Engineered approaches to reducing soluble P losses

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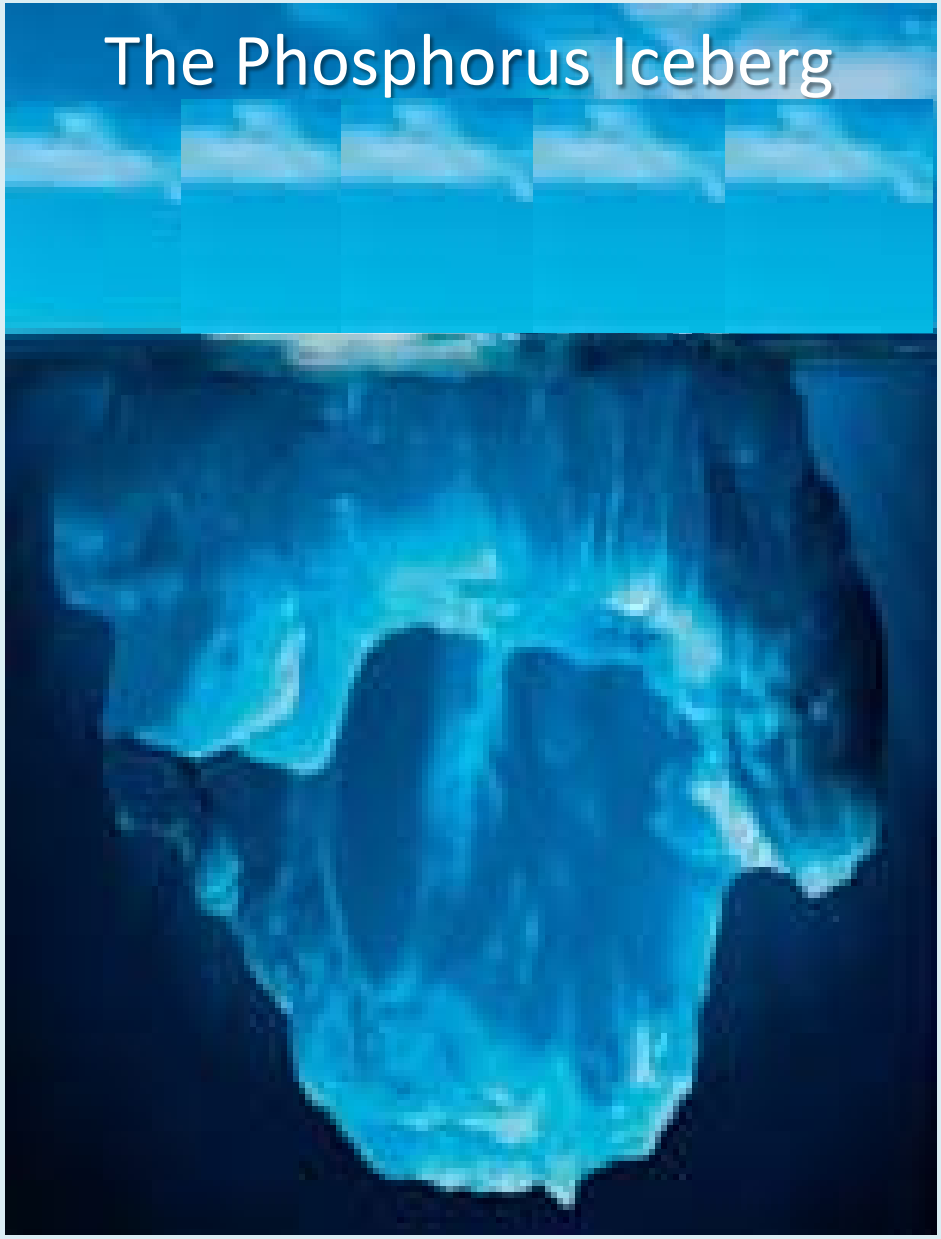
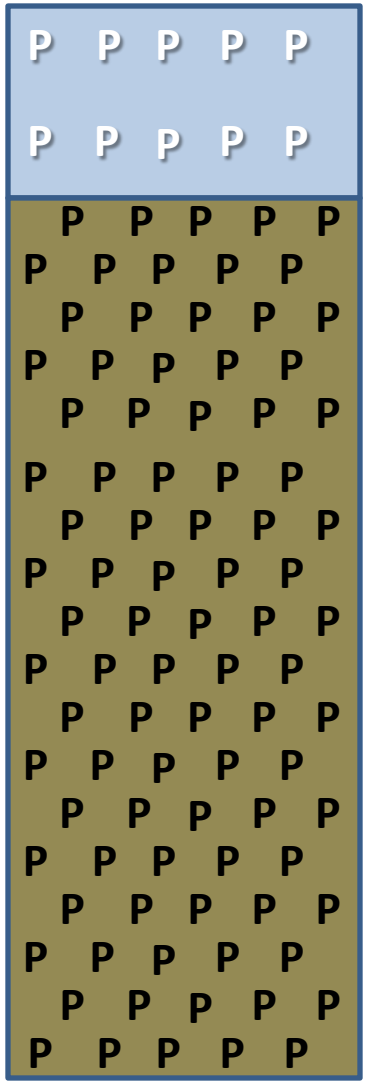
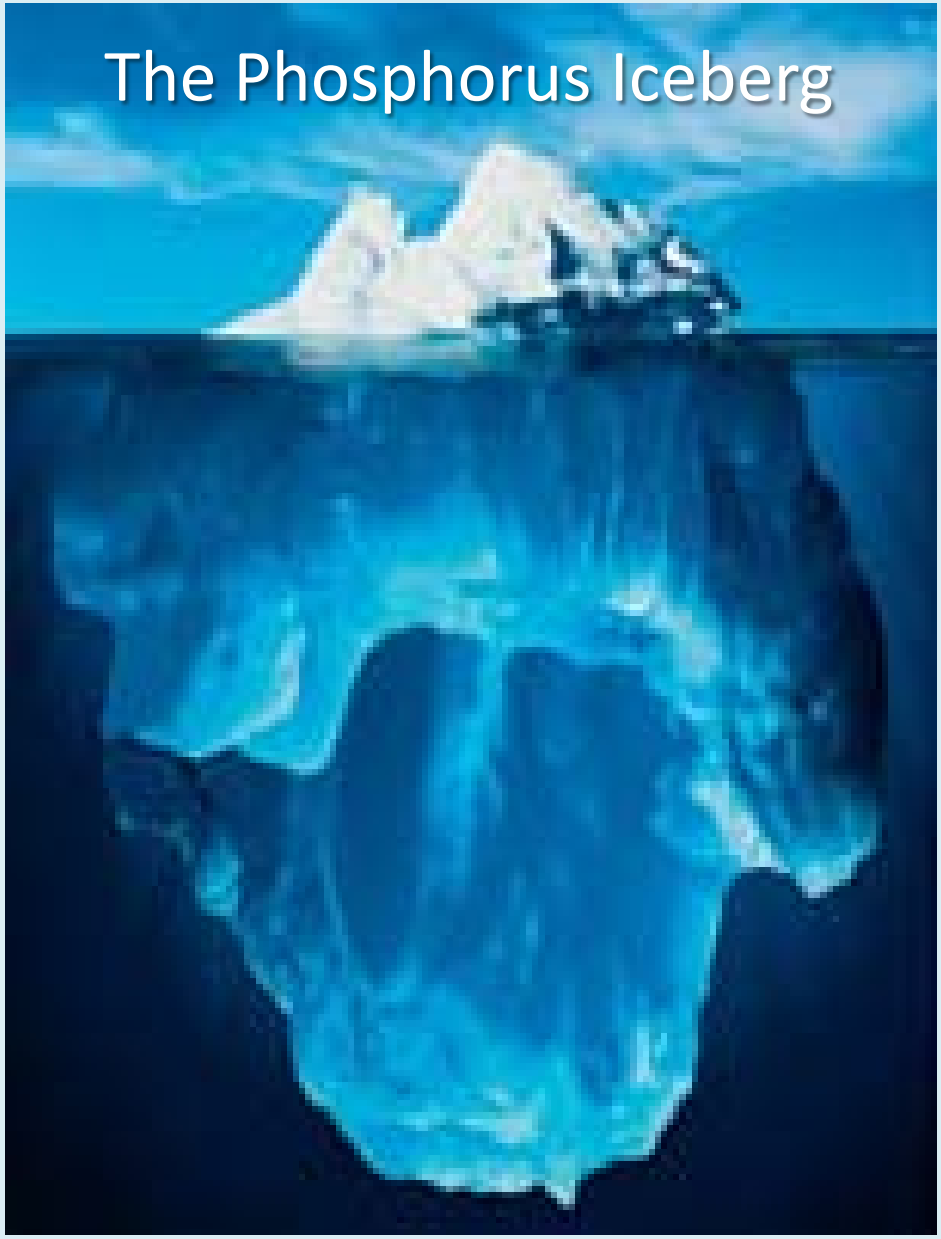
Outline

- The problem: Legacy P and the need for sorption technologies
- A basic understanding of phosphorus sorption by industrial byproducts
- FGD (synthetic) gypsum and its use on the Eastern Shore of the Chesapeake Bay



Legacy Phosphorus





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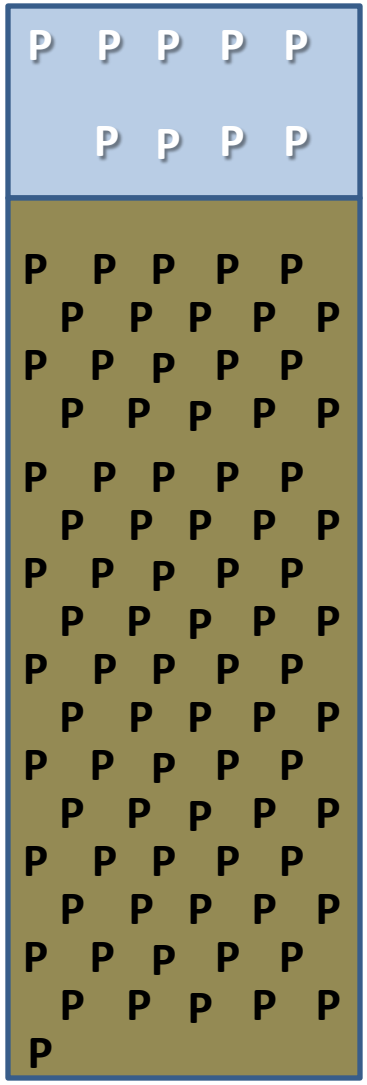
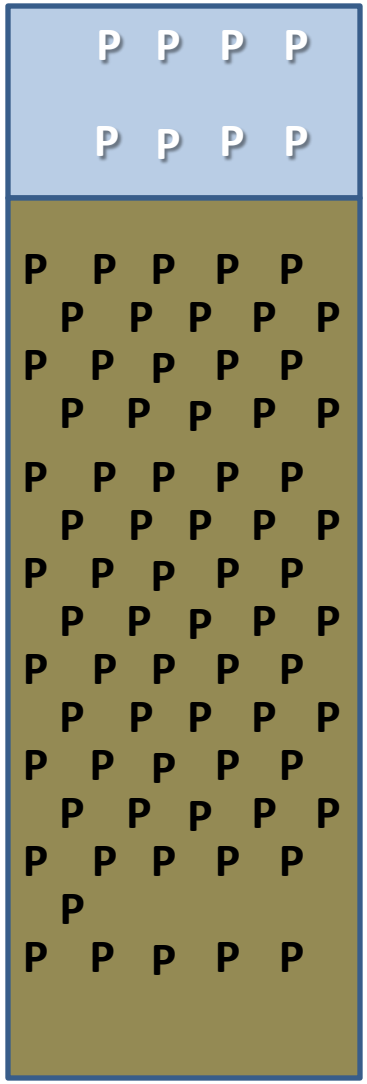
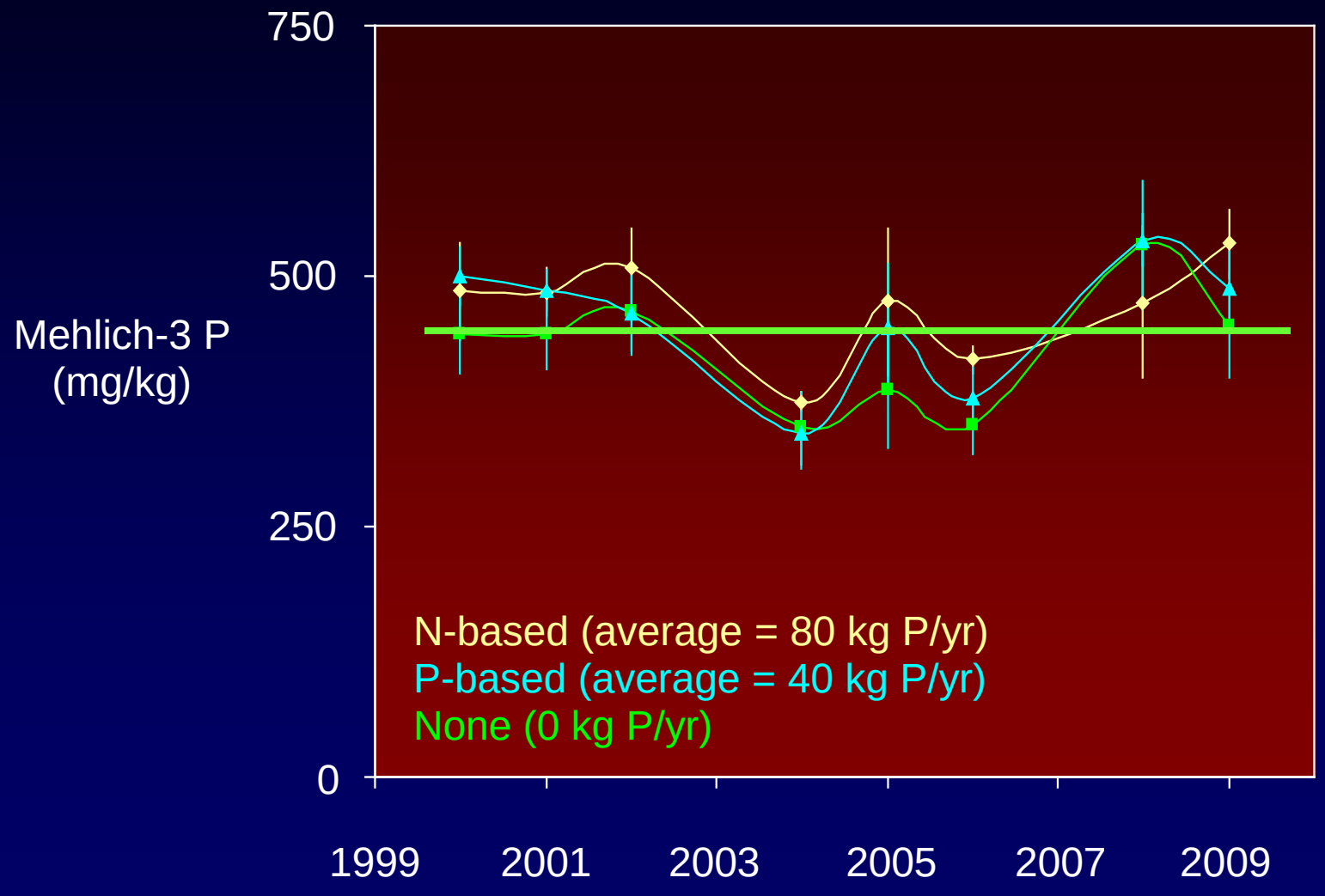


Legacy Phosphorus



No change in soil test P after one decade (variability is due to pH changes)



Sorption Strategies

- Add Ca, Al, or Fe compounds to soil
  - Source and cost of compounds
    - Pure compounds are costly

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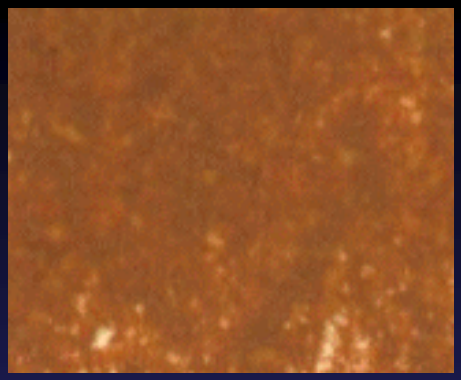
Phosphorus sorbing byproducts

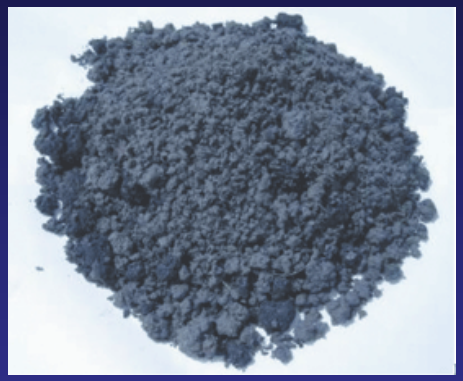


Acid mine drainage treatment residuals (Fe & Al oxides)

Drinking water treatment residuals (alum)

Bauxite mining and production waste (red mud)

Fly ash



Paper mill waste

Steel slag waste

Recycled gypsum or FGD gypsum (calcium)

Sorption: Precipitation & Adsorption

- Precipitation: $PO_{4\ sol} + Ca_{sol} = Ca_3(PO_4)_2 \downarrow$

  Fe & Al also form precipitates with PO_4

- Adsorption: $PO_{4\ sol}$ bonds to surfaces of soil particles, especially those coated with iron and aluminum oxides and hydroxides

  Fe_2O_3 FeOOH $Fe(OH)_3$ and others

  Al_2O_3 AlOOH $Al(OH)_3$ and others

adsorption much more rapid than precipitation

Sorption Strategies

- Add Ca, Al, or Fe compounds to soil
  - Source and cost of compounds
    - Pure compounds are costly
    - Industrial Byproducts may contain toxics
  - Cost of transportation and application
    - One acre furrow slice weighs 2M lbs
    - 5 % equals 50 tons per acre
  - Agronomic benefits?

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Sorption Strategies

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- Add Ca, Al or Fe compounds to manure
  - Change N : P ratio; apply manure for N benefit

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Sorption Strategies

- Add Ca, Al, or Fe compounds to soil
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- Add Ca, Al or Fe compounds to manure
  - Change N : P ratio; apply manure for N benefit
- Use Ca, Al or Fe compounds to filter ag drainage water to remove P_{sol}

120 tons of synthetic gypsum
5 truck loads
Provided by Constellation Energy
Free - including delivery to site
Arthur Allen
University of Maryland Eastern Shore

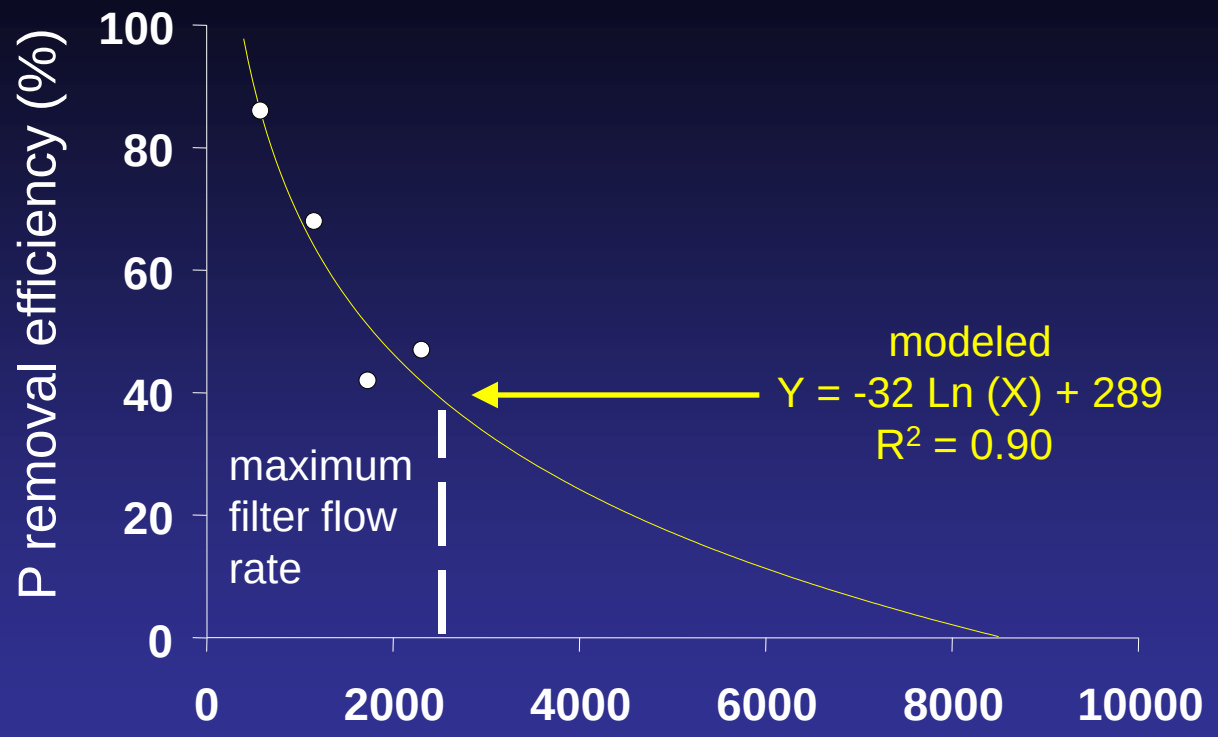
Compound V-notch straight walled weir

Six 100 ft - 4 inch tile drains

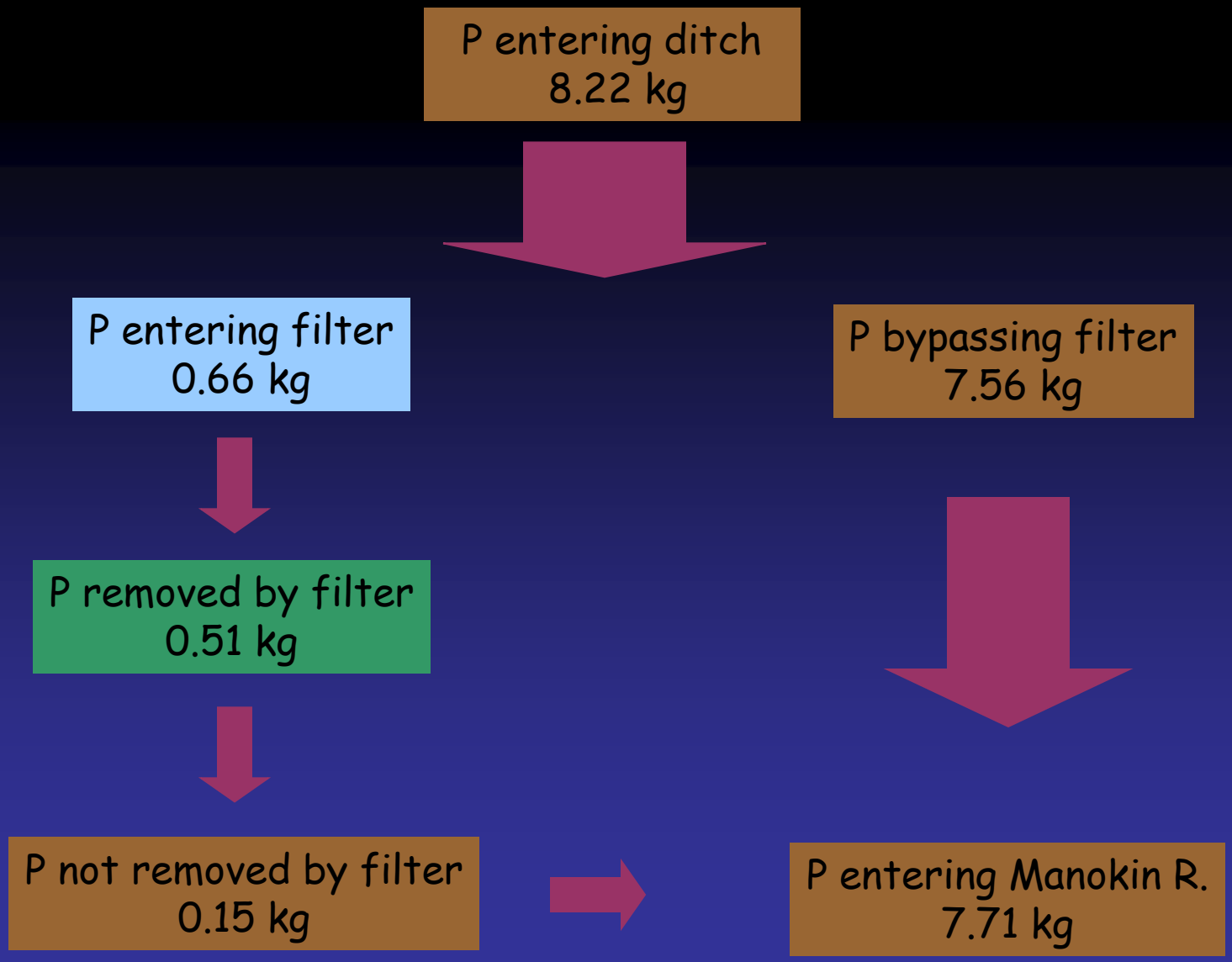
All results are mg/L

Solution Label	P IN	P OUT	As IN	As OUT
Instrument detection limit mg/L		**0.010**		**0.005**
UMES 04711	0.692	0.069	-0.004	0.004
UMES 04712	2.118	0.025	0.004	0.003
UMES 04713	3.134	0.065	0.014	-0.001
UMES 04714	4.007	0.047	0.019	-0.004

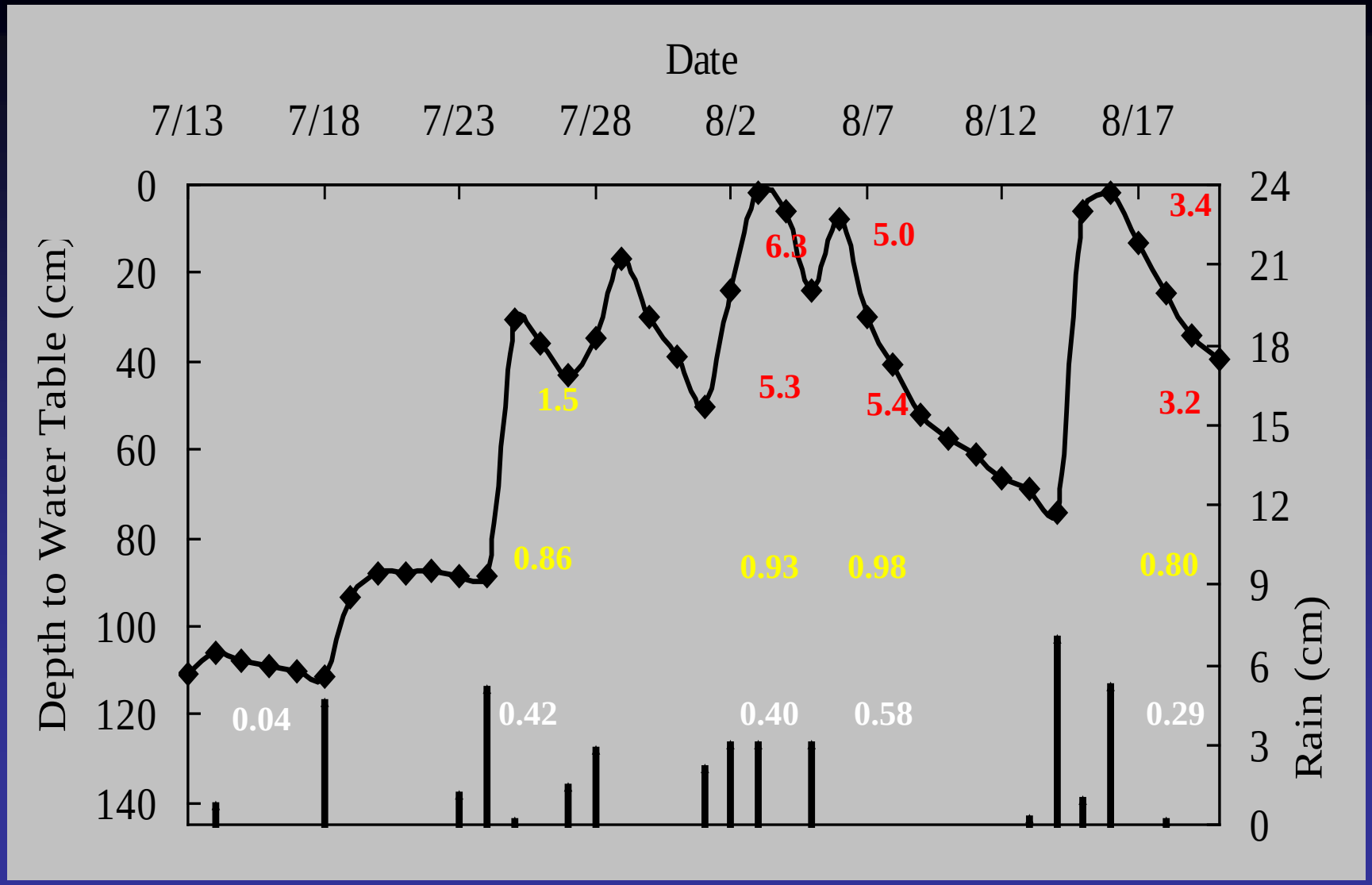
FGD Gypsum Filter P removal efficiency



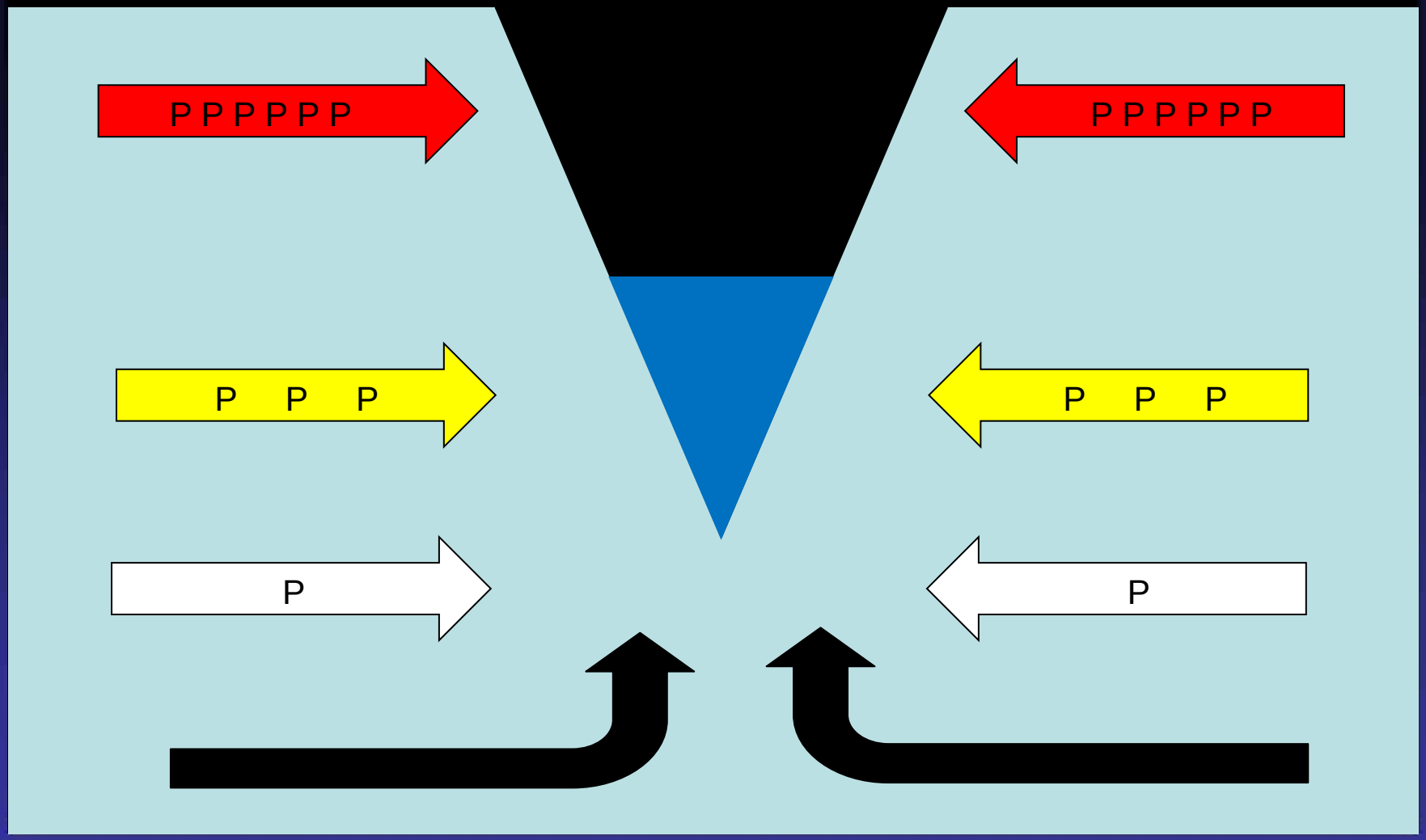
P removal by gypsum filter for April 18, 2007 Storm event 3.31 inches of rain in 30 hrs.



Soluble P in Relation to Depth to Groundwater

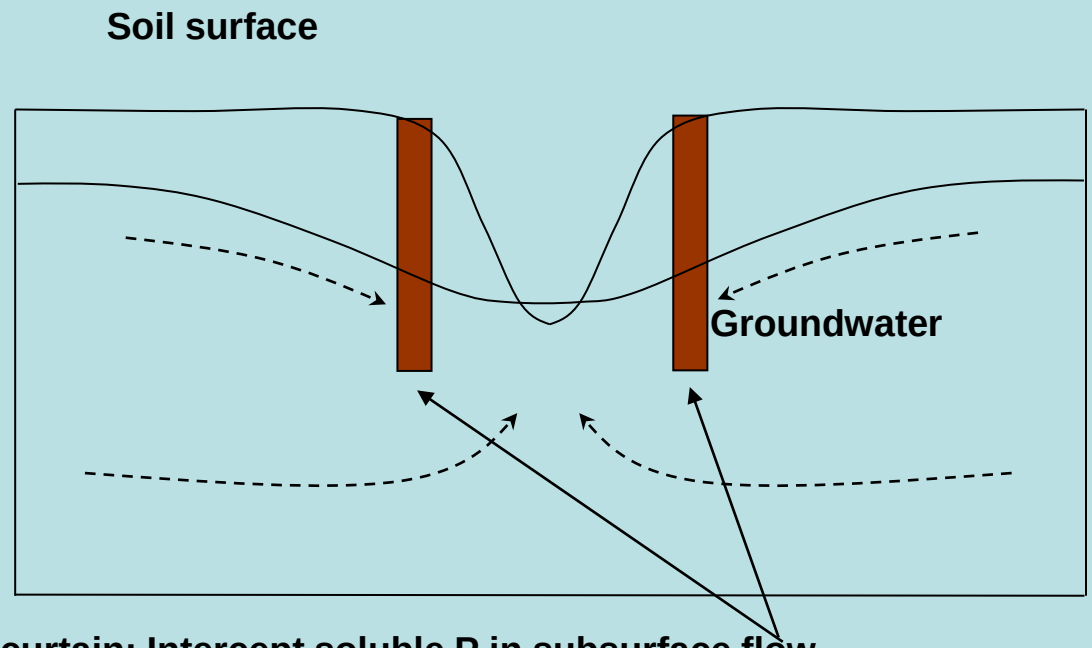


Soluble P Transport Pathway



Gypsum Curtain

- Application on the Coastal Plain

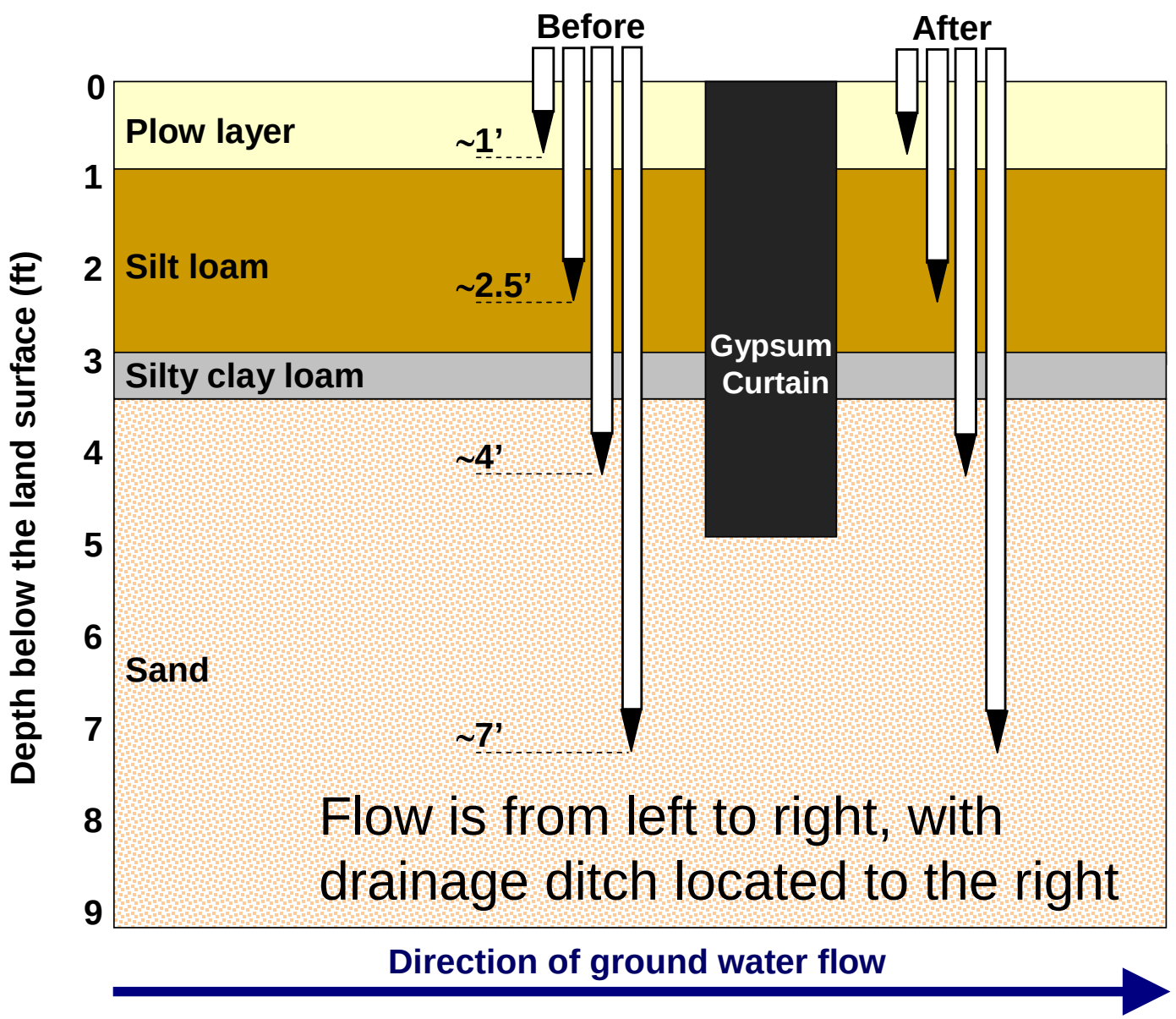


Gypsum curtain: Intercept soluble P in subsurface flow

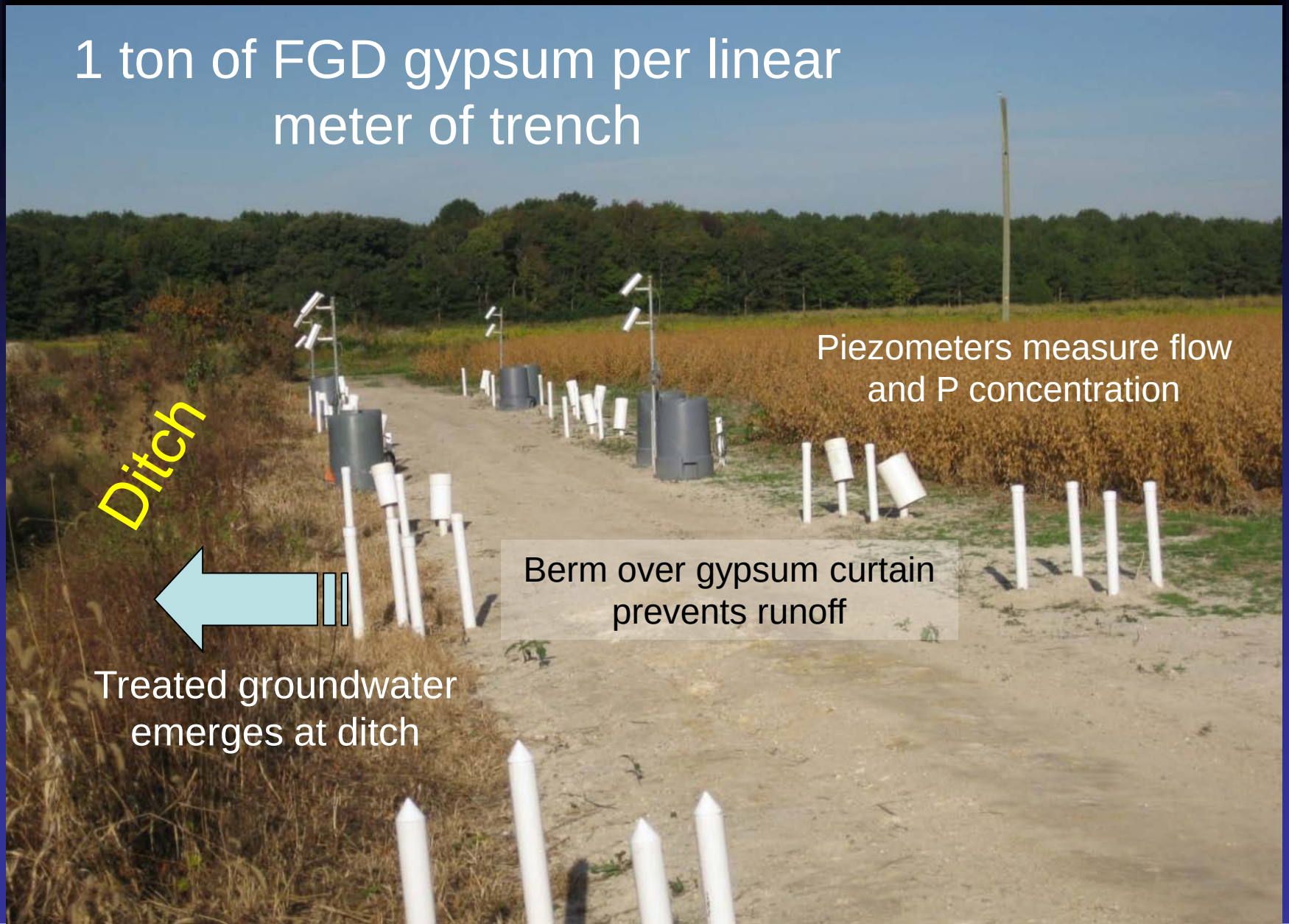
80
08.14.2009

Installed with fertilizer spreader
17 truck loads

Piezometer Nest Design for Gypsum Curtains



Gypsum Source: Constellation Power Generation



$1M CIG Proposal w/ $1M matching

Waiting for Funding and EPA Approval

QUESTIONS?