Using Field Instrumentation to Validate Numerical Modeling

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Background

A hydrologic time lag (t_T) exists between agricultural practices and changes in water quality. This delay includes both unsaturated zone (t_u) and groundwater (t_s) components. Tracer tests can indicate t_u, but are prohibitively costly and time consuming. Numerical models (Hydrus 1D) provide an alternative.

Vero *et al*. (2014) tested the effects of data complexity and temporal resolution on the efficacy of said methods. These estimates need to be validated against *in situ* tracer tests, to determine the suitability of the modeling approach.

Objectives

- The primary objective is to test the validity of low vs. high complexity t_u estimates generated using Hydrus 1D against recorded tracer breakthrough curves,
- Secondary objectives are:
  - To contribute to a holistic t_T analysis in contrasting vulnerable watersheds,
  - To assess the performance of continuous electrical conductivity monitoring vs. interval-based water sampling as indicators of tracer breakthrough.

Hydrus Estimates

- Profiles were constructed in Hydrus 1D corresponding to pit descriptions from the field sites (Table 1).
- Simulations based on low to high complexity soil hydraulic data, according to Vero et al., 2014:

A. Textural Class
B. Particle Size Distribution
C. Soil Water Characteristic Curve (SWCC)
D. SWCC excluding the -15 bar pressure

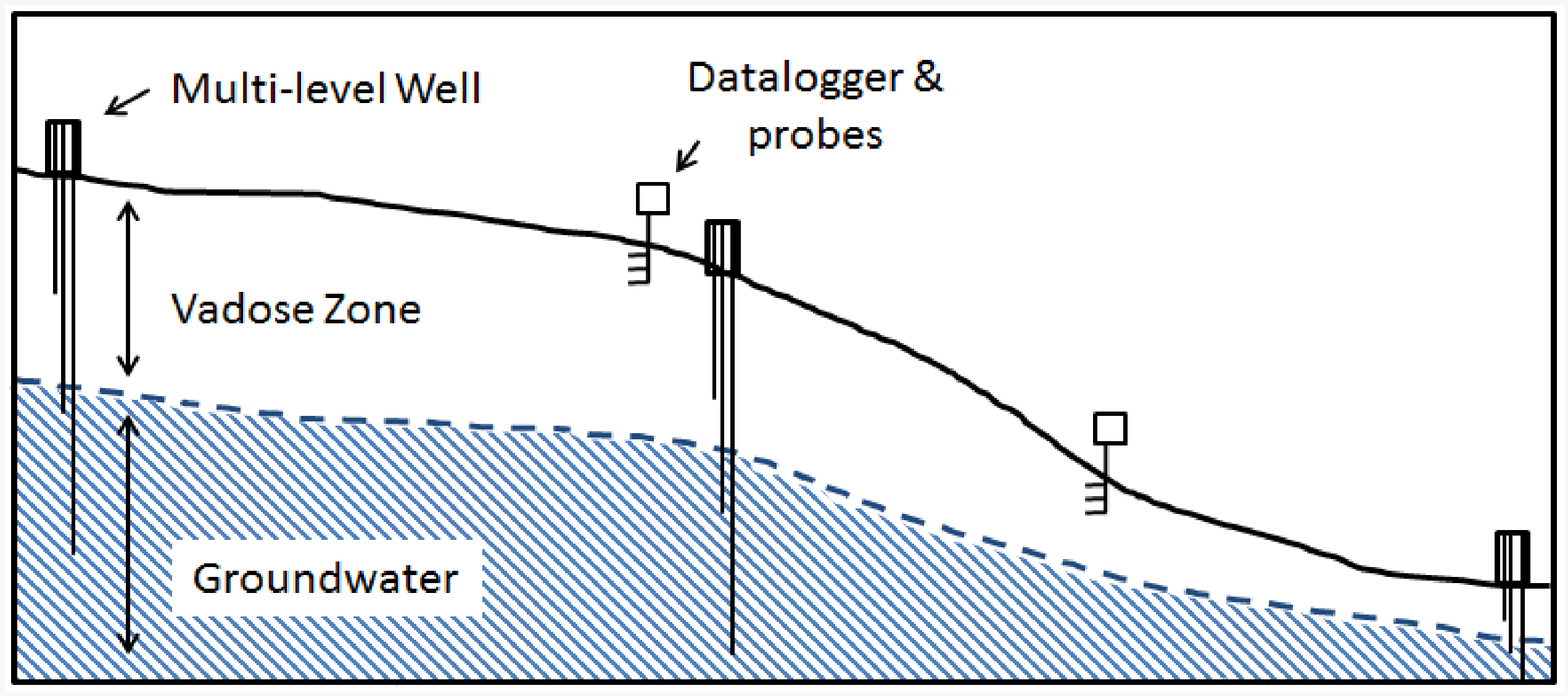

Fig. 1: Field installations along a catena

Methodology

- 2 soil pits excavated within a high resolution groundwater monitoring network (Fig. 1) in 2 well-drained watersheds (grassland and arable) in Ireland (Table 1)
- Soil cores obtained from each horizon
  - Particle size analysis,
  - SWCC analysis (centrifuge method)
- Profile description in accordance with Irish Soil Information Survey

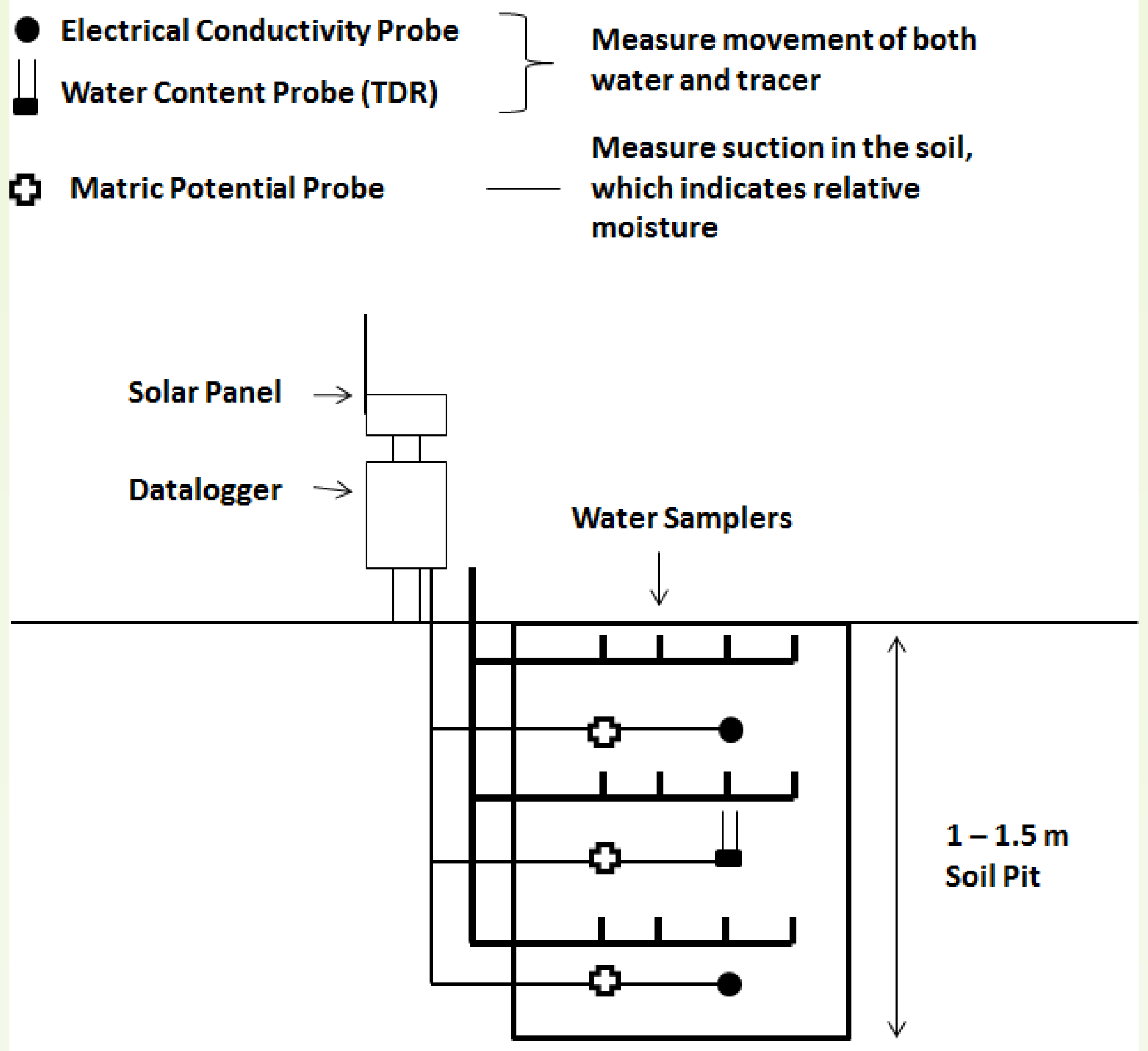

Fig. 2: Field instrumentation

Field Instrumentation (Fig. 2)

- MacroRhizon water samplers for pore water analysis and tracer detection,
- TDRs & temperature probes indicating volumetric moisture content,
- Electrical conductivity probes (5TE) indicating volumetric moisture content and high resolution tracer monitoring,
- Matric potential probes (MPS-2) indicating soil water potential,
- Synoptic weather recording station providing hourly meteorological data.

- Potassium Bromide (KBr) (200 kg ha^{-1} over a 5x5 m area) to be applied in November – start of recharge period

References

Vero *et al*., 2014. Journal of Contaminant Hydrology

Site	Position	Layer	Depth (cm)	Texture	Particle Size Analysis (%)			Permeability Characteristics	Aquifer Type
					Sand	Silt	Clay		
Arable	Lower	Ap	0-10	Clay	33	24	43	Moderately drained soil and fractured slate overlying poorly permeable bedrock	Poorly productive
		Cr	10-25	Loam	47	31	22		
	Mid-slope	Ap1	0-25	Clay Loam	43	30	27		
		Ap2	25-100	Clay Loam	35	31	34		
		BC	100-140	Clay Loam	36	34	30		
Grassland	Lower	Ap	0-8	Clay	27	28	45	Moderately drained topsoil overlying highly permeable subsoil	Productive
		Bs	8-22	Clay Loam	31	35	34		
		Ah	22-40	Clay Loam	34	33	33		
	Mid-slope	Ap	0-6	Clay Loam	36	33	31		
		Bs	6-33	Clay Loam	34	36	30		
		Cr	33-65	Clay Loam	33	35	32		

Table 1: Profile descriptions

Results - Expected Breakthroughs

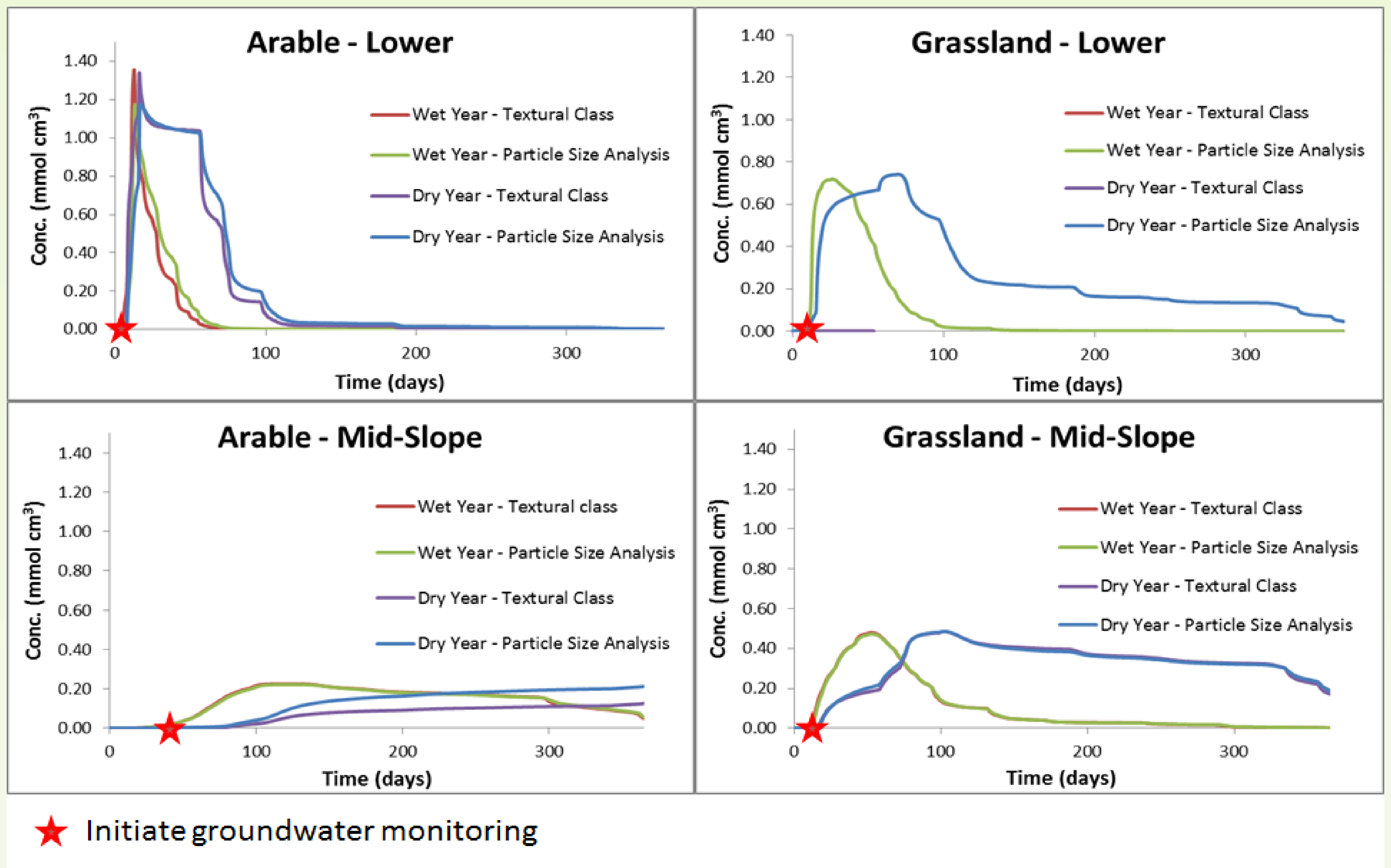

Fig. 3: Low complexity breakthrough simulations

The breakthrough curves for wet and dry sample years for the four soil pits, based on the readily available low complexity data, are shown in Fig. 3. This indicates the timescales in which to expect tracer breakthrough, and informs when groundwater monitoring should be initiated. Such estimates can provide guidance as to the optimum frequency of sampling during a vadose or groundwater monitoring campaign. Based on these simulations, groundwater monitoring in the arable and grassland sites will be initiated at five and ten days post-application, respectively.

Subsequent to full measurement of the bromide tracer, simulations will be made using recorded weather data and all complexity levels, allowing direct comparison between estimated and measured t_u which will allow the accuracy of the numerical model to be assessed.

Full results are expected mid-2015, and will be coupled with on-site groundwater tracer studies to give a holistic assessment of watershed time lag.

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