

**August, 2010**  
**NAFSMA Annual Seminar**

***Whole Life Cost  
and  
Effectiveness  
Implications of BMPs  
for MS4s***

# Tools for Selection of BMPs

- There is a need for concise and objective information to select stormwater surface runoff Best Management Practices (BMPs) that:
  - will be effective, and
  - economically sustainable.
- Few tools exist today, examples:
  - U.S. EPA's *SUSTAIN* model (complex, does not account for maintenance and rehab)
  - WERF' *SUDS* spreadsheet (lacks effectiveness assessment)
  - Neither account for effects of inflation

# New BMP Evaluation Tool

- ***BMP- REALCOST*** model.

Stands for ***R***ational ***E***stimation of ***A***pproximate ***L***ikely ***C***osts of ***S***tormwater ***T***reatment.

- Developed at Colorado State University

- Sponsors:

- Urban Drainage and Flood Control District, Denver, Colorado (UDFCD)
- Urban Watersheds Research Institute, Inc.

# ***BMP-REALCOST* Model**

- Provides estimates of **surface runoff volume reductions**  
(mostly based on field data in the *Int'l BMP Database*)
- Estimates **reductions in pollutant loads** reaching receiving waters  
(based on field data in the *Int'l BMP Database*)

# ***BMP-REALCOST Model***

- **Accounts for inflation of maintenance and rehabilitation costs**  
(defaults to 50-year national average)
- **Accounts for cost of Administrating permit**  
(default assumes 12% of maintenance costs plus costs of regular inspections)
- **Provides Net Present Costs (NPC) for the BMP system analyzed.**

# Planning – Economic Parameters

Planning Horizon (yrs)	<input style="background-color: #d3d3d3; color: red; font-weight: bold; text-align: center; width: 20px; height: 20px;" type="text" value="?"/>	50	Default
Current/Regional ENR CCI	<input style="background-color: #d3d3d3; color: red; font-weight: bold; text-align: center; width: 20px; height: 20px;" type="text" value="?"/>	6507	User-Entered
Inflation Rate (%)	<input style="background-color: #d3d3d3; color: red; font-weight: bold; text-align: center; width: 20px; height: 20px;" type="text" value="?"/>	4.60%	Default
Rate of Return (%)	<input style="background-color: #d3d3d3; color: red; font-weight: bold; text-align: center; width: 20px; height: 20px;" type="text" value="?"/>	5.00%	Default
Admin. Costs as % of Maint. (%)	<input style="background-color: #d3d3d3; color: red; font-weight: bold; text-align: center; width: 20px; height: 20px;" type="text" value="?"/>	12.00%	Default
Select Location for Precip. Values	<input style="background-color: #d3d3d3; color: red; font-weight: bold; text-align: center; width: 20px; height: 20px;" type="text" value="?"/>	Denver	
Mean Annual Precipitation (in)	<input style="background-color: #d3d3d3; color: red; font-weight: bold; text-align: center; width: 20px; height: 20px;" type="text" value="?"/>	15.8	
2-Year, 1-Hour Precipitation (in)	<input style="background-color: #d3d3d3; color: red; font-weight: bold; text-align: center; width: 20px; height: 20px;" type="text" value="?"/>	0.95	
Mean Storm Depth (in)	<input style="background-color: #d3d3d3; color: red; font-weight: bold; text-align: center; width: 20px; height: 20px;" type="text" value="?"/>	0.43	Default

Denver ENR CCI index = 6507 for 2009

# Capital Cost Estimating Model PLD w/Underdrains (Rain Garden)

Capital Costs - Option 1 (default)

Selected

Option 1

	Default	User	Input
Base Cost (C) =	\$10,729.00		\$8,575.56
Unit Cost (X) =	\$9.93		\$7.94
Economy of Scale ( $\alpha$ ) =	1		1
Cont/Eng/Admin (CEA) =	40.00%		40.00%
Land Consumption (CLC) =	0.000023		0.000023

Units (U) = total volume (ft<sup>3</sup>)

# Maintenance-Related Cost Categories in Model

		Frequency per Year			Hours per Unit			Labor Crew Size		
Activity	Units	Default	User	Input	Default	User	Input	Default	User	Input

Hourly Labor Rate			Overhead Factor (%)			Equipment Cost per Hr			Other Costs per Unit		
Default	User	Input	Default	User	Input	Default	User	Input	Default	User	Input

- Possible Activities
  - Lawn Mowing/Lawn Care
  - Replanting vegetation
  - Litter and Debris Removal
  - Sediment Removal (routine)
  - Sediment Removal (non-routine)
  - Sweeping/Vacuuming
  - Scarify Top Sand Layer
  - Traffic Control
  - User specified routine maintenance or minor rehabilitation activities

# List of BMPs Model Can Analyze

BMP Type
<b>Above Ground BMPs:</b>
Concrete Grid Pavers
Constructed Wetland Basin
Extended Detention Basin (dry)
Retention Ponds (wet)
Full Spectrum Detention
Four types of Porous Pavement with and without underdrains, no porous asphalt
Sand Filter Basin w/ and w/o underdrains
Porous Landscape Detention w/ and w/o underdrains sometimes called Rain Garden or Bio-Retention Cell
<b>Underground BMPs</b>
Hydrodynamic Device
Inlet Insert
Medea Filter
Sand Filter Vault
Sediment-Oil Separator
Vault with capture volume (extended detention/retention)

# Land-Use Types in Model and Default Cost/Acre

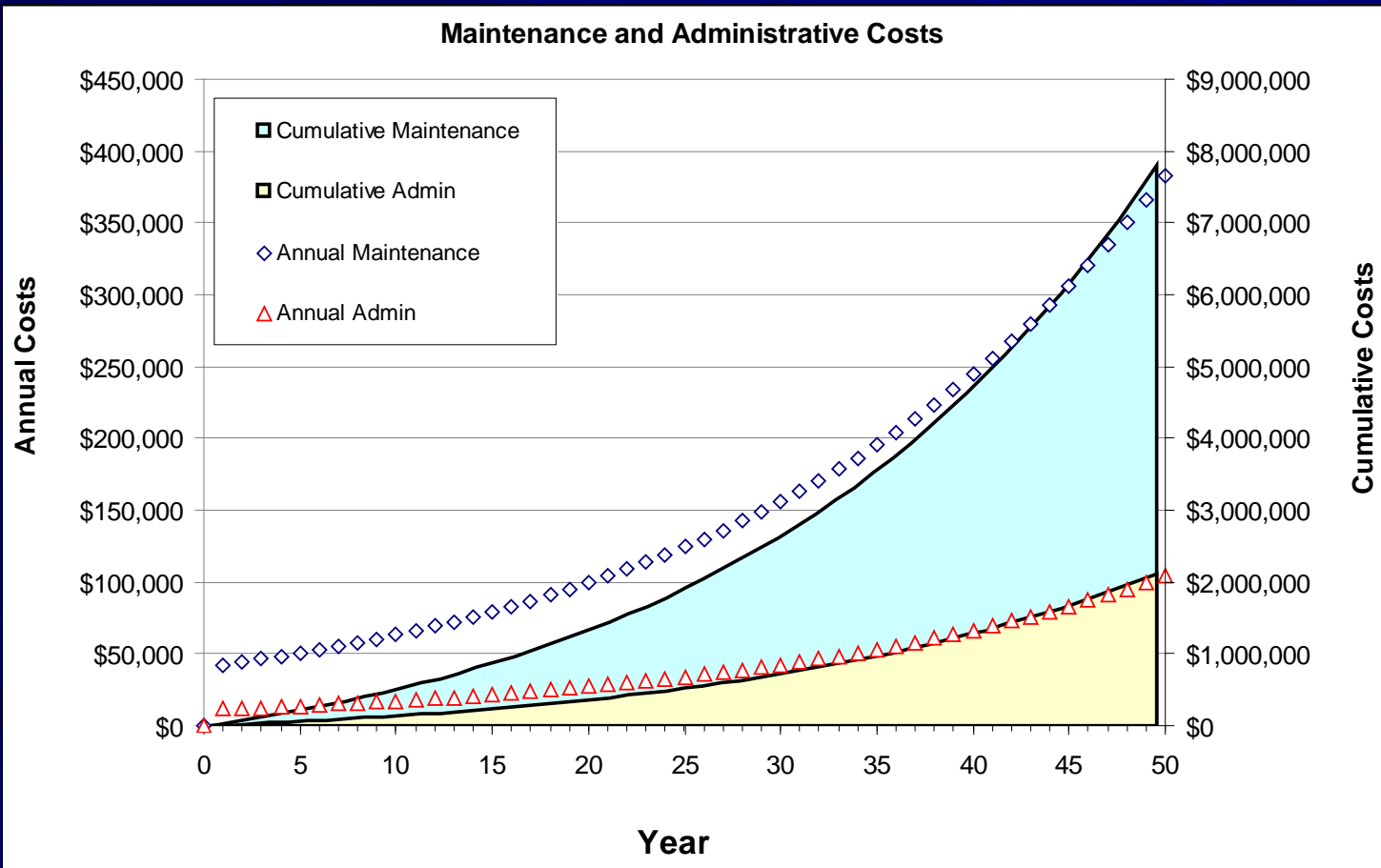
Commercial	\$200,000
Industrial - Light	\$200,000
Industrial - Heavy	\$200,000
Residential - Single Family (1,000 sf)	\$130,000
Residential - Single Family (2,000 sf)	\$130,000
Residential - Single Family (3,000 sf)	\$130,000
Residential - Single Family (4,000 sf)	\$130,000
Residential - Single Family (5,000 sf)	\$130,000
Residential - Multi-Unit (detached)	\$175,000
Residential - Large Lot (>1/2 acre)	\$130,000
Residential - Apartments	\$200,000
Parks, Cemeteries	\$35,000
Institutional	\$130,000
Paved Area	\$200,000
Undeveloped Rural	\$35,000

All unit  
land  
costs  
can be  
overridden  
by user

# Sample Graphical Output

## Maintenance & Administrative Costs

### PLD w/Underdrains Example



# ***BMP-REALCOST*** Model

Available as a free download from the  
Urban Drainage and Flood Control District

[http://udfcd.org/downloads/software/BMP-REALCOST\\_v1.0.zip](http://udfcd.org/downloads/software/BMP-REALCOST_v1.0.zip)

**Or go to:**

[www.udfcd.org](http://www.udfcd.org) -> **Downloads** -> **Software**

**and look for**

**“BMP Life Cycle Cost Analysis Tool...”**

**USING THE *BMP-REALCOST* MODEL**

**LETS EXAMINE A SAMPLE**

**ONE-SQUARE MILE**

**URBAN CATCHMENT**

**DENVER, CO REGION**

# New Development Land Uses for the Example One-Square Mile Urban Catchment

Catchment ID	Land Use	Area (ac)	% Effective Impervious	Land Cost \$/ac
Cross Roads	Commercial	50	95%	\$200,000
Shop & Go	Commercial	15	95%	\$200,000
Apartments	Residential - Apartments	100	80%	\$200,000
Residential 1	Residential 3,000 s.f. Homes	225	51%	\$130,000
Residential 2	Residential 2,000 s.f. Homes	250	39%	\$130,000

# List of BMPs Analyzed in the Example Catchment

<b>BMP Type</b>	<b>No of BMPs</b>	<b>Years Rehab Cycle</b>	<b>% Rehab Cost of Capital</b>
<b>EDB</b> - Extended Detention Basin (dry)	27	35	50
<b>RP</b> - Retention Ponds (wet)	18	35	80
<b>SFB-u</b> - Sand Filter Basin w/ Underdrain	27	25	75
<b>SFB-i</b> - Sand Filter Basin w/Infiltration	27	25	80
<b>PLD-u</b> - Porous Landscape Detention w/Underdrain	543	15	60
<b>PLD-i</b> - Porous Landscape Detention w/Infiltration	543	15	65
<b>PICP-u</b> - Porous Interlocking Concrete Paver w/Underdrain	131	25	80
<b>PICP-i</b> - Porous Interlocking Concrete Paver w/Infiltration	131	25	80
<b>HS</b> - Hydrodynamic Device	355	25	100
<b>II</b> - Inlet Insert	709	2	100

# Runoff Intercepted by BMP Type

<b>BMP Type</b>	<b>Default % of Runoff Intercepted</b>
Hydrodynamic Separator (U)	85%
Inlet Inserts (U)	85%
Perm Interlocking Concrete Pavement	Varies by Run-on (95% or less)
Porous Landscape Detention	85%
Extended Detention Basin	90%
Retention Pond	90%
Sand Filter Basin	90%

**Note: User can override these values**

# Summary of Net Present Costs (New Development)

BMP Type	Net Present Costs (NPC)				
	Capital	Rehabilitation	Maintenance	Administrative	Total
EDB	\$3,200,000	\$400,000	\$1,600,000	\$230,000	\$5,500,000
SFB-u	\$3,900,000	\$1,200,000	\$590,000	\$99,000	\$5,800,000
SFB-i	\$3,600,000	\$1,200,000	\$590,000	\$99,000	\$5,400,000
RP	\$4,000,000	\$480,000	\$2,000,000	\$255,000	\$6,800,000
PLD-u	\$13,100,000	\$10,700,000	\$1,800,000	\$500,000	\$26,100,000
PLD-i	\$12,400,000	\$11,000,000	\$1,800,000	\$500,000	\$25,700,000
PICP-u	\$58,000,000	\$29,000,000	\$510,000	\$94,000	\$87,600,000
PICP-i	\$53,100,000	\$26,500,000	\$510,000	\$94,000	\$80,200,000
HS	\$13,300,000	\$8,300,000	\$15,600,000	\$2,200,000	\$39,500,000
II	\$1,700,000	\$27,000,000	\$8,400,000	\$1,300,000	\$38,400,000

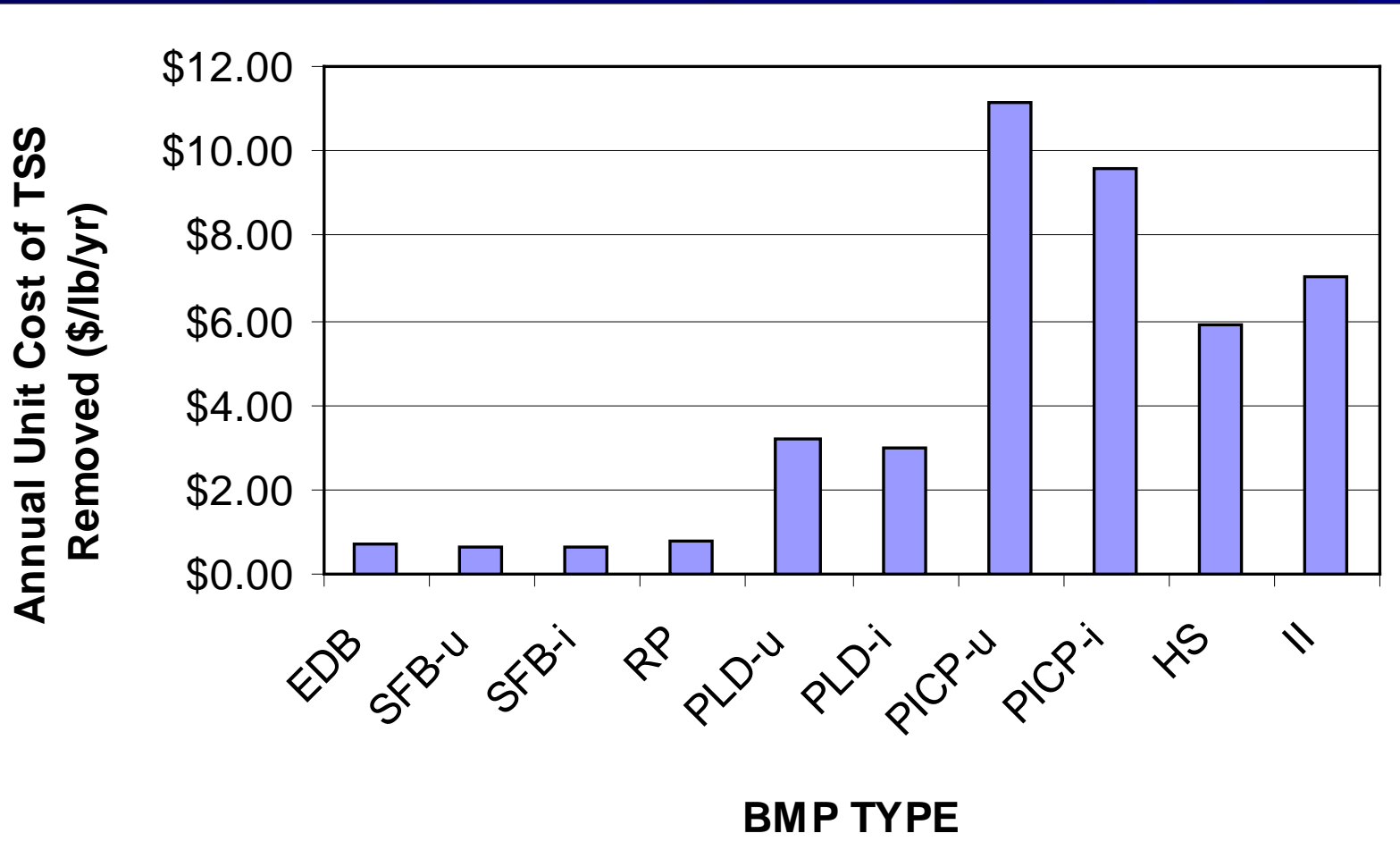
Note: Shown PICP costs are before subtracting cost of conventional pavement.

# Annual Runoff Volume & Load Reductions and Unit Cost of Reductions for TSS, TP and TCu

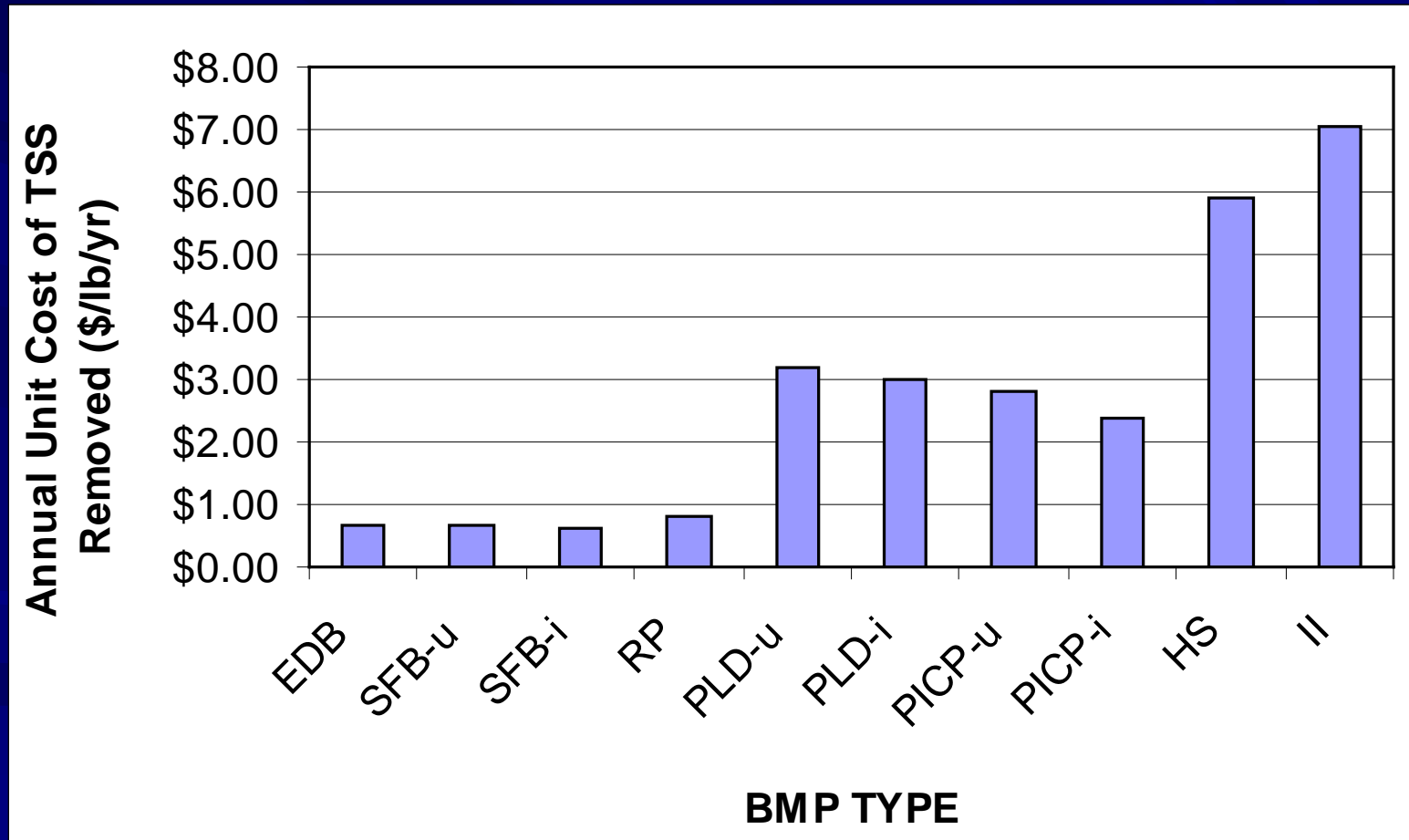
BMP Type	Runoff % Vol. Red'cd	% TSS Load Red'cd	TSS Cost \$/Lb Rem'd	% TP Load Red'cd	TP Cost \$/Lb Rem'd	% TCu Load Red'cd	TCu Cost \$/Lb Rem'd
EDB	27%	82%	\$0.69	70%	\$314	66%	\$6,332
SFB-u	36%	88%	\$0.67	78%	\$295	74%	\$5,942
SFB-i	90%	90%	\$0.61	90%	\$241	90%	\$4,570
RP	6%	85%	\$0.81	73%	\$368	73%	\$6,989
PLD-u	51%	84%	\$3.18	76%	\$1,375	77%	\$25,688
PLD-i	85%	84%	\$3.18	76%	\$1,375	77%	\$25,688
PICP-u	35%	80%	\$11.17 (\$3.79)*	74%	\$4,795 (\$1,199)*	67%	\$99,658 (\$24,914)*
PICP-i	86%	86%	\$9.55 (\$2.39)*	86%	\$3,750 (\$938)*	85%	\$71,193 (\$17,798)*
HS	0%	68%	\$5.91	57%	\$2,778	43%	\$70,233
II	0%	61%	\$7.06	67%	\$2,523	44%	\$73,128

Note: PICP costs in ( ) are after subtracting cost of conventional pavement.

# Unit costs of TSS load removed in \$/lb/yr for each BMPs BEFORE subtracting cost of conventional pavement whole-life costs



# Unit costs of TSS load removed in \$/lb/yr for each BMPs AFTER subtracting cost of conventional pavement whole-life costs



# Observations/Conclusions

NPC for system-wide application of BMPs is proportional to the density of their use.

- The site-level BMPs such as *PLDs, PICP, HS and II* had the higher NPCs
- Community-based BMPs such as *EDB, SFB and RP* had the lowest.

# Observations/Conclusions

Some community-based BMPs, (e.g., *SFBs*) were as robust as *PLDs* in **reducing runoff volumes.**

*EDBs* were almost as robust as *PLDs with underdrains.*

# Observations/Conclusions

Of significance to MS4s are the fiscal commitments for long-term maintenance and rehabilitation of their BMP system.

- The permit holder is responsible to insure that the BMPs will be maintained and rehabilitated.
- Can revenue increases over time keep up with fiscal demands for these activities in the future?
- This model can assist the responsible party in planning for long-term economic liabilities.