



Phosphorus interaction in soils and water  
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# Overview

## Phosphorus dynamics in soils

- Phosphorus forms soil & water
- Interactions with other elements and soil properties
- What this means for build-up and drawn-down of P?

## Pinch-points for P loss on the farm

- Landscape processes & pathways
- Farm scale connectivity - what P measure and where?

# Soluble ortho-phosphate ( $\text{PO}_4^-$ )

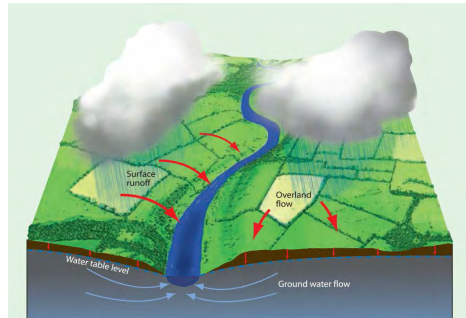
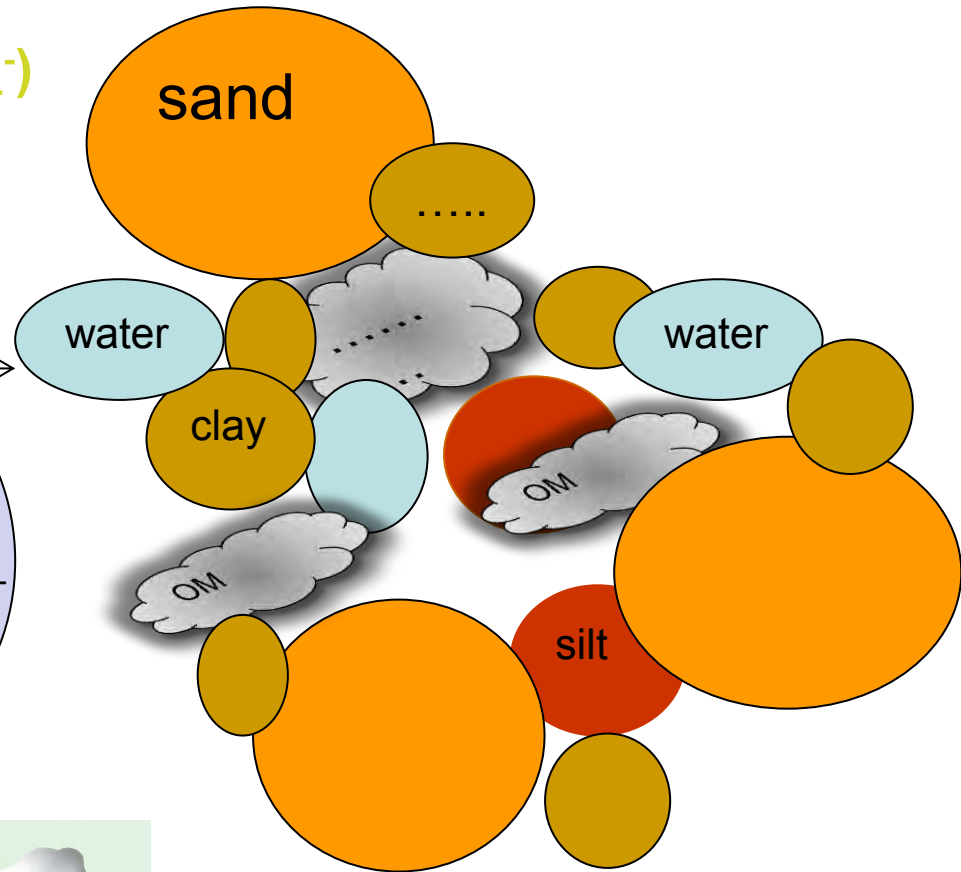
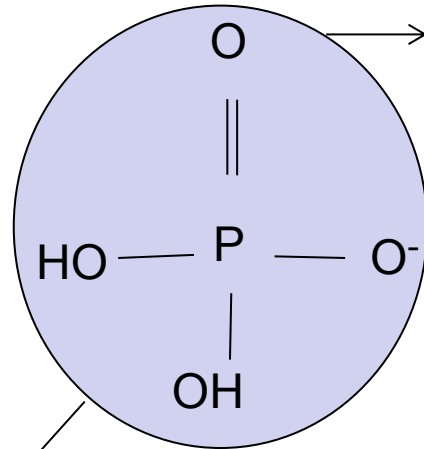
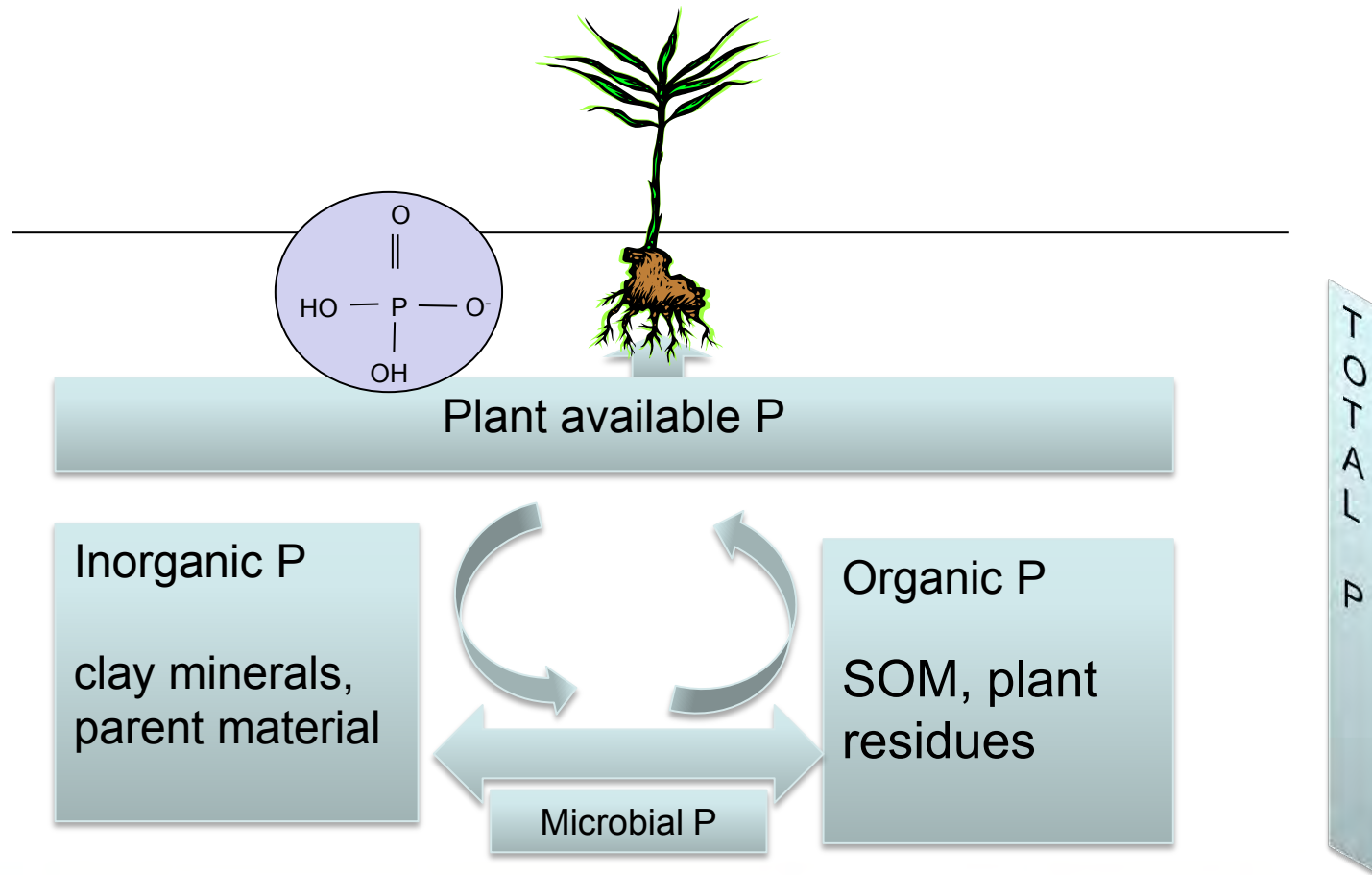
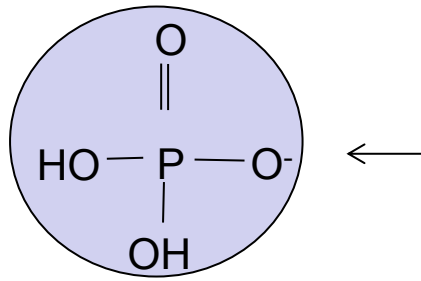


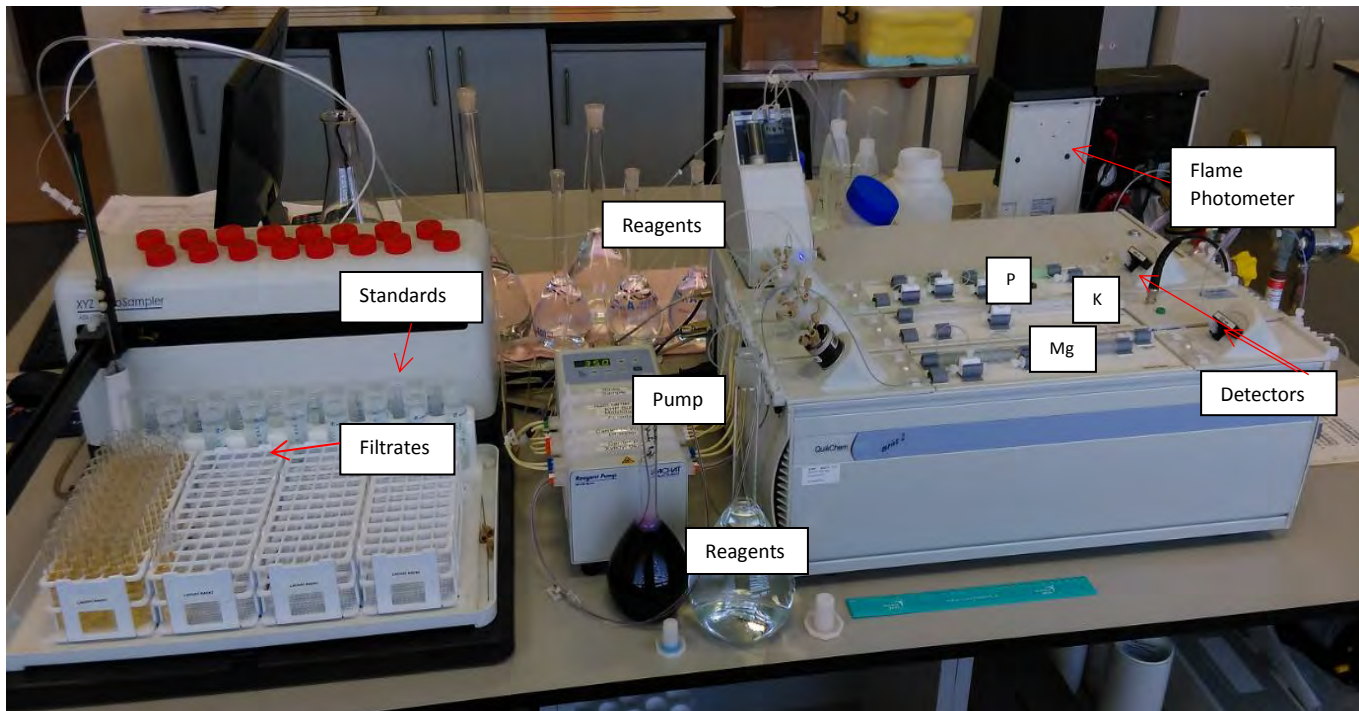
Figure 2. Water flow paths to a river on the soil surface and in ground water.

# P in soil: A simple conceptual model of soil P cycle...unlike N!





We have connected STP with WQ





## Irish soils & P

### Current methods:

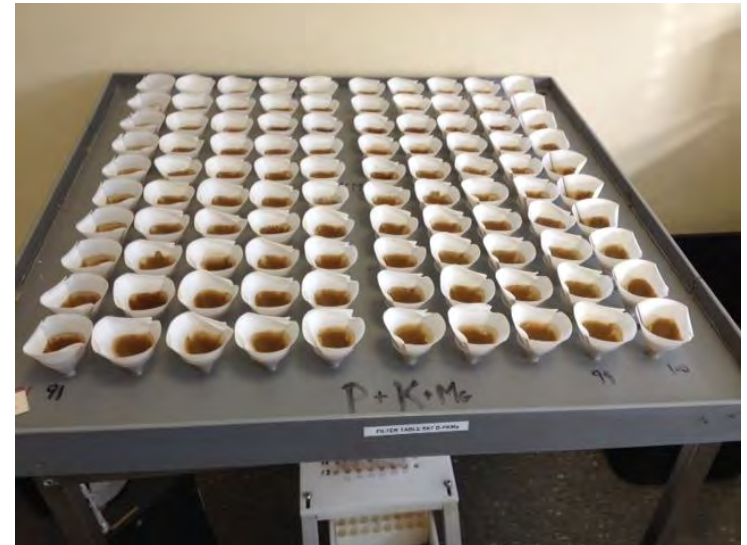
Soil sampling typically every 2- 4 ha, once in 5 years.

Base decisions on few parameters

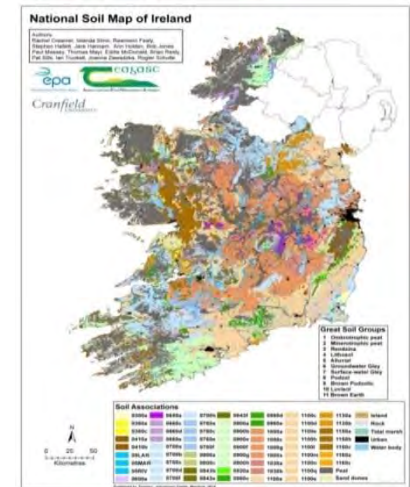
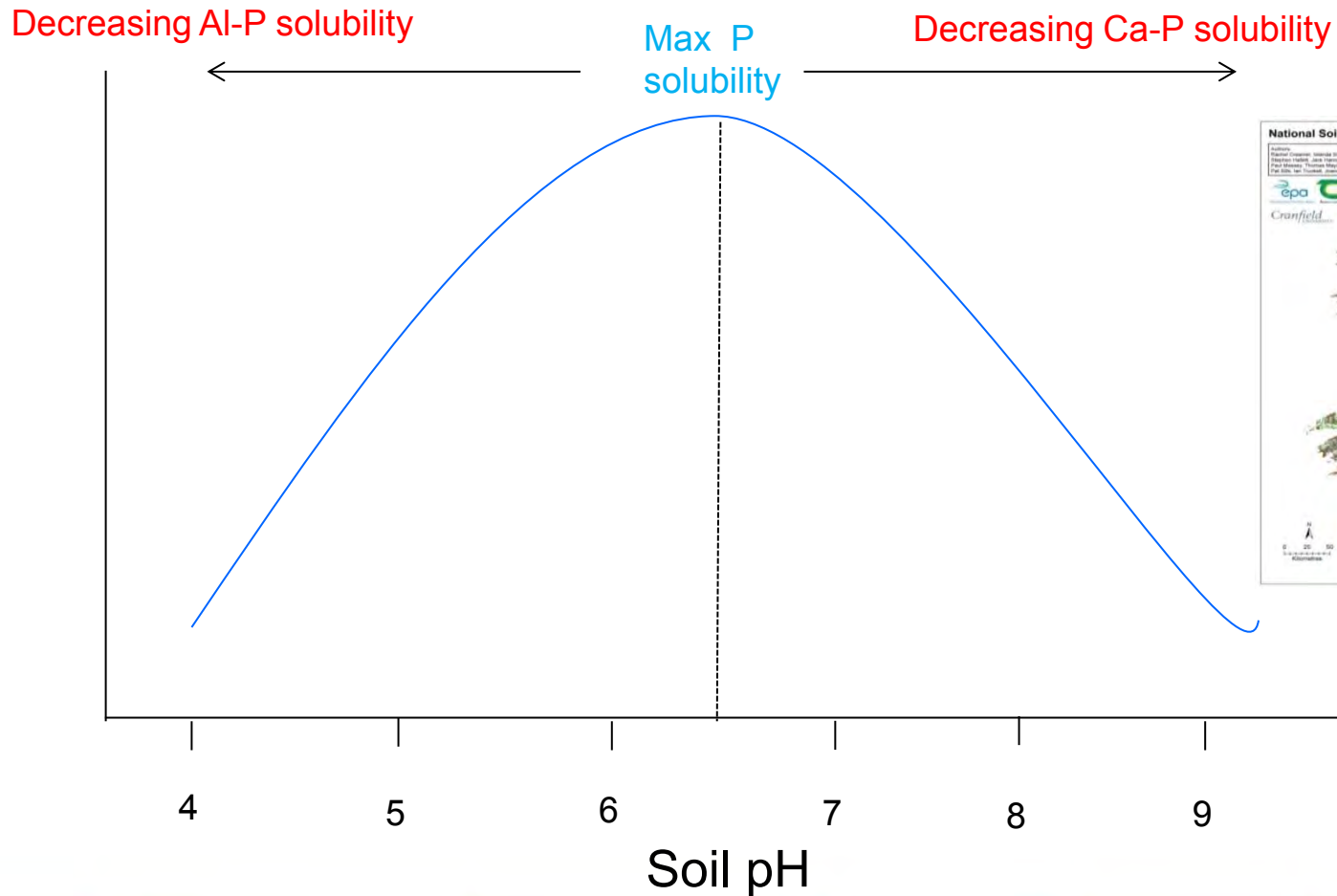
Should we correct for soil type?

### P Index System

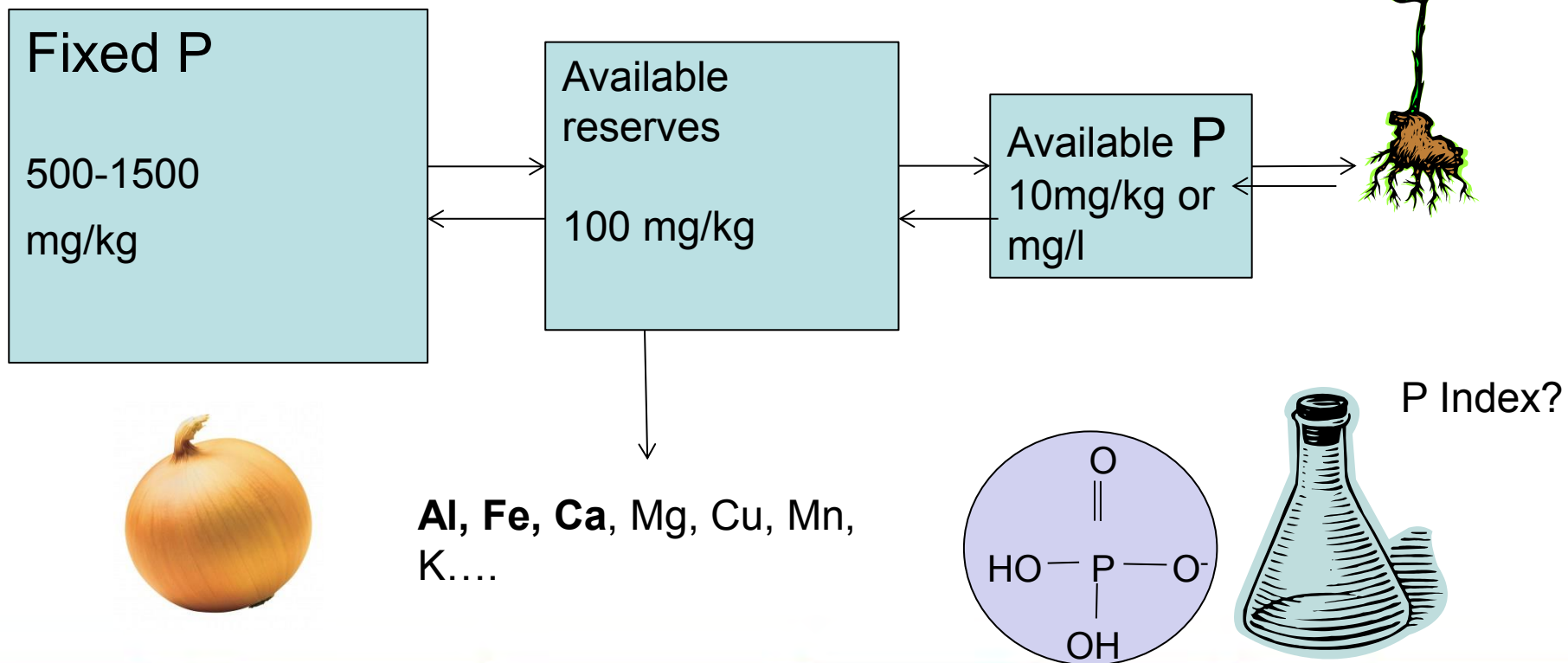
- 1: Deficient
- 2: Low
- 3: Optimum
- 4: Excessive



# Soil controls on P solubility & availability

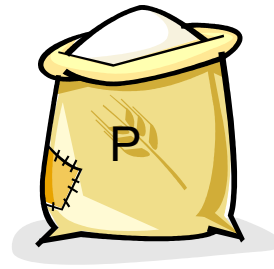


# Inorganic phosphorus pools in soils



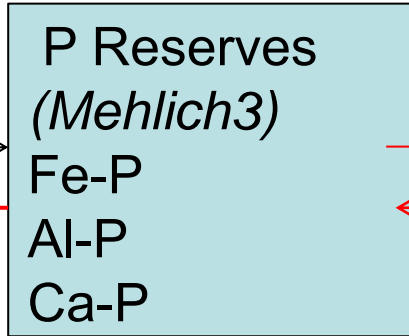
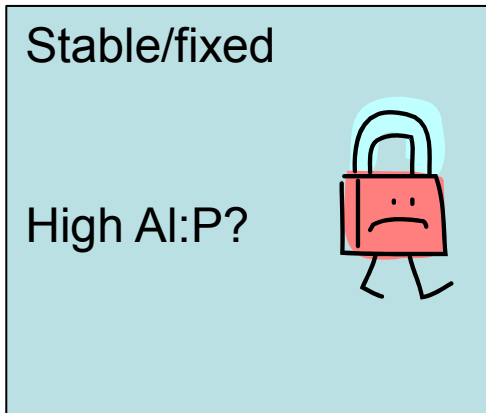
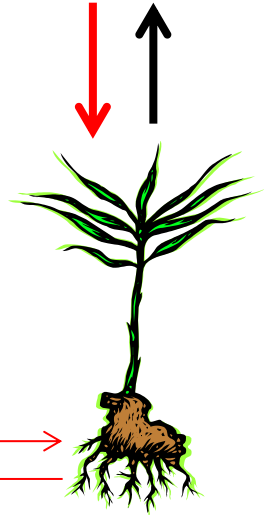


# Build up



Fertiliser inputs

Crop offtake



Check pH?

Slow reaction

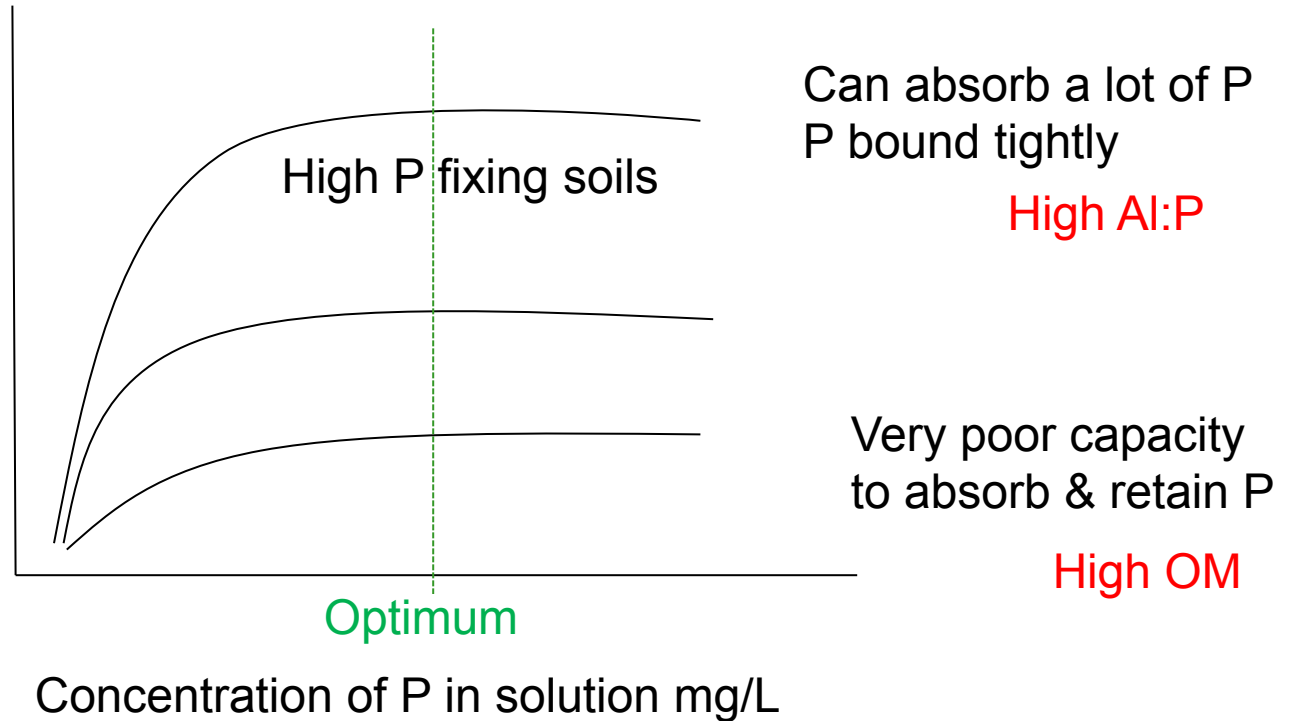
fast followed by slow reaction

fast reaction

# Phosphorus sorption: what happens when we add P to soil Build-up?



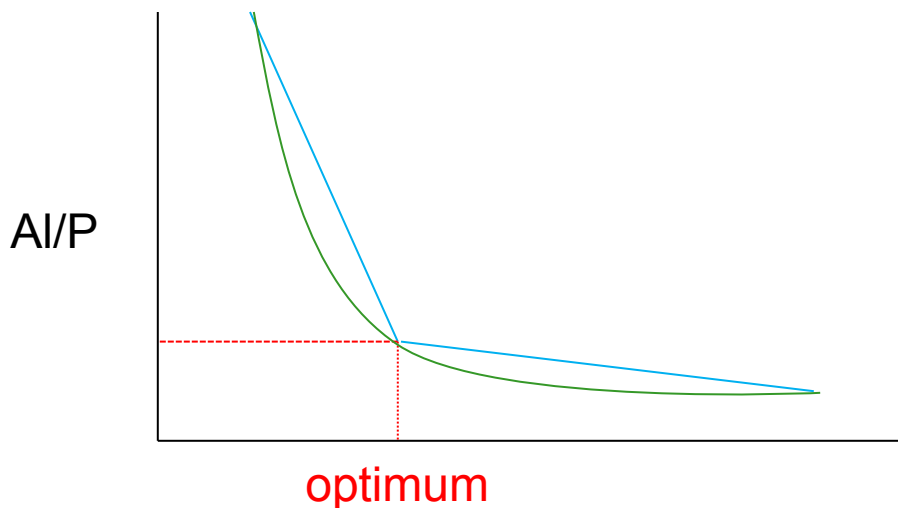
P sorbed onto soil  
Mg/kg



*Be patient with the high P fixers (takes time) & careful with poor P retainers*

## How do these things control P release into solution/water

In Irish soils, Al controls binding energies



Plant available P/soluble ortho-P

Draw-down, or decline from Index 4 to 3 will differ...again give it time.

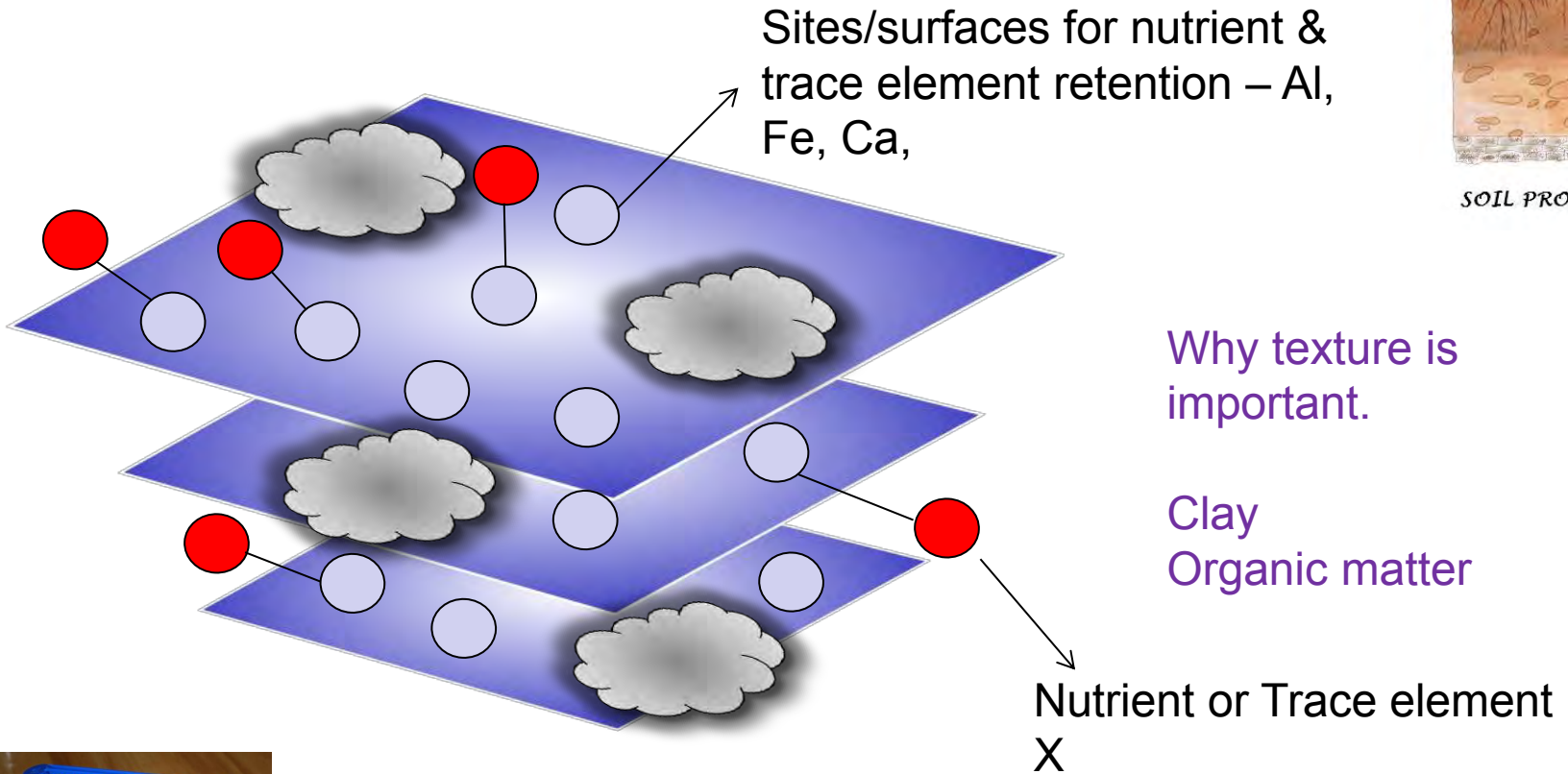
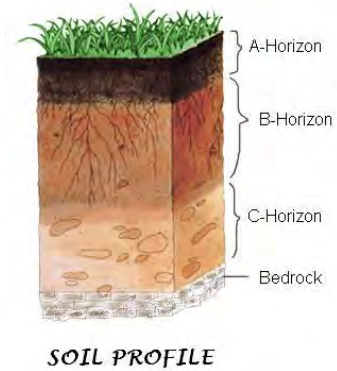
How tight P is 'stuck' onto soil matrix

Al also is a sorption site...placeholder for P.

As P is added, some sorption sites need to fill up first before P can be released into solution

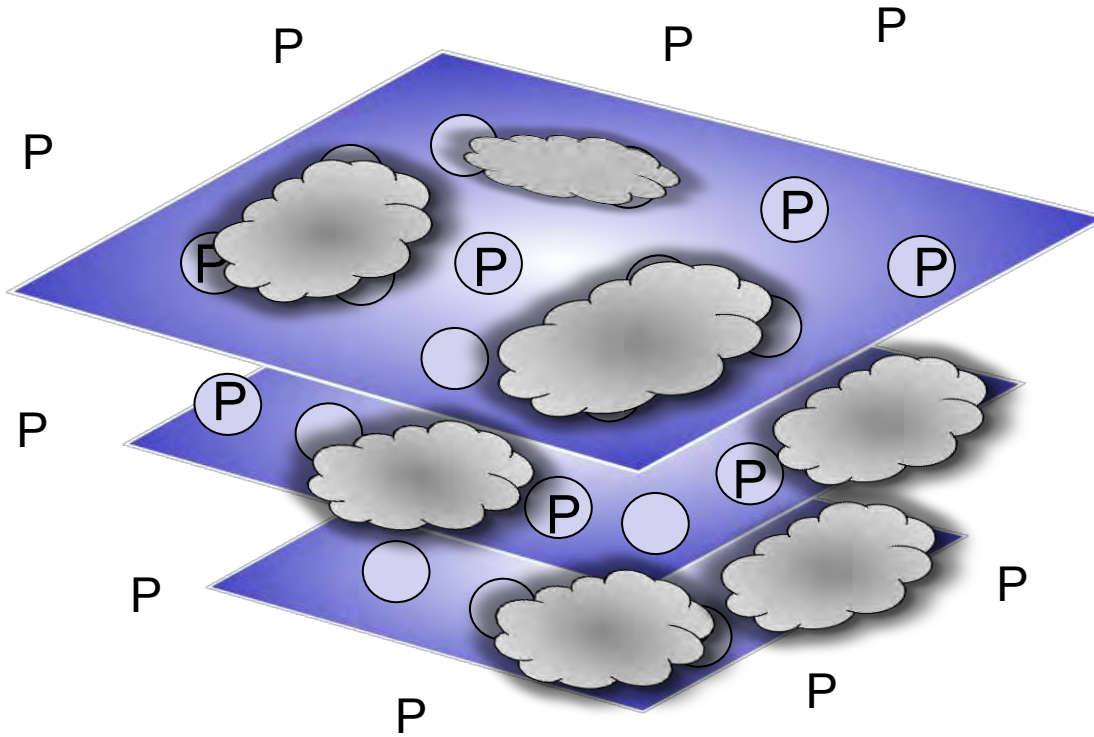


# What's happening on the soil matrix....



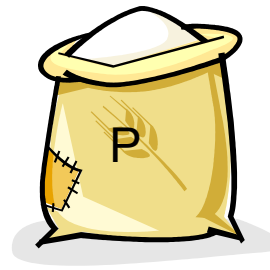
## Organic Matter Influences on P (low P sorption).

Too much of a good thing?



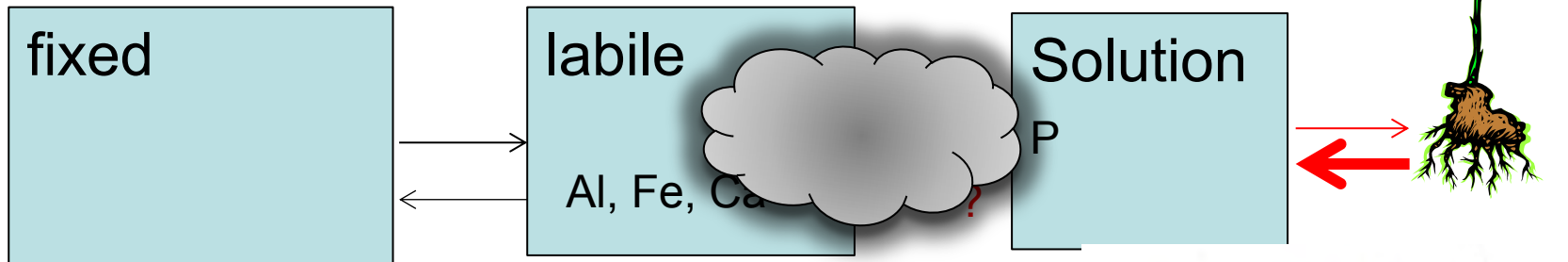
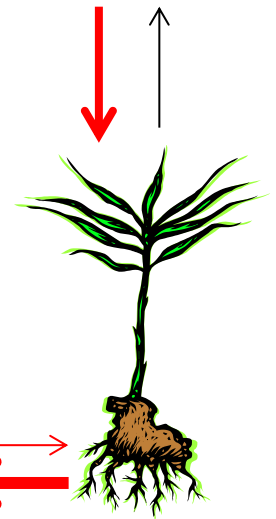
>20% OM in 10 cm depth

# Soil naturally high in organic matter

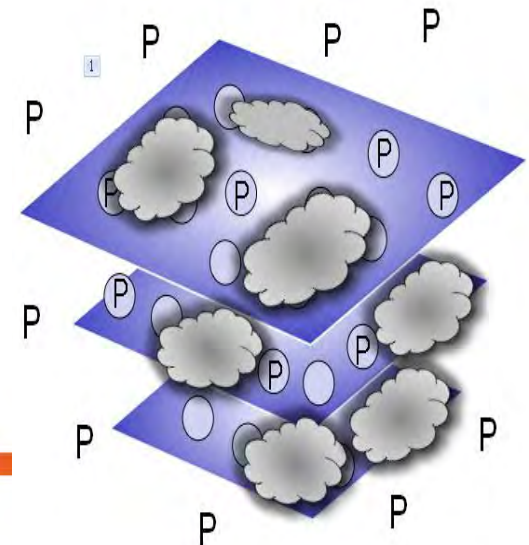


Fertiliser inputs

Crop offtake



High risk of P loss if not taken up by plant.  
No build up!



# High organic matter soils: Histics, humics and Peats



Ombrotrophic Peat



Histic Alluvial

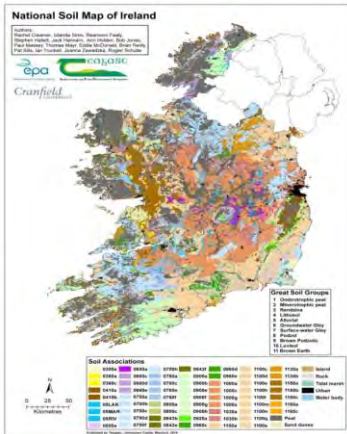


Humic Gley



Humic brown podzolic

# Providing the data to 'know your soil' and understand P dynamics.



PROJECT NAME  
**Terra Soil**

A Research collaboration between Geological Survey Ireland and Teagasc, focused on helping to improve the management of nutrients and trace elements in soil. Terra Soil will support better farming efficiencies by allowing farmers to make more targeted and science-based decisions, which will result in smarter agriculture, less environmental impacts and less wasted resources.

€1M Super project

Approx 2,613,000 tonnes sampled soil

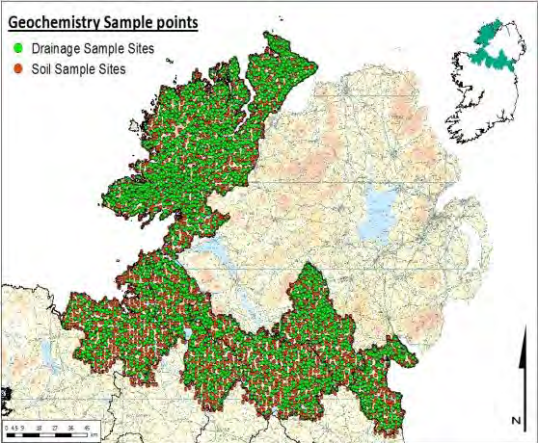
10,000 National samples



**Geological Survey**  
Suirbhéireacht Gheolaíochta  
Ireland | Éireann

*An Roinn Cumarsáide, Gníomhaíochta ar son na hAeráide agus Comhshaoil*  
Department of Communications, Climate Action & Environment

## Agri-environmental Indicators for P in Irish soils



Morgan P, Al, Fe, Ca, texture, %OM/pH.  
Agronomy & water quality models



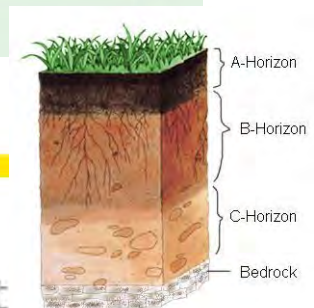
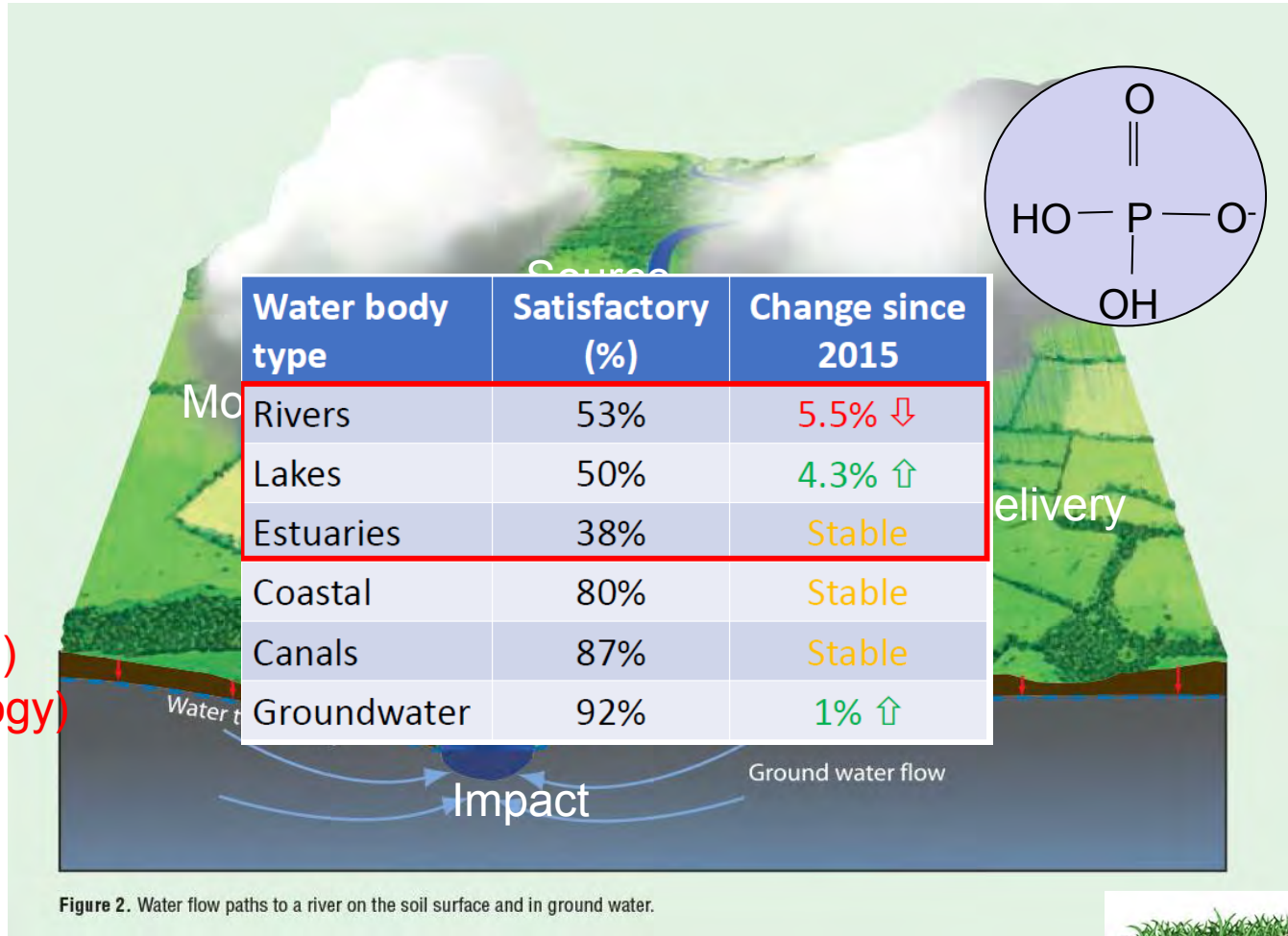
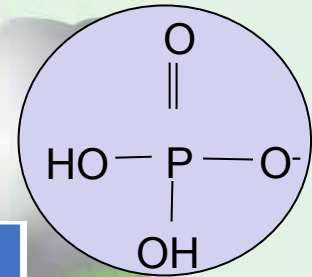
# Landscape scales of diffuse P loss

Transport vector

Poorly drained soils

'flashy catchments'

Source (field)  
Mobilisation (soil)  
Delivery (hydrology)  
Impact (river)

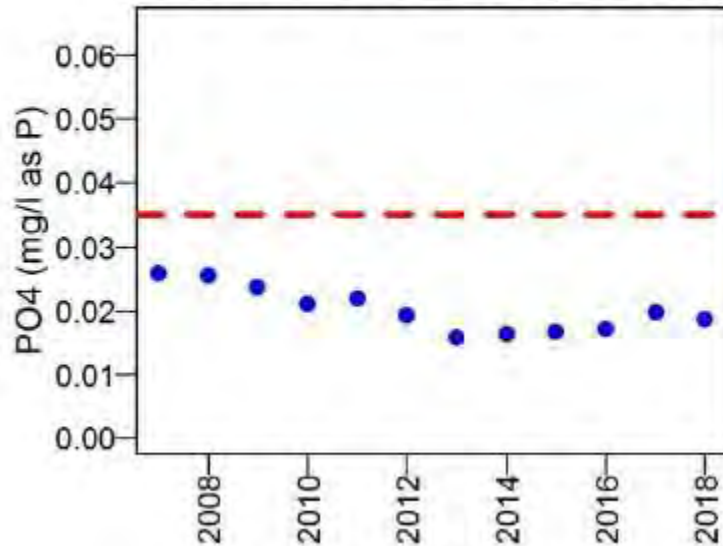


SOIL PROFILE

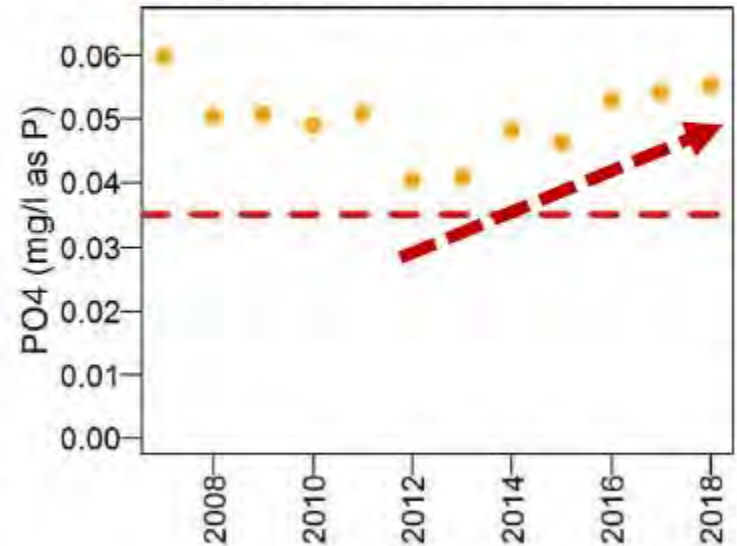
# Why is P loss is a poorly drained soils issue?

P loss to water expressed as load kg/ha/yr

Sub-Catchments without Phosphorus issues



Sub-Catchments with Phosphorus issues where Agriculture is a significant pressure



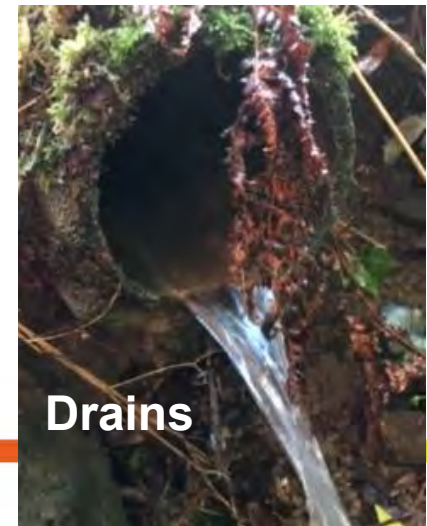
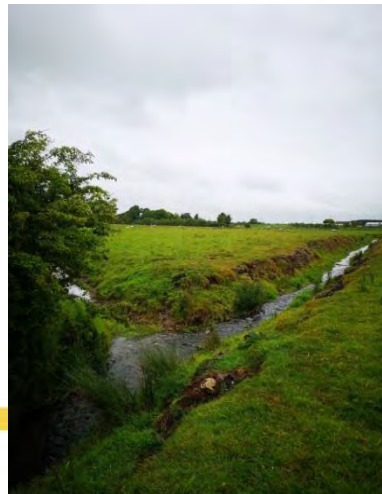
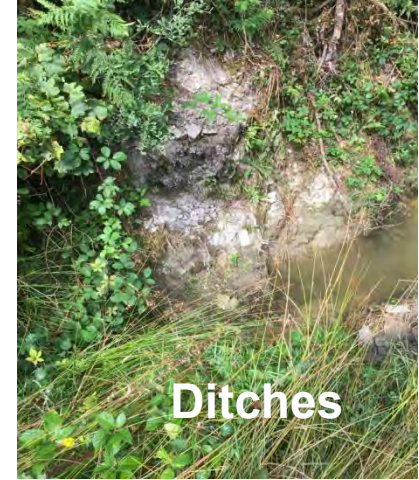
Flow rate is a function of soils' response to rainfall/water

P Load

**Let's talk about farms on poorly drained soils...**

**What are the critical source areas  
(pinchpoints) for P at farm scale?**

# Where are the pathways for P on the farm?

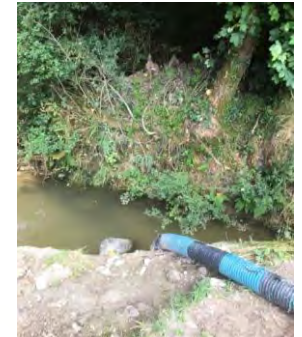


## And runoff from roads & yards...into ditches!



Look out for Owen Fenton's webinar in July on soil hydrology!

@ROADRUN\_Project



# Connectivity: links the pathways up

## Ditches, Drains, Gripes, Sheoughs, Marein Drain....??



# On-farm ditch connectivity to streams and outlets



## The most extensive connectivity feature on a farm?

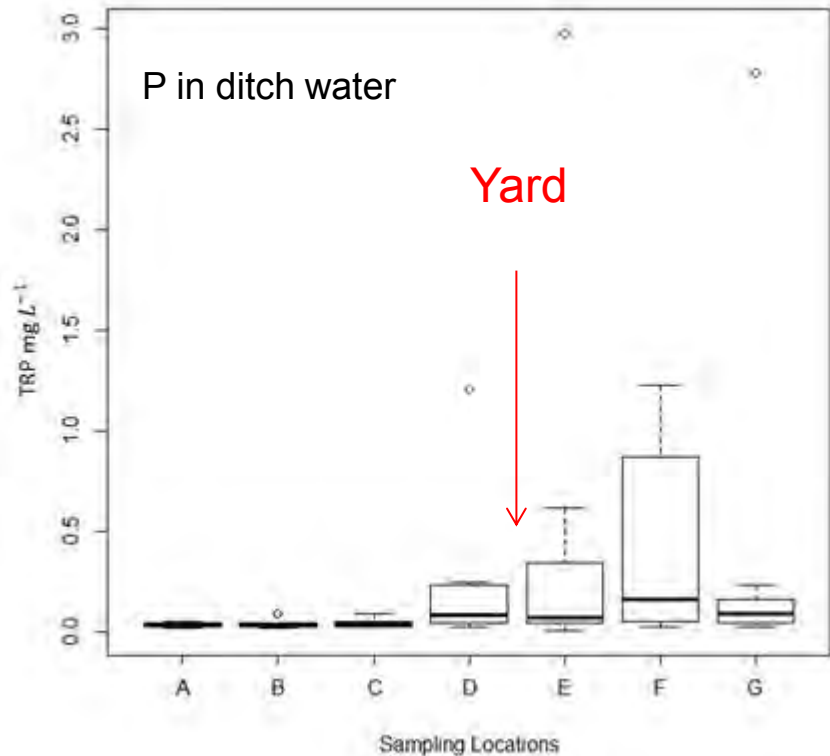
### Legend

- WATER\_RivNetRoutes
- Farm extent
- ⬠ Farmyard
- FY\_connection
- Outlet
- Outflow
- Secondary\_ditch
- Disconnected



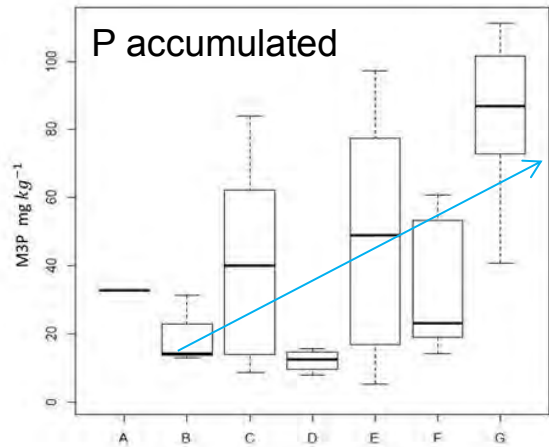
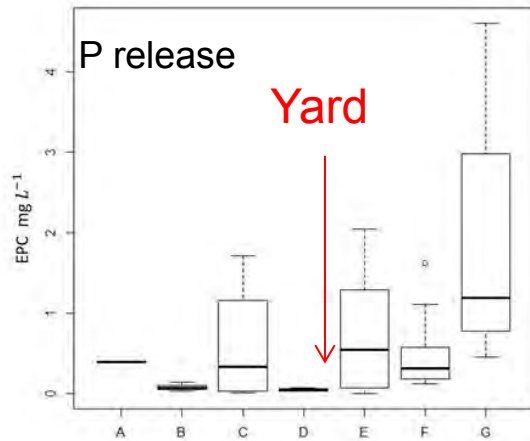


# How ditch water is influenced by what it's connect to?

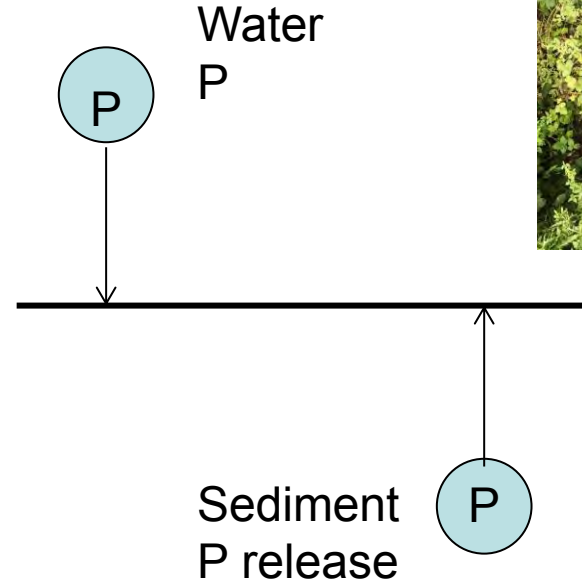


Length of ditch →

# What's in sediment samples along length of ditch?



Direction of flow in ditch



Over time, sediment can accumulate P,  
Sediment becomes a source of P...

**For more on sediment: Daire O'Huallachain Webinar (July).**

# Bringing it all together: pinchpoints for P on the farm?

Source



Pathway



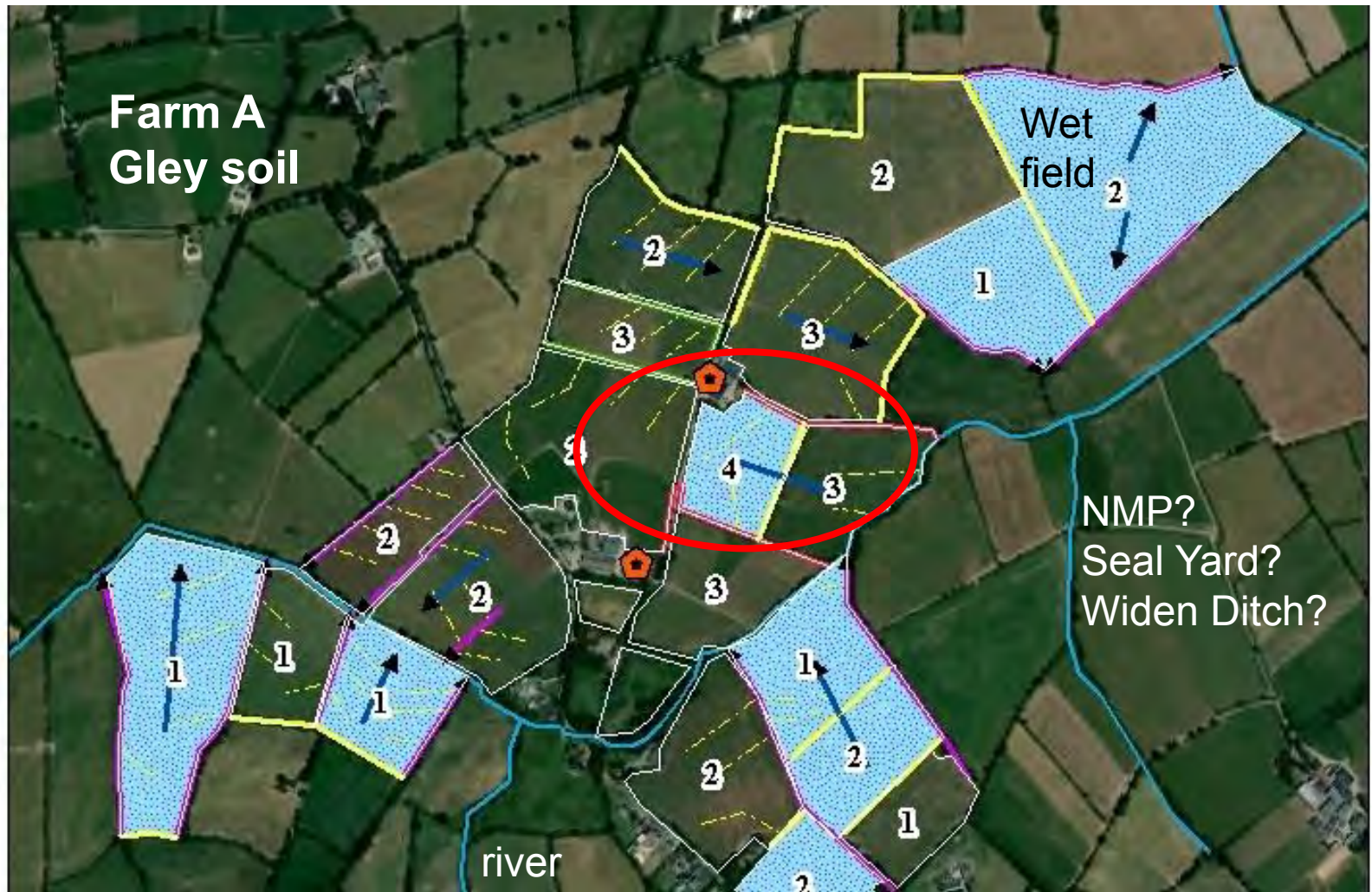
Connectivity



Receptor

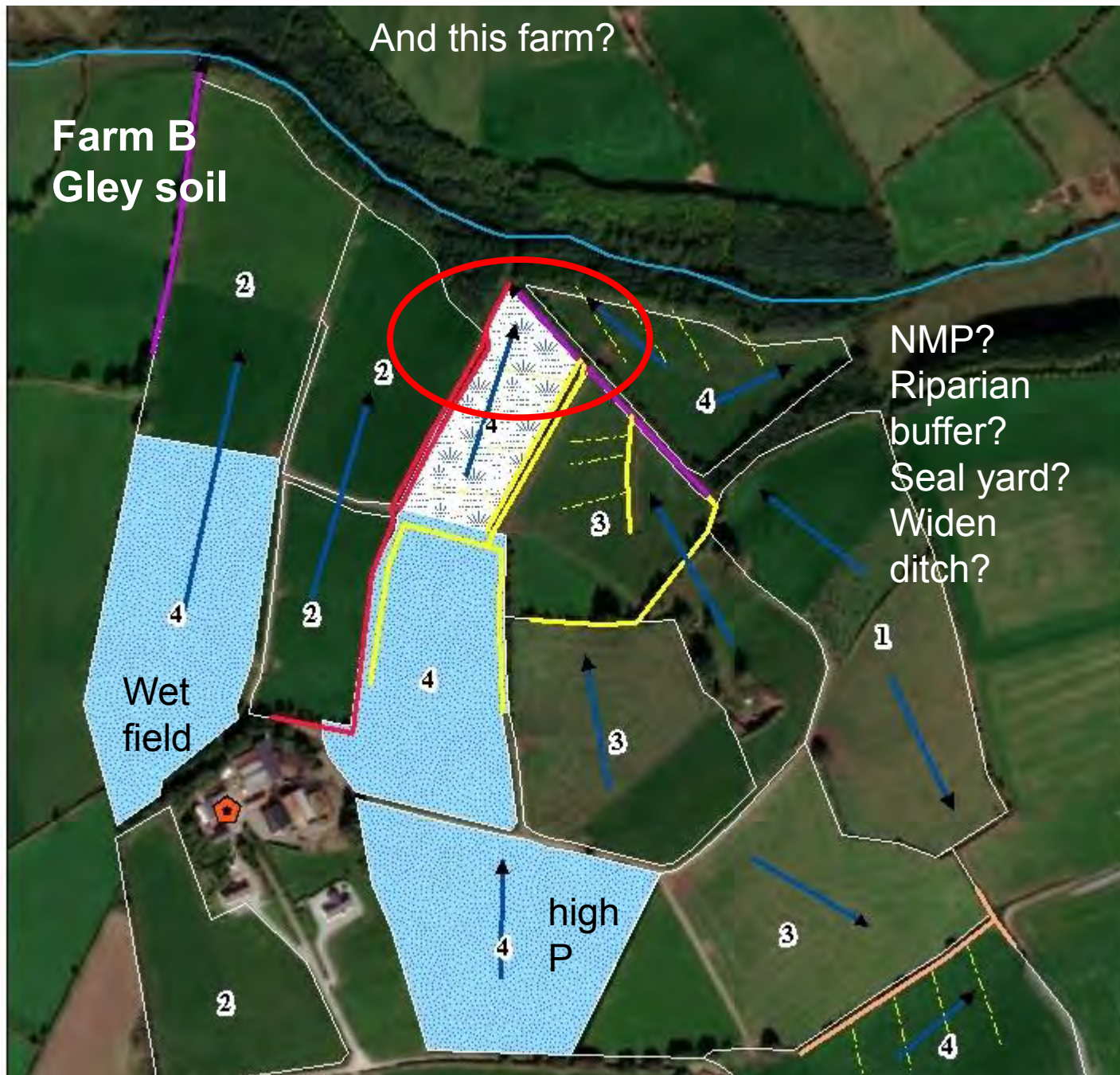


What P measure would you put on this farm & where?



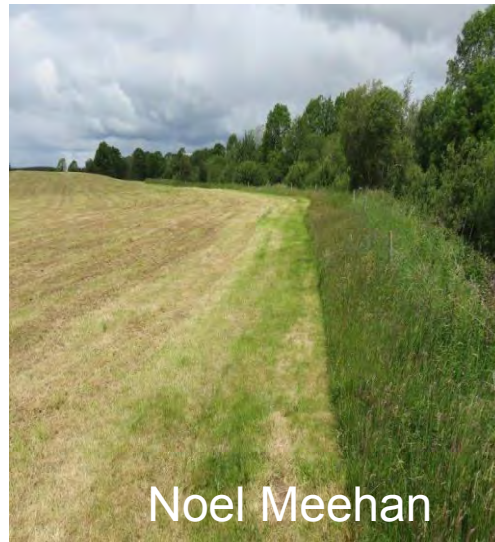
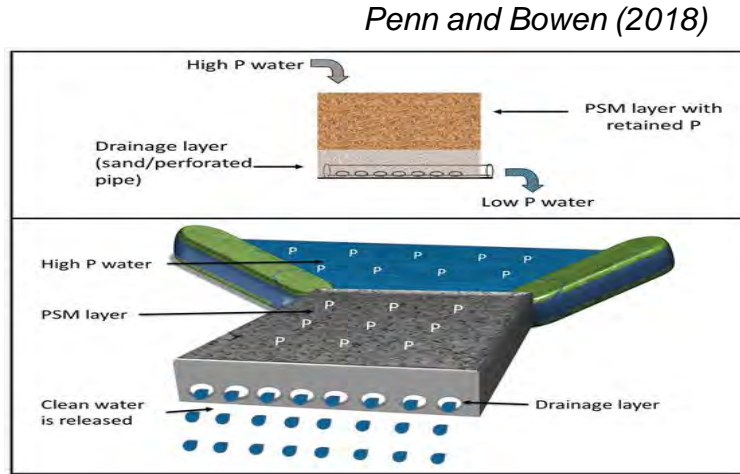
And this farm?

Farm B  
Gley soil



NMP?  
Riparian  
buffer?  
Seal yard?  
Widen  
ditch?

# Dis-connectivity or breaking the pathway...



# Take home messages

## Know your soil

- soil pH
- high organic matter soils are (>20% OM in 10 cm)
- slow to respond to build-up/draw down? (high Al:P or high Ca)

## Identify the critical source areas/pinchpoints for P on your farm?

- Look for connectivity - ditches, drains, wet fields
- Are they connected to a source? High soil P, farm yard
- Are they connected to a stream, river nearby.

## Measure up?

- NMP – even distribution of P
- Seal leaks from yard
- Will a bufferstrip work?
- Trap sediment & widen a ditch?



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Thank you for listening!