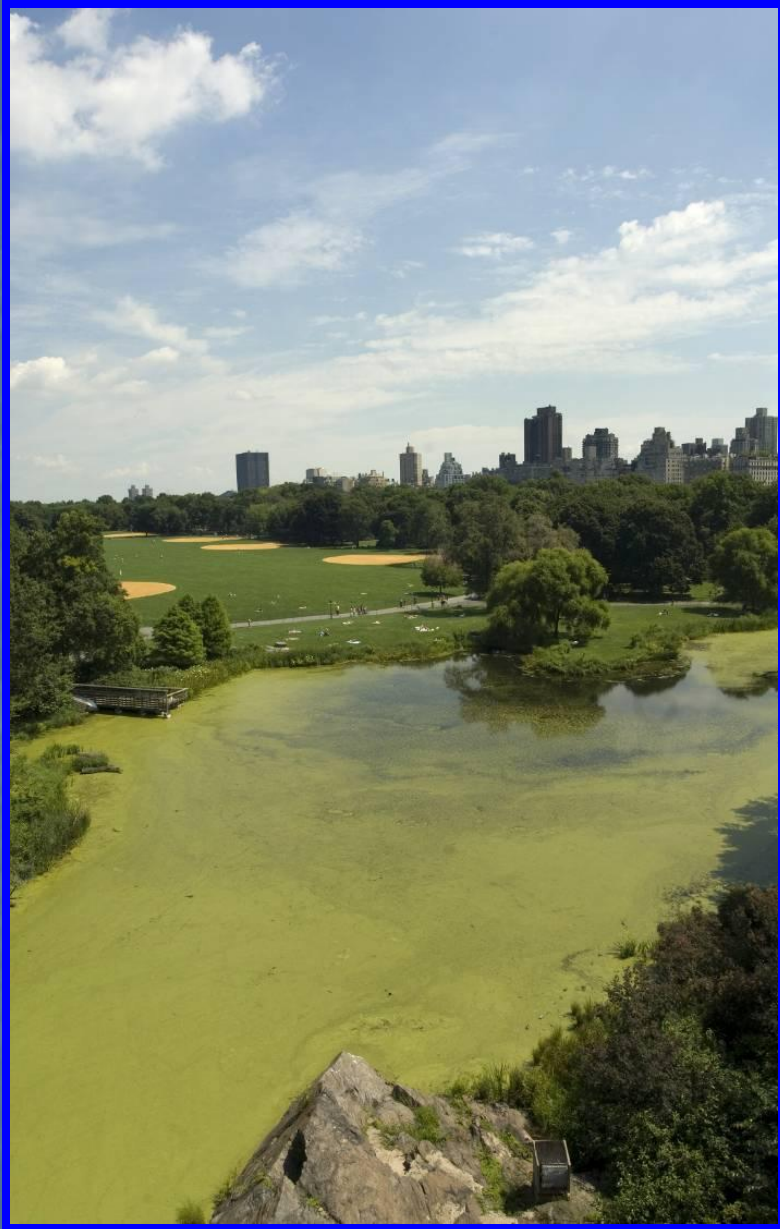


Phosphorus Treatment – Advanced Removal Mechanisms and Amended Design for Stormwater BMPs

Imbrium Systems





Overview

- **Phosphorus Basics**
- **NPS Loads**
- **Stormwater BMP performance**
- **Advanced Phosphorus Removal Mechanism**
- **Amended BMP Designs**
- **Things to Avoid**

Phosphorus Basics

- **Essential nutrient for life**
- **Cyclic between land & water**
- **Limiting nutrient in fresh water**

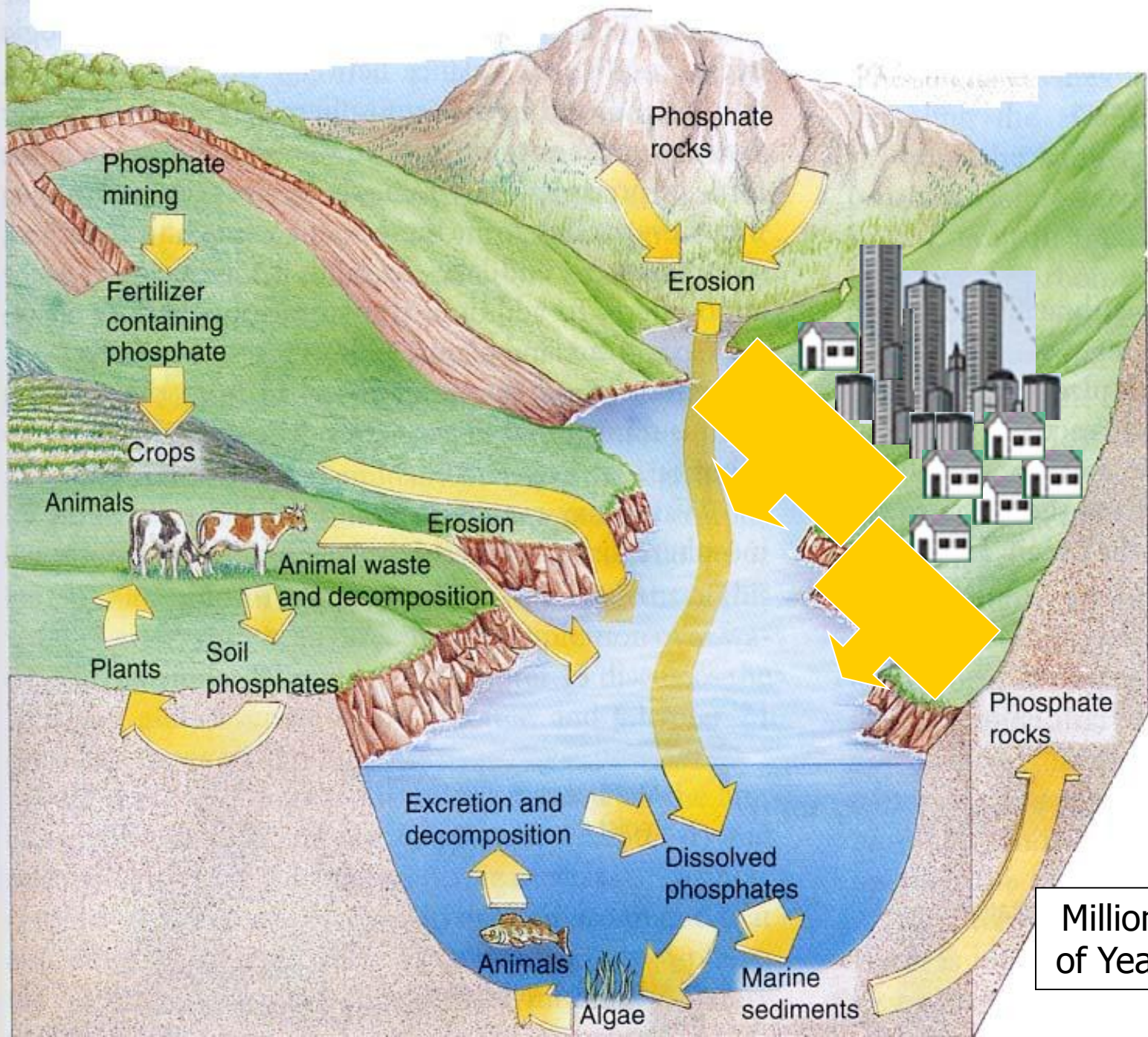
Canadian Experimental Lakes Area # 226:

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

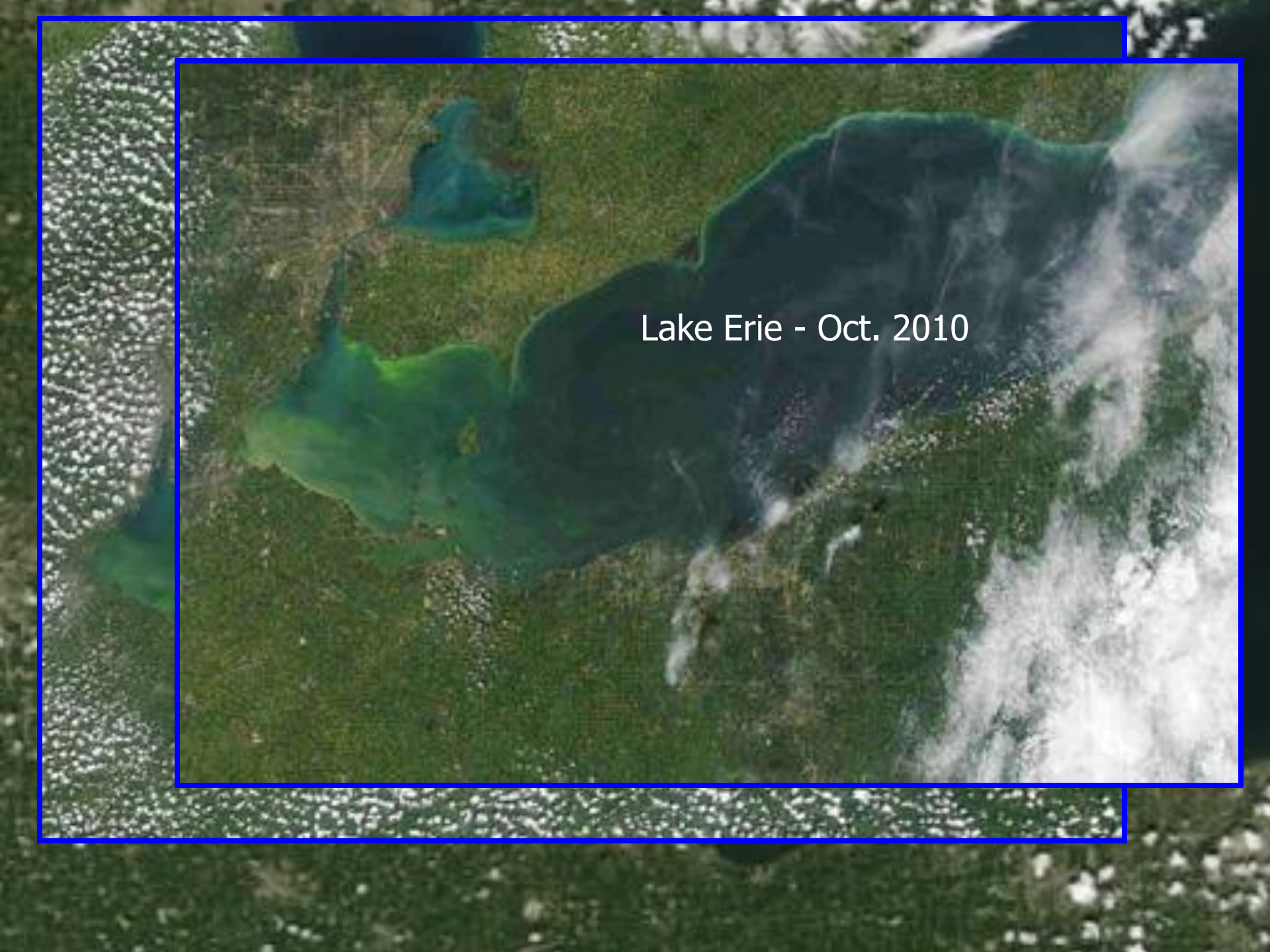


**Phosphorus
added**

Fisheries and Oceans Canada - 1973



Millions of Years

A satellite image of Lake Erie, showing the lake's characteristic shape and surrounding land. The lake is surrounded by a dense forest of green trees. The image is framed by a thick blue border. The text "Lake Erie - Oct. 2010" is centered over the lake.

Lake Erie - Oct. 2010

Problem:

- Excess Phosphorus in fresh water causes ***Eutrophication*** (over enrichment):
 - Algal blooms
 - Micro-toxins ... **Cyanobacteria**
 - Hypoxia
 - Fish kills
 - Invasive species

Lake Champlain

AP & VPR News - 2010



CAUTION

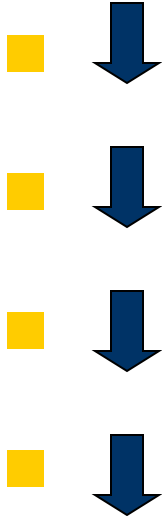
POSTED _____ : Based on counts of the cyanobacteria (blue-green algae), MDPH thresholds for recreational waters have been exceeded.



- Water which looks like the pictures above may contain algae capable of producing toxins that can be dangerous to humans and pets.
- People and pets should avoid contact in areas of algae concentration
- Do not swallow water and rinse off after contact

For further information call:

MA Department of Public Health at 617-624-5757



ms
nunity

Boston Metro

NPS Phosphorus Sources

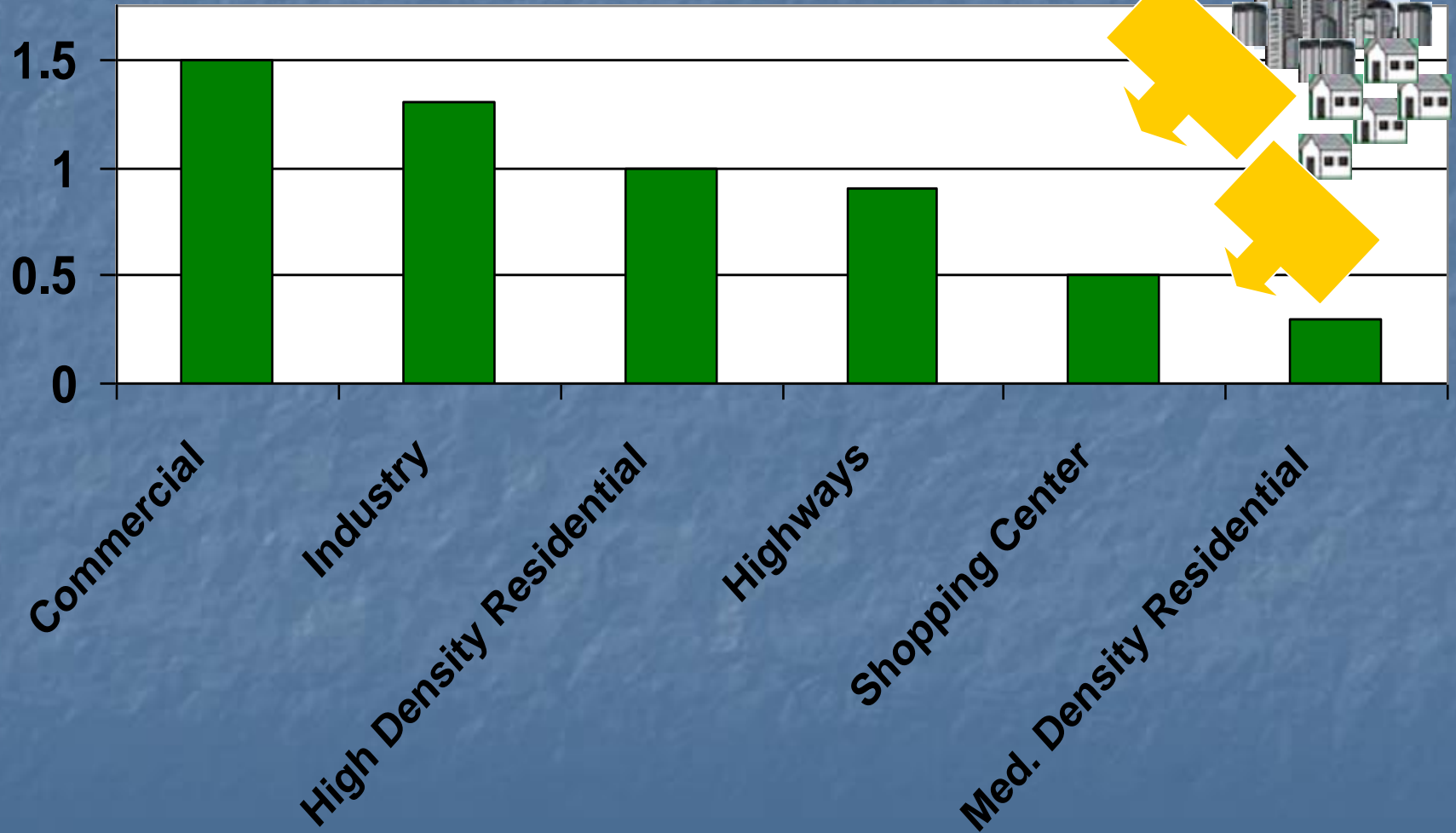
- **Fertilizers**
- **Animal & Pet Waste**
- **Vegetation & Leaves**
- **Detergents**
- **Erosion & Sediment Loss**
- **Hydrocarbons & Lubricants**
- **Airborne Fallout: Dust, Pollen, Fossil Fuels**
- **Waste Water (CSO / Septic)**



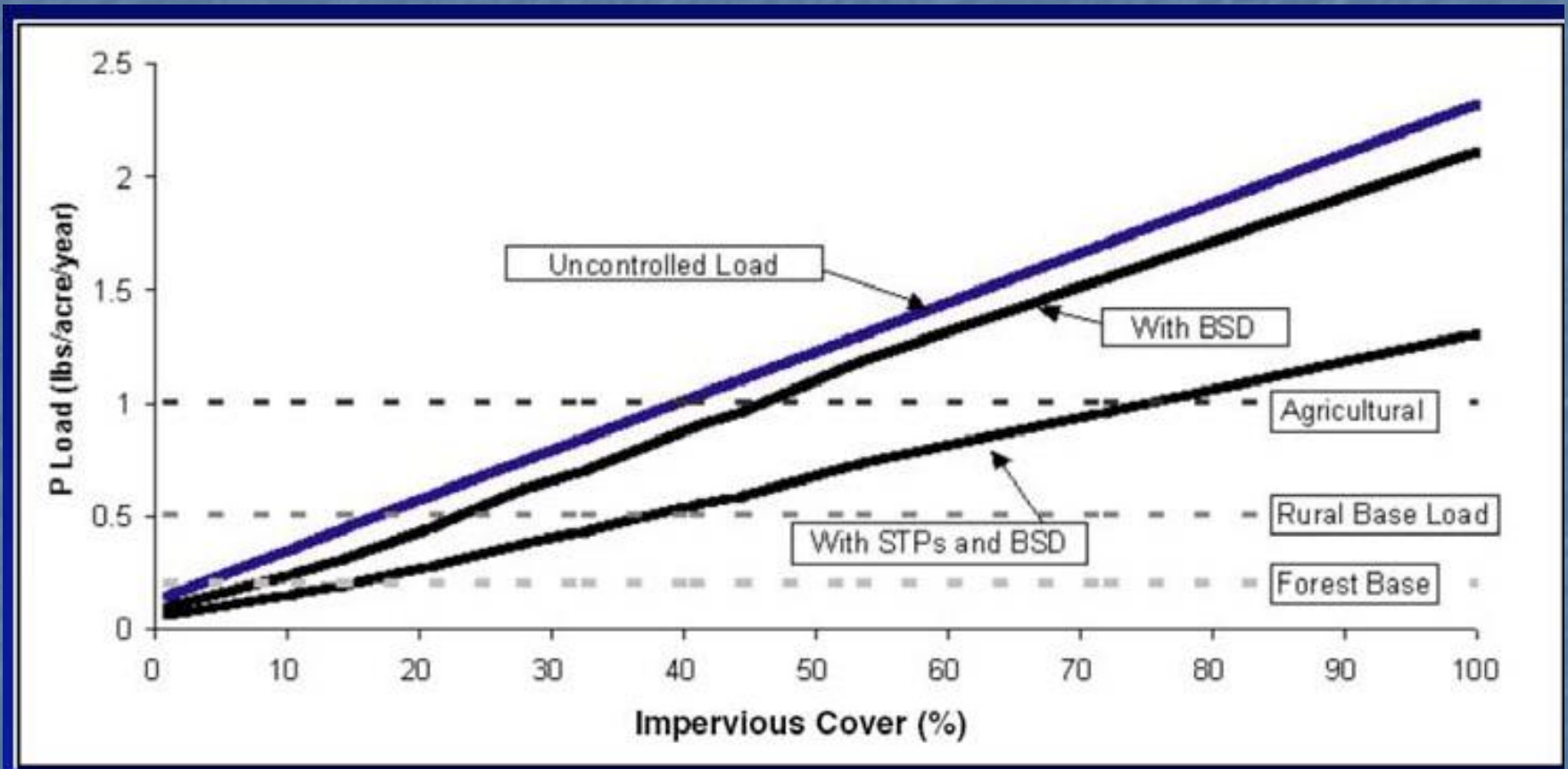


Phosphorus Stormwater Loading by Land Use

Pounds / Acre / Year

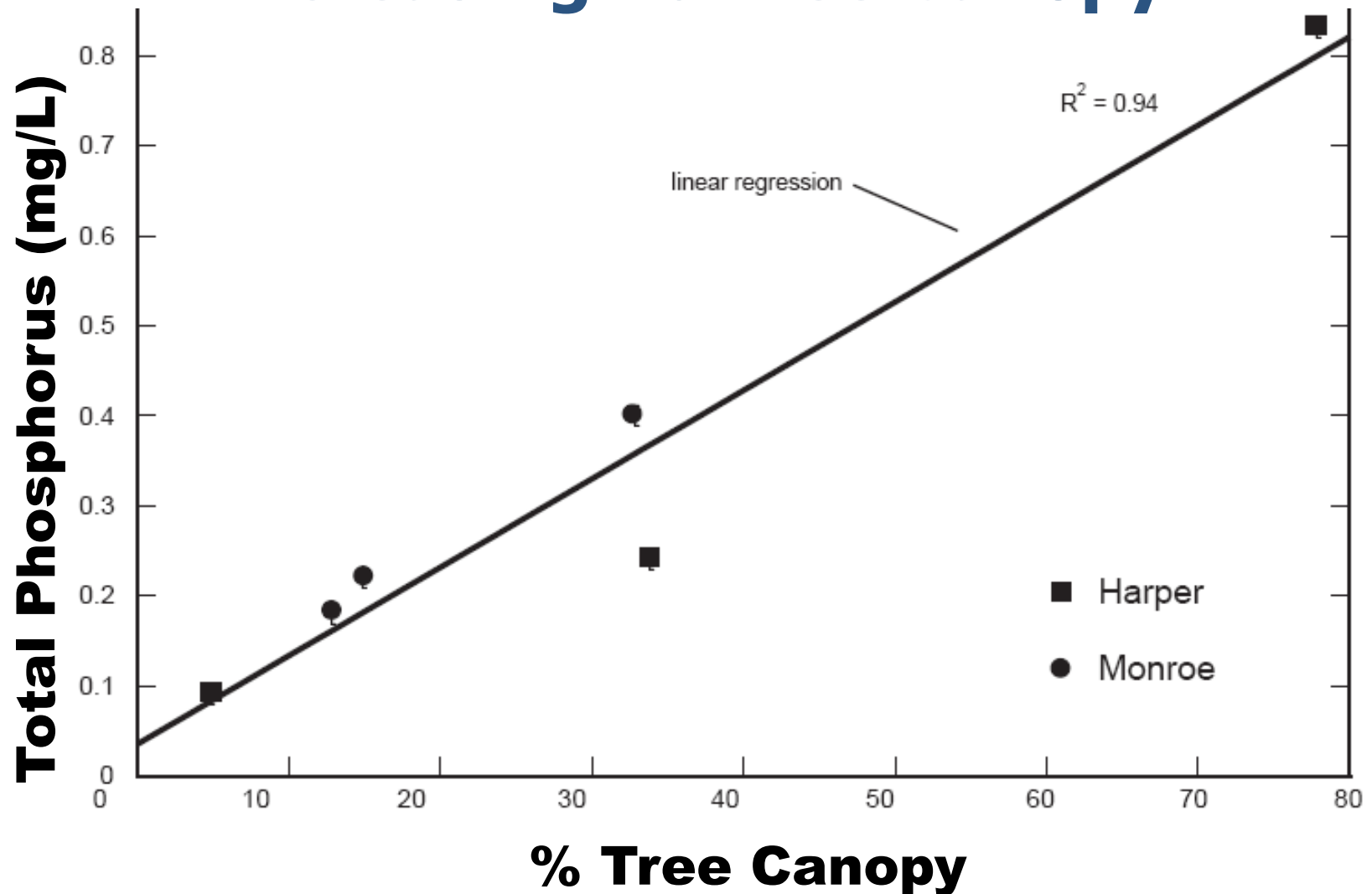


Imperviousness Cover & Phosphorus Load



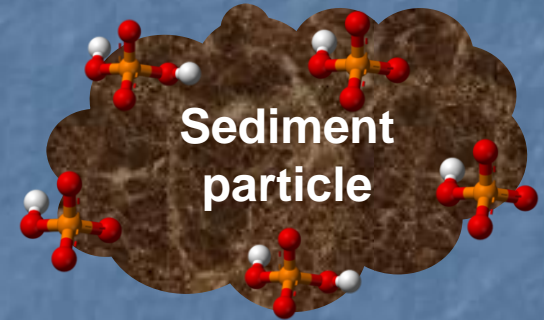


Phosphorus Load with Increasing % Tree Canopy



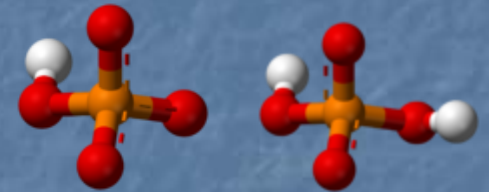
Total Phosphorus (TP) Partitioning

1. Particulate-Bound (PB) Phosphorus



2. Dissolved Phosphorus (DP)

- Bio-available
- **“QUICK SUGAR”** for Algal Blooms



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

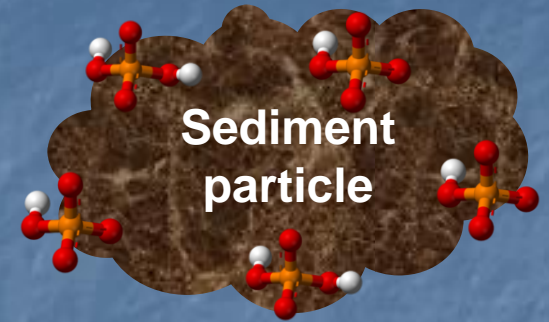
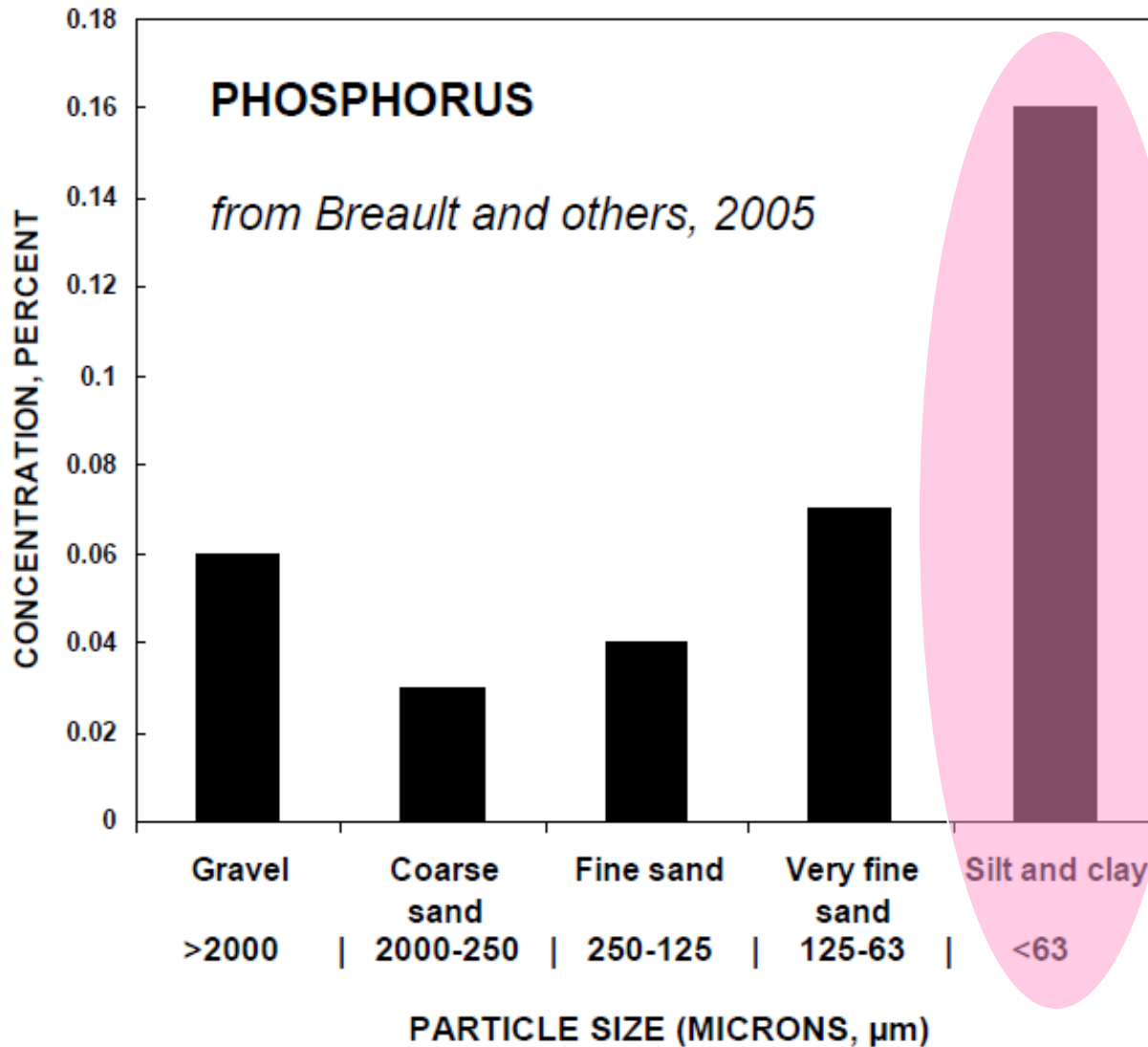
DP = Dissolved Phosphorus

PB = Particulate-bound Phosphorus

National Stormwater Quality Database

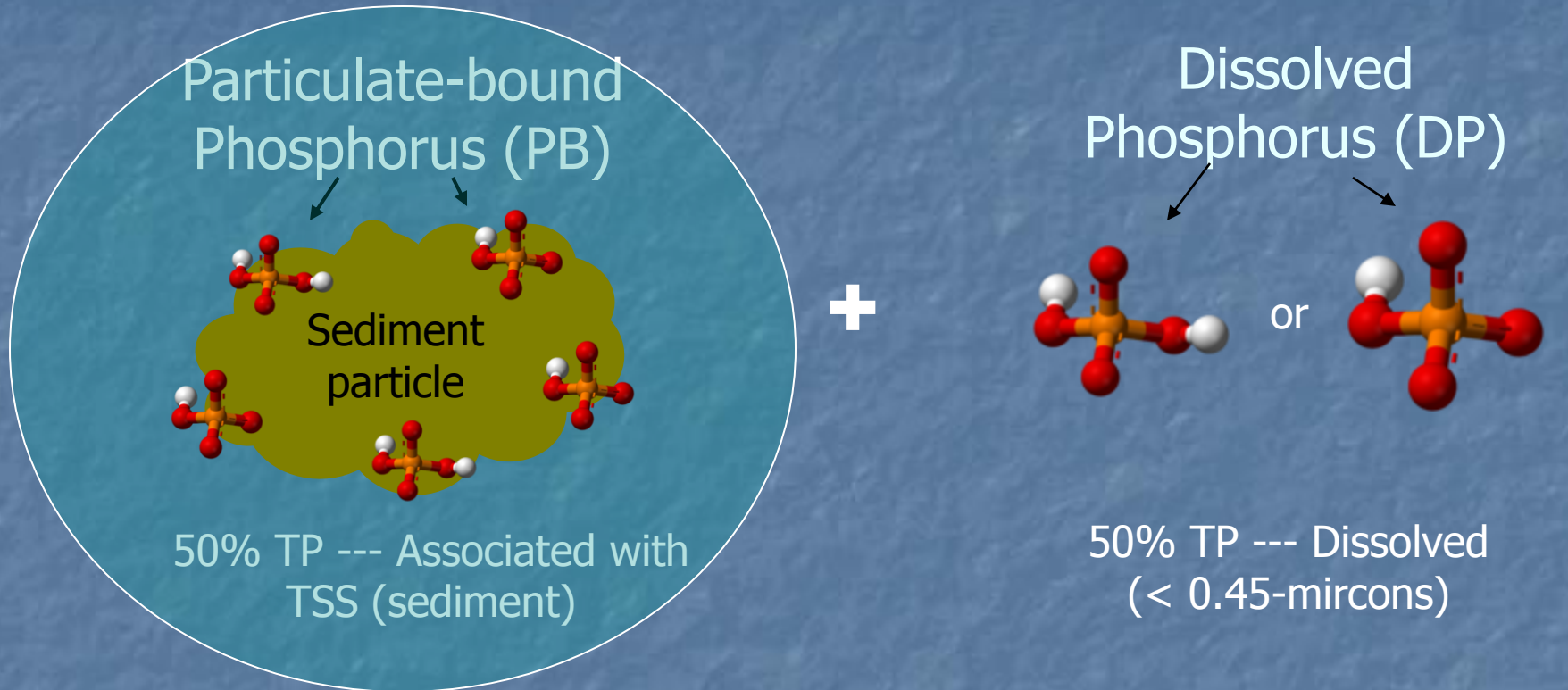
New York State DEC, 2008

Phosphorus in Stormwater



**What
should
you
capture?**

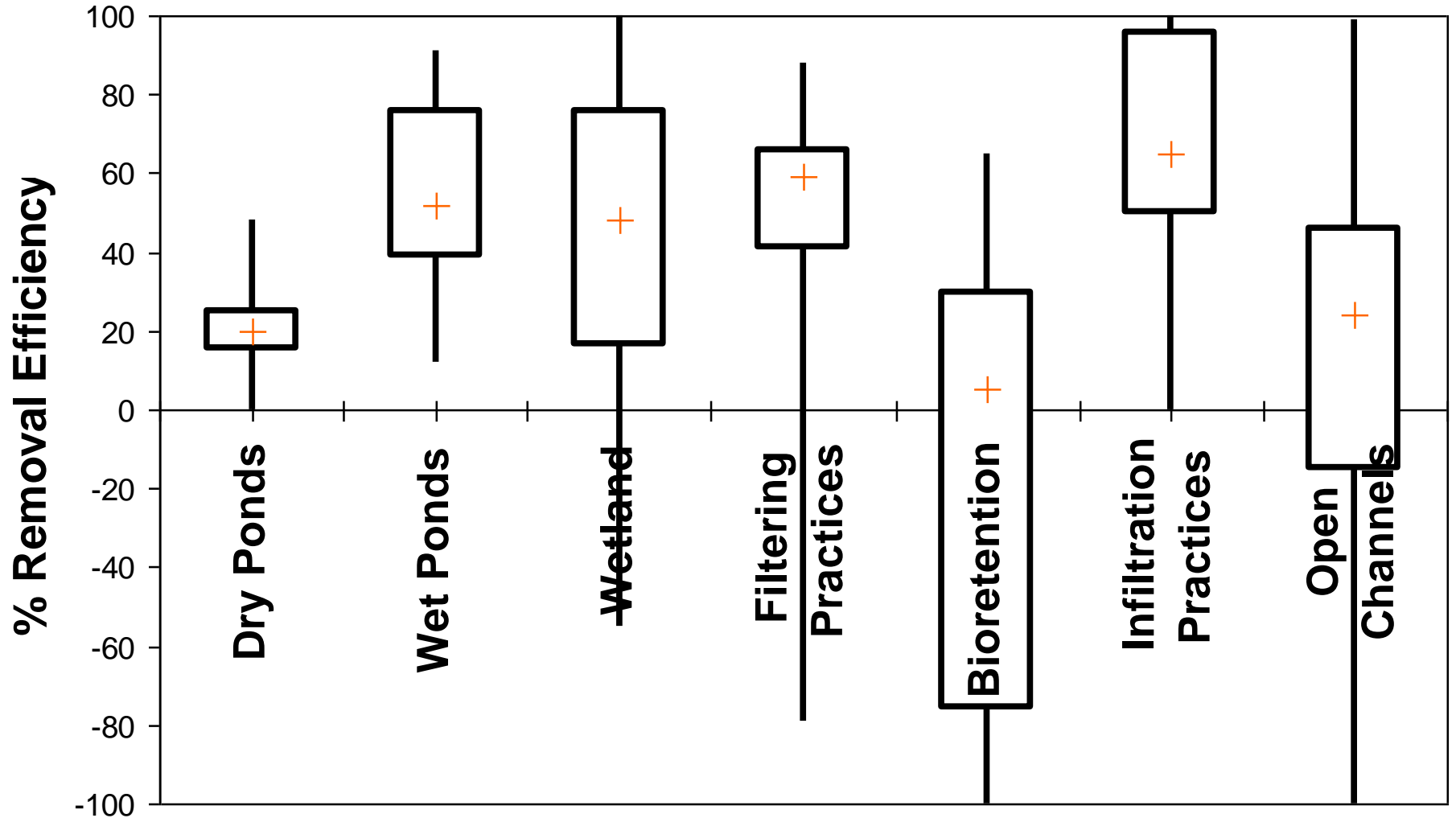
Typical Urban Stormwater BMPs designed to captures 80% TSS:



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

40% (TP) Removal

Range of Total Phosphorus (TP) % Removal per BMP Type

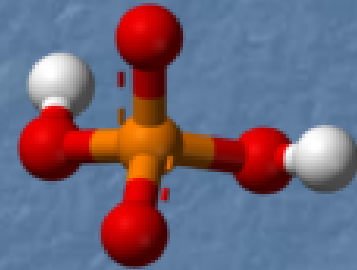


Center for Watershed Protection,

National Pollutant Performance Removal Database version3, Sept. 2007

Factors impacting Phosphorus Fate & Transport

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



Phosphorus Fate

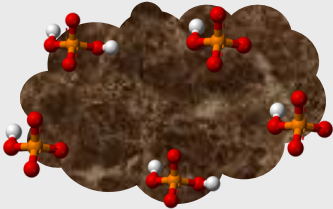
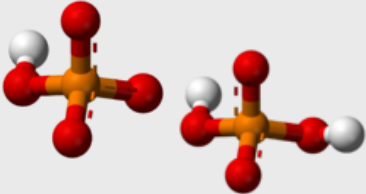
- Phosphorus speciation will shift



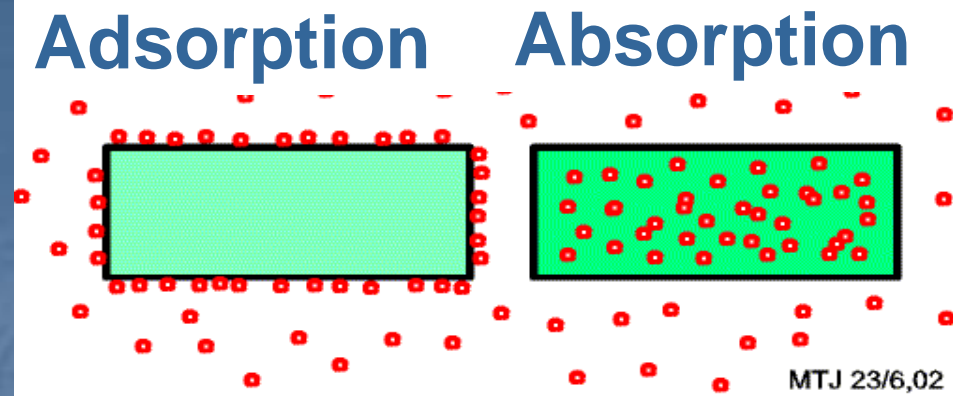
- Some Examples

- Impact of runoff pH of 7.0 vs 5.0
- Detention (pH & time)
- Anaerobic activity / decaying organics

Stormwater TP Removal Mechanisms & Generalized Capability

Unit Process / Removal Mechanism	Total Phosphorus (TP)	
		
Sedimentation	Yes	No
Filtration	Yes	Limited
Biological Uptake	Limited *assuming vegetative harvesting	Limited *assuming vegetative harvesting
Sorption	No	Yes

Sorption



- **Combination of 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 variation

1. ↑ TSS Removal

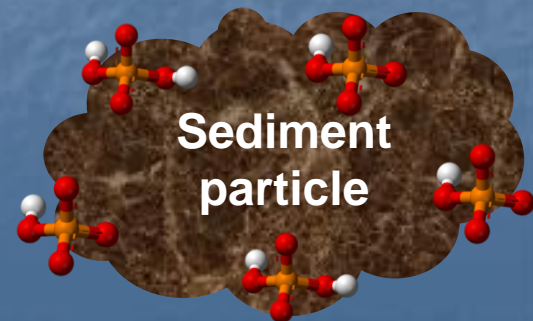
(particulate-bound P Removal)

2. Design / Implement systems to;

A. Capture SILT-sized particles

(63-microns)

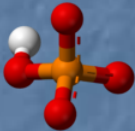
B. Prevent RESUSPENSION



Ways to increase TP removal & reduce variation

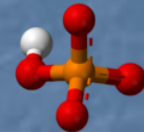
3. Prevent Phosphorus Speciation Shift

- Maintenance?



4. Treat more WQ_v ($> 90\%$)

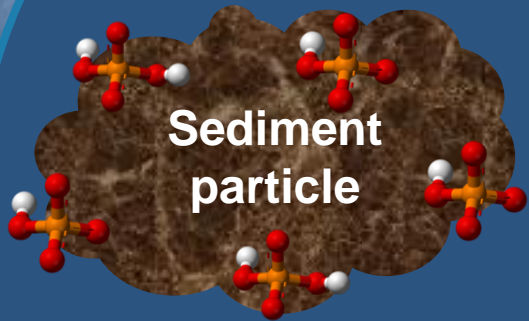
- Runoff Reduction, or increase WQ_v %?



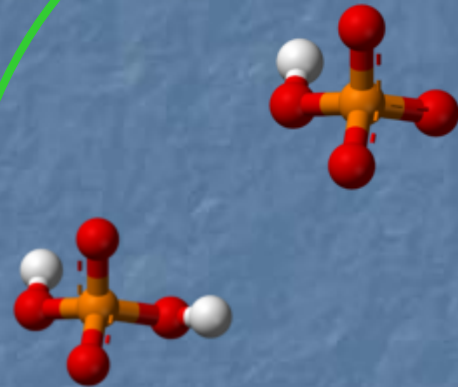
5. Amend & Design BMPs to Capture DP

- Incorporate Sorption Materials to polish

Phosphorus in Stormwater



**Particulate
bound**



**Dissolved
Phosphorus**



Quantifying Sorption Capability for Dissolved Pollutant Removal

- Isotherm –



- Best Case Maximum capacity it can hold?

- Kinetics –

- How fast can it be sorbed?

- 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
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

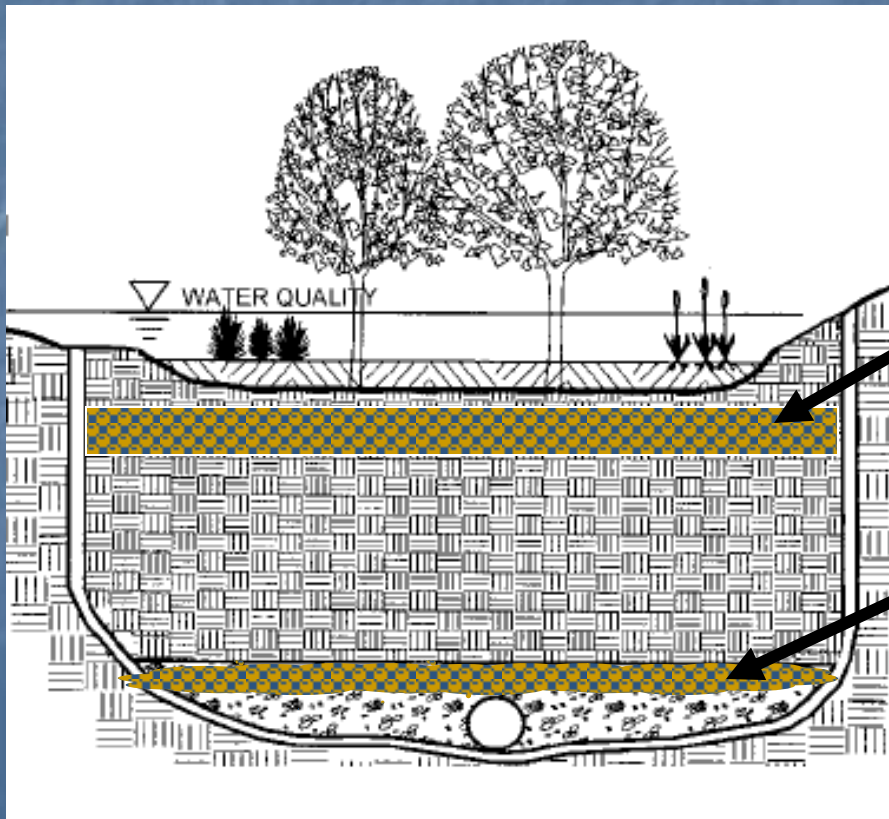
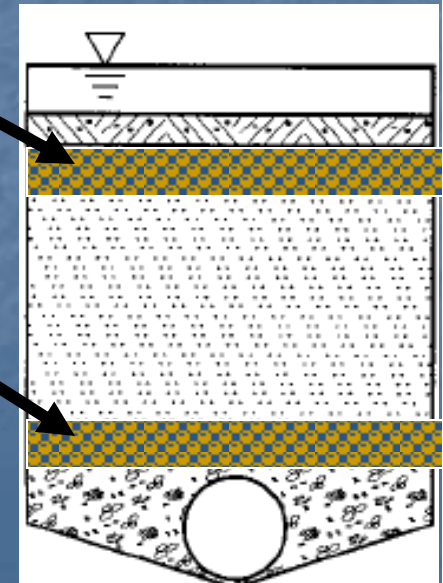
Applications

Amended Low Impact Development Bioretention & Rain gardens



Use Sorption
based Media or
Material

- Layer under mulch
- or
- Part of under drain
- or
- Polishing Cell

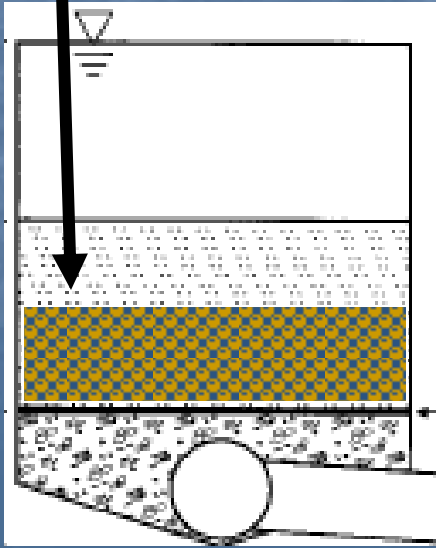
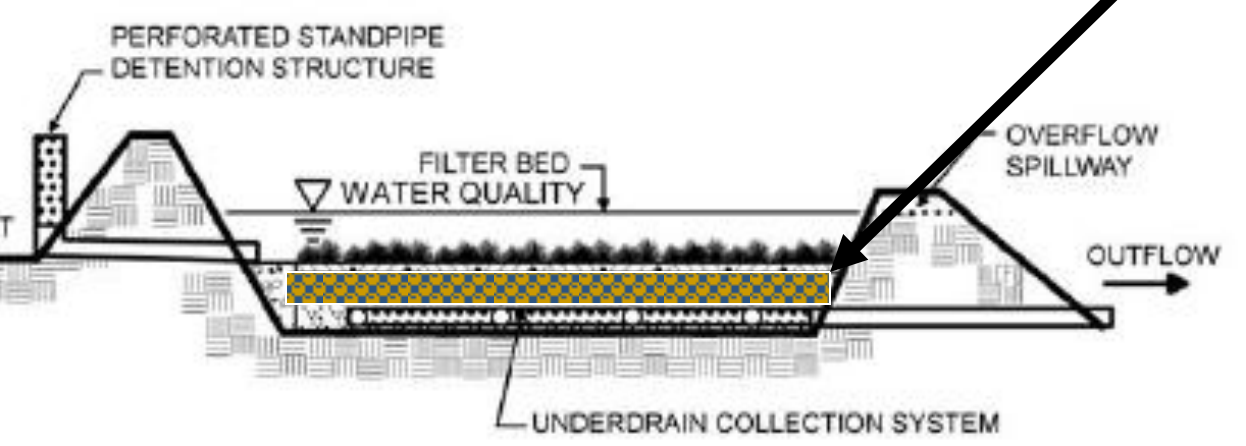


Applications

Amended Surface Filters (sand filters / bioretention)

Use Sorption based Media or Material

- displace part of Sand bed



Applications

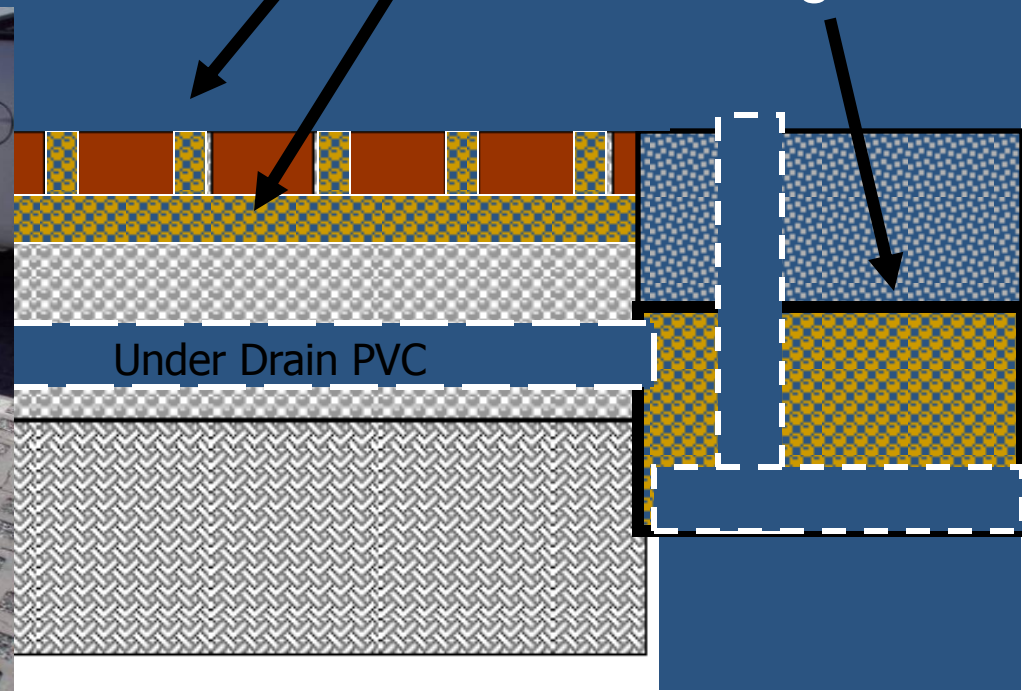
Sorbtive MEDIA

As MEDIA layer or bed in:

- Joints
- Bedding Course
- Polishing Filter

Amended Pervious Pavements

- Interlocking Permeable Pavers



Things to Avoid with “Sorptions” Materials

- **Monitor the use of materials prone to desorption**
 - **Organics / Compost / Soils**
 - **Evaluate Material**
- **Prevent leaching of other Toxics**
 - **pH, Heavy Metals**
 - **Slag, Iron-based materials, other waste by-products**



Summary

- Urban Runoff can be a significant Phosphorus contributor
- Impaired water bodies should use BMPs to treat **Dissolved Phosphorus (DP)**
- BMPs “Best Management Practices” can easily be amended to address DP removal



AP/Larry Dupont – Lake Champlain

Questions?

Scott Perry

301-279-8827

sperry@imbrium.com

