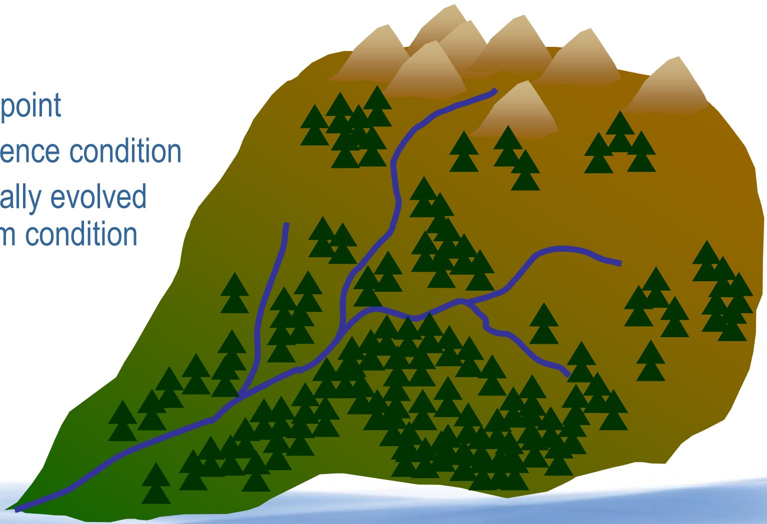
Approaches for Selecting BMPs and Estimating Their Performance

Stephen Carter, PE

The Moving Target

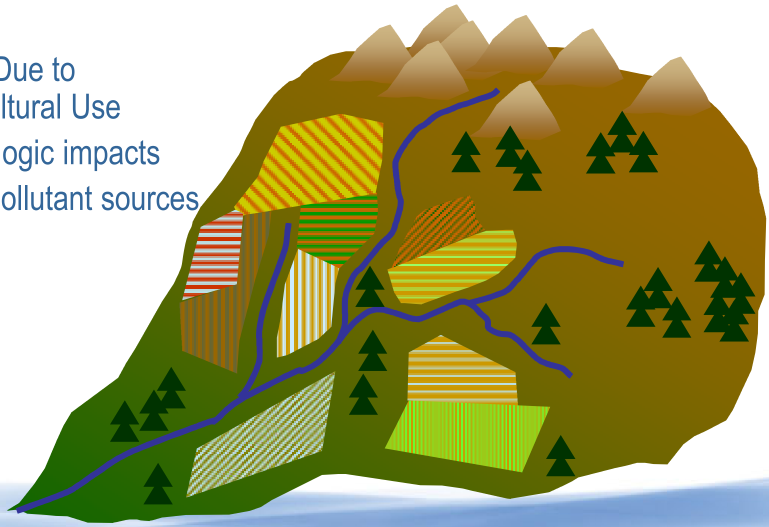
Starting point
- Reference condition
- Naturally evolved stream condition



The Moving Target

Change Due to Agricultural Use

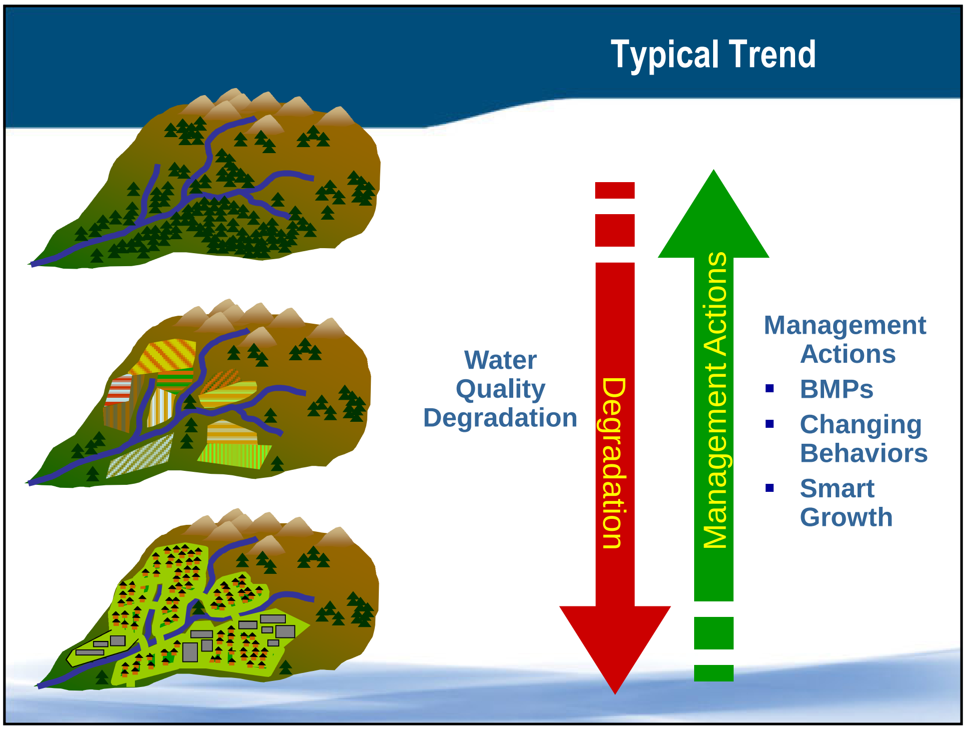
- Hydrologic impacts
- New pollutant sources

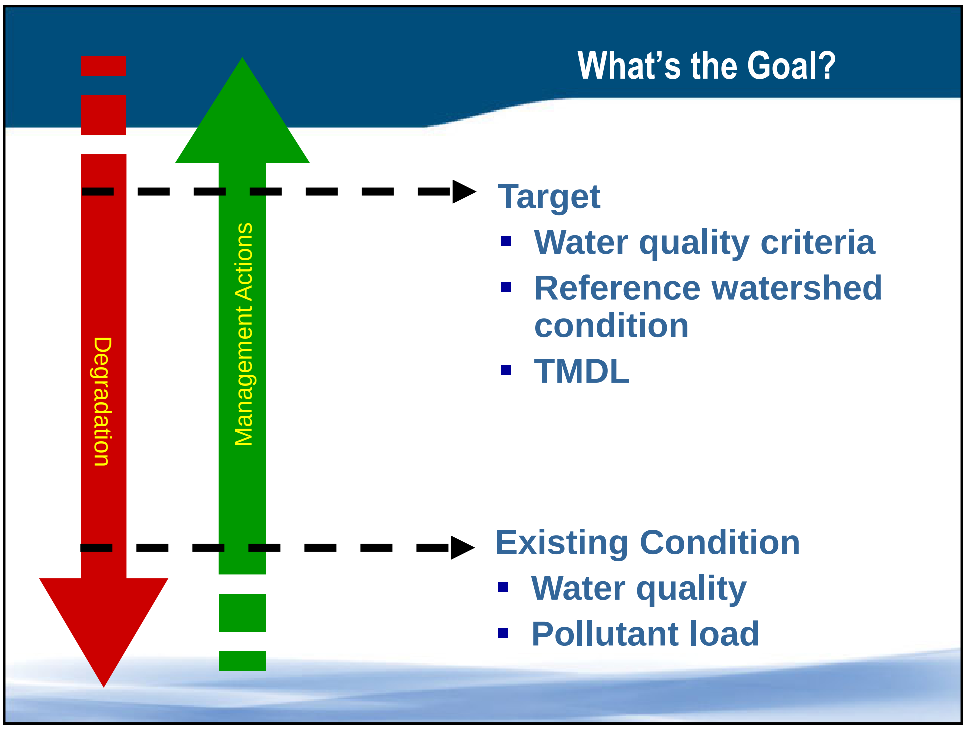


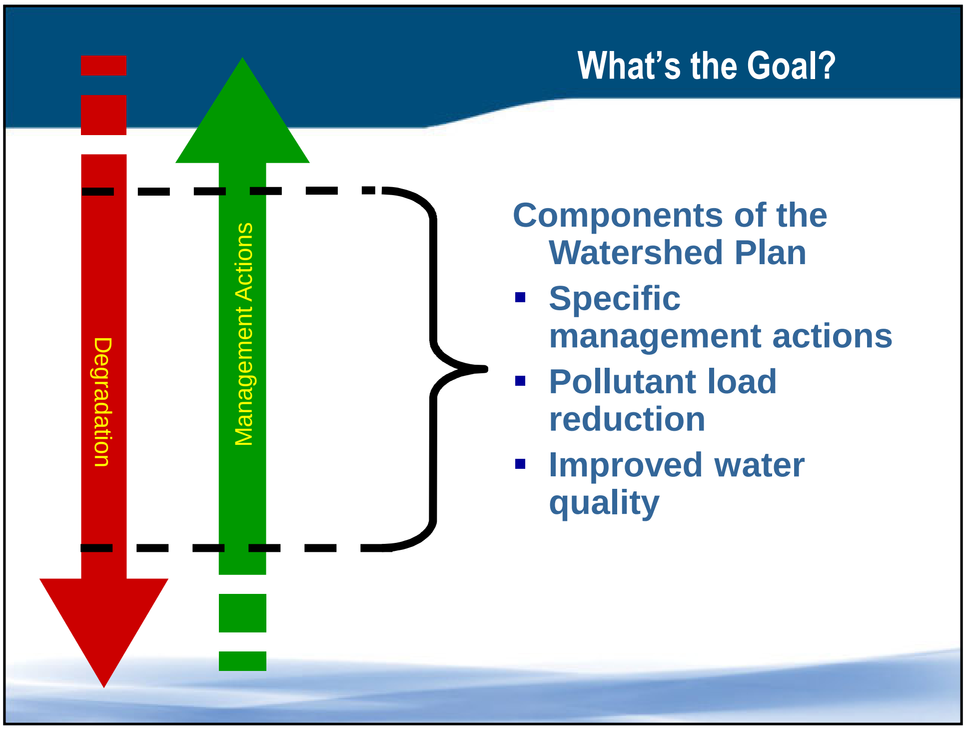
The Moving Target

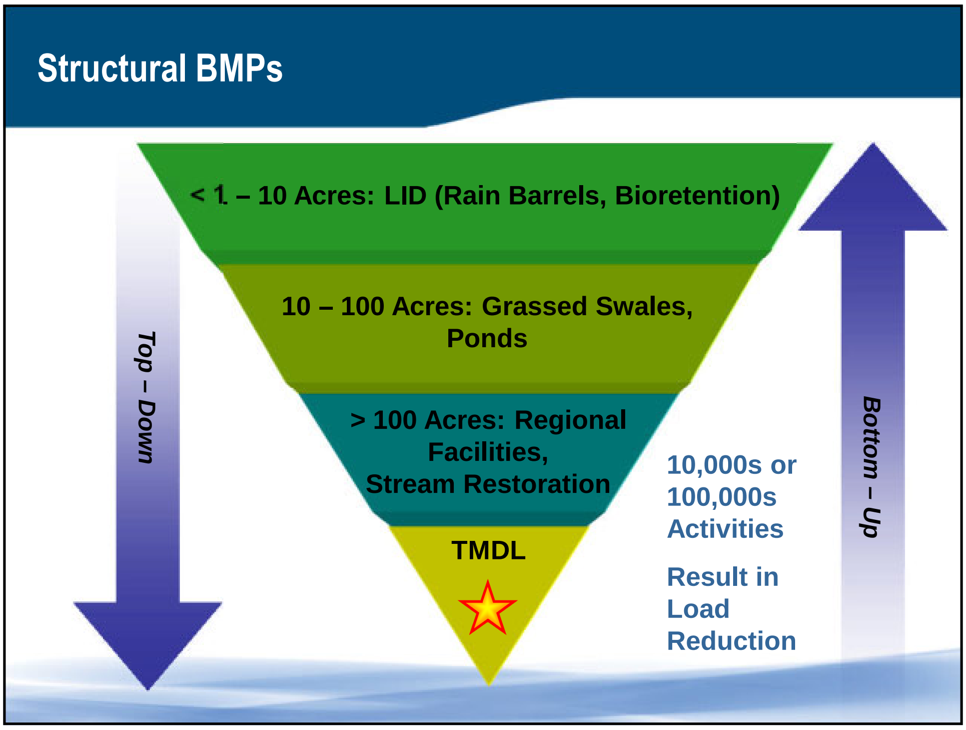
Development

- Increased imperviousness
- Increased runoff
- Additional pollutant sources


Typical Trend
Water Quality Degradation
Degradation
Management Actions
Management Actions
▪ BMPs
▪ Changing Behaviors
▪ Smart Growth


What's the Goal?
Degradation
Management Actions
Target
▪ Water quality criteria
▪ Reference watershed condition
▪ TMDL
Existing Condition
▪ Water quality
▪ Pollutant load


What's the Goal?
Degradation
Management Actions
Components of the Watershed Plan
▪ Specific management actions
▪ Pollutant load reduction
▪ Improved water quality


Structural BMPs
< 1 – 10 Acres: LID (Rain Barrels, Bioretention)
10 – 100 Acres: Grassed Swales, Ponds
> 100 Acres: Regional Facilities, Stream Restoration
TMDL
Top – Down
Bottom – Up
10,000s or 100,000s Activities
Result in Load Reduction

ASCE BMP Database

INTERNATIONAL STORMWATER BMP DATABASE
www.bmpdatabase.org

International Stormwater BMP Database Summary of BMP Categories by State as of November 2011

Category	BMP Category	AL	CA	CO	CT	DE	FL	GA	IL	MA	MD	MI	MN	NC	NH	NJ	NY	OH	OR	PA	TX	VA	WA	WI	Non-U.S.	Total
BR	Bioretention					1				1				11	3				1	1		1	1	4		24
CO	Composite (Treatment Train)		1	5			3						2								8	1	1			21
CX	Control			6			2							1	1					2	2			1	2	17
DB	Detention Basin	2	5	1			3	1		1	1	1	1	1	1		4		2		7	6	2			39
GR	Green Roof			1															7	3						11
GS	Biofilter (Swales & Filter Strips)		40				13							6	1				5		4	11	1		1	82
IB	Infiltration Basin		1																							1
LD	LID (Site Scale)																							1		1
MD	Manufactured Device (Multiple Types)	4	12		1	7	11				1				7	5	1		1	1	9	6	6	5	1	78
MF	Media Filter	1	11	2		1	5								1		1		1		10	1	1			35
MP	Maintenance Practice		2						4					2									12	8		28
OT	Other						1																		1	2
PP	Porous Pavement			6			2						1	4	1			1		3	7				1	26
PT	Percolation Trench/Well						9						1								1					11
RP	Retention Pond	2	4	5			27	1	1			3	5	3	1						8		3	1	1	65
WB	Wetland Basin	2	1				6				3	1			1				1		8	6				29
WC	Wetland Channel	4	3	2			2						4								2					17
Total		15	80	28	1	9	84	2	5	2	5	5	14	28	17	5	6	1	18	10	66	32	27	20	7	487

Source: International Stormwater BMP Database, November 17, 2011.

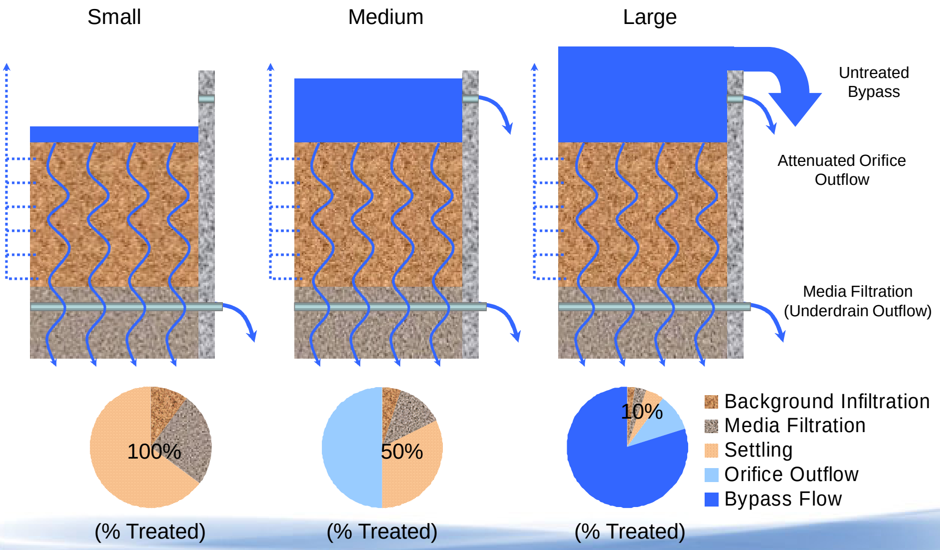
ASCE BMP Database

	A	B	C	D	E	F	G	H	I	J	K	L
1	WQX Parameter			SITENAME	BMPName	Monitoring Station Type	Include in Analysis	# Even	Geomean (pink > std)	Median	Min	Max
2	**Enterococcus**	BR	BR	I-95 Plaza Bioretention Cell	Bioretention Cell	Inflow		8	35,209	59,000	2,600	160,000
3	Enterococcus	BR	BR	I-95 Plaza Bioretention Cell	Bioretention Cell	Outflow		9	15,349	14,000	1,700	160,000
4	Enterococcus	CO	CO	Fallbrook Detention Basin E500-12-00	E500-12-00 Detention Facility Composite System	Inflow	no	1	24,196	24,196	24,196	24,196
5	Enterococcus	DB	DB	El Dorado Detention Basin B504-03-00	B504-03-00 Detention Basin	Inflow		13	5,505	10,100	119	43,700
6	Enterococcus	DB	DB	El Dorado Detention Basin B504-03-00	B504-03-00 Detention Basin	Outflow		13	1,469	2,420	1	198,600
7	Enterococcus	MD	MD	Fallbrook Detention Basin E500-12-00	Floatables control system	Inflow	no	1	24,196	24,196	24,196	24,196
8	Enterococcus	MD	MD	Fallbrook Detention Basin E500-12-00	Floatables control system	Outflow	no	1	24,196	24,196	24,196	24,196
9	Enterococcus	MD	MD	I-95 Plaza AbTech Ultra-Urban Filter w/ Smart Spon	I-95 Plaza AbTech Ultra-Urban Filter with Smart Sponge Plus Antimicrobial Additive	Inflow		11	2,300	840	100	160,000
10	Enterococcus	MD	MD	I-95 Plaza AbTech Ultra-Urban Filter w/ Smart Spon	I-95 Plaza AbTech Ultra-Urban Filter with Smart Sponge Plus Antimicrobial Additive	Outflow		11	6,770	1,890	310	160,000
11	Enterococcus	MD	MD	I-95 Plaza AbTech Ultra-Urban Filter w/Smart Spong	AbTech Ultra-Urban Filter with Smart Sponge	Inflow		10	14,599	51,500	200	199,000
12	Enterococcus	MD	MD	I-95 Plaza AbTech Ultra-Urban Filter w/Smart Spong	AbTech Ultra-Urban Filter with Smart Sponge	Outflow		9	8,171	5,000	940	160,000
13	Enterococcus	MD	MD	I-95 Plaza BaySaver	BaySaver	Inflow		7	18,676	17,000	1,700	160,000
14	Enterococcus	MD	MD	I-95 Plaza BaySaver	BaySaver	Outflow		10	11,234	10,500	400	160,000
15	Enterococcus	MD	MD	I-95 Plaza HydroKleen Filter	HydroKleen Filter	Inflow		8	7,256	5,000	200	160,000
16	Enterococcus	MD	MD	I-95 Plaza HydroKleen Filter	HydroKleen Filter	Outflow		8	16,835	11,000	5,000	240,000
17	Enterococcus	MD	MD	I-95 Plaza StormFilter	I-95 Plaza StormFilter	Inflow		11	2,999	7,000	200	30,000
18	Enterococcus	MD	MD	I-95 Plaza StormFilter	I-95 Plaza StormFilter	Outflow		10	5,618	6,600	200	160,000

ASCE BMP Database

CAT	SITENAME	BMPNAME	Count of Events	Average Precipitation Depth (cm	Watershed Area (ha)	Sum of Inflow (L	Sum of Outflow (L)	Relative Volume Reduction by Study
BI	I-605/SR-91 Strip	605/91 Strip	6	4.57	0.20	209,913	136,572	35%
BI	Altadena (strip)	Altadena Strip	12	3.60	0.69	1,845,664	1,578,777	14%
BI	Carlsbad Biofiltration Strip	Carlsbad strip	13	1.60	0.97	1,177,729	142,066	88%
BI	Sand Canyon 2 RVTS	Irvine A RVTS	6	4.09	0.71	94,207	57,602	39%
BI	Sand Canyon 4 RVTS	Irvine C RVTS	4	5.30	1.04	75,326	57,622	24%
BI	Murrieta RVTS	Murrieta 4 meters 1	3	5.59	0.04	50,893	50,652	0%
BI	Murrieta RVTS	Murrieta 4 meters 2	3	5.75	0.04	55,426	39,627	29%
BI	Clayton Level Spreader/GFS at I-40/NC-42	NC DOT Grass Strip	9	2.05	0.35	485,945	396,334	18%
BI	Redding RVTS	Redding RVTS 2.2 m	20	4.15	0.03	199,901	170,161	15%
BI	Redding RVTS	Redding RVTS 4.2 m	23	4.33	0.03	248,722	165,849	33%
BI	Sacramento RVTS	Sacramento RVTS 2	30	1.81	0.04	147,726	122,890	17%
BI	Sacramento RVTS	Sacramento RVTS 3	24	1.73	0.04	103,369	54,101	48%
BI	Sacramento RVTS	Sacramento RVTS 4	17	2.00	0.04	93,464	38,443	59%
BI	Sacramento RVTS	Sacramento RVTS 5	16	1.92	0.04	77,129	36,895	52%
BI	San Rafael RVTS	San Rafael RVTS 2	34	2.89	0.13	772,001	314,979	59%
BI	Westfield Level Spreader	Westfield Level Spreader	23	2.43	0.87	34,209	5,259	85%
BRU	Greensboro bioretention-G1	G1	57	2.63	0.20	2,673,968	299,818	89%
BRU	Greensboro bioretention-G2	G2	65	2.30	0.19	2,673,969	152,307	94%
BRU	Hal Marshall Bioretention Cell	Hal Marshall Bioretention Cell	10	2.05	0.37	666,862	286,312	57%
BRU	Louisburg bioretention-L1	L1	30	2.40	0.36	2,356,203	1,136,398	52%
BRU	Louisburg bioretention-L2	L2	29	2.40	0.22	1,184,820	741,764	37%
BRU	Graham H.S. Bioretention Cells	North cell	17	2.07	0.69	904,712	588,682	35%
BRU	Graham H.S. Bioretention Cells	South cell	19	2.11	0.69	1,212,645	490,800	60%
BS	29 North Swale B	29 N Swale B	3	1.23	0.35	13,300	1,992	85%
BS	29 South Swale	29 S Swale	4	3.35	0.33	143,508	85,059	41%
BS	I-5/I-605 Swale	5/605 swale	7	4.48	0.28	507,495	274,334	46%
BS	I-605/SR-91 Swale	605/91 swale	4	4.57	0.08	110,549	39,021	65%

BMP Processes



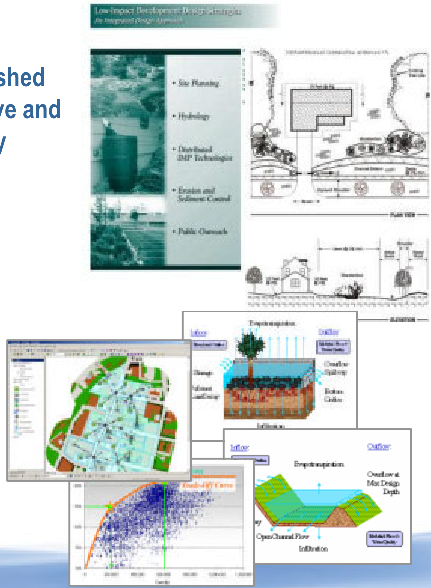
BMP Decision Support System (BMPDSS)

Prince George's County, MD

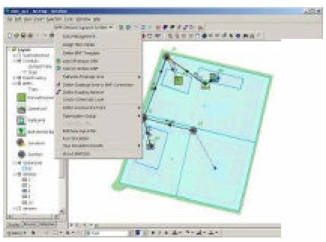
National leader in stormwater and watershed management – one of the most innovative and highly reference programs in the country

Highlights:

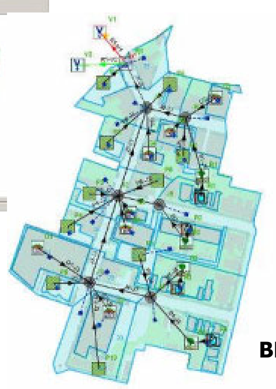
- Basis for national strategies to address stormwater challenges
- First and most referenced LID guidance and design manuals
- Developed the BMP Decision Support System (BMPDSS)



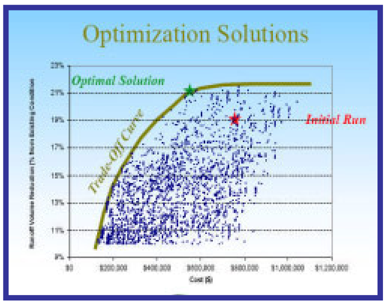
BMP Decision Support System (BMPDSS)



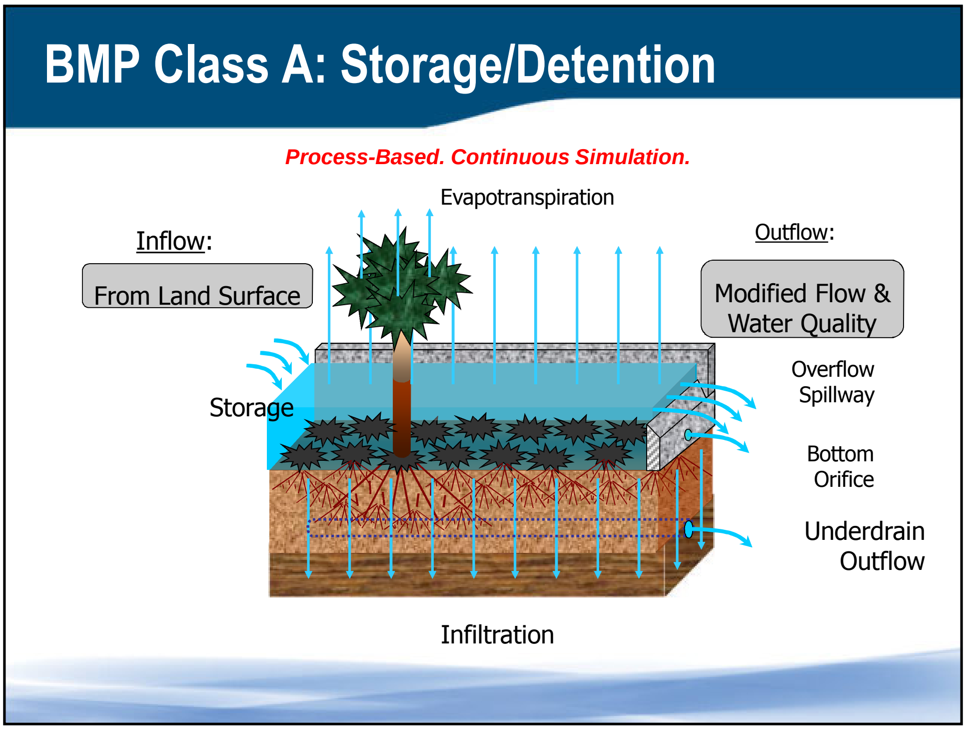
BMPDSS Interface

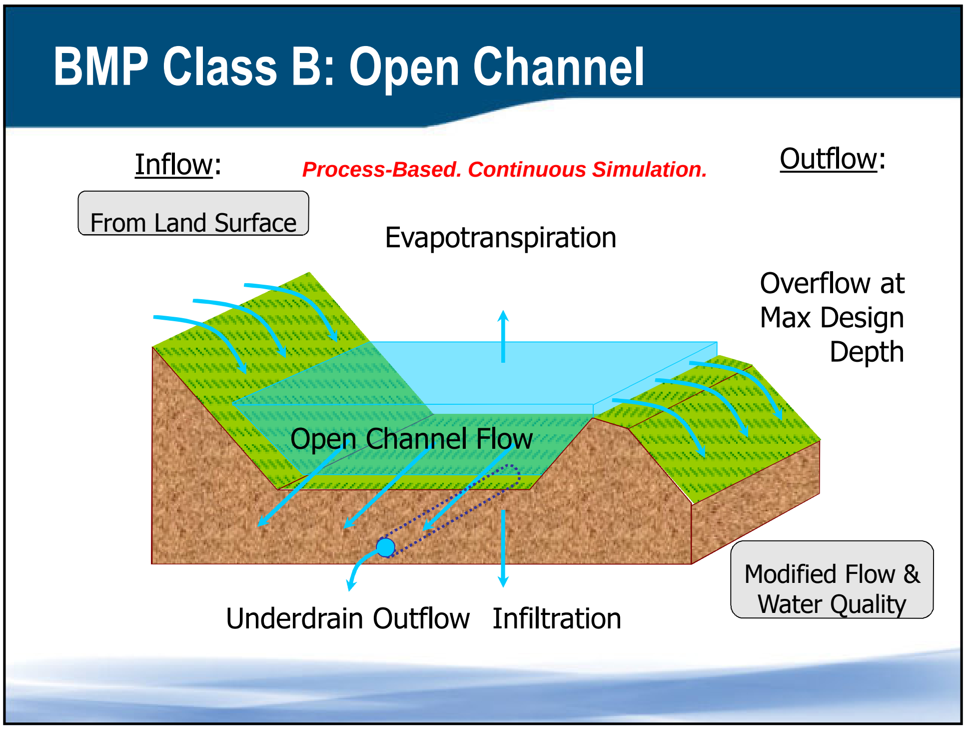


BMPDSS Set Up



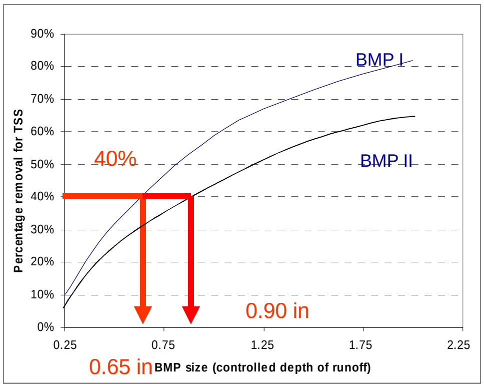
BMPDSS Output:
BMP Optimization


BMP Class A: Storage/Detention
Process-Based. Continuous Simulation.
Evapotranspiration
Inflow:
From Land Surface
Outflow:
Modified Flow & Water Quality
Storage
Overflow Spillway
Bottom Orifice
Underdrain Outflow
Infiltration

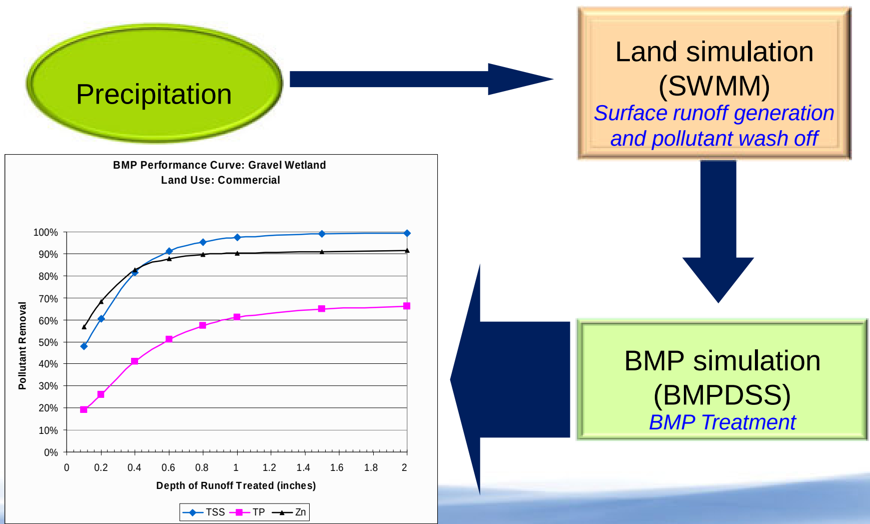

BMP Class B: Open Channel
Inflow:
Process-Based. Continuous Simulation.
Outflow:
From Land Surface
Evapotranspiration
Overflow at Max Design Depth
Open Channel Flow
Modified Flow & Water Quality
Underdrain Outflow
Infiltration

BMP Performance Curve Concept

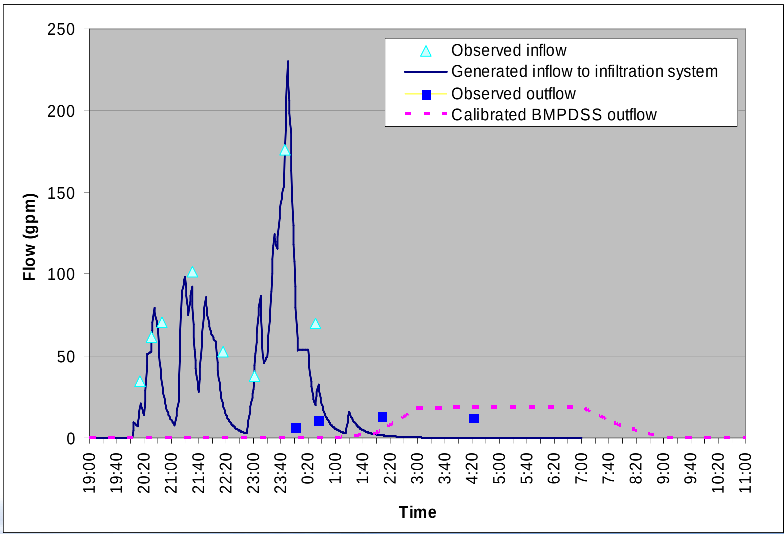
- Performed for EPA Region 10
- BMPs curves developed from calibrated models and detailed performance data
- Provides long-term cumulative performance estimates based on BMP capacity
- Eliminates the need for detailed modeling and evaluation in individual applications



BMP Performance Curve Development Scheme



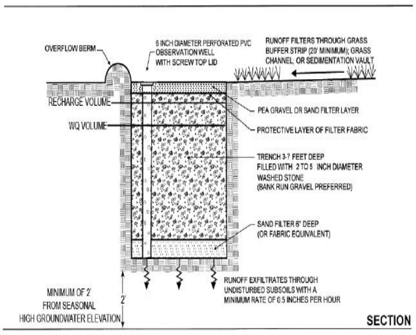
BMPDSS Calibration for Event 1/12/2006: Hydrology

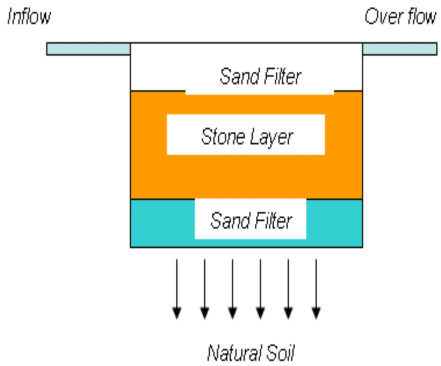


BMPDSS Calibration: Water Quality

Calibration events			Pollutants TSS	TP	Zn
08/13/2005	Observed EMC (mg/L)	Inflow	72.13	0.16	0.11
08/13/2005	Observed EMC (mg/L)	Outflow	0.17	0.03	0
08/13/2005	BMPDSS performance	Calibrated outflow	0.17	0.03	0.006
08/13/2005	BMPDSS performance	Decay	0.76	0.31	0.47
08/13/2005	BMPDSS performance	Perct. removal	0.93	0.70	0.85
01/12/2006	Observed EMC (mg/L)	Inflow	52.06	0.10	0.03
01/12/2006	Observed EMC (mg/L)	Outflow	0	0.01	0
01/12/2006	BMPDSS performance	Calibrated outflow	0.03	0.01	0.001
01/12/2006	BMPDSS performance	Decay	0.73	0.29	0.44
01/12/2006	BMPDSS performance	Perct. removal	0.90	0.65	0.81
05/09/2006	Observed EMC (mg/L)	Inflow	94.03	0.12	0.04
05/09/2006	Observed EMC (mg/L)	Outflow	0	0.02	0
05/09/2006	BMPDSS performance	Calibrated outflow	0.01	0.02	0
05/09/2006	BMPDSS performance	Decay	0.73	0.21	0.44
05/09/2006	BMPDSS performance	Perct. removal	0.91	0.50	0.79
Calibrated parameters		**Decay**	**0.74**	**0.27**	**0.45**
Calibrated parameters		**Perct. removal**	**0.91**	**0.62**	**0.82**

BMP Representation in BMPDSS





Generation of BMP Performance Curves

Land uses (5)

- Commercial
- Industrial
- High-density residential
- Medium-density residential
- Low-density residential

BMPs (8)

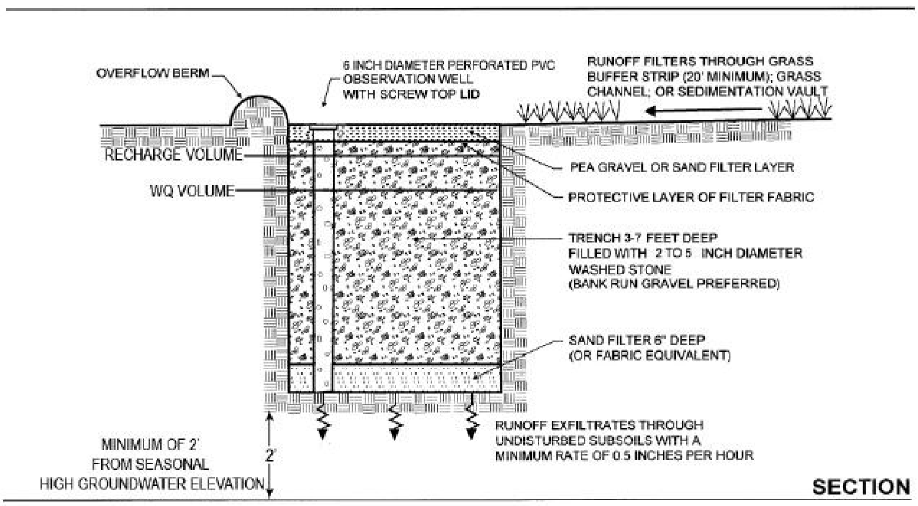
- Infiltration basin (6 infiltration rates)
- Infiltration trenches (6 infiltration rates)
- Bio-retention
- Porous pavement
- WQ Swales
- Extended dry detention
- Wet pond
- Gravel wetland

Pollutants (3)

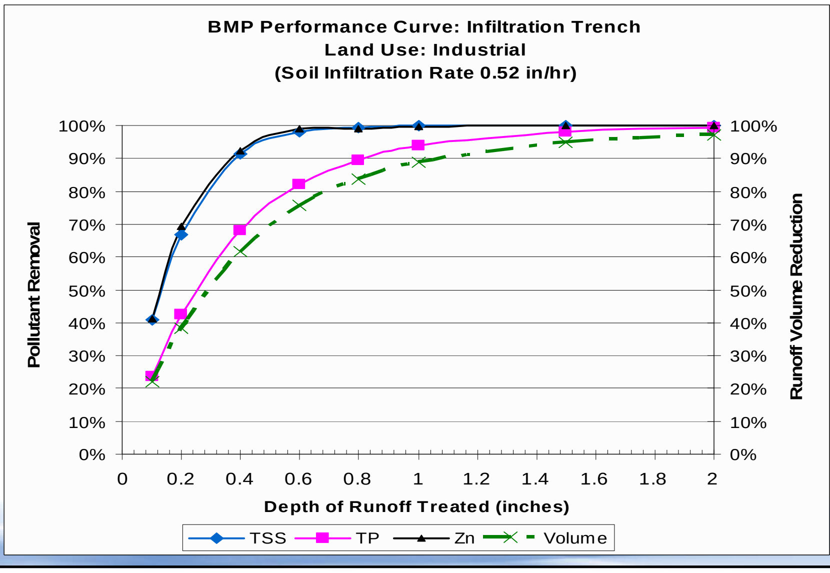
- TSS
- TP
- Zn

90 Figures and 282 Curves in total

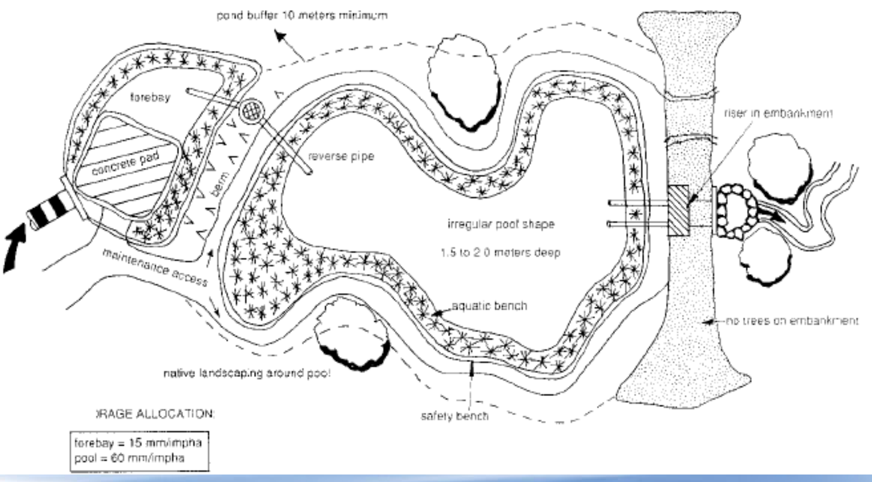
Infiltration Trench



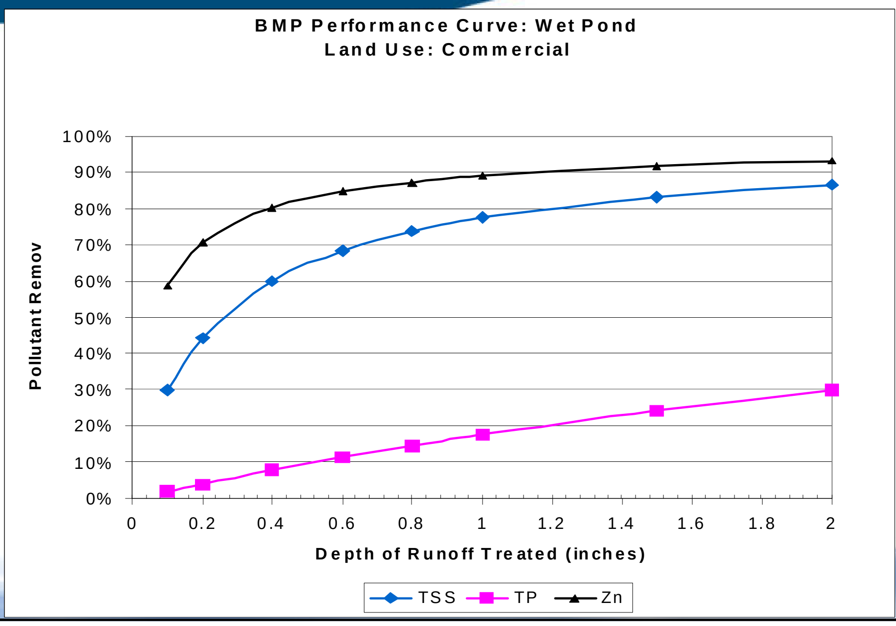
Infiltration Trench



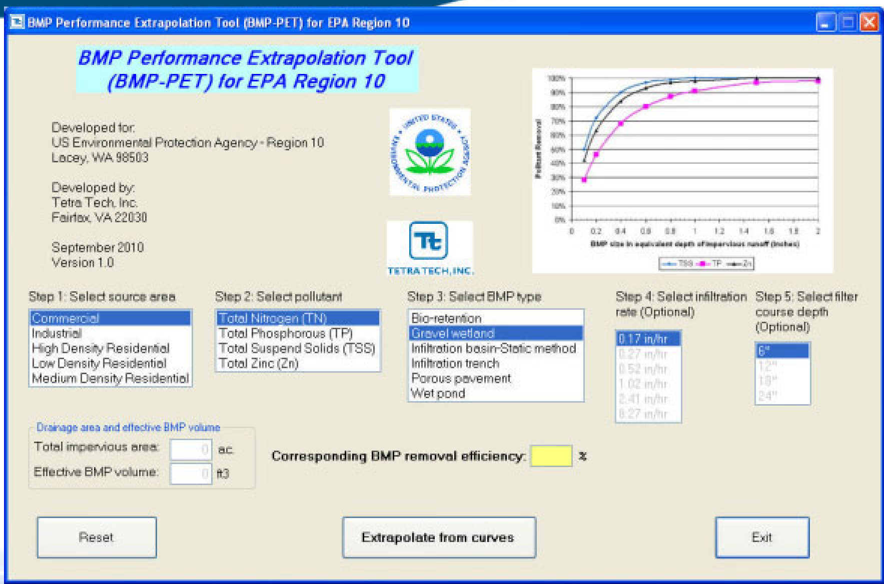
Wet Pond



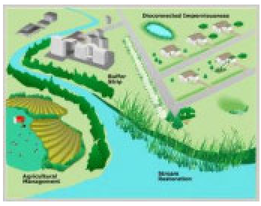
Wet Pond



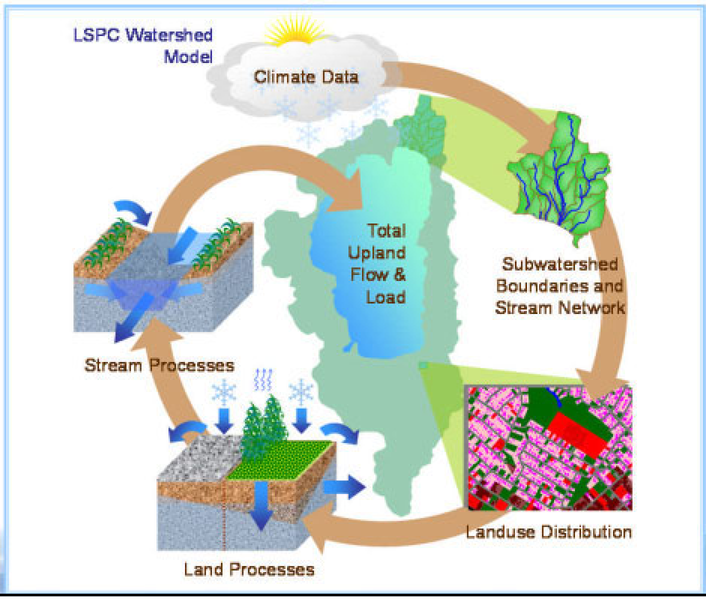
Curve Extrapolation Tool



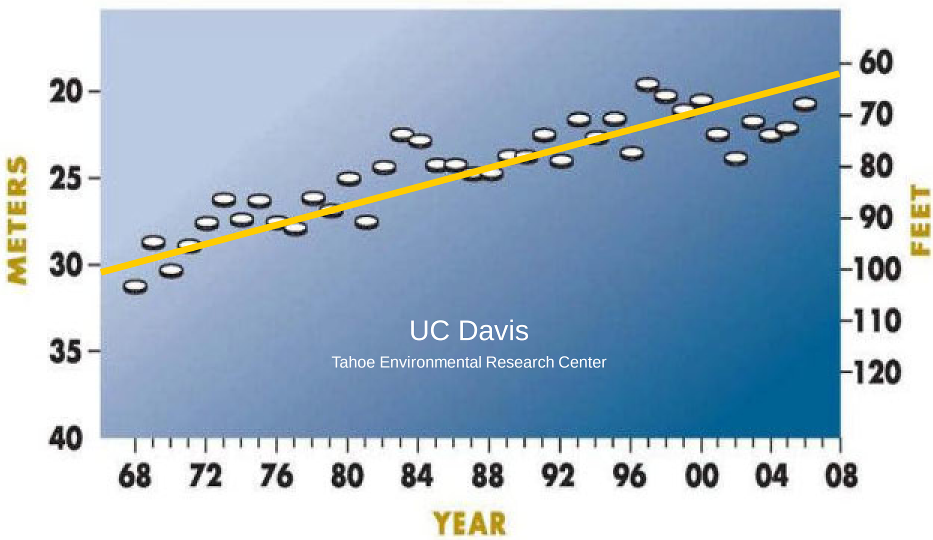
BMP Scale Considerations



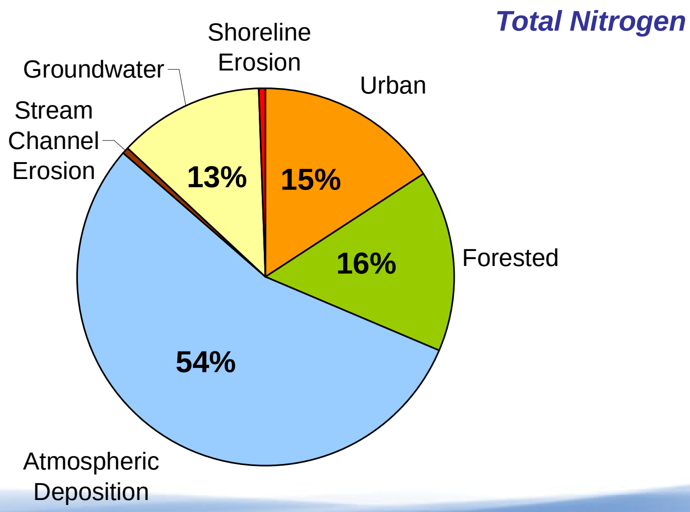
Lake Tahoe



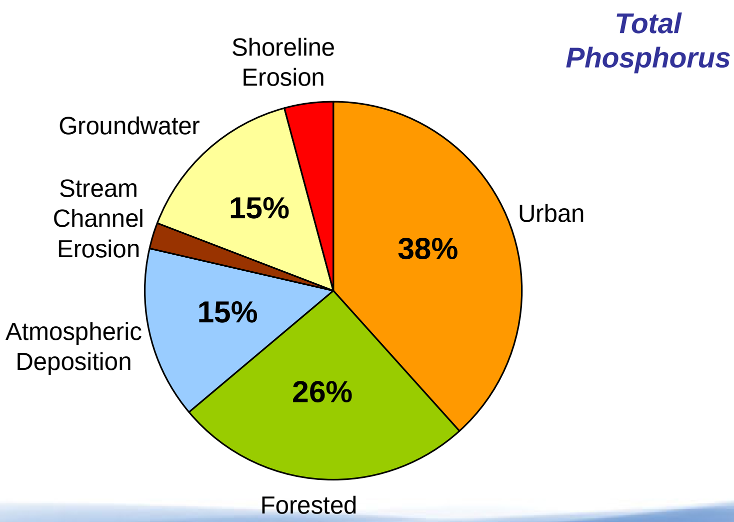
Decline of Lake Tahoe Clarity



Pollutant Load Budget

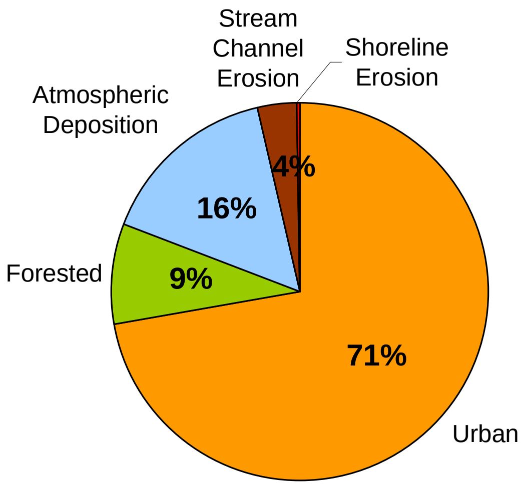


Pollutant Load Budget:

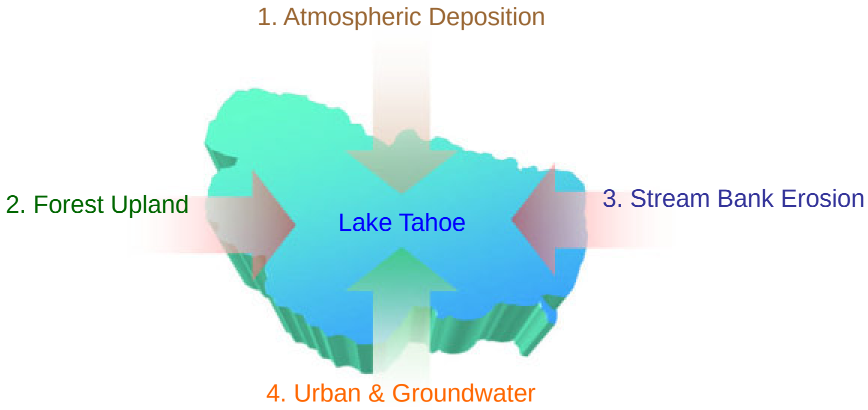


Pollutant Load Budget

Fine Sediment Particles

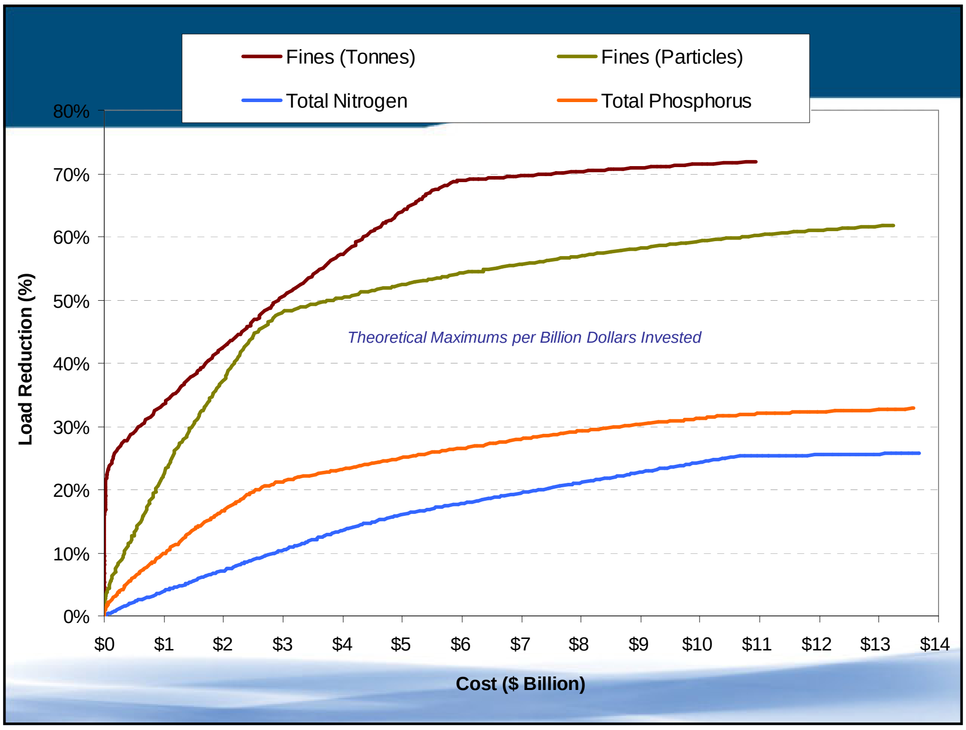


Lake Tahoe Source Category Groups (SCGs)



Management Settings and Tiers

Atmospheric Deposition	
Settings	Four spatially based settings, measured by concentric rings of distance from the lake
Tiers	Four tiers per setting were applied, based on two different treatment levels from two different groups of pollutant sources. The first group was vehicle emisions, and the second group included transportation infrastructure or structural controls
Forest Uplands	
Settings	Three source based settings, including (A) unpaved roads, (B) highly erodible forest and recreational areas, (C) burned, plus harvested, plus relatively undisturbed forest areas
Tiers	Three tiers per setting with increasing degree of treatment: low, medium, and high
Stream Channel	
Settings	Three treatable segments along the top three most sediment-productive streams in the Basin: (1) Blackwood Ck, (2) Upper Truckee, and (3) Ward Creek
Tiers	Three levels of treatment with varying intensities and stabilization activities
Urban Upland	
Settings	Four settings based on the different combinations of slope (moderate or steep) and impervious configuration (concentrated or dispersed).
Tiers	Two tiers of differing intensity and sophistication of treatment activities, plus a third "Pump and Treat" stormwater tier for concentrated impervious areas only



Packaging and Assessment Tool (PAT)

Step 1. Formulate Problem Objectives

Control ID	Control Name	Percent Reduction
1	Particles (E+18)	32%
2	TN (MT/yr)	5%
3	TP (MT/yr)	10%
4	Fines (MT/yr)	0%
5	Clarity Depth (ft)	0%

Legend

System Value
User Input

◉ Minimize Cost / Fixed Target(s)
○ Fixed Cost / Maximize Control

Fixed Cost:	$1,000,000,000	*Maximize Control*
Solution Tolerance:	$0.00	*Stop Condition*
Report the top	3	*Best Solutions*

Rank Feasible Alternatives

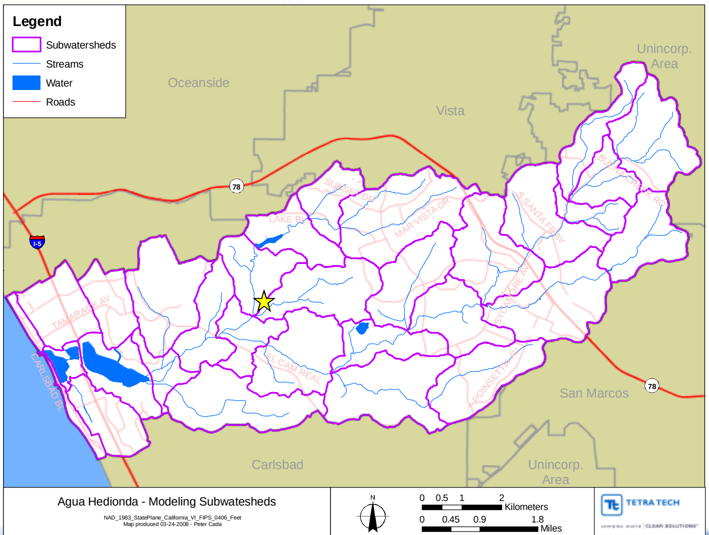
Step 2. Define Problem Constraints

TREATID	SCG	Setting	Tier	MIN_LOA	MAX_LOA
101	Atmospheric	Setting 1	VE Tier 2	0%	0%
102	Atmospheric	Setting 1	VE Tier 3	0%	0%
103	Atmospheric	Setting 1	TIOS Tier 2	0%	80%
104	Atmospheric	Setting 1	TIOS Tier 3	0%	80%
...	...	...	...	...	...
407	Urban & Groundwater	Disp.-Moderate	Tier 1	0%	100%
408	Urban & Groundwater	Disp.-Moderate	Tier 2	0%	100%
409	Urban & Groundwater	Disp.-Steep	Tier 1	0%	100%
410	Urban & Groundwater	Disp.-Steep	Tier 2	0%	100%

Step 3. Rank Feasible Alternatives by Cost

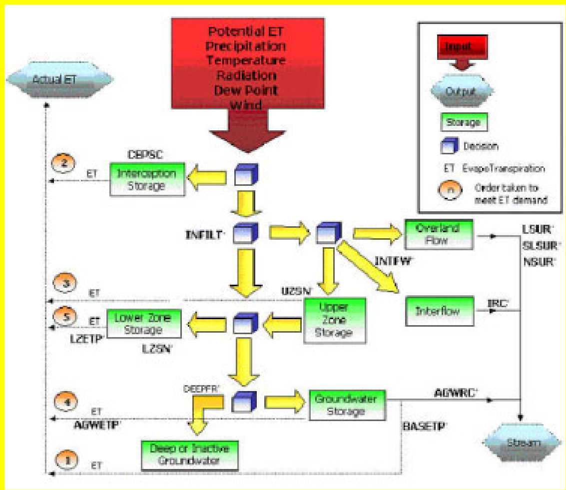
Rank Feasible Alternatives

Agua Hedionda Watershed Management Plan



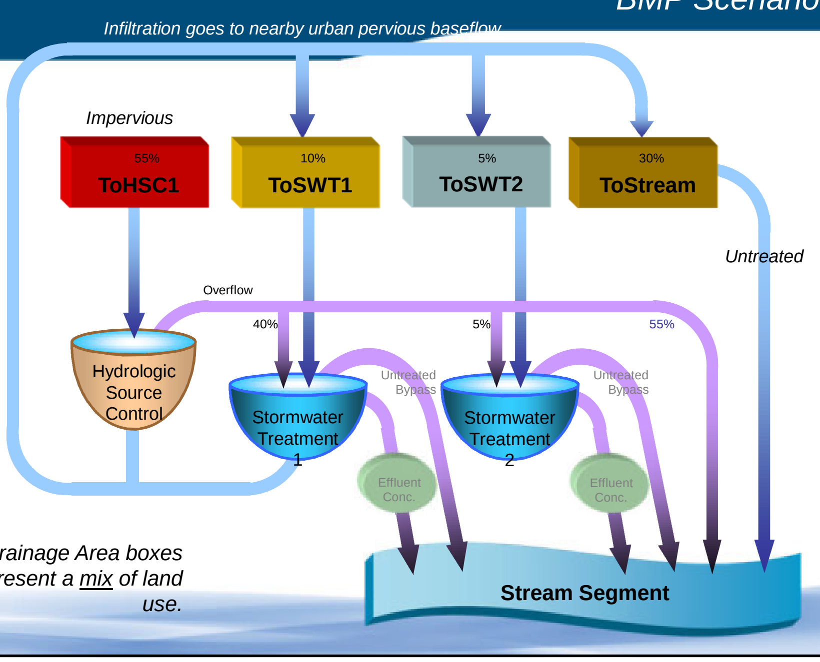
Model - LSPC

- Hydrologic Components:
  - Precipitation
  - Interception
  - Evapotranspiration
  - Overland flow
  - Infiltration
  - Interflow
  - Subsurface storage
  - Groundwater flow
  - Groundwater loss



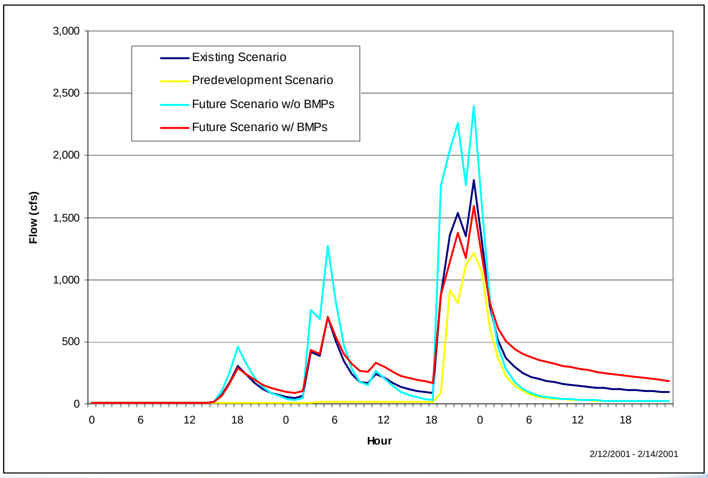
Schematic of Stanford Watershed Model

BMP Scenario

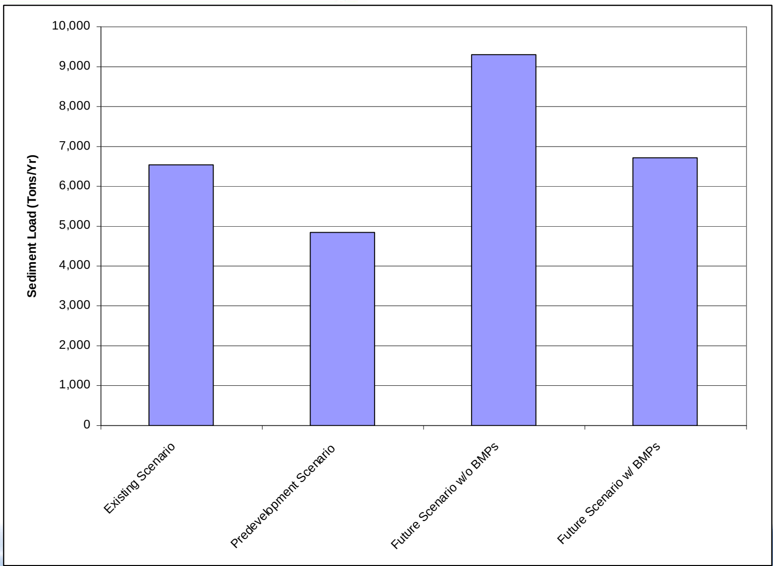


Drainage Area boxes represent a mix of land use.

Storm Hydrograph

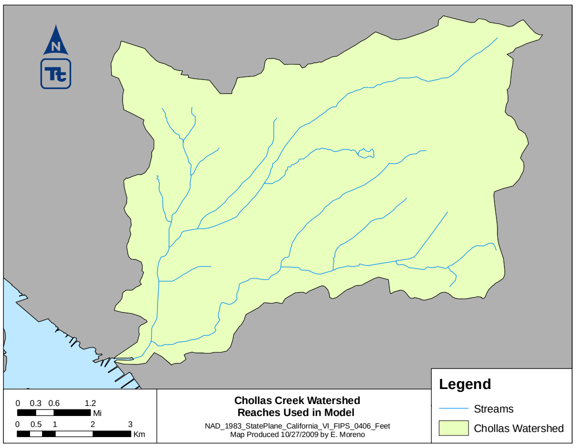


Sediment Loading at Lagoon



City of San Diego Evaluation of Structural and Nonstructural BMP Performance

- Chollas Creek Watershed
- LSPC Model
  - Suspended sediment
  - Trace metals
    - Copper
    - Lead
    - Zinc
  - Bacteria



Modeling Scenarios

- Long-term simulations (e.g., 10 years)
  - Capture a range of conditions
- Scenarios
  - Current conditions
    - Baseline scenario for comparison
  - Management scenarios
    - Individual BMPs
    - Combinations

Modeled BMPs

Modeled BMP	Scenarios and Combinations										
Irrigation control	●						●		●		●
Hydrologic source control											
Bioretention		●					●		●		●
Stormwater control											
Detention basin			●						●		●
Source control											
Copper reduction				●						●	●
Bacteria reduction					●			●		●	●
Street sweeping						●		●		●	●

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BMP Representation within a Watershed Model

- LSPC does not include explicit representation of individual BMPs
  - Assumptions are developed to represent BMPs
- Modeling assumptions can be based on
  - Specified BMP operational or design requirements
  - BMP literature information
  - Special studies on BMP performance

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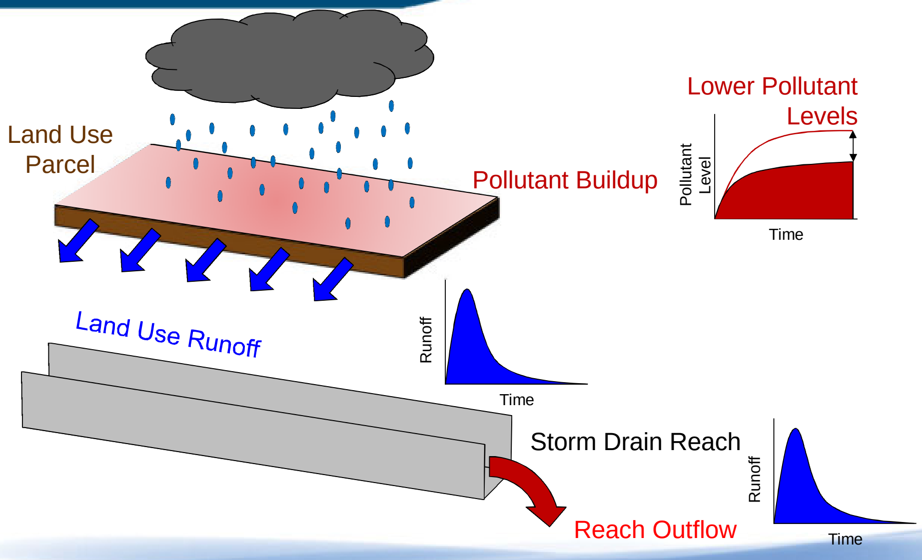
Source Control



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Source Control

- Examples
  - Reduced irrigation, treet sweeping, brake pad modification, pet BMPs



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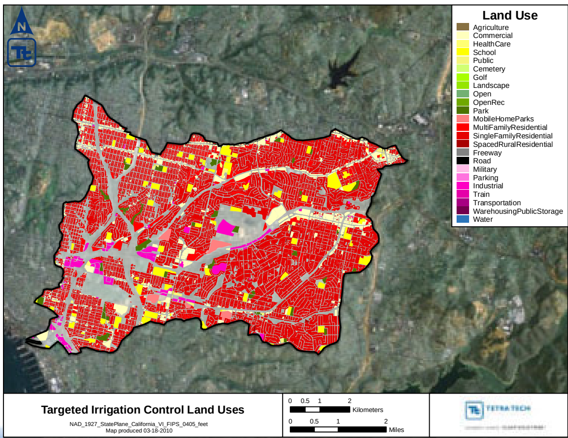
Modeled BMPs

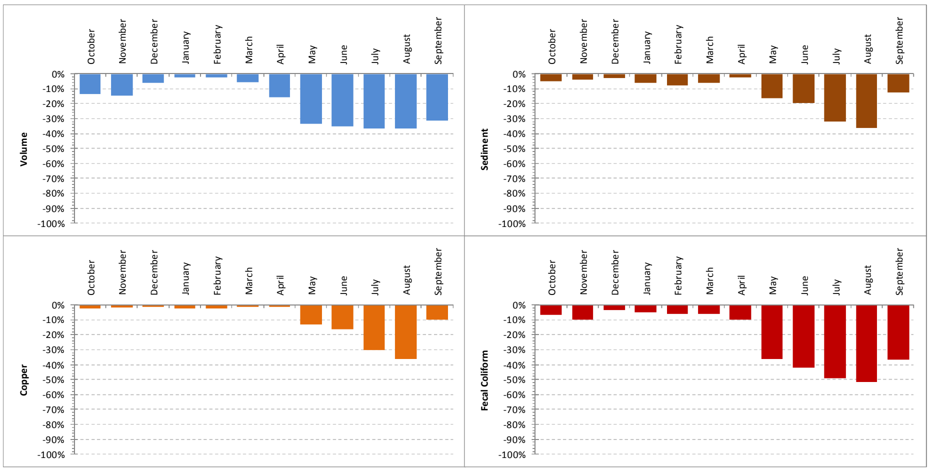
Modeled BMP	Scenarios and Combinations										
Irrigation control	●						●		●		●
Hydrologic source control											
Bioretention		●					●		●		●
Stormwater control											
Detention basin			●						●		●
Source control											
Copper reduction				●						●	●
Bacteria reduction					●			●		●	●
Street sweeping						●		●		●	●

Irrigation Control – Model Application

- Targeted land uses
  - Parks
  - Residential areas
  - Industrial
  - Commercial
  - Schools
- Reduce
  - 10, 20, 40, 75%



Irrigation Control – Monthly Reductions

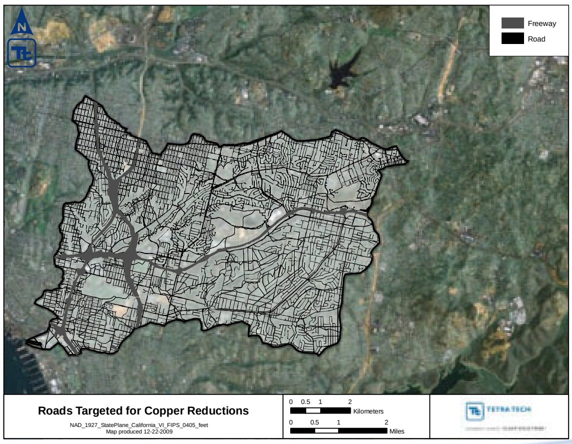


Modeled BMPs

Modeled BMP	Scenarios and Combinations										
Irrigation control	●						●		●		●
Hydrologic source control											
Bioretention		●					●		●		●
Stormwater control											
Detention basin			●						●		●
Source control											
Copper reduction				●						●	●
Bacteria reduction					●			●		●	●
Street sweeping						●		●		●	●

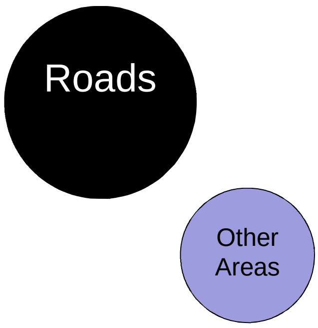
Source Control – Cu Red. Targeted Land Use

- Targeted land uses
  - Roads
  - Freeways
  - All Impervious*

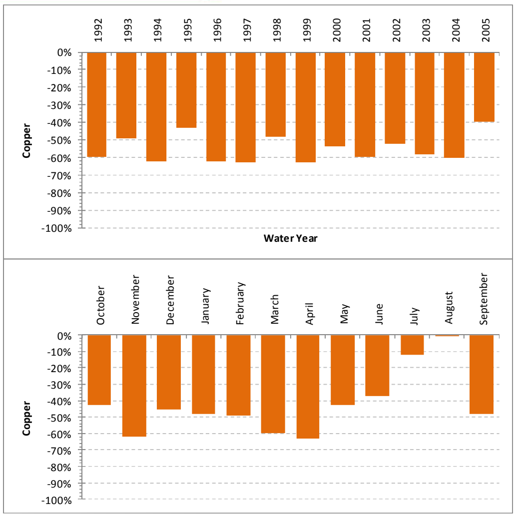


Source Control – Cu Red. Mobile Sources

- Reduction in copper on roads by targeted reduction
- Brake dust is resuspended deposits on other land uses
  - Assumed a reduction of ½ of road reduction



Source Control – Cu Red. Load Reductions

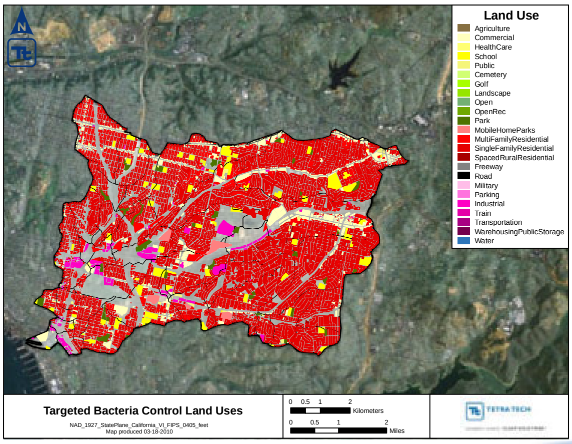


Modeled BMPs

Modeled BMP	Scenarios and Combinations										
Irrigation control	●						●		●		●
Hydrologic source control											
Bioretention		●					●		●		●
Stormwater control											
Detention basin			●						●		●
Source control											
Copper reduction				●						●	●
Bacteria reduction					●			●		●	●
Street sweeping						●		●		●	●

Source Control – Bacteria Targeted Land Use

- Targeted land uses
  - Residential
  - Parks



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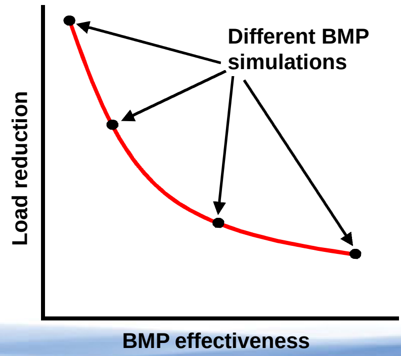
BMP Model Application

- Reduce bacteria levels by 10, 20, 40 and 80%
  - Reduce POTFW
  - Reduce SQOLIM and WSQOP



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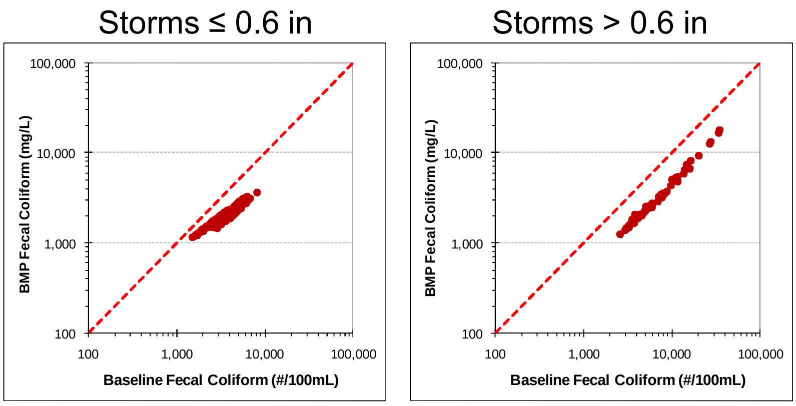
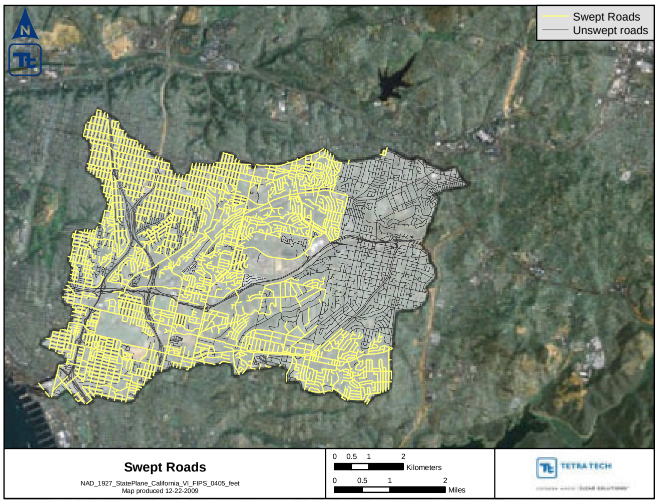
Source Control – Bacteria Storm EMC Reductions



Modeled BMPs

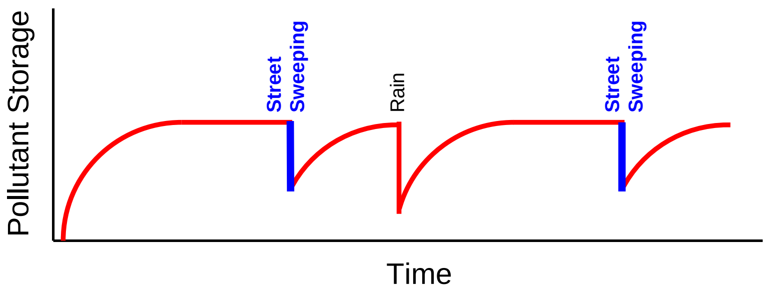
Modeled BMP	Scenarios and Combinations										
Irrigation control	●						●		●		●
Hydrologic source control											
Bioretention		●					●		●		●
Stormwater control											
Detention basin			●						●		●
Source control											
Copper reduction				●						●	●
Bacteria reduction					●			●		●	●
Street sweeping						●		●		●	●

Street Sweeping – Swept Roads

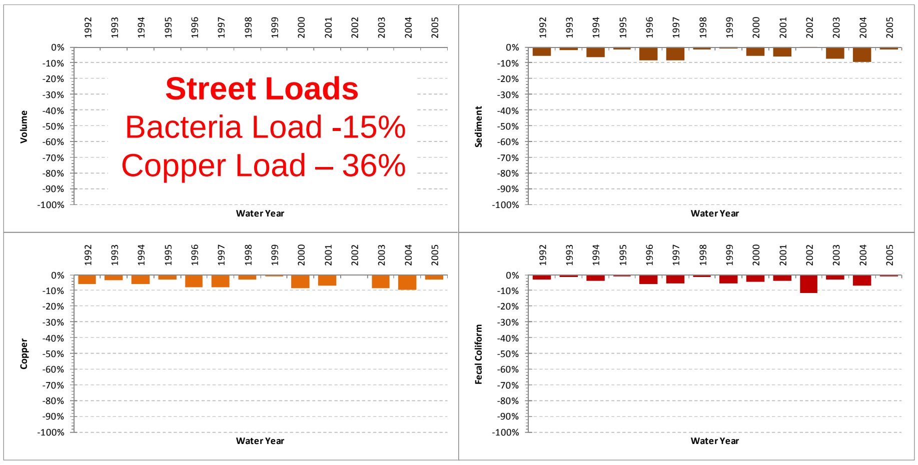


Street Sweeping Effects

- Reduce pollutant levels on roads



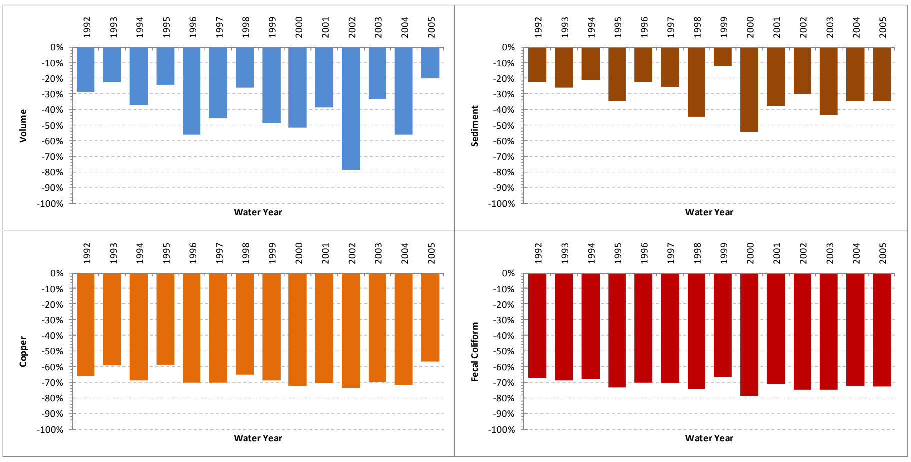
Street Sweeping – Load Reductions



Modeled BMPs

Modeled BMP	Scenarios and Combinations										
Irrigation control	●						●		●		●
Hydrologic source control											
Bioretention		●					●		●		●
Stormwater control											
Detention basin			●						●		●
Source control											
Copper reduction				●						●	●
Bacteria reduction					●			●		●	●
Street sweeping						●		●		●	●

Combination Simulations – Annual Loads



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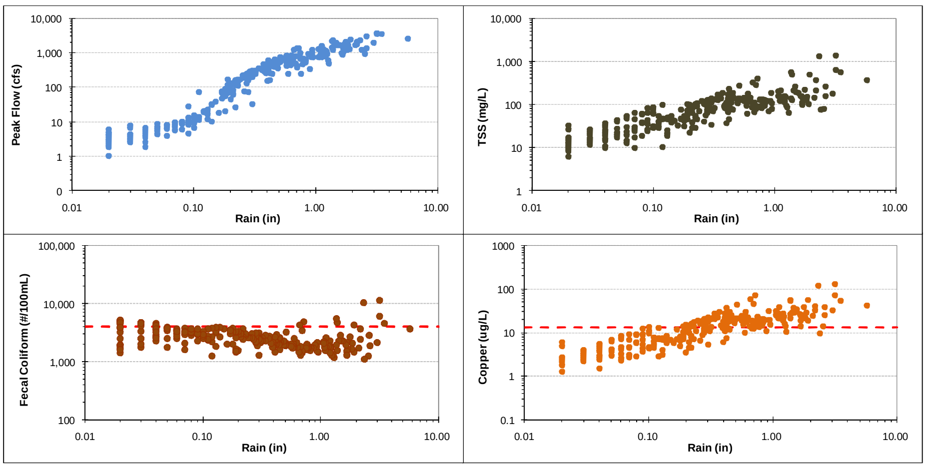
Combination Simulations –Loads by Storm Size



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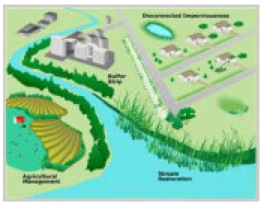
BMP Scale Considerations



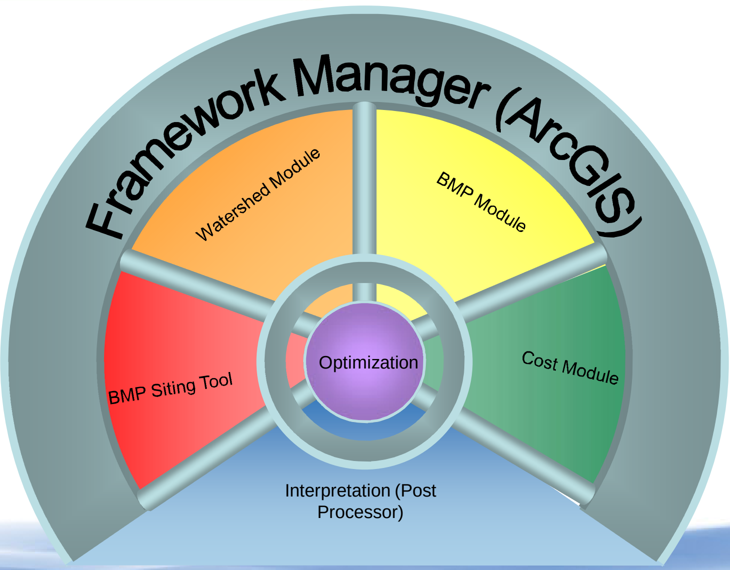
What is *SUSTAIN*?

- ***SUSTAIN*** – **S**ystem for **U**rban **S**tormwater **T**reatment, and **A**nalysis **IN**tegratration
- An ArcGIS-based framework designed to support evaluation and decision-making:
  - How effective are BMPs or green infrastructure (GI) in reducing runoff and pollutant loadings?
  - What are the most cost-effective BMP options meeting the water quantity and quality objectives?
    - Where, what type, and how large?

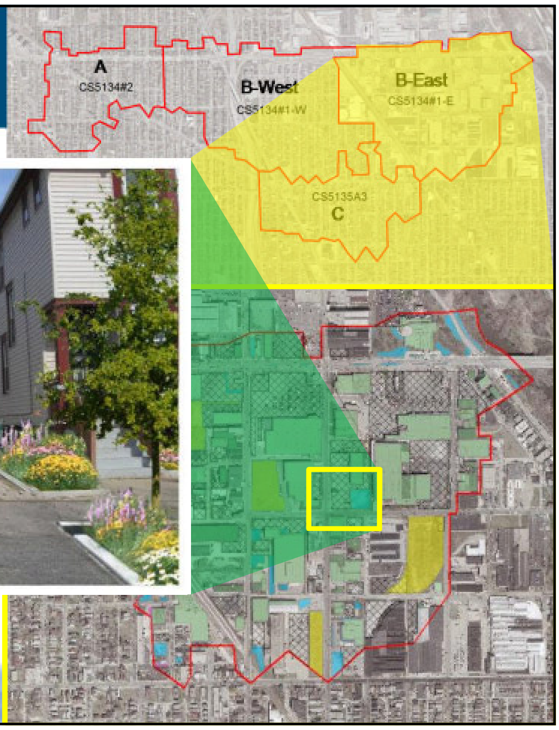
Where It Applies?

- Evaluate and select BMPs to achieve loading targets set by a **TMDL**
- Identify protective management practices and evaluate pollutant loadings for **Source Water Protection**
- Develop cost-effective management options for a municipal **MS4** program
- Determine a cost-effective mix of green infrastructure measures to help meet optimal flow reduction goals in a **CSO** control study

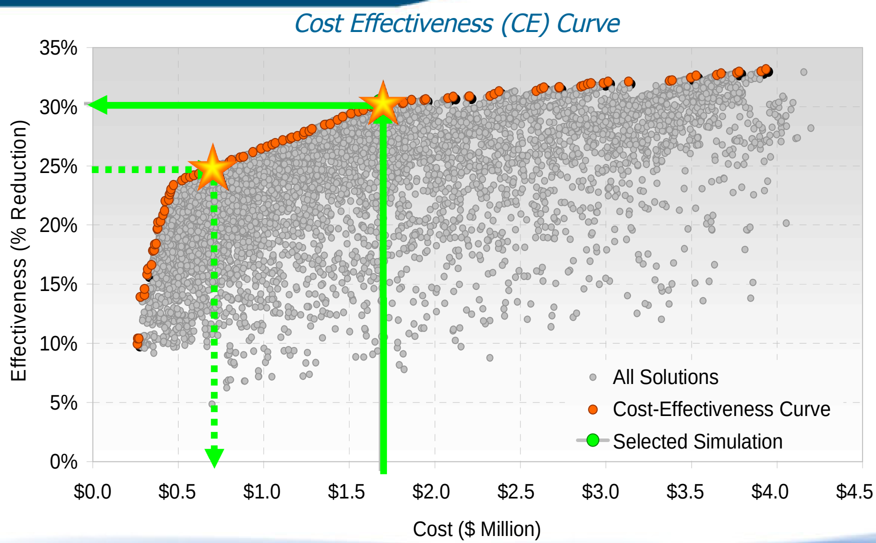
SUSTAIN Components



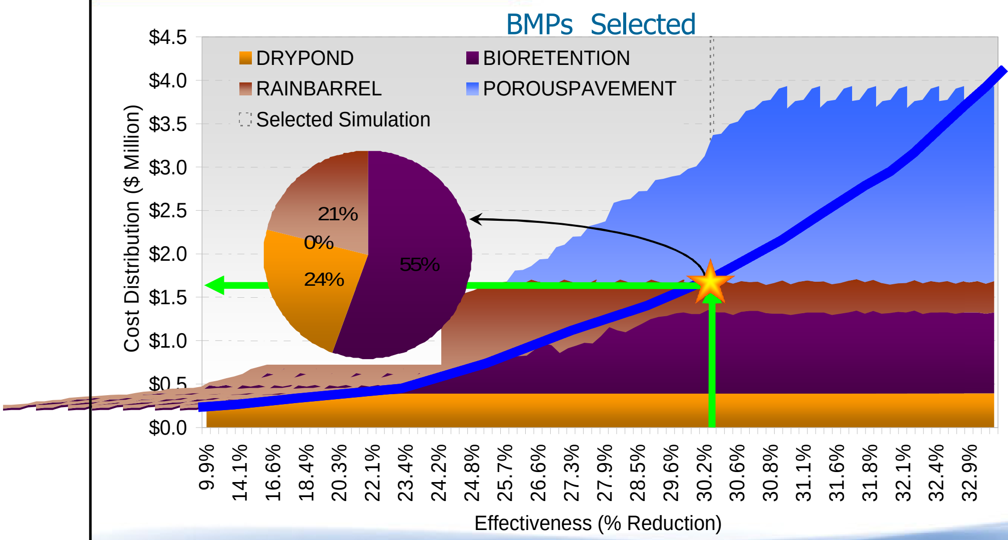
Implementation and Data Collection



BMP Optimization



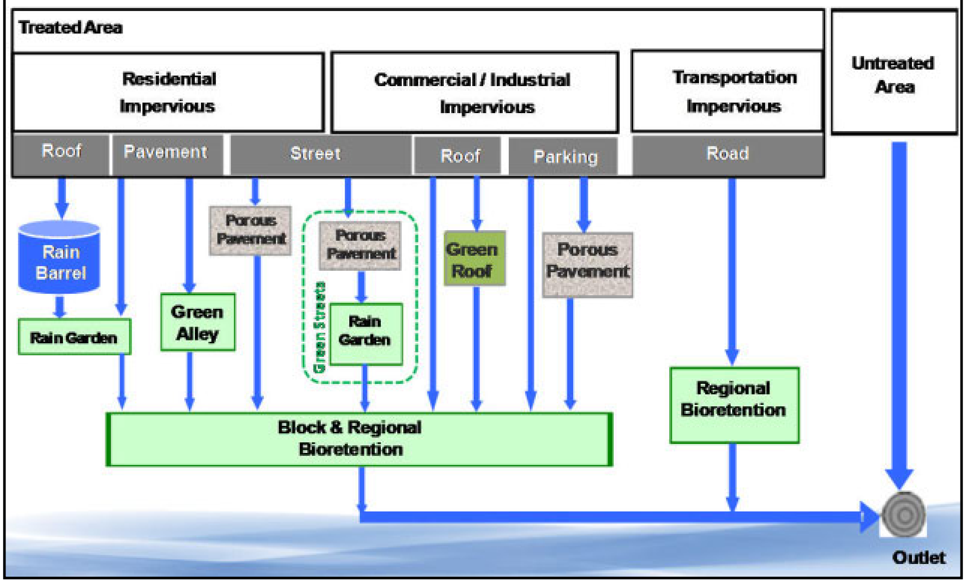
BMP Optimization



Milwaukee Municipal Sewerage District

- Proposed ultimate goal of eliminating all overflows by 2035
- Explore potential benefits of widespread adoption of green infrastructure (GI) to reduce overflows
- Potential benefits measured by:
  - Environmental outcomes (pollution reductions)
  - Economic and social outcomes (triple bottom line)

BMP Configuration:
Aggregate BMP Network



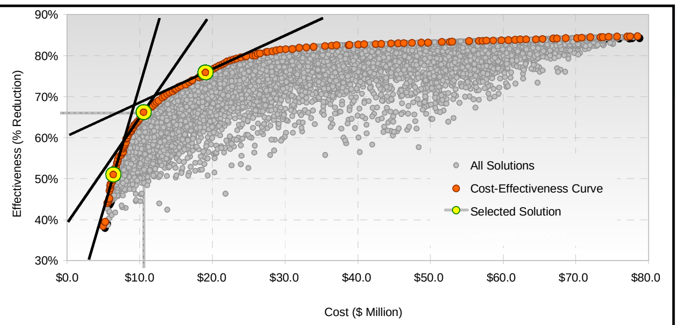
Cost-Effective Solutions

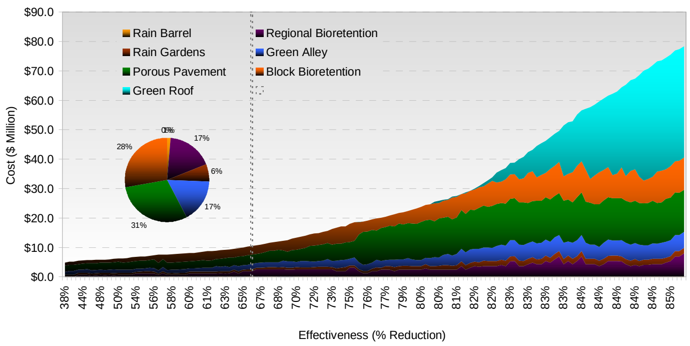
- Reduction:

  66.0%

- Cost:

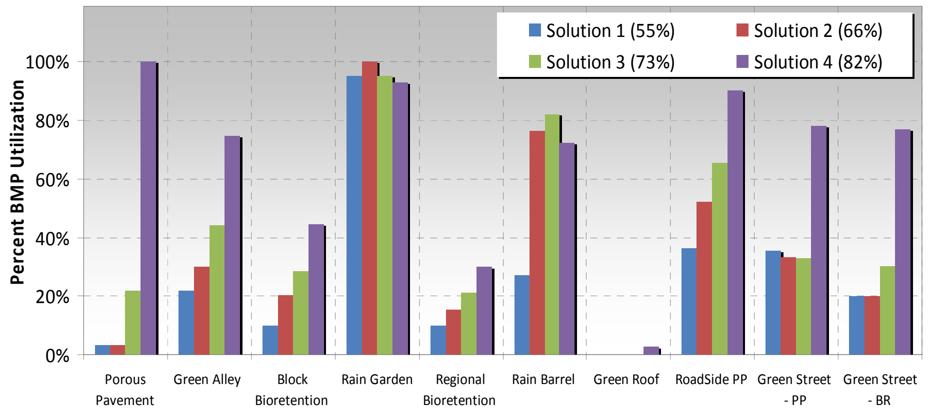
  $10.6 Mil





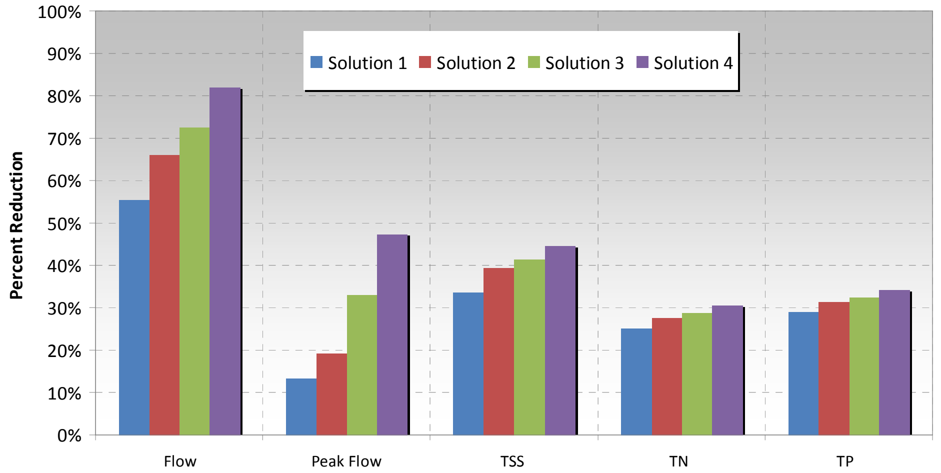
Results: BMP Utilization

Solution	Cost ($ million)	Annual Volume Reduction (%)
1	$7.2	55.4%
2	$10.6	66.0%
3	$15.7	72.6%
4	$32.0	81.9%



Results: Water Quality Benefit

Solution	Cost ($ million)	Annual Volume Reduction (%)
1	$7.2	55.4%
2	$10.6	66.0%
3	$15.7	72.6%
4	$32.0	81.9%



Triple Bottom Line Analysis

- Social, economic, and environmental benefits of green infrastructure
- Need to illustrate benefits to motivate change
  - More beautiful neighborhoods, higher property values, improved safety and increased jobs
  - Environmental stewardship benefits

ENVIRONMENT

- Reduced Stormwater/Sediment
- Increased Groundwater Recharge
- Carbon Sequestration
- Reduced Energy Use and Heat Island Effect

SOCIAL

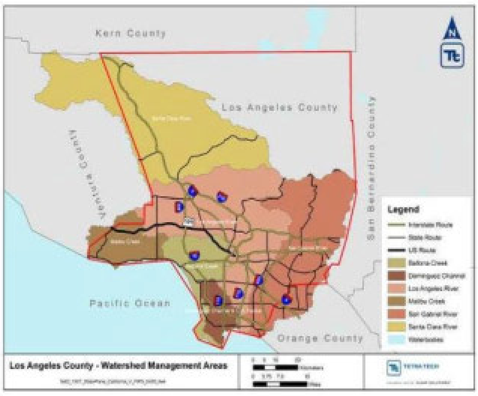
- Improved Quality of Life and Aesthetics
- Increased Recreational Opportunities

ECONOMIC

- Job Creation
- Reduced Infrastructure Cost
- Reduced Pumping Costs
- Increased Property Values

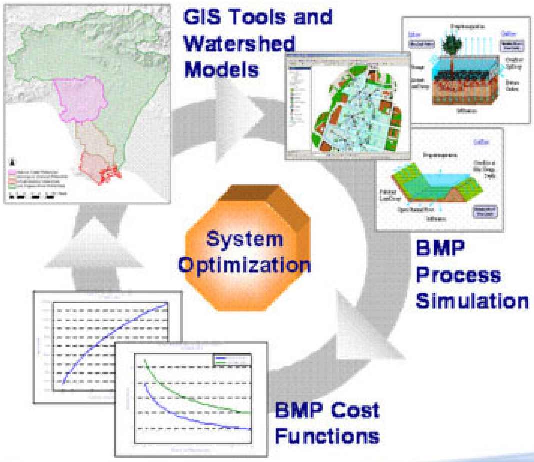
LA County Department of Public Works

- Develop a technical framework for a Water Quality Funding Initiative
- Provide a tool for urban runoff and stormwater quality management that allows for:
  - BMP implementation at local scale
  - Watershed management at regional scale



Watershed Management Modeling System (WMMS)

- Linked models
  - Loading Simulation Program C++ (LSPC)
  - EPA's SUSTAIN
- Methods for optimization of BMP placement and design
- Locally derived cost functions
- Partnership with EPA

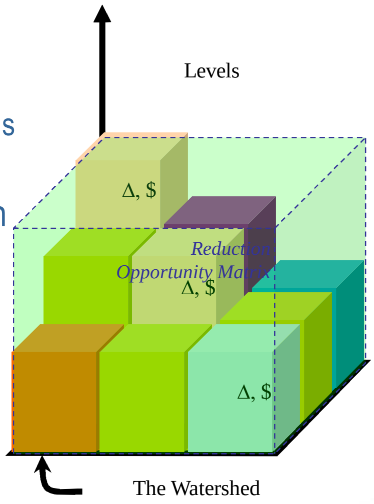


Overview of WMMS

- Total area > 8,000 square kilometers
- Land characteristics
- 148 precipitation gages
- Modeled pollutants and TMDL targets include: TN, TP, TCu, TPb, TZn, and Fecal Coliform
- Compliance required at approximately 300 locations

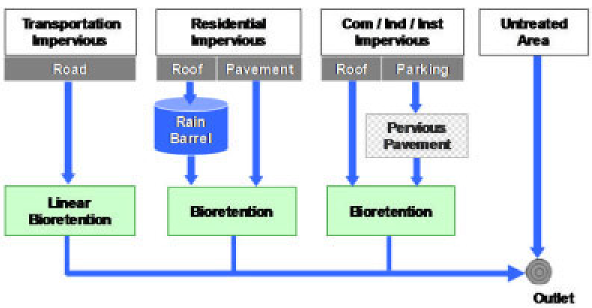
Management Categories and Levels

- Management Categories
  - Based on physiography:
    - slope, impervious area, impervious configuration, roads density
  - Factors that drive BMP selection
- Management Levels
  - Combinations of BMPs
  - Increasing degree of controls represented
  - Includes associated costs



Small-Scale Model Configuration

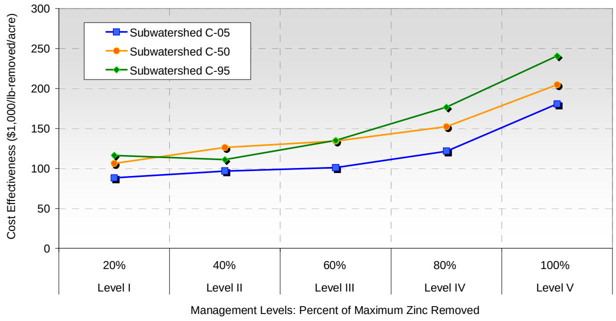
- Treatment pathways from four generalized drainage areas
- Distributed Structural BMPs
  - Permeable Pavement
  - Bioretention
  - Rain Barrels



Cost versus Load Reduction

Management Levels

- Discrete intervals along the maximum feasible treatment curve
- Levels 20%,40%, 60%, 80%, &100%



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Degrees of Practice

- Risk-based approach for compliance optimization:
  - Instream Targets →← Subwatershed Management Levels
- Degree of Practice = Allowable exceedences under extreme conditions

Degree of Practice	Wet-Weather Allowable Exceedence (Percent of Time)	Wet-Weather TMDL Compliance (Percent of Time)
I	25%	75%
II	15%	85%
III	10%	90%
IV	5%	95%
V	0%	100%

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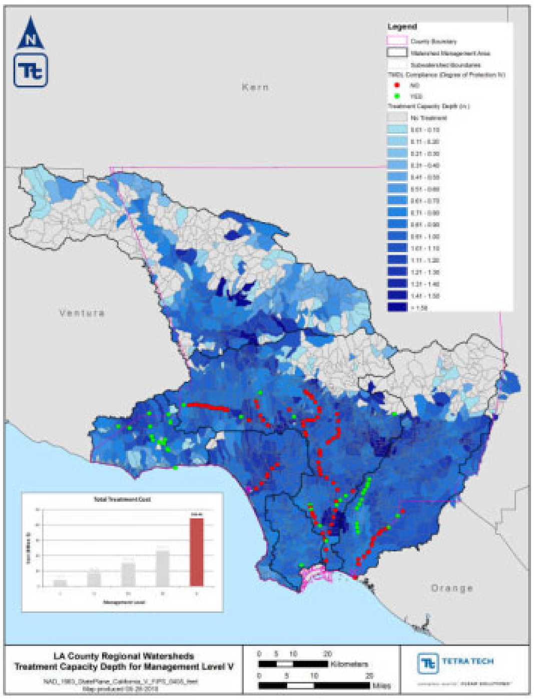
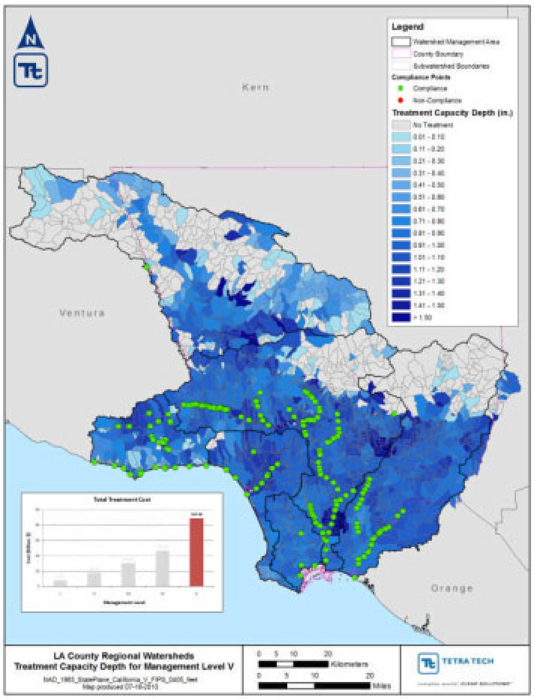
Management Level (V)
100% Degree of Protection

- 100% wet-weather compliance
- Even with uniform application of Management Level V, *most* points *do not* comply at the 100% Degree of Protection



Management Level (V)
85% Degree of Protection

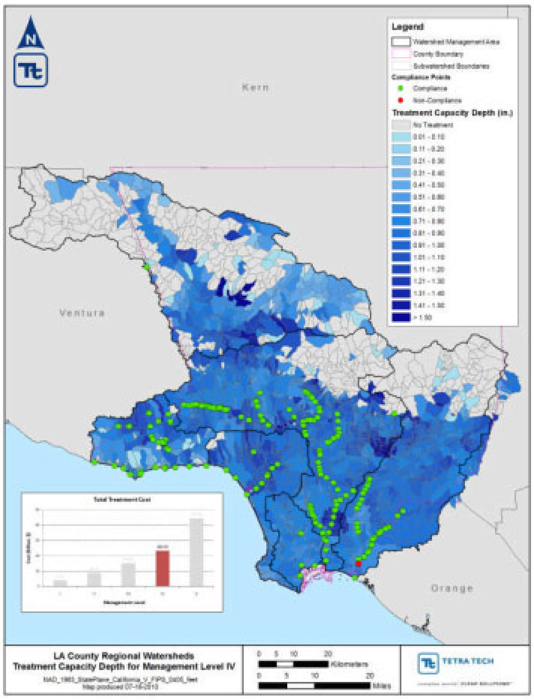
- Total Treatment Cost: $44.48 billion
- No Centralized BMPs Required
- For uniform application of Management Level V, all points comply at the 85% Degree of Protection



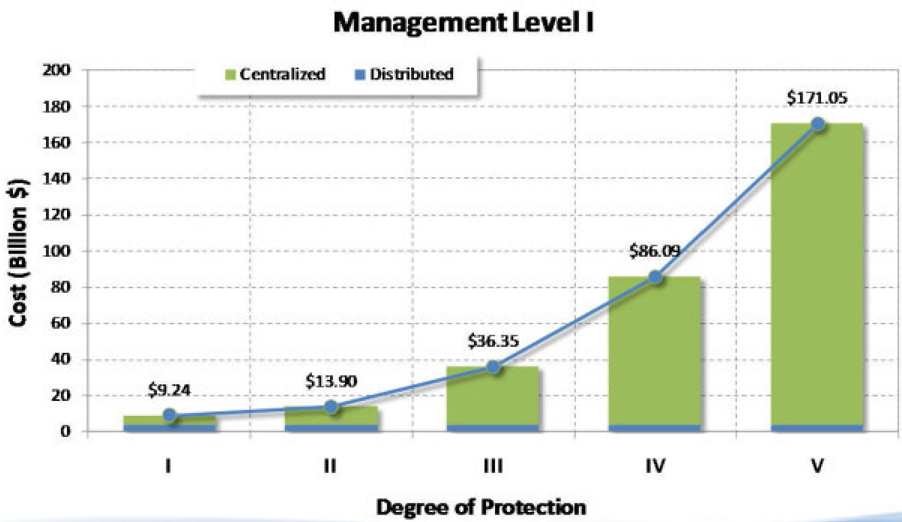
Management Level (IV)

85% Degree of Protection

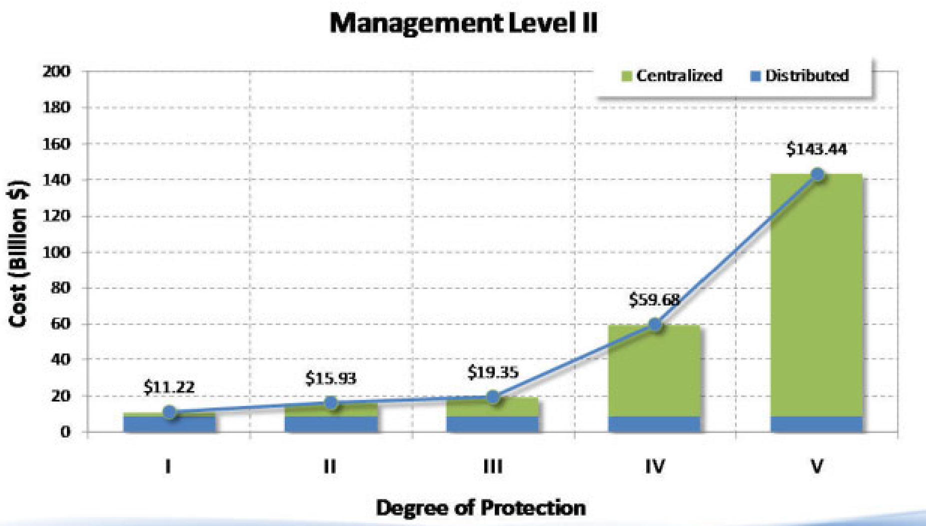
- Total Treatment Cost: $23.33 billion
- Additional Centralized BMPs for compliance: $1.09 billion
- Total: $24.42 Billion



Cost Distribution vs. DoP for Proportional Scenario



Cost Distribution vs. DoP for Proportional Scenario



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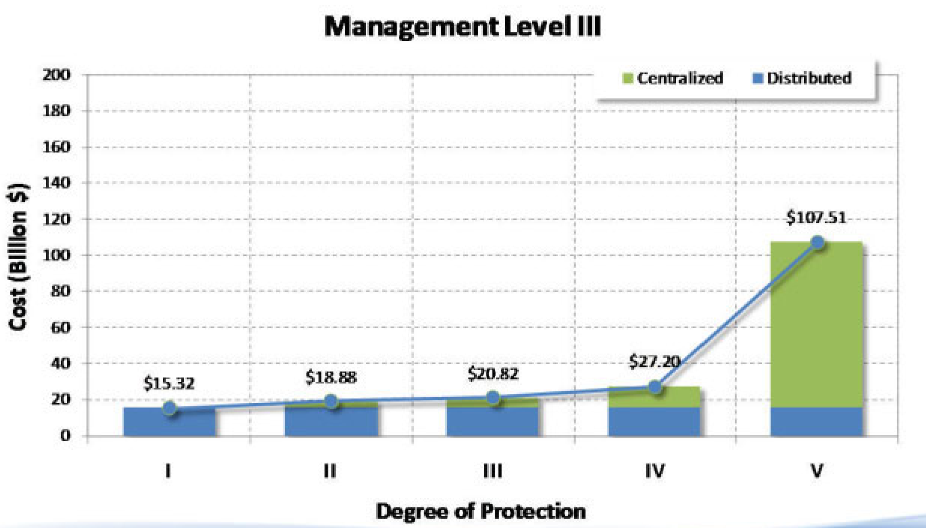
Cost Distribution vs. DoP for Proportional Scenario



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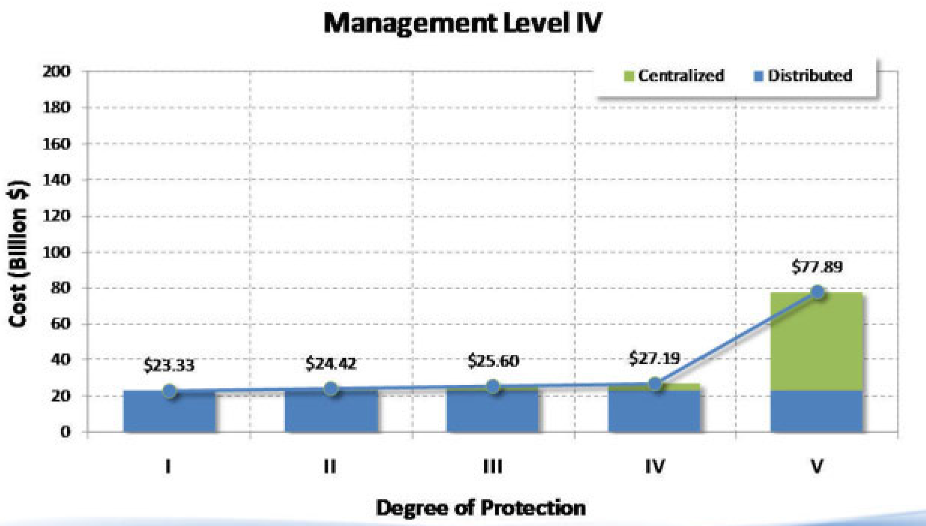
Cost Distribution vs. DoP for Proportional Scenario



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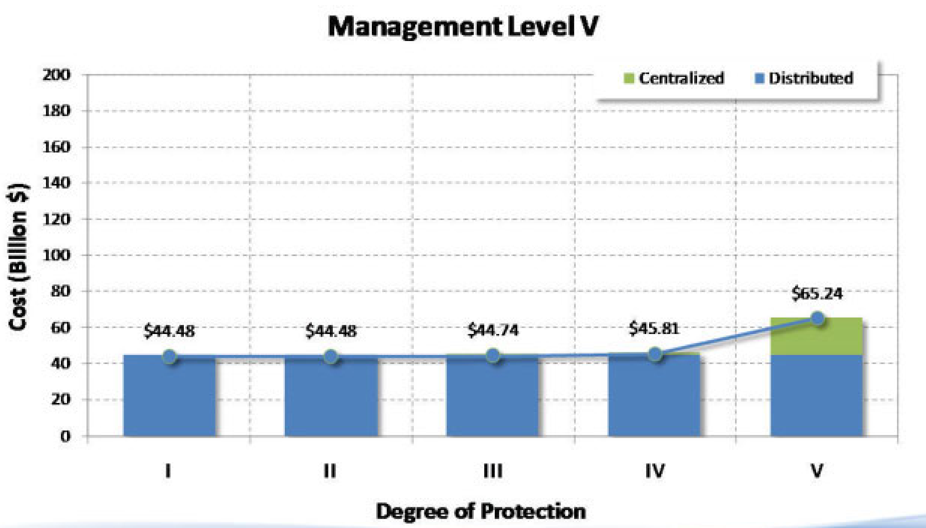
Cost Distribution vs. DoP for Proportional Scenario



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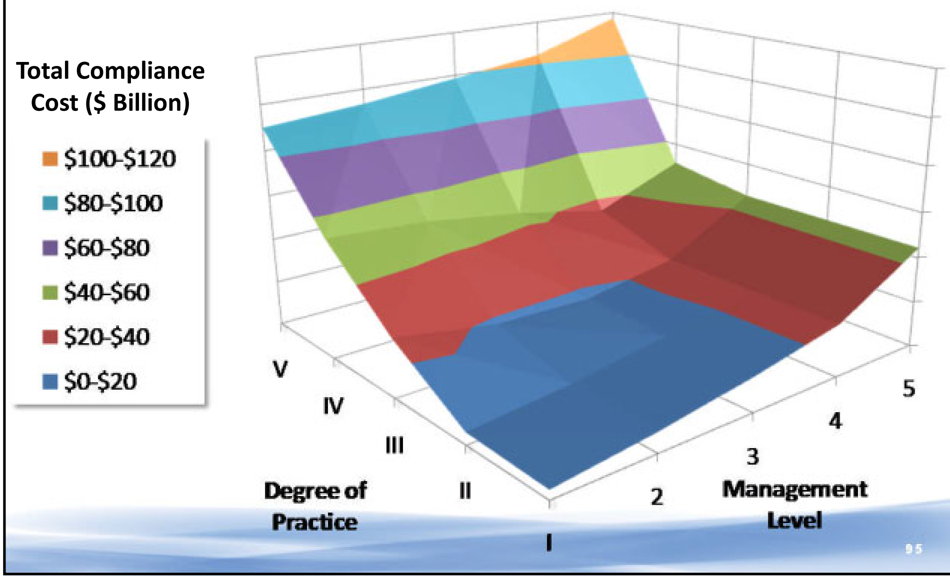
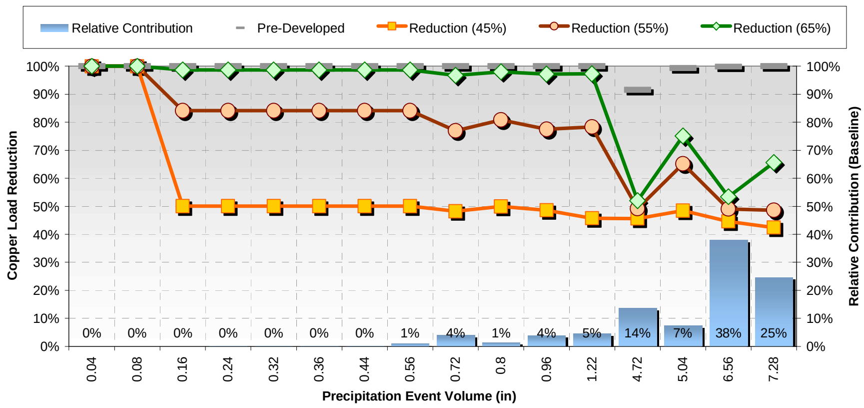
Total “Compliance” Cost by Management Level and Degree of Practice ($ Billion)



Storm Size Analyses

- Load reduction by rainfall event



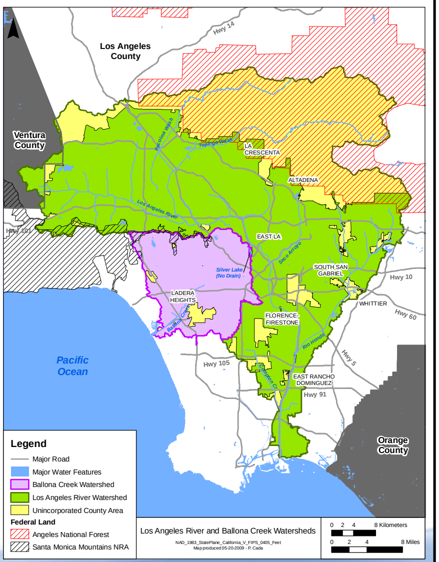
TMDL Implementation/Water Quality Improvement Planning

Multi-Pollutant TMDL Implementation Plans for Los Angeles County

Address multiple TMDLs for Ballona Creek and Los Angeles River

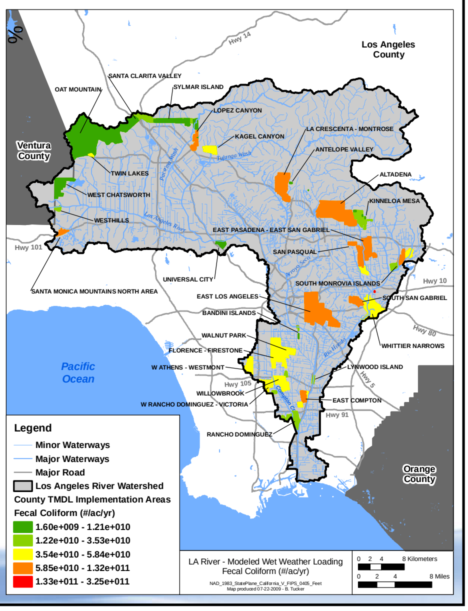
Highlights:

- Integrated water resources approach
- Field investigations of potential BMP sites
- Application of WMMS
- Negotiations with regulators on interpretation of TMDLs, water quality standards, and MEP



TMDL Implementation/Water Quality Improvement Planning

Pollutant source characterization and prioritization



BMP Development and Engineering Services

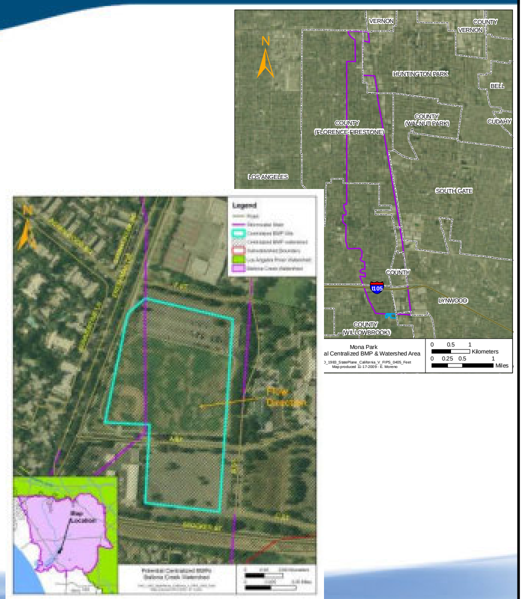
Evaluating feasibility of sites for BMPs

- GIS screening
- Comparison to priority pollutant source areas
- Field investigations

BMP Development and Engineering Services

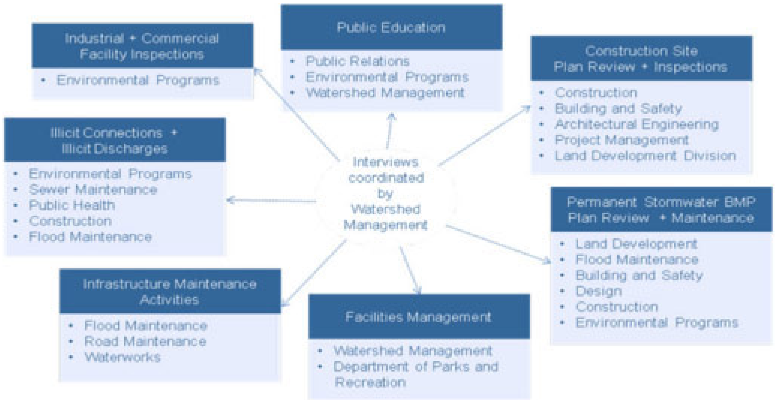
Conceptual design

- Understanding of the drainage area
  - Flow
  - Pollutant loading
- Opportunity for integration of multiple benefits
- Linkage to existing storm drain system

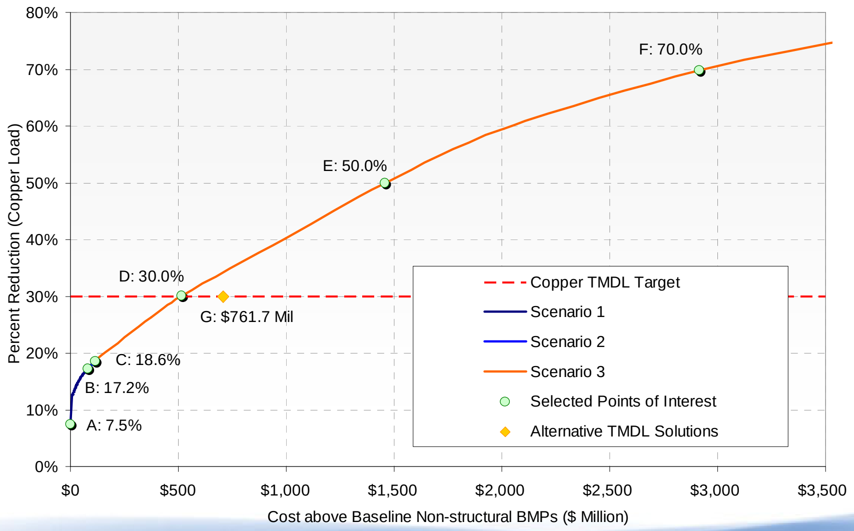


Los Angeles County TMDL Implementation Plans

Assessment of existing stormwater program elements and procedures

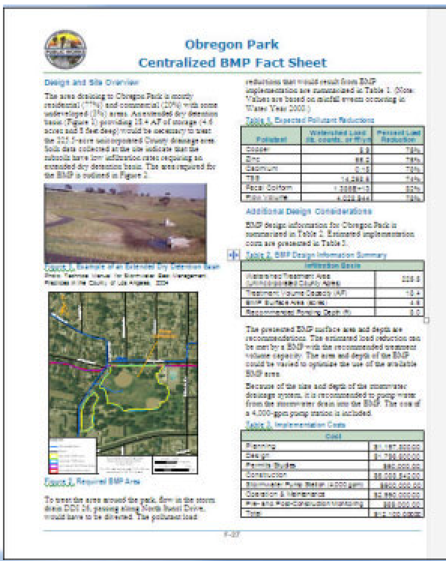


TMDL Implementation/Water Quality Improvement Planning



TMDL Implementation/Water Quality Improvement Planning

- Conceptual designs
- Quantified benefits
- Considerations for implementation
  - Infiltration
  - O&M
- Costs



Questions