Built Environment: Resilient Water Features

Presenter: **Dr. Robert Roseen**
Waterstone Engineering

Presenter: **Dr. David Burdick**
University of New Hampshire

Weathering Change: Local Solutions for Strong Communities

ANTIOCH UNIVERSITY NEW ENGLAND

Center for Climate Preparedness and Community Resilience

www.communityresilience-center.org

Abigail Abrash Walton, Co-Director

Strengthen communities to prepare, respond and recover in the face of climate impacts and other disruptions through collaborative, innovative solutions.

ANTIOCH UNIVERSITY NEW ENGLAND
Center for Climate Preparedness and Community Resilience

Climate Resilience Certificate for Professionals

Antioch University New England's Center for Climate Preparedness, in conjunction with Antioch's Sustainable Development and Climate Change graduate program, has initiated a set of six on-line courses leading to an accredited Climate Resilience Certificate for Professionals.

- Engage in each course for 4 weeks.
- Courses can be taken either for graduate credit or for professional continuing education credits.
- Increase your skill set in climate resilience for better outcomes.
- Discover solutions to local issues you face on the job or in your community.
- Register for one course or the whole series.

Visit our website for more information about this series and the certificate program.

http://www.communityresilience-center.org/climate-change-resilience-series/

ANTIOCH UNIVERSITY NEW ENGLAND
Center for Climate Preparedness and Community Resilience

Climate Impacts: Vulnerability and Adaptation Planning

Dates: February 3 – March 2, 2019

Registration deadline: January 29, 2019

Local and regional governments are leaders in climate change due to their unique position to make a wide range of decisions that can mitigate and adapt to our changing climate. Because they are on the frontline, many communities have conducted vulnerability assessments and engaged in adaptation planning.

This module will enable participants to assess impacts to a business, community, or sector based on specific climate projections for a specific locale. This focuses on identifying what and who are most vulnerable to such impacts, which requires the ability to facilitate a stakeholder process to prioritize these identified vulnerabilities, including with respect to business supply chains, and actionable responses. This module will also provide you with the overview of planning for resiliency and adaptation at different scales.

Instructor: Christa Daniels, Ph.D.

Register for this course: http://www.communityresilience-center.org/climate-change-resilience-series/

U.S. Climate Resilience Toolkit

www.toolkit.climate.gov

Ned Gardiner,
Engagement Manger

Meet the challenges of a changing climate by finding information and tools to help you understand and address your climate risks.

Logistics

•If you can hear me, you are already connected to the Broadcast and do not need to call in.

•If you have a question, please write it in the Q&A section (not Chat) and select to All Panelists, so we can see the questions.

•If you are having technical difficulty, please use Chat and send to Host, so we can address the issue with you directly.

•The presentation will be recorded and posted to the Antioch website within a week: www.communityresilience-center.org

Questions

- Please submit questions via the Q&A section (not Chat)

- Select to All Panelists.

- If we are not able to get to your question today, we will try to address it after the webinar in our general follow up email or you may hear directly from the presenters.

Built Environment: Resilient Water Features

Weathering Change: Local Solutions for Strong Communities

Green Infrastructure and Flood Resiliency-Land Use Management as an Adaptation Strategy in the Built Environment: Exeter Resilience Project

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Resilient Water Features

Weathering Change: Local Solutions for Strong Communities
2018-19 Webinar Series
January 24, 2019

OVERVIEW

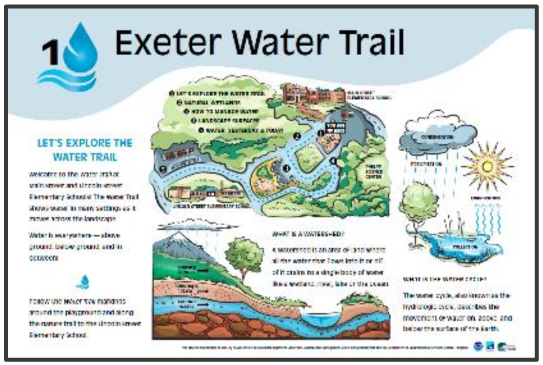
- ✓ Innovative Communication Methods
- ✓ Climate Adaptation Policy
- ✓ Resilient Stormwater Management

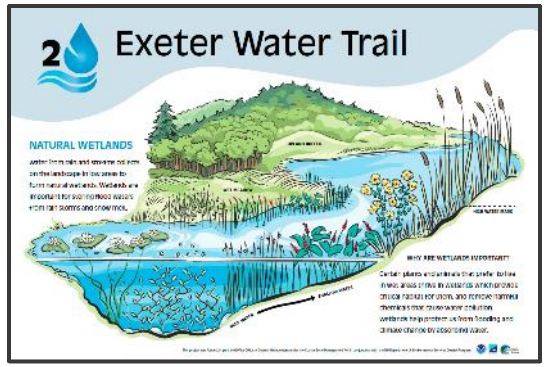
Support for this project was provided by the National Oceanic and Atmospheric Administration Office for Coastal Management pursuant to the Coastal Zone Management Act of 1972 in conjunction with the NH Department of Environmental Services Coastal Program, as a FY2016 Project of Special Merit Grant, Award # NA16NOS4190157.

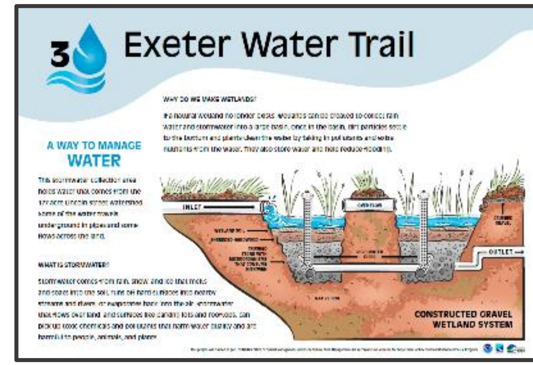
Innovative Communications

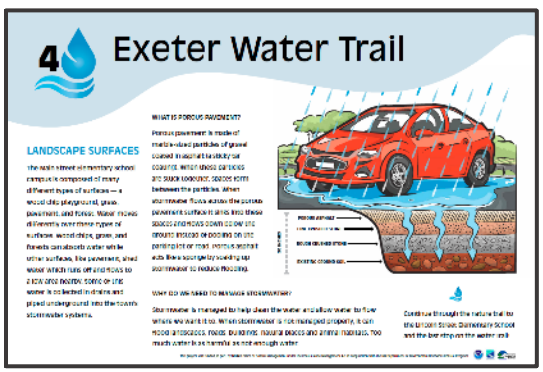
Educational installation at Main Street and Lincoln Street Elementary Schools

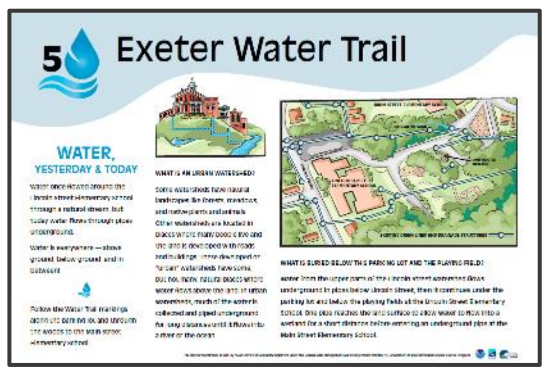
Reaches students Kindergarten through grade 5, yearly reinforcement, workbooks











Water Cycle, Flooding

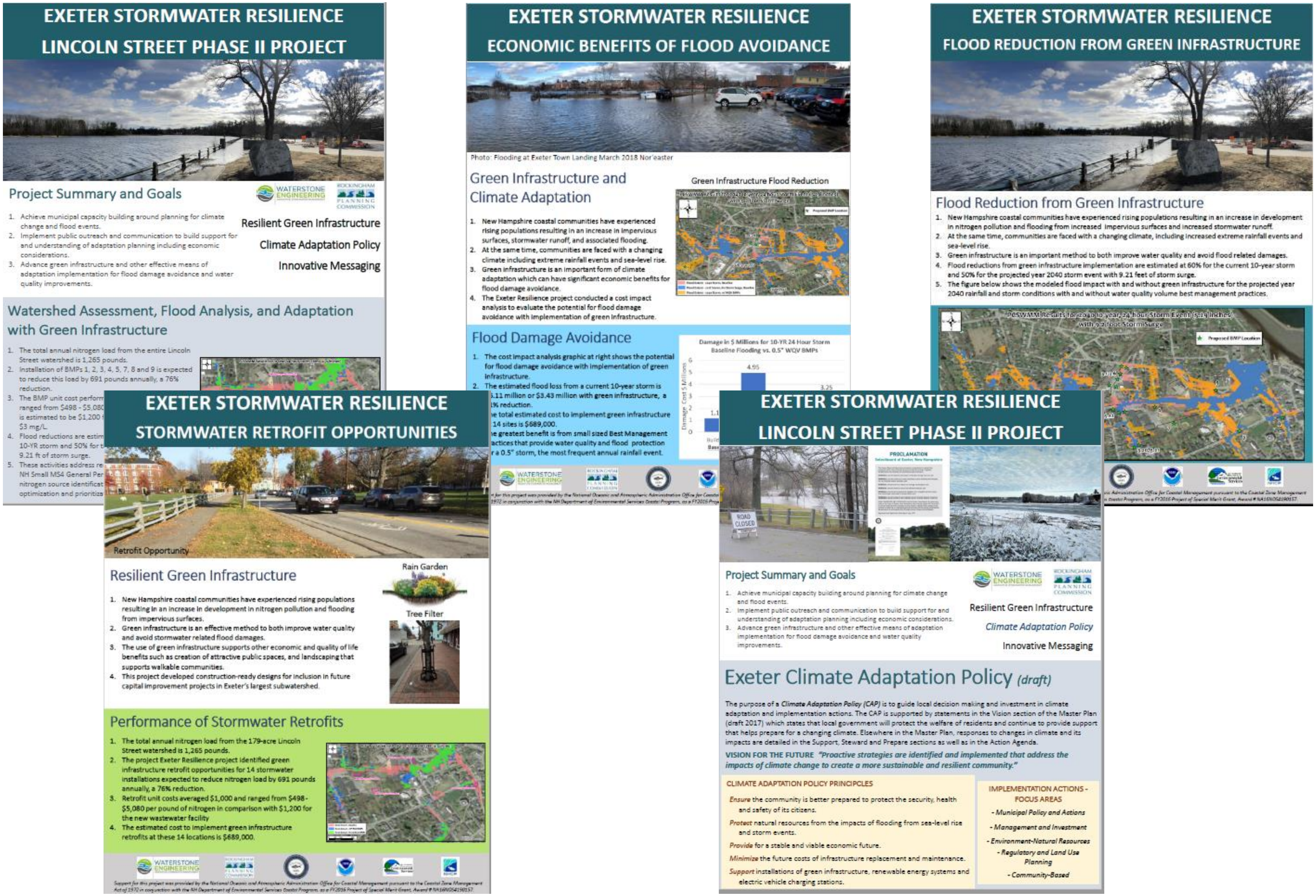
Surface interactions

Natural Wetlands

Constructed Wetlands

Porous Pavement

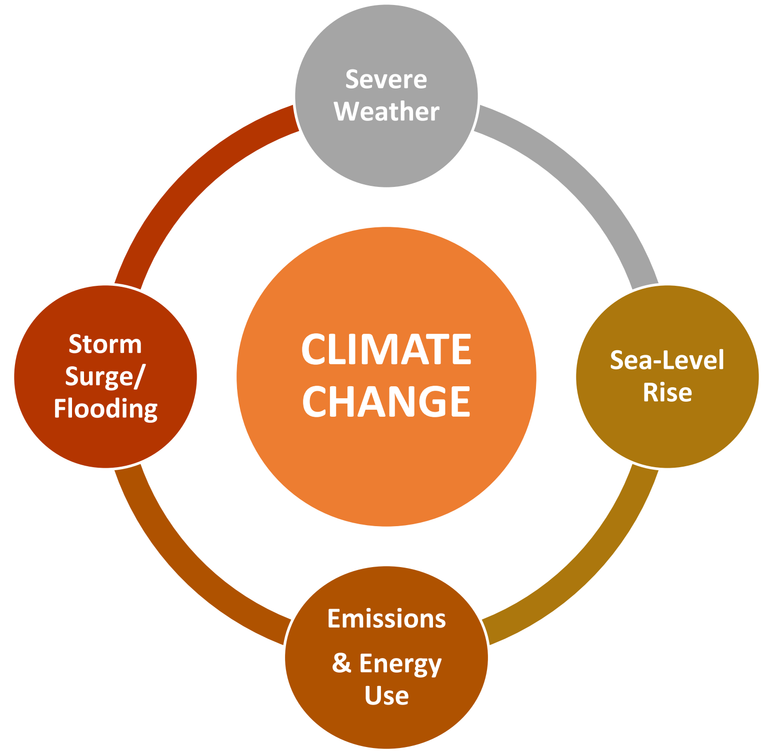
Stormwater Management


EXETER STORMWATER RESILIENCE
LINCOLN STREET PHASE II PROJECT
Project Summary and Goals
1. Achieve municipal capacity building around planning for climate change and flood events.
2. Implement public outreach and communication to build support for and understanding of adaptation planning including economic considerations.
3. Advance green infrastructure and other effective means of adaptation implementation for flood damage avoidance and water quality improvements.
Resilient Green Infrastructure
Climate Adaptation Policy
Innovative Messaging
Watershed Assessment, Flood Analysis, and Adaptation with Green Infrastructure
EXETER STORMWATER RESILIENCE
ECONOMIC BENEFITS OF FLOOD AVOIDANCE
Photo: Flooding at Exeter Town Landing March 2018 Nor'easter
Green Infrastructure and Climate Adaptation
Green Infrastructure Flood Reduction
1. New Hampshire coastal communities have experienced rising populations resulting in an increase in impervious surfaces, stormwater runoff, and associated flooding.
2. At the same time, communities are faced with a changing climate including extreme rainfall events and sea-level rise.
3. Green infrastructure is an important form of climate adaptation which can have significant economic benefits for flood damage avoidance.
4. The Exeter Resilience project conducted a cost impact analysis to evaluate the potential for flood damage avoidance with implementation of green infrastructure.
Flood Damage Avoidance
Damage in $ Millions for 10-YR 24 Hour Storm Baseline Flooding vs. 0.5" WQV BMPs
EXETER STORMWATER RESILIENCE
FLOOD REDUCTION FROM GREEN INFRASTRUCTURE
Flood Reduction from Green Infrastructure
1. New Hampshire coastal communities have experienced rising populations resulting in an increase in development in nitrogen pollution and flooding from increased impervious surfaces and increased stormwater runoff.
2. At the same time, communities are faced with a changing climate, including increased extreme rainfall events and sea-level rise.
3. Green infrastructure is an important method to both improve water quality and avoid flood related damages.
4. Flood reductions from green infrastructure implementation are estimated at 60% for the current 10-year storm and 50% for the projected year 2040 storm event with 9.21 feet of storm surge.
5. The figure below shows the modeled flood impact with and without green infrastructure for the projected year 2040 rainfall and storm conditions with and without water quality volume best management practices.
EXETER STORMWATER RESILIENCE
STORMWATER RETROFIT OPPORTUNITIES
Retrofit Opportunity
Resilient Green Infrastructure
Rain Garden
Tree Filter
1. New Hampshire coastal communities have experienced rising populations resulting in an increase in development in nitrogen pollution and flooding from impervious surfaces.
2. Green infrastructure is an effective method to both improve water quality and avoid stormwater related flood damages.
3. The use of green infrastructure supports other economic and quality of life benefits such as creation of attractive public spaces, and landscaping that supports walkable communities.
4. This project developed construction-ready designs for inclusion in future capital improvement projects in Exeter's largest subwatershed.
Performance of Stormwater Retrofits
1. The total annual nitrogen load from the 179-acre Lincoln Street watershed is 1,265 pounds.
2. The project Exeter Resilience project identified green infrastructure retrofit opportunities for 14 stormwater installations expected to reduce nitrogen load by 691 pounds annually, a 76% reduction.
3. Retrofit unit costs averaged $1,000 and ranged from $498-$5,080 per pound of nitrogen in comparison with $1,200 for the new wastewater facility
4. The estimated cost to implement green infrastructure retrofits at these 14 locations is $689,000.
EXETER STORMWATER RESILIENCE
LINCOLN STREET PHASE II PROJECT
ROAD CLOSED
PROCLAMATION
Project Summary and Goals
1. Achieve municipal capacity building around planning for climate change and flood events.
2. Implement public outreach and communication to build support for and understanding of adaptation planning including economic considerations.
3. Advance green infrastructure and other effective means of adaptation implementation for flood damage avoidance and water quality improvements.
Resilient Green Infrastructure
Climate Adaptation Policy
Innovative Messaging
Exeter Climate Adaptation Policy (draft)
The purpose of a Climate Adaptation Policy (CAP) is to guide local decision making and investment in climate adaptation and implementation actions. The CAP is supported by statements in the Vision section of the Master Plan (draft 2017) which states that local government will protect the welfare of residents and continue to provide support that helps prepare for a changing climate. Elsewhere in the Master Plan, responses to changes in climate and its impacts are detailed in the Support, Steward and Prepare sections as well as in the Action Agenda.
VISION FOR THE FUTURE "Proactive strategies are identified and implemented that address the impacts of climate change to create a more sustainable and resilient community."
CLIMATE ADAPTATION POLICY PRINCIPLES
Ensure the community is better prepared to protect the security, health and safety of its citizens.
Protect natural resources from the impacts of flooding from sea-level rise and storm events.
Provide for a stable and viable economic future.
Minimize the future costs of infrastructure replacement and maintenance.
Support installations of green infrastructure, renewable energy systems and electric vehicle charging stations.
IMPLEMENTATION ACTIONS - FOCUS AREAS
- Municipal Policy and Actions
- Management and Investment
- Environment-Natural Resources
- Regulatory and Land Use Planning
- Community-Based

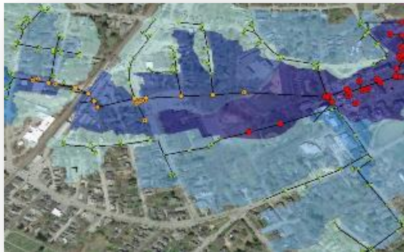
Climate Adaptation Policy *(draft)*

Recipe for Process/Methods

- ✓ Supported by Master Plan
- ✓ Audit of Zoning and Regulations
- ✓ Community Initiatives and Activities
- ✓ Capital Improvement/Infrastructure Management Plans
- ✓ Coordination with elected officials, staff, boards, commissions
- ✓ Exeter "Climate Proclamation" (to uphold principles of Paris Climate Accord)

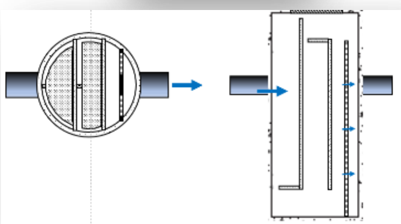


Overview



1. Watershed Modeling

2. Identify Green Infrastructure Retrofit Locations



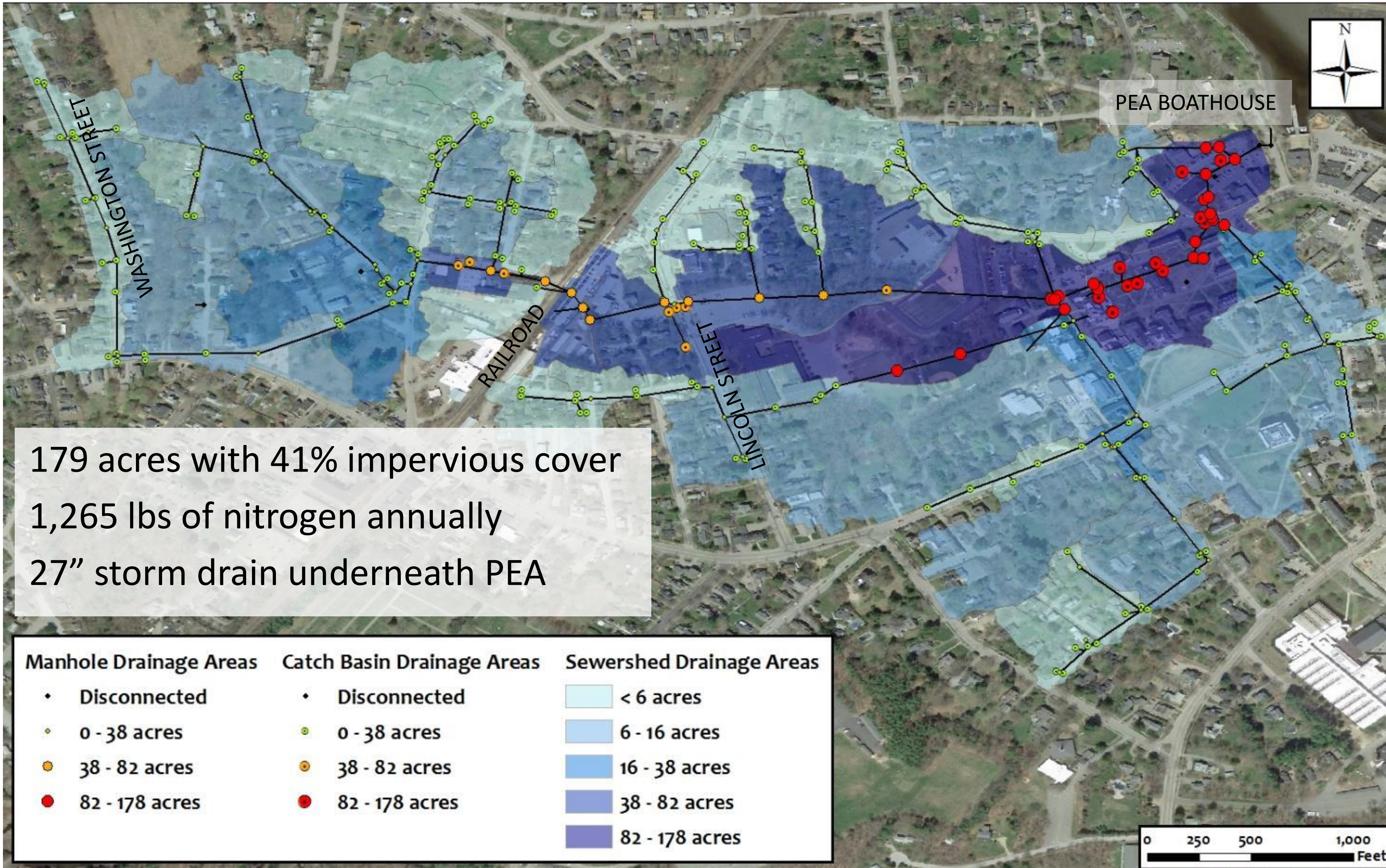
3. Project Design

4. Nutrient and Flooding Reduction

HAZUS
EARTHQUAKE • WIND • FLOOD • TSUNAMI

5. HAZUS Damage Costing

WATERSHED CHARACTERISTICS



STORMWATER RETROFIT OPPORTUNITIES

- Annual Nitrogen from the 179-acre watershed = 1,265 lbs.
- 14 identified green infrastructure retrofit opportunities
- BMPs to reduce Nitrogen by 76% or 691 pounds annually.
- Retrofit unit costs averaged $1,000 and ranged from $498 - $5,080 per pound of Nitrogen in comparison with $1,200 for the new wastewater facility
- Estimated cost to implement GI retrofits = $689,000.

Rain Garden

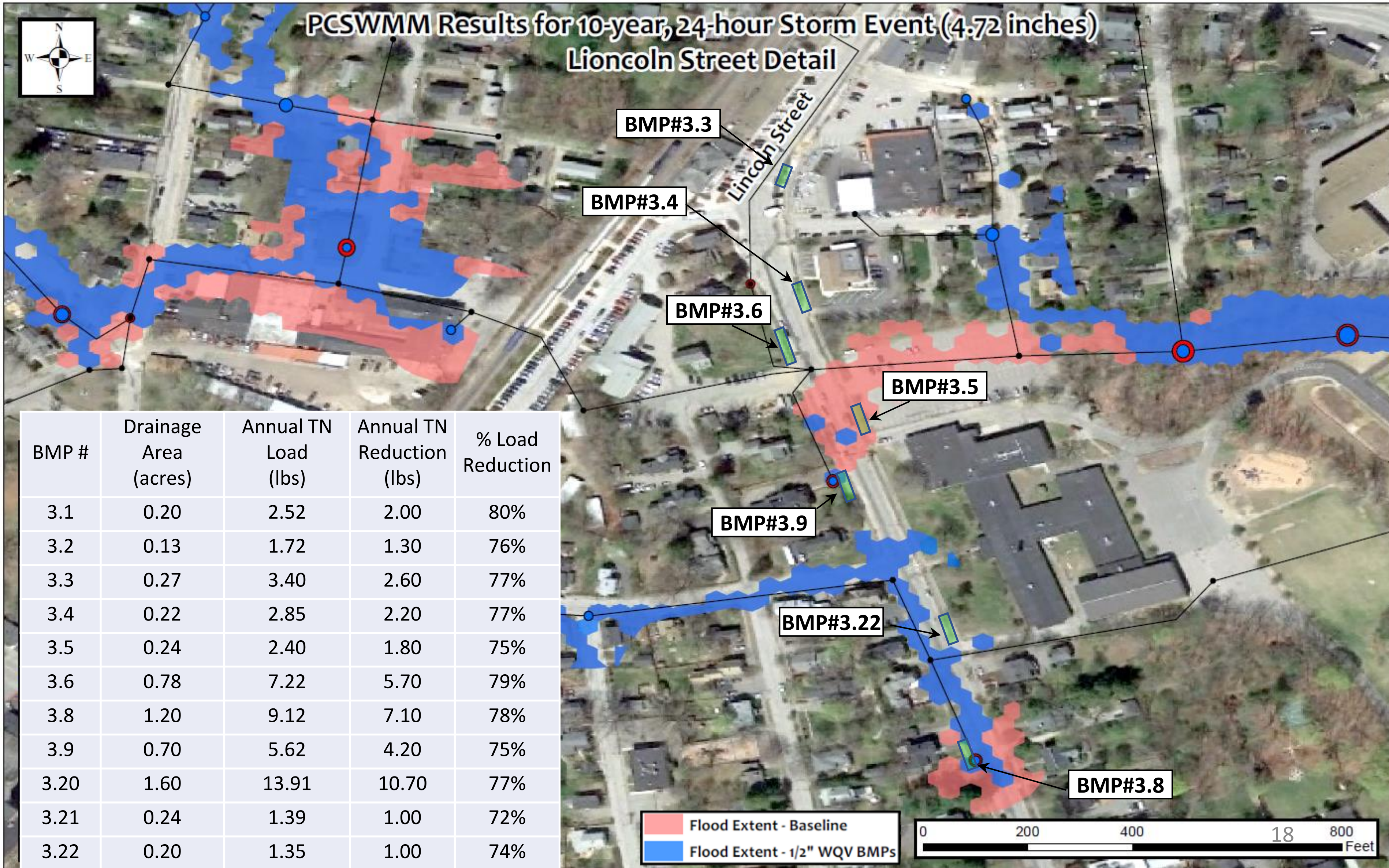
Tree Filter

FLOOD REDUCTION FROM GREEN INFRASTRUCTURE

Modeled Flood Impacts
for 2018, and 2040 With and Without Green Infrastructure

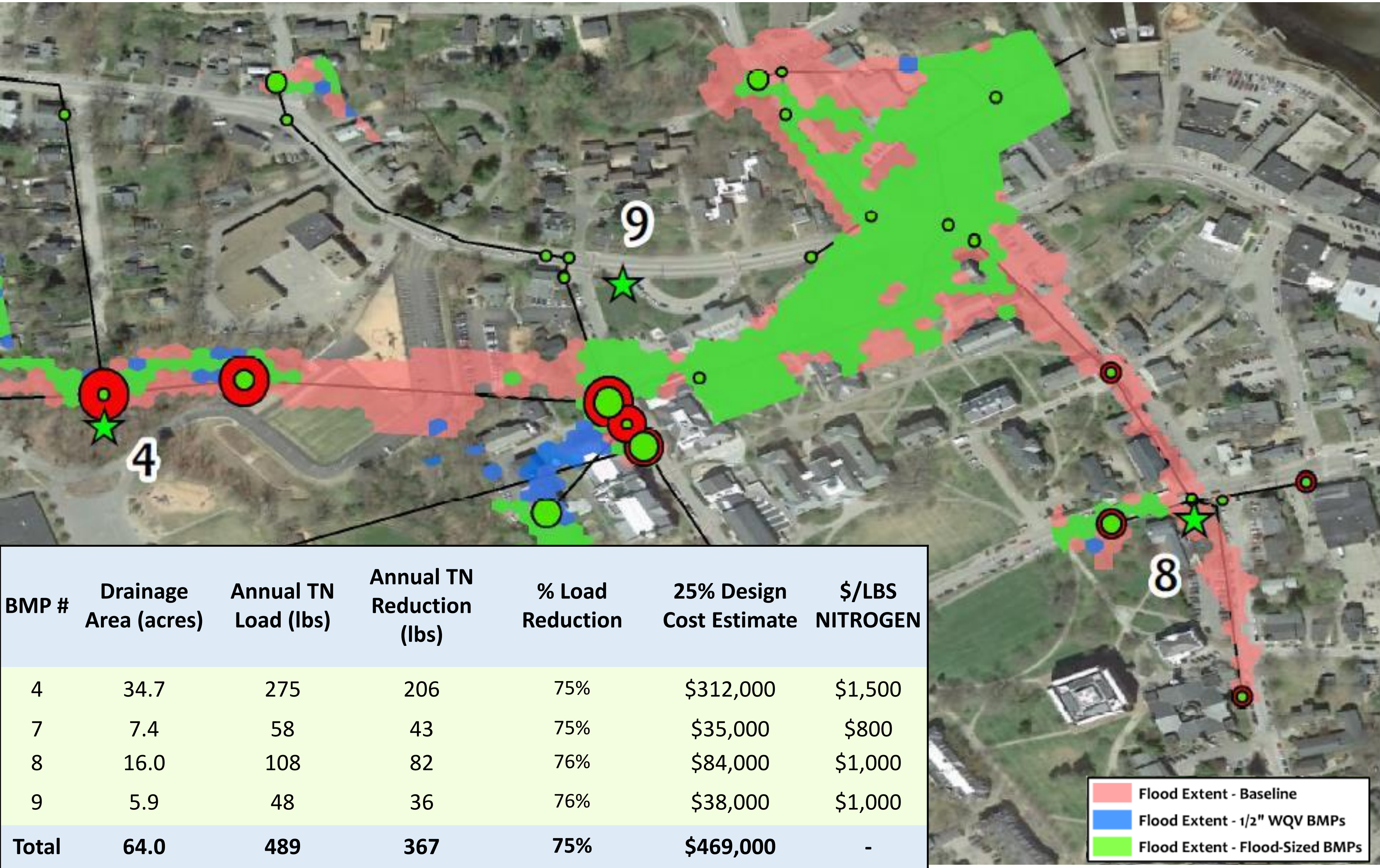
- **Flood reduction by GI = 60% for 10-year storm, current**
- **Flood reduction by GI = 50% for the 10-year storm in 2040 with 9.21 feet of storm surge.**

FLOODING AND NITROGEN LOAD REDUCTION – LINCOLN ST



BMP #	Drainage Area (acres)	Annual TN Load (lbs)	Annual TN Reduction (lbs)	% Load Reduction
3.1	0.20	2.52	2.00	80%
3.2	0.13	1.72	1.30	76%
3.3	0.27	3.40	2.60	77%
3.4	0.22	2.85	2.20	77%
3.5	0.24	2.40	1.80	75%
3.6	0.78	7.22	5.70	79%
3.8	1.20	9.12	7.10	78%
3.9	0.70	5.62	4.20	75%
3.20	1.60	13.91	10.70	77%
3.21	0.24	1.39	1.00	72%
3.22	0.20	1.35	1.00	74%

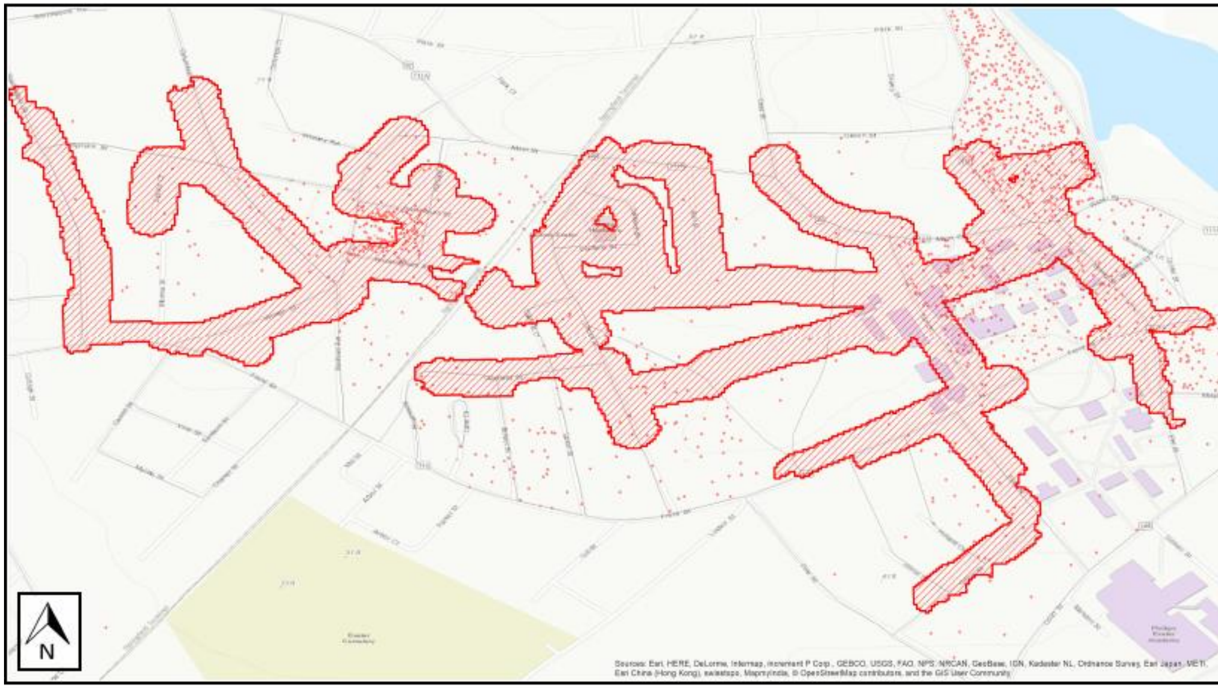
FLOODING AND NITROGEN LOAD REDUCTION – ELM ST, FRONT ST & TAN LANE



BMP #	Drainage Area (acres)	Annual TN Load (lbs)	Annual TN Reduction (lbs)	% Load Reduction	25% Design Cost Estimate	$/LBS NITROGEN
4	34.7	275	206	75%	$312,000	$1,500
7	7.4	58	43	75%	$35,000	$800
8	16.0	108	82	76%	$84,000	$1,000
9	5.9	48	36	76%	$38,000	$1,000
Total	**64.0**	**489**	**367**	**75%**	**$469,000**	**-**

HAZUS Analysis and Damage Cost Avoidance

Total Economic Loss (1 dot = $300K) Overview Map



FEMA

HAZUS
EARTHQUAKE • WIND • FLOOD • TSUNAMI

ECONOMIC BENEFITS OF FLOOD AVOIDANCE

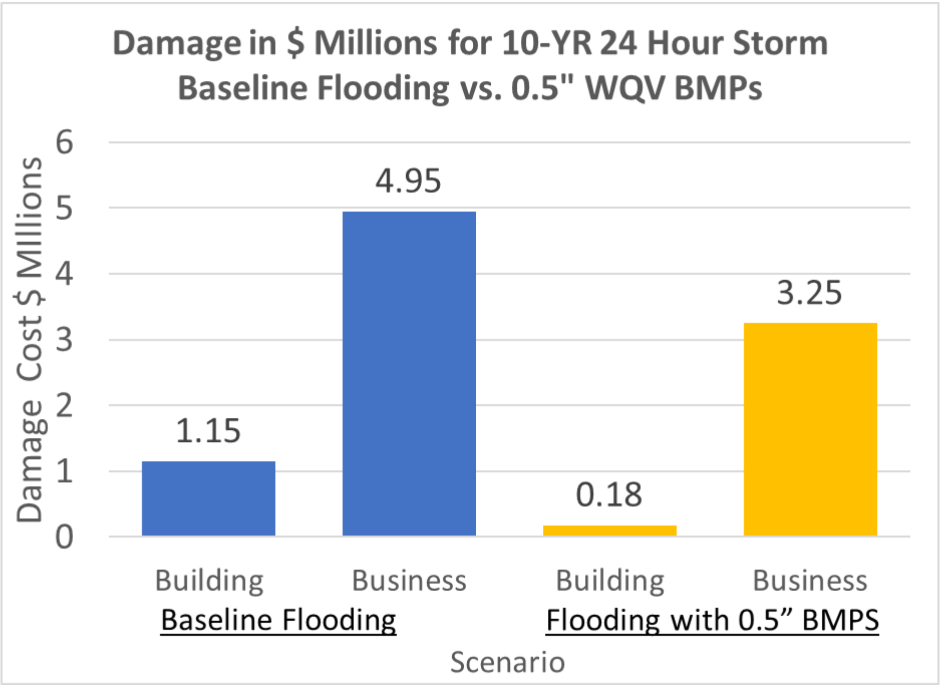
Photo: Flooding at Exeter Town Landing March 2018 Nor'easter

1. The estimated flood loss from a current 10-year storm is $6.11 million or $3.43 million with green infrastructure, a 51% reduction.

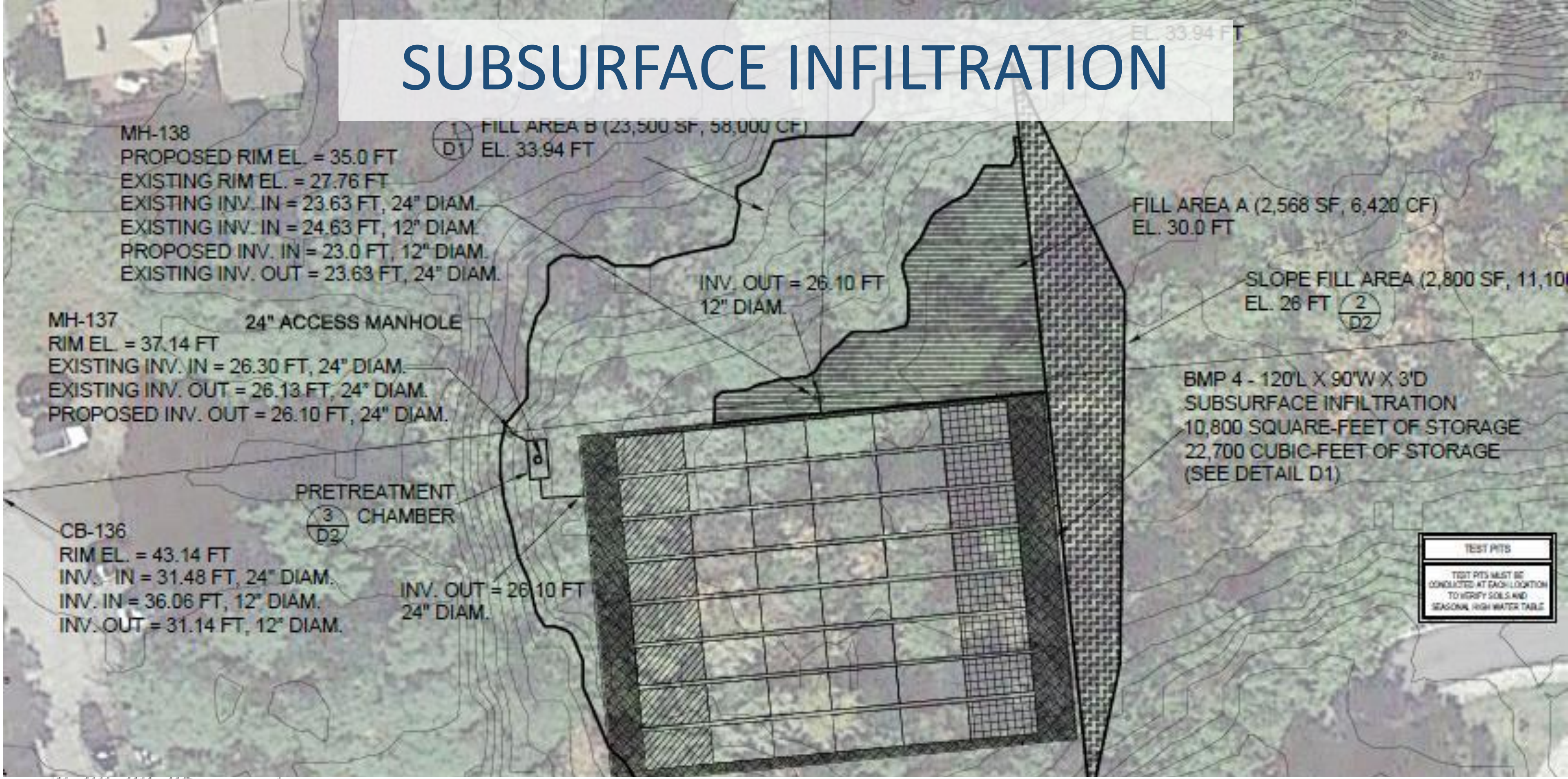
2. The total estimated cost to implement green infrastructure at 14 sites is $689,000.

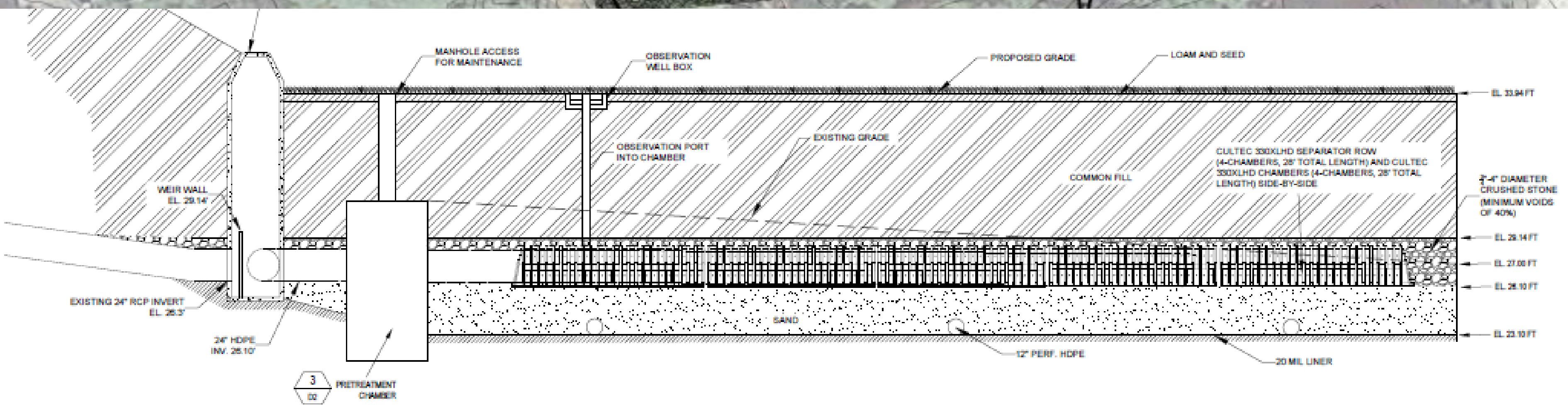
3. This benefit is from small sized Best Management Practices that provide water quality and flood protection for a 0.5" storm, the most frequent annual rainfall event.

Economic Impact Analysis of Flood Damage Avoidance With Implementation Of Green Infrastructure

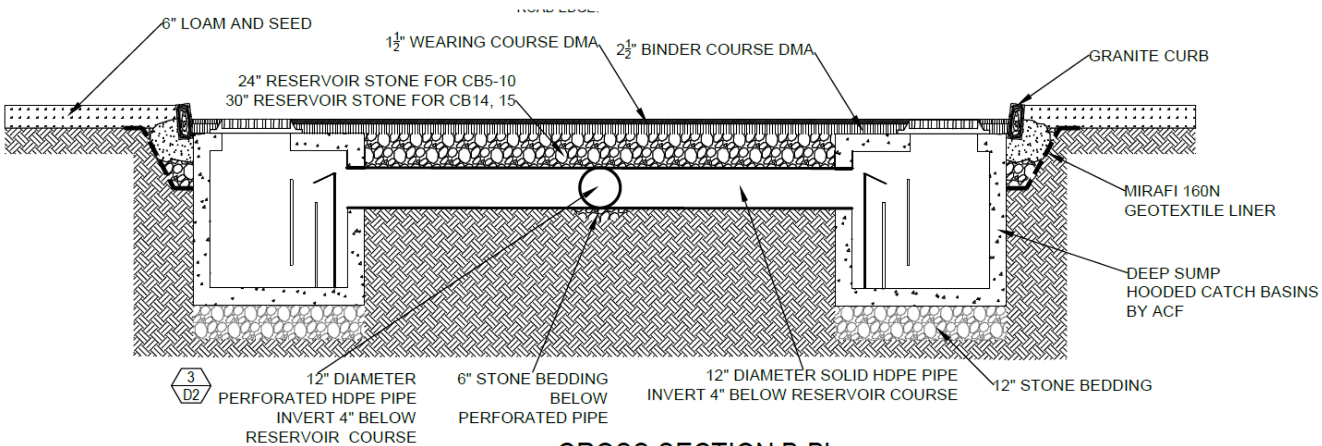


SUBSURFACE INFILTRATION





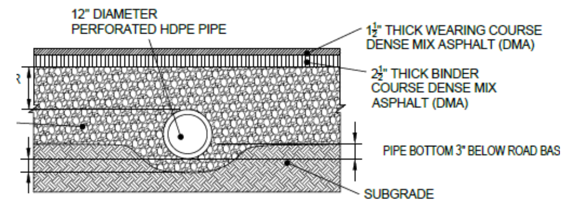
Infiltration Examples



CROSS SECTION B-B'

2 D2 INFILTRATION SYSTEM WITH DEEP SUMP HOODED CATCH BASIN (CB5-10, 14, 15)

NOT TO SCALE



12" PERFORATED PIPE STONE BEDDING DETAIL (CB5-10, 14, 15)

NOT TO SCALE

INFILTRATION TRENCH WITH PRETX CATCHBASINS

BIOSWALE WITH PRETX CATCHBASINS

RIGHT-OF-WAY INFILTRATION

- SHALLOW DEPTH GRASSED BIOSWALES ARE EASY TO MAINTAIN
- CAN BE LOCATED EASILY WITHIN EXISTING RIGHT-OF-WAY
- CONNECTED TO EXISTING DRAINAGE INFRASTRUCTURE
- RELATIVELY LOW COST

POTENTIAL APPLICATIONS

BIOSWALE

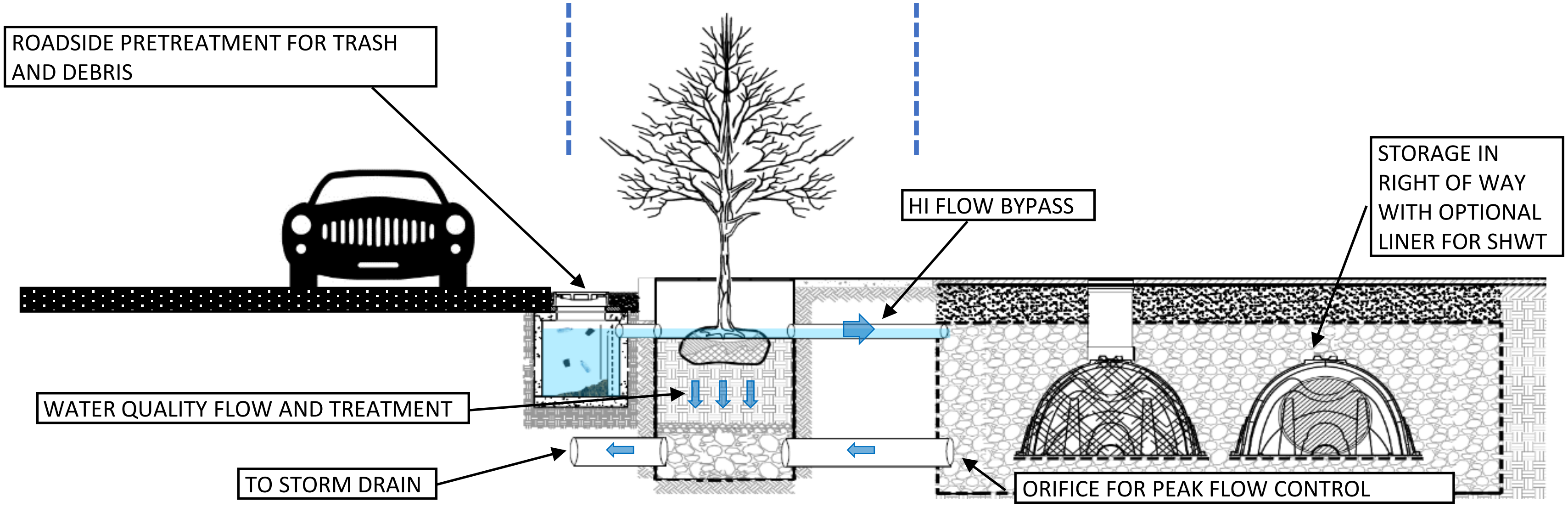
TREE PLANTERS

Flood Control Applications

1. PRETREATMENT FOR MAINTENANCE

2. BIOFILTER FOR WATER QUALITY

3. STORAGE FOR PEAK AND VOLUME REDUCTION

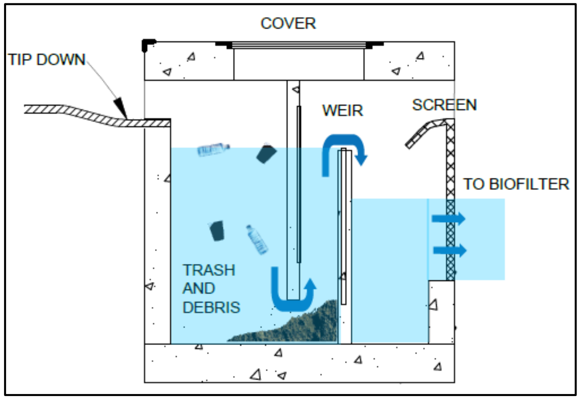


Low Maintenance Asset Management With Pretreatment

- In urban environments return on investment may be 1-2 years
- Goal is to use existing staff, equipment for standard catch basin cleaning
- Land-use and trash and debris load
- Aesthetics
- Cost to maintain versus cost of pretreatment

Condition Shortly After Install

Anderson Street Bioswale



PRETX - Curb by ACF

Condition After Winter

SOURCE: NYC OFFICE OF GREEN INFRASTRUCTURE

Table 7: Engineering Cost Estimates for BMPs 1, 2, 3, 4, 5, 7, 8 and 9

LOCATION	BMP #	DRAINAGE AREA (ACRES)	ANNUAL TN REDUCTION (LBS)	% LOAD REDUCTION	95% DESIGN COST ESTIMATE	$/LBS NITROGEN
WINTER STREET	1	12.9	68.2	76%	$45,900	$680
	2	24.6	120.2	76%	$79,000	$660
Subtotal	-	**37.4**	**188.4**	**76%**	**$124,900**	-
LINCOLN STREET NORTH	3.1	0.2	2.0	80%	$8,000	$4,000
	3.2	0.1	1.3	76%	$6,600	$5,080
	3.3	0.3	2.6	77%	$12,000	$4,620
	3.4	0.2	2.2	77%	$9,900	$4,500
	3.5	0.2	1.8	75%	$7,000	$3,890
	3.6	0.8	5.7	79%	$21,800	$3,830
	3.8	1.2	7.1	78%	$22,000	$3,100
	3.9	0.7	4.2	75%	$13,600	$3,240
	3.22	0.2	1.0	77%	$3,000	$3,000
Subtotal	-	**3.9**	**27.9**	**77%**	**$103,900**	-
LINCOLN STREET SOUTH	3.20	1.6	10.7	77%	$33,000	$3,090
	3.21	0.2	1.0	72%	$2,800	$2,800
Subtotal	-	**1.8**	**11.7**	**76%**	**$35,800**	-
FRONT STREET	5	20.3	71.7	52%	$45,200	$640
PHASE 2	4	32.43	230	90%	$259,900	$1,130
	7	7.41	7	12%	$33,100	$4,560
	8	15.99	107	99%	$53,500	$500
	9	5.86	47	99%	$33,600	$700
Subtotal	-	**61.7**	**391**	**83%**	**$380,000**	**$970**
Total	-	**125**	**691**	**76%**	**$689,825**	-

1. **The estimated flood loss from a current 10-year storm is $6.11 million or $3.43 million with green infrastructure, a 51% reduction.**

2. **The total estimated cost to implement green infrastructure at 14 sites is $689,000.**

Thank you!

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ROCKINGHAM PLANNING COMMISSION

http://www.rpc-nh.org/regional-community-planning/climate-change/exeter-resilience

Living Shorelines in Coastal New Hampshire

Tom Ballestero, Civil & Environmental Engineering
David Burdick, Jackson Estuarine Lab
Gregg Moore, Jackson Estuarine Lab
University of New Hampshire

University of New Hampshire
COASTAL HABITAT
CHART

University of New Hampshire

OUTLINE

- Coastal Risk Factors
  - Why do coasts need protecting?
- Living Shorelines defined
  - Some details of salt marshes
- Regional Efforts to Use Living Shorelines
- Case Studies
- Conclusions

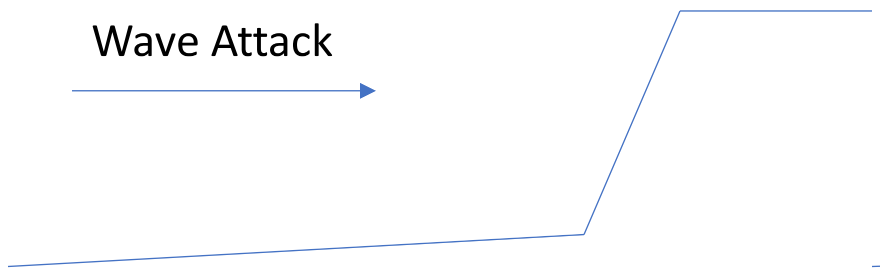
Why do coasts need protection?

- Sea Level
- Surge
- Waves

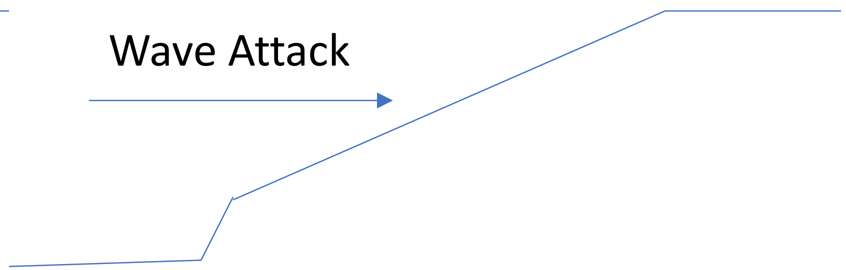
Will Brown, 2017

How Can Living Shorelines Help?

- Longer distance of energy loss - flatter slope
- Vegetation
  - Dissipates wave/surge energy
  - Small wave height reduced 63% by 7 m marsh width (Morgan et al. 2009)
  - Provides habitat



Eroding Shore / Traditional Protection



Living Shoreline Protection

What are Living Shorelines?

A combination of artificial and natural components supported by dynamic physical and biological processes to promote healthy, stabilized shorelines.

Living Shorelines Project at the Edenhouse Boat Ramp, Edenton, NC; ©Tracy Skrabal

Breaking the erosion cycle:

- Erosive forces hit resistant material at steeper slopes
- Erodible, vegetated material at low slopes

Living Shorelines

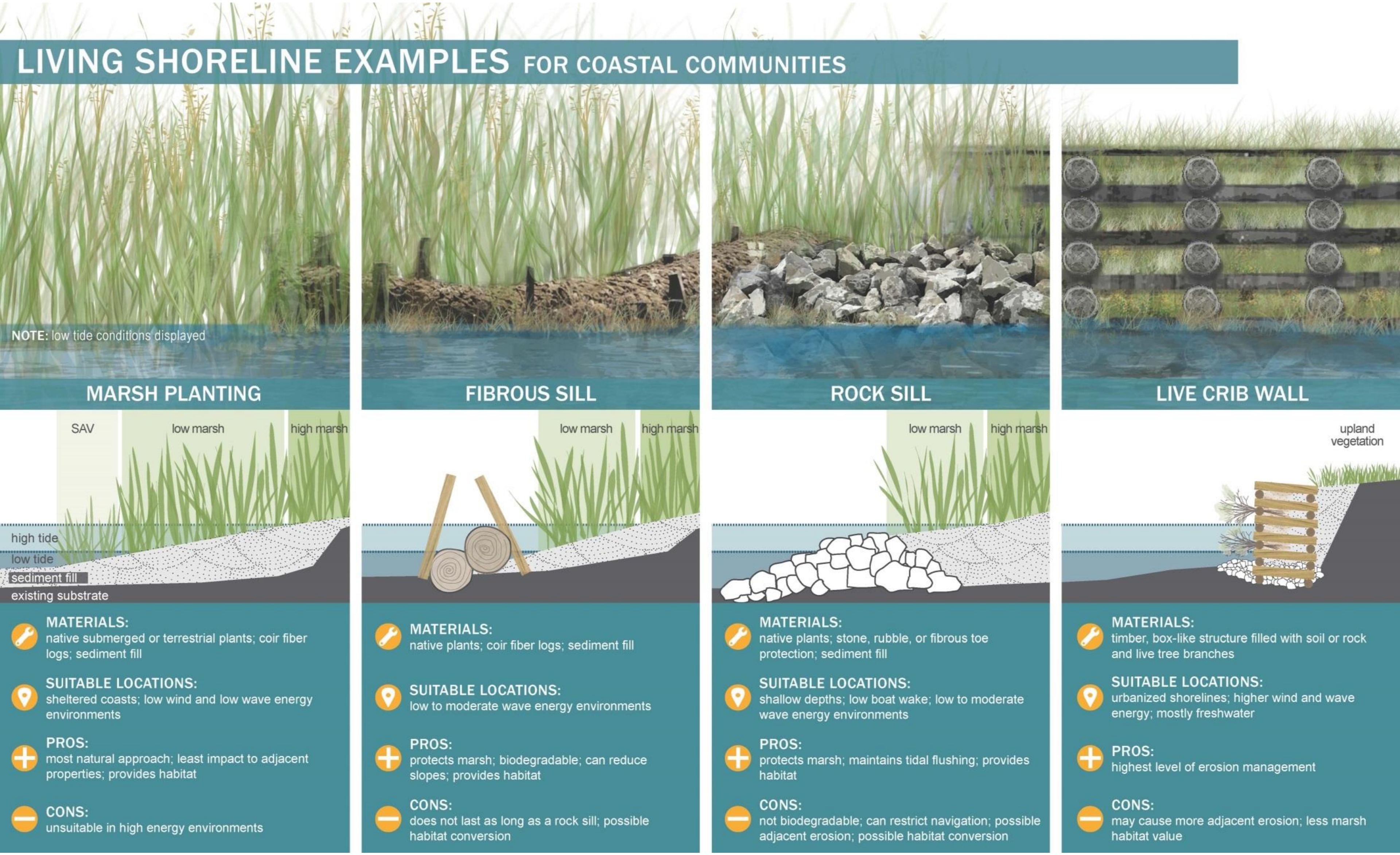
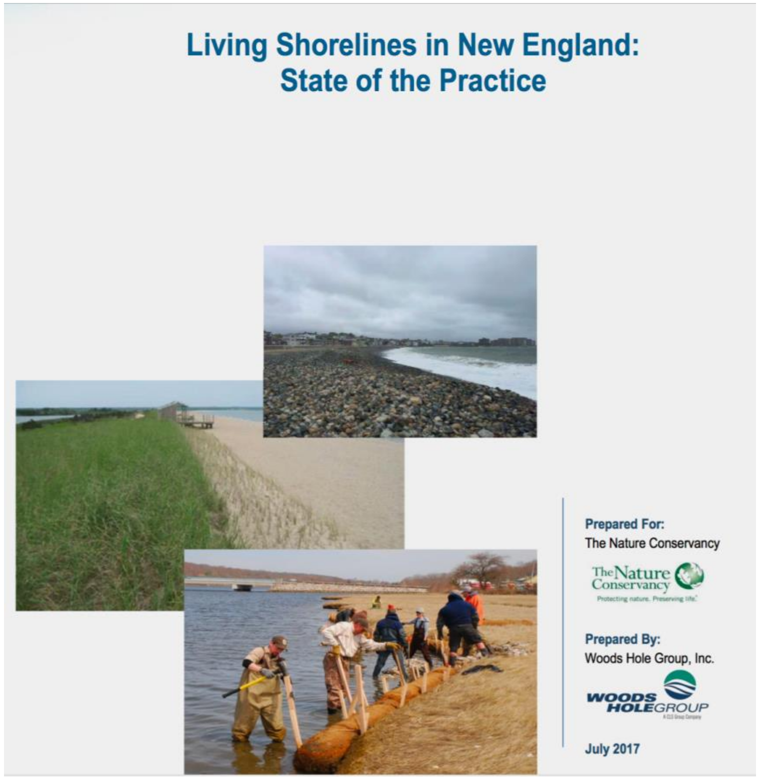


Illustration: Liz Podowski King. Original content: Carolyn LaBarbiera and Liz Podowski King with support from the New York Department of State. Adapted for use by the NHDES Coastal Program.

Regional Efforts

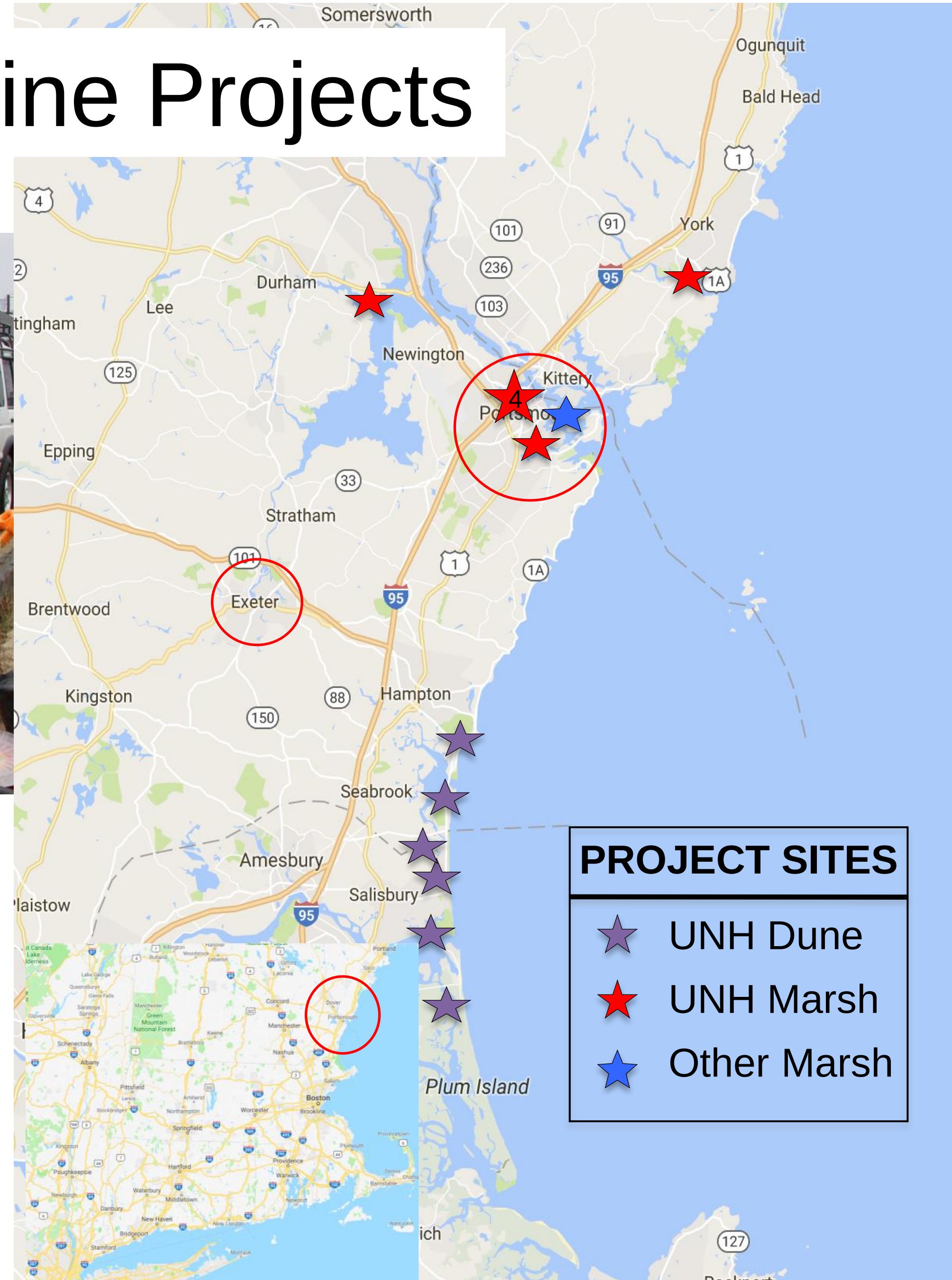
- State of the Practice
  - The Nature Conservancy, Woods Hole Group, NH Coastal Program, UNH, ME Coastal Survey and others
- New Project- All NE States:
  - Define the range of Living Shorelines
  - Implement Several Pilot Projects
  - Identify New England Issues
  - Monitoring Protocols
- Site Suitability Model for Living Shorelines in New Hampshire
  - NOAA Fellow Vidya Balasubramanyam



Challenges of northern shoreline projects

- Low light
- Short growing season
- Large tidal range
- Ice

Local Living Shoreline Projects



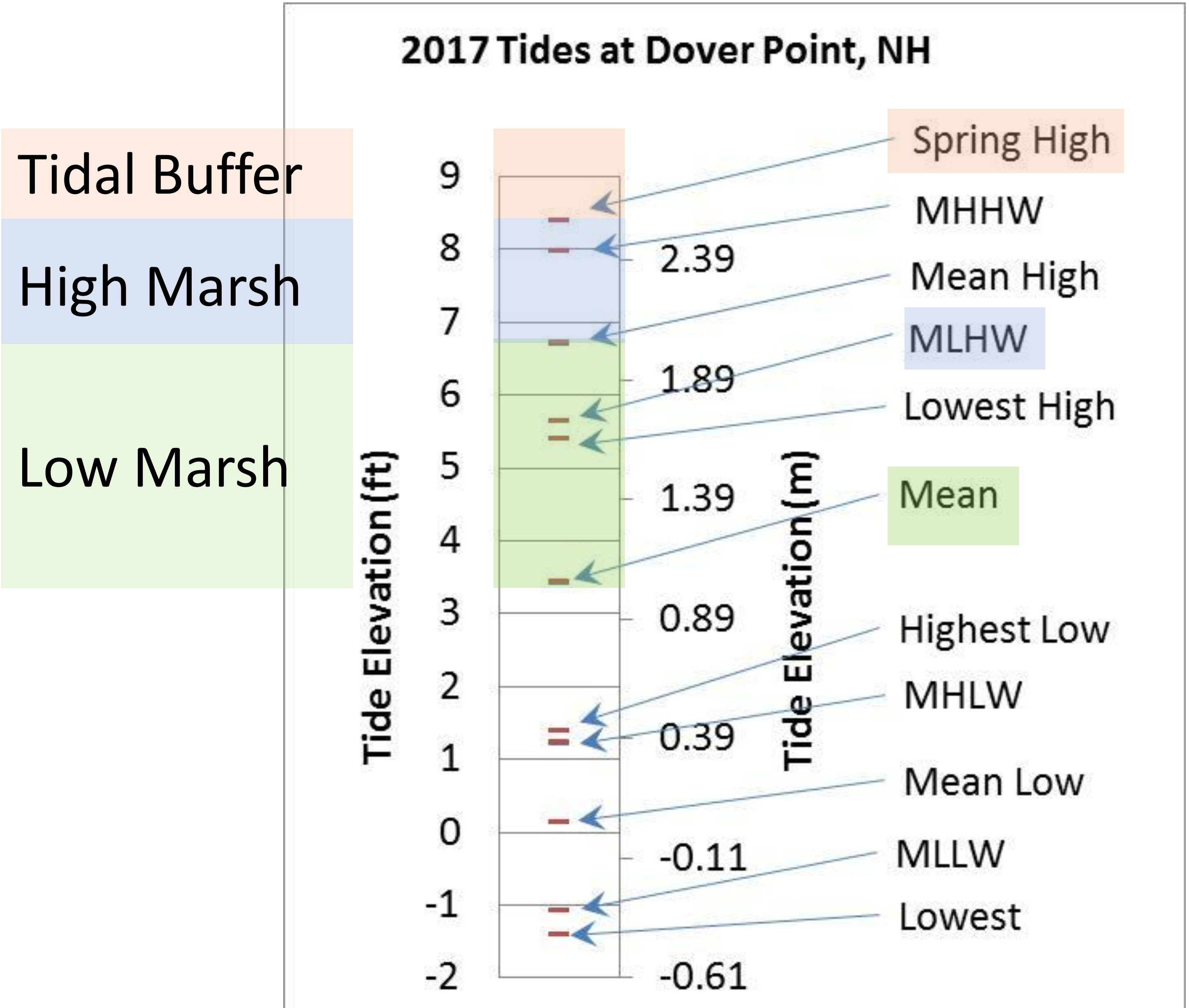
Coastal Habitat Restoration Team: Burdick, Moore, Grizzle, Eberhardt, Ashcraft, Ballestero, Technicians and Students

University of New Hampshire
COASTAL HABITAT RESTORATION TEAM
CHART

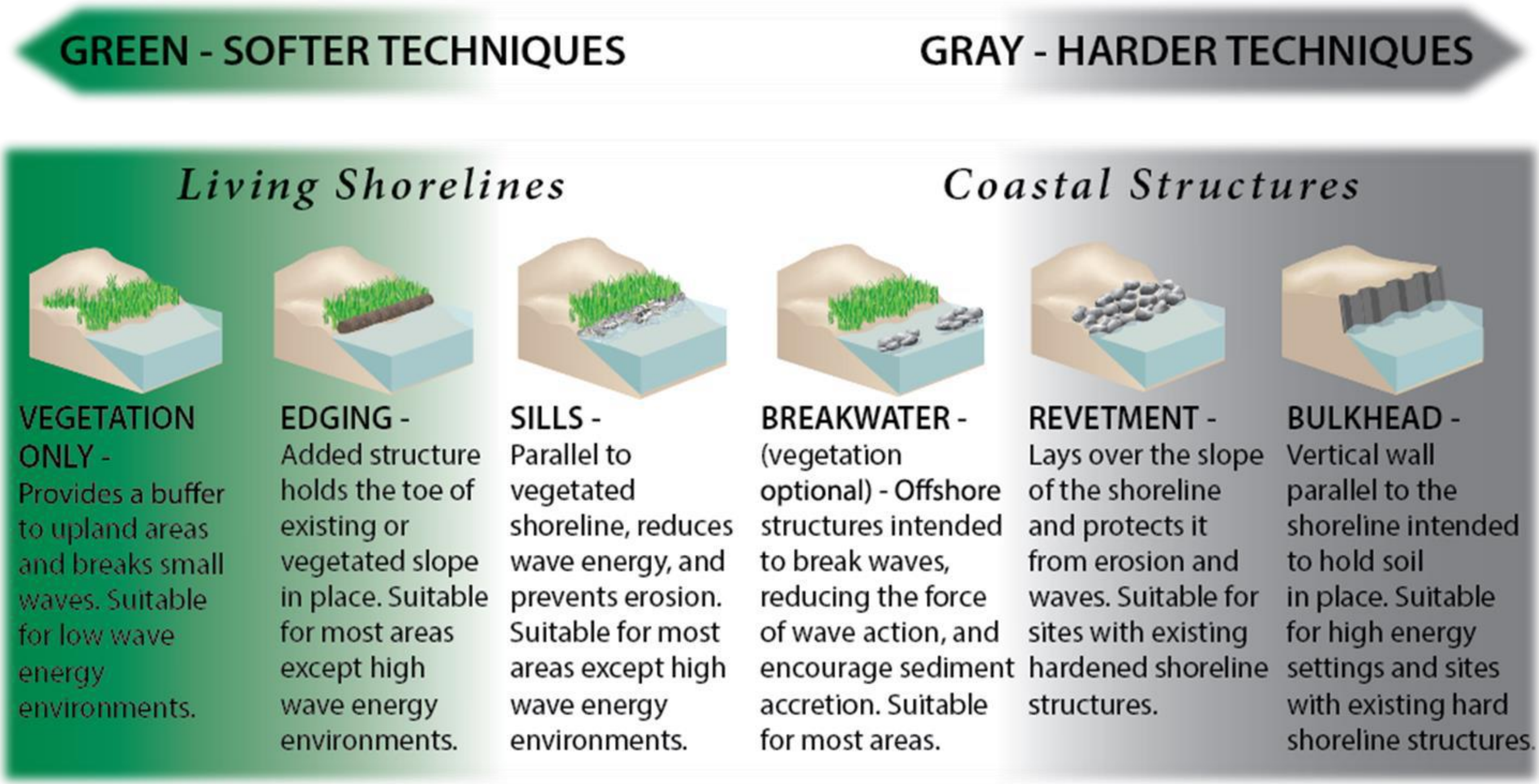
The Case for Building Salt Marshes into Living Shorelines

- Salt marshes are among our most productive and valuable ecosystems
- Loss of 30% of historical salt marshes
- Future for marshes is not bright - SLR/CC
- Created marshes erode EVEN if shoreline protected
  - 1993 salt marsh creation lost 20% of area in five years in North Mill Pond
- Salt marshes protect, survive and heal following storms
  - Gittman et al. 2014

Design Marsh with Plant Zones

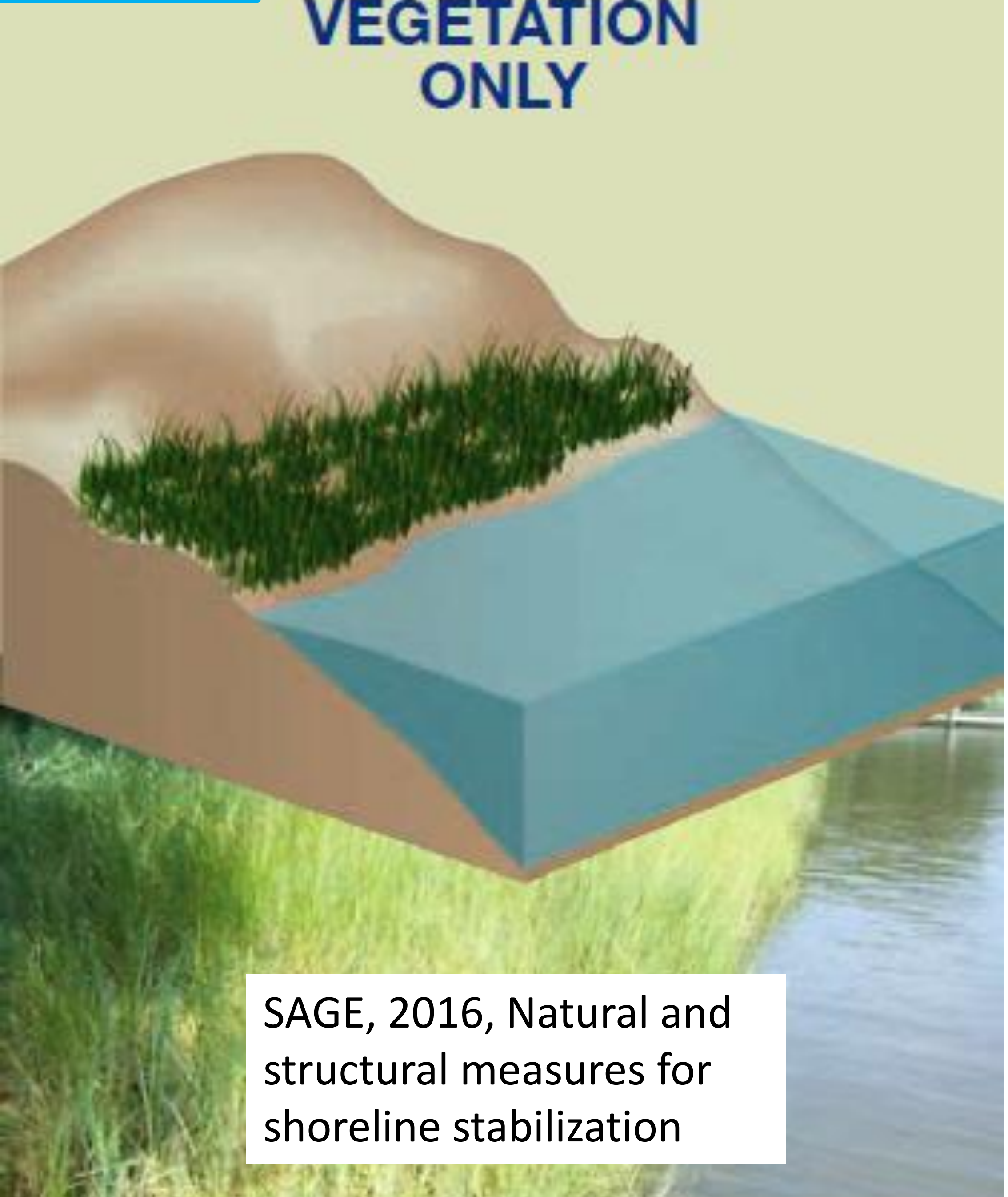


Ranges of Options



Guidance for Considering Use of Living Shorelines, NOAA 2015

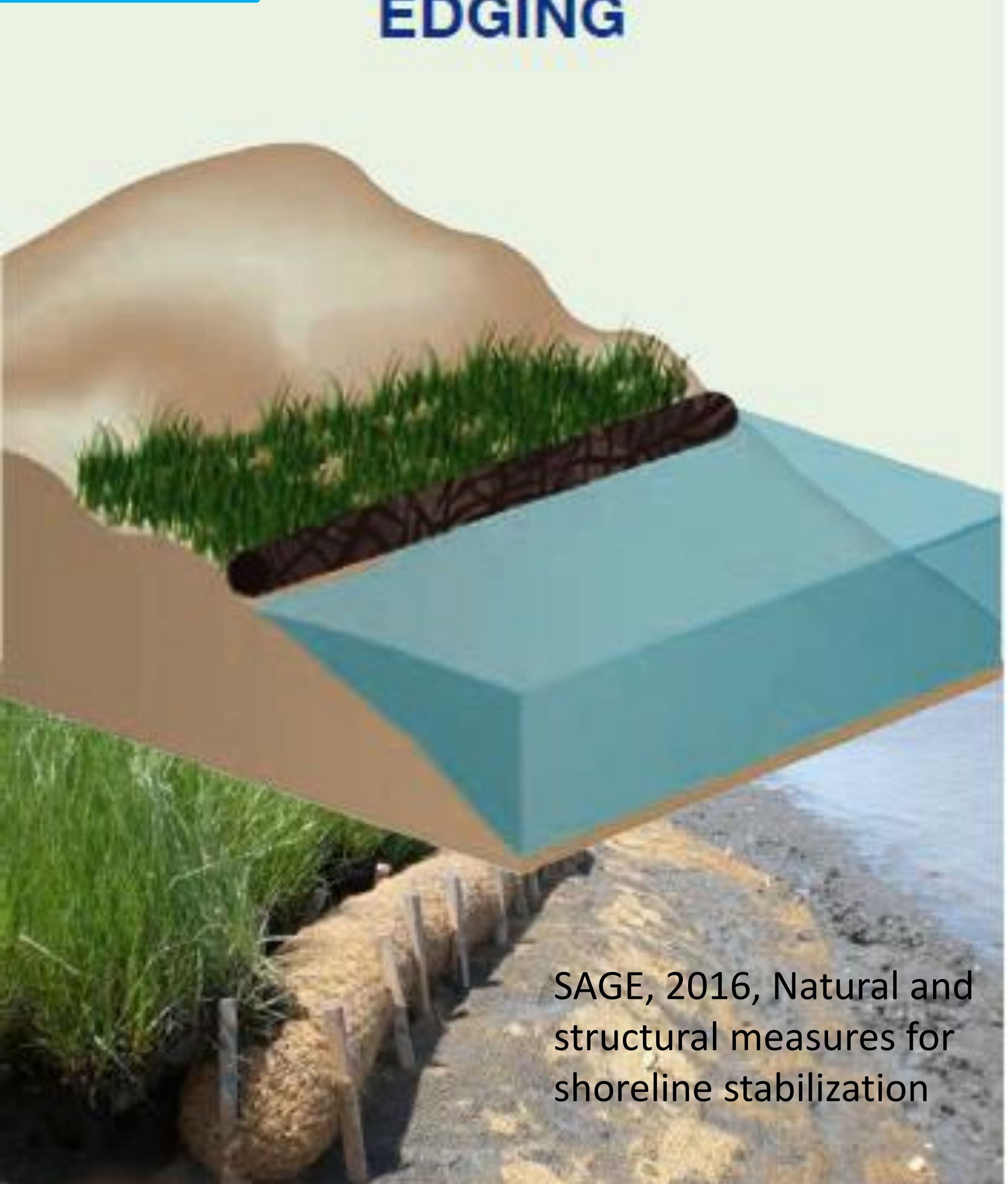
Case Studies



SAGE, 2016, Natural and structural measures for shoreline stabilization

Mill Pond Way berm removal, 2010
North Mill Pond, Portsmouth, NH

Case Studies



SAGE, 2016, Natural and structural measures for shoreline stabilization

Brewster Street Mitigation on North Mill Pond (Stantec)

Portsmouth, NH
North Mill Pond at Brewster St.
Mitigation Implemented in 2016

Pre-existing conditions

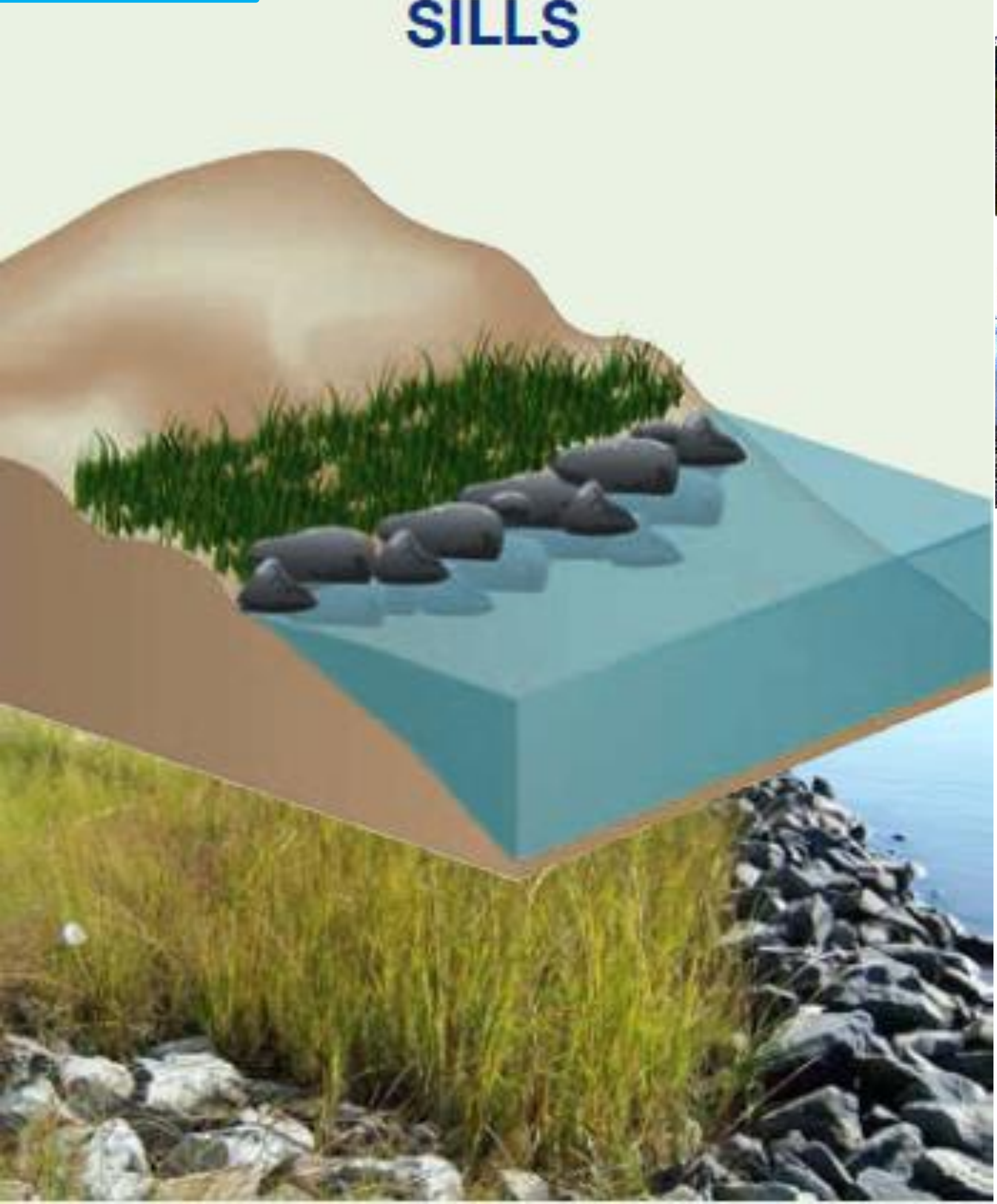
Fill to Designs Grades

Plant With Plugs . . .

and boulders to break up ice

Final Product

Case Studies



Marsh built in South Mill Pond 2001, Portsmouth, in front of seawall and behind sill constructed from existing rocks on site.

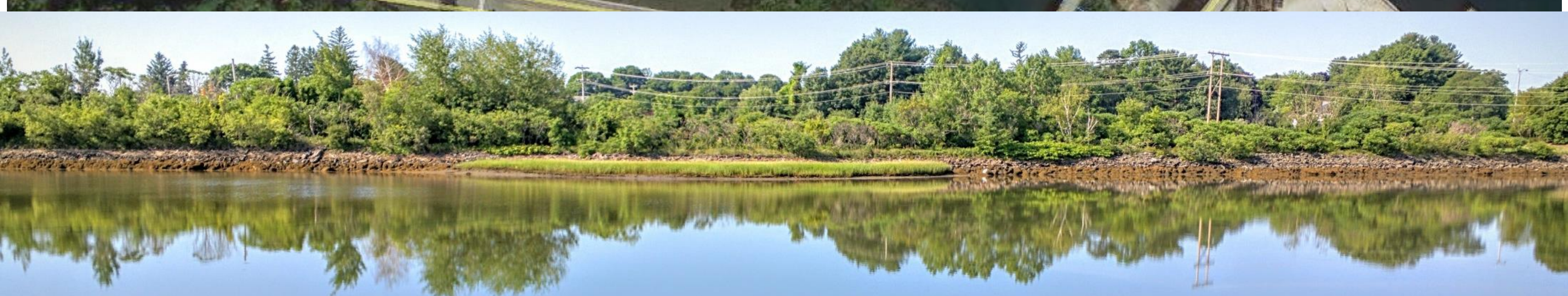
SAGE, 2016, Natural and structural measures for shoreline stabilization

Case Study:
Living Shoreline Marsh with Sill

1) Cutts Cove Portsmouth
   - Designed as restoration of salt marsh
   - Approach is to partially remove rip-rap wall
   - Sill provides a 'climate ready' feature for 2060

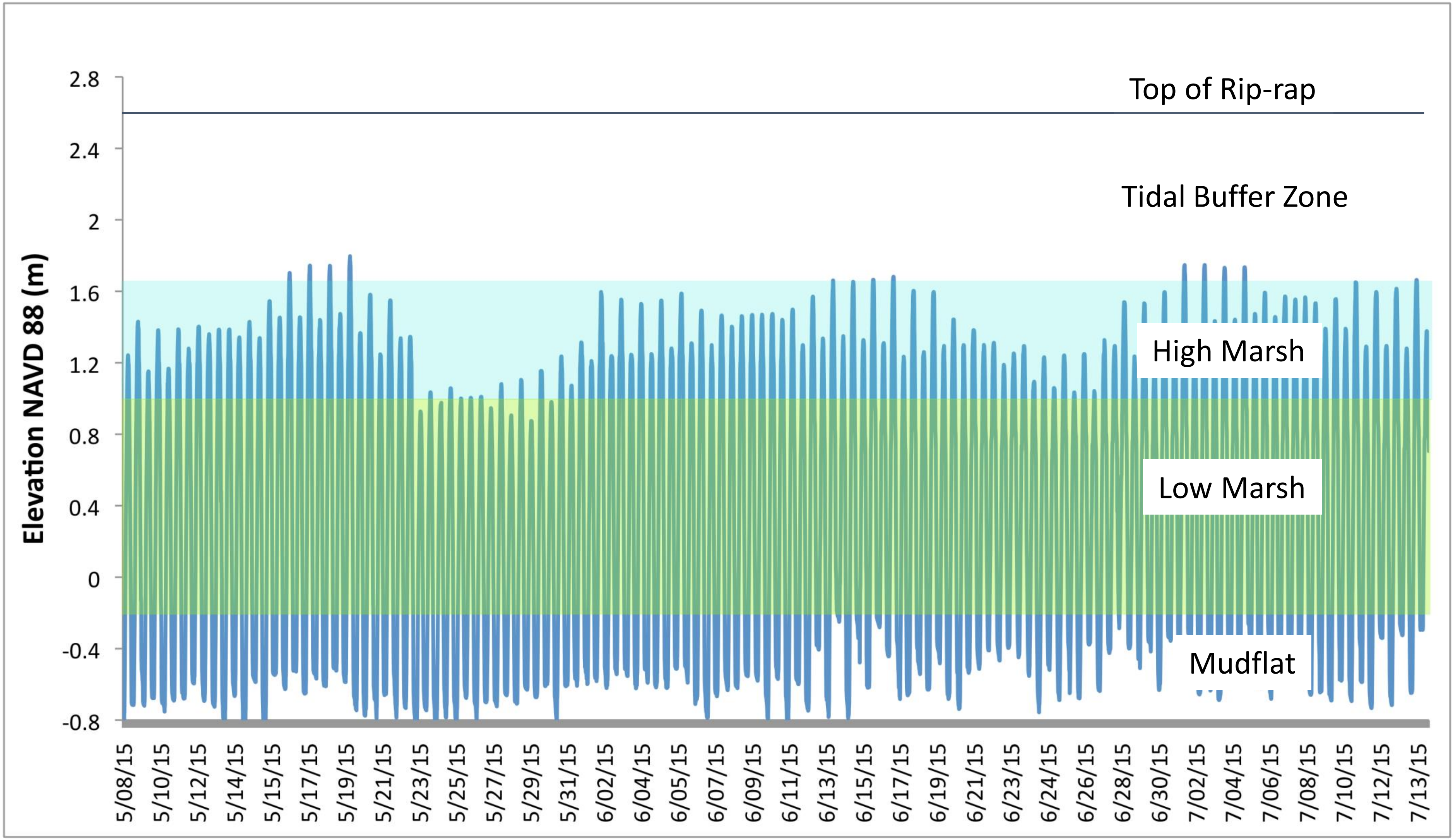
Cutts Cove


95
Forrest St
Cutts Ave
Brigham Ln
Michael Succi Dr
Chase Dr
Sarah Mildred Long Bridge
1

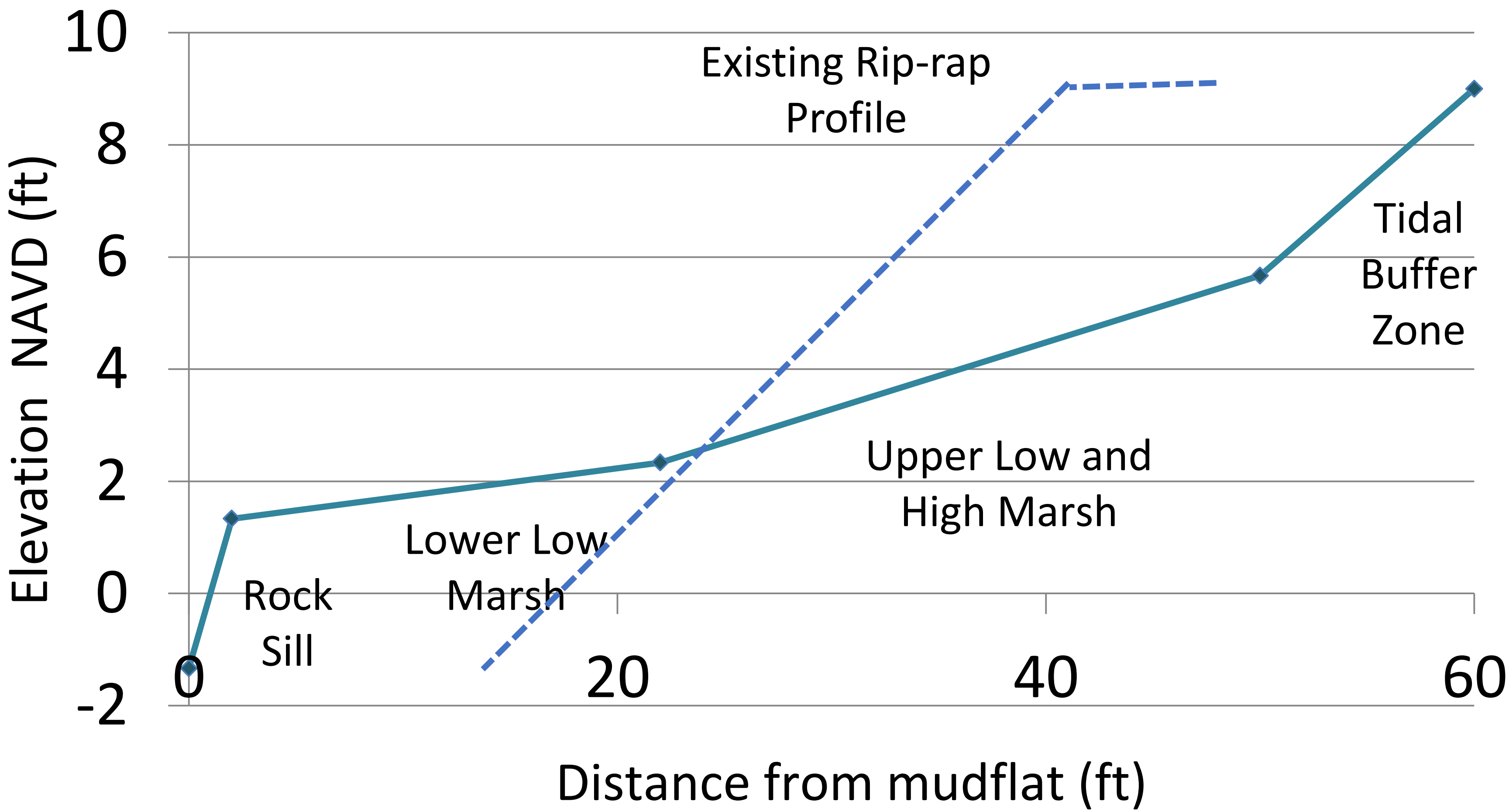


Case Studies

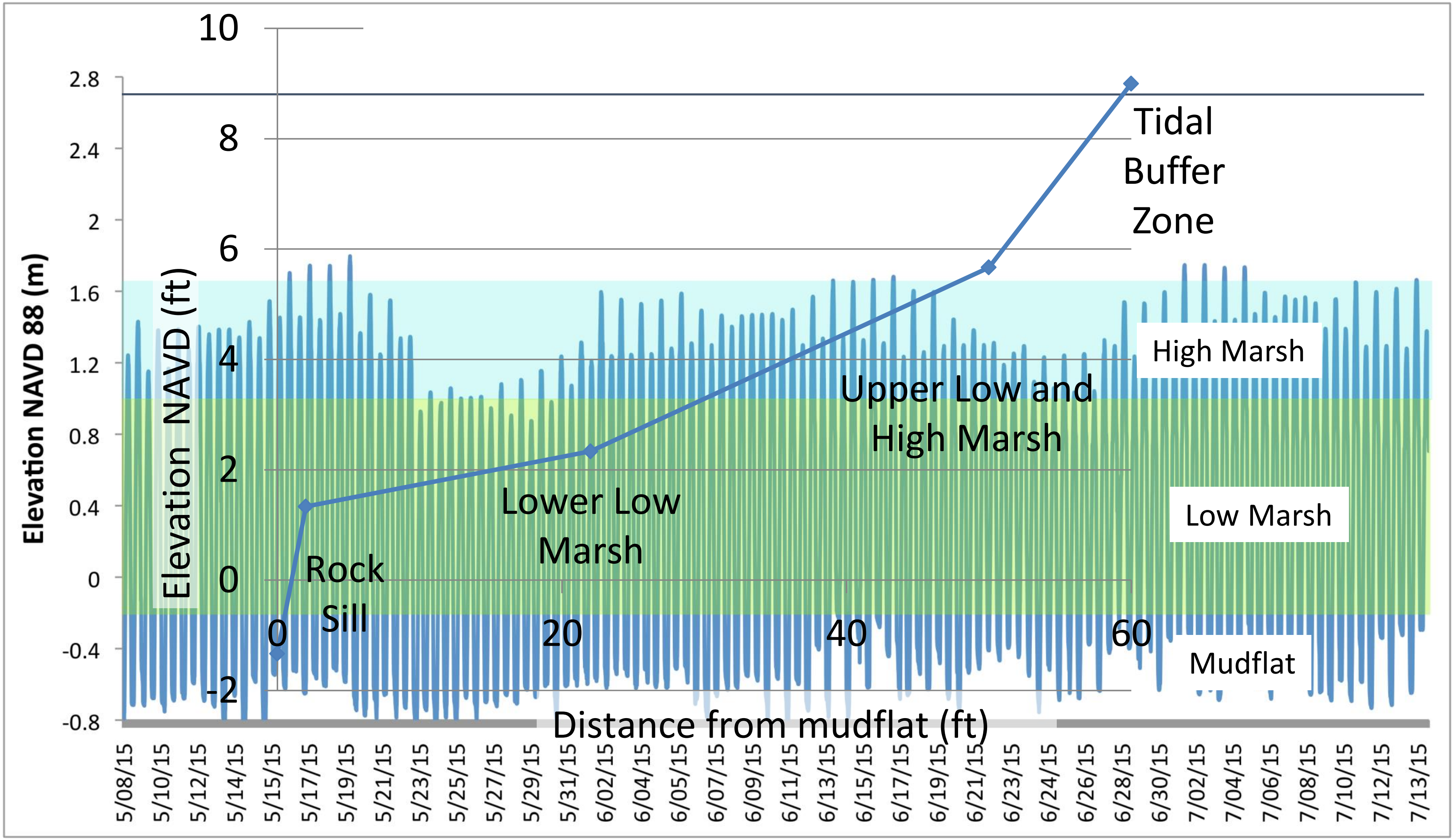
Tides and existing marshes in Cutts Cove



Cutts Cove Profiles and Ecosystems



Tides and existing marshes in Cutts Cove



Construction Sequence

Clear and Grub

Flatten rip-rap wall and build stone edge

Construction Sequence

Clear and Grub

Flatten rip-rap wall and build stone edge

Backfill with sandy silt to elevation

Planting and Maintenance

Measures of Success

- Monitoring
  - Erosion
  - Plant establishment and growth
  - Animal use of habitat

Conclusions

- Recognize limited growing season
- Difficulty increases with tidal range and physical exposure to shear stress from waves ***and ice***
- Be prepared to irrigate
- Be aware of conditions that can reduce success: shade & animals (geese, crabs, snails, people)
- Consider management (including people management) at the landscape scale

Questions

- **Please submit questions via the Q&A section (not Chat)**
- **Select to All Panelists.**
- **If we are not able to get to your question today, we will try to address it after the webinar in our general follow up email or you may hear directly from the presenters.**

Join us again in February for:

Innovative Engagement Strategies

Thursday, February 21, 2019 12:00-1:15 PM EST

Struggling to engage stakeholders in outreach events? This session will cover innovative, emergent practices to engage the community. Through best practices and lesson learned, participants will learn the basics of developing an effective climate engagement strategy for their target audiences. This session will cover:

- Tips on developing values based framing;
- Examples of community engagement approaches
- Common communication challenges and how to overcome these challenges based on translated and applied social science research.

Presenter:
Cara Pike, MS
Climate Access

Thank You

Please take the time to fill out the short evaluation for this webinar so we can continue to bring you topics that are most useful for you. An evaluation link has already been emailed to you.

The 2018-19 Webinar Series is generously sponsored by:

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