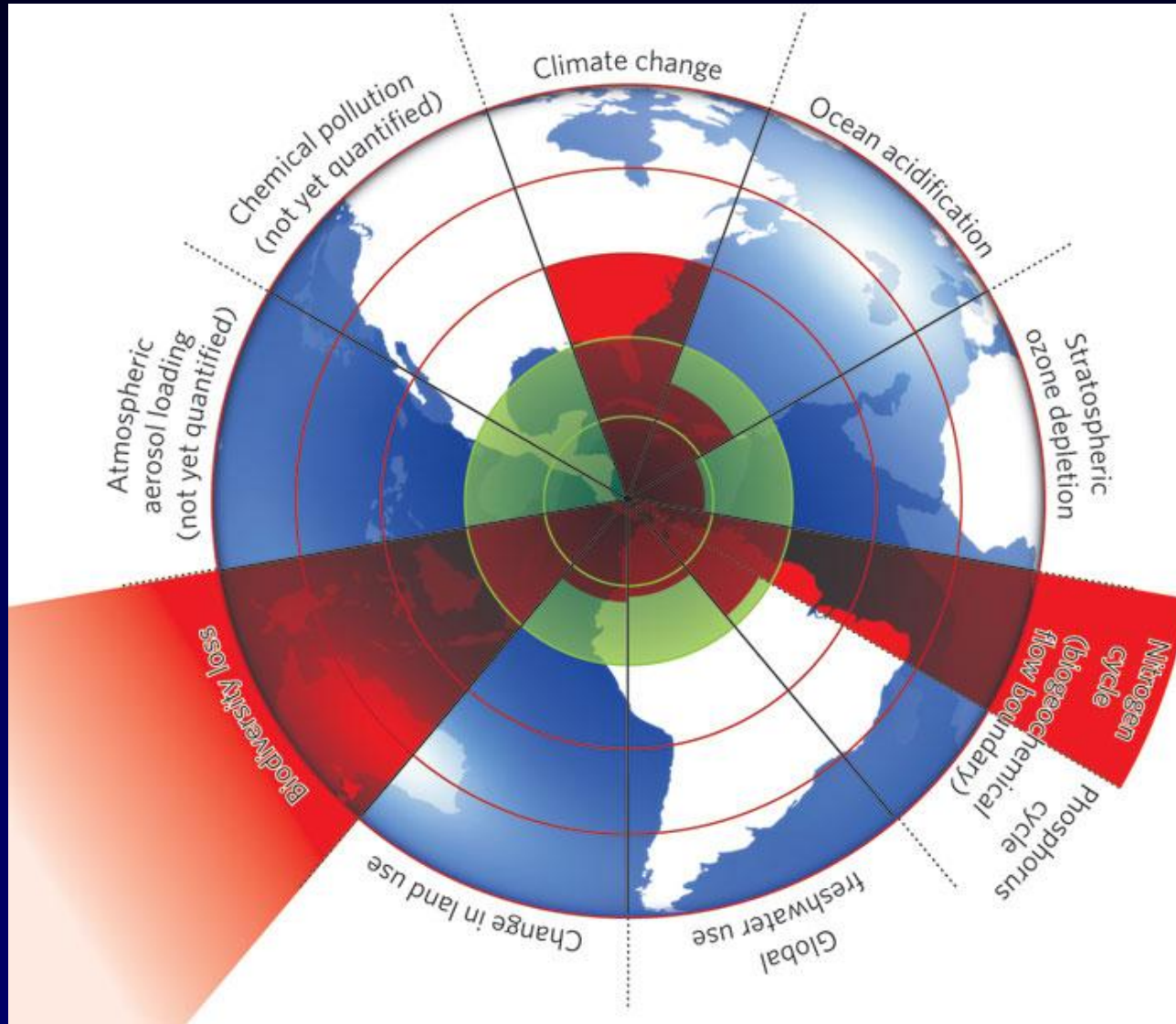


Filtering mediums for treating  
stormwater runoff:  
Lessons from ditch drained agriculture

R.B. Bryant  
USDA Agricultural Research Service  
University Park, PA

# A safe operating space for humanity

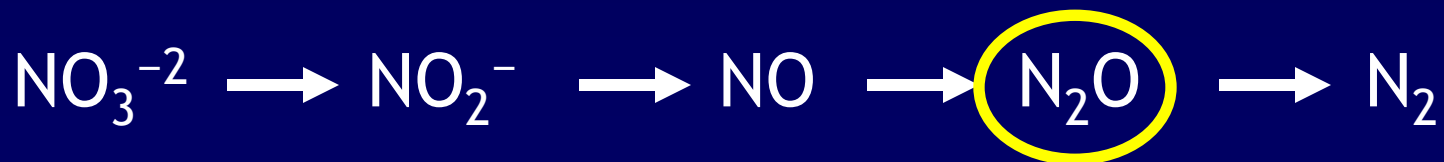
Johan Rockström, et al. 2009 *Nature* 461, 472-475



# Denitrification

A microbially facilitated process of nitrate reduction (performed by a large group of heterotrophic facultative **anaerobic bacteria**) that may ultimately produce molecular nitrogen ( $N_2$ ).

Microbes consume carbon and scavenge nitrate



**Greenhouse gas**

# Denitrification Wall



**3:30**      **Dr. Laura Christianson**  
(Conservation Fund Freshwater Institute)

Wood chip bioreactors:  
A cutting edge strategy for water  
quality

# Phosphorus sorption reactions

P reacts with Ca, Fe, Al, and OM



Surface reactions: exchange, ligand

with iron, aluminum, organic matter

# P sorbing industrial byproducts



FGD gypsum  
“synthetic”  
gypsum  
(calcium)



Acid mine  
drainage  
treatment  
residuals  
(Fe & Al  
oxides)



Fly ash



Bauxite  
mining and  
production  
waste (red  
mud)



Drinking water  
treatment  
residuals  
(alum)



Steel slag  
waste

# Flue Gas Desulfurization Gypsum



- Low contaminants
- Widely available
- Silt size
- Handles easily
- High solubility releases Ca
- Precipitation reaction is relatively slow

# Coal Combustion Fly Ash



- Contains heavy metals
- Widely available
- Sand to gravel size
- Handles easily
- Insoluble Fe and Al
- Sorption reaction is relatively rapid

# Drinking Water Treatment Residuals



- Low contaminants
- Widely available
- Ground to gravel size
- Raw material must be dried and ground
- Aluminum sulfate (alum)
- Rapid sorption reaction

# Acid Mine Treatment Residuals



- Contains heavy metals
- Available in PA
- Silt to gravel size
- Handles easily
- Fe and Al oxides
- Rapid sorption reaction

# Bauxite (Aluminum ore) Mining Waste



- Contains heavy metals
- Jamaica mines
- Silt to gravel size
- Handles easily
- Carbonate, Fe oxides, clays
- Rapid sorption reaction

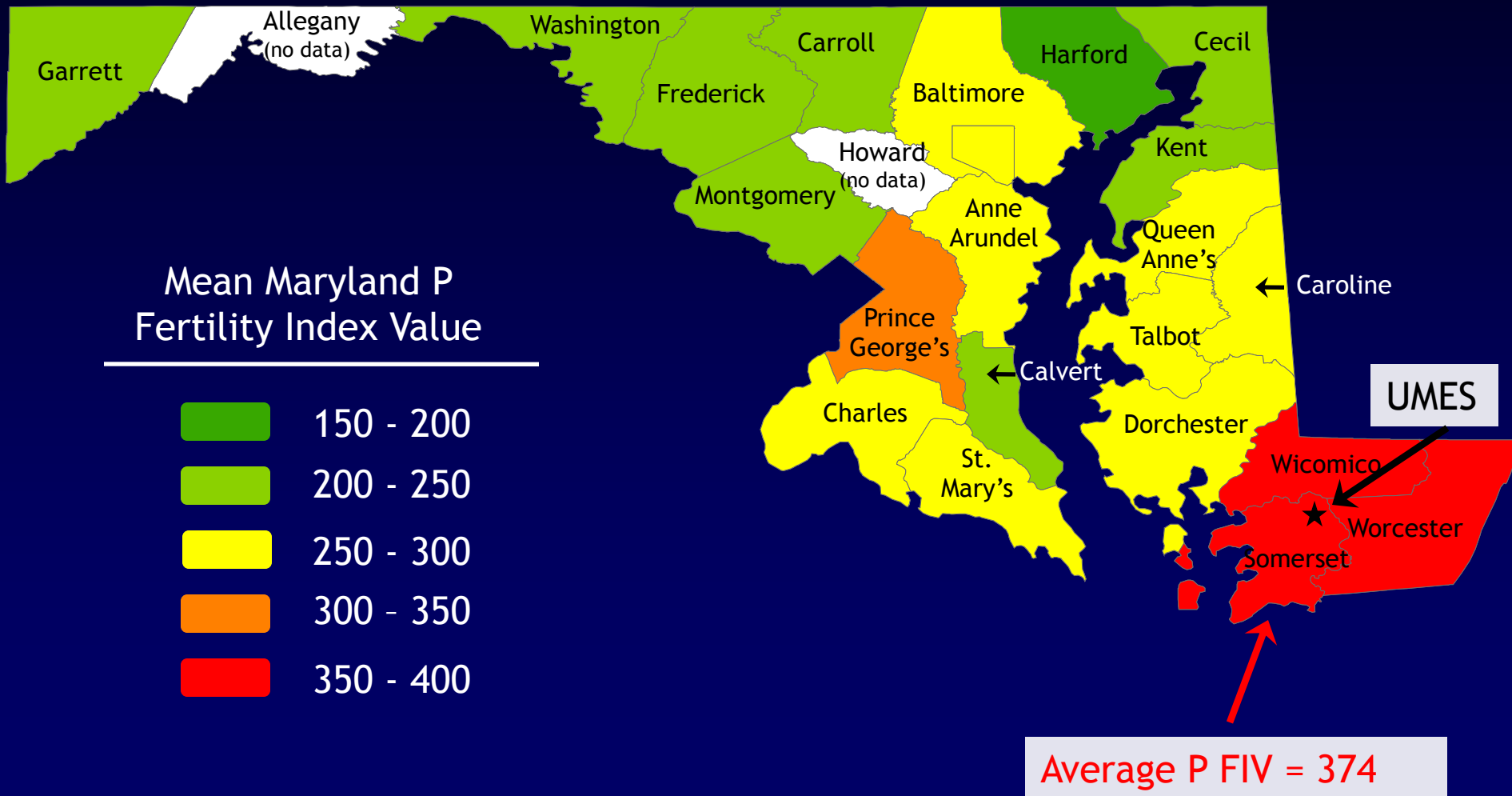
# Steel Slag Waste



- Contains heavy metals
- Widely available
- Gravel size
- Handles easily
- Fe and Al oxides and Ca
- Rapid sorption reaction and Ca precipitation

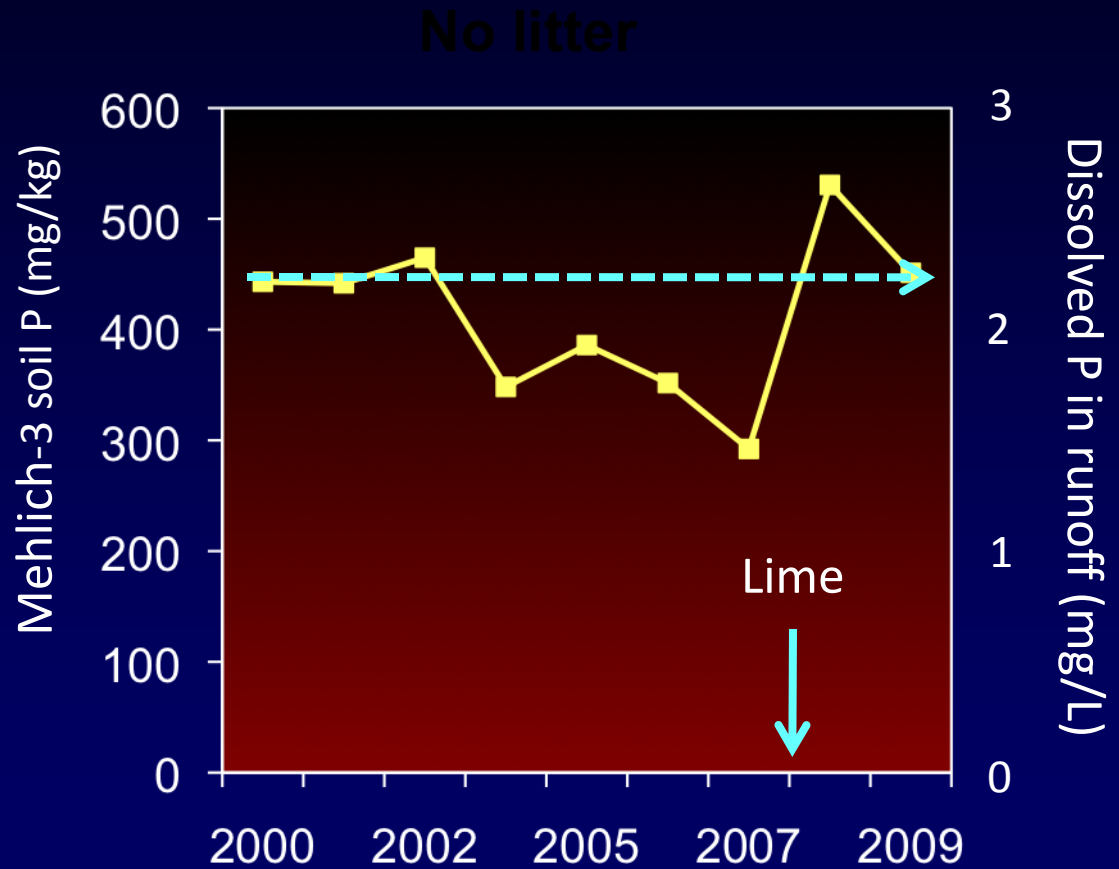
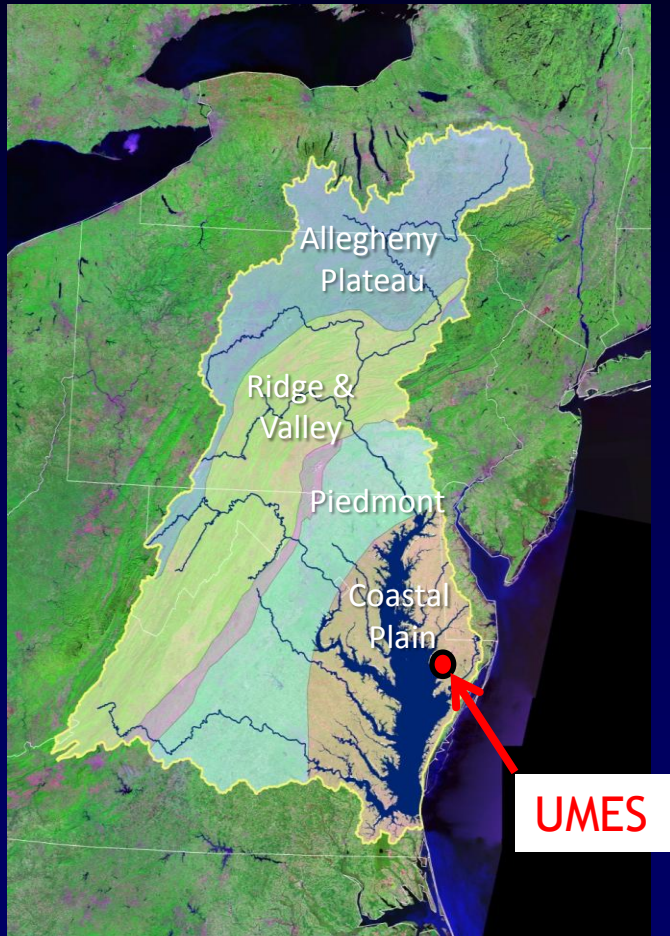
# Soil test P levels are high on the Eastern Shore of Maryland

*Restricted to fields where the Maryland P Index was run (FIV > 150 only)*



# No change in soil test P after one decade of continuous corn : Zero P additions

*High soil P has water quality consequences*

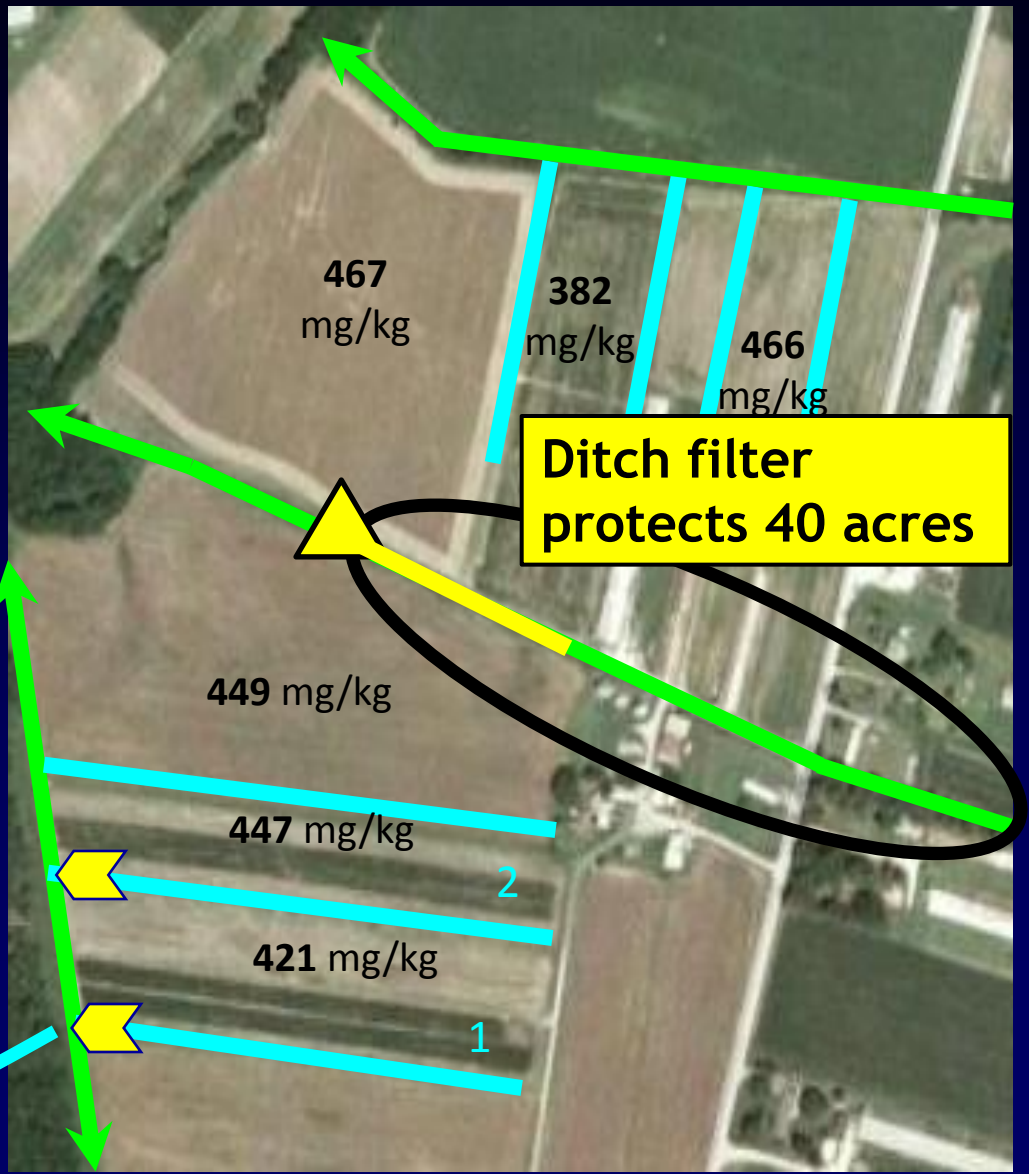
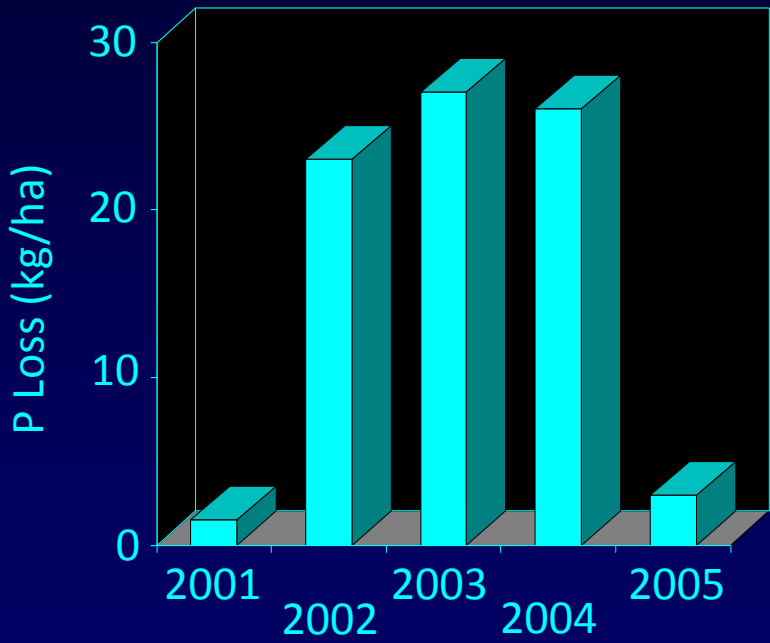


Maryland, USA (Kleinman et al., 2010)

# Total P loads from drainage ditches

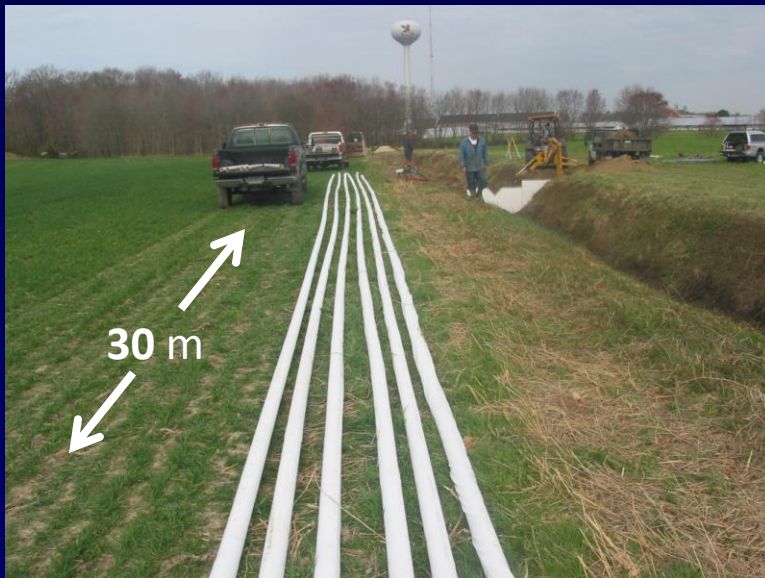
*Annual loads vary with precipitation*

UMES Experiment Station  
Former Poultry Farm



# FGD gypsum filter - 1<sup>st</sup> generation

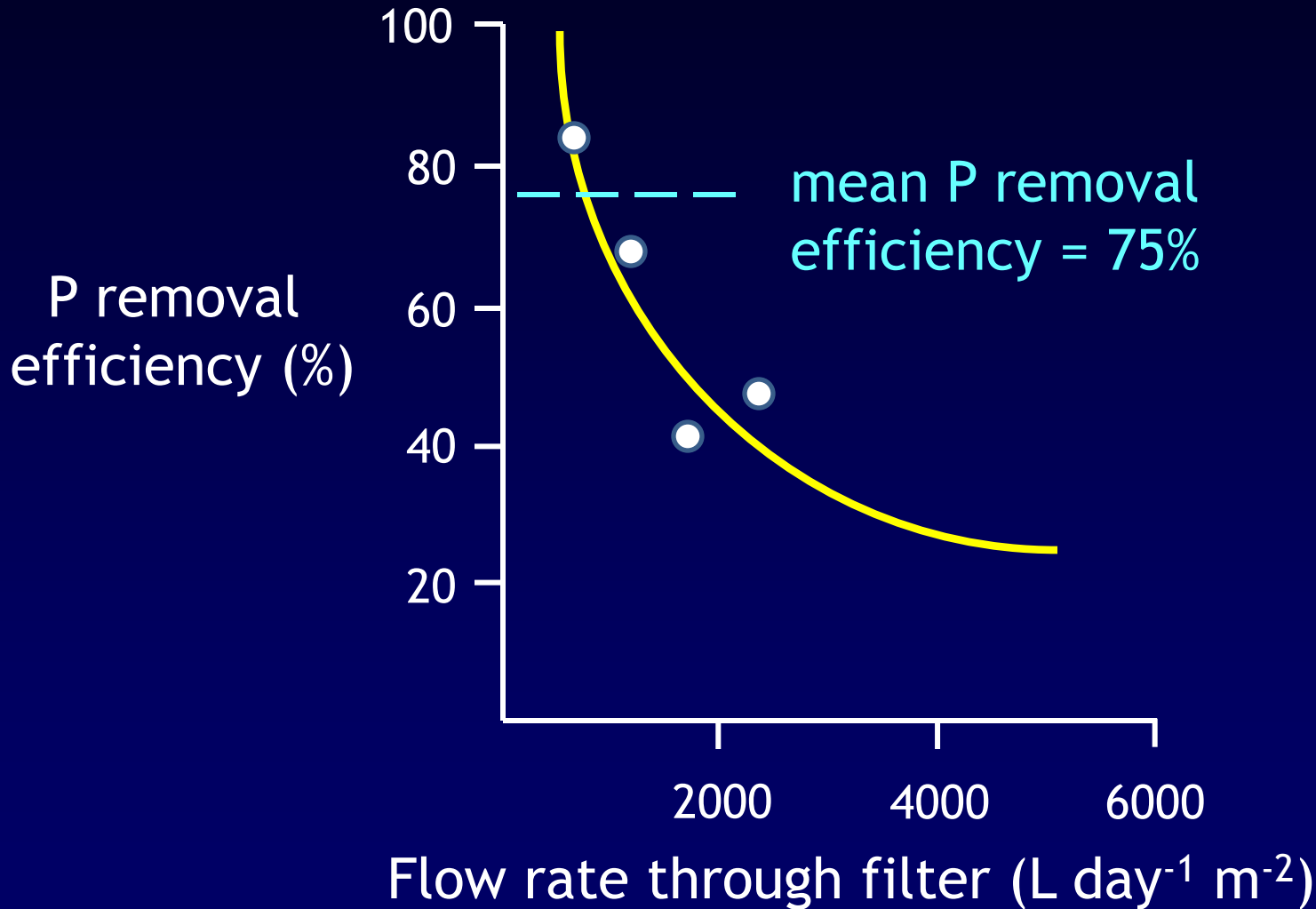
120 tons of FGD gypsum (5 truck loads)



# P Removal by filtration



# P removal efficiency is greatest at low flow rates



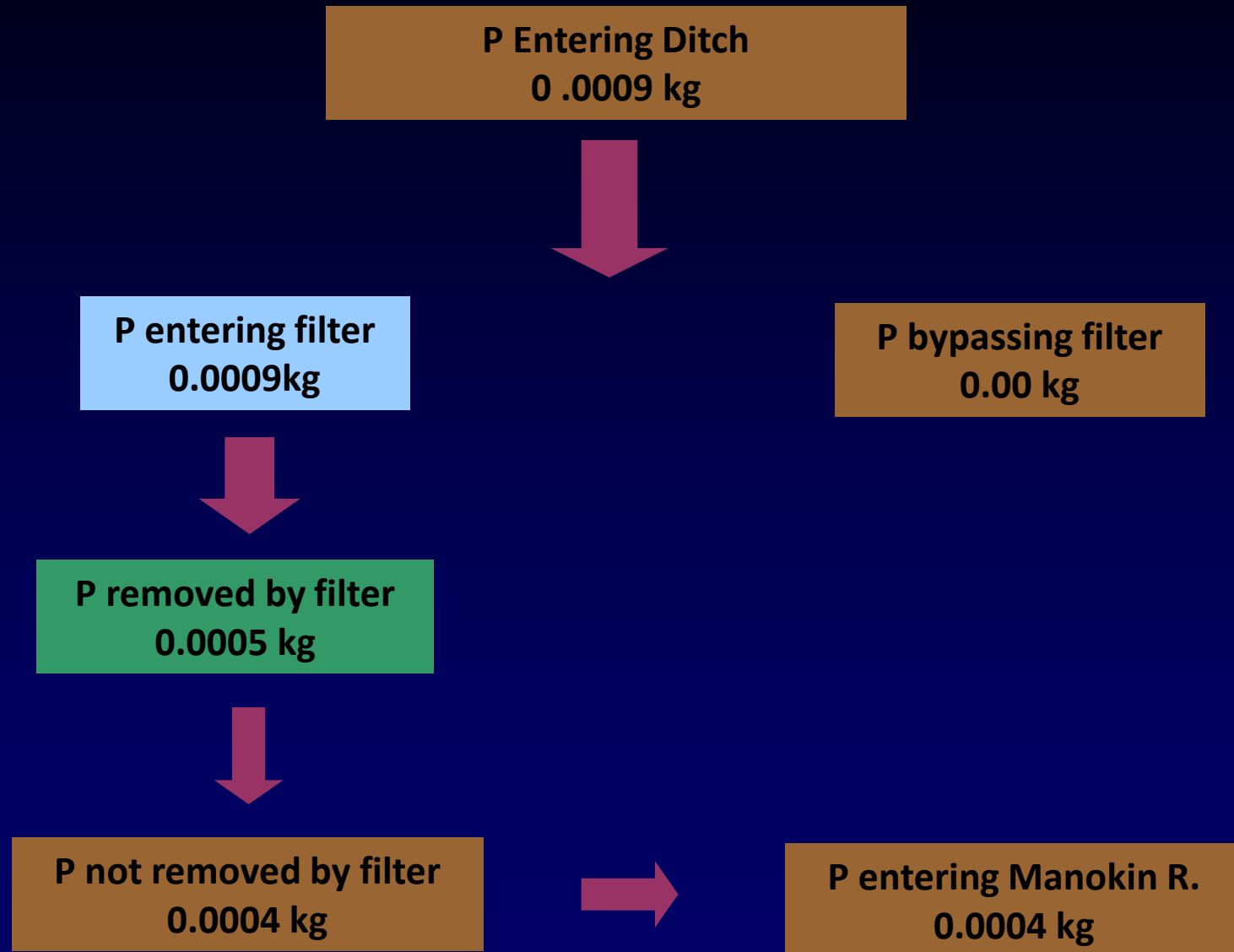
# Arsenate behaves like phosphate

*As concentrations in filtrate  $\leq$  ditch drainage water*

Solution Label	P IN	P OUT	As IN	As OUT
Instrument detection limit mg/L	— — — —	— — — —	mg/L	— — — —
		0.010		0.005
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
UMES max	7.570	0.050	0.028	-0.001

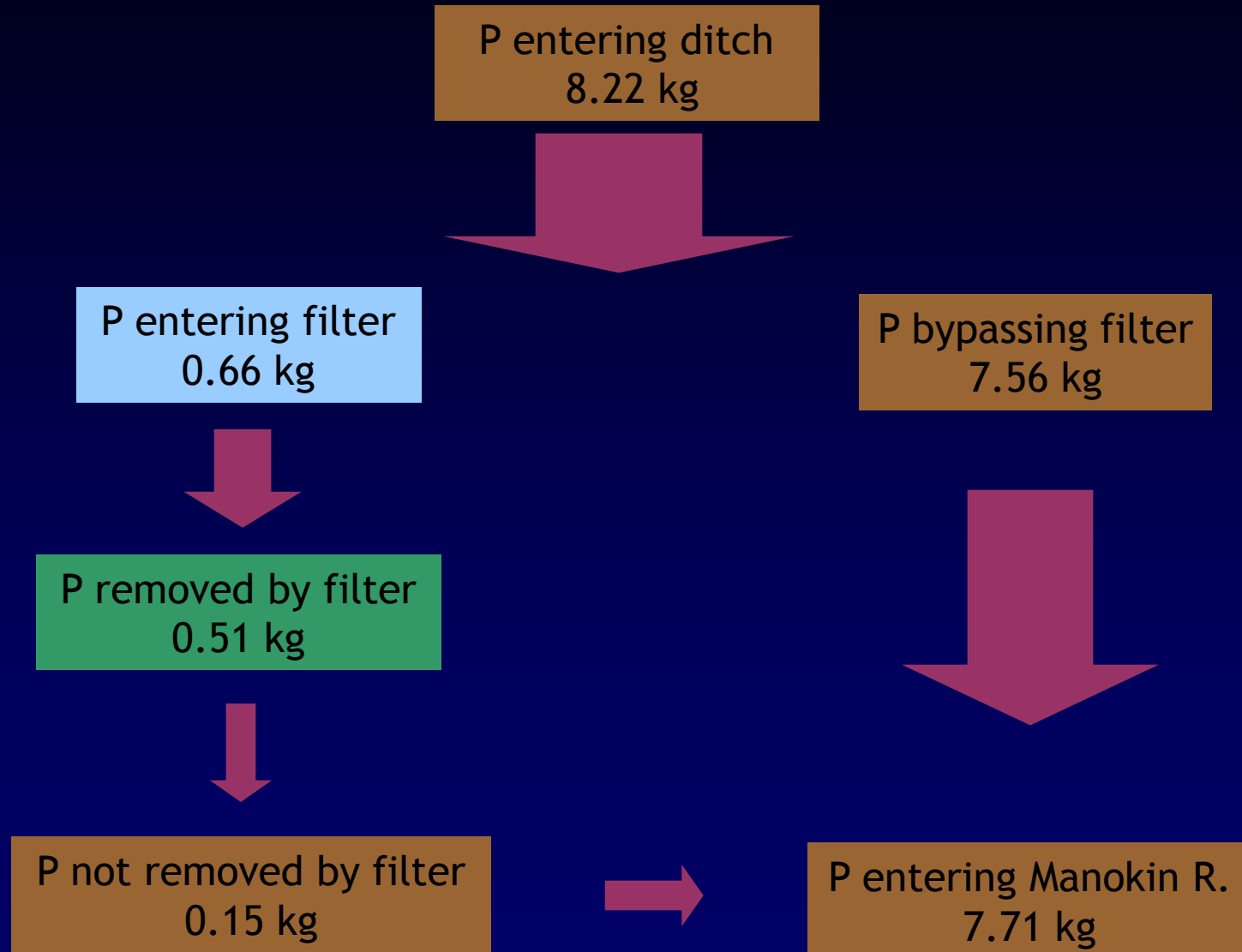
# P removal by gypsum filter for April 13, 2007

Storm event: 0.64 inches of rain in 13 hrs.

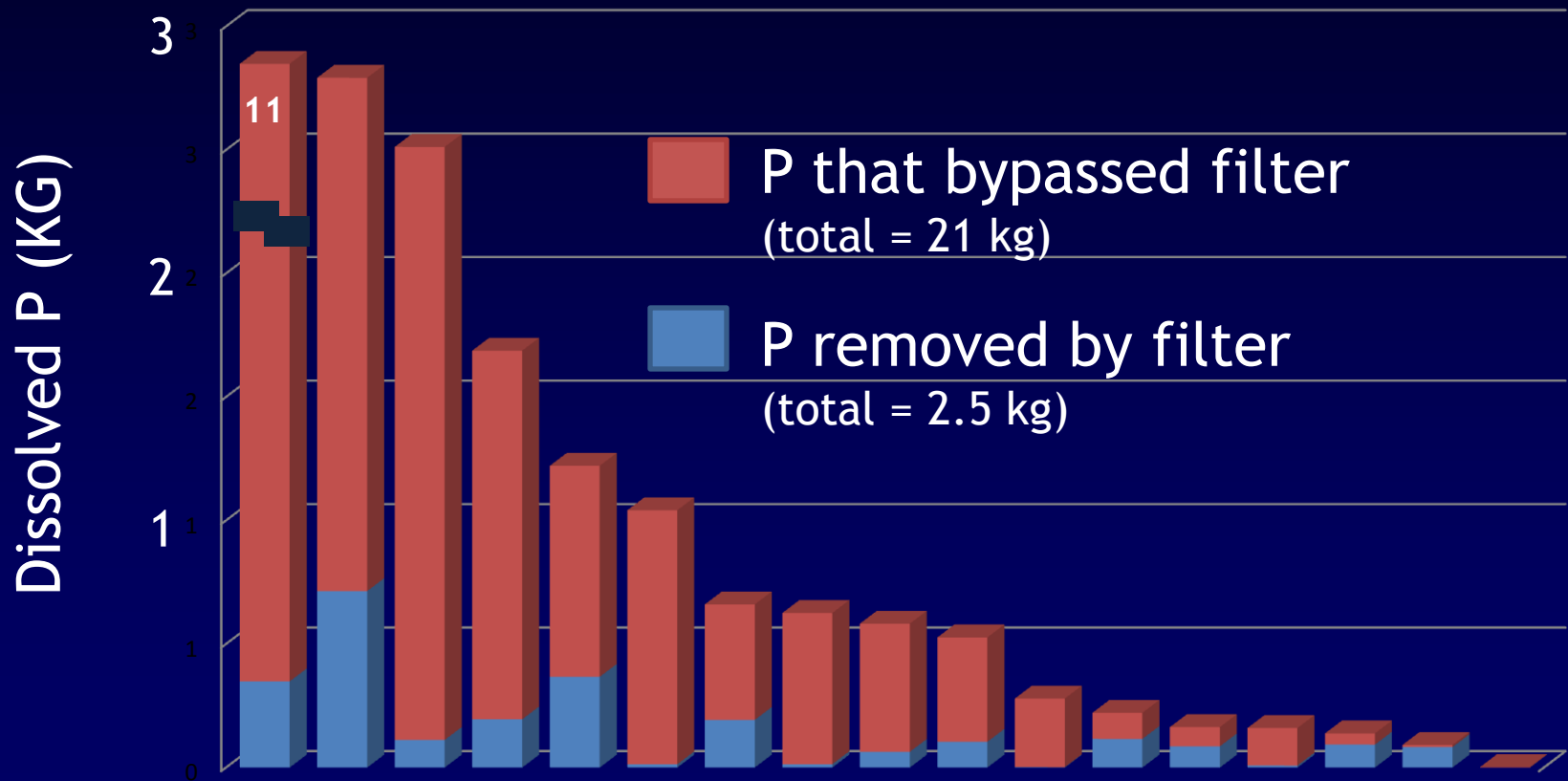


# P removal by gypsum filter for April 18, 2007

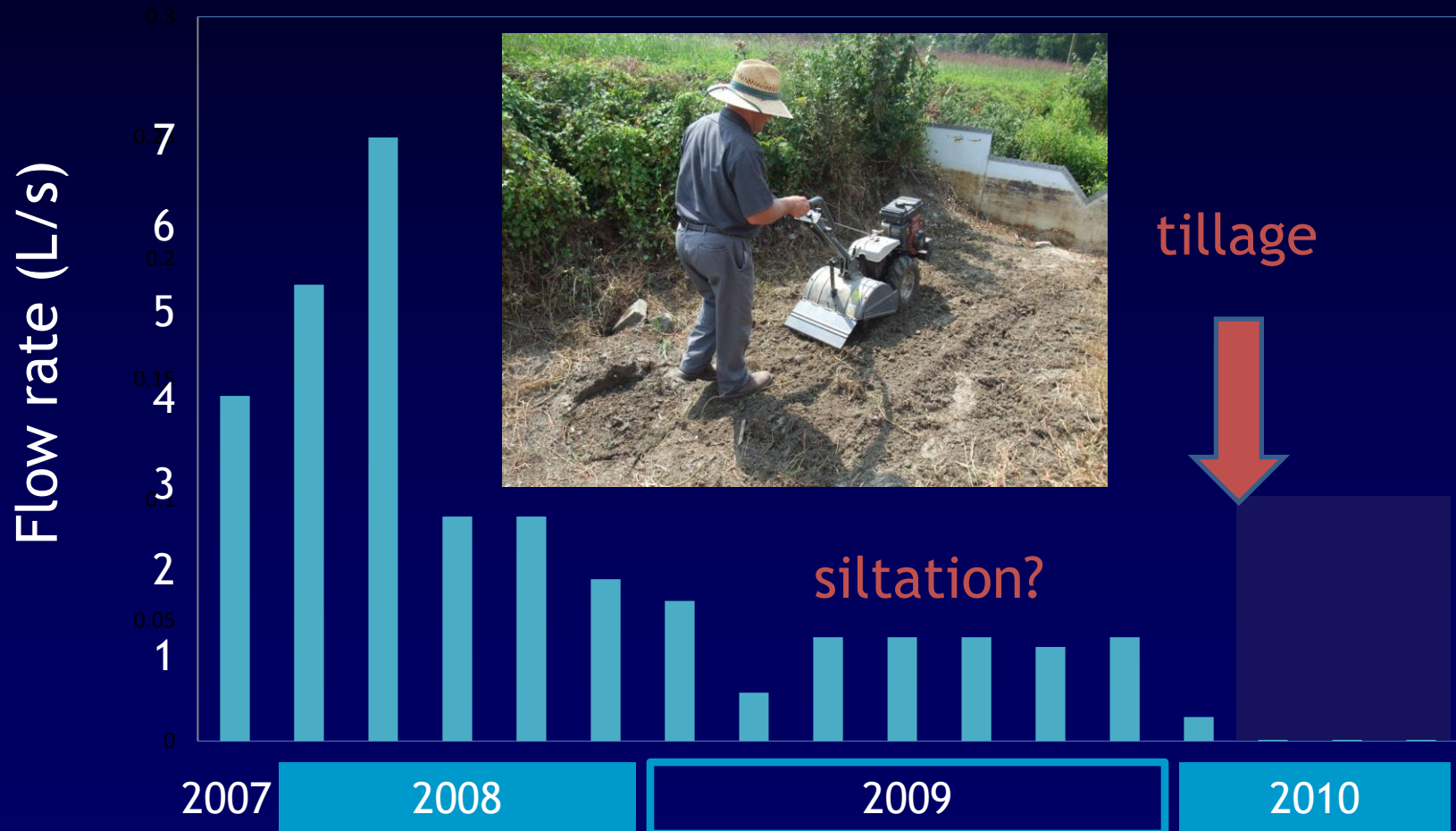
Storm event: 3.31 inches of rain in 30 hrs.



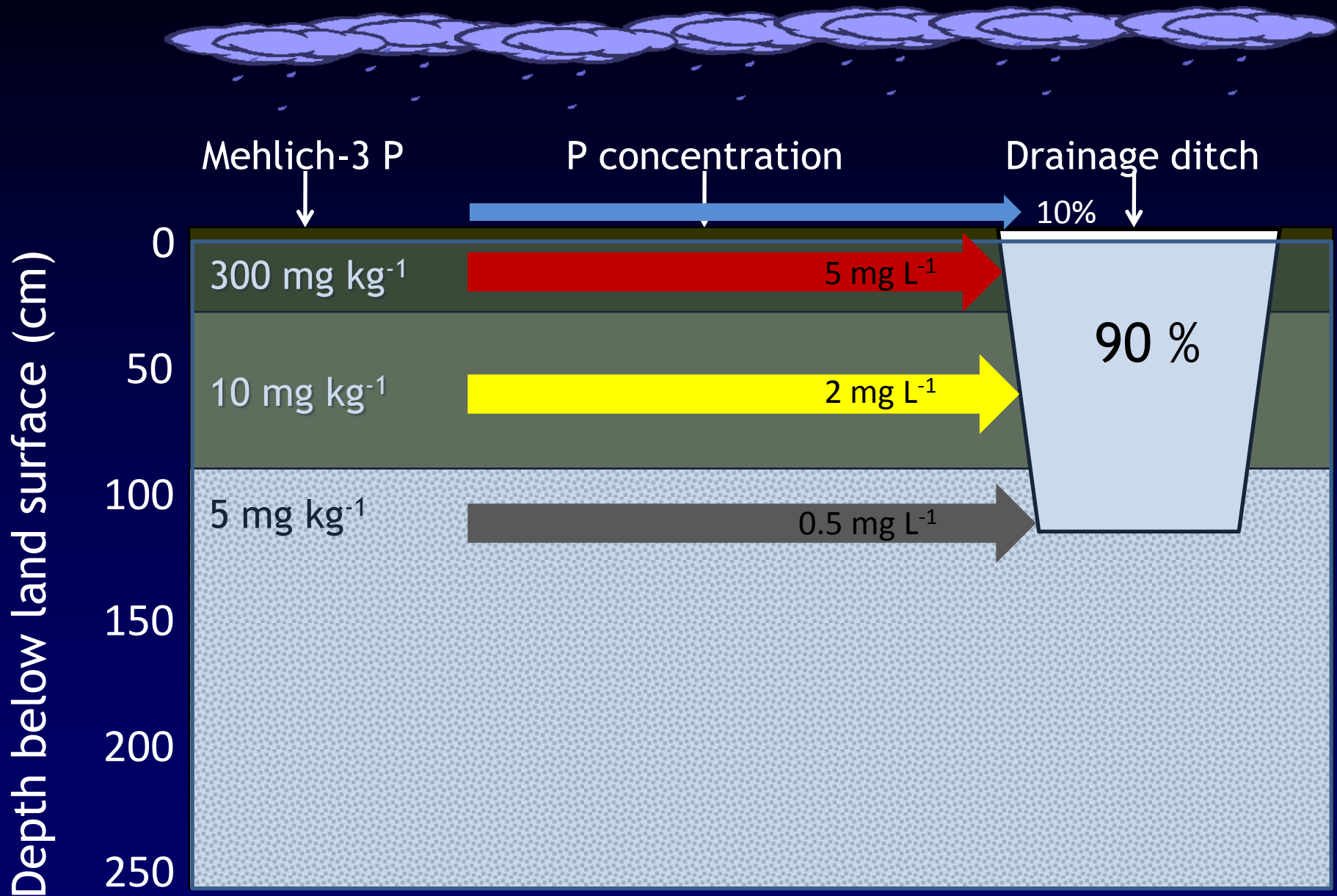
# Dissolved P loads in 17 storm events



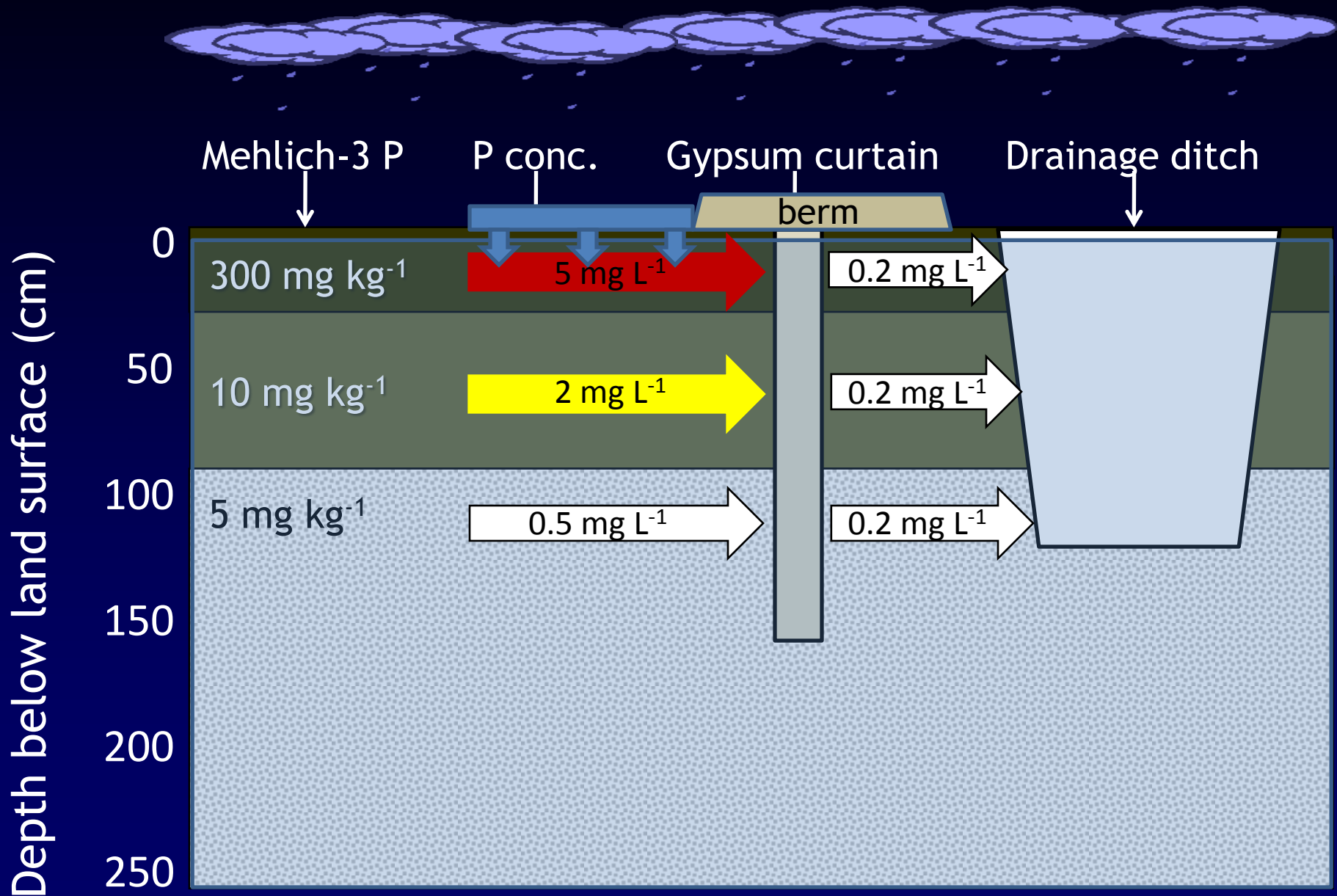
# Maximum flow rate through gypsum over time



# P transport processes in Coastal Plain soils



# FGD gypsum "curtain" - 2<sup>nd</sup> generation



# FGD gypsum "curtain" - 2<sup>nd</sup> generation



# FGD gypsum “curtain” - 2<sup>nd</sup> generation

*Applying the practice at a larger scale*



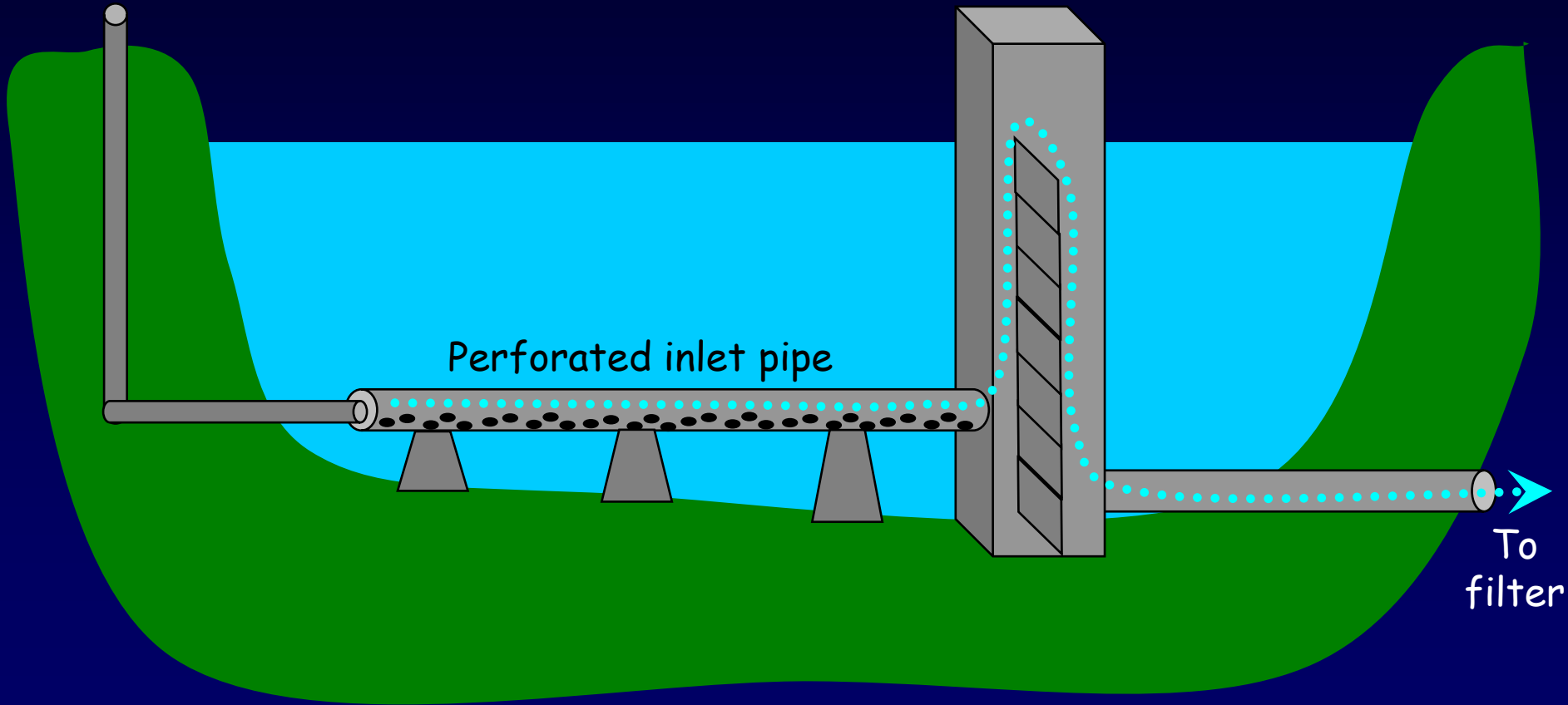
# Detention pond inlet

Clean out

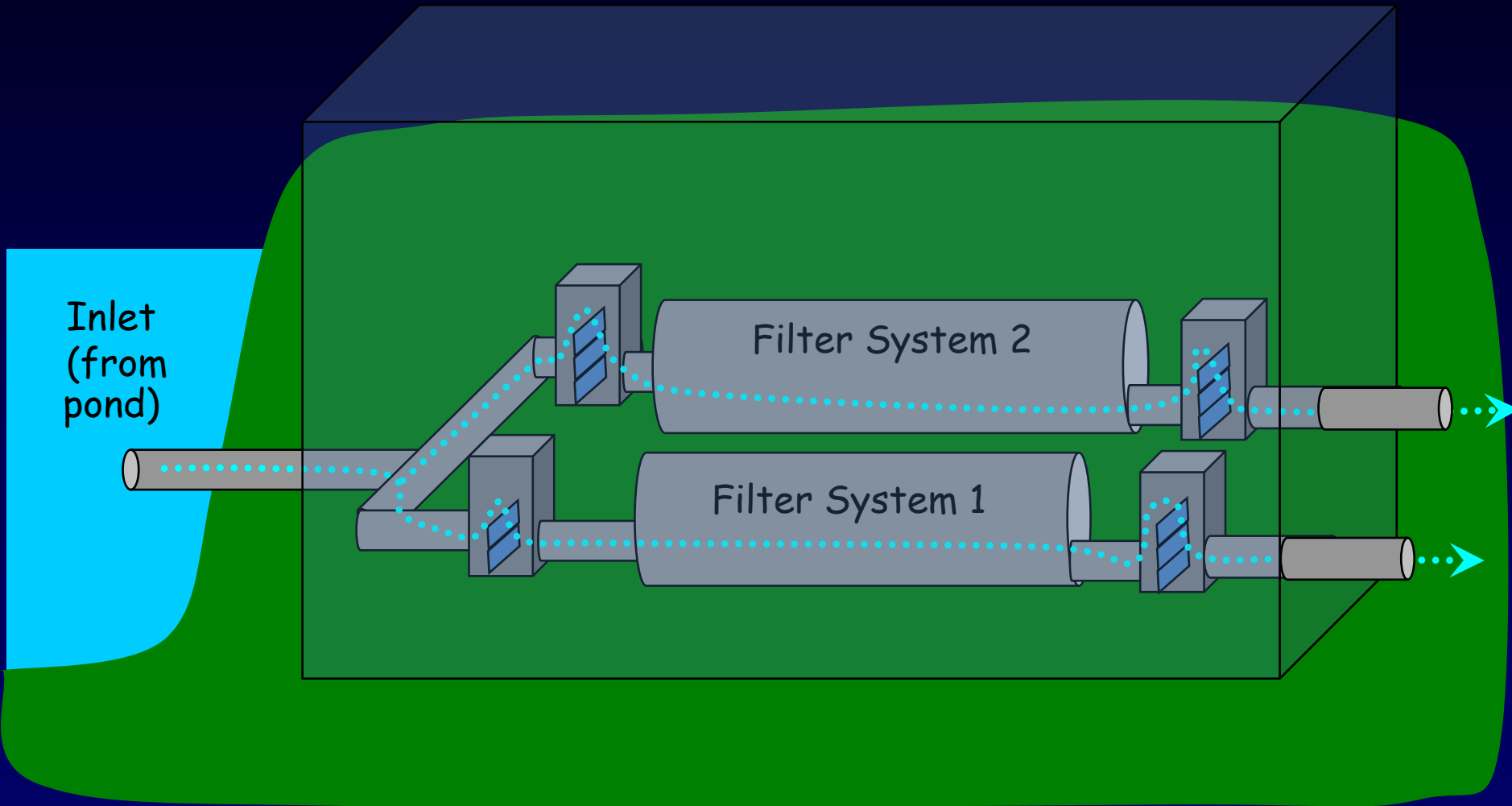
Drainage  
control  
structure

Perforated inlet pipe

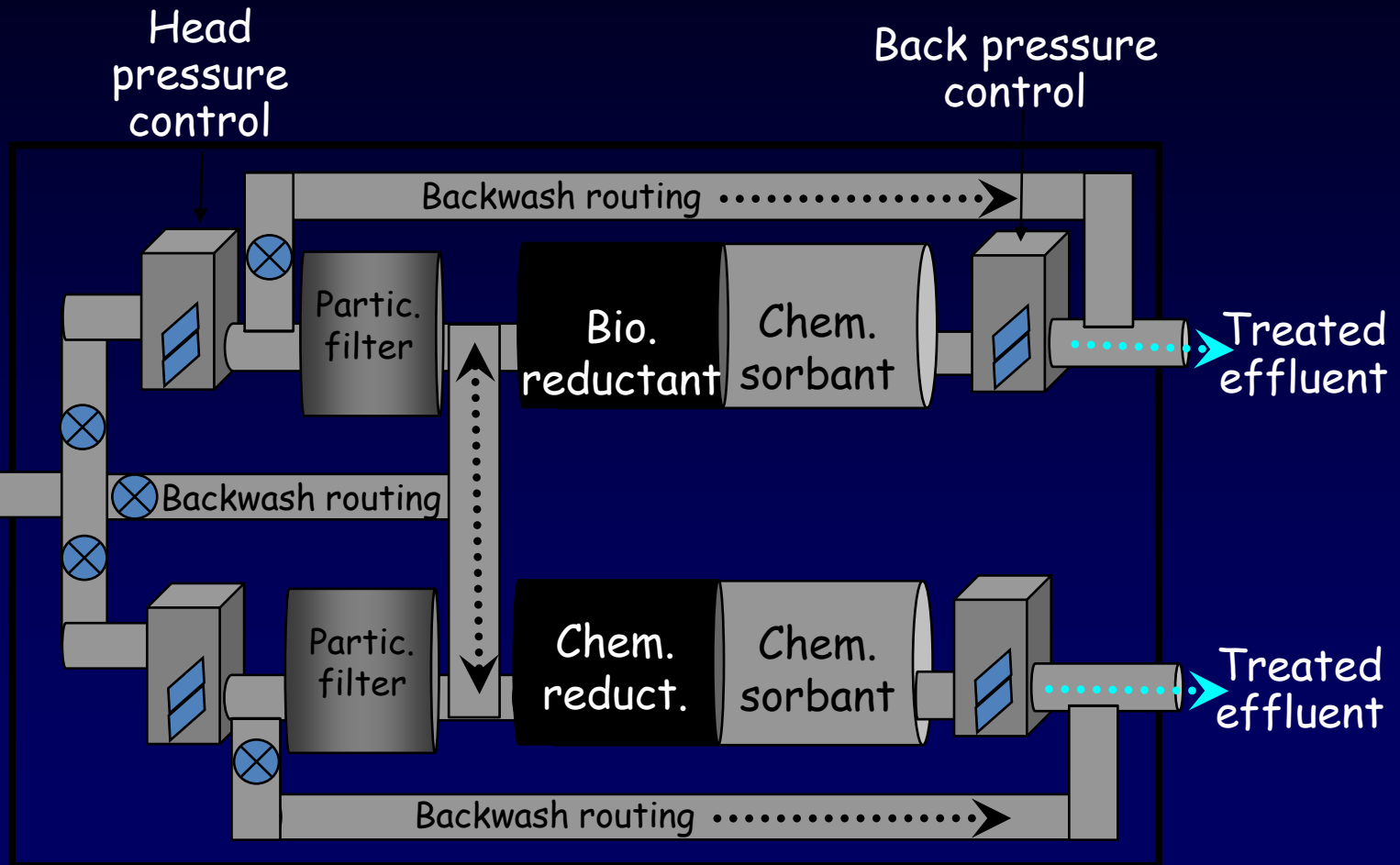
To  
filter



# Filter vault - simultaneous testing of multiple systems



# Filter vault (top view)



# Questions?

