

# Nitrate Removal in Constructed Wetlands

## BATCH versus FIELD RESULTS

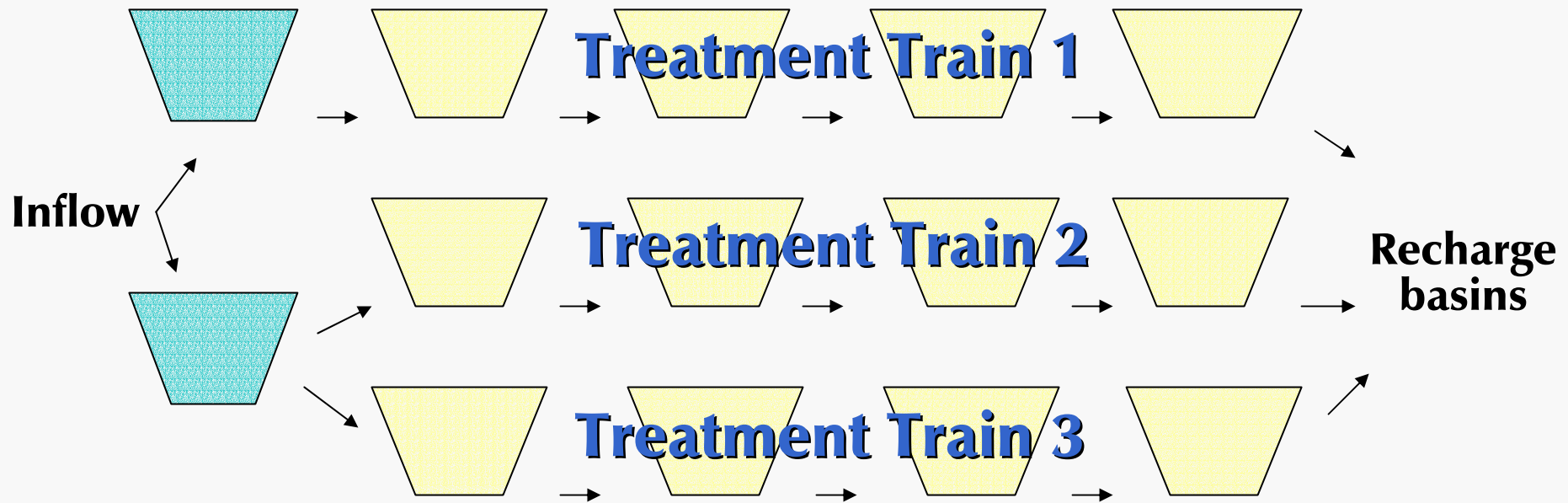
Andrew Komor - Dr. Peter Fox





**PACE**  
PACIFIC ADVANCED  
CIVIL ENGINEERING



# Avondale Treatment Schematic



 - 5 acre equalization basin

 - 5 acre wetland (2 acres vegetative Island)

# Recharge Basins

I-10

Thomas Rd.

McDowell Rd.

1

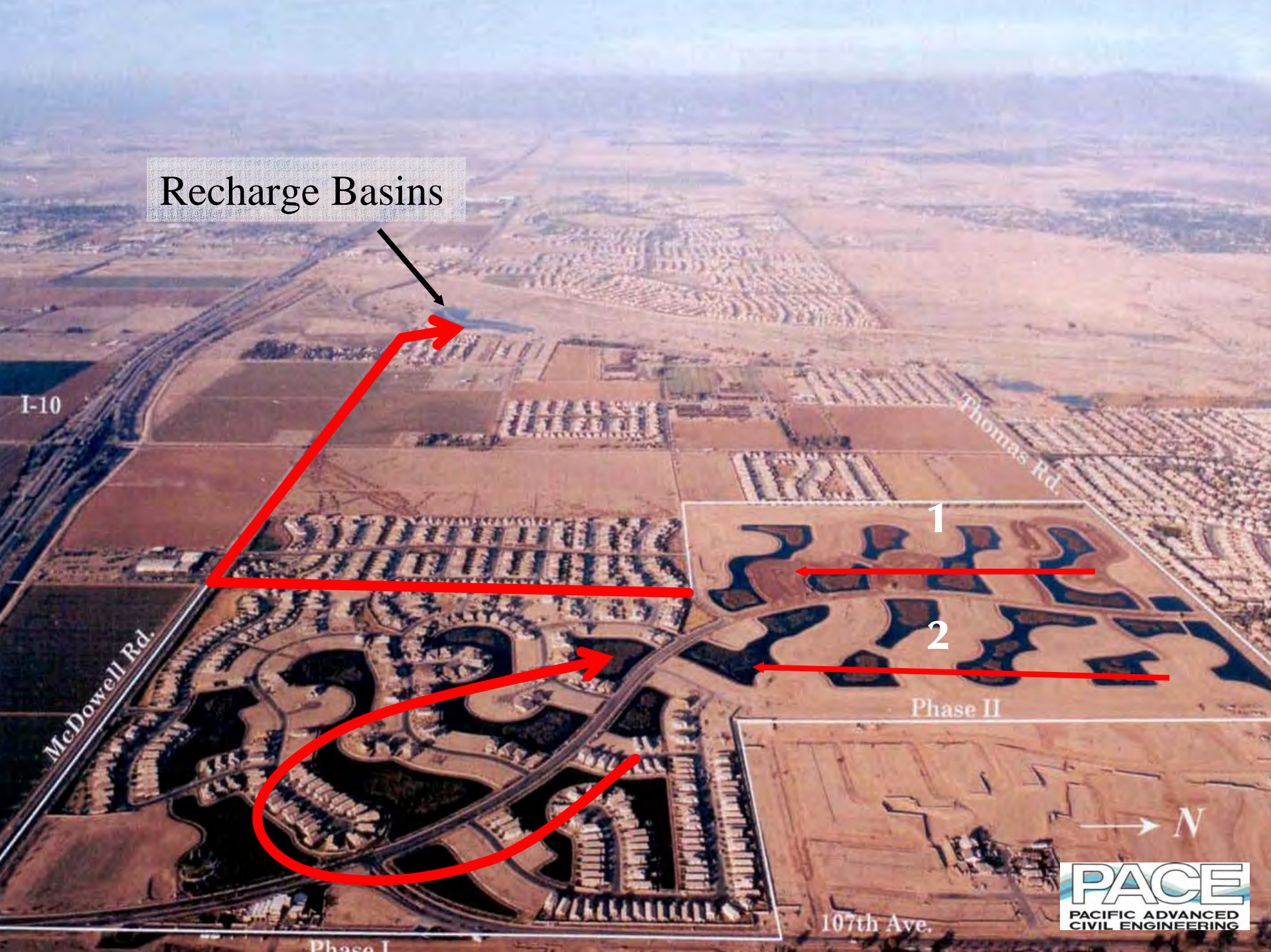
2

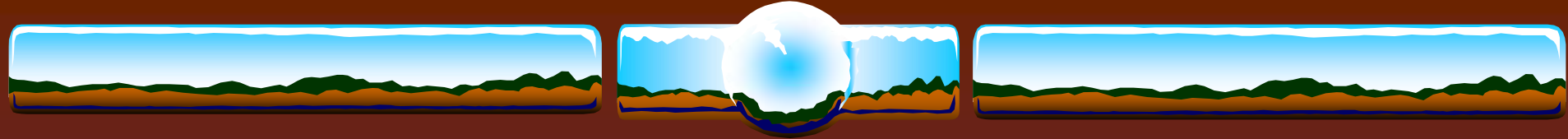
Phase II

N

107th Ave.

Phase I





# **How is Nitrate removed in wetlands?**

**Under anoxic conditions, Nitrate ( $\text{NO}_3^-$ ) is an alternative electron acceptor used for microbial respiration.**

**Wetland sediments are ideal environments for these organisms consisting of low  $[\text{O}_2]$  and high levels of electron donor.**



# Wetlands of Avondale Study

- 1. Calculate rates of N loading/removal**
- 2. Determine limiting factors for denitrification**
- 3. Develop wetland design criteria**





# **Rates of Nitrate Removal**

- 1. Annual Mass Balance**
- 2. Zero-Flow Field Sampling w/Time**
- 3. Continuous-Flow Field Sampling**
- 4. Laboratory Batch Experiments**



# Annual Mass Balance

Mass Change in N (kg/day) =

$$Q_{\text{out}} * [\text{NO}_3\text{-N}]_{\text{out}} - Q_{\text{in}} * [\text{NO}_3\text{-N}]_{\text{in}}$$

**Assume:**

**Organic N, Nitrite ( $\text{NO}_2^-$ ), and Ammonia ( $\text{NH}_3$ )  
Constituents are Negligible**



# Mass Balance Results

10/99-10/00 Adjusted N Removal = **34 kg N/day**  
= **1.2 kg N** per acre vegetative area

*(rates based on 78-acres; 30-acres vegetative area)*



# Zero-Flow Field Sampling

## Wetland Cells 7 & 9:



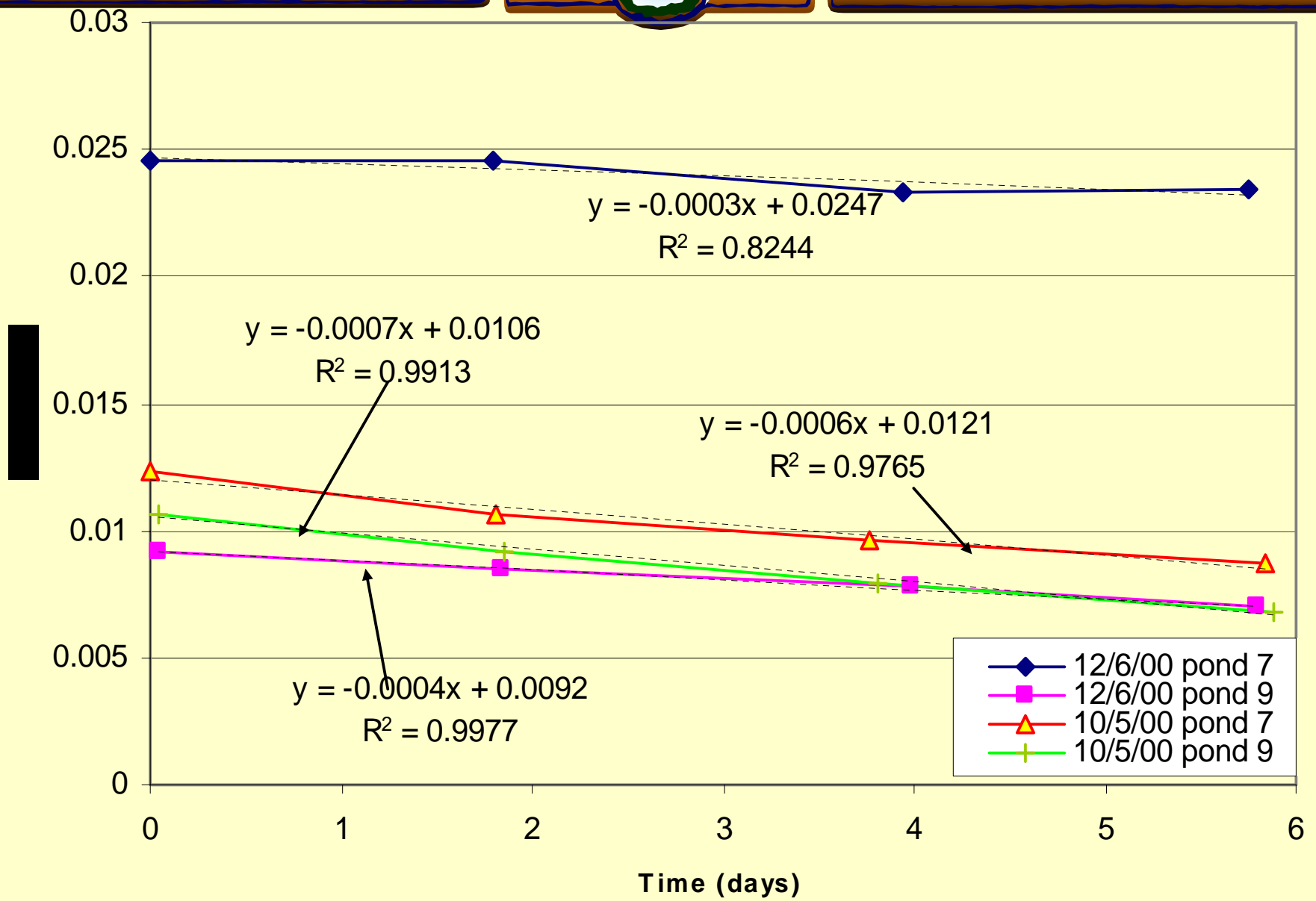
10/5/00 (22° C)  $\Delta$  [NO<sub>x</sub>] :

1.7-1.9 kg N/acre\*day

12/6/01 (13° C)  $\Delta$  [NO<sub>x</sub>] :

0.8-1.1 kg N/acre\*day

# [NOx]/[Cl] versus Time





# Continuous Flow Field Sampling

Denitrification Rates Estimated Based on:

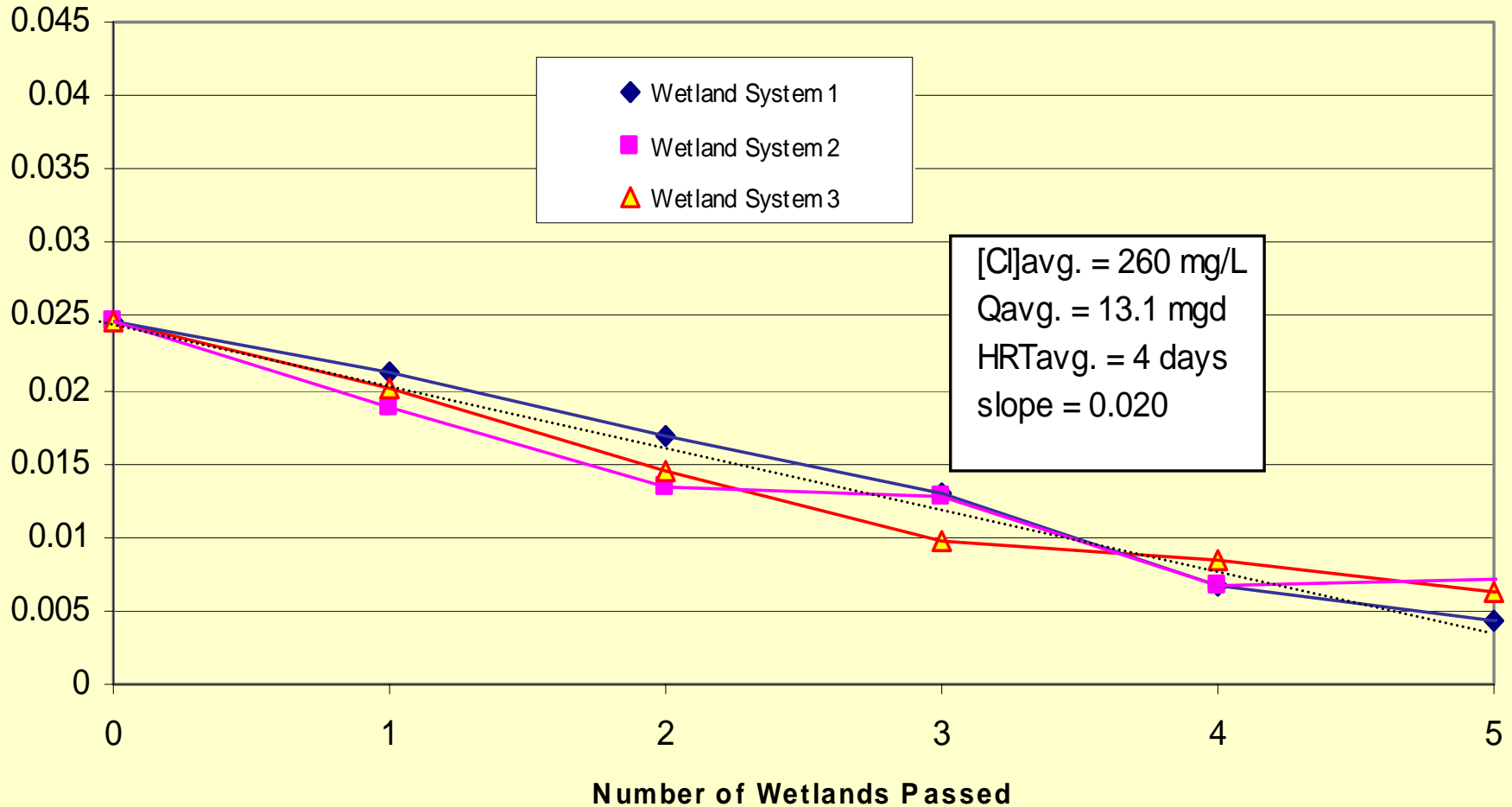
Slope of  $\Delta$  [NO<sub>x</sub>] vs. # Wetlands Passed Plot

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system hydraulic retention time

# Continuous-Flow Field Sampling: 8/25/00

(Nitrate/Chloride) versus Number of Wetlands Passed



Denitrification Rates = 0.7- 2.6 kg N/acre\*day

# Laboratory Experiments





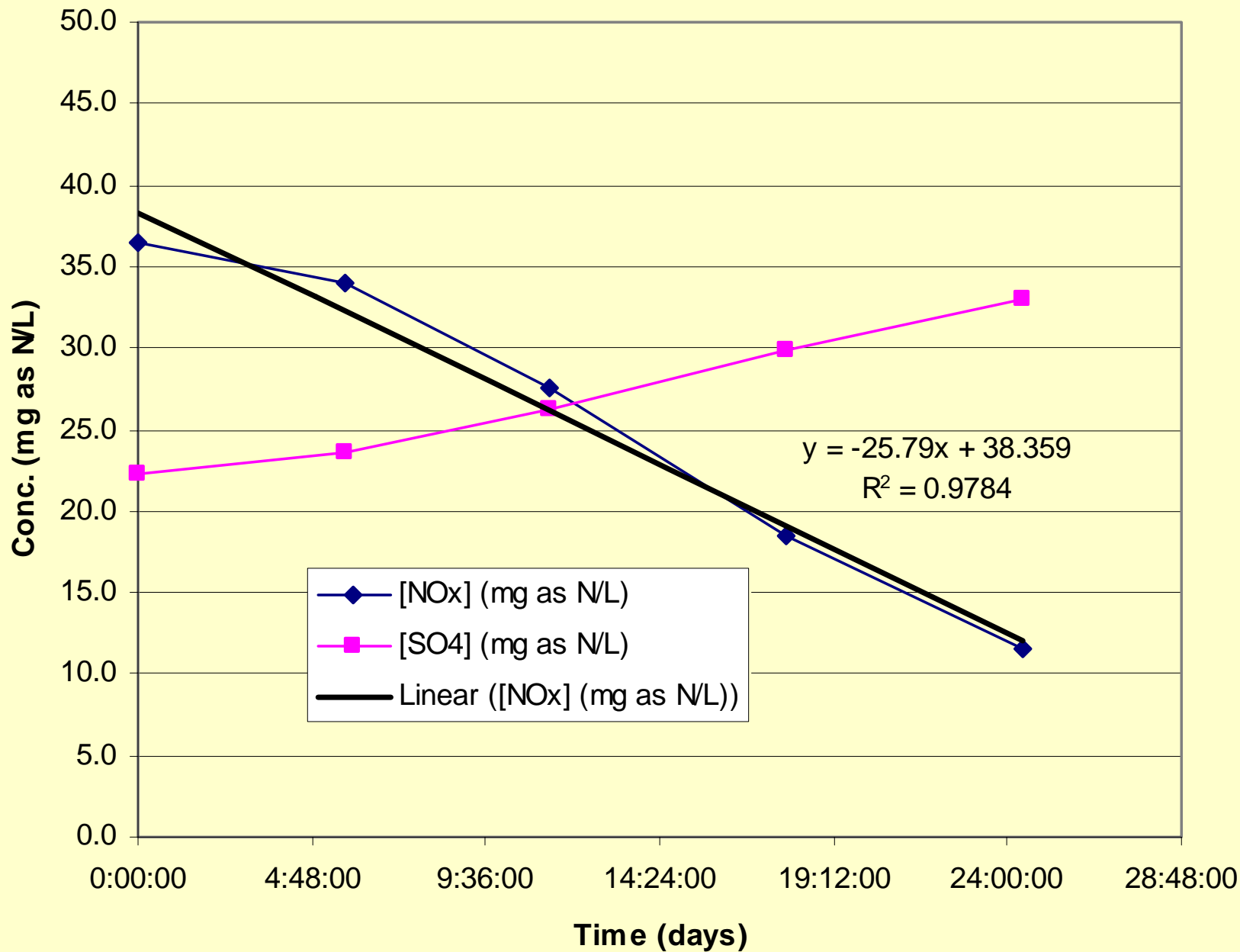
# How were Batch Experiments Performed?

1. Collect 1" diameter sediment cores
2. Fill 165mL serum bottles with sediment, 80mL wetland water
3. Purge headspace with nitrogen gas

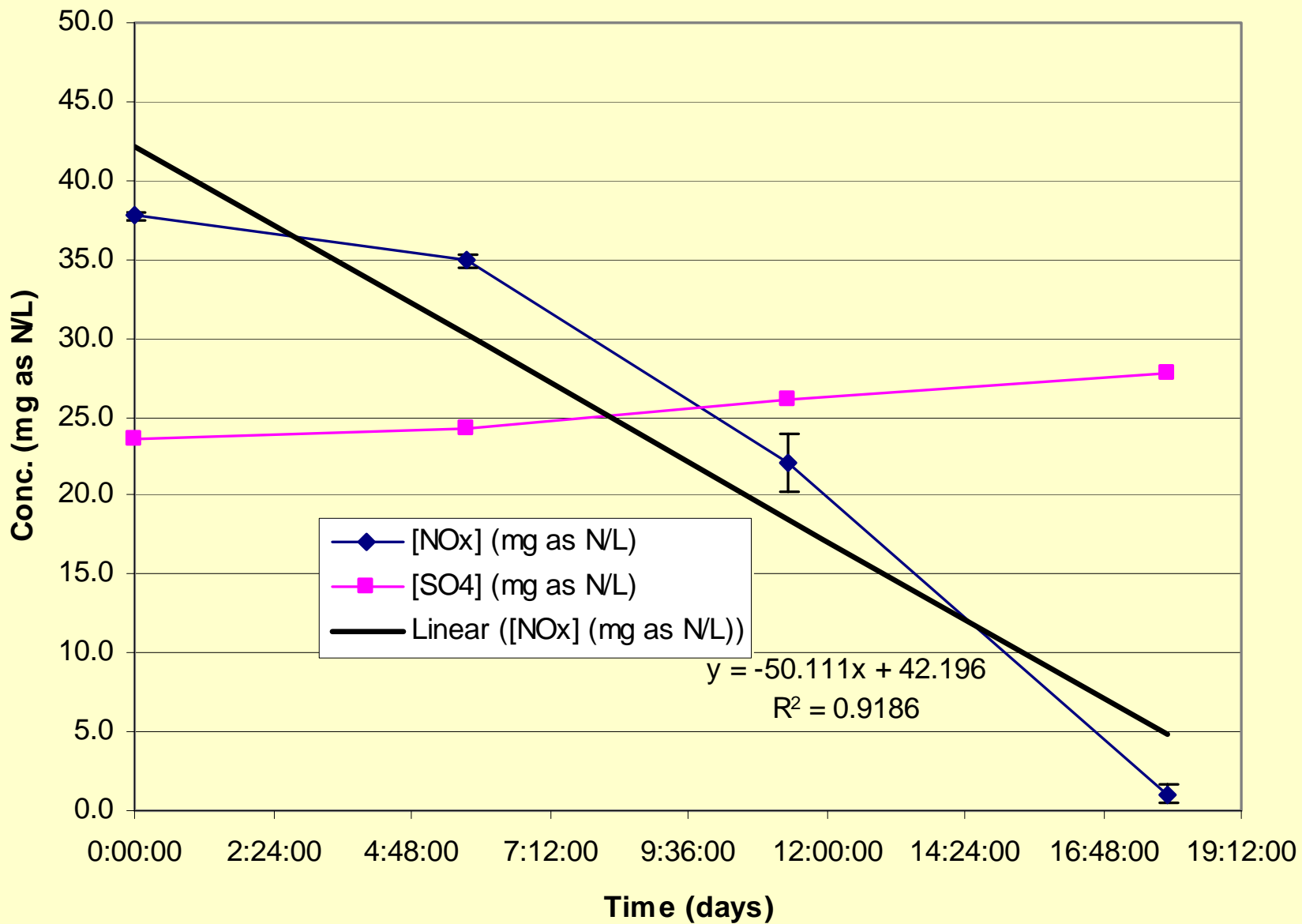


4. Ammend bottles with nitrate and electron donor
5. Mix bottles on shaker table in the dark
6. Monitor ionic concentrations with time

# Avondale010207: soil (2-4 cm depth); 2m M NO3-



Avondale010207: soil (2-4 cm), 2mM NO3-, 2g finely chopped fresh plants





# Laboratory Results

**2mM NO<sub>3</sub><sup>-</sup> Amended Experiments:**

$$\Delta [\text{NO}_x] = 13.6 - 20.6 \text{ kg/acre*day}$$

Addition of Plants:

1. Increase in rates were function of chopping size
2. Dried plants had less effect than fresh plants
3. Glucose & plants had similar factors of inc. rates



# **Experimental Results (continued)...**

## **Addition of Sulfide:**

1. Generally increased rates by a factor of 1.5
2. Inhibitory effect in some circumstances

## **Headspace Analysis:**

1. Complete denitrification observed in most cases
2. Acetylene and sulfide inhibitory in final step



# Conclusions

1. Lab NO<sub>x</sub> removal rates were 10X higher than field rates, indicating mass transfer resistance in the field
2. Both field and lab rates were zero-order in nature, and advection did not affect field rates significantly
3. Temp. increases of 15°C increased field rates 3-fold



# Conclusions (cont...)

4. Field and lab results displayed combined mechanisms of autotrophic and heterotrophic reactions
5. Sulfur reduction/oxidation was evident and vital to system performance



**Arizona Dept. of Water Resources**

**City of Avondale**



**Integrated Water Resources**

