NJ Living Shorelines Engineering Guidelines Project

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Literature Review & Gap Analysis

- Designed to summarize what else is out there and what info it contains
- Layout
  - Summarize NJ work
    - White paper, GP, DELSI, Engineering Guidelines
  - What other states are doing
  - Current Initiatives
    - COPRI, NACCS, NNBF, Sage, NYC Research Plan, TNC
  - Gaps
    - Case studies, monitoring, valuation, ice, wakes, specific types of LS

State Reports and Guidelines

- Alabama (AL)
- Delaware (DE)
- Georgia (GA)
- Maryland (MD)
- Massachusetts (MA)
- Michigan (MI)
- New York (NY)
- North Carolina (NC)
- Rhode Island (RI)
- Texas (TX)
- Vermont (VT)
- Virginia (VA)
- Washington (WA)

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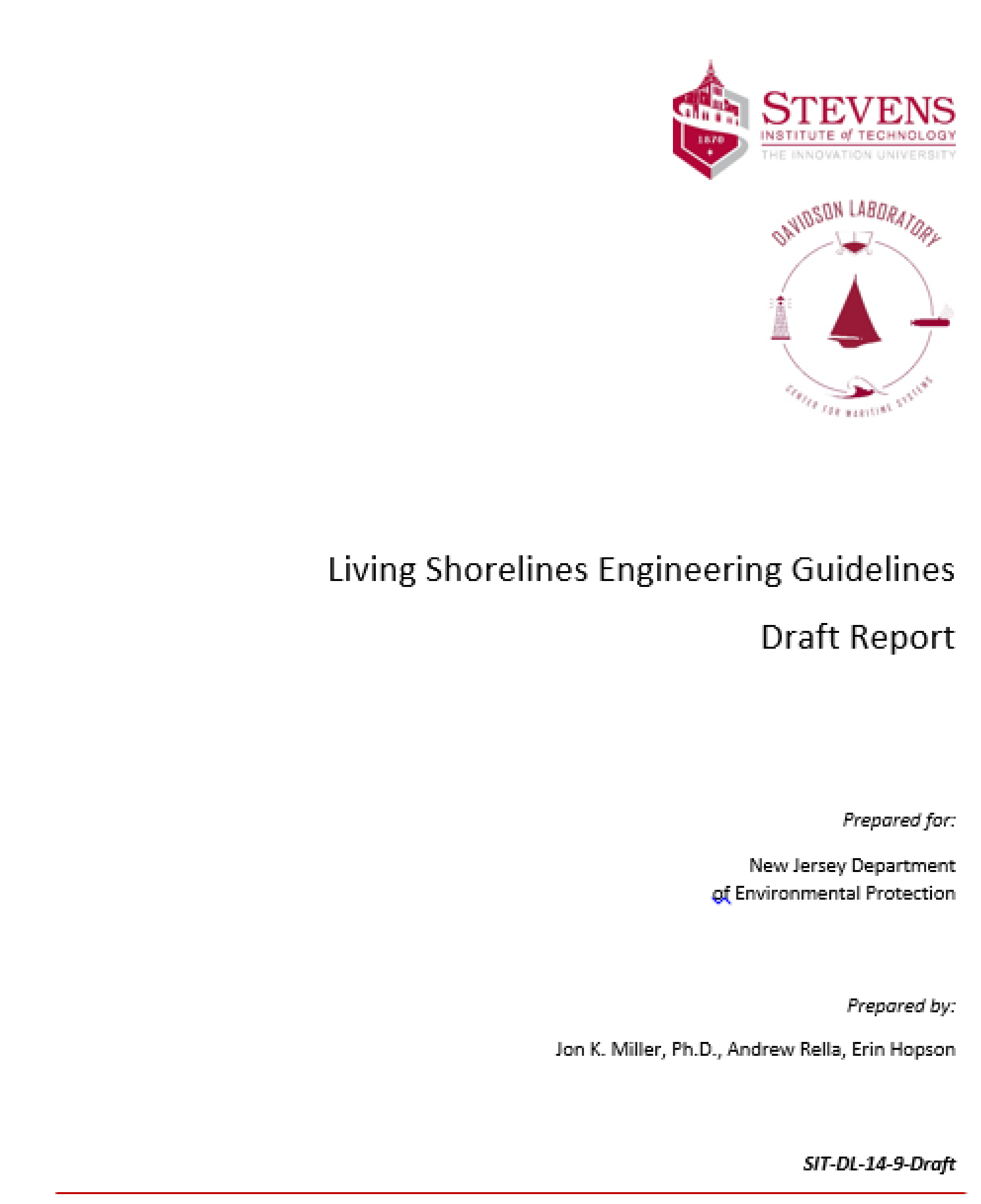
Engineering Guidelines

- Primary Objectives
  - Provide guidance to engineers and regulators on the engineering components of living shorelines design
  - ***Provide a common starting place to ensure consistency with GP 29 (N.J.A.C. 7:7-7.29) – "Living Shorelines GP"***
  - Reduce the number of potential failures due to poor design/construction



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Living Shorelines Engineering Guidelines

Draft Report

Prepared for:

New Jersey Department of Environmental Protection

Prepared by:

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SIT-DL-14-9-Draft

Usage

- Engineer knows they're expected to follow guidelines
- NJDEP knows what engineer is expected to consider
- Meant to be "complete", but impossible to include everything
- Not intended to be prescriptive, but rather encourage the innovation that living shorelines projects require
- Designed to be a living document
  - Deficiencies will be brought to light as the guidelines are used
  - Measuring and monitoring will be essential to refining guidance
  - Perhaps combine/integrate with ecological guidelines (?)

Approach

1. Identify factors relevant to living shoreline design
   - Mix of traditional, traditional evaluated non-traditionally, and non-traditional
   - Categorize as system, hydrodynamic, terrestrial, ecological, additional considerations
   - Provide guidance for selecting between alternatives
2. Describe approaches for determining required parameters
   - Consider different levels of rigor for different parameters and projects
3. Provide example of how these parameters influence design
   - Sills*, breakwaters*, joint planted revetment, reef balls*, living reef*

* Marsh creation assumed behind the structures

Parameter List

System Parameters

Erosion History
Sea Level Rise
Tidal Range

Hydrodynamic Parameters

Wind Waves
Wakes
Currents
Ice
Storm Surge

Ecological Parameters

Water Quality
Soil Type
Sunlight Exposure

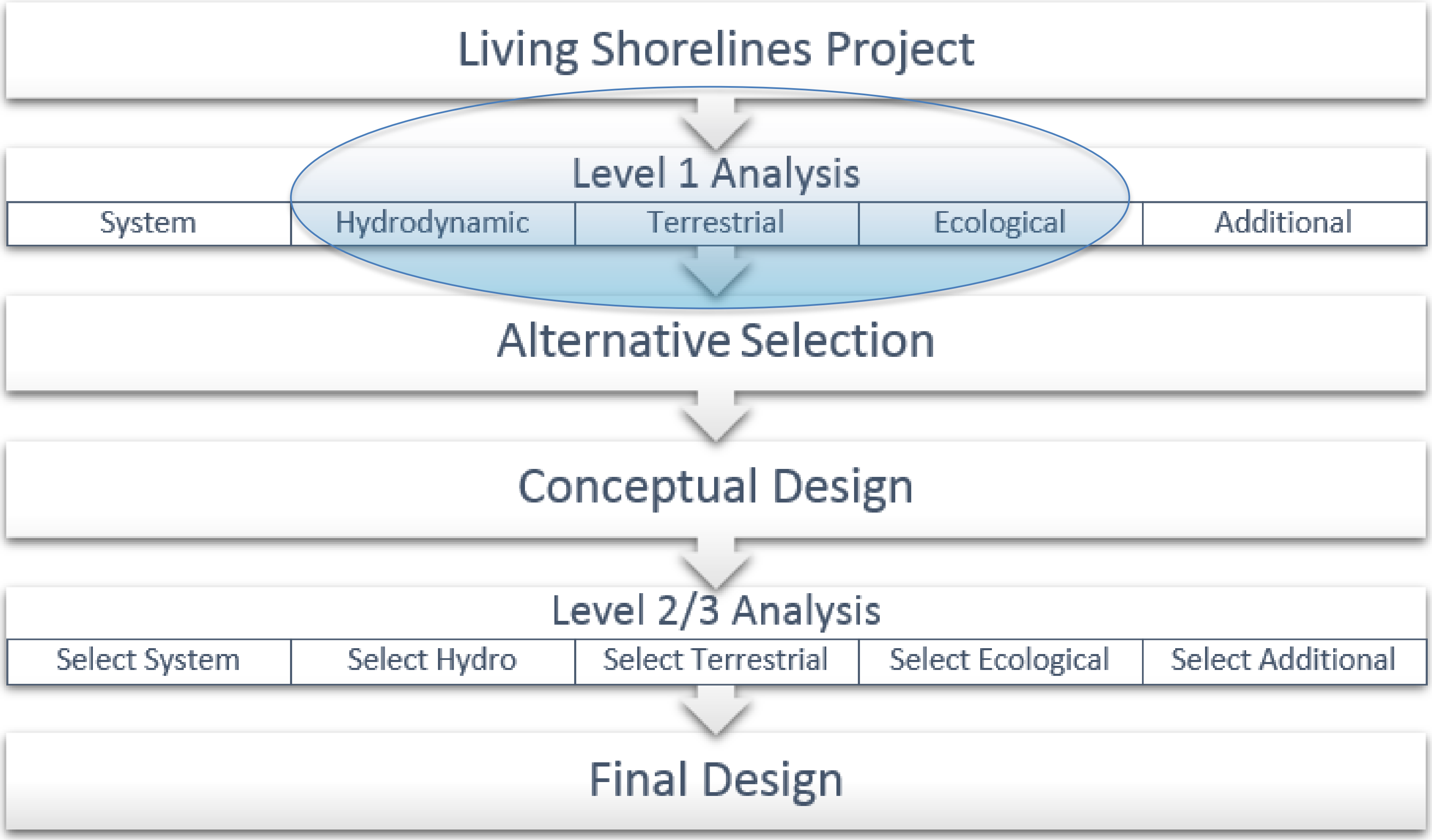
Terrestrial Parameters

Upland Slope
Shoreline Slope
Width
Nearshore Slope
Offshore Depth
Soil Bearing Capacity

Additional Considerations

Permits/Regulatory
End Effects
Constructability
Native/Invasive Species
Debris Impact
Project Monitoring

Suggested Design Approach



Example: Wind Waves

- Along with wakes, typically the dominant cause of erosion
- Both the maximum and the average wave may be of concern
- Basis for most of the critical structural design parameters

Wind Waves

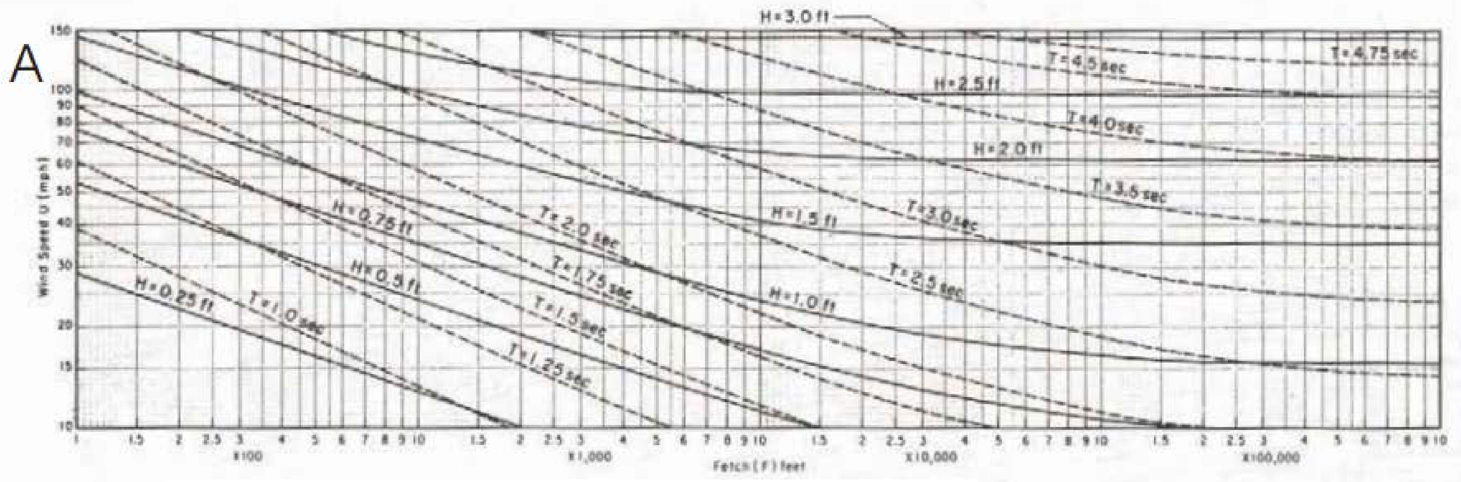
- Level 1 Analysis
  - Fetch Analysis (average and max)
  - Based on work of Hardaway (1984, 1999)

Energy	Fetch (mi)	Weight (lb)	Diameter (ft)	Sill/Marsh BW/Beach	Width (ft)
Very Low	<0.5	300-900	1.4-2.0	Sill/Marsh	-
Low	0.5 - 1.0	300-900	1.4-2.0	Sill/Marsh	-
Medium	1.0 – 5.0	400-1,200	1.5-2.1	Sill/Marsh	40-70
Medium	1.0-5.0	800-2,000	2.0-2.6	BW/Beach	35-45
High	5.0 - 15.0	2,000-5,000	2.6-3.5	BW/Beach	45-65
Very High	>15.0	2,000-5,000	2.6-3.5	BW/Beach	45-65

Wind Waves

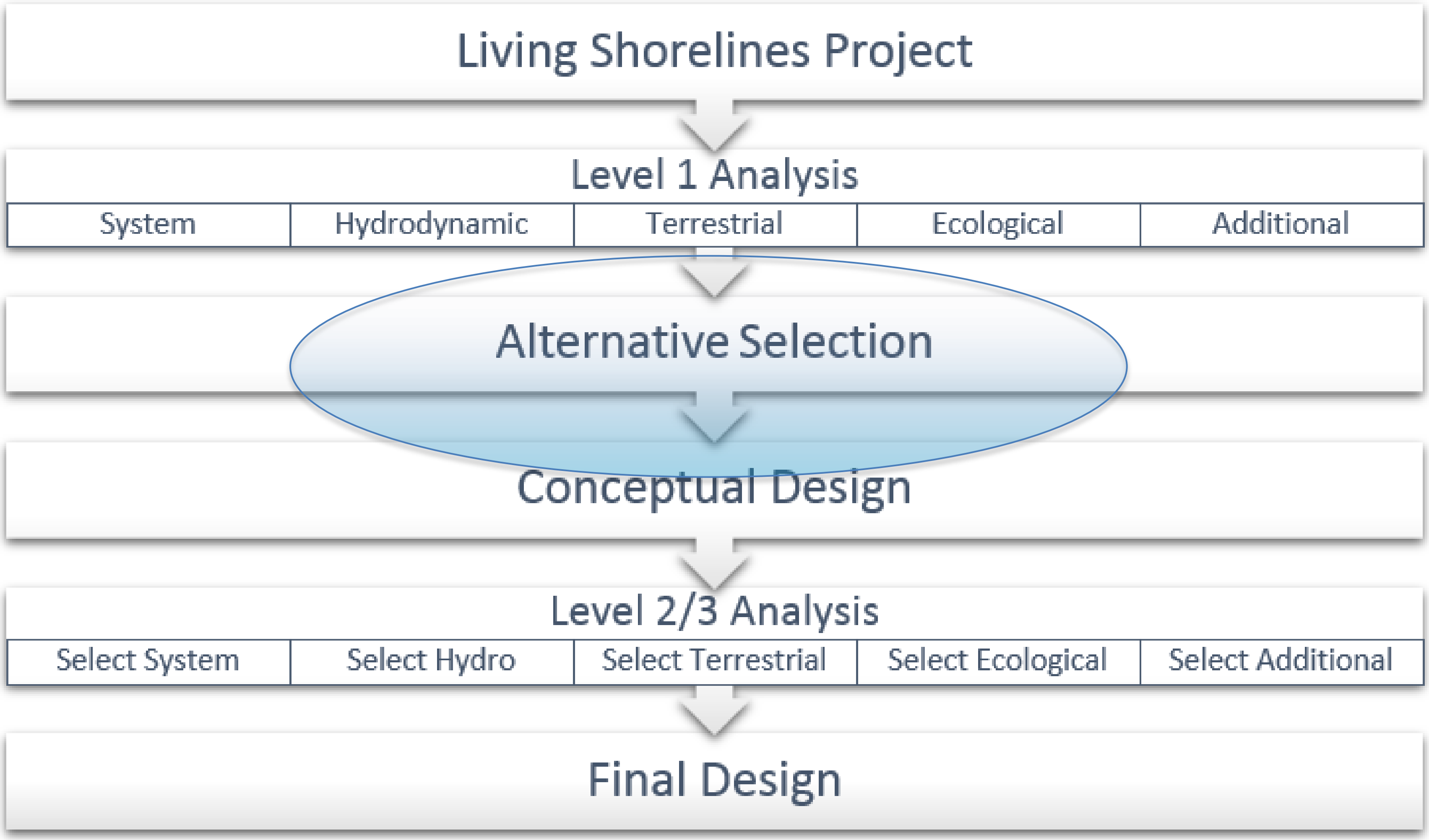
- Alternative Level 1 Analysis
  - SMB Type
    - Multiple flavors
    - Depth limited equations
    - Shallow water curves

$$H_w = 0.283 \tanh\left[0.530\left(\frac{gd}{U^2}\right)^{0.75}\right] \tanh\left\{\frac{0.0125\left(\frac{gF}{U^2}\right)^{0.42}}{\tanh\left[0.530\left(\frac{gd}{U^2}\right)^{0.75}\right]}\right\}\frac{U^2}{g}$$



Constant Depth = 5 feet.

Suggested Design Approach



Selection Criteria

	Marsh Sill	Breakwater	Revetment	Living Reef	Reef Balls
System Parameters					
Erosion History	***Low-Med***	***Med-High***	***Med-High***	***Low-Med***	***Low-Med***
Relative Sea Level	Low-Mod	Low-High	***Low-High***	Low-Mod	Low-Mod
Tidal Range	***Low-Mod***	Low-High	Low-High	***Low-Mod***	Low-Mod
Hydrodynamic Parameters					
Wind Waves	***Low-Mod***	***High***	***Mod-High***	***Low-Mod***	***Low-Mod***
Wakes	***Low-Mod***	***High***	***Mod-High***	***Low-Mod***	***Low-Mod***
Currents	Low-Mod	Mod-High	Mod-High	Low-Mod	Low-Mod
Ice	***Low***	***Low-Mod***	***Low-High***	***Low***	Low-Mod
Storm Surge	Low-High	***Low-High***	***Low-High***	Low-High	Low-High

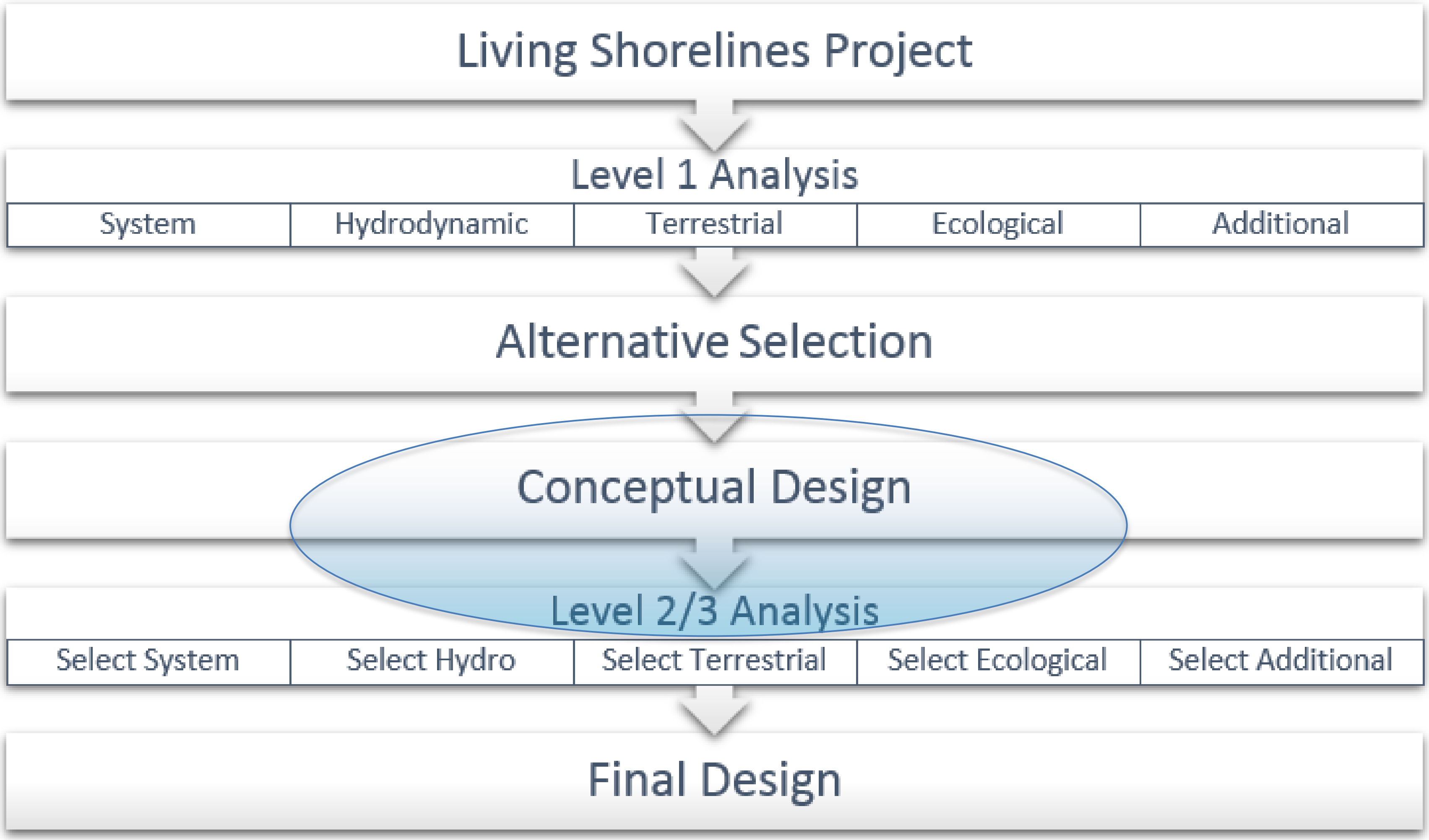
Bold denotes critical parameters requiring level 2/3 analysis

Quantitative Interpretation

- Based on guidance where established criteria
  - Only available for a limited number of parameters
  - Should be revisited on the basis of monitoring data

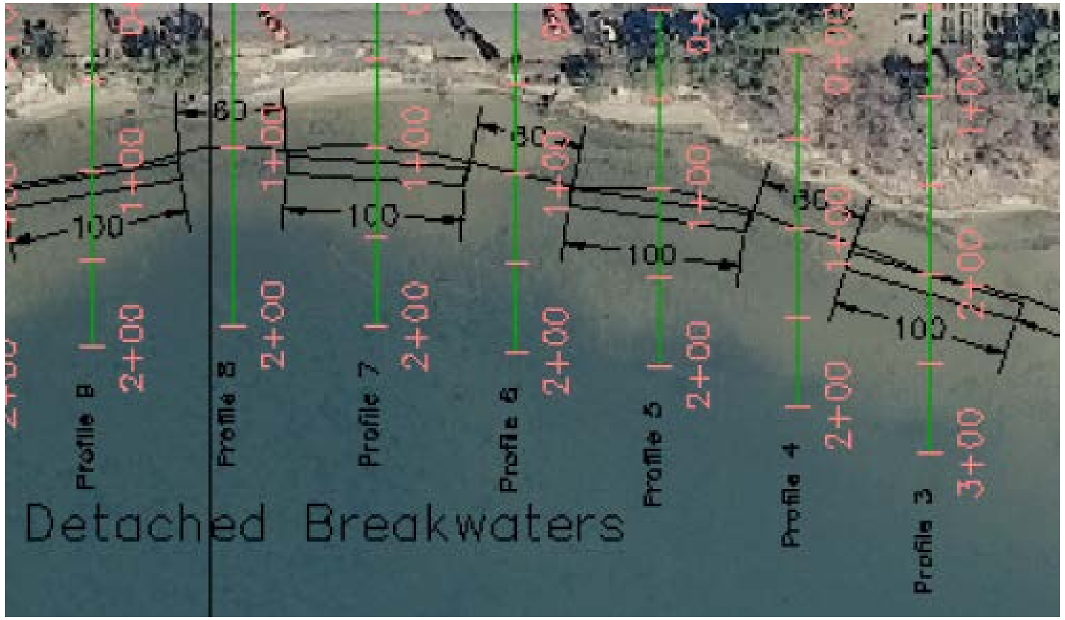
	Criterion		
Parameter	Low/Mild	Moderate	High/Steep
System Parameters			
Erosion History	<2 ft/yr	2 ft/yr to 4 ft/yr	>4 ft/yr
Sea Level Rise	<0.2 in/yr	0.2 in/yr to 0.4 in/yr	>0.4 in/yr
Tidal Range	< 1.5 ft	1.5 ft to 4 ft	> 4 ft
Hydrodynamic Parameters			
Waves	< 1 ft	1 ft to 3 ft	> 3 ft
Wakes	< 1 ft	1 ft to 3 ft	> 3 ft
Currents	< 1.25 kts	1.25 kts to 4.75 kts	>4.75 kts
Ice	< 2 in	2 in to 6 in	> 6 in
Storm Surge	<1 ft	1 ft to 3 ft	>3 ft

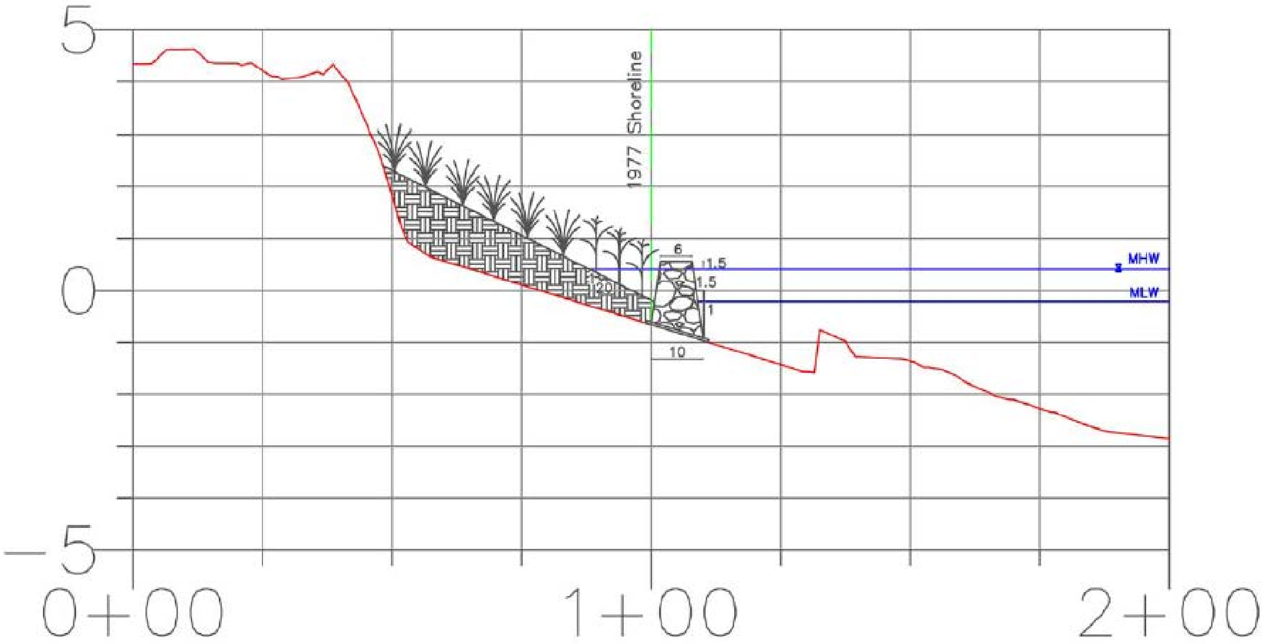
Suggested Design Approach



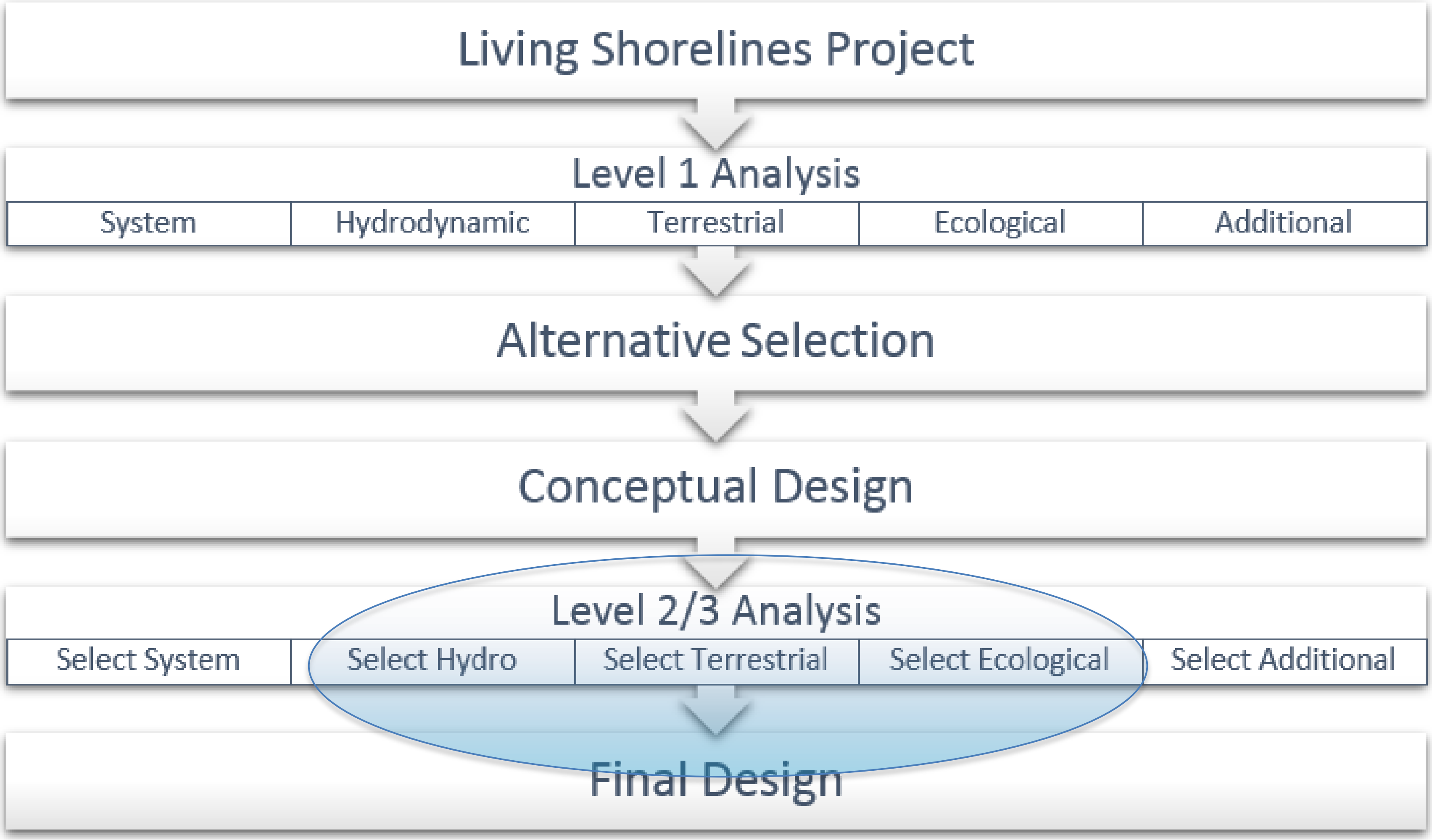
Conceptual Design

- Plan and profile





Suggested Design Approach

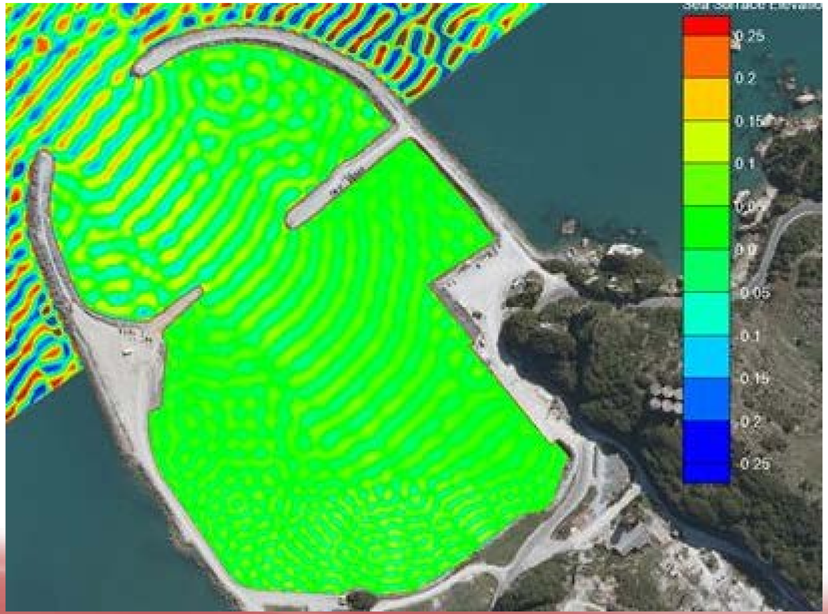


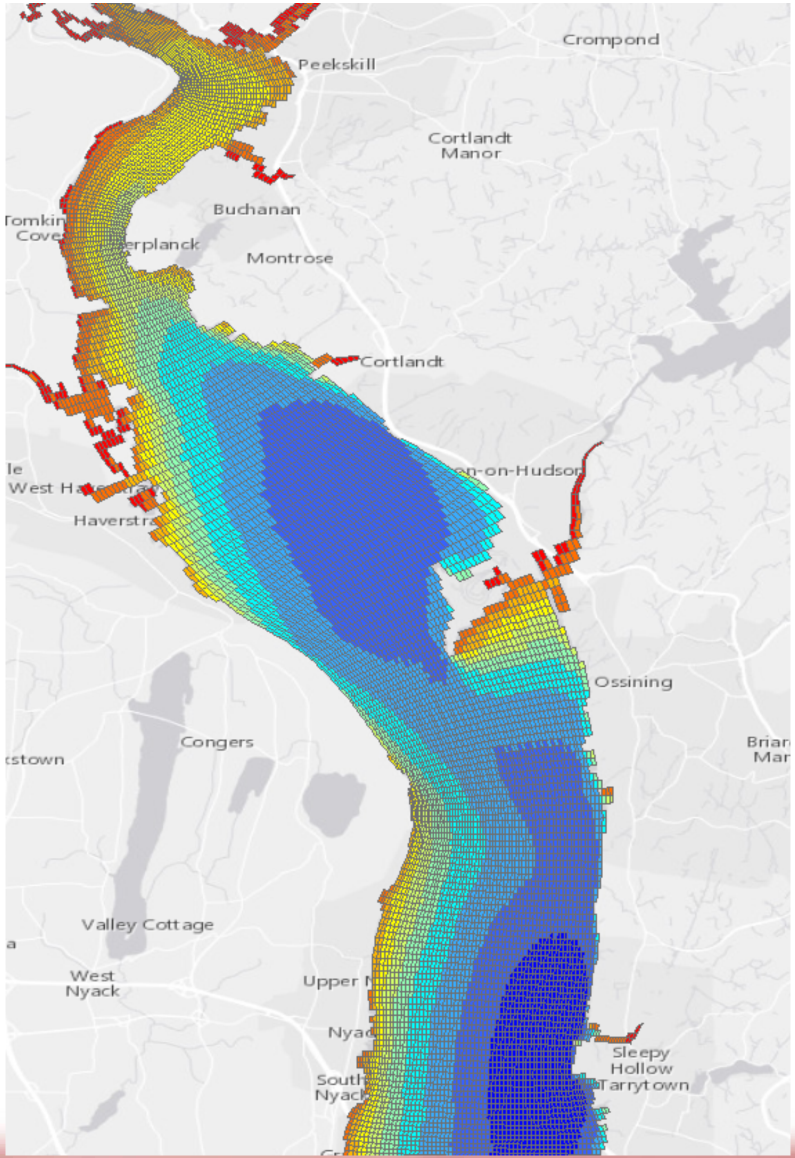
Example: Wind Waves

- Level 2 Analysis
  - Collect measurements
    - Provides real data at the site, but…
    - Consider factors like seasonality, etc.
    - Instrumentation
      - Pressure gauge
      - Accelerometer buoy
      - Acoustic wave gauge
      - Ultrasonic range measurement
      - Wave wire
      - Lidar/radar
      - Visual

Example: Wind Waves

- Level 3 Analysis
  - Modeling
  - Can capture important bathymetric induced modifications to the wave field





Suggested Design Approach

Living Shorelines Project

Level 1 Analysis

System	Hydrodynamic	Terrestrial	Ecological	Additional

Alternative Selection

Conceptual Design

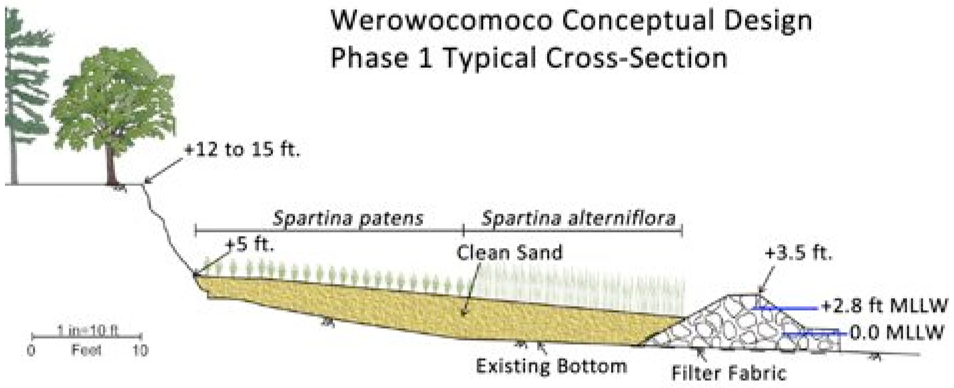
Level 2/3 Analysis

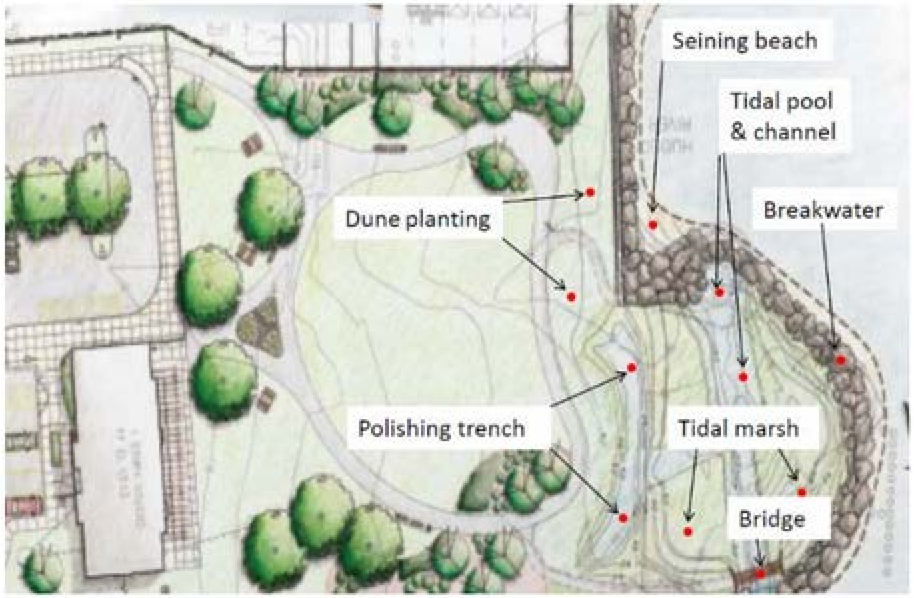
Select System	Select Hydro	Select Terrestrial	Select Ecological	Select Additional

Final Design

Final Design

- Plan, profile, detailed specifications





Approach Specific Guidance

- Sill
- Revetment
- Breakwater
- Living Reef
- Reef Balls

Marsh Sill

Description

Sills are low elevation typically stone structures that are constructed in the water parallel to the existing shoreline. Sills are often used as armoring for fringe marshes or wetlands that require a higher degree of protection. Sills dissipate wave energy and reduce bank erosion, causing waves to break on the offshore structure, rather than upon the natural, more fragile shore. Additionally, the tamed area of water lying behind the sill allows sand and sediment to accumulate between the structure and the shoreline. With time this process can eventually raise the elevation of the bottom and create a perched beach. This unique effect not only serves to further stabilize the shoreline or marsh behind the sill, but replaces lost and eroded land. Often the area between the sill and the shoreline is filled during construction to accelerate the development of the perched beach and planted with marsh plantings for stabilization.

Figure 7: Typical Sill

Each Parameter Discussed

Hydrodynamic Parameters

Wind Waves

Approaches for designing marsh sills for wave heights range from the simple fetch based approaches presented in the main body of these guidelines, to more traditional engineering approaches based on a design wave height. Traditional engineering approaches for the design of rubble mound structures are discussed in the *Coastal Engineering Manual* (US Army Corps of Engineers, 2002) and *The Rock Manual* (CIRIA; CUR; CETMF, 2012). Relevant considerations include the geometry of the structure, the size of the armor units, the amount of energy dissipation, spacing (for segmented sills), and scour potential. The two most frequently used approaches to select the appropriate armor stone based on the structure geometry and the incident wave conditions are the (Hudson, 1959) and (Van der Meer, 1988) formulas.

Parting Thoughts…

- Interest is staggering
- Need to find out what works for NJ
  - Unique urban environments
  - Ice?
  - Need to get projects on the ground
  - Monitoring will be critical
- Guidelines will need to be updated

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