Selection, Design and Construction of a Multilevel Groundwater Monitoring System

EPA Region 10 Fractured Rock Workshop

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EPA Region 10 - Seattle
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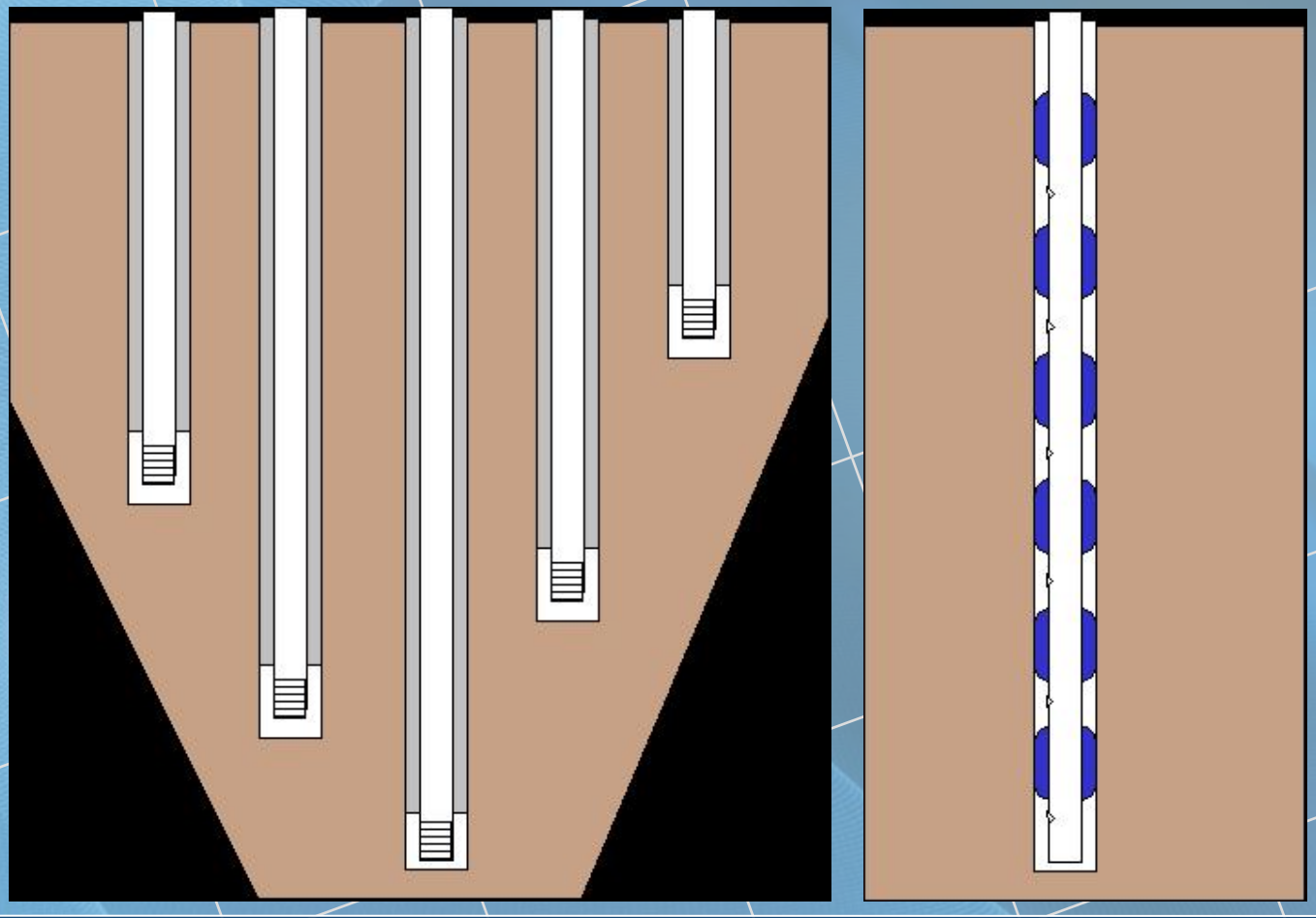

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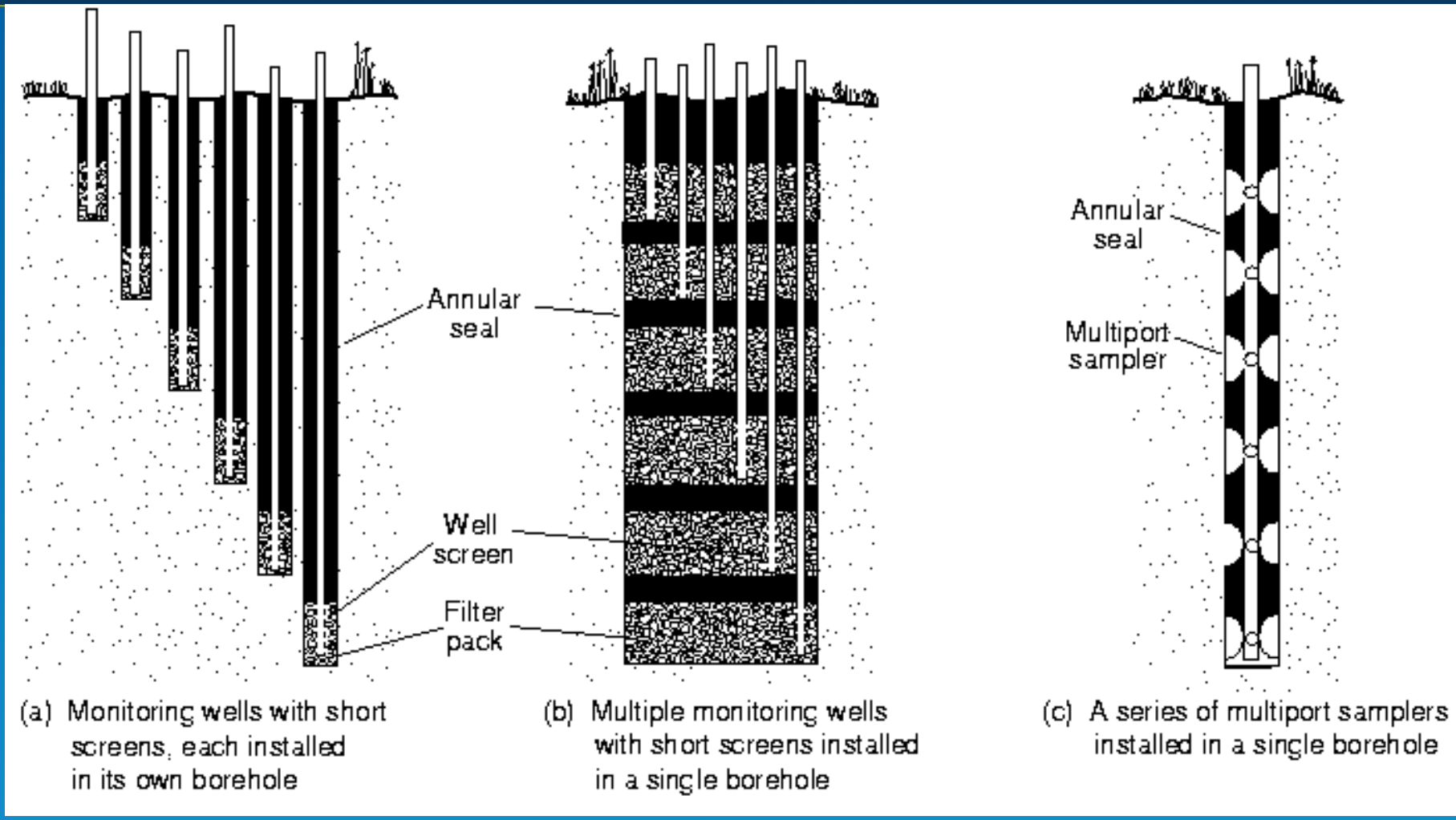
What is a Multilevel Groundwater Monitoring System?



(a) Monitoring wells with short screens, each installed in its own borehole

(b) Multiple monitoring wells with short screens installed in a single borehole

(c) A series of multiport samplers installed in a single borehole

Commercially Available MLS Technologies

- **Waterloo** (Solinst) modular Multilevel System (MLS)
- **Westbay** (Schlumberger) Multi-port (MP) System Water
- Water **FLUTe**™ (Flexible Liner Underground Technologies)

All are good quality and widely used

Other systems not covered in this presentation, such as;

- Solinst CMT
- BESST Barcad and ZIST
- Waterloo Continuous Multichannel Tube (CMT) system

Why Use a Multilevel System?

- Driven by the Conceptual Site Model (CSM):
  - Project objectives
    - Need to characterize complex Site conditions
  - Hydrogeology
    - Depth to water
    - Aquifer Thickness
  - Stratigraphy (i.e. vertical expanse of fractured rock aquifer)
  - Vertical and Lateral extent of groundwater contamination

- Selection Considerations:
  - Sustainability, Monitoring needs, Downhole equipment, O&M, Drilling methods, Work area, Decommissioning.

Advantages of a Multilevel System

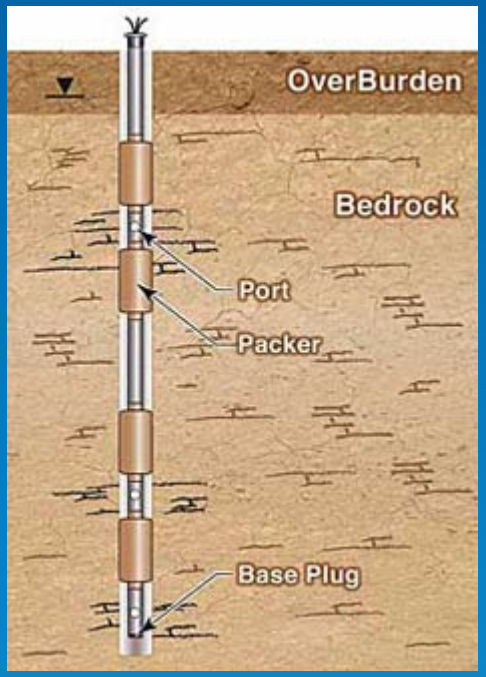
- Depth discreet water quality and water level elevation data
- Reduced footprint (One borehole/well (multiple ports) vs multiple borings/nested wells)
- Reduced drilling costs (One borehole, less derived waste)
- Reduced sampling costs vs conventional wells

Disadvantages of a Multilevel System

- Requires specialized support equipment and training (Waterloo and FLUTe need gas drive pump/bladder pump; Westbay needs wire line tool)
- Limited use as observation wells during aquifer testing
- Life span/downhole equipment failures/O&M

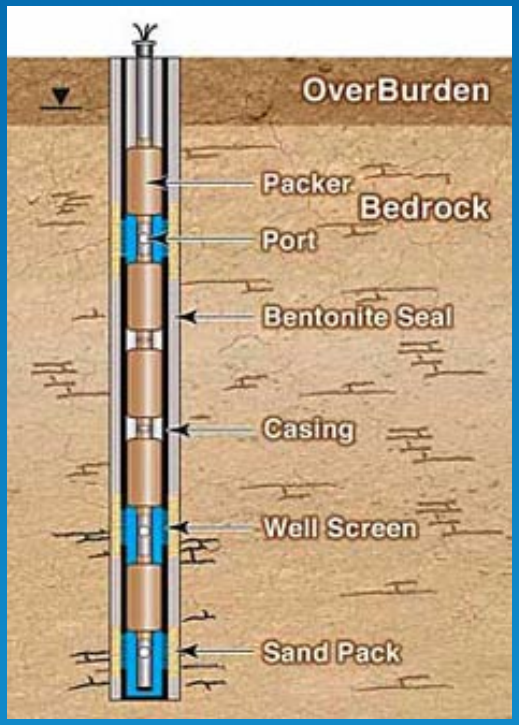
Assumption: All systems assume that ambient groundwater flow maintains representative groundwater at the sampling port.

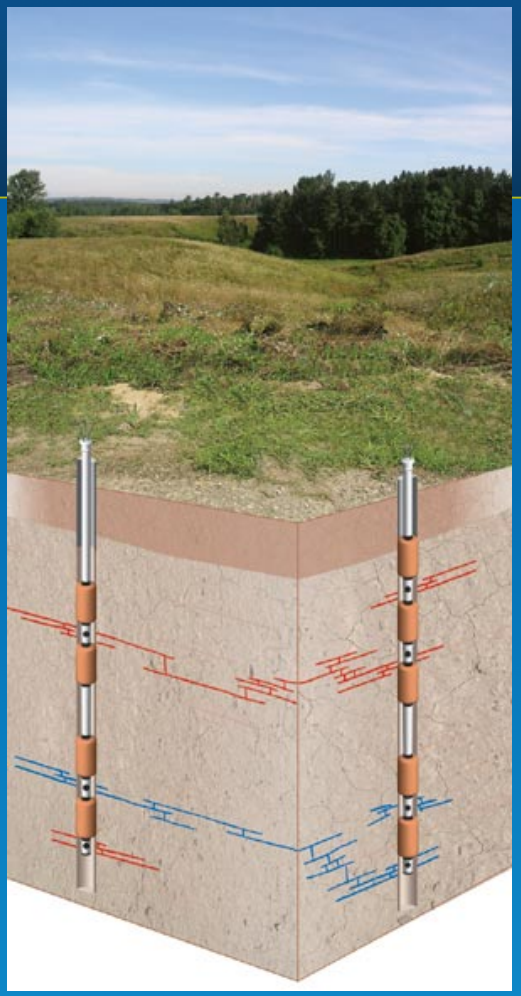
Waterloo System



Installation in an open borehole

Installation in a well





Monitoring fracture zones

Source: Solinst

Waterloo System Advantages

- Gas drive sampling (double valve or bladder pump)
- Able to obtain large sample volumes (i.e. treatability studies)
- Low-flow capable and collect water quality parameters
- Proven technology

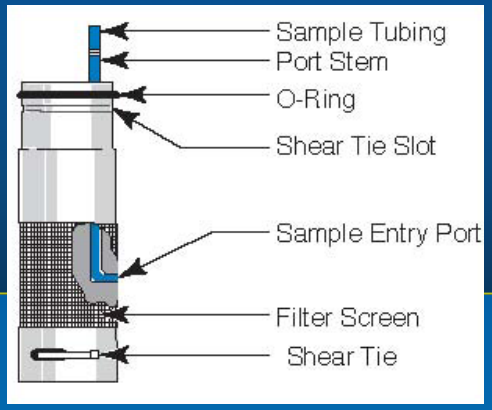
Waterloo System Disadvantages

- Relatively complicated installation process
- Requires expansive work area (laid out assembly)
- Downhole equipment (packers, transducers, pumps) – assess
- Tubing problems (kinks during installation)

Waterloo System Layout

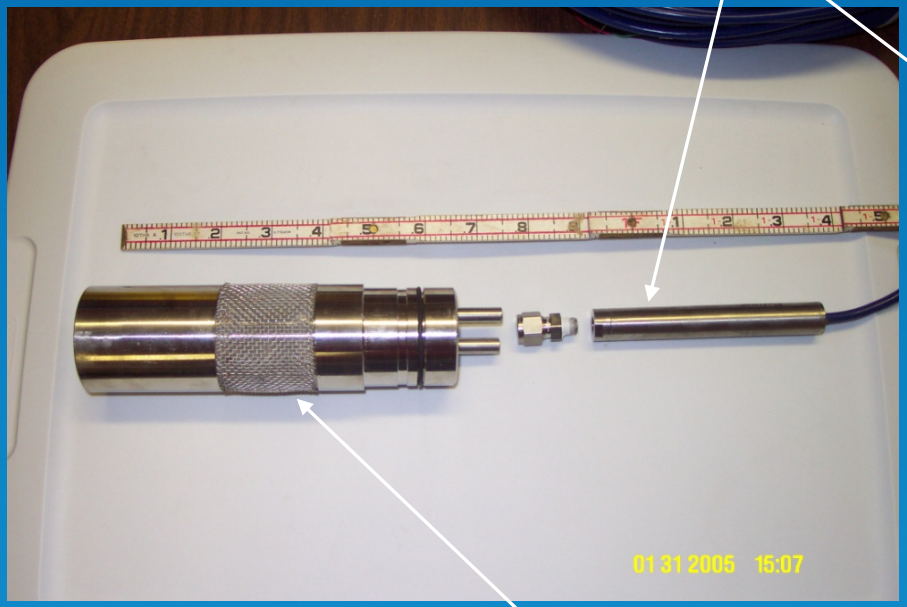
Waterloo Components Going Downhole

Waterloo Components



Bladder Pump

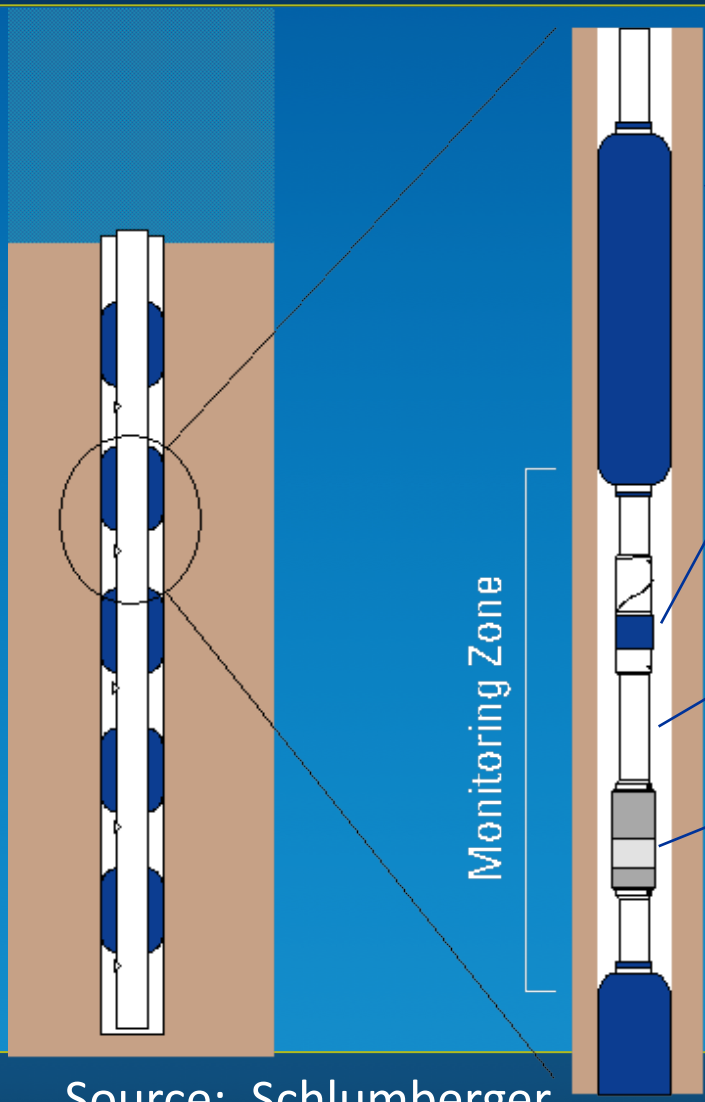
Transducer



Sampling Port

Waterloo System Sampling

Westbay System



1. Packer
(reliable seal)

2. Measurement port
(sampling and in-situ measurements)

4. Casing (variable lengths)

3. Pumping port (for hydraulic conductivity testing and purging

Source: Schlumberger

Westbay System Advantages

- Relatively simple installation/Requires small work space
- Transducer and sampler are on a wire line
- Joints are pressure tested during installation
- Packers are inflated with water to a specific pressure
- Long term maintenance requirements are low
- Proven technology

Westbay System Disadvantages

- Maximum volume per trip is 1 liter
- No pre-purge or low-flow sample collection method
- Limited capability to collect water quality data, especially DO.

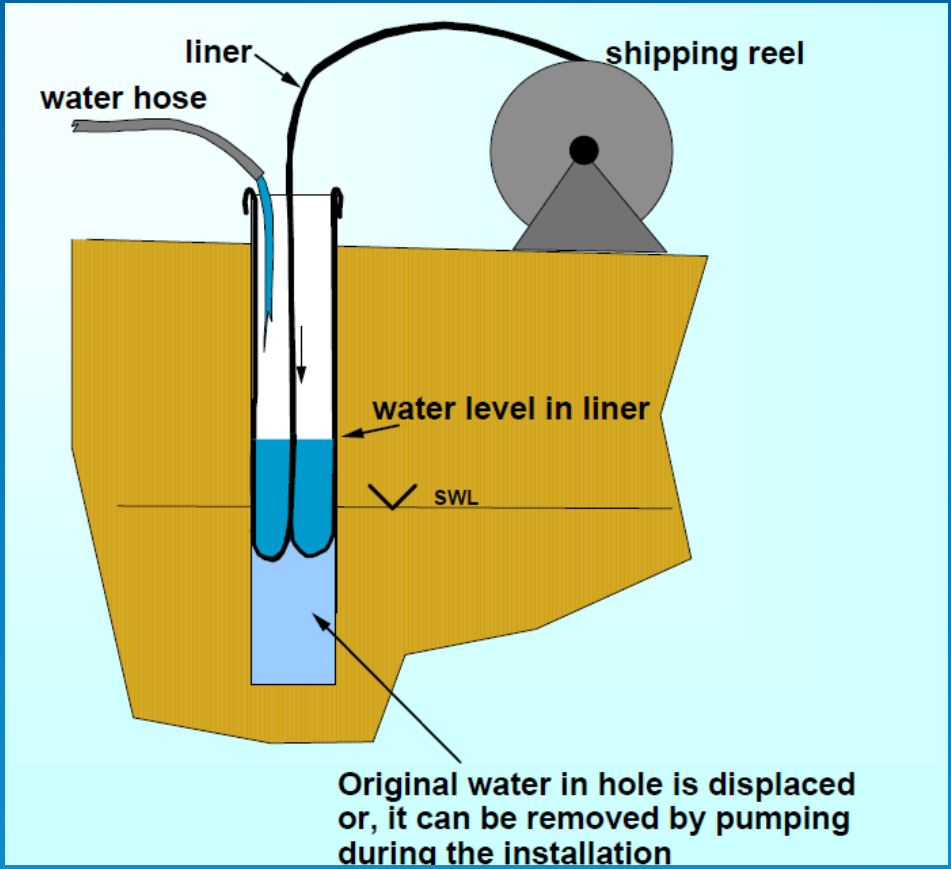
Westbay Equipment Layout

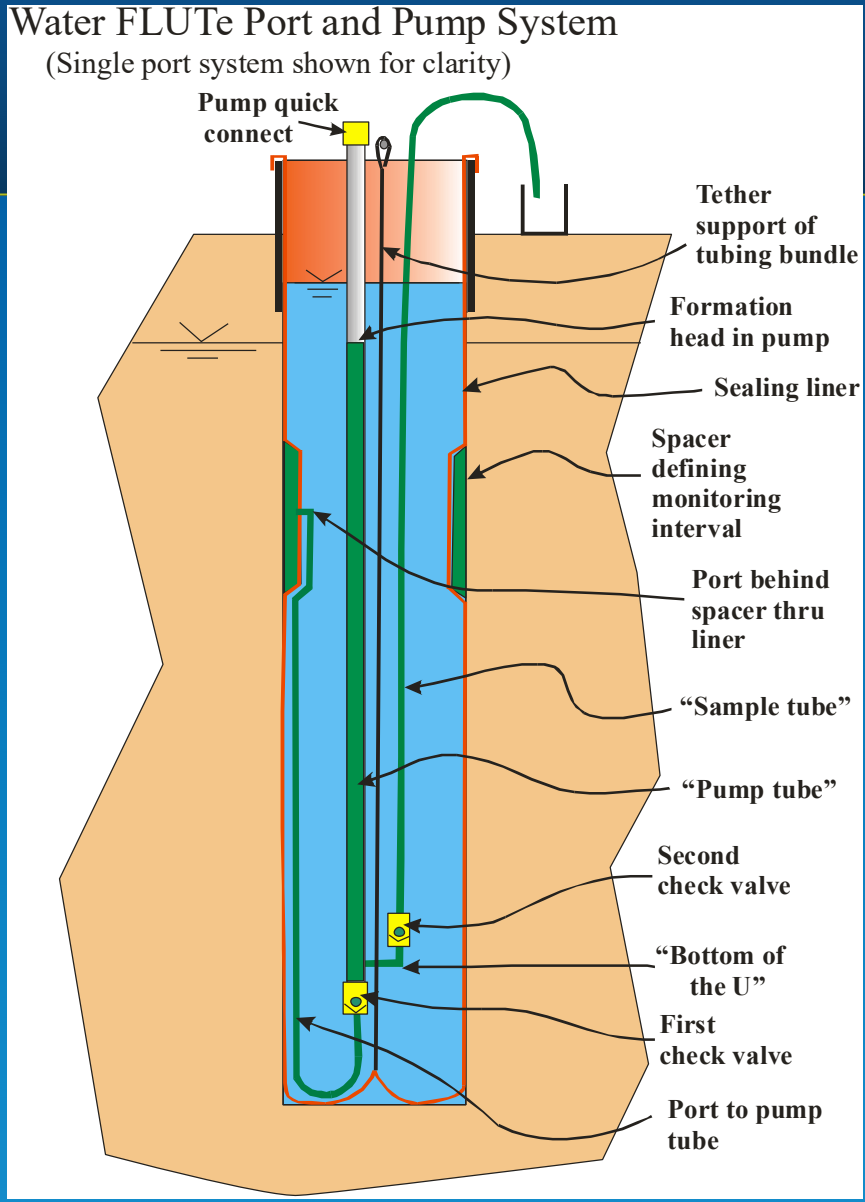
Westbay Pumping (gray) and Measurement Port

Westbay Packer Installation and Pressure Testing

Westbay Sampling Equipment

FLUTe™ System





Source: FLUT Ltd.

FLUTe™ System Advantages

- Liner seals entire borehole wall
- Relatively simple installation process/Relatively small work area
- Gas drive sampling/Practical to obtain large sample volumes
- Low-flow capable and water quality parameter measurements
- Proven technology

FLUTe™ System Disadvantages

- Pumps and transducers are downhole
- Fabric liner can rip or tear
- Gas lines must be purged to obtain current water level readings
- The water level inside the liner must be checked and maintained above the static head in the formation

The “quintet” is:

1. The Blank Liner

   Seals the borehole with liner installation

2. The NAPL FLUTe

   For mapping pure product on the hole wall

3. The Felt Activated Carbon Technique (FACT)

   Maps the dissolved phase in the pore space and fractures

4. The Transmissivity Profiler

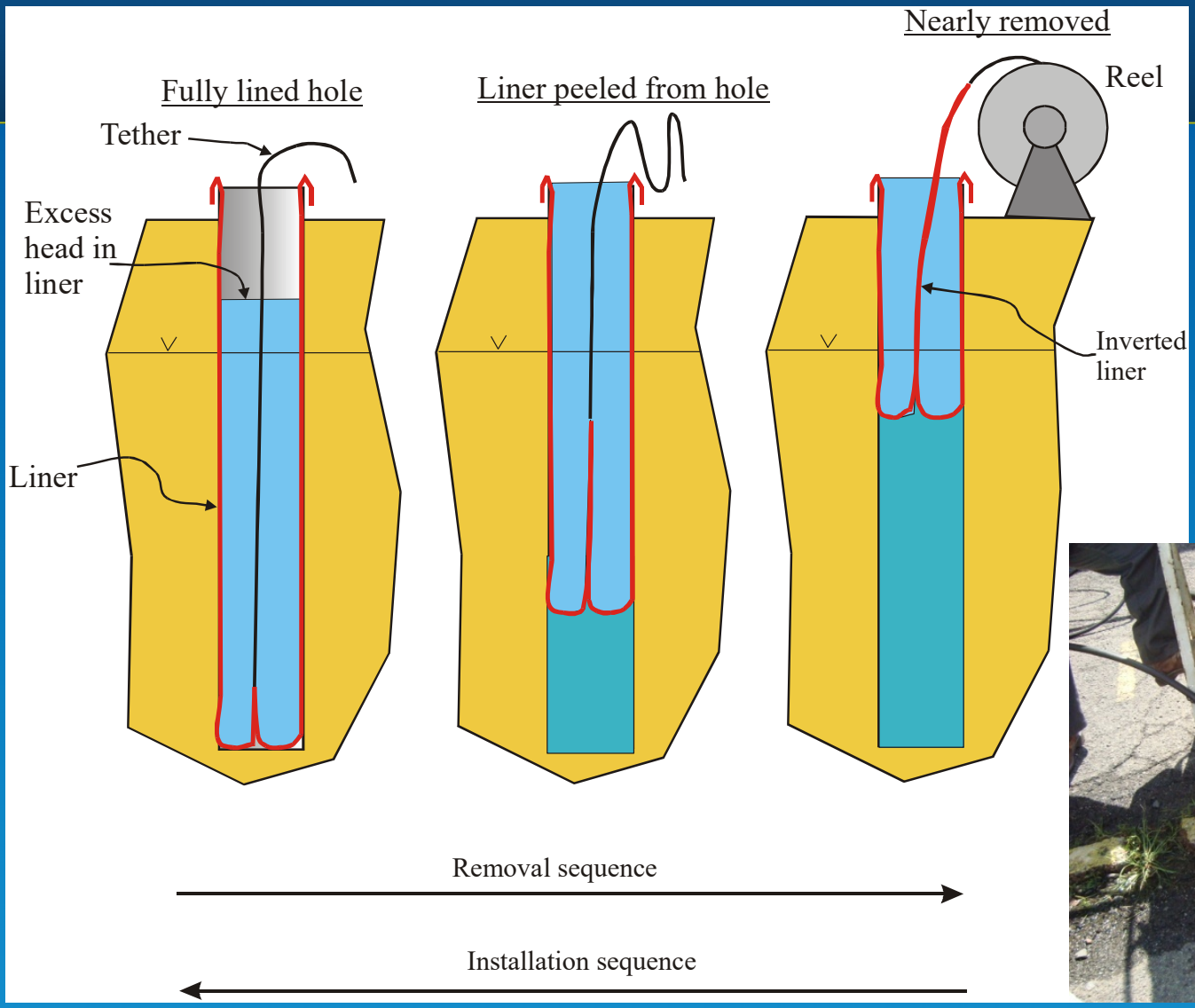
   Maps the borehole transmissivity during the sealing liner installation

5. The Water FLUTe

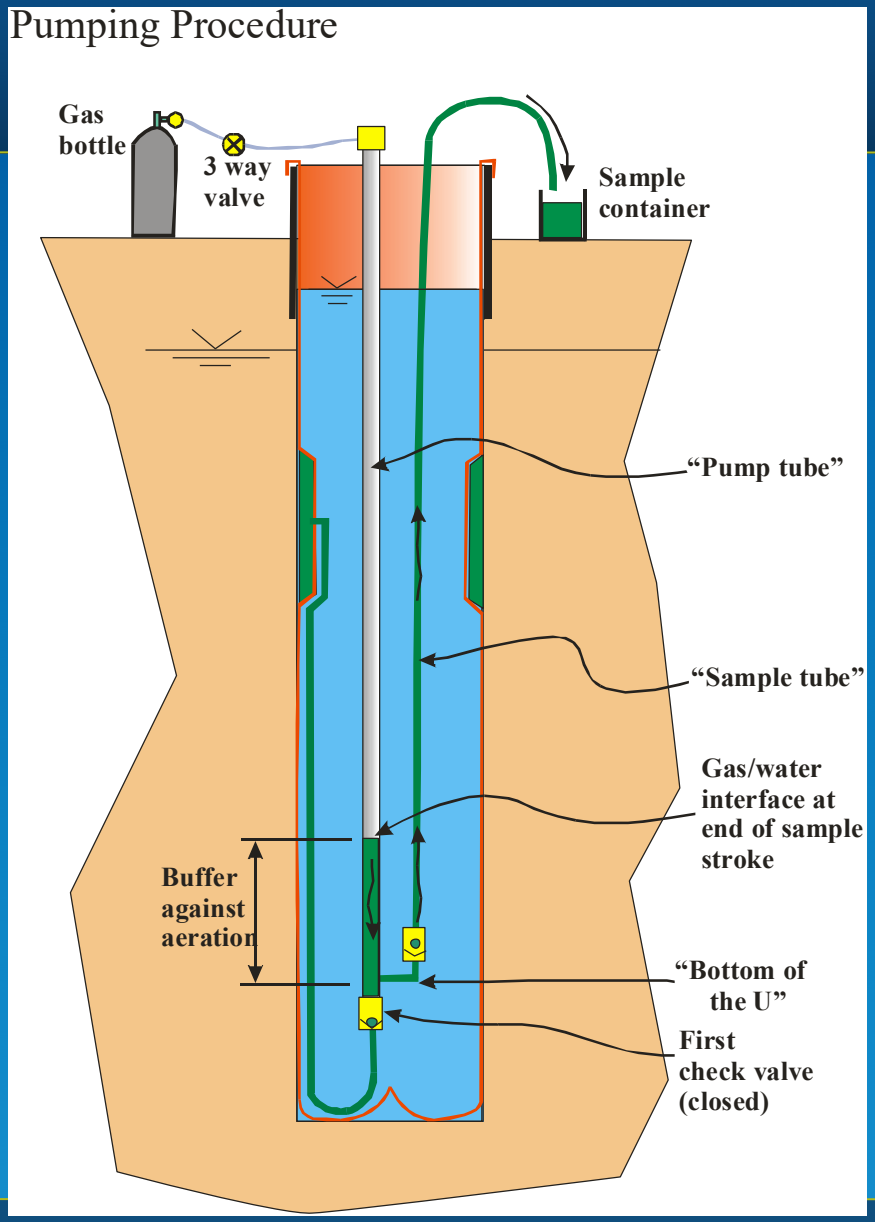
   A Multi-level ground water sampling and head measurement system

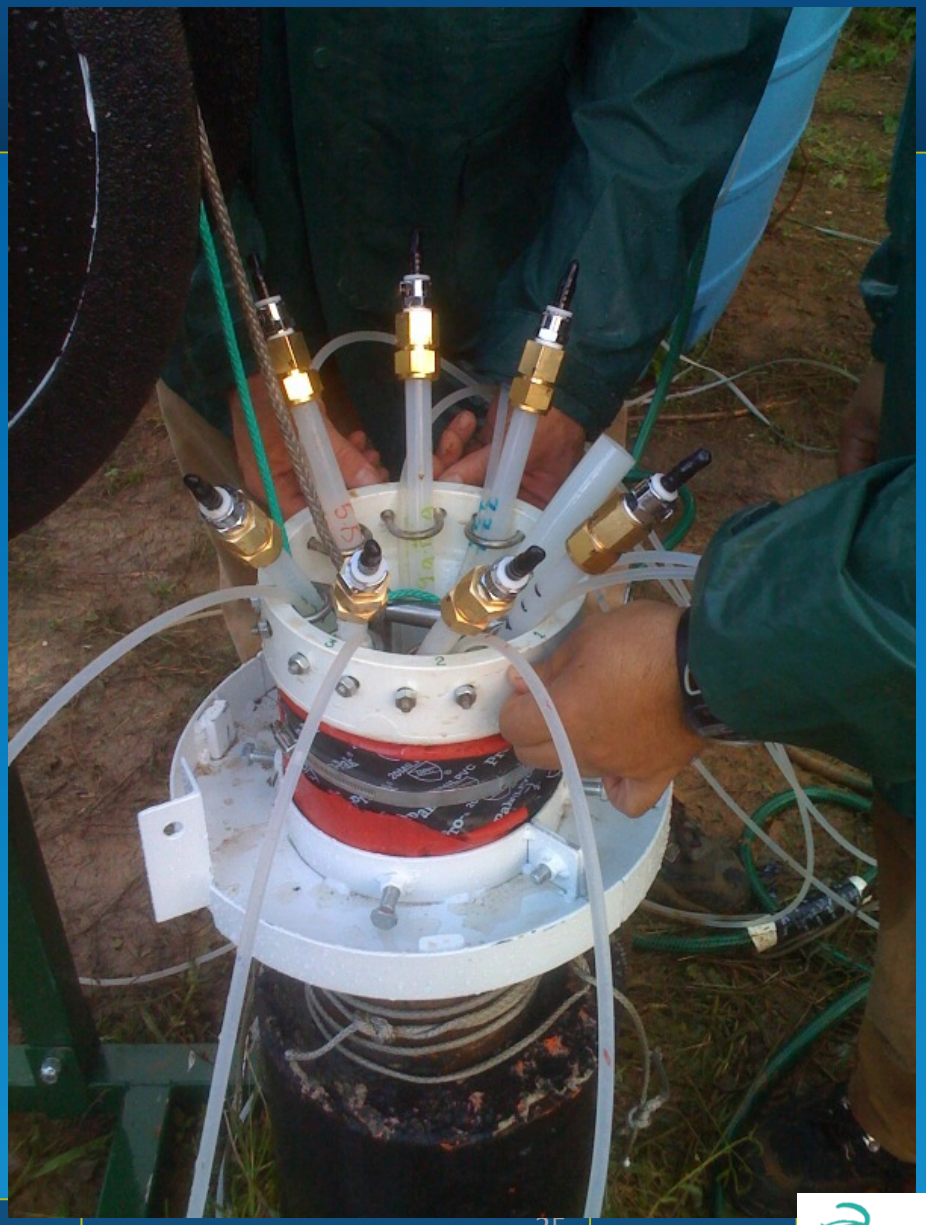
Water FLUTe™ and Blank Liner

FLUTe™ Installation



Water FLUTe™ Sampling Procedure





FLUTe™ Examples

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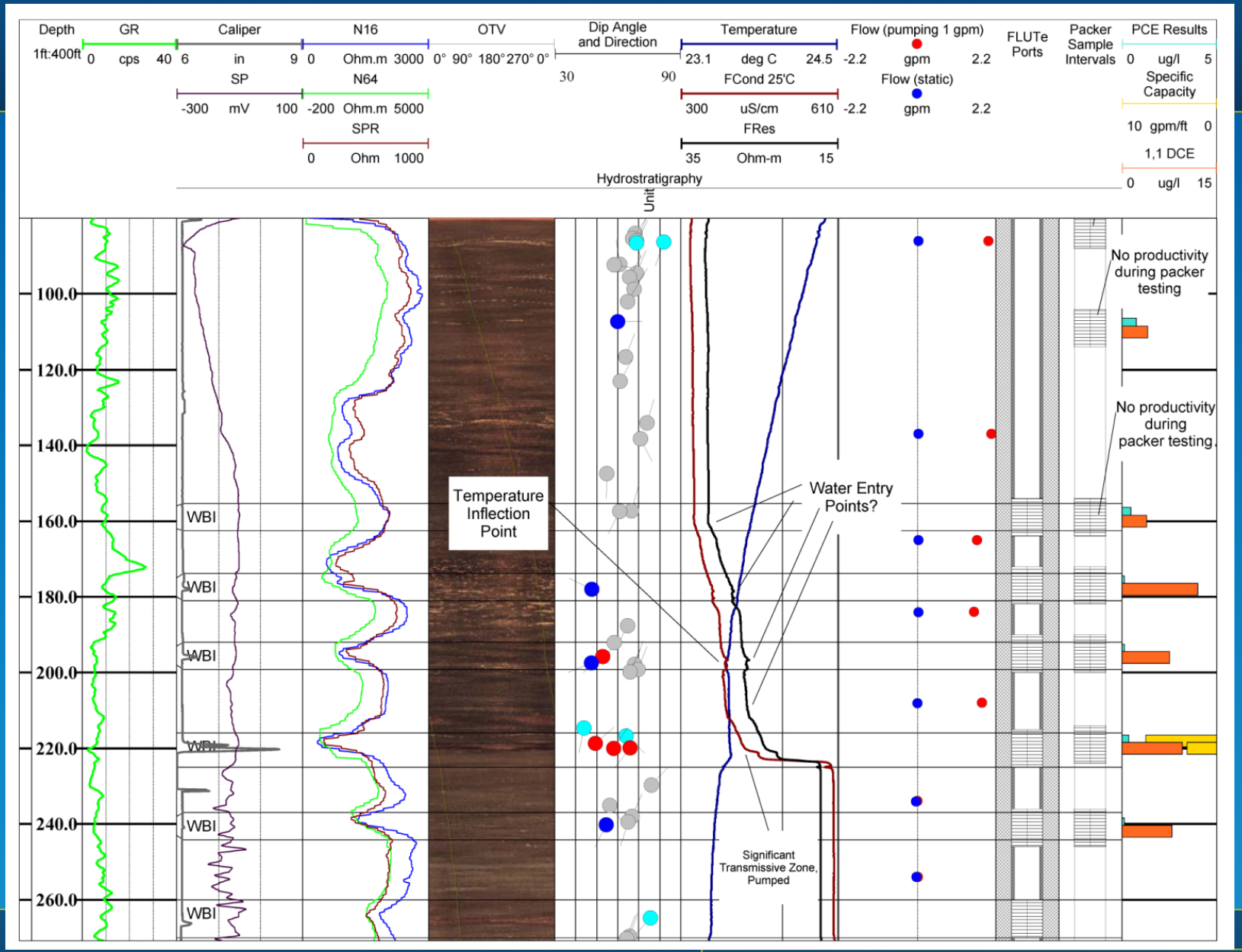
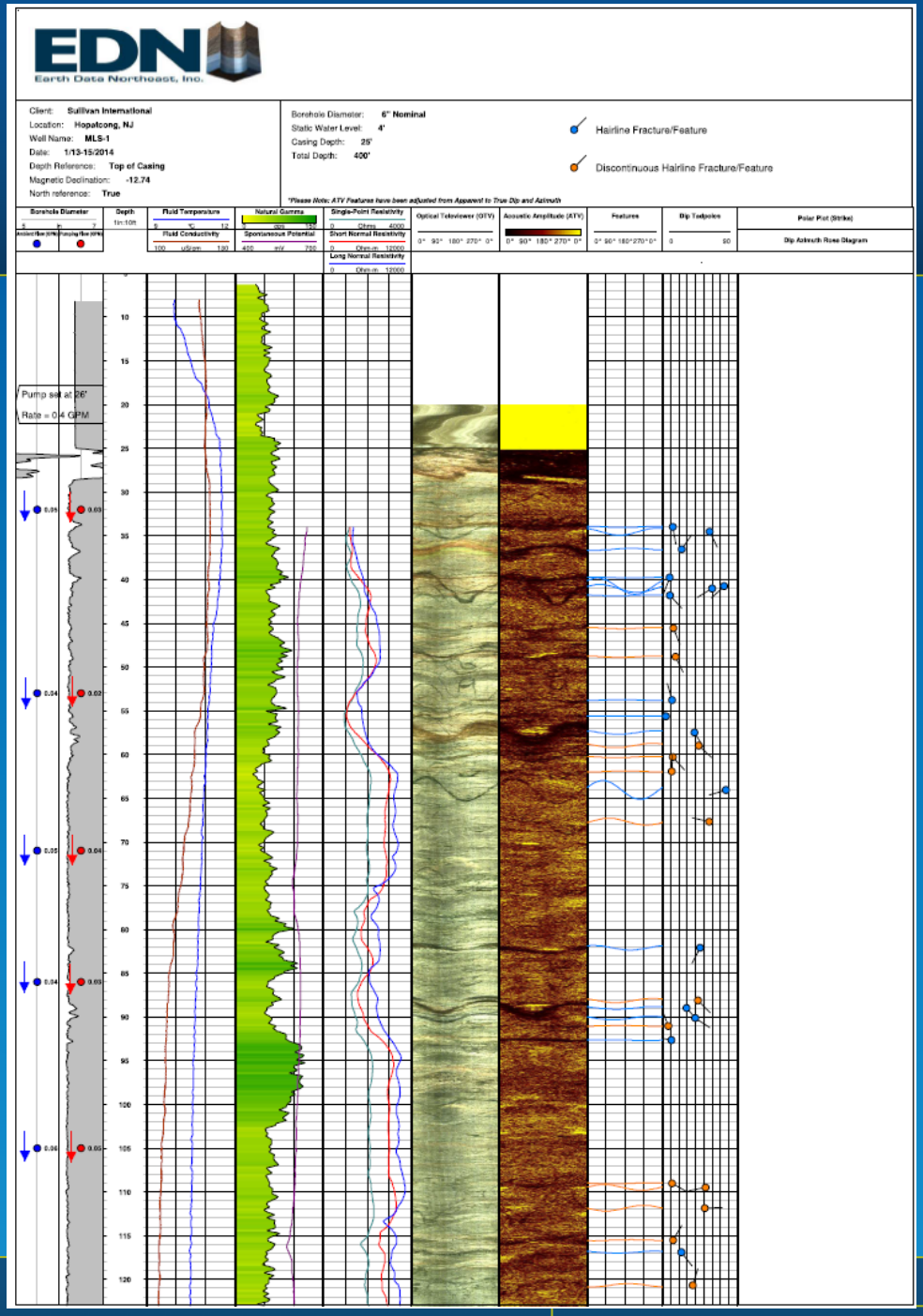
FLUTe™ Examples

Design Considerations

- Multilevel system design is based on:
  - Good Conceptual Site Model/Knowledge of Site geology (horiz and vertical hydrostratigraphic data, some groundwater quality data)
  - Desired number of ports (based on borehole packer testing, in-situ groundwater sampling and borehole downhole geophysical logging)
  - Optimal borehole or well diameter/Maximum depth of installation
  - (Overburden) Direct push, sonic drilling, or hollow stem auger
  - (Bedrock) Rock core, air rotary, casing advance

Design Using Packer Testing and Borehole Geophysics





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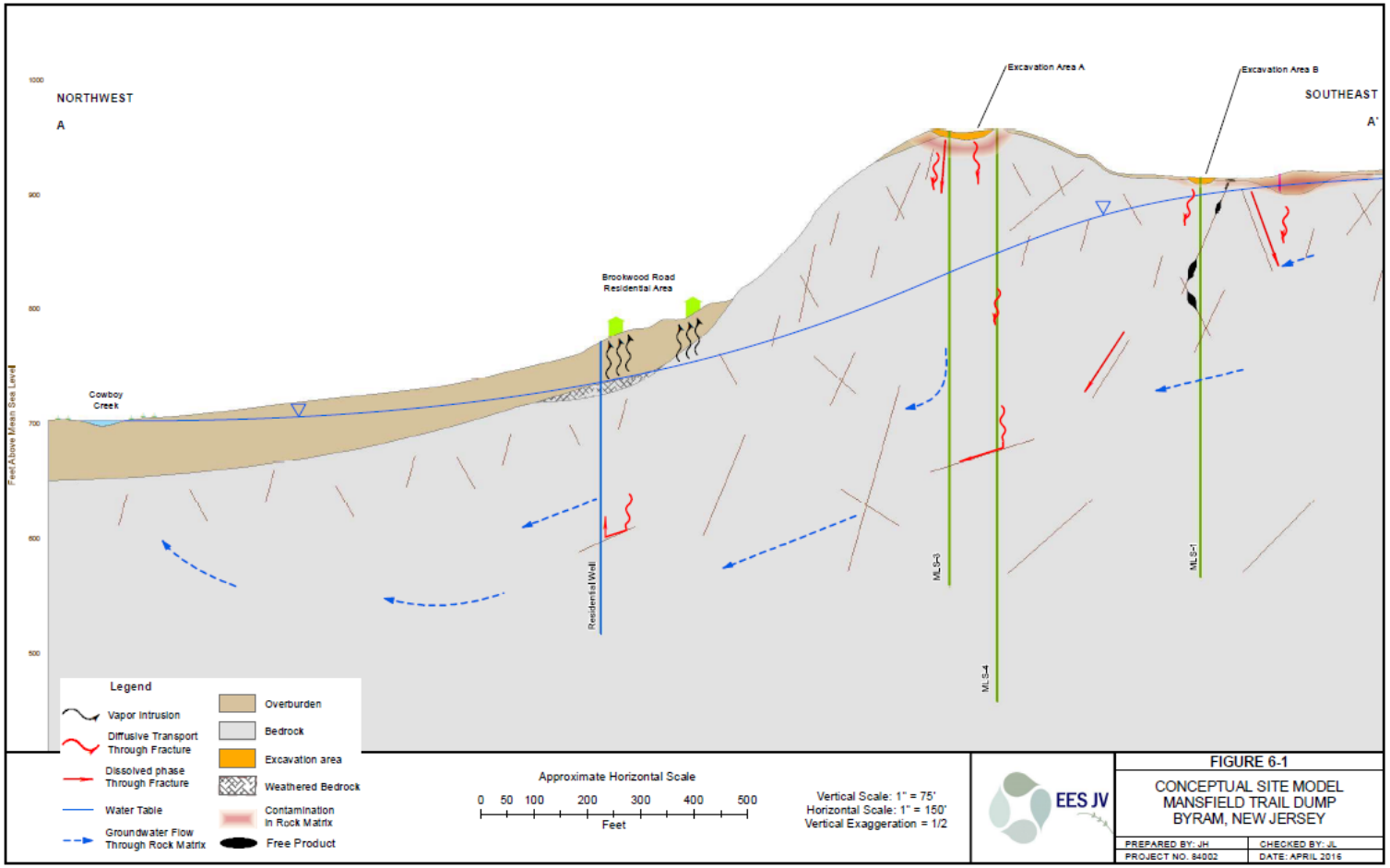
Site Characterization Using Multilevel Well Data



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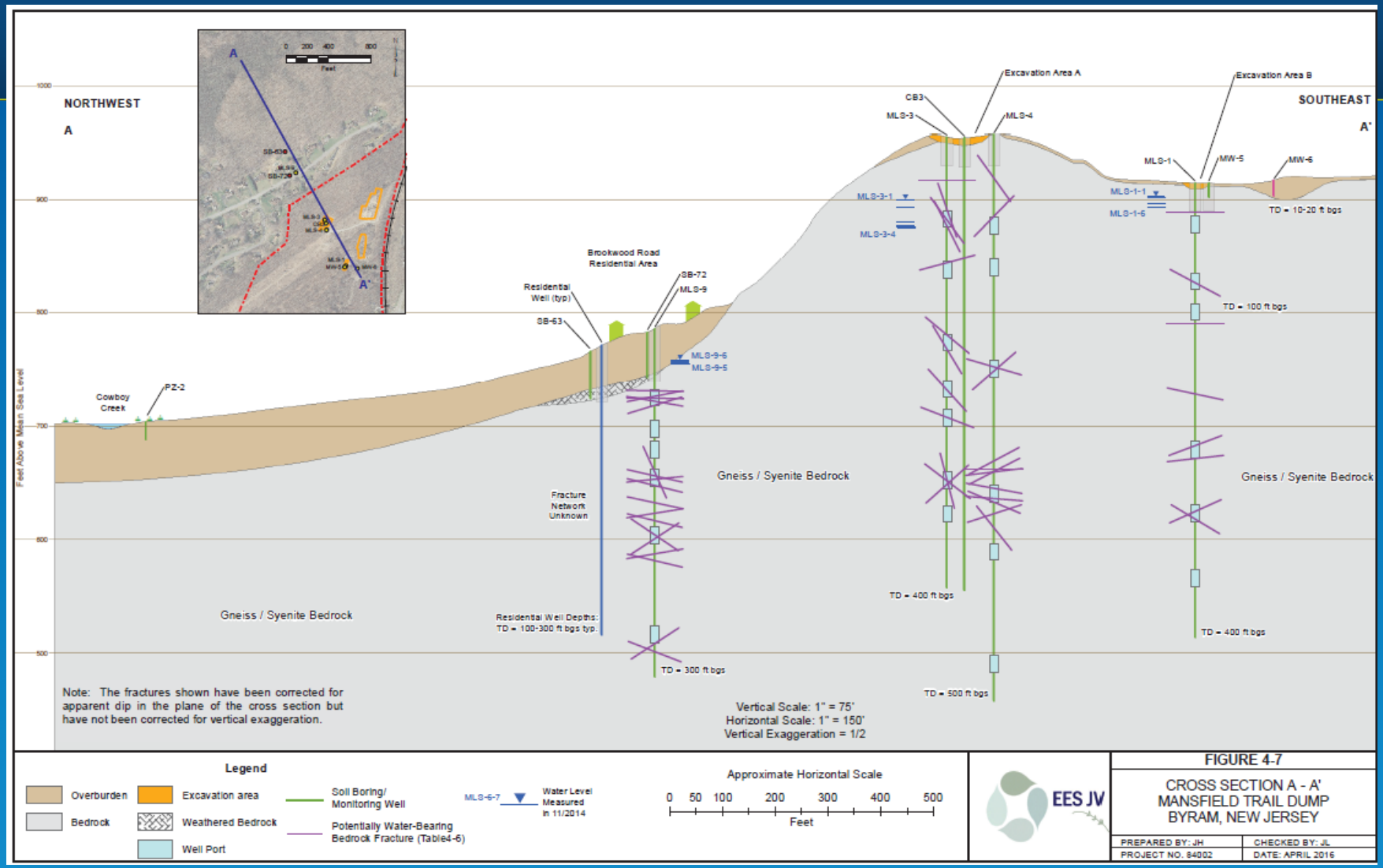

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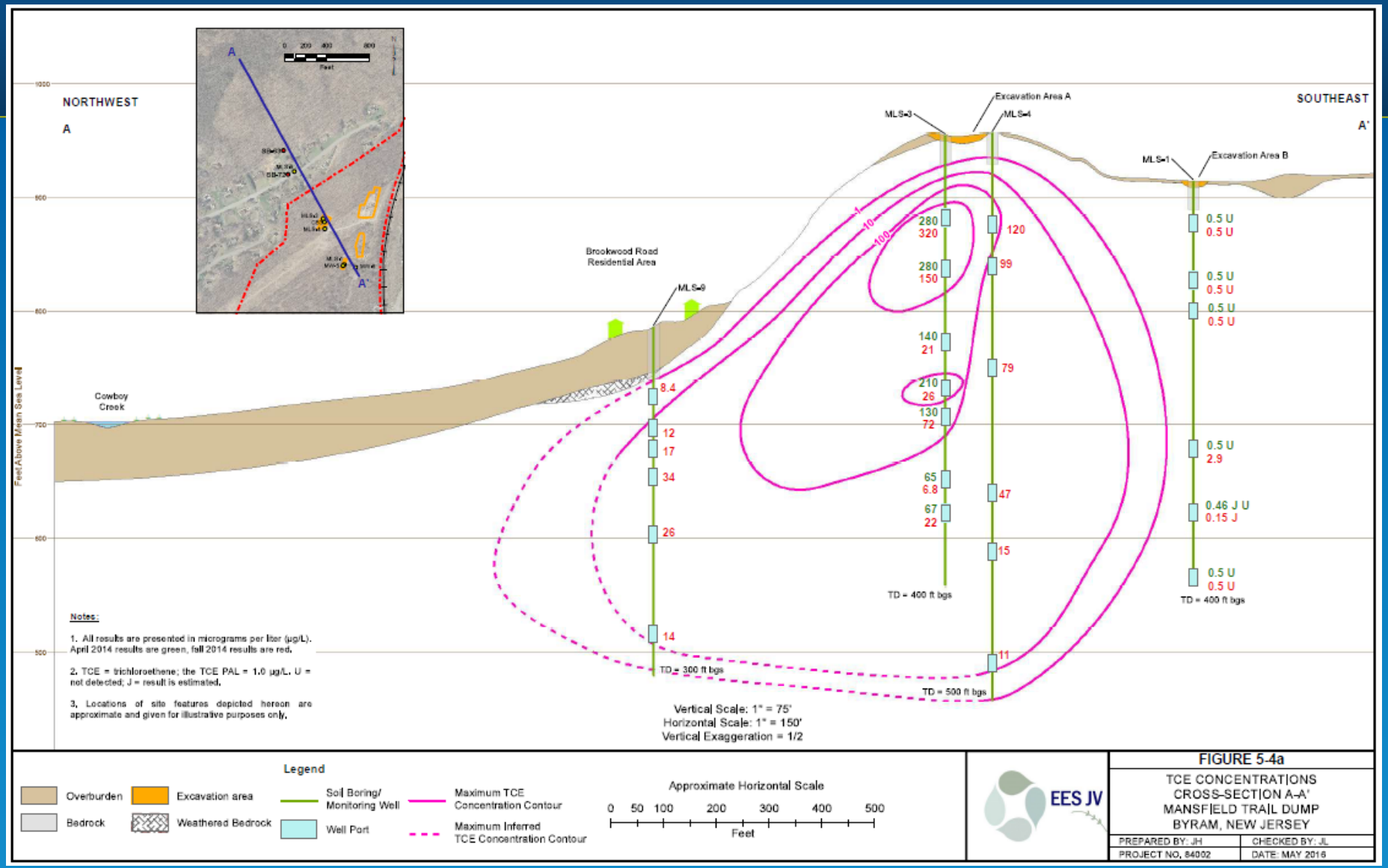
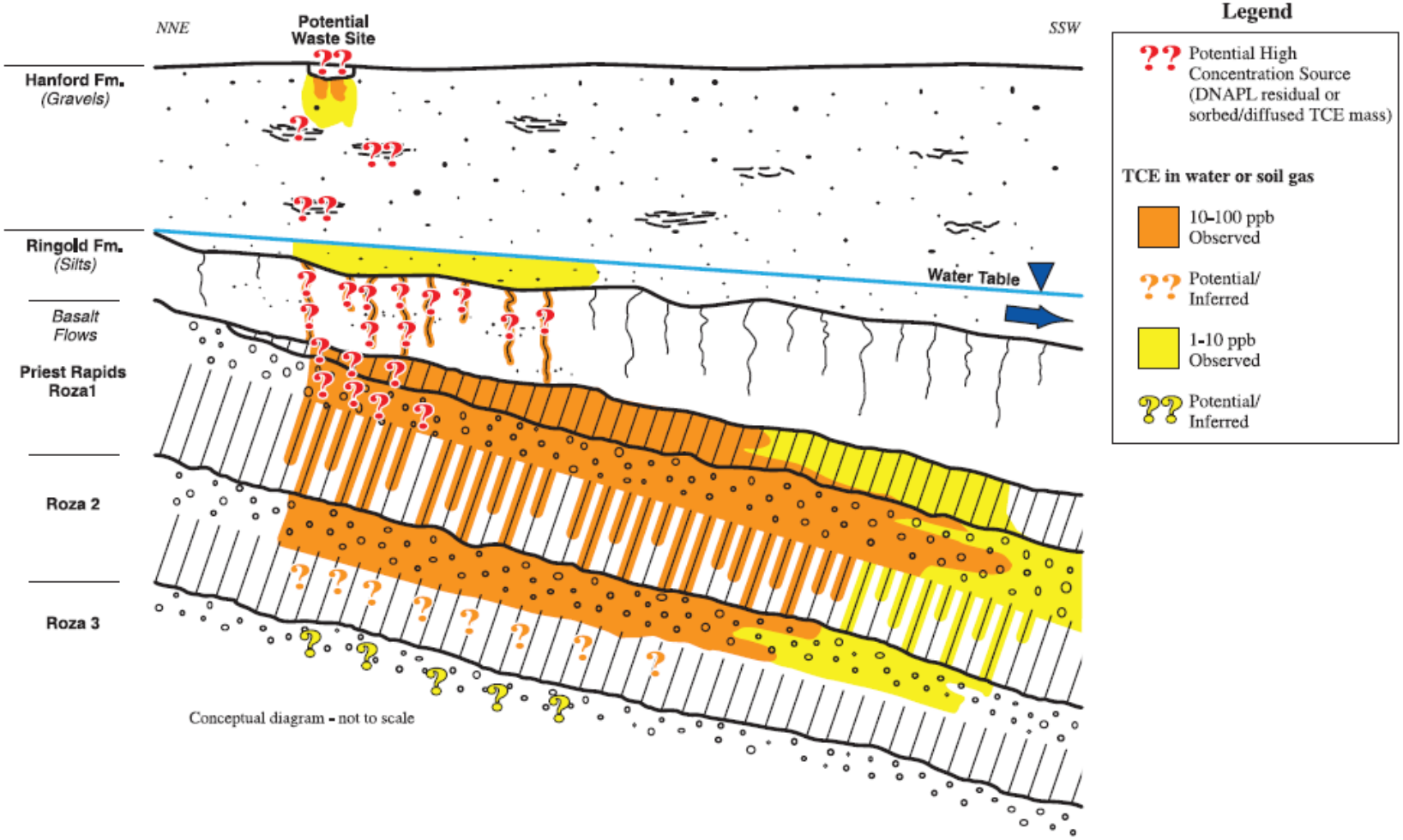


Figure 3.

Hydrogeologic Conceptual Model:
TCE Occurrence and Migration Pathways



Questions