

History of the Evolution of High Resolution Tools and Methods for Groundwater Monitoring

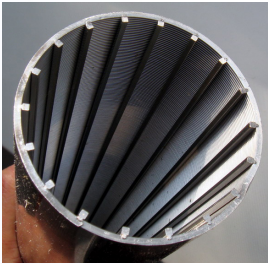
Dr Gary Wealthall

- A Brief History of [MLS] Time
- MLS Well Design
- Advancing Process Understanding
- Closing Comments



A Brief History of [MLS] Time

A Brief History of (MLS) Time



Traditional Wells



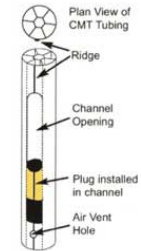
Westbay
[1978]



Waterloo
[1987]



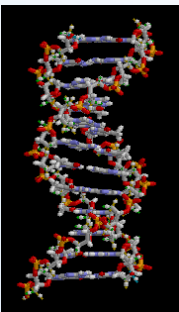
Flute
[1994]



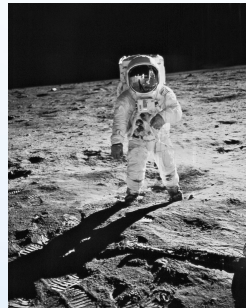
Solinst CMT
[1999]



1950



1970



Cherry and Johnson, 1982

1990

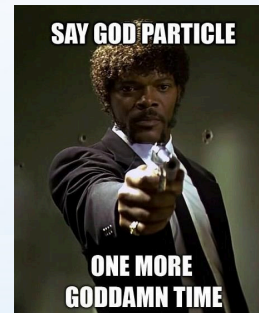


Guilbeault et al, 2005

Cherry et al., 2007

Thornton and Wealthall, 2008

2010





MLS Well Design

This is generally unknown at all sties before use of the MLS begins

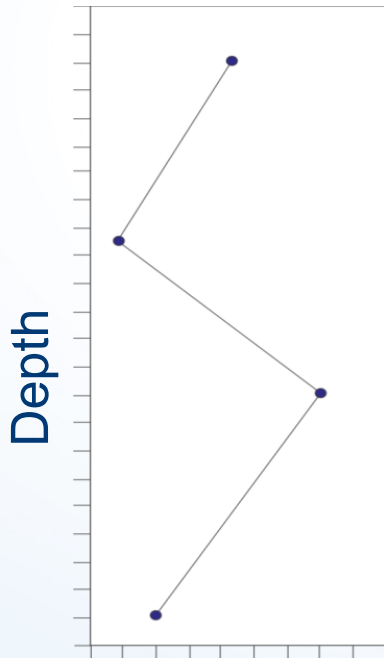
**“You never know what is enough unless you know
what is more than enough”**

-William Blake – English Poet (1757 to 1827)

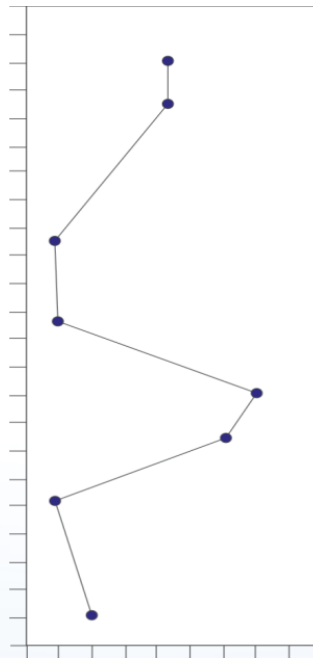
Therefore, start with as many ports as is practical



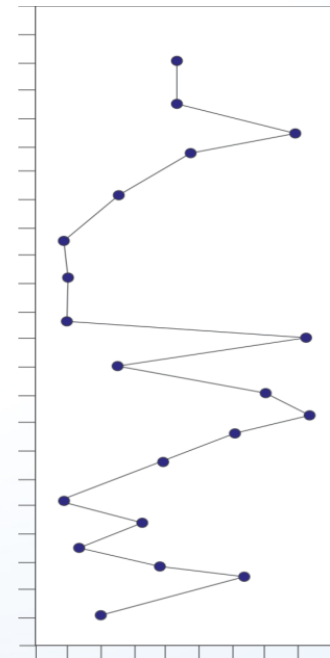
4 Levels



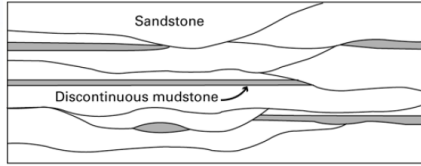
8 Levels



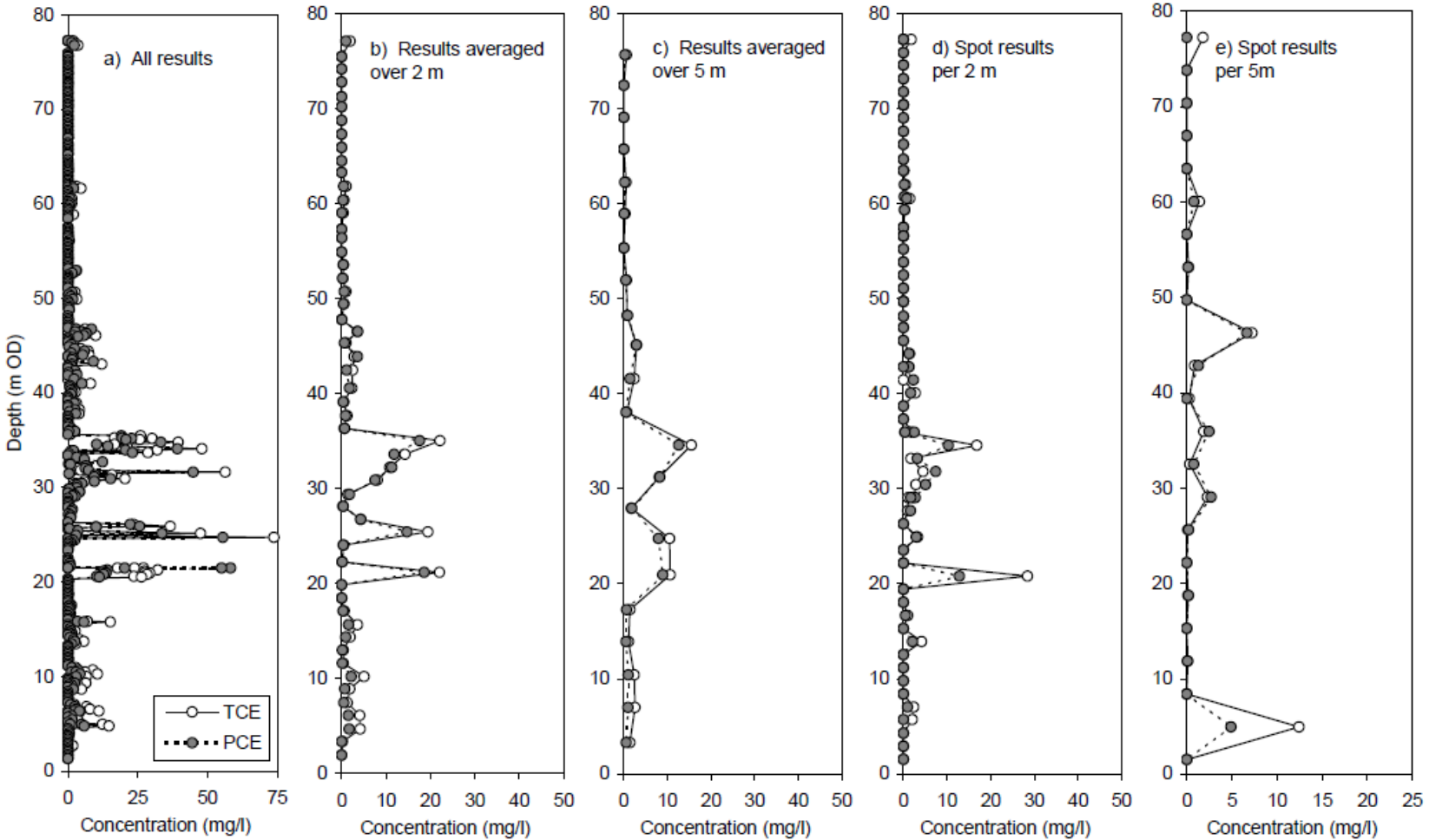
20 Levels



Sparse profiles are typically misleading and often useless



Sampling Density (Bedrock)



Essential Factors Concerning Selection of a Multi Level System

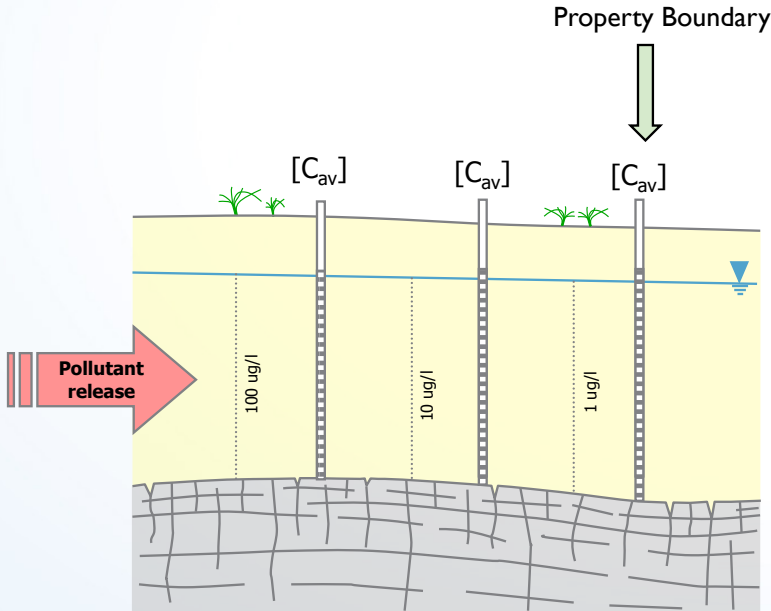
1. Type of geology
2. Maximum depth
3. Hole conditions
4. Depth to water table
5. Expected head differentials
6. Number of ports needed
7. Permanent or temporary
8. Chemical reactivity
9. Transducer or manual WL readings
10. Sample volume required
11. Purging needed or not
12. Sample exposure minimization
13. Complexity of installation method
14. Simplicity/speed of sampling
15. Quality assurance/reliability
16. Types of drilling machines available

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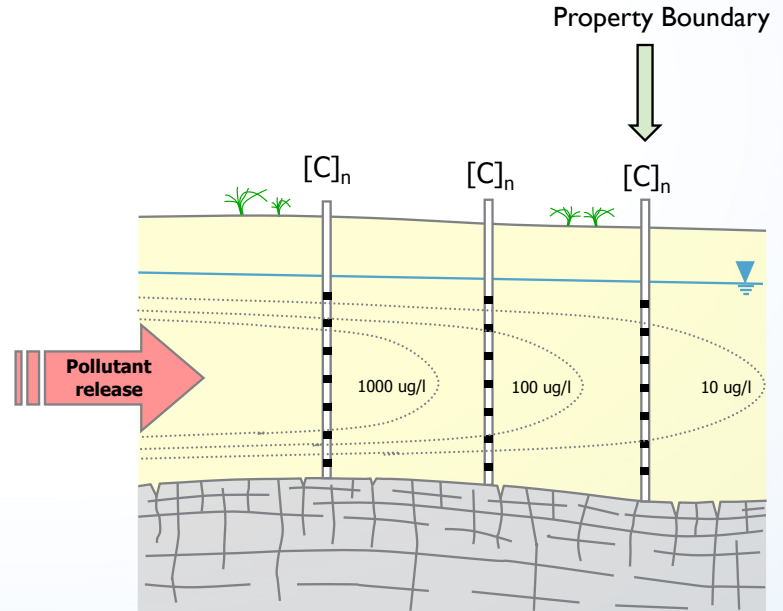
Advancing Process Understanding

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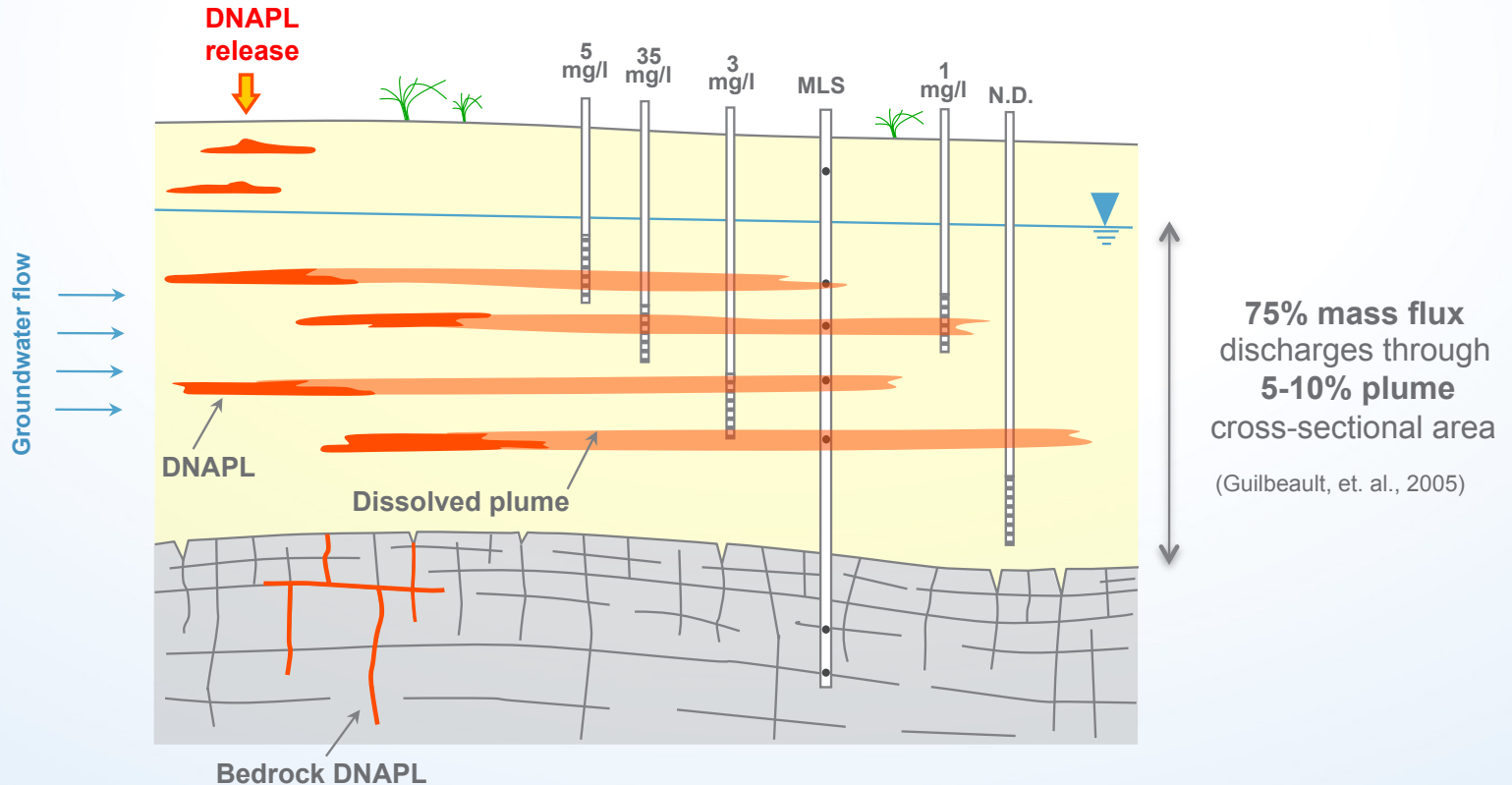


**Fully-screened wells
(integrated)**

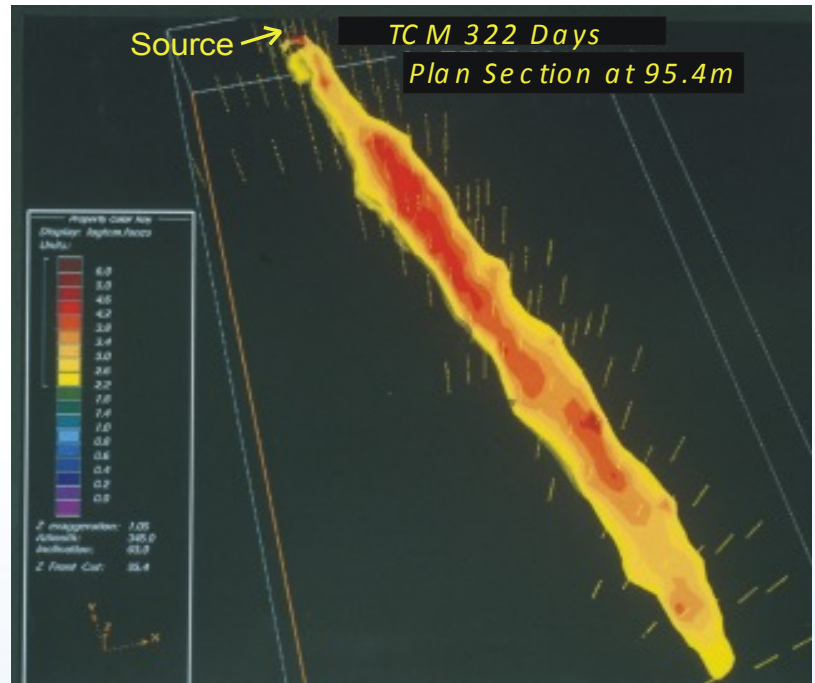


**Multilevel samplers
(point source)**

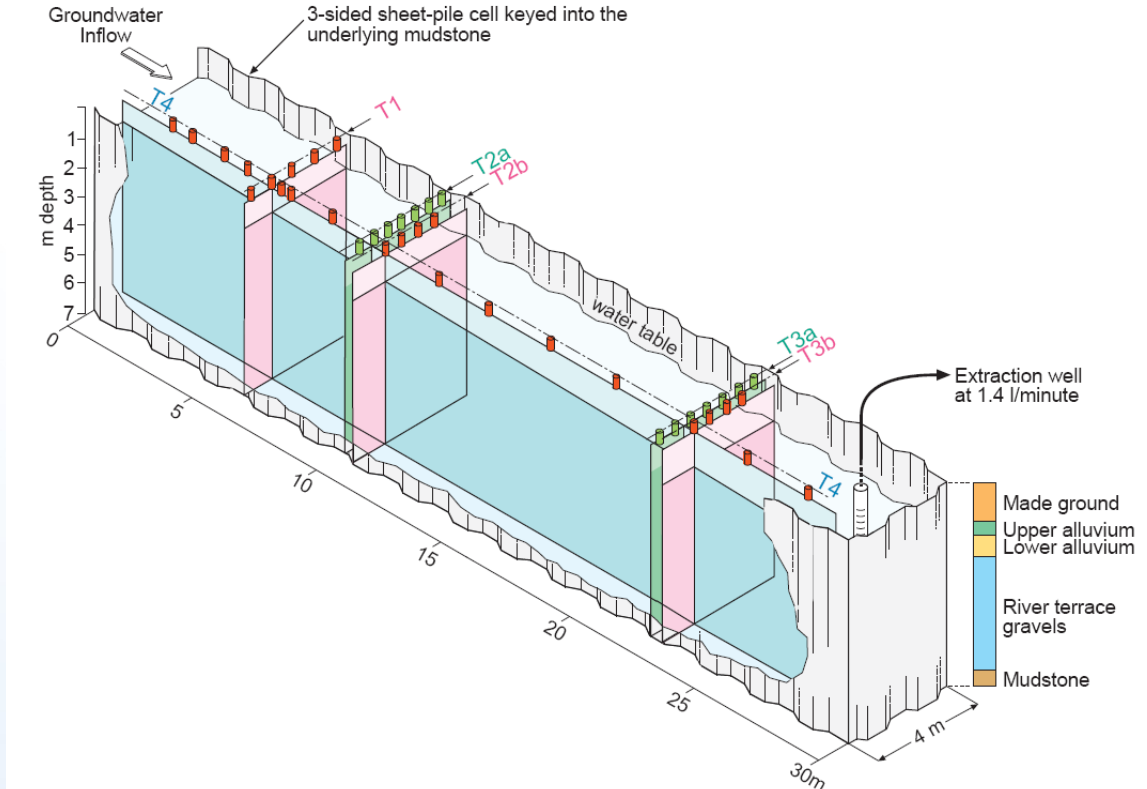
Increasingly Sophisticated Remedial Technologies Demand More Sophisticated Well Completions



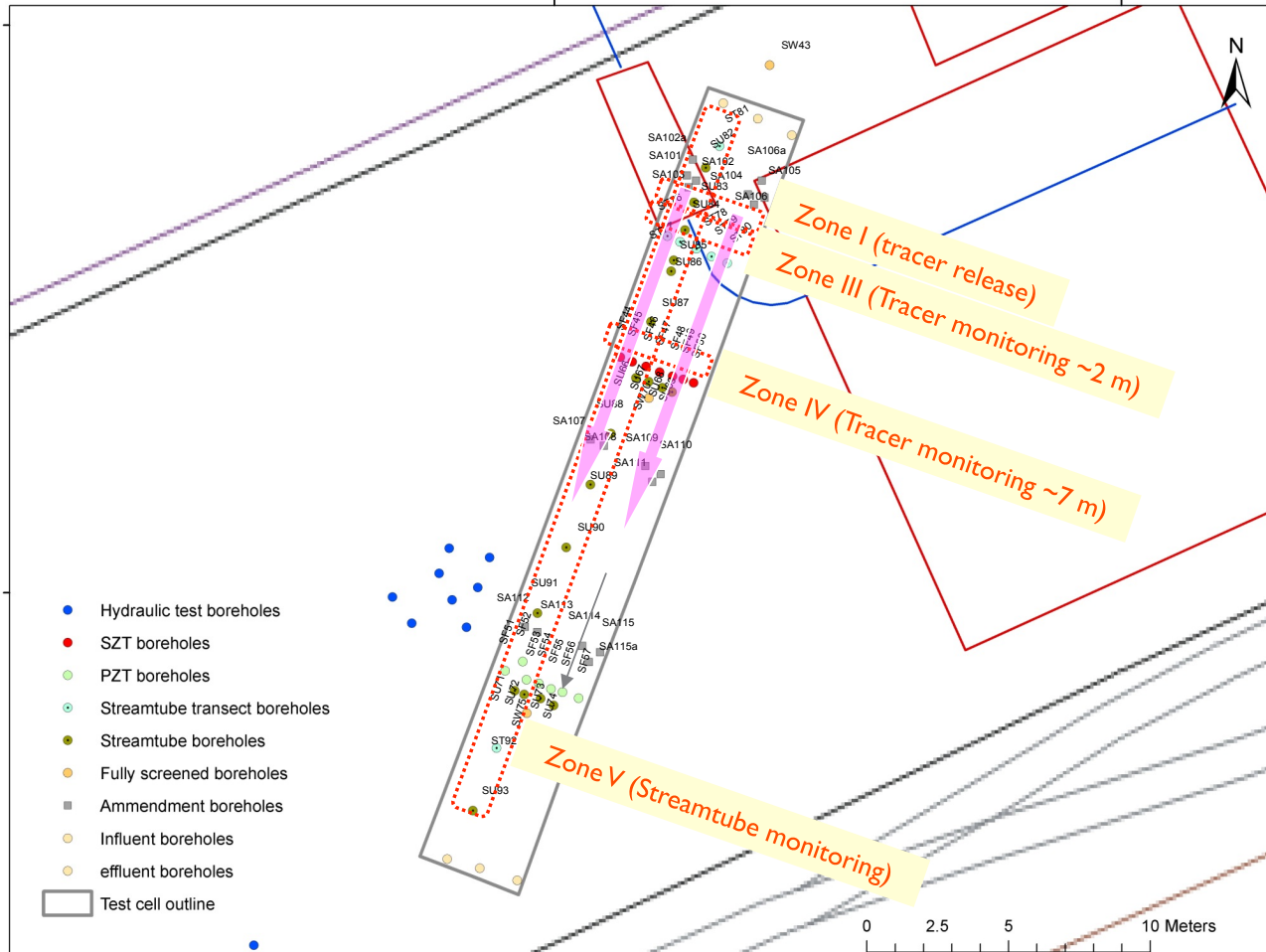
MLS Wells Revealed that Narrow DNAPL Source Zones Lead to Narrow Plumes



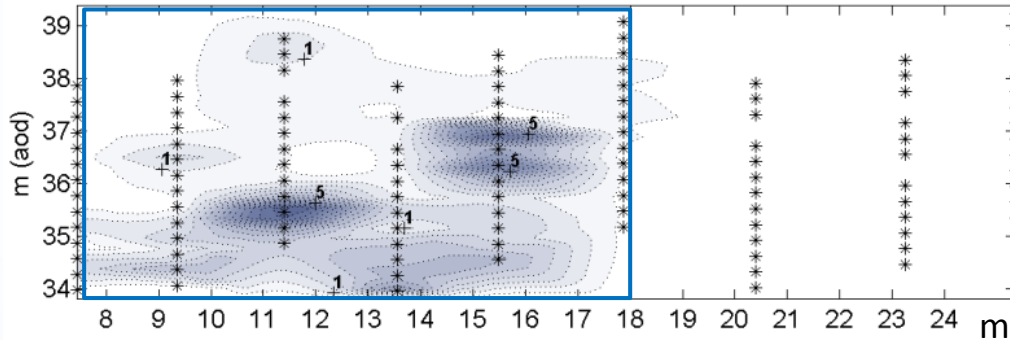
MLS Transects to Quantify Hydraulic Parameters



Tracer Test MLS Transects

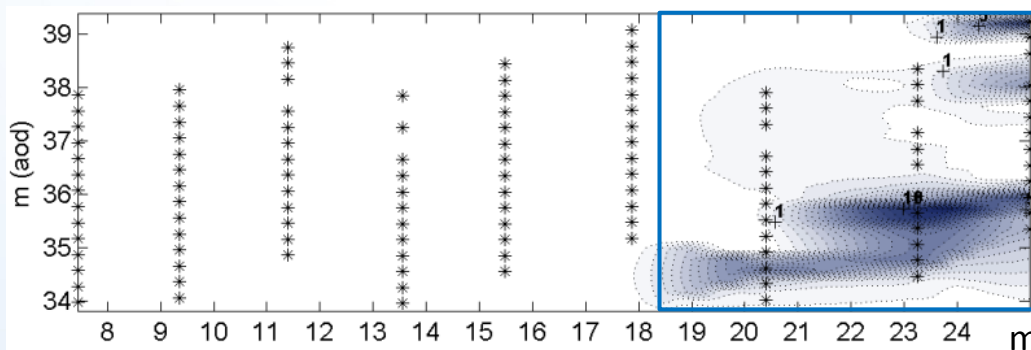


T5: Scale and velocity dependent α_L



$$\bar{v} = 1.44 \text{ m/d}$$

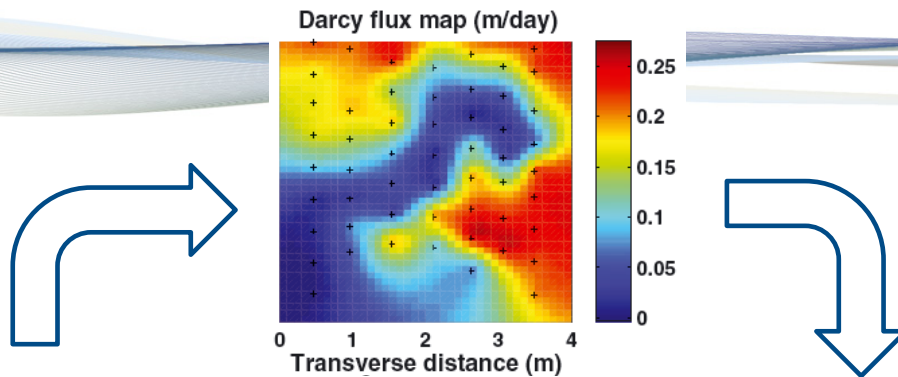
$$\alpha_L = 0.43 \text{ m}$$



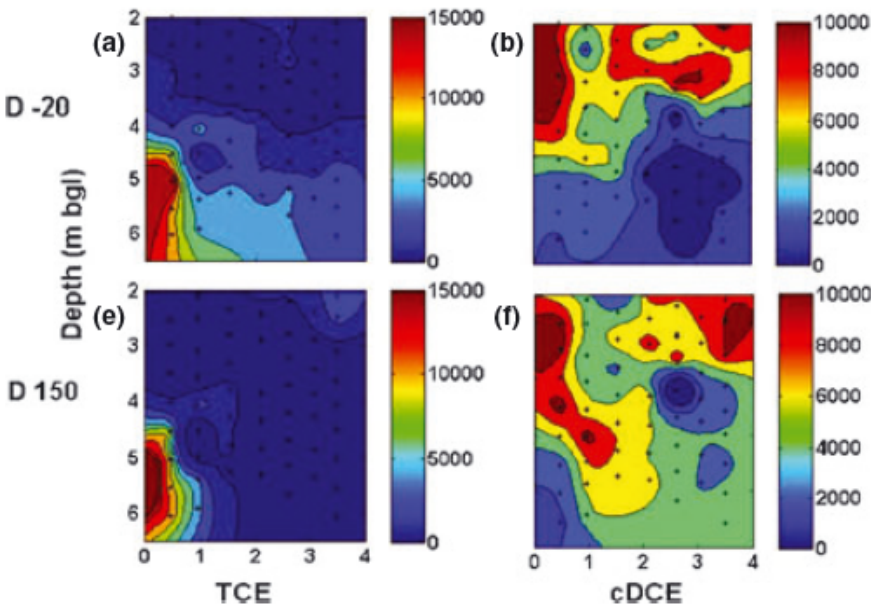
$$\bar{v} = 2.99 \text{ m/d}$$

$$\alpha_L = 0.09 \text{ m}$$

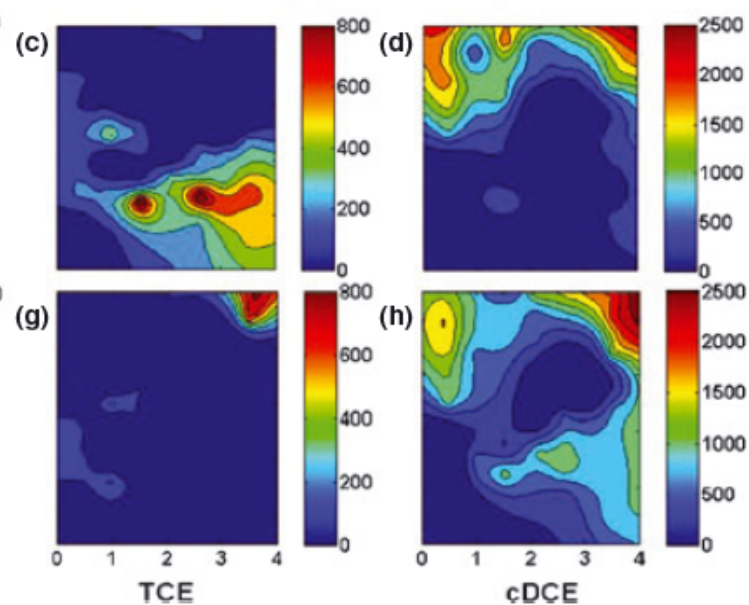
Use of MLS Wells for Flux-Based Assessments



Concentration Map (μM)



Flux Map ($\text{mmol m}^{-2} \text{d}^{-1}$)





Closing Comments

Why are we Still Discussing MLS technologies?

- The commercial industry is still relatively small, although MLS systems are now mature
- There are few, if any, comprehensive publications concerning the use of MLS systems
- The professional community of groundwater scientists and engineers is still under-educated about the value of the data obtained from MLS wells and may be unprepared for the level of sophisticated decision making needed to properly select and use MLSs
- There are many ways to fail when installing a multi-level system and to avoid failure requires careful planning and support by highly qualified field technicians and drill crews

MLS education should be a prerequisite in the training of hydrogeologists



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Thank you for your attention

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Round Table Discussion: Full Panel & Attendees

MLS systems

- Where next?
- Acceptance of flux versus concentration metrics
- Provision of best practice guidance

Fractured Bedrock Characterization

- What are the key factors that limit characterization (and eventually the remediation) of bedrock groundwater systems
- How do we maximize the use of fractured bedrock research sites?

Education and Awareness

- How do we translate research findings to best practice?
- Development of Standard Protocols
- Cost Benefit Assessment
- Professional Accreditation