Urban Watershed Renewal in Berry Brook, NH An Examination of Impervious Cover, Stream Restoration, and Ecosystem Resilience

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4 May 2019

Lake George, NY

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NYSFOLA

Participants at the Beginning:

- City of Dover Staff
- UNH Stormwater Center
- NH Department of Environmental Services
- Environmental Protection Agency

NY Lakes – Part of My Youth

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Stormwater

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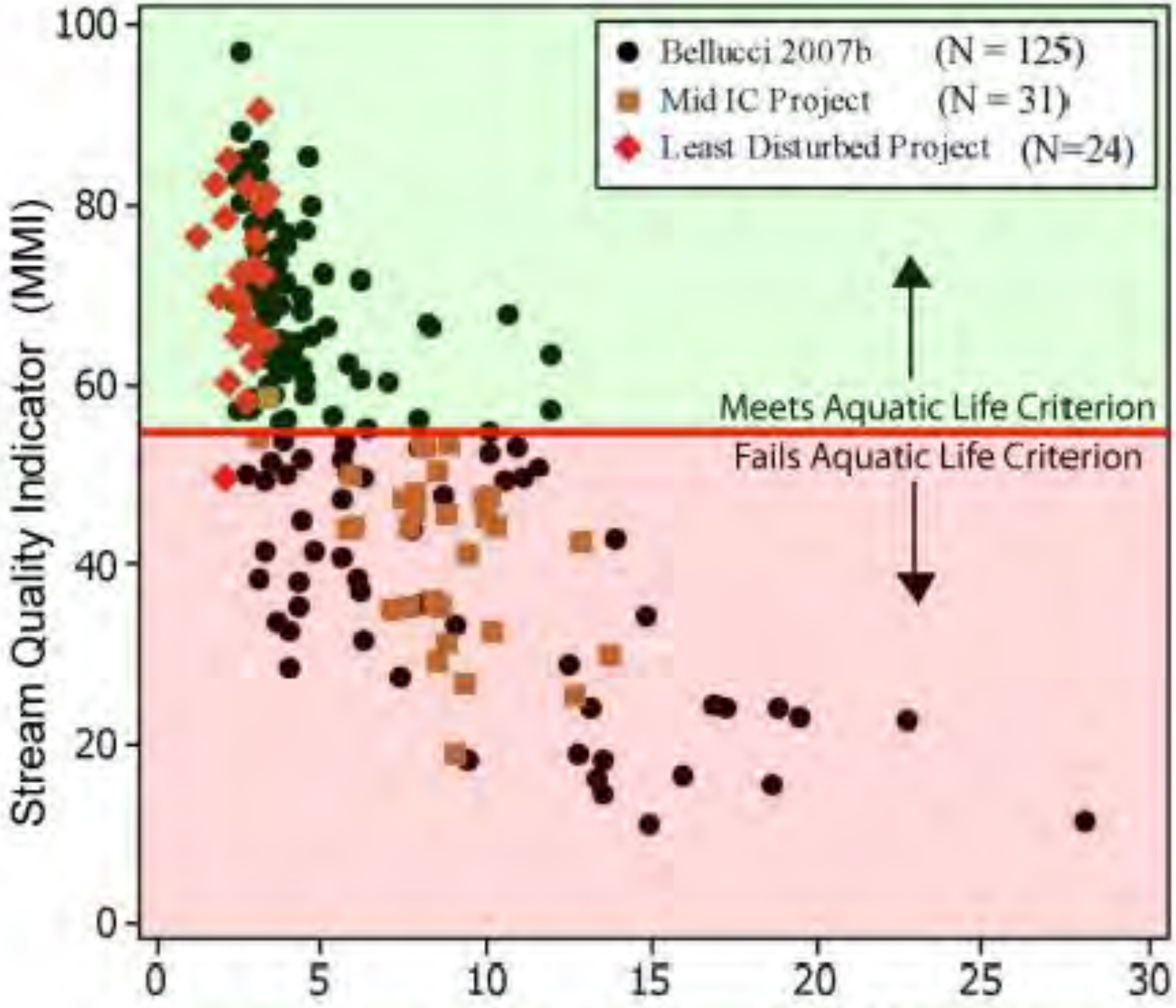

Figure. Adapted from WSB 2010 & Bulluci 2007.

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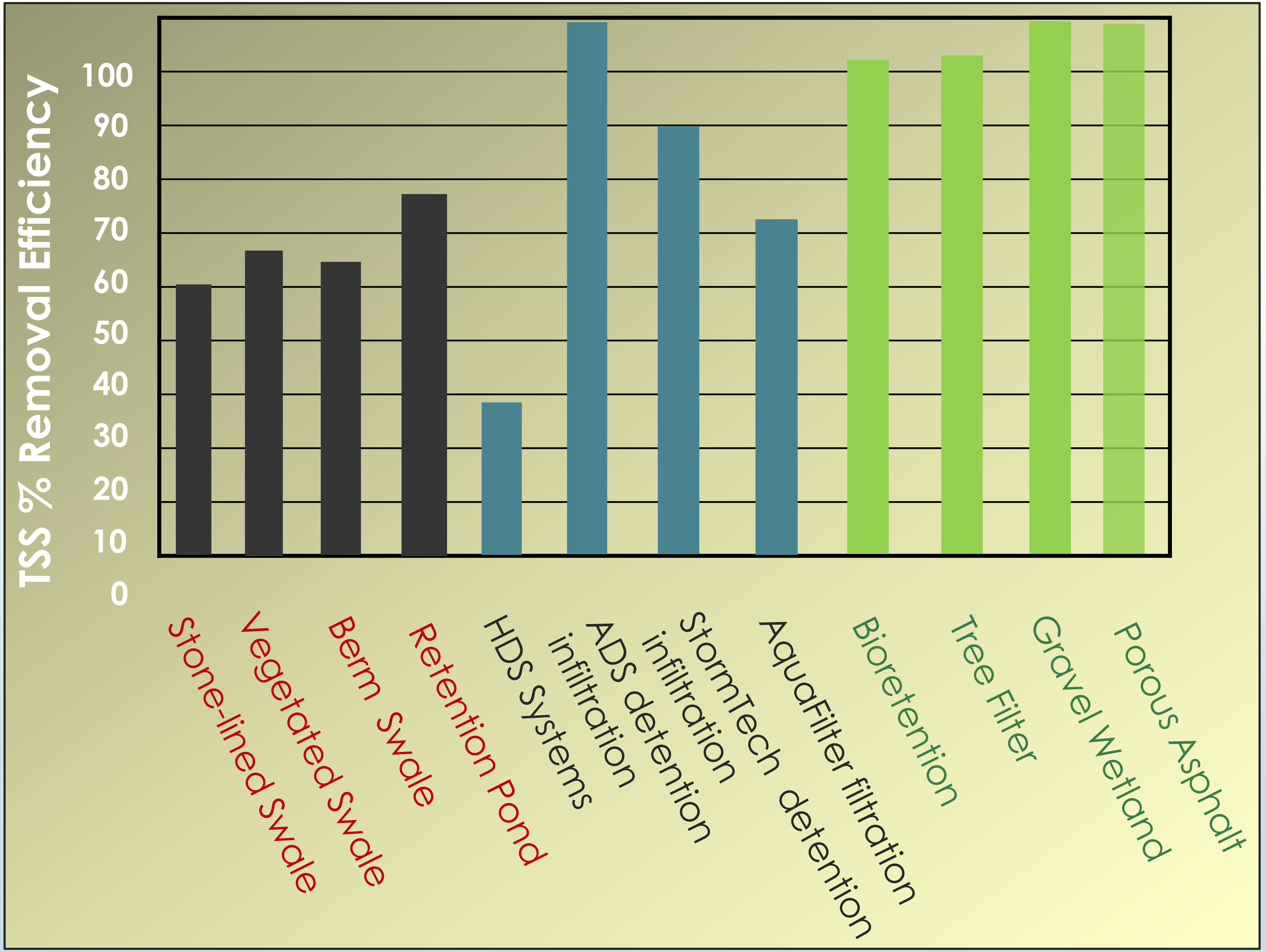
TSS Removal Efficiencies



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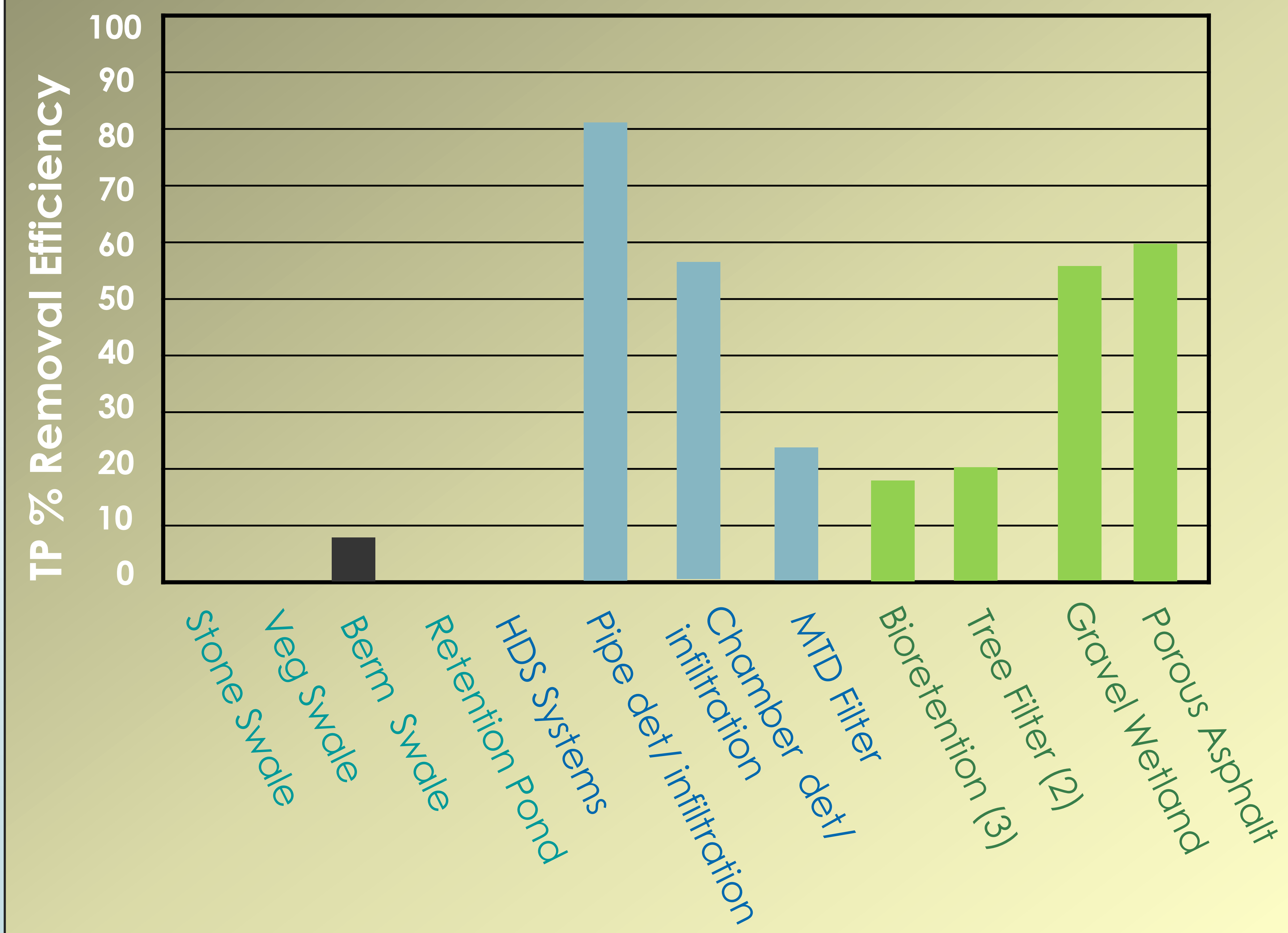
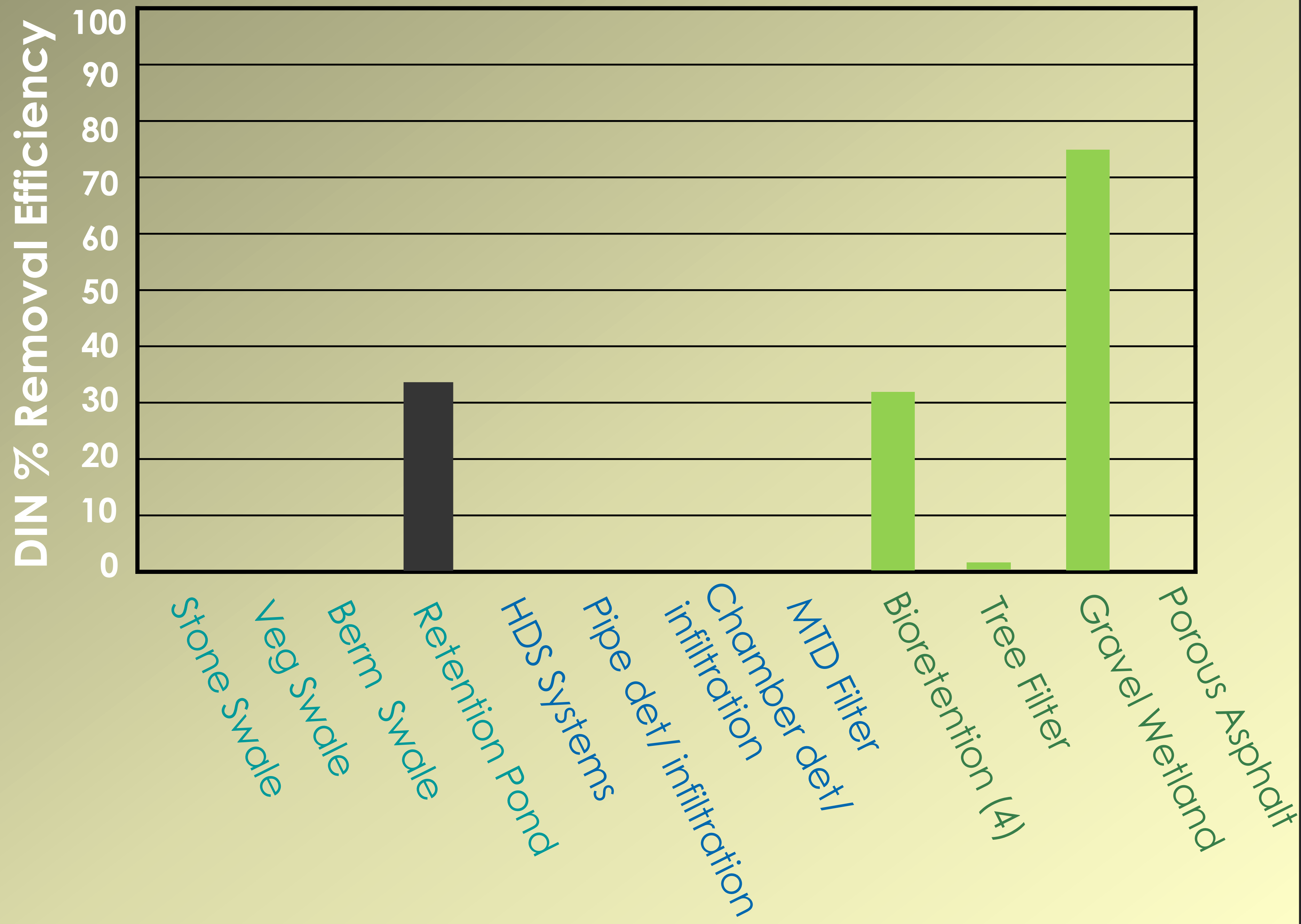
TP Removal Efficiencies



DIN Removal Efficiencies



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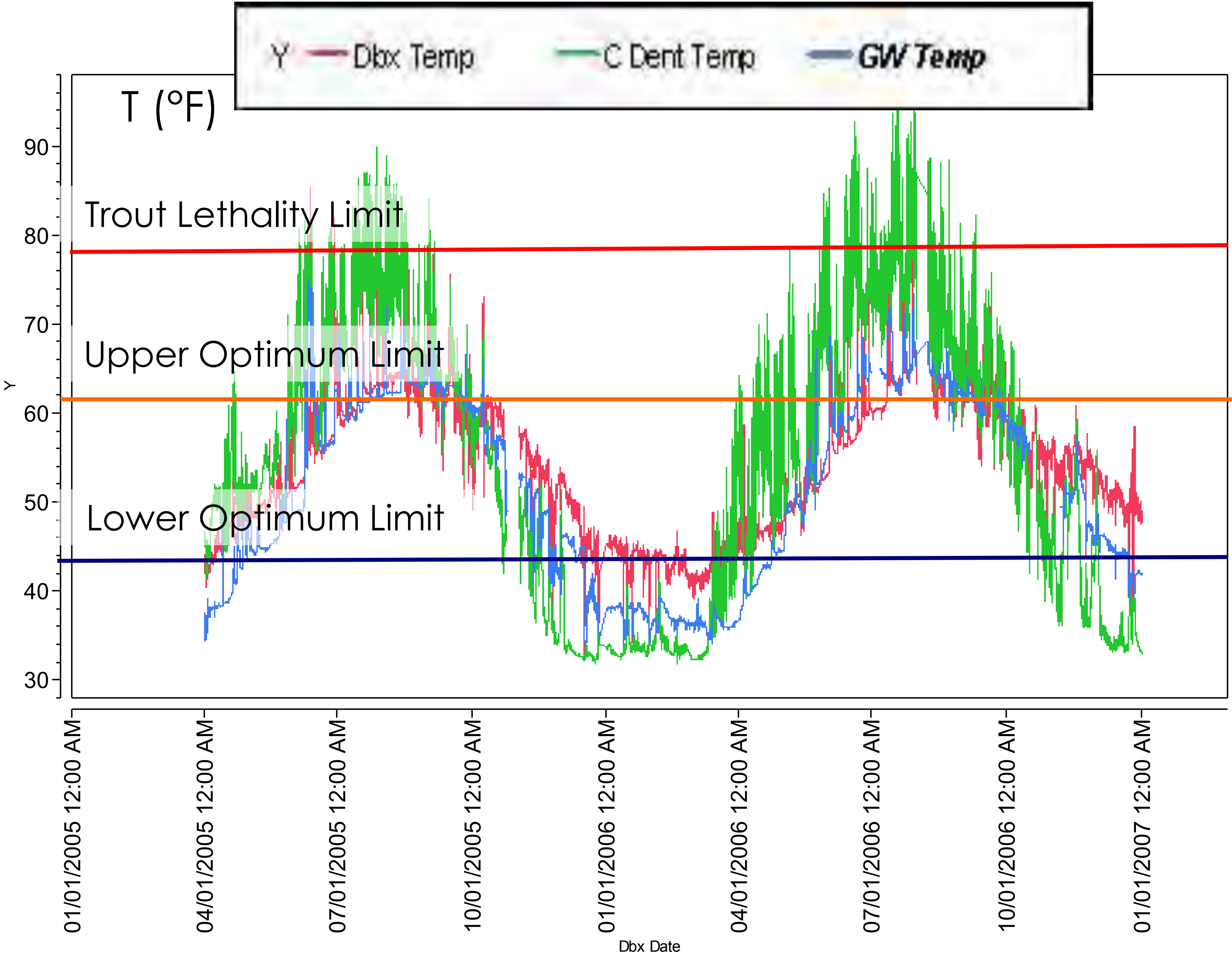
Thermal Impacts



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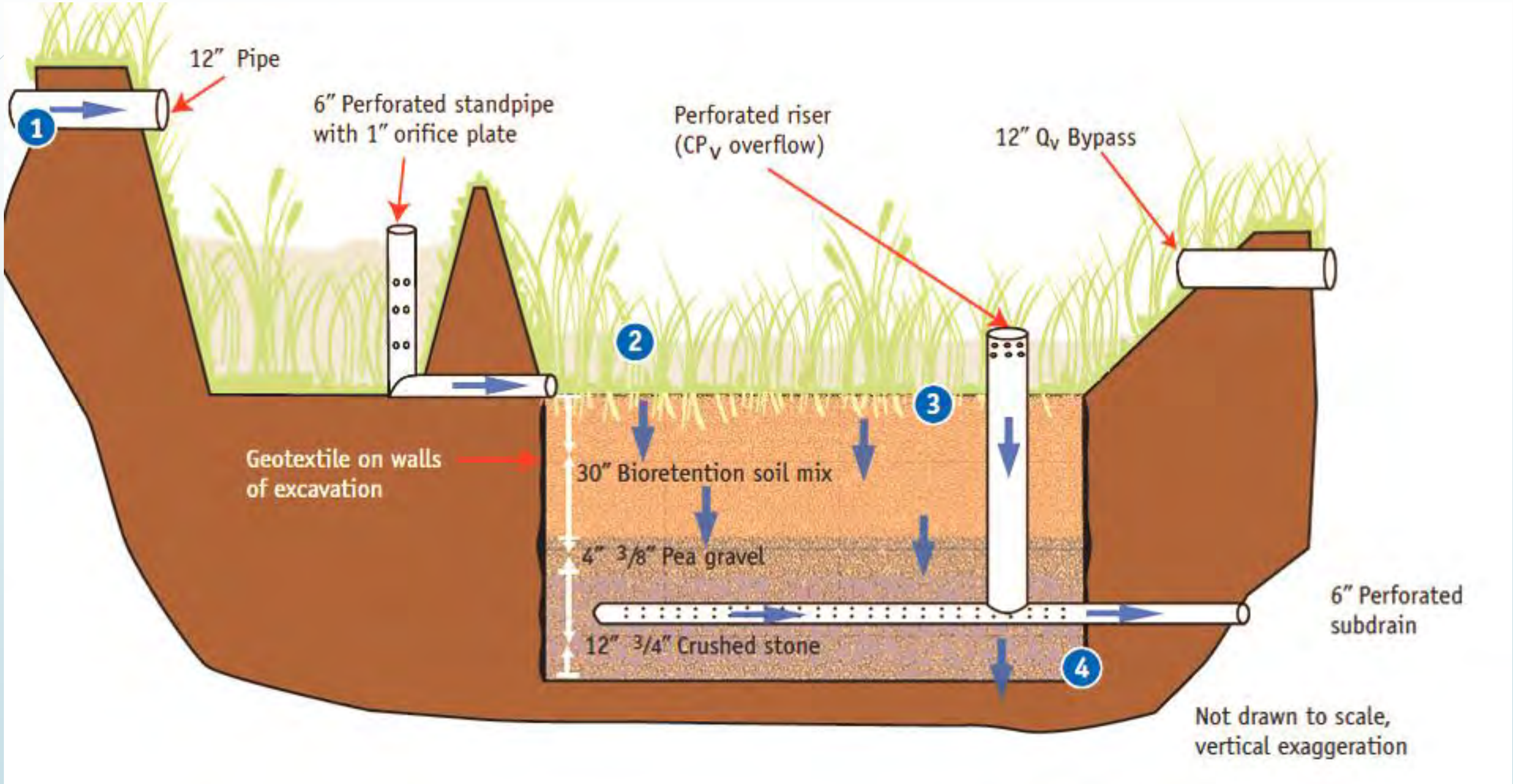
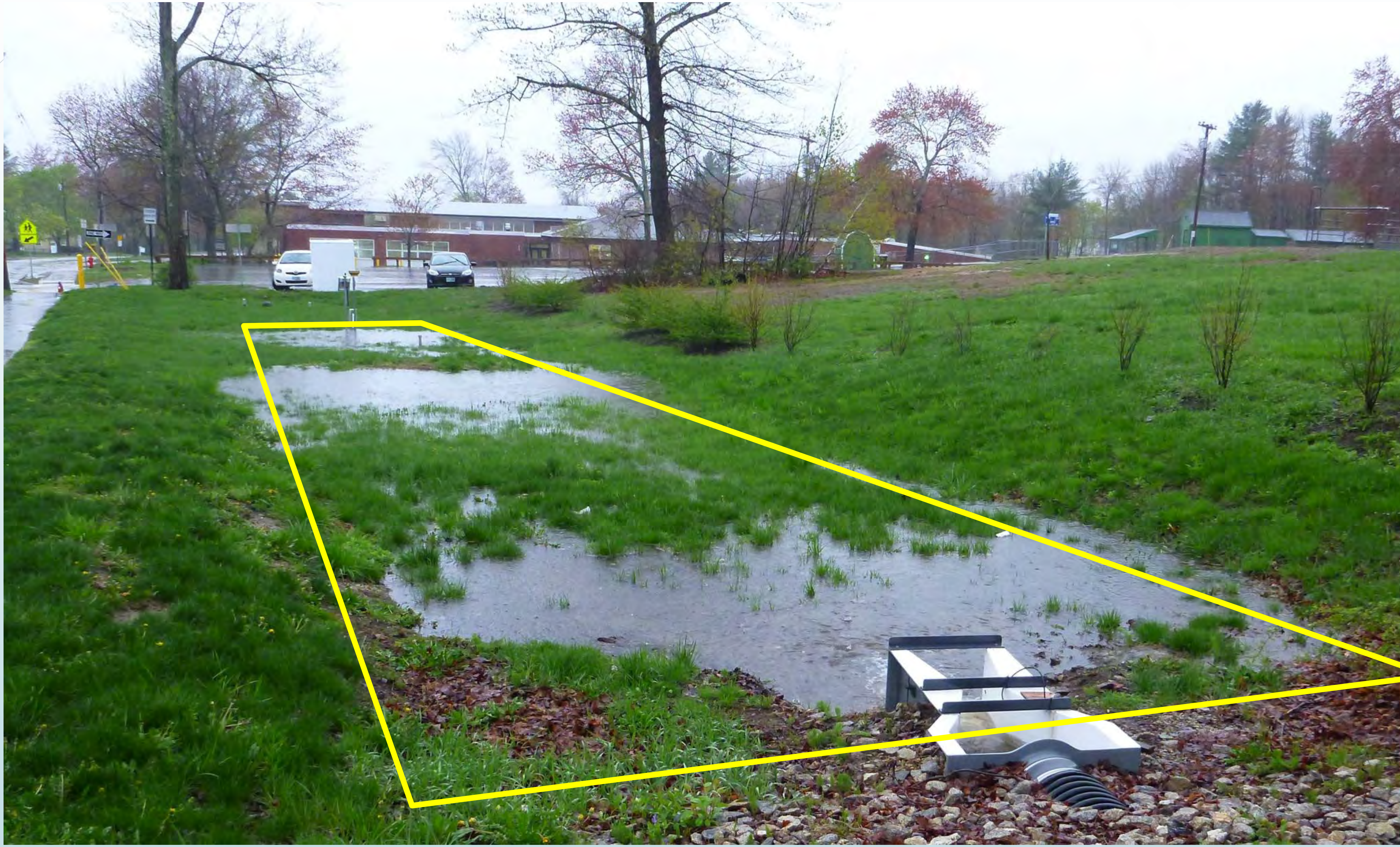
Introduction: Bioretention Filters



UNHSC *2009 Biannual Report*

Site Study: Bioretention (during 1 in. storm)



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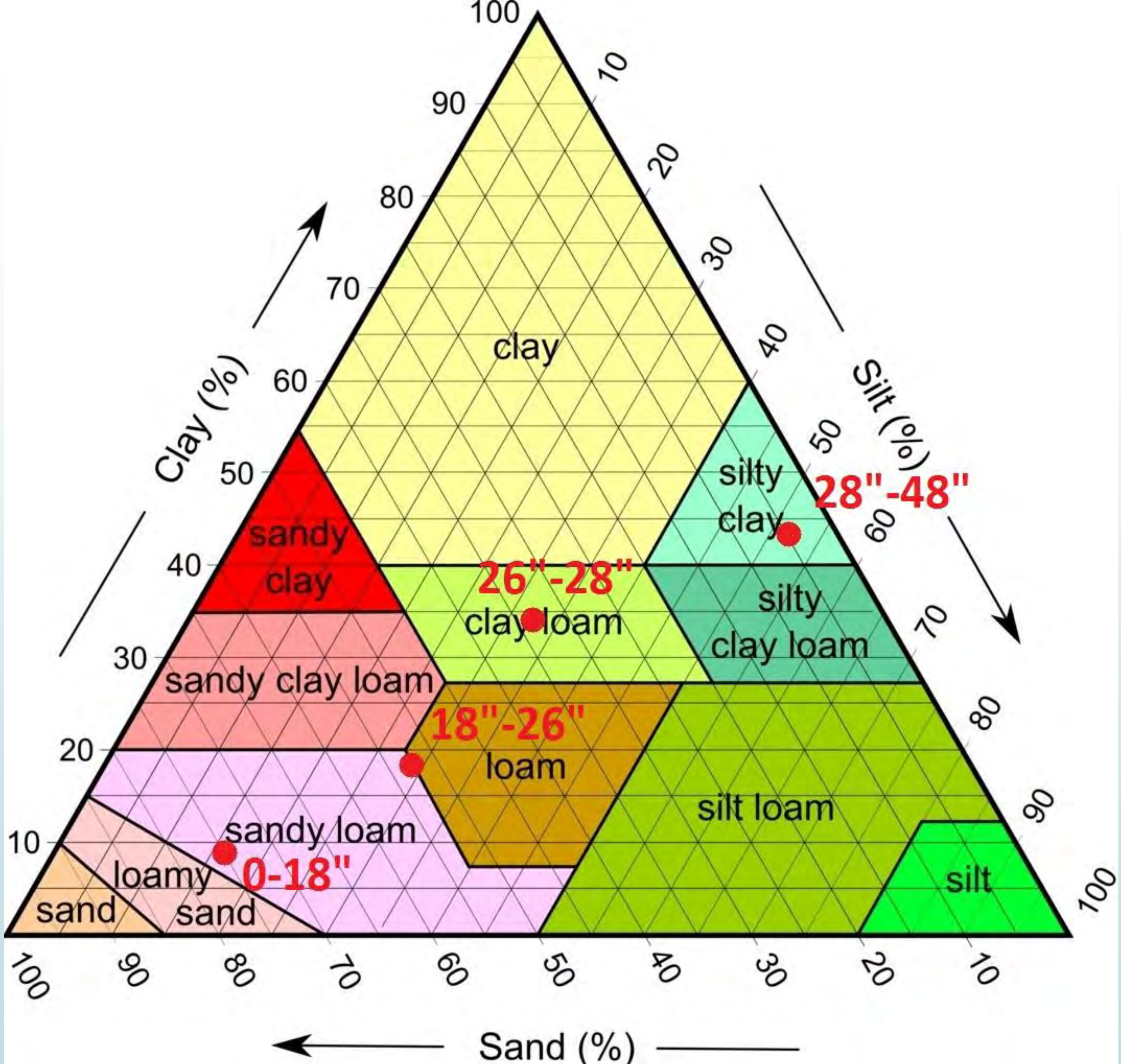

Clay (%)
Silt (%)
Sand (%)
clay
sandy clay
silty clay
clay loam
silty clay loam
sandy clay loam
loam
silt loam
sandy loam
loamy sand
sand
silt
28"-48"
26"-28"
18"-26"
0-18"

Site Study: Horne St., Dover, NH

- Watershed area 22 acres
- Subdivision of 1/3 ac. lots
- 38% impervious cover
- CN 60
- Time of concentration
  - Estimated with TR-55 Velocity method: 17 minutes
  - Median observed: 16.5 minutes
- Median observed lag time of 9 minutes
- Filter is 2,100 ft^2 (140 ft x 15 ft)
- **Watershed to bioretention area ratio of 455:1**
- Current design rainfall 0.16 inch

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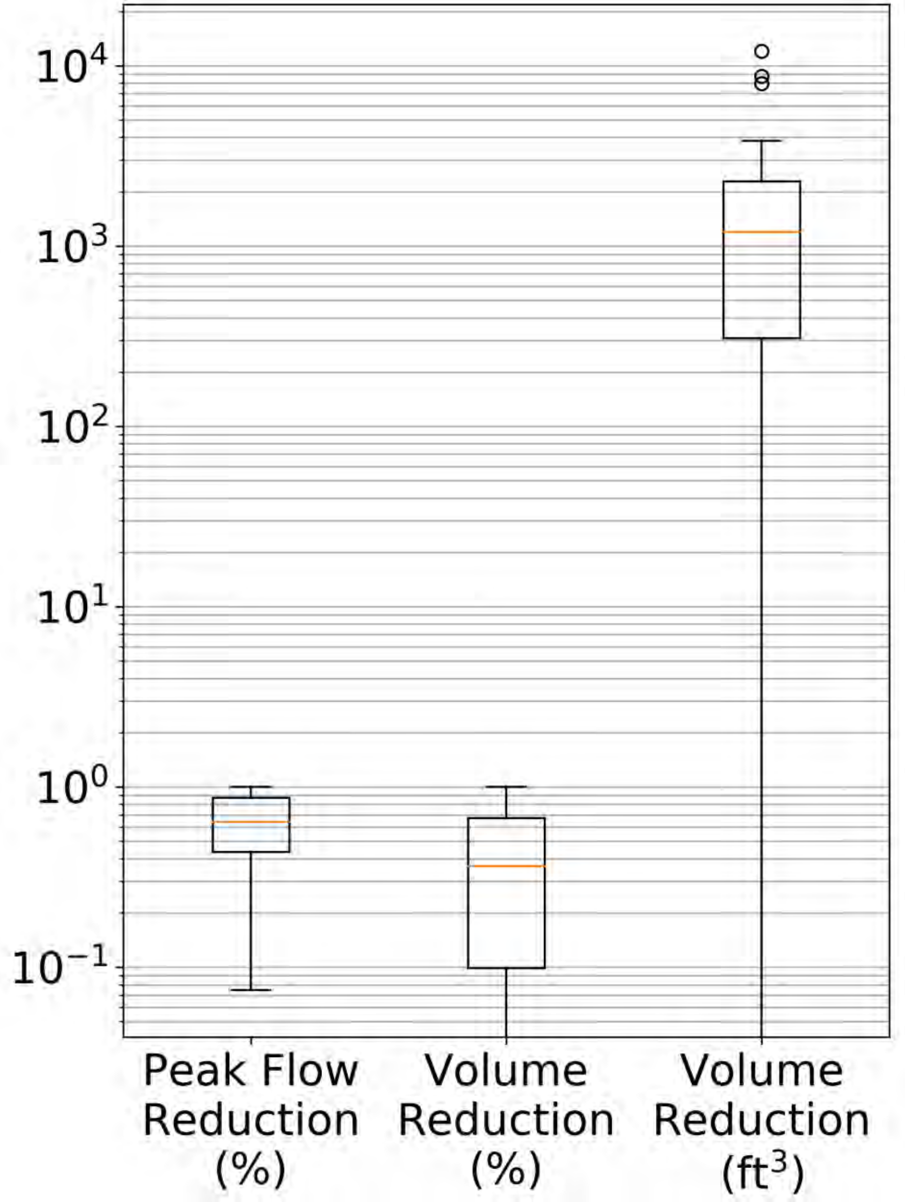
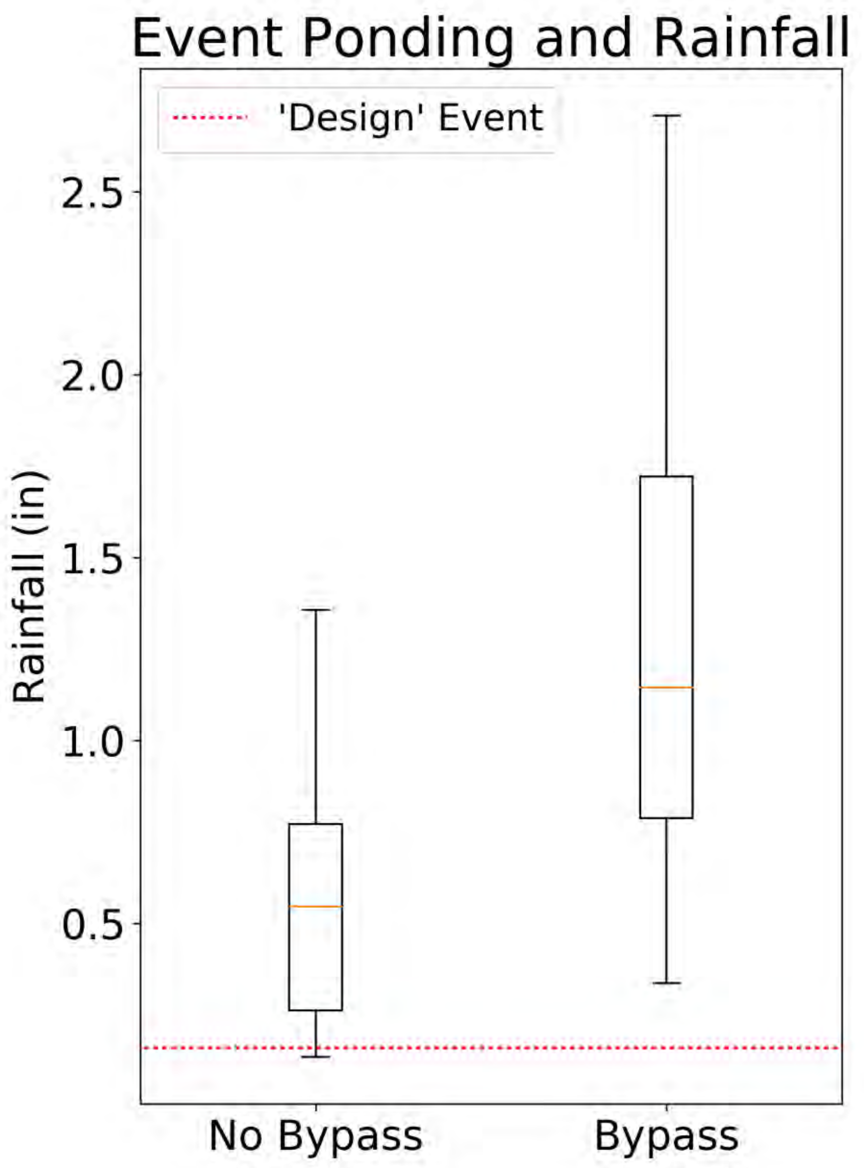
Site Study: Performance

Medians

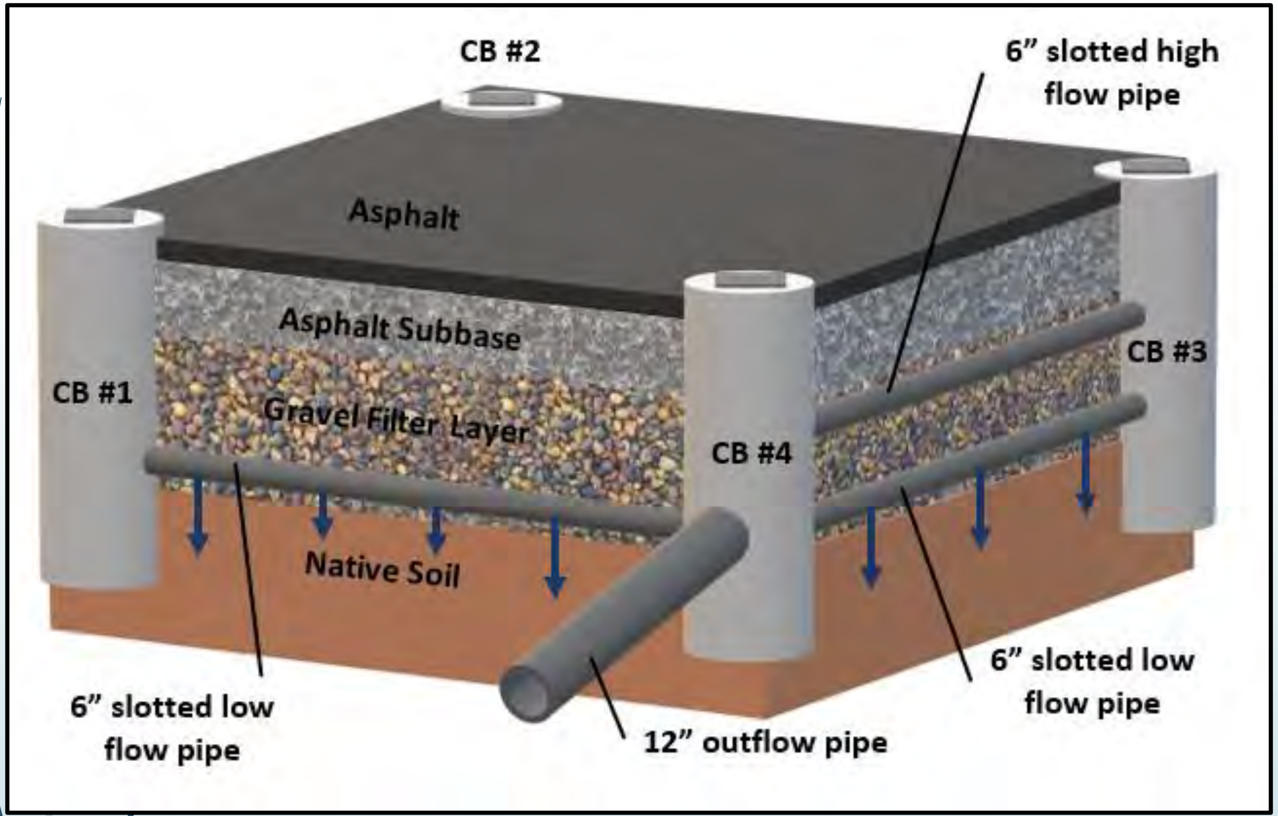
64% 36% 1190 ft³



0.55 in. 1.1 in.



Grove St. System



System Diagram

Grove St SGF Drainage Area

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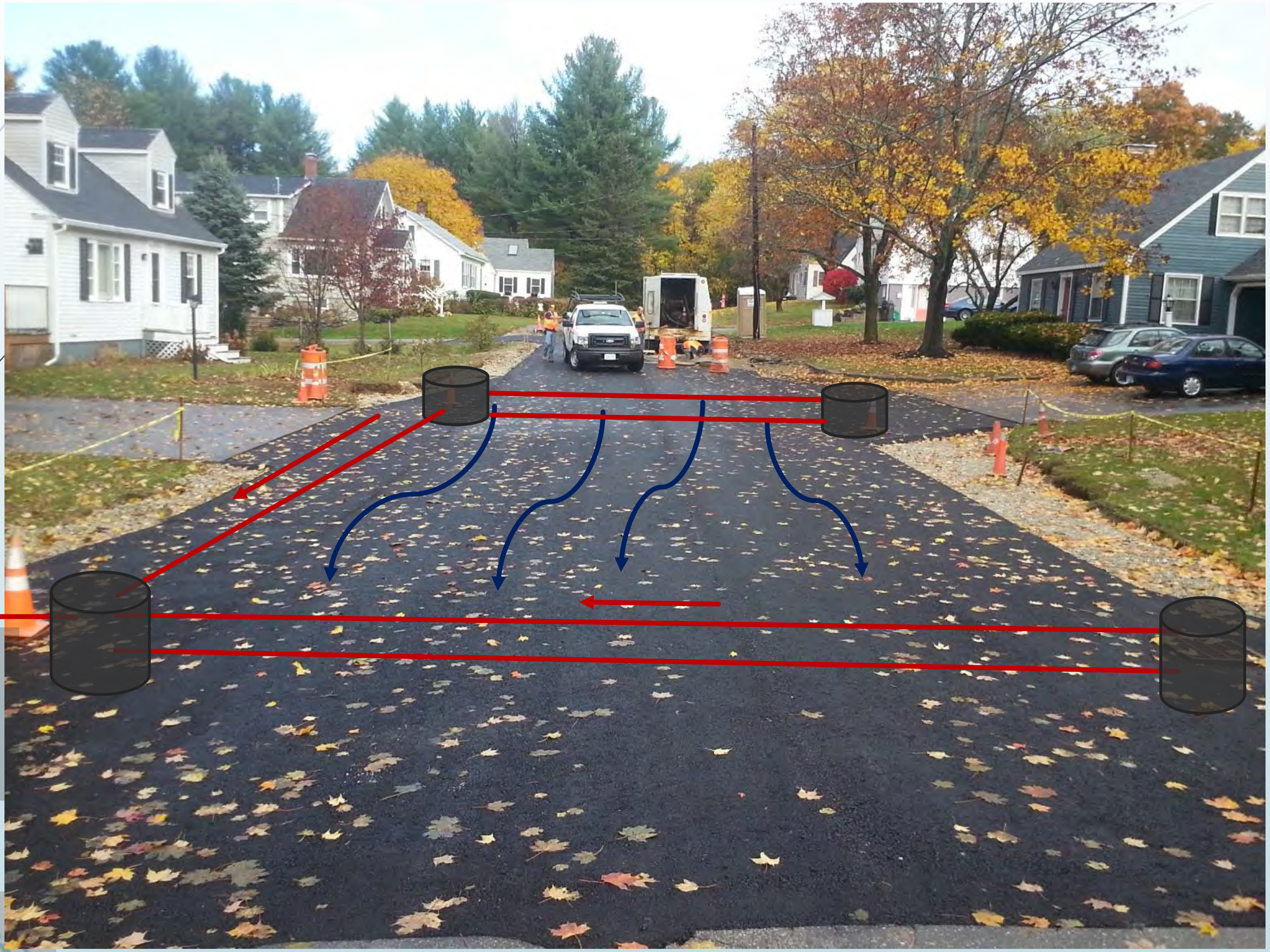
GI: Subsurface Gravel Filter



To Existing Swale

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Excavation

Excavation 90% complete

October 7, 2015

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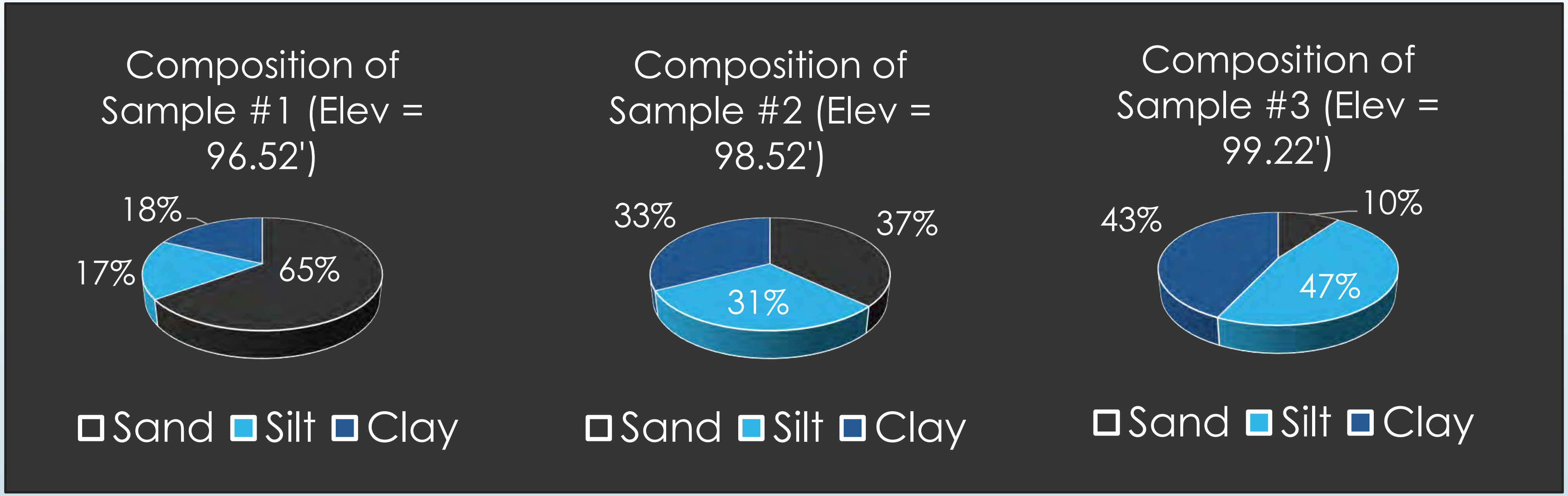
Pipe installation

Pipe installation between CB#1 & CB#2

October 8, 2015

Grove St. Native Soil Composition



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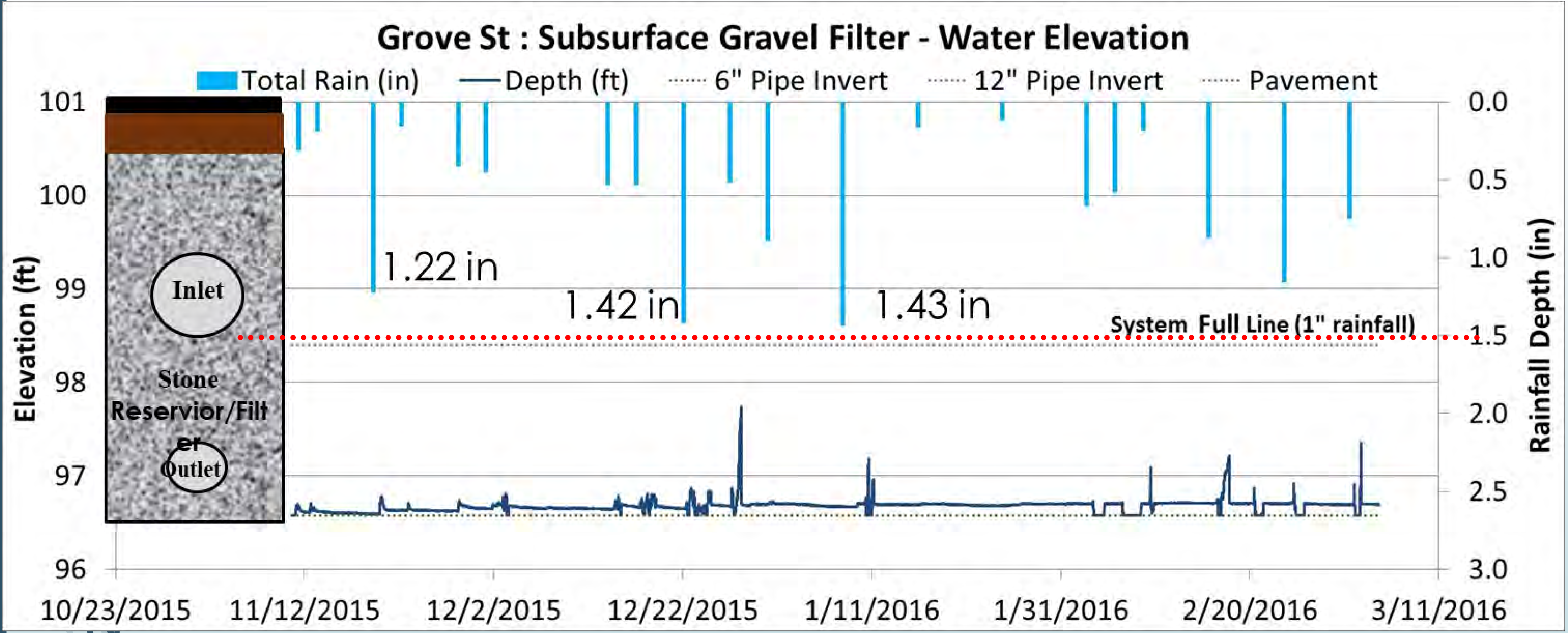
System Water Level History



Grove Street Design Specs

Parameters	Grove St SGF	
	Original Values	Updated Values
Drainage Area (acres)	1.44	4.10
Time of Concentration (min)	8.3	13.74
Weighted Curve Number (-)	88	83
Potential Maximum Retention (in)	1.36	2.05
Initial Abstraction (in)	0.27	0.41
% Impervious Area	22%	31%
WQV (Ac-In)	0.36	1.35
WQV (ft^3)	1307	4910
Constructed Storage Volume (ft^3)	1320	1320
% of WQV	101%	27%

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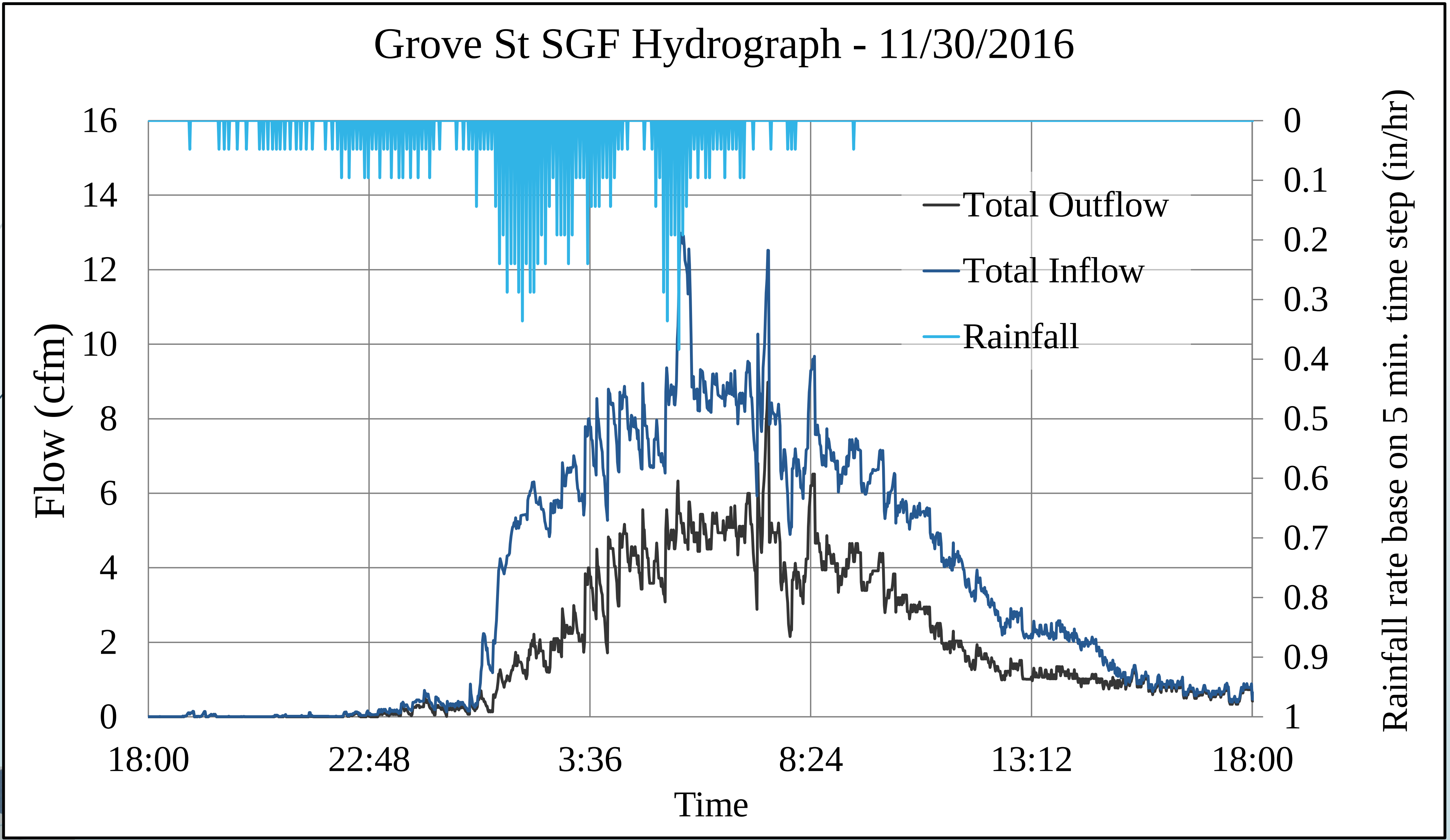
Develop Storm Hydrographs



Performance Analysis using Water Balances

Grove St Performance Summary:

- Cumulative runoff volume reduction of 84%
- Peak flow reduction of 88%
- System never completely filled
  - Maximum water depth of 1.94ft for 1.25-inch rain event on 4/6/2017

Maximum Recorded Flow Rates (ft^3/min)	
Inflow	82
Outflow	59

Cumulative Flow Volumes (ft^3)	
System Inflow Volume	76,695
System Inflow Volume	12,272
Infiltration Volume	64,423

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Maintenance Must be Included in the Design Process

Not by the designers, but by the people who are expected to do it or pay for it

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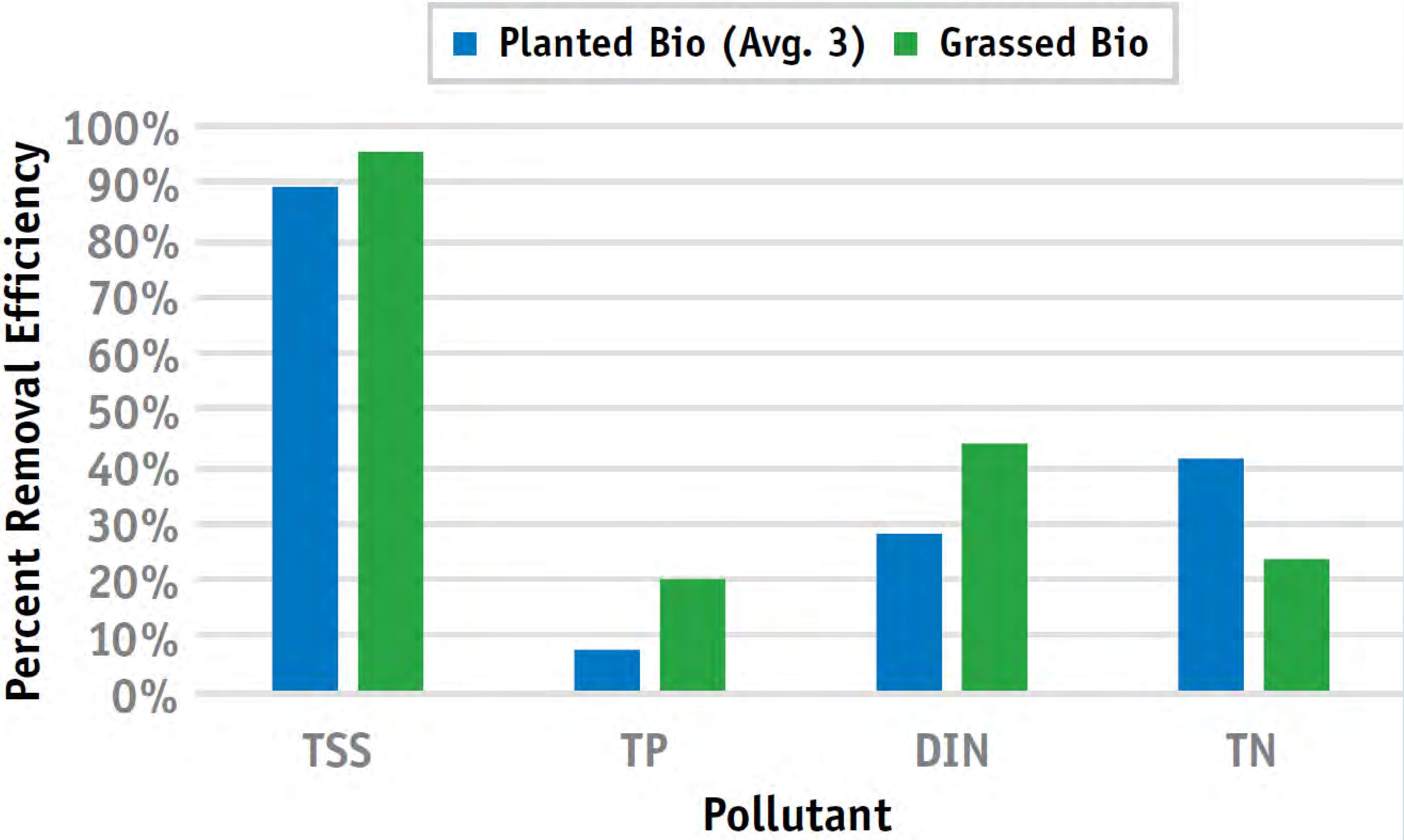
Comparison of Pollutant Removal Efficiency Planted vs Grassed Bioretention



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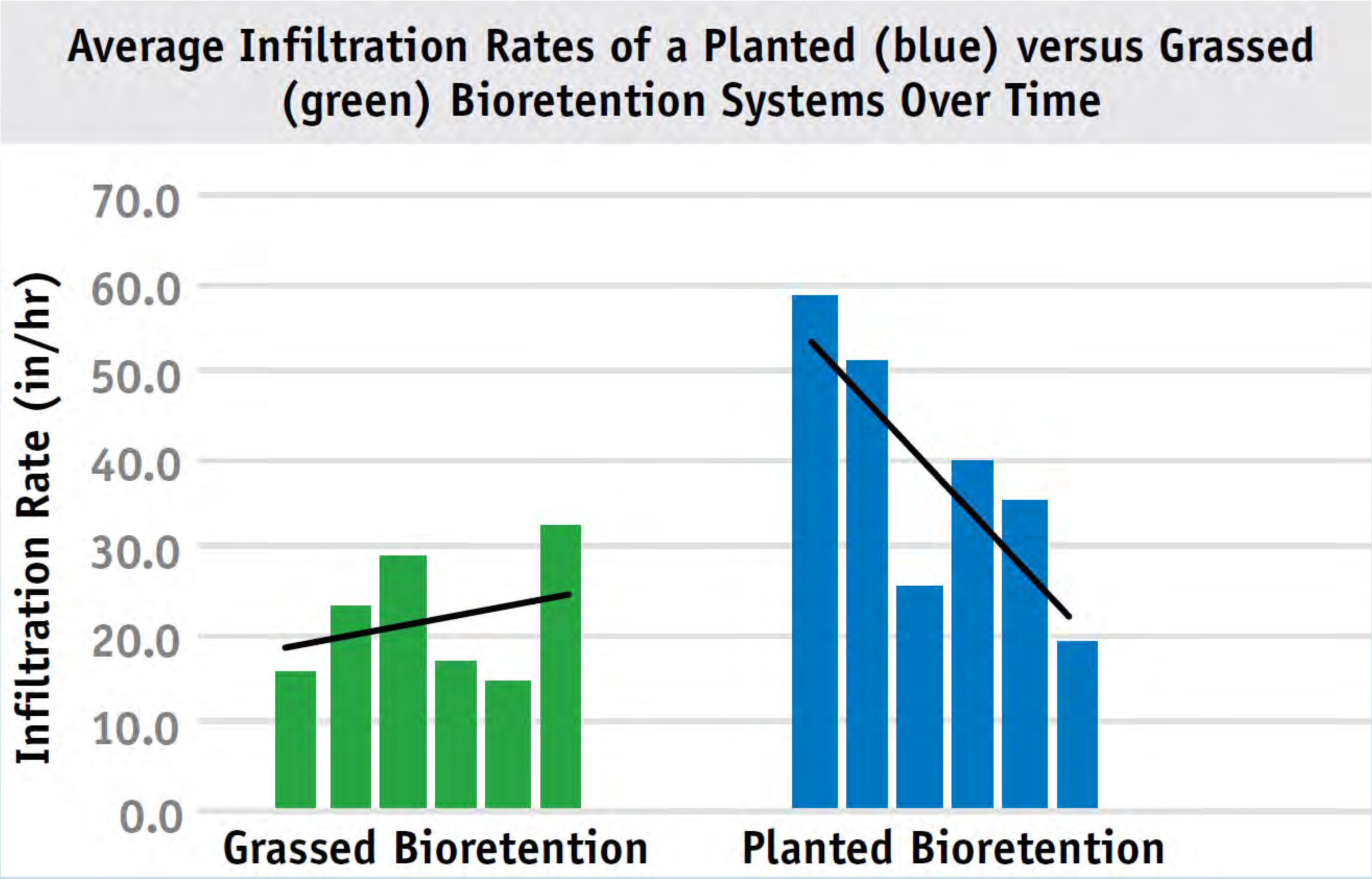
Grassed vs Planted Surface Infiltration Rates



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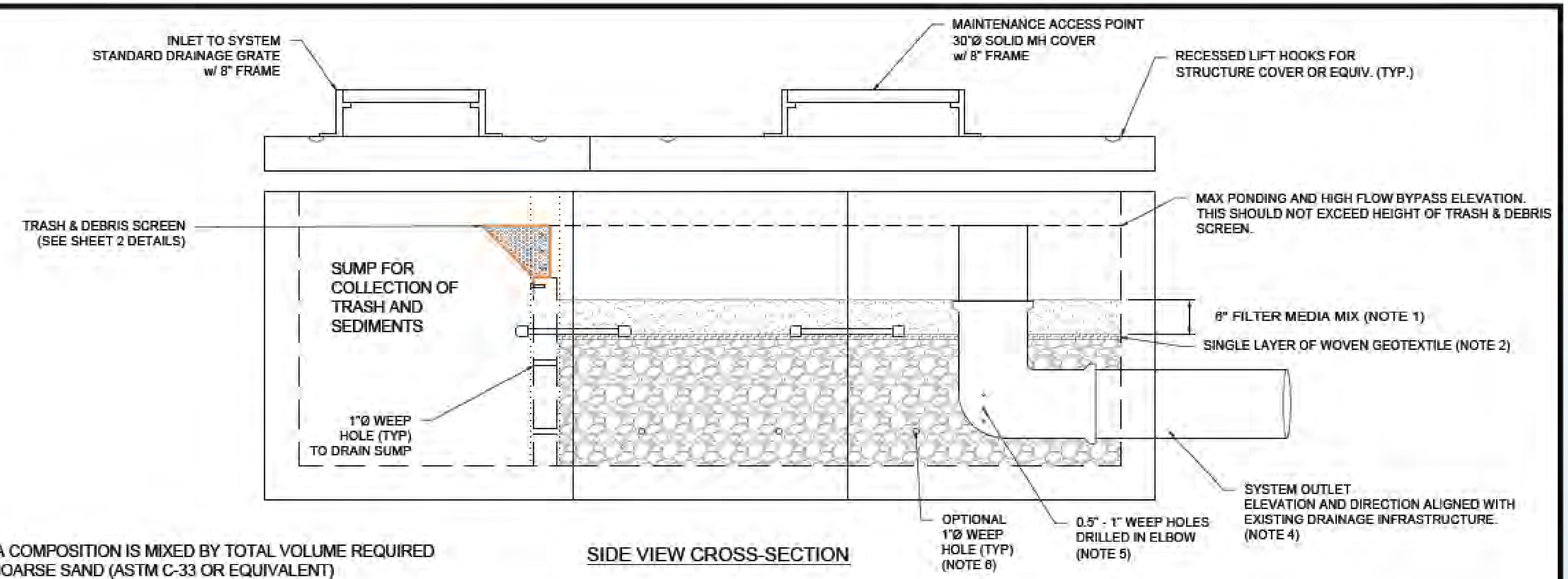
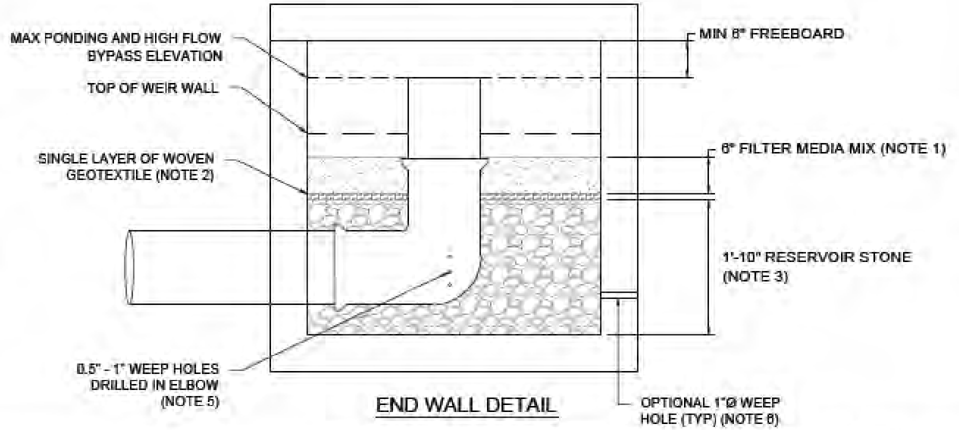
Sectional Media Box Filter Design – version 3



SIDE VIEW CROSS-SECTION

NOTES:

1. FILTER MEDIA COMPOSITION IS MIXED BY TOTAL VOLUME REQUIRED
   - 1.1. 75-85% COARSE SAND (ASTM C-33 OR EQUIVALENT)
   - 1.2. 15-25% LOAM OR TOP SOIL
   - 1.3. 0-5% WATER TREATMENT RESIDUALS OR IRON FILINGS. THIS IS AN AMENDMENT USED FOR ENHANCED PHOSPHORUS ADSORPTION
2. WOVEN GEOTEXTILE LAYER OR SILT FENCE MATERIAL. THIS LAYER IS TO REMOVE ALL SILT SIZE PARTICLES AND LARGER AND PROTECT THE RESERVOIR STONE FROM FILLING WITH FINES. THIS IS ALSO THE DEPTH OF ROUTINE MAINTENANCE, WHICH INVOLVES REMOVING FILTER MEDIA AND GEOTEXTILE AND REPLACING WITH NEW.
3. RESERVOIR STONE CAN CONSIST OF A WIDE RANGE OF STONE SIZES. PREFERABLY A WASHED STONE OF CONSISTENT GRADATION, e.g. ¾" OR No. 57 STONE.
4. SYSTEM OUTLET CONFIGURATION CONSISTS OF A 90° ELBOW AND SHORT STUB PIECES OF HDPE DOUBLE WALLED OR SDR 35. THE ELEVATION AND DIRECTION THAT THE OUTLET EXITS THE SYSTEM WILL BE DETERMINED BY THE RESIDENT ENGINEER. THE OUTLET CAN BE PLUMBED TO BEST FIT THE EXISTING INFRASTRUCTURE.THE OUTLET PIPE SHALL BE SIZED TO PASS THE PREFERRED DESIGN STORM.
5. DRAINAGE HOLES SHOULD BE DRILLED IN THE OUTLET ELBOW TO DRAIN THE WATER DURING AND BETWEEN STORMS. THE HOLES SHALL BE IN A VERTICAL PLACEMENT TO PROVIDE ADDITIONAL CAPACITY AS THE SYSTEM FILLS. THE HOLES SHOULD BE SMALL ENOUGH TO PREVENT RESERVOIR STONE FROM DRAINING THROUGH. NUMBER AND SIZE OF HOLES CAN BE DETERMINE BY RESIDENT ENGINEER.
6. OPTIONAL 1" WEEP HOLES IN EXTERIOR WALLS OF BOX STRUCTURE CAN BE REMOVED FROM PRODUCTION OR PLUGGED IF PREFERRED. BENEFITS INCLUDE: SYSTEM DRAIN DOWN BETWEEN STORMS, GROUNDWATER RECHARGE, AND VOLUME REDUCTION.



END WALL DETAIL

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Durham, NH 03824
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Fax (603) 862-3957
http://www.unh.edu/unhsc

No.	Date	Revision
Designed: TAP	Checked: JJH	Approved:

GRAPHIC SCALE 0 20" 40"
Original Drawing Size = 11 x 17 in.

N

Project: Sectional Media Box Filter Typical Installation Detail

Date: February 22, 2017

Sheet No. 3 of 3

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Retrofits and Sizing

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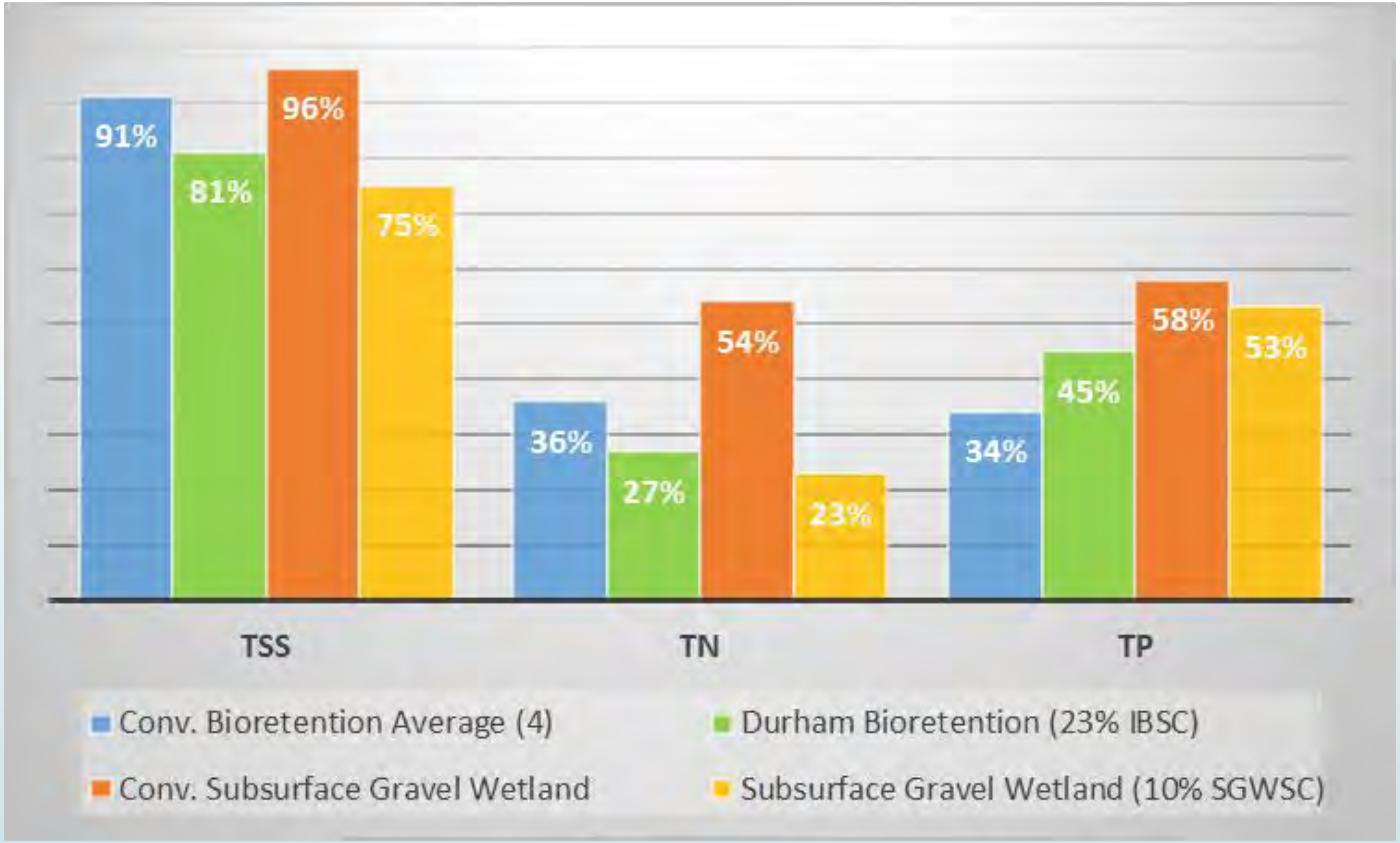
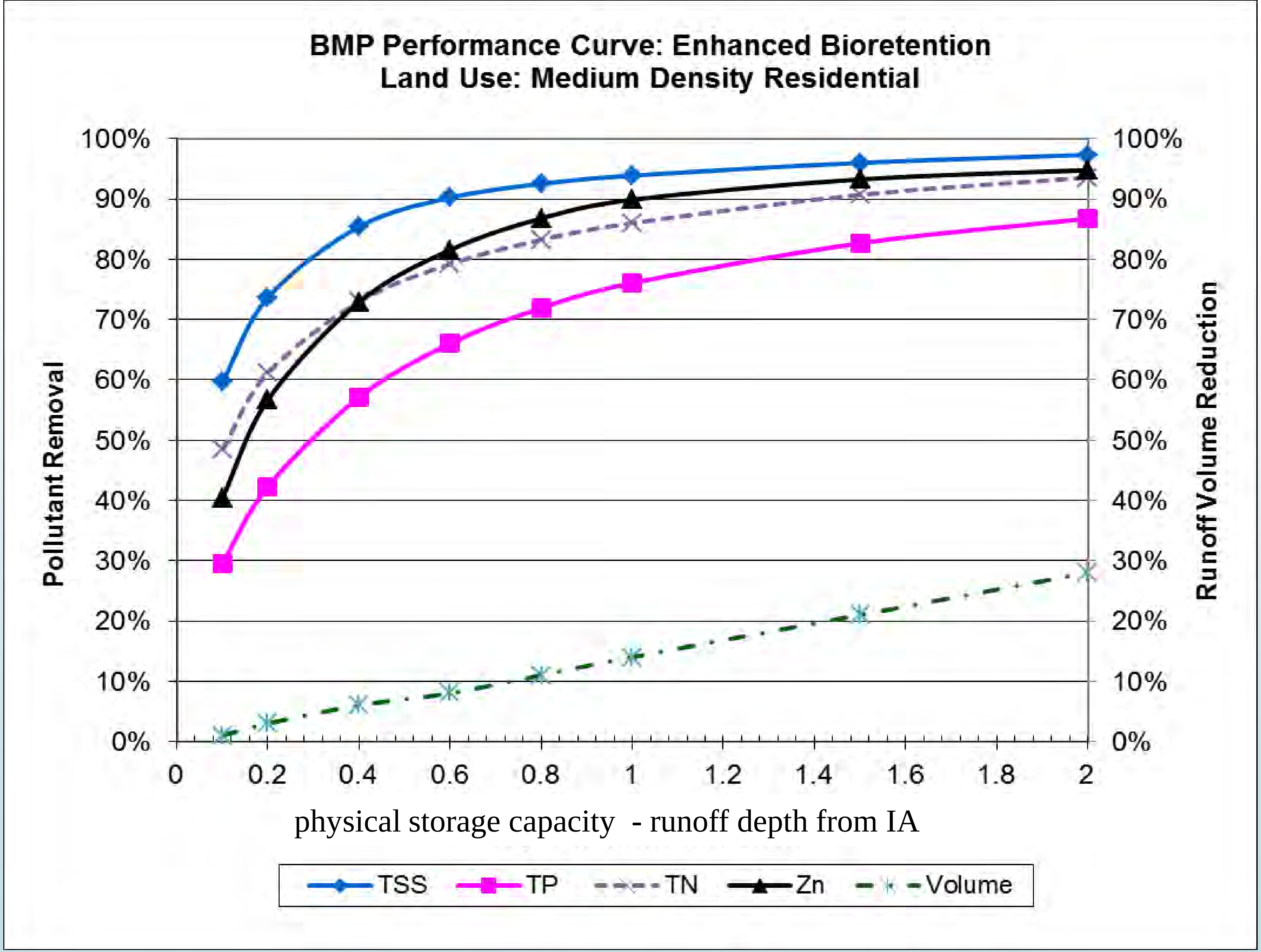
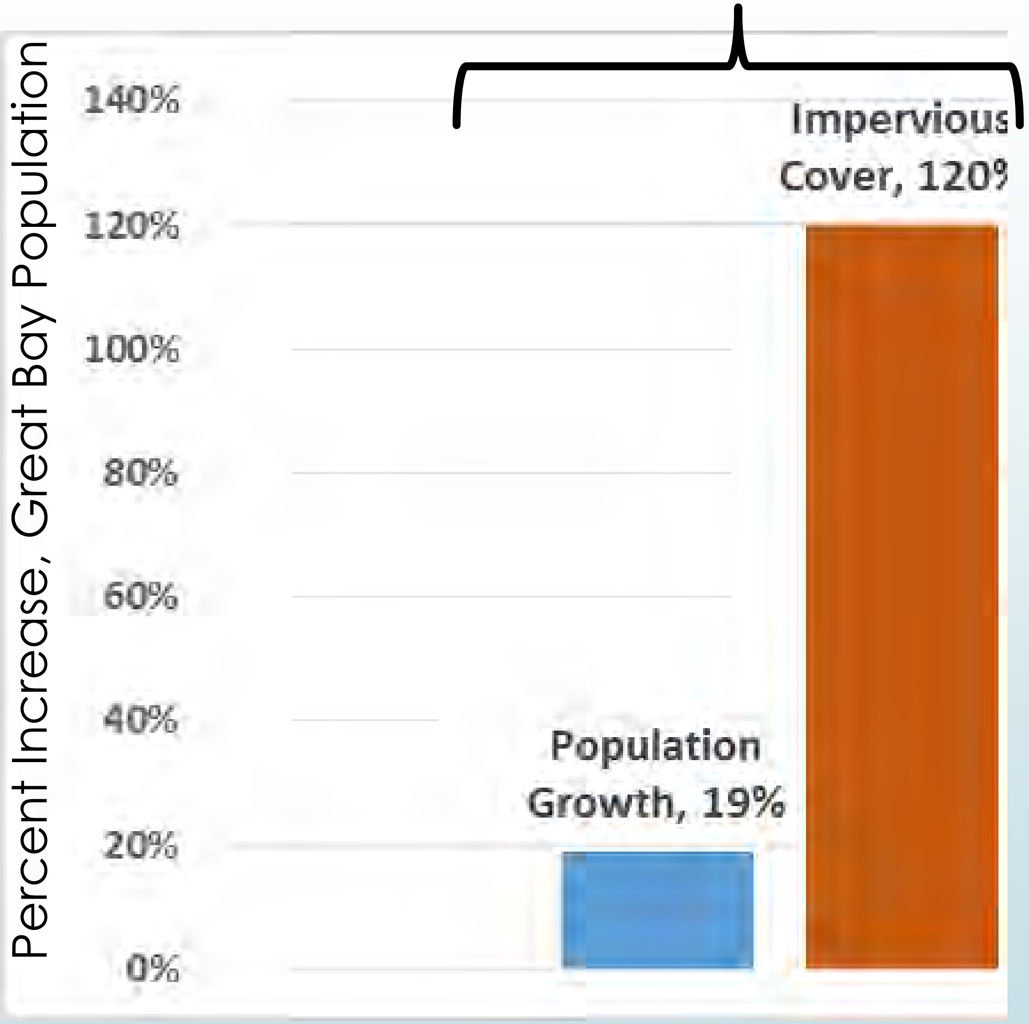


System	TSS	TN	TP
Conv. Bioretention Average (4)	91%	36%	34%
Durham Bioretention (23% IBSC)	81%	27%	45%
Conv. Subsurface Gravel Wetland	96%	54%	58%
Subsurface Gravel Wetland (10% SGWSC)	75%	23%	53%

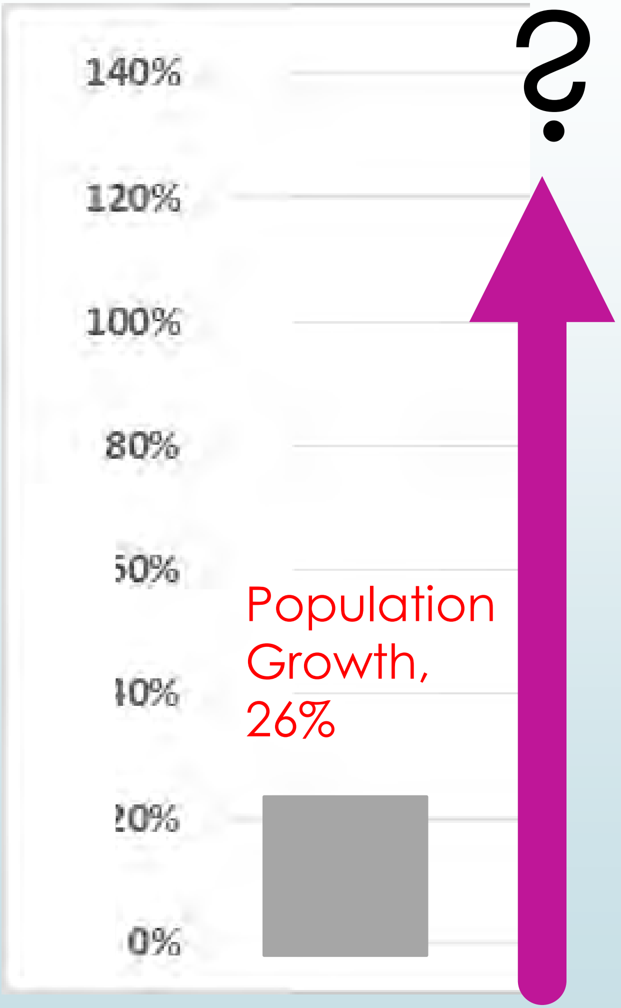

BMP Performance Curve: Enhanced Bioretention
Land Use: Medium Density Residential
Pollutant Removal
Runoff Volume Reduction
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
physical storage capacity - runoff depth from IA
TSS
TP
TN
Zn
Volume

Population Growth and Impervious Cover

Last 20 years



Next 30 years



From 1990 to 2010 (Source: US Census; UNH earth systems research center; PREP; 2010-2040 Projections, UNHSC)

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Yes, climate change gives us pause to think, but IC is the 800-pound gorilla

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Urban Watershed Renewal through LID and Stream Restoration

LID Stormwater Management



Outcome: water quality treatment, volume reduction, and baseflow augmentation

Wetland and Stream Restoration



Outcome: stream provides aquatic habitat, reduce/eliminate fish passage barriers, restore ecosystem services

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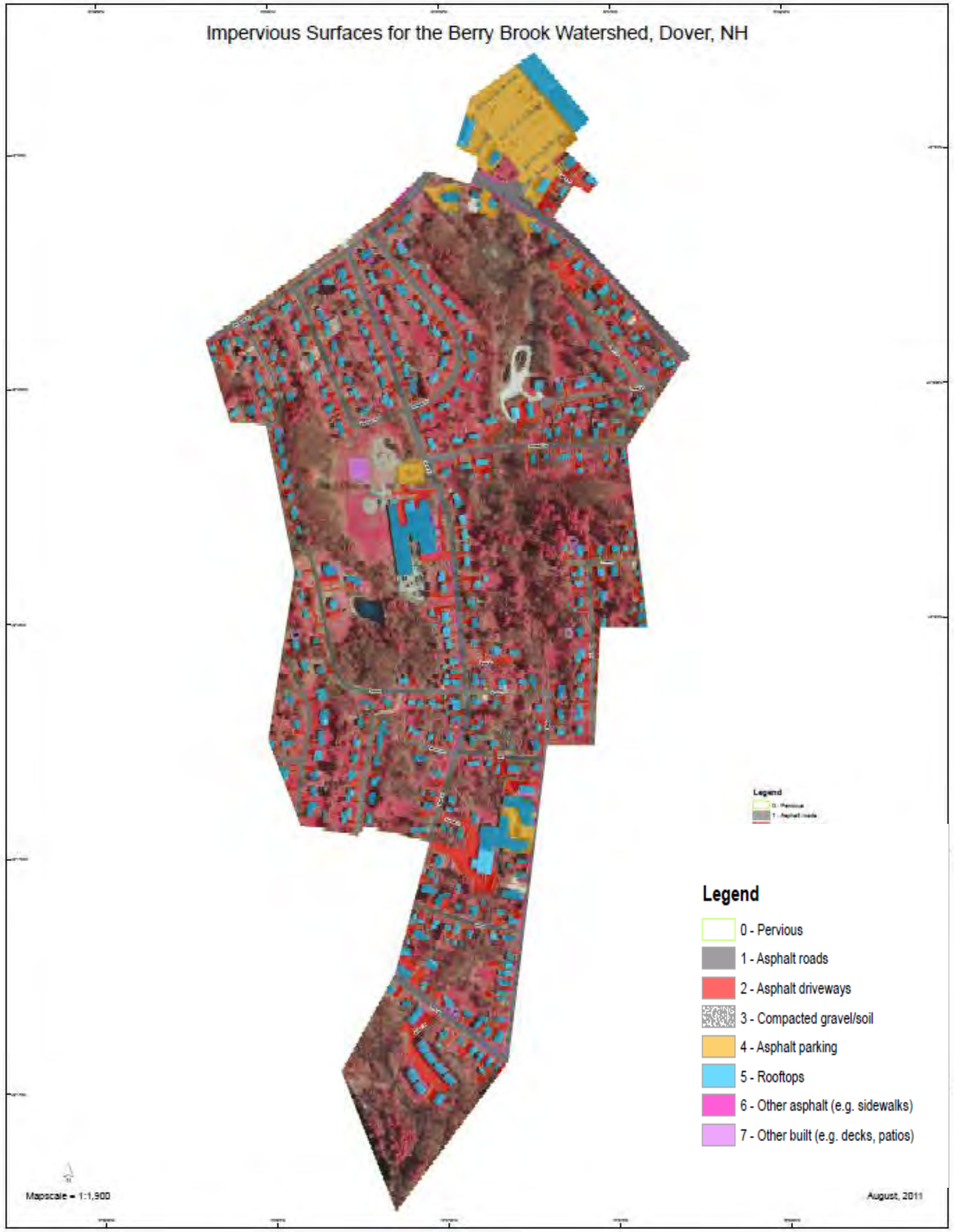
Berry Brook Watershed Overview Impervious Surfaces



Surface	Area (acres)
Total Watershed	185
Pervious	129.4
Asphalt Roads	14.3
Asphalt Driveways	12.4
Compacted Soil	1.0
Parking Lots	7.0
Rooftops	17.6
Other Asphalt	1.7
Other (decks, patios)	1.3
Impervious Total	55.3 (30%)

Source: Adapted from Mapping Impervious Surfaces in the Berry Brook Watershed Complex Systems Research Center, August, 2011

Berry Brook Watershed Renewal Project

Berry Brook Dover, NH

- NHDES named Berry Brook to the 303d list of impaired surface waters due to lack of aquatic life support.

Project Comprised of 2 Components

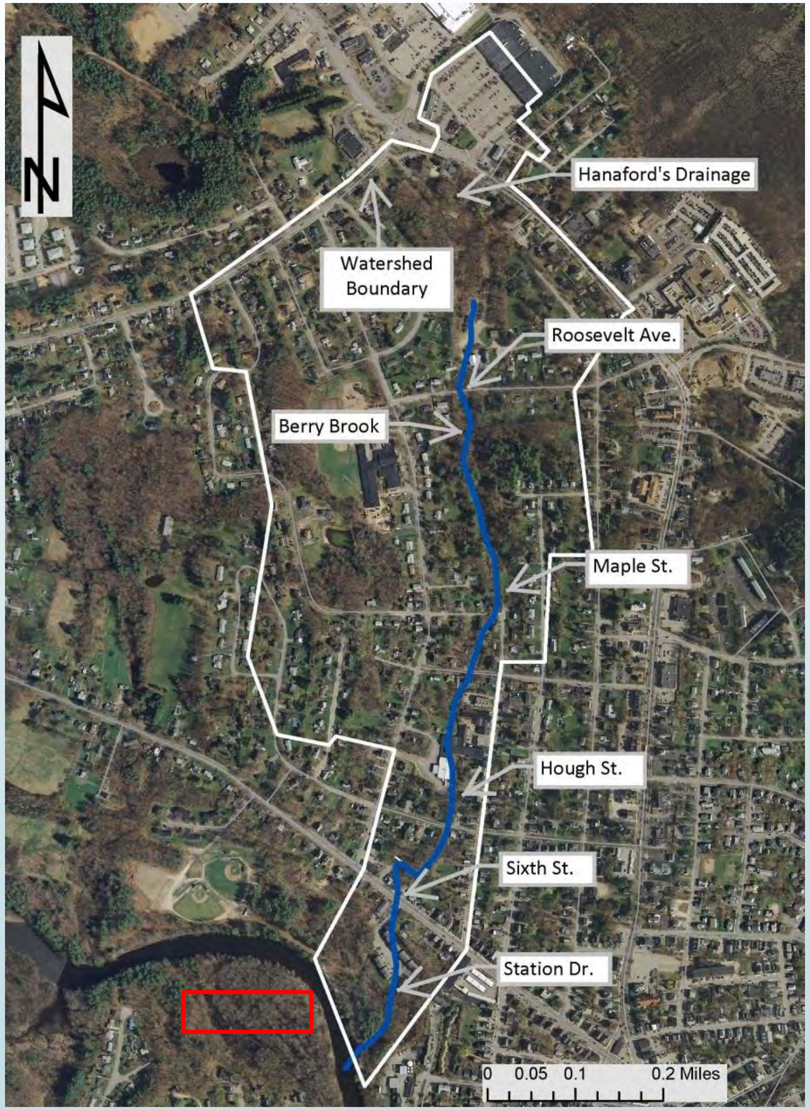
1) Stream and wetland restoration (~800ft)
2) Stormwater management (24 LID Systems)
   - Treatment of 20.7 IC acres

Berry Brook Watershed area ~185acres

Berry Brook stream length is approx. 1.15 miles

Urbanized - high density area (30% EIC)

Berry Brook Watershed –Delineation and Monitoring Locations



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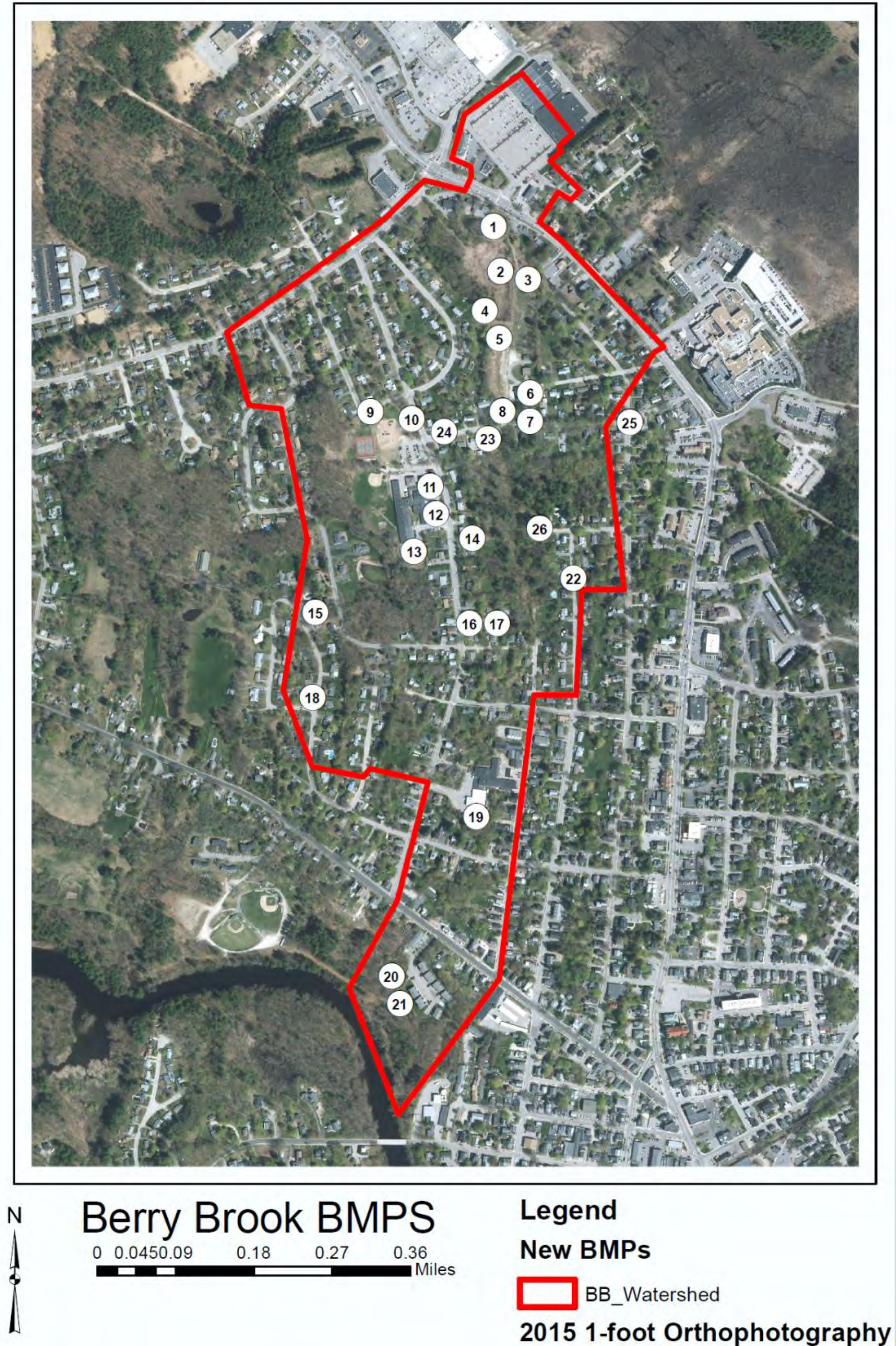
Retrofit Locations



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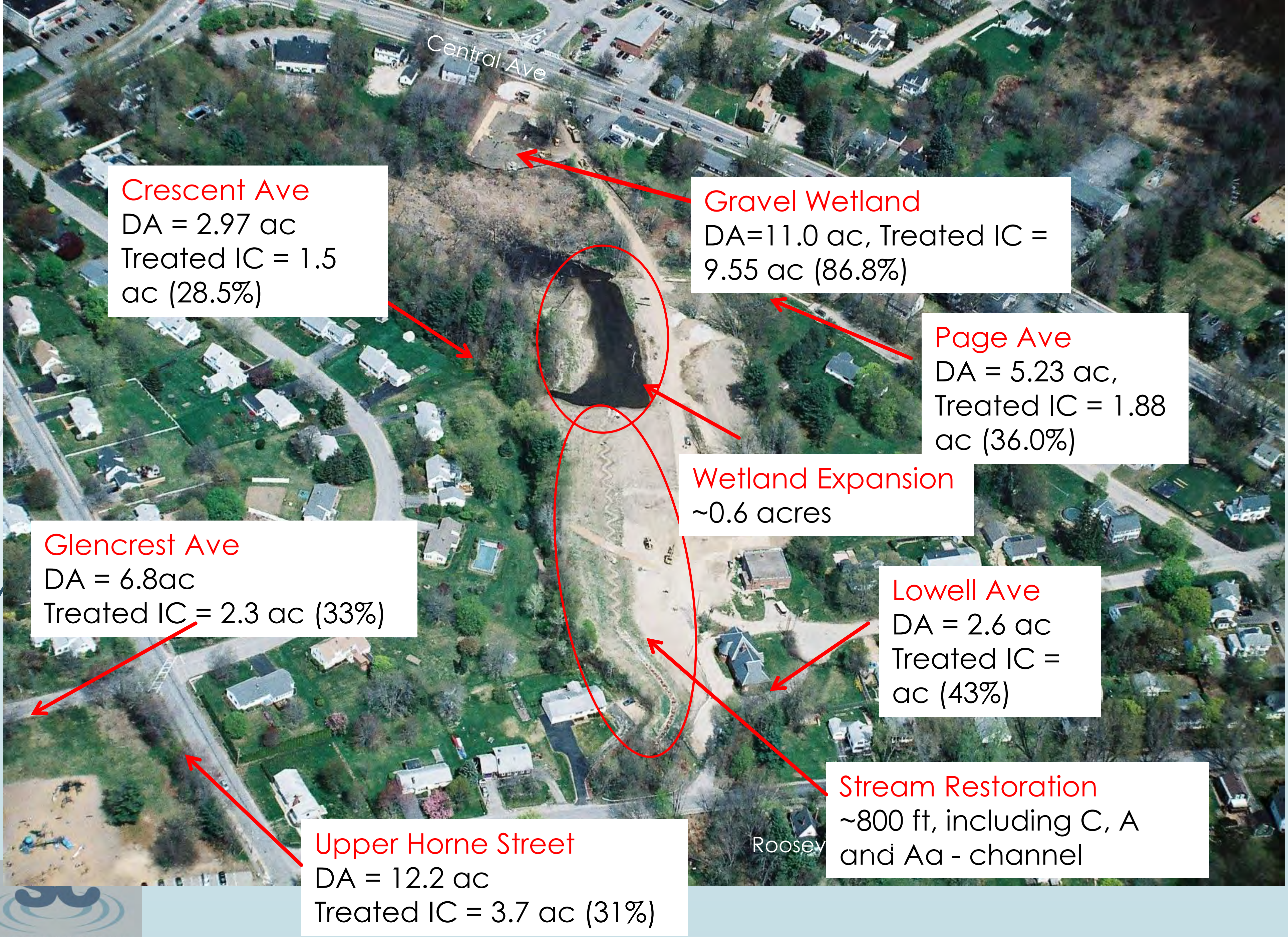

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Installed Green Stormwater Infrastructure

- 12 bioretention systems,
- 1 tree filter,
- 1 subsurface gravel wetland,
- One-acre of new wetland,
- Day-lighted and restored 1,100 linear feet of stream at the headwaters and restored 500 linear feet of stream at the confluence including two new geomorphically-designed stream crossings
- 3 grass-lined swales
- 2 subsurface gravel filters
- 1 infiltration trench system
- 3 innovative filtering catch basin designs

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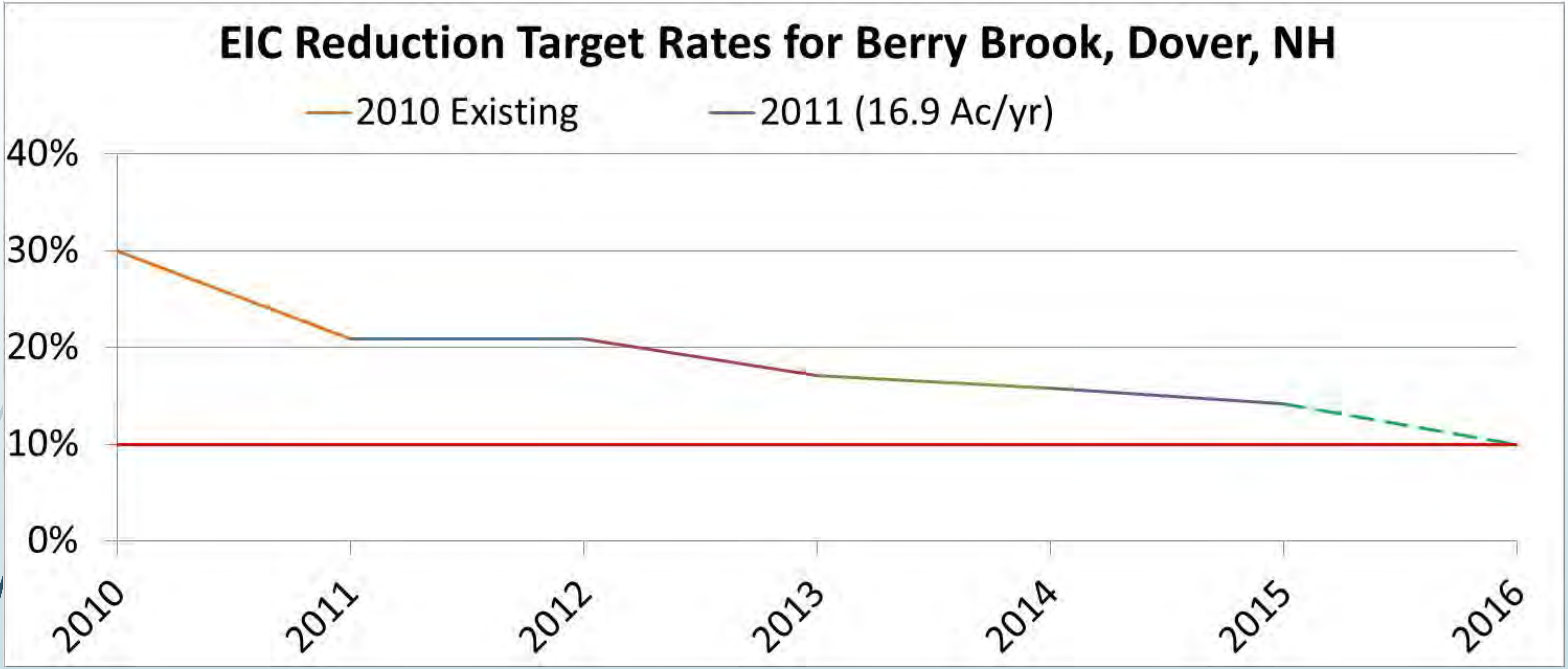
Getting to 10% EIC



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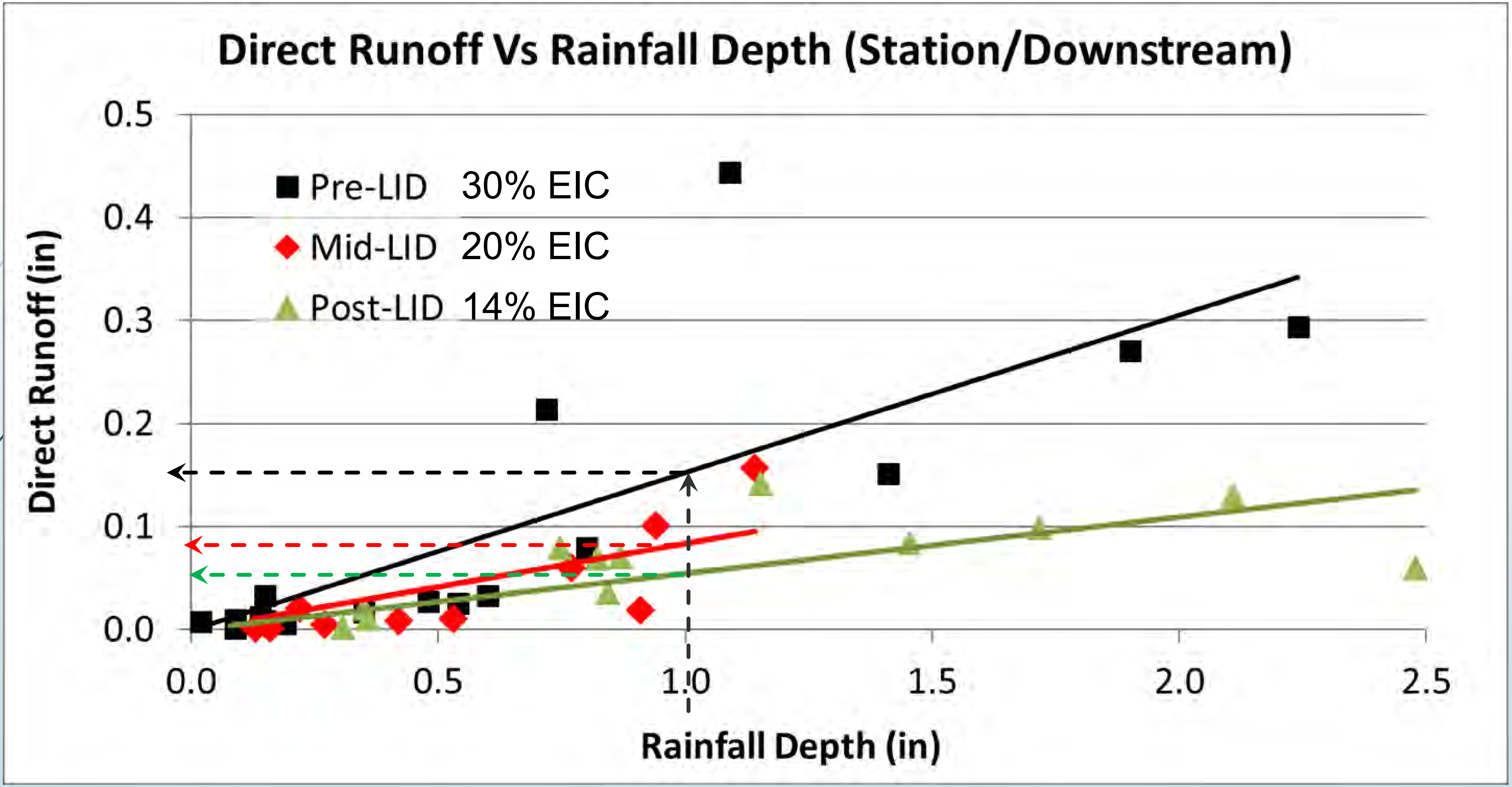
Reducing Runoff Volume



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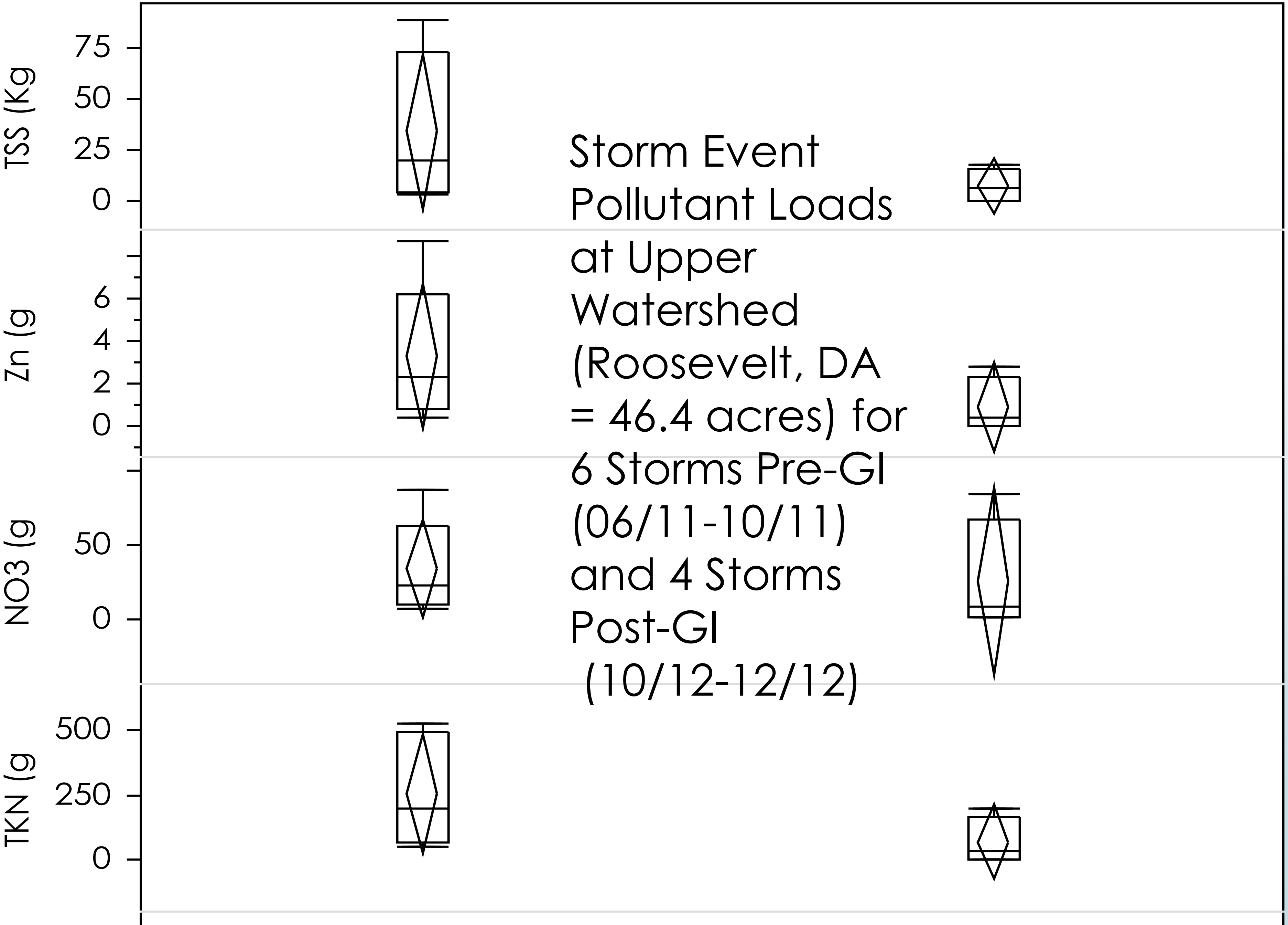
Effect of Reducing Watershed CN

CN	Amount of Rain to Generate Runoff (in)	Pn	Pe
74	0.4	68.1%	31.9%
64	0.5	74.4%	25.6%
59	0.6	80.1%	19.9%

Storm Event Pollutant Loads at Upper Watershed (Roosevelt, DA = 46.4 acres) for 6 Storms Pre-GI (06/11-10/11) and 4 Storms Post-GI (10/12-12/12)



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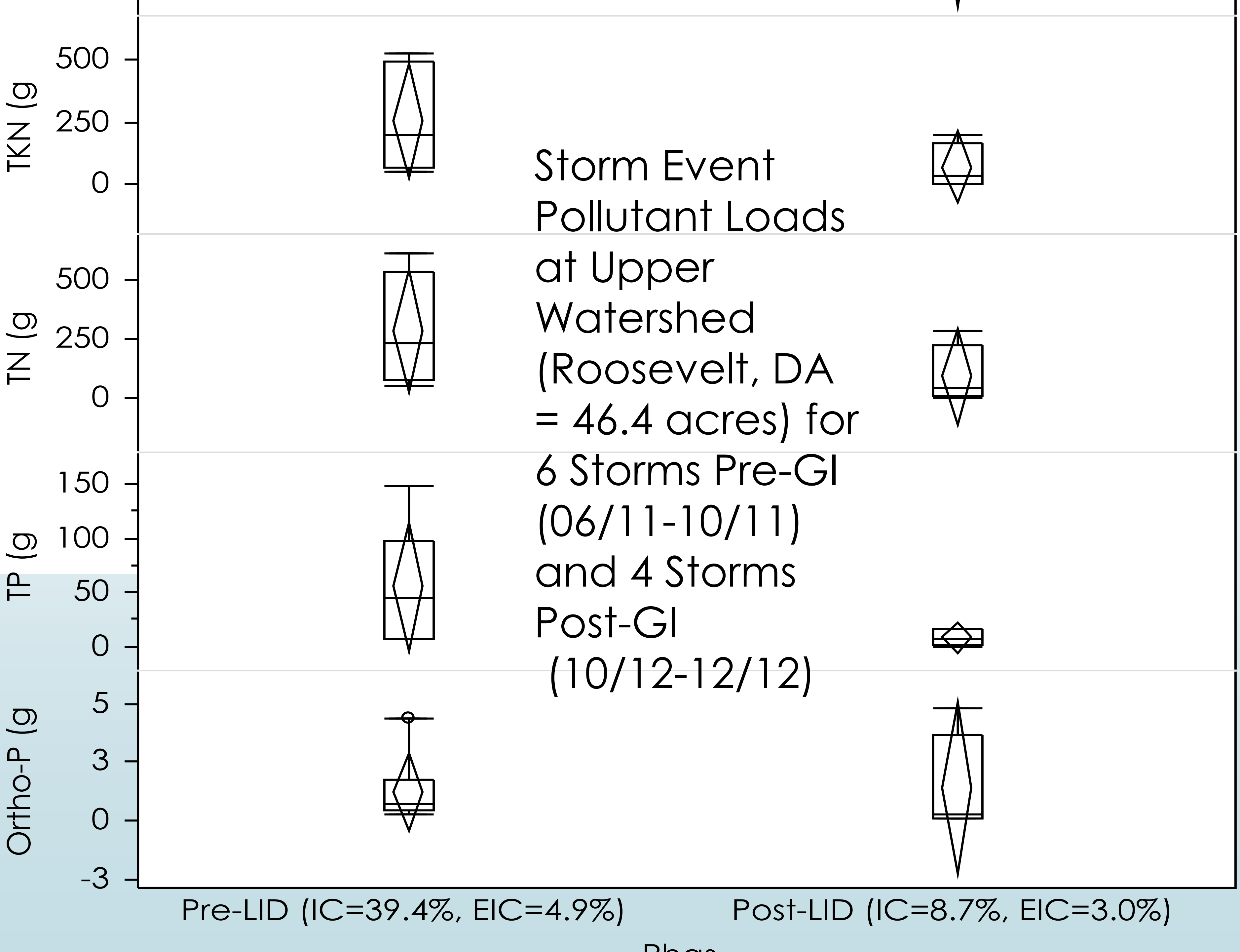
Storm Event Pollutant Loads at Upper Watershed (Roosevelt, DA = 46.4 acres) for 6 Storms Pre-GI (06/11-10/11) and 4 Storms Post-GI (10/12-12/12)



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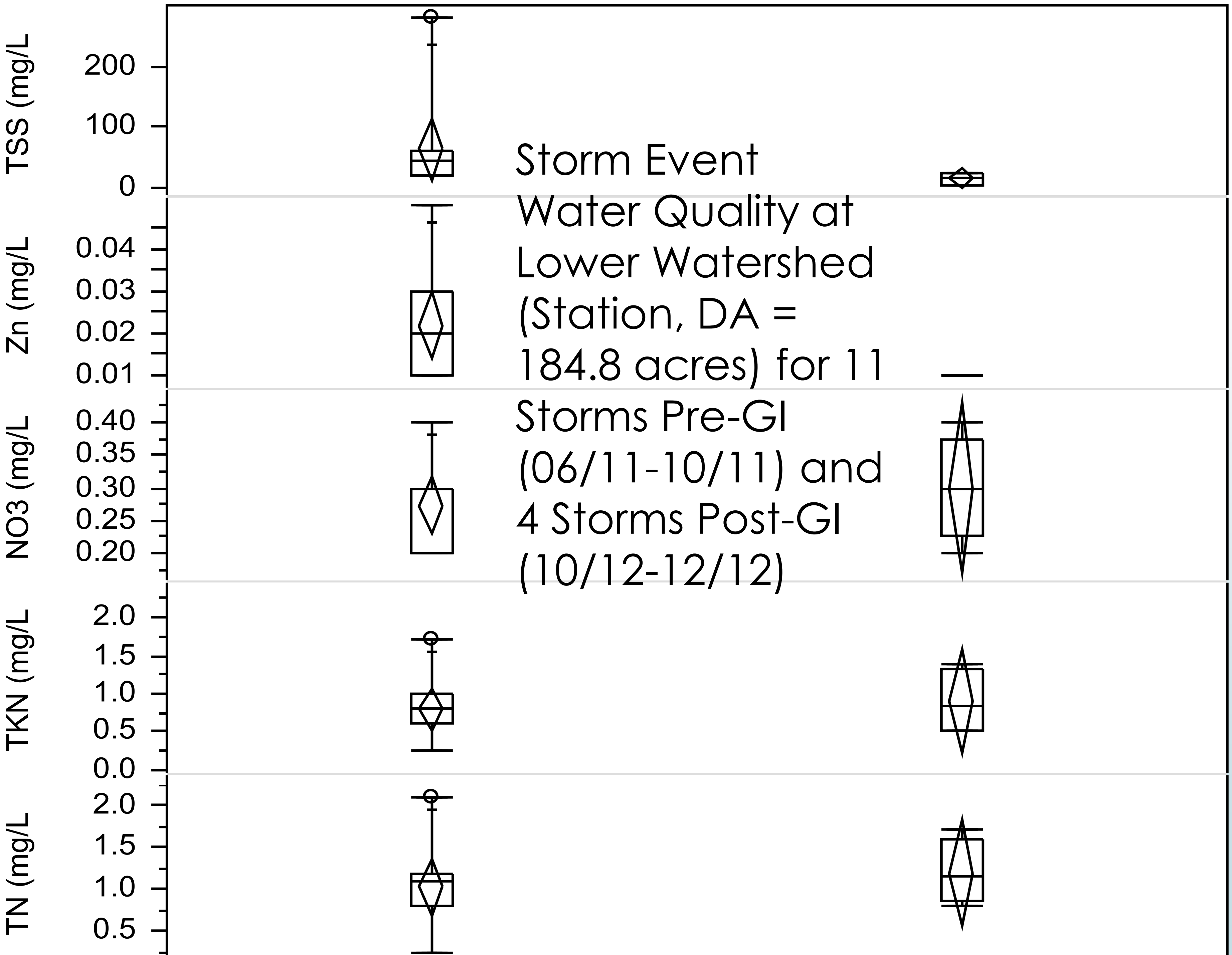

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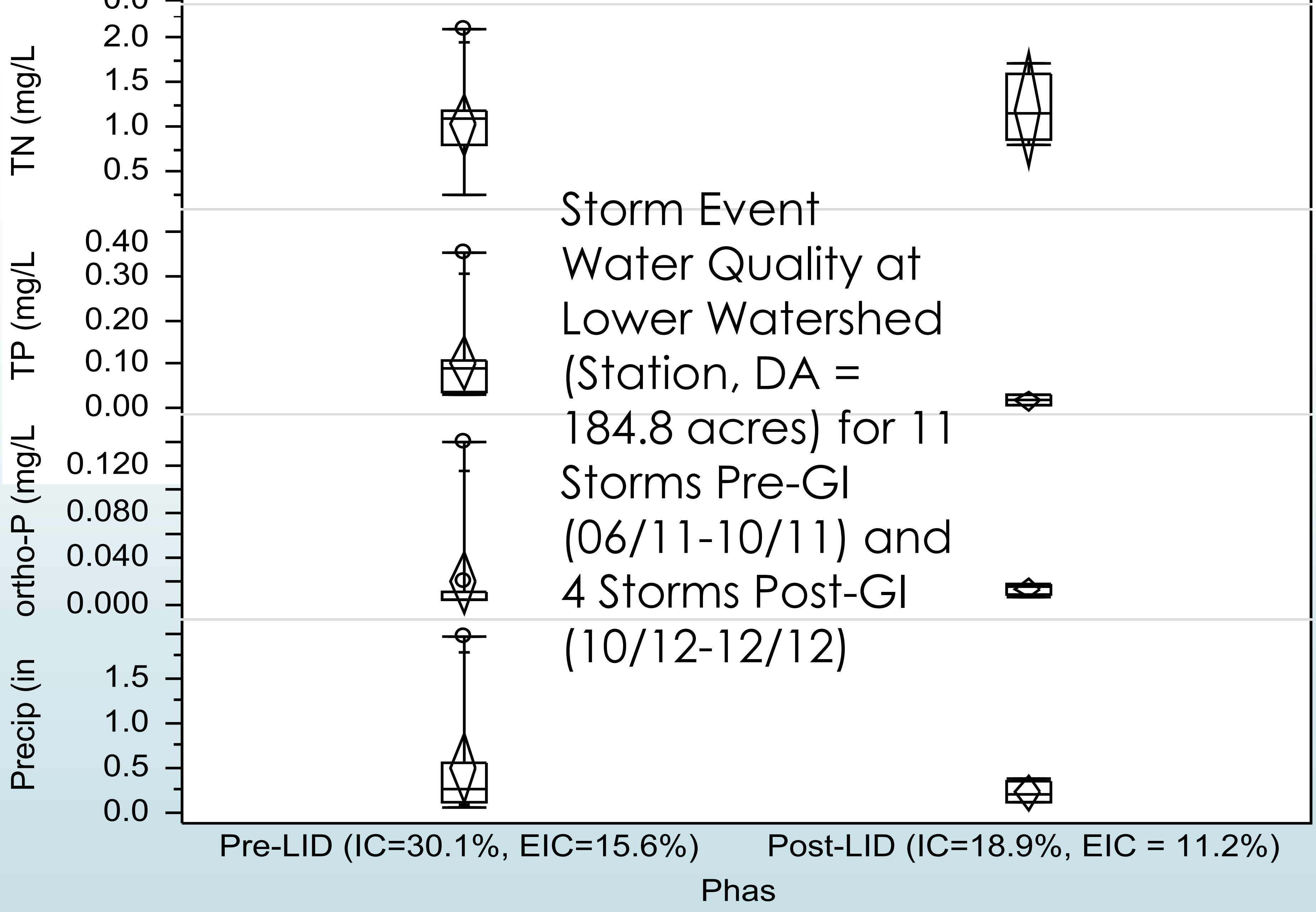
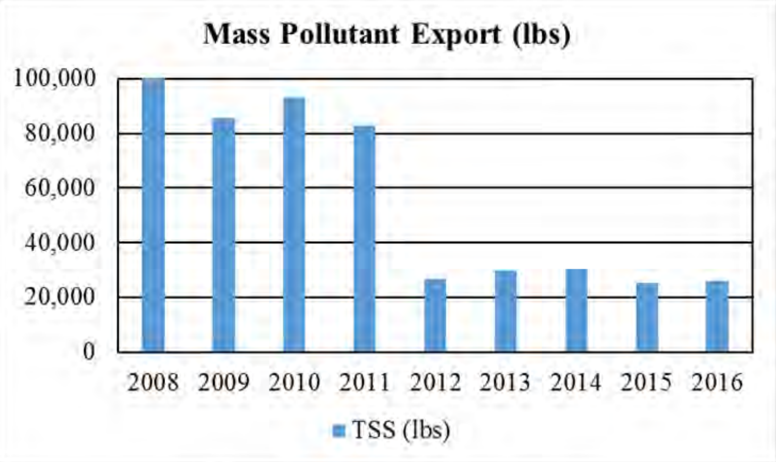
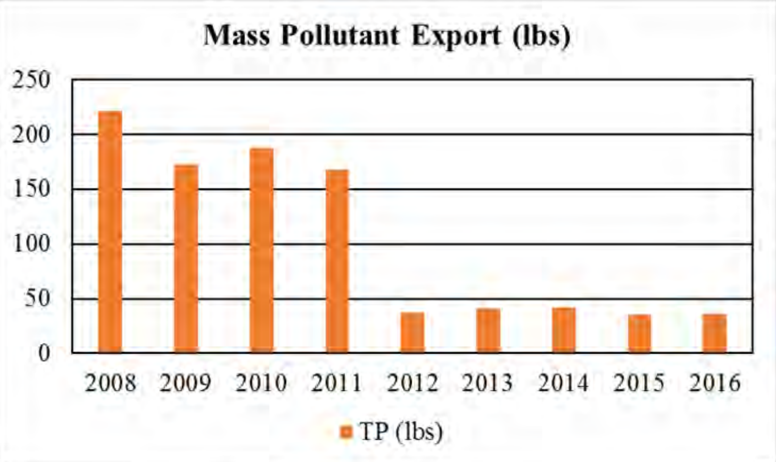
Storm Event Water Quality at Lower Watershed (Station, DA = 184.8 acres) for 11 Storms Pre-GI (06/11-10/11) and 4 Storms Post-GI (10/12-12/12)

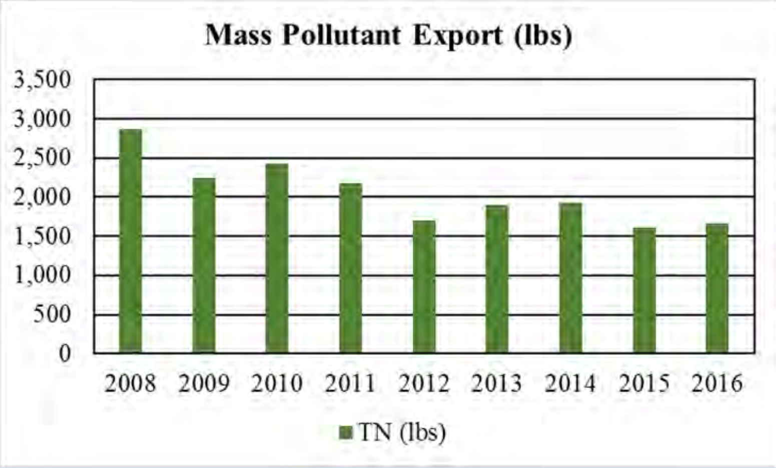


Modeled Water Quality

Year	A	P	CN	TSS (lbs)	TP (lbs)	TN (lbs)
2008-20011	185	56.14	74	92,719	188	2,428
20012-2016	185	42.20	62	27,575	38	1,762
Annual Reductions (lb./yr.)				65,144	149	667
Simple Method (lb./yr.)				57,223	201	1,127







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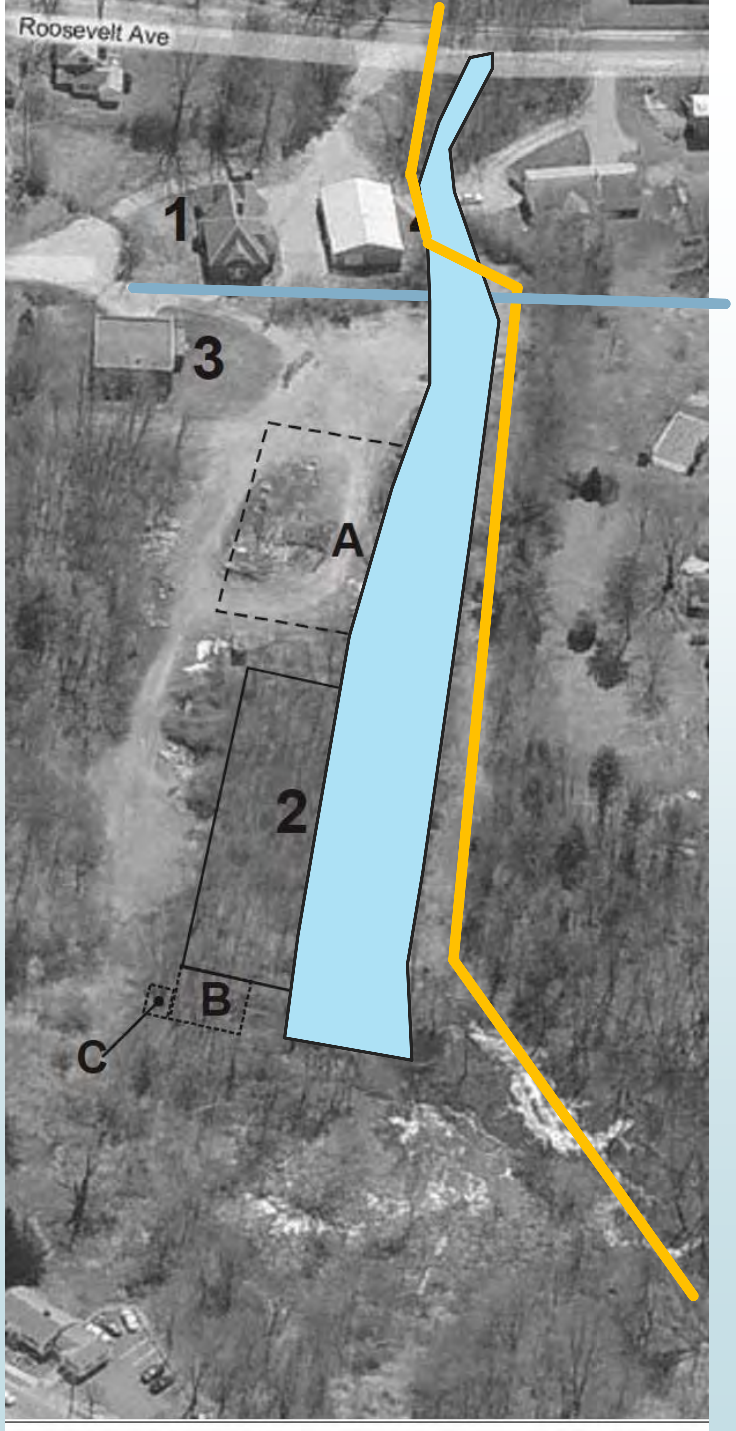
Roosevelt Ave
1
3
A
2
B
C

Stream Headwaters

Wetland Outflow to Buried Pipe

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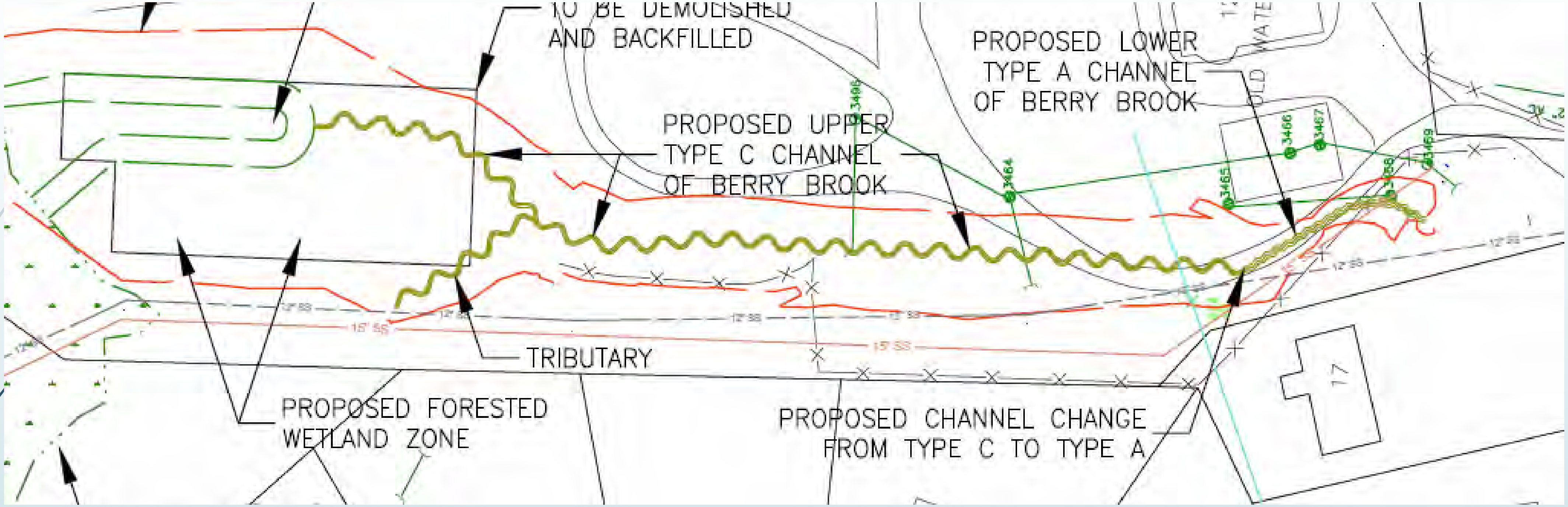
Wetlands Followed by Storage Yard

Initial Design



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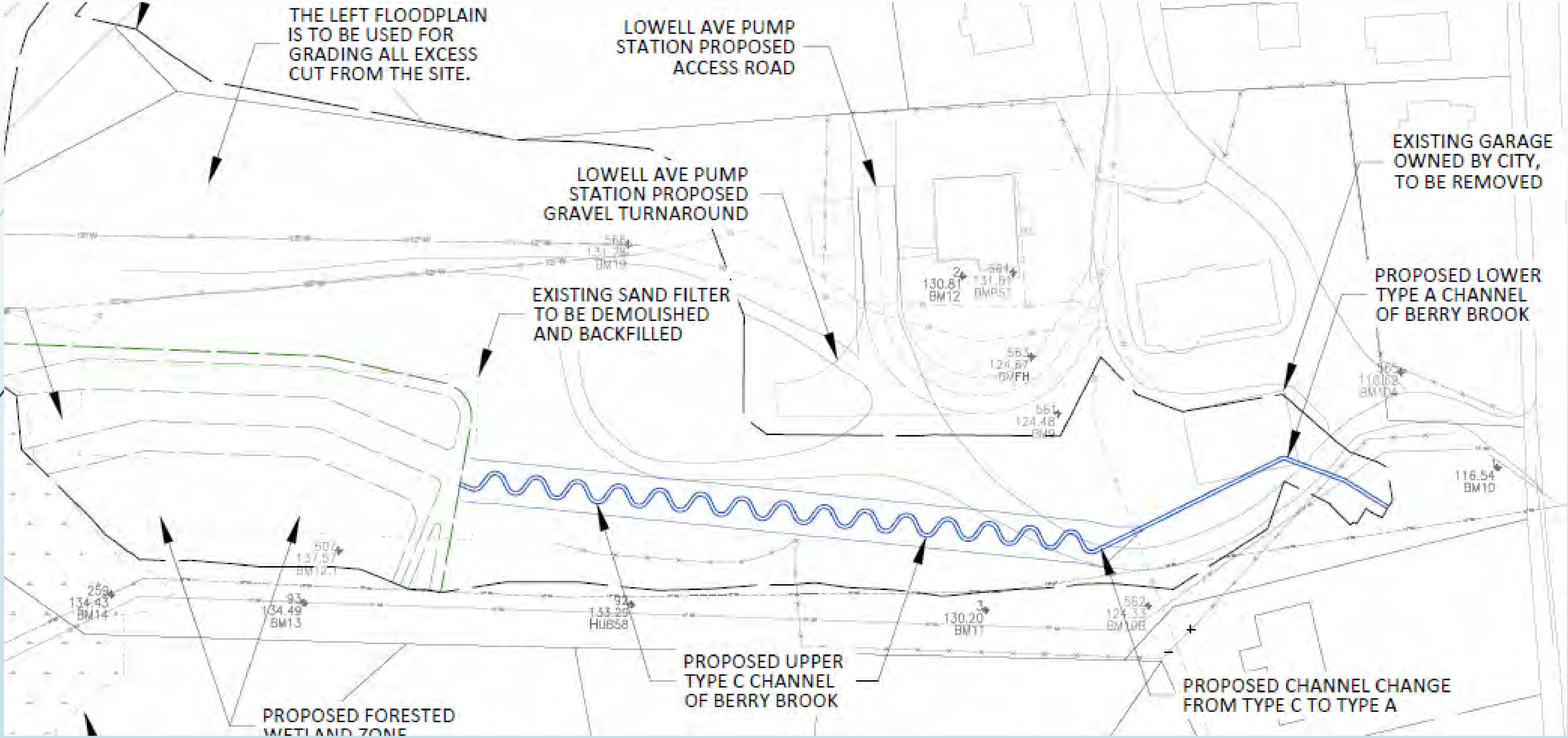
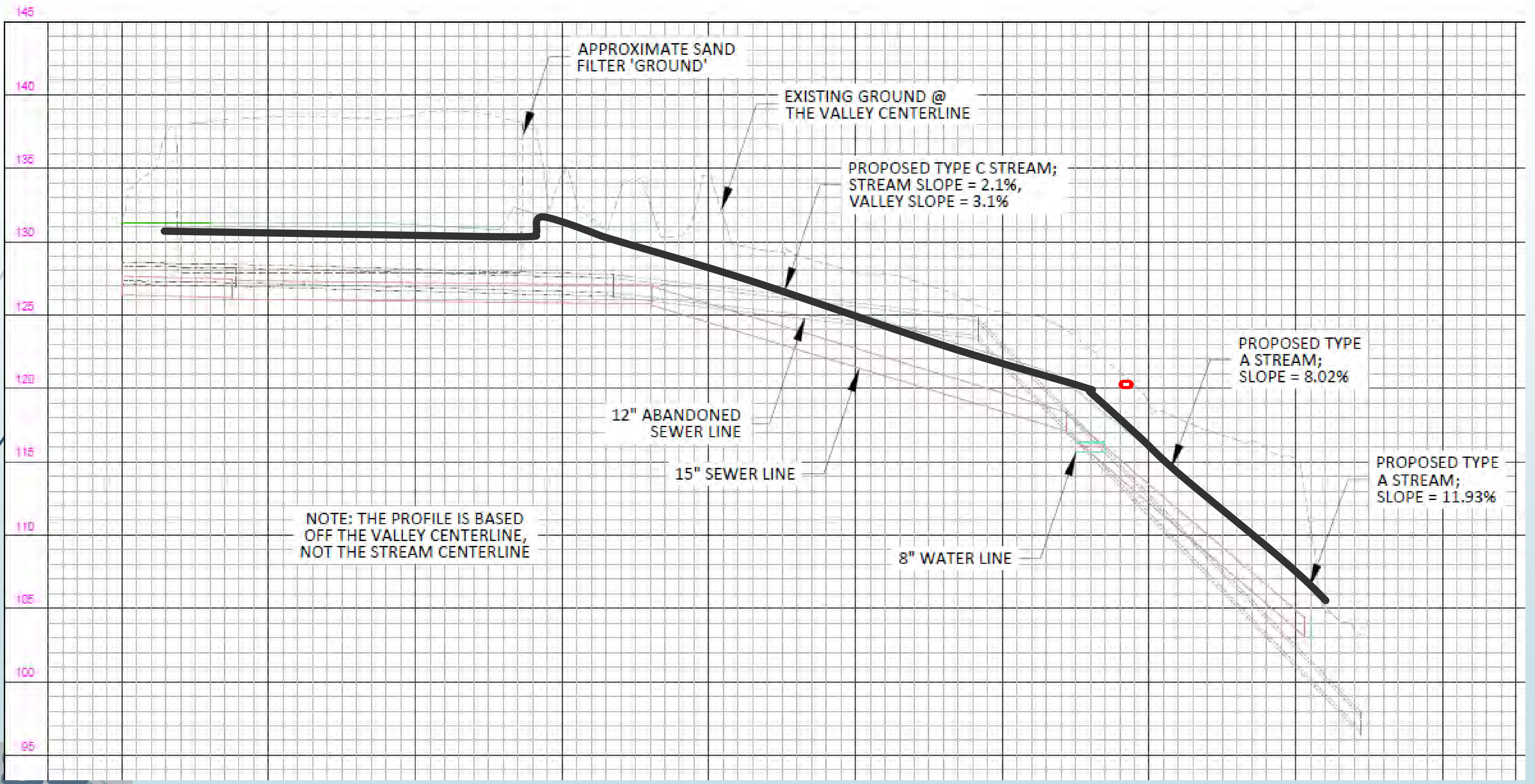
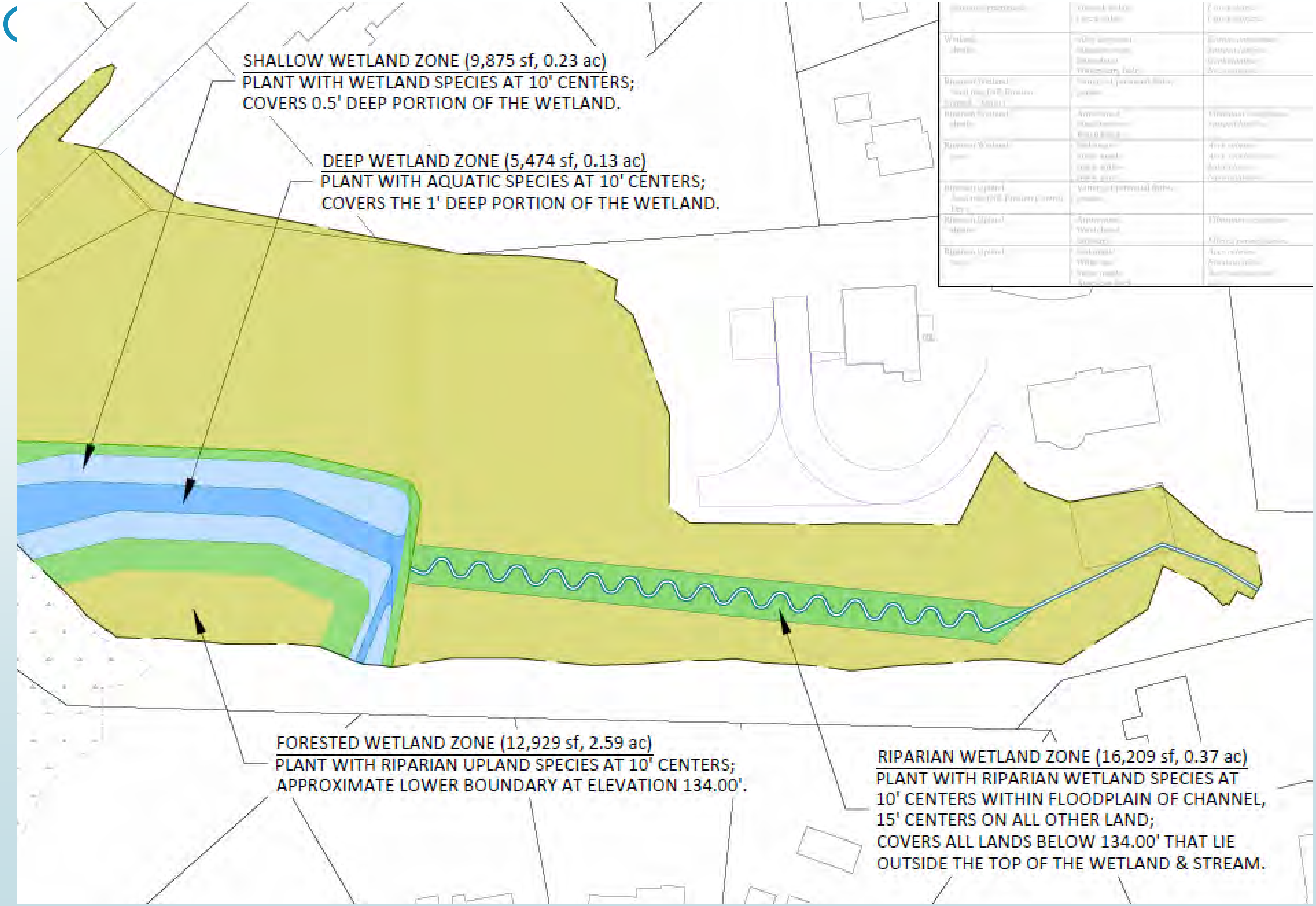
Expanded Wetlands, Shrinking Stream



Design Profile



Planting Pl



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21 March 2012

Construct Aa Step-Pools

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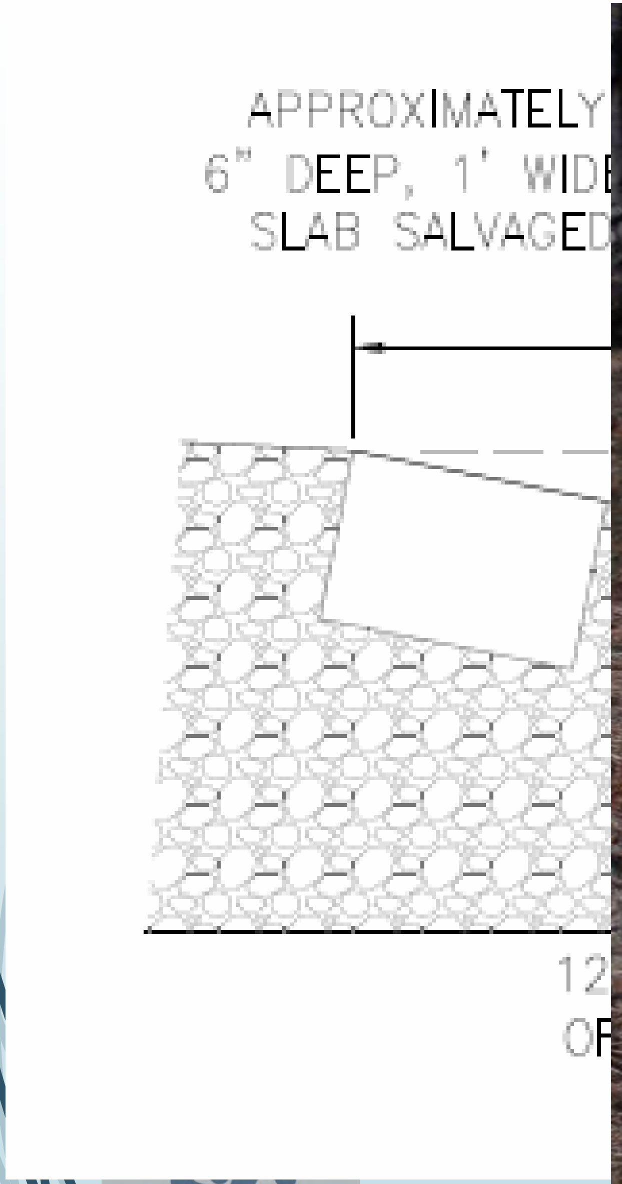
At-Grade Stream Crossing



Created Wetland

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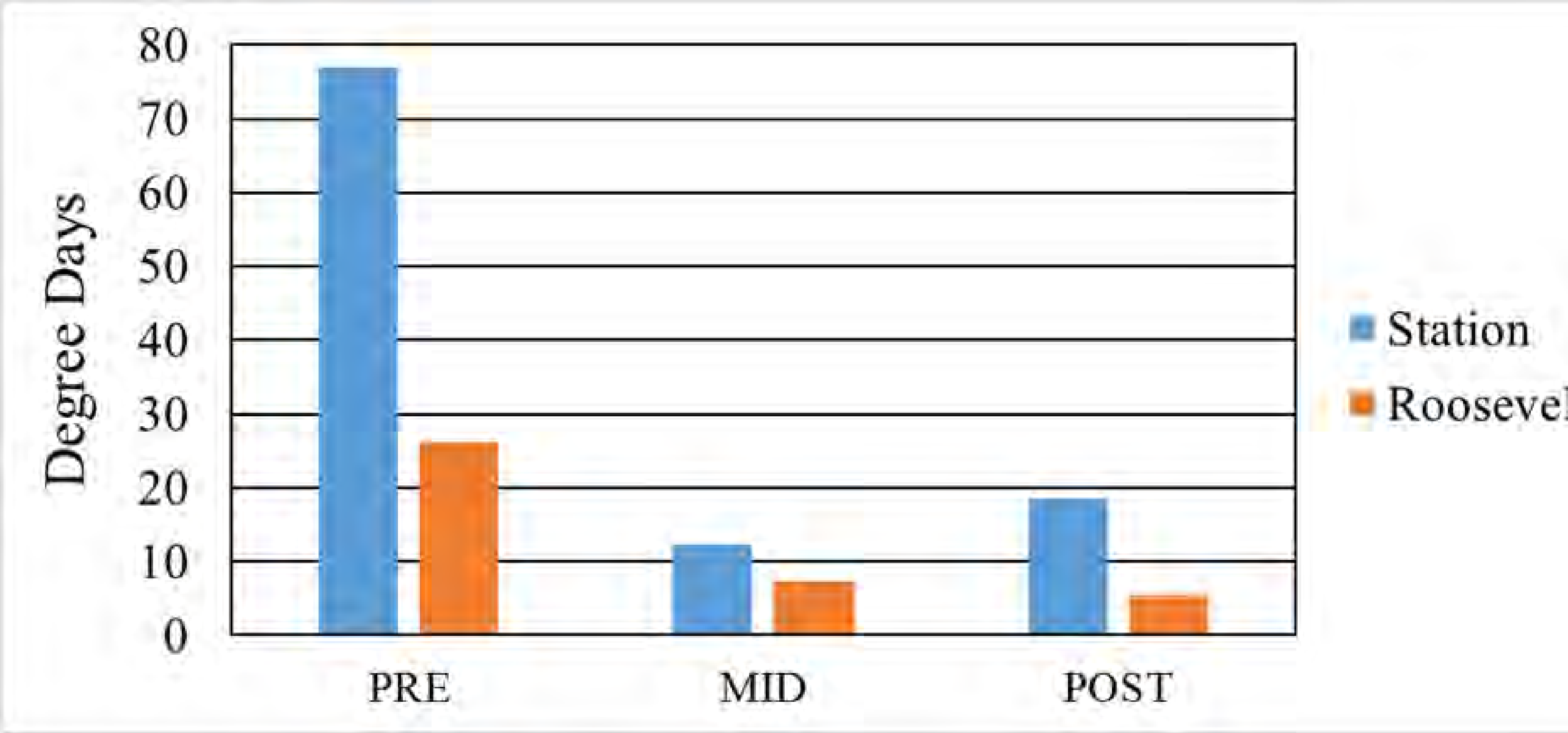
2013/06/09

Treatment Period	Start	End	BB EIC (End of TP)
Pre	June 2011	September 2011	30.0%
TP1	October 2011	December 2011	20.0 %
TP2	January 2012	December 2012	15.8%
TP3	January 2013	December 2013	14.8%
TP4	January 2014	December 2014	14.3%
TP5	January 2015	December 2015	12.5%
TP6	January 2016	December 2016	11.7%

Summer Cooling



One degree day is a day when the average stream temperature is one degree Fahrenheit above 65 degrees F. This is important as the temperature that a Brook Trout begins to feel heat stress is 65 °F. Therefore a day with an average daily stream temperature of 71 degrees would represent 6 degree days.

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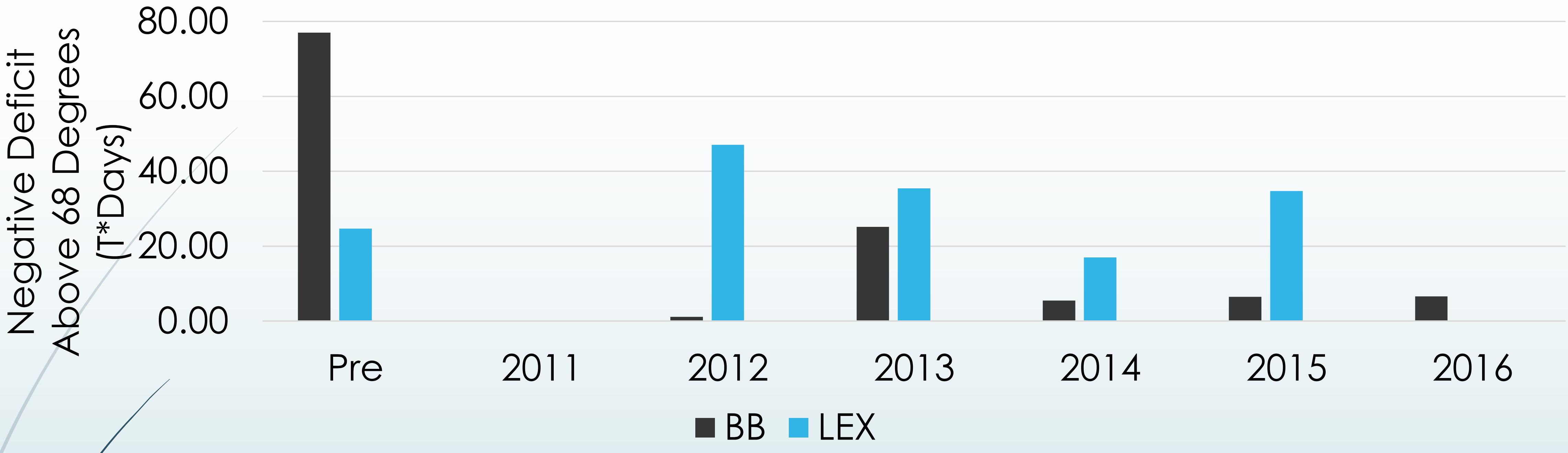

Thermal Response

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The Rare Chiquita Fish

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http://www.unh.edu/erg/cstev

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Funding and Results

- Funding: 3 watershed assistance grants and 1 aquatic resource mitigation grant with match from the city.

Berry Brook Project: Getting to 10%	
Cost	$1,322,000
Grant Funds	$793,000
Match (min estimate)	529,000
# GI Systems	26
DCIA Reduced	37 acres
TSS Reductions (lb./yr.)	57,223
TP Reductions (lb./yr.)	201
TN Reductions (lb./yr.)	1,127

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