The Use of *in situ* Real-Time Direct-Sensing Field Measurements to Enhance the Effectiveness of High Resolution Site Characterization Approaches – Membrane Interface Probe with Hydraulic Profiling Tool (MiHPT) – A Case Study

National Environmental Monitoring Conference
Sampling and Field Measurements Session
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The Problem

- Almost all sites are a complex system of soil, groundwater, surface water, etc. that interact with chemicals released into the environment!

- Extrapolating information from small data sets of "high quality" data to reflect large site-wide conditions is almost ALWAYS inaccurate & misleading.

- Limited characterization results in poor decisions regarding:
  - Exposure Risks
  - Remedial Actions

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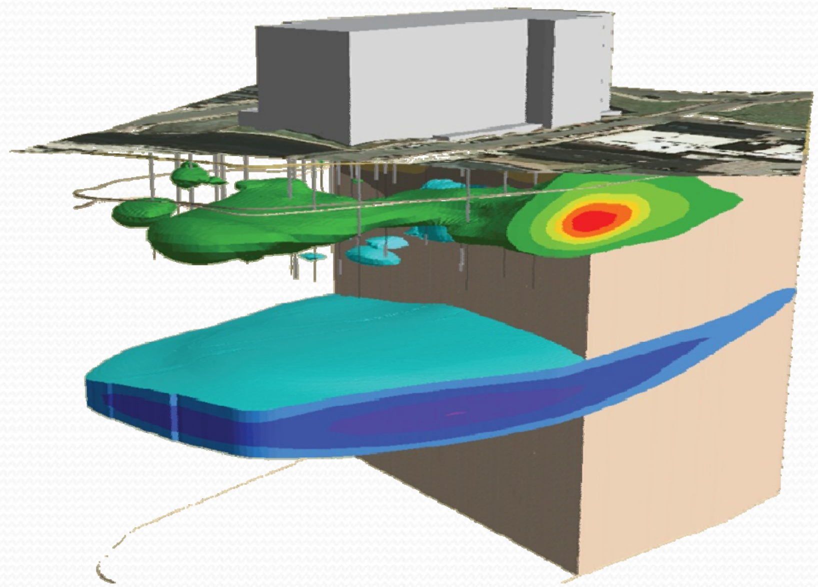
The Solution

- High Resolution Site Characterization (HRSC)
  - Utilizes real-time field measurements, dynamic work strategies and systematic planning
  - Overall goal of increasing data density and reducing uncertainty.



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High Resolution Site Characterization Options

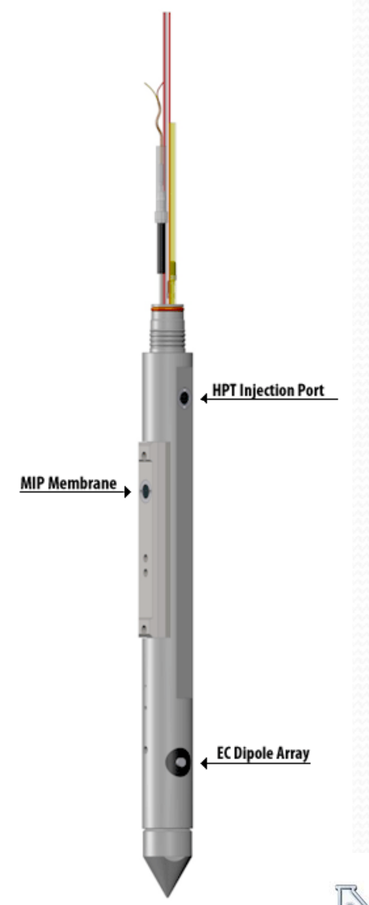
- Prior to common availability of real-time direct sensing tools, field measurement techniques were typically associated with:
  - Mobile Laboratories
  - Field Test-Kits

- A number of direct-sensing options are now available and include:
  - Electrical Conductivity (EC)
  - Cone Penetrometer (CPT) tooling
  - Ultra-Violet Fluorescence Technologies (FFD, UVOST, TARGOST)
  - Membrane Interface Probe (MIP)
  - Hydraulic Profiling Tool (HPT)

Membrane Interface Probe with Hydraulic Profiling Tool (MiHPT)

- Developed by Geoprobe
- MiHPT combines MIP, EC, and HPT in a single downhole tool

- Electrical Conductivity (EC)
  - Current is passed through the formation and read by the probe
  - High electrical conductivity is indicative to fine grained material (i.e., clays and silts)
  - Low electrical conductivity is indicative to coarse grained material (i.e., sands and gravels)



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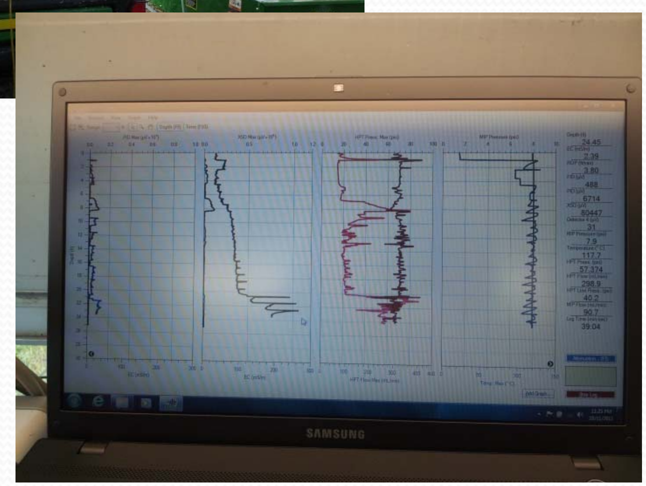
Membrane Interface Probe with Hydraulic Profiling Tool (MiHPT)

- MiHPT combines MIP, EC, and HPT in a single downhole tool

- Hydraulic Profiling Tool (HPT)
  - Uses a downhole transducer to measure the pressure response of soil to the injection of water
  - HPT can provide an estimate of hydraulic conductivity (k) and static water level elevations after post processing dissipation tests



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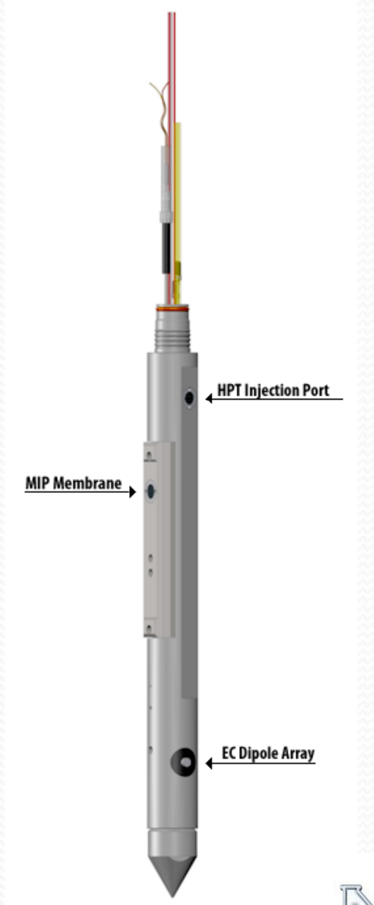
Membrane Interface Probe with Hydraulic Profiling Tool (MiHPT)

- MiHPT combines MIP, EC, and HPT in a single downhole tool
- Membrane Interface Probe (MIP)
  - Screening tool with semi-quantitative capabilities
  - Diffusion occurs by concentration gradient from formation to a clean carrier gas.
  - Up-hole detectors are configured for expected contaminants:
    - PID (BTEX compounds)
    - ECD/ELCD/XSD (Chlorinated Specific)
    - FID (Straight chain hydrocarbons)



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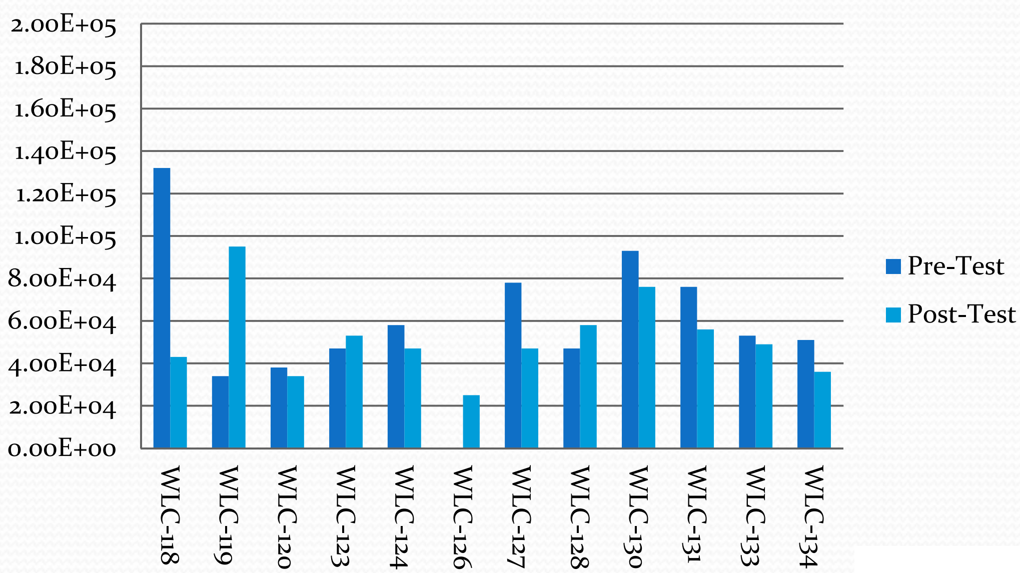
MIP Detector Configuration and QAQC

- PID and XSD detectors were chosen for this project to best detect chlorinated compounds.
- Detectors were run in tandem configuration (Flow is not split to increase mass across detectors)
- XSD utilized because of superior working range and stability compared to ECD and ELCD detectors
- EC/HPT and MIP pre and post-test QAQC completed at each location.

Response Test Results



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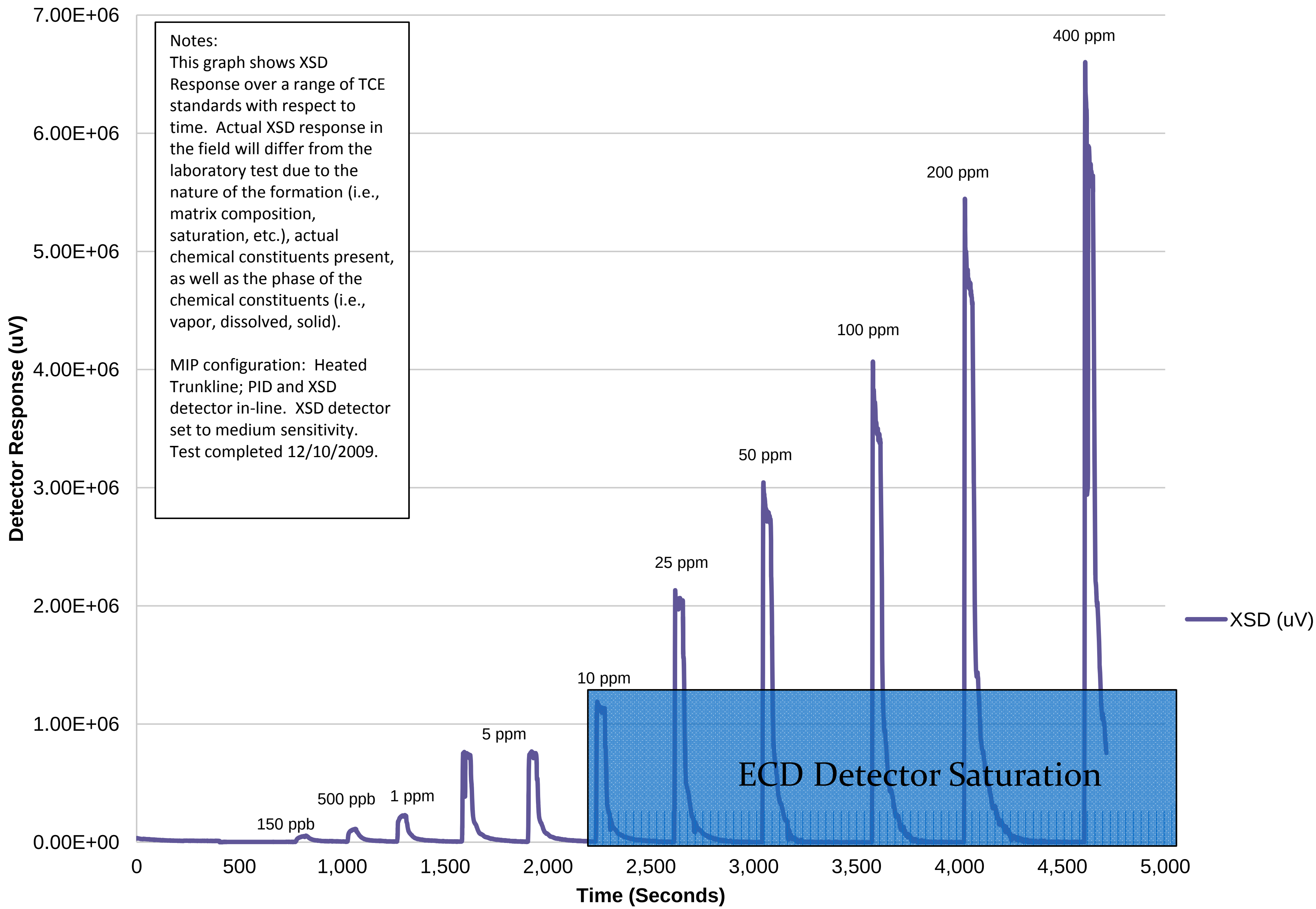
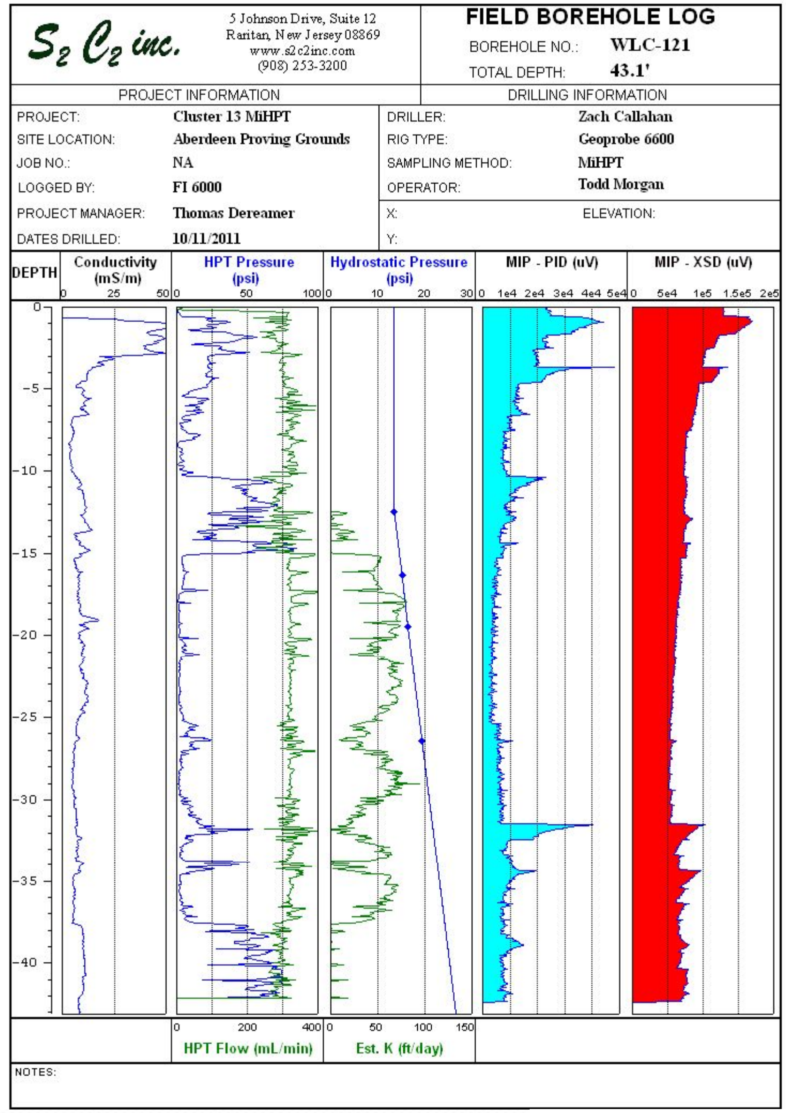
Membrane Interface Probe HTL - TCE Response Test - XSD



MiHPT Output

- Example MiHPT Log with
  - EC data (mS/m)
  - HPT Pressure Graph (psi)
  - HPT Flow Graph (ml/min)
  - Hydrostatic Pressure (from HPT Dissipation Tests) (psi)
  - Estimated K (ft/day)
  - MIP-PID Response (uV)
  - MIP-XSD Response (uV)



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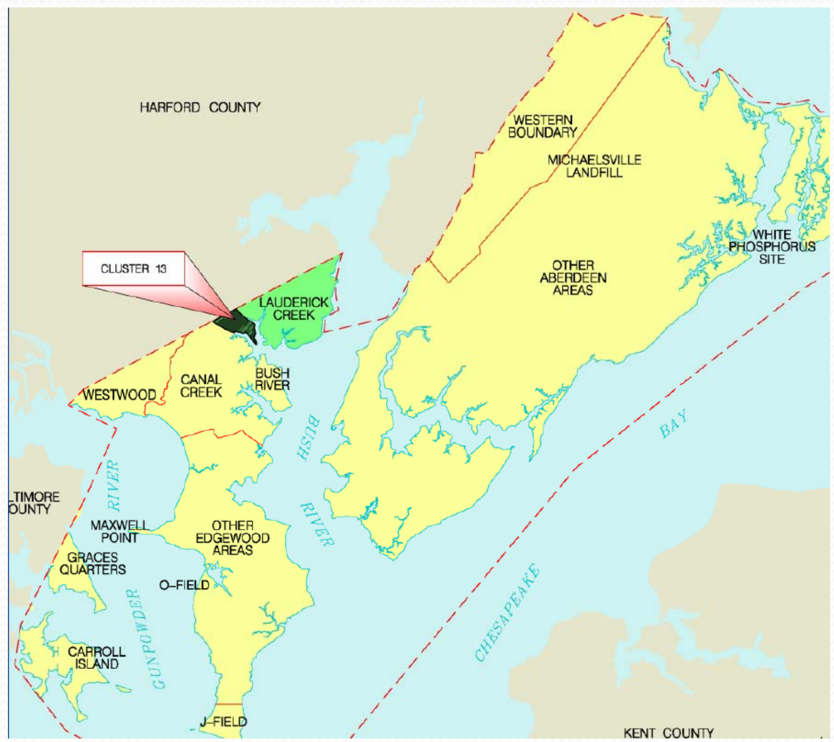
MiHPT Case Study – Cluster 13 Site

- U.S. Army Garrison, Cluster 13 Site located at Aberdeen Proving Grounds, Maryland working with Sovereign Consulting
- Shallow groundwater impacted with chlorinated solvents primarily 1,1,2,2-tetrachloroethane (TeCA)
- A pilot test for an Electrical Resistive Heating (ERH) system was proposed
- HRSC program was initiated prior to implementation of the pilot test to:
  - Better define the treatment area and depths,
  - Determine the subsurface contaminant distribution,
  - Identify the presence of a clay ridge,
  - Assist with the design of a comprehensive monitoring well network



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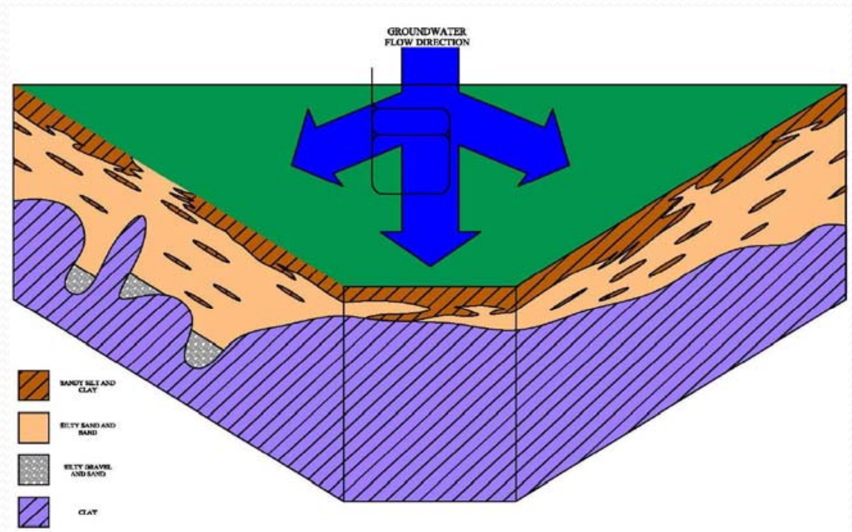
MiHPT Case Study – Cluster 13 Site

- Initial Conceptual Site Model (CSM):
  - Aquifer between fine grained vadose zone and basal clay confining layer
  - Groundwater discharges through organic silt in northern and southern tributaries of Bush River
  - Previous EC logging showed poor resolution with little EC response
  - Project geologist suspected that majority of the contaminant mass was bound up in the low permeability silt/clay zones



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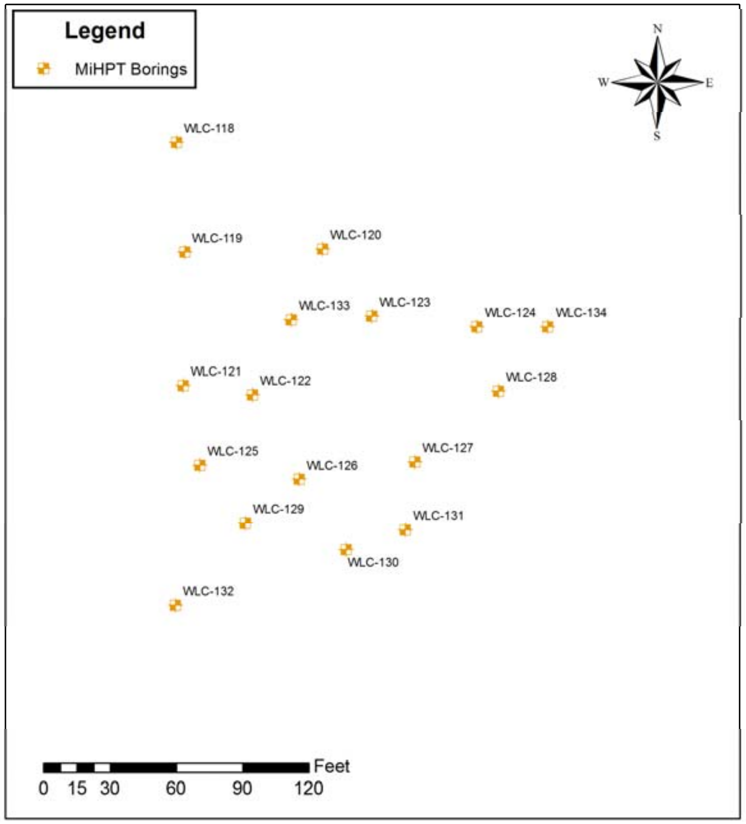
MiHPT Direct-Sensing Program

- 17 MiHPT pushes were advanced to depths of approx. 45 ft bgs
- 29 Confirmation groundwater samples collected from 15 temporary points co-located with MiHPT locations



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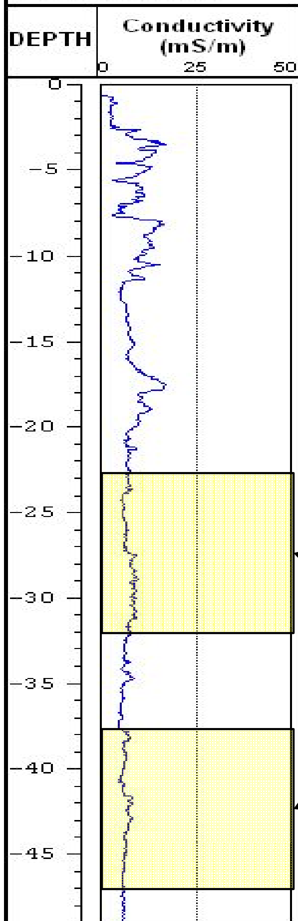
FIELD BOREHOLE LOG

BOREHOLE NO.: **WLC-125**

TOTAL DEPTH: **49.3'**

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Cluster 13 MIHPT	DRILLER:	Zach Callahan
SITE LOCATION:	Aberdeen Proving Grounds	RIG TYPE:	Geoprobe 6600
JOB NO.:	NA	SAMPLING METHOD:	MIHPT
LOGGED BY:	FI 6000	OPERATOR:	Todd Morgan
PROJECT MANAGER:	Thomas Dereamer	NORTHING:	ELEVATION:
DATES DRILLED:	10/11/2011	EASTING:	



Little variation in EC values suggest that the sub-surface material is somewhat homogeneous

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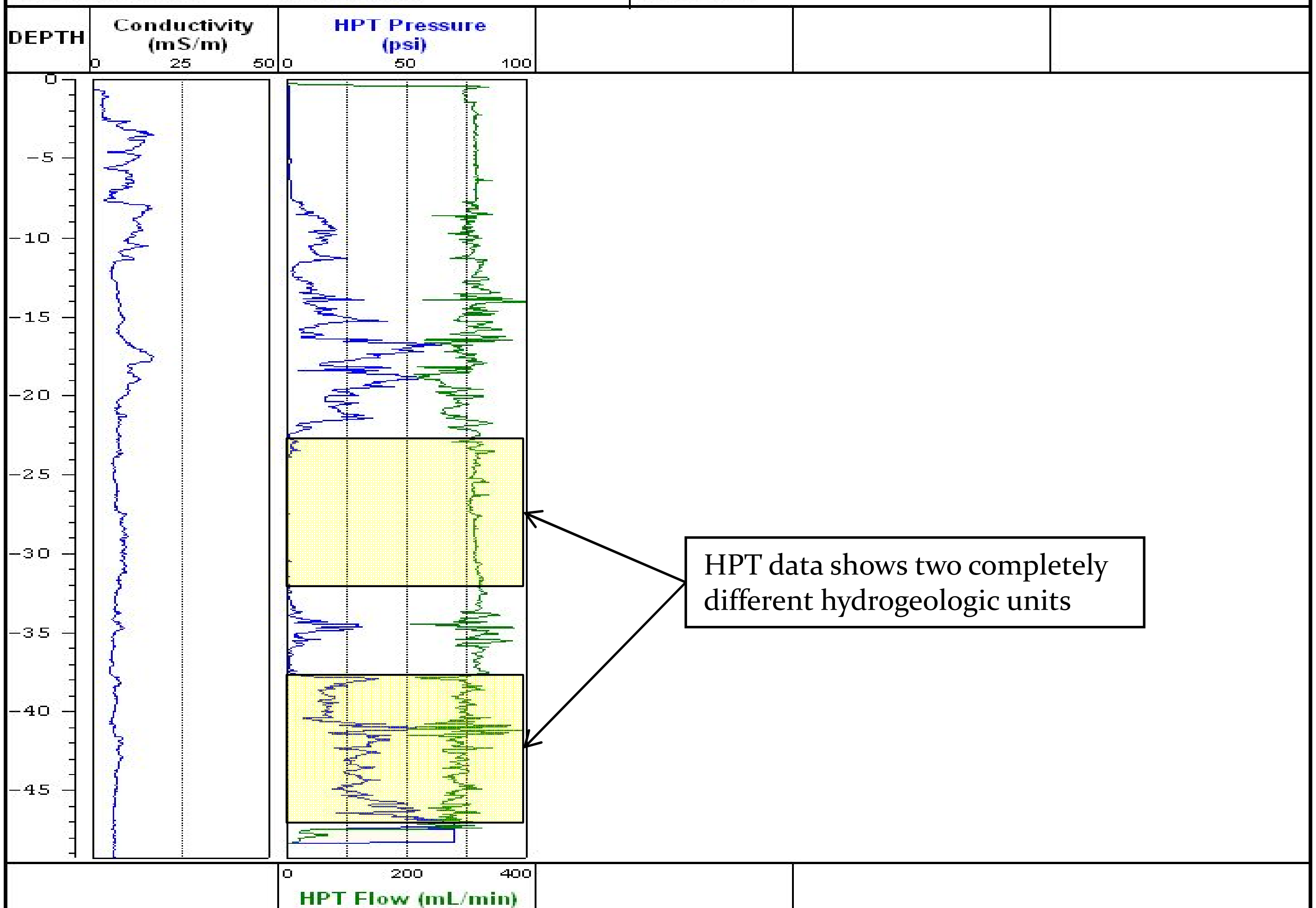
DATES DRILLED:	**10/11/2011**	EASTING:	



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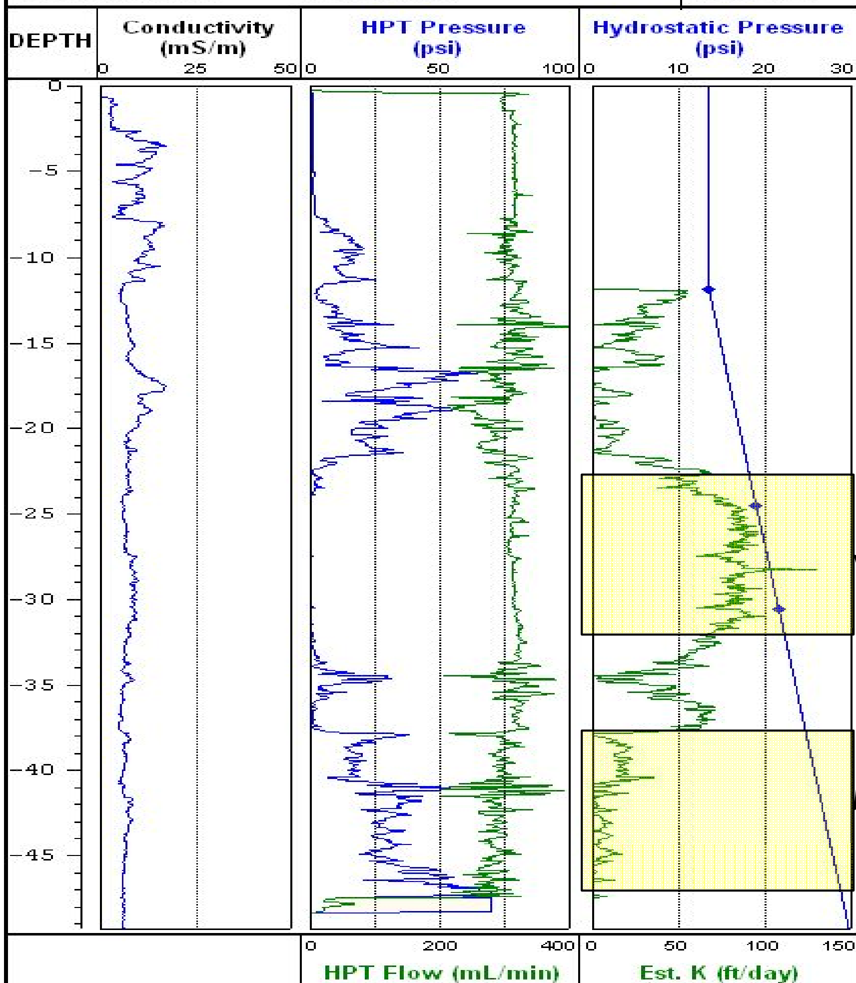
PROJECT MANAGER:	Thomas Dereamer	NORTHING:	ELEVATION:
DATES DRILLED:	10/11/2011	EASTING:	



Estimated K derived from HPT data and dissipation tests shows very high permeability in upper unit and low permeability in lower unit

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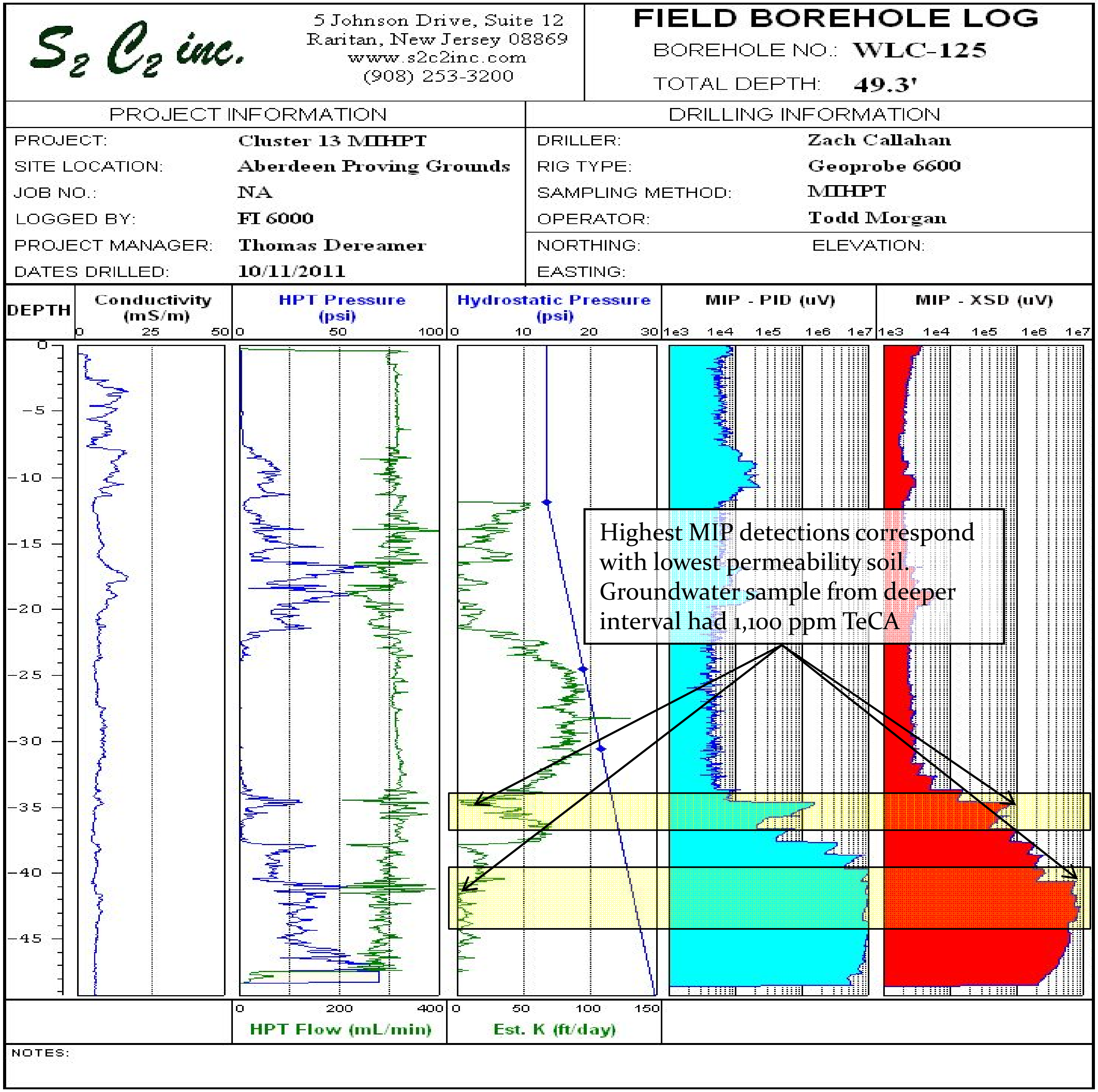
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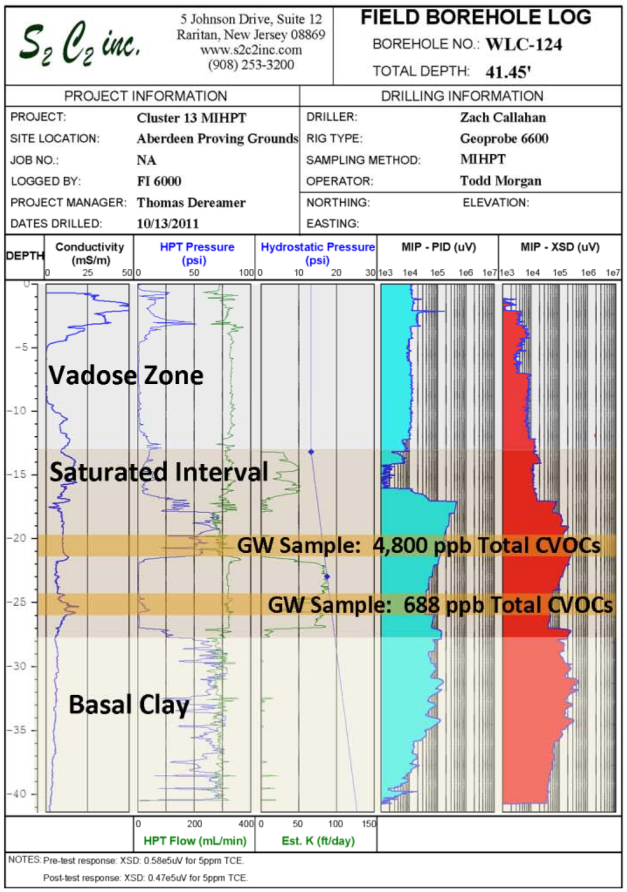
JOB NO.: NA
LOGGED BY: FI 6000
PROJECT MANAGER: Thomas Dereamer
DATES DRILLED: 10/11/2011
DRILLING INFORMATION
DRILLER: Zach Callahan
RIG TYPE: Geoprobe 6600
SAMPLING METHOD: MIHPT
OPERATOR: Todd Morgan
NORTHING:
ELEVATION:
EASTING:
DEPTH
Conductivity (mS/m)
HPT Pressure (psi)
Hydrostatic Pressure (psi)
MIP - PID (uV)
MIP - XSD (uV)
HPT Flow (mL/min)
Est. K (ft/day)
NOTES:
Highest MIP detections correspond with lowest permeability soil. Groundwater sample from deeper interval had 1,100 ppm TeCA

MiHPT Logs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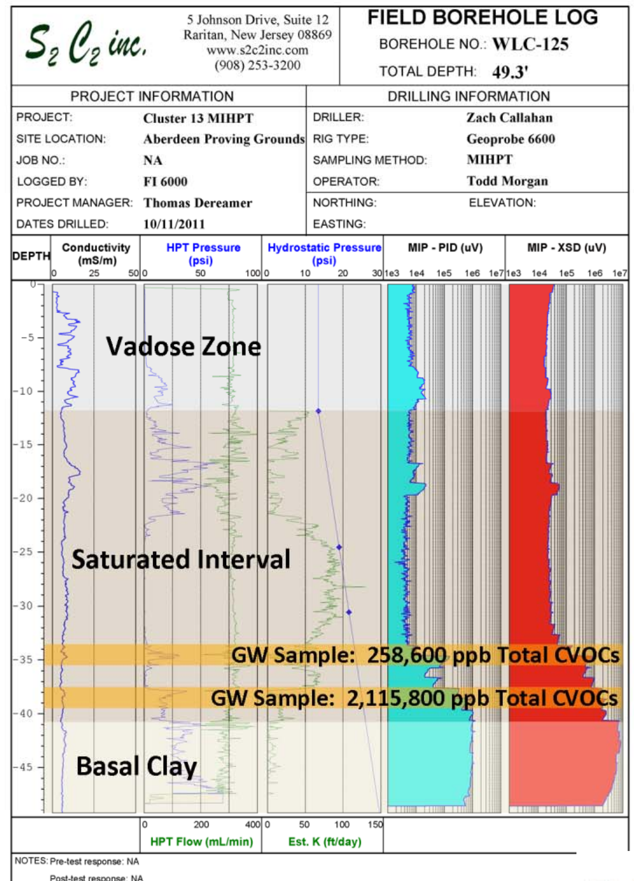
FIELD BOREHOLE LOG
BOREHOLE NO.: WLC-124
TOTAL DEPTH: 41.45'
PROJECT INFORMATION
PROJECT: Cluster 13 MIHPT
SITE LOCATION: Aberdeen Proving Grounds
JOB NO.: NA
LOGGED BY: FI 6000
PROJECT MANAGER: Thomas Dereamer
DATES DRILLED: 10/13/2011
DRILLING INFORMATION
DRILLER: Zach Callahan
RIG TYPE: Geoprobe 6600
SAMPLING METHOD: MIHPT
OPERATOR: Todd Morgan
NORTHING:
ELEVATION:
EASTING:
DEPTH
Conductivity (mS/m)
HPT Pressure (psi)
Hydrostatic Pressure (psi)
MIP - PID (uV)
MIP - XSD (uV)
Vadose Zone
Saturated Interval
GW Sample: 4,800 ppb Total CVOCs
GW Sample: 688 ppb Total CVOCs
Basal Clay
HPT Flow (mL/min)
Est. K (ft/day)
NOTES: Pre-test response: XSD: 0.58e5uV for 5ppm TCE.
Post-test response: XSD: 0.47e5uV for 5ppm TCE.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DRILLER: Zach Callahan
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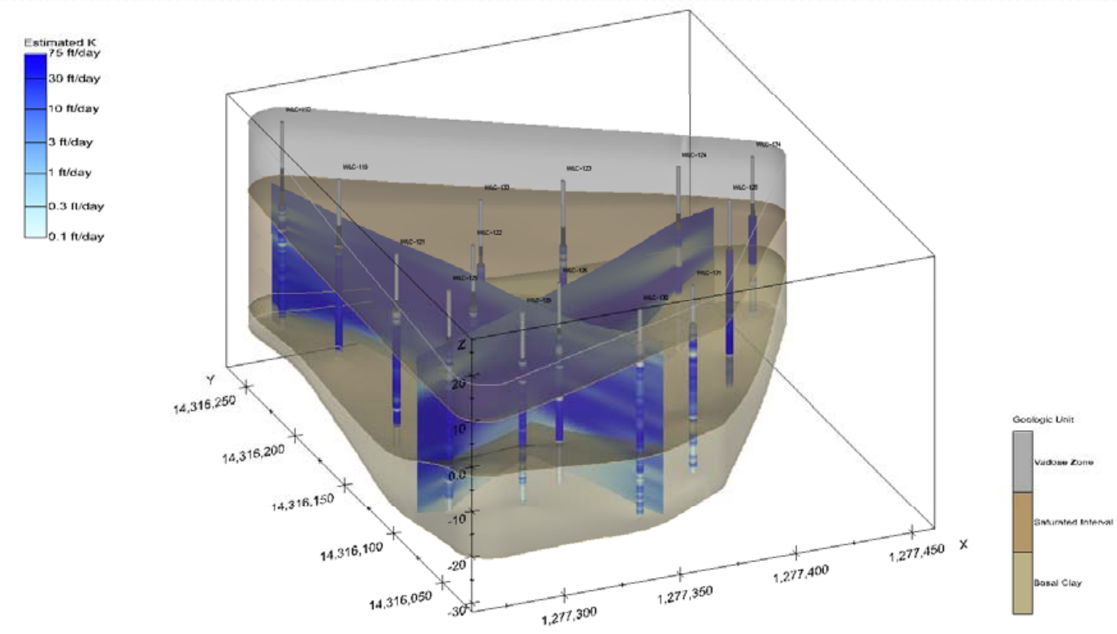
SAMPLING METHOD: MIHPT
OPERATOR: Todd Morgan
NORTHING:
ELEVATION:
EASTING:
DEPTH
Conductivity (mS/m)
HPT Pressure (psi)
Hydrostatic Pressure (psi)
MIP - PID (uV)
MIP - XSD (uV)
Vadose Zone
Saturated Interval
GW Sample: 258,600 ppb Total CVOCs
GW Sample: 2,115,800 ppb Total CVOCs
Basal Clay
HPT Flow (mL/min)
Est. K (ft/day)
NOTES: Pre-test response: NA
Post-test response: NA

Data Visualization

- Visualized in Ctech's Mining Visualization Software (MVS)
- Interpreted contacts:
  - Vadose Zone
  - Saturated Interval
  - Basal Clay
- 3D Kriging
  - MIP XSD
  - Estimated K



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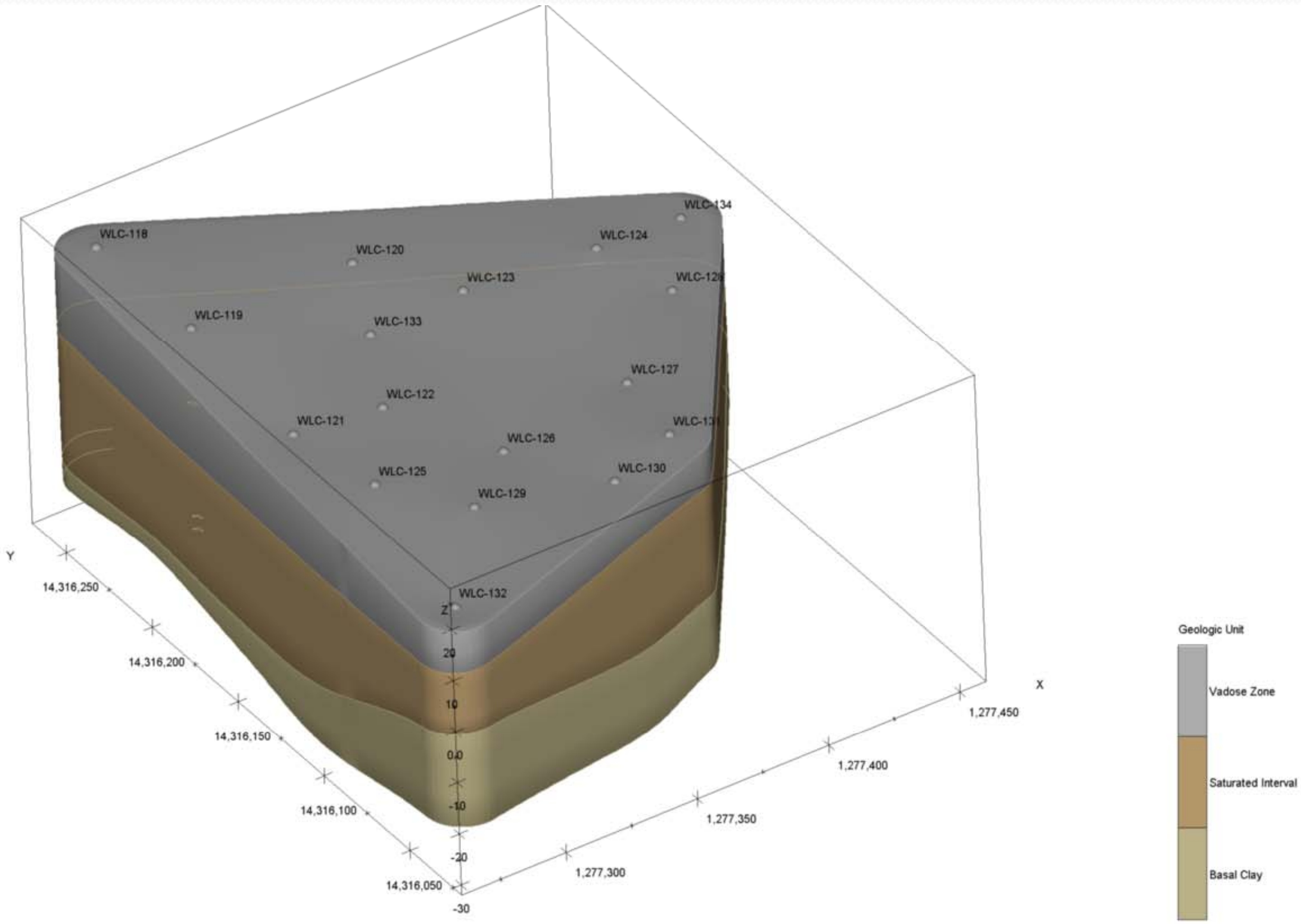
Data Visualization – Geologic Model



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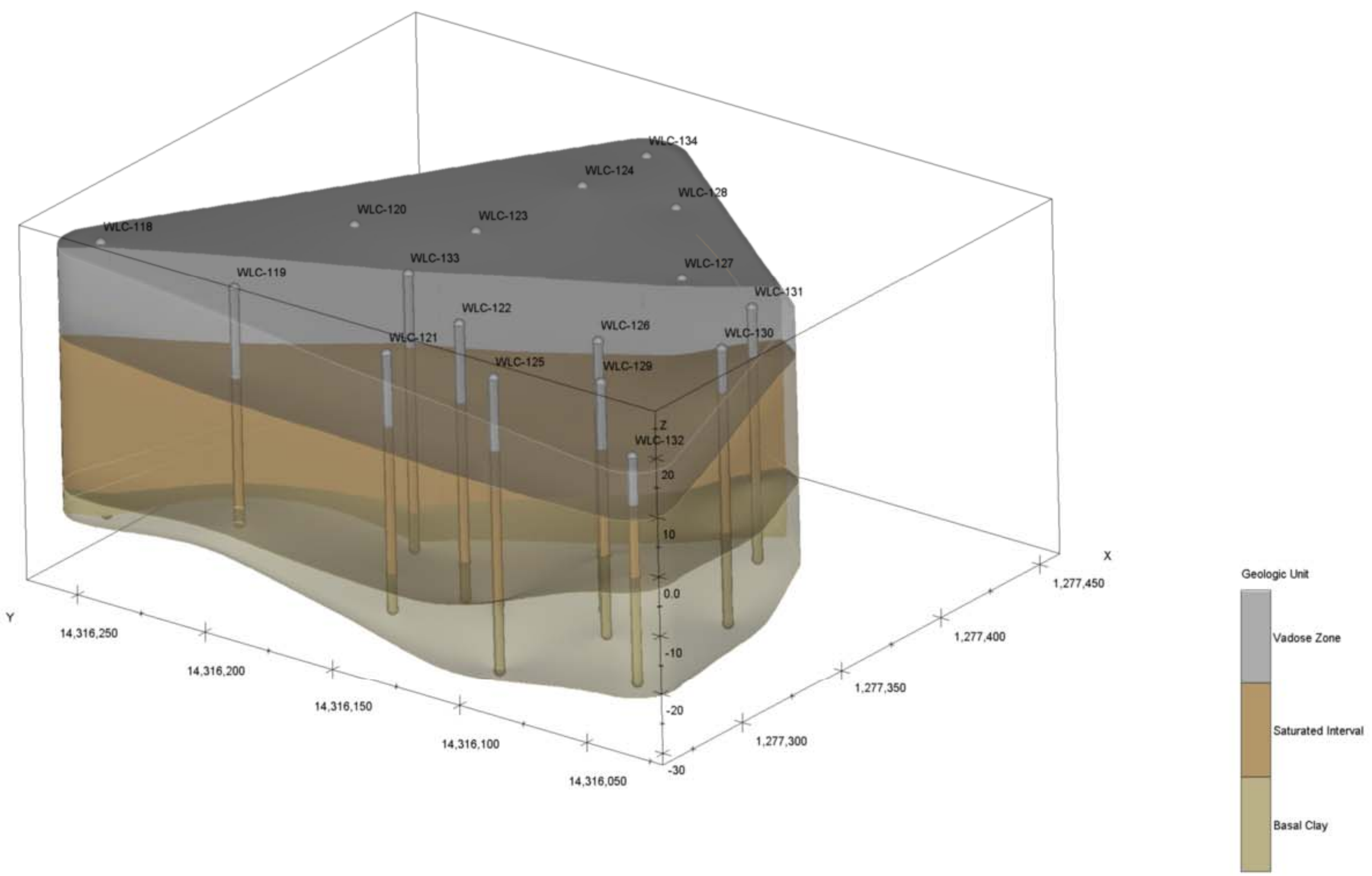

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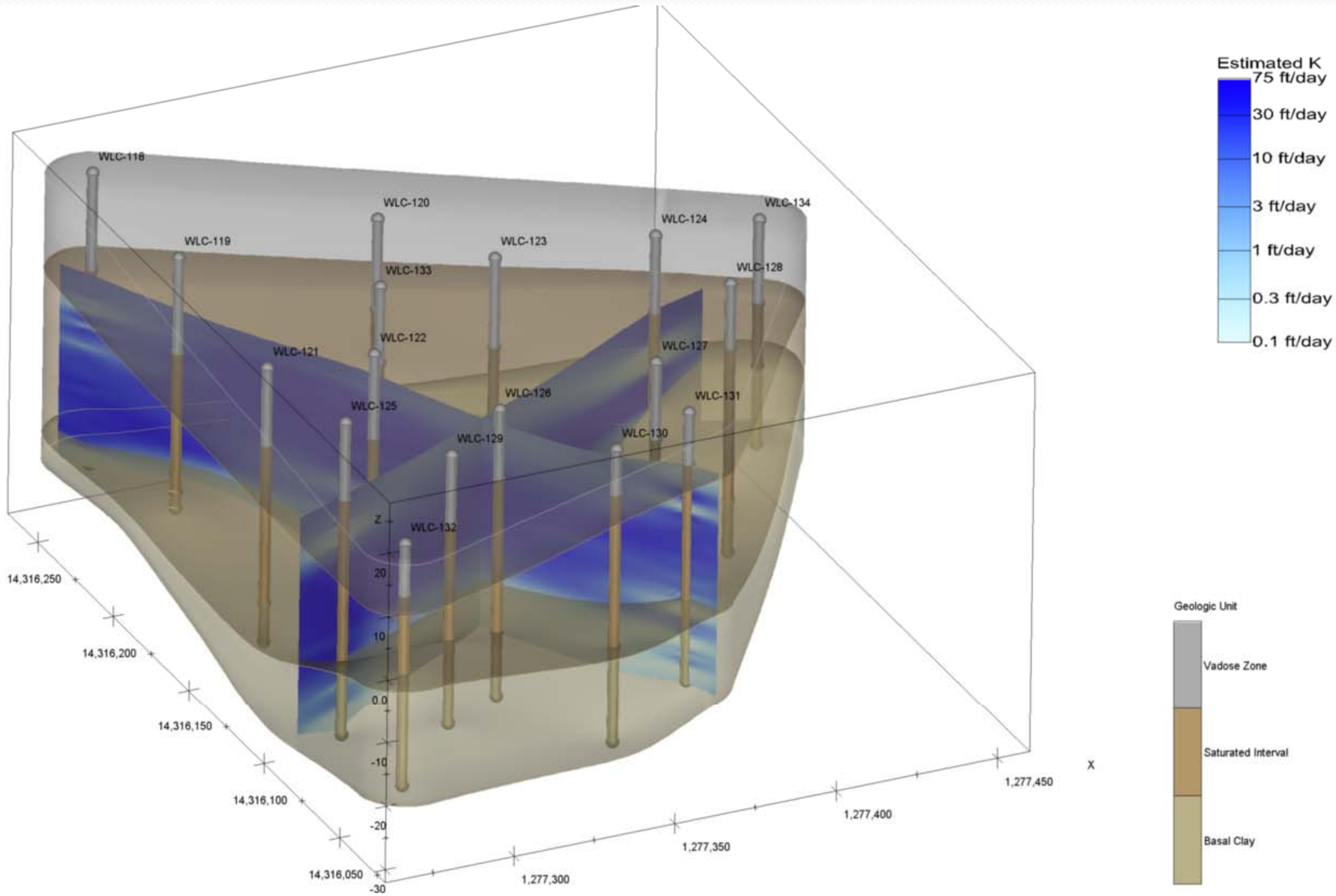

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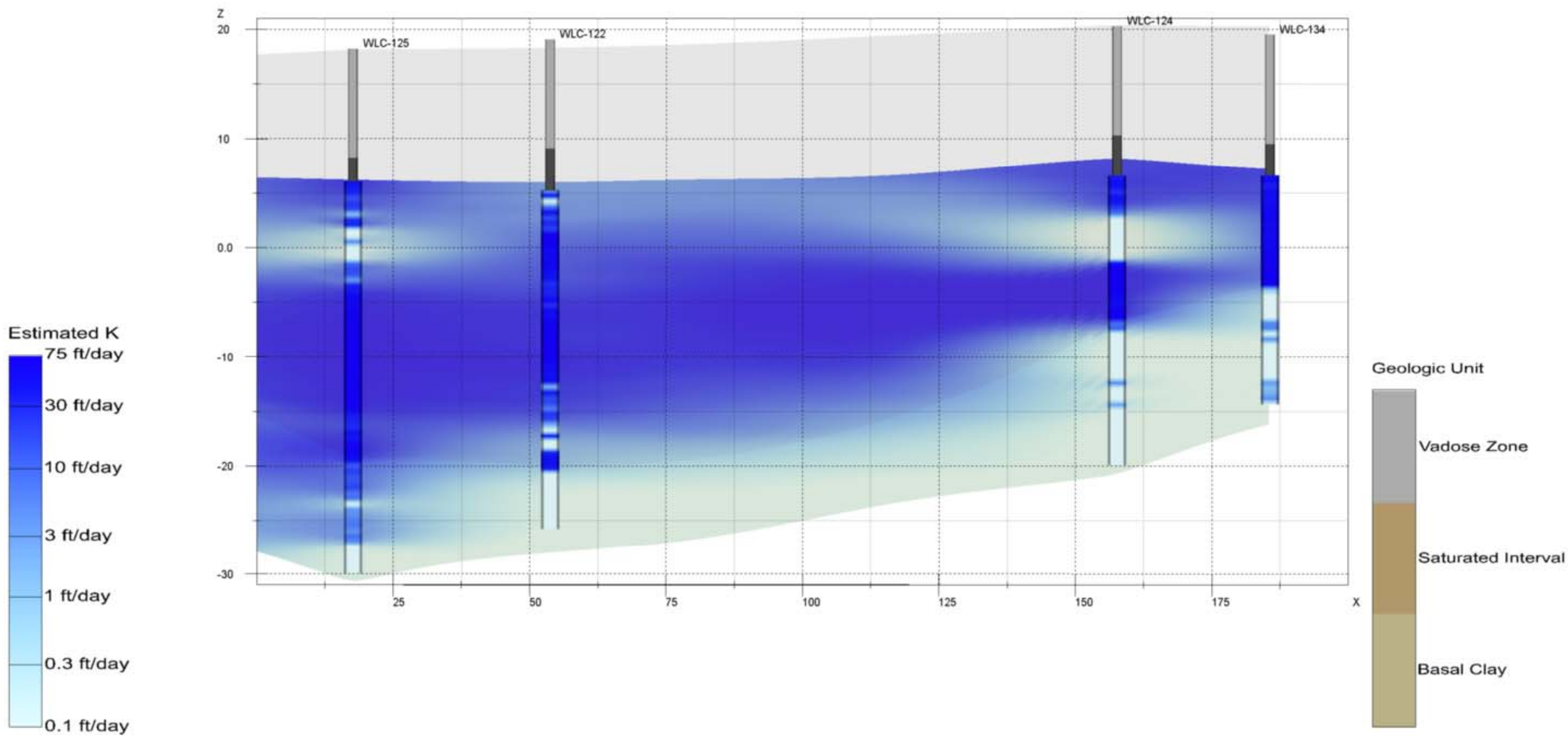
Data Visualization – Cross Section



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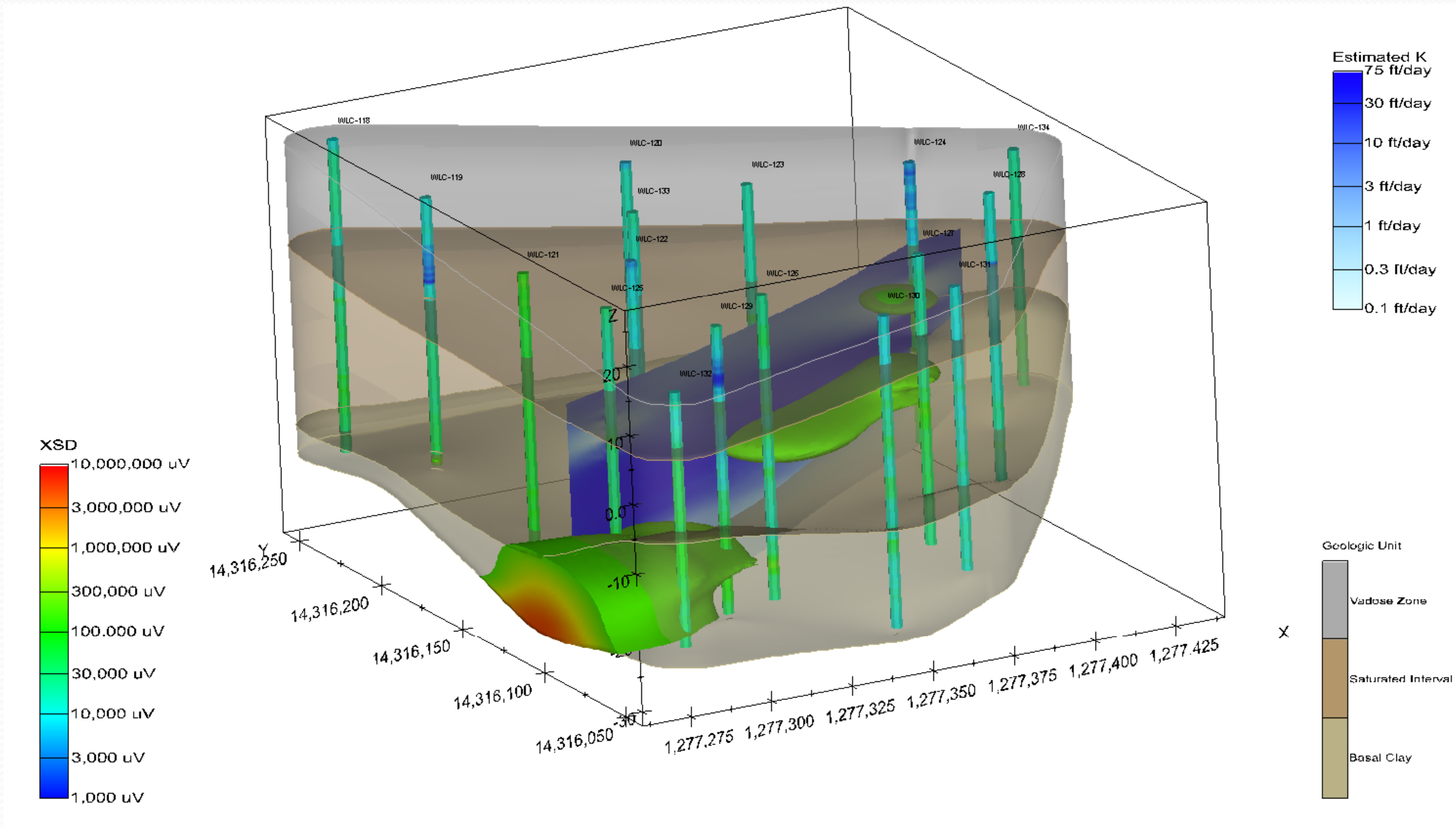
Data Visualization – MIP-XSD Plume



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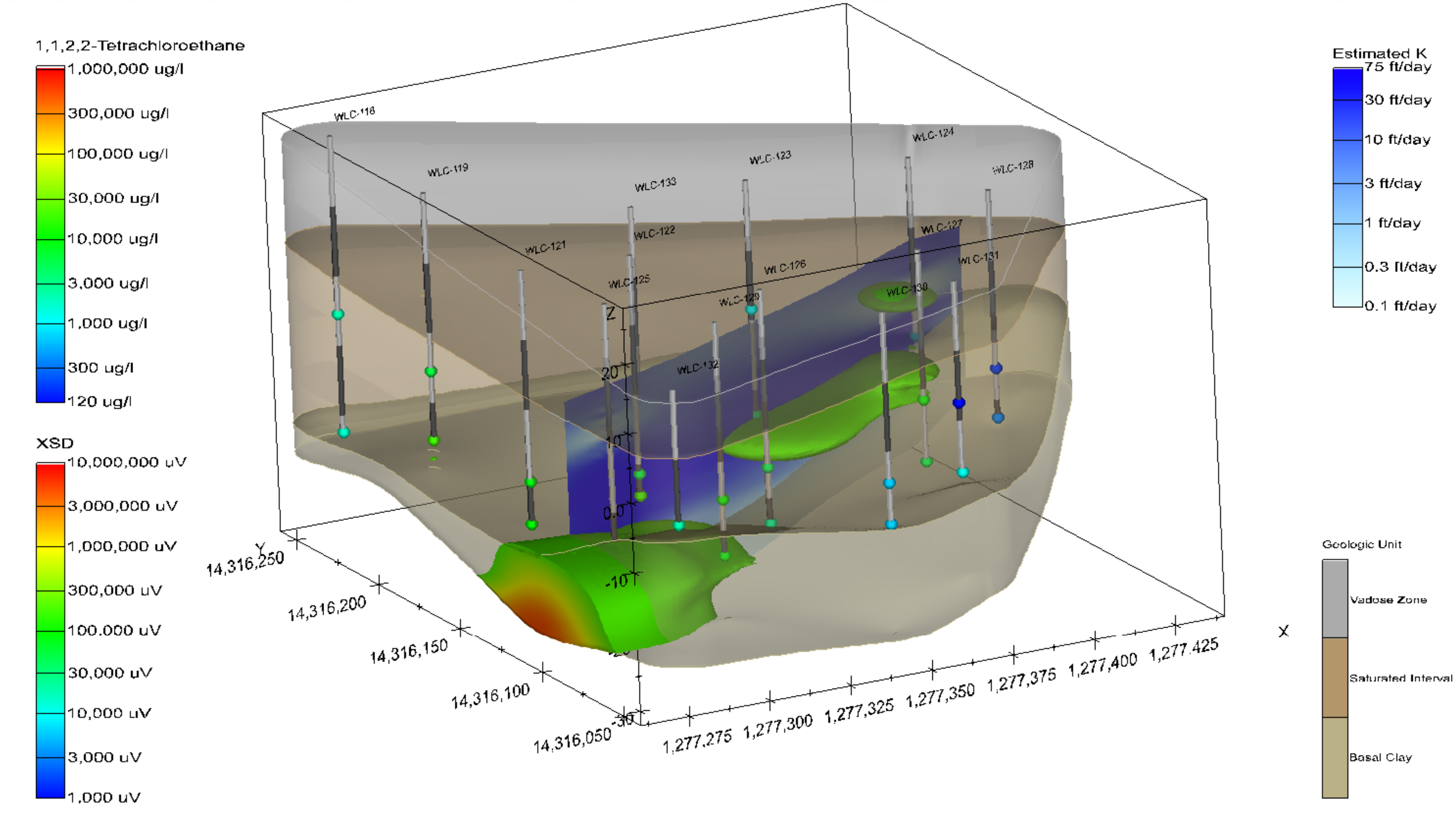
Data Visualization – MIP-XSD Plume



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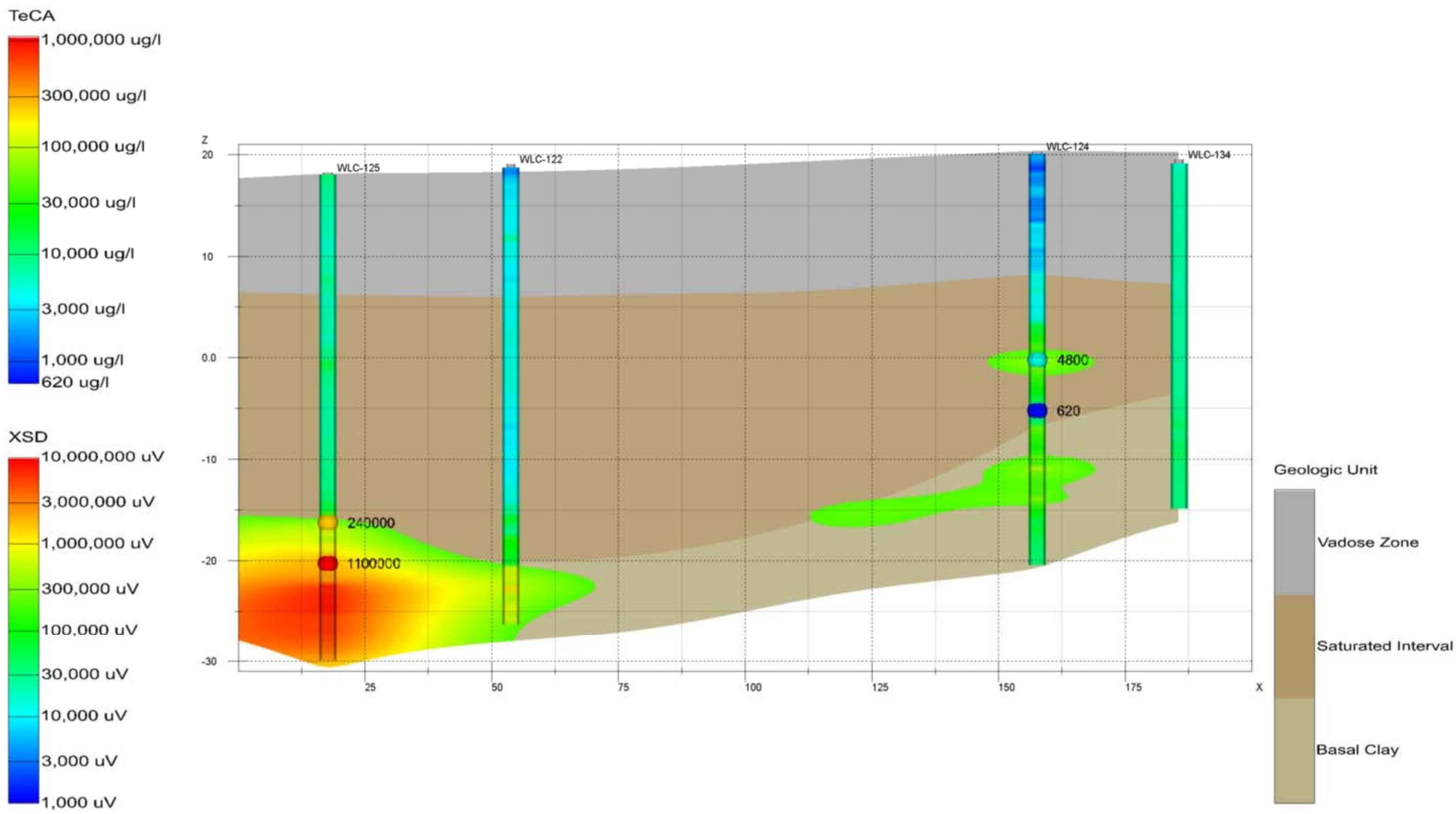
Data Visualization – MIP-XSD Plume



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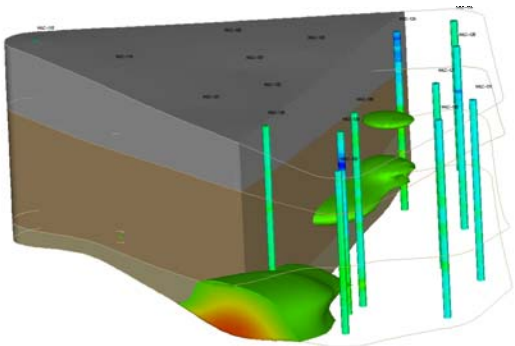
Conclusions

- HRSC program was implemented in two mobilizations over 3-4 weeks. ERH system installed 4 months following HRSC program
- Highest MIP-PID and MIP-XSD detections were recorded in low permeability zones located within the saturated zone or within the top of the basal clay
- Excellent correlation between MIP-detector response and confirmation groundwater sample results
- Relationship between contaminant distribution and fine-grained clays was clearly defined
- ERH Pilot Study Amendments
  - Fifteen monitoring wells installed (4 within the treatment area and 11 outside the treatment area)
  - Electrode configuration shifted to the southwest



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