PPP LOSS FROM RUNOFF AND DRAINAGE

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INTRODUCTION

On-going projects in Ireland

- WATERPROTECT
- DIFFUSE TOOLS
- Source To Tap
- FAIRWAY

INTRODUCTION

WATERPROTECT

- MCPA is a widely used herbicide in Ireland
- Diffuse transfer mechanisms include incidental loss via drift, surface runoff, leaching and groundwater flow
- Large spatial distribution of MCPA found in rivers exceeding drinking water standards
- Soil and sediments high in organic carbon and low in oxygen poses a previously unrecognised risk for MPCA in the Irish environment
- **There is a need for a better understanding of the physical/chemical mechanisms at the catchment scale**

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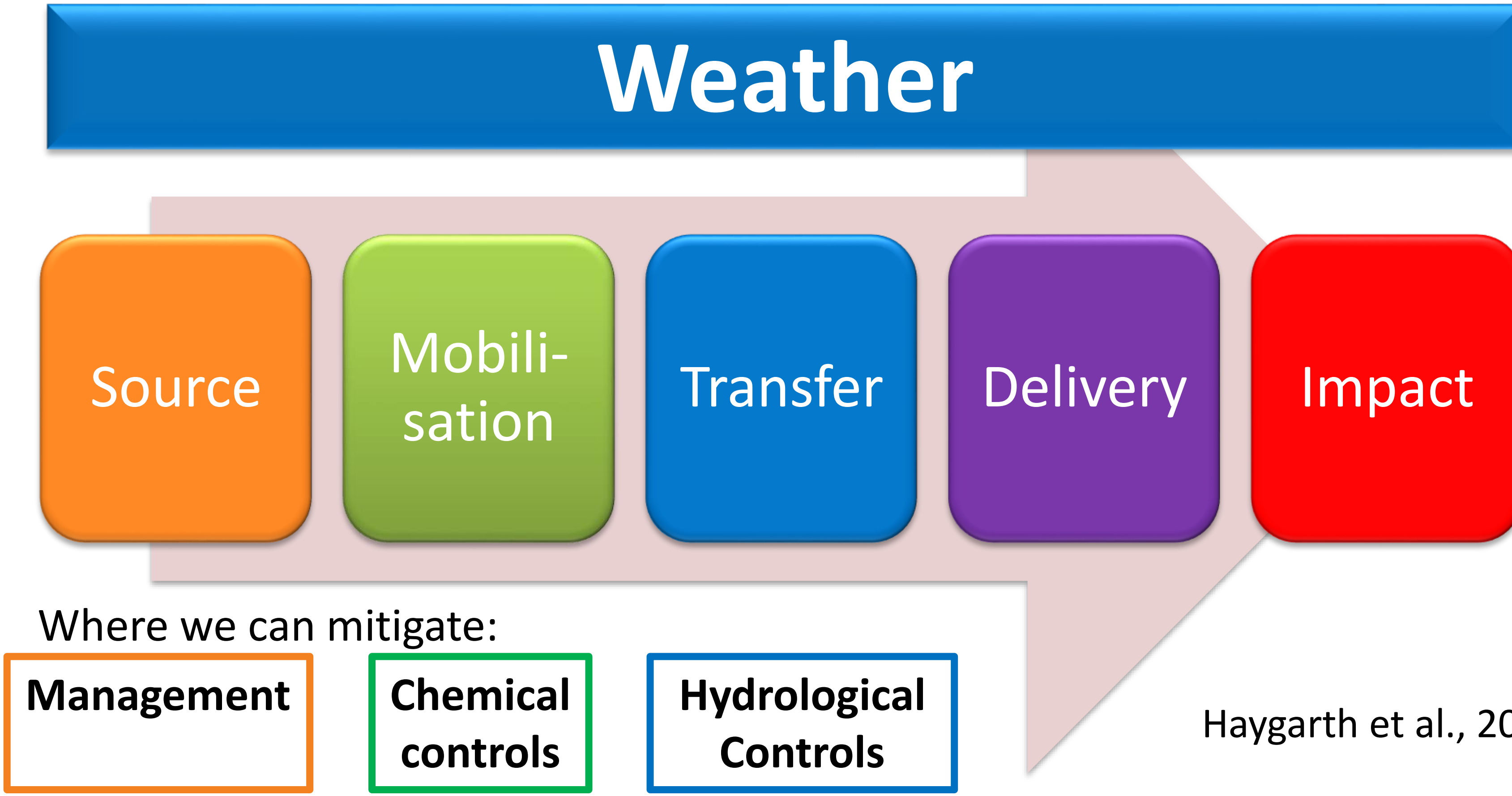
AGRICULTURAL CATCHMENTS PROGRAMME

“Transfer Continuum”



Haygarth et al., 2005

Poses challenges for mitigation strategies!

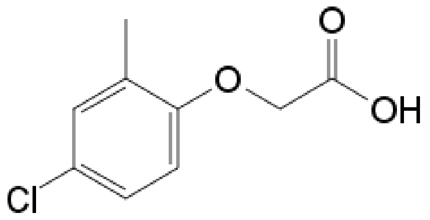
Few monitoring studies targeted at understanding catchment-scale processes

MOBILISATION – MCPA PROPERTIES

I. Does not absorb strongly to soils (500 to 1000 times lower adsorption coefficient than some other pesticides)

II. Soluble

- **Highly mobile and susceptible to transport!**



MOBILISATION - CHEMICAL CONTROLS

WATERPROTECT

- Breakdown is largely controlled by :

  i) oxygen availability

  ii) temperature

  iii) pH

  iv) nutrient content
- **Soil type important**

- Aerobic conditions = quick degradation ($t_{1/2}$ ~ 10 days)
- Anaerobic conditions = slow degradation ($t_{1/2}$ ~ 2000 days)
- **Potential for legacy stores in saturated soils**

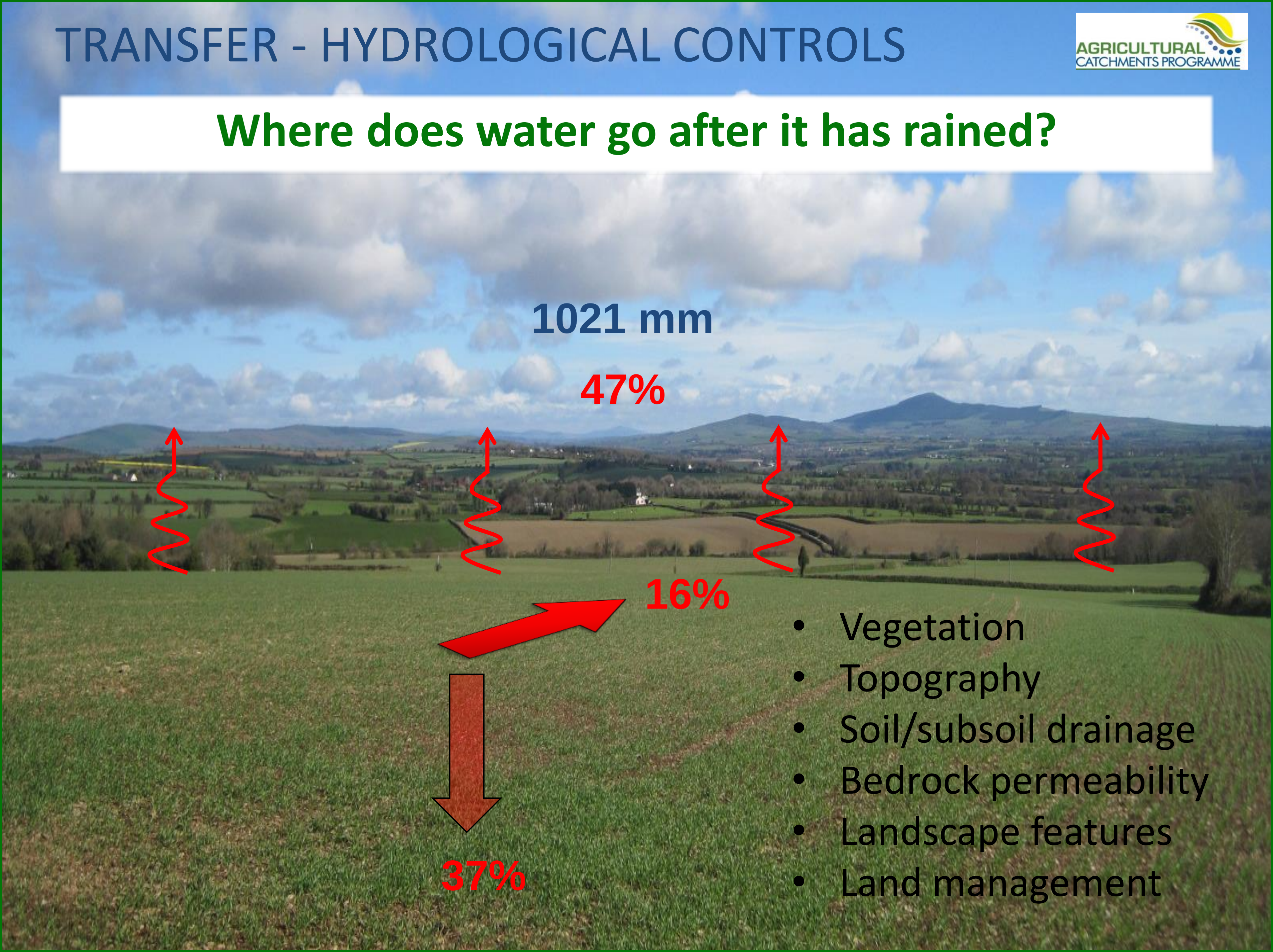
- Breakdown produces metabolites

  4C2MP was found in 17% of groundwater samples (McManus *et al.*, 2017)
- **Need to understand the influence of soil/subsoil/bedrock properties**

TRANSFER - HYDROLOGICAL CONTROLS

AGRICULTURAL CATCHMENTS PROGRAMME

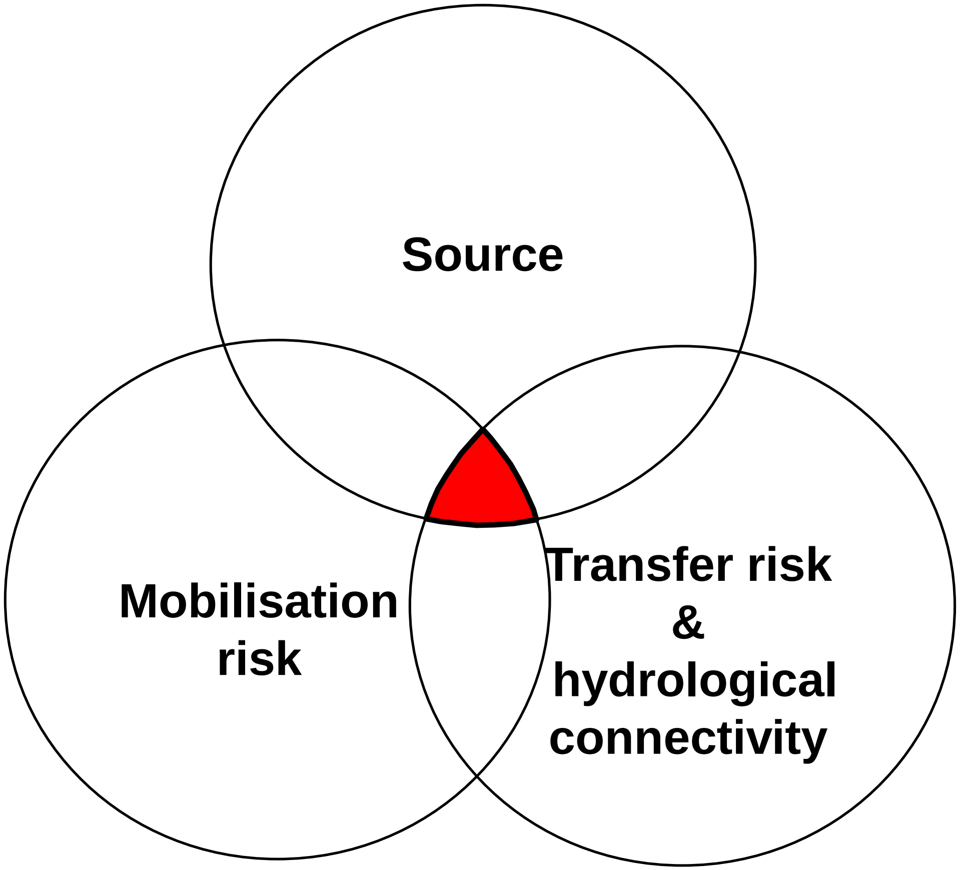
Where does water go after it has rained?



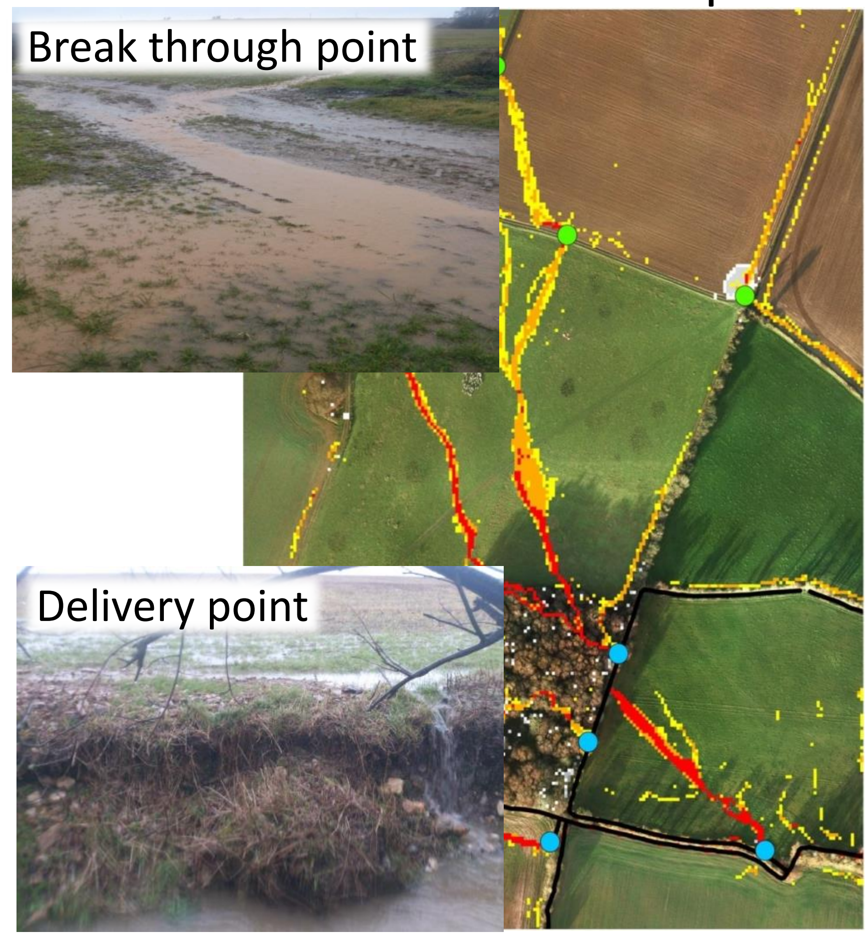
- Vegetation
- Topography
- Soil/subsoil drainage
- Bedrock permeability
- Landscape features
- Land management

TRANSFER – SURFACE PATHWAYS

Critical Source Areas (CSA's)

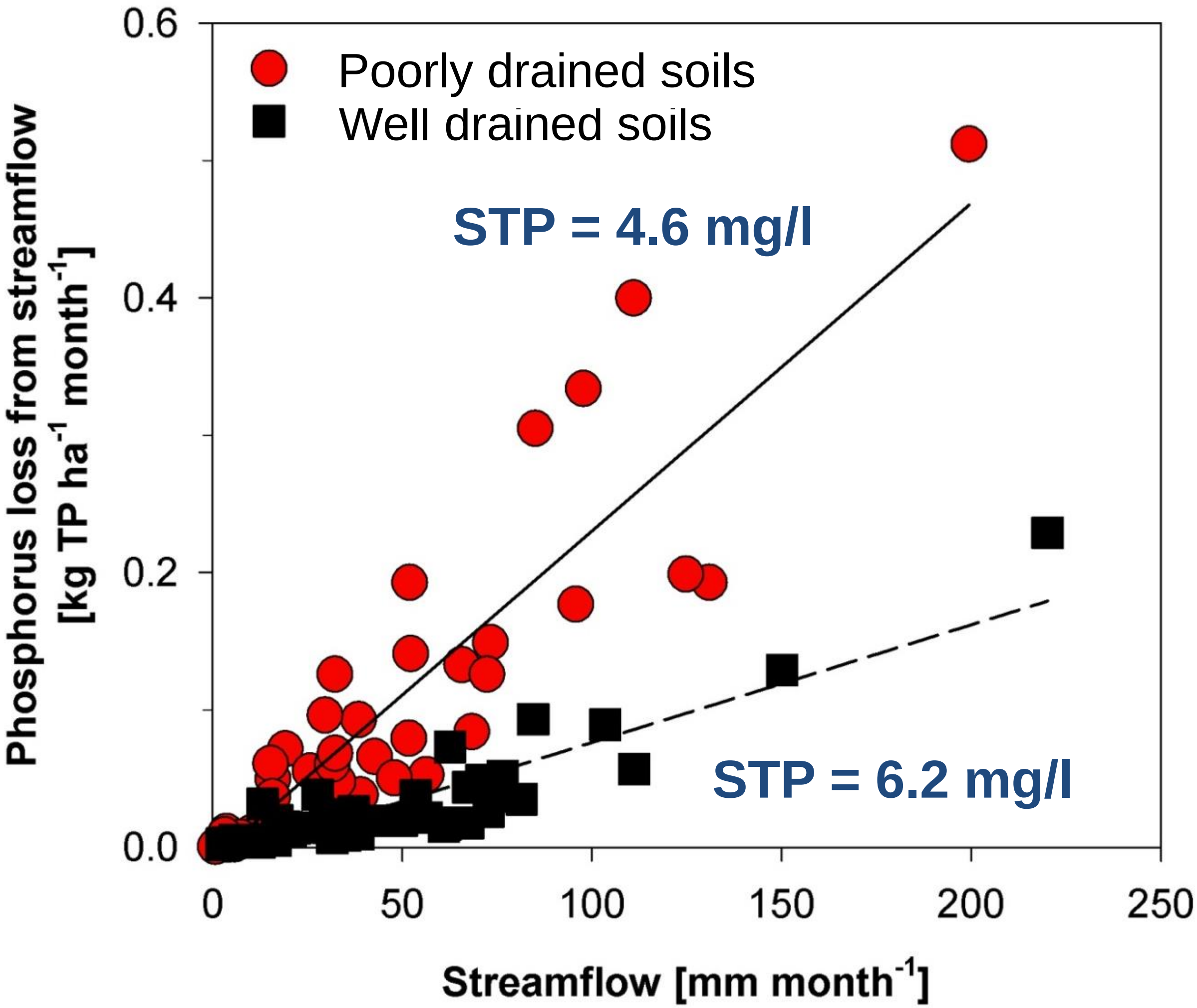


CSA index maps



Thomas et al., AEE, 2016

TRANSFER – CATCHMENT SCALE



- Flow controls overrides source pressure
- Larger inter-annual P loss than between catchments
- One size does not fit all!

Mellander et al., HP 2015

TRANSFER - TEMPORAL

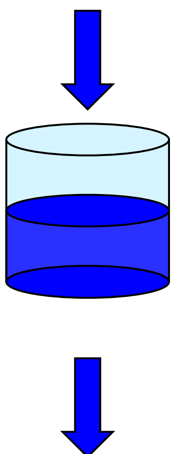
Summer event (Jun 2012)

- SMD = 31 mm
- Rainfall = 25 mm
- Stream flow = 2 mm
- P loss = 1.6 g TRP/ha

Winter event (Nov 2012)

- SMD = 0 mm
- Rainfall = 29 mm
- Stream flow = 20 mm
- P loss = 6.5 g TRP/ha

25 mm



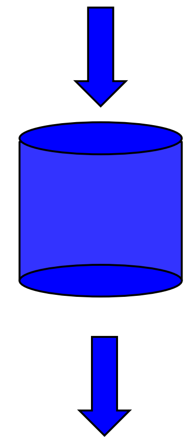
31 mm

2 mm

1.6 g TRP/ha

Four times higher P loss in the winter event!

29 mm



0 mm

20 mm

6.5 g TRP/ha

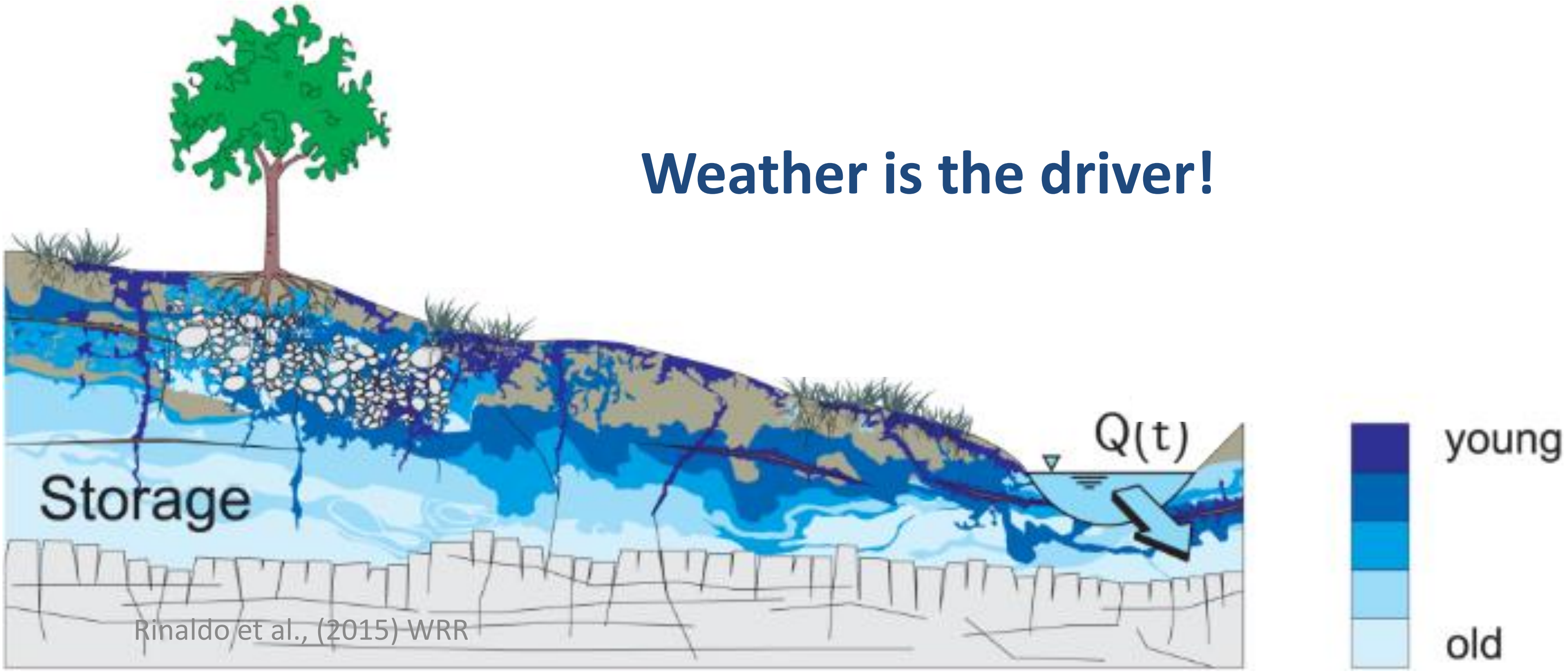
Soil moisture conditions & weather forecast need consideration before application

TRANSFER - MIX

WATERPROTECT

- Heterogeneous landscape - rivers consists of water of different ages
- MCPA can be:
  i. rapidly mobilised from rain events occurring just after application
  ii. leached to anaerobic conditions in slow moving groundwater
  iii. reside in anaerobic stores (soil aggregates and sediments).

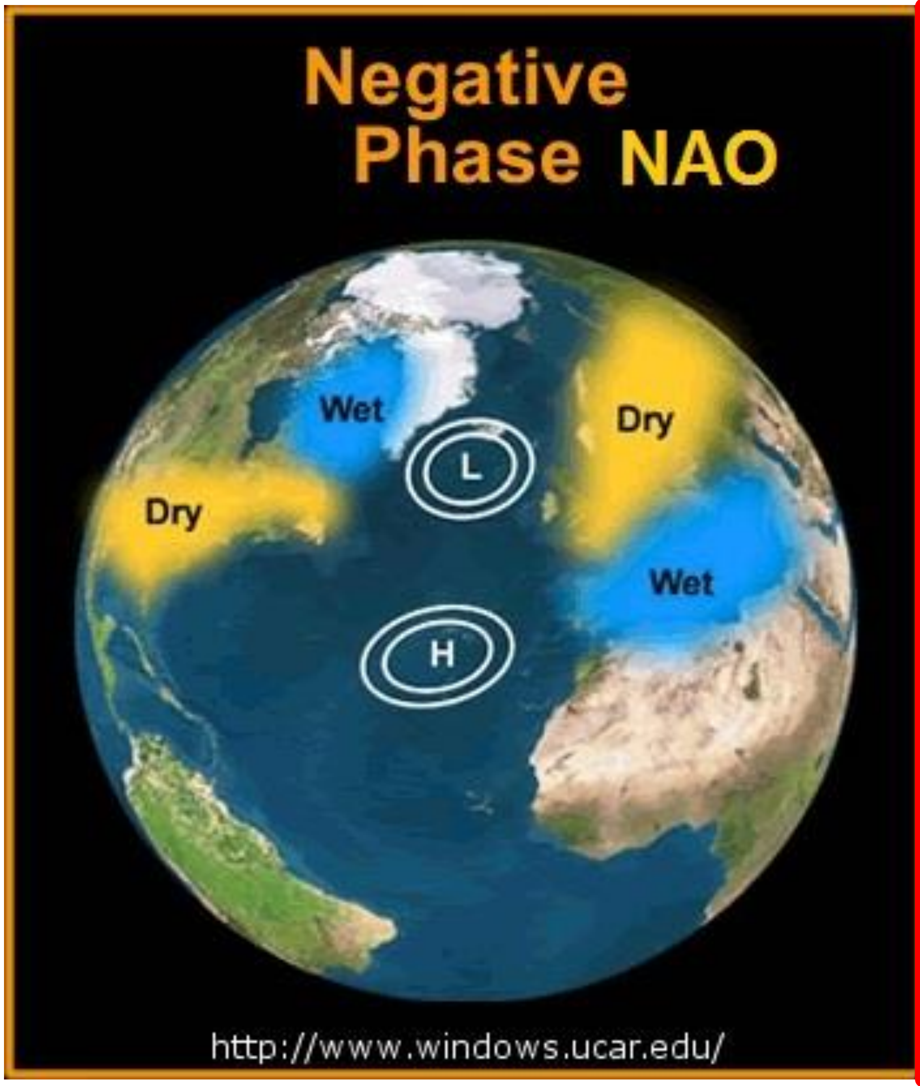
Weather is the driver!

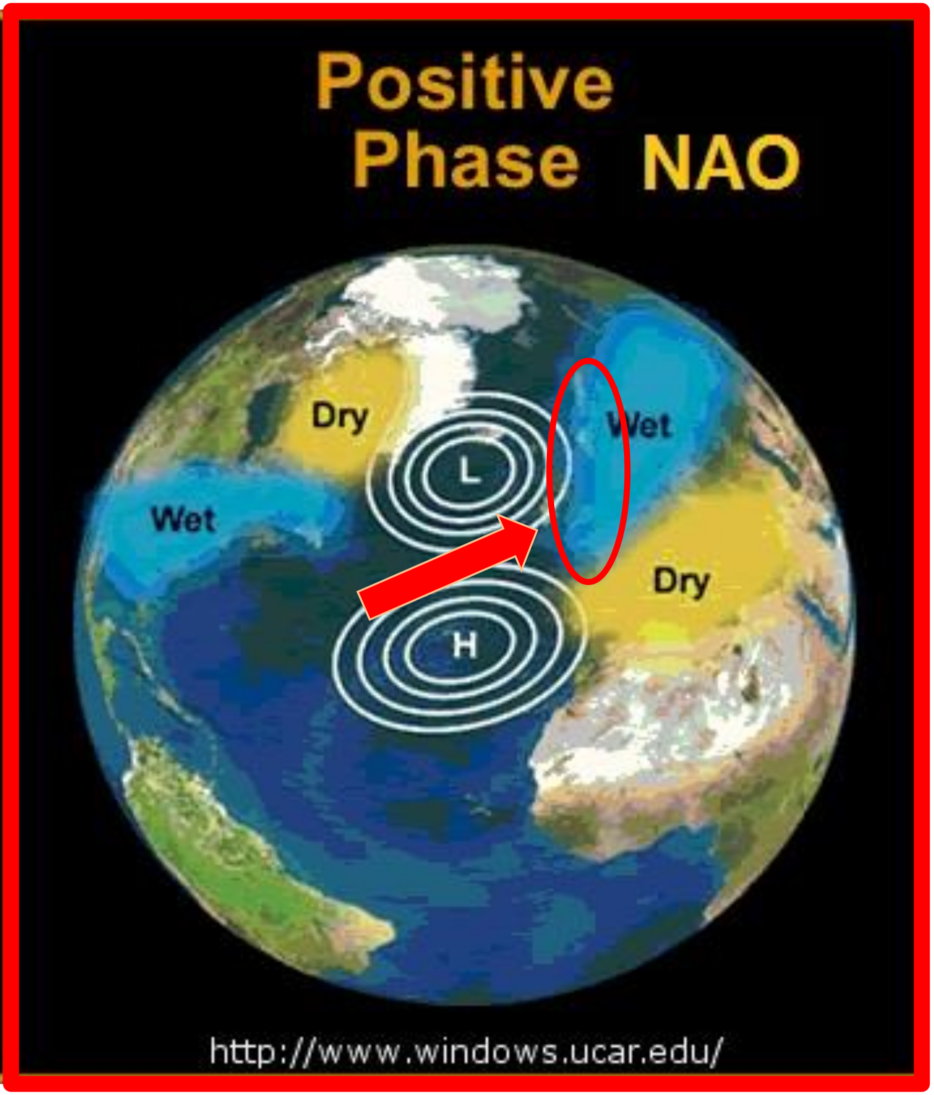


Rinaldo et al., (2015) WRR

WEATHER

Large-scale weather systems - North Atlantic Oscillation

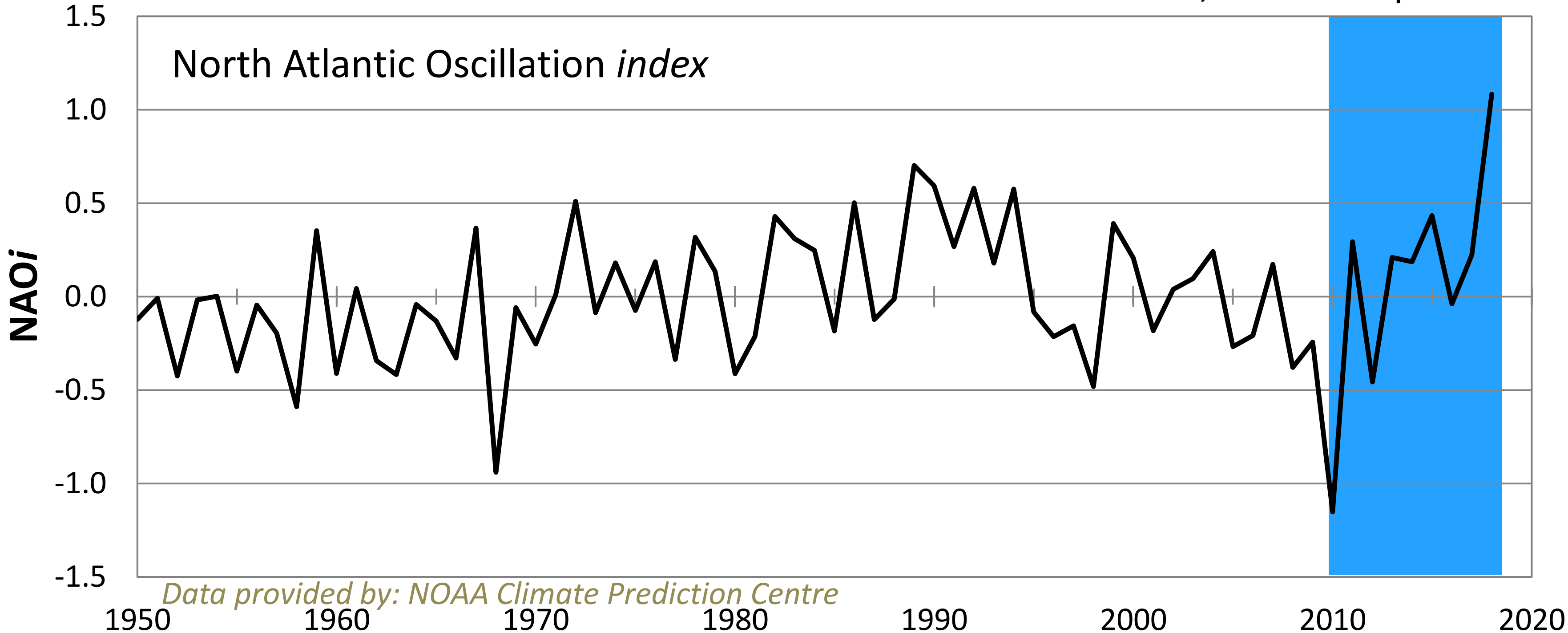




WEATHER

- Warmer/drier summers and larger rain events in winter
- Water quality parameters in small river catchments were found to be correlated to decadal changes in oceanic-scale weather systems
- Response different for different catchment typologies.

Mellander et al., Nat Sci Rep 2018



WEATHER EXTREMES

Poses challenges for mitigation strategies!

MITIGATION MEASURES

WATERPROTECT

"Decision Support Tree" for BMP's adapted from TOPPS

Risk by infiltration and transfer

Proximity to Surface Water	Permeability of the Topsoil	Steepness of Slope	Risk Class & Scenario
Field Adjacent to Water Body	Low	Steep (>5 %)	I 7
		Moderate (2-5 %)	I 6
		Shallow (< 2 %)	I 5
	Moderate	Steep (>5 %)	I 4
		Moderate (2-5 %)	I 3
		Shallow (< 2 %)	I 2
	High	Steep (>5 %)	I 3
		Moderate (2-5 %)	I 2
		Shallow (< 2 %)	I 1

Proximity to Surface Water					Risk Class & Scenario
Field Adjacent to Water Body	Transfer of run-off downhill	Yes	Run-off reaches water body?	Yes	T 3
				No	T 2
		No			T 1

I - infiltration
T- transfer

MITIGATION MEASURES

WATERPROTECT

Risk Class and Scenario	Measures	
I 7, T 3, I 4 / I 6, S 4	In- field measures (necessary)	BMP: 8, 9, 10, 49, 50, 51, 52, 67, 68, 69
	Edge-of-field measures (necessary)	BMP: 11, 47, 54, 55, 66
	Landscape measures (necessary)	BMP: 12, 47, 53, 55
I 5, I 3, S 3 / SD 3	In- field measures (necessary)	BMP: 8, 9, 10, 49, 50, 51, 52, 67, 68, 69
	Edge-of-field measures (necessary)	BMP: 11, 47, 54, 55, 66
	Landscape measures (usefull)	BMP: 12, 47, 53, 55
I 2, S 2 / SD 2	In- field measures (necessary)	BMP: 8, 9, 10, 49, 50, 51, 52, 67, 68, 69
	Edge-of-field measures (usefull)	BMP: 11, 47, 54, 55, 66
I 1, S 1 / SD 1, T1, T 2	In- field measures (necessary)	BMP: 8, 9, 10, 49, 50, 51, 52, 67, 68, 69

S=saturation; T=transfer; SD=saturation by drainage water; I=infiltration

- Must avoid risky sites and risky times when applying PPPs
- Soil moisture conditions and weather forecast needs to be considerated before application – decision support tools

- Need for more theoretical understanding of transport/risk at the catchment scale
- A Simple Transport Model

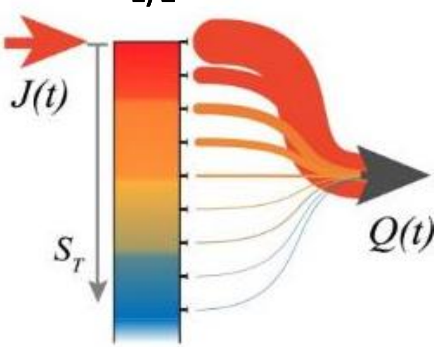
Concentration in River **Applied Concentration** **Distribution of travel times**

$$C_Q(t) = \int_{-\infty}^{t} C_{in}(t_i)\, p_Q(t - t_i, t)\, dt_i$$

Considers:

- Spatial and temporal rain statistics
- Biodegradation rate decreasing more quickly with solute age

Aerobic: $t_{1/2}$ = 20 days



Anaerobic: $t_{1/2}$ = 2000 days

McGrath et al., STOTEN (2019)

SUMMARY

- MCPA is highly mobile and susceptible to transport
- Soil type, topography and management are important for mobilisation, transfer and hydrological connectivity
- Climate is a key driver
- Fast flow during rainfall/drainage events occurring soon after application is likely the dominant mechanism for transport (*e.g*. McGrath, 2008)
- Transfer from legacy
- Pesticide transfer models are useful to:
  i. understand the risks at the catchment scale
  ii. interpret monitoring data
  iii. extrapolate our findings spatially and tempoarily
  iv. direct mitigation measures.

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CONCLUSIONS

WATERPROTECT

- Efficient mitigation measures:
  i. hinders mobilisation, transfer and hydrological connectivity
  ii. considers soil moisture conditions and weather forecast before application
  iii. avoids risky sites and risky times
- We need to better understand the mechanisms, drivers and controls of mobilisation and transfer processes within the agricultural landscape

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BUILDING A NEW DATABASE

WATERPROTECT

I. Collating existing data
II. Spatial overview: Surveying and sampling of private groundwater wells
III. Seasonal overview: monitoring of MCPA in rivers using *passive sampling*
IV. Flow events: field-scale event based storm sampling using *auto samplers*

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SPATIAL -WELL SAMPLING

CHRIS FENNELL

- Sampling and surveying of householders wells
- Analysis:
  i. Temp, EC, pH, ORP, DO
  ii. nutrients, major/minor ions, metals
  iii. 17 acid herbicide parent compounds (quantitative)
  iv. Screening (presence/absence) >2000 compounds

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- Sampling technique based on the free flow of analytes
  i. Screening approach (presence/absence)
  ii. Time weighted average (TWA) concentrations via laboratory calibrations (identify compound specific uptake rate)
- Effectively concentrate pollutants compared to spot sampling lower analytical detection limits

ChemCatcher

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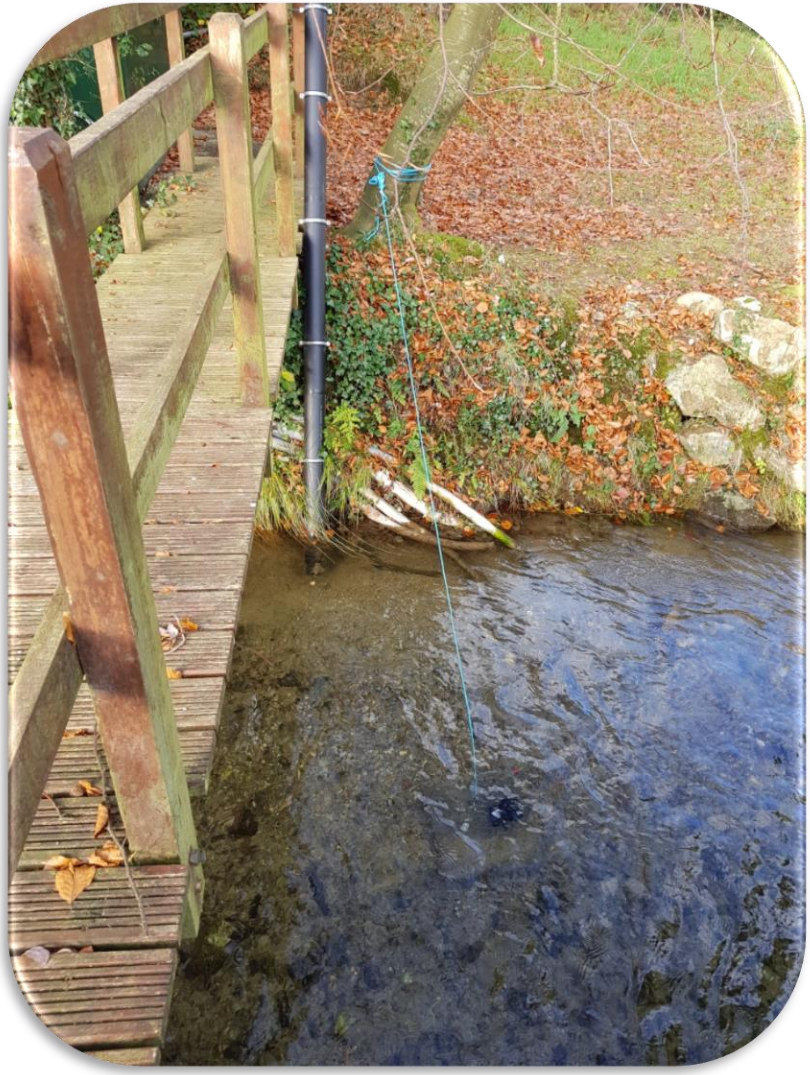
TEMPORAL - PASSIVE SAMPLING

CHRIS FENNELL

WATERPROTECT

- First deployment at ACP Wexford catchment outlets on 06/11/2018
- To be continued for one year with concurrent grab sampling

ChemCatcher



EVENT SAMPLING

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