

Optimization of Bioretention Soil Mix for Nutrient Removal

LID Research and Innovation Symposium

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Department of Civil Engineering
University of New Hampshire**



Special Thanks

Tom Ballestero – UNHSC Director

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Funders:

Stantec

EPA Region 1

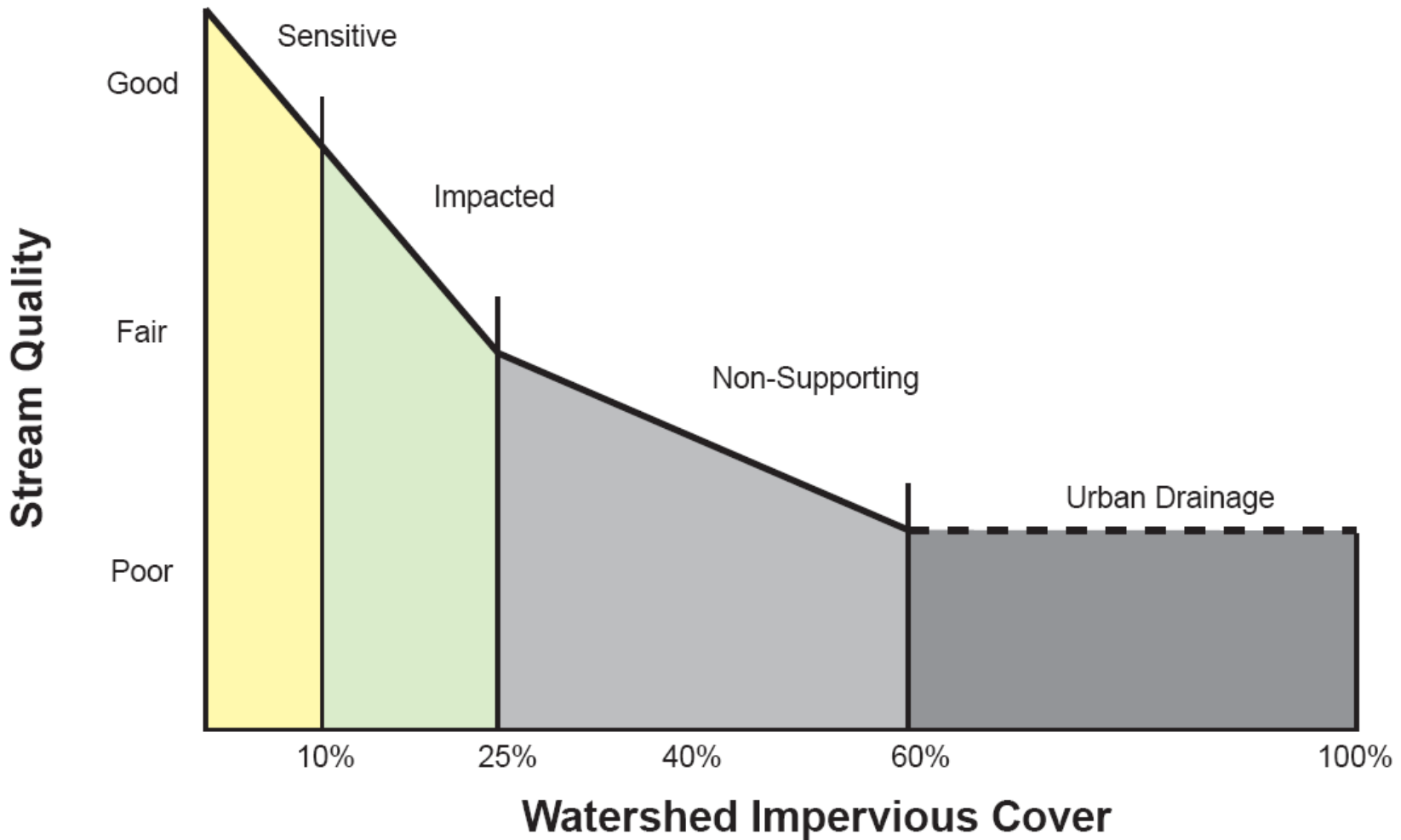
Part of the Problem – Point Source Pollution



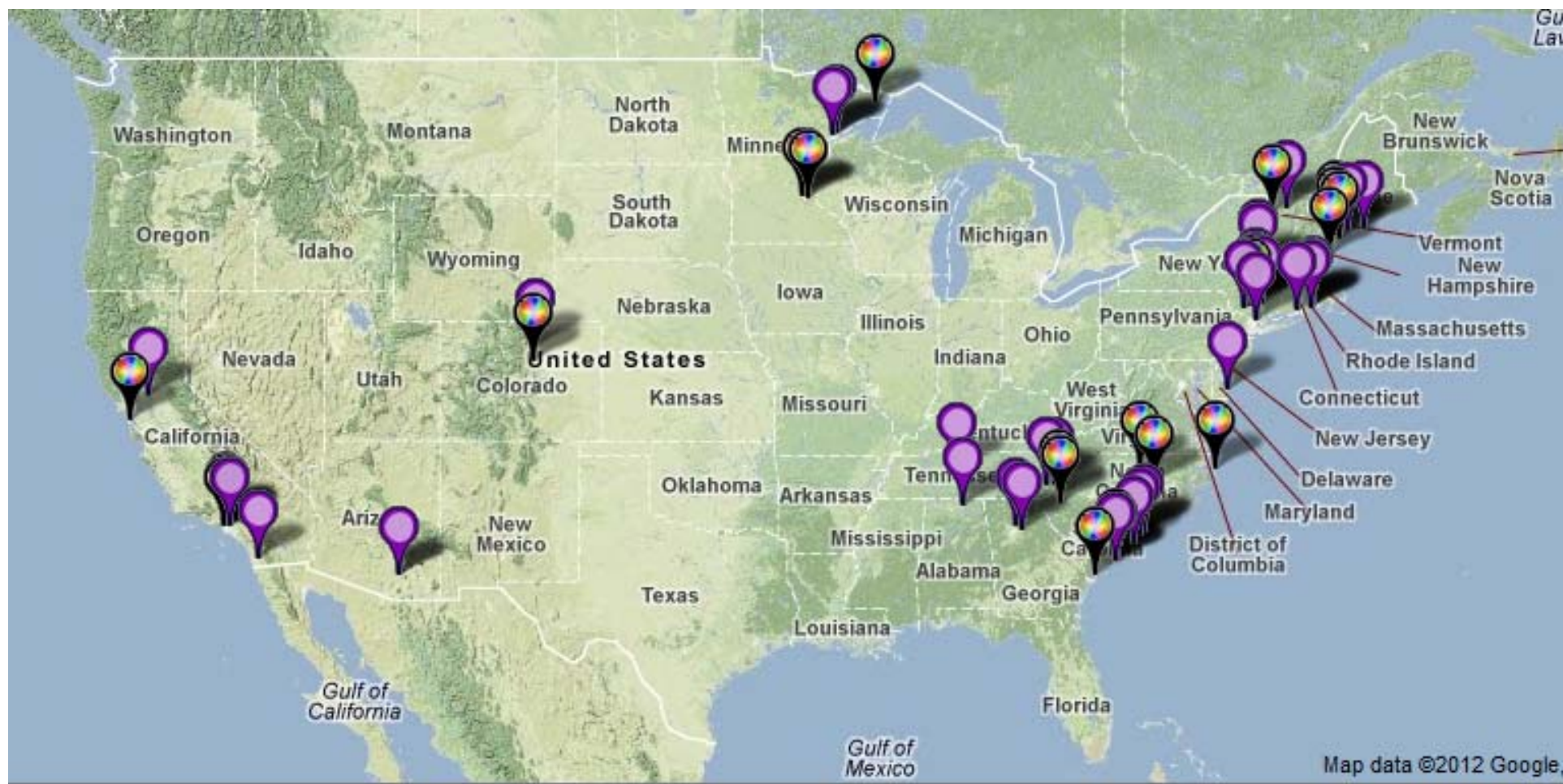
SMP97-11/1-CLEVELAND, O.: Firemen stand on bridge over Cuyahoga River to play water on tug Arizona as fire, started in an oil slick on the river, swept docks at the Great Lakes Towing Co., here today. The blaze destroyed three tugs, three building and the ship repair yards. Damage was not estimated. UNITED PRESS TELEPHOTO

FW

Impact of Impervious Cover



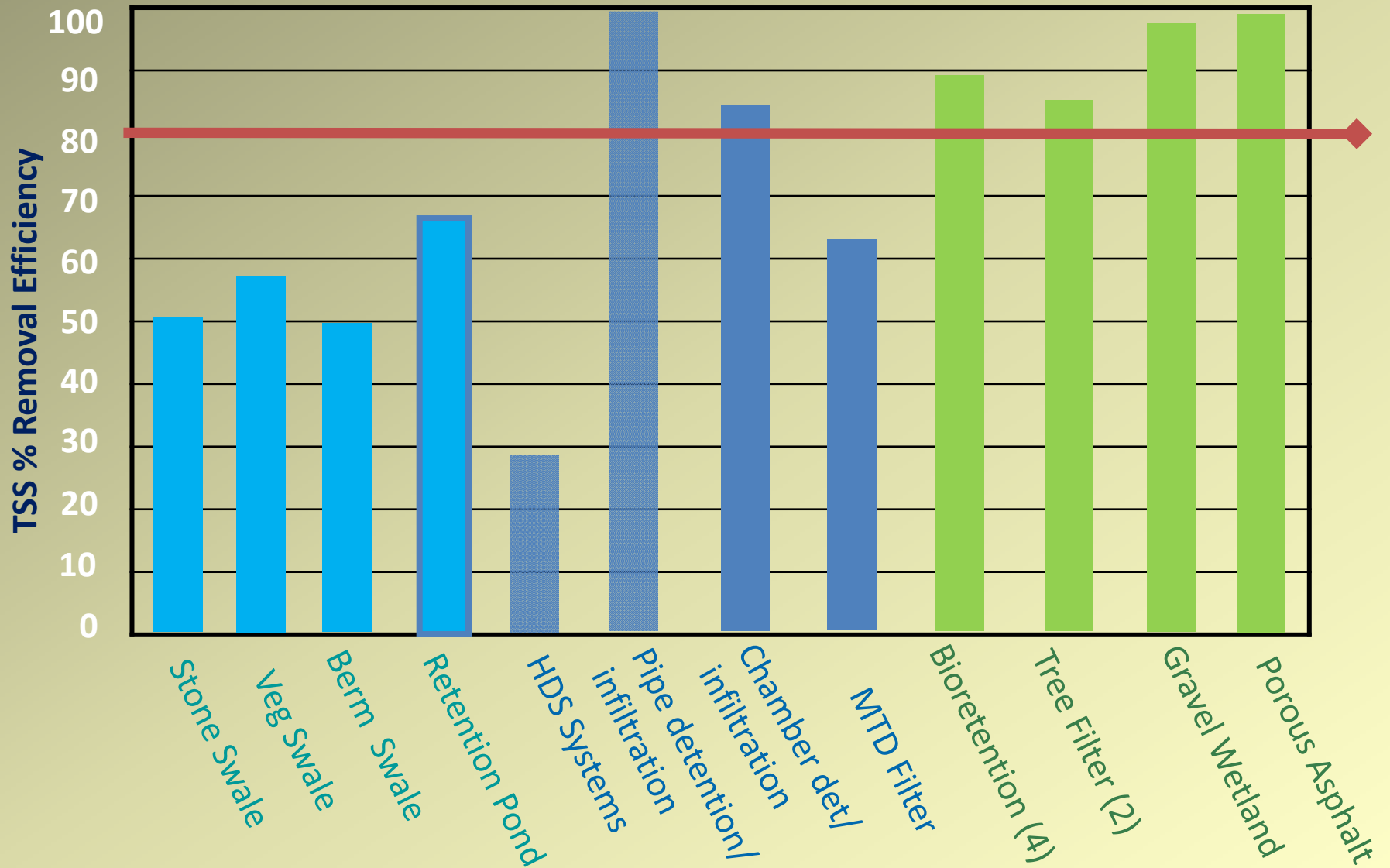
LID in 2006



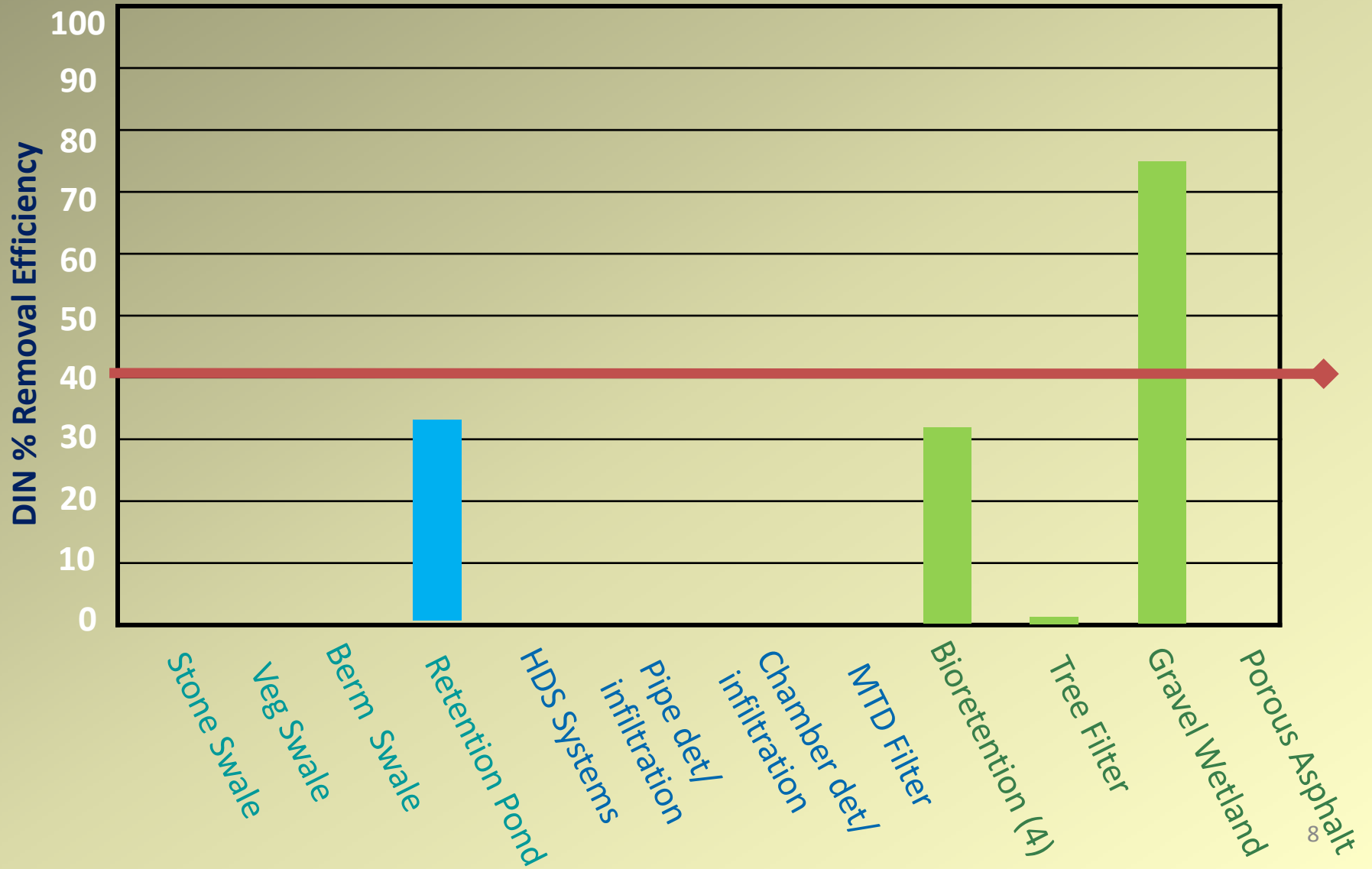
LID in 2013



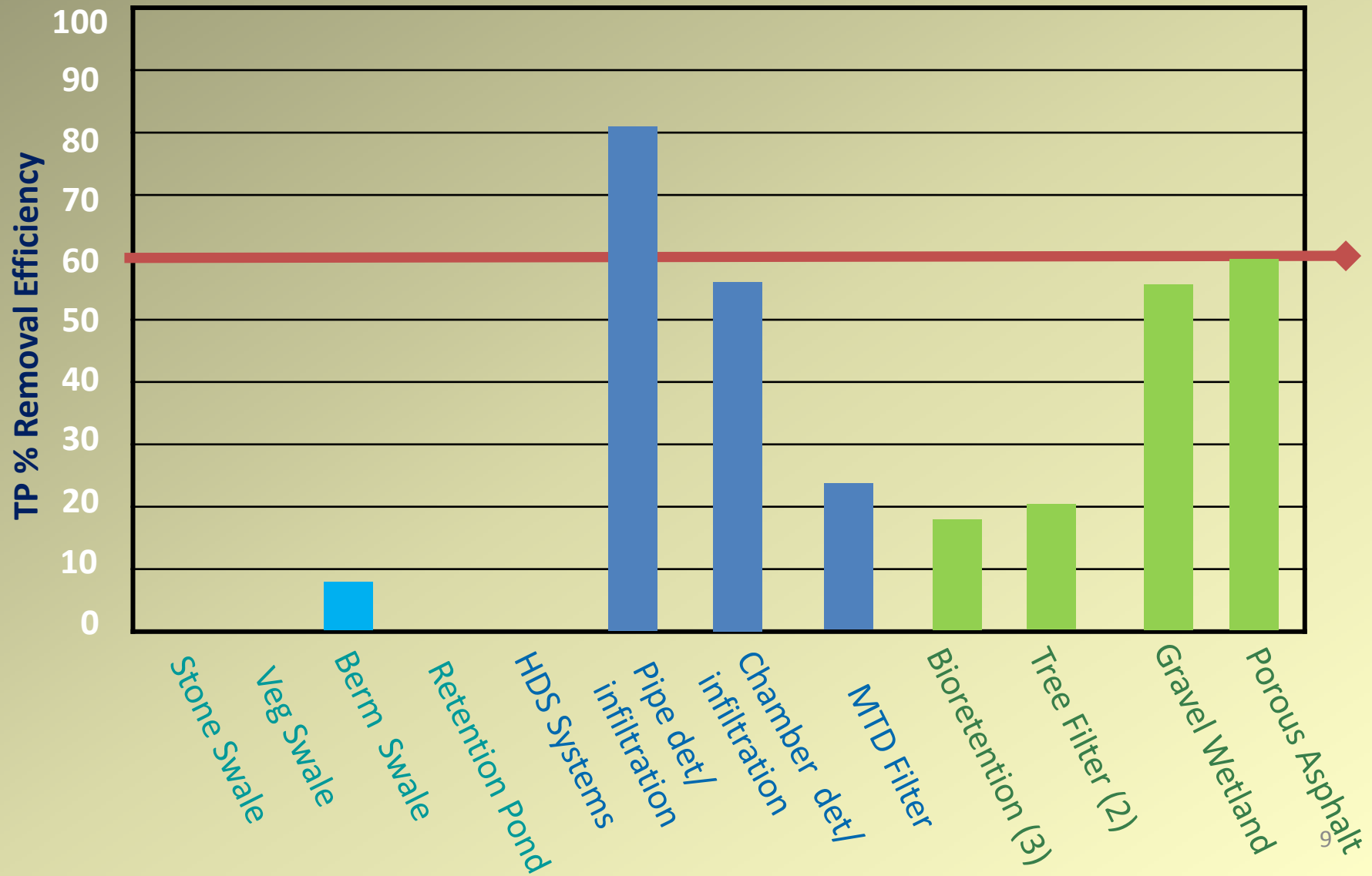
TSS Removal Efficiencies



DIN Removal Efficiencies



TP Removal Efficiencies



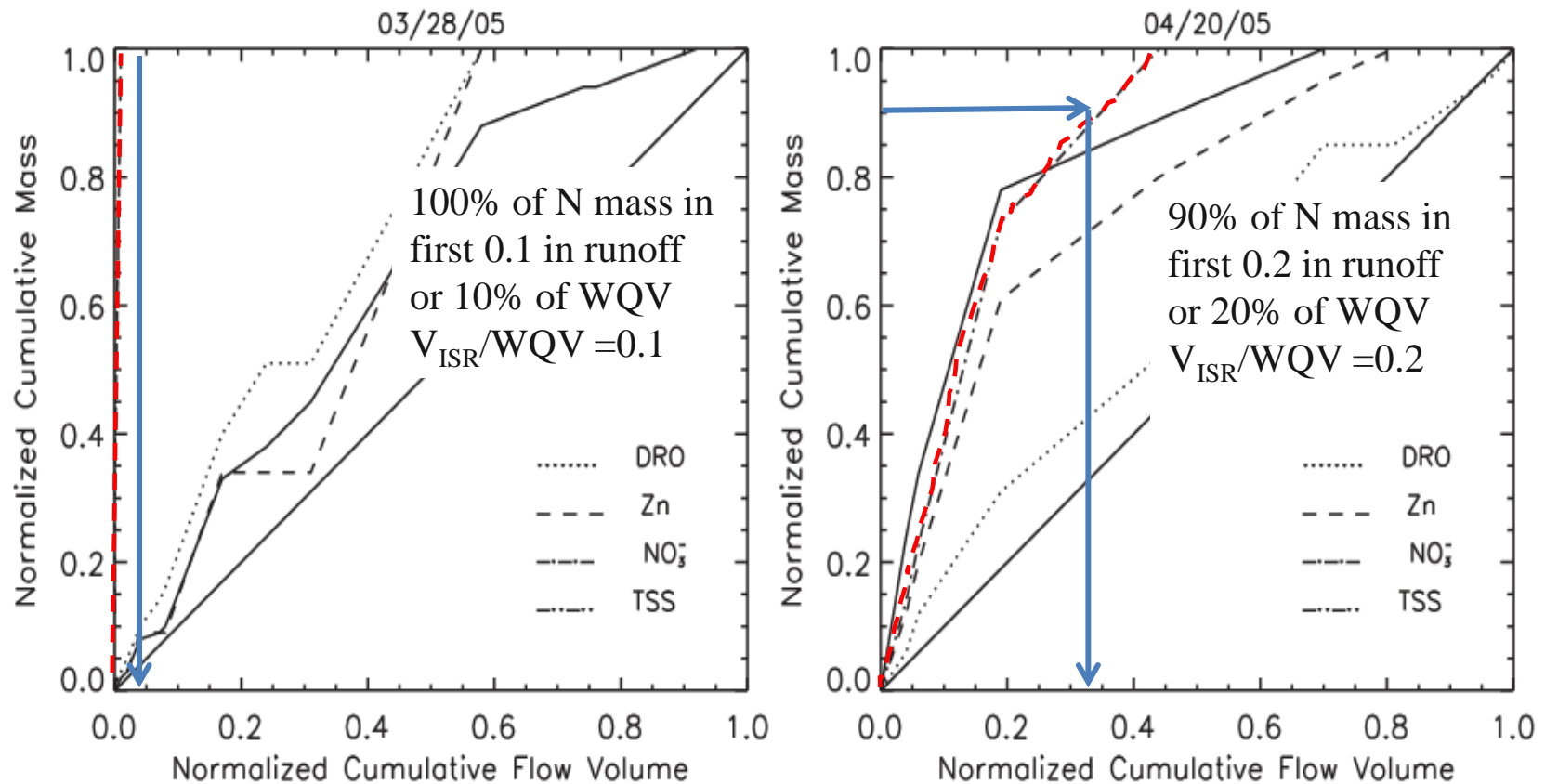
Unit Operations & Processes (UOPs) in the Gravel Wetland

- Physical Operations
- Biological Processes
- Chemical Processes
- Hydrologic Operations



What we know

- Nitrogen is controlled through vegetative uptake and anaerobically through microbial denitrification
- Phosphorus is controlled through veg uptake and sorbed to electrostatically charged soil particles (clay/humus/orgnaic matter)



Mass loading for DRO, Zn, NO₃, TSS as a function of normalized storm volume for two storms: (a) a large 2.3 in rainfall over 1685 minutes; (b) a smaller 0.6 in storm depth over 490 minute. DRO=diesel range organics, Zn= zinc, NO₃= nitrate, TSS= total suspended solids

Experimental Design

Phase 1: Test Drain time
and ISR:WQV Ratio

Phase 2: Test
bioretention soil mix and
four different soil
amendments

Phase 3: optimize the
ratio of loam to sand for
P removal, as well as to
further optimize the soil
to soil amendment ratio
for top mixes (Fe_2 and
WTR)

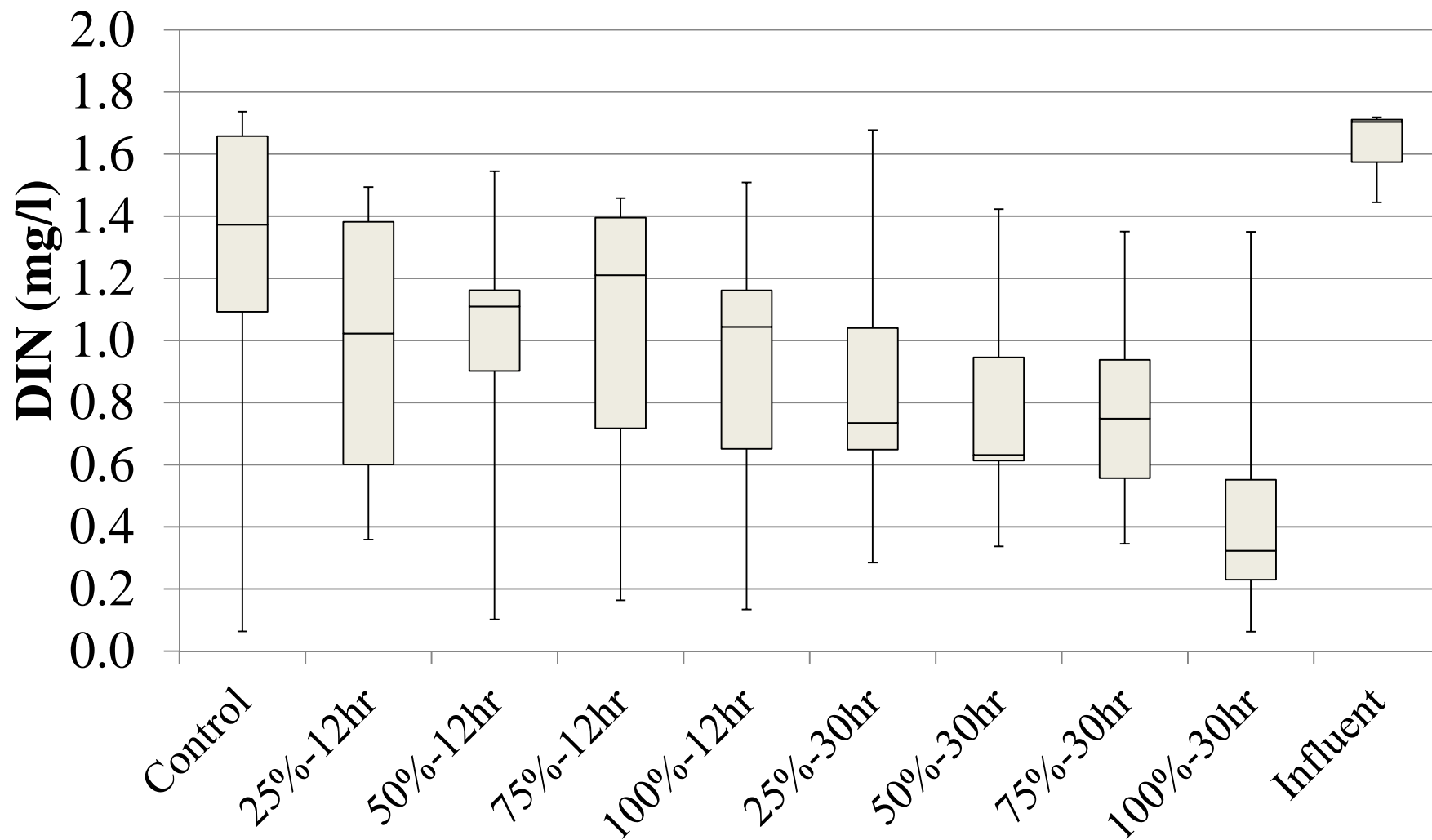


Phase 1

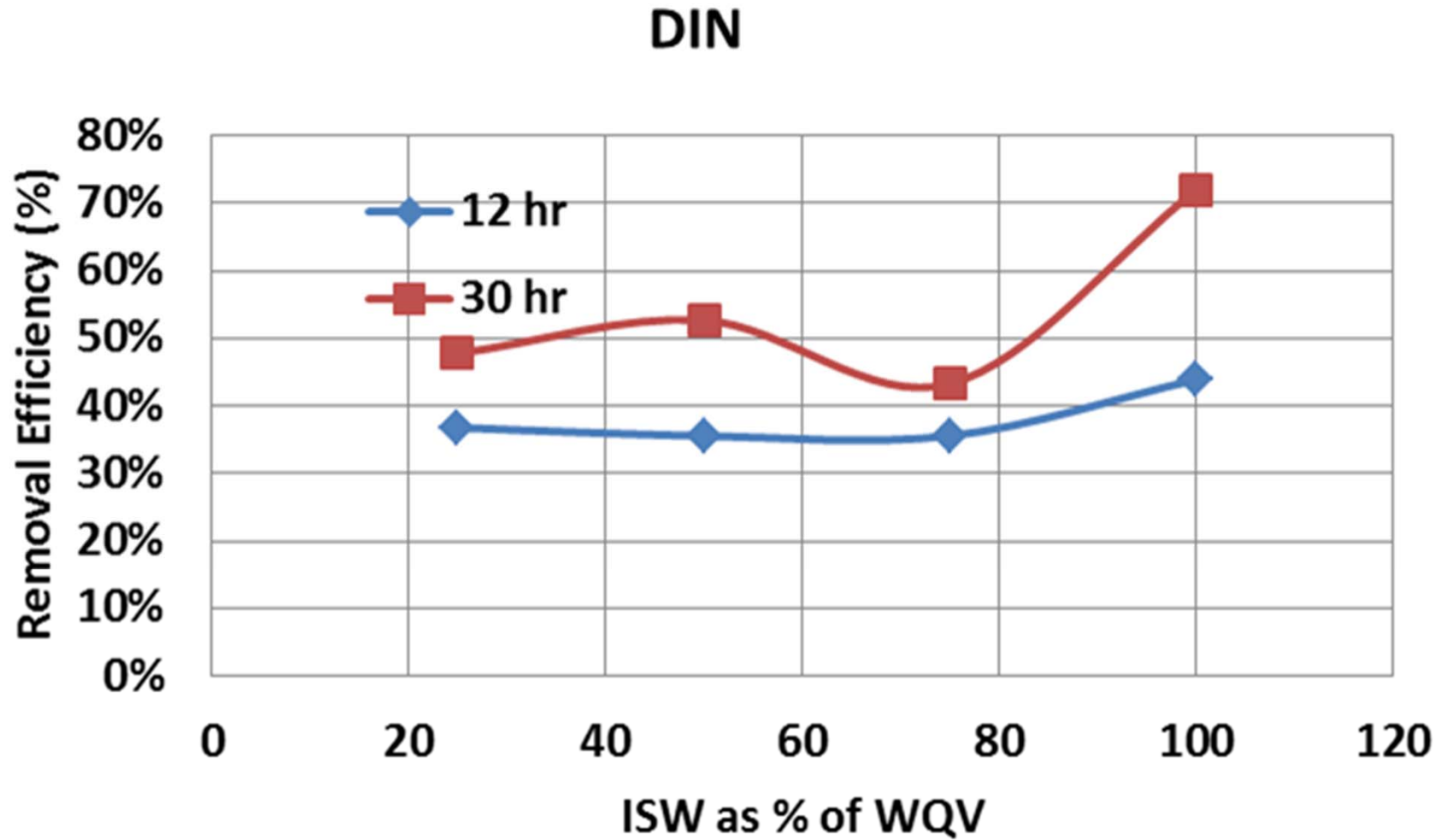
Column #	Soil Mix and saturation zone size	Notes
T1-N0	UNHSC BSM with no saturation zone (control)	<ul style="list-style-type: none"> • Drainage to filter ratio 80:1 • Soil depth in columns: 24" • 12 hour drain time • Soil tested: UNHSC mix
T1-N1	UNHSC BSM with 25% WQV	
T1-N2	UNHSC BSM with 50% WQV	
T1-N3	UNHSC BSM with 75% WQV	
T1-N4	UNHSC BSM with 100% WQV	
T1-N5	UNHSC BSM with 25% WQV	<ul style="list-style-type: none"> • Drainage to filter ratio 80:1 • Soil depth in columns: 24" • 30 hour drain time • Soil tested: UNHSC mix
T1-N6	UNHSC BSM with 50% WQV	
T1-N7	UNHSC BSM with 75% WQV	
T1-N8	UNHSC BSM with 100% WQV	



Nitrogen Results



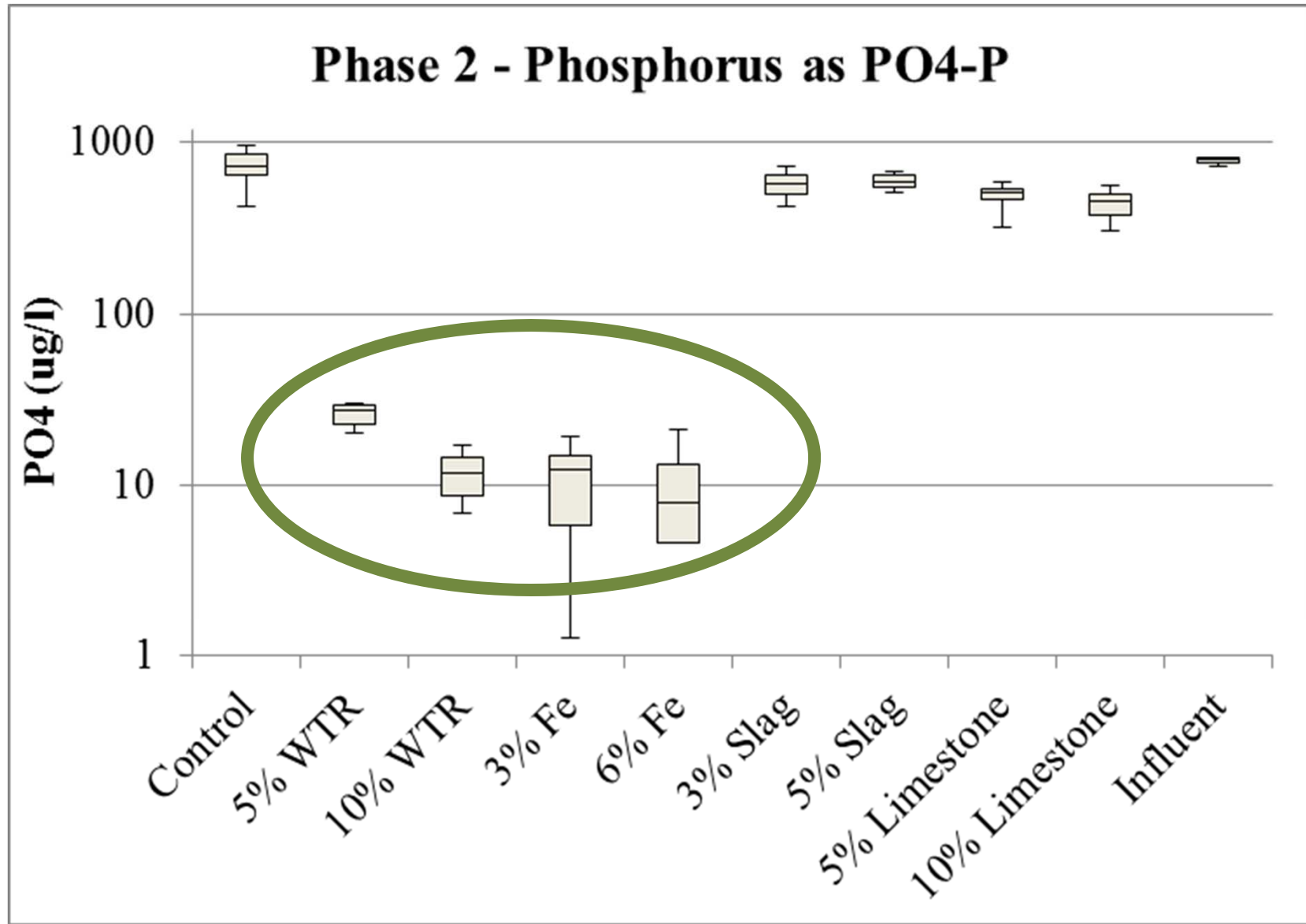
Nitrogen Results



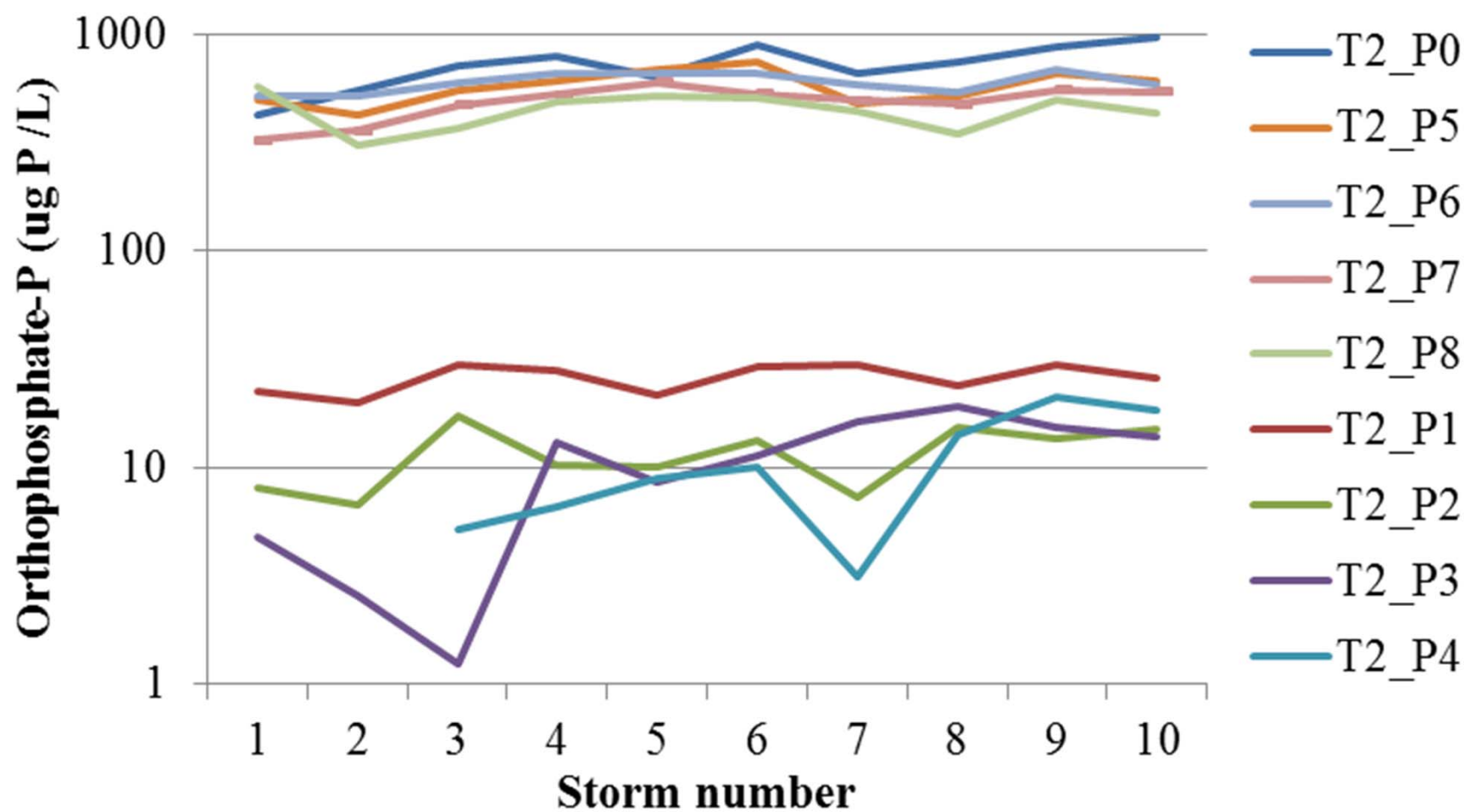
Phase 2: Phosphorus

Column #	Soil Mix	Notes
T2-P0	UNHSC BSM (control)	<ul style="list-style-type: none"> • Drainage to filter ratio 80:1 • Soil depth in columns: 24" • 24 hour drain time • Soil tested: UNHSC mix
T2-P1	UNHSC 95% BSM + 5% WTR	
T2-P2	UNHSC 90% BSM + 10% WTR	
T2-P3	UNHSC 97% BSM+3% Fe ₂	
T2-P4	UNHSC 94% BSM+6% Fe ₂	
T2-P5	UNHSC 97% BSM+3% Slag	
T2-P6	UNHSC 95% BSM+5% Slag	
T2-P7	UNHSC 95% BSM +5% Limestone	
T2-P8	UNHSC 90% BSM +10% Limestone	

Phosphorus Results



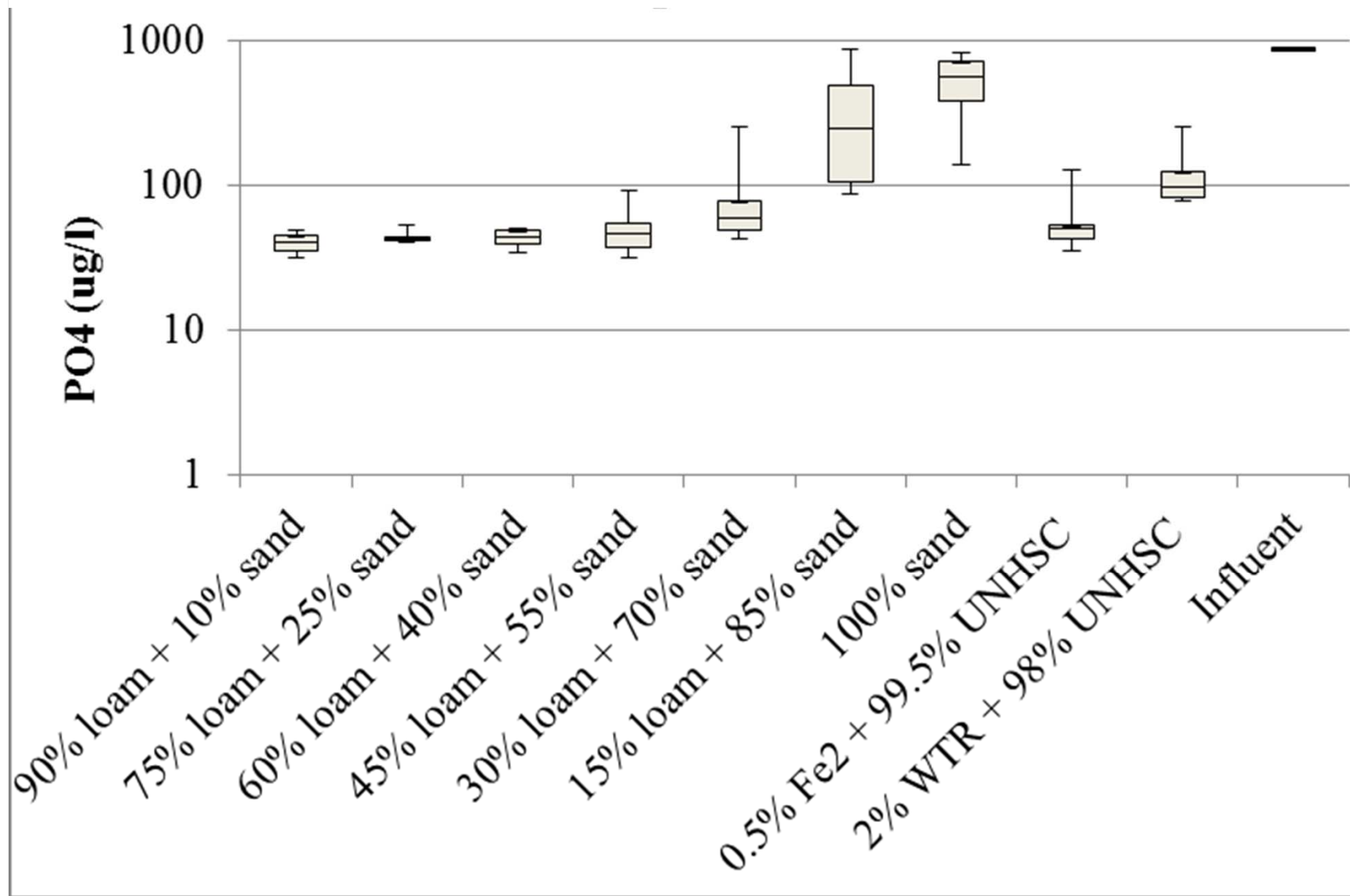
Phase 2 - PO₄-P

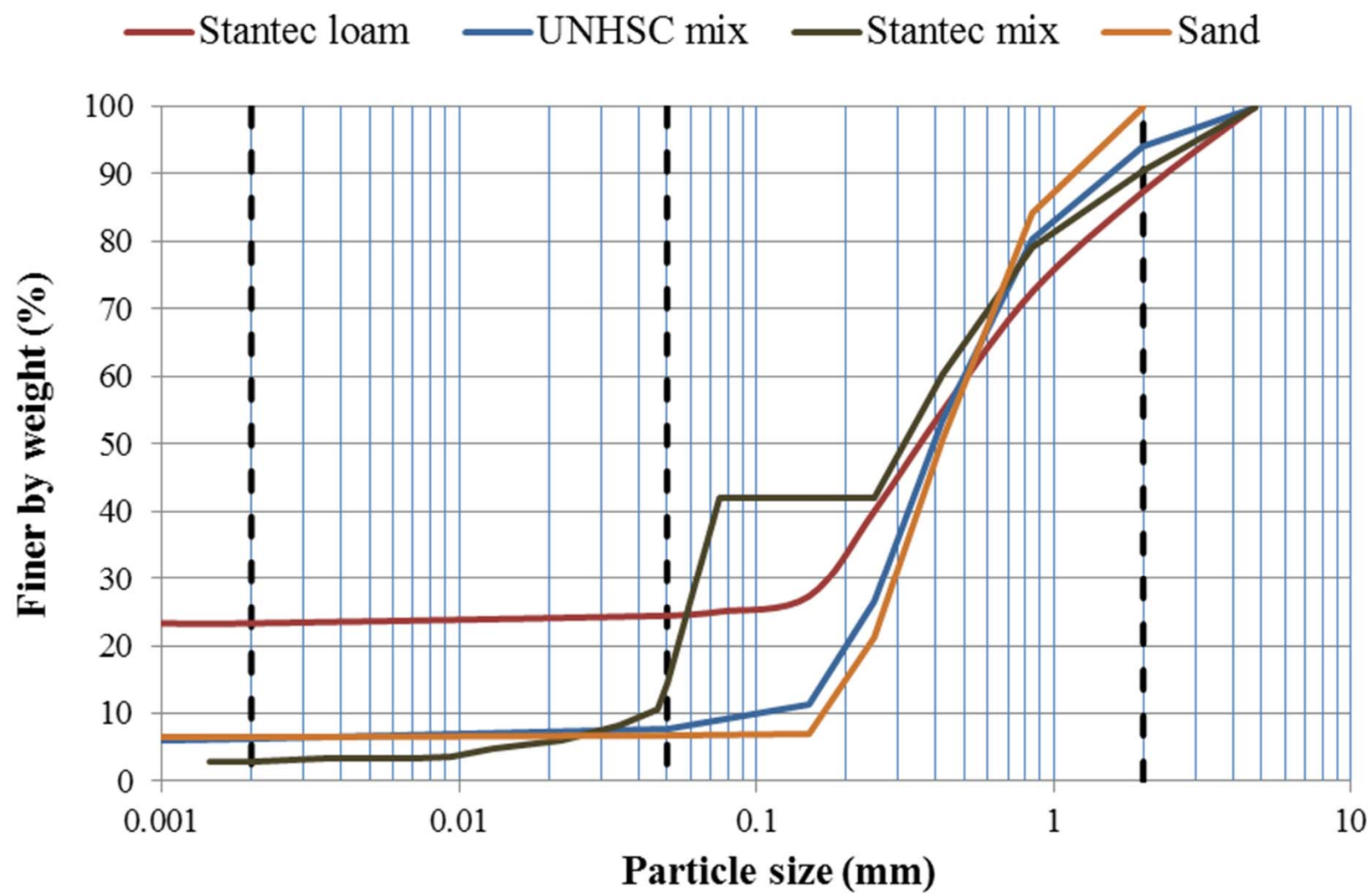


Phase 3: Phosphorus Optimization

Column #	Soil Mix	Notes
T4-P1	90% Stantec loam + 10% sand	<ul style="list-style-type: none">• Drainage to filter ratio 25:1• Soil depth: 12"• Percentage of amending materials was based on test results from Phases 2 and 3
T4-P2	75% Stantec loam + 25% sand	
T4-P3	60% Stantec loam + 40% sand	
T4-P4	45% Stantec loam + 55% sand	
T4-P5	30% Stantec loam + 70% sand	
T4-P6	15% Stantec loam + 85% sand	
T4-P7	100% sand	
T4-P8	0.5% Fe ₂ + 99.5% UNHSC mix	
T4-P9	2% WTR + 98% UNHSC mix	

Optimization Results





Conclusions - the obvious!

- Compost leaches nutrients
- Filters are superior at sediment removal
- Hydraulic loading ratio and retention time have a large influence on performance



Conclusions – the promising...

- Modified bio systems show remarkable improvements to DIN and Ortho-P removals in the lab and in the field: ~ 60 - >90%
- Nitrogen removal is less media dependent and improves with ISR and with longer retention
- Loam has an excellent P-sorp capacity and should be incorporated in higher proportions in BSM

Conclusions – the curious...

- Details regarding BSM components are vague at best
- If optimal RE are to be achieved designs should be fine tuned and systems maintained



An aerial photograph of a wide river flowing through a landscape with autumn foliage. A bridge crosses the river in the upper middle section. The riverbanks are covered with trees in shades of green, yellow, and orange. There are some marshy areas with small pools of water along the banks. The word "Questions?" is overlaid in large, bold, black text in the center of the image.

Questions?