

Evolving Research for Stormwater Management

Timothy Puls, UNH Stormwater Center

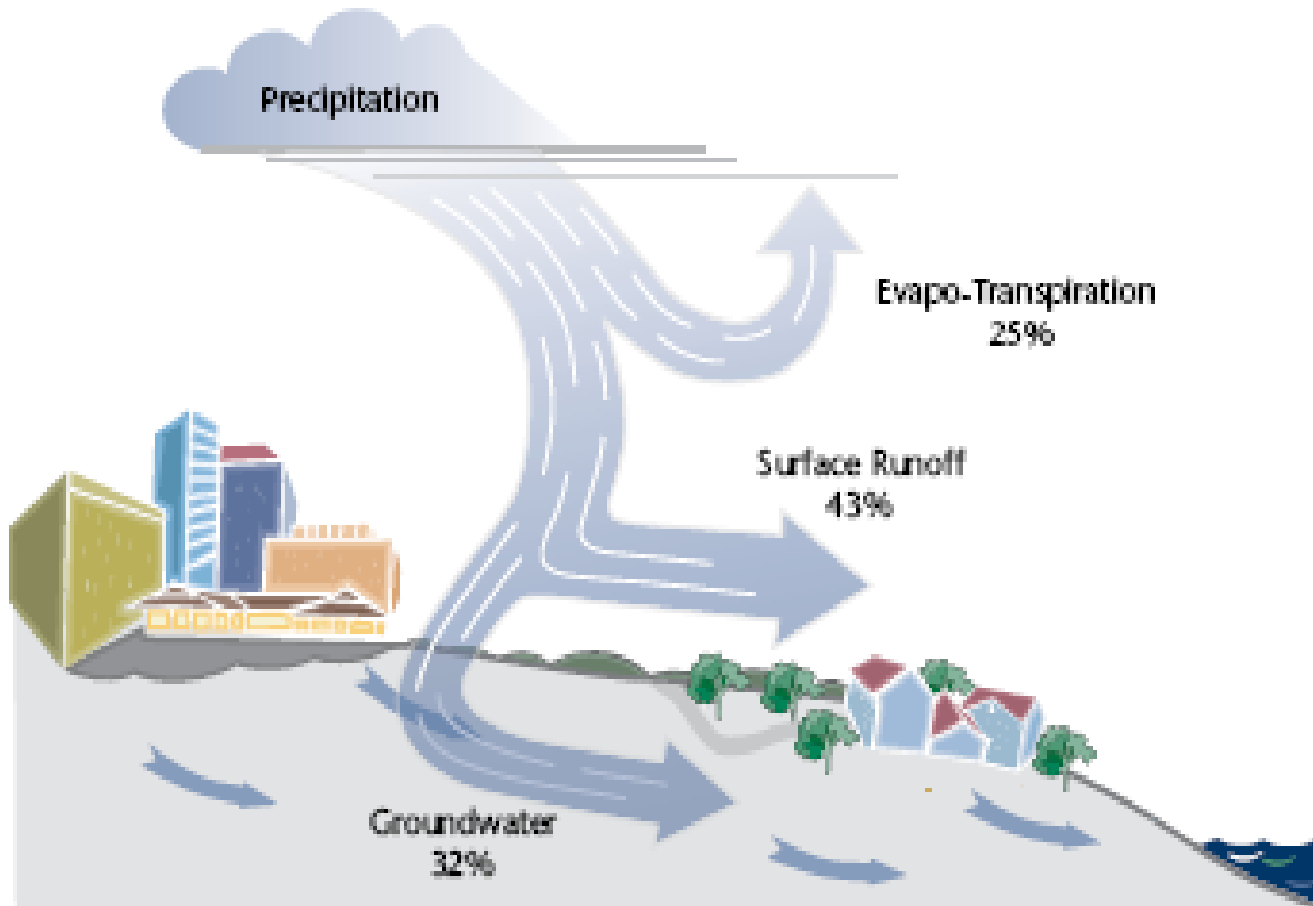
Providing Data to Protect Water Quality Since 2004

NPS is Part of the Problem and managing it is part of the solution



Water Cycle

TYPICAL ANNUAL WATER BUDGET: DEVELOPED WATERSHED







Hydrodynamic Separator



Isolator Row



Subsurface Infiltration



Filter Unit



Porous Asphalt



Pervious Concrete



Retention Pond



Stone Swale



Veg Swale



Gravel Wetland



Sand Filter

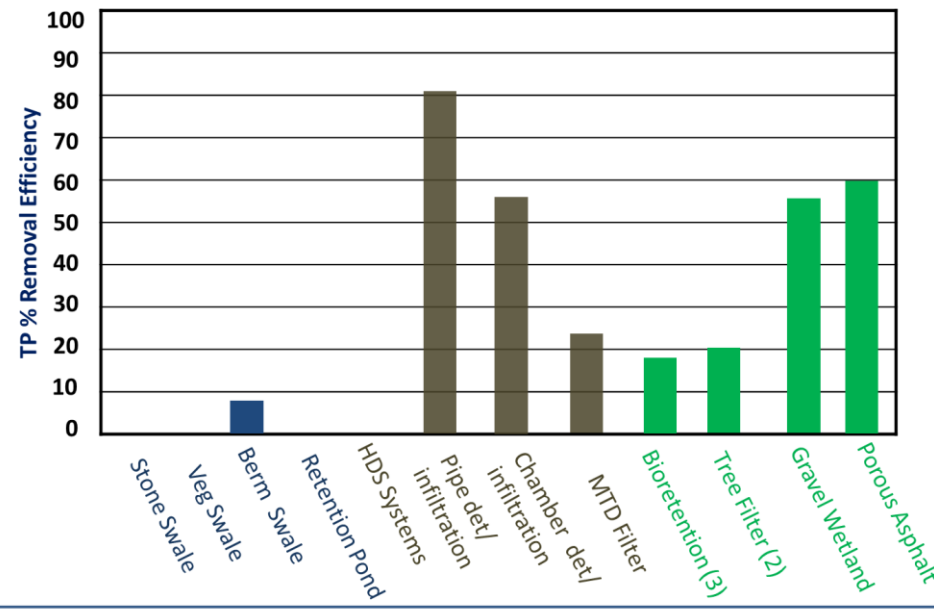
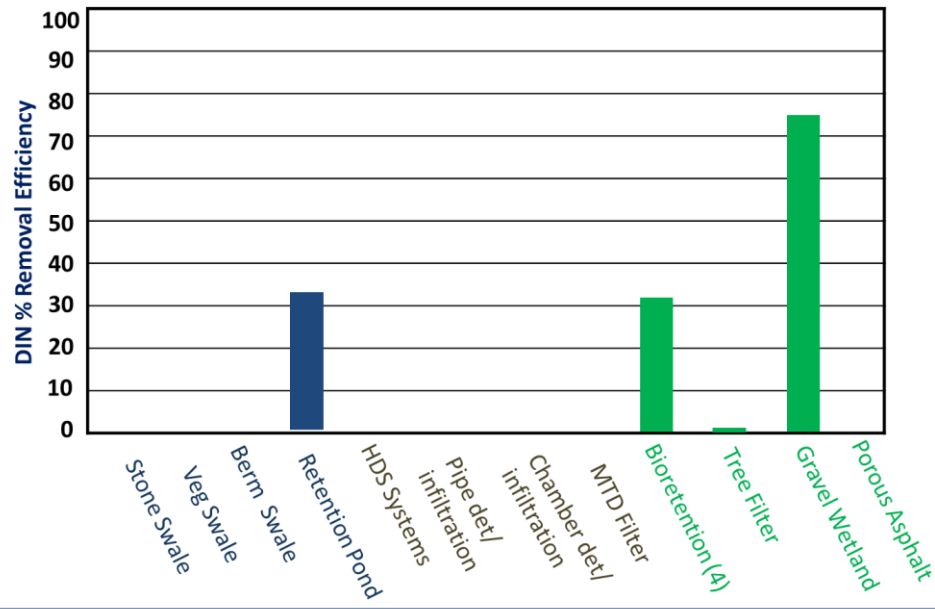
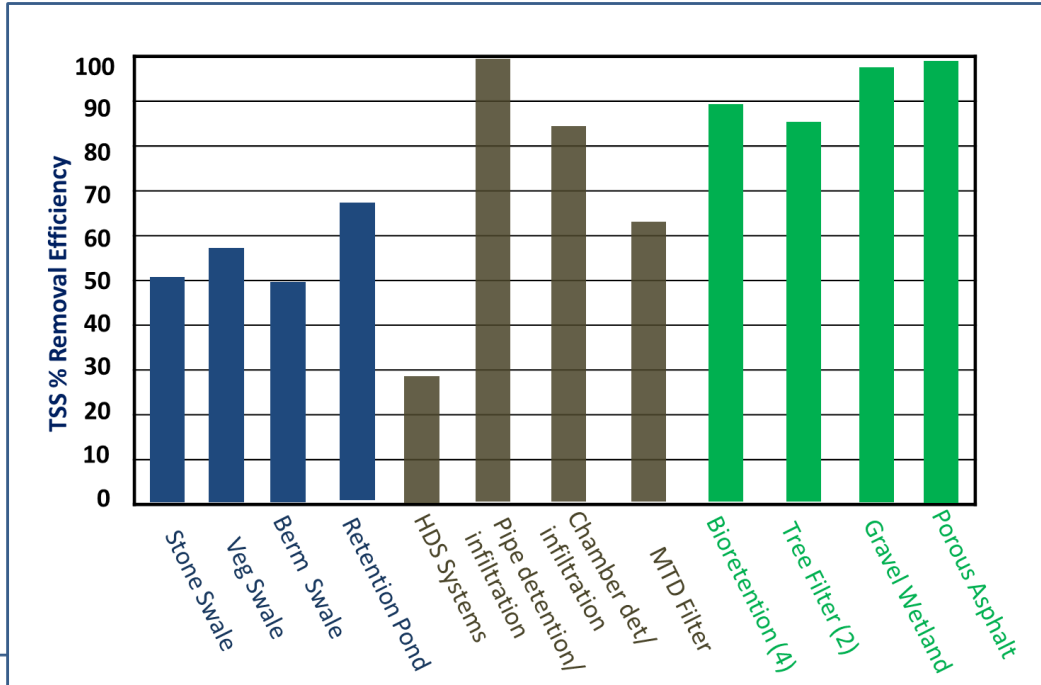


Bioretention Unit



Tree Filter

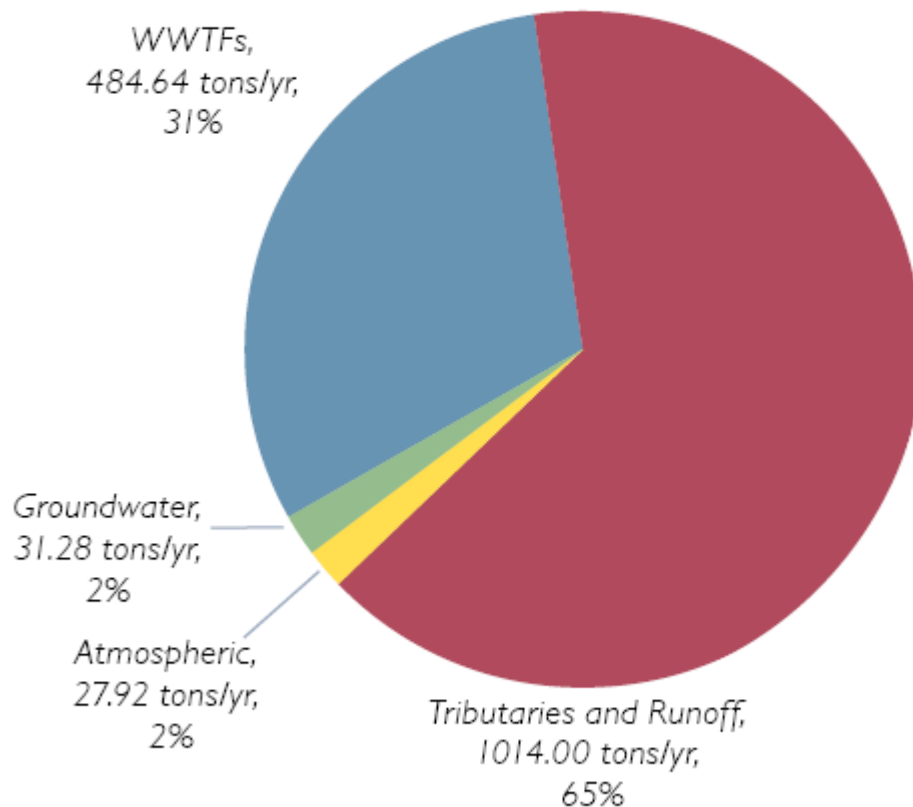
Common Pollutant RE's



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

Great Bay

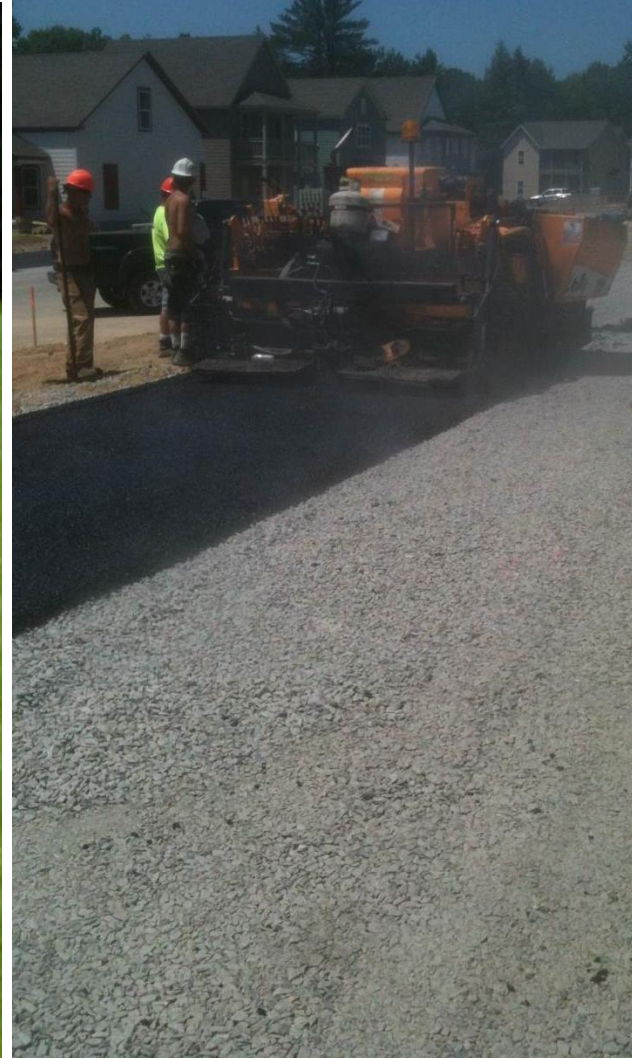
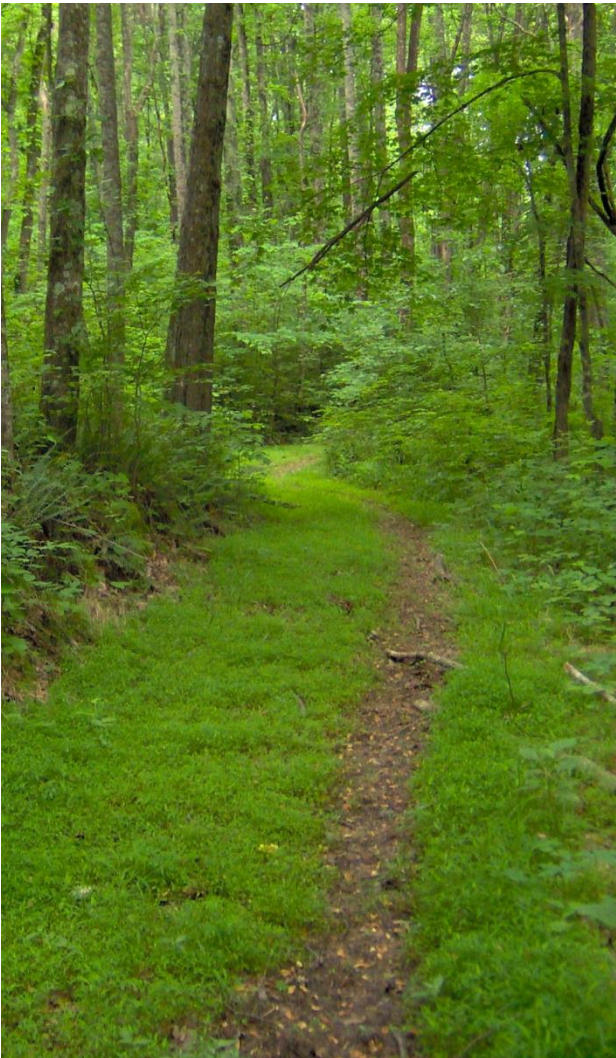
Total nitrogen loads to the Great Bay Estuary from different sources in 2006-2008 (Figure 11)



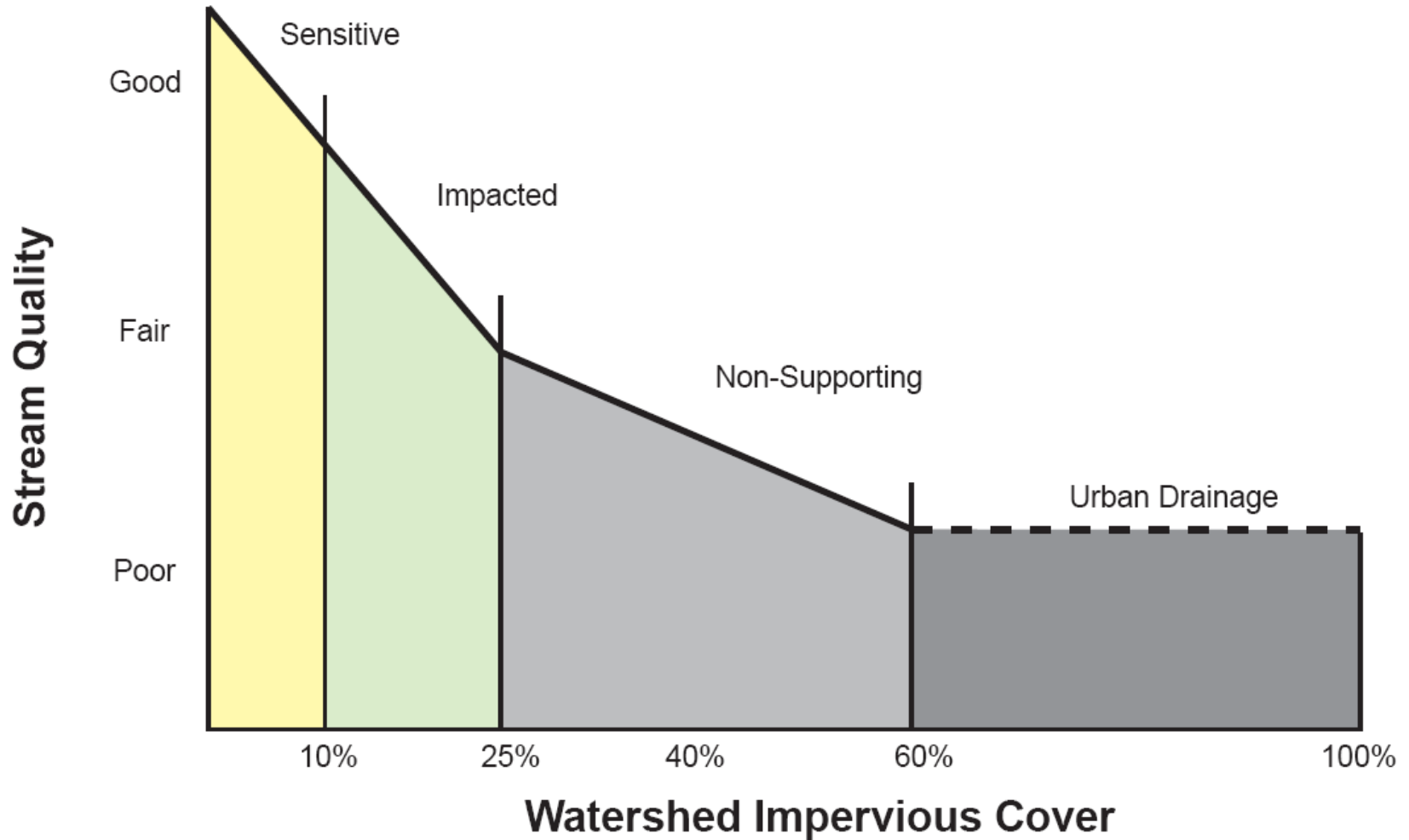
Data Source: PREP (2009)

- August 2009 the Great Bay was added to the 303(d) list for Nitrogen
- Cost estimates range in the tens of millions to comply with effluent limits

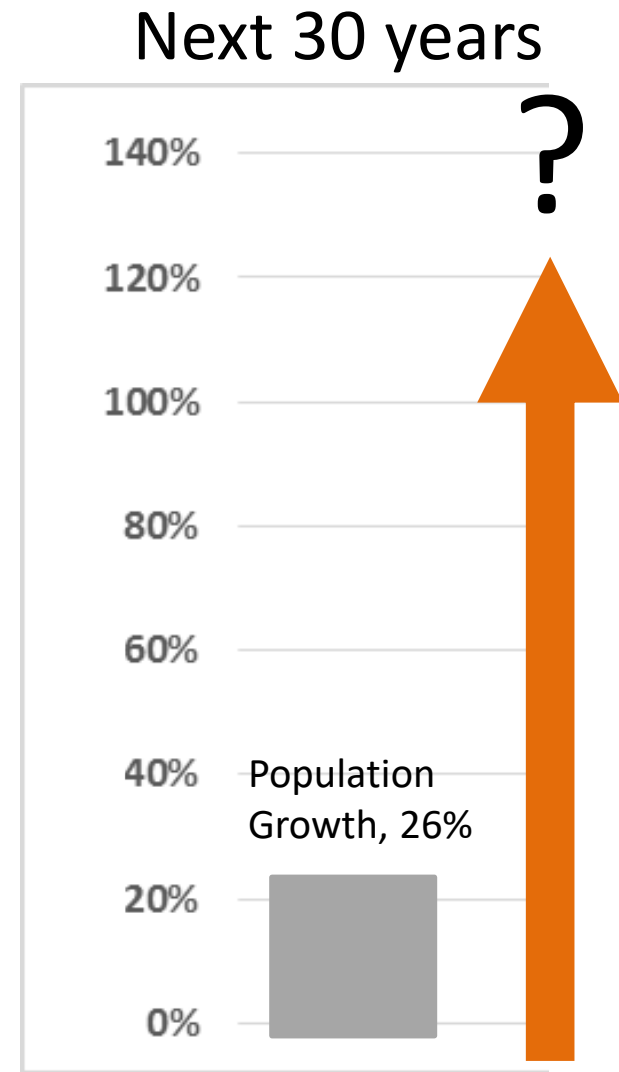
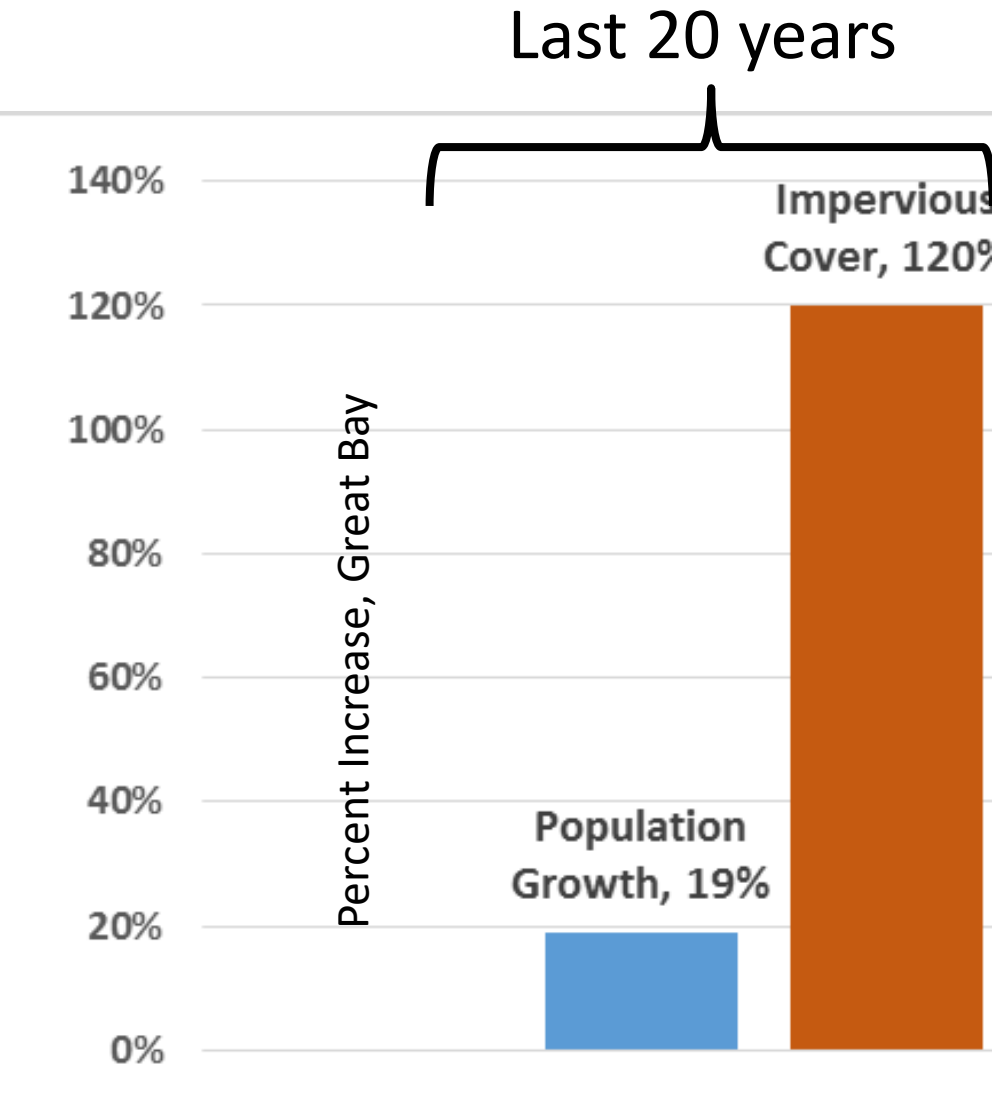
Land Use Determines Delivery



Impact of Impervious Cover



Population Growth & Quality Problem




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

Cost for Compliance

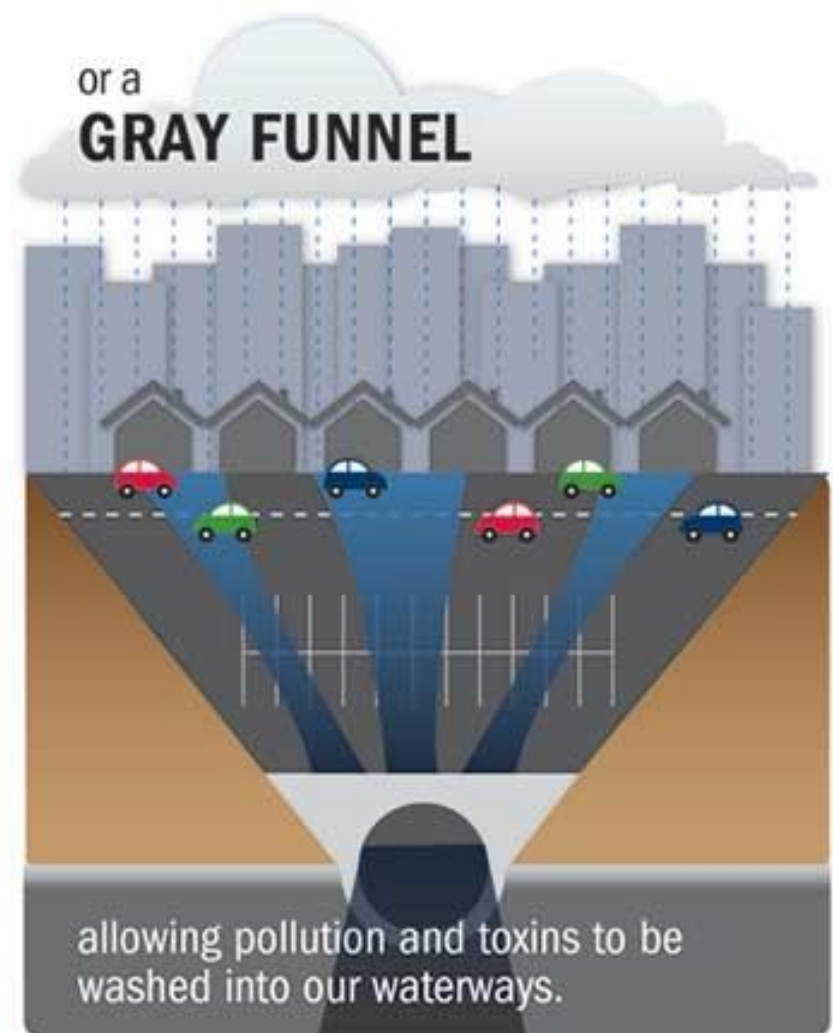
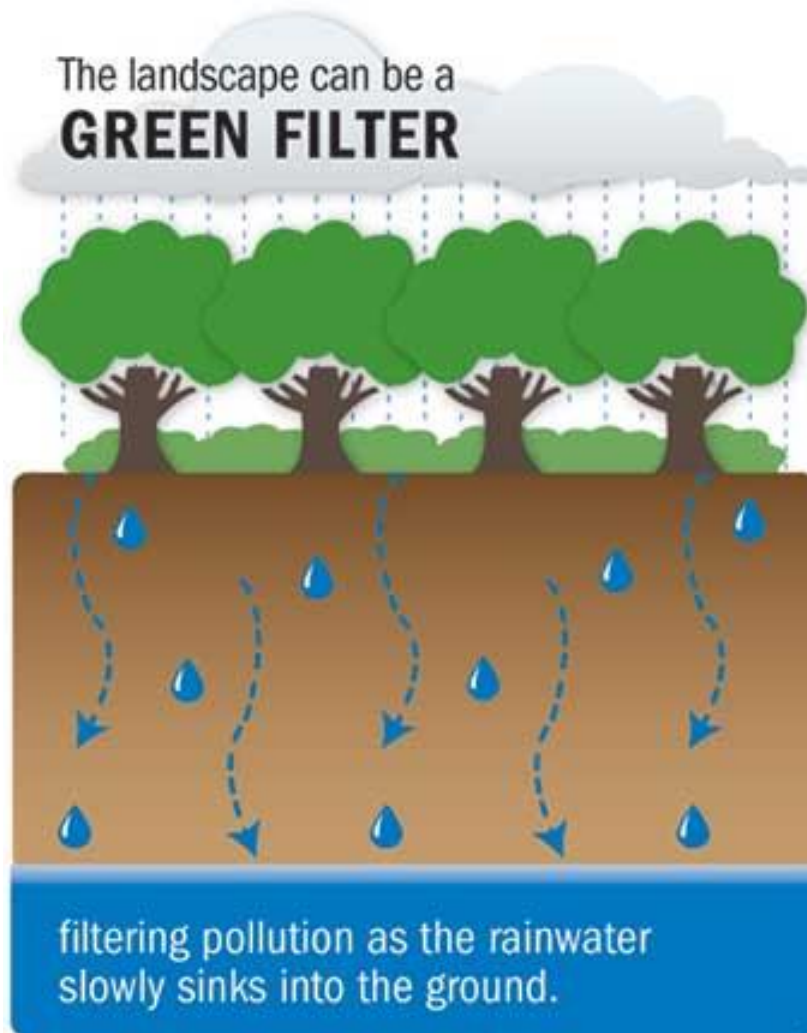
Estimator	Compliance Estimate
EPA -rural	\$98,700
EPA-suburban	\$287,375
EPA-urban	\$409,250
Consultant	\$250,000 – \$1,500,000
Governor	\$26,000,000

Land Use Changes: Economic Impacts



1. Loss of revenue due to impacts to tourism and natural resources
2. Expenses from stress to municipal infrastructure

Solutions



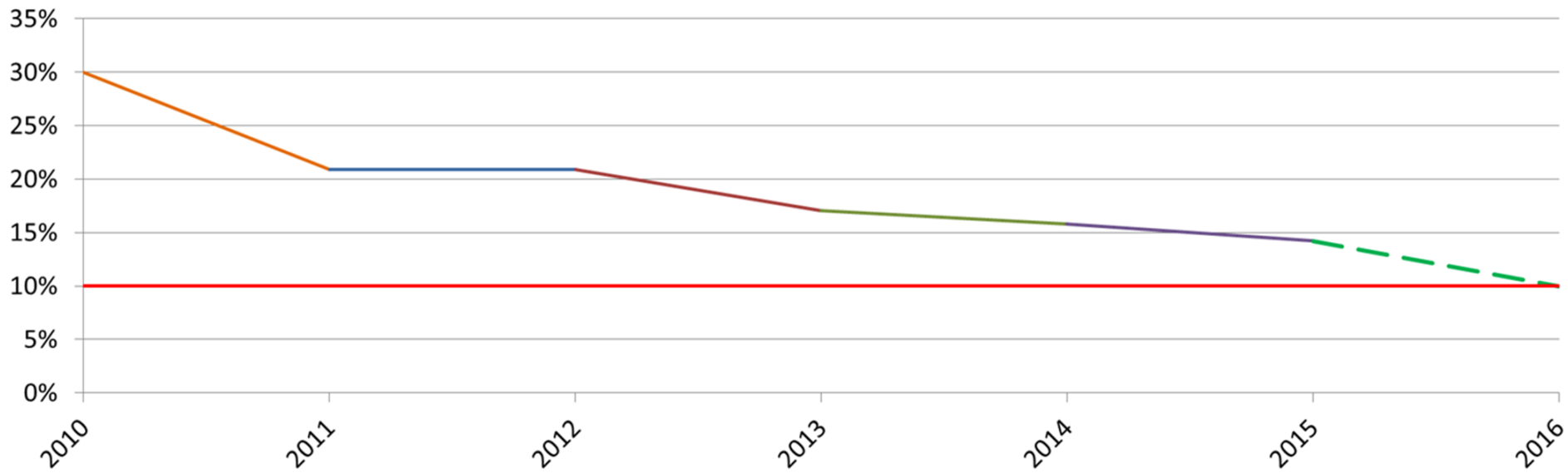
What do we do?



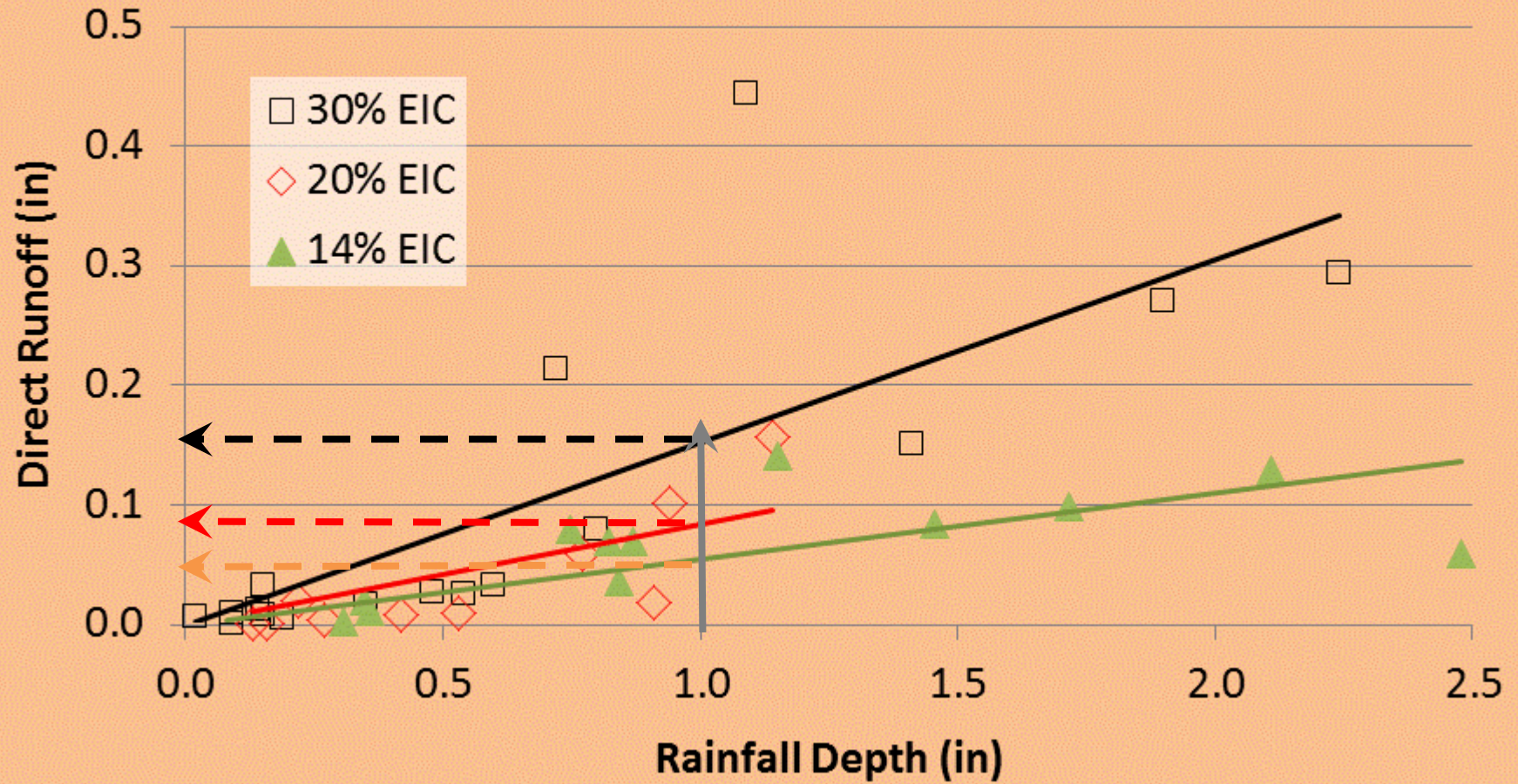
Berry Brook

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



EIC Pre vs. Post (Station Dr.)



Results for Berry Brook at Station Drive

1-Inch Storm, $I_a = 0.05 S^1$

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%

¹Hawkins, 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"](#).

What is Maintenance

- Often Maintenance only occurs when there is failure
- There is a perception that LID systems require more maintenance
- Some claim LID systems fail and will require expensive repairs
- Our current practices have a high degree of failure and significant cost impacts—however we are familiar with it



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Tools of the trade...



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Two Types of Raingardens

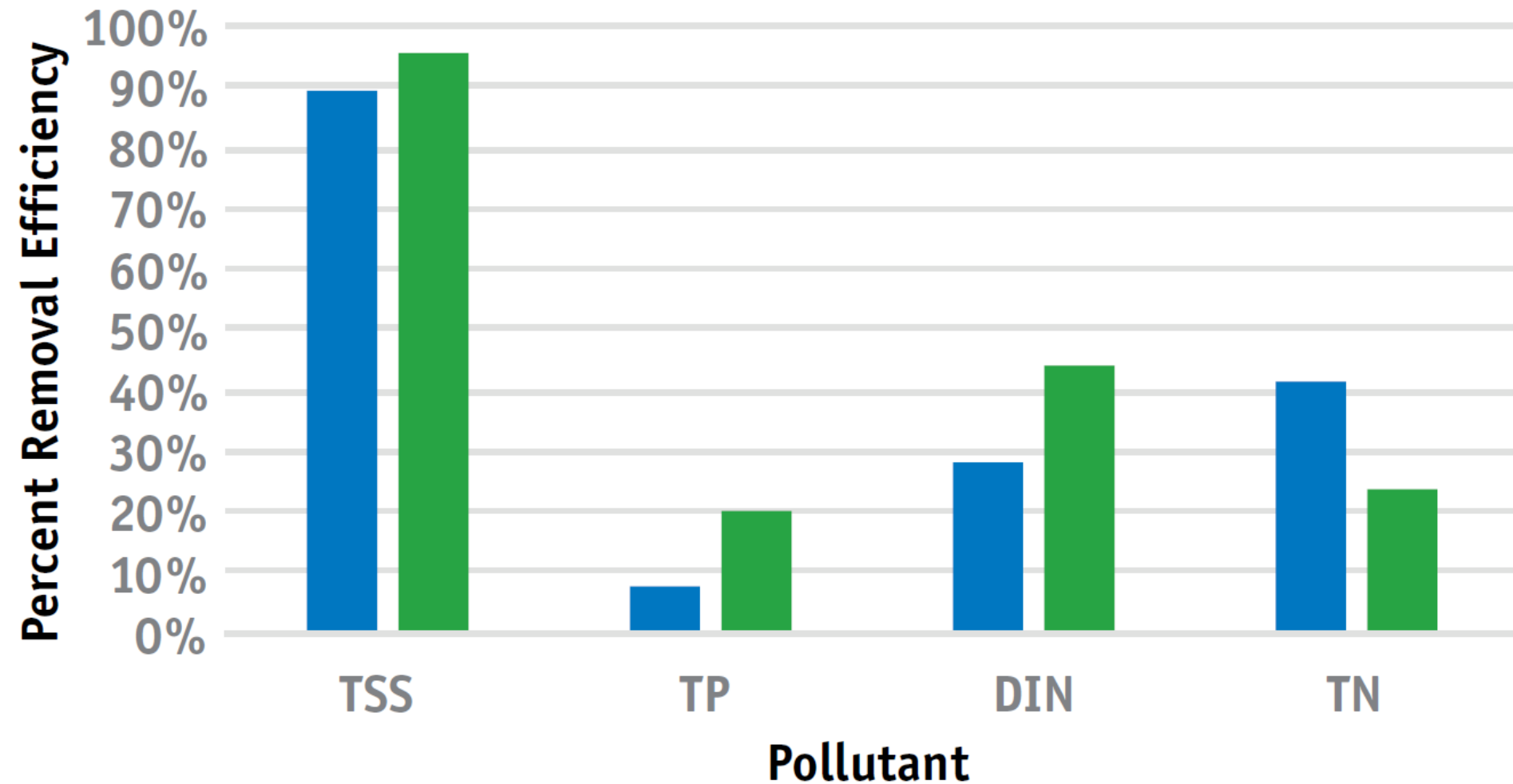


Dense Vegetated Cover

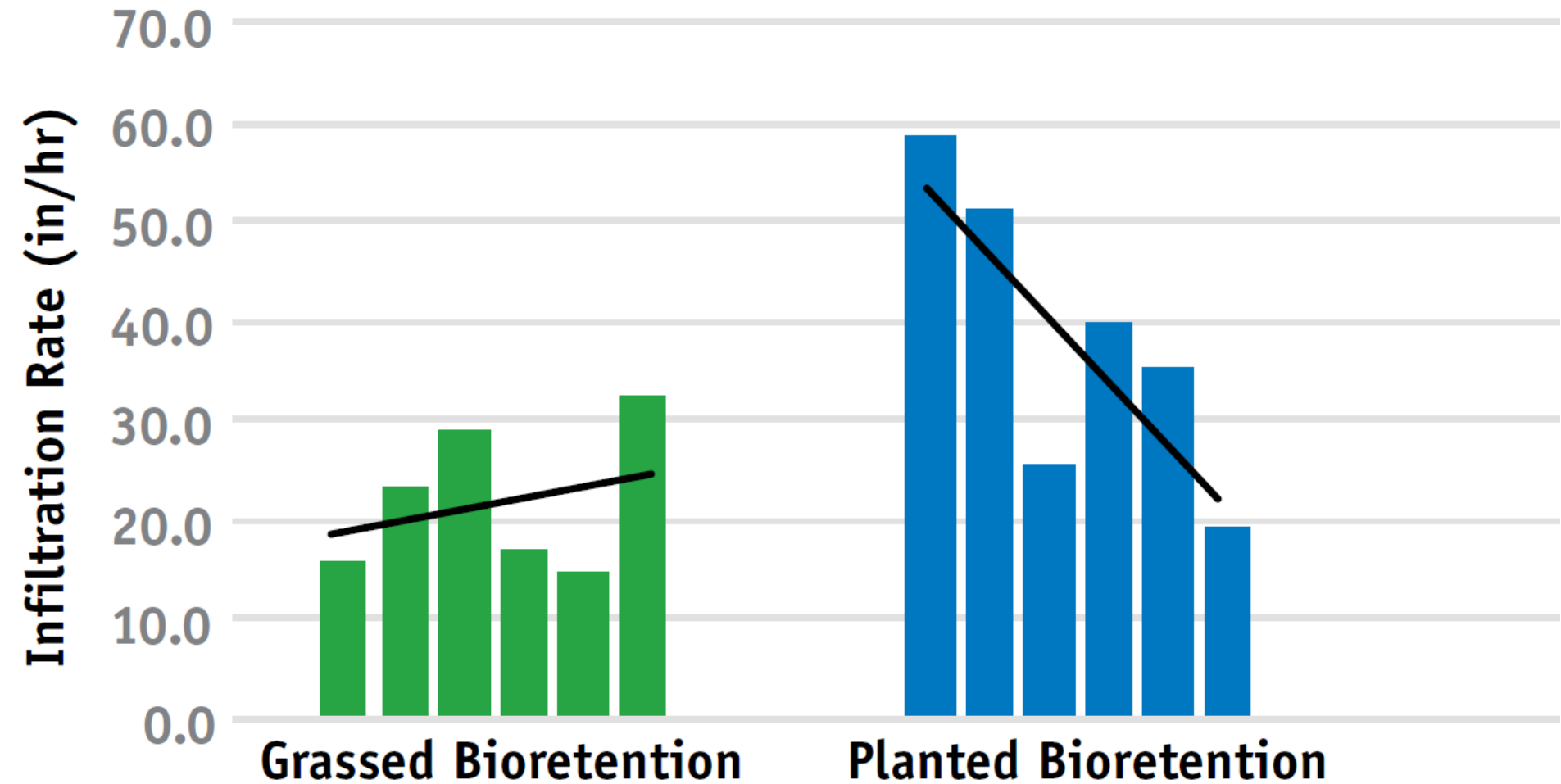


Comparison of Pollutant Removal Efficiency Planted vs Grassed Bioretention

■ Planted Bio (Avg. 3) ■ Grassed Bio



Average Infiltration Rates of a Planted (blue) versus Grassed (green) Bioretention Systems Over Time



Maintenance Complexity is defined as:

Minimal	Simple
Stormwater Professional or Consultant is seldom needed ☐	Stormwater Professional or Consultant is occasionally needed
Moderate	Complicated
Stormwater Professional or Consultant is needed half the time	Stormwater Professional or Consultant is always needed

Reactive

Episodic maintenance,
cheap in short term,
expensive in the long
term

Periodic/Predictive

Science basis,
schedulable activities,
more cost effective

Proactive

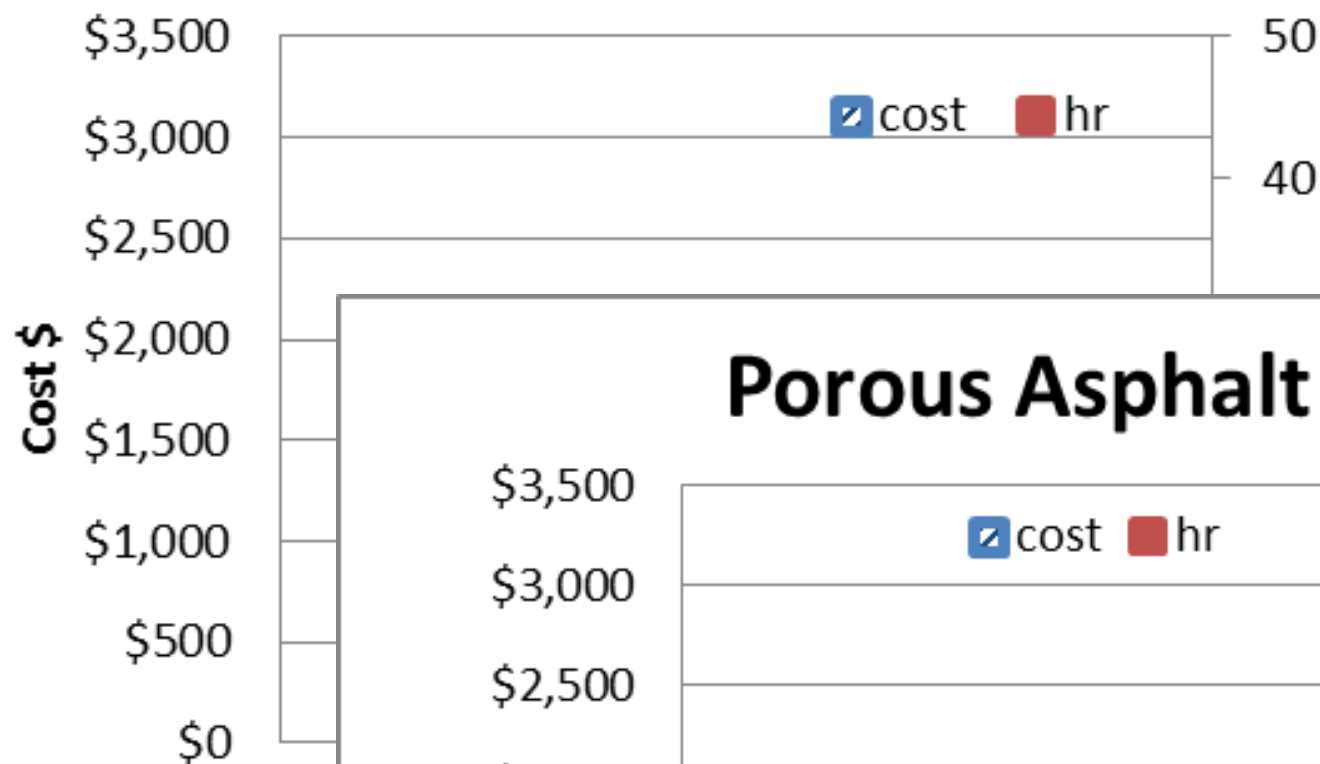
Cost effective,
preventative operations

+

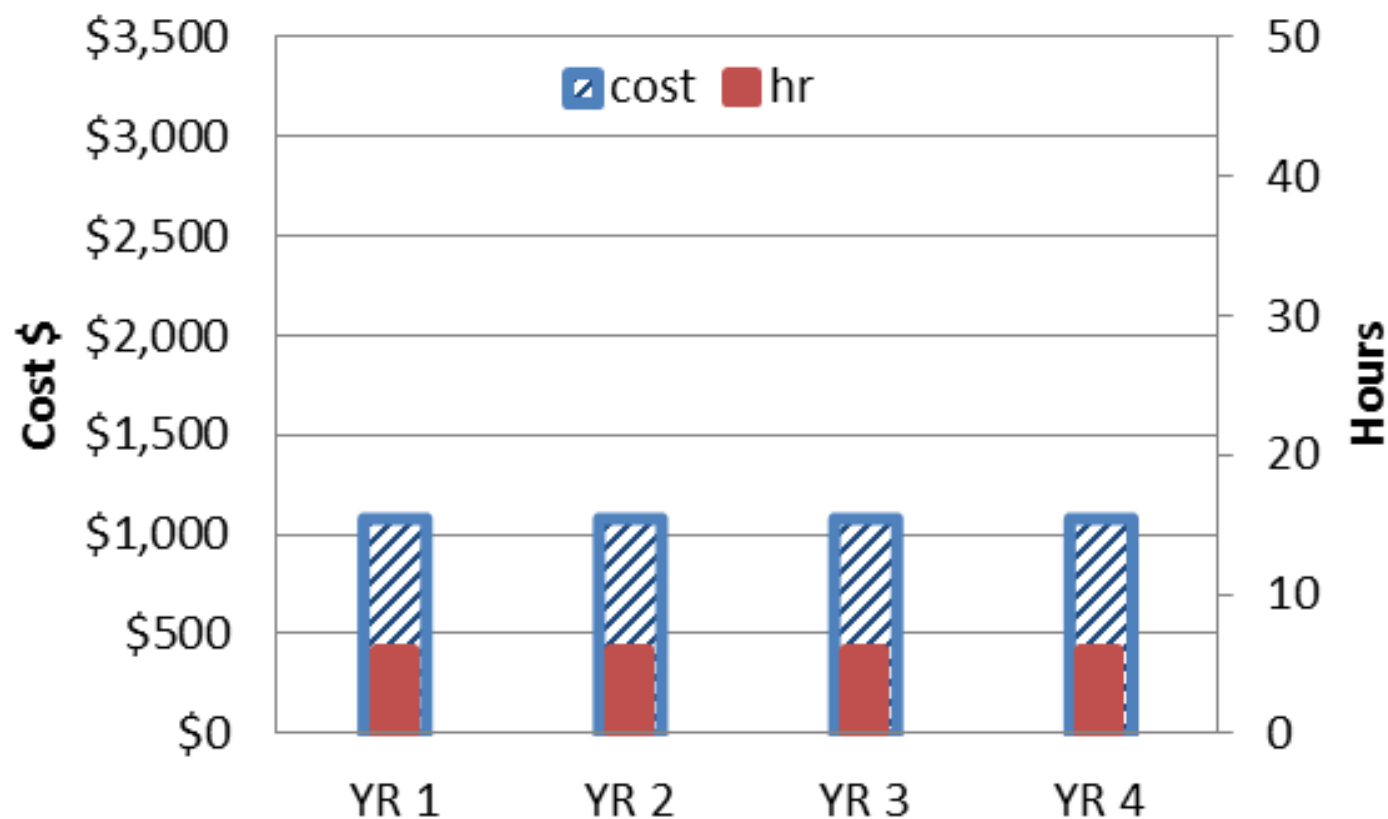
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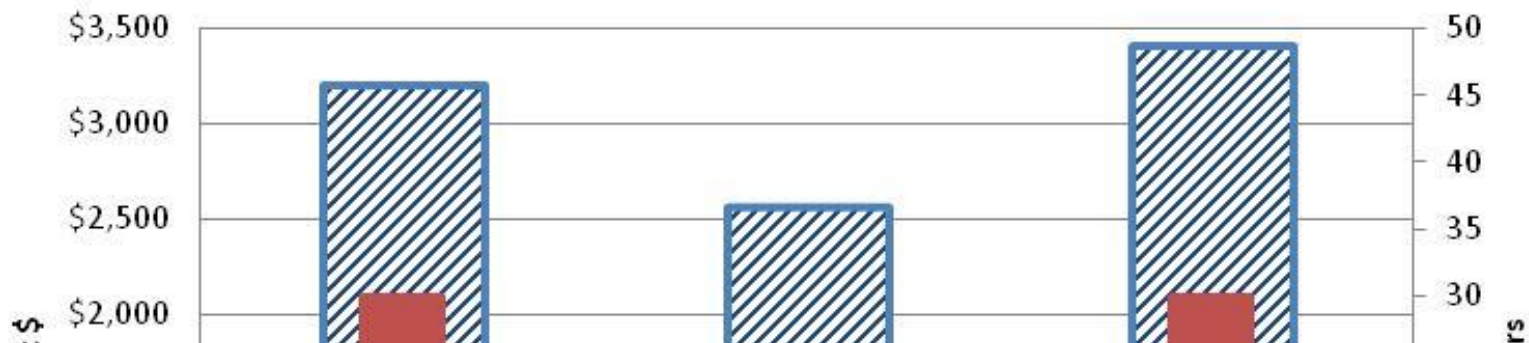
Bioretention



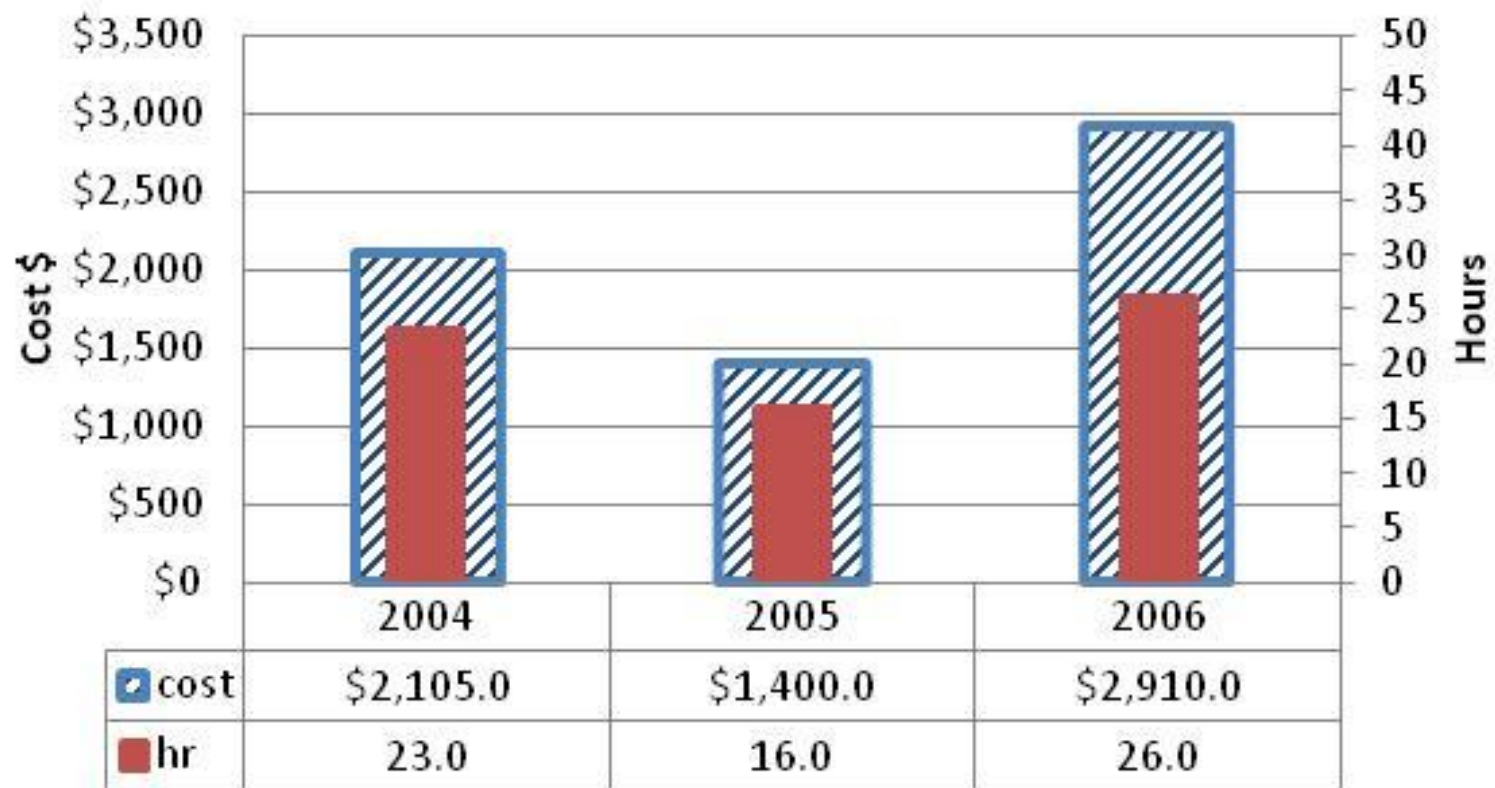
Porous Asphalt



Retention Pond



Gravel Wetland

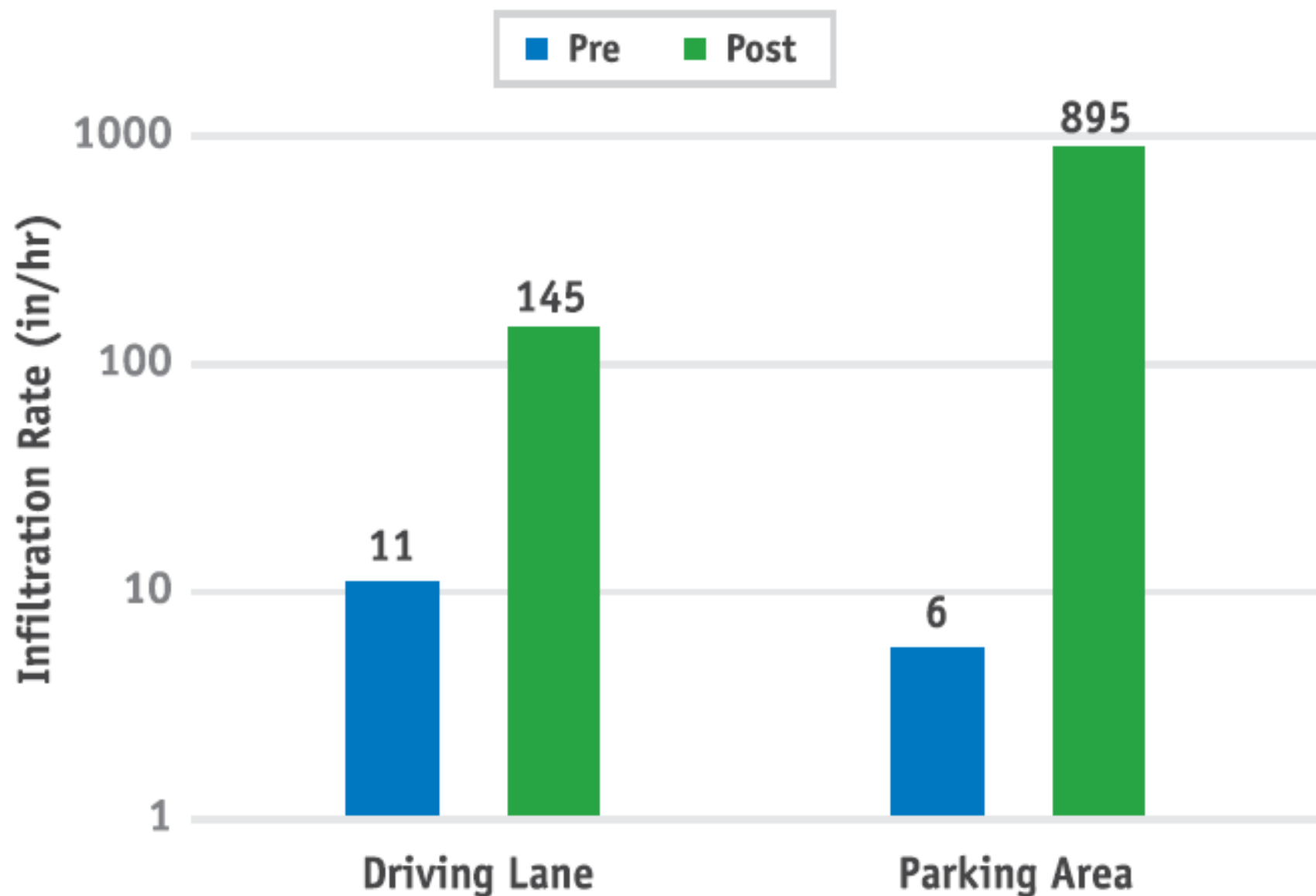


Economics of Installation vs Maintenance Costs, normalized by area

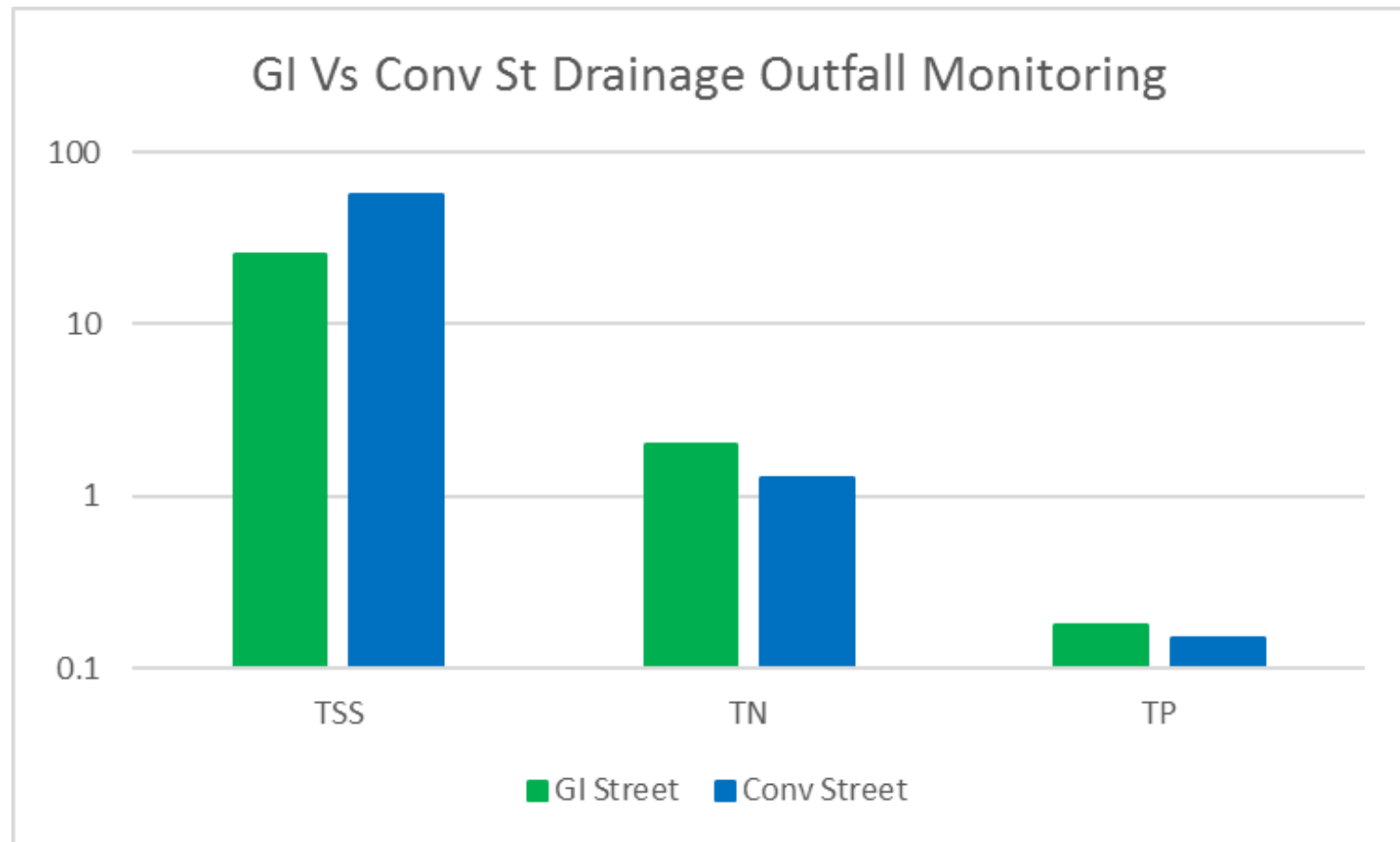
Parameter	Vegetated Swale	Wet Pond	Dry Pond	Sand Filter	Gravel Wetland	Bioretention	Porous Asphalt
Capital Cost (\$)	12,000	13,500	13,500	12,500	22,500	21,550	21,800
Inflated 2012 Capital Cost	14,600	16,500	16,500	15,200	27,400	25,600	26,600
Maintenance and Capital Cost Comparison	17.8	5.4	6.9	5.4	12.8	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%



UNH Permeable Pavement Demo Site: Infiltration Rate Pre & Post Maintenance



Cost of No Maintenance



SGW Maintenance Before



SGW Maintenance After

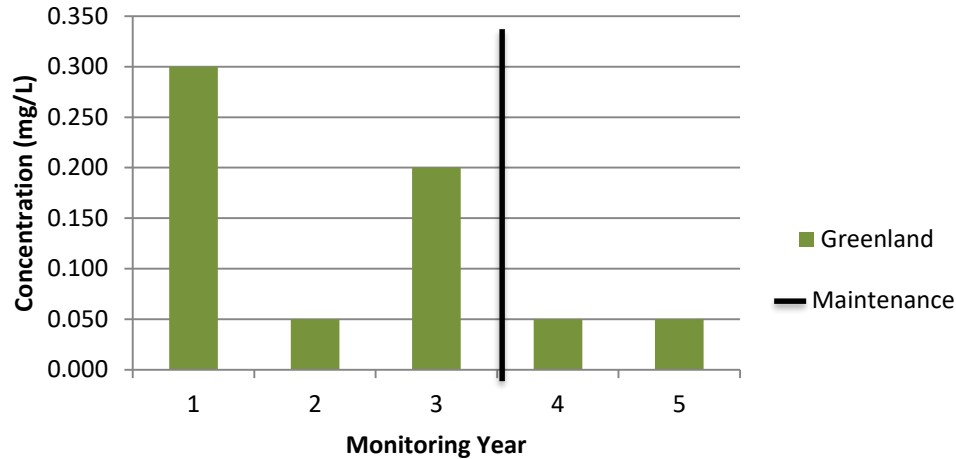


SGW 2 Months Later

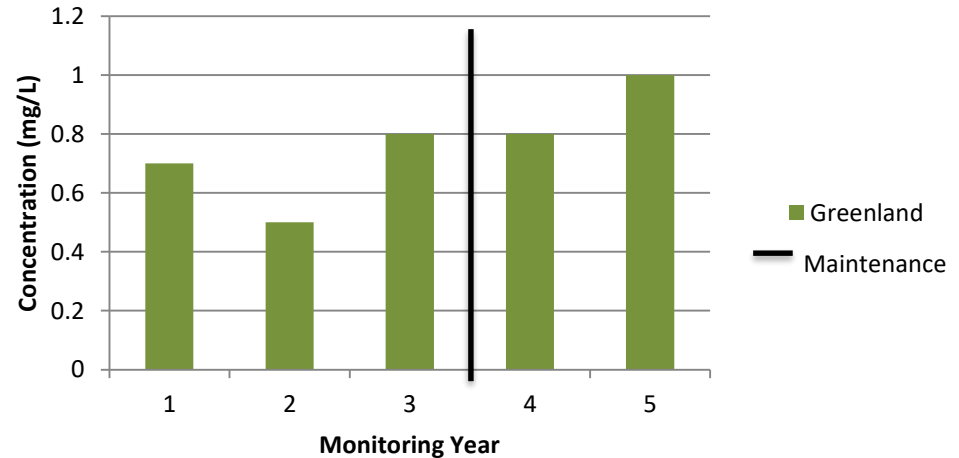


Greenland SGW – Monitoring

Nitrate : Annual Effluent Median EMC

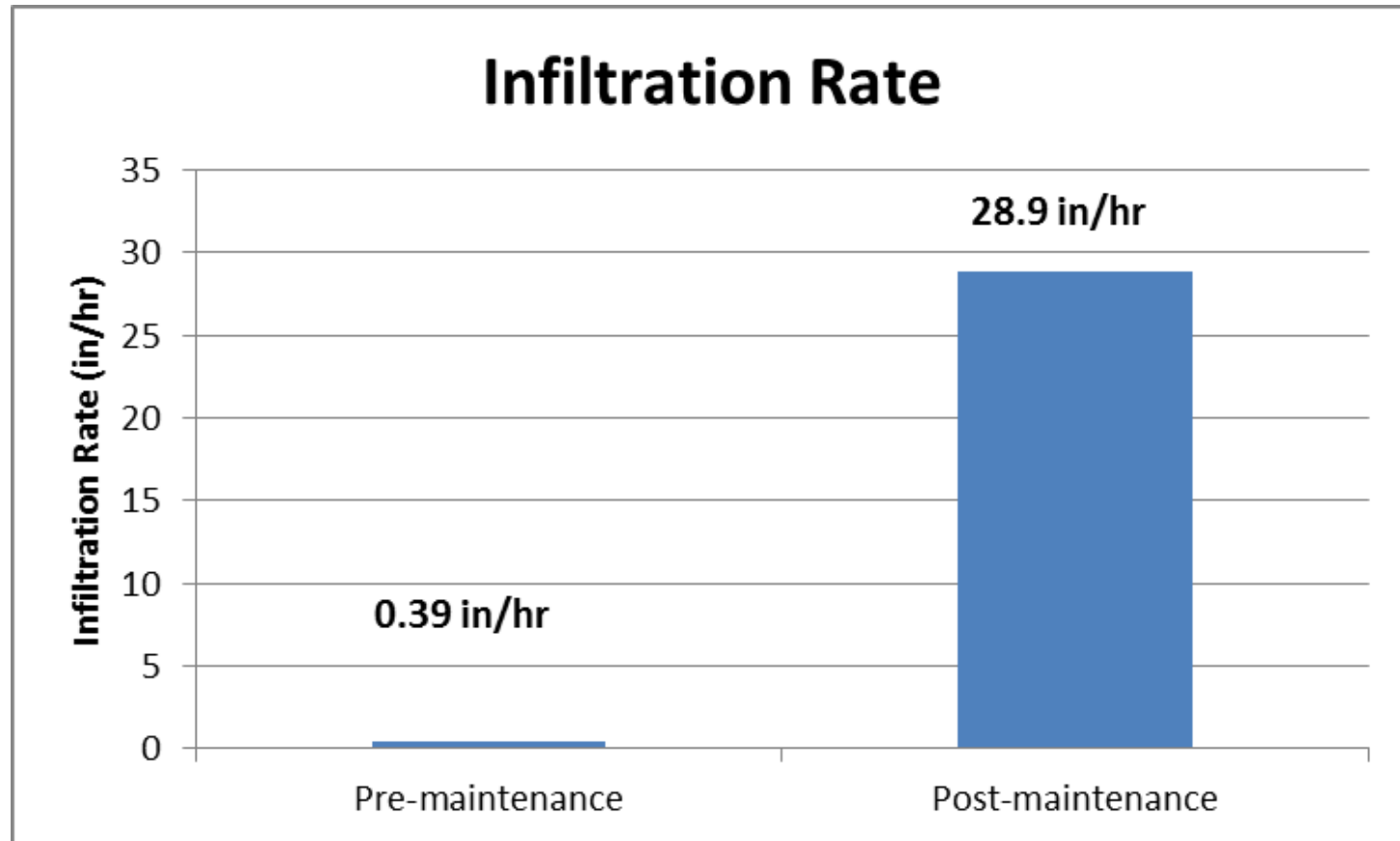


Total Nitrogen : Annual Effluent Median EMC





Result of Maintenance



Pollutant (per year)	Amount
TSS	179 lbs.
Cigarette Butts	4,392
Misc. Trash	752



Maintenance Activity	Minimum Frequency	Estimated Time Commitment	Number of Employees
Inspection	2 times per year	30 minutes taking time to fill out checklist in UNHSC document ¹	1
Clean Pretreatment Trash Screens and Pick Up Trash in system	1 time per month on average	30-60 minutes per visit	1
Spring Cleaning	1 time per year	4 hours	2

Total personnel hours per year: 16-21 hours
Estimated \$1,500 – \$2,000 (30,000 sf of IC Treated)

Conclusions

- Maintenance is the number 1 consideration
- Systems should be designed to meet the maintenance culture and expectations of the owner
- There is a lot of work to be done
- The barriers are not technical
- It starts with you!

Questions???

