Florida Chamber Summer School
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Stormwater Treatment Wetlands

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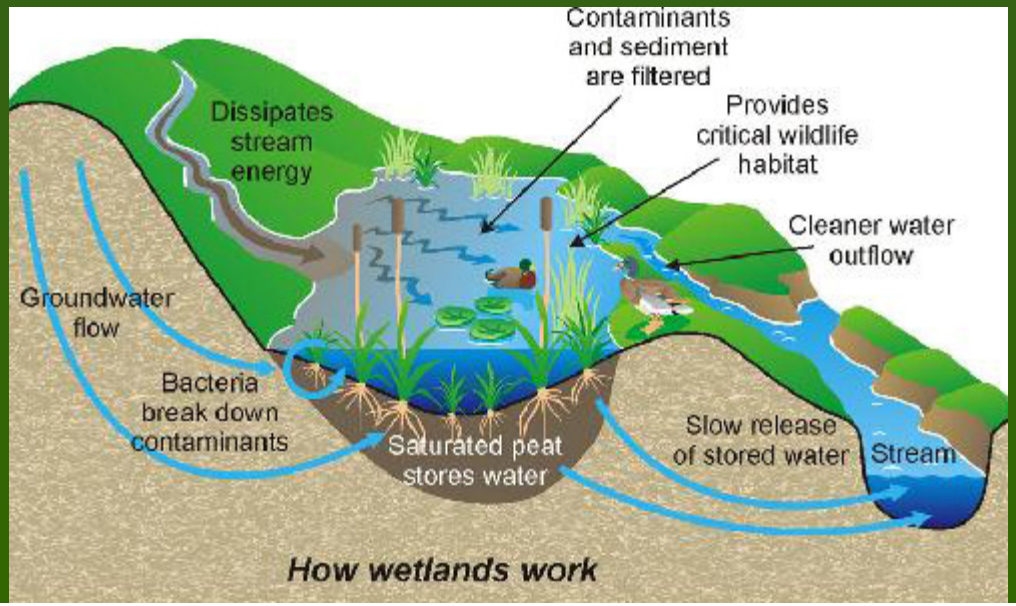
Why Wetlands?

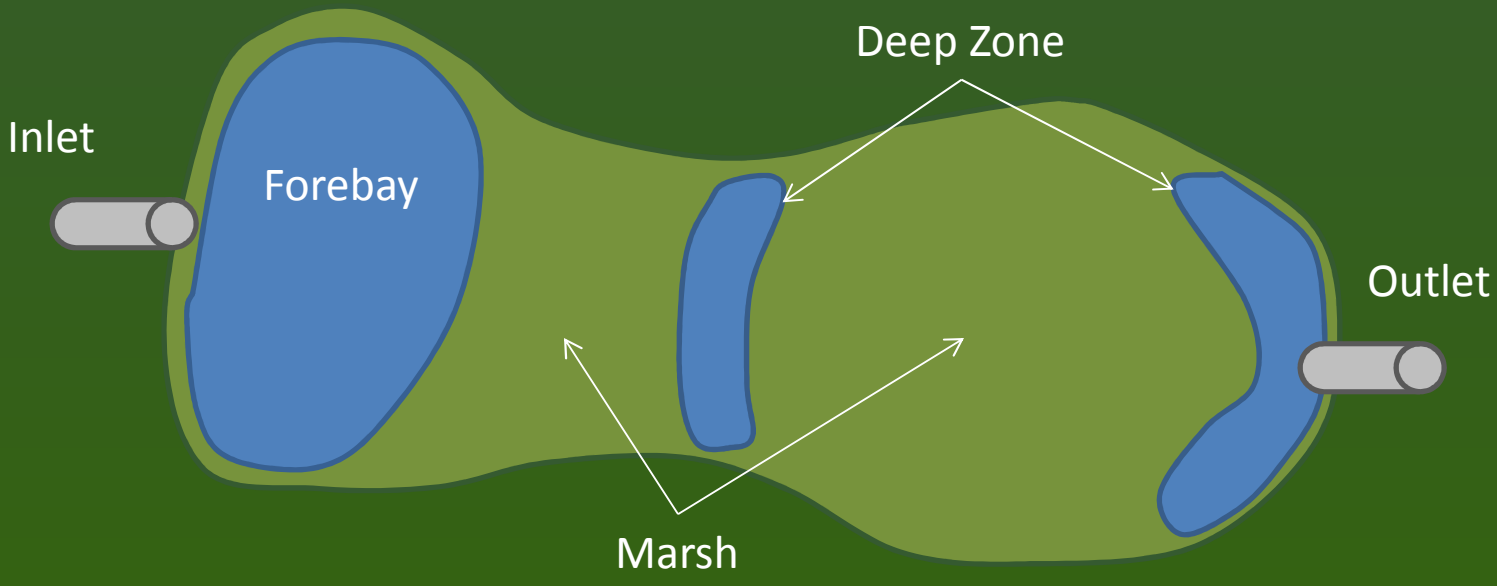
- Wetlands are the natural stormwater management systems in the landscape
- Wetlands remove or transform a wide range of pollutants found in urban runoff (BOD, TSS, N, P, pathogens, metals, hydrocarbons, etc.)

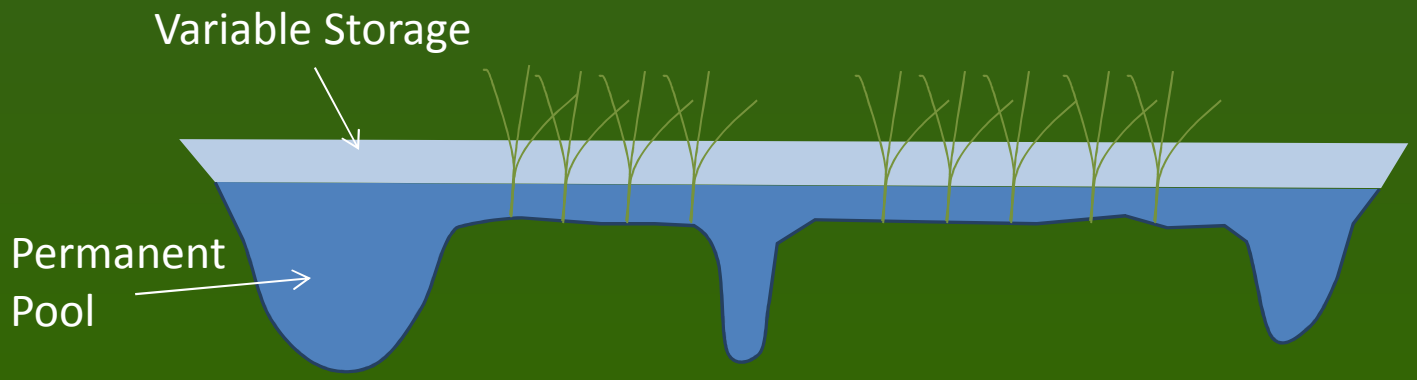


Stormwater Wetland Plant Communities

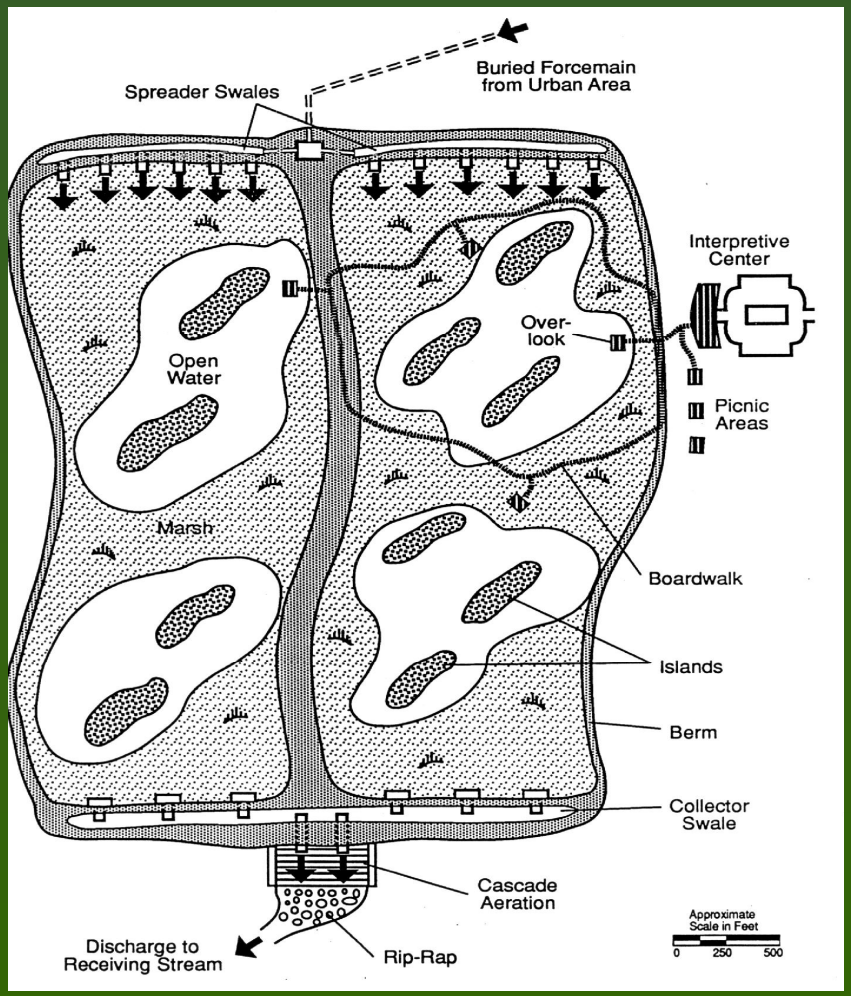
- Similar planting palette as wastewater wetlands
- Potentially wider range of hydrologic tolerance required
- Salt tolerance necessary in brackish/coastal systems

Typical Stormwater Wetland Layout



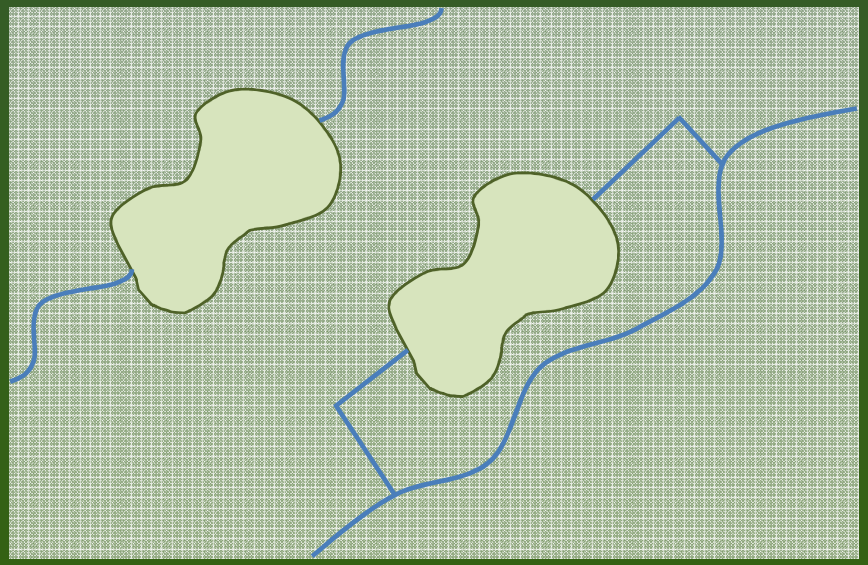


Conceptual Design for Multiple Benefits



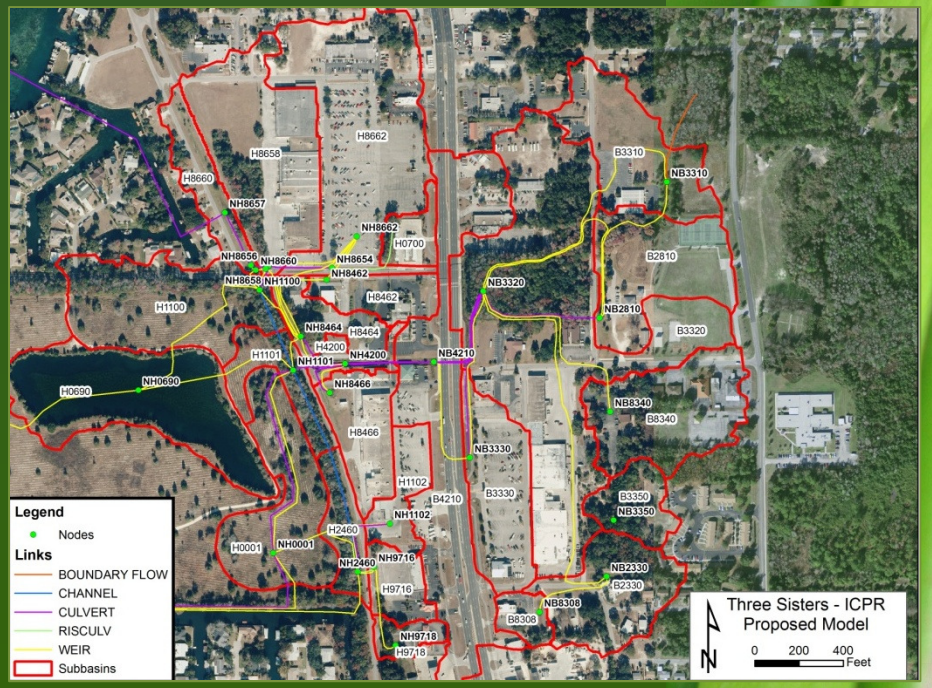
Design Considerations

- System Location
  - In-line
  - Off-line
- Flow Delivery
  - Gravity
  - Pumping
- Outlet Design
  - Flexibility is important
- Wetland Hydrology
  - Too dry = soil oxidation, nutrient export, transitional/upland vegetation
  - Too wet = pond



Stormwater Design Basis

- Flow Characteristics
  - Rainfall
  - Infiltration
  - Runoff
- Pollutant Loads
  - Watershed characteristics
  - Estimated concentrations
  - Direct measurement
- Design Methods
  - Wetland:watershed area
  - Design storm detention
  - Annual averaging
  - Dynamic modeling



Method 1: Wetland/Watershed Area

- Measure area of drainage basin
- Apply selected Wetland to Watershed Area Ratio (WWAR), typically 2 to 5%
- Allocate wetland surface area to 20% pool and 80% marsh

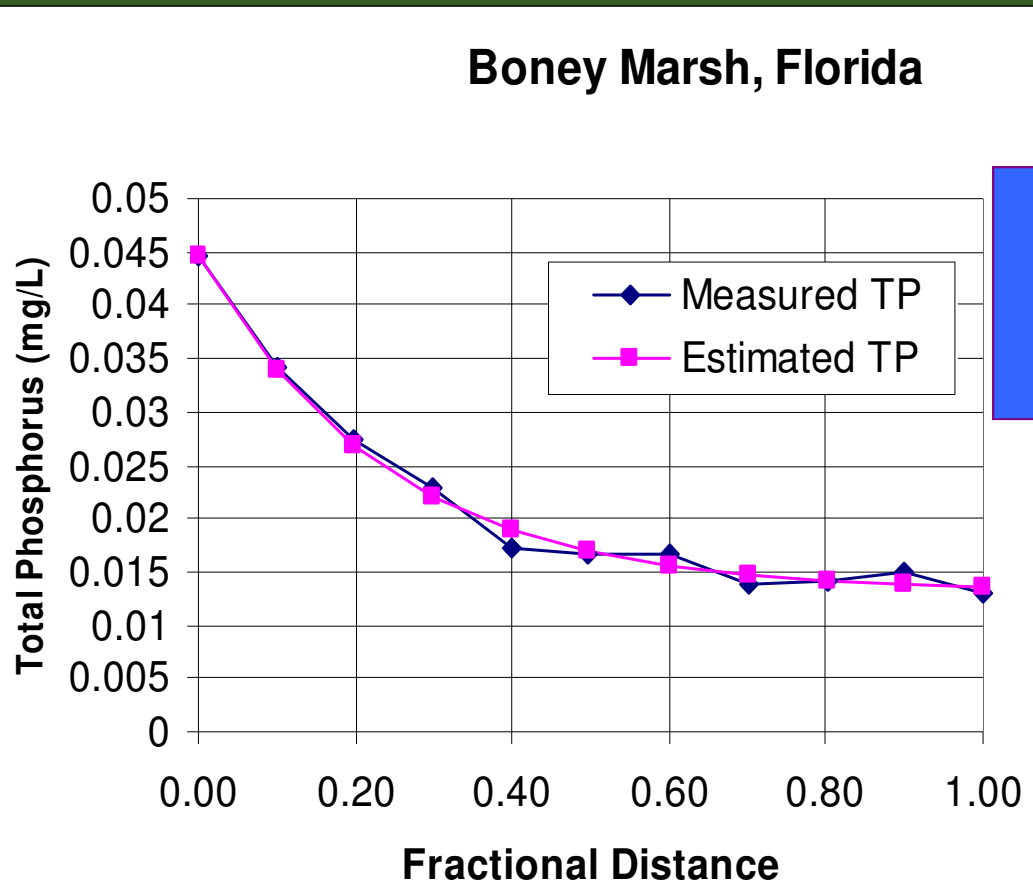
Method 2: Design Storm Detention

- Measure area of drainage basin
- Find 90th percentile of rainfall quantity distribution
- Determine runoff coefficient
- Calculate design runoff volume
- Allocate wetland volume 40% pool and 60% marsh
- Allocate wetland surface area to 20% pool and 80% marsh (marsh depth = 0.3 x pool depth)

Method 3: Annual Averaging

- Estimate event mean concentrations of pollutants
- Compute HLR to meet water quality target using first-order equation
- Estimate runoff coefficient
- Calculate design annual runoff volume
- Allocate wetland surface area to 20% pool and 80% marsh and select appropriate water depths

Method 3: k-C* Model Fit to Boney Marsh, FL TP Data



Best Fit

k = 39 m/yr

C* = 0.013 mg/L

Method 4: Dynamic Modeling

- Only available for TP
- Construct daily time series for flow, inflow concentration, rainfall, and ET
- Adjust wetland area in DSMTA Version 2 (www.wwwalker.net) to meet desired load or concentration reduction
- Future release of DMSTA for nitrogen species
- Phosphorus removal is often the area-controlling parameter in wetlands, so goals for BOD, TSS, TN may be met by default

Method 4: DMSTA Version 2 Phosphorus Balance

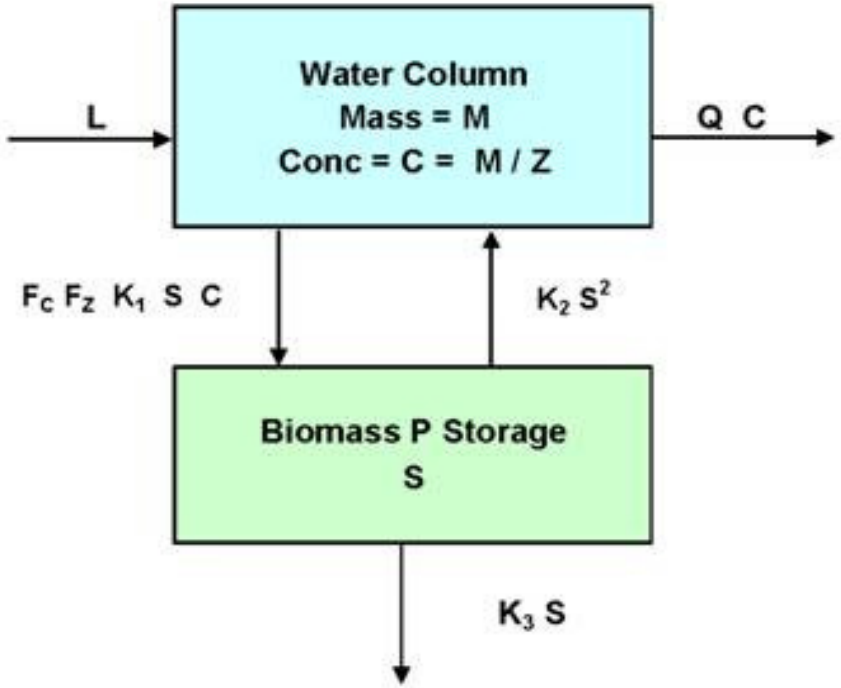
One CSTR at Steady-State

Unit Area Storage & Fluxes

Concs in mg/m3

Fluxes in mg/m2-yr

Storage in mg/m2



F_Z = Depth Multiplier

F_C = Conc Multiplier

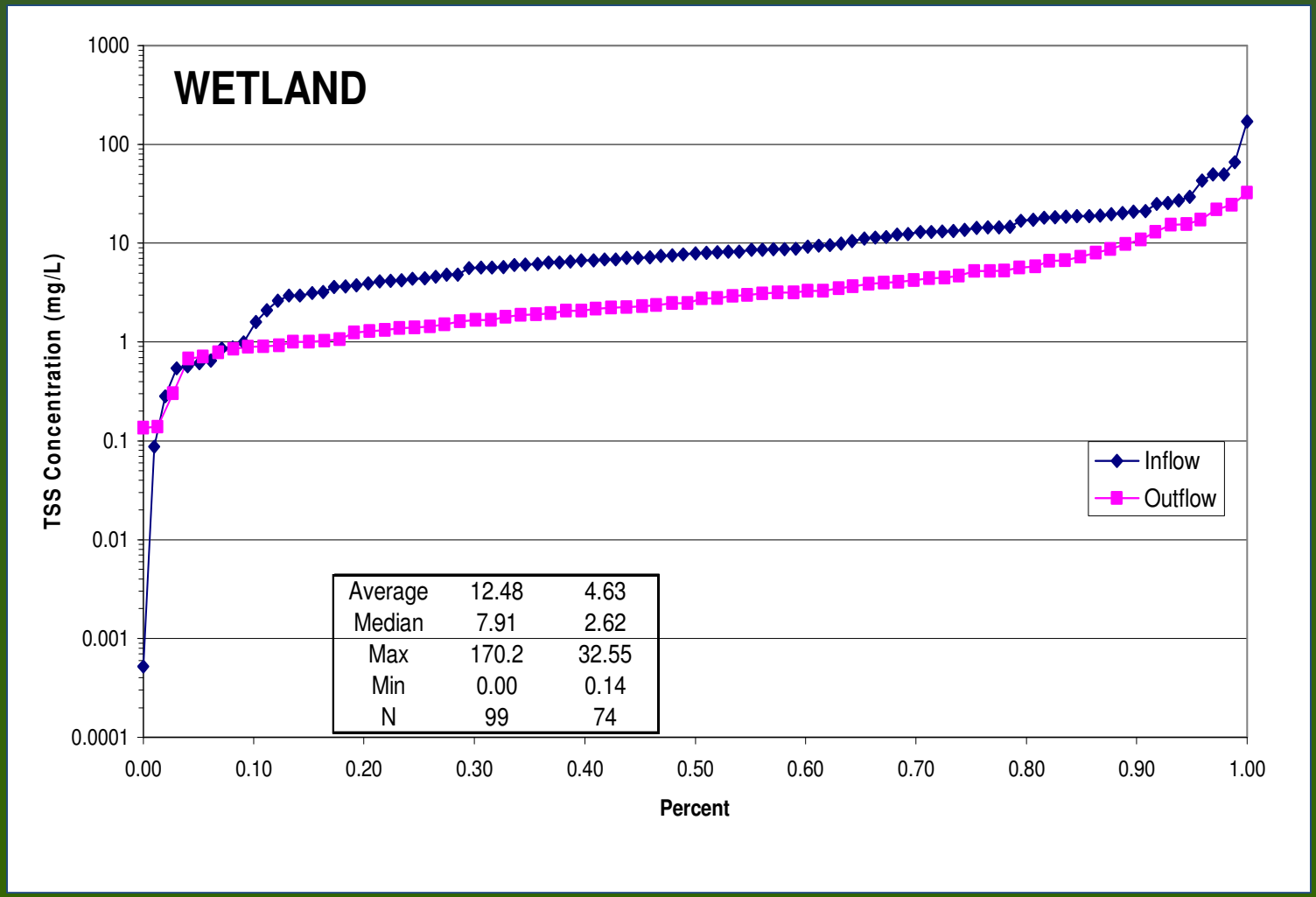
State Variables:

M	Water Column P Storage	mg/m^2
S	Temporary P Storage in Biota, etc.	mg/m^2
Z	Water Column Mean Depth	m

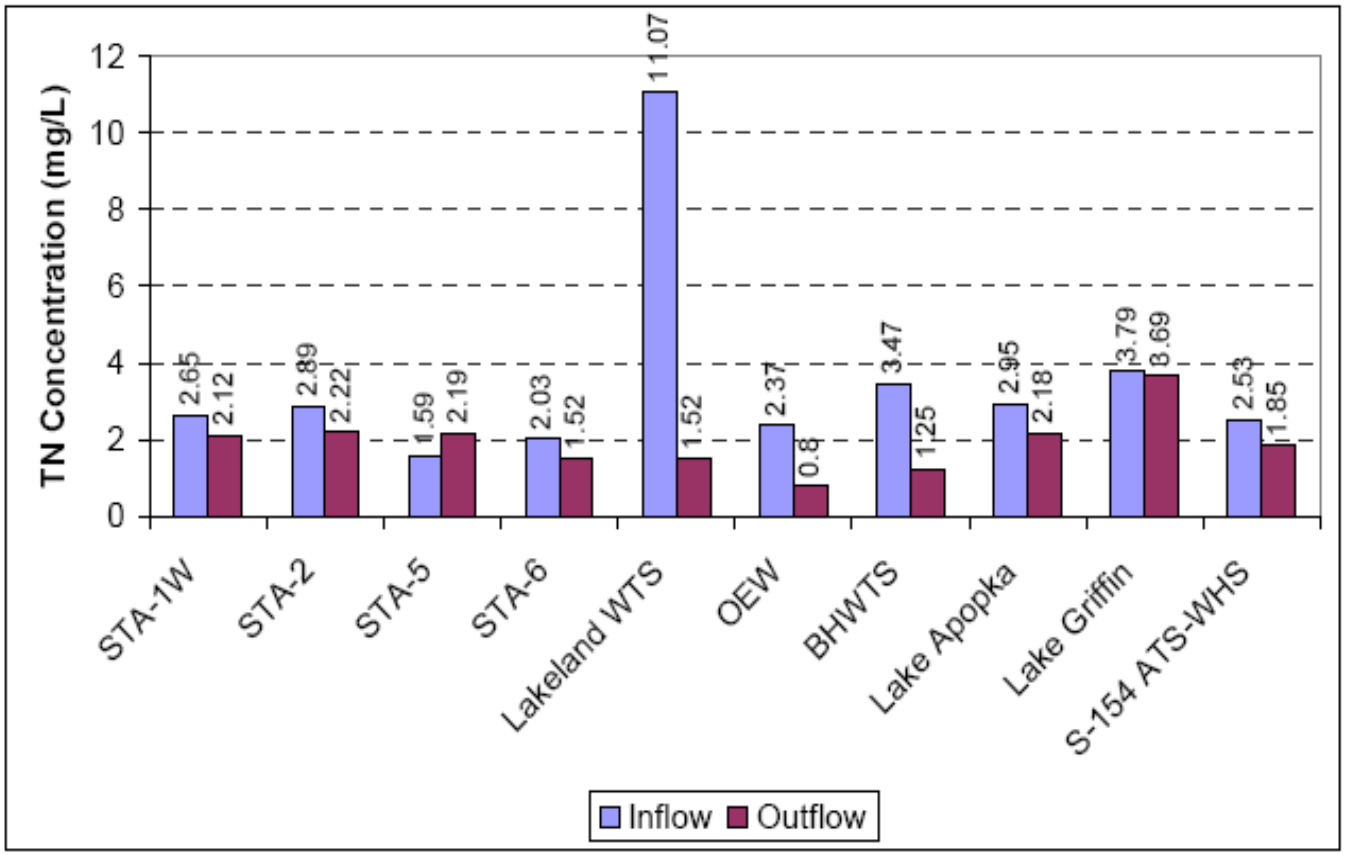
Keys to Maximize Water Quality Benefits

- Hydraulic design depends on project goals
  - Load Reduction
  - Concentration Reduction
- Maximize internal hydraulic efficiency
- Minimize water depths in marsh
  - 6-12” for permanent pool
  - 18-24” during design storm event
- Limit open water to 10-20% of total surface area

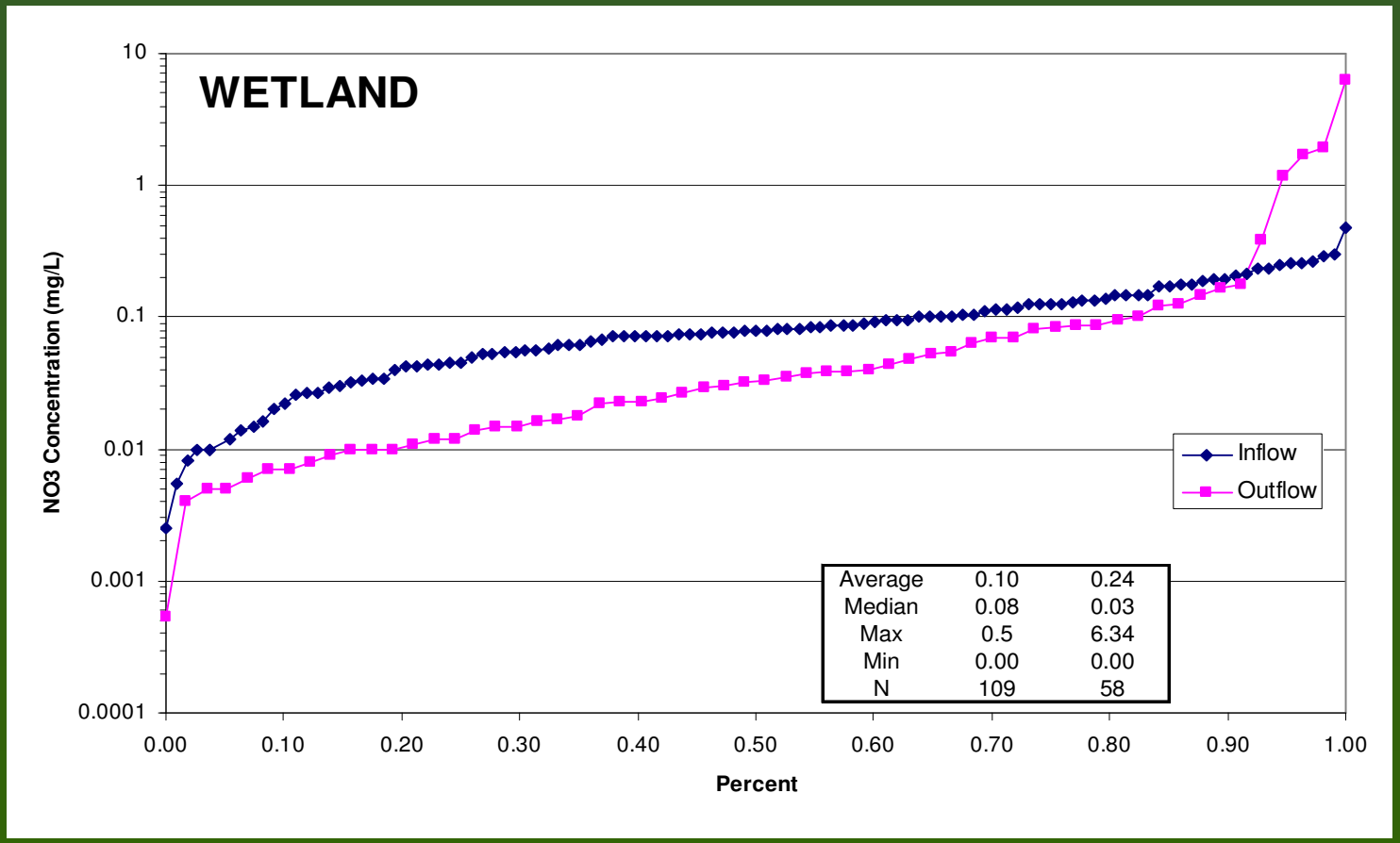
FL Stormwater Wetland TSS Data



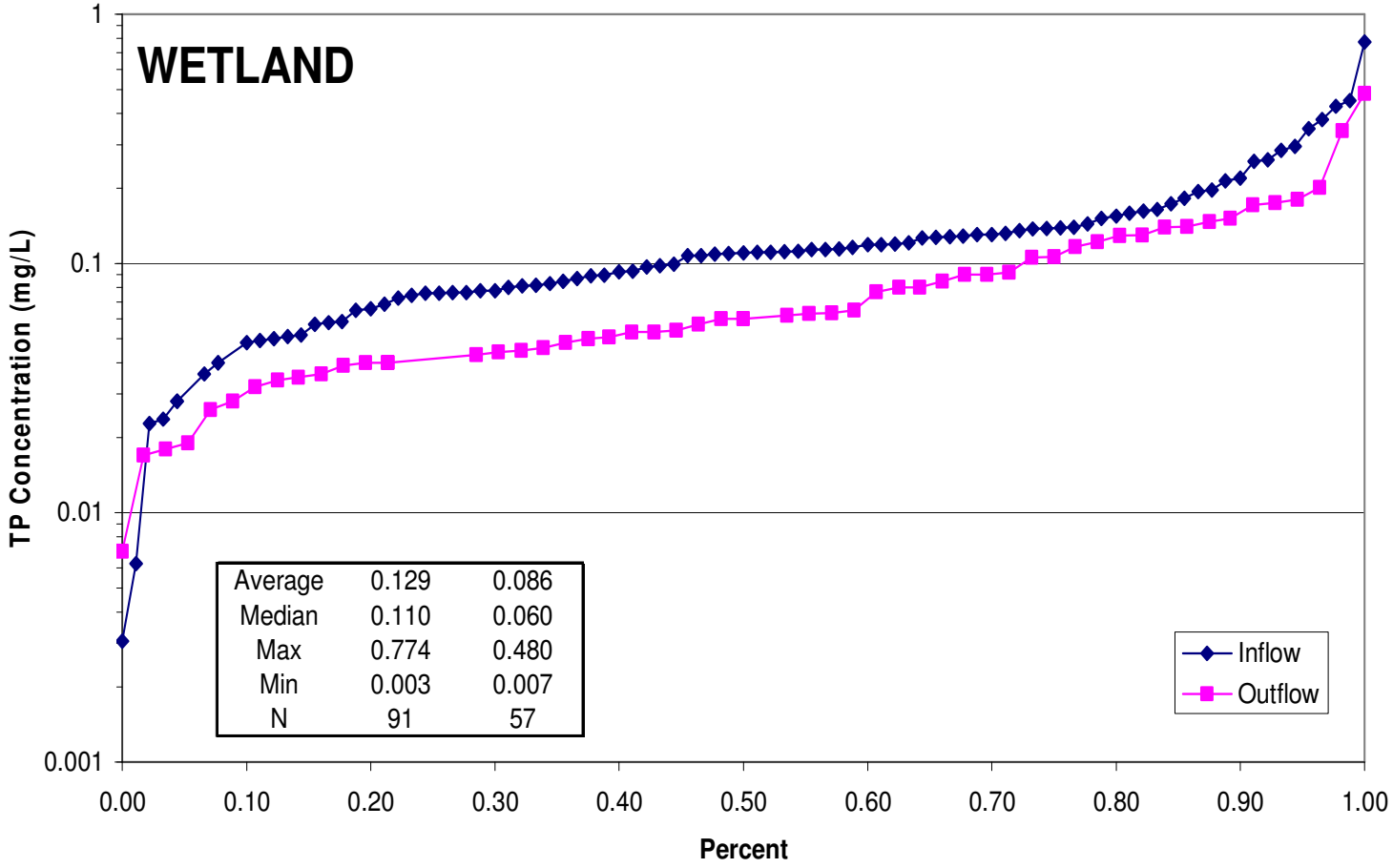
FL Wetland TN Data



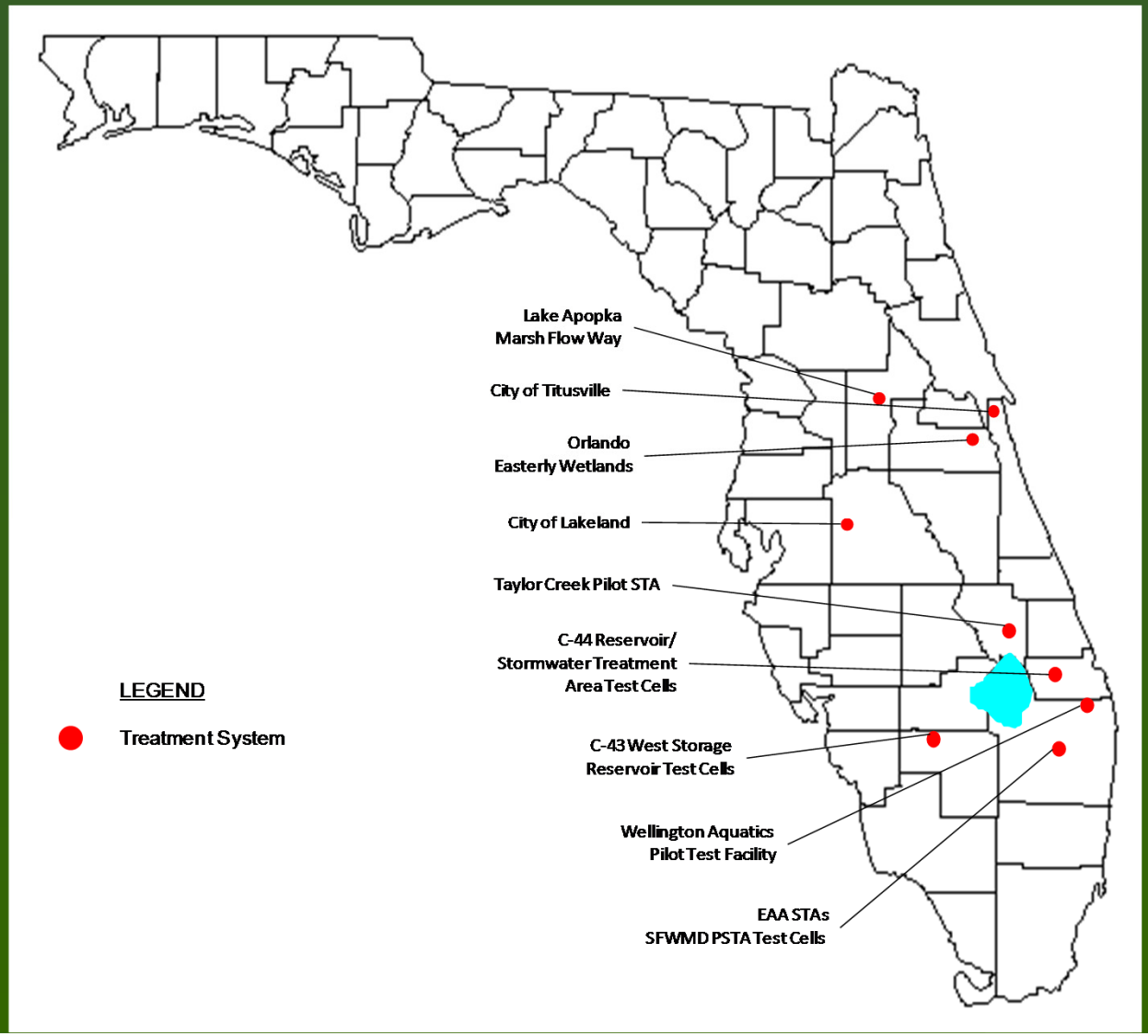
FL Stormwater Wetland NOX Data



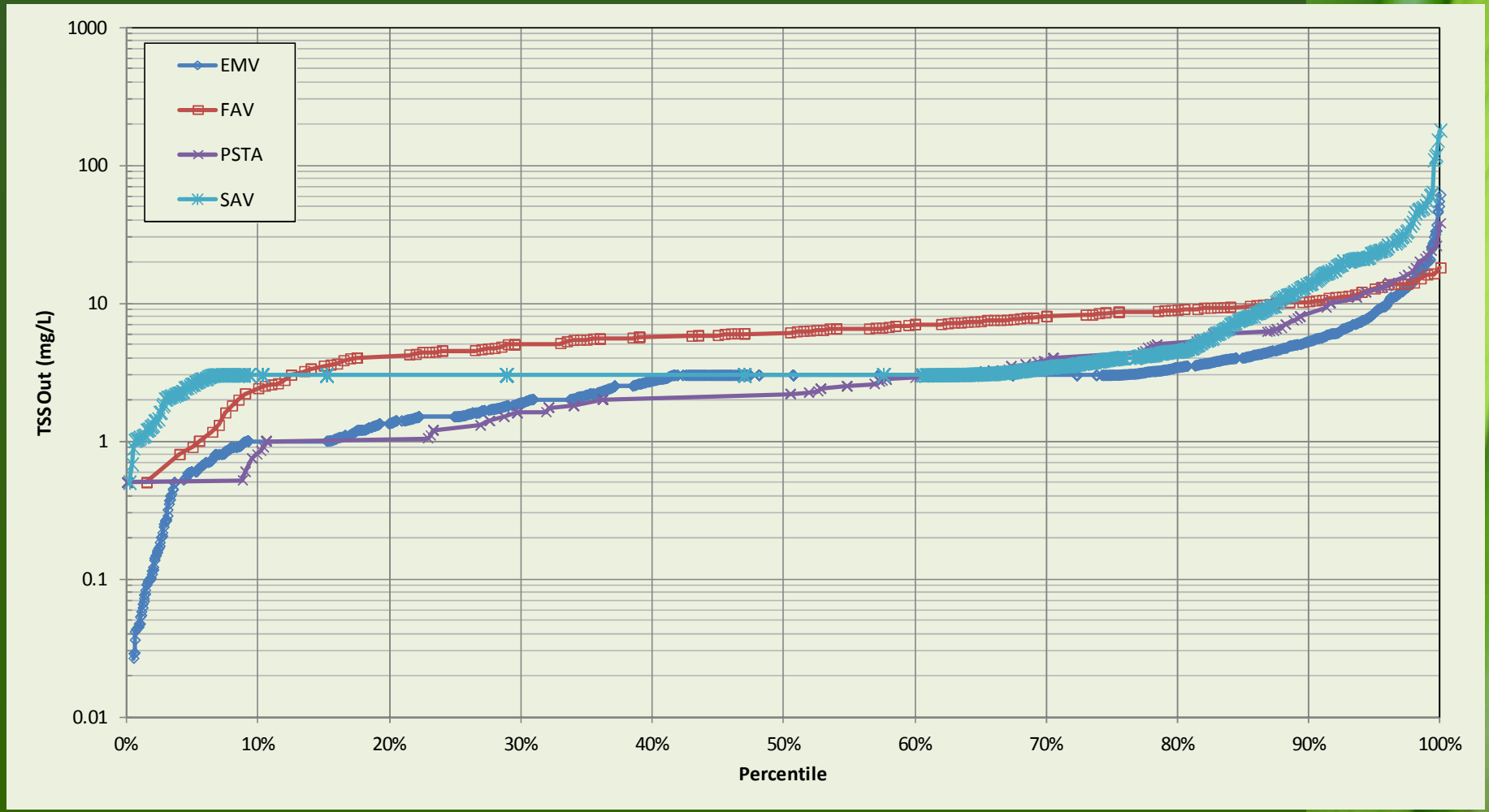
FL Stormwater Wetland TP Data



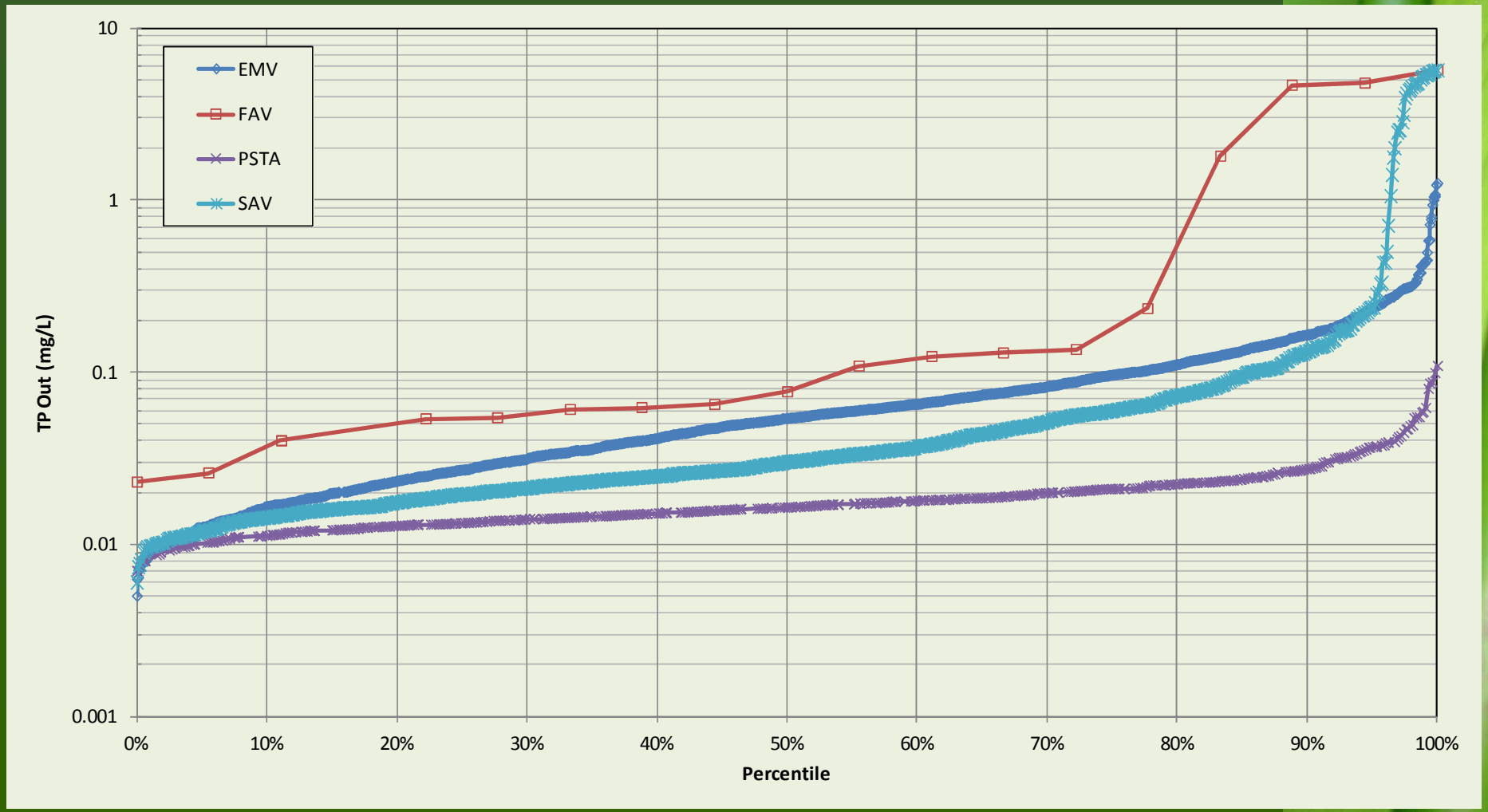
Detailed Study by Vegetation and Substrate Type



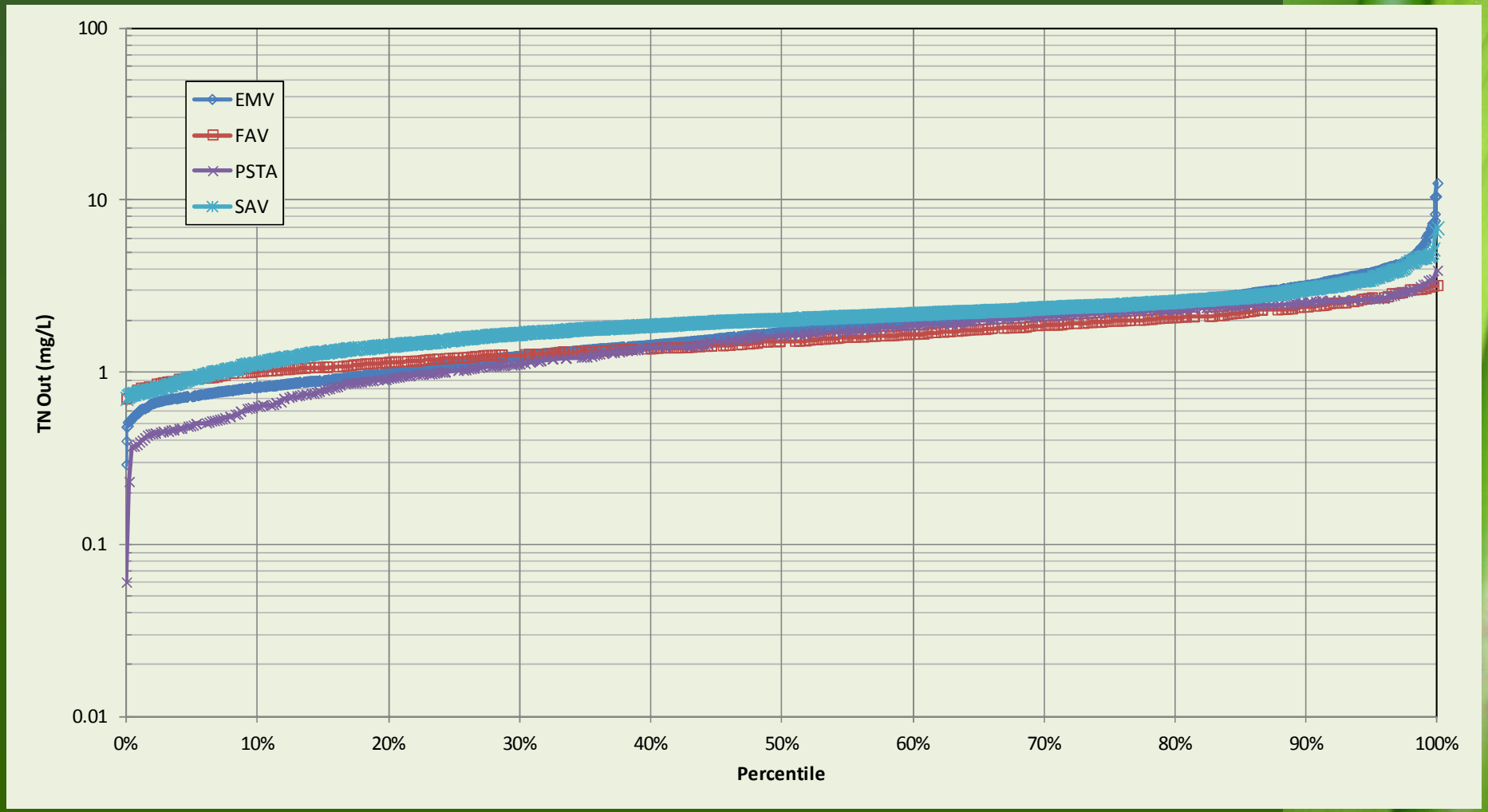
Outlet TSS vs. Vegetation Type



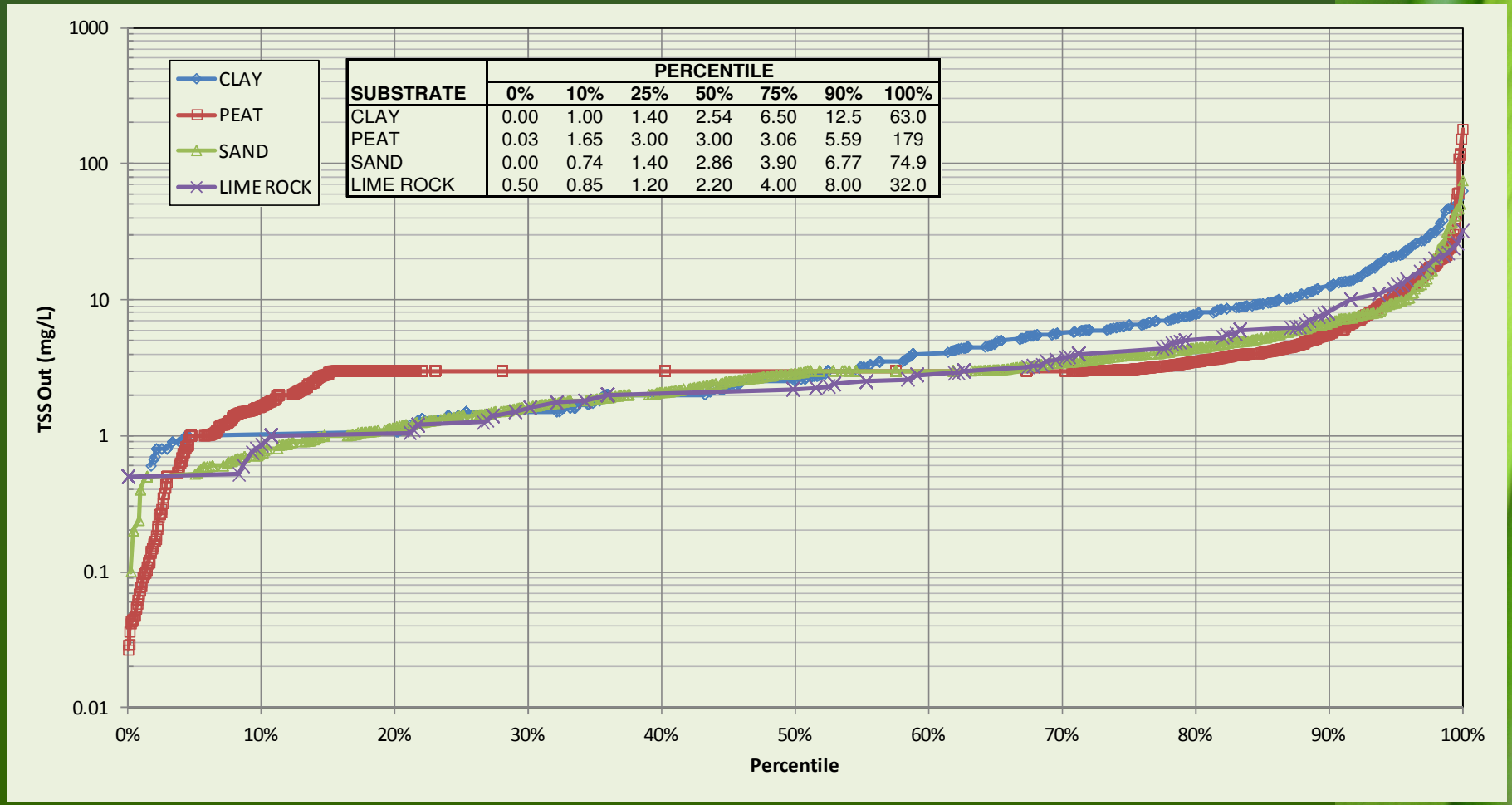
Outlet TP vs. Vegetation Type



Outlet TN vs. Vegetation Type

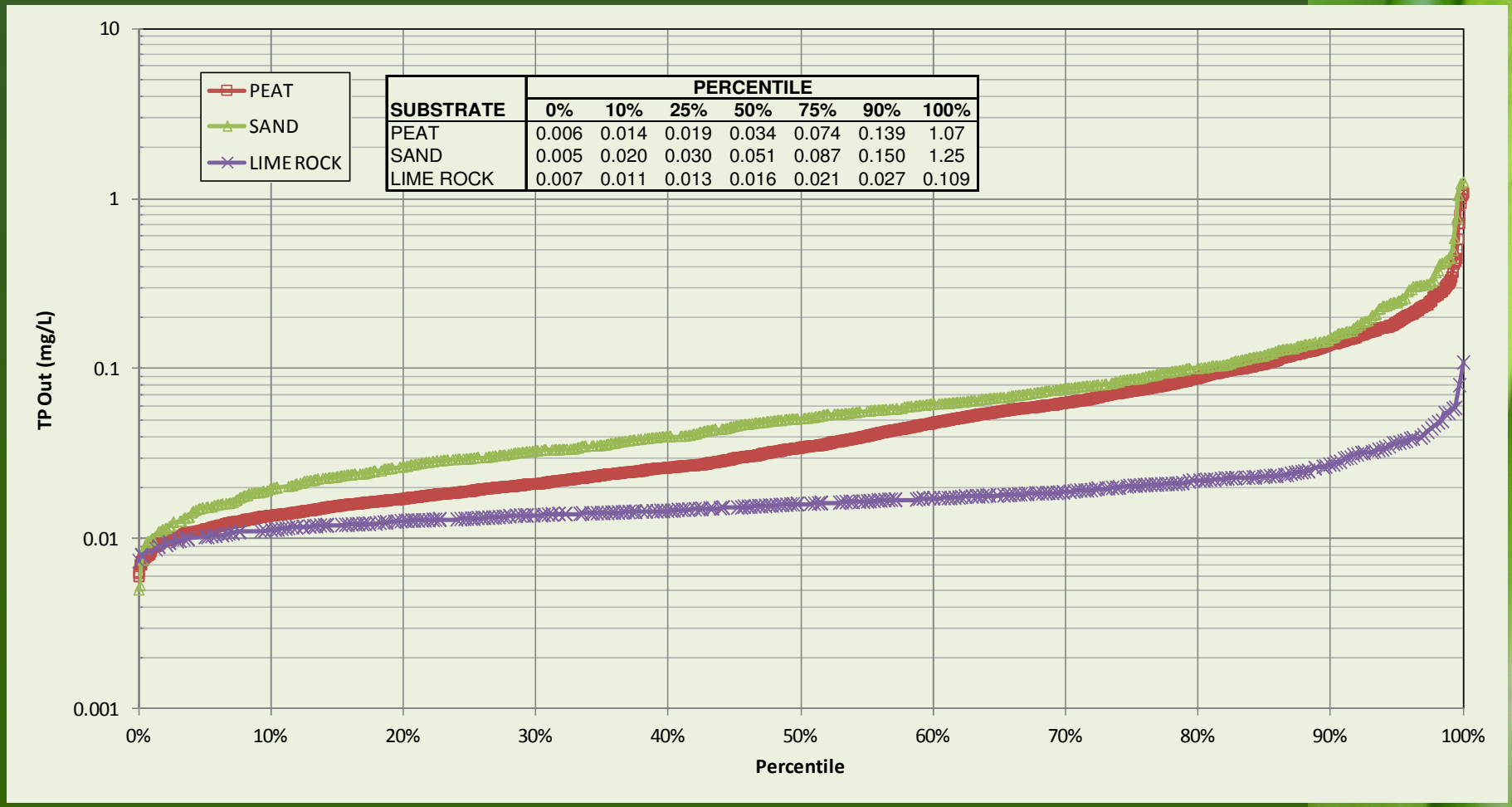


Outlet TSS vs. Substrate Type



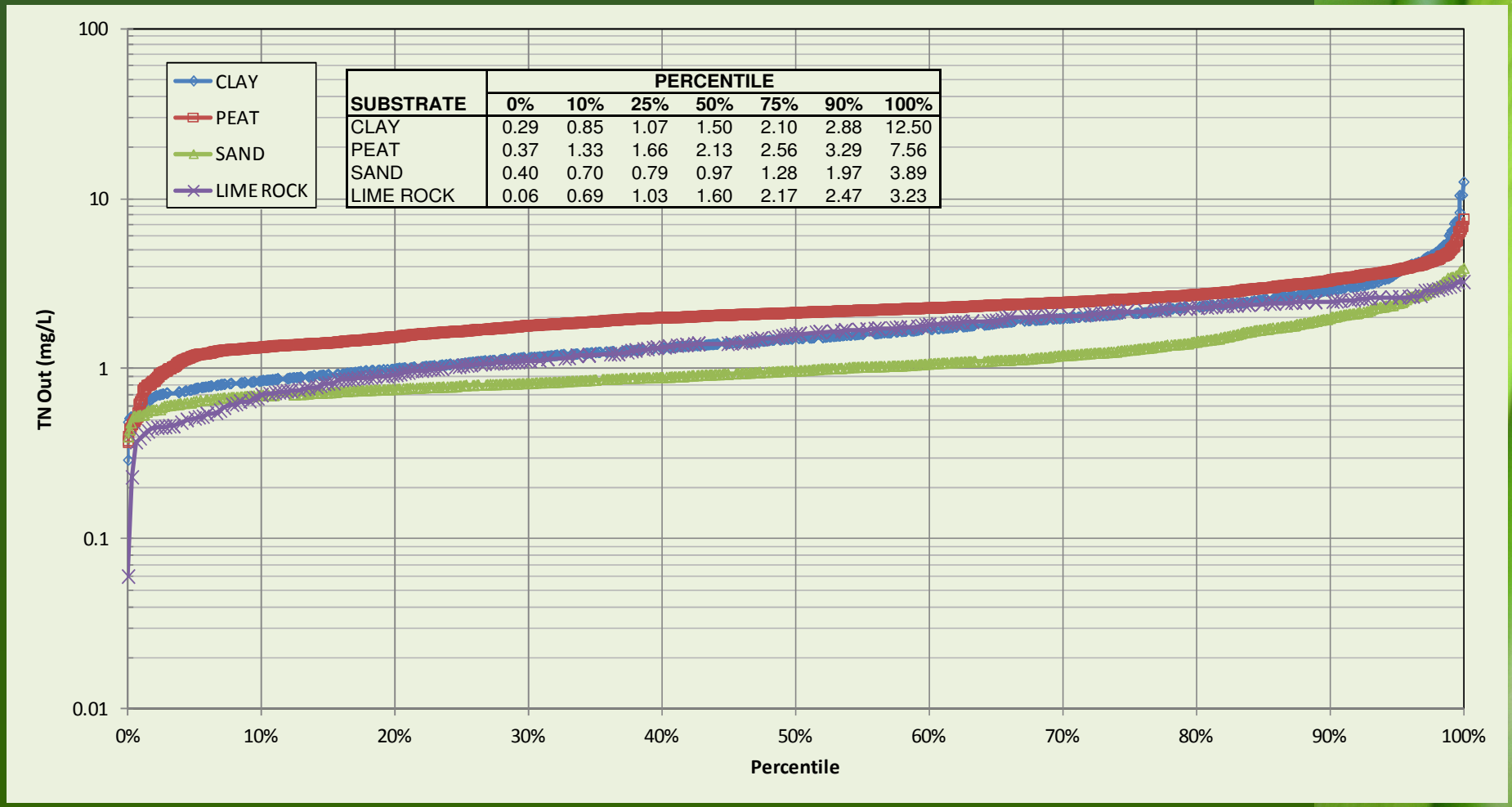
SUBSTRATE	PERCENTILE						
	0%	10%	25%	50%	75%	90%	100%
CLAY	0.00	1.00	1.40	2.54	6.50	12.5	63.0
PEAT	0.03	1.65	3.00	3.00	3.06	5.59	179
SAND	0.00	0.74	1.40	2.86	3.90	6.77	74.9
LIME ROCK	0.50	0.85	1.20	2.20	4.00	8.00	32.0

Outlet TP vs. Substrate Type



SUBSTRATE	PERCENTILE						
	0%	10%	25%	50%	75%	90%	100%
PEAT	0.006	0.014	0.019	0.034	0.074	0.139	1.07
SAND	0.005	0.020	0.030	0.051	0.087	0.150	1.25
LIME ROCK	0.007	0.011	0.013	0.016	0.021	0.027	0.109

Outlet TN vs. Substrate Type



SUBSTRATE	PERCENTILE						
	0%	10%	25%	50%	75%	90%	100%
CLAY	0.29	0.85	1.07	1.50	2.10	2.88	12.50
PEAT	0.37	1.33	1.66	2.13	2.56	3.29	7.56
SAND	0.40	0.70	0.79	0.97	1.28	1.97	3.89
LIME ROCK	0.06	0.69	1.03	1.60	2.17	2.47	3.23

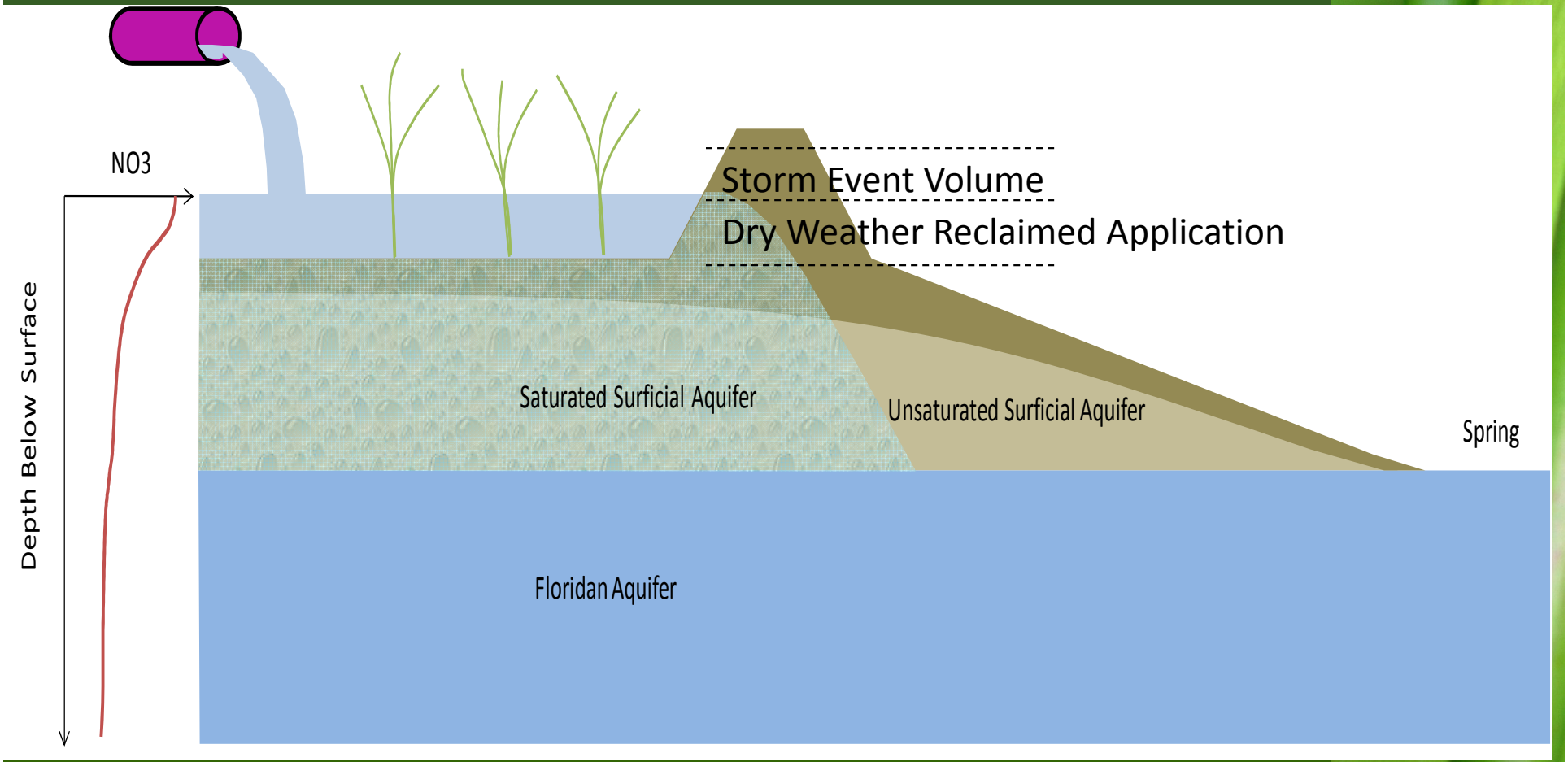
Expansions of SW Wetland Technology

- Floating wetlands as add-ons in wet detention ponds
- LID modular systems
- Hybrid chemical treatment/wetland systems
- Soil amendments

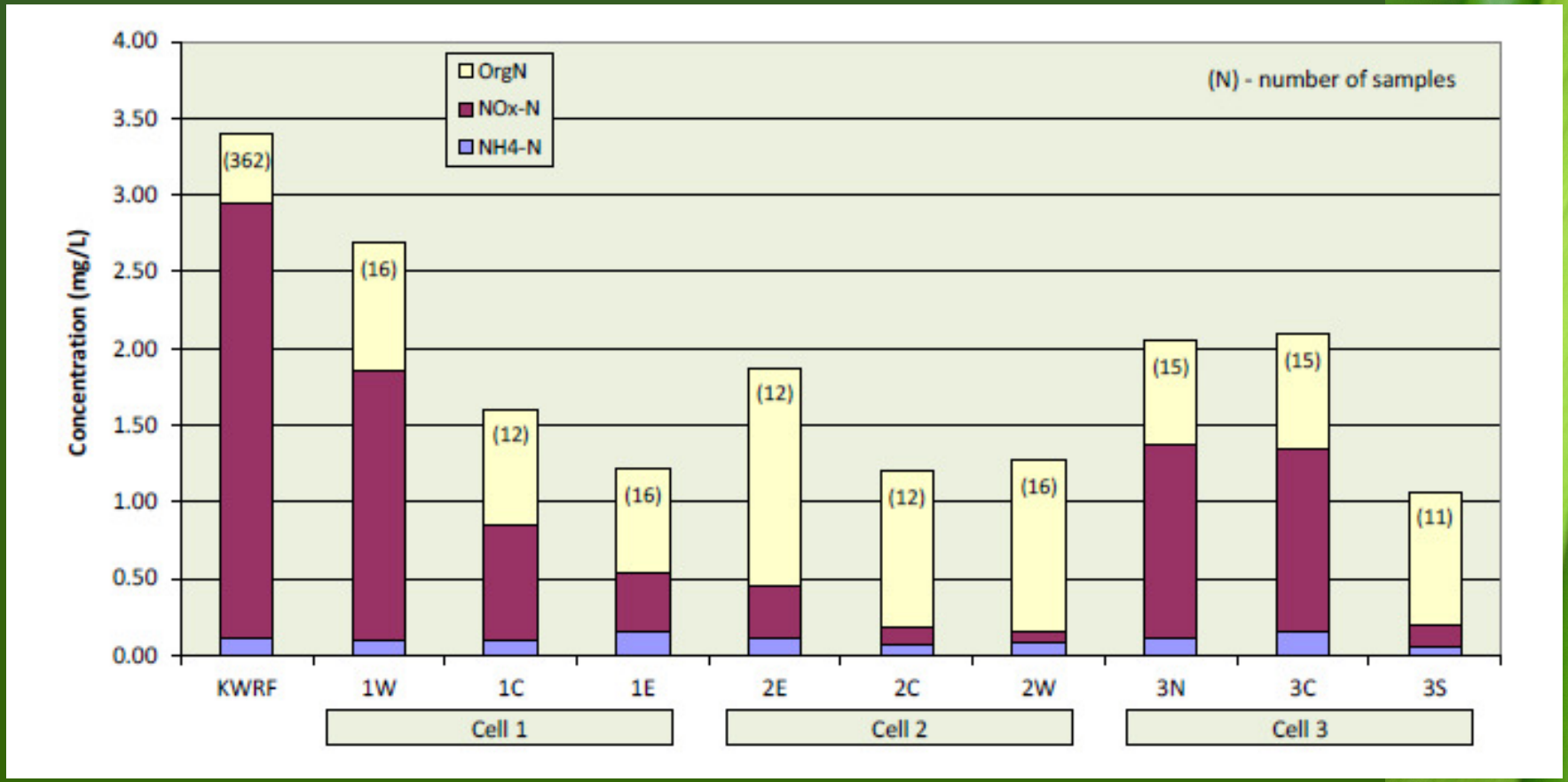
Emerging SW Issues

- Effects of reclaimed water irrigation on stormwater systems (Harper 2012)
  - 2/3 of WWTP's produce secondary quality reclaimed water (TN: 2-15 times stronger than runoff; TP: 8-60 times stronger)
  - 1/3 of WWTP's produce tertiary quality reclaimed water (similar to high density residential runoff)
  - Tendency by homeowners to over-irrigate
- Dry retention favored in many areas but presumption of 100% load reduction is "Bad Science"

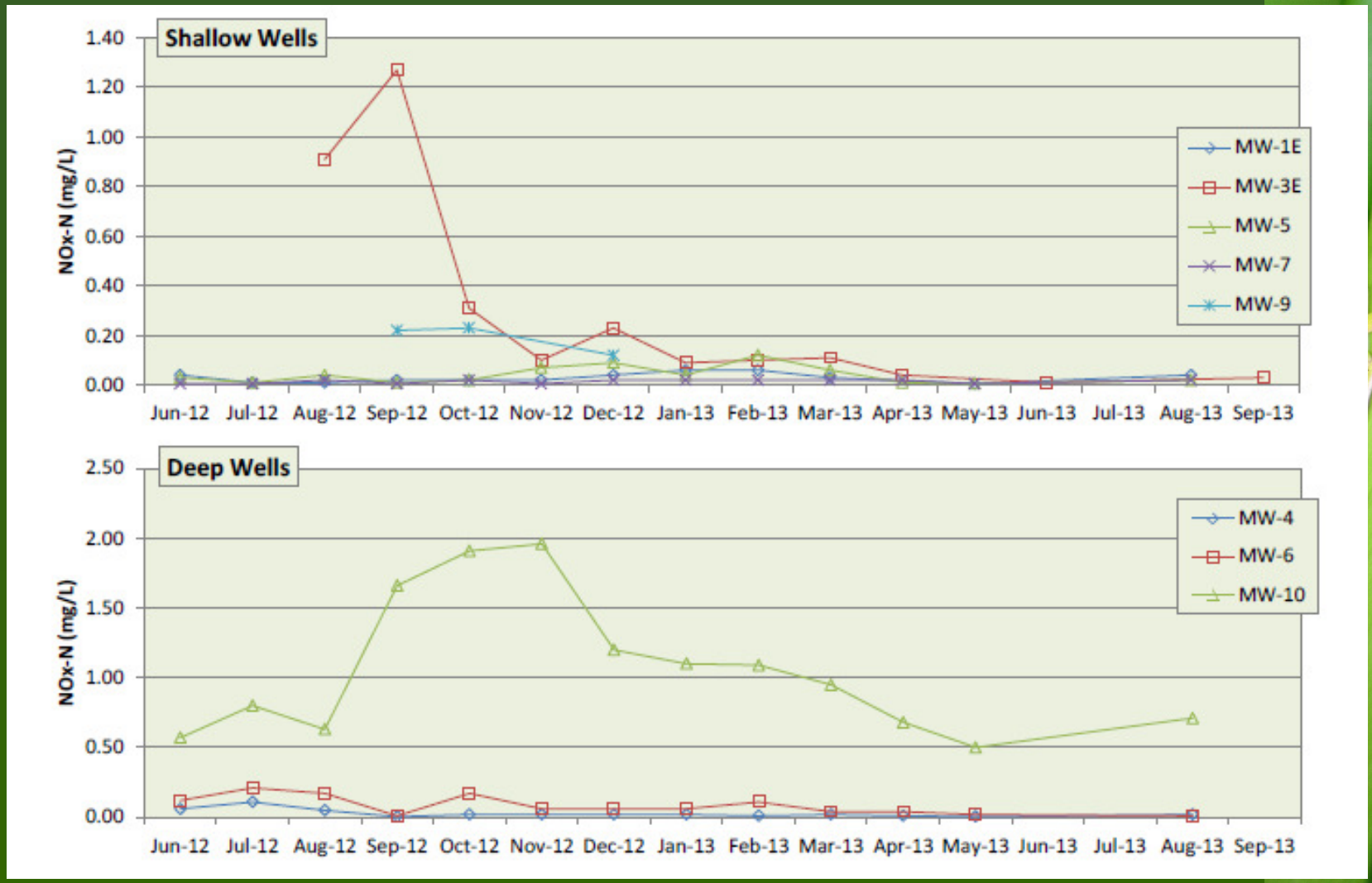
Dry Retention – Wetland Conversion for Nitrate Removal



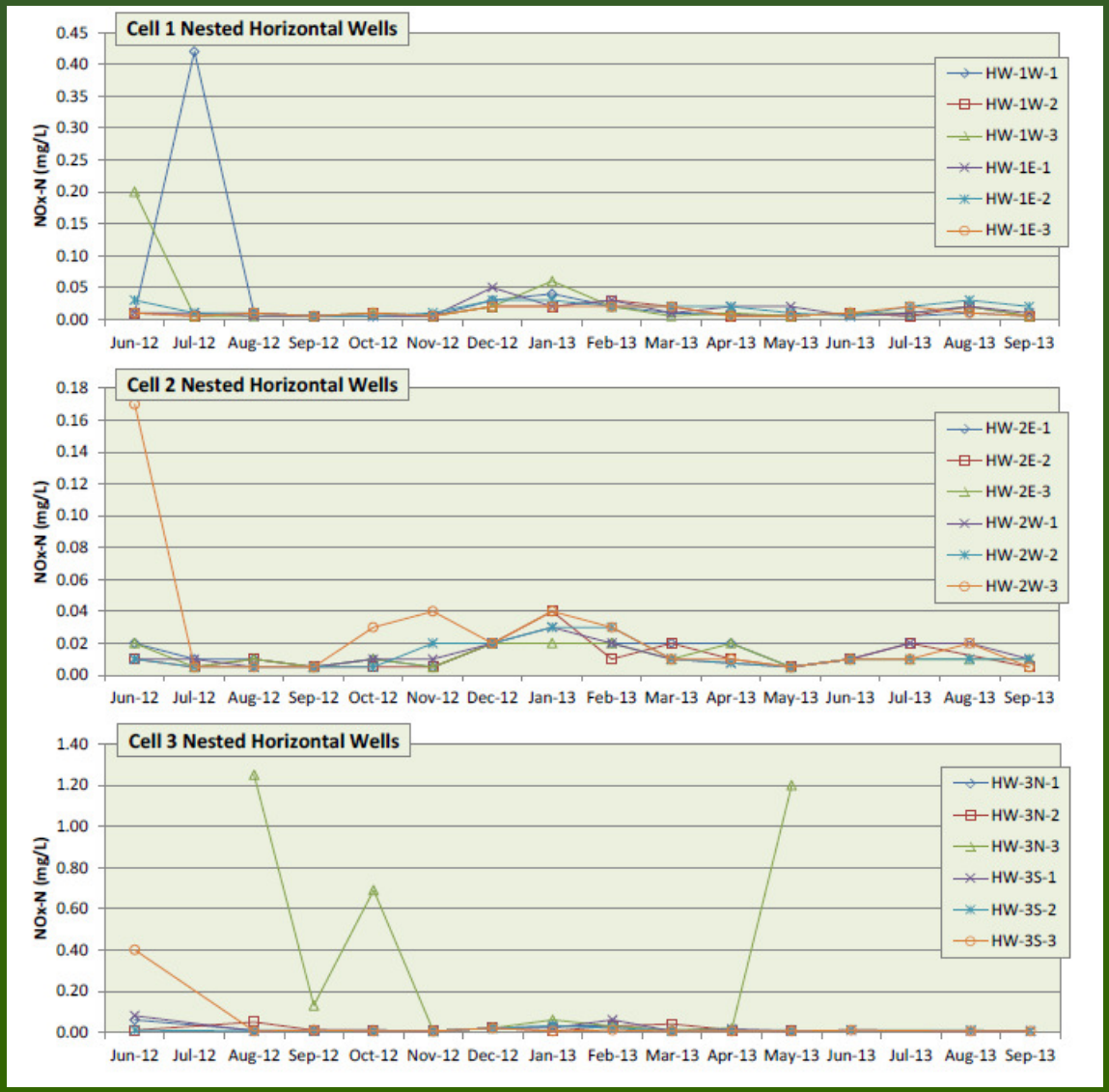
Infiltrating Wetland Surface Water Nitrogen Concentrations



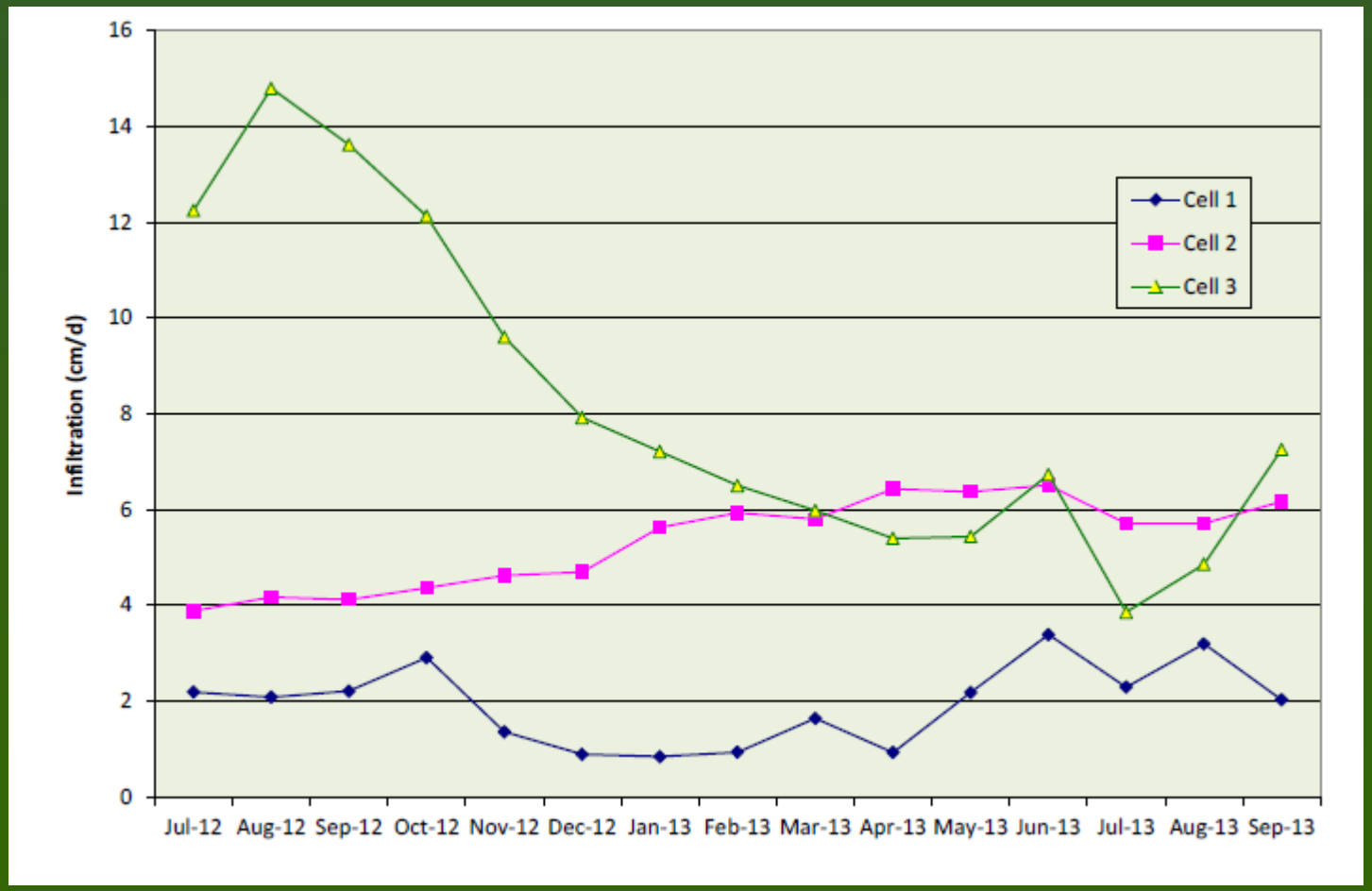
Infiltrating Wetland Groundwater Nitrate Concentrations



Infiltrating Wetland Shallow Groundwater Concentrations



Infiltration Rates



Questions