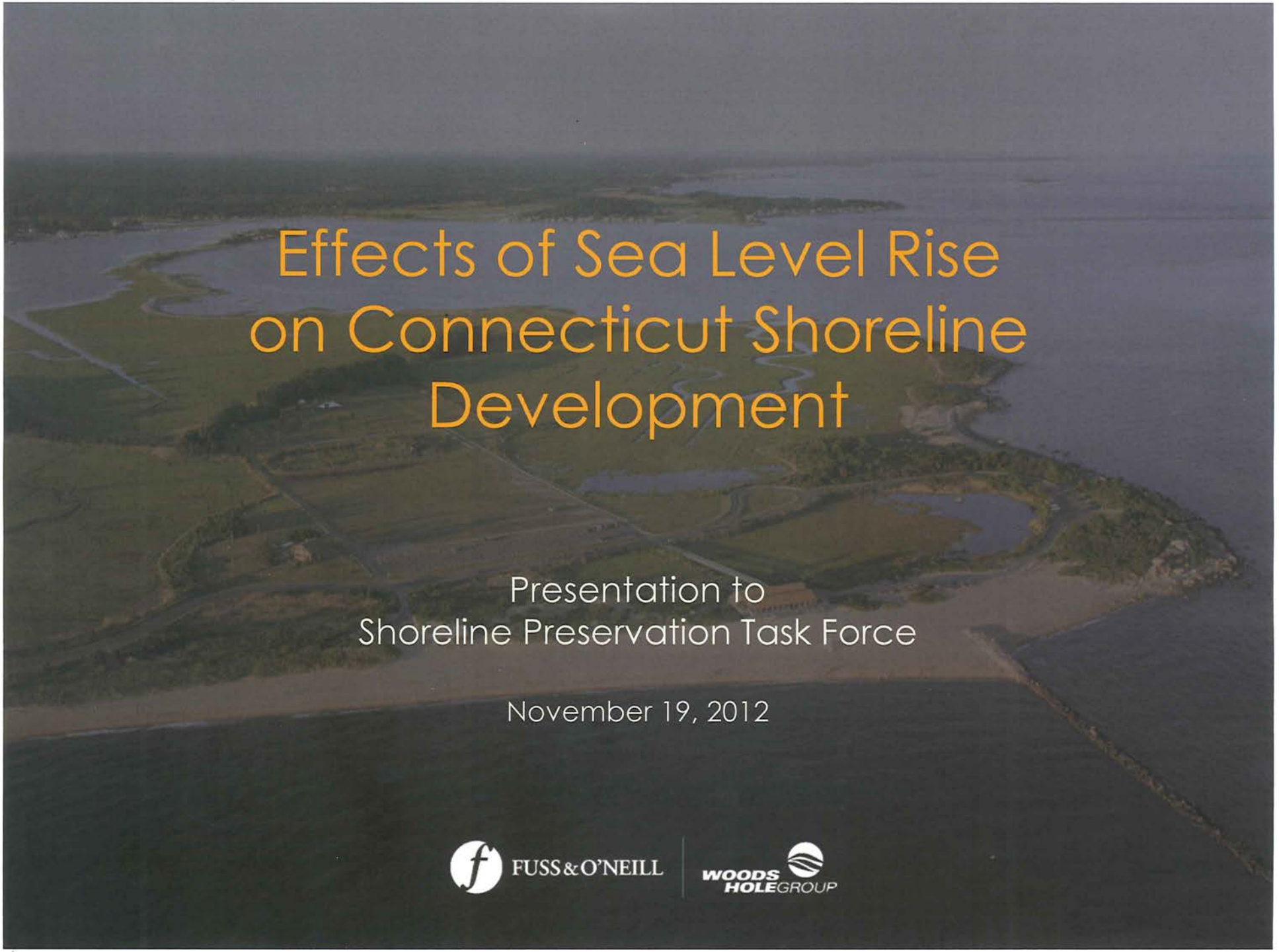

Effects of Sea Level Rise on Connecticut Shoreline Development

Presentation to
Shoreline Preservation Task Force

November 19, 2012

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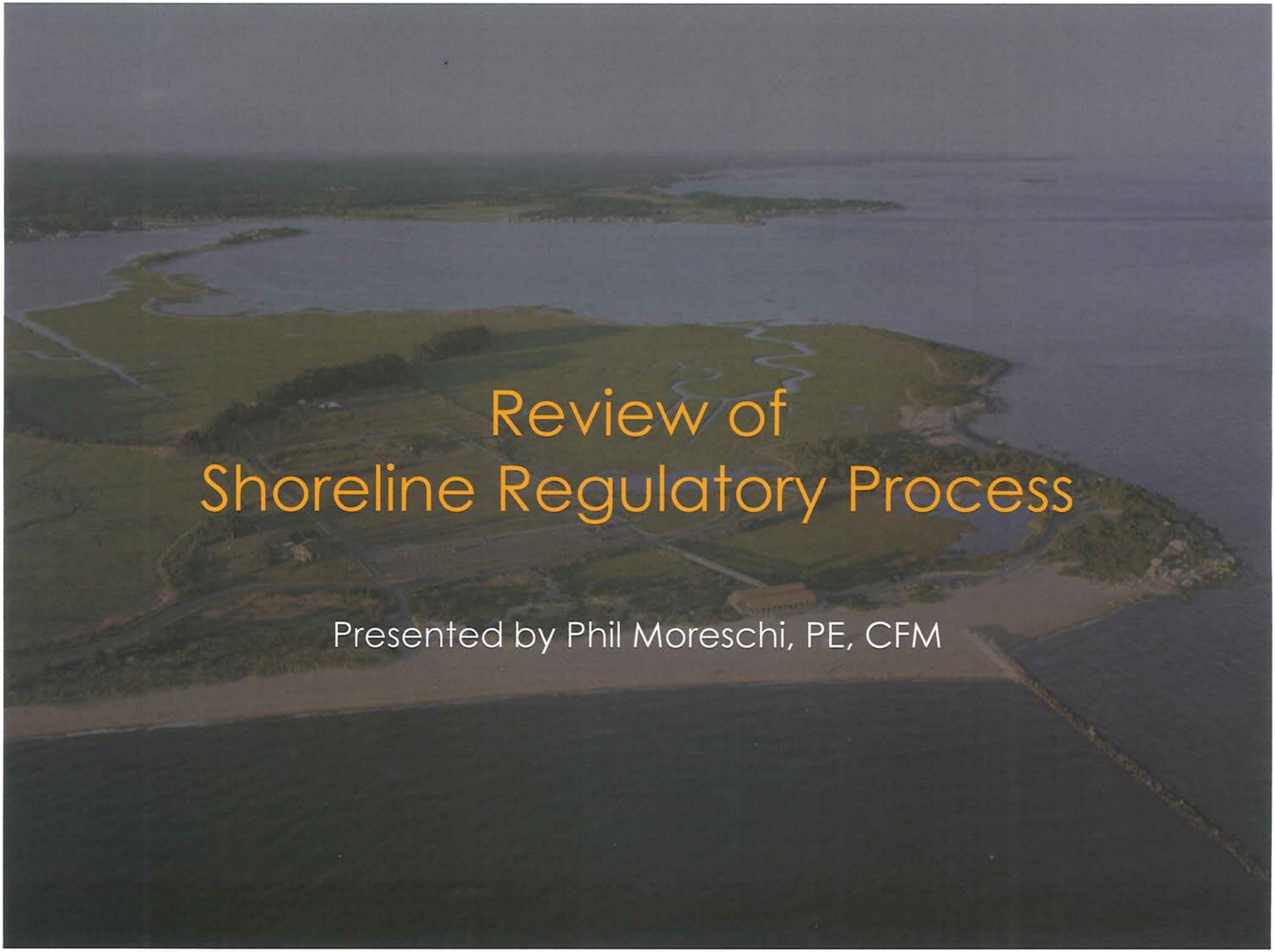
Discussion Topics

- Review of Shoreline Regulatory Process
- Discussion of Sea Level Rise
- Development in Connecticut's Coastal Areas



Review of Shoreline Regulatory Process

Presented by Phil Moreschi, PE, CFM

Review of Shoreline Regulatory Process

Legislation Governing Land Use on the Shoreline

- Municipal Regulations
- State Regulations
- Federal Regulations

Local (Municipal) Permitting

- Coastal Area Management Program
- Inland Wetlands & Watercourses Act
- FEMA Flood Insurance Program

DEEP & OPM

- Office of Long Island Sound Programs
  - Coastal Area Management Act
  - Structures & Dredging Act
  - Tidal Wetlands Act
- Inland Waters Division
  - Wetlands & Watercourses Program
  - Flood Management Certification
  - 401 Water Quality Certification
  - NPDES Stormwater Permits
- State Plan of Conservation & Development

Federal Authority

- Coastal Zone Management Act (1972)
  - NOAA's Office of Ocean and Coastal Resource Management (OCRM)
- U.S. Army Corps of Engineers
  - Section 10 Rivers & Harbors Act
  - Section 404 Placement of Dredge Spoils
- Federal Emergency Management Agency
  - Flood Insurance Program
  - Hazard Mitigation Planning

Coastal Area Management Act

Protects Coastal Resources

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Coastal Area Management Act

- Zoning Ordinances
  - Coastal Resources
    - Beaches & Dunes
    - Intertidal Flats
    - Tidal Wetlands
    - Bluffs & Escarpments
  - Coastal Boundary
  - Coastal Site Plan
  - Coastal Consistency Review!
  - Mandatory Referral to DEEP
    - Shoreline Flood & Erosion Control Structures
    - Proposed Zoning Change/Plan of Conservation & Development

Coastal Area Management Act

- Coastal Site Plan Review Process – Assess:
  - Resource impacts, suitability, benefits & impacts on water dependent uses, mitigation
- Coastal Site Plan Review Process – Must Consider:
  - Private property rights, sea level rise, structural measures,
  - Minimization of shoreline armoring, protection of life & property, reduce future public expense
  - Feasible, less environmentally damaging alternatives

National Flood Insurance Act 1968

National Flood Insurance Program Established

National Flood Insurance Program

- Major Components
  - Mapping
  - Regulations
  - Insurance
- Insurance Subsidy For Existing Flood Prone Development
- 2004 National Flood Insurance Reform Act
  - Mitigation assistance for repetitive losses
  - Digital flood hazard data
  - Education of Insurance Agents

Flood Mapping

- Maps depict flood risk – 1% Annual Chance Flood
- Maps support flood insurance premium ratings
- Maps indicate those areas for mandatory insurance

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Requirements of Local Government

- Flood Plain Administrator – Enforces NFIP Regs
- Adopt Local Regs – Meet or Exceed NFIP Regs
- Non-Participating Community
  - No NFIP Flood Insurance Available
  - No Grants or Federal Loans for work in SFHA
  - Limited Disaster Assistance
- Permit Required for All Development in SFHA

Flood Insurance Program Shortcomings

- Mapping Elevation Errors
- Hydrologic Changes in Watershed – Flow Data
- Not Accounting for Sea Level Rise

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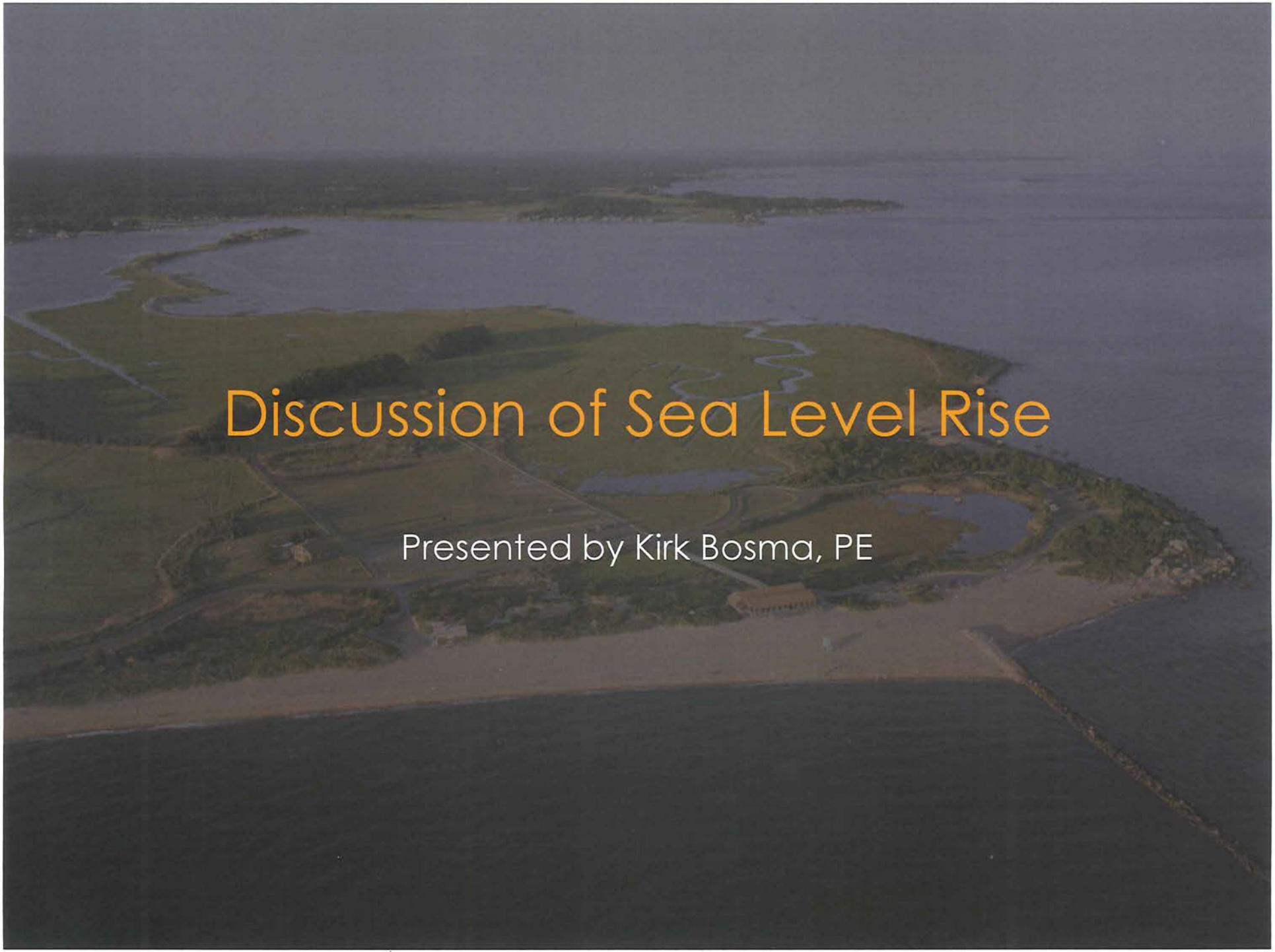
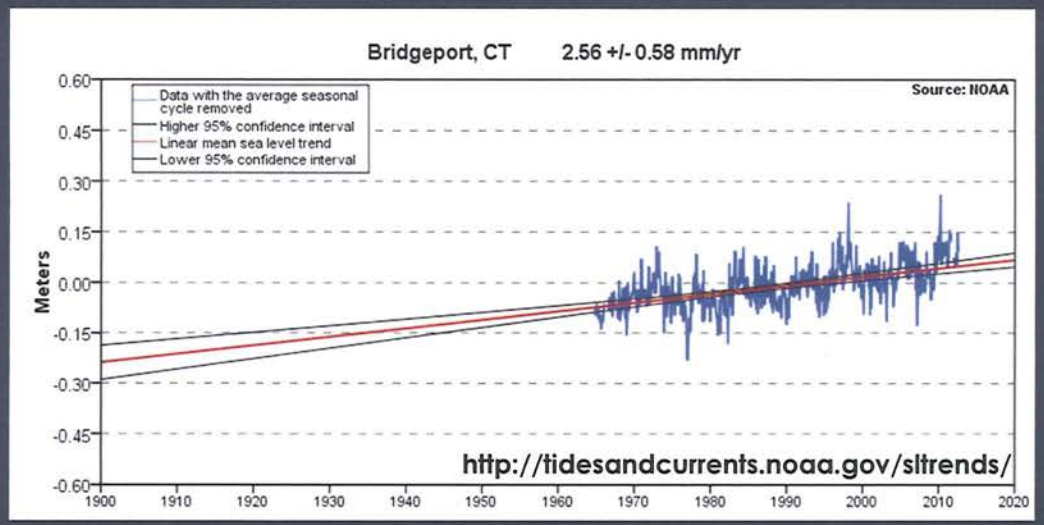


Discussion of Sea Level Rise

Presented by Kirk Bosma, PE

Background on Sea Level Rise

- Sea Level Rise (SLR)
  - Thermal expansion of ocean water
  - Increased input of water from land-based sources
- Northeast SLR is higher than global average
  - 1.75 mm/yr (Maine) to 6.05 mm/yr (Virginia)
  - Global average = 1.7 mm/yr



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Background on Sea Level Rise

- Eustatic versus Relative SLR
  - Eustatic => Increase in Ocean Volume (SLR)
  - Relative => SLR and local land movement (measured by local tide gauges)

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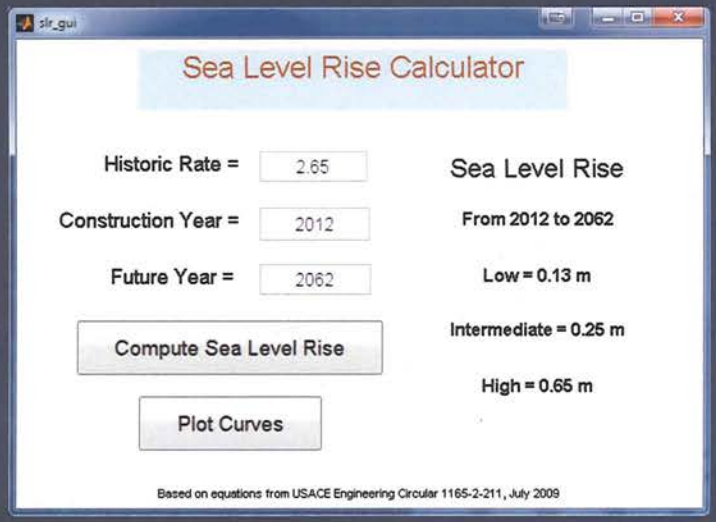
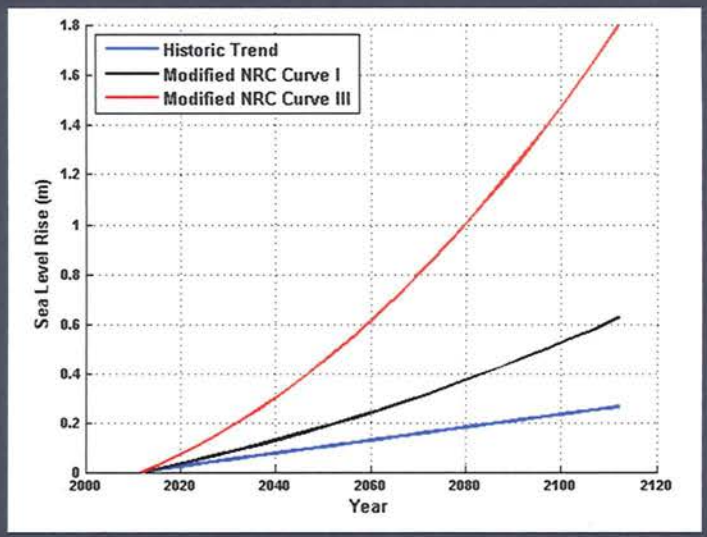
Projections of SLR

- Wide range of projections
  - Intergovernmental Panel on Climate Change (IPCC)
  - National Research Council
  - Vermeer and Rahmstorf (2009)
- Greater in northeast due to changes in ocean circulation (Yin et al., 2009)
- Difficulty in translating global estimates to local level
- Exact magnitude of SLR is difficult to predict…however trend of rising water will continue

Projections of SLR

- USACE guidance for incorporating SLR in civil works projects
  - Provides a range of estimates or scenarios (low, intermediate, high)
  - Derives locally specific estimates for sea level rise which span a broader range of scenarios than the IPCC estimates alone
  - Reviewed and revised on a regular basis





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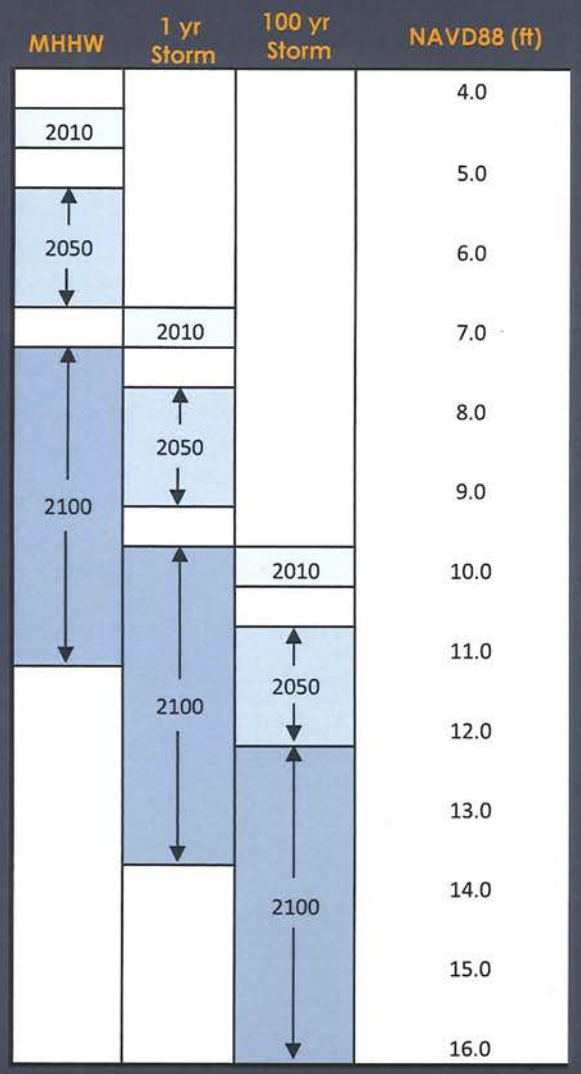
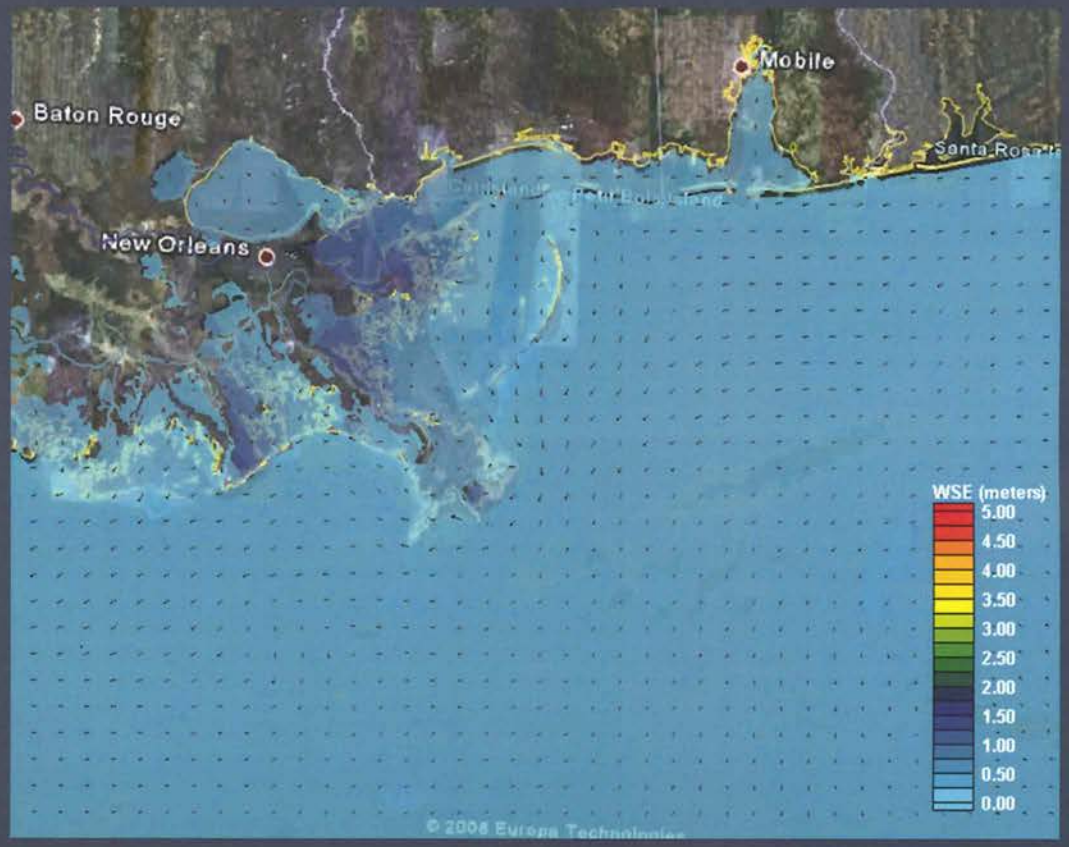
Importance of Storms





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Sea Level Rise Planning Process

- Example:
  - Step 1: Predict relative sea level rise at site over 50 years
  - Step 2: Gather relevant information on project area
  - Step 3: Conduct relative sea level rise impact analysis
  - Step 4: Incorporate sea level rise analysis into project design
  - Step 5: Develop and implement plans for project maintenance and monitoring
- Adaptation plan

Thames Estuary 2100 plan

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Groton and Groton Long Point, CT

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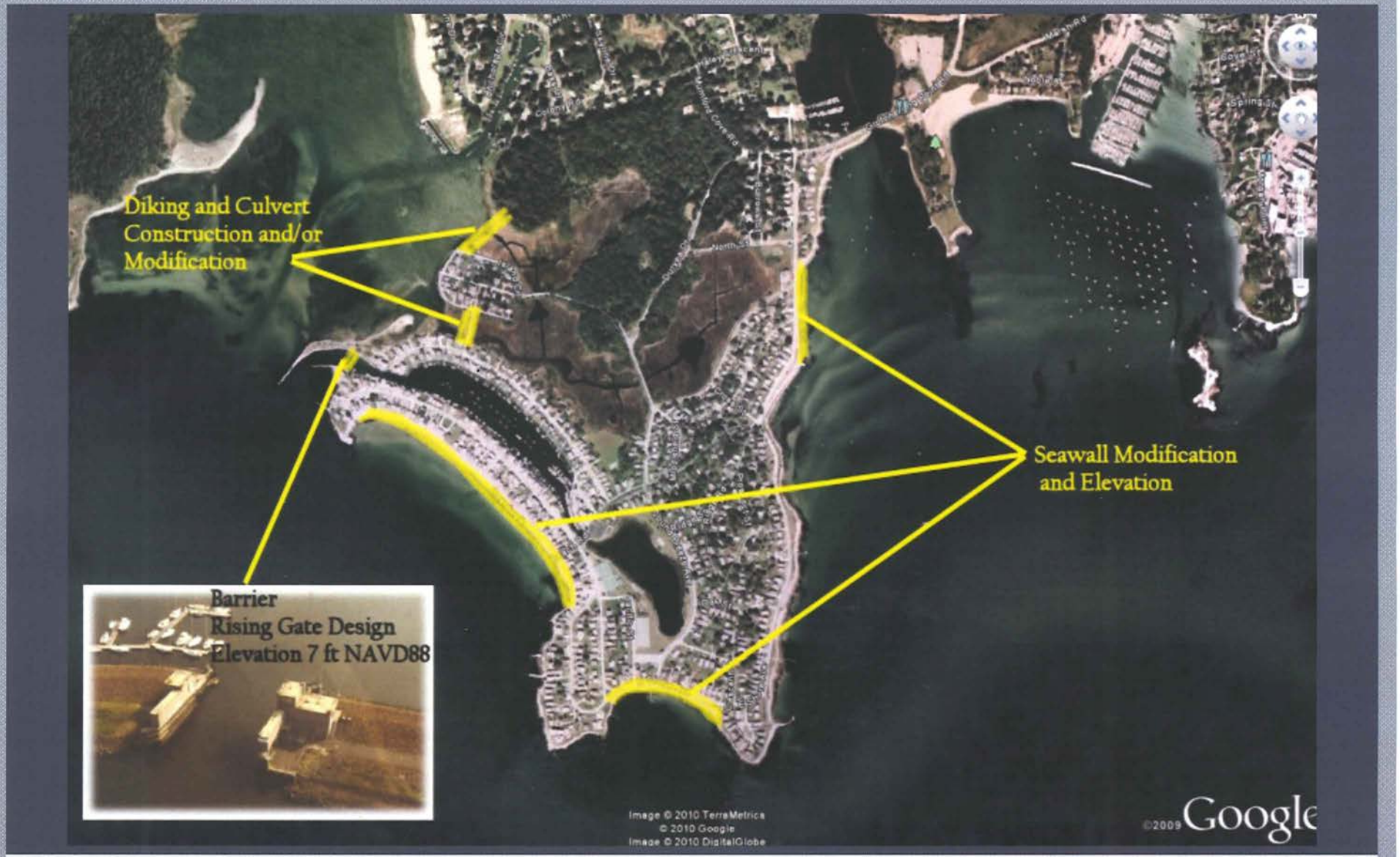
Groton and Groton Long Point, CT



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East Boston, MA

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Examples

Mean Higher High Water (MHHW) Timeline	Annual (1-year) Storm Surge Timeline	100-year Storm Surge Timeline	Approximate Maximum Water Surface Elevation (ft, NAVD88)	Upland Flooding Potential	Recommended Engineering Adaptations	Estimated Adaptation Cost*	Upland Flooding Potential	Recommended Engineering Adaptations	Estimated Adaptation Cost*
2010 / 2050			4.0 – 6.0	No Flooding Expected	No Action Required	N/A	Poor Drainage of Bayside Expo Parking areas during heavy rainfall events. No Flooding of areas from Dorchester Bay waters.	Minor flood proofing of structures Installation of a pump house and pumped based-drainage system for parking area*	Capital Cost: $ 2.0 Million Annual Maintenance Costs: $ 10,000
2010 / 2050 / 2100	2010 / 2050		7.0 – 9.0	Flooding of Morrissey Blvd. approximately 1/4 mile south of campus entrance. No flooding of campus entrance or campus facilities					
2100	2100	2010 / 2050	10.0 – 12.0	Flooding of campus entrance. Initially from Patten's Cove (tidal pond to the west of entrance), and subsequently from Savin Hill Cove.	Tidal control structure installation at entrance to Patten's Cove. Soft solution (beach nourishment and vegetation enhancement) along Savin Hill Cove.	Capital Cost: $500-750,000 Annual Maintenance Costs: $10,000	Flooding of Bayside Expo areas from Dorchester Bay. Water overtops harbor walk in places.	Modular seawall installation at critical locations along Harbor walk Seawall extension along Harbor walk as needed	Capital Cost*: $1.0-1.5 million (1,000 foot length) Annual Maintenance Costs: $15,000
		2100	13.0 – 16.0	Widespread flooding of UMASS Boston Campus, Morrissey Blvd. and surrounding areas	In addition to adaptations above, additional flood proofing and elevation of critical infrastructure. Evacuate during storm event and return.	Capital Cost: $20 per square foot of building for wet flood proofing	Widespread flooding of UMASS Boston Campus, Morrissey Blvd. and surrounding areas	In addition to adaptations above, additional flood proofing and elevation of critical infrastructure. Evacuate during storm event and return.	Capital Cost: $20 per square foot of building for wet flood proofing

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Hard Engineering Alternatives

- Hard Engineering Alternatives for SLR

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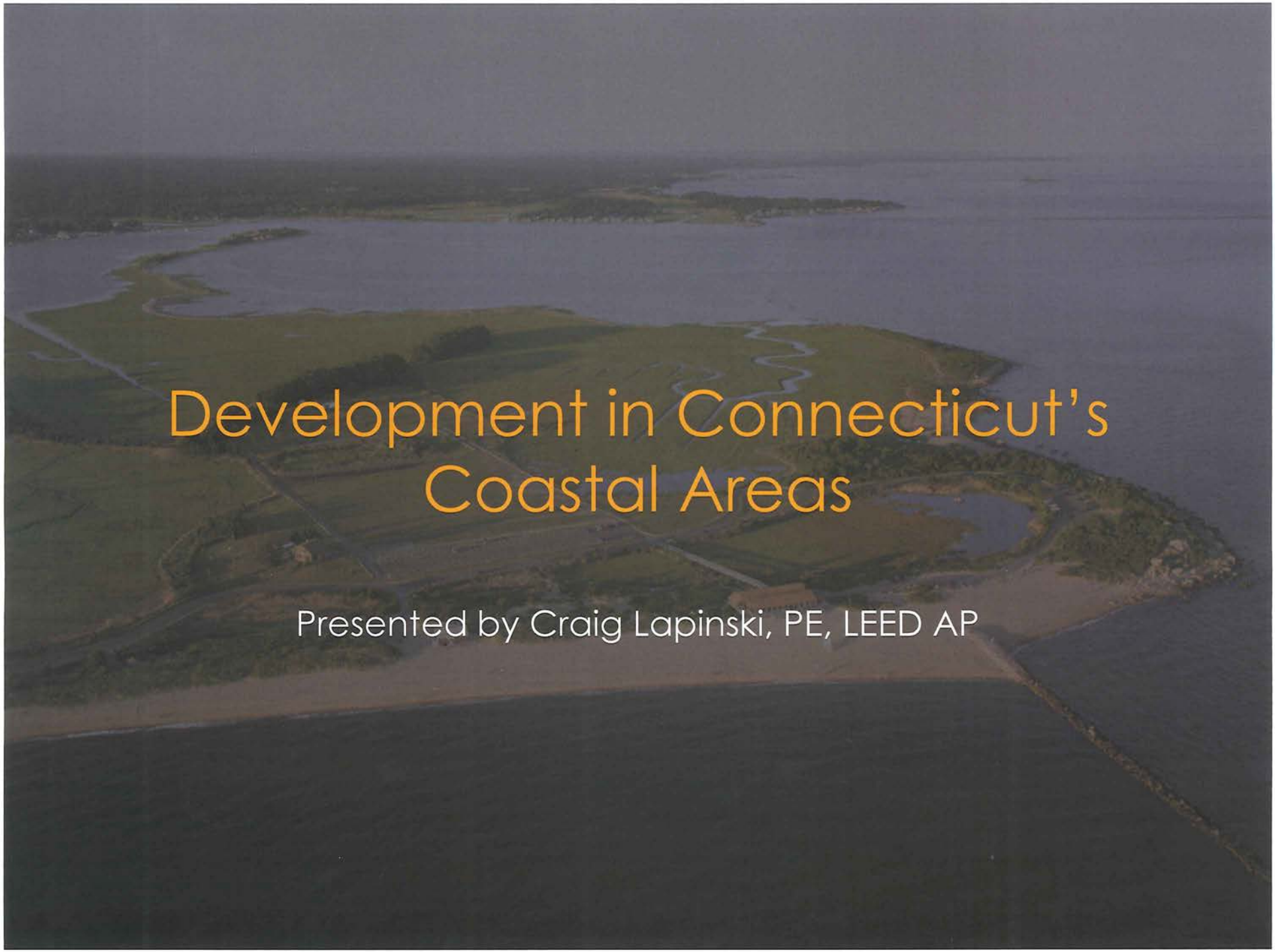
Soft Engineering Alternatives

- Soft Engineering Alternatives for SLR

Structural Alternatives

- Structural Alternatives for SLR



Development in Connecticut's Coastal Areas

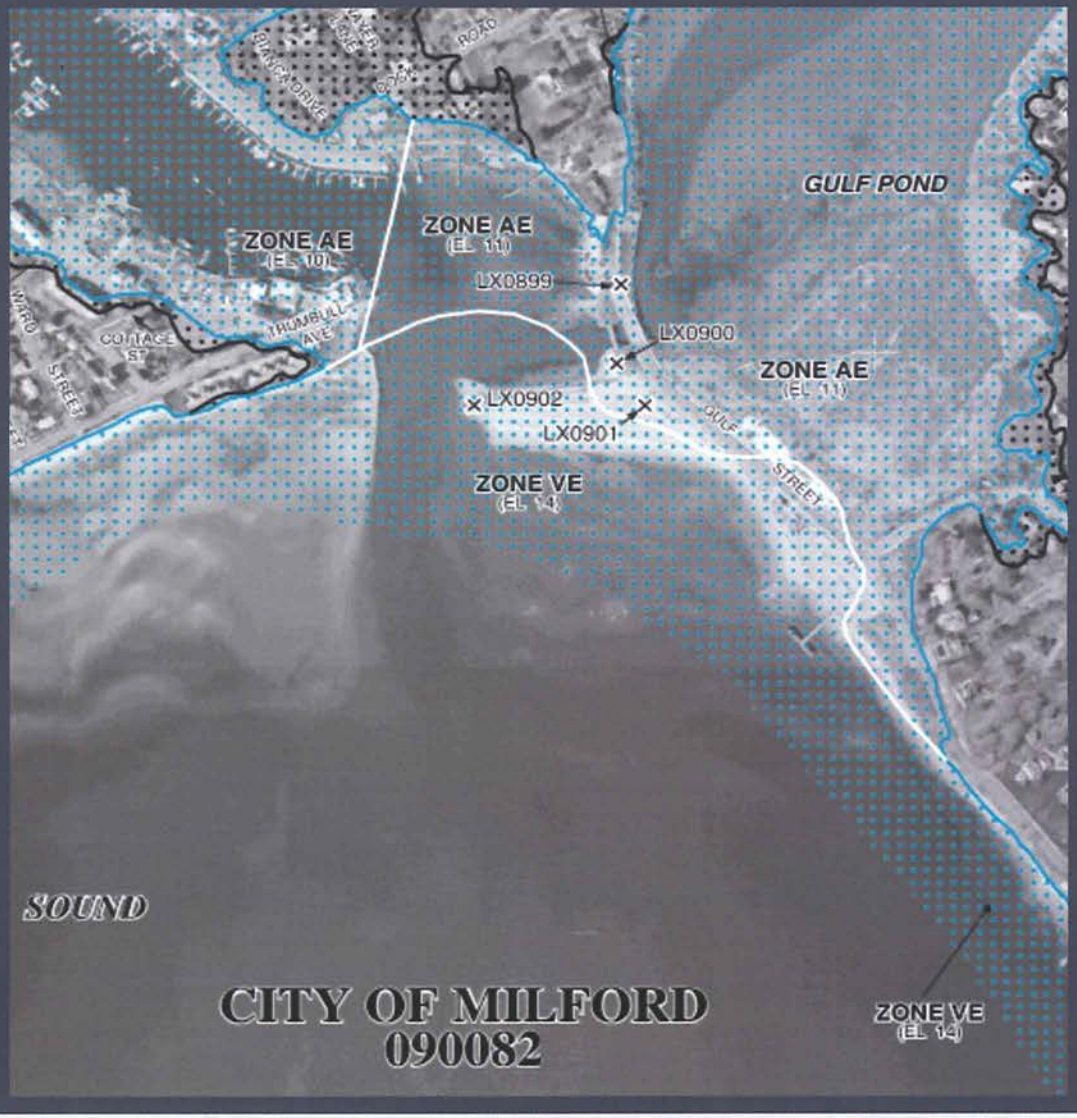
Presented by Craig Lapinski, PE, LEED AP

FEMA Coastal Flood Zones

- V Zones (Coastal High Hazard Area)
  - Area that floods during a100-year storm with waves ≥ 3 feet
- A Zones
  - Area that floods during a100-yr storm
- X Zones
  - Area that floods during a100- to 500-year storm

Base Flood Elevation (BFE)

- Includes:
  - Stillwater flood depth
  - Normal tide cycle
  - Wave effects



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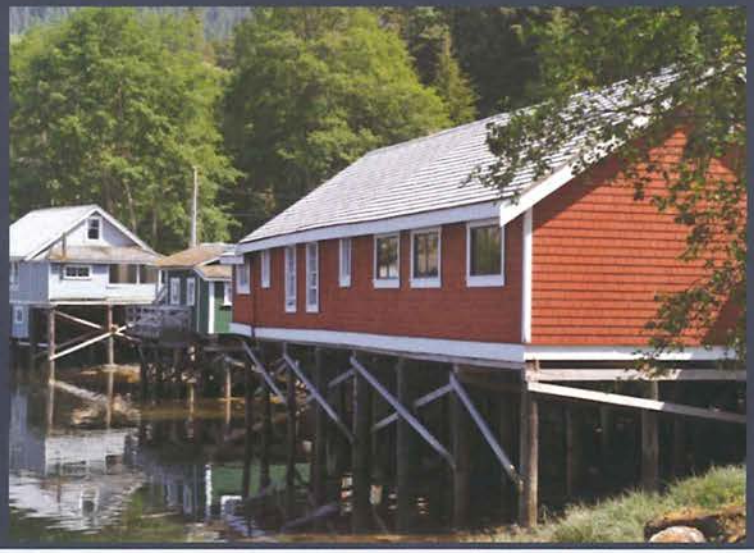
Design in V Zones

- The lowest horizontal structural member supporting the bottom floor must be above the BFE
- Electrical equipment must be elevated above the BFE
- Area below the BFE
  - Only Parking, building access and storage is allowed
  - The space below the BFE must be free of obstructions
  - Walls must be break-away design
- Foundation Design
  - Code requirements more stringent than an A Zone



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Design in A Zones

- The lowest habitable floor must be above the BFE
- Electrical equipment must be elevated above the BFE
- Area below the BFE
  - Only Parking, building access and storage is allowed
  - Other non-residential structures require floodproofing
- Foundation design
  - Must resist flood-related forces
  - Have openings to equalize hydrostatic pressures

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Design in X Zones

- Definition (Title 25, Chapter 476a, Sec. 25-68b):
  - (4) "Critical activity" means any activity, including but not limited to, the treatment storage and disposal of hazardous waste and siting of hospitals, housing for the elderly, schools or residences, in the 0.2 per cent floodplain in which the commissioner determines that a slight chance of flooding is too great
- Critical Activities in X Zones must be designed for a 500-year flood event
- Connecticut's definition of "Critical Activity" different than Federal "Critical Use" definition

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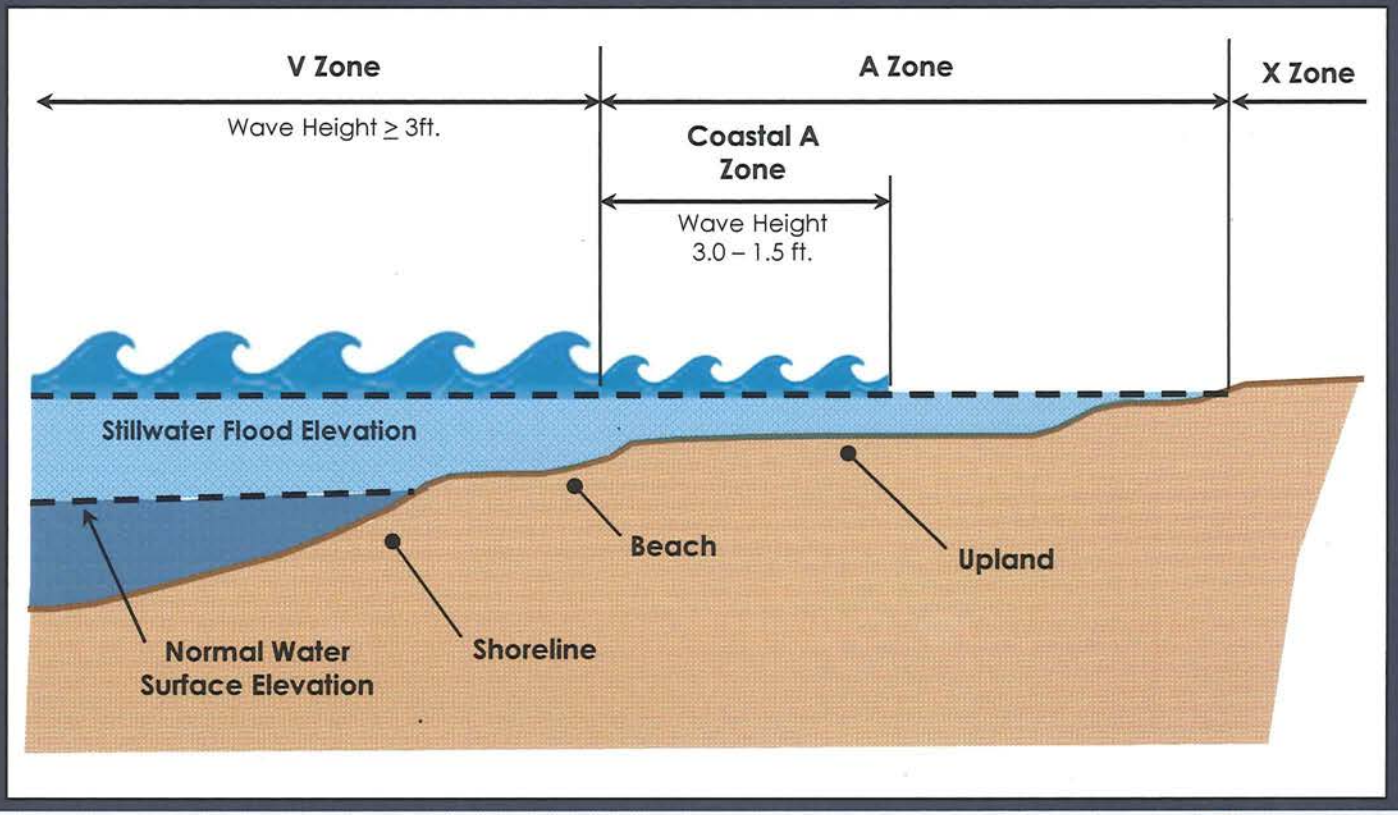
Coastal A Zones

- Not mapped by FEMA
- Wave heights ≥1.5 and <3 feet during base flood
- Local regulations may require special consideration



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Other Design Considerations

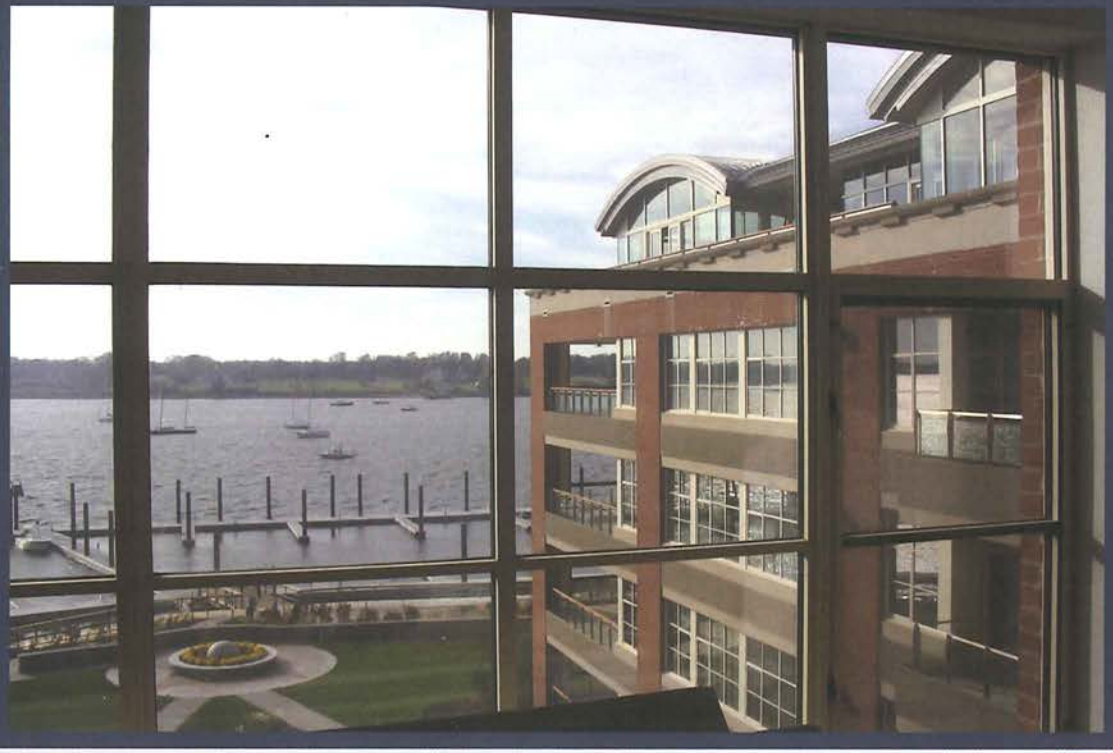
- Accounting for wave run-up and erosion
  - Specify surfaces that can withstand wave forces
- Developing in a dynamic environment
  - Shorelines are constantly changing!

Public Act 12-101 Implications

- Incorporates sea level rise into the Coastal Management Act's general goals and policies of coastal planning (as of October 1, 2012)
- Defines "Rise in Sea Level" as:
  - "the arithmetic mean of the most recent equivalent per decade rise in the surface level of the tidal and coastal waters of the state, as documented for an annual, decadal or centenary period, at any sites specified in the state in National Oceanic and Atmospheric online or printed publications."
- Does not bar municipalities from considering more conservative rise in sea level scenarios
  - Open to interpretation
  - Uncertainty may create additional "risk" for developers

Smart Coastal Development

- Balance is Key!
  - Do: Understand the design life for the project
  - Do: Account for rise in sea level in the design
  - Don't: Overdesign to make a project cost prohibitive



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Open Discussion