Engineering Soil Types Capacity to Remove Pollutants as a Function of Depth in Bioretention Systems

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What Are We Going To Talk About?

- Study Design to Improve State Technical Standards
- Results from first 2 years of monitoring Media-1 Bioretention Cells in Neenah
- Modification to New Soil Media
- Results from third year of monitoring Media-2

Technical Standard 1004 trying to achieve a balance between:

1. **Adequate infiltration rate**
2. **Reducing pollutant concentration**
3. **Supporting plant growth cell depths**
4. **Cost**

Soil Mixing

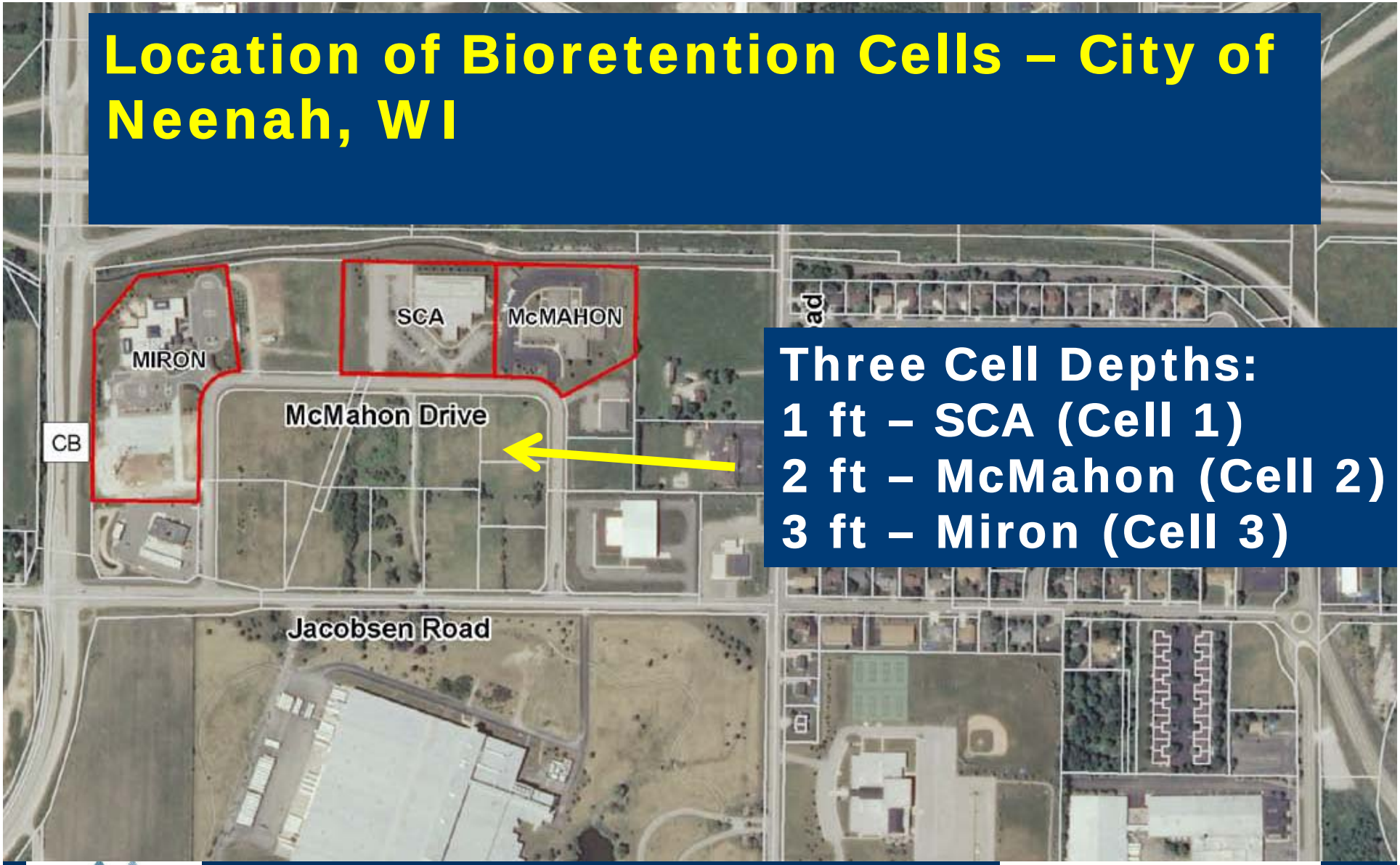
Guidelines for Depth of Engineered Soil – William Hunt, 2006

Pollutant	Minimum Engineered Mix Depth
TSS	No Minimum
Metals	18 inches
TP	24 inches
TN	36 inches

Media-1 for Three Tests Systems in Neenah – Technical Standard 1004

Engineered Soil Mix
50% sand/50% compost

Location of Bioretention Cells – City of Neenah, WI



Three Cell Depths:
1 ft – SCA (Cell 1)
2 ft – McMahon (Cell 2)
3 ft – Miron (Cell 3)

SCA

McMAHON
ENGINEERS ARCHITECTS

TEAM Miron
Customer Driven Solutions

Neenah Bioretention – Clay Soils and High Bedrock

Geosynthetic Fabric and Perforated Drain Pipe

Perforated Drain Pipe & Filter Sock


Completed System in Neenah
08/21/2009 14:33

Monitoring Tasks:

1. Flow and EMCs inlet
2. Flow and EMCs outlet
3. Bypass flow
4. Soil Moisture
5. Weather
6. Soil Chemistry

Media-1 Efficiency Ratios for TSS:

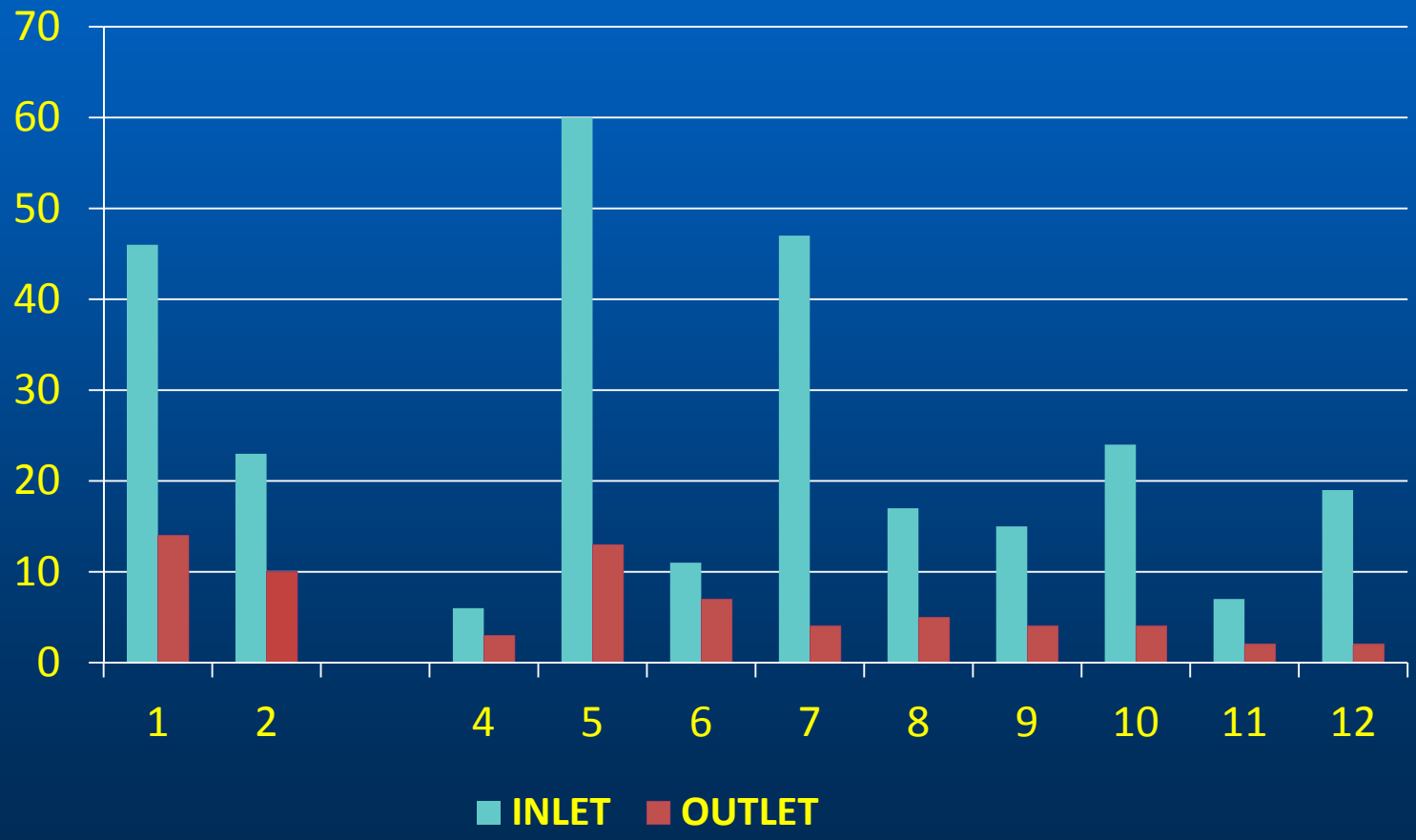
Eff Ratio = 1- (avg. outlet conc./avg. inlet conc.)

Site	Inlet TSS, mg/l	Outlet TSS, mg/l	Efficiency Ratio TSS, %
Cell 1 (16)	113	10	91
Cell 2 (19)	31	6	81
Cell 3 (21)	27	9	65

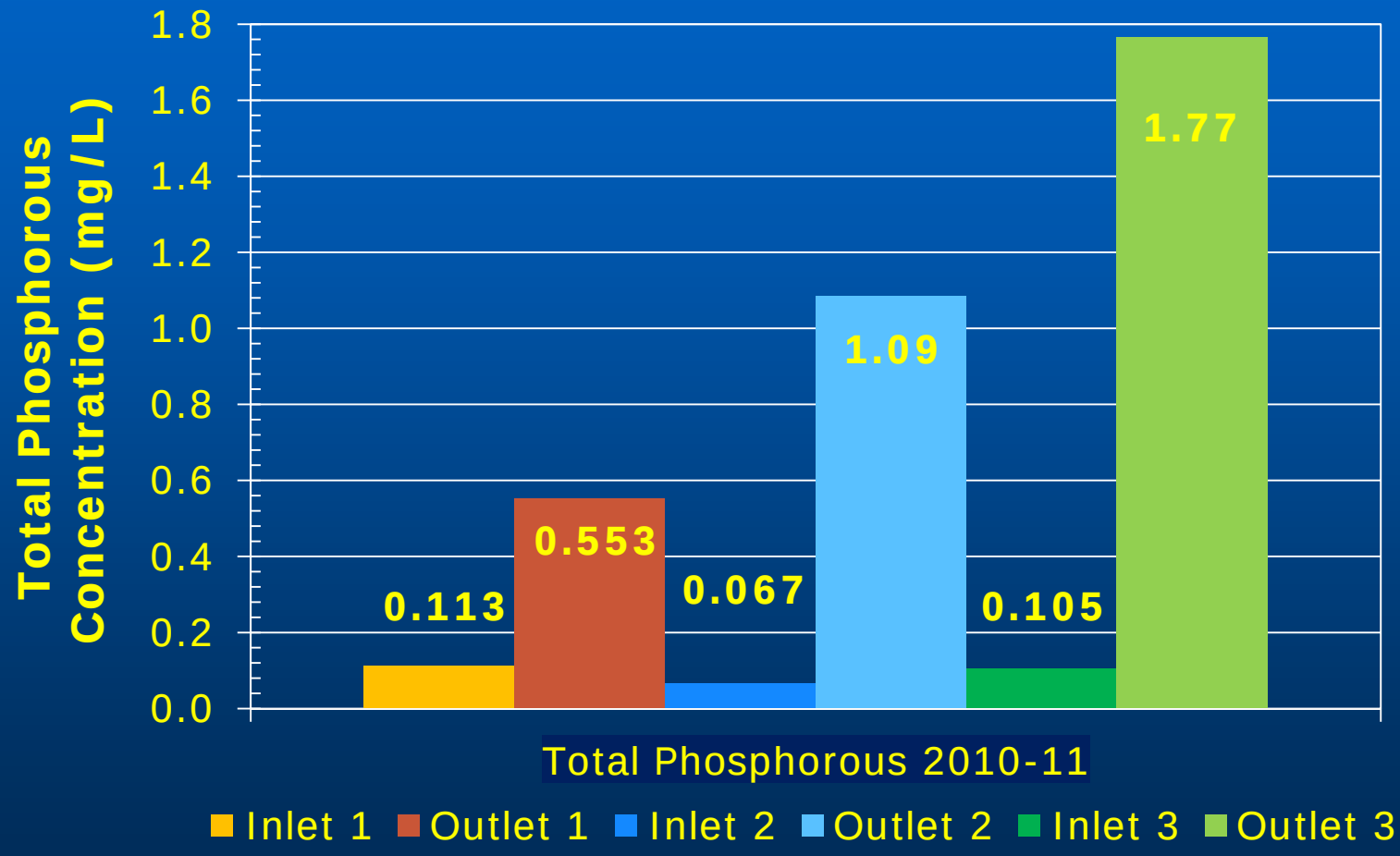
TSS Efficiency Ratios from Other Sites

Site	Inlet TSS, mg/l	Outlet TSS, mg/l	Efficiency Ratio, %
Brown, 2010	25	7	71
Hatt, 2008	39	4	76
Davis,2007	34	13	62
Li, 2009	66	6	88

Media-1 Suspended Sediment Concentration, mg/l, at the Inlet and Outlet of 2 Foot Depth Media



Media-1 Comparing Average Inlet and Outlet Total Phosphorus Concentrations

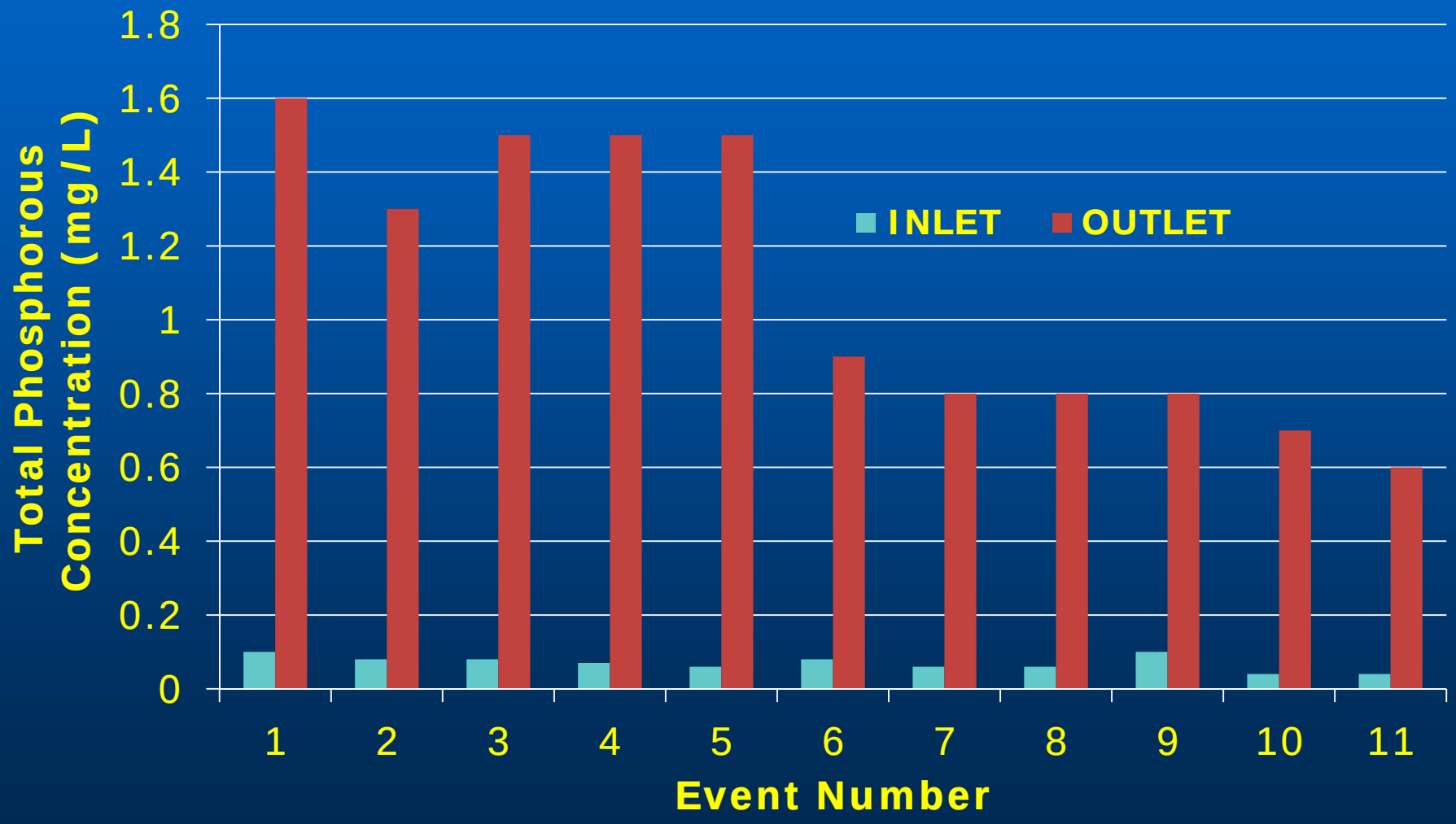


Reductions -400 percent or greater

Export of TP at Other Sites

Site	TP Inlet, mg/l	TP Outlet, mg/l	Efficiency Ratio TP, %
Hatt, 2008: HO	0.07	0.17	-398 (300mg/Kg – P)
Hunt, 2006: HP			-269
Li,2009: HO	0.1	0.35	-200

Media-1 Total Phosphorus Concentrations at the Inlet and Outlet of 2 Foot Depth Media-1



Diss. P is about 85% of TP

Simulating Event with City Water to Determine Mobility of Media Particles

Type of Value	2 Foot Depth Media	3 Foot Depth Media
City Water - Inlet TSS	< 2 mg/l	< 2 mg/l
City Water - Outlet TSS	3	3
Last Event Outlet TSS	6	9
City Water – Outlet TP	0.6	0.9
Last Event Outlet TP	0.6	0.9
Particle Size - Outlet	< 63 microns	< 63 microns

TP Concentration After 2 Years in Media-1 at Different Depths

Type of Sample	TP Concentration, mg/kg
Media-1 before installed	367
2 inches	223
4 to 6 inches	302
18 inches	304
24 inches	212

Media-1 During Installation

Immediate Change to Bioretention Engineered Soil Mix – Technical Standard 1004

The planting mix shall consist of 70 to 85% sand and 15 to 30% compost


Adam St. Inlets to
Rain Gardens

Engineered Soil Mixes Designed to Eliminate P Export

Source	% Sand	% Fines	% O M	CEC, meq/100g	Perm. in/hr
Austin	70-90	2-10	1-4	10	
FAWB	Loamy sand	< 3 w/w	<5 w/w		4-12
NCSU	85-88	8-12	3-5	>10	2

What is P Reduction Using Suggested Soil Mix?

Source	Inlet TP, mg/l	Outlet TP, mg/l	TP Removal, %	Comment
Brown, 2010	0.073	0.059	19 (1 event higher)	2.5% Compost
Hunt, 2006			22-68	Low P index (<30)
Hatt, 2008	0.4	0.07	82	Sandy loam

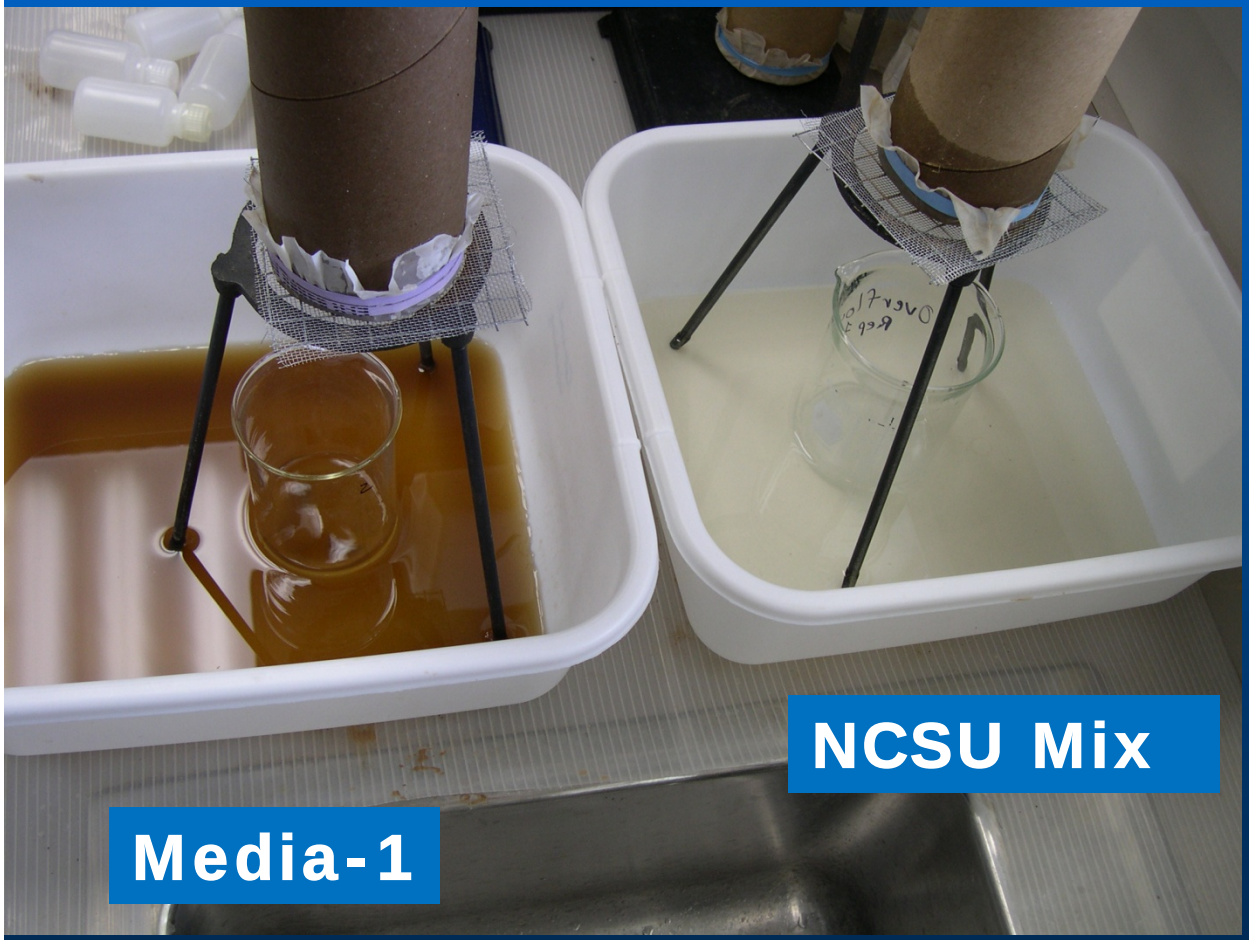
Arkal Pressurized Sand Filter

TSS	83%
TP	54%
Diss. P	9%

Austin Surface Sand Filter – 18 to 24 inches Thick

TSS	75 to 87%
TP	27 to 61%

What About Removing Dissolved Phosphorus?



1. Conduct Leaching Tests on Media-1 and NCSU Mix
2. Determine Best Additive to Enhance P Sorption.

Mauricio Avila and Philip Barack- University Soils and Plant Lab. & Soils Dept.

Choices of Additives to Reduce Dissolved P

Media-2 for Three Tests Systems in Neenah

- 86% Sand;
- 11% Peat Moss;
- 3% SorbtiveMedia (Imbrium)

Replacing Media at Neenah Sites

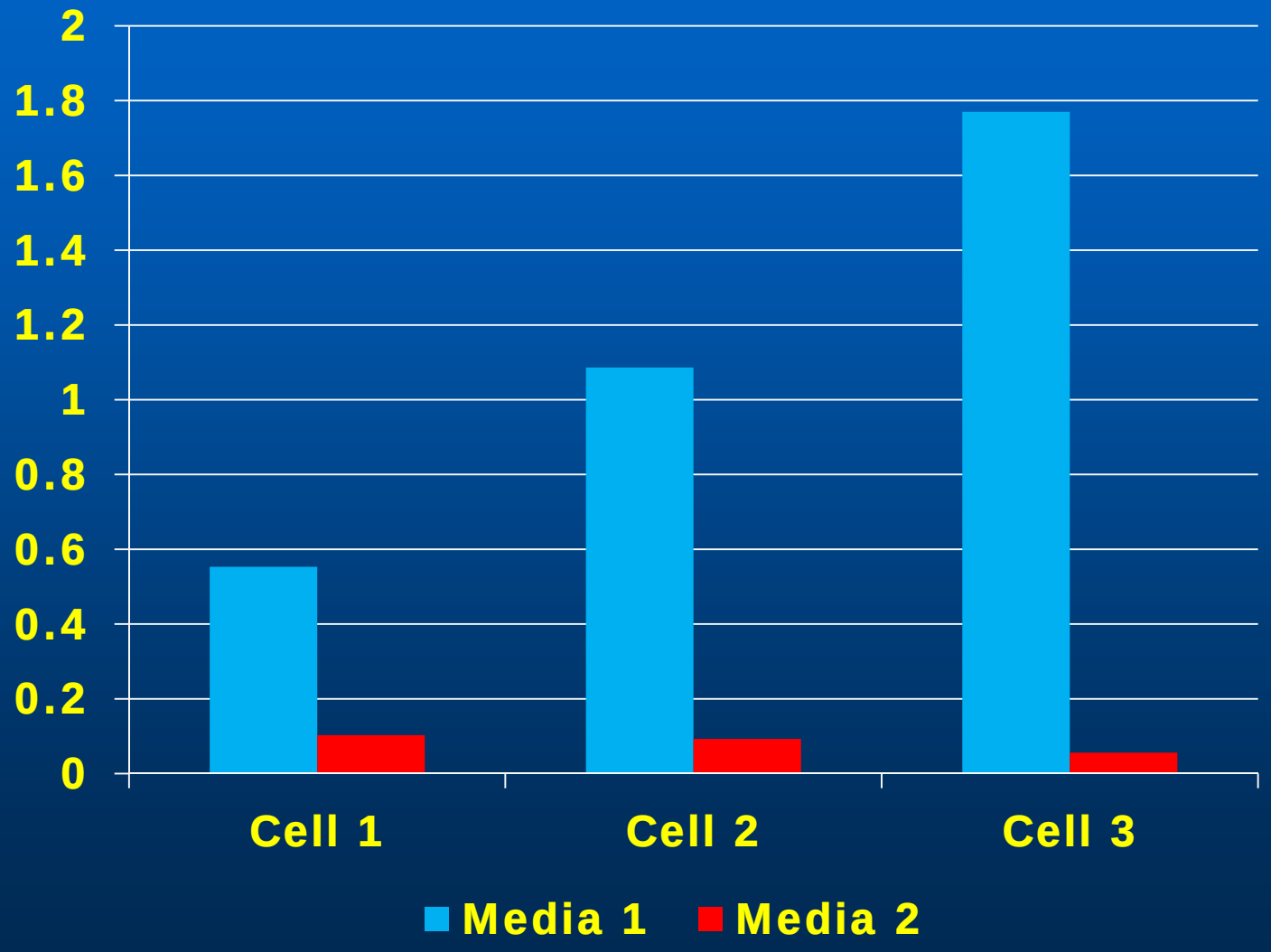

Media-2 (McMahon) 2 feet deep; 86% Concrete Sand, 11% Peat Moss, and 3% Sorbtive Media
11/15/2011

Media-2 Efficiency Ratios for TSS:

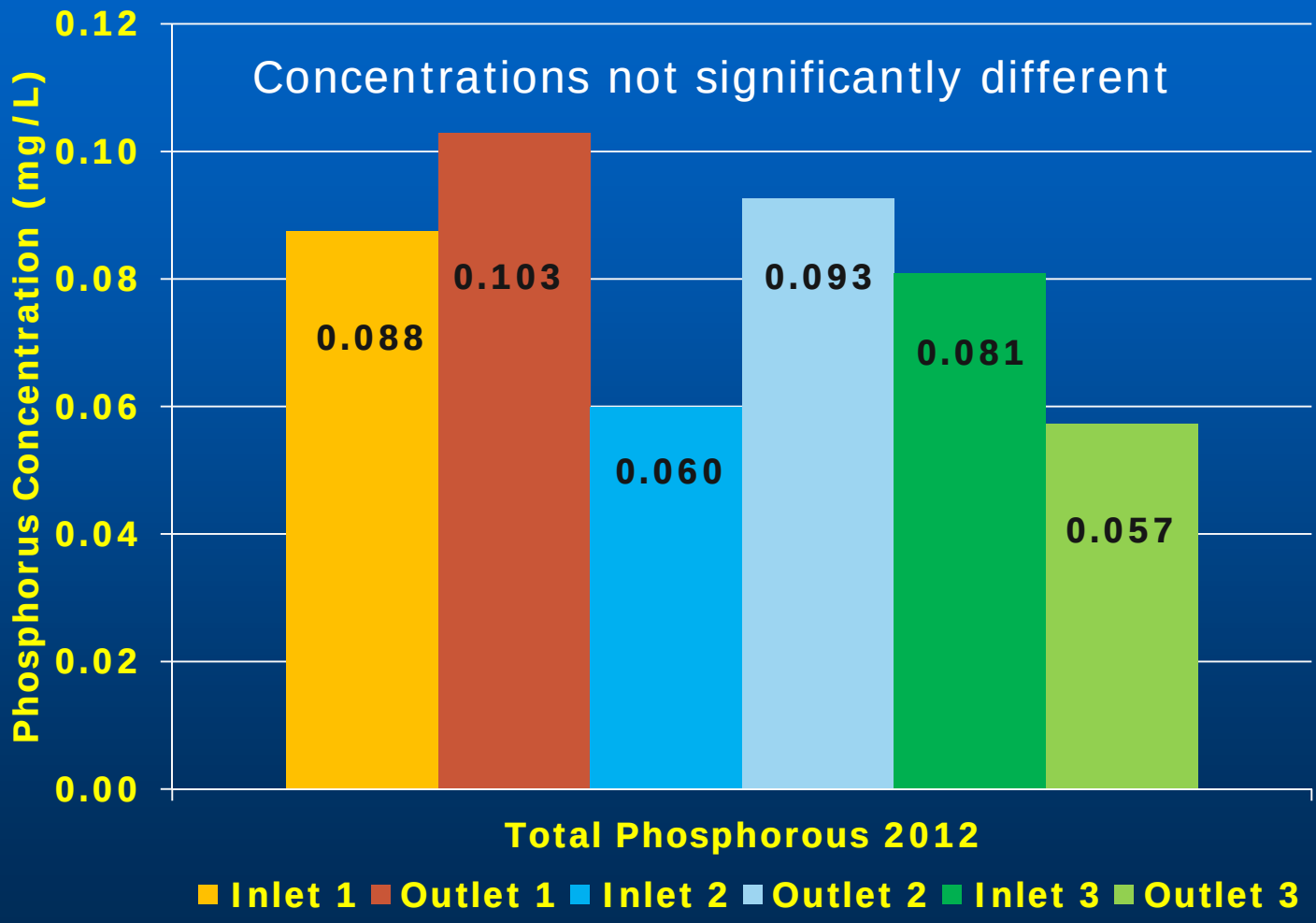
Eff Ratio = 1- (avg. outlet conc./avg. inlet conc.)

Site	Inlet TSS, mg/l	Outlet TSS, mg/l	Efficiency Ratio TSS, %
Cell 1 (16)	62	8	88
Cell 2 (16)	32	9	71
Cell 3 (14)	46	12	74

Comparison of Outlet Total P Concentrations for Media 1 and 2



Media-2 Comparing Average Inlet and Outlet Total Phosphorus Concentrations



Diss. P is about 45% of TP

Implication from this Study

- **Modify the Technical Standards**
- **Layering growth layer on top of media**
- **Removal of Dissolved Phosphorous by Sorptive Media**