# Treatment Wetlands - Design and Operation

SYMBIONT

# Introduction

- Phosphorus is a nutrient that promotes excessive biomass growth in water
- Phosphorus removal from Wastewater & Stormwater is a daunting problem
- Phosphorus discharge criteria is likely to become more stringent
- Phosphorus is the smallest nutrient component needed for biomass (C : N : P = 106 : 16 : 1)

# Concepts

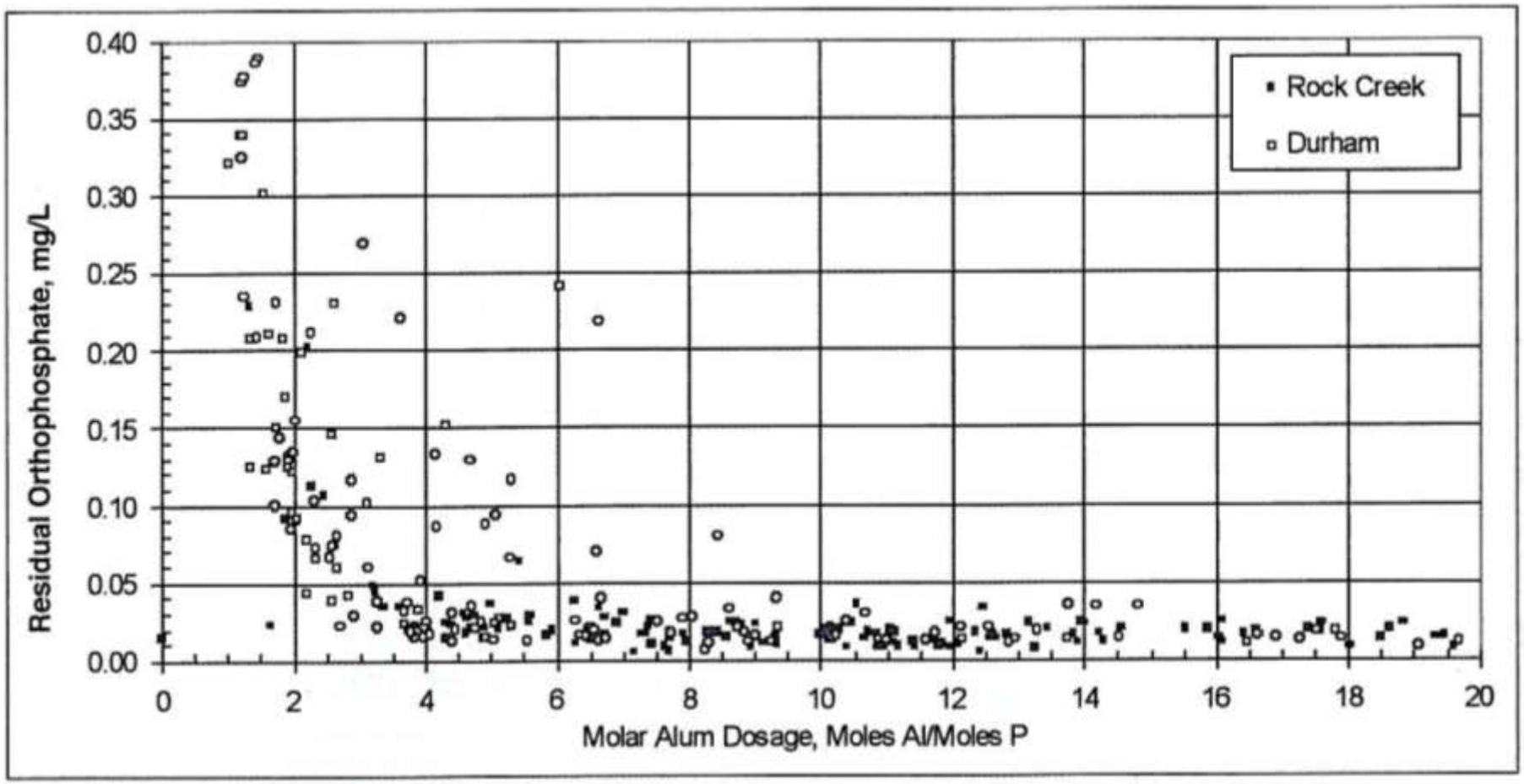
- Treatment Wetlands are useful for Advanced Phosphorus Treatment
- This presentation will discuss:
  - Treatment mechanisms
  - Design considerations
  - Operational considerations

# No Substitutes

Treatment Wetlands DO NOT replace Traditional Wastewater Treatment Systems

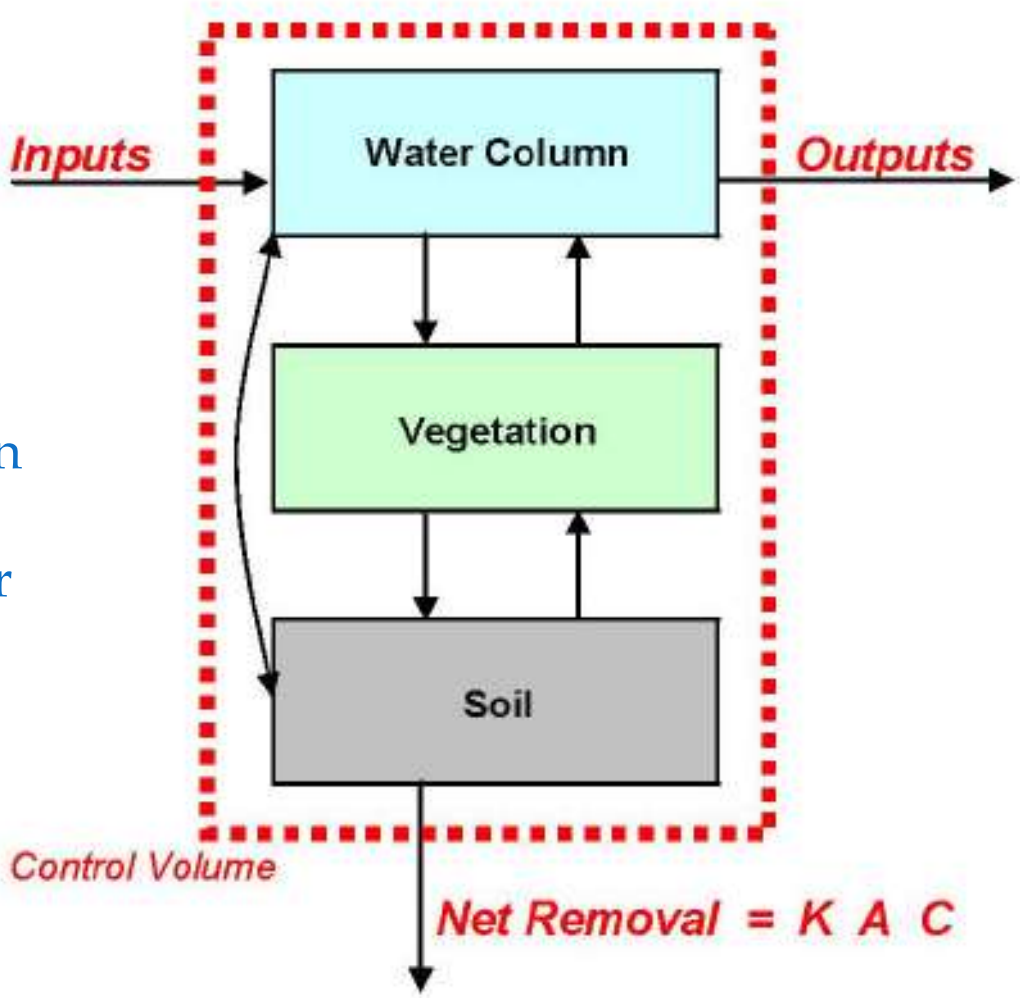
Treatment Wetlands provide **Effluent Polishing!**

# What about Chemical Treatment?




Source: Johnson, Daigger, & Moss, Water Environment & Technology, Aug 2010

# Phosphorus Fate Model




**W**etland dry-outs can re-mobilize **P** into water column

**P**hosphorus Removal provided by uptake in Biomass, Soil, and Sedimentation

Source: DMSTA2 Training, Walker, 2004

# Phosphorus Removal Estimate

**Phosphorus Removal Rate (R) = K A C**

where: **R** = removal rate (g/yr)
**K** = settling rate (m/yr)
**A** = effective treatment area ($m^2$)
**C** = water column **P** concentration ($g/m^3$)

**Many Factors Influence the Settling Rate**

# Wetland Vegetation Effect

K ~ 10-15 m/yr

Emergent

Submersed Aquatic Vegetation "SAV"

K ~ 30-60 m/yr

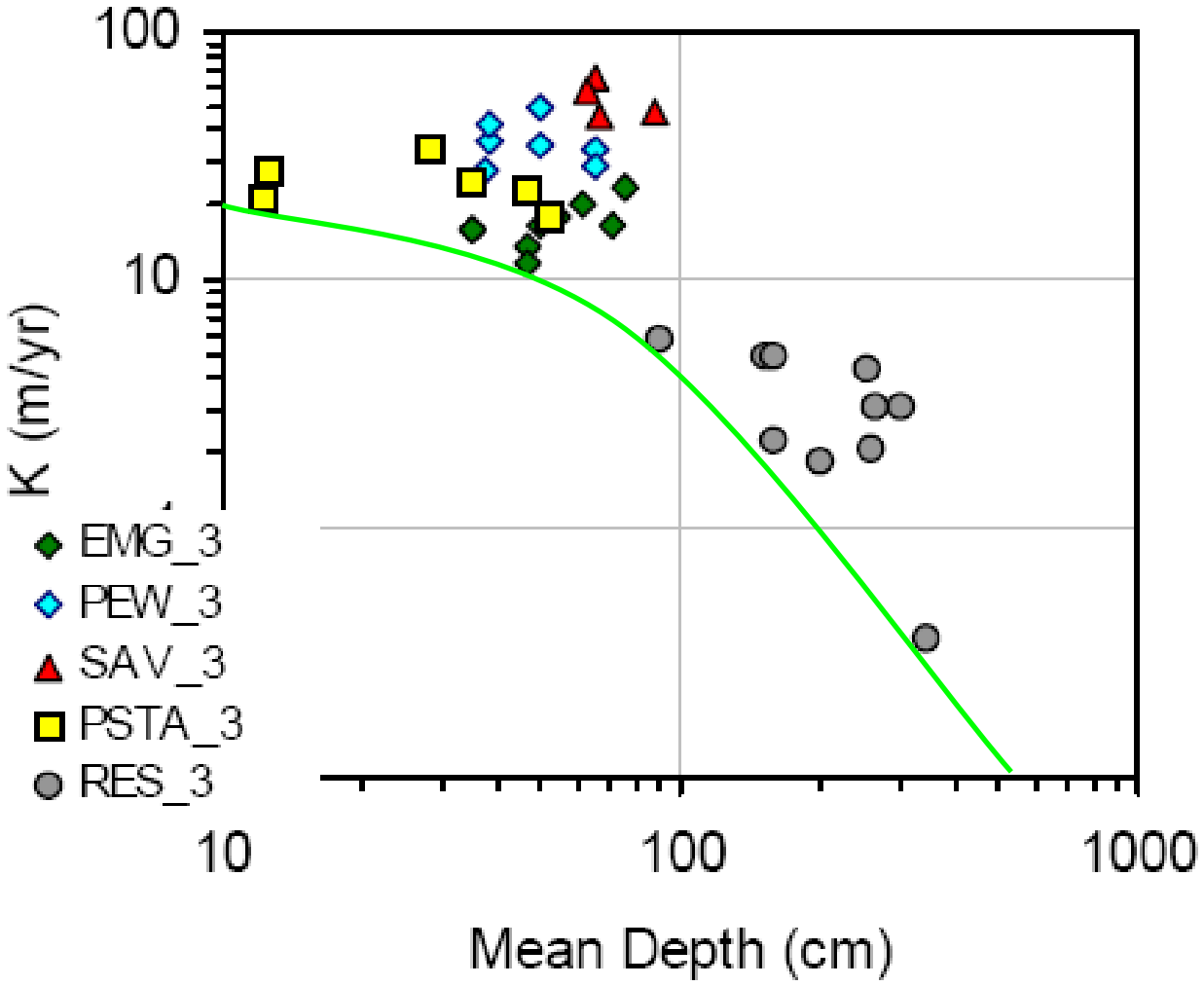
Transition @ 15-20 ppb

Periphyton / "PSTA"

K ~ 20-30 m/yr

Source: DMSTA2 Training, Walker, 2004

# Water Column Depth Effect




Source: DMSTA2 Training, Walker, 2004

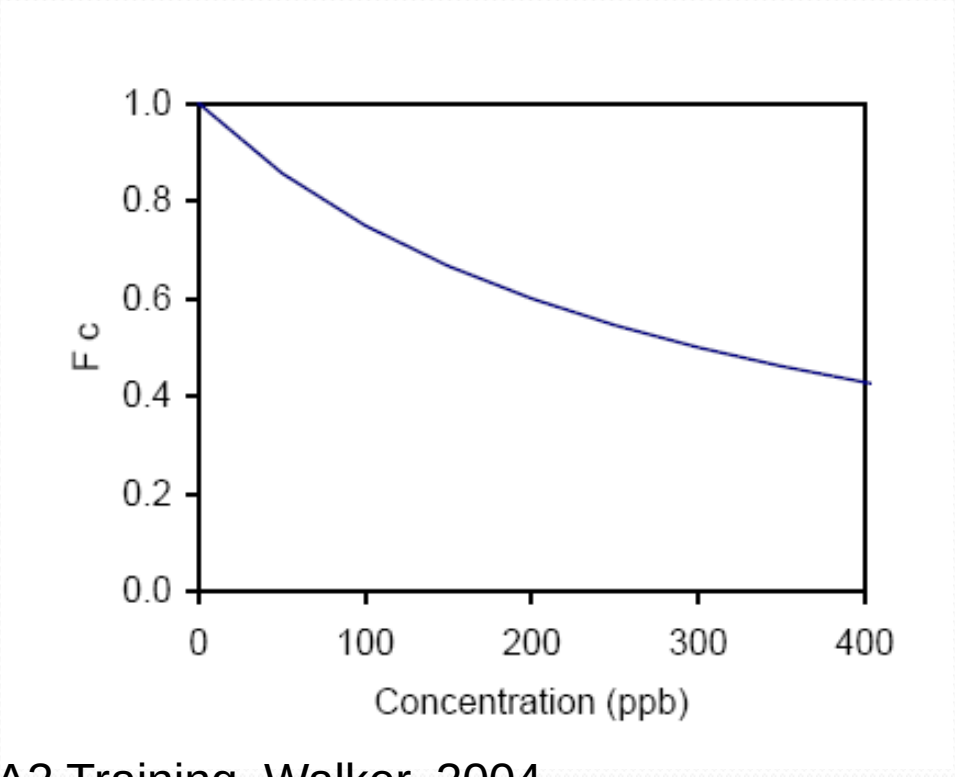
# Aqueous Metal Concentration Effect

- Elevated Iron, Aluminum, and Calcium concentration Improves **P** Removal
- **P**hosphorus complexes with these Metals to improve Floculation and Sedimentation
- **M**idwestern Waters are typically high in Calcium

Source: Wastewater Treatment Wetlands: Applications and Treatment Efficiency, IFAS, 1999.

# Influent Phosphorus Concentration Effect

- **P** Removal Rate Improves with Reduced **P** Influent Concentration




Source: DMSTA2 Training, Walker, 2004

# Surface Flow vs. Subsurface Flow Wetlands?

## Surface Flow

- Requires Less Excavation
- Uses Existing Soils
- Able to Remove Sediments
- Not Subject to Soil Clogging
- Greater Ability to Store Water

## Subsurface Flow

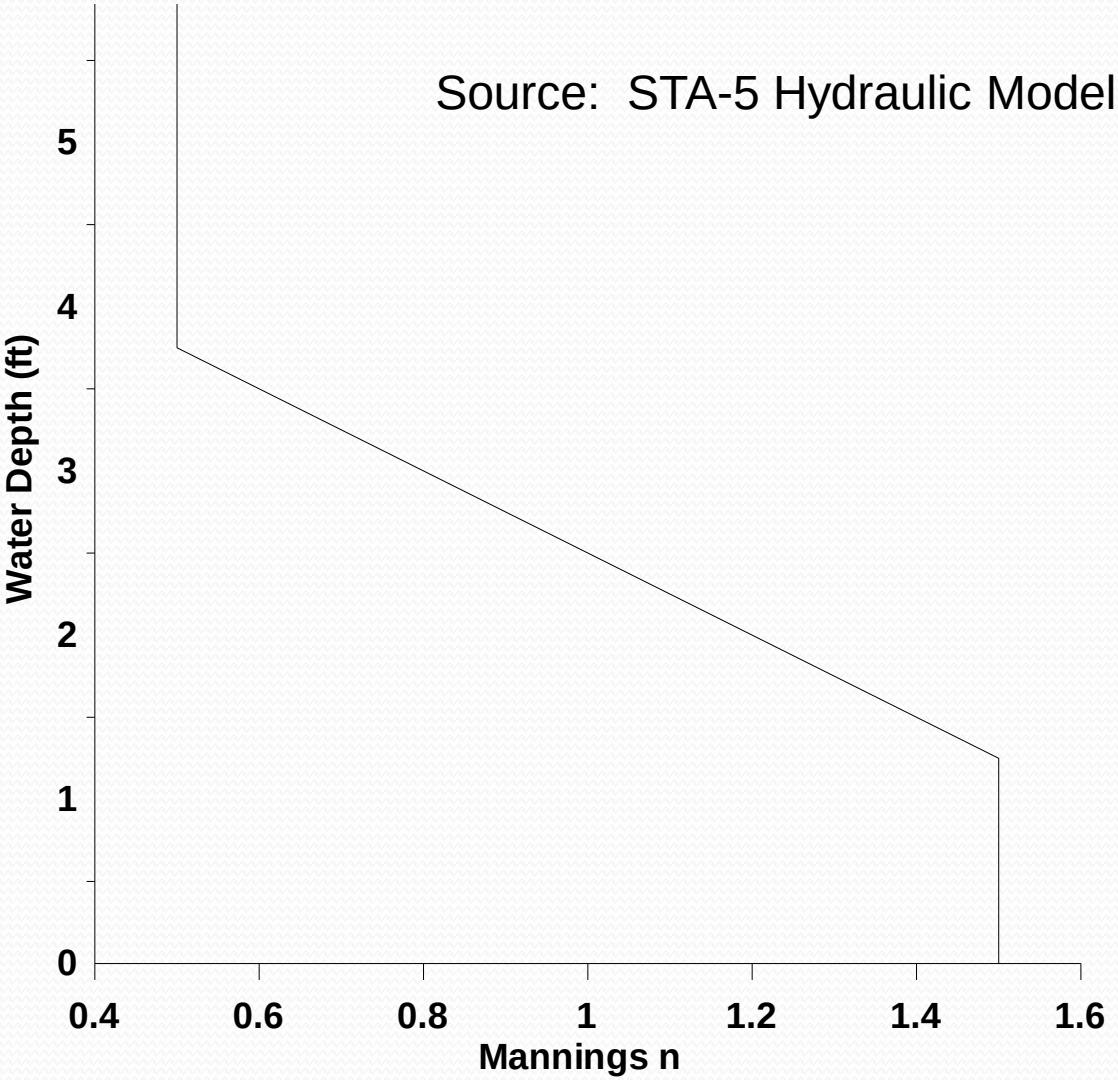
- Requires Permeable soil or Over-Excavation to place permeable soil
- Less Prone to Freezing

# Wetland Design Concepts

- **D**esirable Flow Velocity  < 0.1 ft/sec
- **W**etland Dry-Out is **VERY** Detrimental to Treatment Performance
- **N**eed Structures to Spread and Collect Flow
- **N**eed Structures to Collect and Store Sediment
- **H**igh Hydraulic Flow Resistance is Typical

# Depth-Dependent Friction Character of Wetlands

Source: STA-5 Hydraulic Modeling, SFWMD, 2004



# Important Design Components

**Hydraulic Loading Rate must be Low (< 4 cm / day)**

- Low Loading gives **P** the opportunity to settle or be utilized
- This requires at least **20 acres** to treat each **1 MGD** of flow
- To get High Performance, it may require **50 acres** to treat each **1 MGD** of flow

# Important Design Components

## Different Plant Communities like Different Depths

- Emergent Plants like Depths between ~ **6 & 12 inches**
- Submersed Plants like Depths between ~ **12 & 24 inches**
- **D**eeper Pools and Ditches provide important Aquatic Habitat and Over-Wintering capability
- **H**aving only Emergent Plants is **NOT** best for treatment performance

# Important Design Components

## Relatively Uniform Water Level Should be Maintained in Wetland

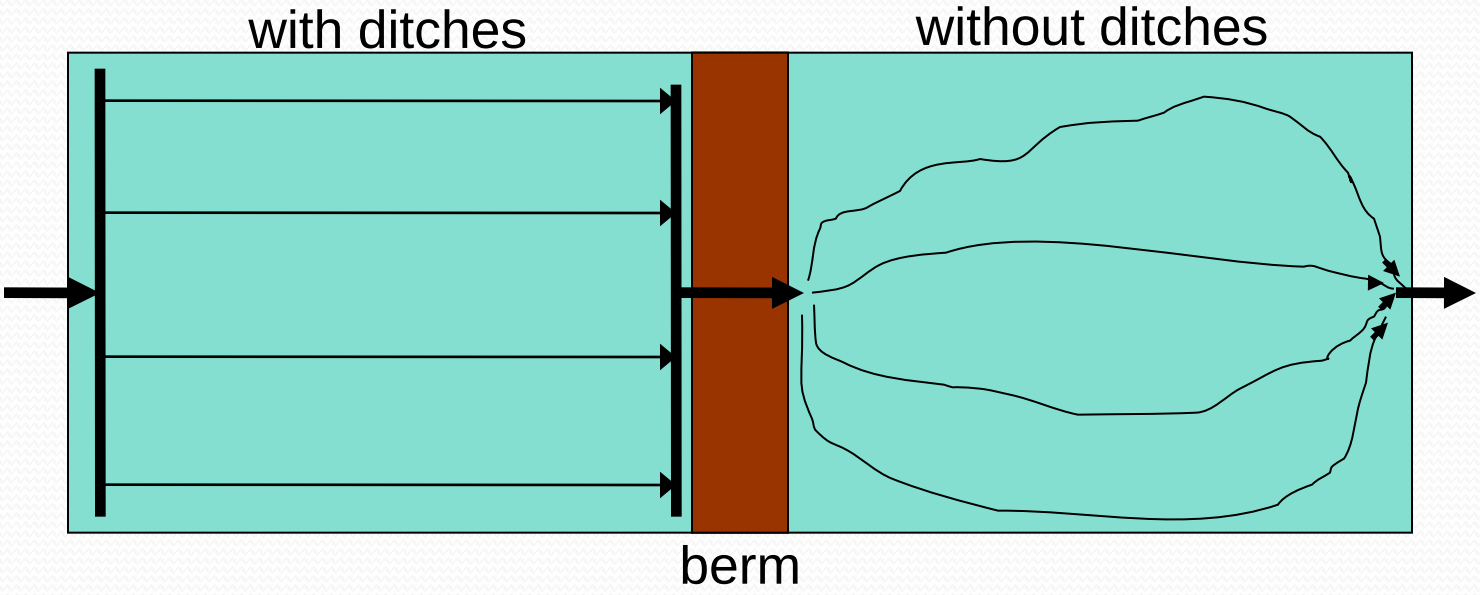
- Vegetation Communities like Constant Depth
- Inundation is Tolerable, but Duration of Inundation is Inversely Proportional to Depth Increase.

i.e. **4-ft** depth increase for **1 day**
**2-ft** depth increase for **3 days**
**1-ft** depth increase for **7 days**

# Important Design Components

## Use Flow Spreader Ditches and Flow Collector Ditches

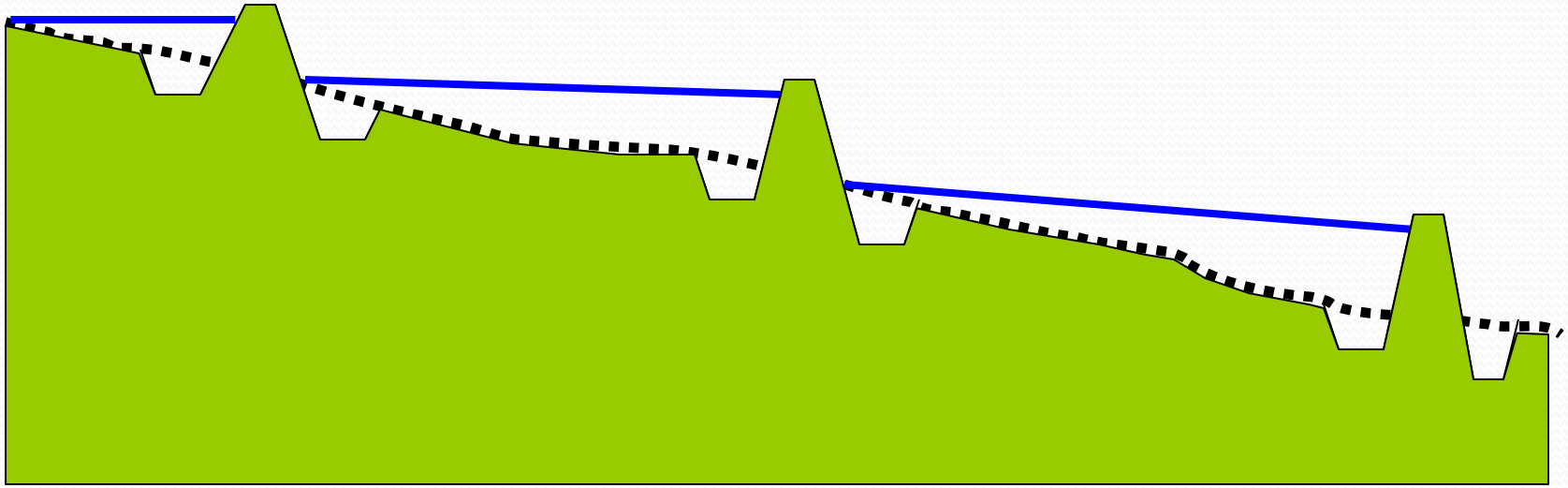
Provides better Distribution and Control of Water



# Important Design Components

## Create more Uniform Topography with Terraces

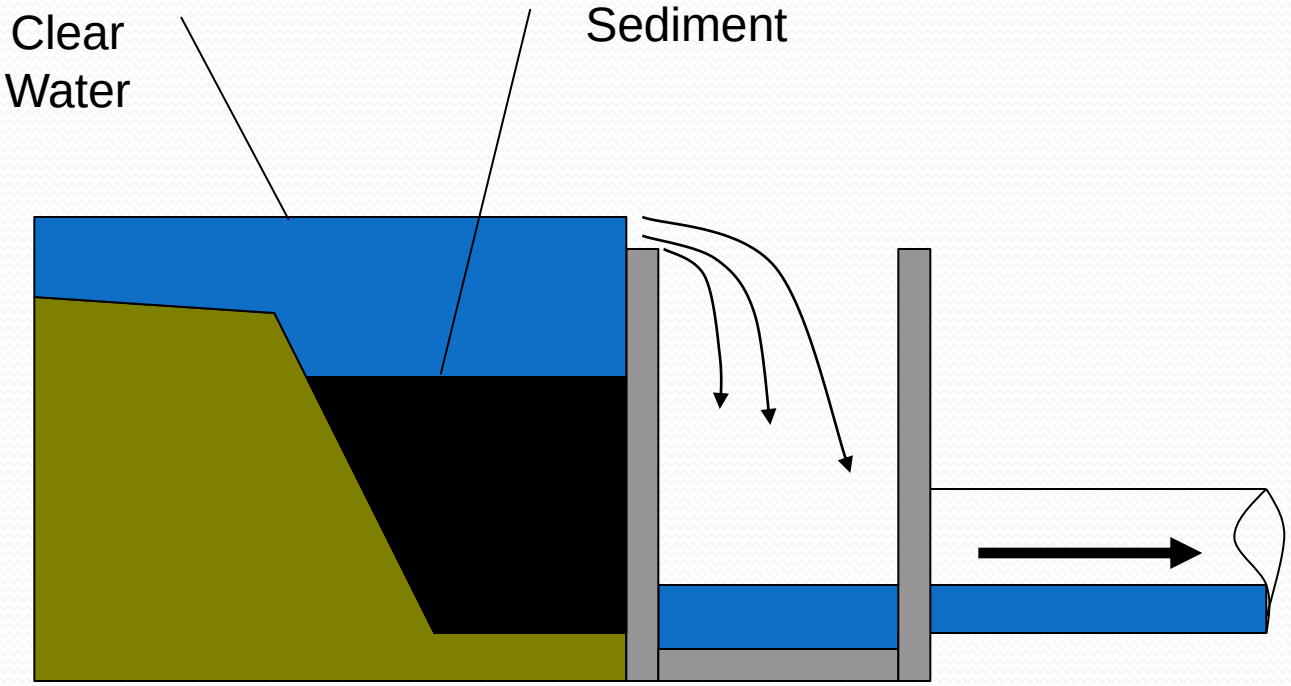
Low Flow Velocity needs Low Relief



# Important Design Components

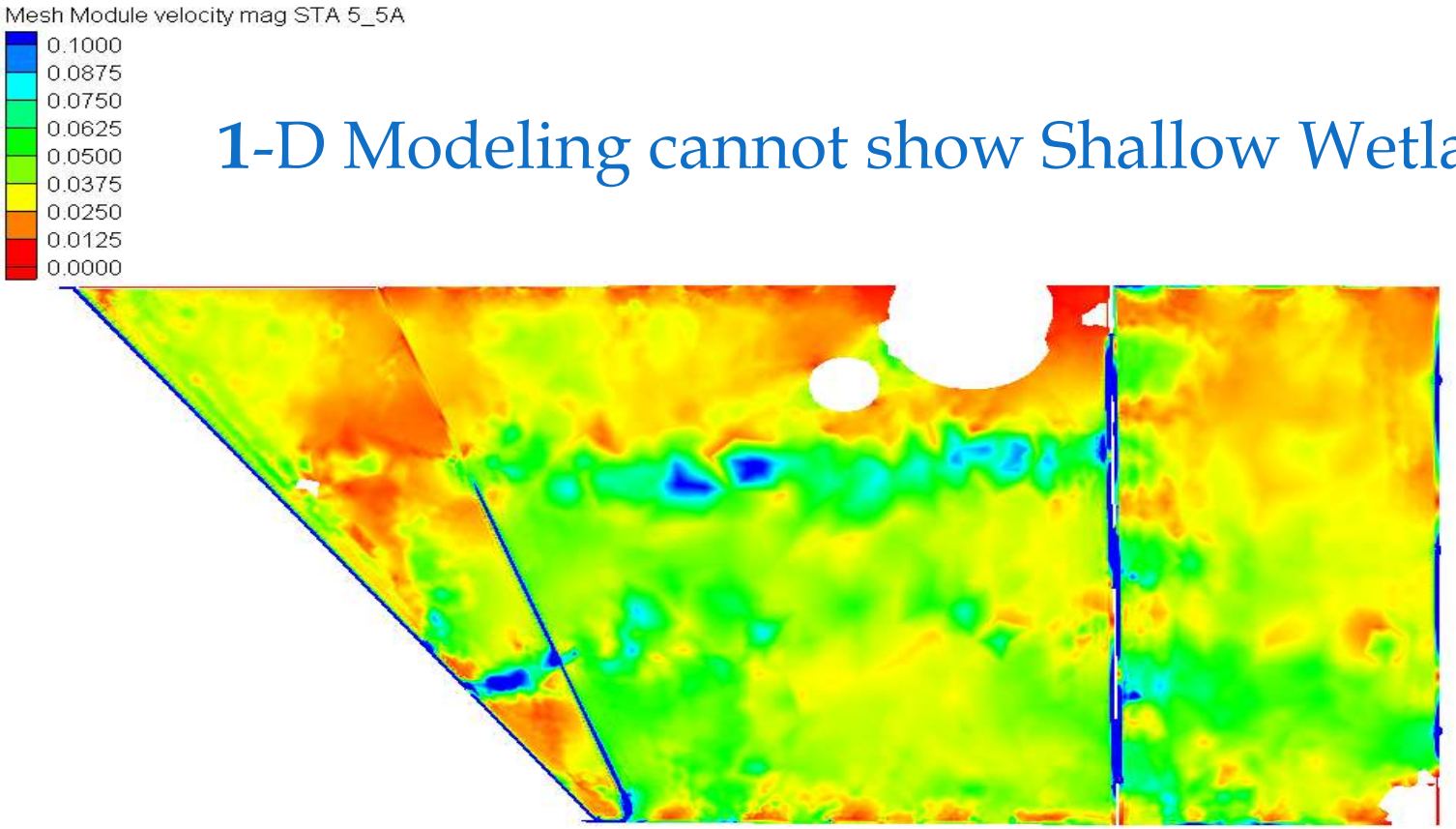
## Discharge Structures should be Overflow Type (e.g. Weirs)

Decant the Water and leave **P**-rich Sediment behind



# Important Design Components

## Use 2-D Hydraulic Modeling to Assess Flow through Wetlands

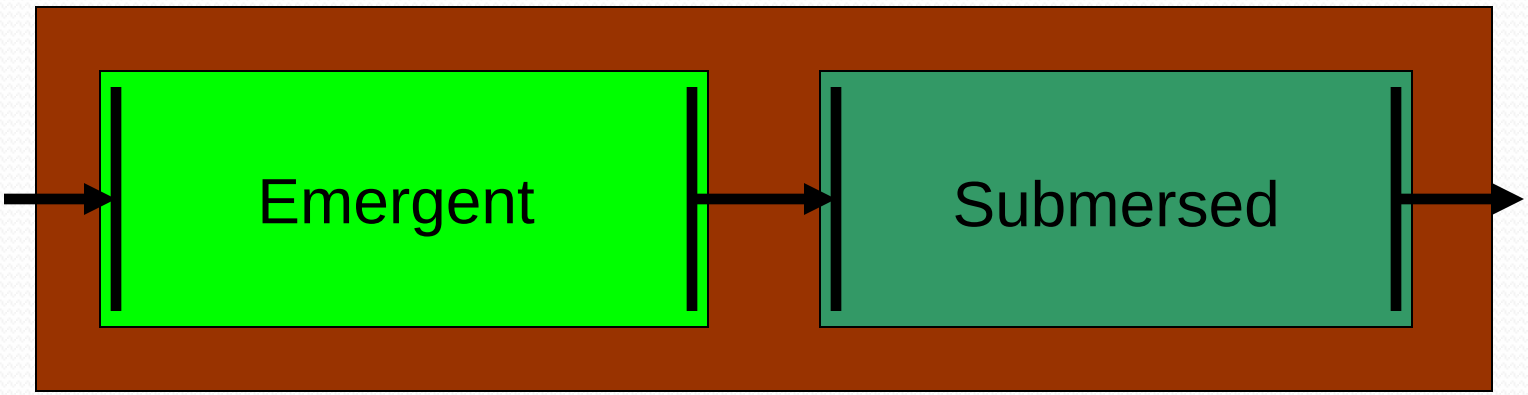



1-D Modeling cannot show Shallow Wetland Flow

# Important Design Components

## Create a Variety of Plant Communities across Wetland

- **G**reen, Emergent plants are not always necessary. Other Plant Species can provide better **P** Removal
- **A** Treatment Train of Emergent and Submersed Vegetation provides Improved **P** Removal



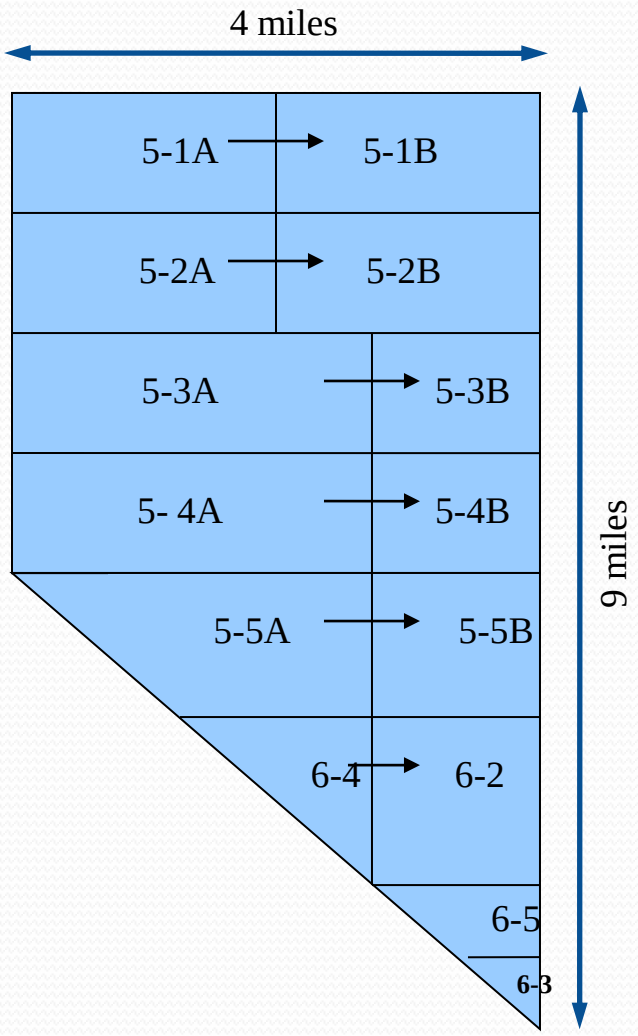
# Important Design Components

## Create structures that allow you to Harvest P-rich Sediments

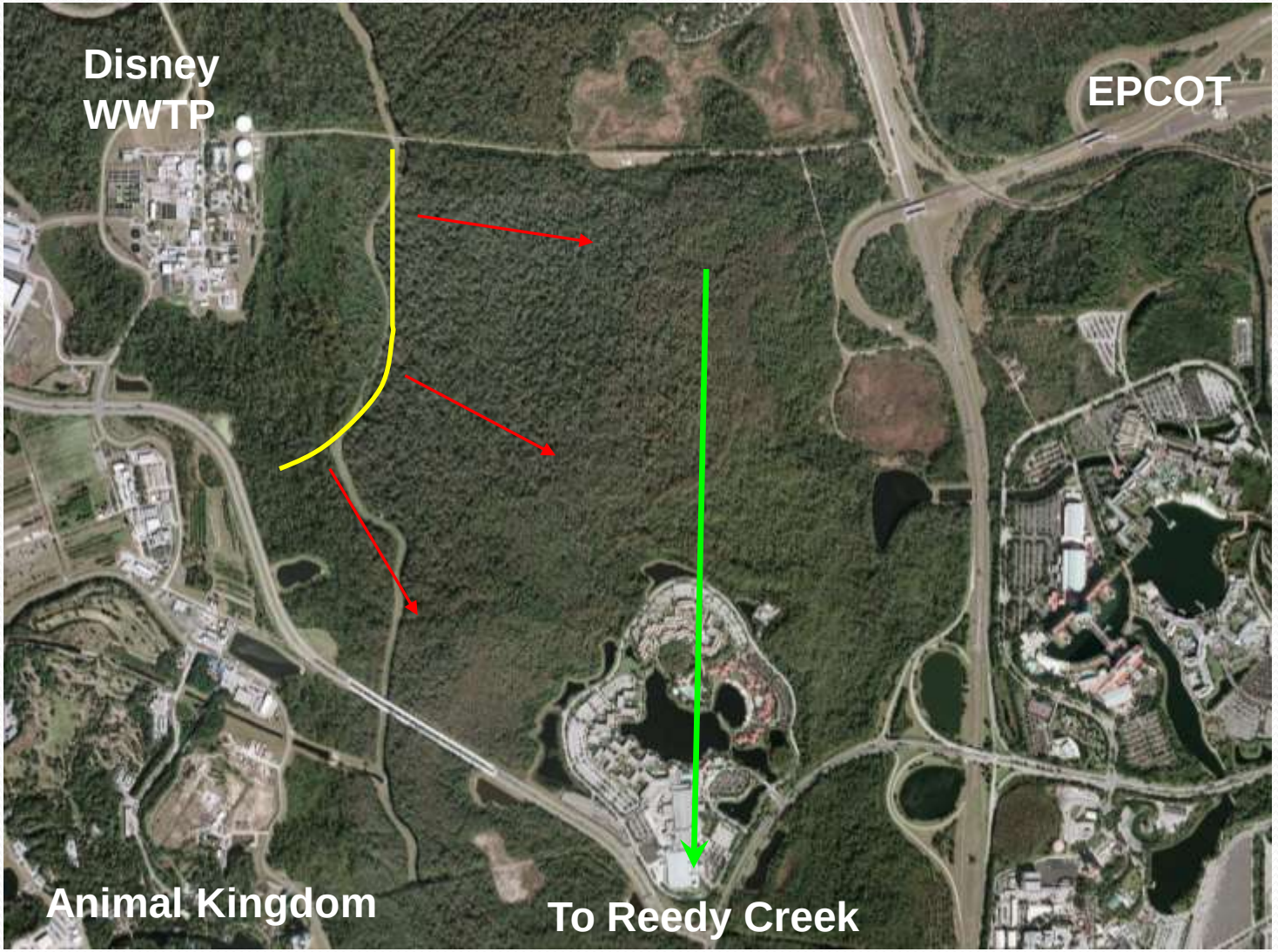
Ditches and Pools adjacent to Berms allow Equipment Access (Excavators, Dredges, Trucks)

# Stormwater Treatment Areas 5 & 6

- **H**andles over 900 MGD and reduces Total **P** Concentrations to less than 0.025 mg/L
- **I**nfluent **P** Concentrations typically less than 0.5 mg/L
- **O**ver 16,000 acres of Wetlands
- **O**ver 50 Gated Control Structures



# Reedy Creek Wetland Failure



# Mosquito Control

- Serious disease vector that must be controlled
- Control with fish, maintain permanent fish population with deeper pools within wetland
- Control with larvicide and adulticide applied to water as needed to control breakouts

# Beaver & Muskrat Control

- **A**nimals that can create Serious Damage to Treatment Wetland vegetation and structures
- **F**ence to keep out of Treatment Wetlands
- **T**rap or hunt to control populations
- **P**rotect Structures from clogging with Beaver Deceivers

# Bird Control

- **C**an damage Vegetation Population
- **M**ay add significant Waste and Bacteria to Water
- **L**imit the Open Water areas of Treatment Cells to Reduce Fly-In Potential
- **M**aintain Thickly-Vegetated Fringe around Open Water to Reduce Walk-In Potential

# Maintenance Requirements

- **S**ediment Removal is a Requirement for Long-Term Operation
- **A**ctive Vegetation Management will Probably be needed at Times (Herbicides, Selective Removal, Replanting, etc.)
- **E**xpect to Spend at least $1,000 per Year per Acre for Maintenance

# Summary

- Treatment Wetlands do not Replace Conventional WW Treatment
- Treatment Wetlands can reduce Phosphorus to very Low Concentrations (<< 0.1 mg/L) without Metals Toxicity
- Treatment Wetlands DO NOT provide good Nitrogen Removal
- Treatment Wetlands require active Management and Maintenance for High Performance
- Surface Flow Wetlands are superior to Subsurface Flow Wetlands in Performance, Construction, and Maintenance

# The End (Product)

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