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Living Shorelines in New England
State of the Practice

The issue:

Coastal erosion:

Impact: People, Infrastructure, Habitat

Solution:

Advance living shorelines:

Erosion control plus co-benefits.

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Living Shorelines in New England State of the Practice

NOAA Regional Resilience Grant Program

High Resolution Coastal Inundation Modeling and Advancement of Green Infrastructure and Living Shoreline Approaches in the Northeast

Awarded to NERACOOS and NROC + Many Partners

Living Shorelines in New England
State of the Practice

Literature: Review pertinent resources

Primary Source Research:

- Federal and state regulators
- Coastal engineers/practitioners
- Conservation orgs
- Academia

Number of experts who provided input:

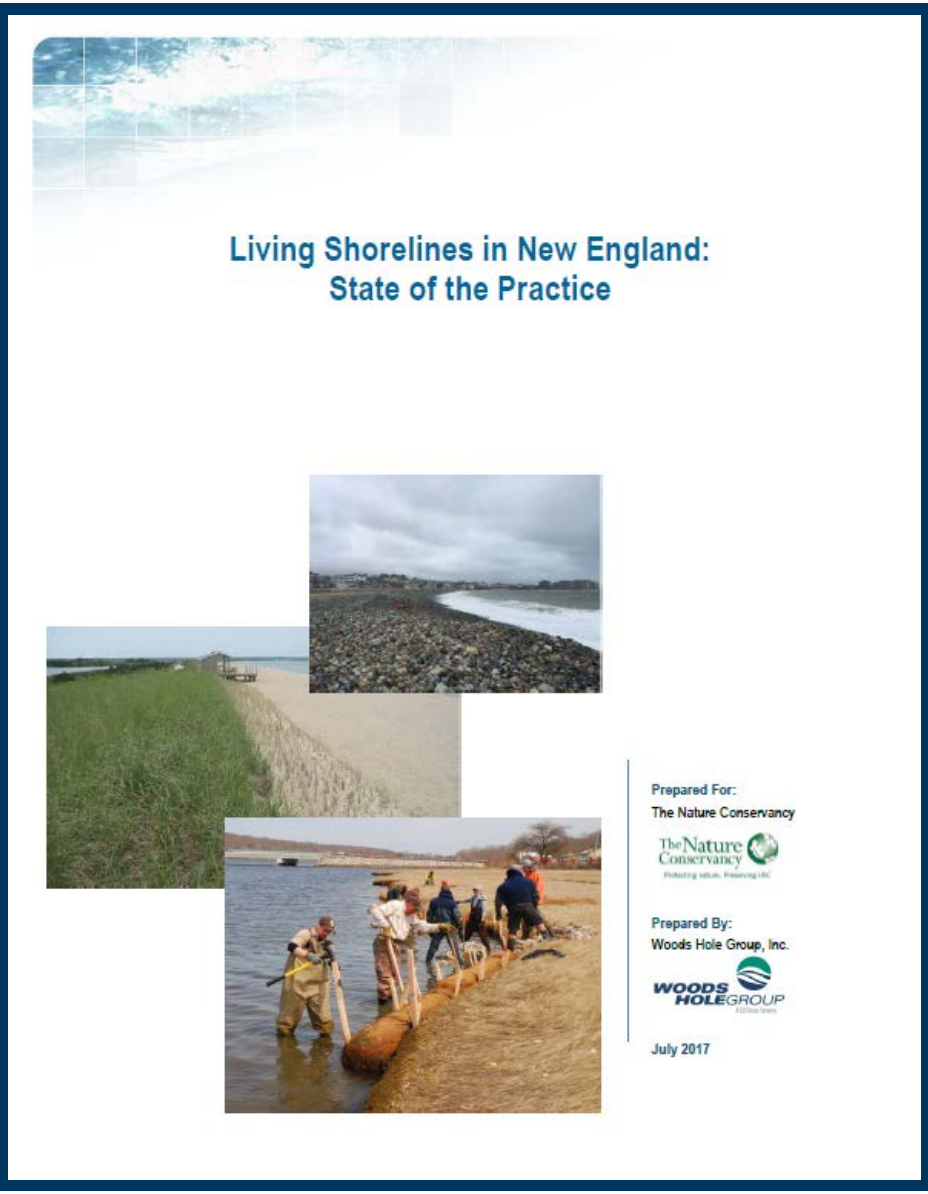
- Survey/interviews: 14
- Meetings/workshops: 23
- Total: 37

Product = State of the Practice REPORT

Living Shorelines in New England: State of the Practice

Report:

1. Findings
2. Profile pages
3. Applicability index



State of the Practice Report: Key Findings

- Living shorelines – important tool
  - Erosion Control
  - Co-benefits
- Co-benefits – valuable
  - ecosystem services, habitat, water quality/quantity, carbon sequestration, maintenance of natural coastal processes, sediment transport, visual
- Siting – critically important
  - Success possible when design type aligns with conditions

State of the Practice Report: Key Findings: Challenges

GENERAL

- Terminology - definitions
- Funding
- Permitting
- Perceptions: ‘green is less resilient than gray’

New England Specific

  - Ice
  - Short growing season for plantings
  - Tide range
- Lack of existing projects
  - Data gap on effectiveness and impacts

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State of the Practice Report: Sample Survey Question

What are the benefits of using a living shoreline approach compared to a gray design to shoreline protection?

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State of the Practice Report Profile pages

Profile Page Living Shoreline Categories	Specific Terminology Used in Other Sources
1. Dune Restoration (Natural)	Dune nourishment
	Dune restoration
2. Dune Restoration (Engineered Core)	Artificial dunes
	Dune nourishment
	Cobble berm
3. Beach Nourishment	Beach nourishment
	Cobble berm
4. Coastal Bank Protection (Natural)	Coir rolls with vegetation
	Natural fiber blankets
	Regrading
	Natural fiber logs (or bio-logs)
5. Coastal Bank Protection (Engineered Core)	Regrading w/sand tubes
	Bank stabilization with coir envelopes
6. Natural Marsh Creation/Enhancement	Enhancement of marsh
	Creation of coastal wetlands
	Fringe marsh creation
7. Marsh Creation/Enhancement (w/Toe Protection)	Fringe marsh constructed with oyster or mussel shells
	Fringe marsh constructed with bio-logs
	Marsh sill or reef balls with planted marsh
8. Living Breakwaters	Oyster or mussel reef
	Reef balls

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State of the Practice Profile Pages Intro

Living Shorelines Introduction

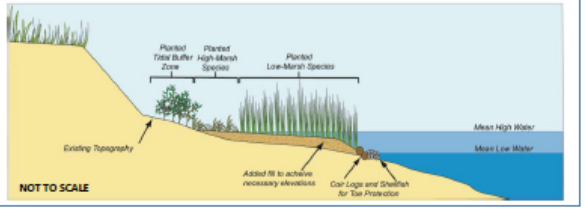
A detailed profile page was created for each of the eight (8) living shoreline types listed below. The purpose of these profile pages is to provide a comprehensive overview of the design recommendations, siting criteria and regulatory topics pertinent to a range of living shorelines designs that practitioners and regulators can use as a quick reference in the field or as an informational tool when educating home owners.

Living Shoreline Types

1. Dune – Natural
2. Dune – Engineered Core
3. Beach Nourishment
4. Coastal Bank – Natural
5. Coastal Bank – Engineered Core
6. Natural Marsh Creation/Enhancement
7. Marsh Creation/Enhancement w/Toe Protection
8. Living Breakwater

Design Schematics

The following living shoreline profile pages provide an example design schematic for each of the eight living shoreline types. Each schematic shows a generalized cross-section of the installed design. In addition, they illustrate each design's location relative to MHW and MLW, whether plantings are recommended, if fill is required, and any other major components of the design. It is important to note that these are not full engineering designs, and due to each sites unique conditions, a site specific plan, developed by an experienced practitioner is required for all living shoreline projects. Also note that these design schematics are meant to provide a general concept only, and are not drawn to scale.



Case Study

One example case study, with the following information, is provided for each living shoreline type.

Project Proponent	The party responsible for the project.
Status	The status of the project (i.e. design stage, under construction, or completed) and completion date if appropriate.
Permitting Insights	This section notes any specific permitting hurdles that occurred, or any regulatory insights that might help facilitate similar projects in the future.
Construction Notes	This section identifies major construction methods or techniques, any unique materials that were used, or deviations from a traditional design to accommodate site specific conditions.
Maintenance Issues	If the project is complete and has entered the maintenance phase, this section will note whether the project has functioned correctly, if it is holding up, and/or if any specific maintenance needs have been required since construction.
Final Cost	This section provides costs for the project, broken down into permitting, construction, monitoring, etc. when possible.
Challenges	This sections highlights any unique challenges associated with a particular project and how they were handled.

Explanation of Design Overview Tables

Materials	A description of materials most commonly used to complete a living shoreline project of this type.
Habitat Components	A list of what types of coastal habitats are created or impacted by a living shoreline project of this type.
Durability and Maintenance	Although specific timelines are impossible to provide in this context, general guidelines and schedules for probable maintenance needs, and design durability are detailed here.
Design Life	Although specific design life timelines will vary by site for each living shoreline type, this section provides some insight into factors that could influence design life.
Ecological Services Provided	This section provides an overview of the ecological services that could be provided or improved through the installation of that particular type of living shoreline project.
Unique Adaptations to NE Challenges (e.g. ice, winter storms, cold temps)	This section provides any unique practices or design improvements that could be made to improve the performance of the design given New England climactic and tidal challenges.

Acronyms and Definitions

cy	Cubic yards; one cubic yard equal 27 cubic feet. Project materials are often measured in cubic yards.
MHW	Mean High Water: The average of all the high water (i.e. high tide) heights observed over a period of time.
MTL	Mean Tide Level: The average of mean high water and mean low water.
MLW	Mean Low Water: The average of all the low water (i.e. low tide) heights observed over a period of time.
SAV	Submerged aquatic vegetation, which includes seagrasses such as eelgrass (*Zostera marina*) and widgeon grass (*Ruppia maritima*).
Sediment	Naturally occurring materials that have been broken down by weathering and erosion. Finer, small-grained sediments are silts or clays. Slightly coarser sediments are sands. Even larger materials are gravels or cobbles.

Misquamicut Beach Dune Restoration, Westerly, RI
Photo courtesy of Janet Friedman

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State of the Practice Profile Pages Intro

Living Shorelines Introduction

Overview of Regulatory and Review Agencies Table

This table is intended to provide a comprehensive list of all the regulatory and review agencies that would potentially need to be contacted for a particular type of living shoreline project. State agencies are listed separately for each of the five coastal northeast states (Maine, New Hampshire, Massachusetts, Rhode Island and Connecticut). Federal agencies that may need to be contacted for a project in any state are also listed. Note that these lists represent the full range of potential agencies. If projects do not exceed certain thresholds (e.g. extending below MHW, exceeding a certain footprint area) they may not be required to contact or receive a permit from all agencies listed.

City Beach Nourishment, Warwick, RI
Photo courtesy of Janet Freedman

Reef Ball Living Breakwater and Marsh Restoration
Stratford, CT
Photo courtesy of Jennifer Mattei

Use and Applicability of Profile Pages

The profile pages that follow have been developed to improve the understanding of eight (8) different living shoreline designs. They have been designed to facilitate communication among the public, regulators, practitioners and researchers and to provide a common starting place for more detailed design discussions to follow. They are one of many resources available to those interested in coastal resilience. The compact layout provides a printable 11" x 17" page that can be used in the field or office. The format captures the primary focus areas required to identify which living shoreline designs are a good fit for a specific site (note that there may be multiple living shoreline options for some sites). The reader is presented with specific site characteristics, a conceptualization of the overall design, the challenges and benefits associated with each living shoreline design type, identification of the regulatory agencies involved in approving a design, and an illustration of how all of those components come together in a case study for each living shoreline type. These profile pages are expected to be updated periodically as more data become available. These profile pages should not take the place of a more comprehensive site evaluation and design process, but are intended to help further engage stakeholders and experts in an informed discussion about various living shoreline types.

Explanation Key for Siting Characteristics and Design Considerations

Selection Characteristics	Definitions and Categories
ES Energy State	A measure of the wave height, current strength and storm surge frequency of a site that would be suitable for a particular living shoreline project type. **High**: Project site has waves greater than 5 feet, strong currents, high storm surge Moderate: Project site has 2 to 5 foot waves, moderate currents, moderate storm surge Low: Project site has waves less than 2 feet in height, low current, low storm surge
EE Existing Environmental Resources	Existing environmental resources that a proposed living shoreline project is able to overlap with. **Coastal Bank** **Salt Marsh** **Vegetated Upland** **Coastal Dune** **Mudflat** **Coastal Beach** **Subtidal**
SR Nearby Sensitive Resources	Nearby sensitive resources that, with proper planning and design, may be compatible with a particular living shoreline type. **Endangered/Threatened Species** **Submerged Aquatic Vegetation (SAV)** **Shellfish** **Cobble or Rocky Bottom Habitat**
TR Tidal Range	The magnitude of tidal range at a site that would be suitable for a particular type of living shoreline design. **High**: Tide range at project site is more than 9 feet Moderate: Tide range at project site is between 3 and 9 feet Low: Tide range at project site is less than 3 feet
EL Elevation	The elevation, with respect to the tide range, where a particular living shoreline project type should be sited. **Above MHW**: Project footprint is entirely above MHW **MHW to MLW**: Project footprint is located within the intertidal zone **Below MLW**: Project footprint is located in subtidal areas
IS Intertidal Slope	The intertidal slope appropriate for siting a particular living shoreline project type. **Steep**: Project site has an intertidal slope steeper than 3:1 (base:height) **Moderate**: Project site has an intertidal slope between 3:1 and 5:1 (base:height) **Flat**: Project site has an intertidal slope flatter than 5:1 (base:height)
BS Bathymetric Slope	The nearshore bathymetric slope appropriate for siting a particular living shoreline project type. **Steep**: Project site has an bathymetric slope steeper than 3:1 (base:height) **Moderate**: Project site has an bathymetric slope between 3:1 and 5:1 (base:height) **Flat**: Project site has an bathymetric slope flatter than 5:1 (base:height)
ER Erosion	The rate of coastal erosion at a site that would be suitable for a particular living shoreline project type. **High**: Erosion at project site is high (>3 feet/year) **Moderate**: Erosion at project site is moderate (1-3 feet/year) **Low**: Erosion at project site is low (<1 foot/year)

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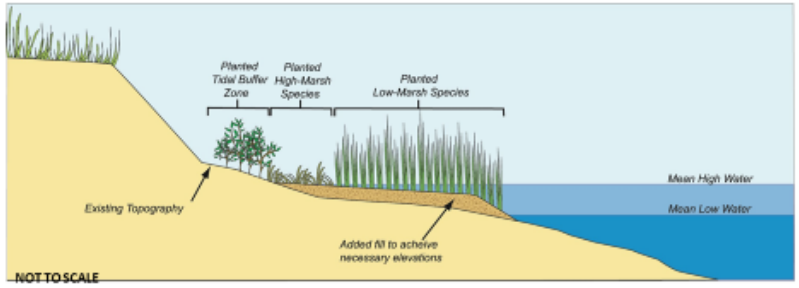
State of the Practice Report Profile Example

Natural Marsh Creation/Enhancement

Marsh vegetation, such as native low (*Spartina alterniflora)* and high marsh (*Spartina patens*) species, can be planted along the shoreline. Roots help hold soil in place, and shoots will break small waves and increase sedimentation – vegetation projects such as this are a minimally invasive approach.

Objectives: dissipates wave energy, habitat creation, shoreline stabilization

Design Schematics



Case Study

Sachuest Point Restoration, Middletown, RI

The U.S. Fish & Wildlife Service and The Nature Conservancy developed this project at the Sachuest Point National Wildlife Refuge to help the area better withstand the impacts of sea-level rise and coastal storm surge. Storm surge and wave erosion, combined with the lack of sediment replenishment from estuaries whose rivers have been dammed, left the existing salt marsh at a point where it could not keep up with sea-level rise. With little opportunity to migrate, due to being constrained by Third Beach, the best solution to protect Sachuest Point was to raise the elevation of the marsh itself.


Sachuest Point, Middletown, RI
Photo courtesy of Jennifer White

Project Proponent	USFWS, The Nature Conservancy, Save The Bay, Town of Middletown, Norman Bird Sanctuary
Status	Initial construction and planting: Spring 2016.
Permitting Insights	Care was taken to prevent sediment plumes from entering the Sakonnet that could negatively affect winter flounder. Testing was done to ensure material was clean and of appropriate grain size. Ensured that elevations remained within the tidal marsh elevation range.
Construction Notes	Sand was trucked to the site and placed on the marsh with machines. The surface was contoured to create high and low marsh elevations. Salt tolerant grass plugs grown out from local seed sources were planted in the spring following sediment placement.
Maintenance Issues	Fencing was used to protect plant plugs from winter grazing by Canada Geese. Additional planting will occur in 2017.
Final Cost	$634,000 for sediment placement; $36,100 for growing of plant plugs.
Challenges	A drought during the growing season of 2016 caused mortality of some plant plugs, and maintenance of anti-grazing fencing during/after winter storms to prevent damage by geese.

Design Overview

Materials	Native marsh plants appropriate for salinity and site conditions. Plugs of marsh grass can be planted to augment bare or sparse areas.[11] Sediment may be necessary if the project area needs to be filled to obtain appropriate elevations, to provide a suitably gradual slope for marsh creation, or to enable a marsh to maintain its elevation with respect to the sea-level rise.[11] Bird exclusion fencing may be necessary to avoid predation while plants develop.[16]
Habitat Components	Salt marsh; Tidal buffer landward of the salt marsh; Coastal beach; Mud flat.
Durability and Maintenance	Plants that are removed or die during the early stages of growth must be replaced immediately to ensure the undisturbed growth of the remaining plants. The removal of debris and selective pruning of trees is also a good maintenance practice to ensure that sunlight reaches plants. Protection measures, such as fencing, must be taken to keep waterfowl from eating the young plants.[6] Ongoing maintenance of invasive species and runoff issues will be important to the long-term success of the project. After significant growth has occurred only periodic inspections may be necessary.
Design Life	It is important to recognize that design life may be shorter in the future given changes in sedimentation rates, accelerating sea-level rise and other climate change impacts.
Ecological Services Provided	Increases water infiltration, uptake of nutrients, filtration, denitrification and sediment retention.[2,3] The extensive root systems of marsh vegetation help to retain the existing soil, thus reducing erosion while plant stems attenuate wave energy.[11] A healthy salt marsh may reduce wave energy. Marshes provide habitat for many species of plants and animals, and maintain the aquatic/terrestrial interface.[2] Marshes also provide natural shore erosion control, better water quality, recreation and education opportunities, and carbon sequestration (blue carbon).[12]
Unique Adaptations to NE Challenges (e.g. ice, winter storms, cold temps)	Including roughened surfaces, such as emergent vegetation can help break up ice sheets.[4] Marshes can respond better to ice if gentler slopes (6:1-10:1) are used and by incorporating shrubs. Planting in the spring will allow vegetation time to become established before it has to withstand ice.[8,13] Consider using pre-planted mats to compensate for a shorter growing season. Hardy, salt-tolerant shrubs (e.g., *Iva frutescens* and *Baccharis halimifolia*) are well-suited for shorelines affected by ice.[13]

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State of the Practice Report Profile Example

Natural Marsh Creation/Enhancement

Fringing marsh living shoreline projects have proven successful with or without protective structures such as fiber rolls or sills, but projects without protective structures are most likely to be successful on sheltered waterways where there is low natural wave action and limited wave action from boating activities.


Allin's Cove, Barrington, RI
Photo courtesy of Janet Freedman


Fringing Marsh Project, Indigo Point, S. Kingstown, RI
Photo courtesy of Janet Freedman

Regulatory and Review Agencies

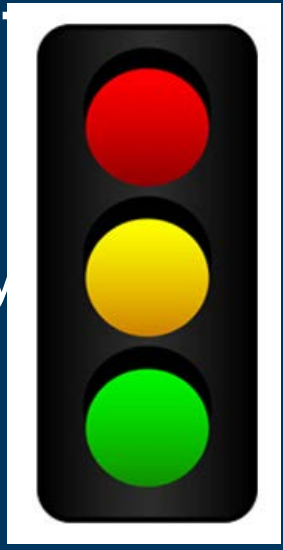
Maine	Municipal Shoreland Zoning, Municipal Floodplain, ME Dept. of Environmental Protection, ME Land Use Planning Commission, ME Coastal Program, ME Department of Marine Resources, ME Department of Inland Fisheries and Wildlife, ME Geological Survey, and ME Submerged Lands Program.
New Hampshire	Local Conservation Commission, NH Natural Heritage Bureau, NH Department of Environmental Services (Wetlands Bureau, Shoreland Program, and Coastal Program), and NH Fish & Game Department.
Massachusetts	Local Conservation Commission, MA Dept. of Environmental Protection (Waterways and Water Quality), MA Division of Fisheries and Wildlife (Natural Heritage and Endangered Species Program), MA Environmental Policy Act, and MA Office of Coastal Zone Management.
Rhode Island	Coastal Resources Management Program, and RI Dept. of Environmental Management.
Connecticut	Local Planning and Zoning Commission, and CT Department of Energy and Environmental Protection.
Federal (for all states)	U.S. Army Corps of Engineers, National Marine Fisheries Service, U.S. Environmental Protection Agency, and U.S. Fish and Wildlife Service.

Siting Characteristics and Design Considerations

Selection Characteristics	Detail
ES Energy State	Low to moderate. Works best in low energy sites (i.e. less than 2 feet of short waves, low current and low storm surge).[3] Sites with a fetch >5 miles are not recommended.[15]
EE Existing Environmental Resources	Coastal beach; mud flat; salt marsh
SR Nearby Sensitive Resources	Endangered and threatened species. If the project is proposed in or adjacent to habitat for protected wildlife species or horseshoe crab spawning areas, there may be limitations on the time of year for construction.[1] Shellfish beds and essential fish habitats will restrict where a marsh can be extended. Construction may produce short term habitat impacts, but in the long term, the marsh area should provide enhanced wildlife and fisheries habitat.
TR Tidal Range	Low to high
EL Elevation	MLW to MHW; Above MHW. For low marsh, the lowest grade should be MTL and extend up to MHW. High marsh plantings should extend between MHW and MHHW.[3] Tidal buffer should be planted above highest observable tide.
IS Intertidal Slope	Flat. With slopes 5:1 (base:height) and flatter, plants can be utilized without additional erosion control.[3] Between 5:1 and 3:1, marsh projects may not work without additional toe stabilization.[3] The wider the intertidal zone, the more effective the marsh is at dissipating wave energy.[7] A minimum width of the planting should be 10 feet.[15]
BS Bathymetric Slope	Flat to moderate
ER Erosion	Low to moderate
Other Characteristics	**Detail**
Boat Traffic	If boat wakes are perceived to be a significant problem, the site should be treated as a higher energy site and may be more suitable with a sill or other toe protection.
Ice Sensitivity	Planted marsh areas with gentle slopes and intermixed shrubs will handle ice the best. Shrubs have a significant advantage over other types of vegetation because they have deep fibrous root systems and a structure that remains in place throughout the winter months.[8] Plant in the spring to allow plants to become established well before ice becomes a concern.[8]
Climate Vulnerability	Planted marsh areas may have a difficult time adapting to sea level rise.[7] If there is space on a project site, designs should anticipate marsh migration in response to sea level rise.[13]
Surrounding Land Use	Existing structures on site, like seawalls, may force living shoreline projects to have a steeper slope than desirable. Seawalls will limit the inland migration potential of the salt marsh in the future. Steeper slopes leave little opportunity for wave energy dissipation.[13] Marshes require sunlight to thrive; trees must be pruned or removed to allow for at least four to six hours of sunlight a day;[6] this will increase vegetation growth.[11,15] Although it is possible to create a marsh on most shorelines, marsh creation is not recommended for sites where they are not a natural feature along comparable natural shorelines.[11]

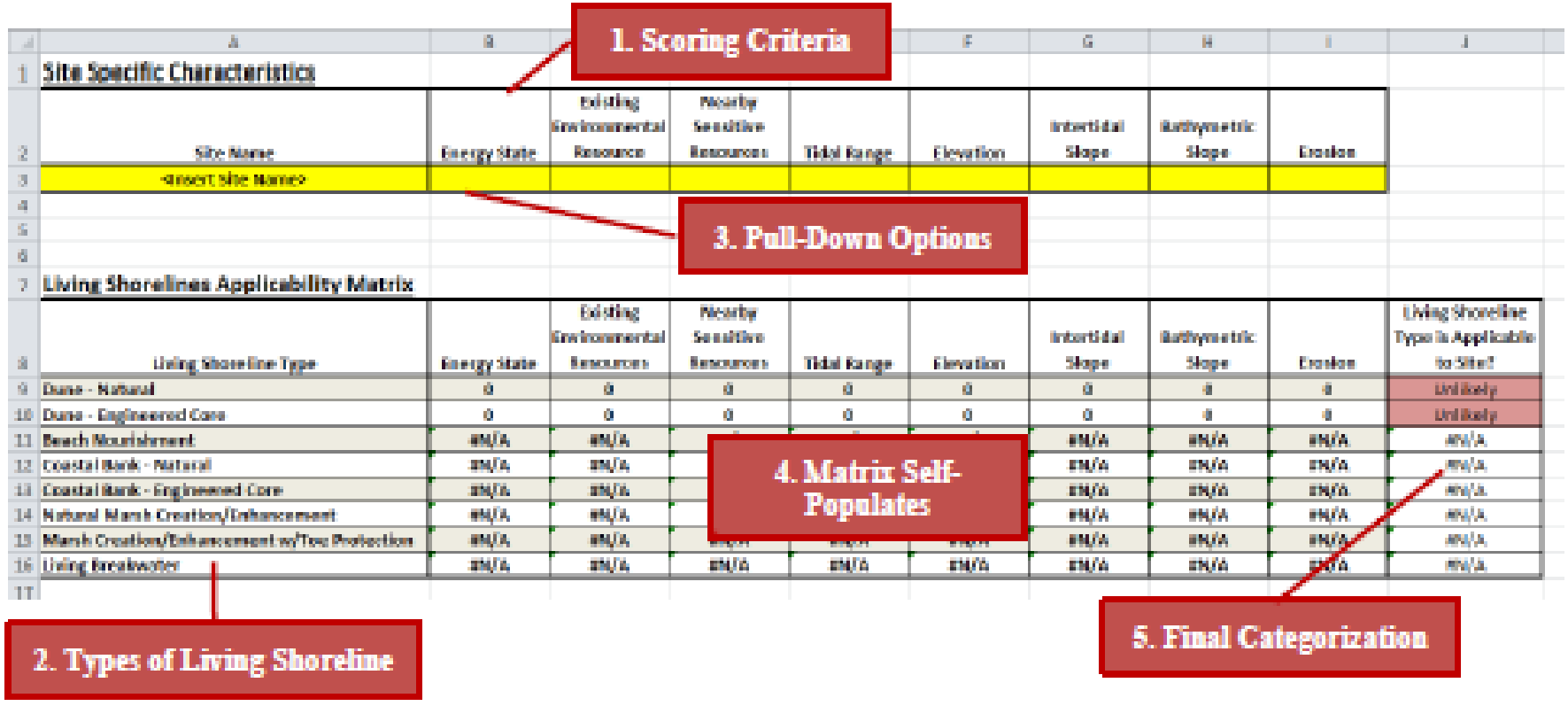
State of the Practice Report Applicability Index

- Excel based siting tool
- Living shoreline types – Same as Profile Pages
- User inputs site characteristics → Results:
  - High level suitability
    - Stoplight approach
    - (Green-likely, Yellow-possible, Red-unlikely



State of the Practice Report Applicability Index

Sample Page



	A	B	C	D	E	F	G	H	I	J
1	Site Specific Characteristics									
2	Site Name	Energy State	Existing Environmental Resource	Nearby Sensitive Resources	Tidal Range	Elevation	Intertidal Slope	Bathymetric Slope	Erosion	
3	<Insert Site Name>									
4										
5										
6										
7	Living Shorelines Applicability Matrix									
8	Living Shoreline Type	Energy State	Existing Environmental Resources	Nearby Sensitive Resources	Tidal Range	Elevation	Intertidal Slope	Bathymetric Slope	Erosion	Living Shoreline Type is Applicable to Site?
9	Dune - Natural	0	0	0	0	0	0	0	0	Unlikely
10	Dune - Engineered Core	0	0	0	0	0	0	0	0	Unlikely
11	Beach Nourishment	#N/A	#N/A				#N/A	#N/A	#N/A	#N/A
12	Coastal Bank - Natural	#N/A	#N/A				#N/A	#N/A	#N/A	#N/A
13	Coastal Bank - Engineered Core	#N/A	#N/A				#N/A	#N/A	#N/A	#N/A
14	Natural Marsh Creation/Enhancement	#N/A	#N/A				#N/A	#N/A	#N/A	#N/A
15	Marsh Creation/Enhancement w/Toe Protection	#N/A	#N/A				#N/A	#N/A	#N/A	#N/A
16	Living Revetment	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
17										

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State of the Practice Report Applicability Index

Living Shorelines Applicability Matrix

Living Shoreline Type	Living Shoreline Type is Applicable to Site?
Dune - Natural	Unlikely
Dune - Engineered Core	Unlikely
Beach Nourishment	Likely
Coastal Bank - Natural	Likely
Coastal Bank - Engineered Core	Possible
Natural Marsh Creation/Enhancement	Likely
Marsh Creation/Enhancement w/Toe Protection	Likely
Living Breakwater	Possible

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Acknowledgements

Living Shorelines in New England: State of the Practice

http://www.conservationgateway.org/ConservationPractices/Marine/Pages/new-england-living-shorelines.aspx

Steve Kirk, Coastal Program Manager
The Nature Conservancy
stephen.kirk@tnc.org