsh

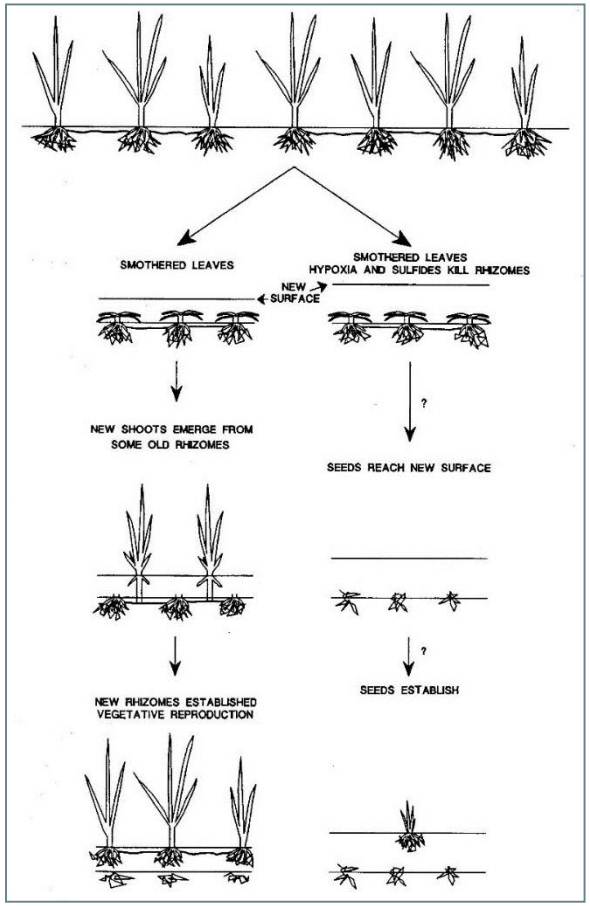


Illustration of conceptual model for marsh recovery after thin-layer disposal

Questions?