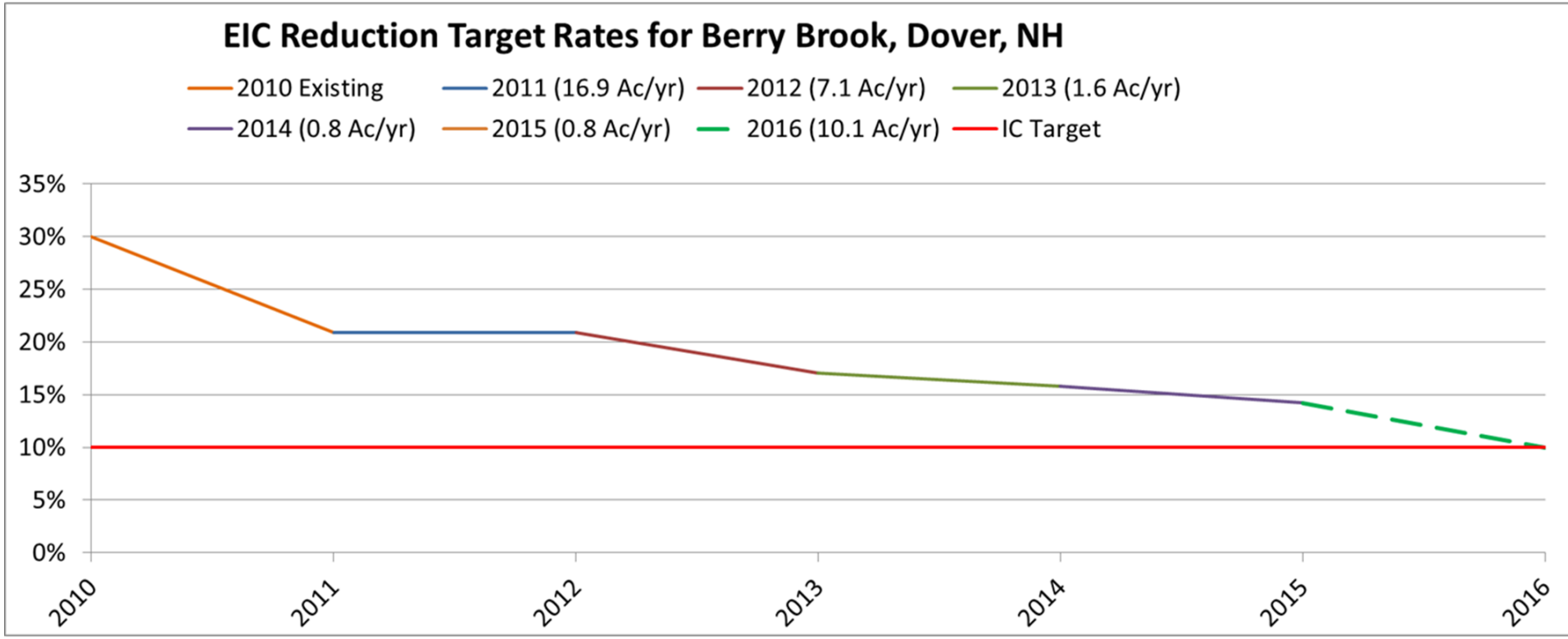
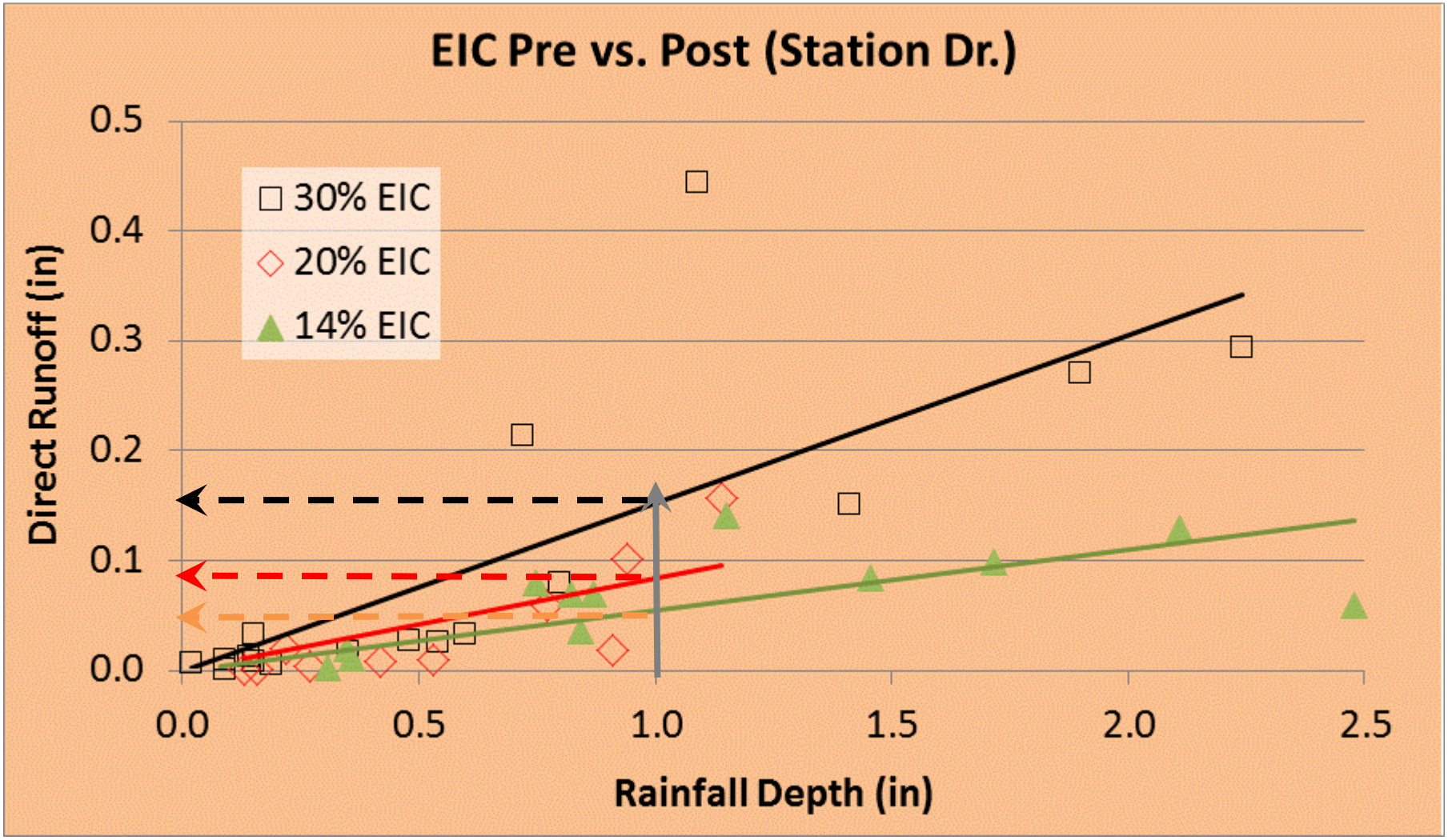
# Evolving Research for Stormwater Management

James Houle, UNH Stormwater Center

Providing Data to Protect Water Quality Since 2004

# Berry Brook


EIC Reduction Target Rates for Berry Brook, Dover, NH
2010 Existing
2011 (16.9 Ac/yr)
2012 (7.1 Ac/yr)
2013 (1.6 Ac/yr)
2014 (0.8 Ac/yr)
2015 (0.8 Ac/yr)
2016 (10.1 Ac/yr)
IC Target
35%
30%
25%
20%
15%
10%
5%
0%
2010
2011
2012
2013
2014
2015
2016


EIC Pre vs. Post (Station Dr.)
Direct Runoff (in)
0.5
0.4
0.3
0.2
0.1
0.0
30% EIC
20% EIC
14% EIC
0.0
0.5
1.0
1.5
2.0
2.5
Rainfall Depth (in)

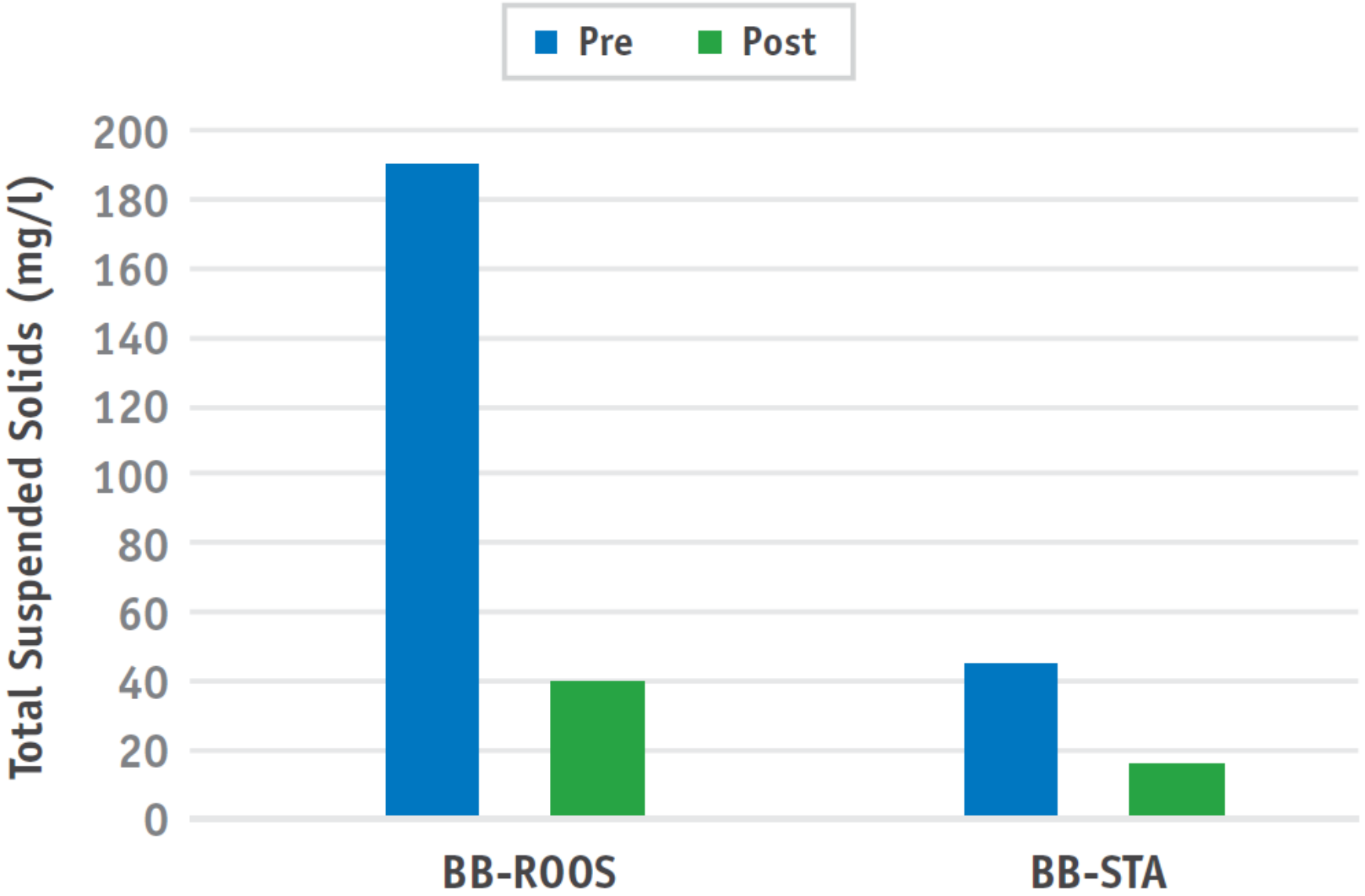
# Results for Berry Brook at Station Drive

## 1-Inch Storm, Ia = 0.05 S[1]

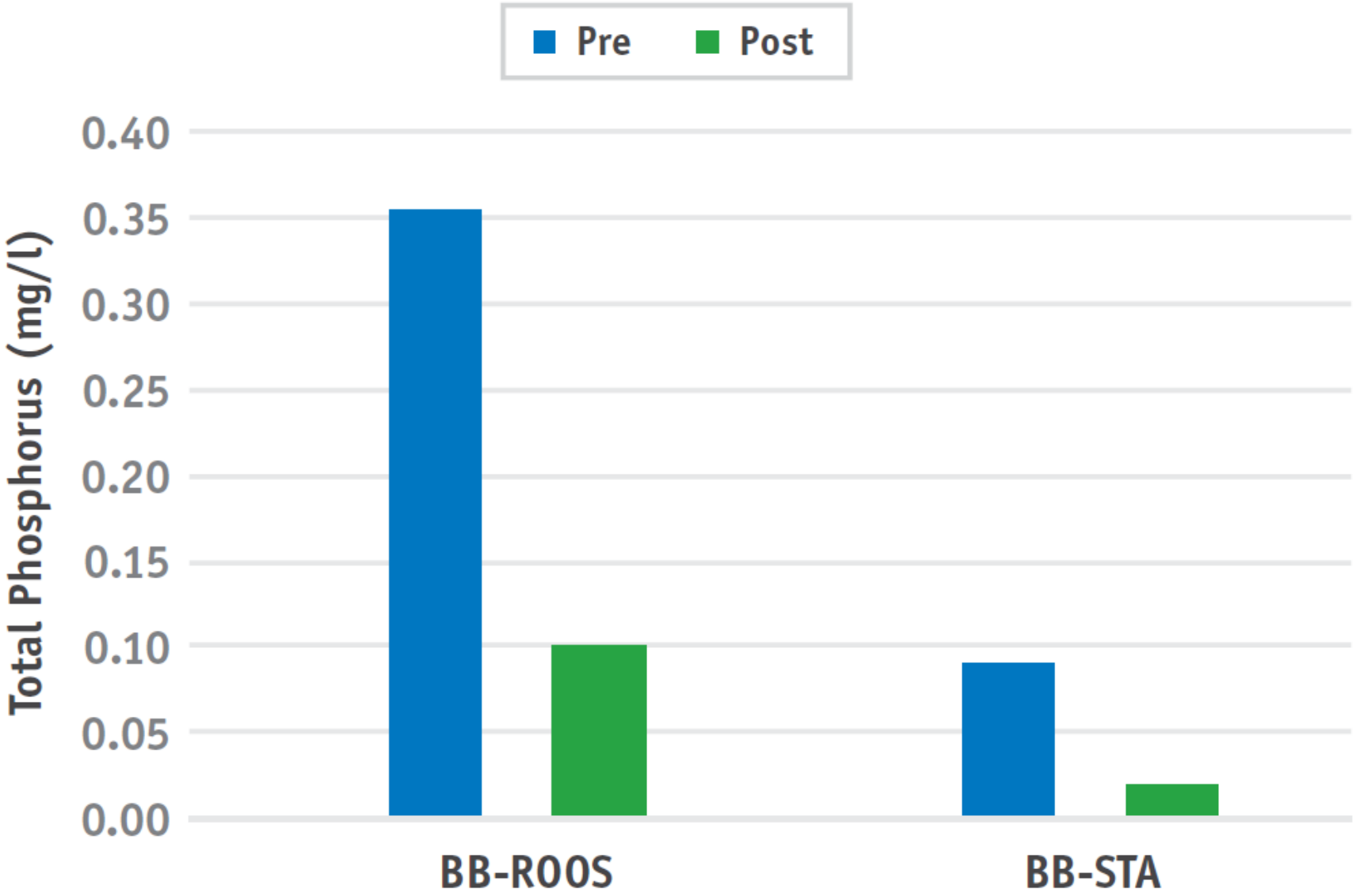
| Year | % IC | P (in) | Q (in) | S (in) | CN | Q Reduction |
|---|---|---|---|---|---|---|
| 2011 | 30 | 1.00 | 0.153 | 3.59 | 74 | |
| 2012 | 20 | 1.00 | 0.084 | 5.54 | 64 | 45.3% |
| 2015 | 14 | 1.00 | 0.055 | 7.02 | 59 | 64.0% |

[1]*Hawkins, R.H.; Jiang, R.; Woodward, D.E.; Hjelmfelt, A.T.; Van Mullem, J.A. (2002). "Runoff Curve Number Method: Examination of the Initial Abstraction Ratio".*

# Berry Brook Water Quality



# Berry Brook Water Quality



# Berry Brook Expenses

| | |
|---|---|
| Expenses | $1,321,700 |
| Grant | $793,000 |
| Match | $528,700 |
| BMPs | 22 |
| DA Treated | 89.5 |
| TSS Reduction | 38,070 |
| TP Reduction | 127.2 |
| TN Reduction | 709.8 |

| Costs per disconnected acre of IC | | | |
|---|---|---|---|
| | PA | NY | NH |
| Actual | $250,000.00 | $320,000.00 | $30,000.00 |

# installation and maintenance cost data, with normalization by area

| Parameter | Vegetated Swale | Wet Pond | Dry Pond | Sand Filter | Gravel Wetland | Bioretention | Porous Asphalt |
|---|---|---|---|---|---|---|---|
| Capital Cost ($) | 12,000 | 13,500 | 13,500 | 12,500 | 22,500 | 21,550 | 21,800 |
| Inflated 2012 Capital Cost | 14,600 | 16,500 | 16,500 | 15,200 | 27,400 | 25,600 | 26,600 |
| Maintenance and Capital Cost Comparison | 17.8 | 5.4 | 6.9 | 5.4 | 12.8 | 13.5 | 24.6 |
| Personnel (hr/yr) | 9.5 | 28.0 | 24.0 | 28.5 | 21.7 | 20.7 | 6.0 |
| Personnel ($/yr) | 823 | 3,060 | 2,380 | 2,808 | 2,138 | 1,890 | 380 |
| Subcontractor Cost ($/yr) | 0 | 0 | 0 | 0 | | 0 | 700 |
| Total Operational Cost ($/yr) | 823 | 3,060 | 2,380 | 2,808 | 2,138 | 1,890 | 1,080 |
| Operation/Capital Cost (%) | 6% | 19% | 14% | 18% | 8% | 8% | 4% |

# Life Cycle Costs Including Maintenance

| BMP | Area of IC treated | WQv (cf) | BMP Area ft3 | Annual Ave Maintenance $ | Annual Maintenance hours | Capital Cost per acre of IC treated | 2010 Adj Capital Cost of system * | Added design contingency of 35% | Capital Costs per $ft^3$ | Capital Costs per cf treated (WQv) | Capital Costs per BMP storage volume (cf) | Capital Costs/sf of IC | Amoritized Life Cylce Costs *** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Vegetated Swale | 1.00 | 3,630 | 5,400 | $822.50 | 9.5 | $11,200.00 | $12,928.68 | $17,453.72 | $3.23 | $4.81 | NA | $0.26 | $33,903.72 |
| Retention Pond | 1.00 | 3,630 | 12,880 | $3,060.00 | 28.0 | $13,700.00 | $15,814.54 | $21,349.63 | $1.66 | $5.88 | $5.88 | $0.31 | $82,549.63 |
| Detention Pond | 1.00 | 3,630 | 12,880 | $2,380.00 | 24.0 | $13,700.00 | $15,814.54 | $21,349.63 | $1.66 | $5.88 | $5.88 | $0.31 | $68,949.63 |
| Chamber System | 1.00 | 3,630 | 434 | Not assessed | Not assessed | $34,000.00 | $34,434.75 | $46,486.91 | $107.13 | $12.81 | $107.13 | $0.78 | Not assessed |
| Sand Filter | 1.00 | 3,630 | 640 | $2,807.50 | 28.5 | $12,417.00 | $14,333.52 | $19,350.25 | $30.23 | $5.33 | $15.51 | $0.29 | $75,500.25 |
| Gravel Wetland | 1.00 | 3,630 | 1,920 | $2,138.33 | 21.7 | $22,300.00 | $25,741.92 | $34,751.59 | $18.10 | $9.57 | $7.59 | $0.51 | $77,518.26 |
| Bioretention | 1.00 | 3,630 | 4,326 | $1,890.00 | 20.7 | $20,000.00 | $23,086.92 | $31,167.34 | $7.21 | $8.59 | $13.37 | $0.46 | $68,967.34 |
| Enhanced Bio | 0.39 | 935 | 373 | $1,890.00 | 21.0 | $29,000.00 | $29,000.00 | $39,150.00 | $105.09 | $41.86 | $105.09 | $0.67 | $68,967.34 |
| Porous Asphalt | 1.00 | 3,630 | 32,670 | $1,080.00 | 6.0 | $21,780.00 | $22,058.49 | $29,778.96 | $0.91 | $8.20 | $4.60 | $0.50 | $51,378.96 |
| Pervious Concrete** | 1.00 | 3,630 | 32,670 | $1,080.00 | 6.0 | $74,052.00 | $74,998.88 | $101,248.49 | $3.10 | $27.89 | $15.63 | $1.70 | $122,848.49 |
| Permiable Interlocking Concrete Pavement ** | 1.00 | 3,630 | 32,670 | $1,080.00 | 6.0 | $74,052.00 | $74,998.88 | $101,248.49 | $3.10 | $27.89 | $15.63 | $1.70 | $122,848.49 |

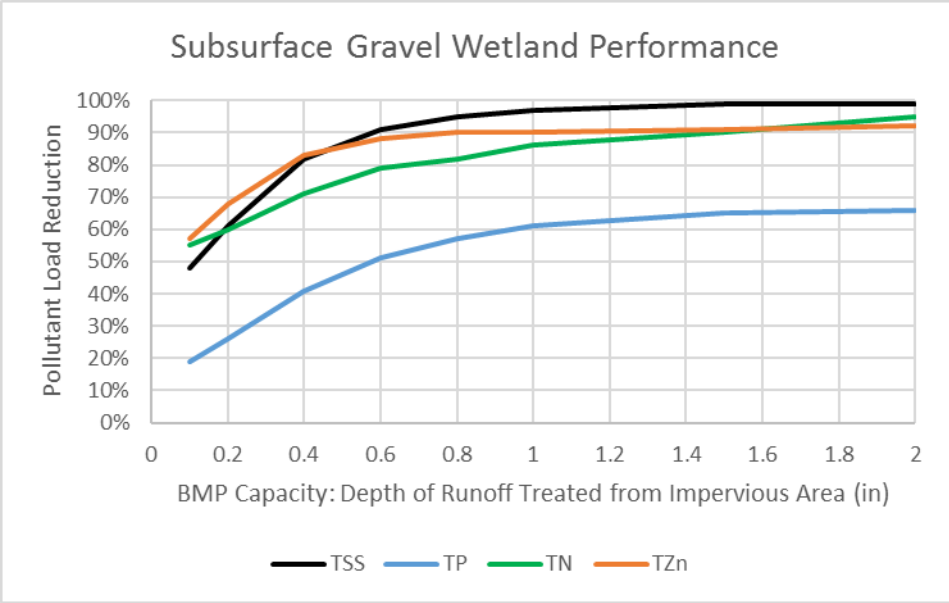
note all costs were converted from 2004 dollars to 2010 dollars with the exception of the permeable pavements which were converted from 2008 dollars to 2010 dollars

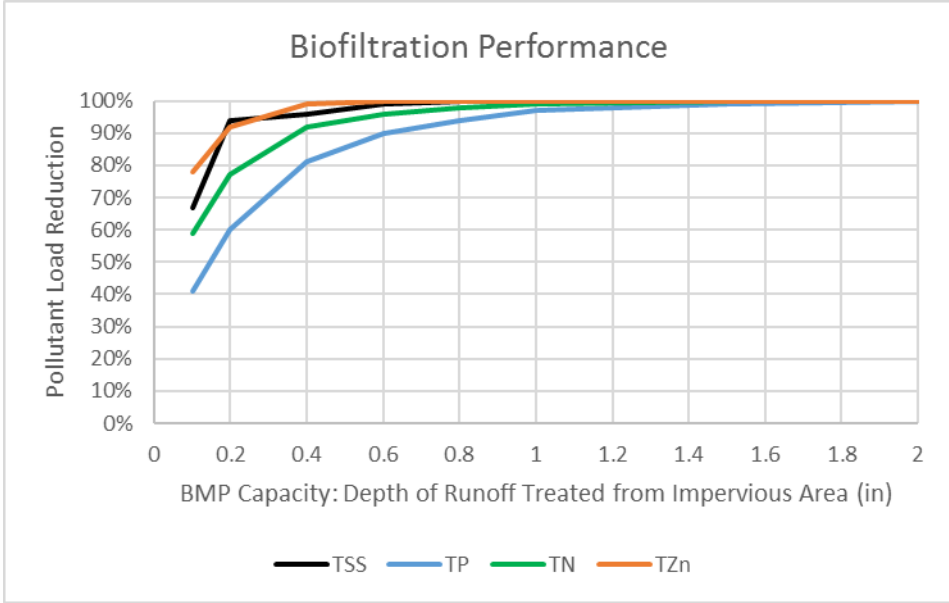
* See reference information from USDOL

** PA cost estimates were calculated as the difference between PA installations and a typcical dense mix pavement equivalent. PC and PICP costs were developed using the same methodology and compared to typical DMA, not typical concrete or paver pavements.

*** Life cycle costs were calculated based on 2010 capital costs and amoritized annual maintenance costs over an expected useful life of 20 years

https://www3.epa.gov/region1/npdes/stormwater/ma/green-infrastructure-stormwater-bmp-cost-estimation.pdf




physical storage capacity - runoff depth from IA (in)

| Analyte | Depth txt | Modeled RE | Measured RE |
|---|---|---|---|
| TSS | 0.1 | 48 | 75 |
| TZn | 0.1 | 57 | 75 |
| TN | 0.1 | 55 | 23 |
| TP | 0.1 | 19 | 53 |

| Analyte | Depth txt | Modeled RE | Measured RE |
|---|---|---|---|
| TSS | 0.23 | 70 | 81 |
| TZn | 0.23 | 88 | 86 |
| TN | 0.23 | 60 | 27 |
| TP | 0.23 | 35 | 45 |

| Stormwater Management Design - 70.5 acre Ultra-Urban Drainage Area | | | |
|---|---|---|---|
| **Sizing Comparison of Capital Costs and Relative Phosphorus Load Removal Efficiency** | | | |
| Best Management Practice Size | Depth of Runoff Treated from Impervious Area (in) | *Storage Volume Cost ($/ft³) | **Total Phosphorus Removal Efficiency (%) |
| Subsurface Gravel Filter - Minimum Size | 0.35 | $1,016,912 | 62% |
| Subsurface Gravel Filter - Moderate Size | 0.5 | $1,452,732 | 80% |
| Subsurface Gravel Filter - Full Size | 1.0 | $2,905,463 | 96% |
| *Storage Volume Cost estimates provided by EPA-Region 1 for Opti-Tool methodology, 2015-Draft | | | |
| **Total Phosphorus %RE based on Appendix F Massachusetts MS4 Permit | | | |

# SGWS Costs

| Cost per pound removed | | |
|---|---|---|
| **Years** | **TP** | **TN** |
| 1 | 8 | 41 |
| **$/lb** | **$289.25** | **$ 56.44** |
| **Years** | **TP** | **TN** |
| 10 | 80 | 410 |
| **$/lb** | **$ 28.93** | **$ 5.64** |


Questions???