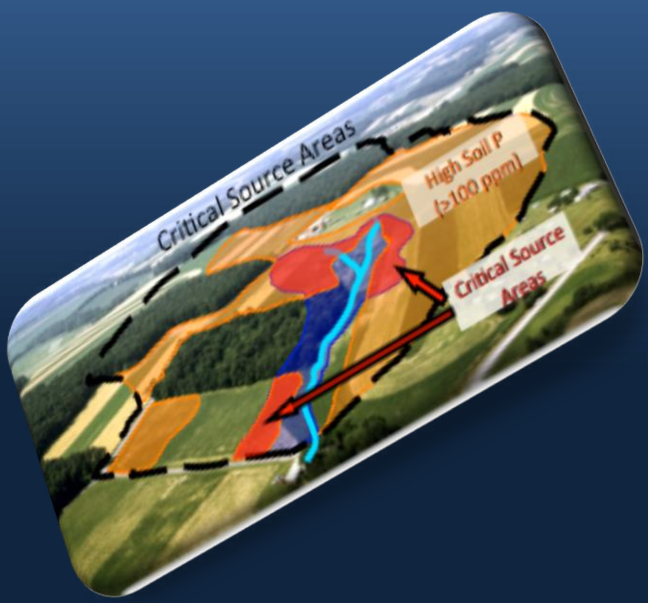
Drainage and legacy P

Global concerns, local problems



Pete Kleinman

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State College, PA 16802

Phosphorus in drainage water

Subsurface transport is ubiquitous

Tile drainage

Tiles create "hydrologic connection"

Route surface runoff and liquid manure

Especially in soils with good structure

Open ditches

Role of shallow lateral flow

Difficulty in managing legacy P

Even in sloping landscapes

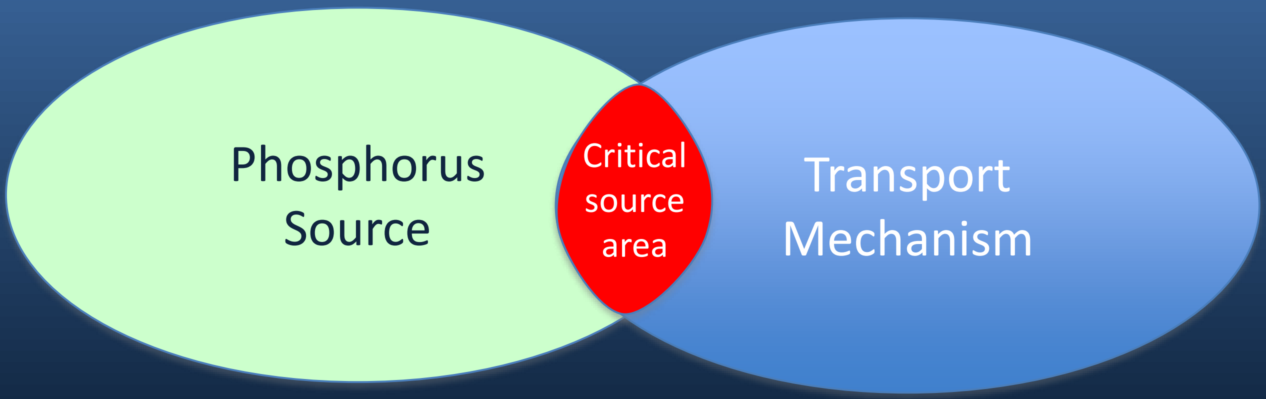
Subsurface transport can be important

Field drainage – ditches and tiles

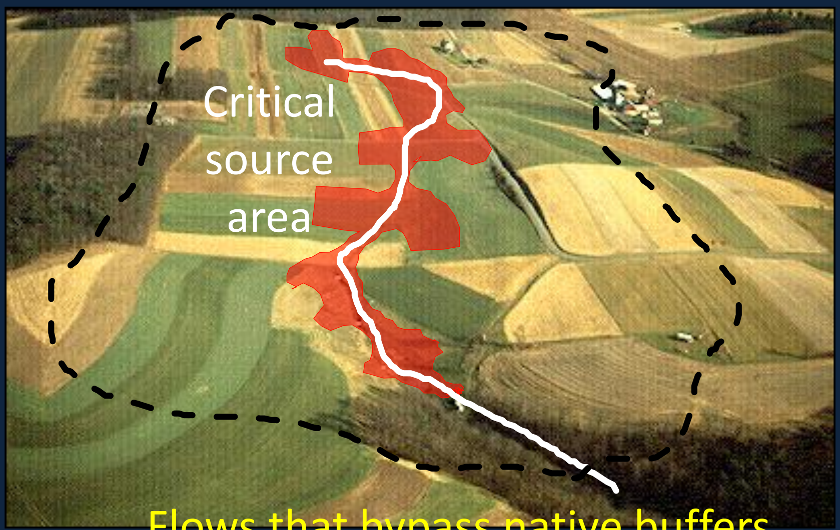
lower water tables, faster travel times, increased connectivity

Phosphorus loss from fields

Managing sources and transport pathways

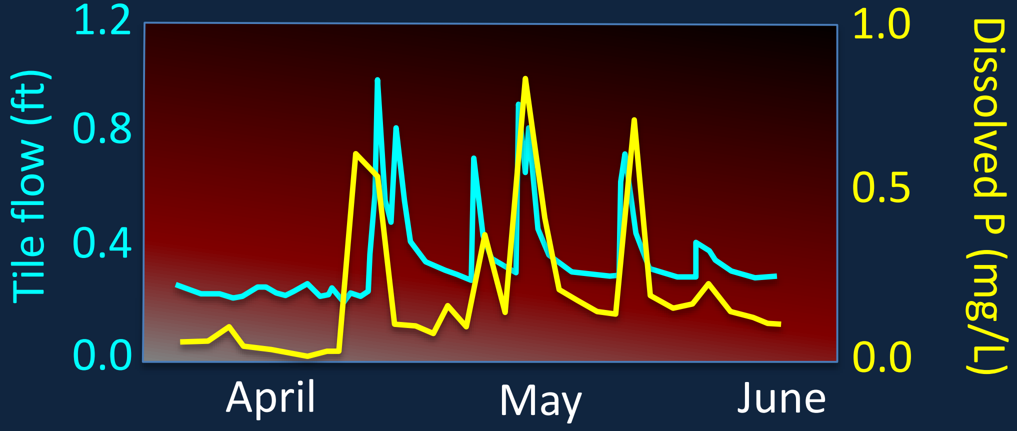


HOT SPOTS



Flows that bypass native buffers

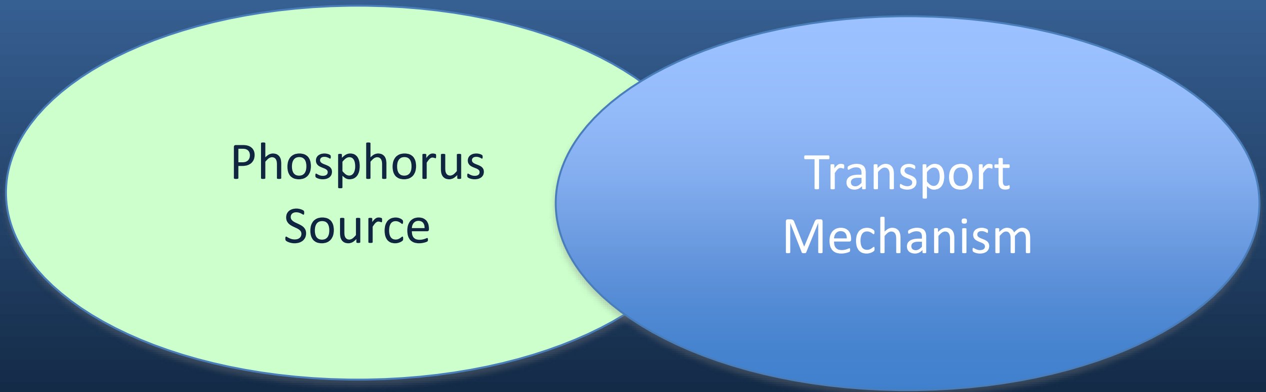
HOT MOMENTS



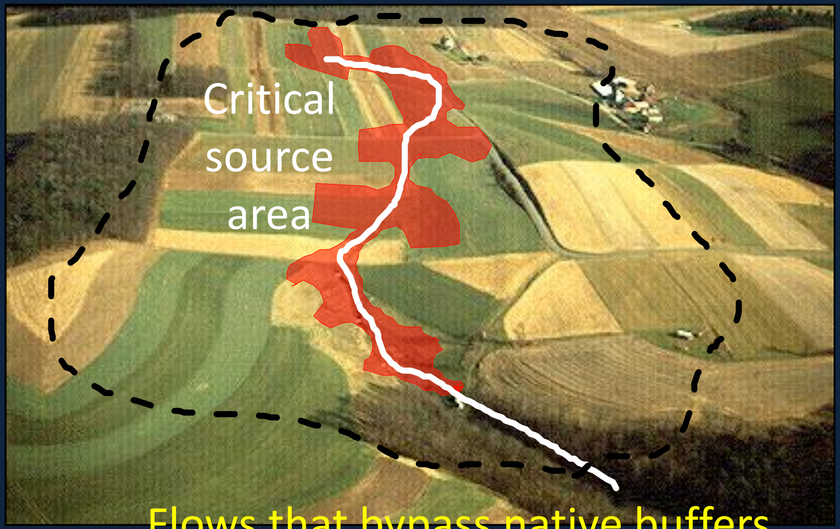
Source: King, USDA-ARS

Phosphorus loss from fields

Managing sources and transport pathways

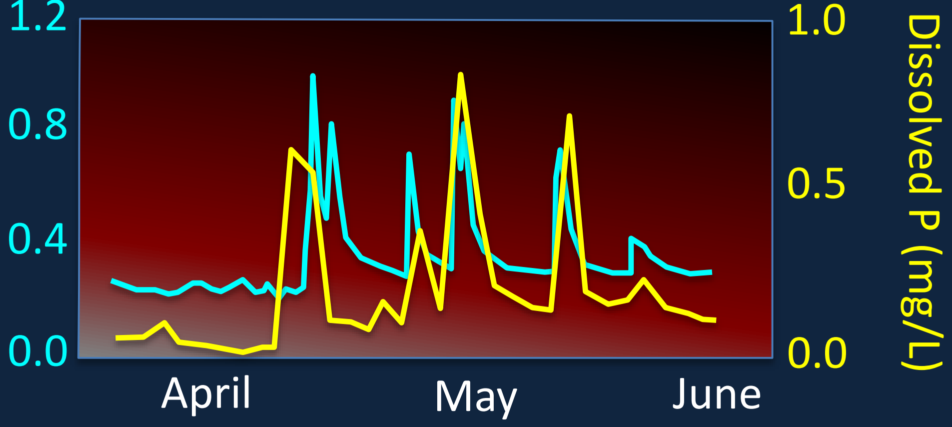


HOT SPOTS



Flows that bypass native buffers

HOT MOMENTS

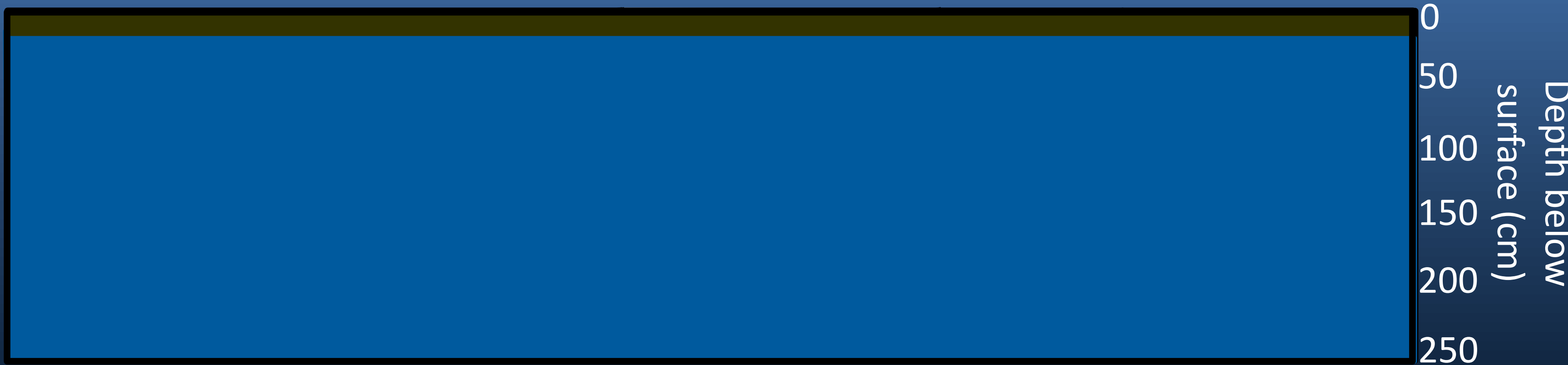


Source: King, USDA-ARS

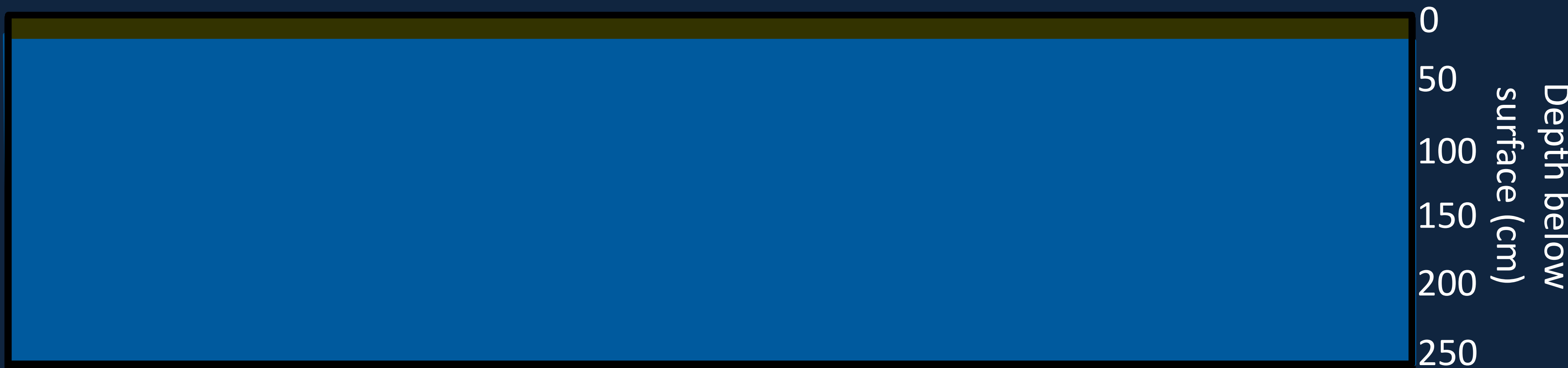
Intensifying artificial drainage

lower water tables, faster travel times, increased connectivity

Ditch drainage

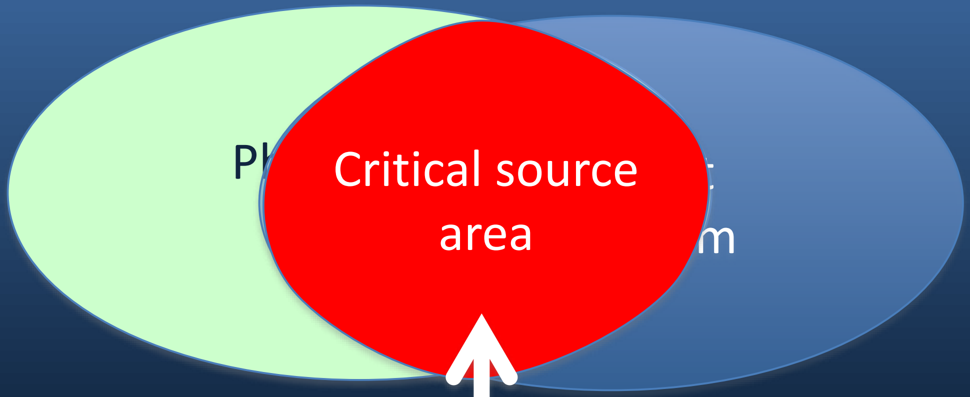


Tile drainage



Managing phosphorus loss

Drainage expands critical source areas and "quick flow"

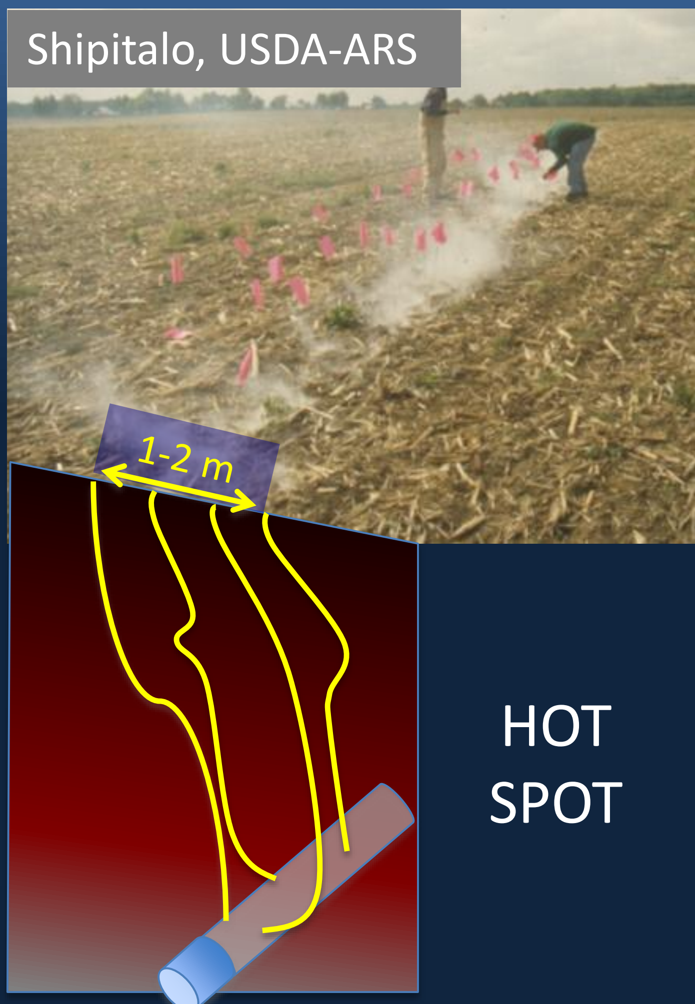


Flat, internal drainage

Hydrologic connectivity

Tile drains route surface runoff

Via macropores



HOT
SPOT

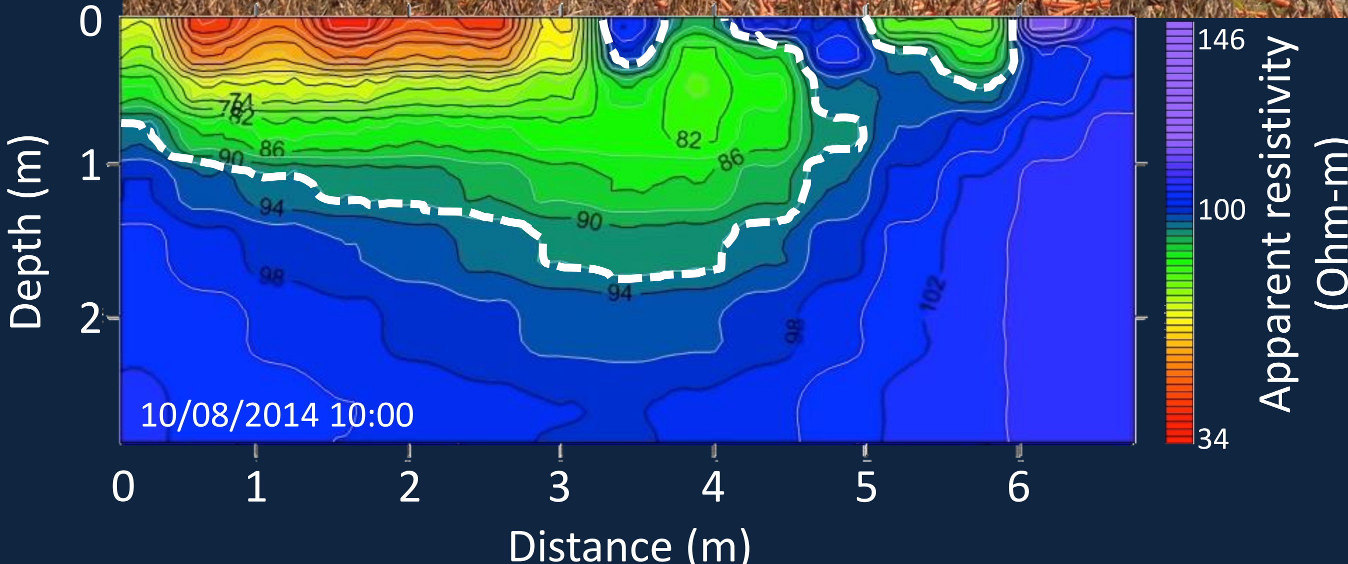
Soil P transfers to drainage ditches

Shallow groundwater is the primary pathway

Kleinman et al., 2007 (J. Soil Water Conserv.)

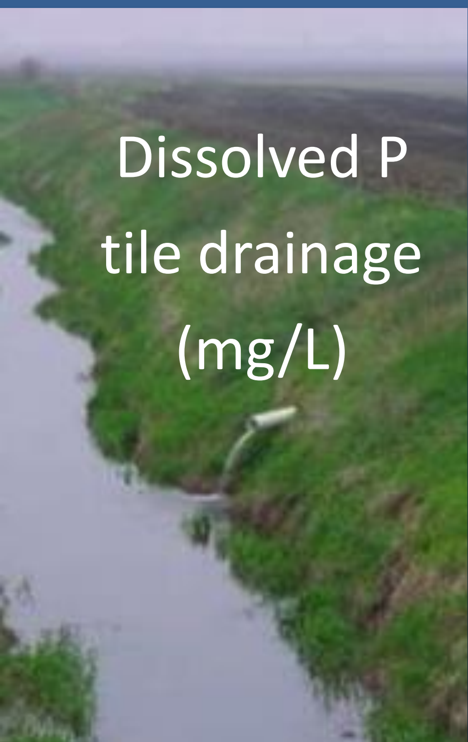
Shallow subsurface flow pathways

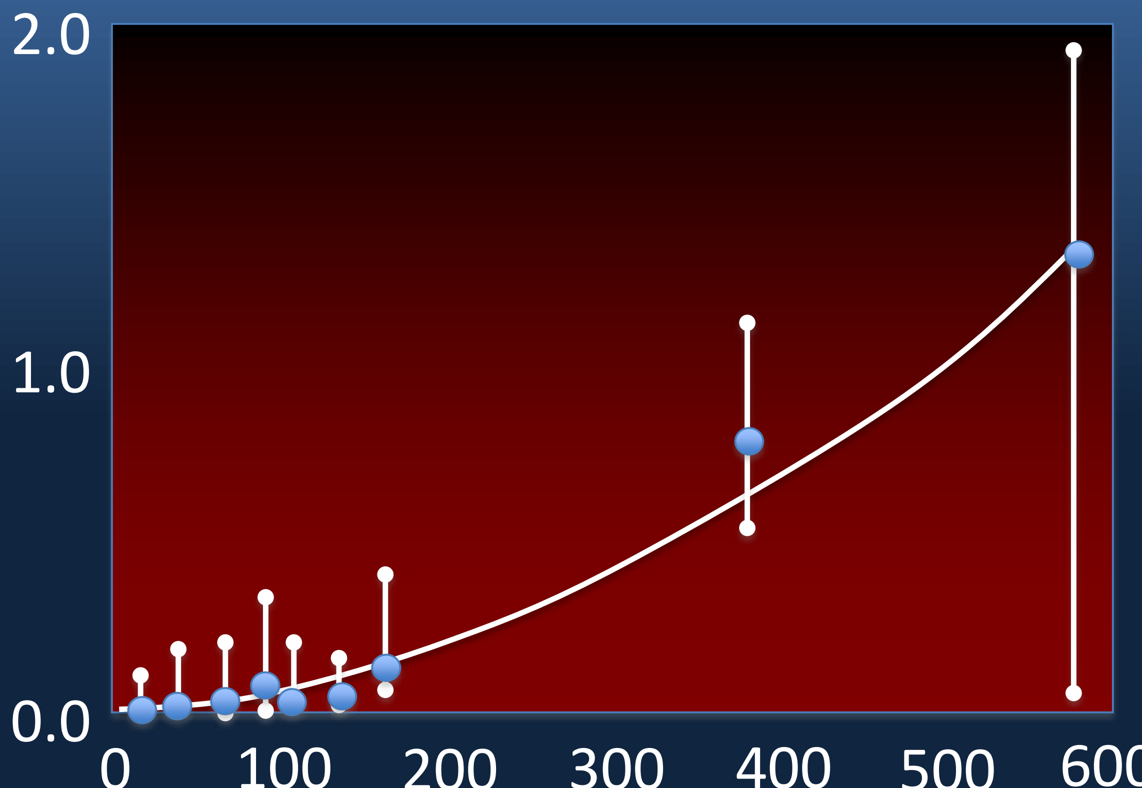
Applying tracers with electrical resistivity imaging

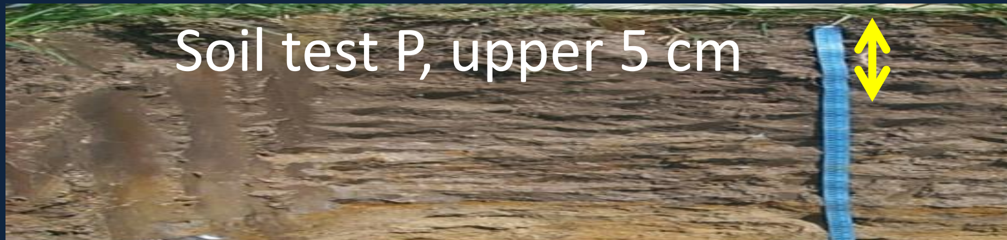


Drainage and subsurface P loss

Many parallels with surface runoff



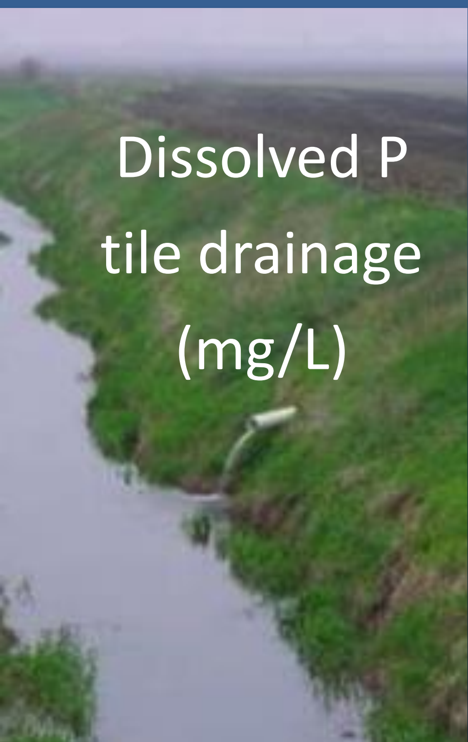


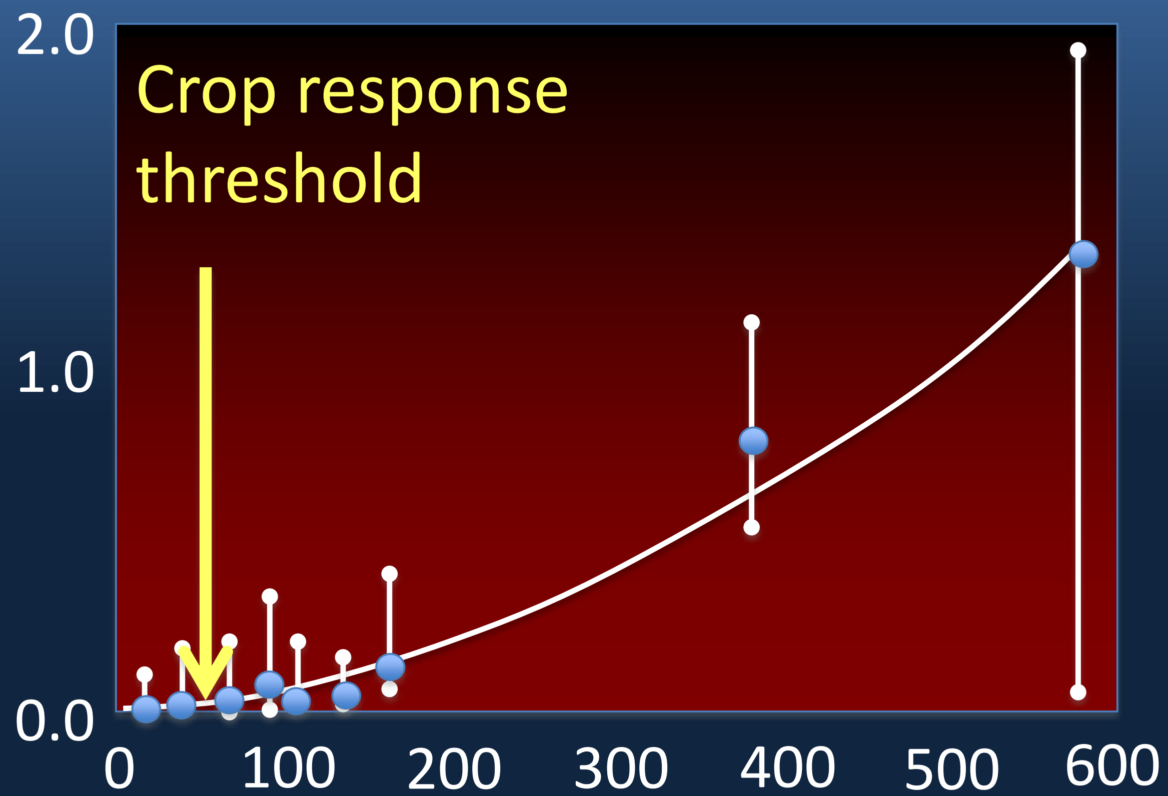


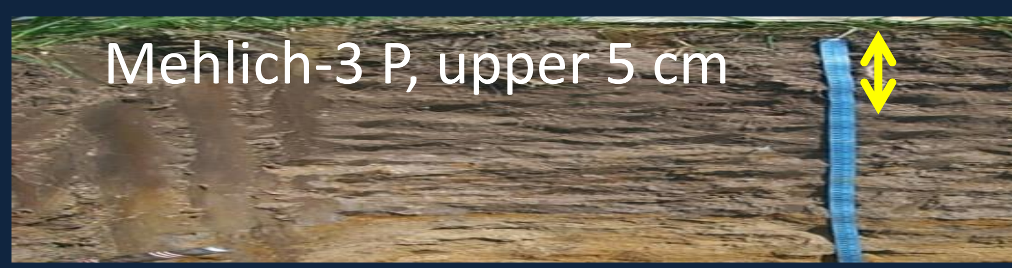
Source: King, USDA-ARS

Drainage and soil P

Follow your land grant university recommendations

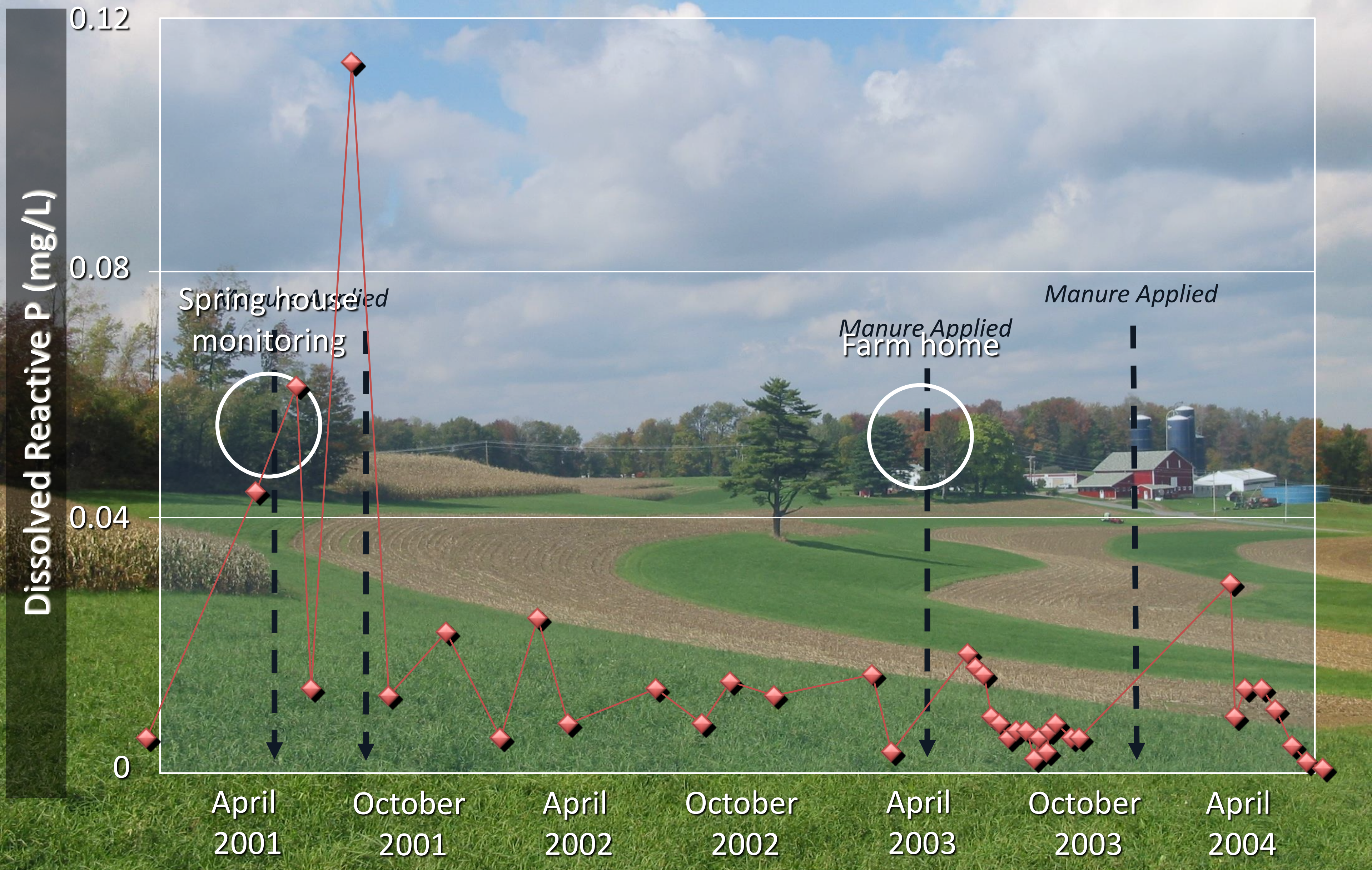






Source: King, USDA-ARS

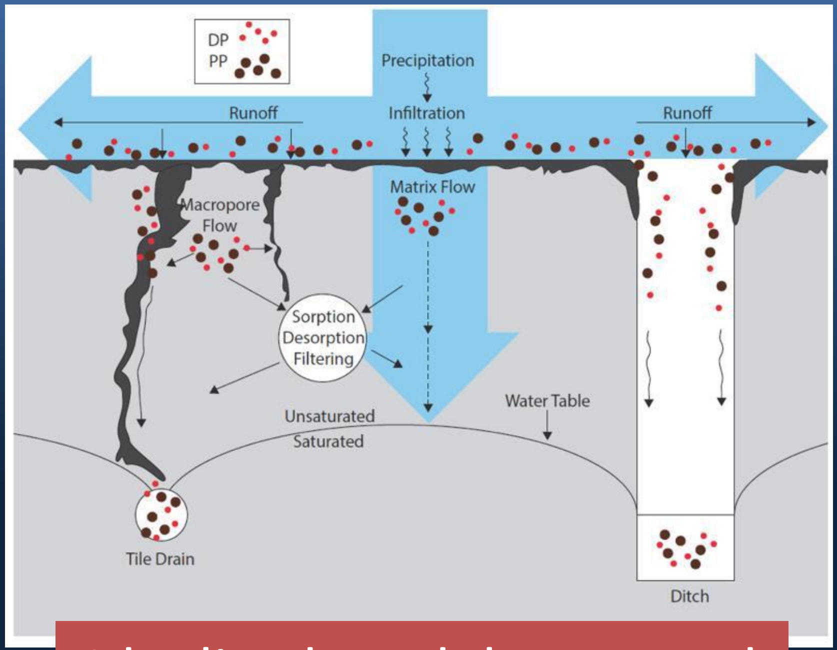
Groundwater P after manure application



Kleinman et al., 2009 (Nutrient Cycling in Agroecosystems)

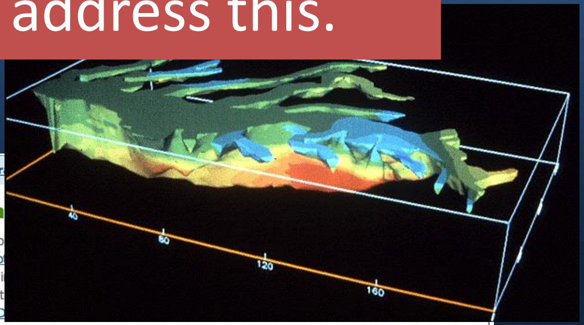
No model gets P in drainage water right

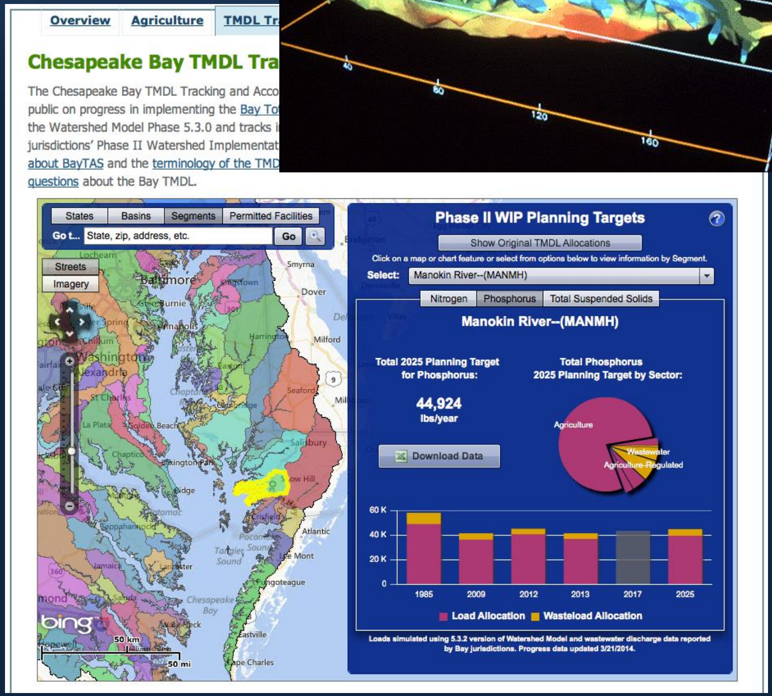
Journal of Environmental Quality, 2015



Idealized model proposed by Radcliffe et al. (2015) after their conclusion

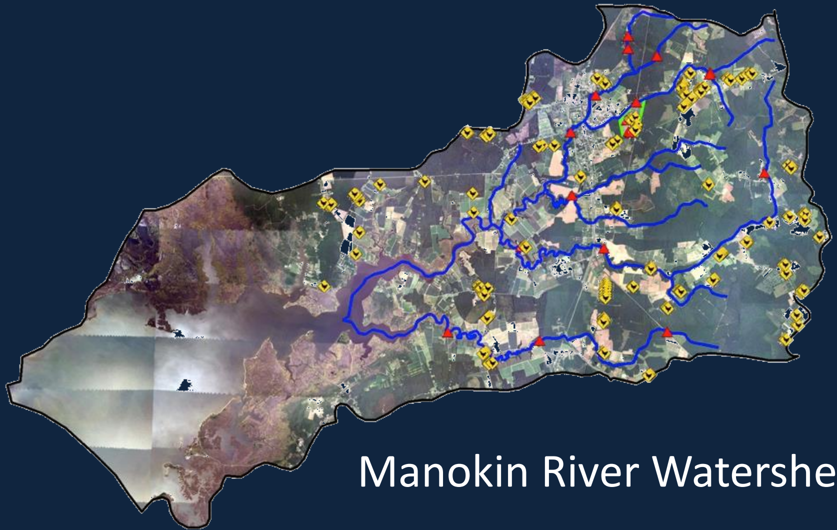
The Bay Model is not alone. Hopefully version 6.0 will address this.





Legacy P and Artificial Drainage

Delmarva Fresh Chickens:
600 million birds, 800,000 tons litter



Manokin River Watershed

Legacy P

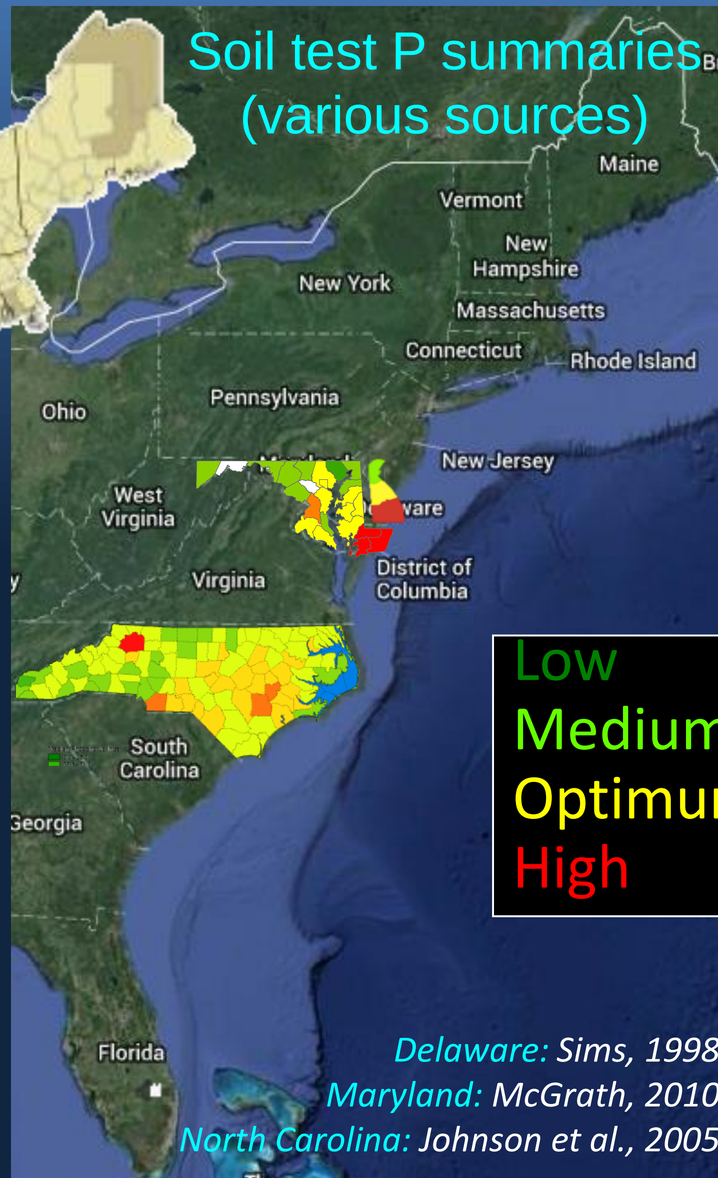
Intensified and specialized farming systems

Disconnect between livestock production and soil P fertility objectives

County P balances (Ag Census)

Maguire et al.: *J. Environ. Qual., 2008*

Soil test P summaries (various sources)



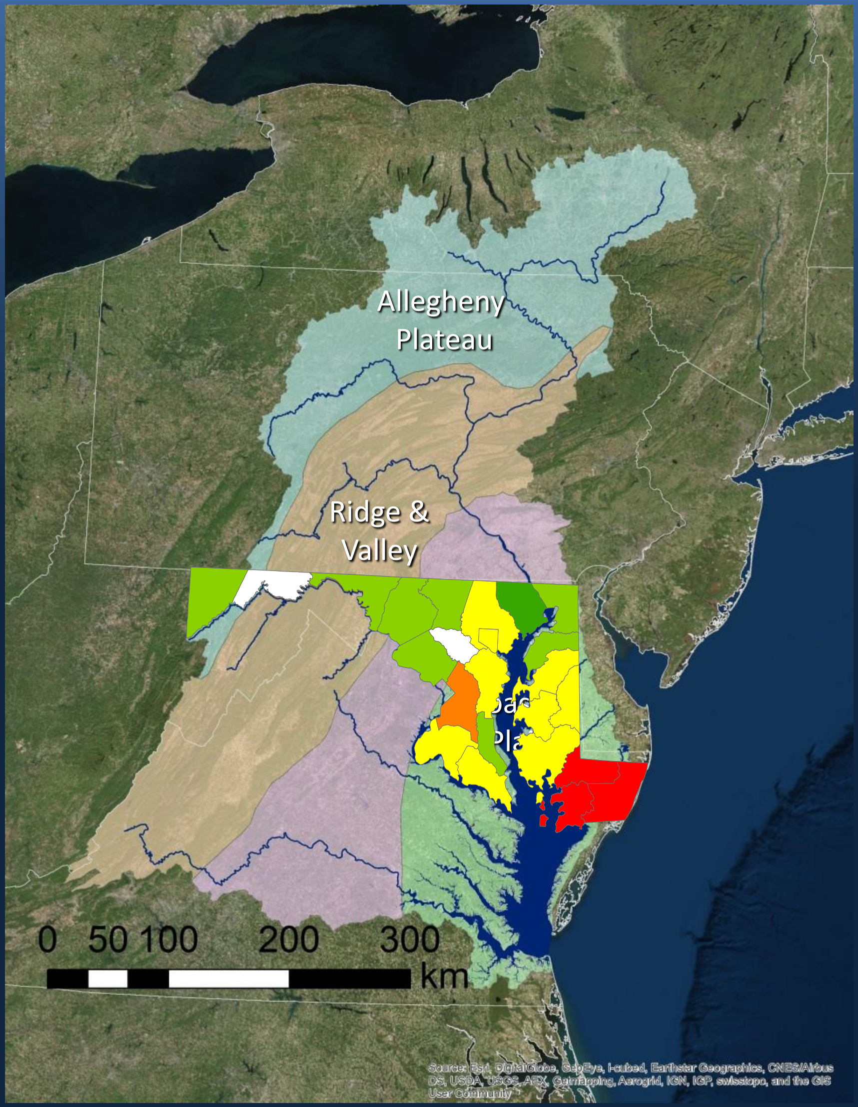
Low
Medium
Optimum
High

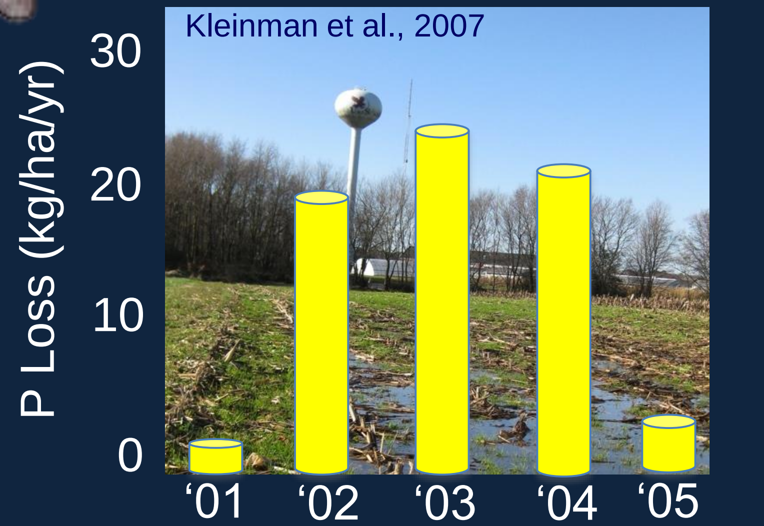
Delaware: *Sims, 1998*
Maryland: *McGrath, 2010*
North Carolina: *Johnson et al., 2005*

Sims et al.: *J. Environ. Qual., 1998*

Open ditches and legacy P

Manokin River Watershed



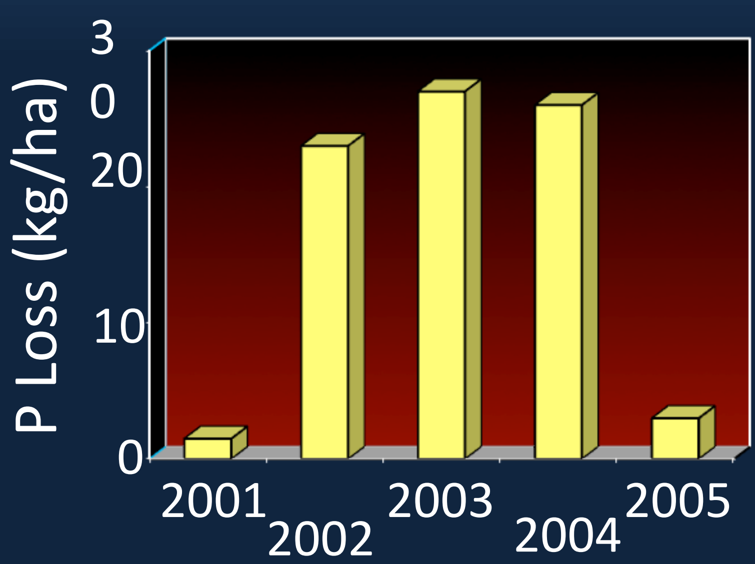


Drainage ditch monitoring network

Drainage Ditches

Connect legacy P sources with streams

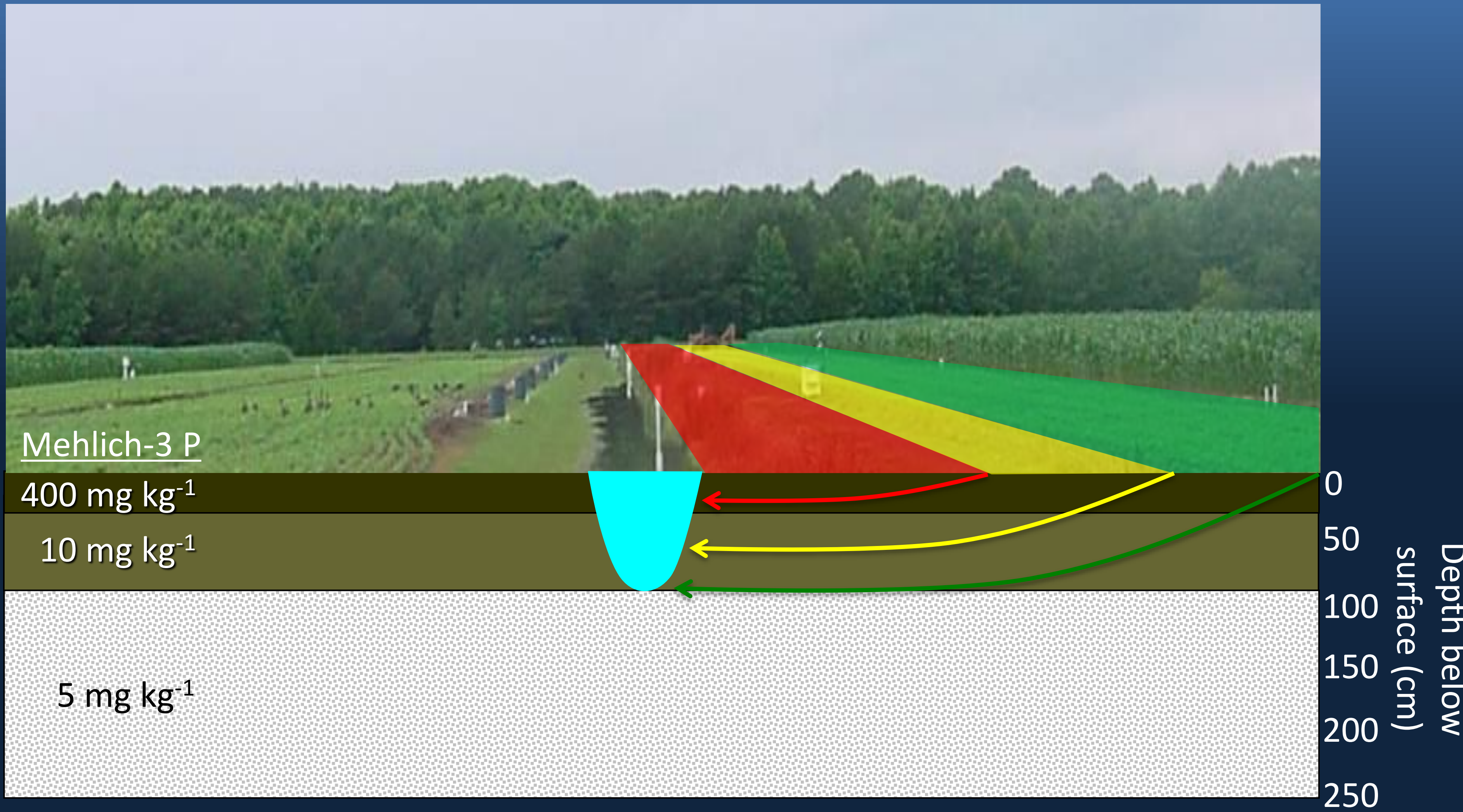
Flashy - drainage fluctuations can be enormous



Kleinman et al., 2007 (J. Soil and Water Conserv.)

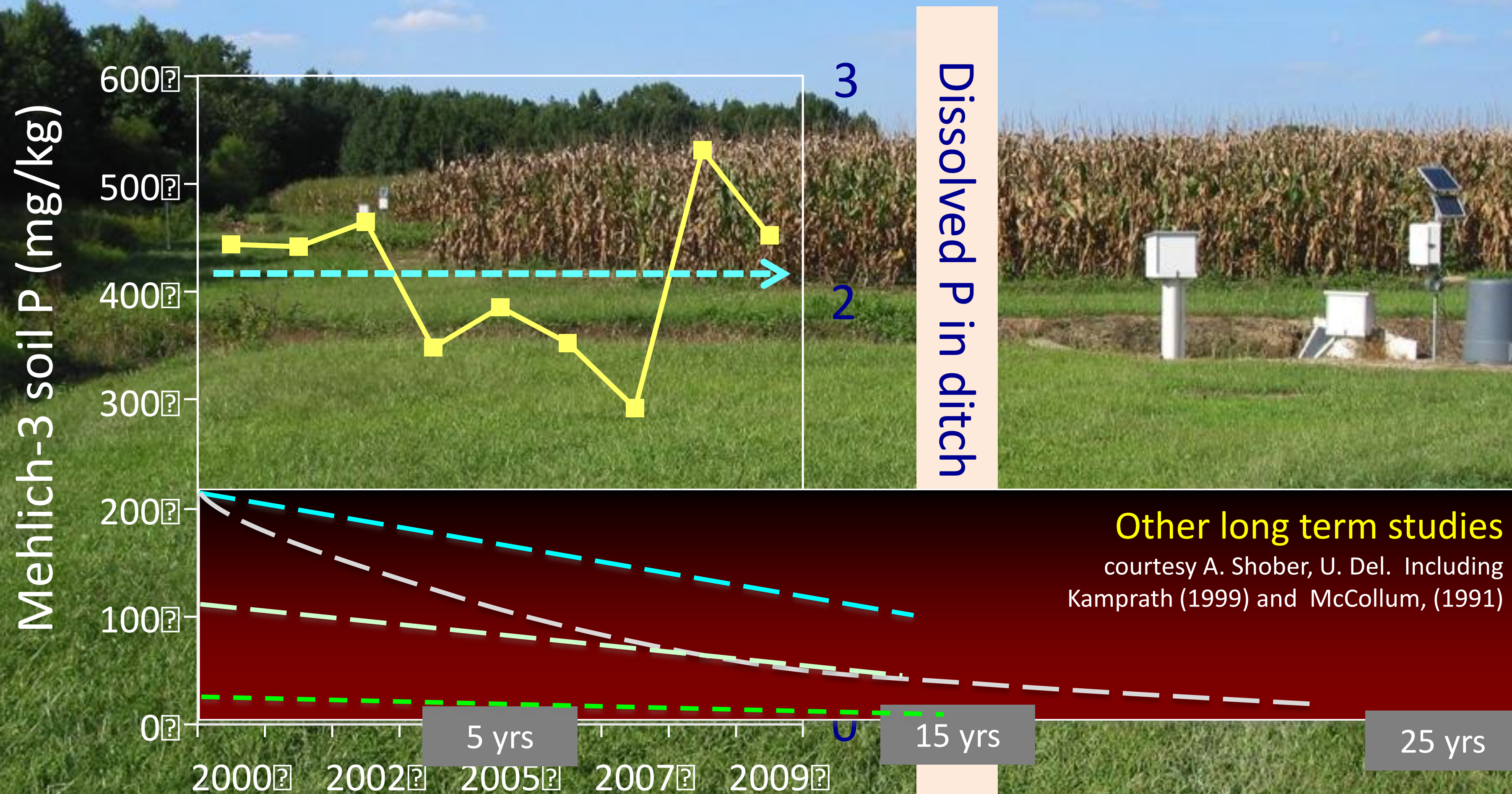
Phosphorus loss in ditch drainage

Greatest risk is in the near-ditch zone (within 5-10 m)



Kleinman et al., 2007 (J. Soil Water Conserv.)

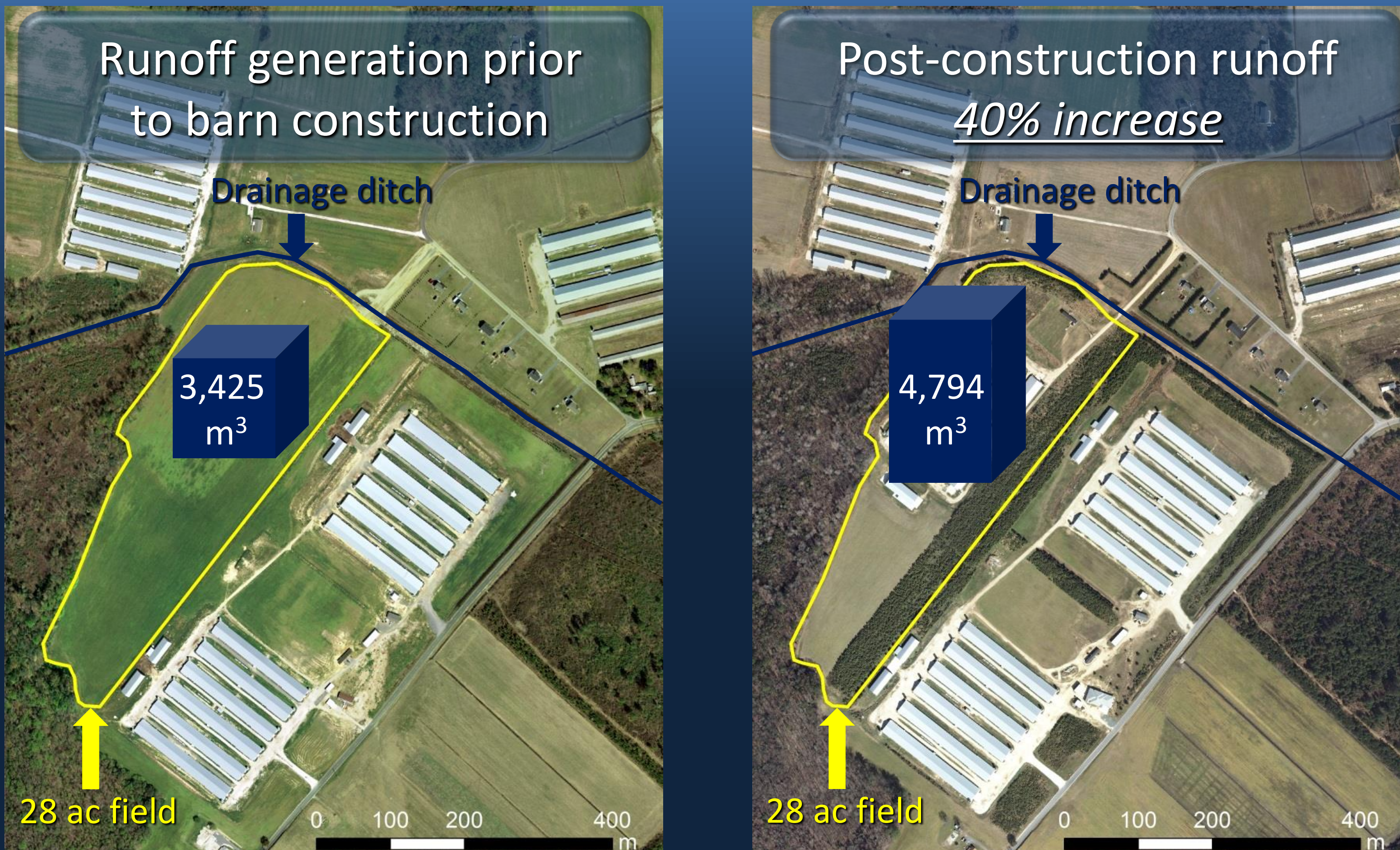
“Mining” legacy P
No change after one decade



Kleinman et al., 2010 (Canadian J. Soil Science)

The "zero acre" farm

Routing storm water through legacy P sources



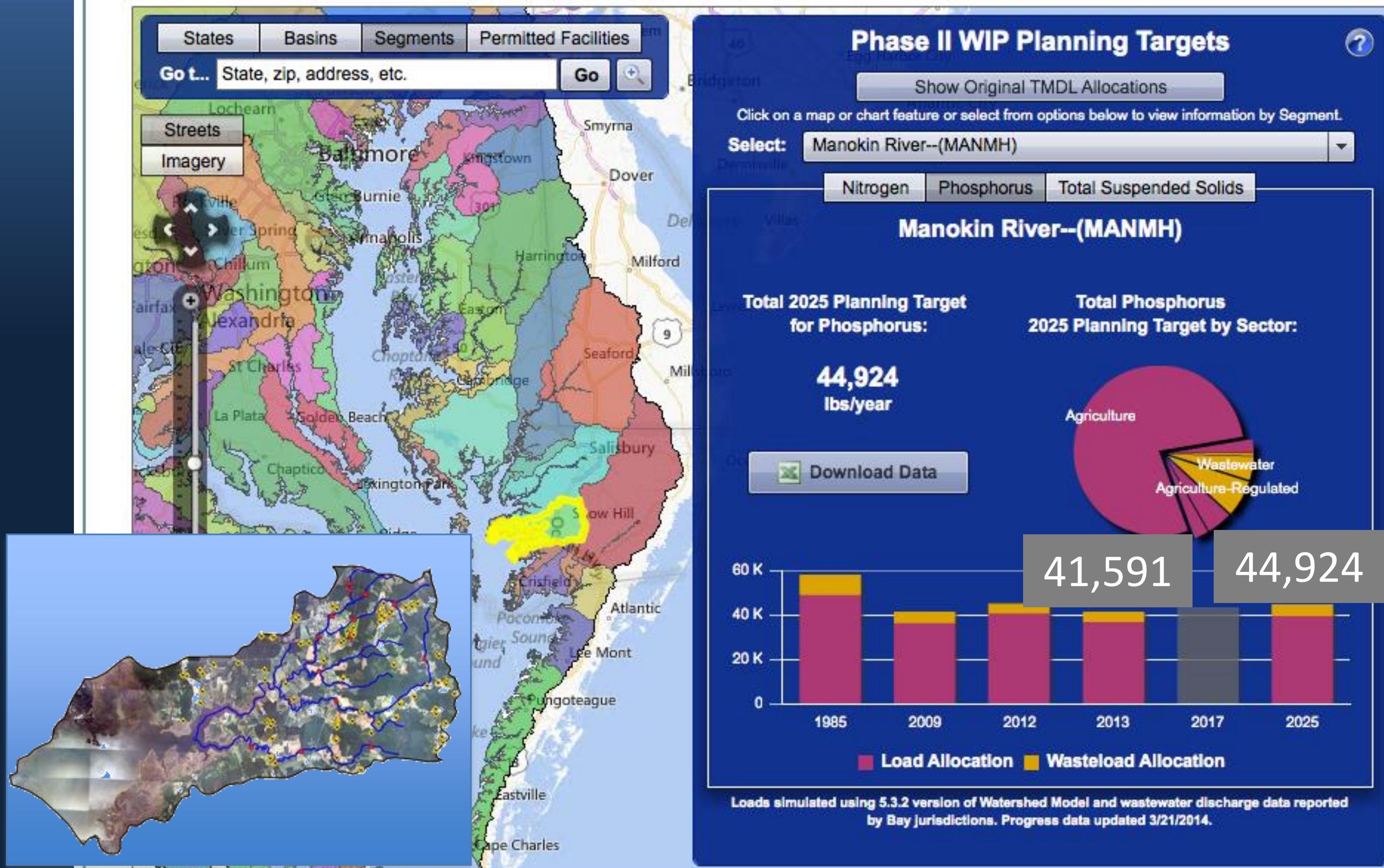
Manokin River
Modeling and monitoring

ChesapeakeStat.net, verified April 1, 2014

...culture | TMDL Tracking | BMP Review | 2009-2011 Milestones | 2012-2013 Milestones

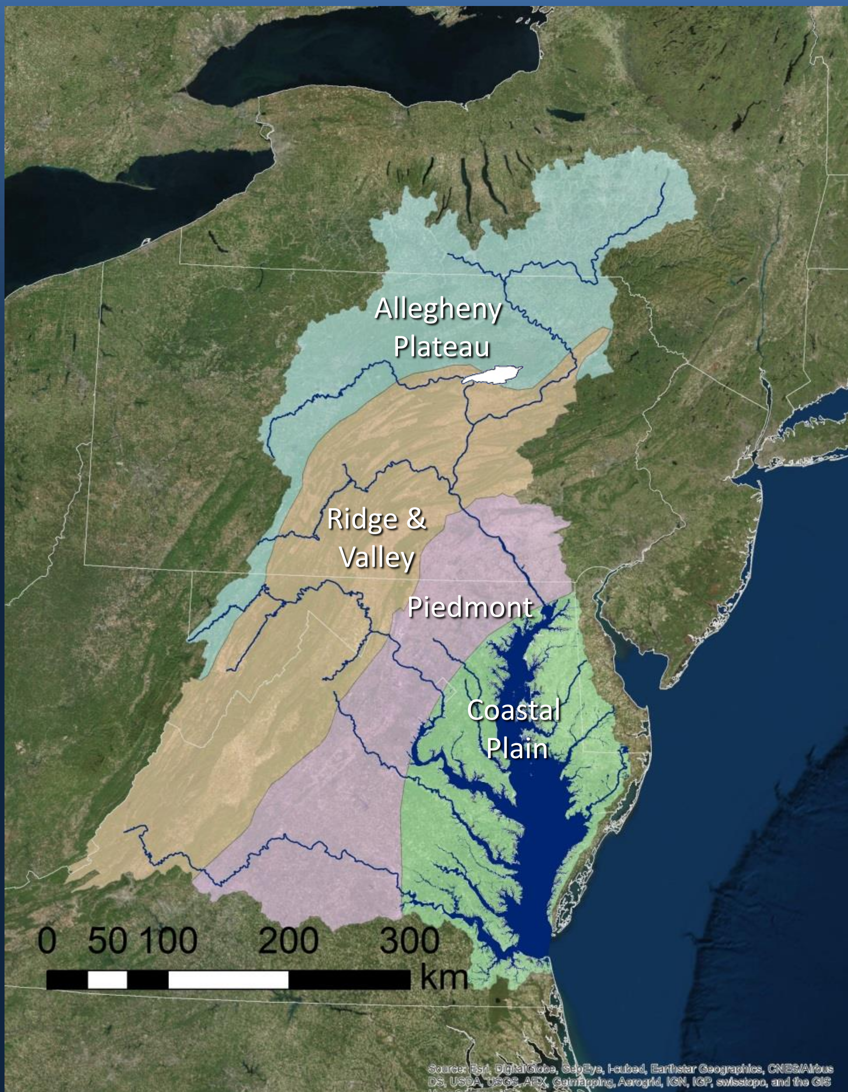
...ay TMDL Tracking and Accounting System

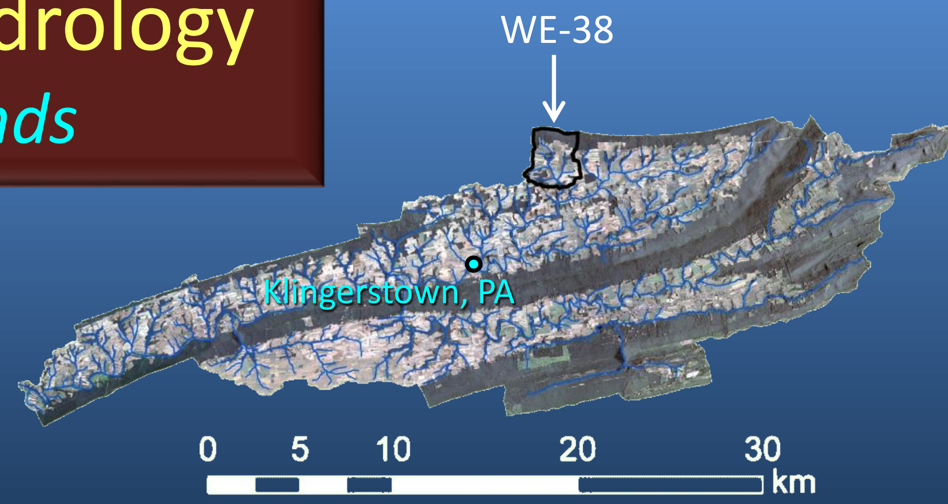
...DL Tracking and Accounting System (BayTAS) was developed to inform EPA, the Bay Jurisdictions, and the ...plementing the Bay Total Maximum Daily Load (Bay TMDL). BayTAS stores the TMDL allocations (based on ...hase 5.3.0 and tracks implementation progress (based on the Watershed Model Phase 5.3.2 and the jurisdictions' Phase II Watershed Implementation Plans (WIPs)). BayTAS data are displayed through the TMDL Tracker. Learn more about BayTAS and the terminology of the TMDL in the glossary found in Section 13 of the TMDL. Get answers to frequently asked questions about the Bay TMDL.



Variable source area hydrology

Chesapeake Bay uplands



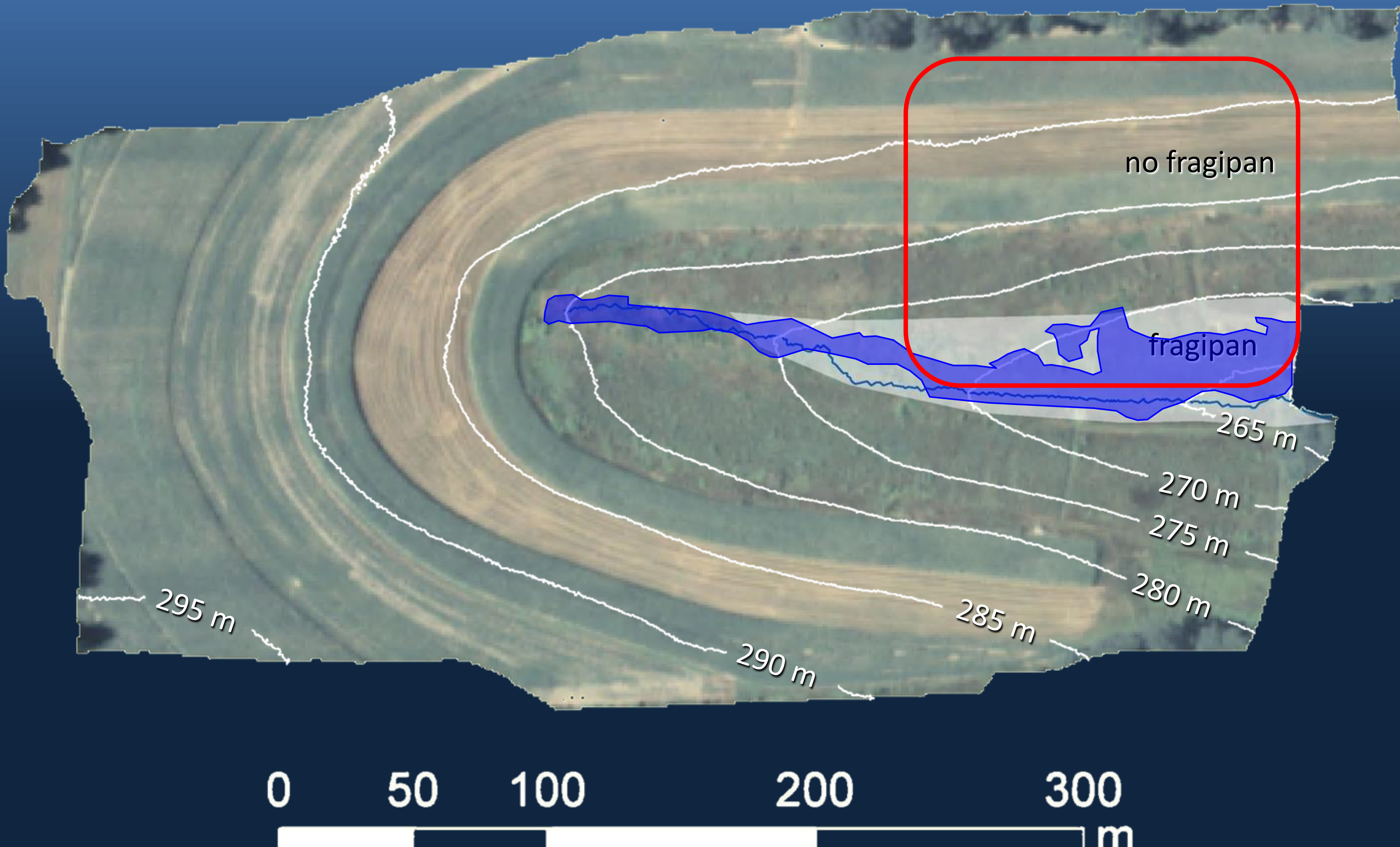


WE-38 Watershed (7.3 km^2)

Mattern (11 ha)

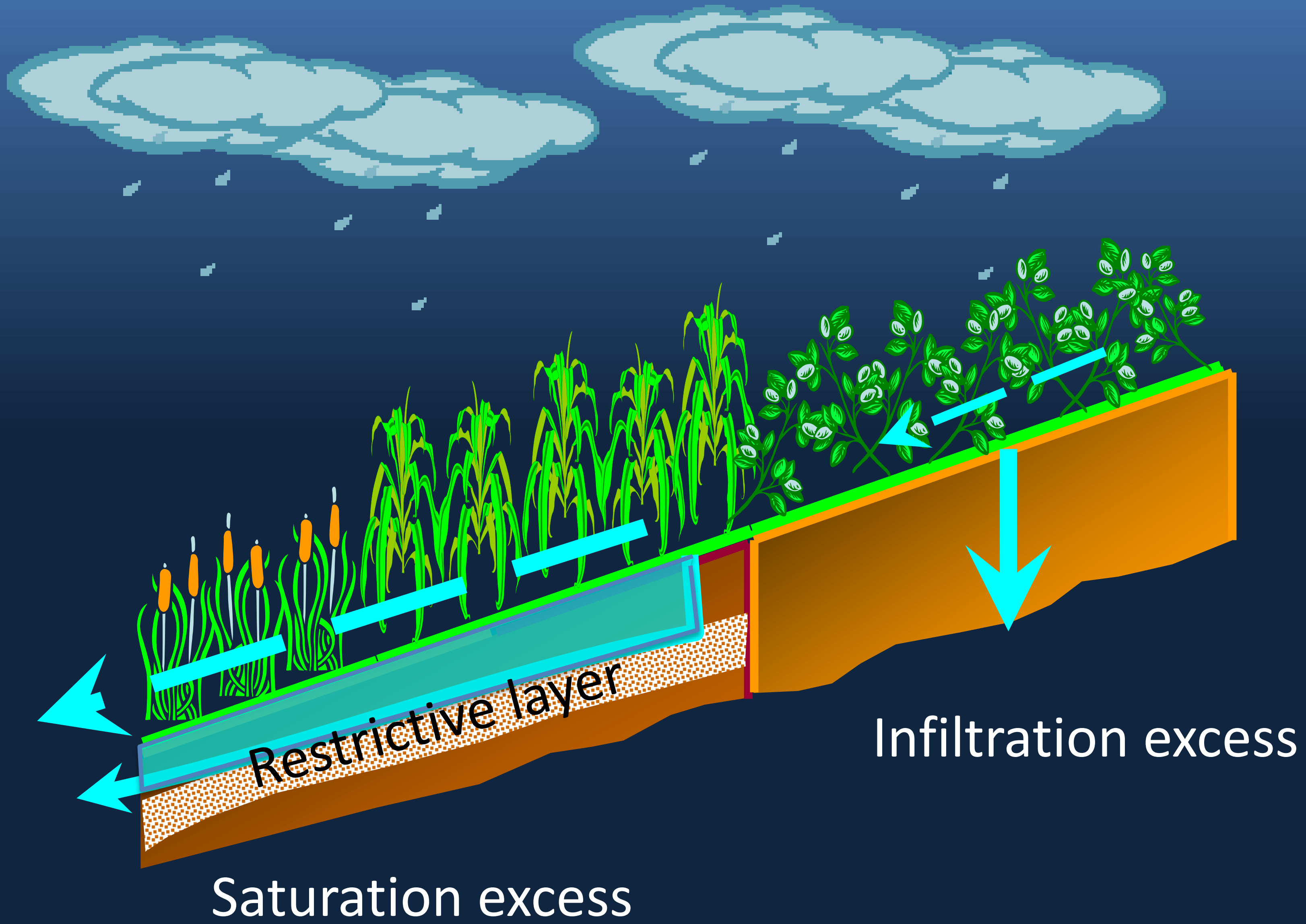
Fragipan soils and zones of saturation

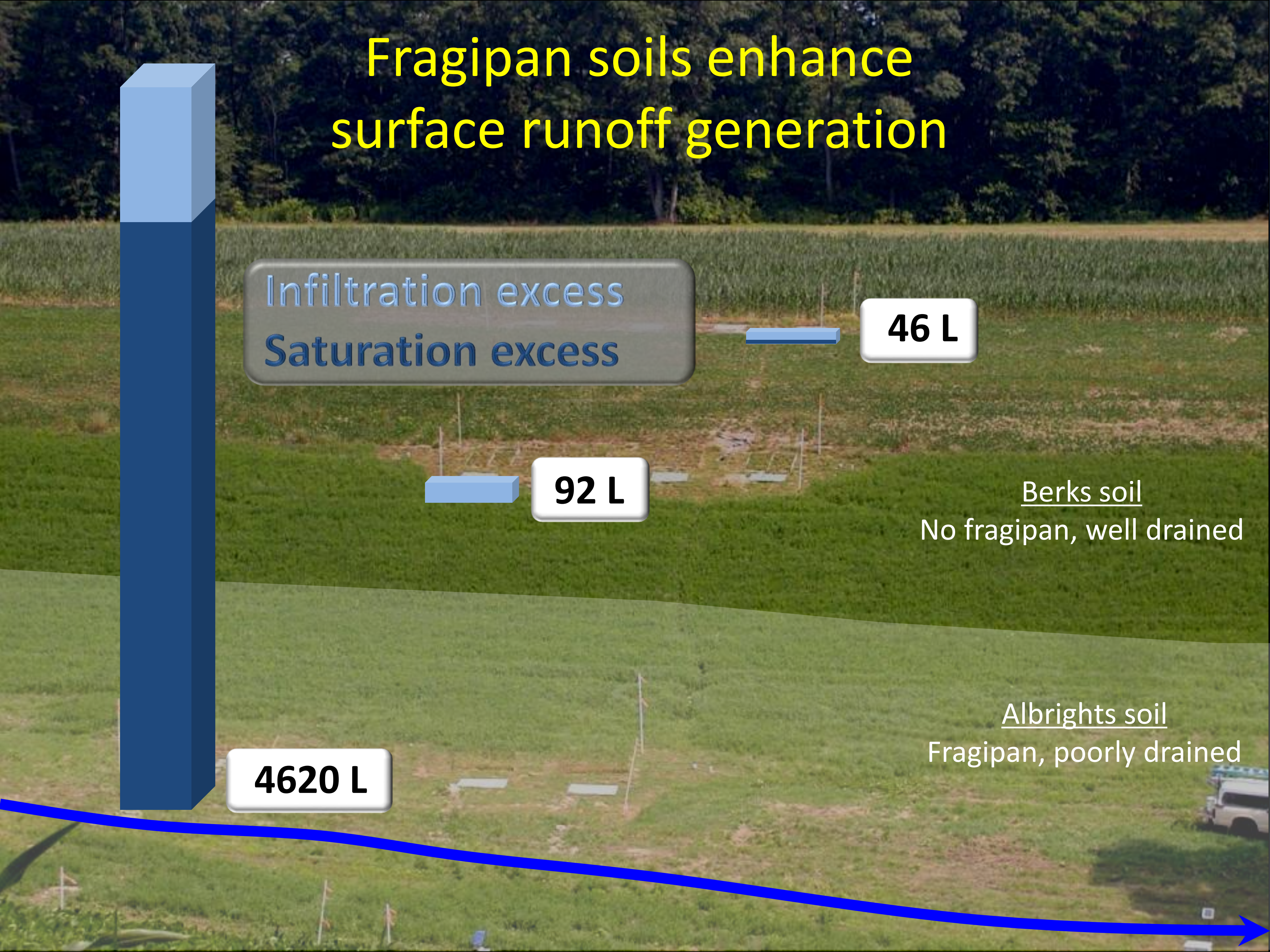
Late October 2003



Surface runoff generation

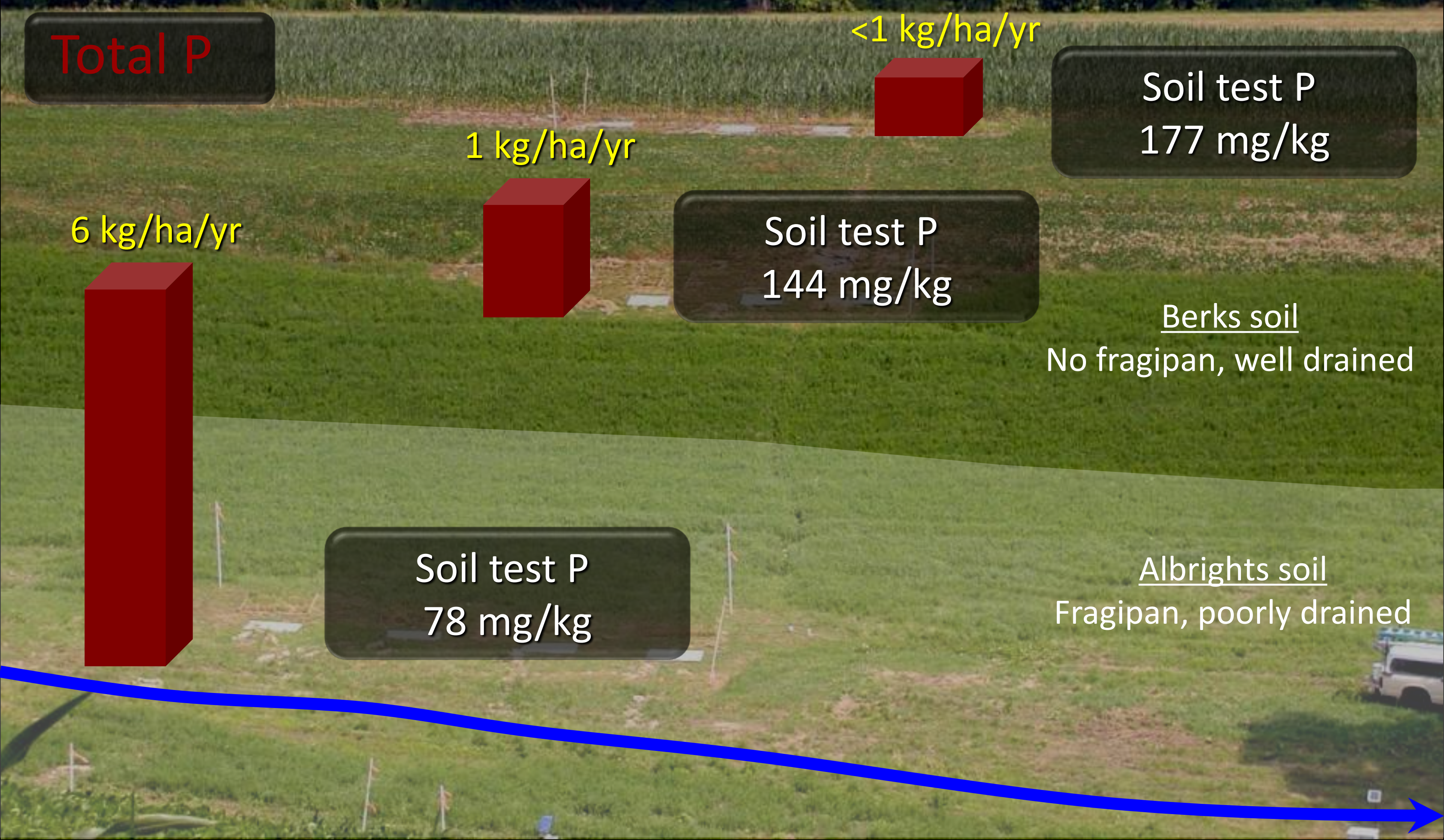
Saturation vs. Infiltration excess





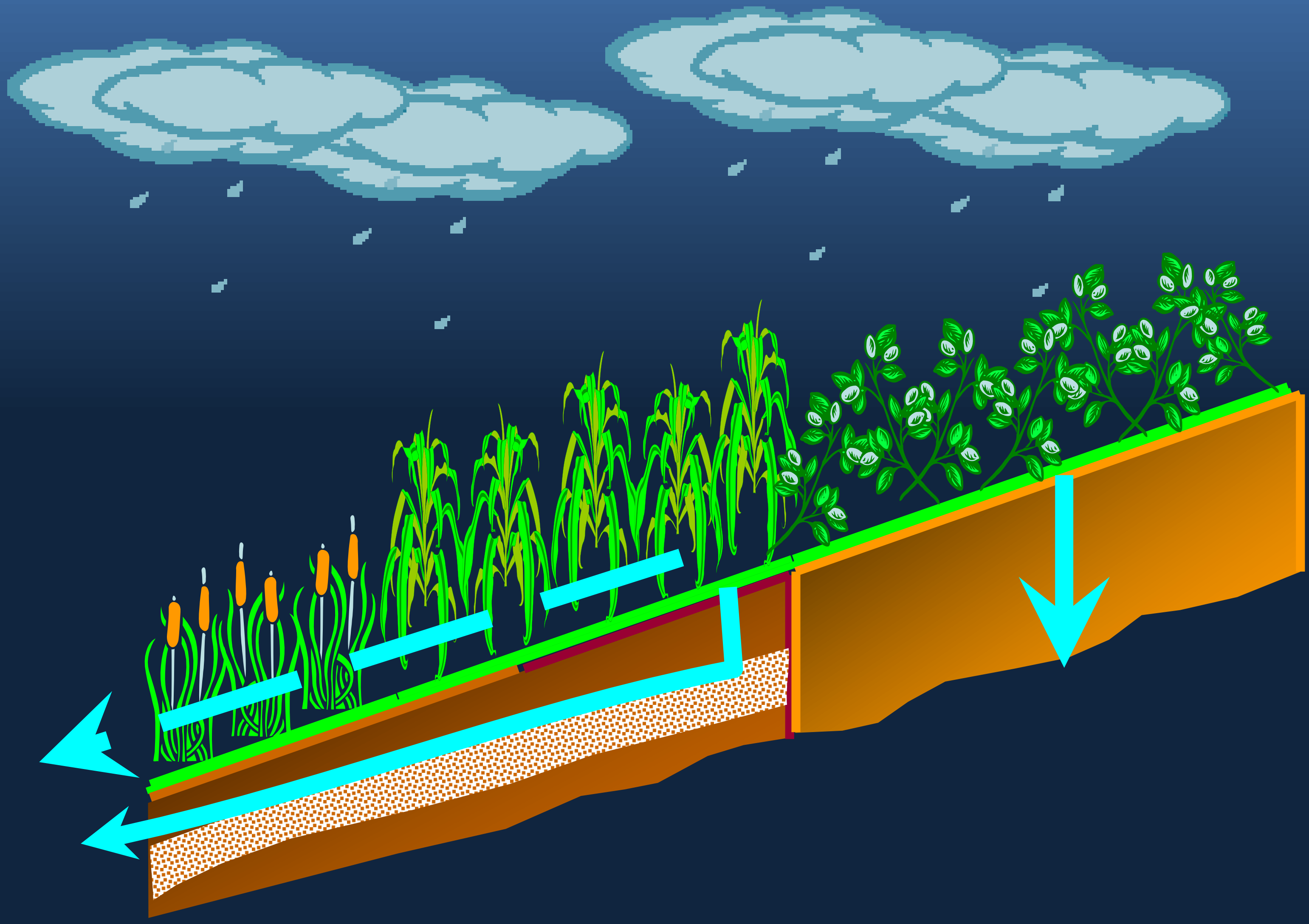
Fragipan soils enhance surface runoff generation
Infiltration excess
Saturation excess
46 L
92 L
4620 L
Berks soil
No fragipan, well drained
Albrights soil
Fragipan, poorly drained

which can lead to large phosphorus (P) losses, even from modest sources



Subsurface P transport in sloping landscapes

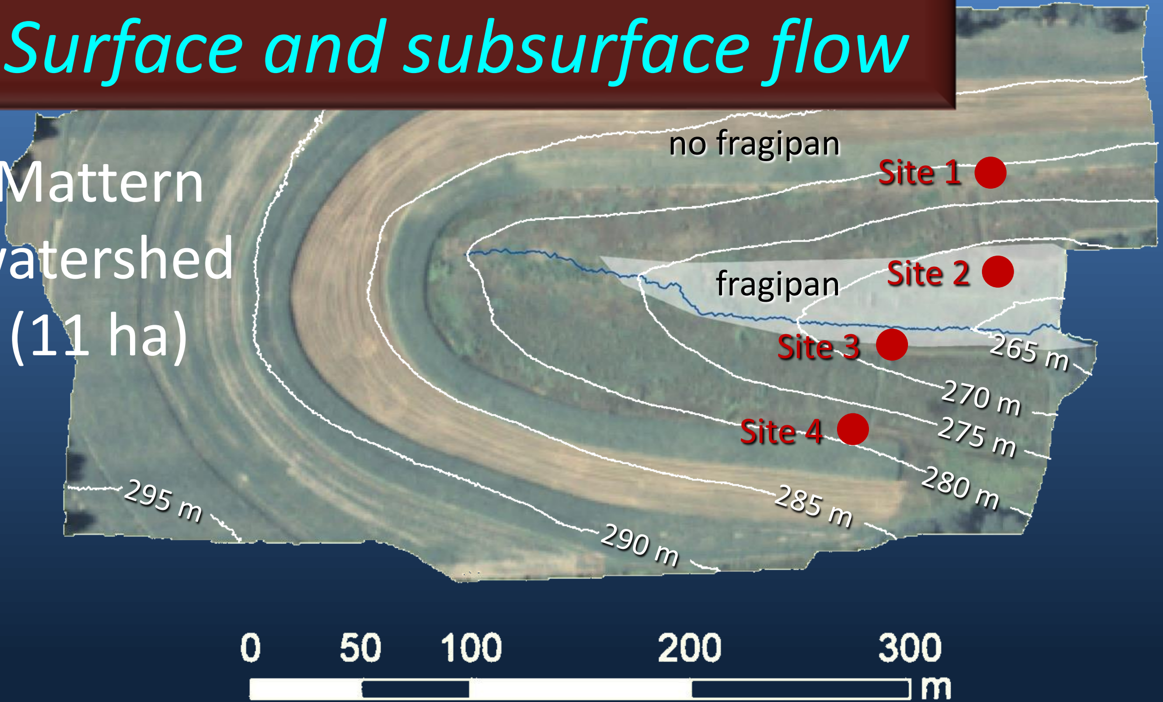
An often overlooked pathway



Hillslope monitoring

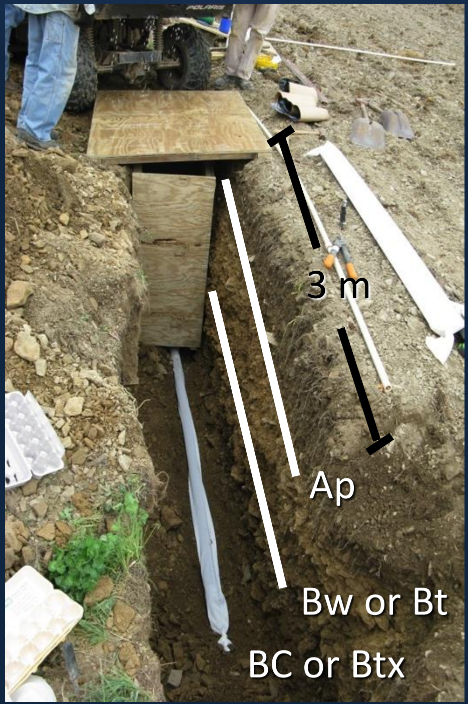
Surface and subsurface flow

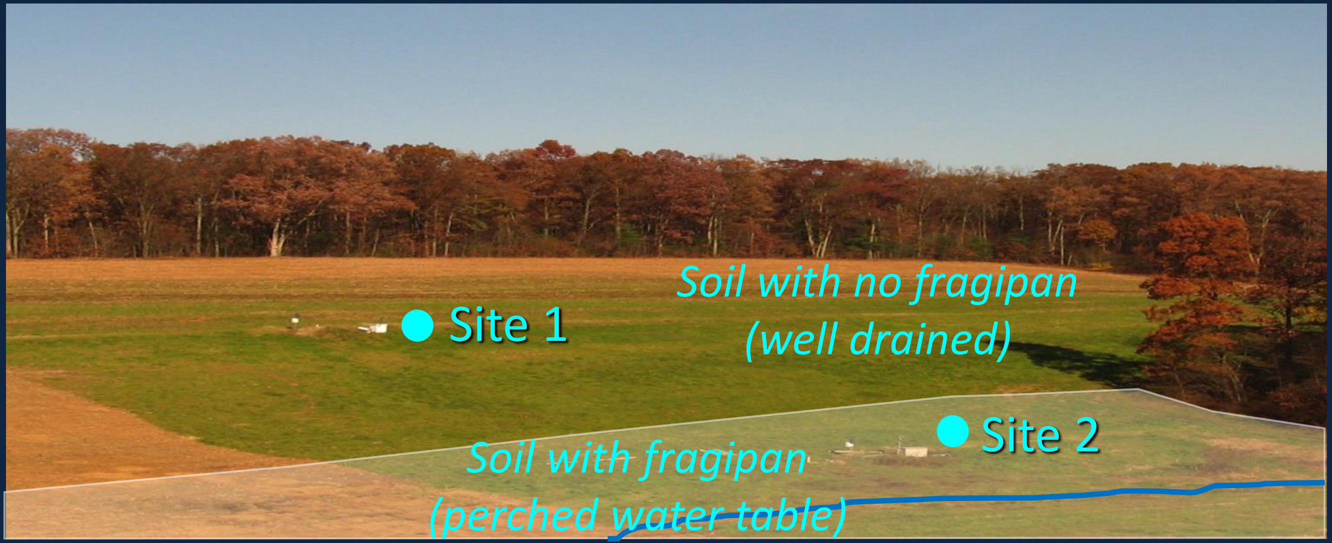
Mattern watershed (11 ha)



Overland flow

Subsurface flow



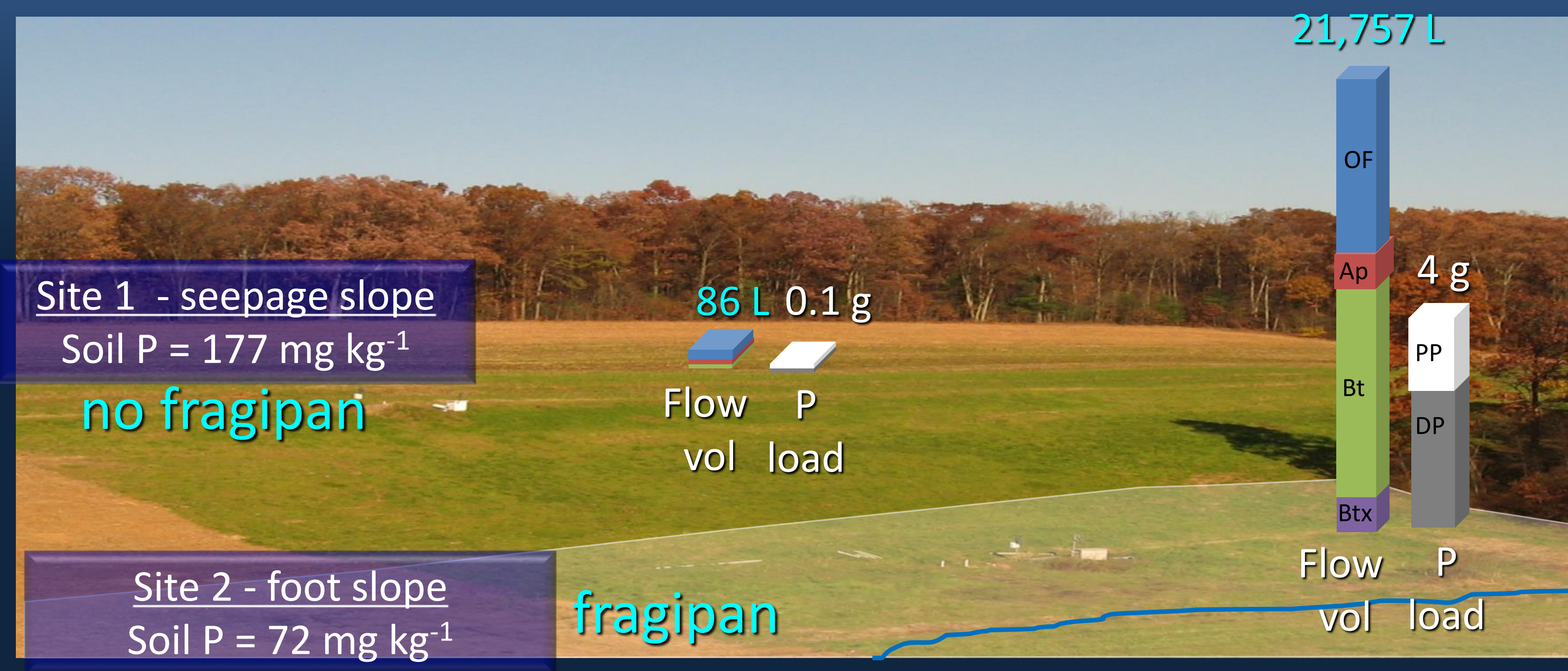


Average P concentrations (mg/L)

Tropical storm Lee (Sept. 4-10, 2011)

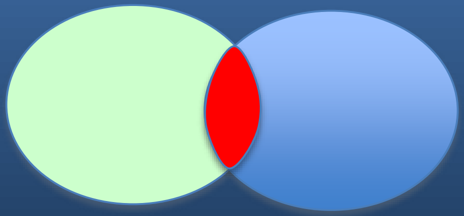
P loads (g) – dominated by flow

Tropical storm Lee (Sept. 4-10, 2011)



Management

All of the above, sooner rather than later



Manure management

Placement	*Close contact with soil minimizes P in drainage water.*
	Applying 1-2 m away from drains avoids bypass.
	Tillage effects are mixed (especially fine textured soils)
Timing	*Avoid periods before storm events and when soils are wet (can't store liquid manures) or dry (and cracked)*
Rate	*Keep application rates as low as possible*
Form	*Liquid manures, amendments to reduce P solubility*

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