National SCIENCE Challenges

OUR LAND AND WATER

Toitū te Whenua, Toiora te Wai

LINKING WATER FLOW AND CONTAMINANT TRANSFER THROUGH MESO-SCALE CATCHMENTS

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NZHS Napier 2017

ESR THE SCIENCE BEHIND THE TRUTH | LANDCARE RESEARCH MANAAKI WHENUA | LINCOLN AGRITECH LTD | agresearch āta mātai, mātai whetū | NIWA Taihoro Nukurangi

‘Sources & Flows’ programme within Our Land and Water

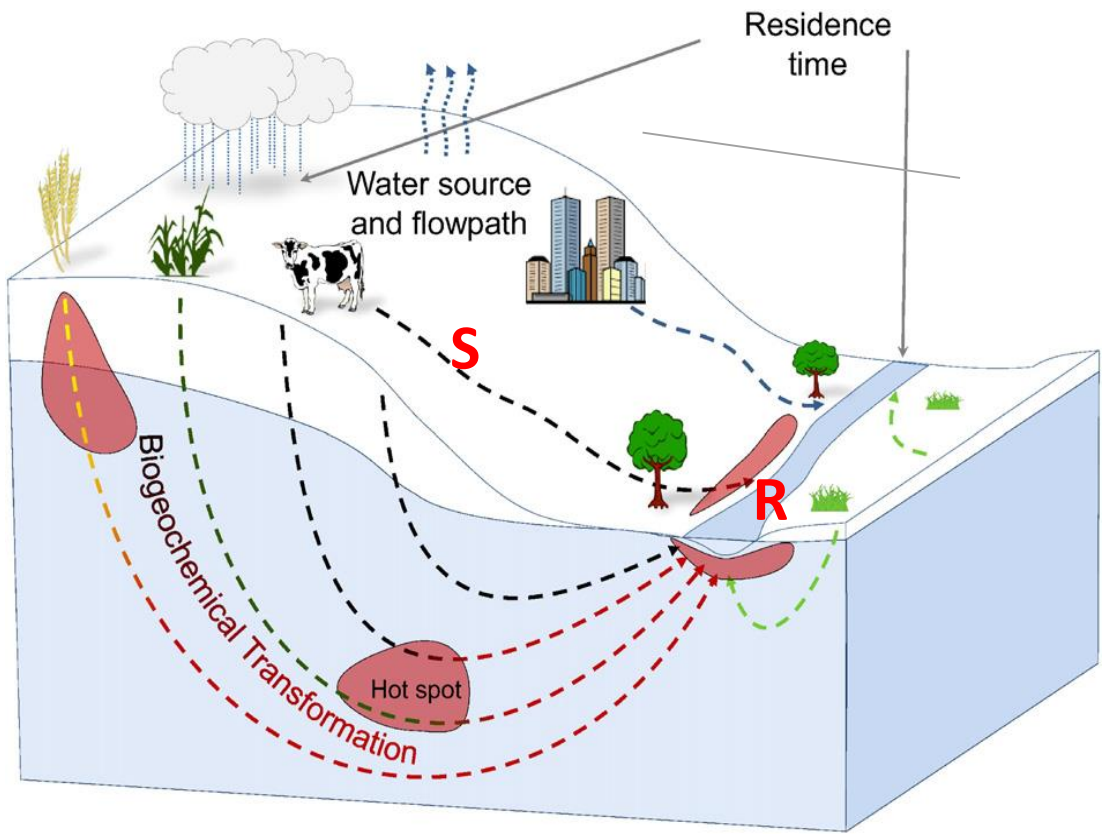
❑ Our Land and Water mission:

“To enhance primary sector production and productivity while maintaining and improving our land and water quality for future generations”.

❑ Sources & Flows objective*:*

“To identify and map key flow pathways and contaminant fluxes in the landscape to inform suitability for land use and response at multiple spatial and temporal scales”.

Key pathways and contaminant fluxes in the landscape

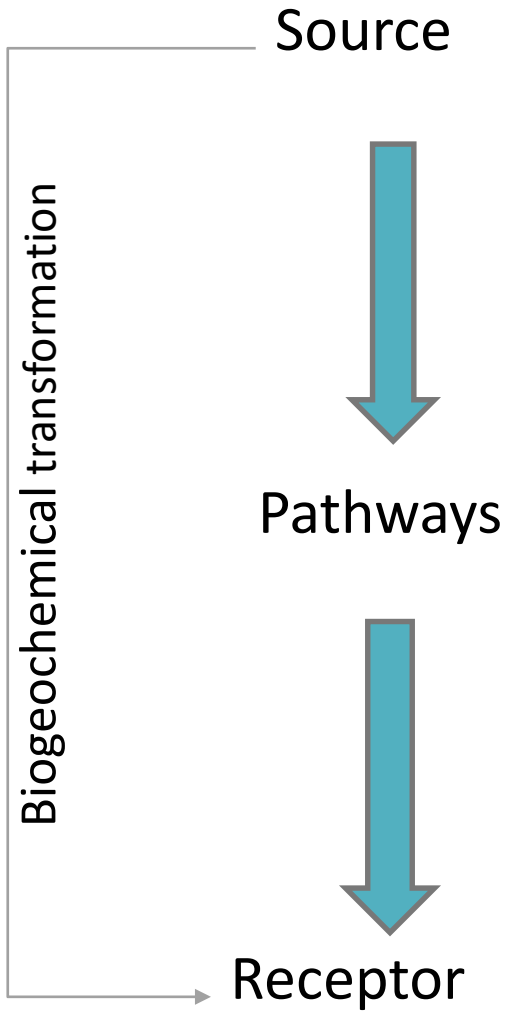


After Abbott et. al. 2016

Basic questions

- Where does water come from ?
- How long does it stay in a catchment?
- What happens along the way ?

Key pathways and contaminant fluxes in the landscape

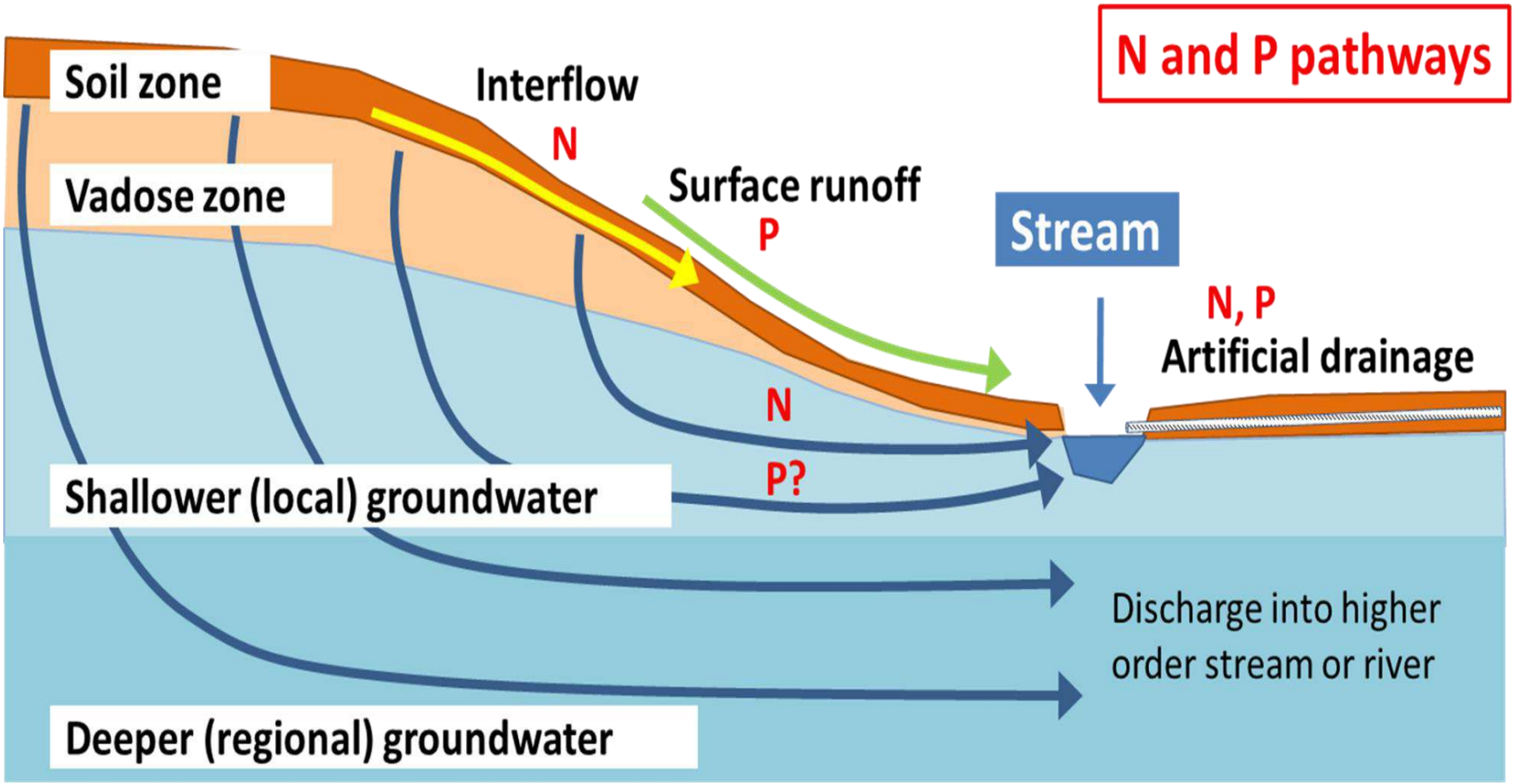


Agriculture
Forestry
Industries etc.

Overland flow
Interflow
Shallow groundwater flow
Deep groundwater flow

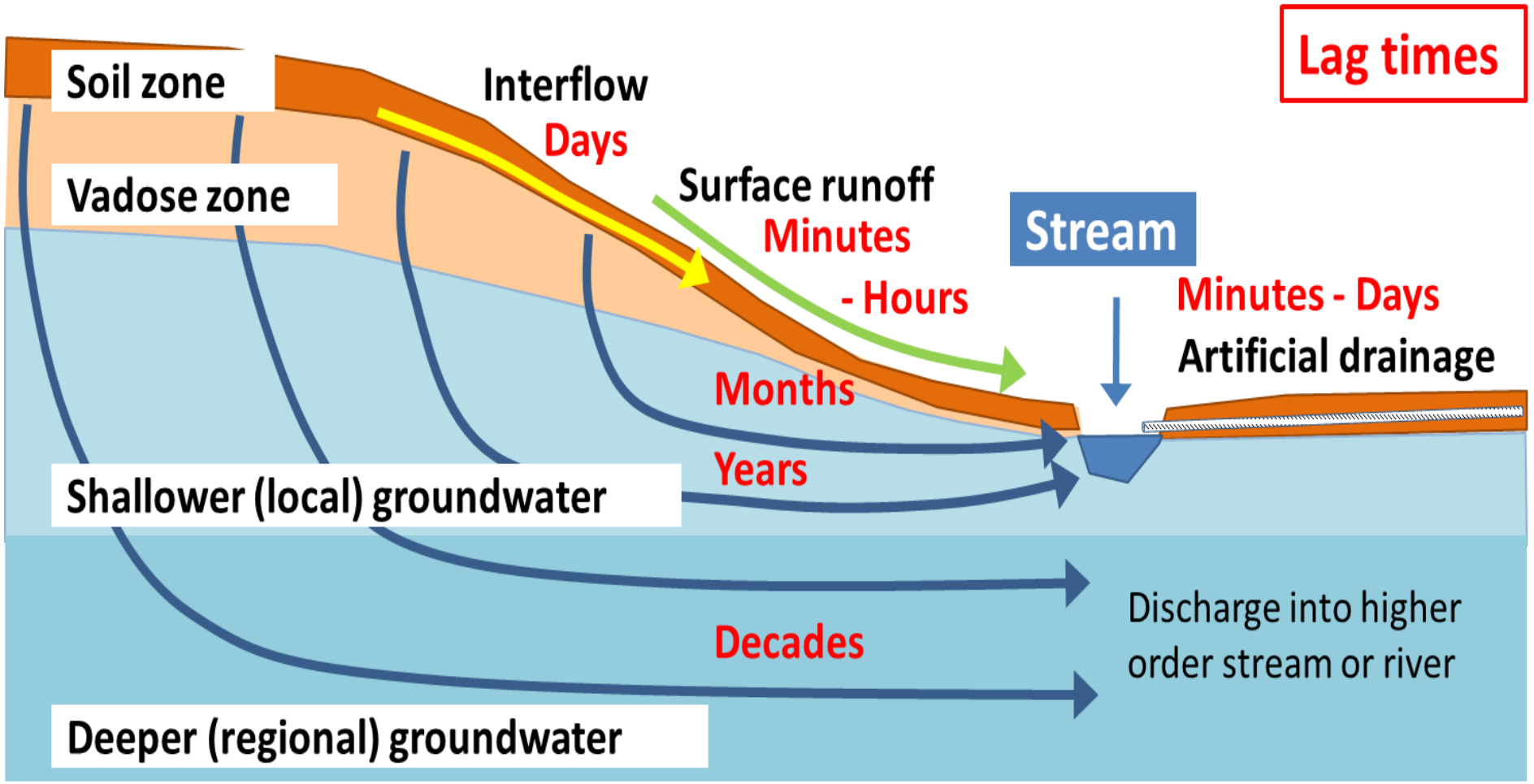
Stream/water bodies

How do contaminants reach the stream?



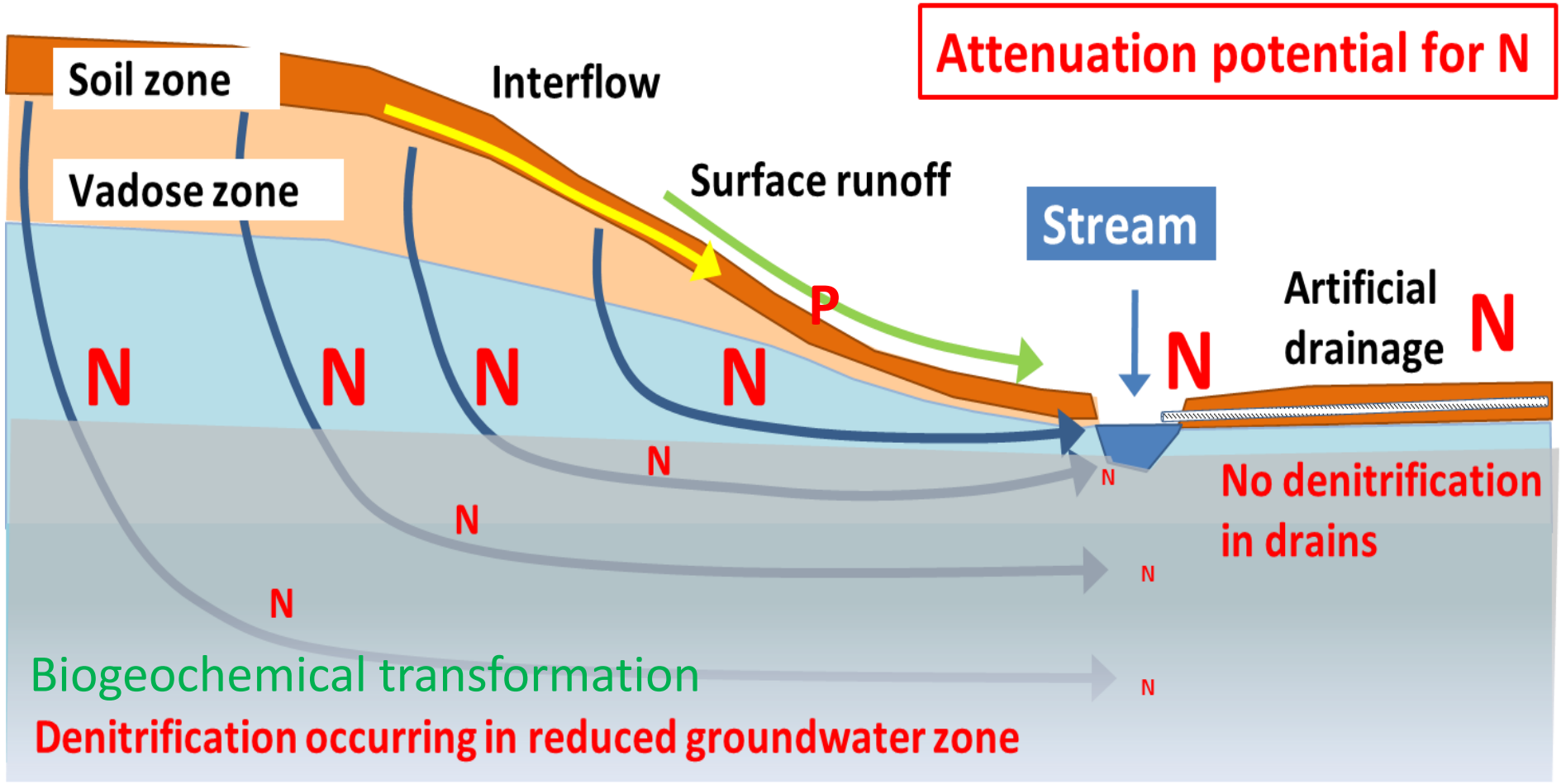
Stenger et al., 2016

How long does water stay in a catchment?



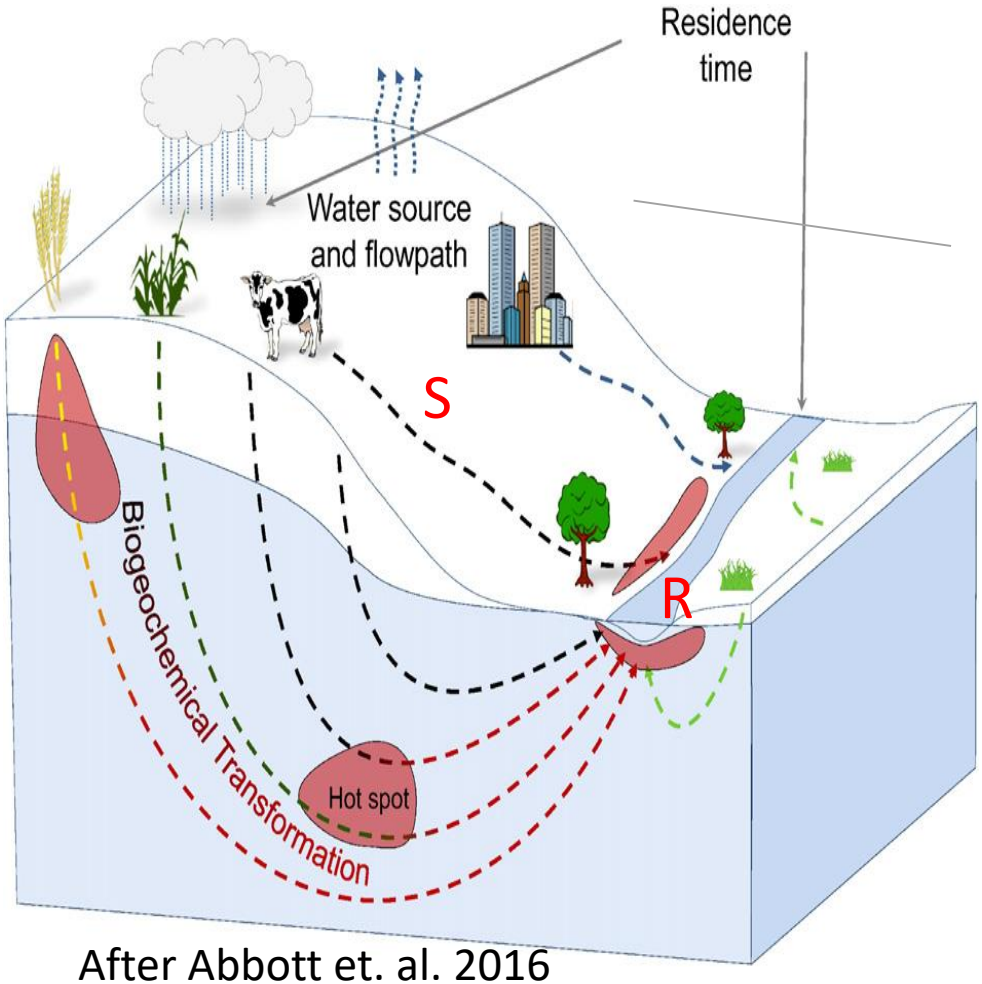
Stenger et al., 2016

What happens during transfer?



Stenger et al., 2016

Spatial and temporal variability



After Abbott et. al. 2016

- Comprehensive country-wide investigations unaffordable
- Transport and transformation processes between sources (S) and receptor (R) still insufficiently understood

Objective

To review the state-of-the-science that describes available approaches to model the link between catchments and their unique chemical, hydrological and isotopic signatures and the dominant transport pathways of contaminants.

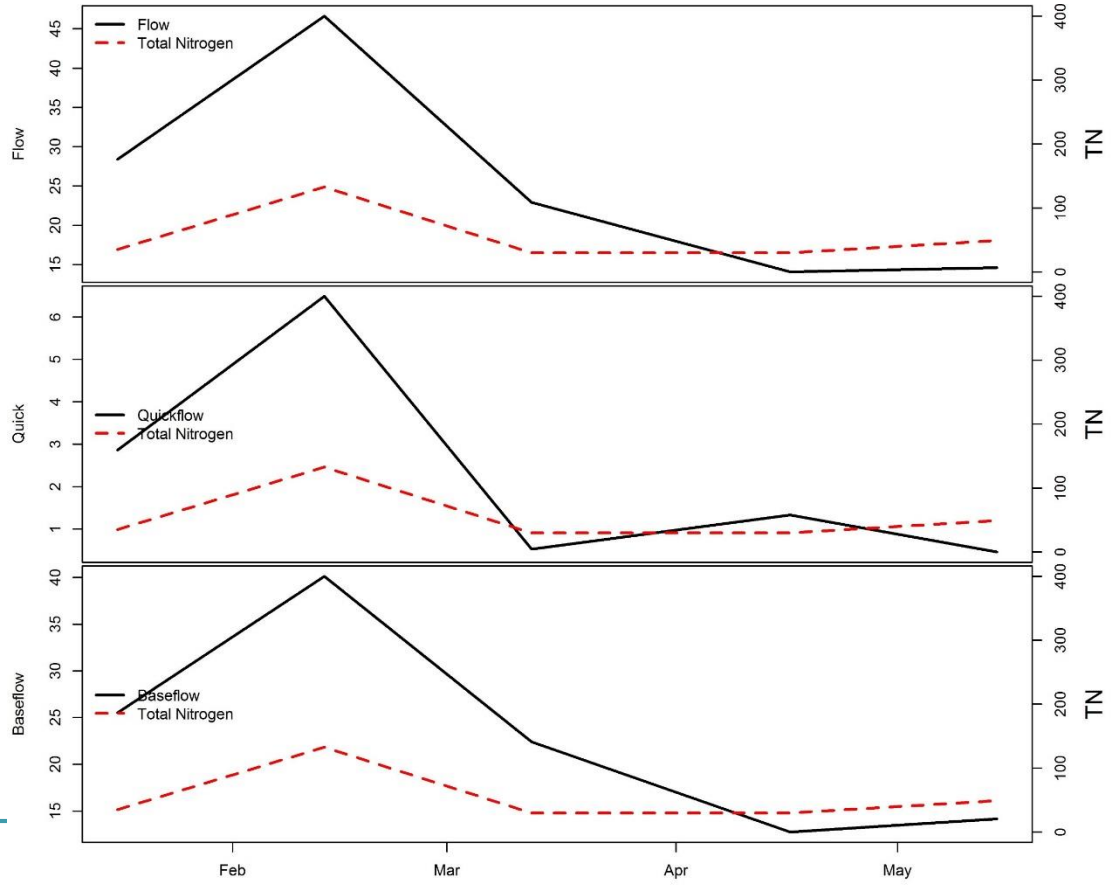
Contaminants

Nutrients

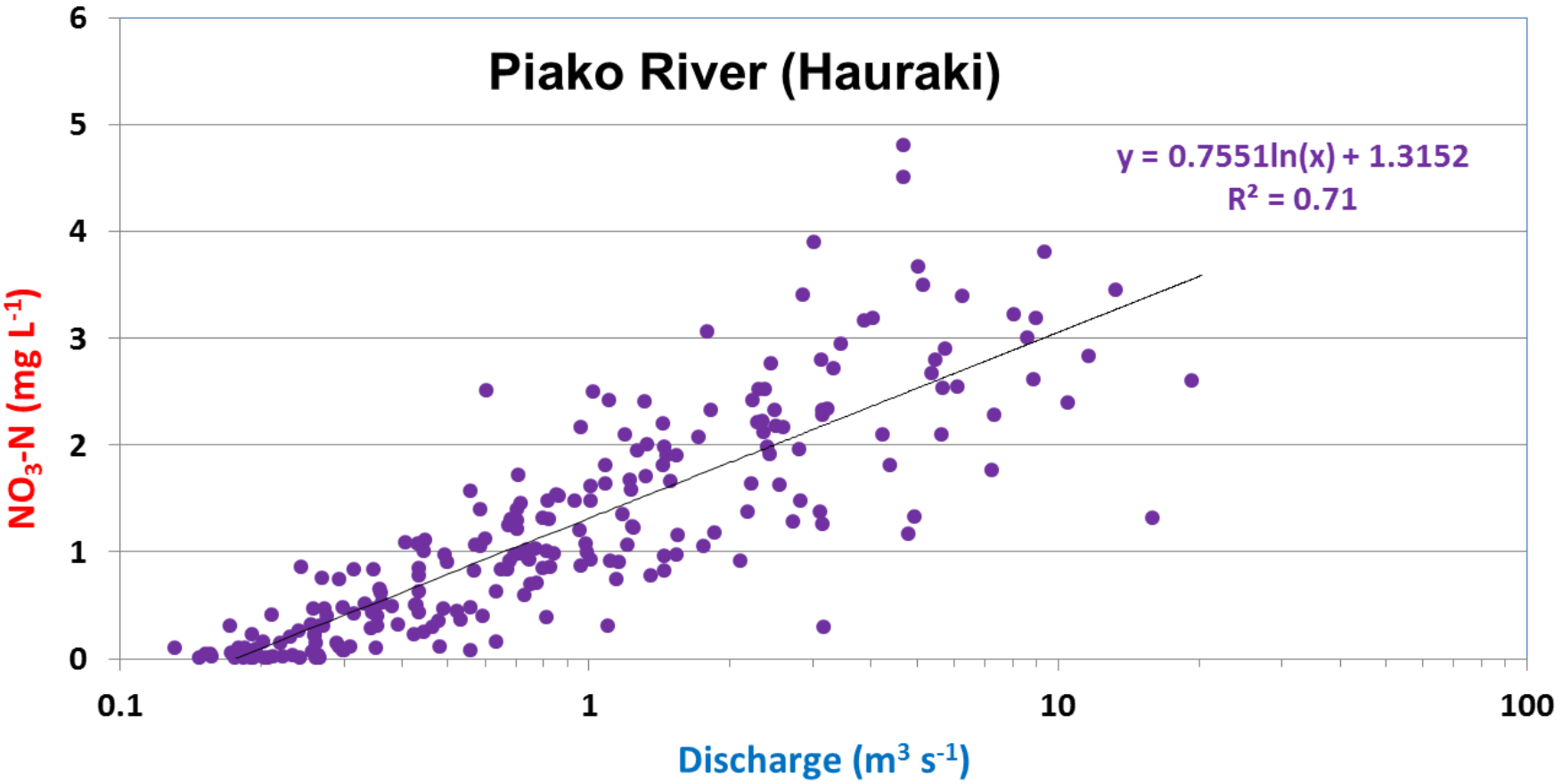
- Nitrogen
- Phosphorus

Sediment

Pathogens (Faecal Indicator Organisms)



Examples: Concentration-Discharge Analysis



Stenger et al., 2014

Extracting pathways info from stream monitoring data

Receptor data

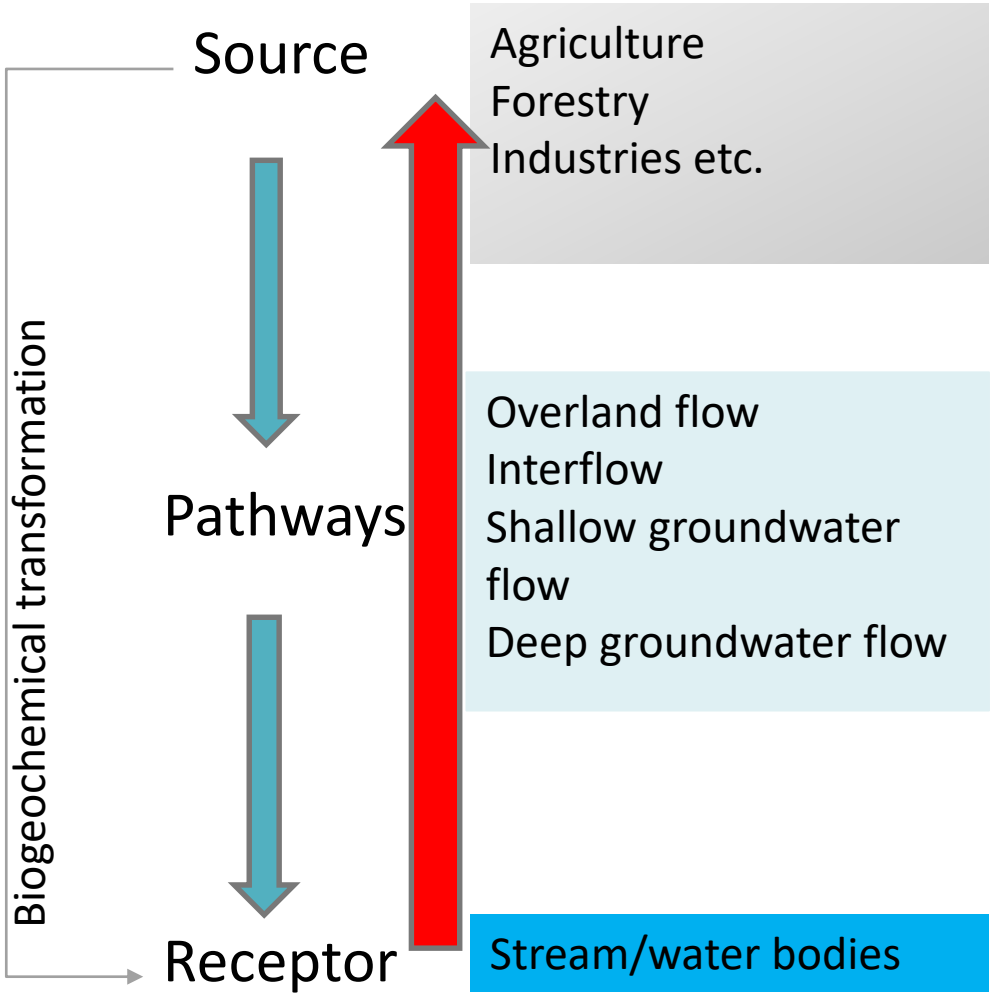
➢Stream flow hydrographs

➢Stream water chemistry

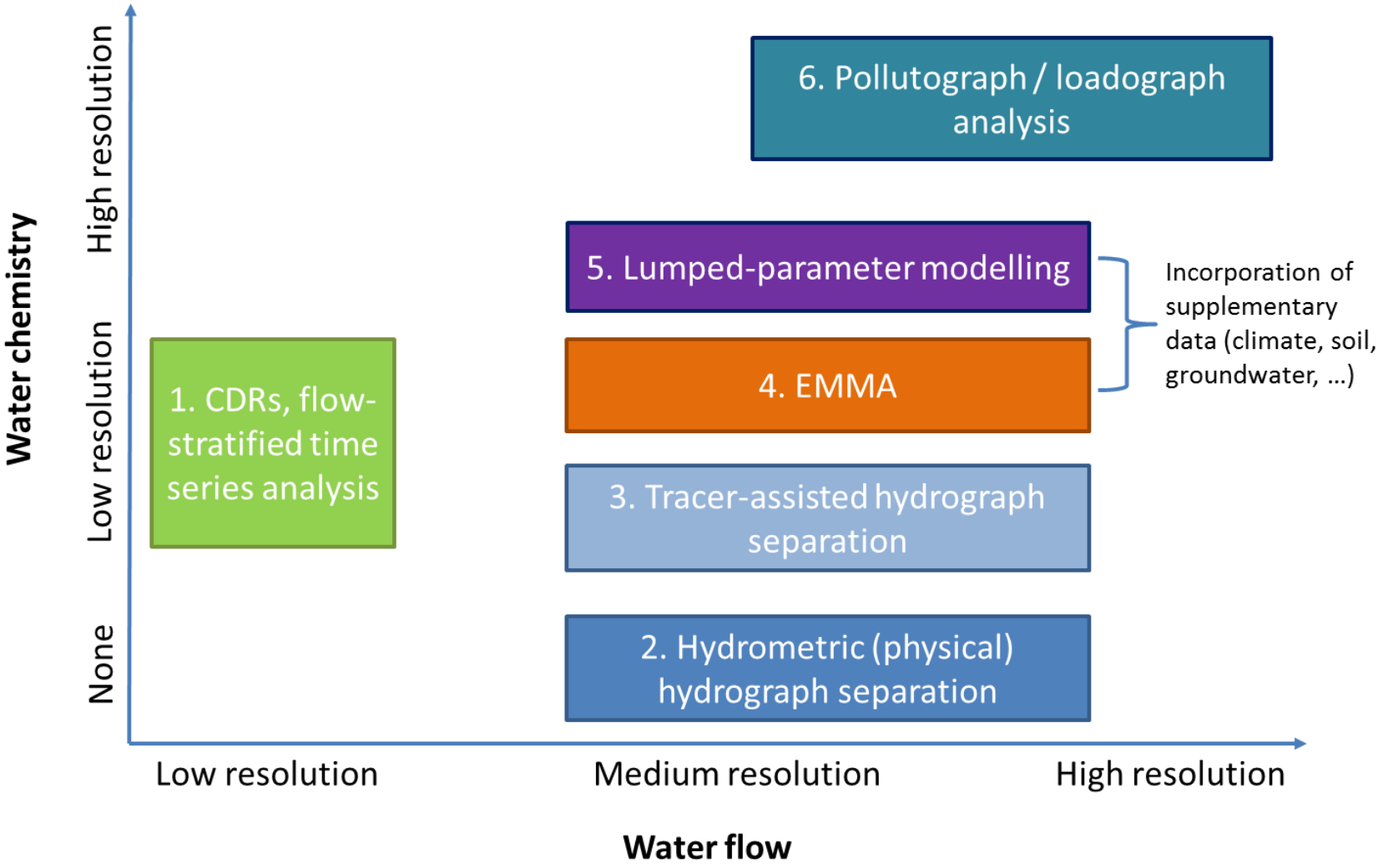
'Reverse hydrology'

➢Analysis of data from receptor end of source-transfer-receptor chain

➢Receptor 'sees' the contributions from all pathways from the entire catchment

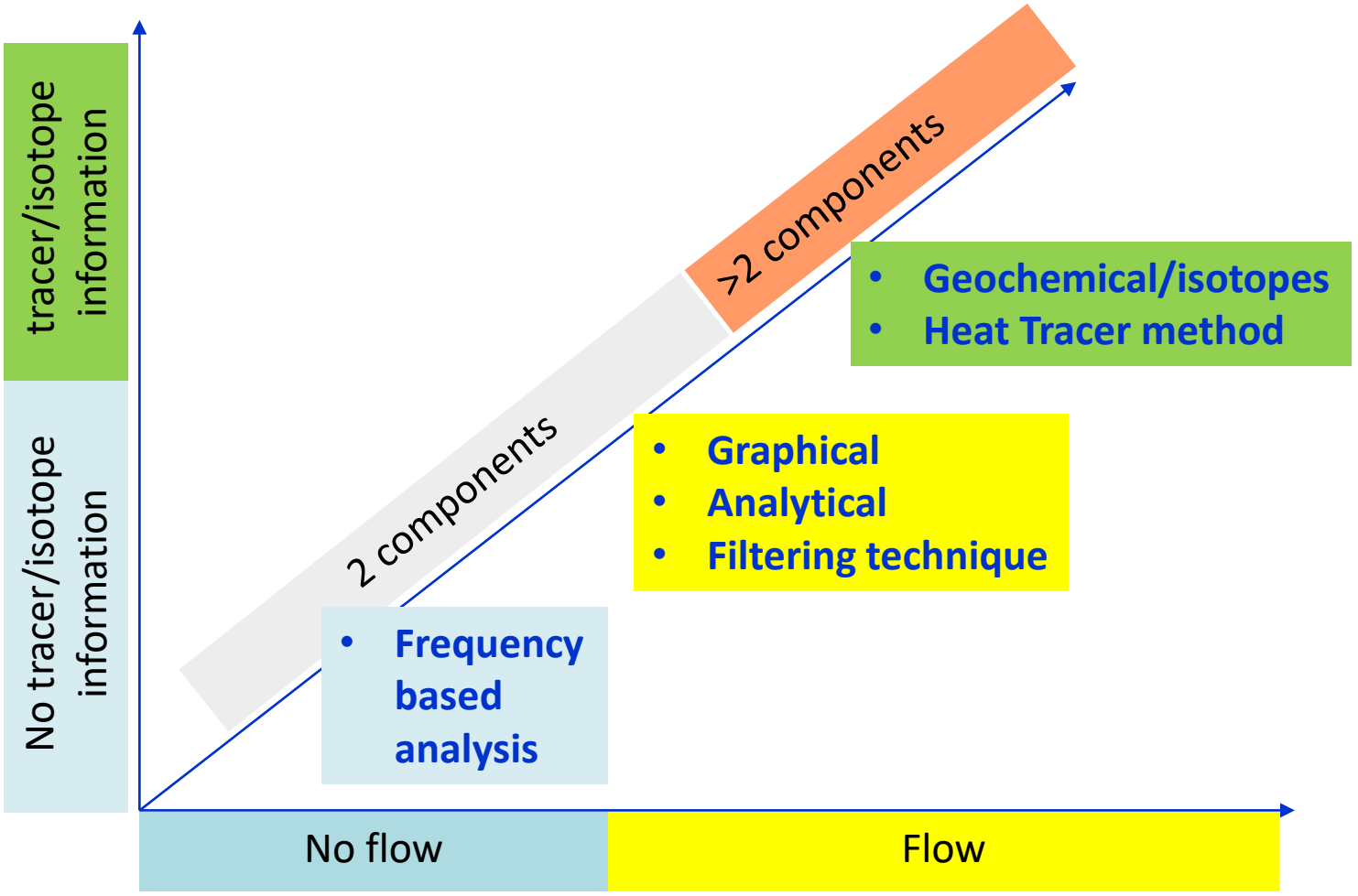


Review of 'Indirect Methods' in Sources & Flows

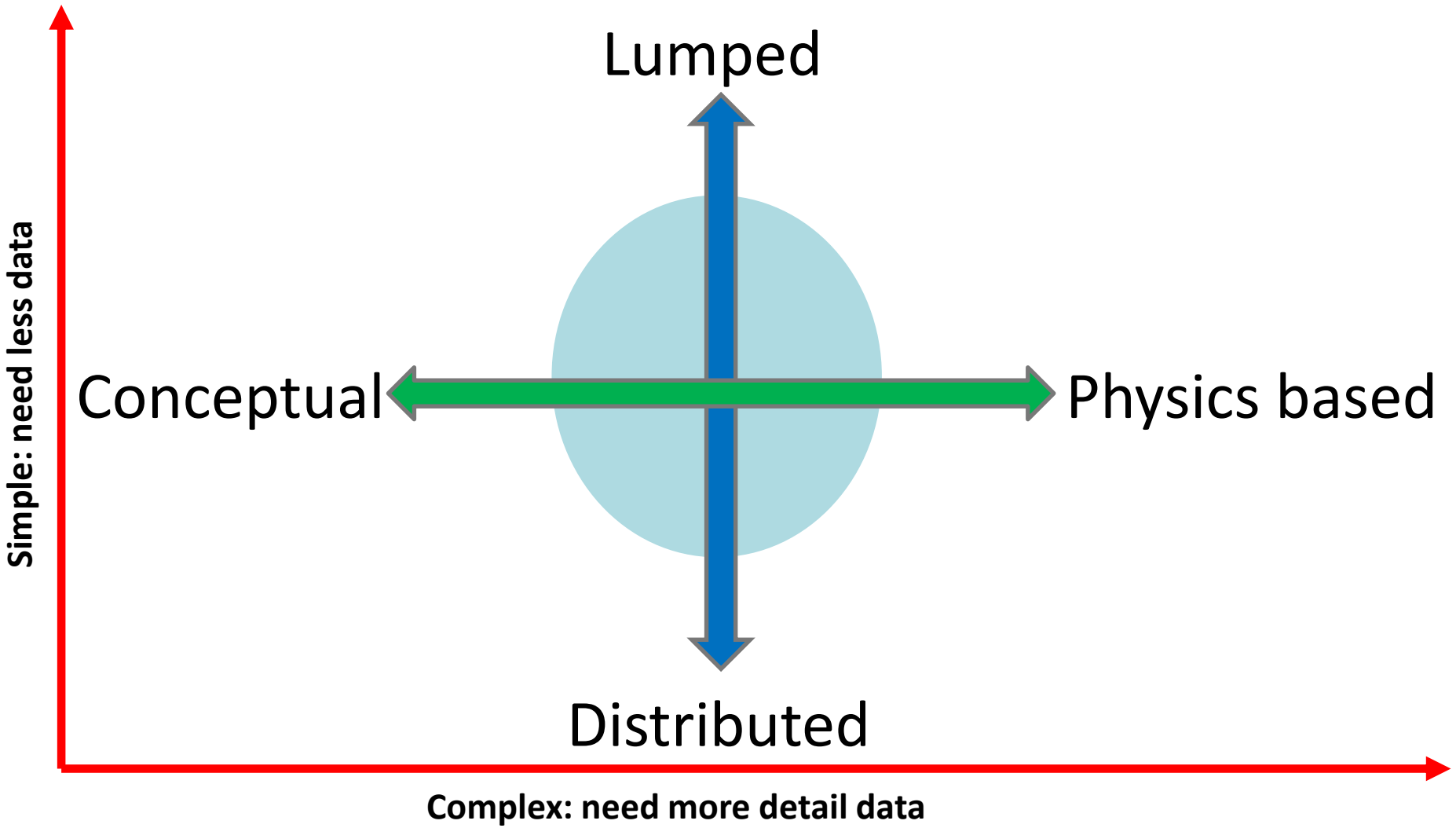


Transfer Pathways Programme (TPP), 2015 – 2018, aligned to OLW-NSC

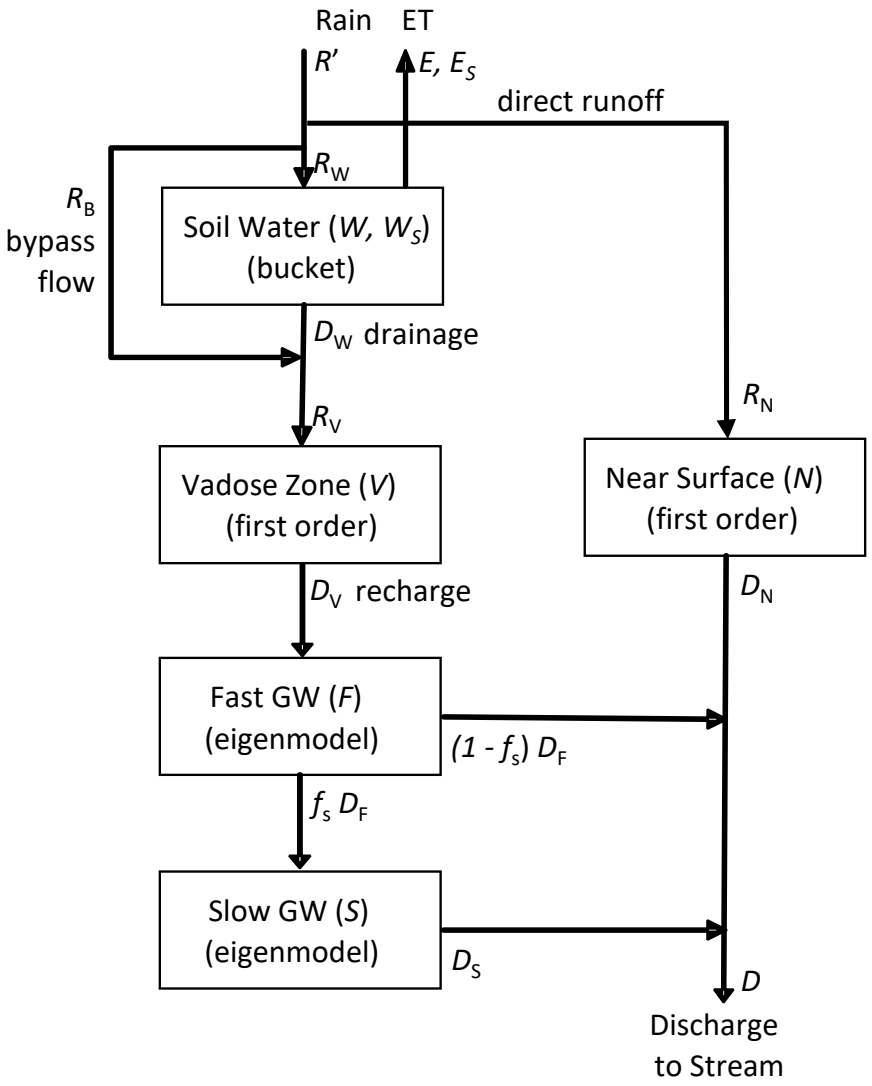
Hydrograph Separation



Hydrochemical modelling



Examples: Modelling of flows along pathways



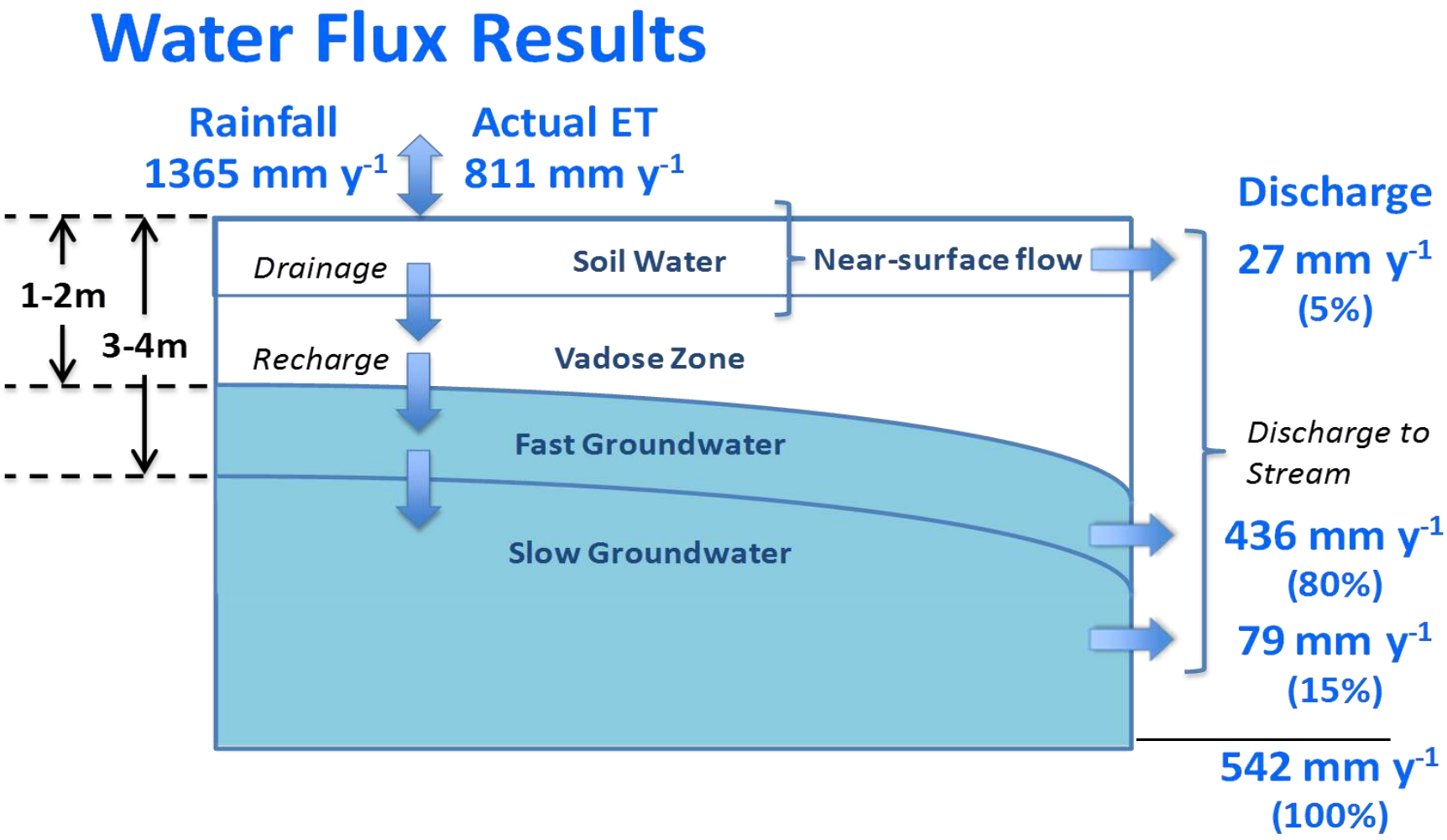
StreamGEM

(Streamflow Generation Eigen Model)

- Requires stream flow, water chemistry, and climate time series
- Remarkably effective provided appropriate calibration methods are used that correctly handle the inherent uncertainties
- Markov Chain Monte Carlo sampling code DREAM$_{ZS}$ used for calibration

Woodward et al., 2013 + 2017

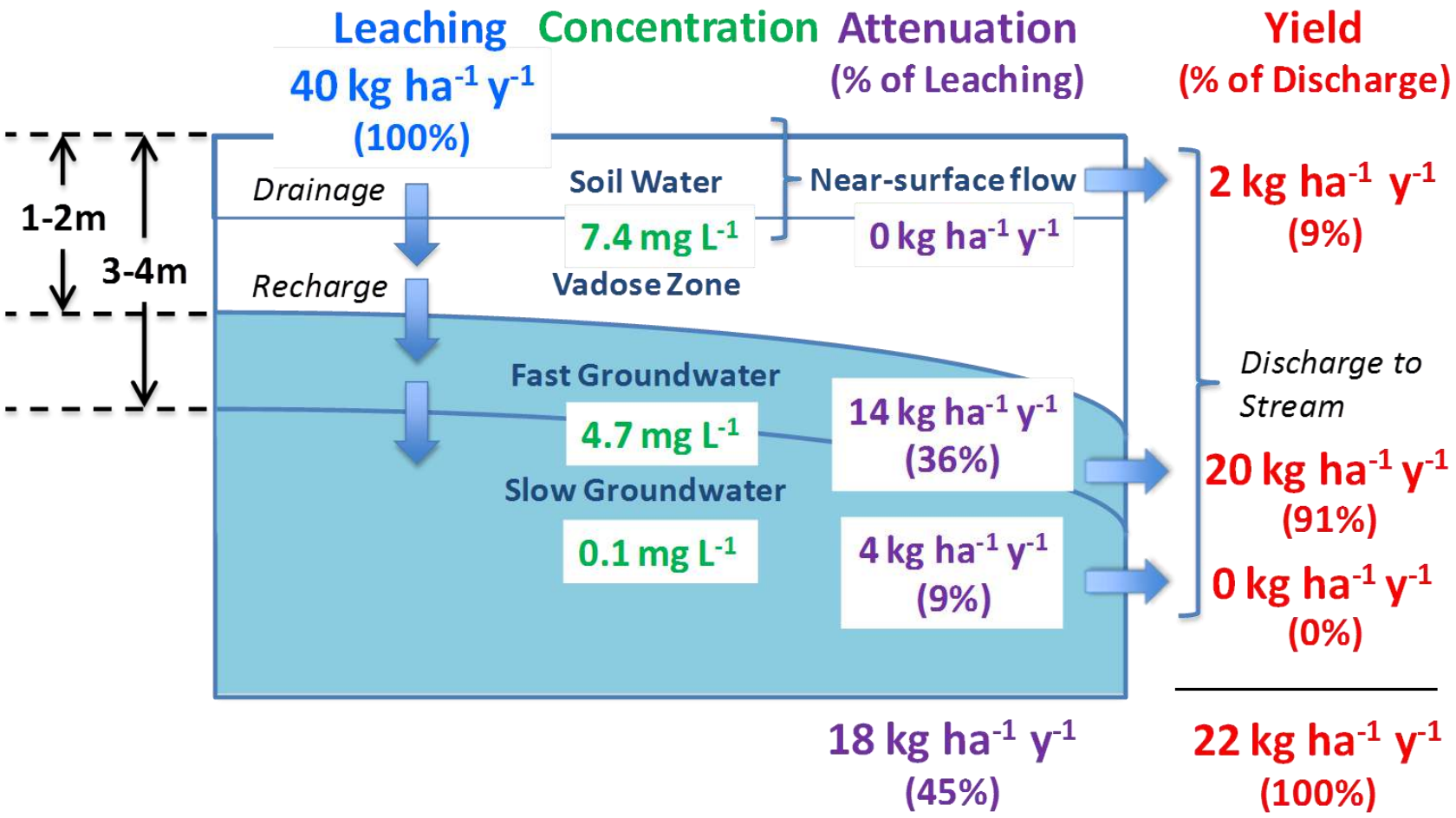
Examples: Modelling of flows along pathways



Woodward et al., 2013 + 2017

Examples: Modelling of flows along pathways

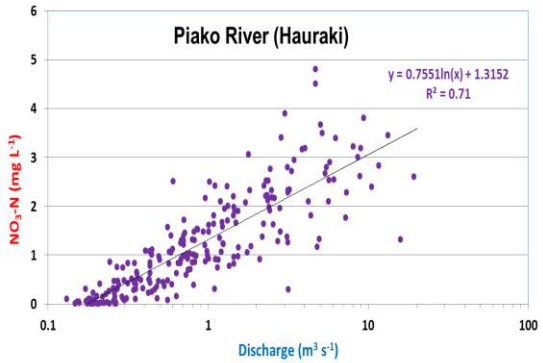
Nitrate Flux Results

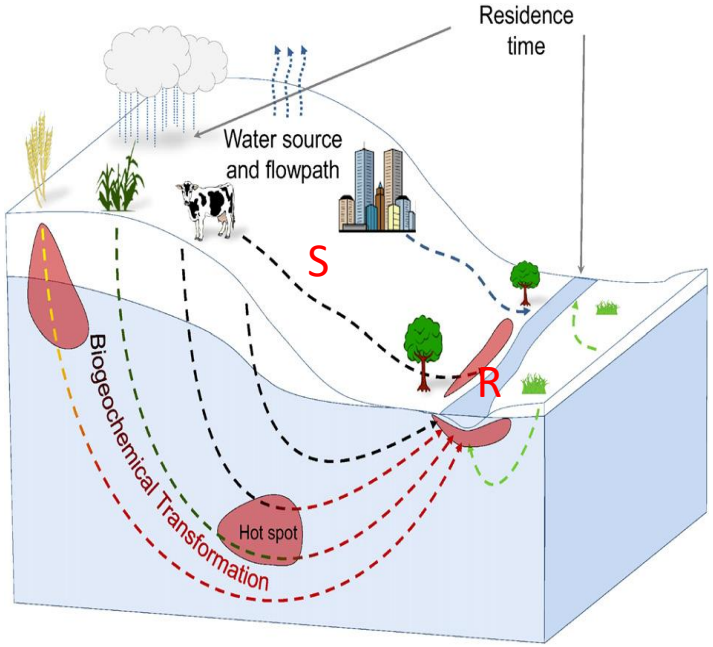


Woodward et al., 2013 + 2017

Summary

- ➢Combined analysis of stream flow and water chemistry time series can provide valuable insights into key flow pathways and contaminant fluxes in the landscape
- ➢Uncertainty analysis crucial
- ➢Temporal variability challenging
- ➢Superposition of spatially and temporally distributed processes will weaken signals in larger catchments





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Hydrograph Separation

Type	Description
Graphical	Methods involve drawing a line from the starting point of the rising limb on the total hydrograph to point on the recession limb
Analytical	Storage-discharge relationships for catchment areas Mathematical algorithms
Filtering technique	Use of digital filters
Frequency based analysis	Flow duration curve, calculates exceedance probability
Geochemical/isotopes	Use of chemical characteristics such as conservative natural isotopes and chemical tracers. Requires long-term sampling from the surface and subsurface flow in different seasons during wet and dry years
Heat Tracer method	Methods based on temperature difference between, surface water and ground water