Application of Water Treatment Residuals to Reduce Phosphorus Loss from Agricultural Land and to Protect Surface and Ground Water

W-1170 Research Efforts

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Source Water
Lake Wister, OK
Neuse River, NC

Strategies to Control Non-point Nutrient Pollution

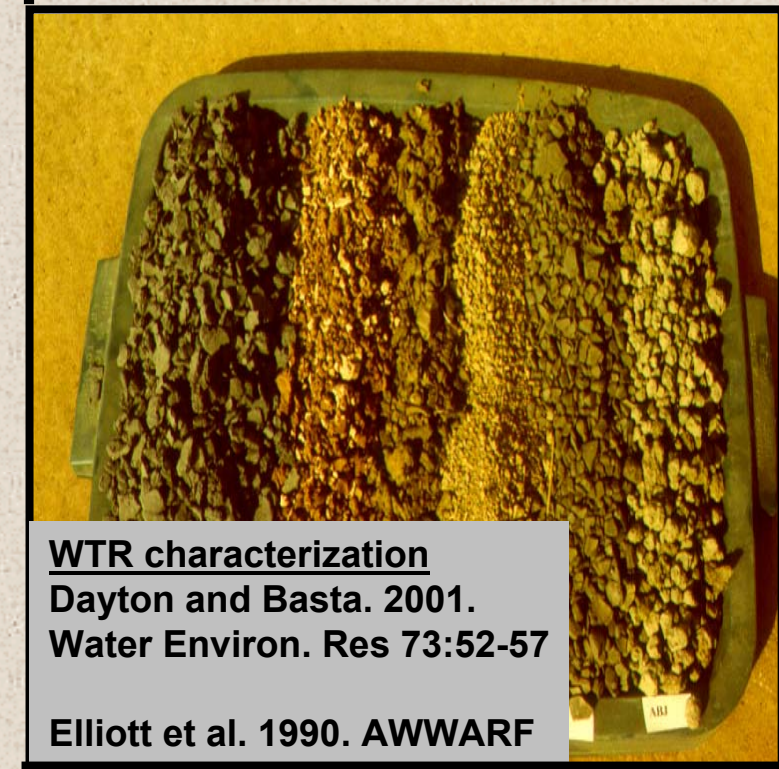
Best Management Practices (BMP)

- Conservation tillage
- Crop residue management
- Cover crops
- Buffer strips
- Contour tillage
- Runoff water impoundment
- Terracing

These strategies are effective in controlling particulate P but not dissolved (or labile) P in agricultural runoff water

New BMPs needed to reduce P loss

Drinking Water Treatment Residuals (WTR) a BMP to Reduce P Transport from Land



WTR characterization
Dayton and Basta. 2001. Water Environ. Res 73:52-57

Elliott et al. 1990. AWWARF

WTR Contains

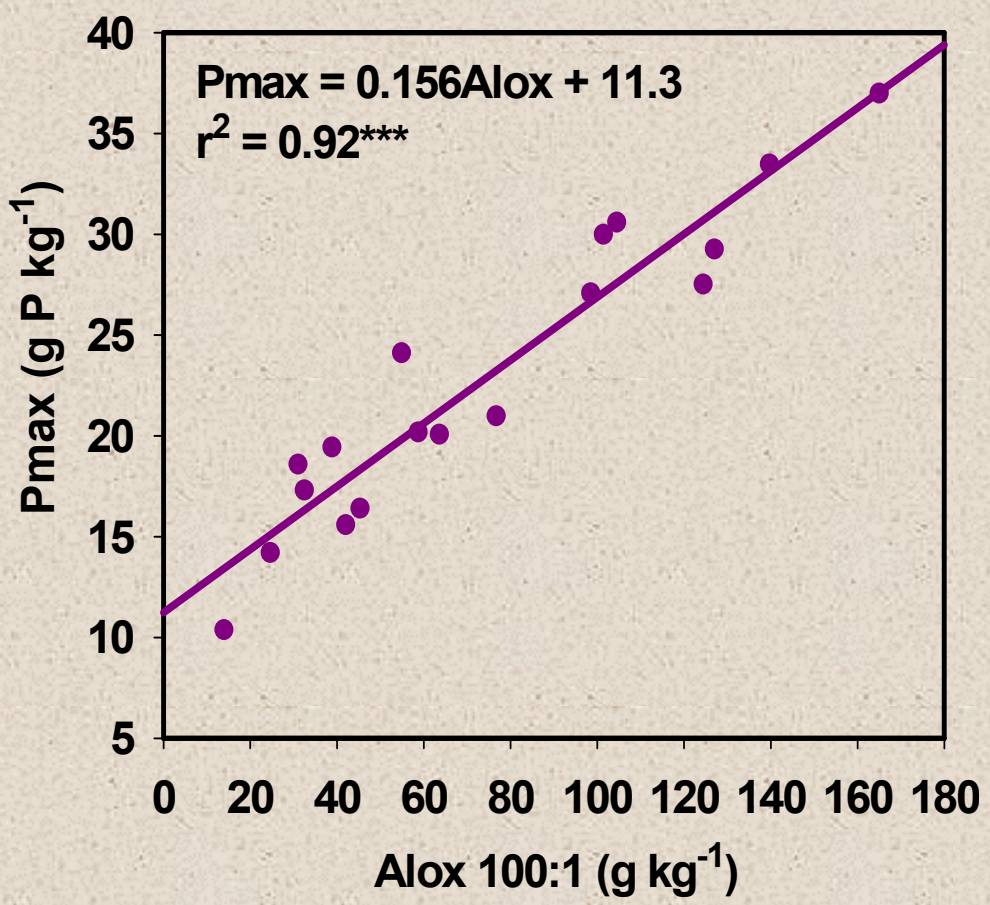
- Sediment
- Coagulant Reaction Products
  Al or Fe oxides -- P sorption

WTR Disposal

- Landfill
- Store in on-site lagoons
- Discharge to sewer system

P Adsorption Capacity of Al-based WTR

Strongly related to amorphous Al oxide



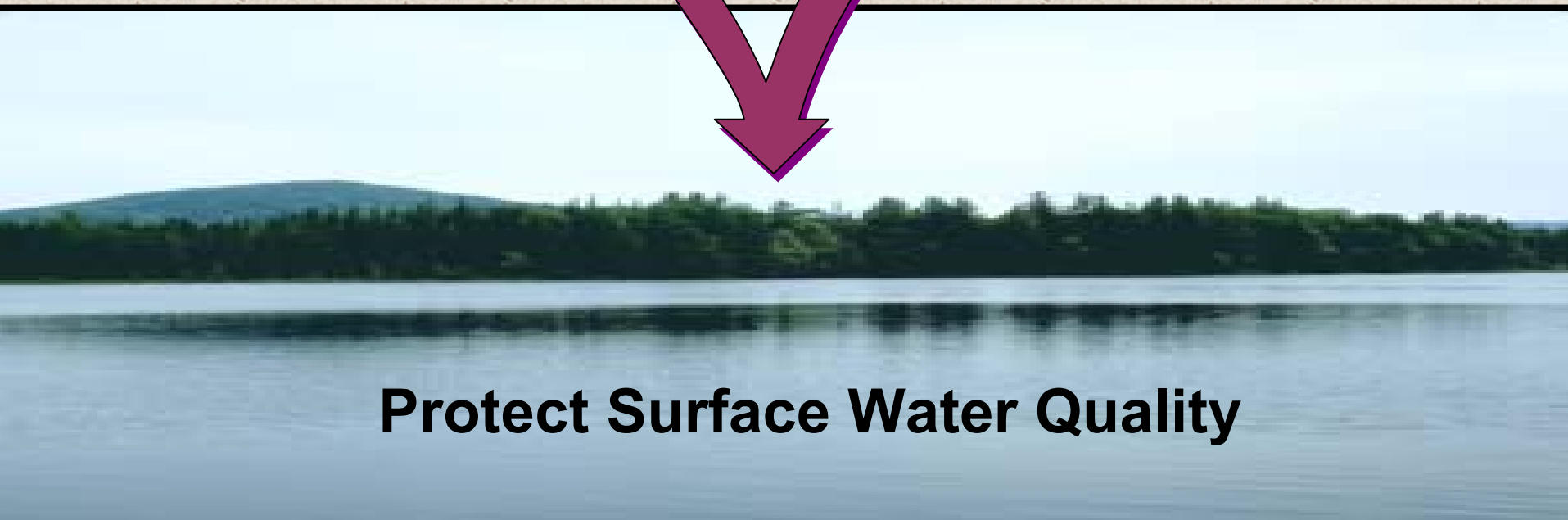
Phosphorus adsorption maxima (P_{max}) strongly correlated with acid ammonium oxalate extractable Al

Dayton and Basta. 2005.
A method for determining the P sorption capacity and amorphous Al of Al-based WTR
J. Environ. Qual. 34:1112-1118.

Select high capacity adsorbers for field use to reduce P runoff / loss from agricultural land

Poultry litter
application to pasture

WTR
Disposal


Protect Surface Water Quality

W-1170 Research Activities
Use of Drinking Water Treatment Residuals (WTR) as a BMP to Reduce P Transport From Land

- **WTR Characterization**

- **Reduction in P solubility / transport**

  Methods to determine WTR application rate
  Incorporation of WTR into NRCS Nutrient Management Planning
  P risk index

- **Stability of adsorbed P**

Published works:
Refereed Journals (30)
Book Chapters (2)
Proceedings / Abstracts (>50)
M.S. Theses / Ph.D. Dissertations (3)

WTR Beneficial Use Options to Reduce P runoff from Agricultural Land

Pasture (unplowed)
mostly soluble runoff P

Surface Apply WTR
Adsorb P from runoff water
Reduce soluble P in runoff

Field Crops (plowed)
mostly soil erosion P

Incorporate WTR into soil
reduce soluble P in soil
Reduce P release from soil

Co-Blending WTR
WTR / Manure
Reduce soluble P

Surface Application of WTR Simulated Runoff Studies

Poultry litter surface applied

↓

WTR applied to box plot

↓

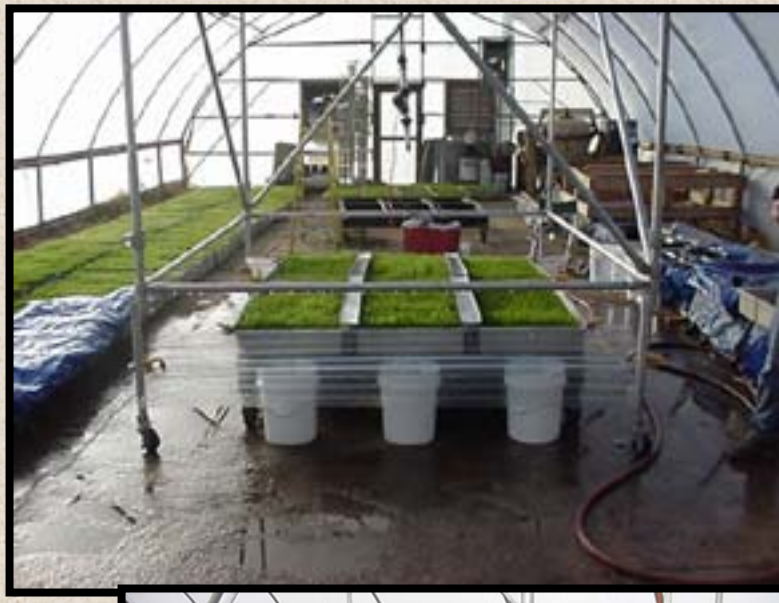
Simulated rainfall applied

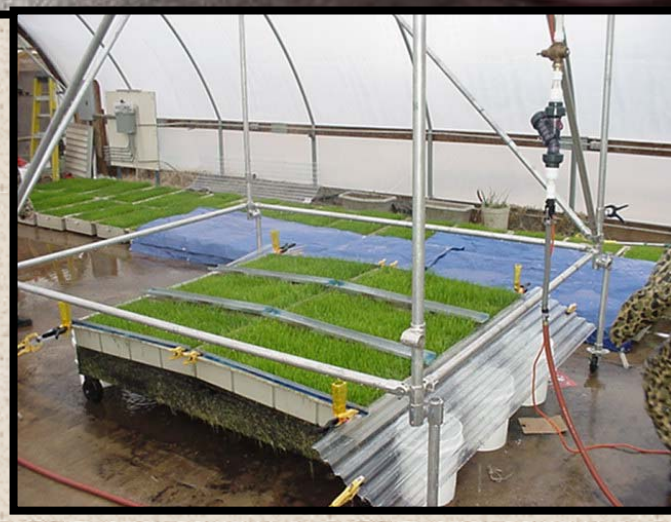
↓

Runoff collected

↓

Reduction in P Runoff from WTR determined

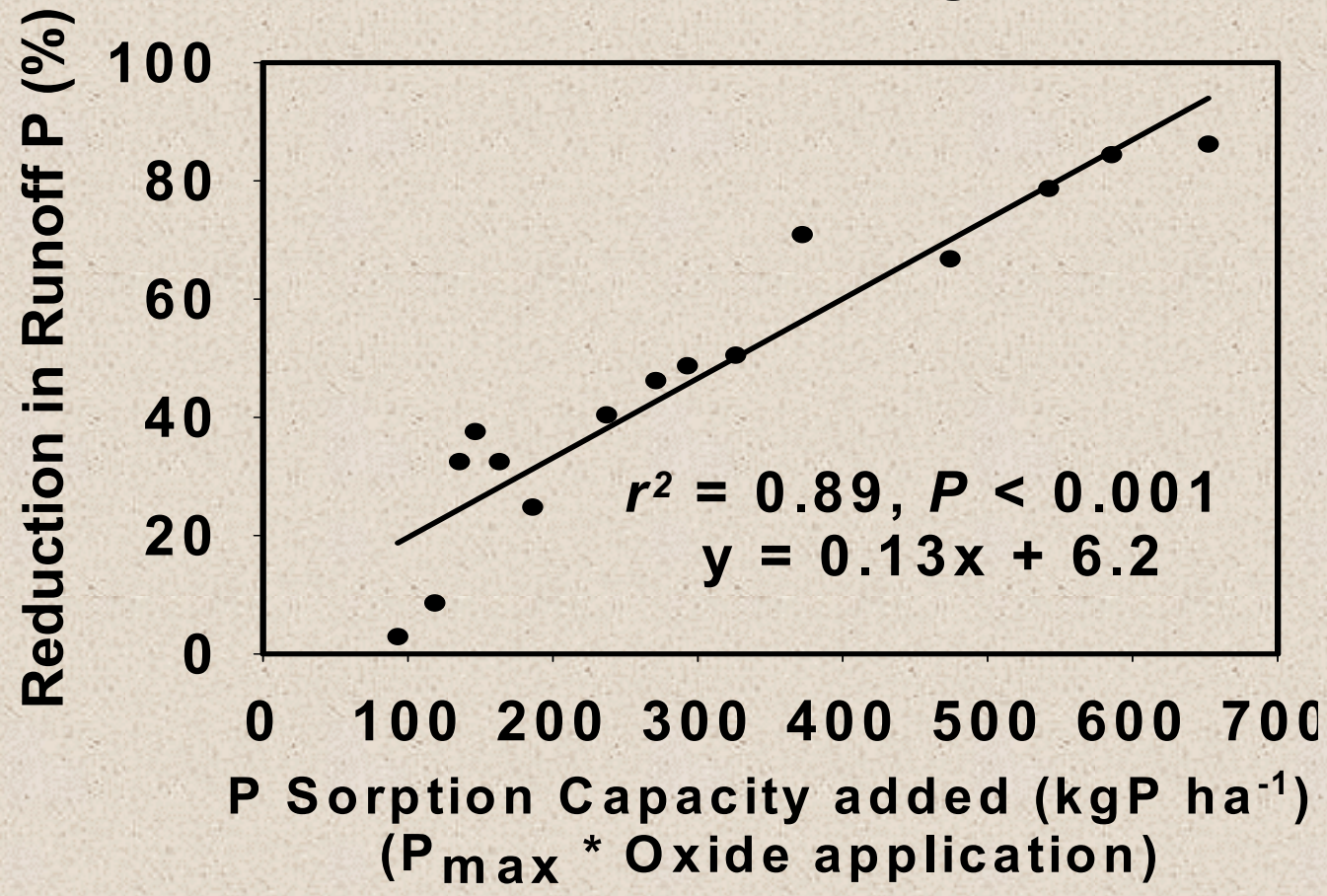




Reductions in Runoff P related to Added P Sorption Capacity

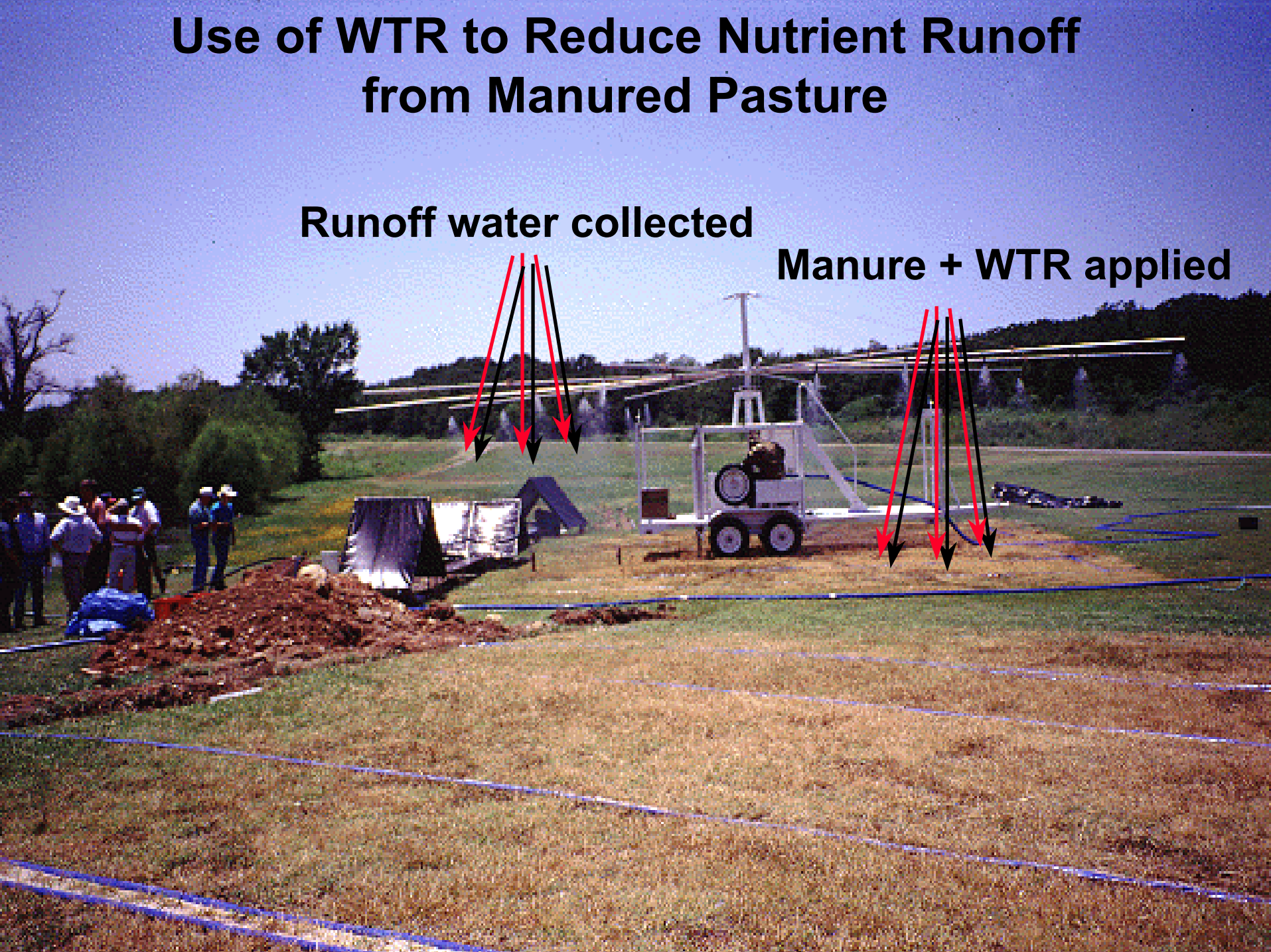
Control = 31 mg P /L

WTR Additions of 0, 5, 10, 20 Mg/ha in a filter strip



Dayton & Basta. 2005. JEQ 34:2112-2117

Use of WTR to Reduce Nutrient Runoff from Manured Pasture



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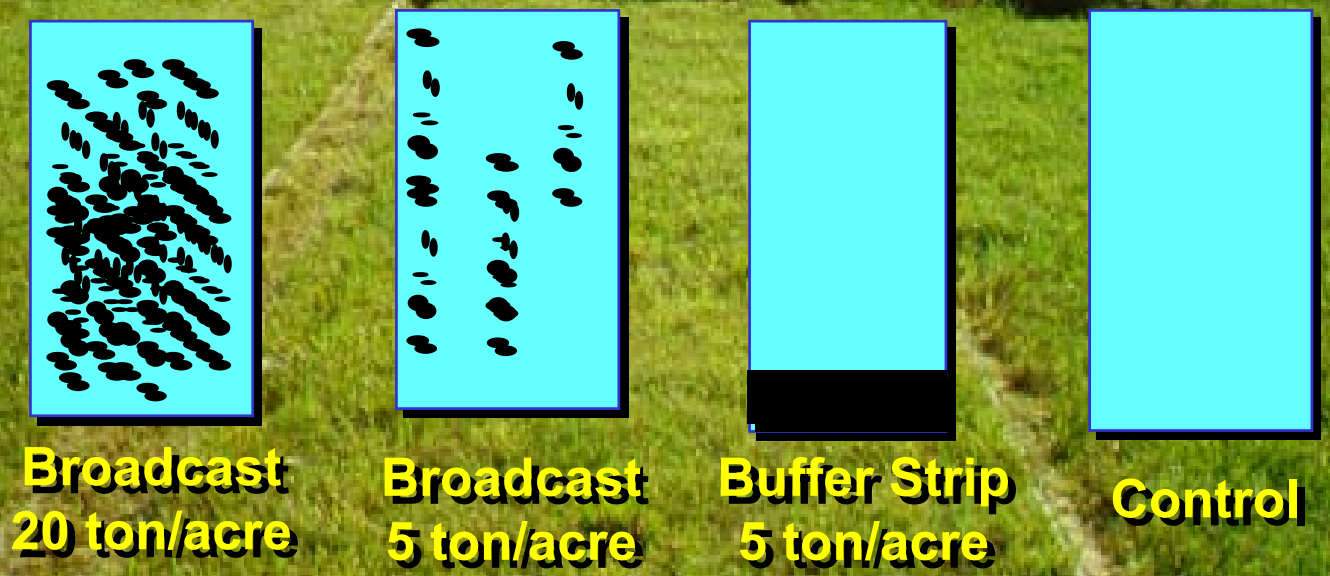
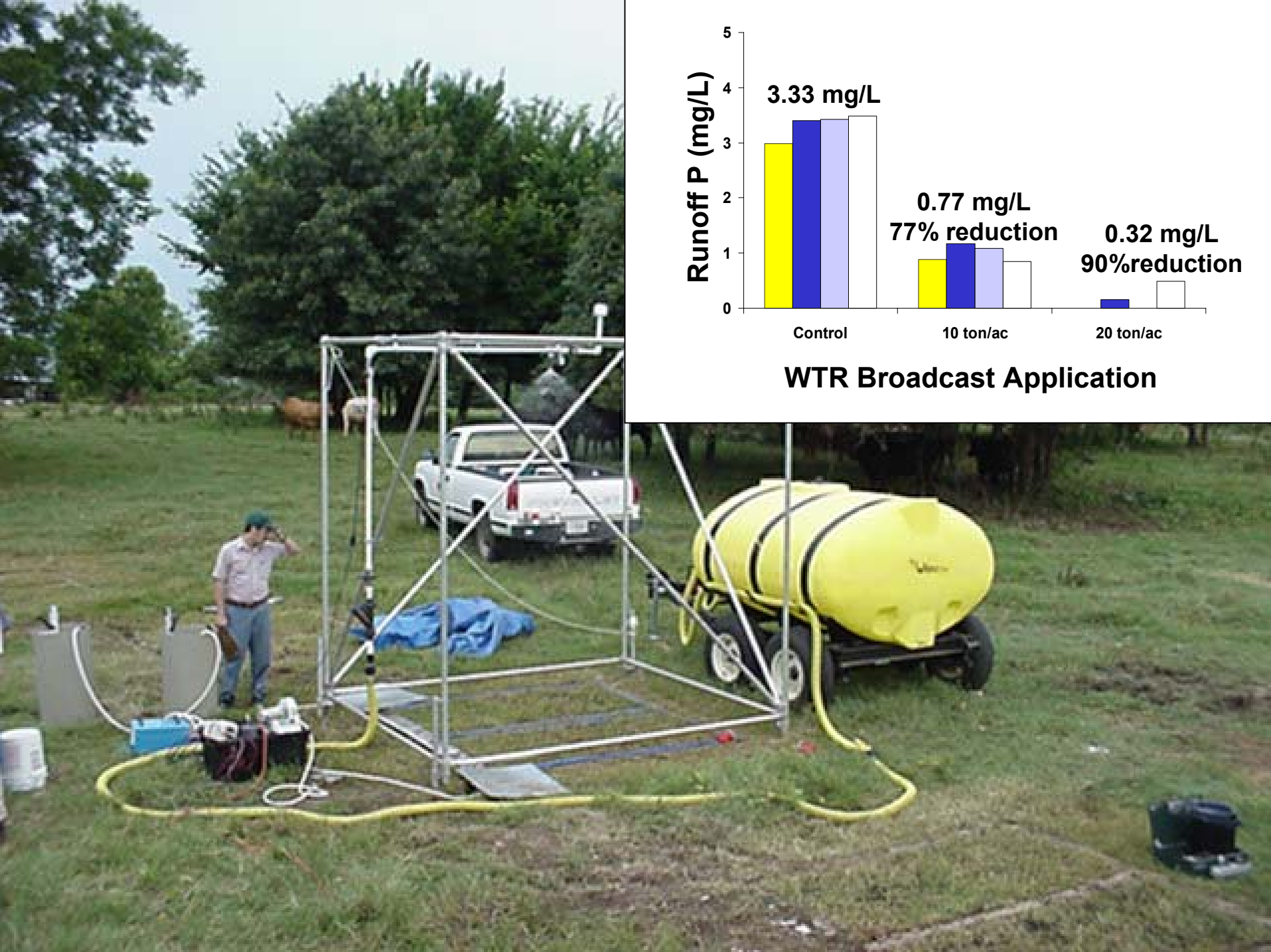
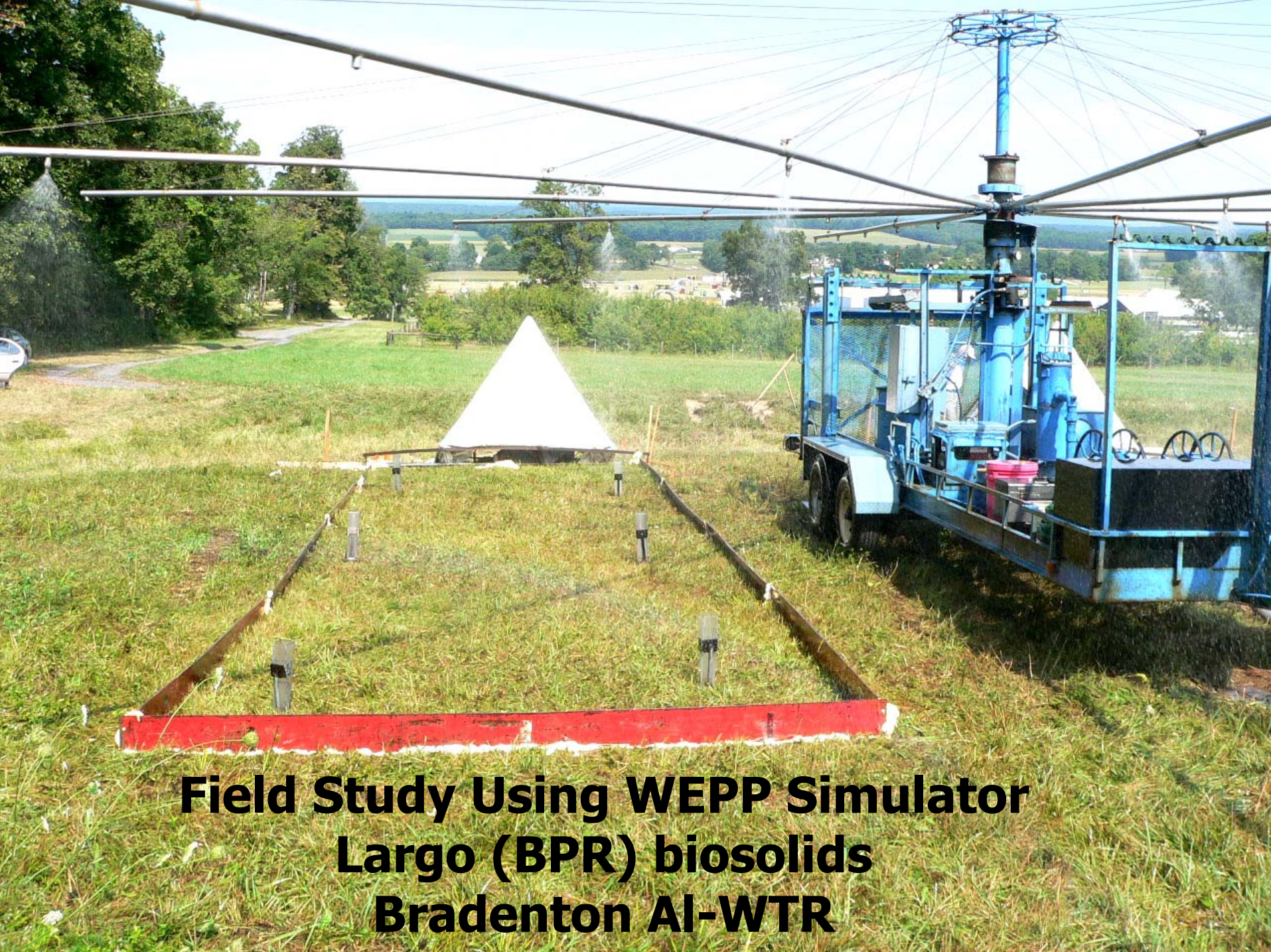
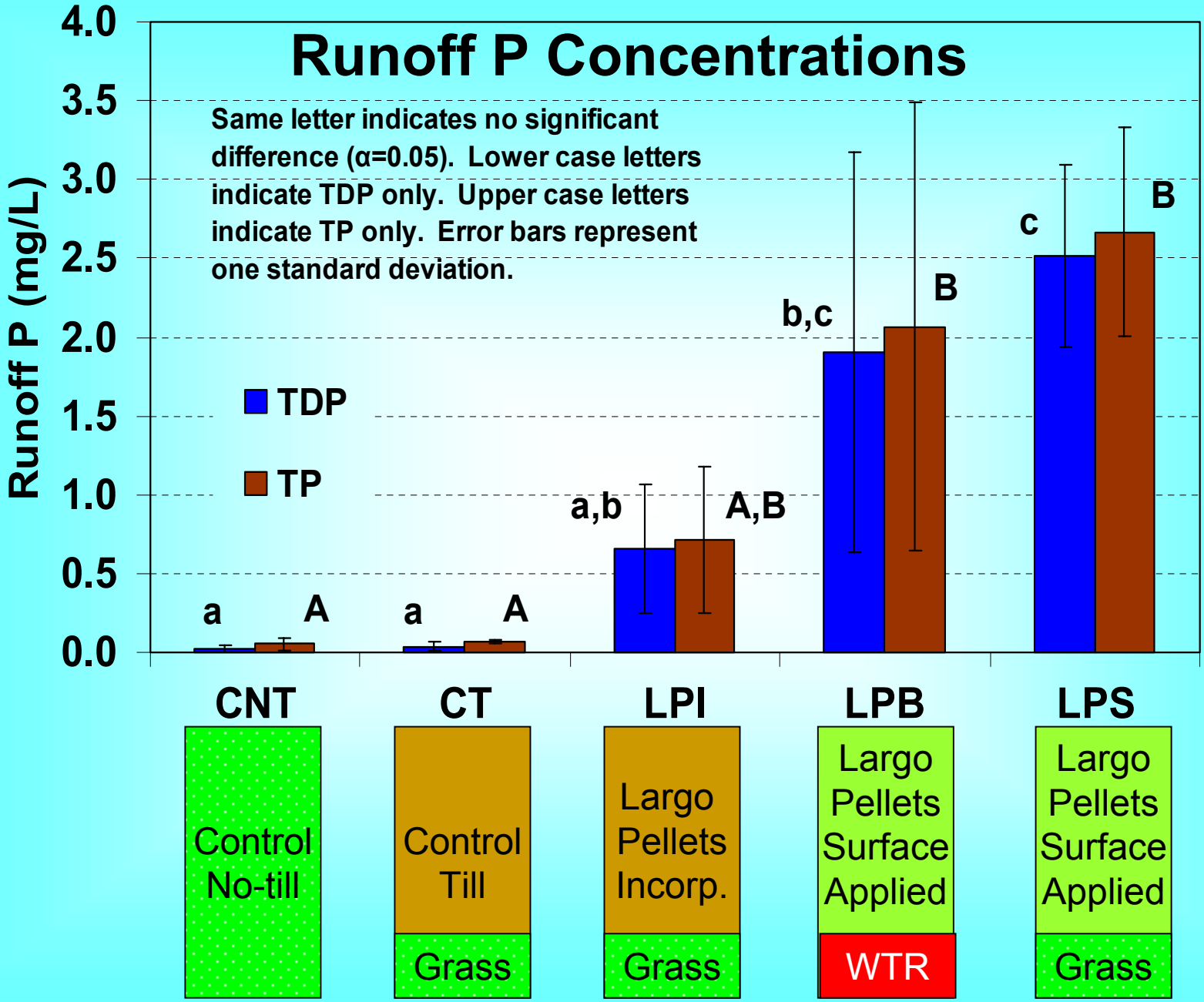


WTR Reduced Runoff P up to 50%

Gallimore et al. 1999. J. Environ. Qual. 28:1474-1478


Runoff P (mg/L)
5
4
3
2
1
0
3.33 mg/L
0.77 mg/L
77% reduction
0.32 mg/L
90%reduction
Control
10 ton/ac
20 ton/ac
WTR Broadcast Application


Field Study Using WEPP Simulator
Largo (BPR) biosolids
Bradenton Al-WTR


Runoff P Concentrations
Same letter indicates no significant difference (α=0.05). Lower case letters indicate TDP only. Upper case letters indicate TP only. Error bars represent one standard deviation.
Runoff P (mg/L)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
TDP
TP
a
A
a
A
a,b
A,B
b,c
B
c
B
CNT
CT
LPI
LPB
LPS
Control No-till
Control Till
Grass
Largo Pellets Incorp.
Grass
Largo Pellets Surface Applied
WTR
Largo Pellets Surface Applied
Grass

Why was the WTR-enhanced buffer strip ineffective?

For the research plots, sheet flow travel time (T) according to NRCS Segmental Method (1986):

$$T = \frac{0.42\,(nL)^{0.8}}{P^{0.5}\,S^{0.4}} = 48 \text{ seconds!}$$

Therefore, inadequate contact time for WTR to sorb significant P from runoff.

Conclusion: Use of WTR-enhanced buffer strips as a BMP requires careful design.

Soil Incorporation of WTR

Soil with Excessive Soil Test P for Crop Production

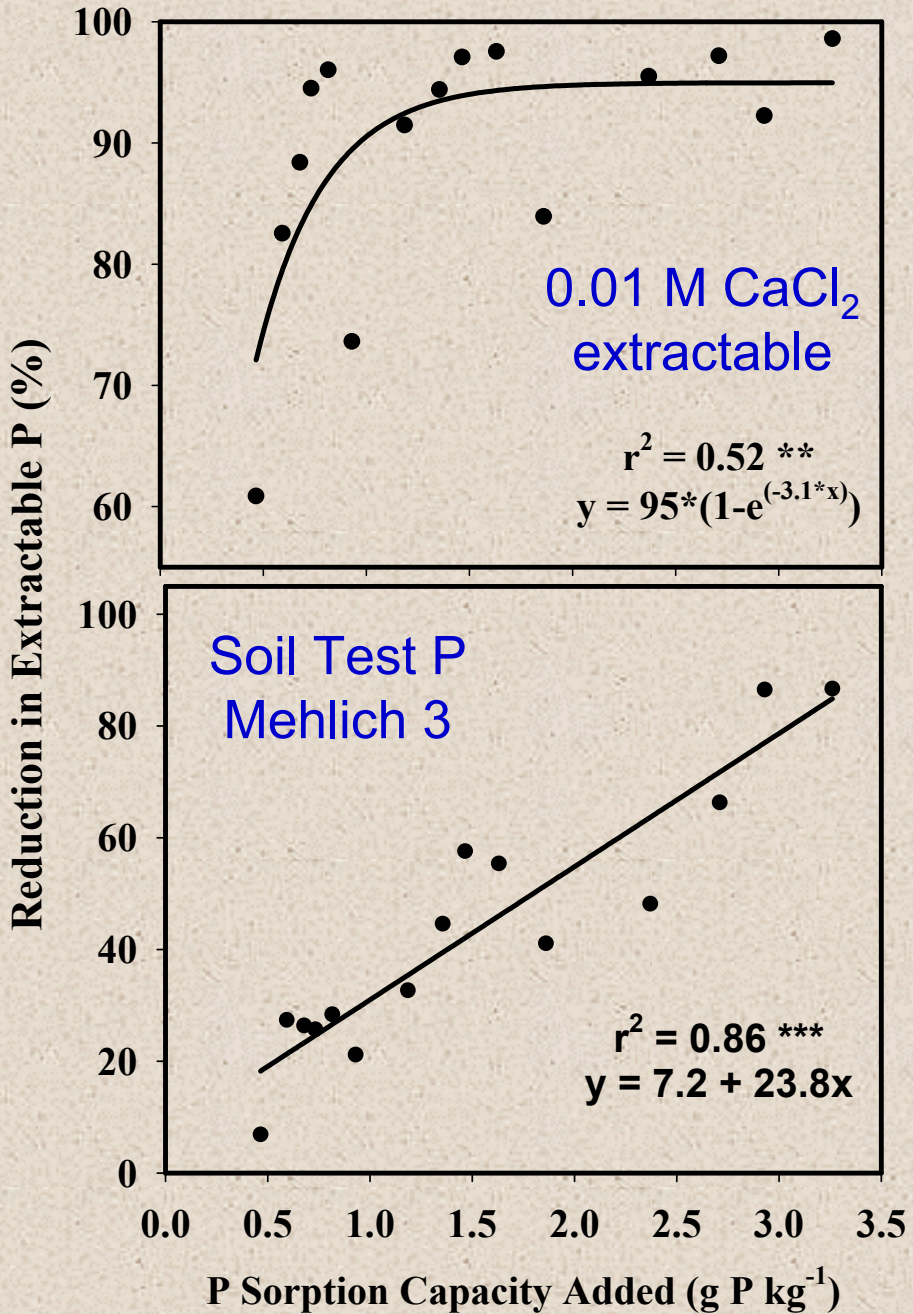
↓

Incubate Soil with WTR at several application rates

↓

Measure Reduction in Soluble / Extractable P

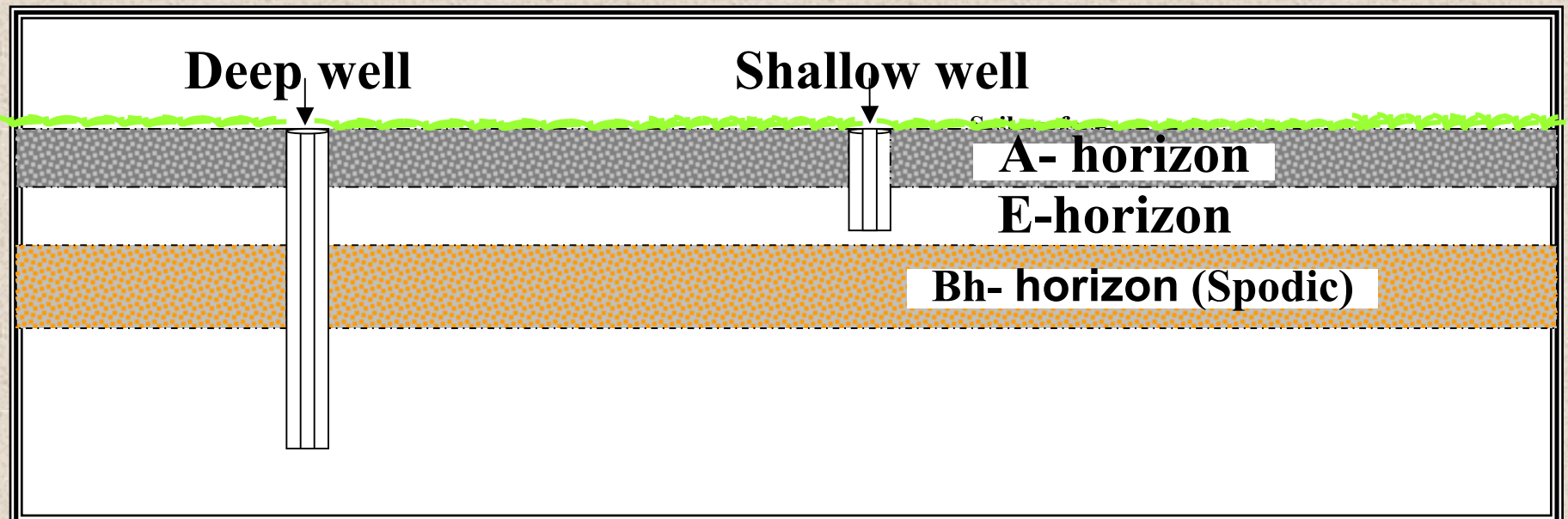
Soil Incorporation of WTR Reduces Extractable P



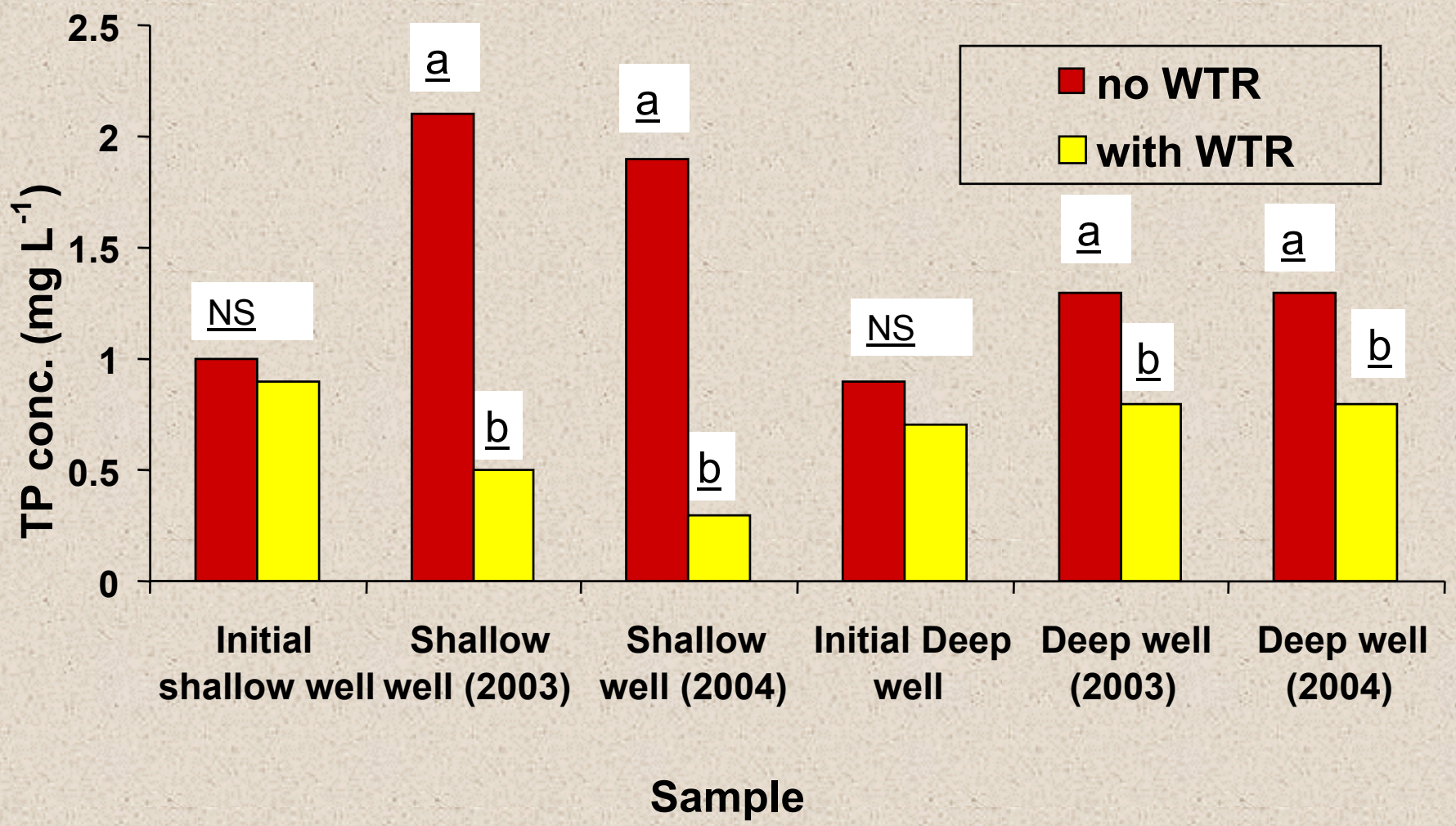
Reductions in Extractable P related to Pmax*WTR

"added sorption capacity"

WTR Application to Reduce P leaching



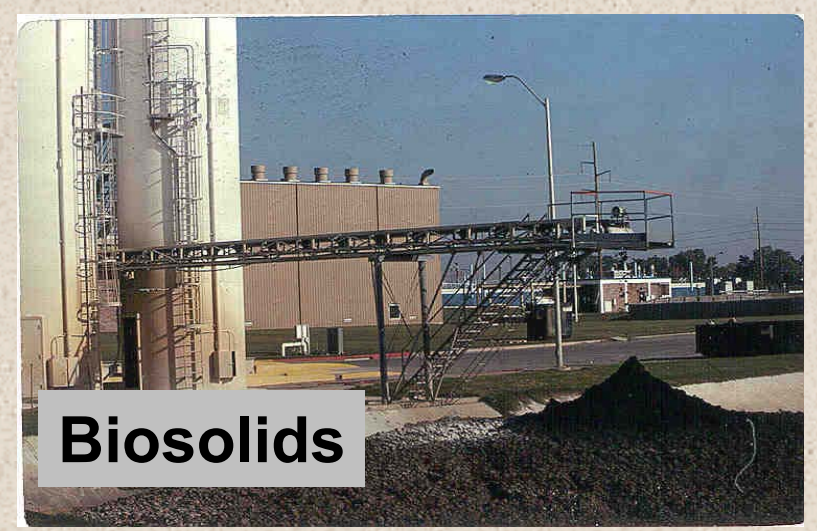
Groundwater Total P



WTR and Manure/Biosolids Co-blending

blend with

blend with



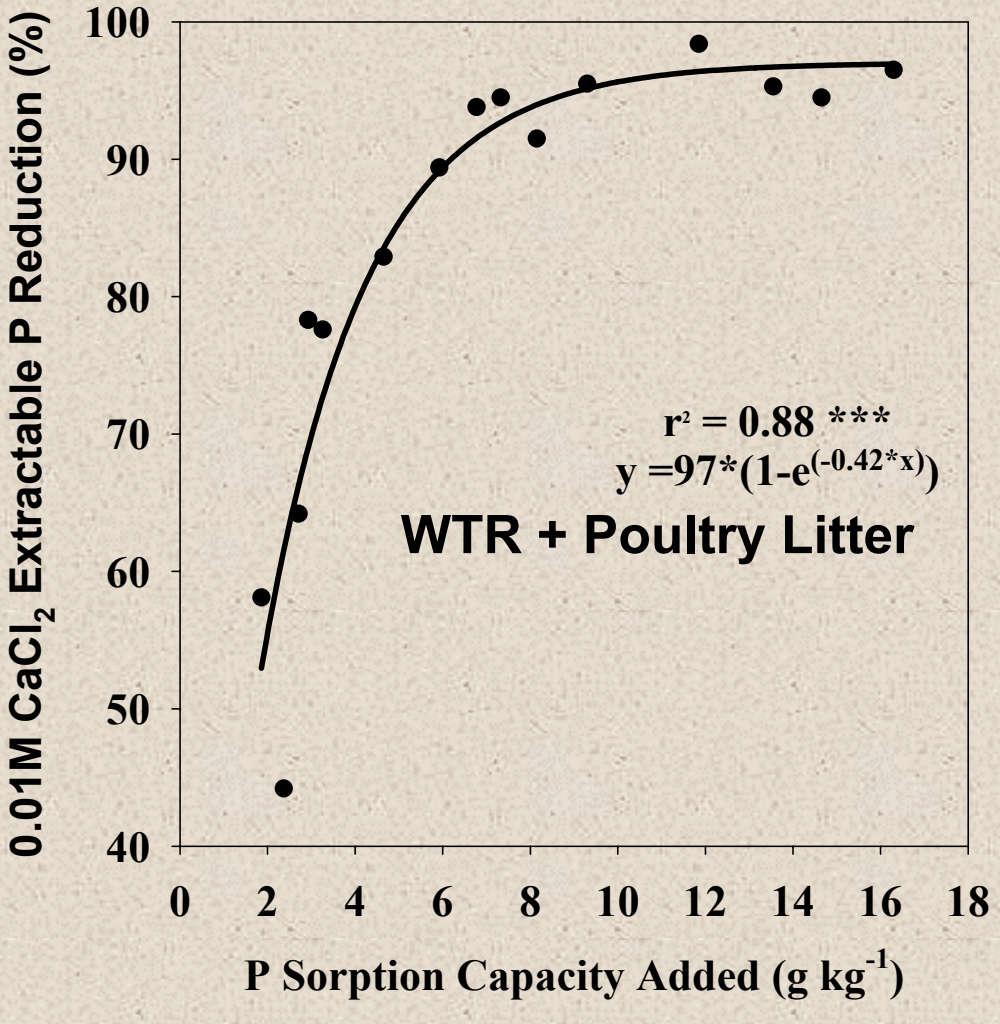
Co-blending with Organic Byproducts

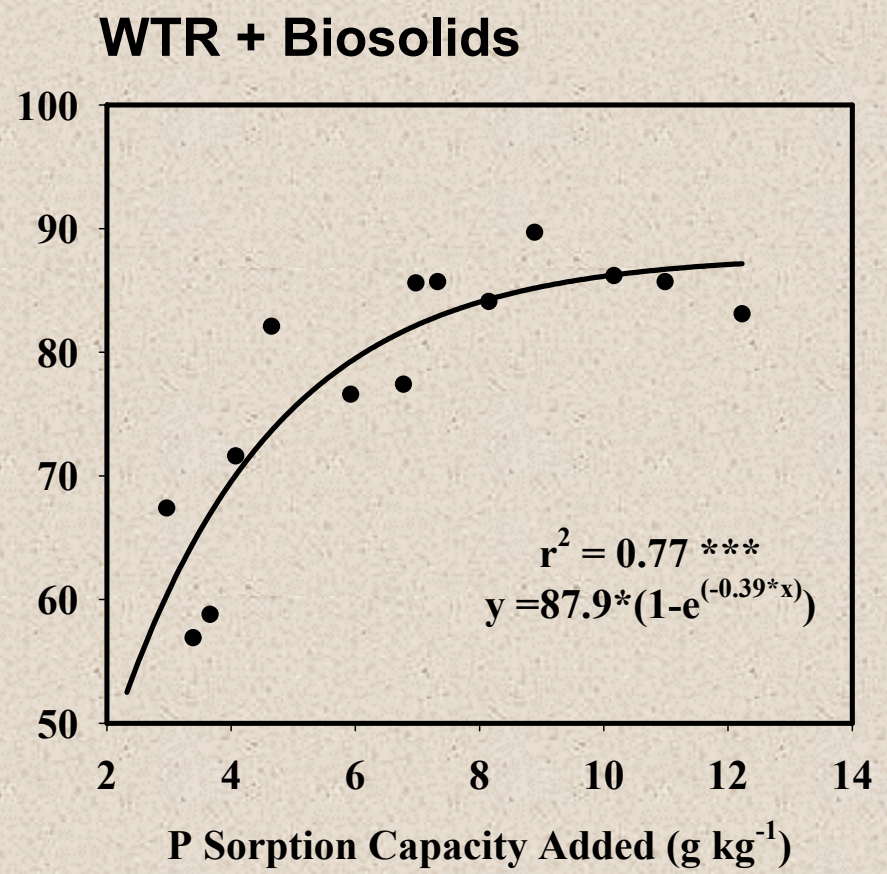
Material	Extractable P $CaCl_2$
	mg kg^{-1}
Poultry Litter	2054
Biosolids	62.5

WTR Blended with:
Poultry litter at: 0, 10, 25, 50 and 75%
Biosolids at: 0, 5, 12.5, 25, and 37.5%

Incubate for 12 wks at 25°C

WTR and Manure/Biosolids Co-blending Reduces Extractable P





Assess Longevity of WTR Effects on P solubility / lability under natural (field) conditions

Agyin-Birikorang. 2007. J. Environ. Qual. 36:316-323.

Field: Two sites in Western Michigan

Soils: (sandy, mixed, mesic Typic Endoaquolls)

- Granby fine sandy loam (site 1) and
- Granby loamy sand (site 2)

Experimental Design: RCBD with 4 reps/treatment

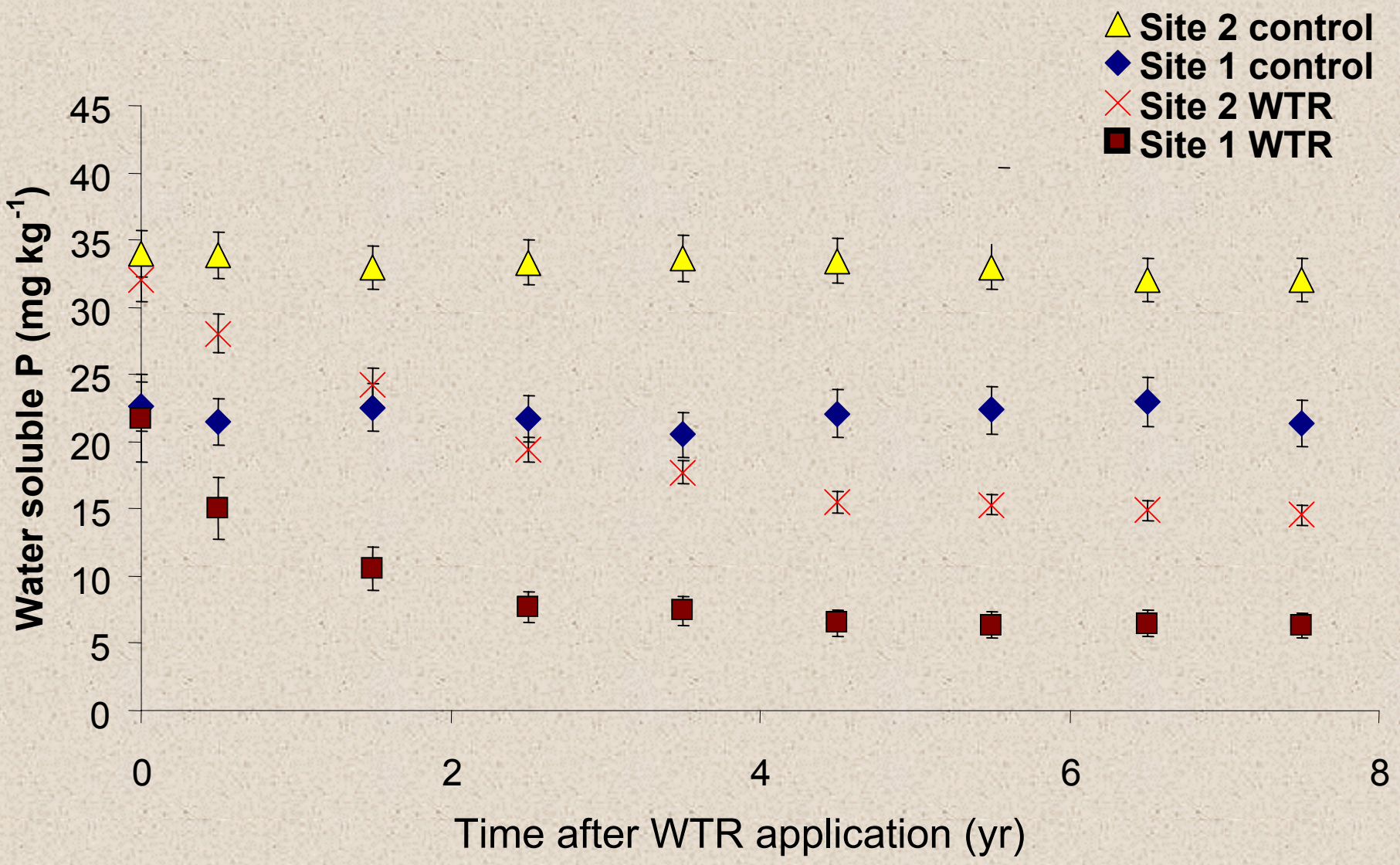
Treatments:

(i) WTR amendment (114 Mg ha^{-1})

(ii) No WTR application

One-time WTR application in spring 1998

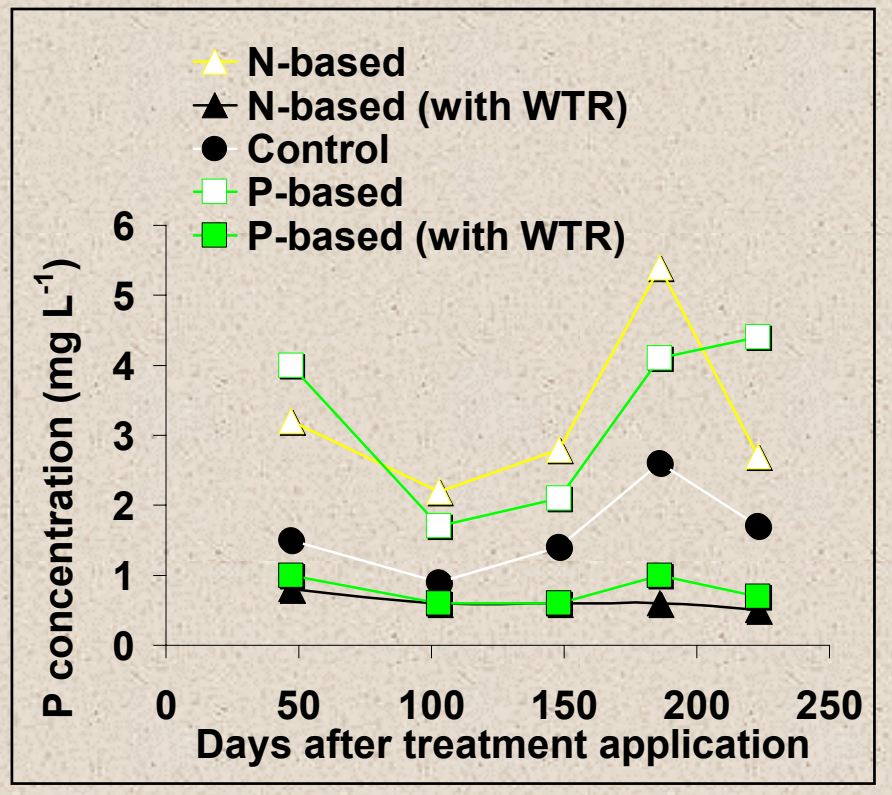
Reductions in Soluble P from WTR last 7.5 yr



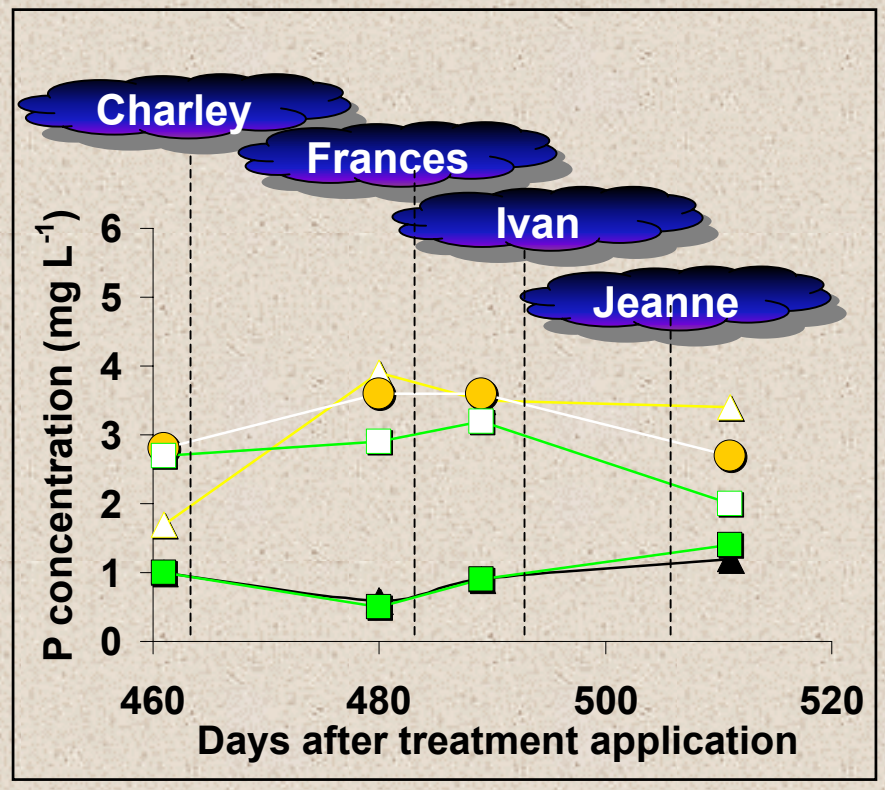
WTR P Reductions Withstand Hurricanes

Groundwater Shallow Well Soluble P

2003

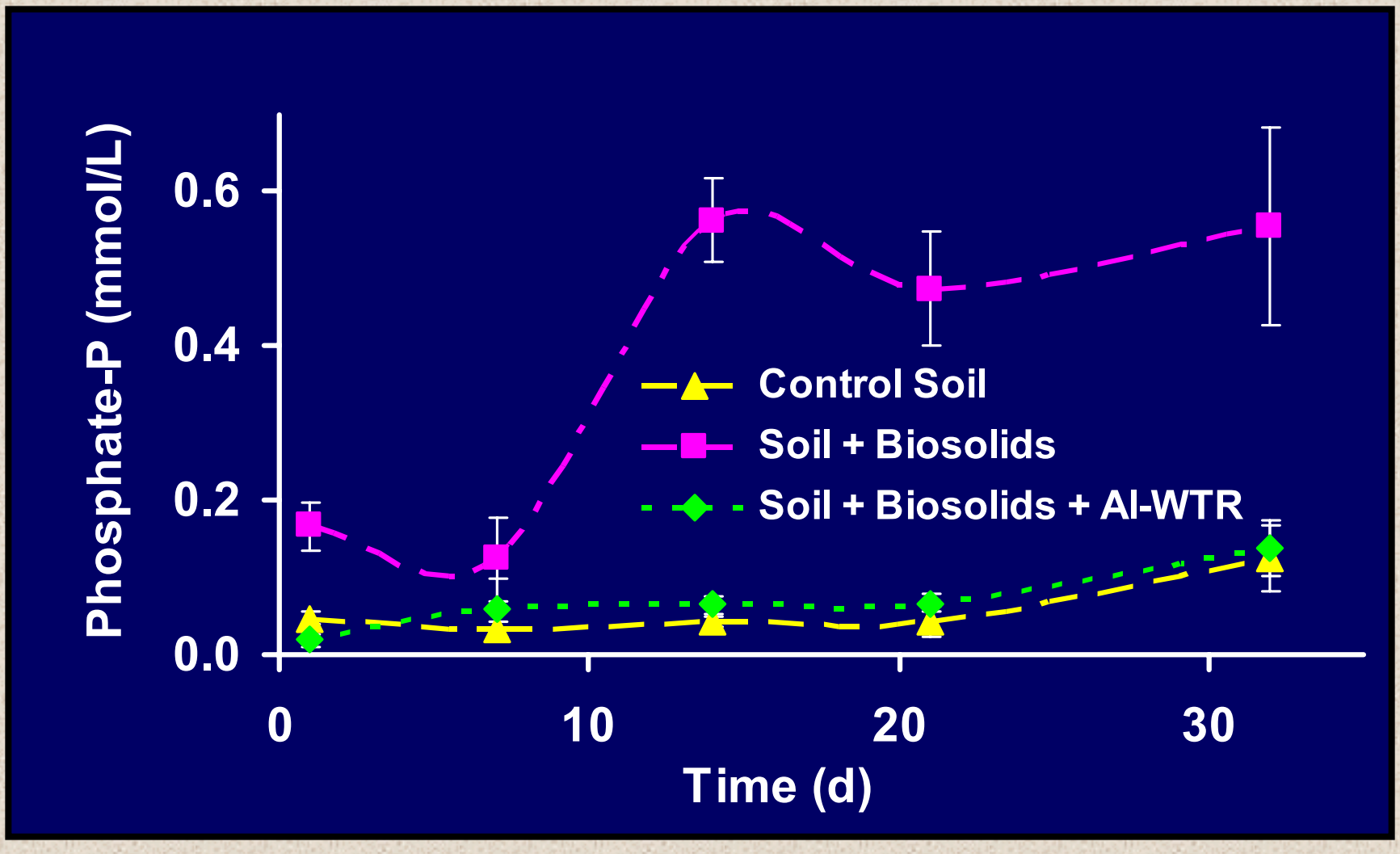


2004



Surface applied WTR consistently reduced groundwater P

WTR-P stable under Anaerobic Conditions



How will Beneficial Use of WTR fit into the NRCS P Risk Framework?

Source terms: Soluble P in manure or biosolids

Soil Test P

Transport factors: Modified Connectivity
buffer strips, grass waterways

"Sorbent" buffer strips
“Enhanced” buffer strips