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

Exeter Resilience Project

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ROCKINGHAM PLANNING COMMISSION

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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.

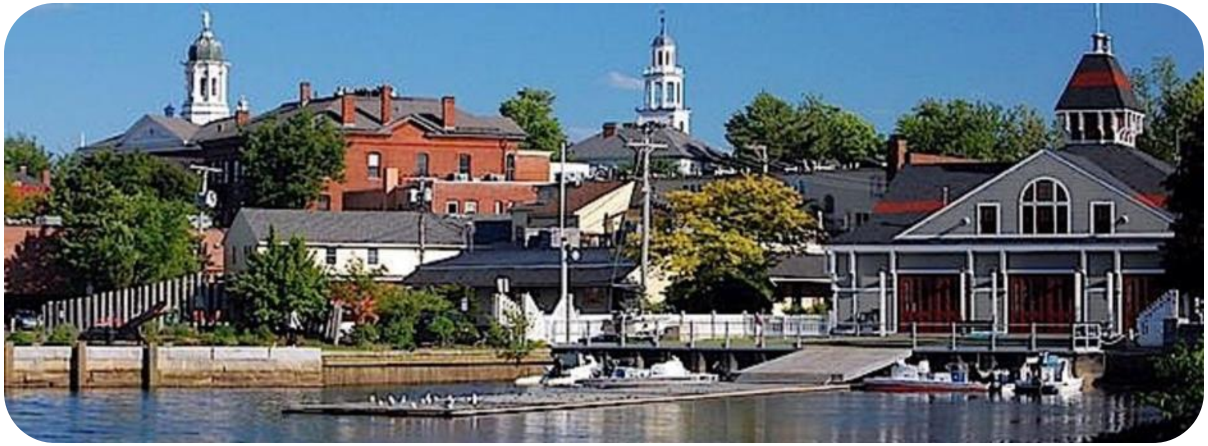
Green Infrastructure and Climate Adaptation

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 improve water quality and avoid stormwater related flood damages.
4. The Exeter Resilience project conducted a cost impact analysis to evaluate the potential for flood damage avoidance with implementation of green infrastructure.
5. 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.

REGIONAL CONTEXT

- In 2009, NHDES concluded that many sub-estuaries in the Great Bay Estuary were impaired by nitrogen, and the Great Bay was placed on the Clean Water Act (CWA) Sec. 303(d) list of impaired and threatened waters (NHDES, 2009).

- New and revised discharge permits in the watershed are now subject to additional nitrogen requirements including the National Pollutant Discharge Elimination System (NPDES) permits for wastewater treatment facilities, and Municipal Separate Storm Sewer Discharge (MS4) permits for stormwater.
- 2017 NH Small MS4 issued, effective in 2018, includes significant new elements such as a focus on illicit discharge detection and elimination, and nutrient management through BMP retrofits.



Innovative Communications

Climate Change – Adaptation - Resilience

Ensuring a Successful Initiative

What is unique about the watershed or area of interest?

What resources are important, prominent, and tell the story?

What is the placed-based connection?

Who are the key stakeholders to engage?

What is the community benefit?

Identify the Audience

Maximize Exposure

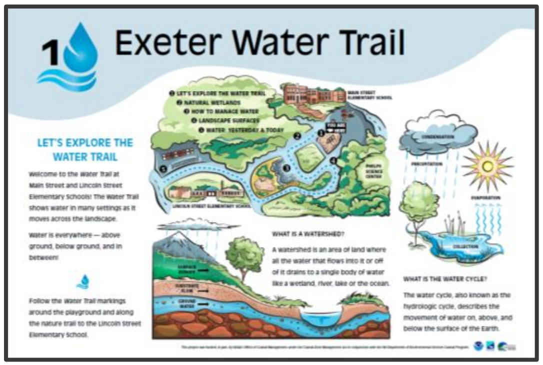
Develop Impactful Message(s)

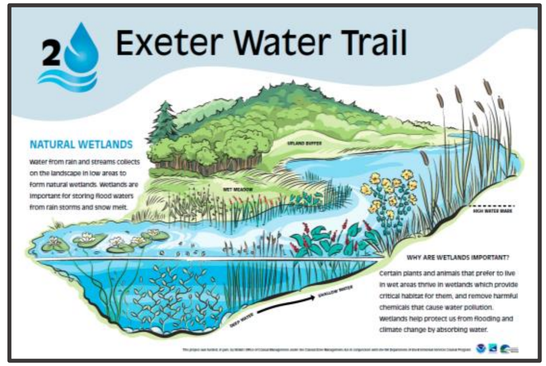
Permanent/Repeatable Installation or Event

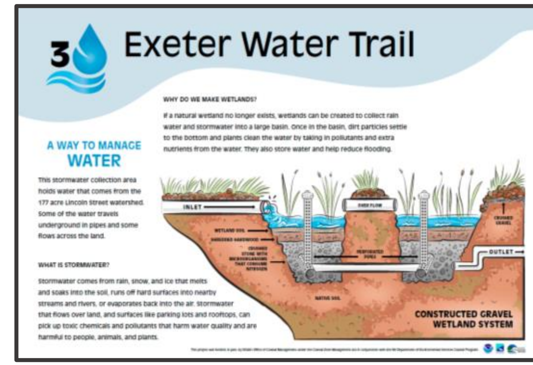
Innovative Communications

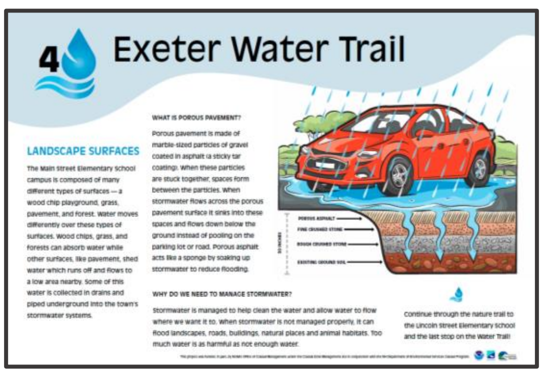
Educational installation at Main Street and Lincoln Street Elementary Schools

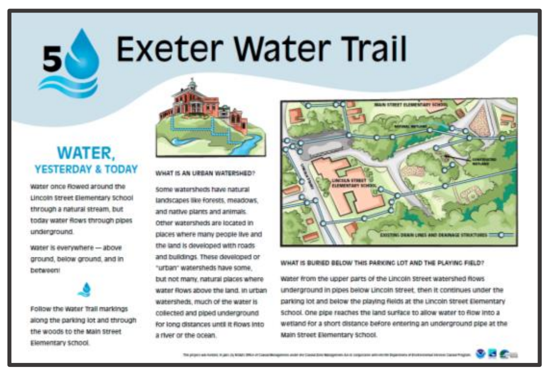
Reaches students Kindergarten through grade 5, yearly reinforcement, workbooks











Water Cycle, Flooding

Surface interactions

Natural Wetlands

Constructed Wetlands

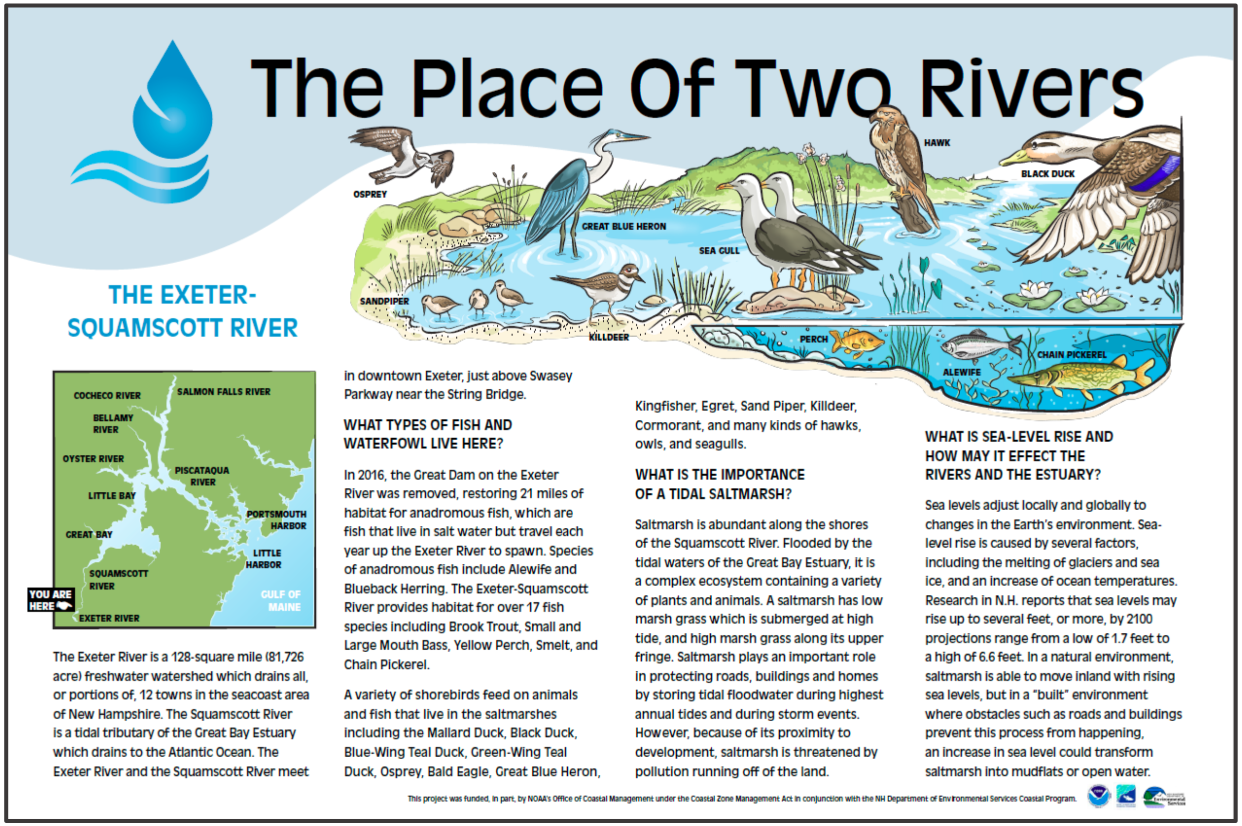
Porous Pavement

Stormwater Management

Innovative Communications

Educational installation at Swasey Parkway, Exeter

Highly Visited Area – Permanent Messaging – Expand with Future Installations



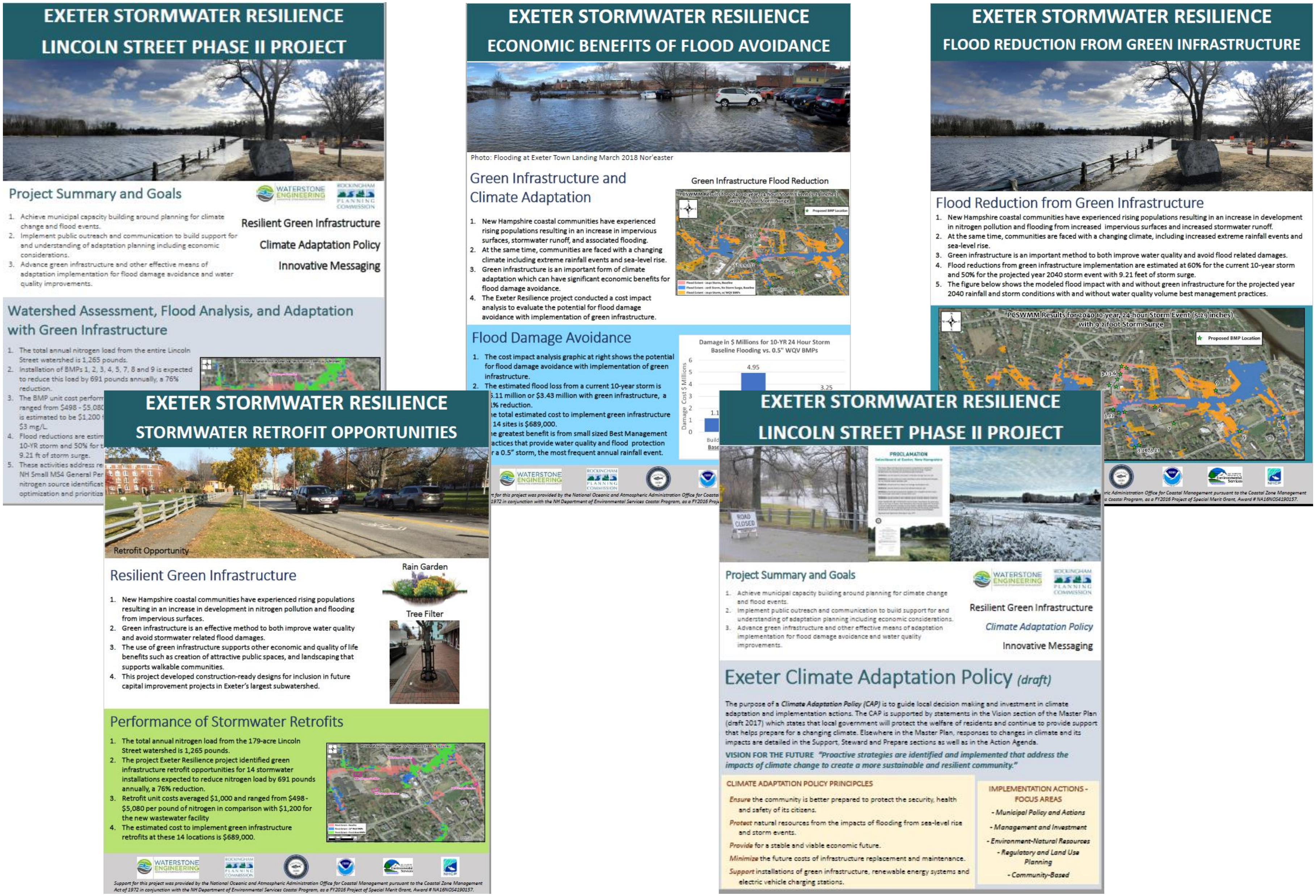
Exeter-Squamscott Rivers

Watershed Facts

Importance of Saltmarsh

Riverine Ecosystems

Impacts of Sea-level Rise


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
PROCLAMATION
ROAD CLOSED
Project Summary and Goals
Resilient Green Infrastructure
Climate Adaptation Policy
Innovative Messaging
Exeter Climate Adaptation Policy (draft)
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)*

Vision Statement

Proactive strategies are identified and implemented that address the impacts of coastal hazards and climate change to create a more sustainable and resilient community.

Purpose

Unified vision, goals, and actions

Guide planning, investment, management, regulations

Support for grants and other funding sources

Living document, informed by best available science/information

Climate Adaptation Policy *(draft)*

Goals

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 renewable energy systems and electric vehicle charging stations.

Municipal Policy and Actions

Management and Investment

Environment-Natural Resources

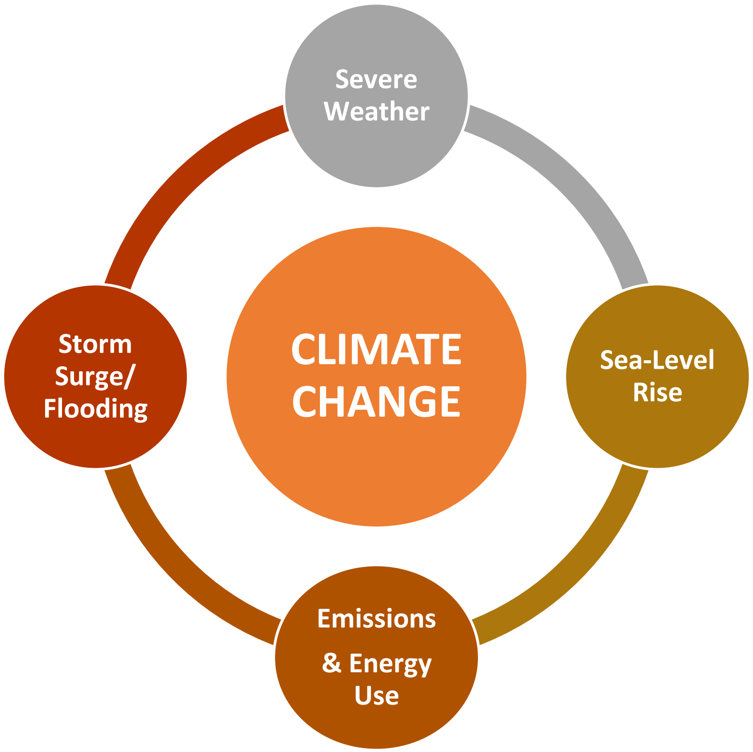
Regulatory and Land Use Planning

Community-Based

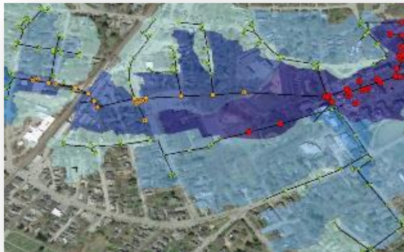
Climate Adaptation Policy *(draft)*

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)

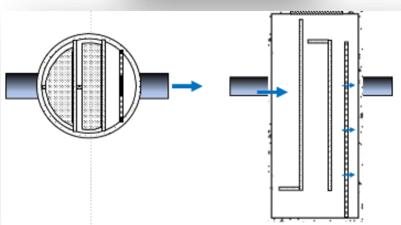


Tasks



1. Watershed Modeling

2. Identify Green Infrastructure Retrofit Locations



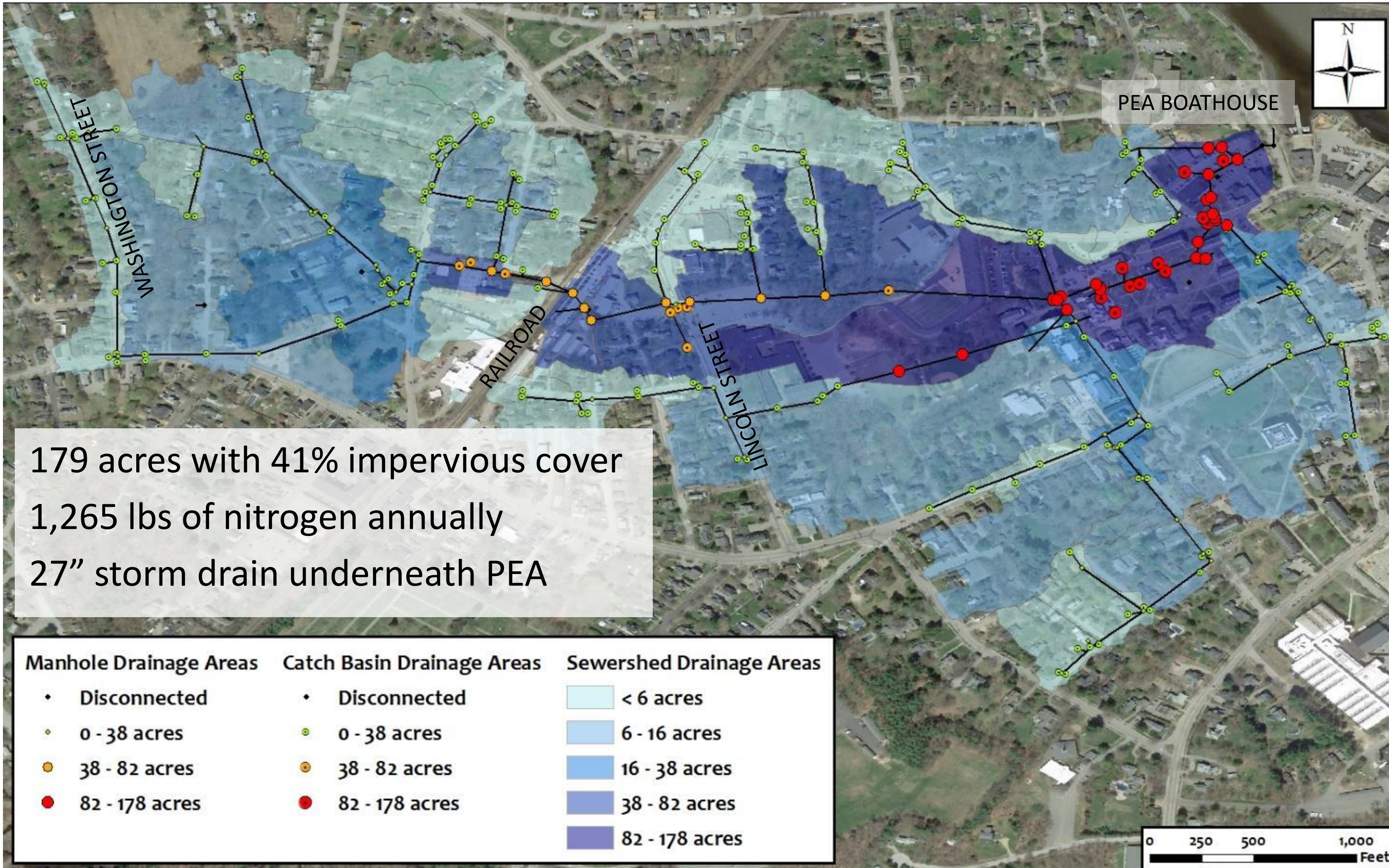
3. Project Design

4. Nutrient and Flooding Reduction

5. HAZUS Damage Costing

Watershed Characteristics

ADD REGIONAL MAP
ANIMATION



179 acres with 41% impervious cover

1,265 lbs of nitrogen annually

27” storm drain underneath PEA

STORMWATER RETROFIT OPPORTUNITIES

Retrofit Opportunity

Rain Garden

1. The total annual nitrogen load from the 179-acre Lincoln Street watershed is 1,265 pounds.

2. The project identified green infrastructure retrofit opportunities for 14 stormwater installations

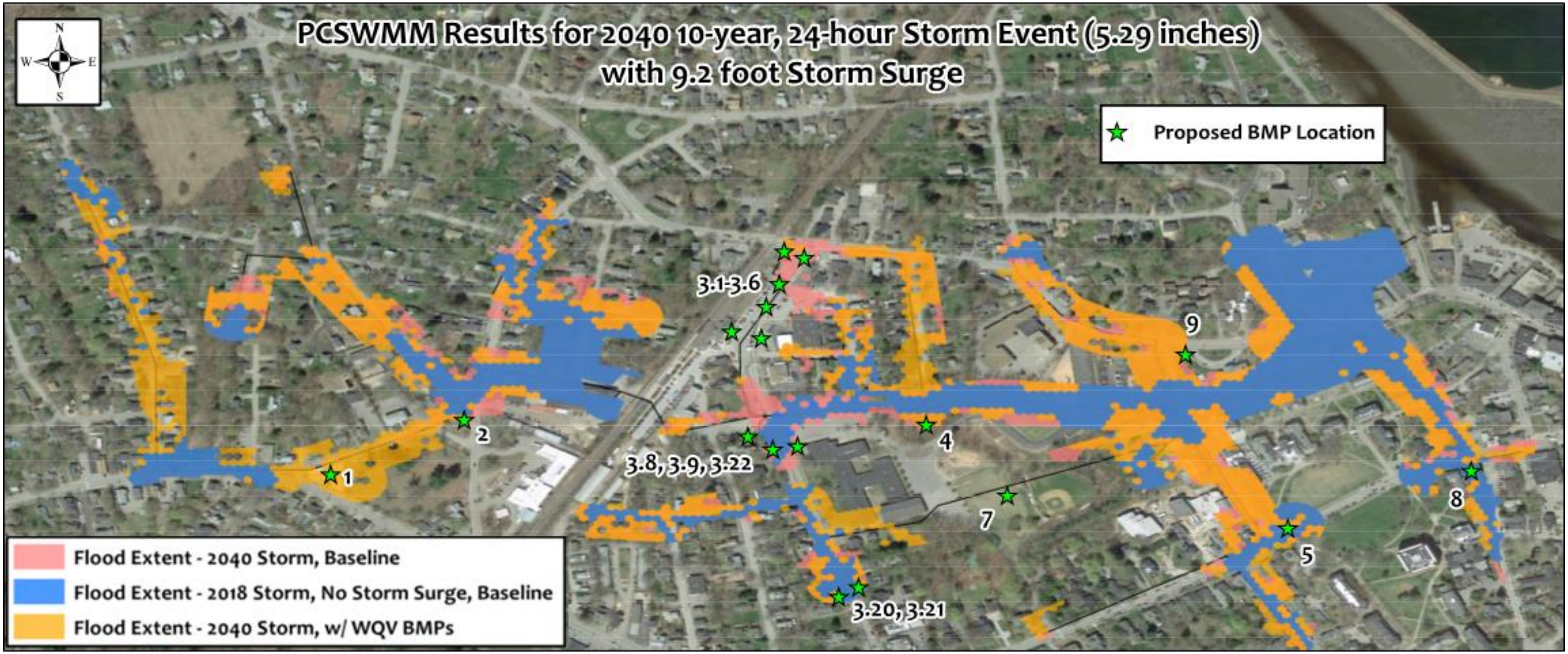
3. BMPs expected to reduce nitrogen load by 691 pounds annually, a 76% reduction.

4. 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

5. The estimated cost to implement green infrastructure retrofits at these 14 locations is $689,000.

Tree Filter

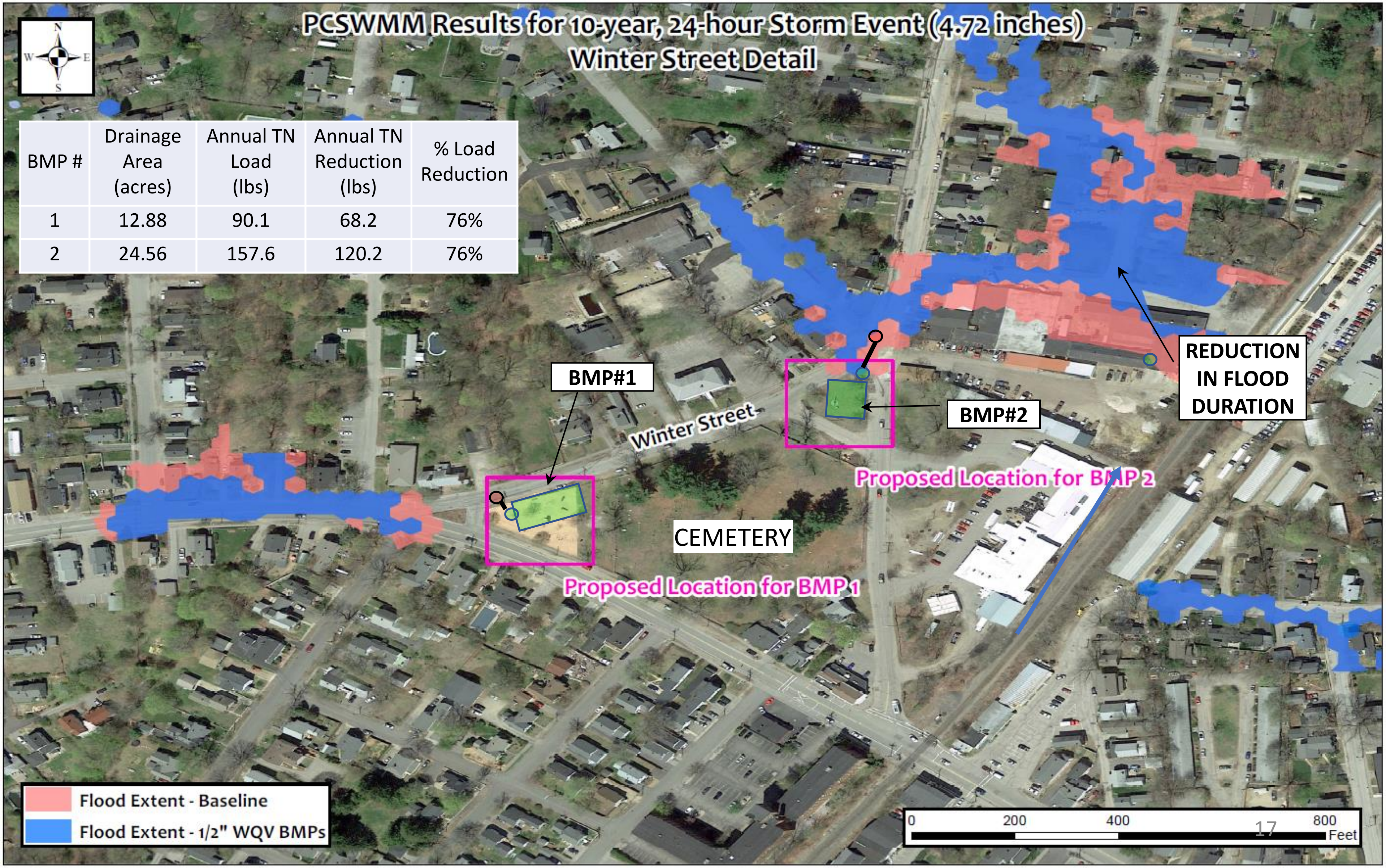
FLOOD REDUCTION FROM GREEN INFRASTRUCTURE



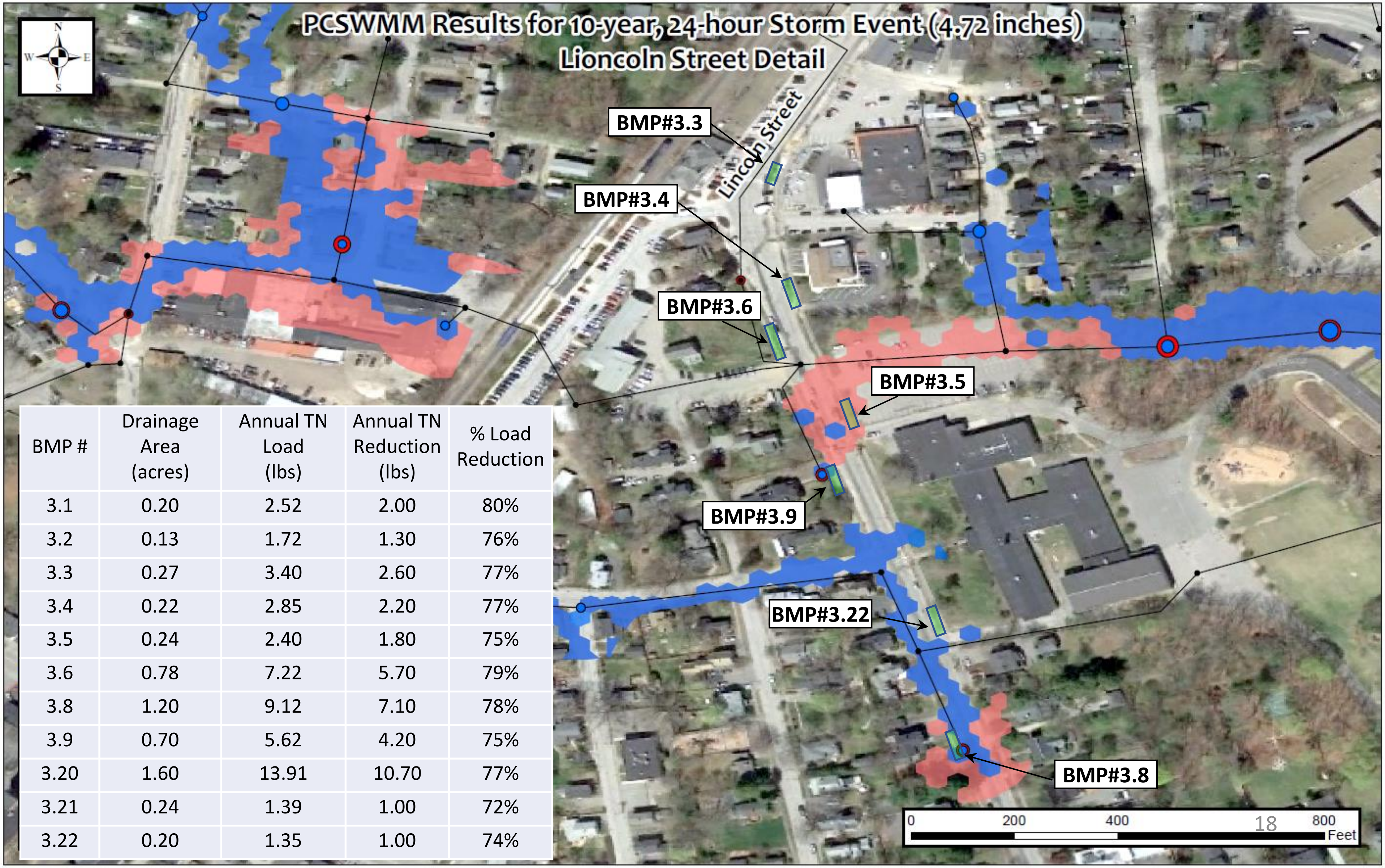
1. **Flood reductions as runoff volume from green infrastructure implementation are estimated at 60% for the current 10-year storm and 50% for the projected year 2040 storm event with 9.21 feet of storm surge.**
2. **The figure shows the modeled flood impact with and without green infrastructure for the projected year 2040 rainfall and storm conditions with and without water quality volume best management practices**

FLOODING BEFORE AND AFTER– WINTER & RAILROAD

BMP #	Drainage Area (acres)	Annual TN Load (lbs)	Annual TN Reduction (lbs)	% Load Reduction
1	12.88	90.1	68.2	76%
2	24.56	157.6	120.2	76%

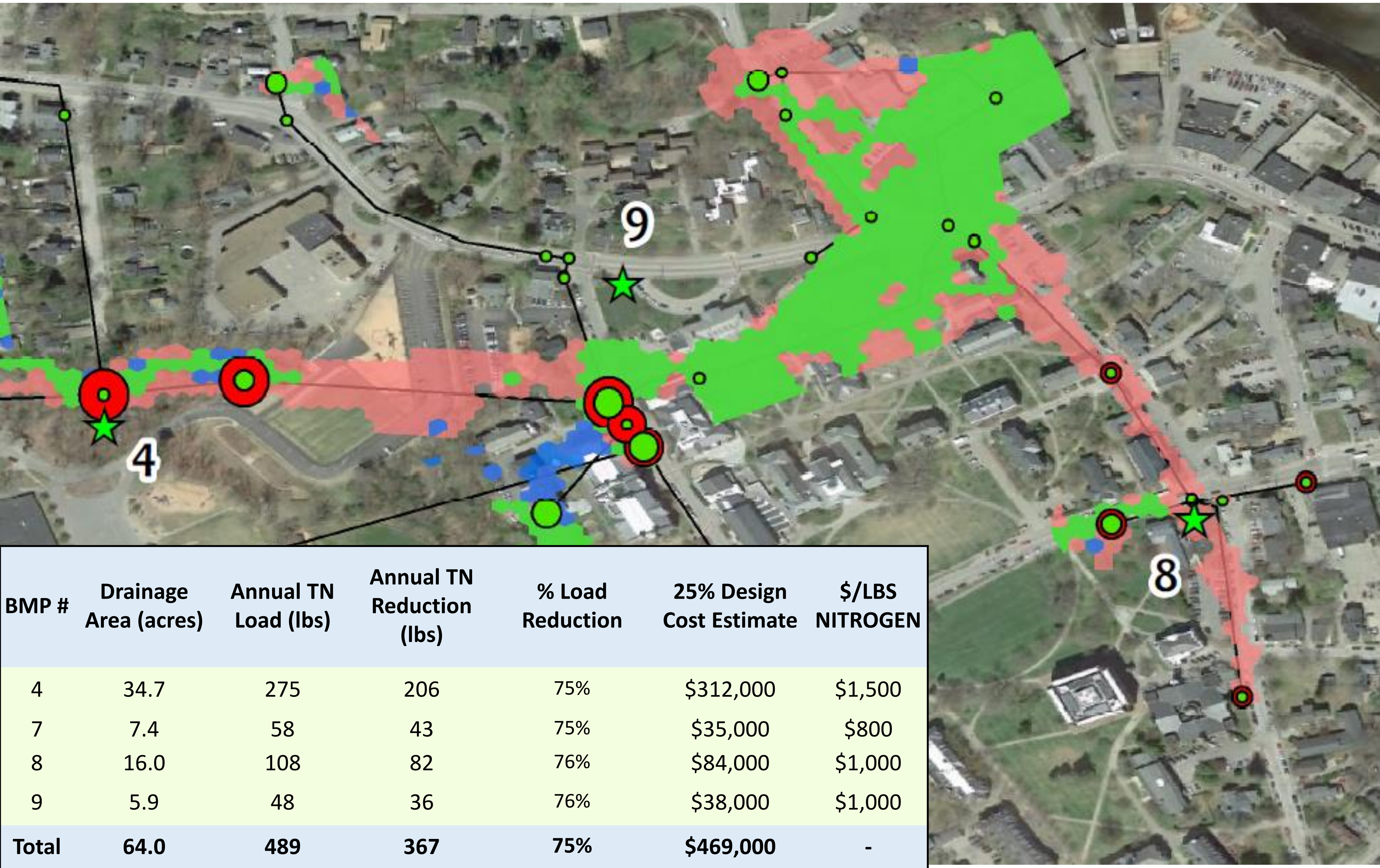


FLOODING BEFORE AND AFTER– RAILROAD AND LINCOLN ST



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%

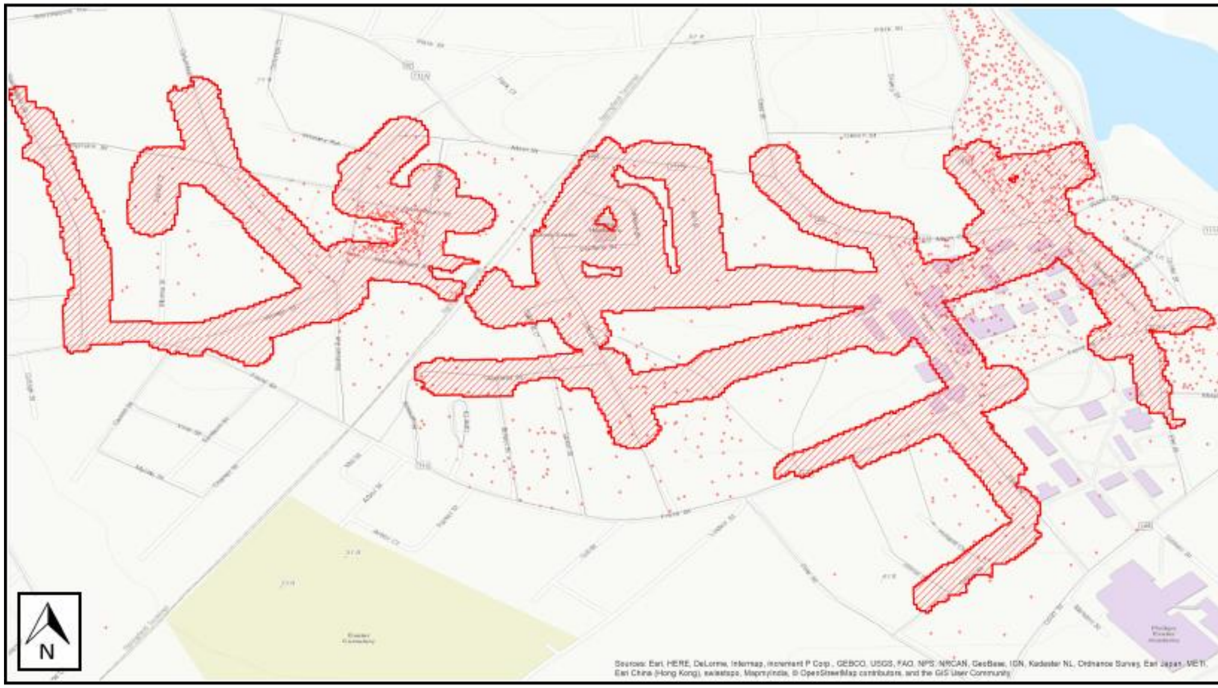
FLOODING BEFORE AND AFTER– ELM ST, FRONT ST & TAN LANE

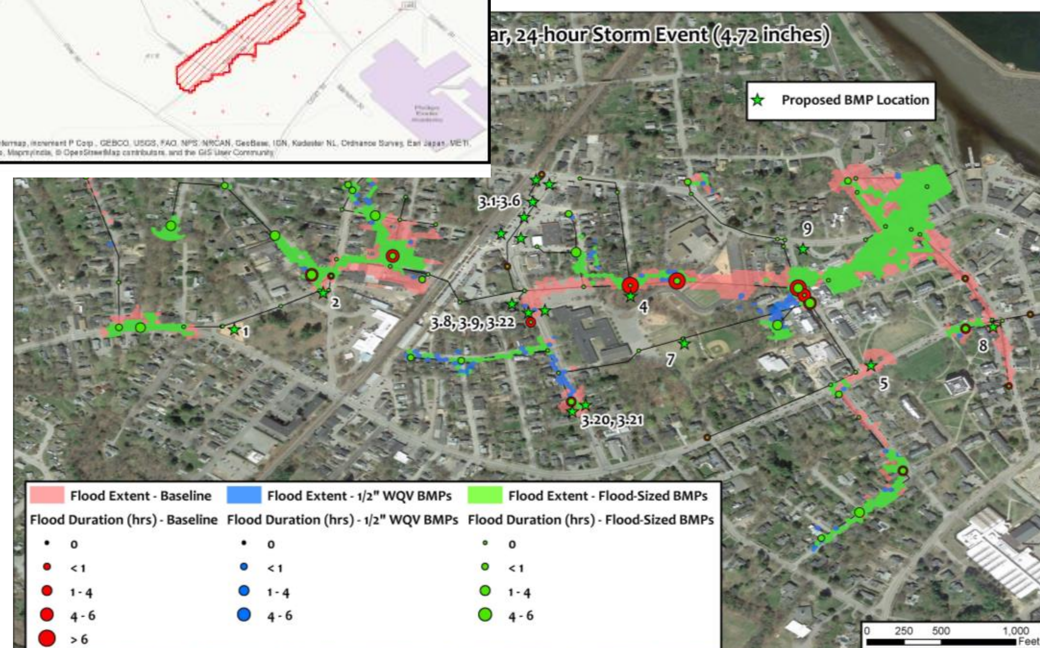


BMP #	Drainage Area (acres)	Annual TN Load (lbs)	Annual TN Reduction (lbs)	% Load Reduction	25% Design Cost Estimate	$/LBS NITROGEN
4	34.7	275	206	75%	$312,000	$1,500
7	7.4	58	43	75%	$35,000	$800
8	16.0	108	82	76%	$84,000	$1,000
9	5.9	48	36	76%	$38,000	$1,000
Total	**64.0**	**489**	**367**	**75%**	**$469,000**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

HAZUS Analysis and Damage Cost Avoidance

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

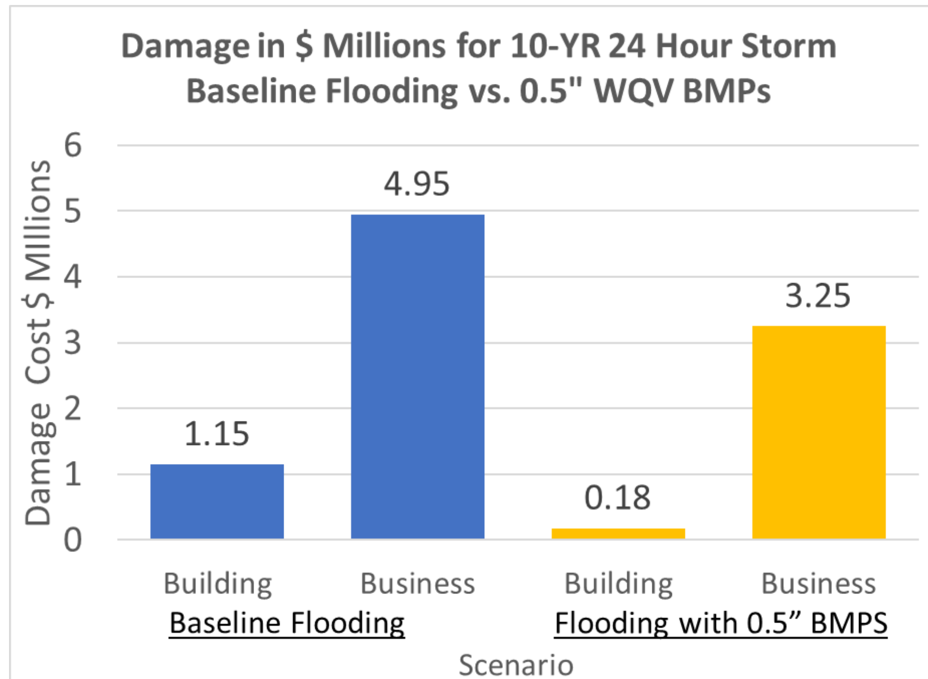




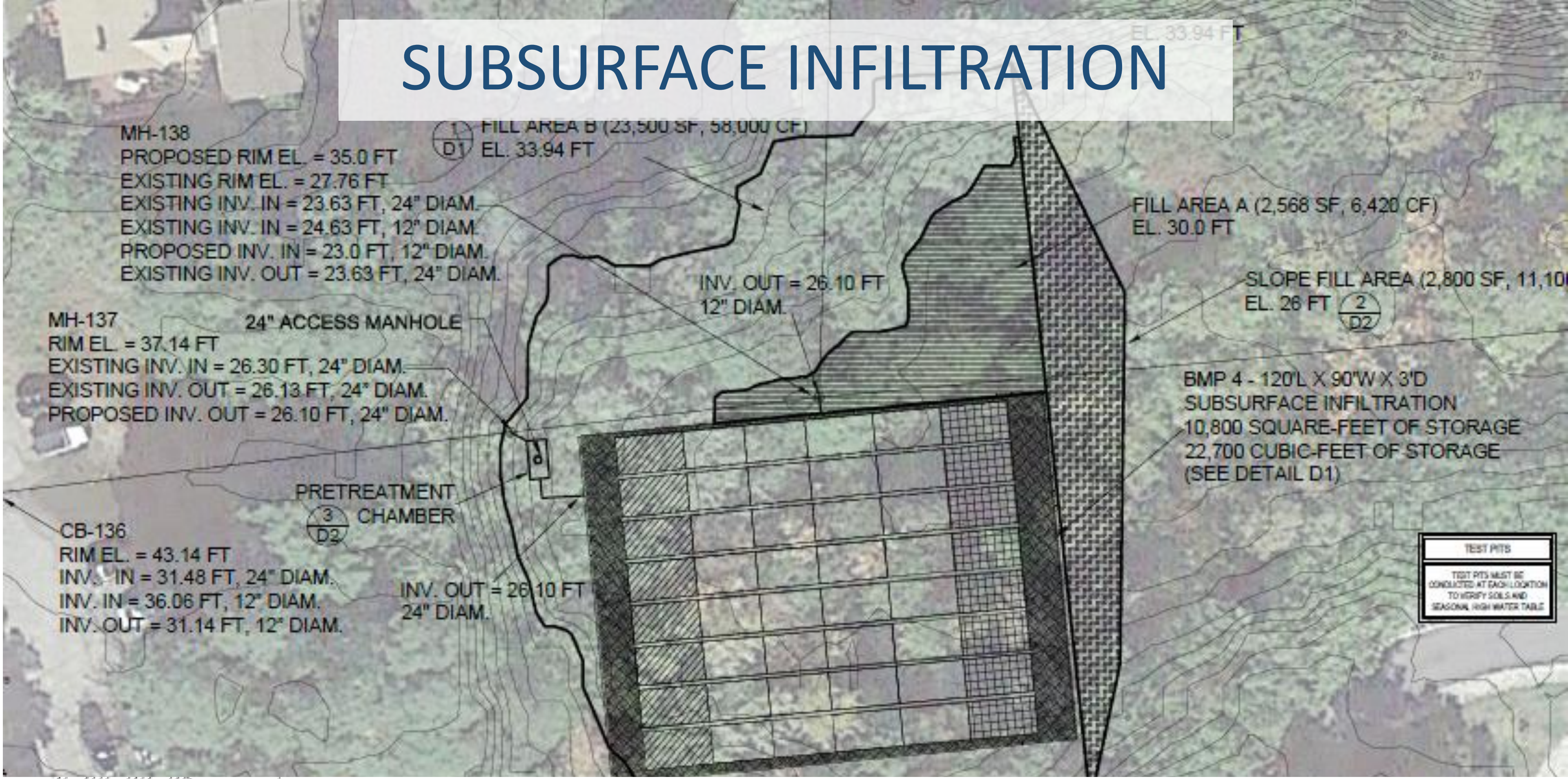
ECONOMIC BENEFITS OF FLOOD AVOIDANCE

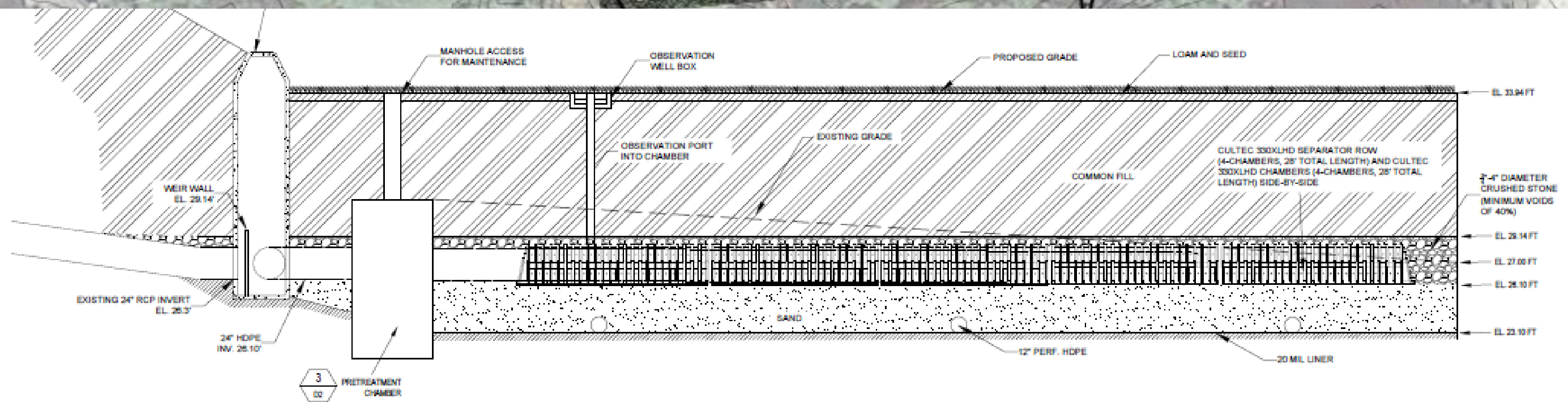
Photo: Flooding at Exeter Town Landing March 2018 Nor'easter

1. The cost impact analysis graphic at right shows the potential for flood damage avoidance with implementation of green infrastructure.
2. The estimated flood loss from a current 10-year storm is $6.11 million or $3.43 million with green infrastructure, a 51% reduction.
3. The total estimated cost to implement green infrastructure at 14 sites is $689,000.
4. The greatest 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.



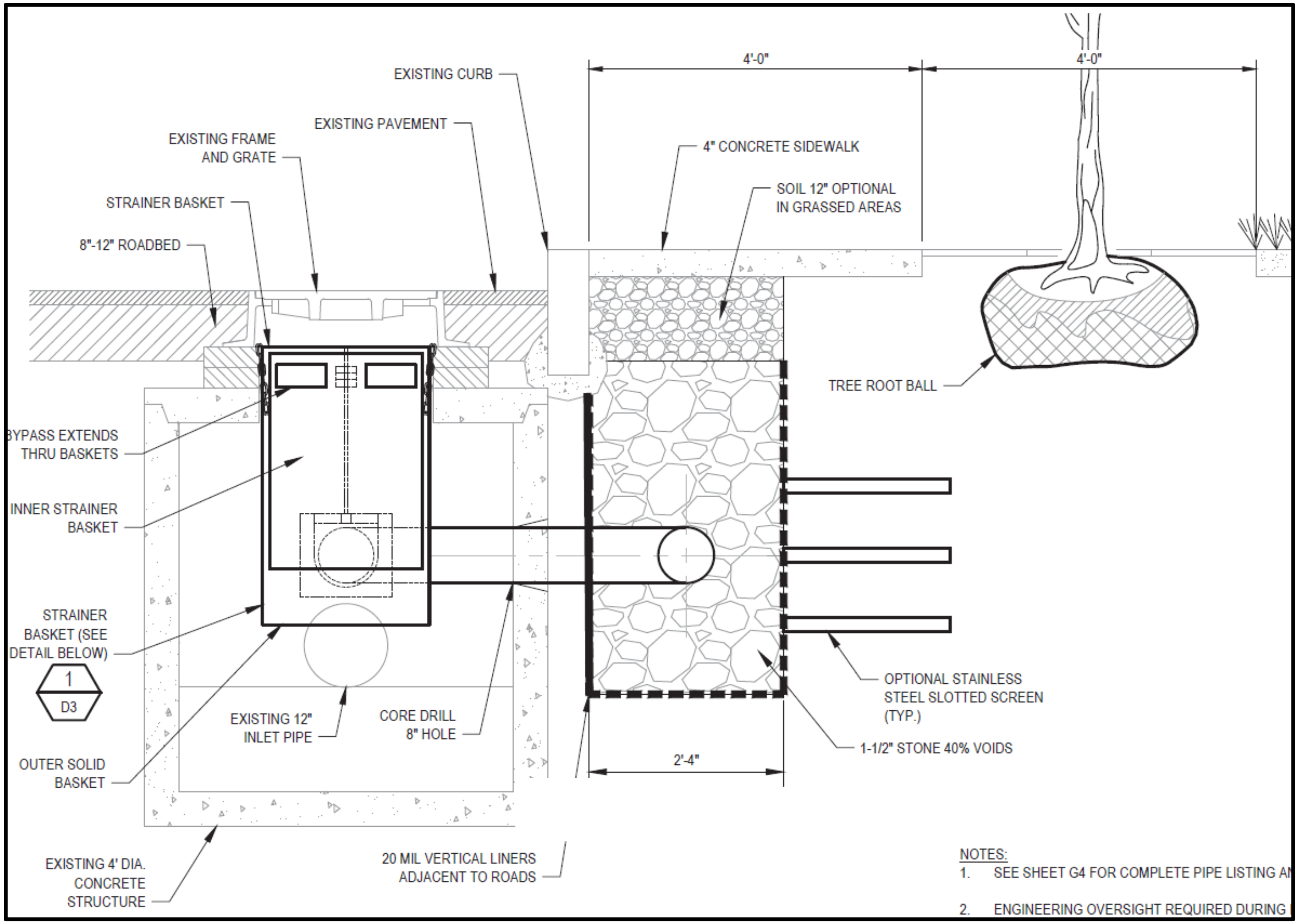
SUBSURFACE INFILTRATION





RIGHT-OF-WAY INFILTRATION

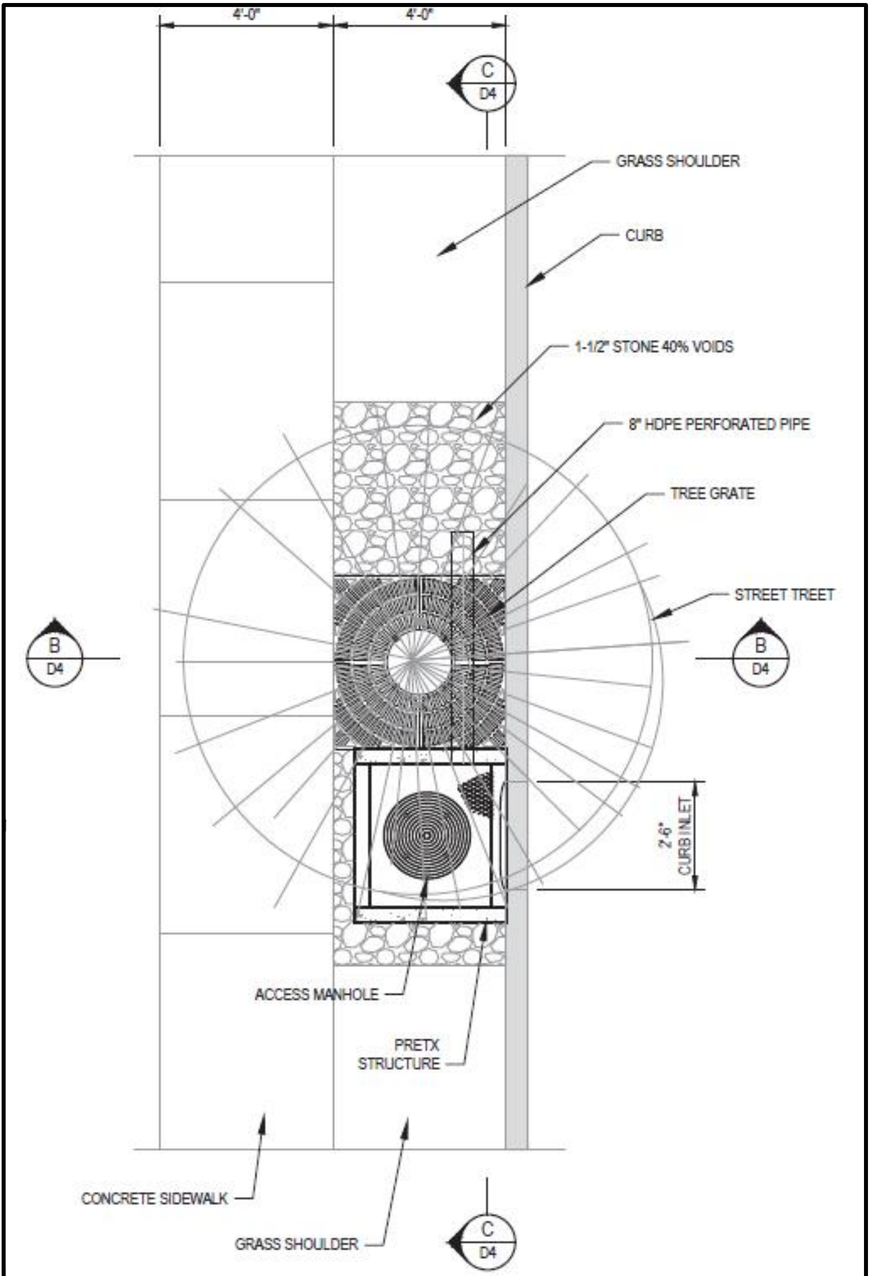
RIGHT-OF-WAY INFILTRATION

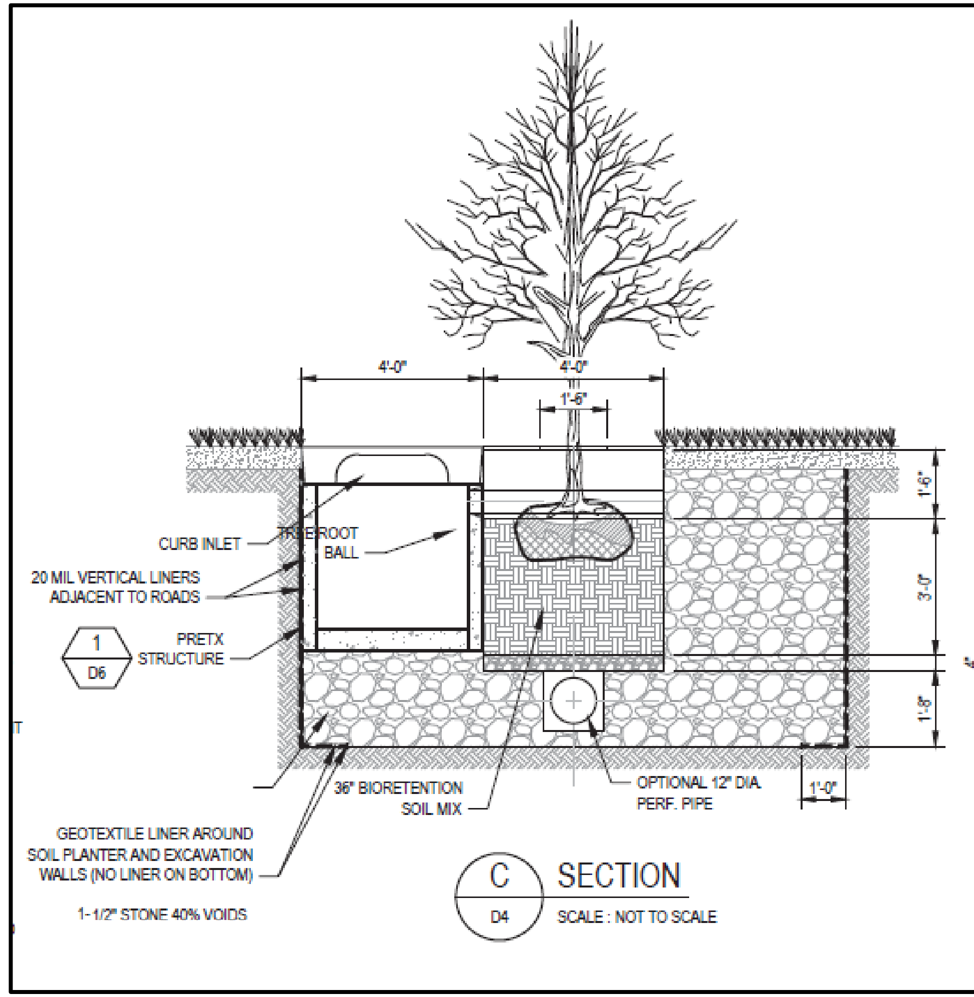


- LOW COST PRETREATMENTINSTALLED IN EXISTING CATCH BASINS AND DRAINAGE INFRASTRUCTURE AND INFILTRATION IN RIGHT-OF-WAY
- MAINTENANCE IS BY STANDARD VACTOR TRUCKS WITH NO SPECIAL EQUIPMENT OR TRAINING

TREE PLANTERS

TREE PLANTERS





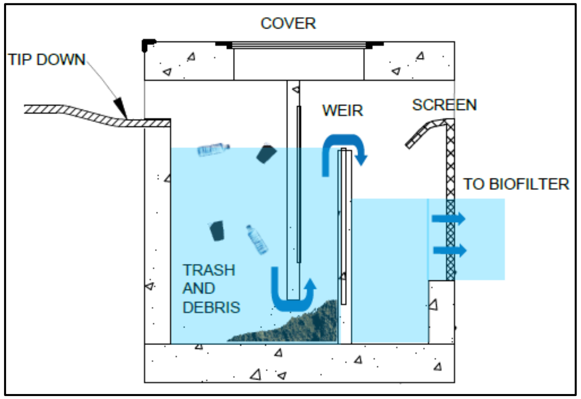
- LOW COST PRETREATMENTINSTALLED IN EXISTING CATCH BASINS AND DRAINAGE INFRASTRUCTURE AND PLANTERS UNDERNEATH SIDEWALK FOR MAXIMUM PEDESTRIAN USAGE
- MAINTENANCE IS BY STANDARD VACTOR TRUCKS WITH NO SPECIAL EQUIPMENT OR TRAINING

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



Pretreatment 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**	-

Nutrient Removal Unit Cost Comparison

Nutrient Control Strategy	Total Annual Cost	Life Cycle Cost Estimate	Lbs N Reduced Per Year	Unit Cost $/Lb N
Durham WW 5 mg/L[1]	$971,140	$13,800,000	5,254	$2,627
Durham WW 3 mg/L[1]	$1,680,340	$23,200,000	8,757	$2,649
WW Incremental Increase[1]	$709,200	$9,400,000	3,503	$2,683
Durham NPS IC Program[1]	$95,000	$475,000	250	$1,900
WISE NPS @ IP 3/5/8 mg/L[2]	$453,333	$13,600,000	17,000	$800
WISE WW @ IP 3/5/8 mg/L[2]	$3,046,667	$91,400,000	95,000	$962
WISE Total @ IP 3/5/8 mg/L[2]	$3,500,000	$105,000,000	112,000	$938
Exeter WW 3 mg/L[3]	$5,789,000	$115,780,000	95,400	$1,214

Notes and Assumptions

Data is from 2012 Oyster River Watershed Integrated Management Plan by VHB, NOS data generated by VHB, WW data by Wright Pierce Facilities Plan Draft

WW data reported is based on 7 month period. It was not adjusted for 12 months as perhaps should be considered for direct comparison with NPS

Assumes 20 Yr SRF Loan for Exeter @3.25% with no state or federal aid

Life Cycle includes capital and operations and maintenance

Present worth is capital at 20-yr;

Data sources: [1] ORWIMP 2014; [2] WISE 2015, [3] Wright Pierce 2014

Thank you!

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