Urban Stormwater Runoff Phosphorus Loading & BMP Treatment Capability

Scott Perry, CPSWQ

Imbrium Systems

Co-authors:

Brian Lee & Joel Garbon

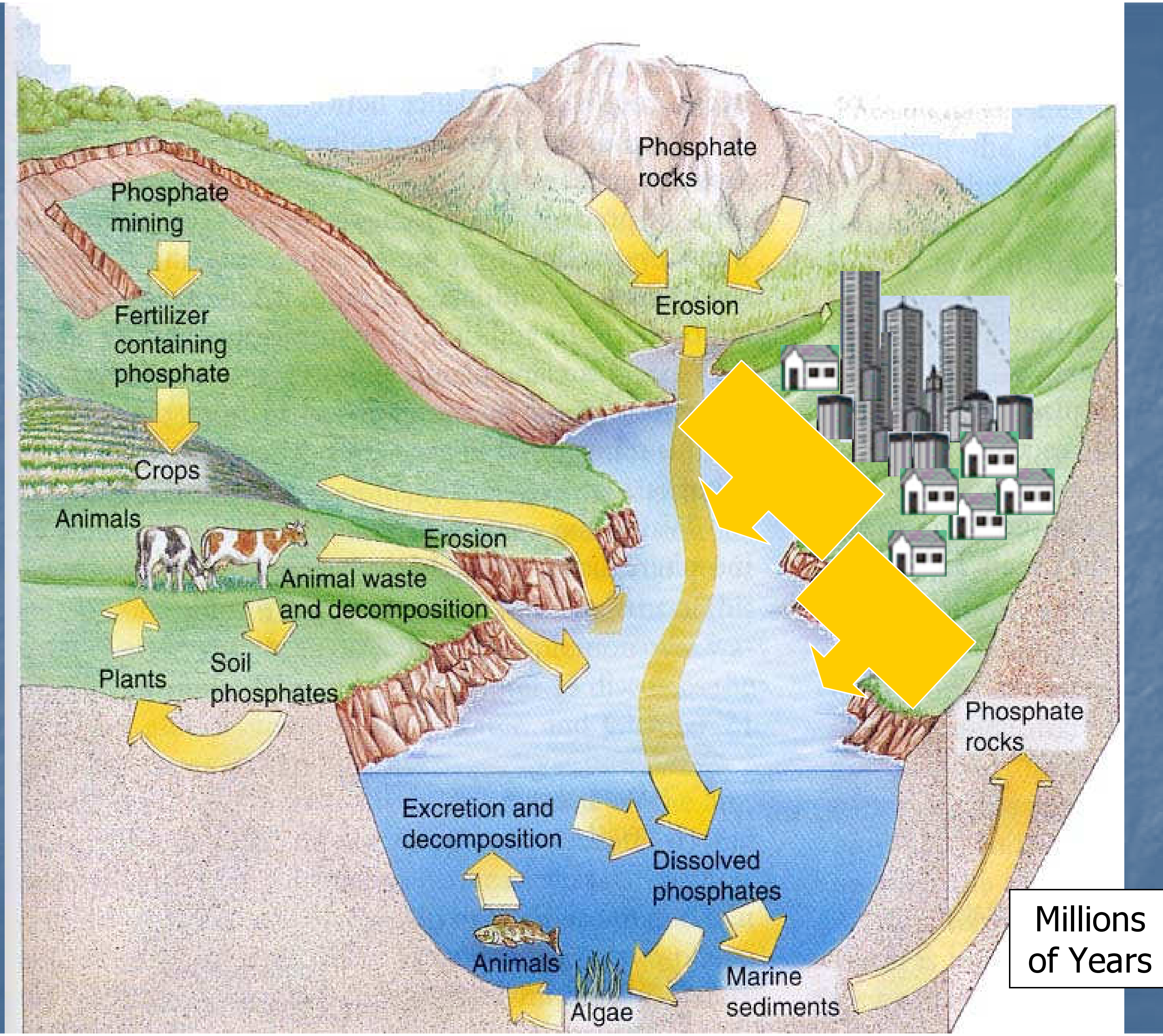
October 22, 2009

Overview

- Phosphorus Basics
- Urban Sources & Loads
- BMP performance
- Advanced Removal Mechanism
- Applications
- Things to Avoid

Phosphorus

- Essential nutrient for life
- Cyclic between Land & Water
- Limiting nutrient in fresh water
- Identified in Stormwater as:
  - **Particulate-bound phosphorus**
  - **Dissolved phosphorus (DP)**



Phosphate rocks
Phosphate mining
Fertilizer containing phosphate
Erosion
Crops
Animals
Erosion
Animal waste and decomposition
Plants
Soil phosphates
Phosphate rocks
Excretion and decomposition
Dissolved phosphates
Animals
Algae
Marine sediments
Millions of Years

Problem:

- Excess Phosphorus in fresh water causes ***Eutrophication*** (over enrichment):
  - Algal blooms
    - Micro-toxins …**Toxic Cyanobacteria**
  - Hypoxia --- depletion of Dissolved Oxygen
    - Fish kills
    - Invasive species

Hampton Roads Bridge Tunnel - AUG. 18, 200
Photo – The Virginia-Pilot / Ryan Henriksen

Aberdeen Creek on the South River – Sept. 2008

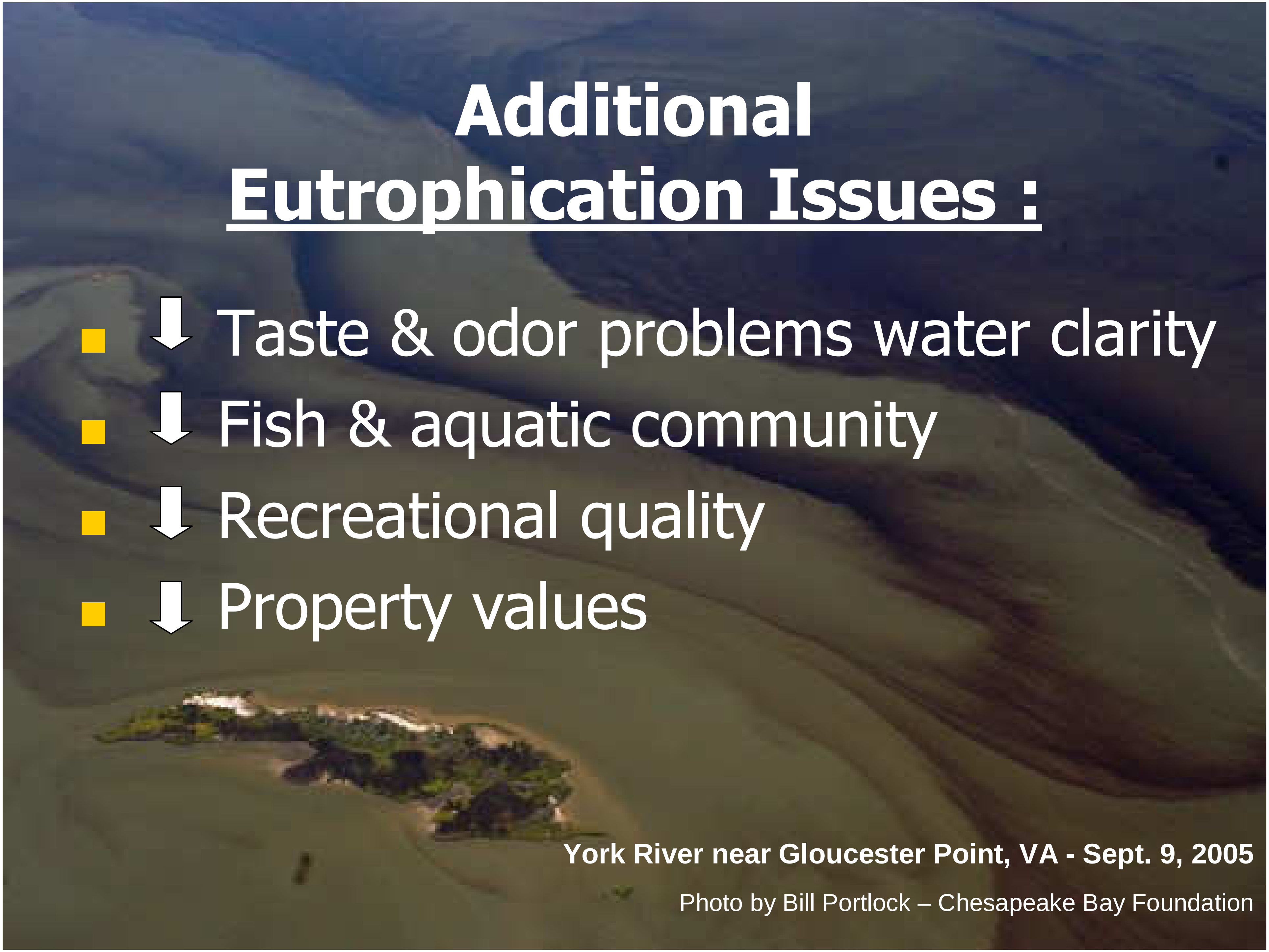
Photo – Chesapeake Bay Foundation

Dobe Point, Potomac Creek – July 2008

Photo - Friends of Stafford Creeks

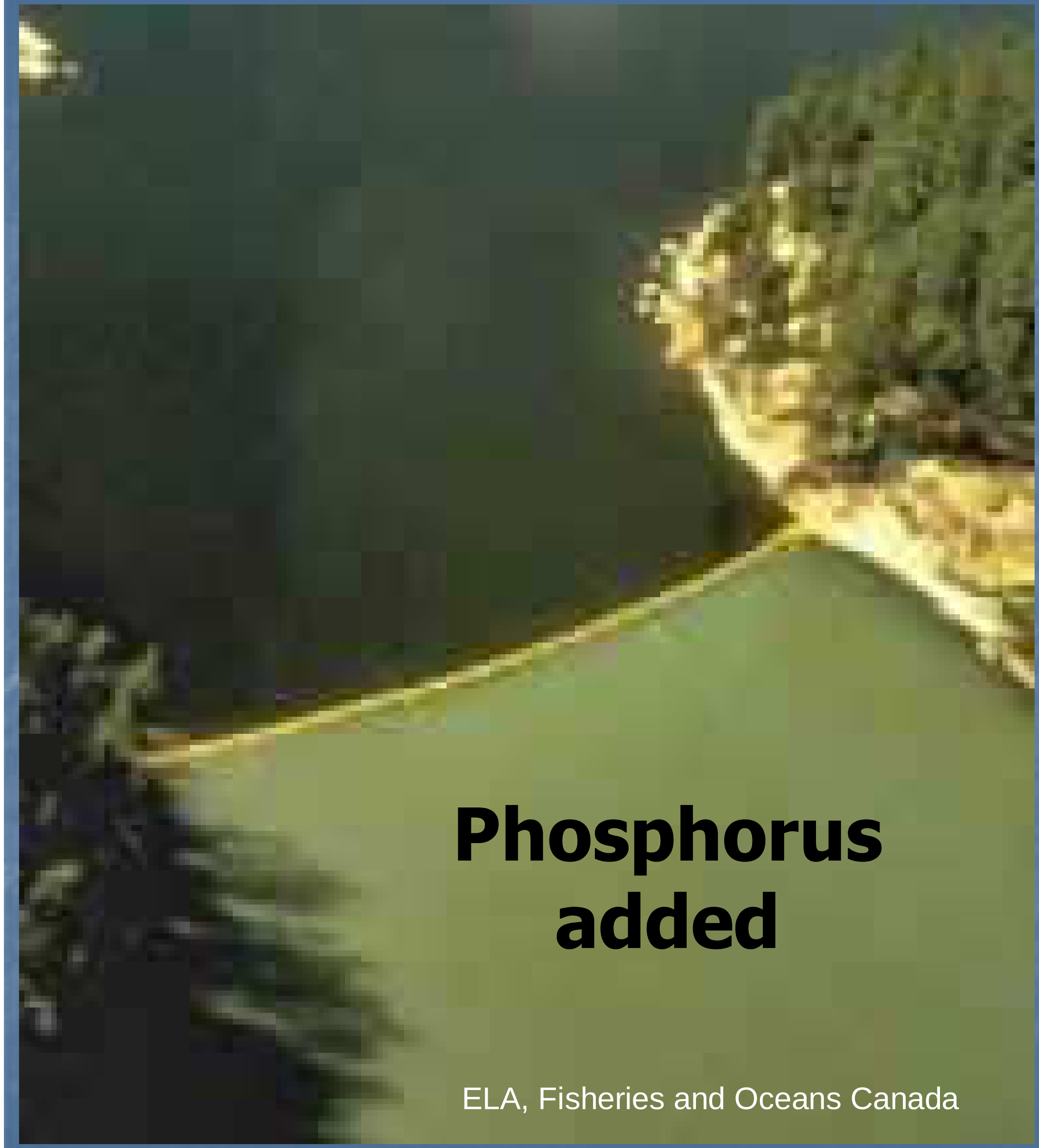
Additional Eutrophication Issues :

- ⇓ Taste & odor problems water clarity
- ⇓ Fish & aquatic community
- ⇓ Recreational quality
- ⇓ Property values



York River near Gloucester Point, VA - Sept. 9, 2005

Photo by Bill Portlock – Chesapeake Bay Foundation



Canadian Experimental Lakes Area # 226:

- Curtain divided lake
- Carbon & Nitrogen added to both sides
- Phosphorus added to lower half

Qingdao, Eastern China`s Shandong province

July, 2008


IT'LL BE CLEAN
FERTILIZER
CHESAPEAKE
TOLES
PA.
VA.
CHESAPEAKE BAY
EPA SYNC. SWIM. COACH
D.C.
MD.
SYNC TOGETHER OR SINK SEPARATELY. —
TOLES
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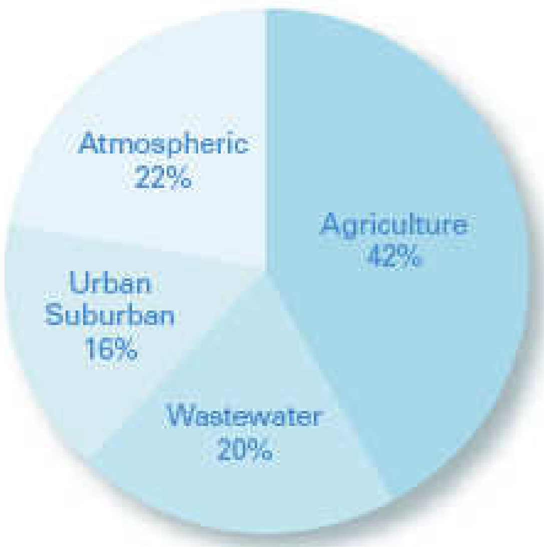
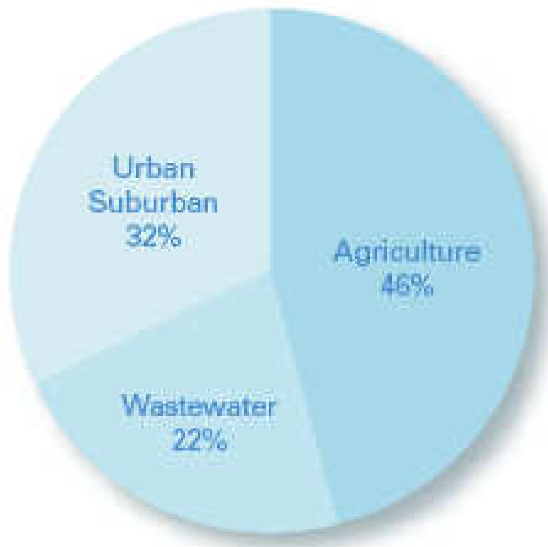
Chesapeake Bay Watershed

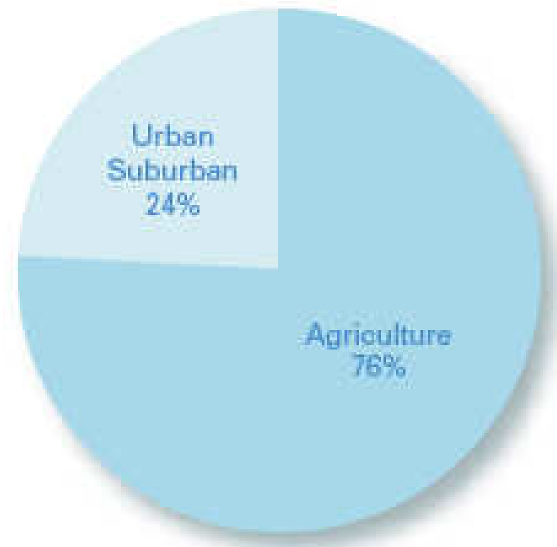
Relative Responsibility for Pollution Loads to the bay



Nitrogen



Phosphorus



Sediment

Bay Barometer
A Health and Restoration Assessment of the Chesapeake Bay and Watershed in 2008
CBP/TRS 293-09 EPA-903-R-09-001 March 2009

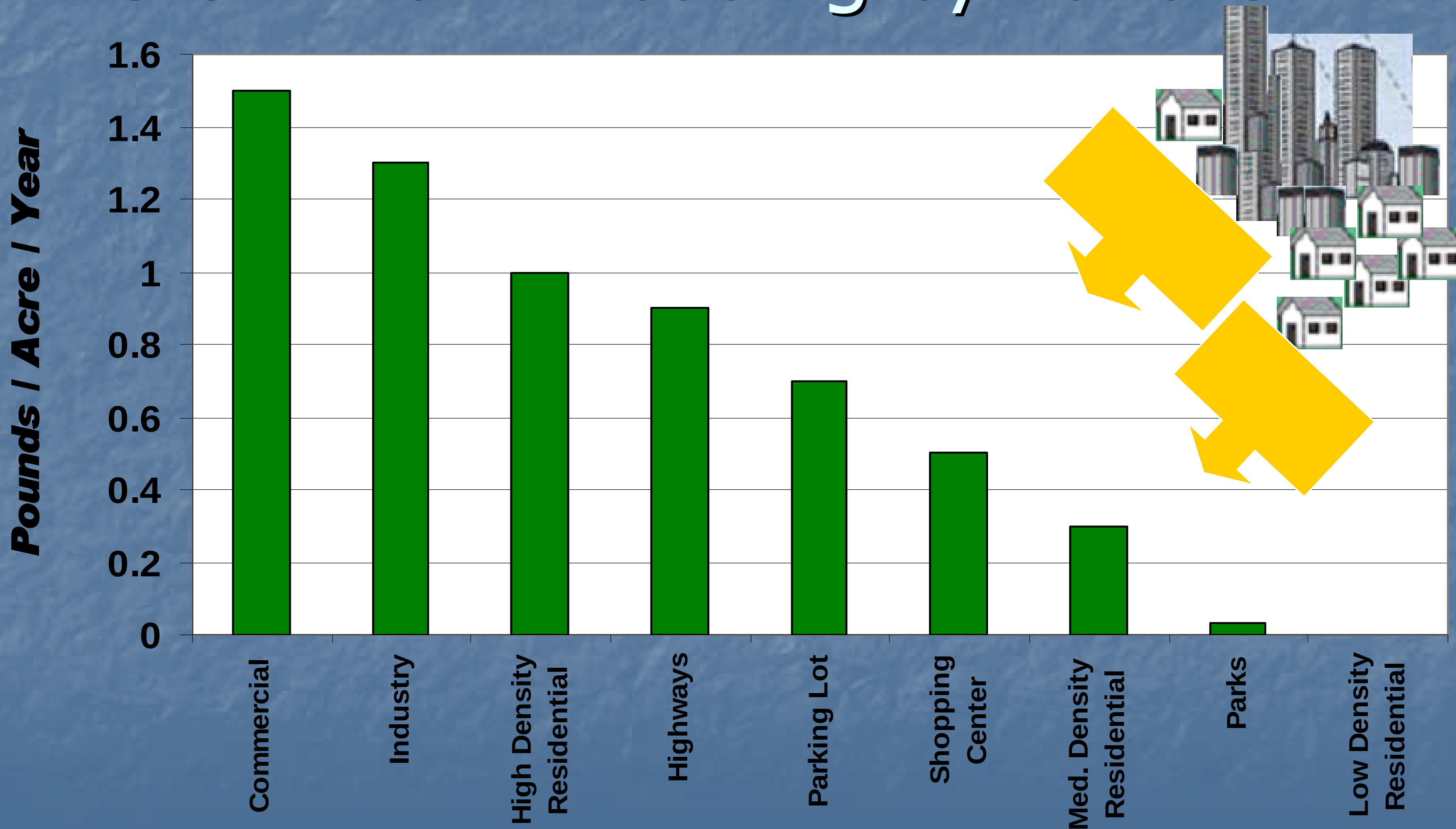
Chesapeake Bay Program
A Watershed Partnership
www.chesapeakebay.net

Typical Urban Stormwater Phosphorus Sources

- Fertilizers
- Waste Water (CSO / Septic)
- Animal Waste
- Development … Sediment Loss & exposure
- Airborne Fallout: Dust, Pollen, Fossil Fuels
- Vegetation / Leaves
- Detergents
- Hydrocarbons & Lubricants

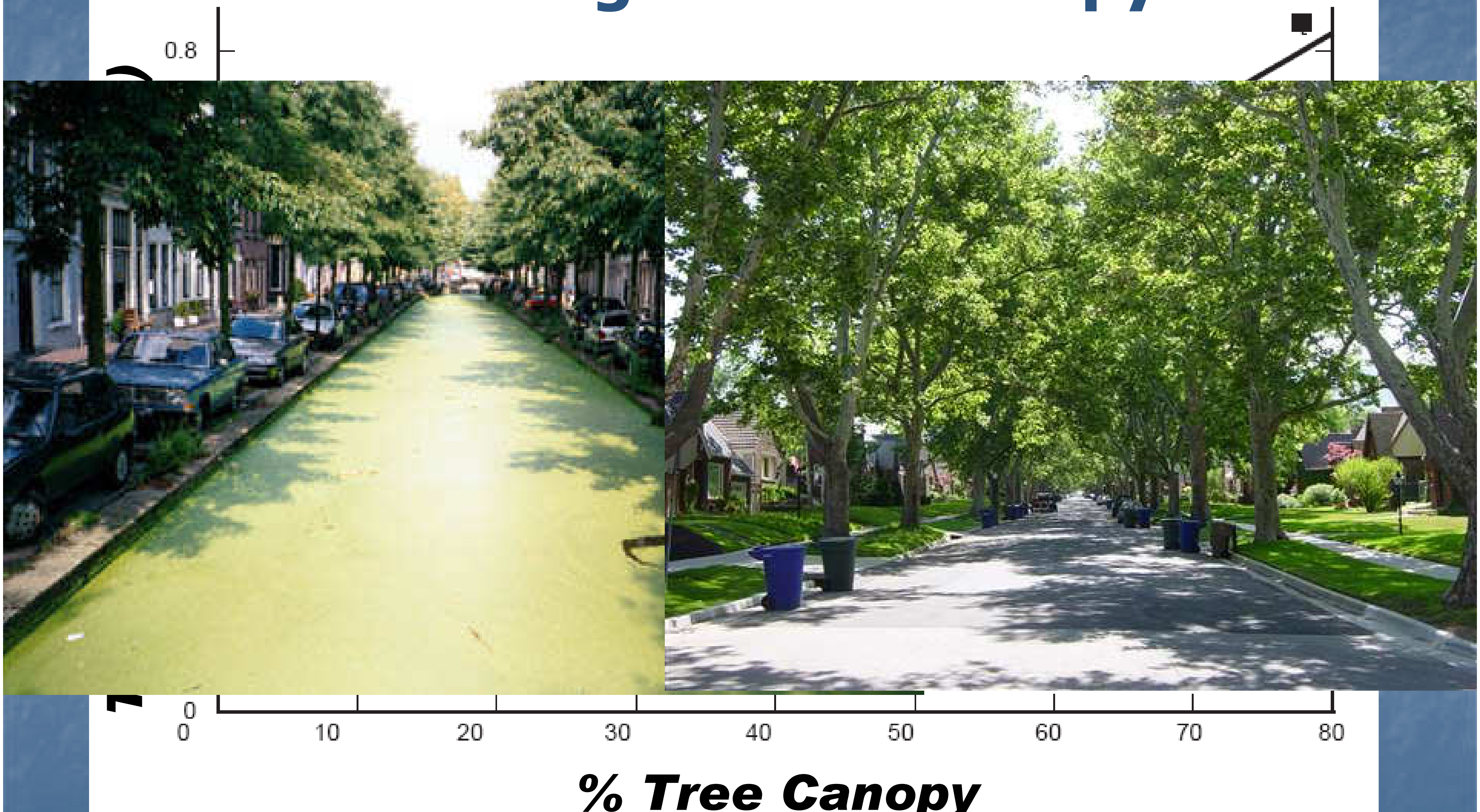
Chesapeake Bay Pollen Load from

Total Phosphorus Stormwater Loading by Land Use



EPA Stormwater BMP Design Guide, 2004

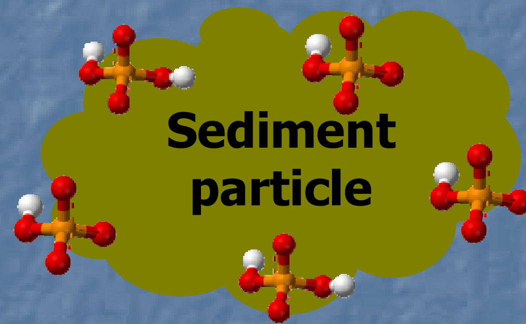
Total Phosphorus Load with Increasing % Tree Canopy



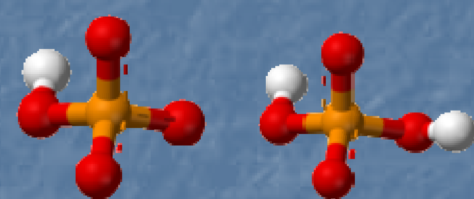
USGS Water-Resources Investigations Report 99–4021

Stormwater
Total Phosphorus (TP) Partitioning

1. **Particulate-Bound (PB) Phosphorus**



2. **Dissolved Phosphorus (DP)**
   - less than 0.45-micron



   - Soluble Reactive Phosphorus (SRP) / Bio-available
   - **"QUICK SUGAR"** for Algal Blooms

Stormwater Runoff
Phosphorus Partitioning by Land Use

	Residential	Commercial	Industrial	Open Space
Ave. TP EMC (mg/L)	0.41	0.34	0.45	0.59
Ave. DP EMC (mg/L)	0.20	0.18	0.16	0.16
% PB	51 %	47 %	64 %	73 %
% DP	49 %	53 %	36 %	27 %

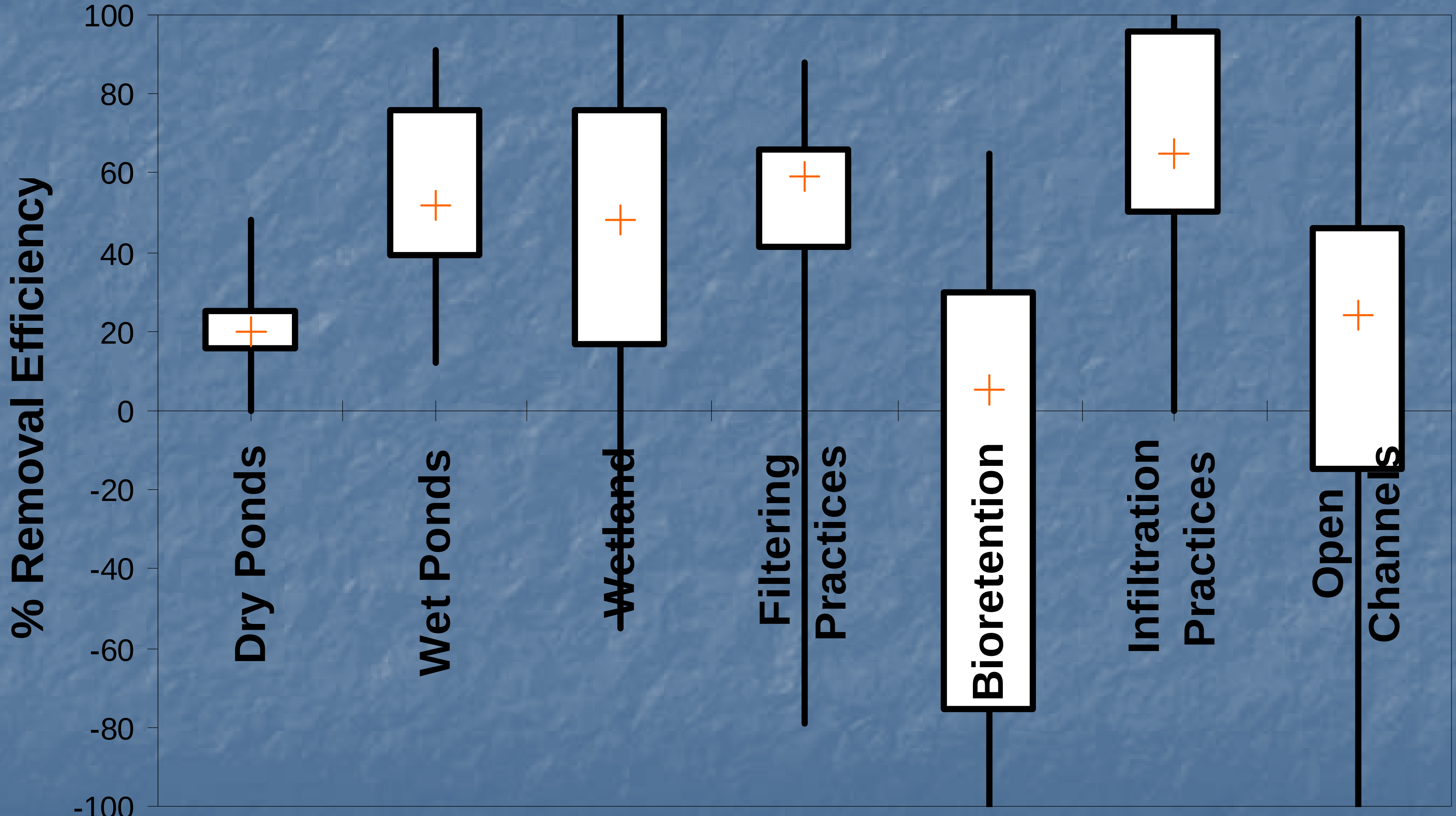
TP = Particulate-bound phosphorus & Dissolved Phosphorus

DP = Dissolved Phosphorus

PB = Particulate-bound Phosphorus

New York State DEC, 2008

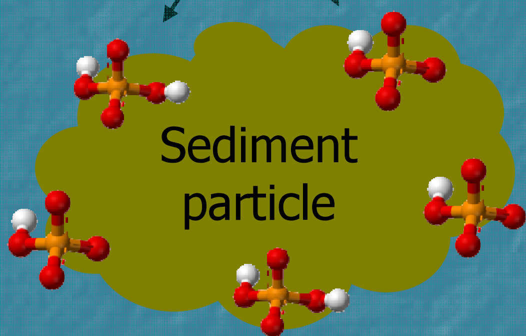
Total Phosphorus (TP) Removal BMP Efficiencies



Center for Watershed Protection, National Pollutant Performance Removal Database version3, Sept. 2007

Typical Urban Stormwater BMPs designed to captures 80% TSS:

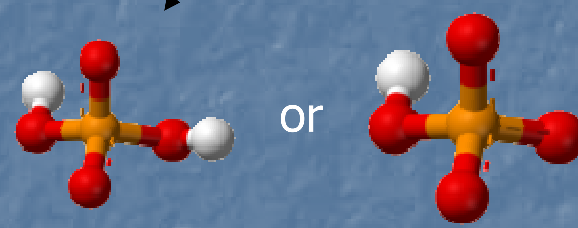
Particulate-bound Phosphorus (PB)



50% TP --- Associated with TSS (sediment)

+

Dissolved Phosphorus (DP)



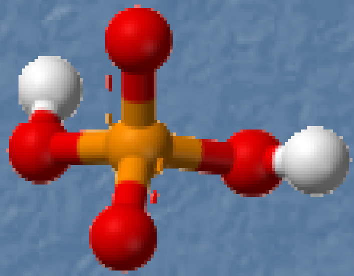
50% TP --- Dissolved (< 0.45-mircons)

80% TSS capture X 50% (particulate-bound phosphorus) =

40% (TP) Removal

Natural factors impacting Phosphorus Fate in Stormwater Runoff & BMPs

- Water chemistry conditions
  - pH
  - Alkalinity
  - Temperature
  - Redox potential
  - Particle charge
  - Concentration
- Time / maintenance frequency



Phosphorus Fate

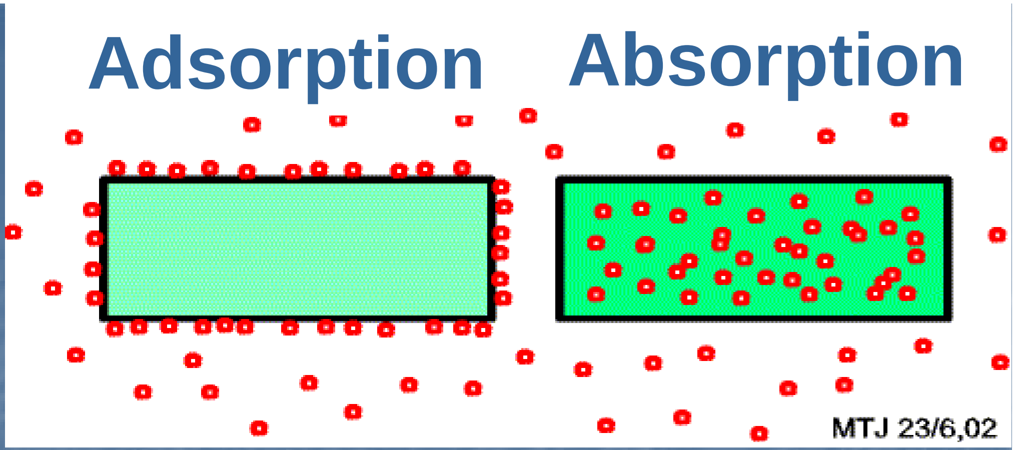
- Phosphorus speciation will shift
  - Sediments release Phosphorus
    - Particulate-bound (PB) shifts into Dissolved Phosphorus (DP)

- Examples
    - Impact of acid rain (pH of 7.0 versus 4.5)
    - Runoff detained versus diluted (pH & time)
      - Denitrificaiton - Anaerobic activity / decaying organics

Stormwater TP Removal Mechanisms & Generalized Capability

Primary Unit Process / Removal Mechanism	Total Phosphorus (TP)	
	Particulate-bound Phosphorus (PB)	Dissolved Phosphorus (DP)
Sedimentation	Yes	No
Filtration	Yes	Limited
Biological Uptake	Limited *assuming vegetative harvesting	Limited *assuming vegetative harvesting
Sorption	No	Yes

Sorption



- Combination of complex physiochemical interactions;
  - Adsorption - surface attachment
  - Absorption - internal attachment (sponge)
  - Ion Exchange - displacement of ions (Ca, Mg, Na)
- **Sorption Capacity --- mg/g**

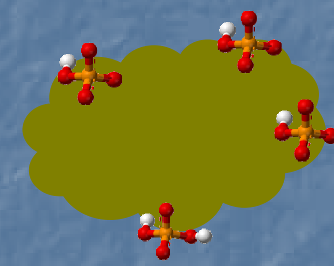
Compared to soils …

- **Ion Exchange Capacity --- meq/100g**

Ways to increase TP removal & reduce performance variance?

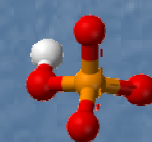
1. ↑ TSS Removal

(particulate-bound P Removal)



- Focus on Filtration & Infiltration
- ↑ Volume treated

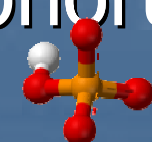
2. Prevent Phosphorus Speciation Shift



- Better BMP Design Consideration / Engineering
- ↑ Maintenance frequency

3. Amend BMPs to Capture Dissolved Phosphorus

- Sorption



Quantifying Sorption Capability for Dissolved Pollutant Removal

- Isotherm –
  - How much can it hold?
- Kinetics –
  - How fast can it go in?
- Breakthrough –
  - How much before it is full? (maintenance)
- Desorption –
  - Retaining DP … is the bond strong enough?

Dissolved Phosphorus (DP) Sorption Performance

(T. Wu et al, Stormwater Phosphorus Adsorption on Oxide Coated Media, WEFTEC,2008)

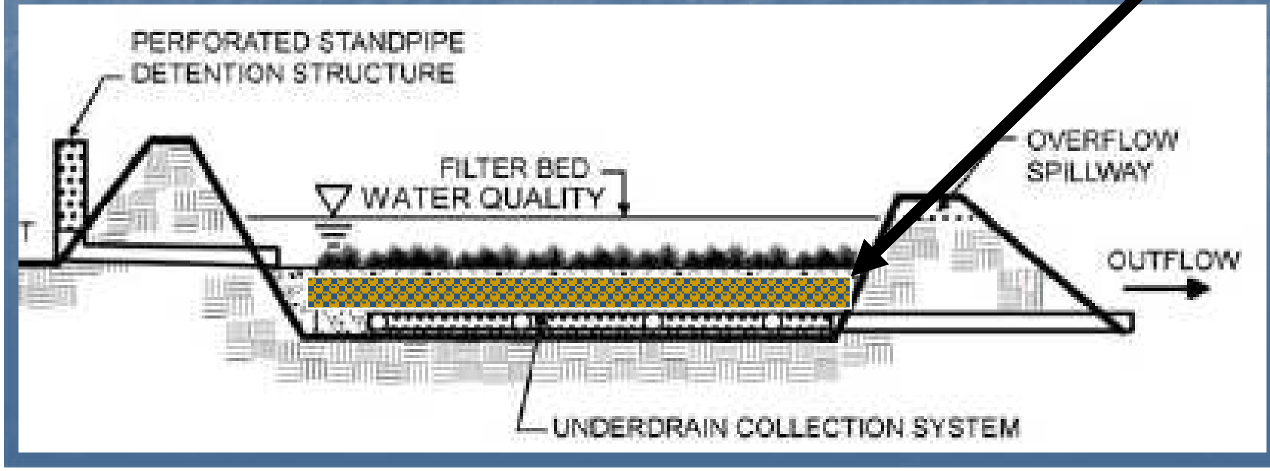
Media Type **(0.5 mm to 10 mm)**	Isotherm K_f (mg/g)	Kinetics q_e (mg/g)	Breakthrough Exhaustion (BVs)	Desorption
Al-oxide Pumice	**0.40**	**1.19**	**1,800 – 2,700**	**No**
Al-oxide Waste Aggregate	**1.3**	**0.51**	**1,450 – 3,600**	**No**
Mod. Activated Alumina	**5.7**	**0.40**	**< 1**	**No**
Zeolite / Perlite / Carbon (ZPG)	**0.05**	**None**	**5**	**Yes**
Perlite	**0.002**	**1.37**	**< 10**	**No**
Recycled Tire	**0.003**	**None**	**< 45**	**Yes**
Expanded Shale	**0.14**	**0.98**	**9 - 50**	**Yes**
Very Finely Graded Medias (< 0.5 mm) with low hydraulic conductivity				
Bioretention Soil	**0.18**	**4.67**	**50**	**No**
Concrete Sand	**< 0.01**	**< 0.001**	**< 5**	**No**

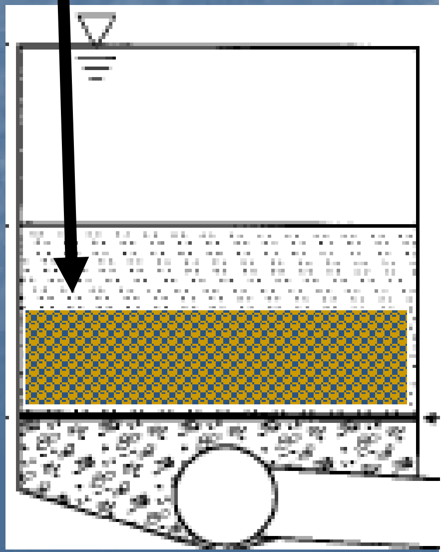
Applications

Amended Sand Filters & Filtration Trenches

Use Sorption based Media or Material

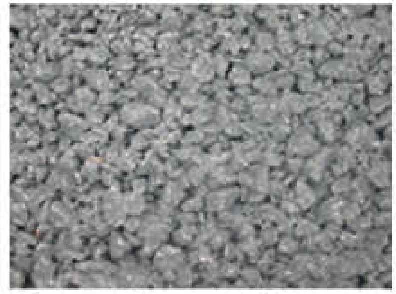
- displace part of Sand bed





Permeable Interlocking Concrete Pavers (PICP)

Concrete Grid Pavers (CGP) "Turfstone"



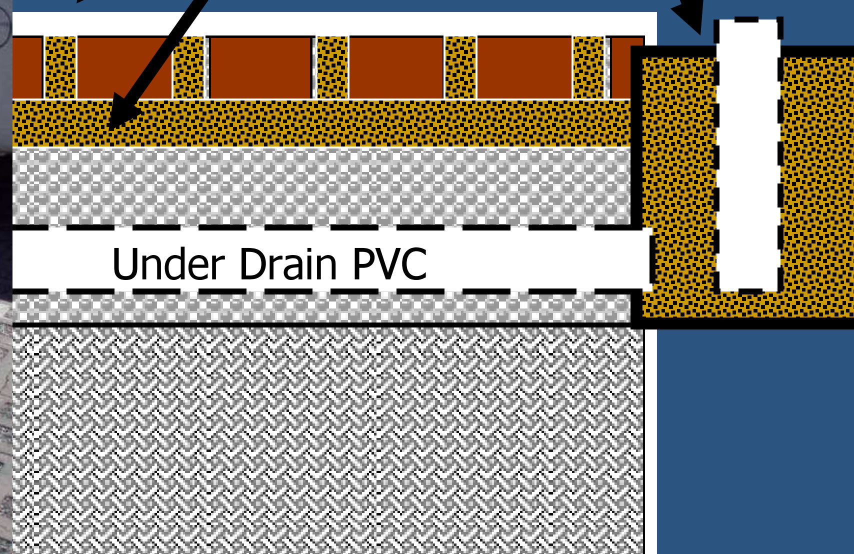
Porous Concrete (PC)

Amended Pervious Pavements

- Interlocking Pavers
- Pervious Pavements

Applications

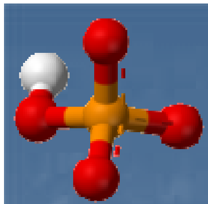
- In Joints
- Bedding Course
- Polishing System



Things to Avoid with “Sorption” Based Materials

- Limit use of materials prone to desorption
  - Organics / Compost / Soils
    - Test P-index & use as an indicator
  - Evaluate Materials upfront
    - Expanded Shale, Recycled Tires, ZPG

- Prevent leaching of other Toxics
  - i.e - Heavy Metals
    - Slag, Iron-based materials, other waste by-products



Summary

To address Algal Blooms & Eutrophication

- Look beyond Total Phosphorus (TP) & account for **Dissolved Phosphorus** (DP)
- **Amend** BMPs to be "Best Management Practices" and address DP removal

Questions?

Scott Perry

301-279-8827

sperry@imbriumsystems.com

The Road Ahead:

Implementing Environmental Site Design in Maryland

Tom Schueler

Chesapeake Stormwater Network

October 22, 2009

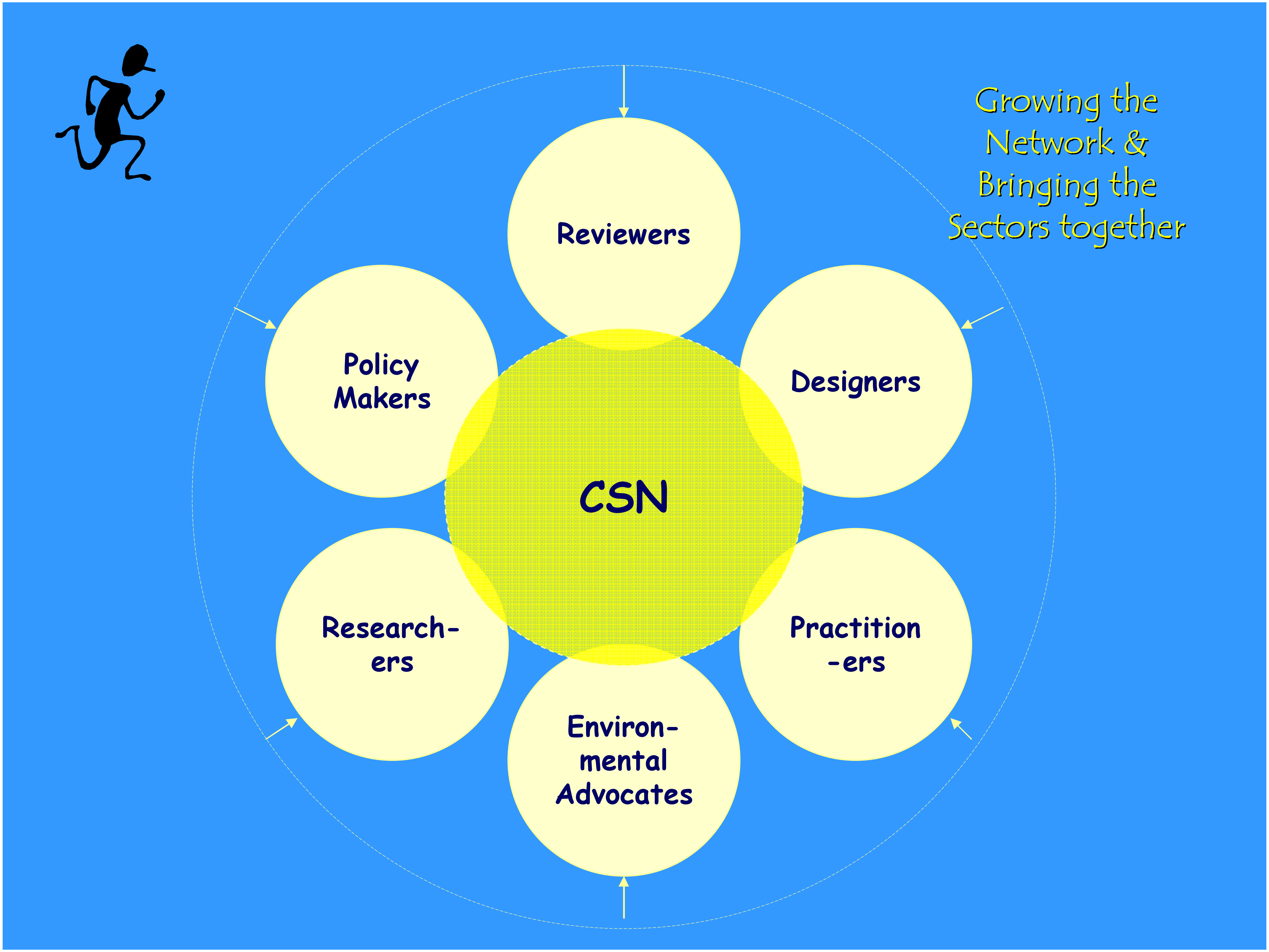
Key Themes

- About Chesapeakle Stormwater Network
- The Future of Stormwater: Tommy the Swammi
- Baywide Stormwater Design Specifications
- MD Runoff Reduction Spreadsheet
- Special Stormwater Technical Bulletins
- **Baywide Stormwater Training**
- Master Stormwater Engineers

Chesapeake Stormwater Network

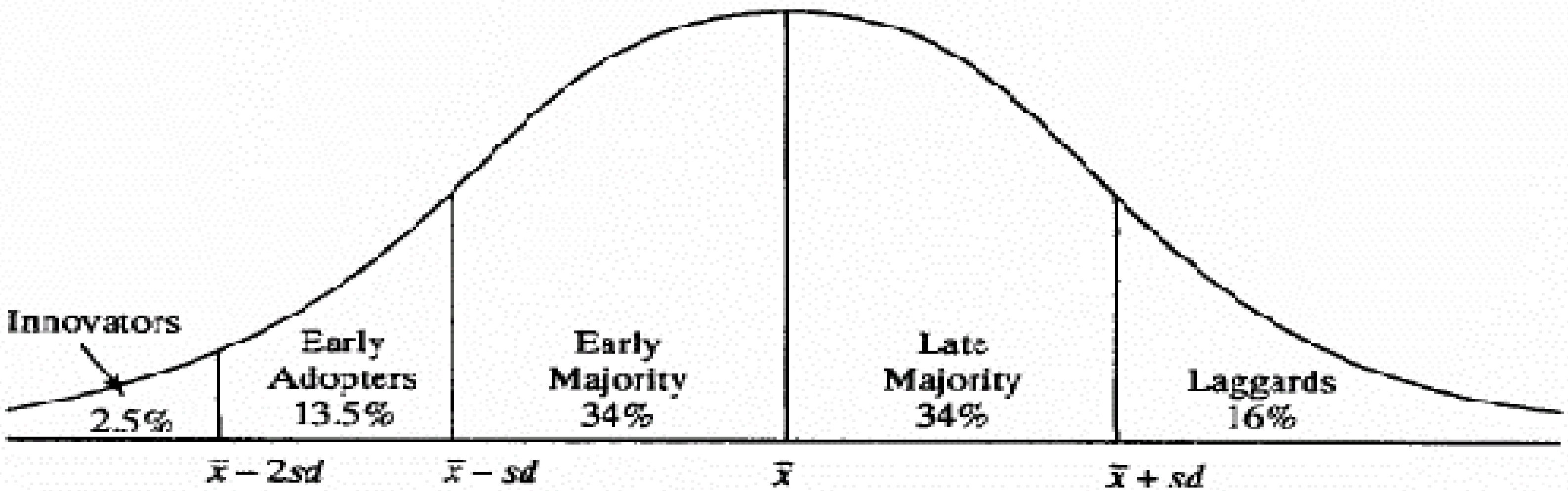
Nonprofit organized to align the local, state, federal and private sectors to solve the Bay stormwater problem through an independent network of concerned stormwater professionals

www.chesapeakestormwater.net


Growing the Network & Bringing the Sectors together
Reviewers
Policy Makers
Designers
CSN
Research-ers
Practition-ers
Environ-mental Advocates

Innovatiion and Adopter Categories

Figure 7-3. Adopter Categorization on the Basis of Innovativeness



The innovativeness dimension, as measured by the time at which an individual adopts an innovation or innovations, is continuous. The innovativeness variable is partitioned into five adopter categories by laying off standard deviations (sd) from the average time of adoption ($\bar{x}$).

Source: Diffusion of Innovation, 5th Edition, Everett M. Rogers

The Future of Stormwater in MD

Tommy the Swammi

Some Future Predictions

Uneven local implementation of new ESD regulations

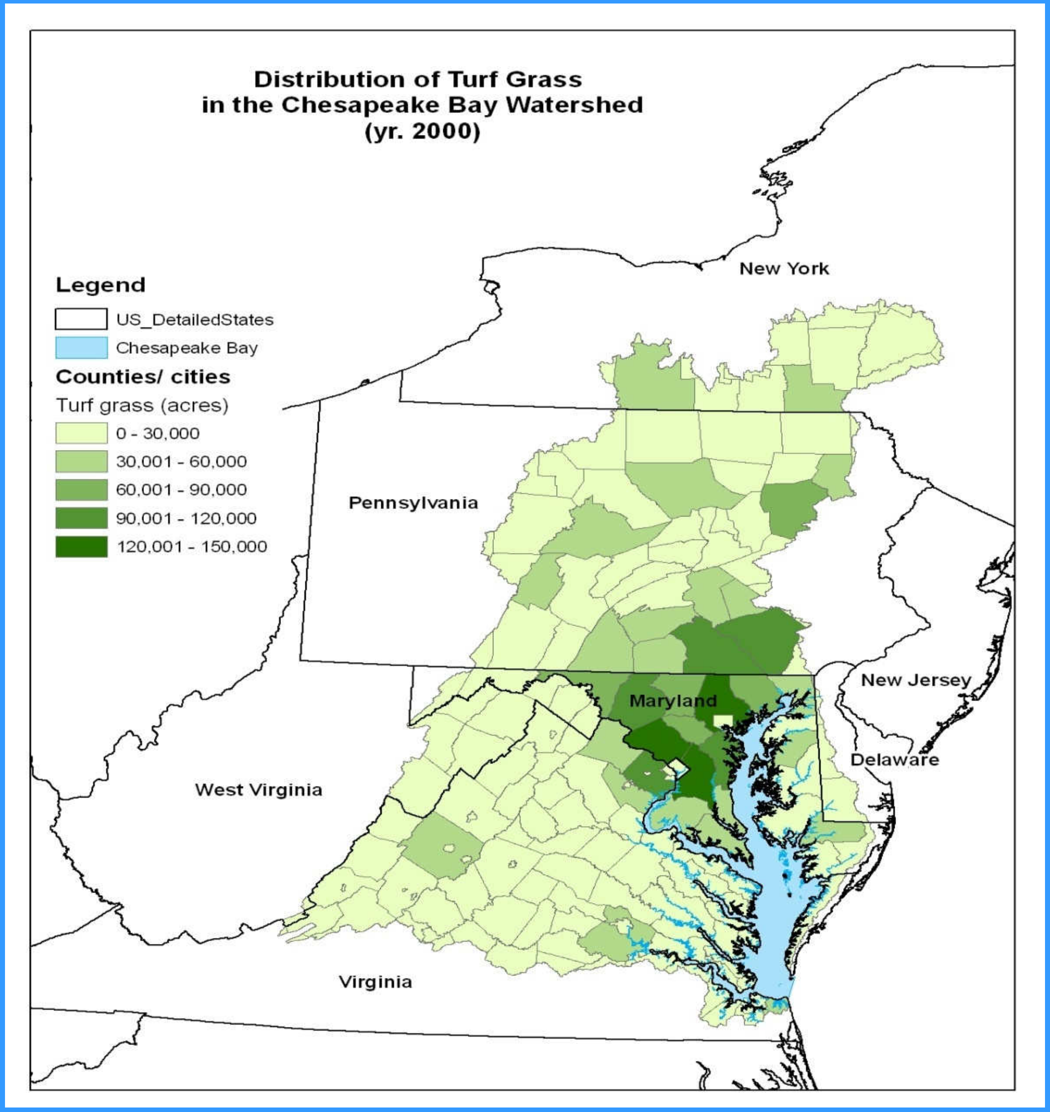
Rapid changes in practices, technology and compliance tools

More stringent EPA stormwater rules for Chesapeake Bay (or nationally)

More numeric municipal, industrial and construction NPDES permits, with more accountability and enforcement

Local nutrient reduction requirements from Bay TMDL

We have Reached the Clipping Point



The Clipping Point: Emergence of Turf Cover As a Major Bay Ecosystem

TURF COVER, BAY WATERSHED 2000

Method 1: 3.82 million acres
Method 2: 3.79 million acres

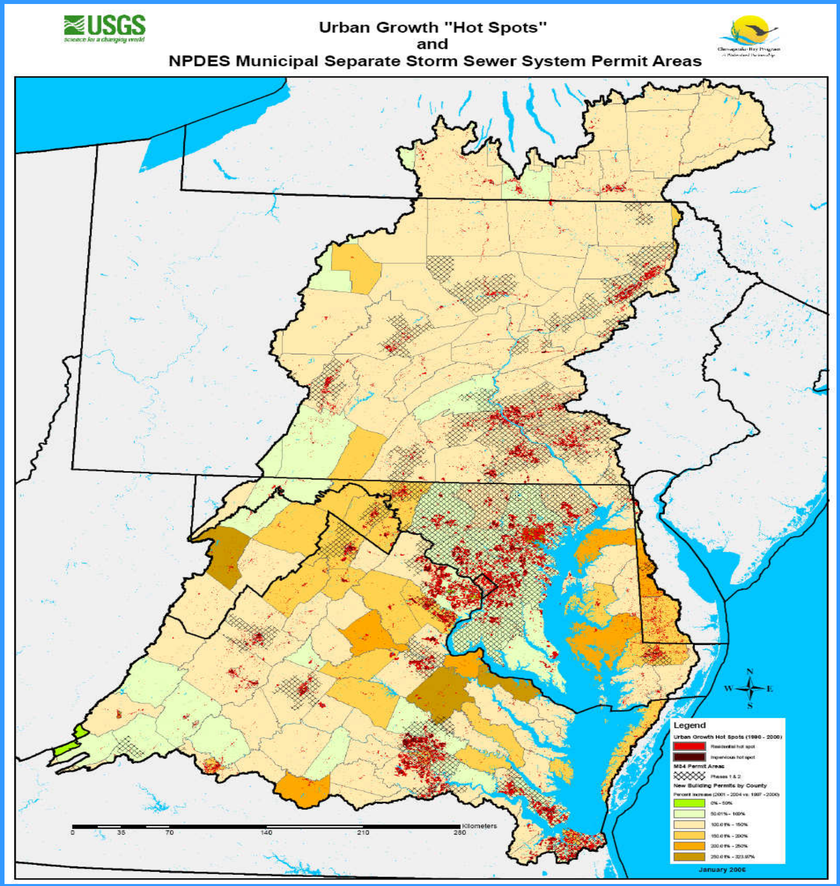
TURF As PERCENT OF BAY LAND AREA

Method 1: 9.5%
Method 2: 9.5%

COMPARISON TO OTHER BAY LAND USES

Row Crops: 9.2% of watershed
Pasture: 7.7%
Hay and Alfalfa: 7.4%
Wetlands: 3.8%

First Annual
Bay-wide
Stormwater Performance Scorecard
2009



Ten Core Implementation Tools Graded

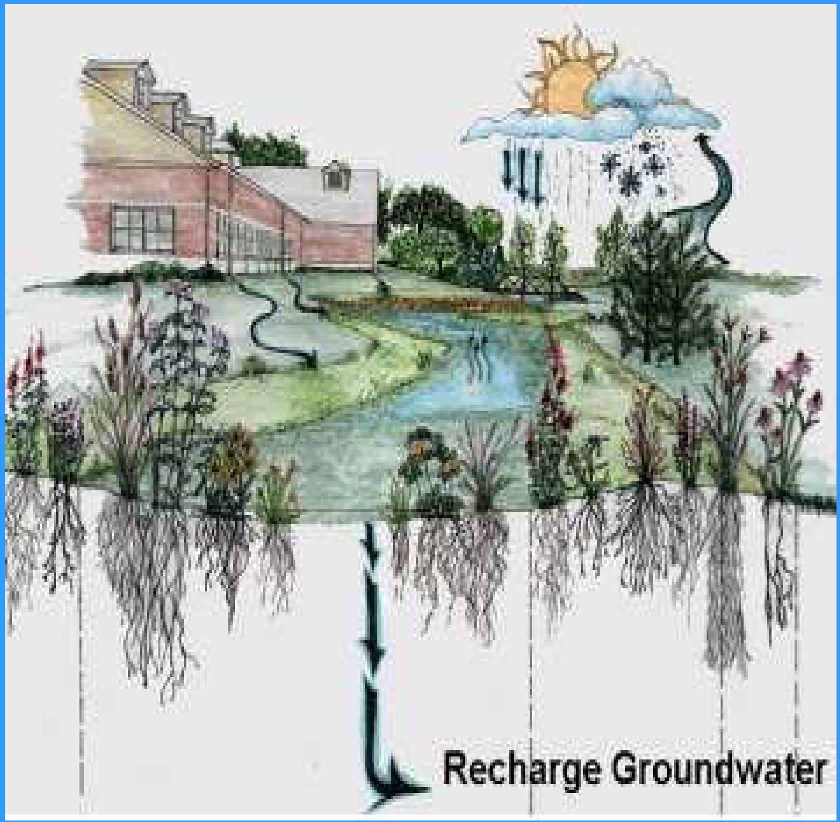
1. Stormwater Permits: Larger Communities
2. Stormwater Permits: Smaller Communities
3. Updated State Stormwater Regulations
4. Updated State Stormwater Manual
5. State Outreach to Localities
6. Public Stormwater Outreach
7. Industrial Stormwater Permits
8. Construction Stormwater Permits
9. Permit Compliance and Enforcement
10. State and Local Stormwater Financing

TABLE 1: BAYWIDE STORMWATER SCORECARD-2009					
Core Programs	DC	MD	PA	VA	WV
Large MS4 Permits	A-	C-	-	D	-
Small MS4 Permits	-	F	D	C+	A
Stormwater Regs	I	B+	I	I	B+
Stormwater Manual	I	C-	B	A-	I
MS4 Outreach	B	D	D	B-	B
Public Outreach	A	D+	F	B	I
Industrial Permits	D	D	D-	B-	D
Construction Permits	B+	C-	D+	C-	D
Permit Enforcement	B+	D	D-	D	D-
Local/ State Financing	A-	C-	F	C+	D+
OVERALL GRADE	**B+**	**D+**	**D**	**C+**	**C**

NPDES Permitting:
The gap between wastewater and stormwater

RUNOFF REDUCTION

Runoff reduction (RR) is defined as the total volume reduced through canopy interception, soil infiltration, evaporation, rainfall harvesting, engineered infiltration, extended filtration or evapotranspiration at small sites



MD Runoff Reduction Spreadsheet

1. Post-Development Project & Land Cover Information					
Constants					
Annual Rainfall (inches)	43				
Target Rainfall Event (inches)	1.00				
Phosphorus EMC (mg/L)	0.28				
Target Phosphorus Load (lb/acre/yr)	0.28				
Pj	0.90				
Land Cover (acres)					
	A soils	**B Soils**	**C Soils**	**D Soils**	**Totals**
Forest/Open Space -- undisturbed, protected forest/open space or	0.0	2.0	4.0		6.0
Managed Turf -- disturbed, graded for yards or other turf to be		6.0	14.0		20.0
Impervious Cover (all soil types)	14.0				14.0
				Total	40.0
Rv Coefficients					
	A soils	**B Soils**	**C Soils**	**D Soils**	
Forest/Open Space	0.02	0.03	0.04	0.05	
Managed Turf	0.15	0.20	0.22	0.25	
Impervious Cover	0.95				

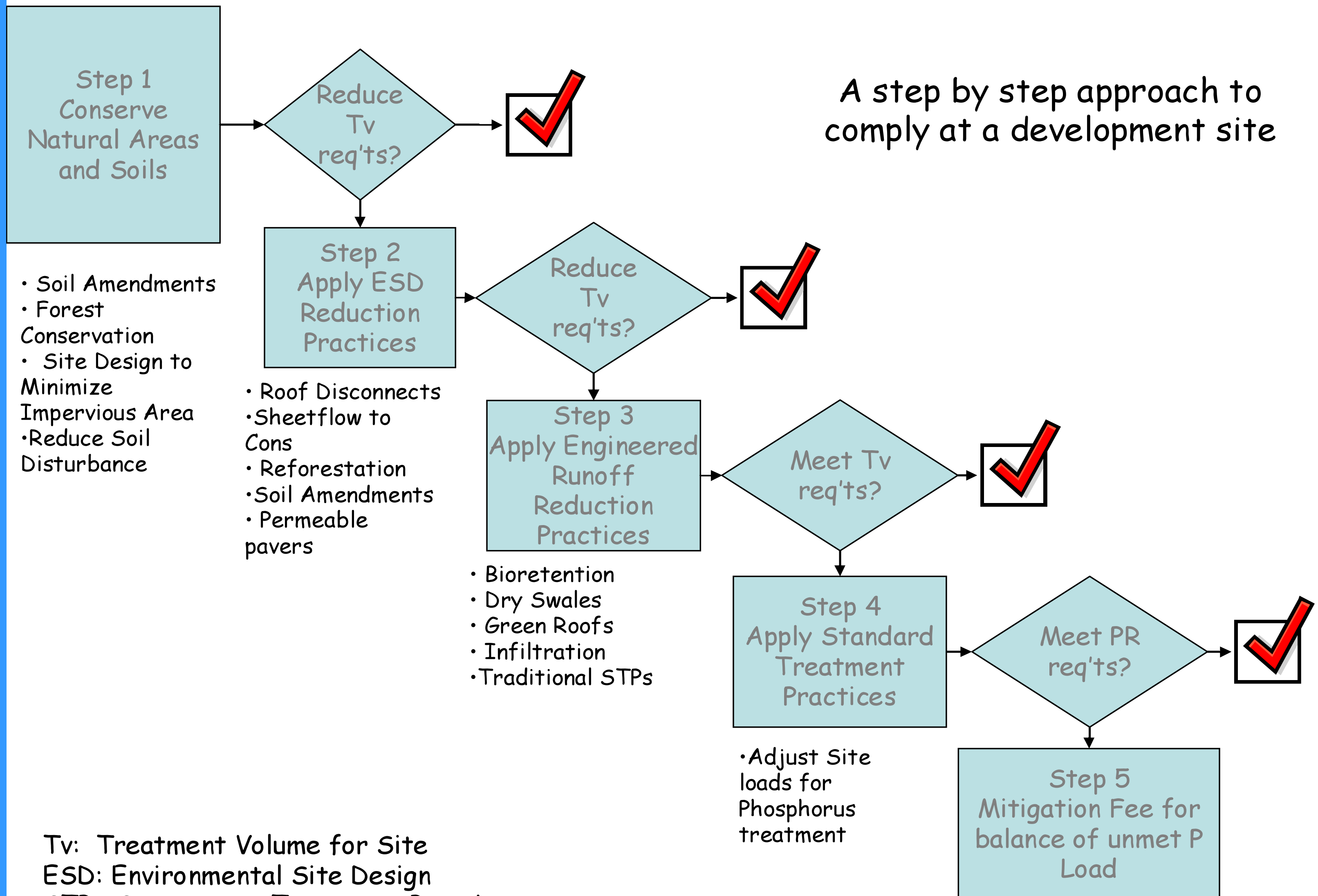
Adapted from VA, but Modified to Conform to MD ESD regs

VA Runoff Reduction Spreadsheet

The VA DCR spreadsheet developed to simplify compliance and has been tested (and revised) on dozens of sites by hundreds of engineers

- ✓ Based on New Science on Runoff Coefficients and Runoff Reduction of Practices
- ✓ Compliance Tool for Early Concepts and Final Design (although individual practice design still required)
- ✓ Excellent Tool for Training and Plan Review
- ✓ Truly Integrates all Practices Together and Rewards a Treatment Train

A step by step approach to comply at a development site



Tv: Treatment Volume for Site
ESD: Environmental Site Design
STP: Stormwater Treatment Practices

Annual Runoff Reduction Rates (%)

Infiltration	50 to 90
Bioretention	40 to 80
Pervious Pavers	45 to 75
Green Roof	45 to 60
Dry Swale	40 to 60
Rain Tanks/Cisterns	40 +
Roof Disconnection	25 to 50
Grass Channel	15 to 30
Dry ED Pond	0 to 15
Wet Pond	0
Sand Filter	0

Source: CWP and CSN (2008)

BIORETENTION DESIGN	
LEVEL 1 DESIGN	LEVEL 2 DESIGN
TV= (Rv)(A)	TV= 1.25 (Rv)(A)
Filter media at least 24" deep	Filter media at least 36" deep
One form of accepted pretreatment	Two or more forms of accepted pretreatment
At least 75% plant cover	At least 90% plant cover, including trees.
One cell design	Two cell design
Underdrain	Infiltration design or underground stone sump

MD Runoff Reduction Spreadsheet

CSN and CWP expect to release MD version by end of 2009

Will initially calculate ESD treatment volume using MDE woods in good conditions “look up” table.

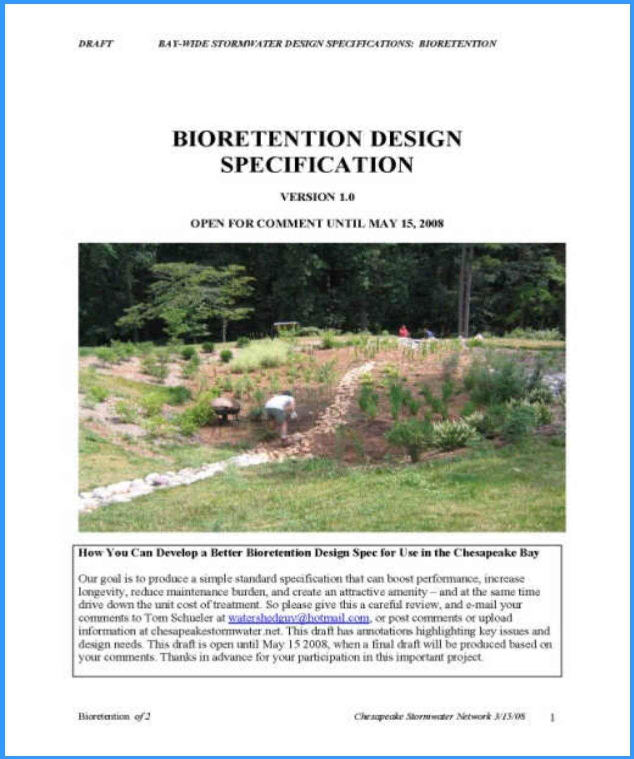
The spreadsheet then accounts for progressive runoff reduction by different ESD practices from up to five different sub-drainage areas at the site.

Allows plan reviewers that ESD to the MEP has been achieved or not, and quickly test alternative combinations

Also computes curve number reductions for larger storms

Need for New Design Tools

- CSN/CWP released 14 new design specs
- Focus on better design, installation and maintenance



DRAFT *BAY-WIDE STORMWATER DESIGN SPECIFICATIONS: BIORETENTION*

BIORETENTION DESIGN SPECIFICATION

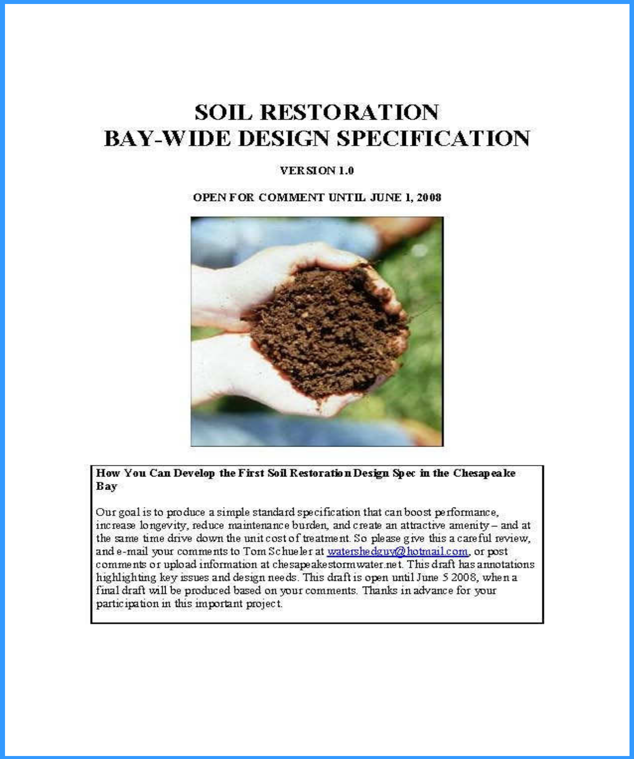
VERSION 1.0

OPEN FOR COMMENT UNTIL MAY 15, 2008

How You Can Develop a Better Bioretention Design Spec for Use in the Chesapeake Bay

Our goal is to produce a simple standard specification that can boost performance, increase longevity, reduce maintenance burden, and create an attractive amenity – and at the same time drive down the unit cost of treatment. So please give this a careful review, and e-mail your comments to Tom Schueler at watershedguy@hotmail.com, or post comments or upload information at chesapeakestormwater.net. This draft has annotations highlighting key issues and design needs. This draft is open until May 15 2008, when a final draft will be produced based on your comments. Thanks in advance for your participation in this important project.

Bioretention *of 2* *Chesapeake Stormwater Network 3/13/08* 1



SOIL RESTORATION BAY-WIDE DESIGN SPECIFICATION

VERSION 1.0

OPEN FOR COMMENT UNTIL JUNE 1, 2008

How You Can Develop the First Soil Restoration Design Spec in the Chesapeake Bay

Our goal is to produce a simple standard specification that can boost performance, increase longevity, reduce maintenance burden, and create an attractive amenity – and at the same time drive down the unit cost of treatment. So please give this a careful review, and e-mail your comments to Tom Schueler at watershedguy@hotmail.com, or post comments or upload information at chesapeakestormwater.net. This draft has annotations highlighting key issues and design needs. This draft is open until June 5 2008, when a final draft will be produced based on your comments. Thanks in advance for your participation in this important project.

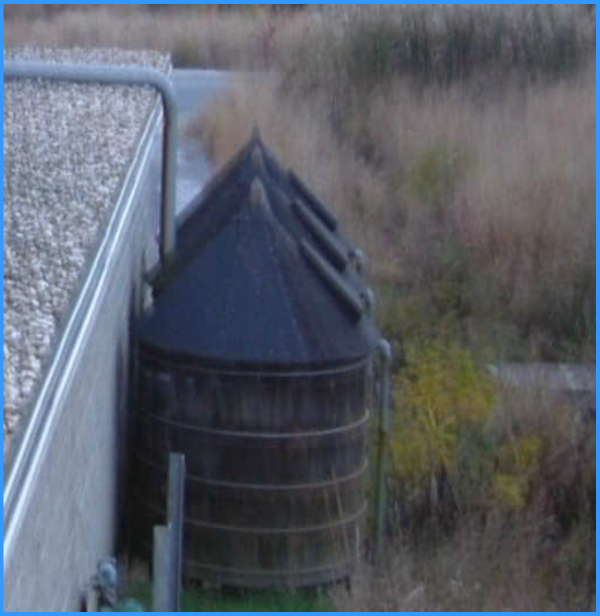
Draft Bay-wide Design Specifications

- Rooftop Disconnection
- Filter Strips
- Grass Channels
- Soil Amendments
- Green Roofs
- Rain Tanks/Rainwater Harvesting
- Permeable Pavement
- Infiltration
- Bioretention
  - Urban Bioretention
- Dry Swales
- Filtering Practices
- Constructed Wetlands
  - Wet Swales
- Wet Ponds
- Extended Detention Ponds

Drafts available at CSN website: www.chesapeakestormwater.net

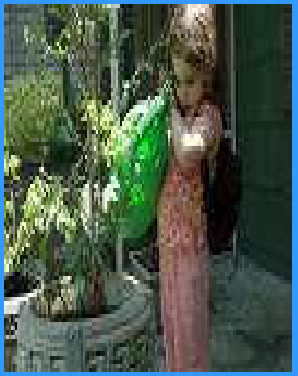
BAY WIDE DESIGN SPEC NO. 6

RAIN TANKS AND CISTERNS



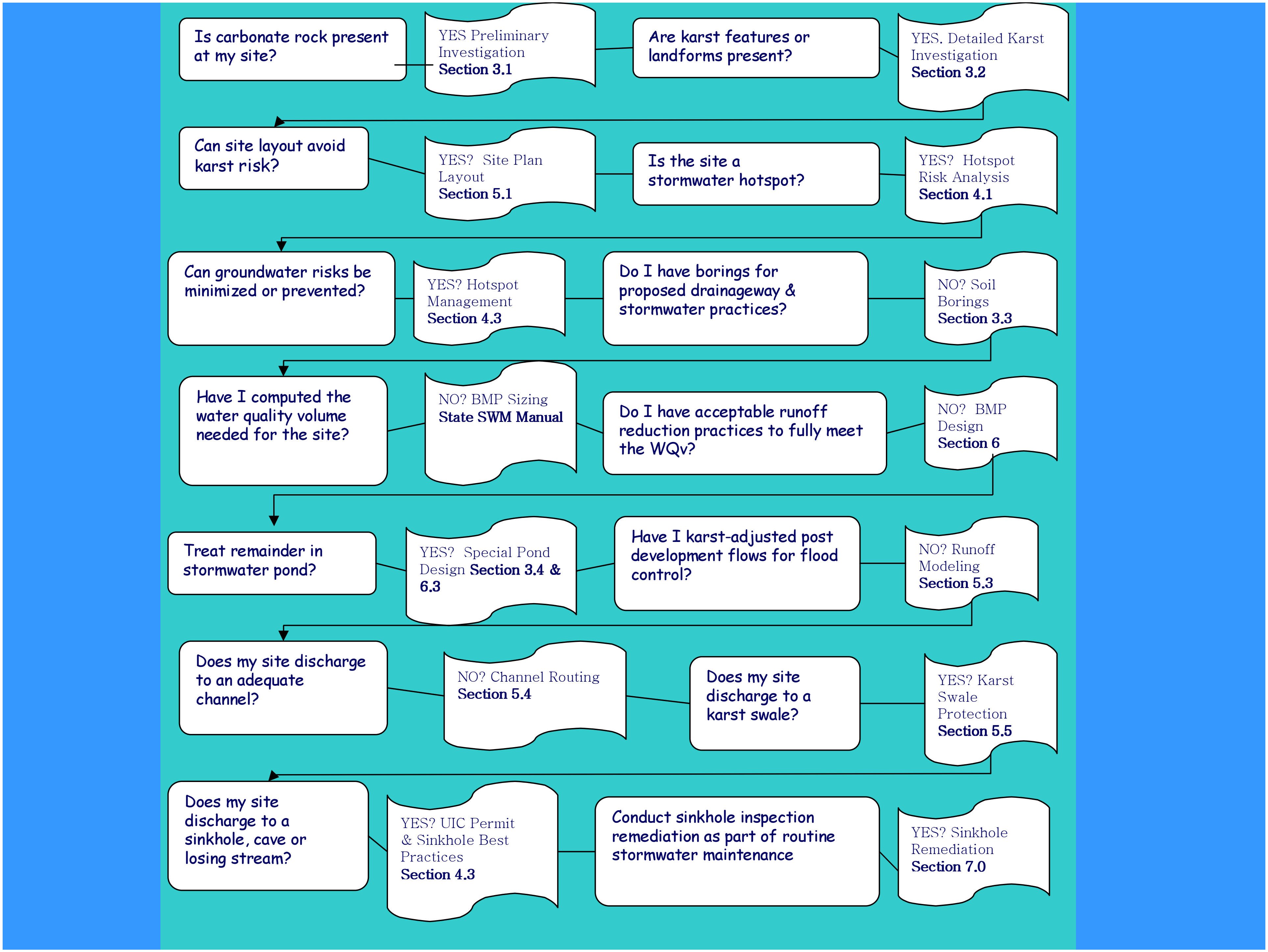


CSN TECHNICAL BULLETIN No. 1

STORMWATER DESIGN GUIDELINES FOR KARST TERRAIN IN THE CHESAPEAKE BAY WATERSHED

VERSION 2.0



Is carbonate rock present at my site?
YES Preliminary Investigation Section 3.1
Are karst features or landforms present?
YES. Detailed Karst Investigation Section 3.2
Can site layout avoid karst risk?
YES? Site Plan Layout Section 5.1
Is the site a stormwater hotspot?
YES? Hotspot Risk Analysis Section 4.1
Can groundwater risks be minimized or prevented?
YES? Hotspot Management Section 4.3
Do I have borings for proposed drainageway & stormwater practices?
NO? Soil Borings Section 3.3
Have I computed the water quality volume needed for the site?
NO? BMP Sizing State SWM Manual
Do I have acceptable runoff reduction practices to fully meet the WQv?
NO? BMP Design Section 6
Treat remainder in stormwater pond?
YES? Special Pond Design Section 3.4 & 6.3
Have I karst-adjusted post development flows for flood control?
NO? Runoff Modeling Section 5.3
Does my site discharge to an adequate channel?
NO? Channel Routing Section 5.4
Does my site discharge to a karst swale?
YES? Karst Swale Protection Section 5.5
Does my site discharge to a sinkhole, cave or losing stream?
YES? UIC Permit & Sinkhole Best Practices Section 4.3
Conduct sinkhole inspection remediation as part of routine stormwater maintenance
YES? Sinkhole Remediation Section 7.0

CSN TECHNICAL BULLETIN No. 2

STORMWATER DESIGN GUIDELINES FOR COASTAL PLAIN TERRAIN IN THE CHESAPEAKE BAY WATERSHED

VERSION 2.0

BMP Selection in Coastal Plain

Preferred	**Accepted**	**Discouraged**	**Prohibited**
Constructed Wetland	Sand Filter	Wet ponds	NONE
Shallow Bioretention	Small-scale Infiltration	Dry ED ponds	
Wet Swale	Green Roofs	Grass Channel	
Rain Tanks/Cisterns	Soil Compost Amendments	Large Scale Infiltration	
Shallow Dry Swale			
Roof Disconnection & Filter Strips			
Permeable Pavers			

New and Innovative Sustainable Stormwater Practices for the City

1. Green Roofs
2. Cisterns and Rain Tanks
3. Foundation Planters
4. Permeable Pavers
5. Expanded Tree Pits
6. Regular Bioretention
7. Street Bioretention
8. Soil Restoration
9. Reforestation
10. Sand Filters

Designating Stormwater Hotspots

Future status of development determines how much treatment is required, whether runoff can be infiltrated or what on-site pollution prevention practices are needed

A Lot of Change Going On in the Bay States

STATE	Runoff Reduction	Channel Protection	Status
DC	Reduce Runoff 1st Inch of Rainfall	No	New Regs New Manual
DE	Reduce Runoff from 2.4 inches of rainfall	YES	New Regs New Manual
MD	Reduce Runoff from 1.0 to 2.4 inches of rainfall	YES	New Regs New Manual?
PA	Reduce Runoff from 1.0 to 2.4 inches of rainfall	YES	2005 Manual
VA	Reduce Runoff from 1.0 to 2.4 inches of rainfall	YES	New Regs New Manual
WV	Reduce runoff from 1st Inch of rainfall	No	New Permit New Manual

Bay-wide Stormwater Training Partnership

BAYWIDE
Stormwater Partners

- Collaborative Stormwater Training in MD, VA, DC and WV w/ focus on local designers and plan reviewers
- $500,000 NFWF Grant over next 30 months (+ $600,000 match)
- MD and DC training coordinated by Chesapeake Stormwater Network
- VA and WV training coordinated by Center for Watershed Protection
- Certificates are awarded for participation (but not certification)

Bay-wide Stormwater Training Partners

BAYWIDE
Stormwater Partners

- Maryland Assoc. of Floodplain and Stormwater Managers
- American Society of Civil Engineers, Maryland Chapter
- Maryland Association of Soil Conservation Districts
- District of Columbia Dept of Environment
- American Society of Civil Engineers, Virginia Chapter
- Virginia Assoc. of Soil & Water Conservation Districts
- Virginia Department of Conservation Resources
- West Virginia Department of Environmental Protection

Piggyback training, resources, and MSEs

Three Levels of Training for Designers and Plan Reviewers

Basic: Participate in several webcasts on new regulations and practices

Advanced: One-day design charette to apply new tools to real world development and redevelopment sites

Master: Two day training session on special topics and teaching others

Other CSN Priorities in 2010

BAYWIDE
Stormwater Partners

- Create MS4 Stormwater Managers Exchange

- Technical Bulletins for Stormwater Design in Trout Waters and Ultra-urban Watersheds

- Technical Assistance for MD Critical Area Commission Staff on Stormwater Compliance

- Second Annual Bay-wide Stormwater Partners Retreat and Bay-wide Stormwater Institute

- Stormwater Research Updates

Master Stormwater Engineers

BAYWIDE
Stormwater Partners

- Up-front two day voluntary training commitment
- Get paid $1,500 for each local design training workshops
- Be eligible to be paid as a local stormwater circuit rider
- Become a Jedi-master to use the force in your own empire
- Marketing and professional development

Webcast Topics

BAYWIDE
Stormwater Partners

- Implementing Your State's Stormwater Regs
- Utilizing the Runoff Reduction Spreadsheet
- Design of Innovative Practices
    - Bioretention
    - Rainwater harvesting
    - Permeable paver
    - Rooftop disconenctions/soil amendments
    - Others
- Stormwater Design for Special Terrain and Receiving Waters
- Construction Inspection and Maintenance

- OTHER TOPICS DEPENDING ON INPUT/SURVEY

Work Between Now and the End of 2009

- Baseline Survey of Current Design and Review Practices
- Training Needs and Preference Survey
- Initial Class of Master Stormwater Engineers (10 in MD)
- Coordination with States and Professional Societies
- On-line training calendar and registration system

Training During 2010 and 2011

BAYWIDE
Stormwater Partners

- 10 stormwater webcasts
- 60 one-day stormwater design charettes to teach new methods
- 4 intensive workshops to create 40 master stormwater engineer trainers
- 500 hours of direct on-site technical assistance to requesting local governments
- 20 self-guided, web-based stormwater training modules

Questions ?