# Strategic Utilization of HRSC Subsurface Imaging Technologies to Optimize the Remediation Phase

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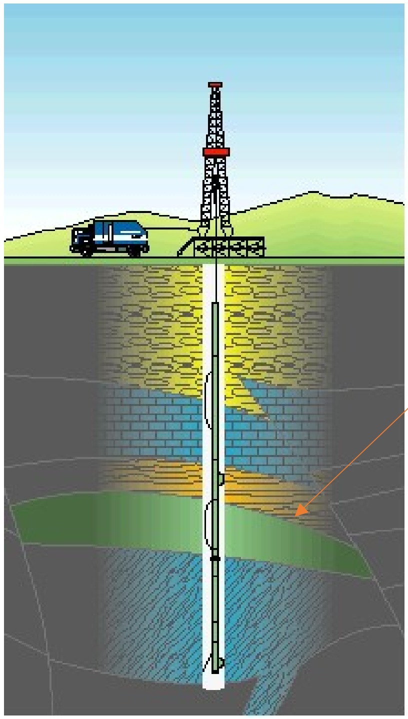
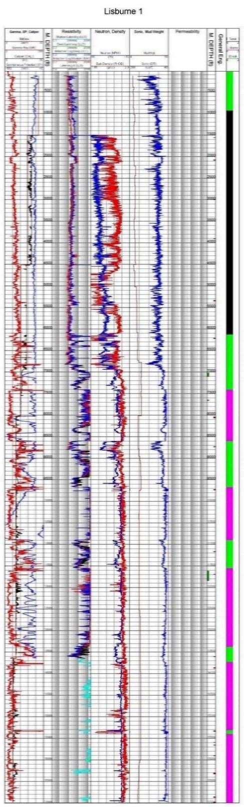
**Headquarters: CO**
**Projects Nationwide & Global**

## High Resolution Site Characterization Technologies

*"The advent of innovative **site characterization technologies** and strategies and the development of more effective treatment methods provide new options for **faster and more effective site cleanup**. New approaches to site cleanup, based on the use of in situ treatment technologies, promote more targeted or "surgical" options. These targeted efforts require the best possible understanding of subsurface features, contaminant distribution, volume and mass."*

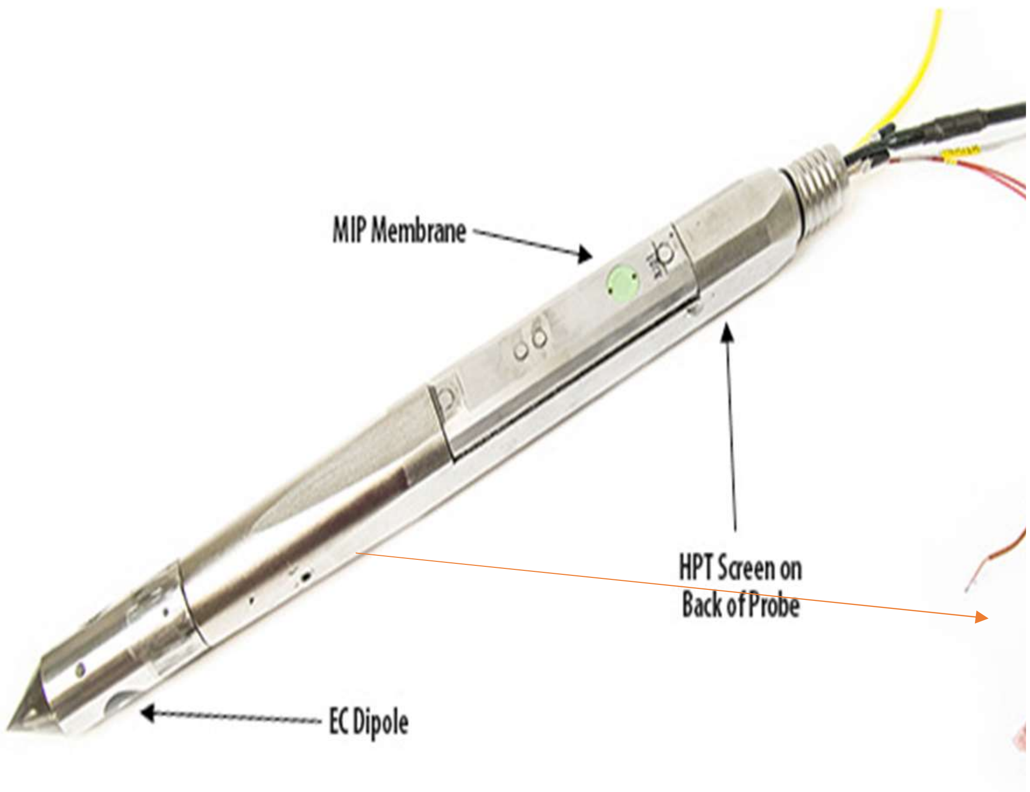
# Evolution of Insitu Technologies – Other Major Industries

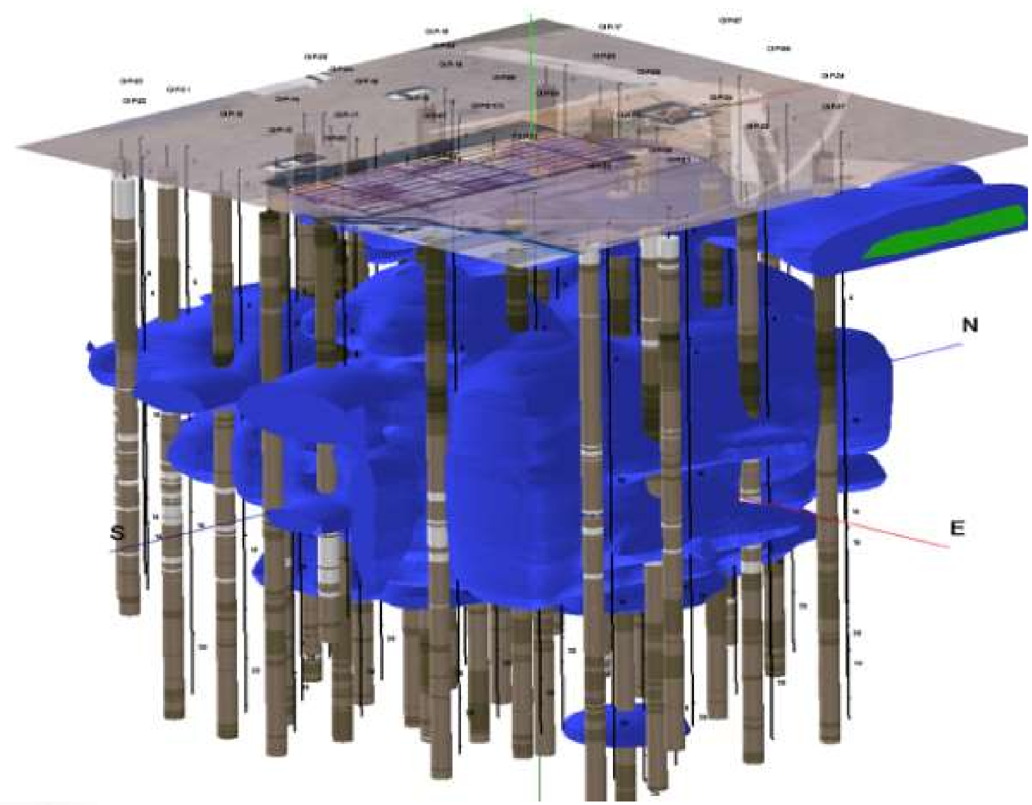






# A Clear and Accurate CSM – To Target Your Remediation

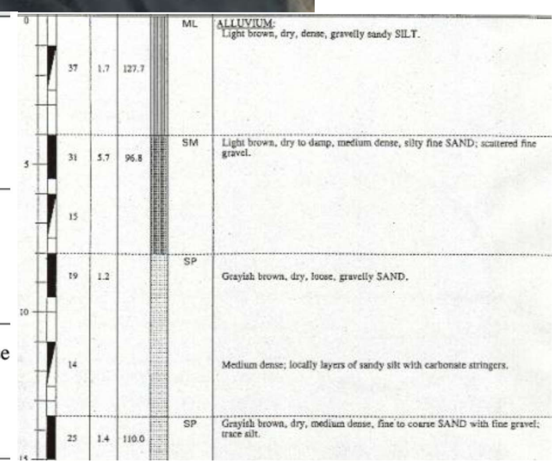


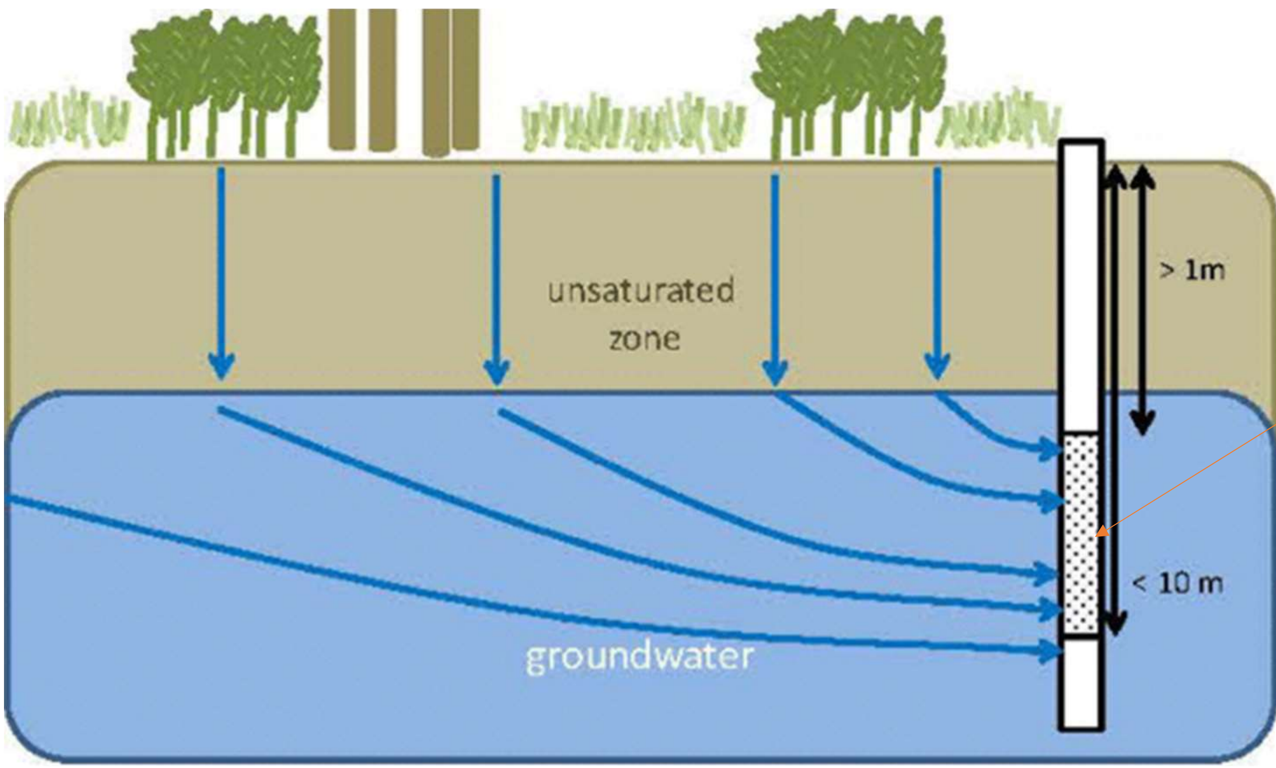
# Traditional Investigative Methods: Soil Core Samples

Is the soil recovery accurate?
2'-3' out of 5'?

| | | |
|---|---|---|
| Ah | 0–25 | dark reddish brown (5YR 3/4), loam, weak blocky subangular to moderate fine granular, soft fragile consistence, many very fine pores, many very fine and common medium roots, dry, non calcareous, clear wavy boundary to |
| AB | 25–60 | diffuse transitional horizon dark reddish brown (5YR 3/6), clay loam, moderate blocky subangular, broken thin clay cutans, many very fine pores, non-calcareous, diffuse boundary to |
| Bt | 60–160 | dark reddish brown (5YR 3/6), clay, strong very coarse subangular blocky, hard consistence, continuous moderately thick clay cutans, many very fine pores, non-calcareous, abrupt irregular boundary to |

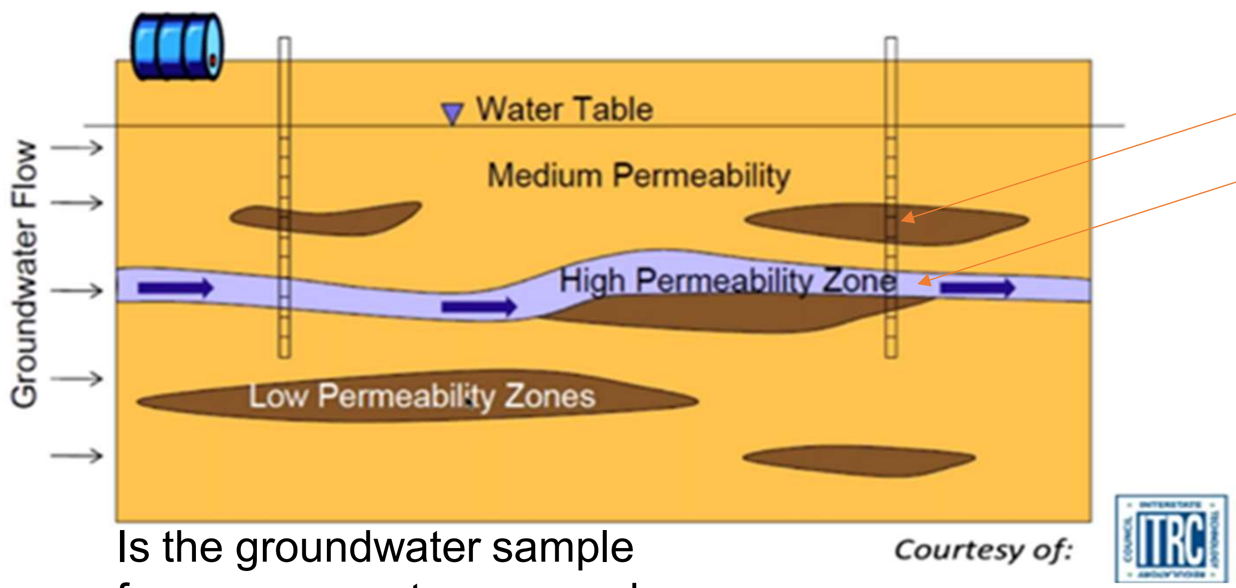


# Traditional Investigative Methods: Monitoring Well Samples




Is the groundwater sample from an accurate screened interval?

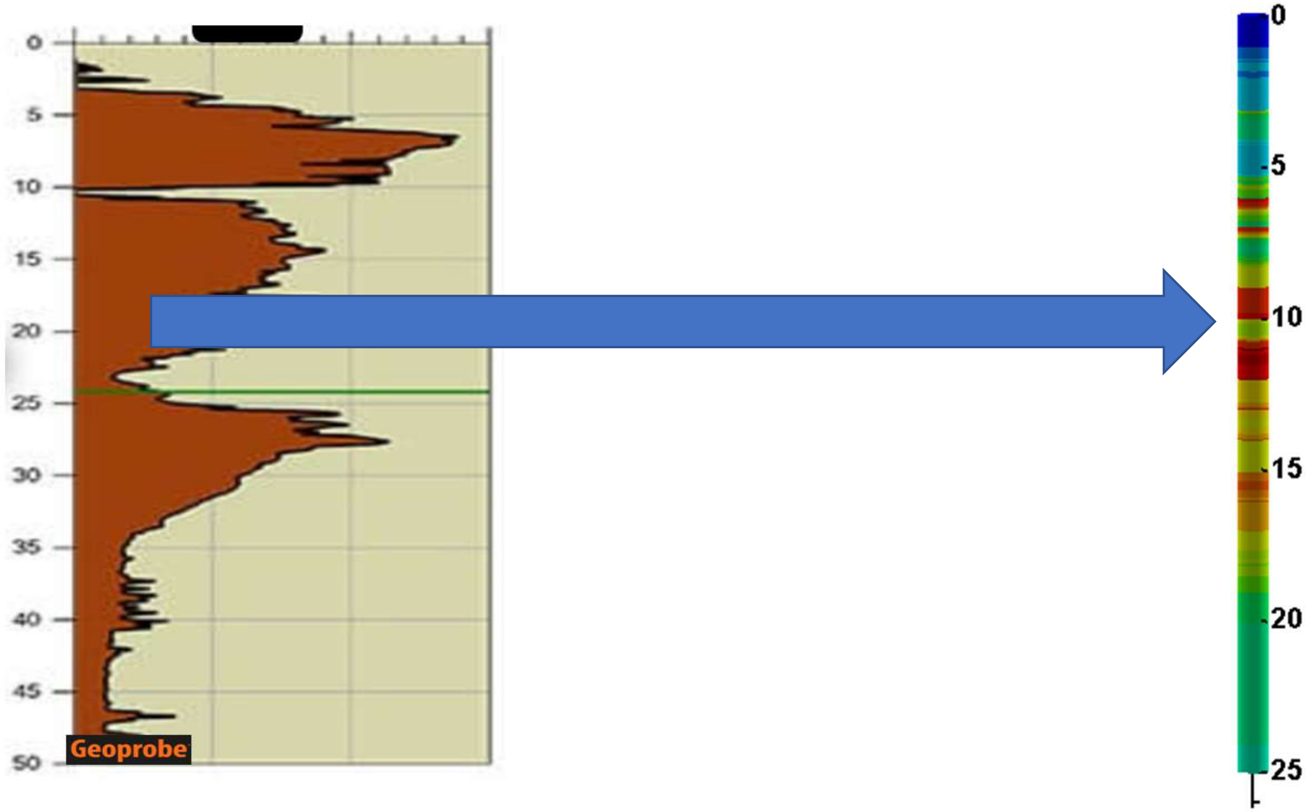
# Traditional Investigative Methods: Monitoring Well Samples




Are unique subsurface features or transmissivity zones affecting your screened intervals?

Is the groundwater sample from an accurate screened interval?

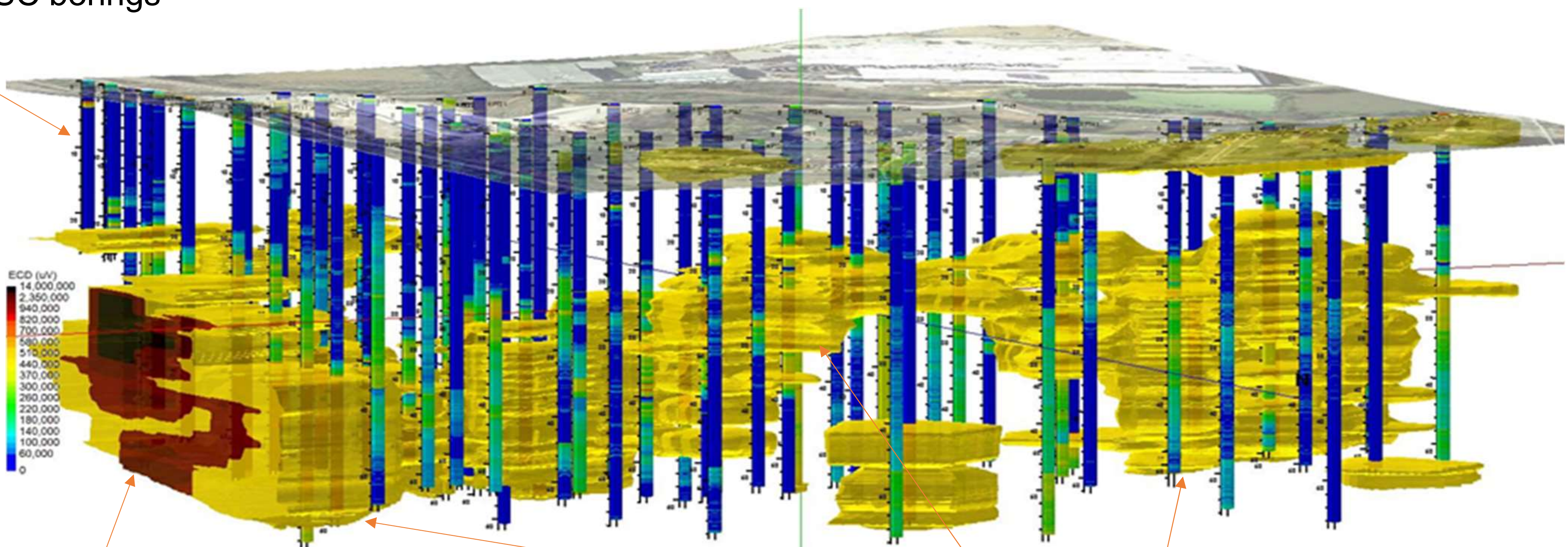
# Traditional Sampling VS Strategic Optimization with HRSC




Eagle Synergistic
Optimizing Technologies, LLC

# Traditional Sampling VS Strategic Optimization with HRSC

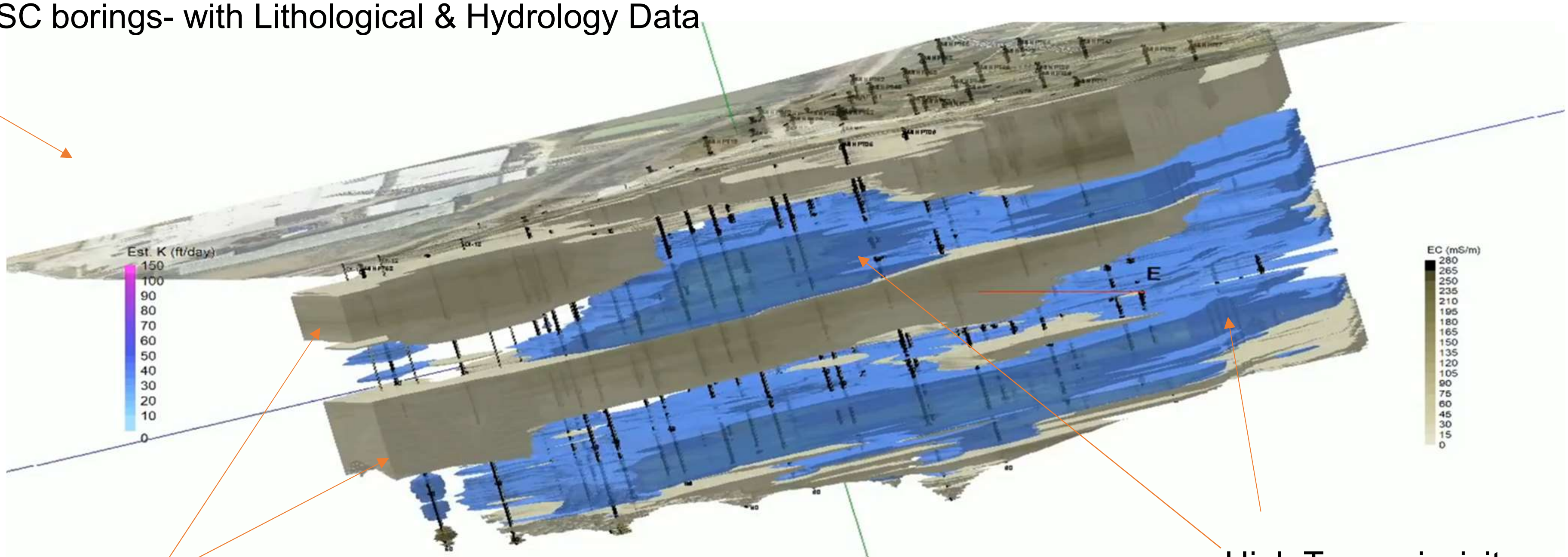
- 60 HRSC borings



- OIP – LNAPL
- Co-mingled plume determination
- MIP – VOCs
  - FID, PID, XSD

# Traditional Sampling VS Strategic Optimization with HRSC

- 60 HRSC borings- with Lithological & Hydrology Data



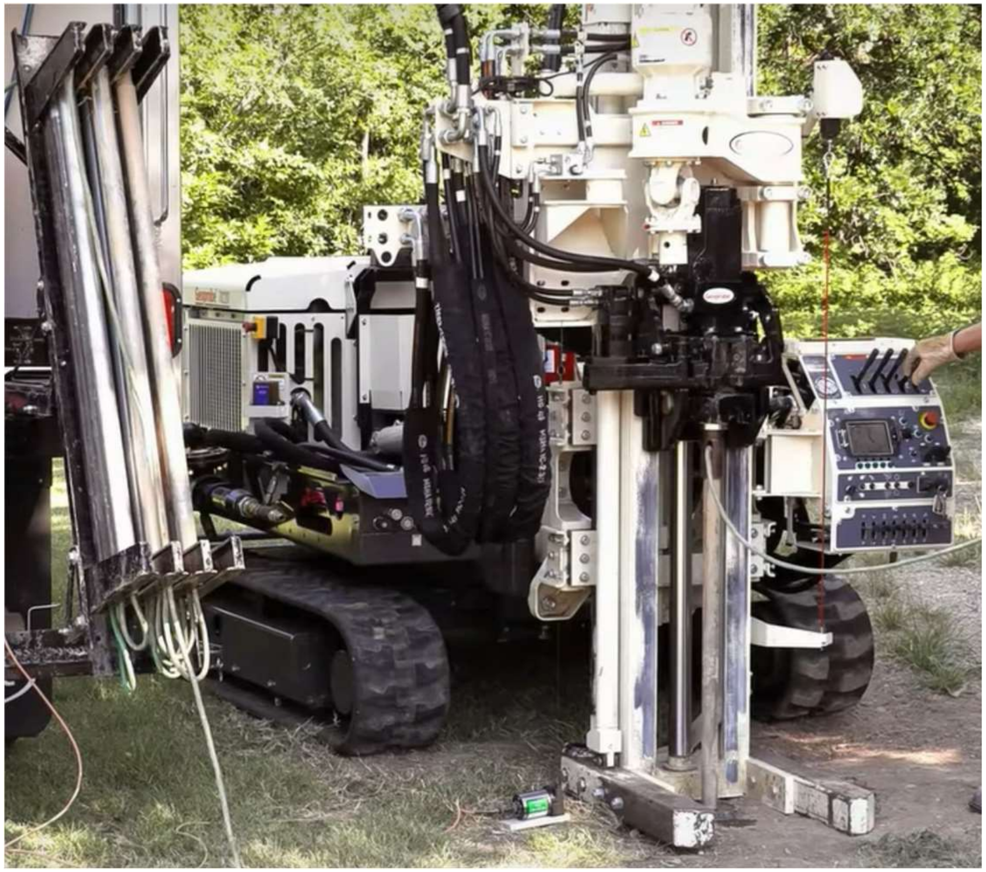

- Confining Zones
- High Transmissivity Zones

# Case Study 1: UST Release & Suspected Multiple Plumes on Same Site

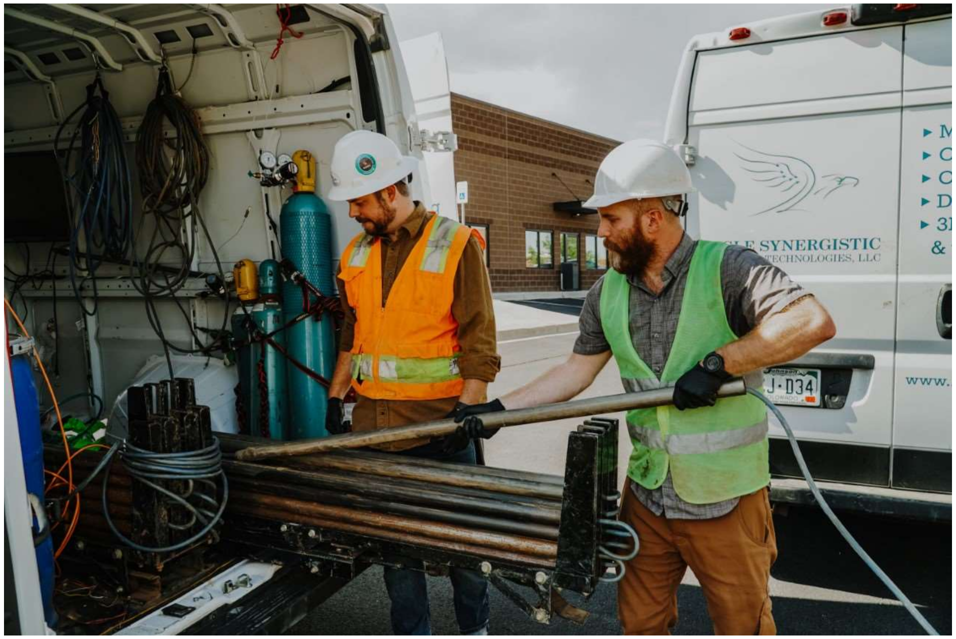
# HRSC Overview

HRSC Mobile Command Centers Units:

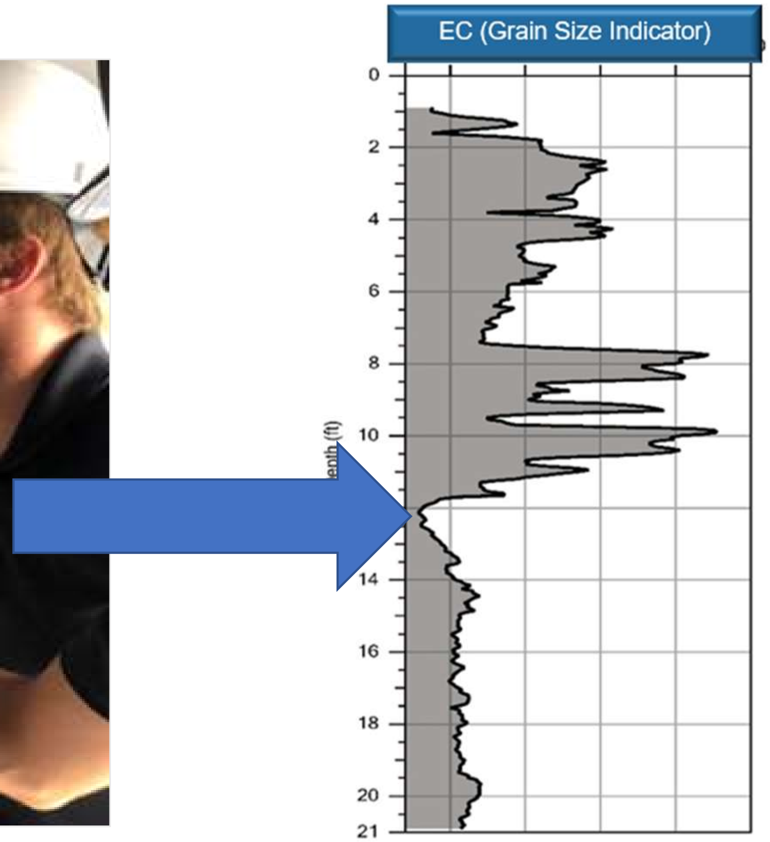
# Advanced by Drill Rig



# HRSC Overview

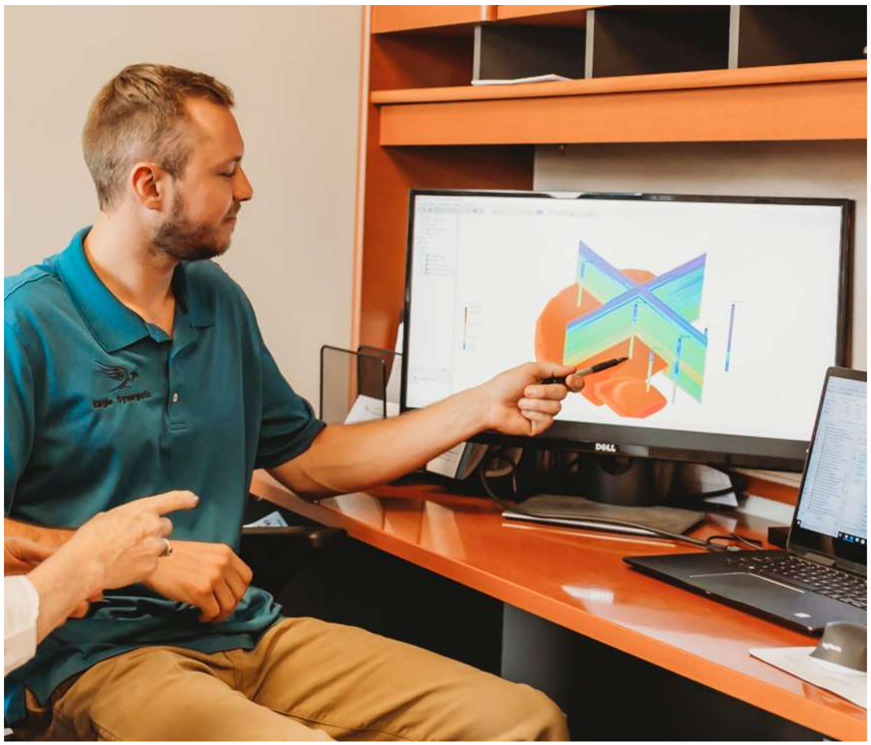



## HRSC Overview



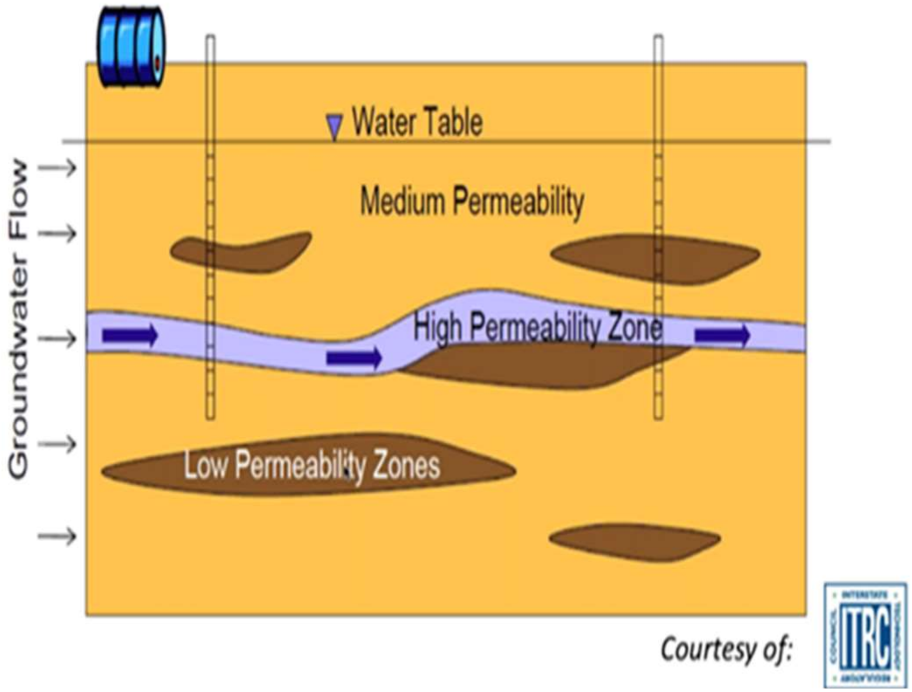
# Strategic & Dynamic HRSC Investigative Process

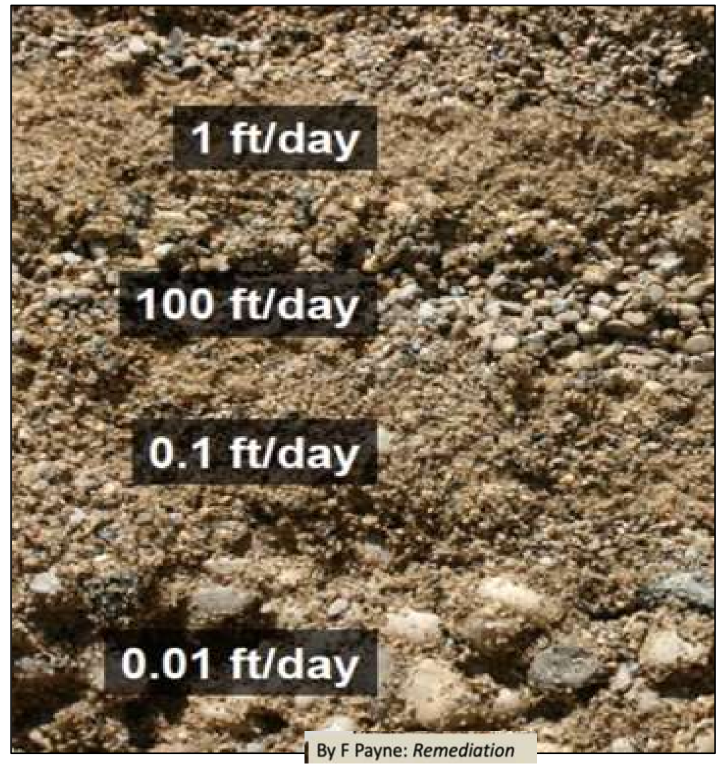
HRSC Specialists working dynamically with you in the field…




…and HRSC Scientists working with you virtually to optimize your project!

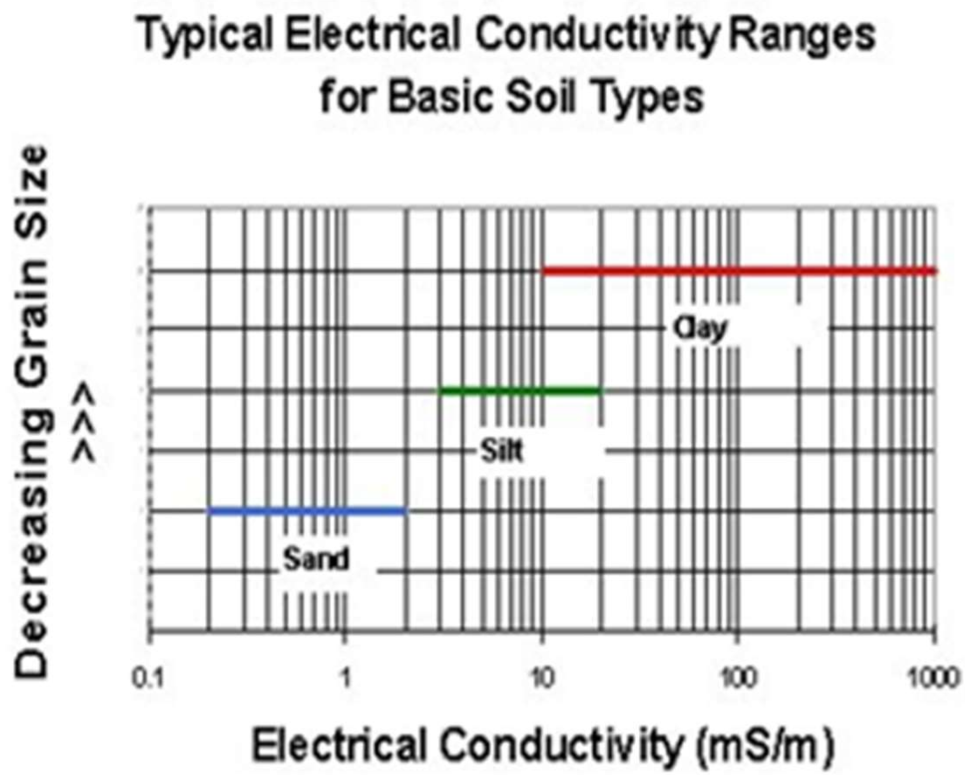
# Impacts of Geology / Hydrogeology



# EC – Electrical Conductivity Detector

Soil Conductivity:
- Indicator of Grain Size
- Ionic Compounds/Salts
- Metals



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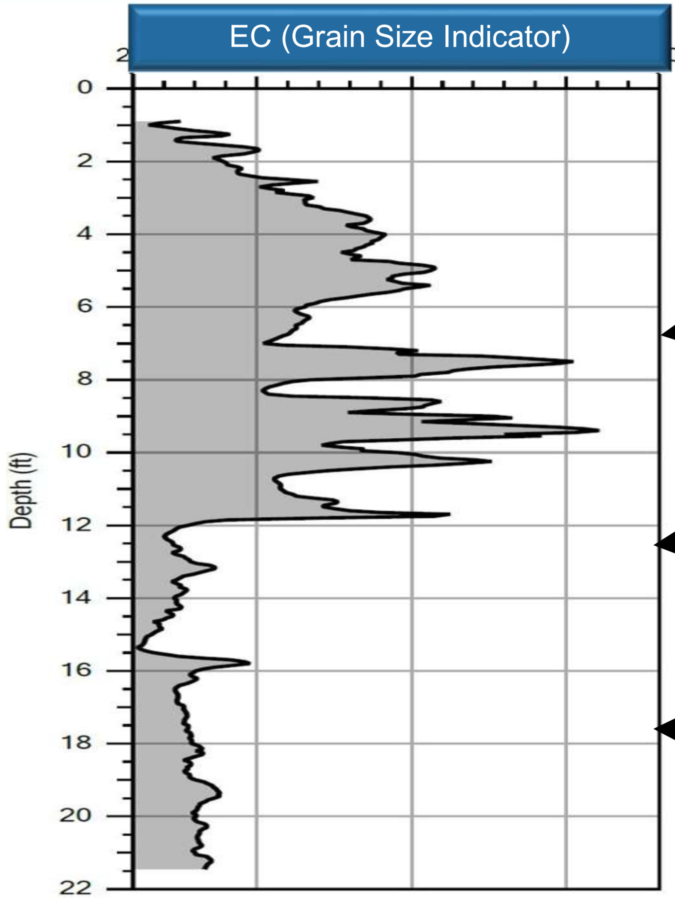
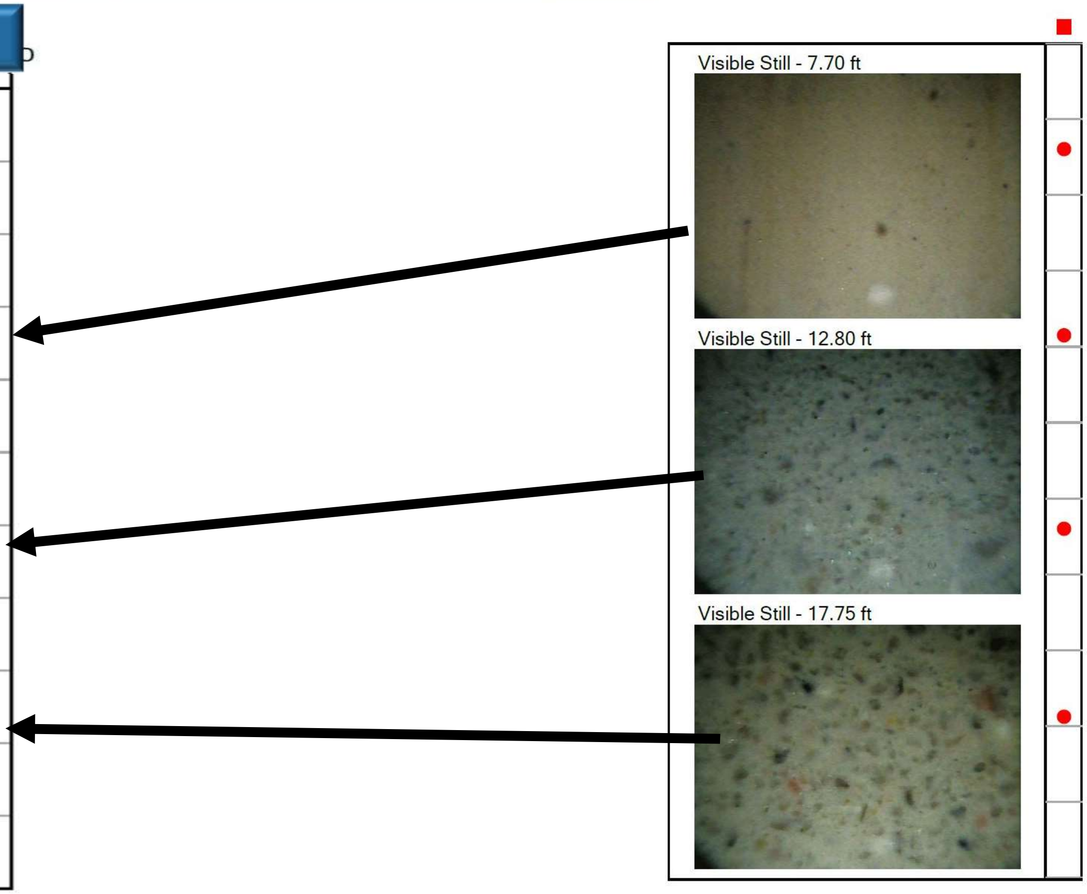
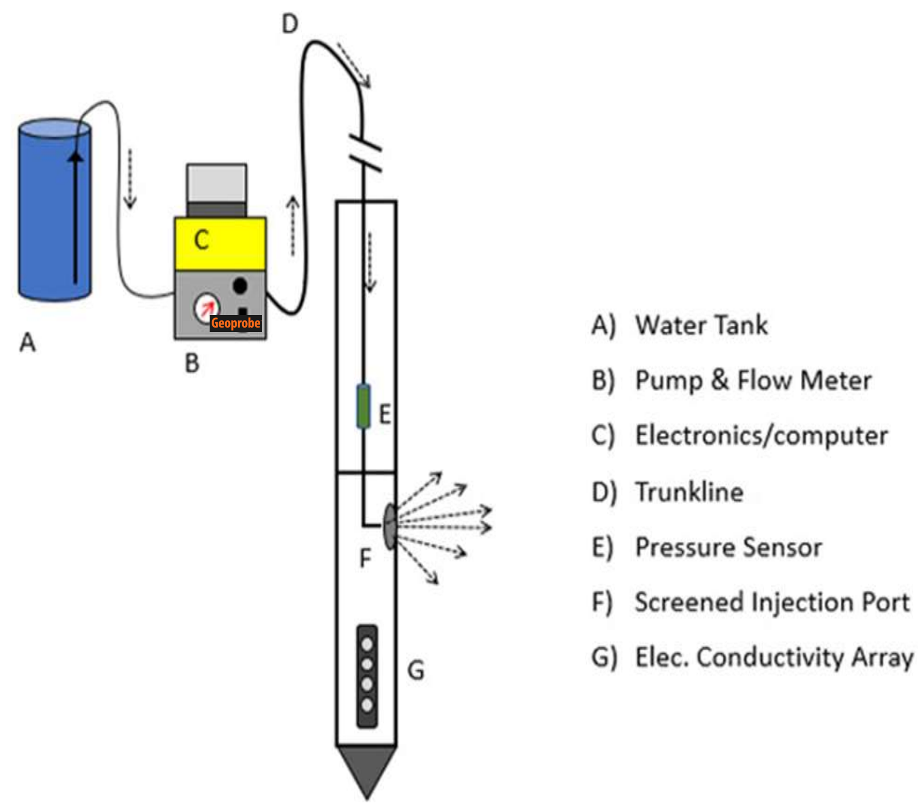


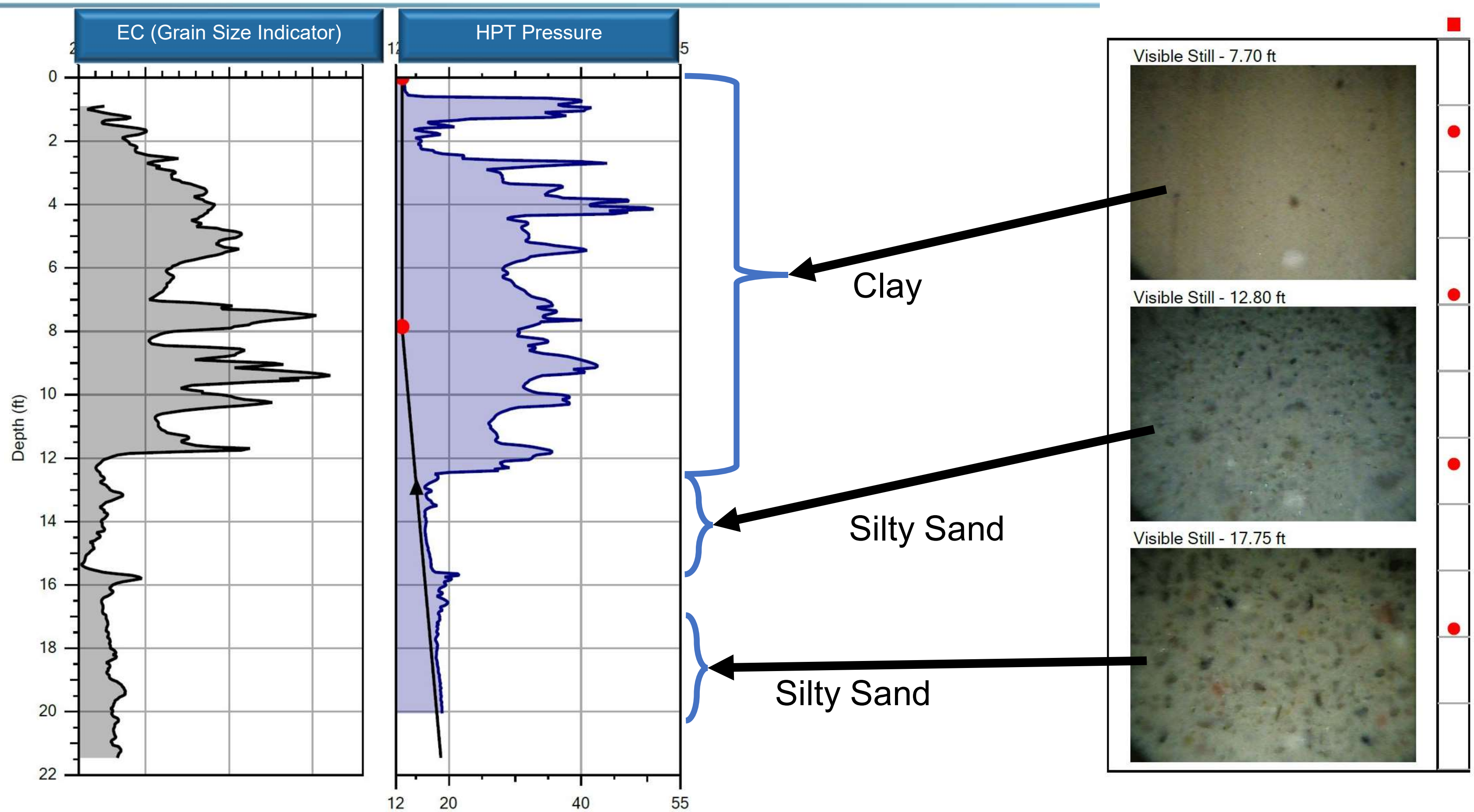
# HPT – Hydraulic Profiling Tool

HPT Pressure:

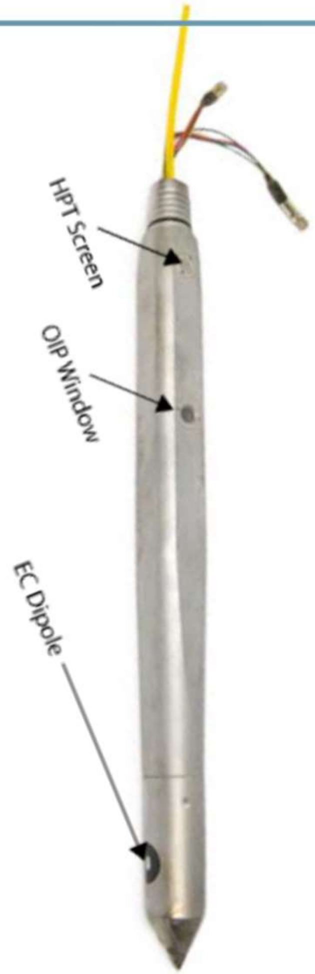
- Indicator of Permeability
- Dissipation Test
  - Hydrostatic Head
- Estimated K values

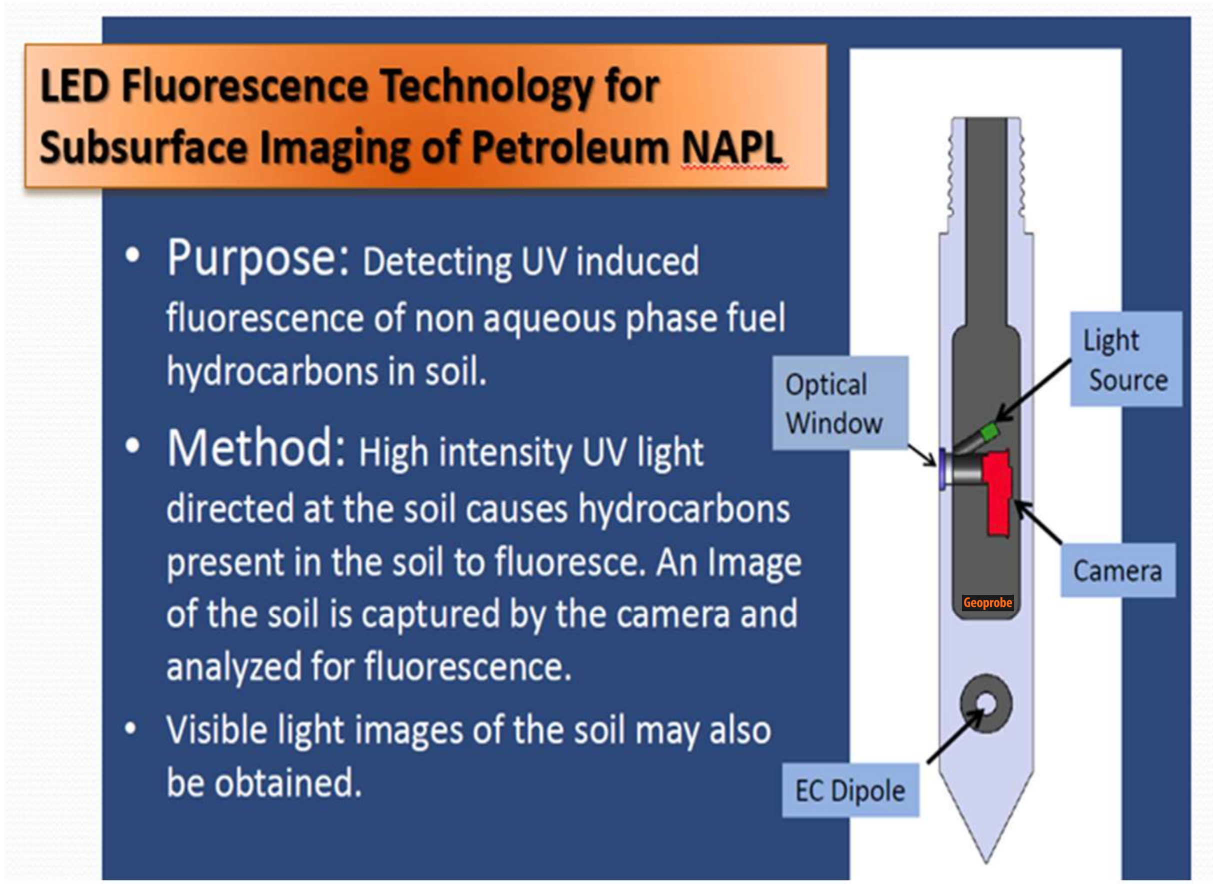


# EC & HPT- Hydraulic Profiling Technology

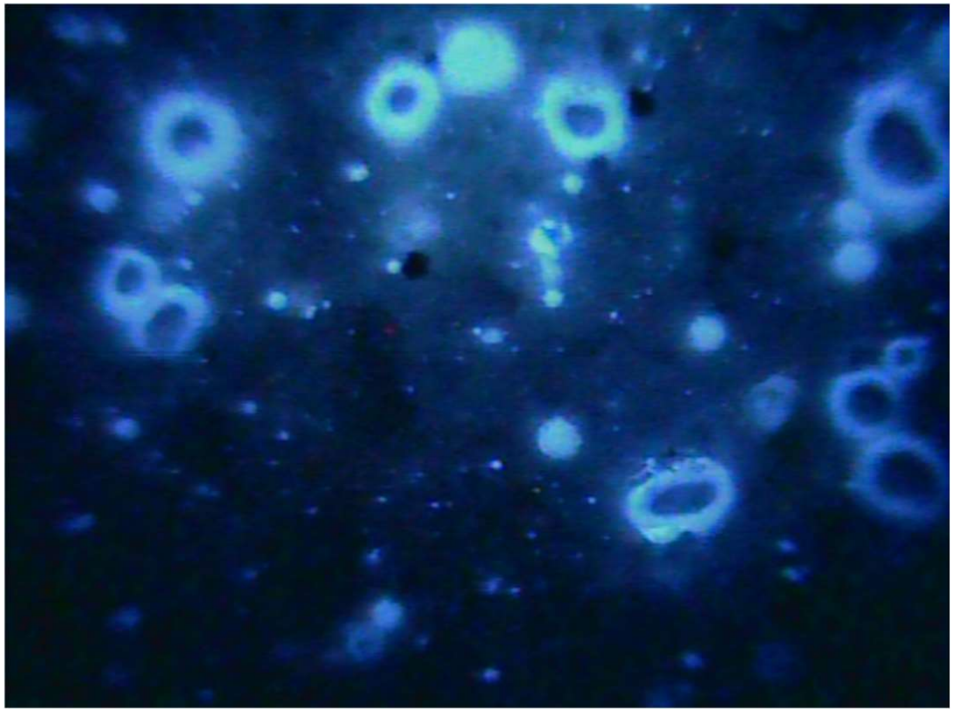


# OIHPT – Optical Image Profiler

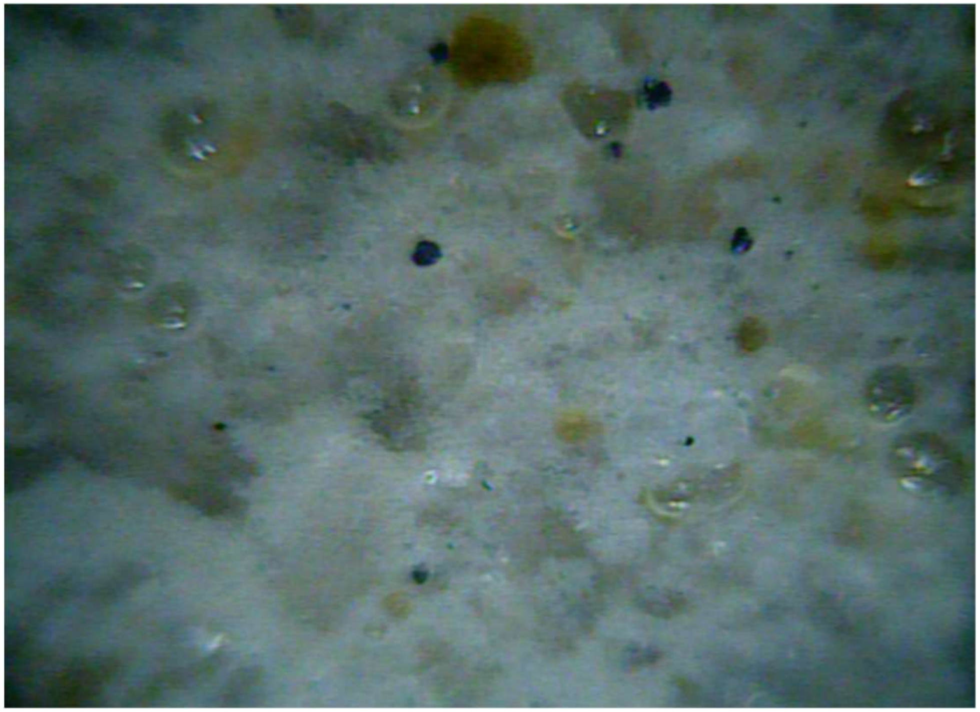


# OIP/HPT - OIHPT – Two Light Sources



UV Light Source



Visible Light Source

# OIHPT – Optical Imaging Profiler



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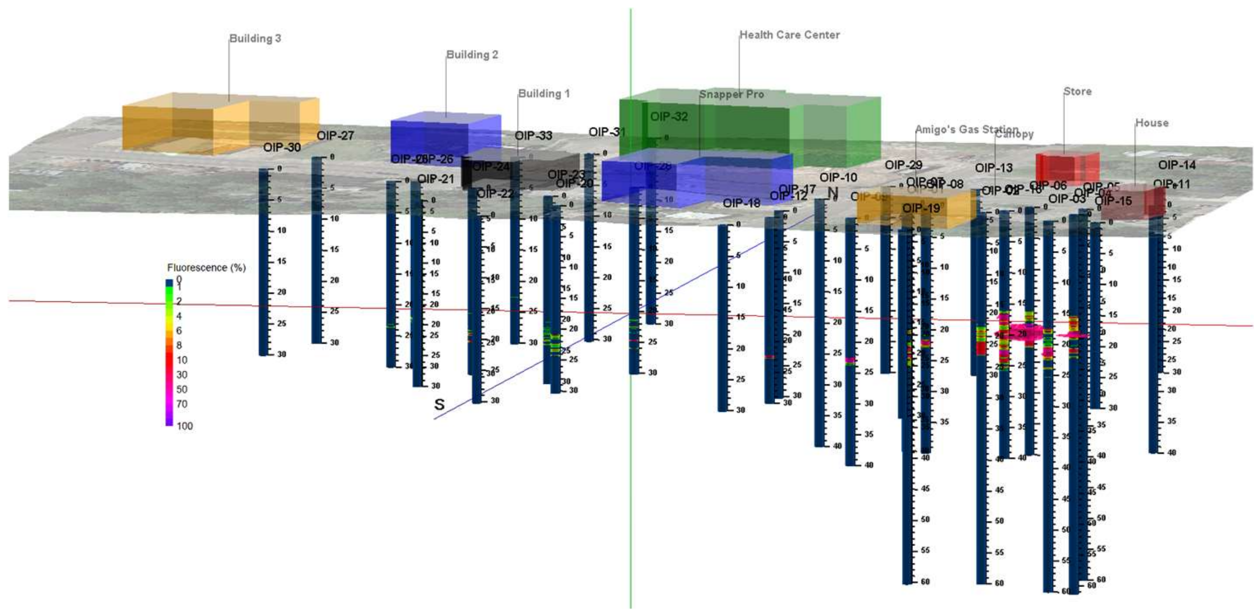
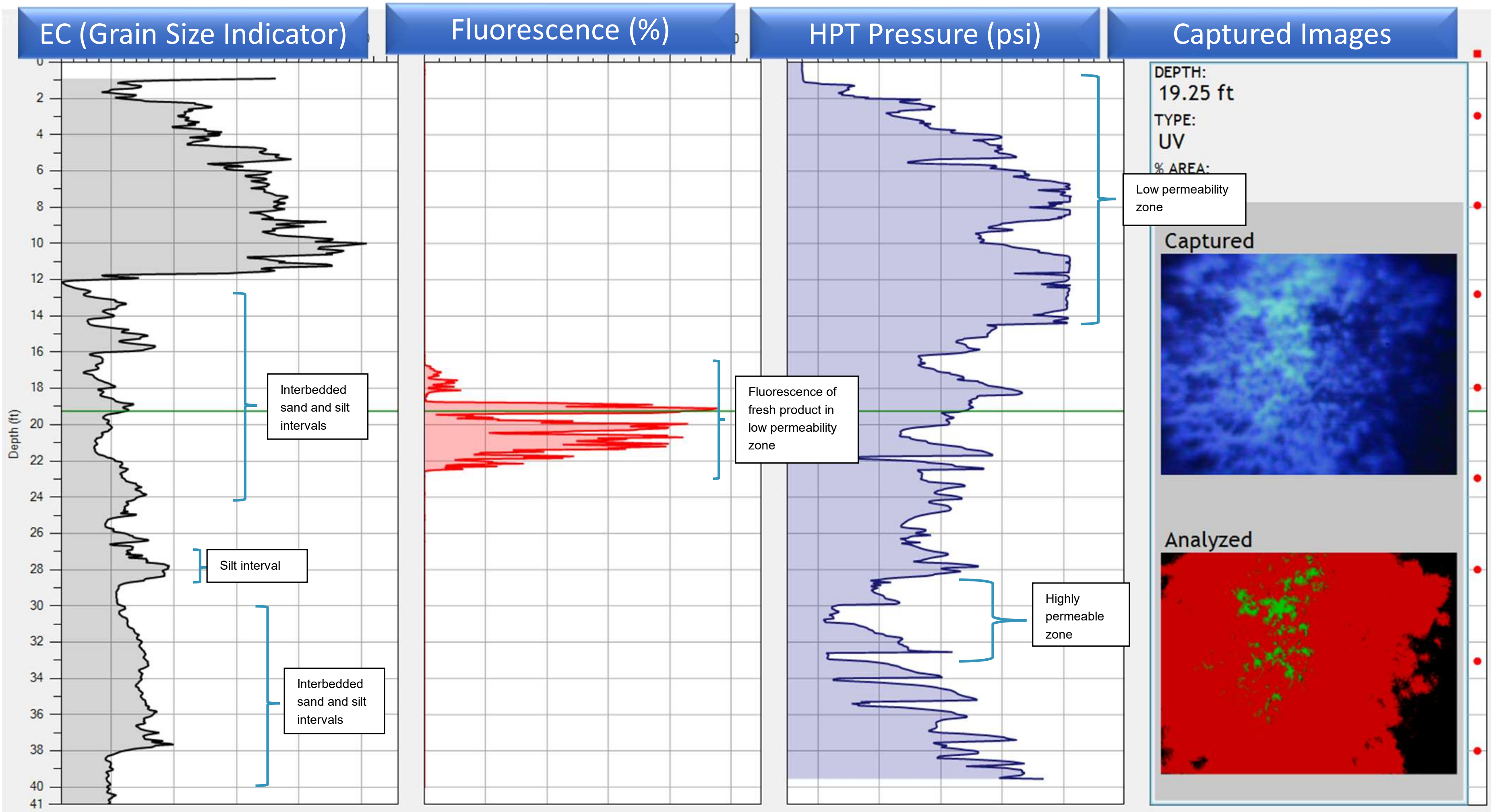
# Case Study 1: OIHPT Borings

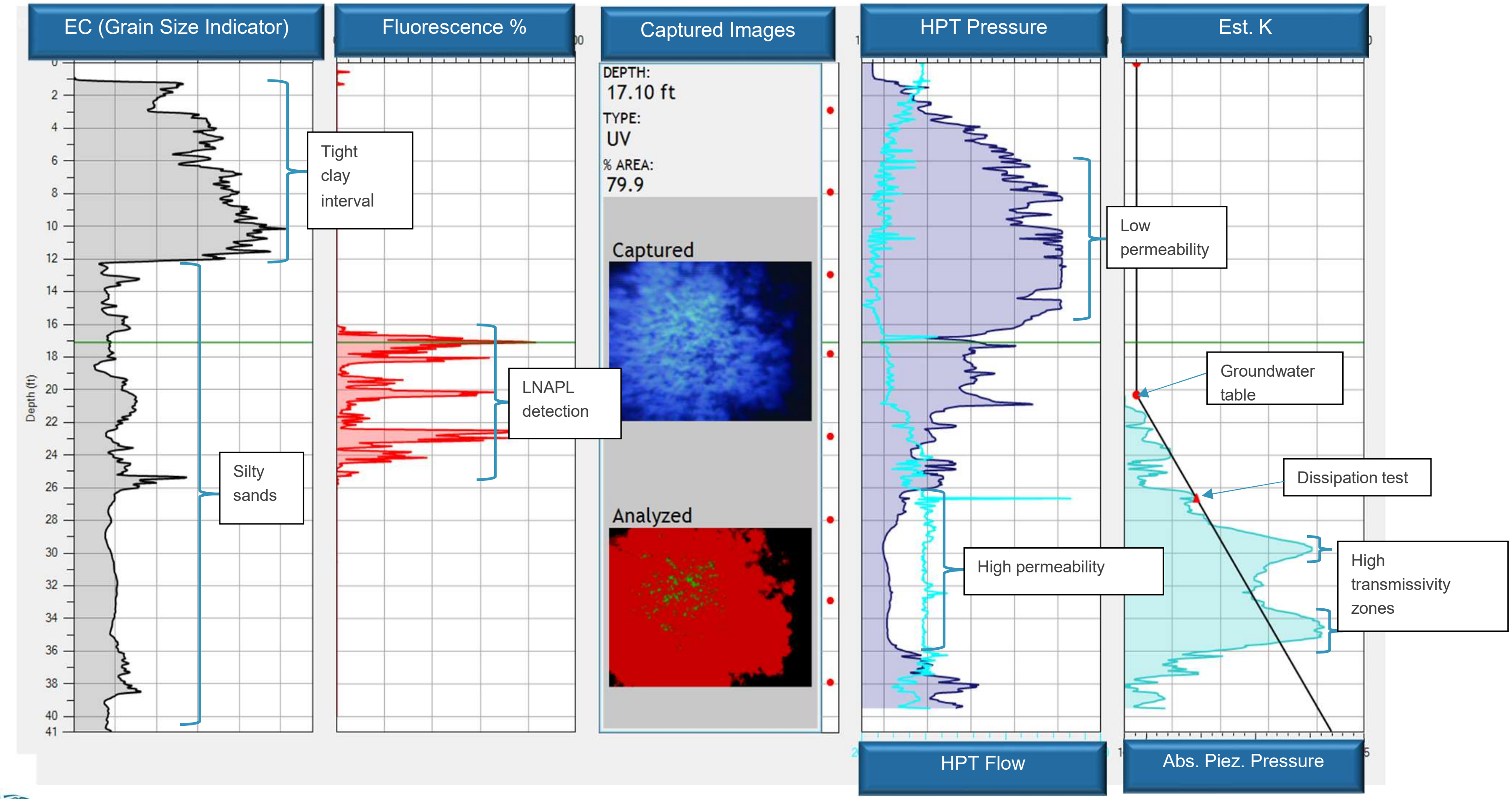
- Conducted 33 OIHPT borings in 5 days
- Total of ~1,200 vertical feet logged
- Spanning a 6 block radius



# OIP Showing Free Phase LNAPL



# OIP Fluorescence Log

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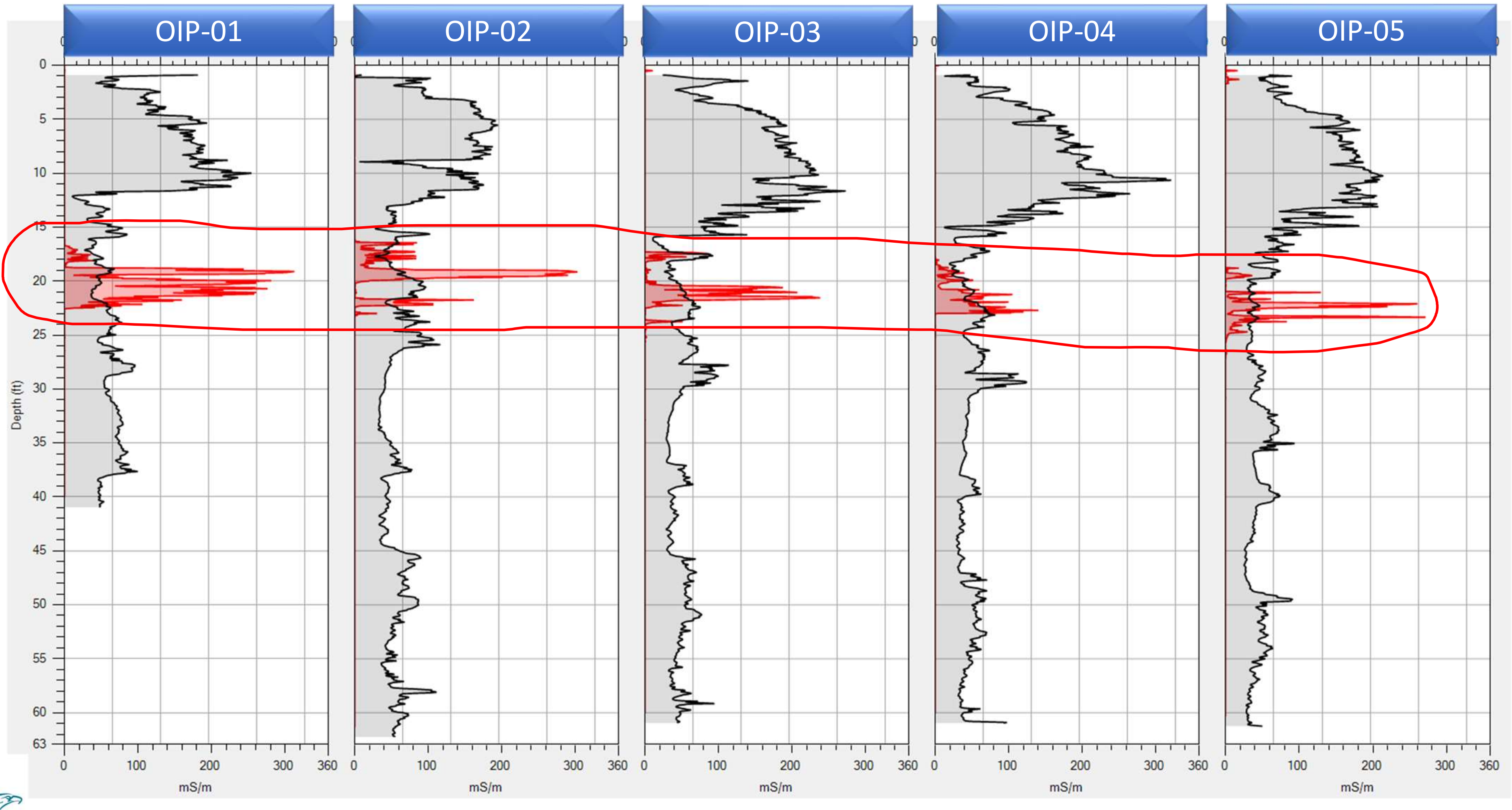
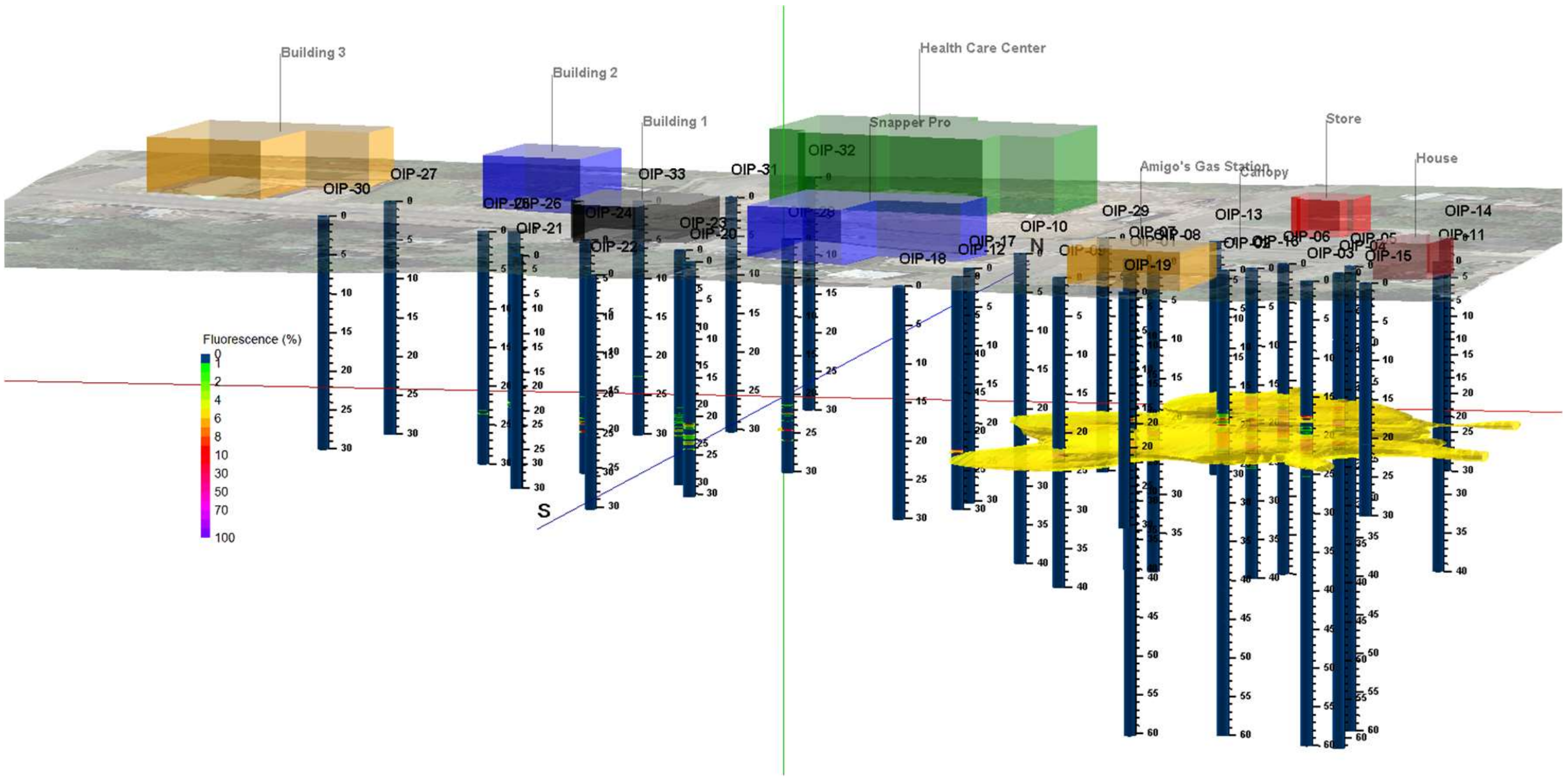
# Fluorescence Detection Cross Section



# OIP Model Aerial View

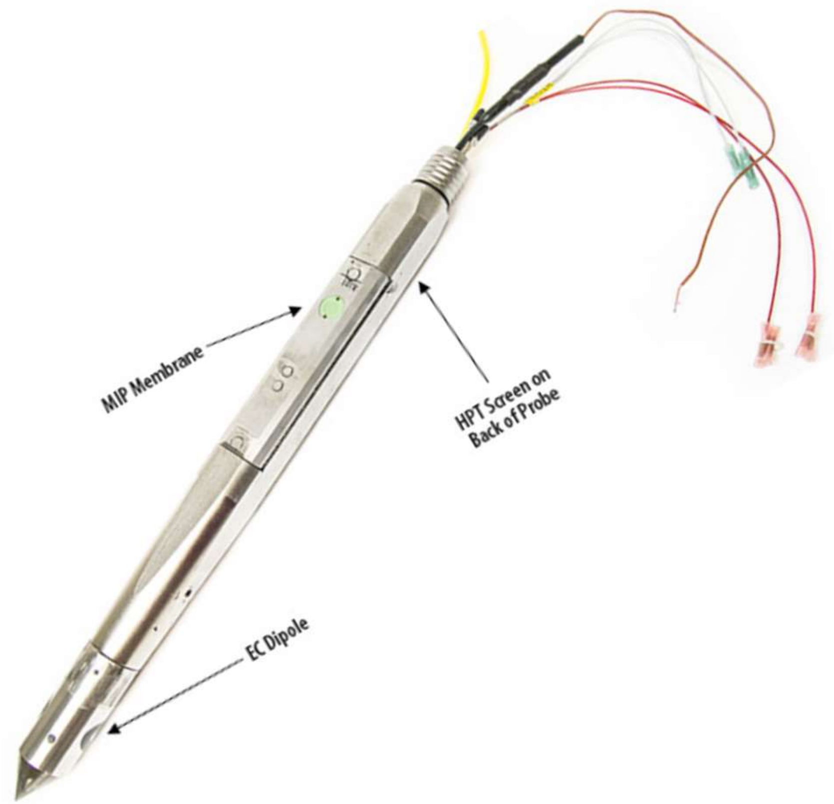
# OIP Model Side Profile



# Overview of HRSC Technology

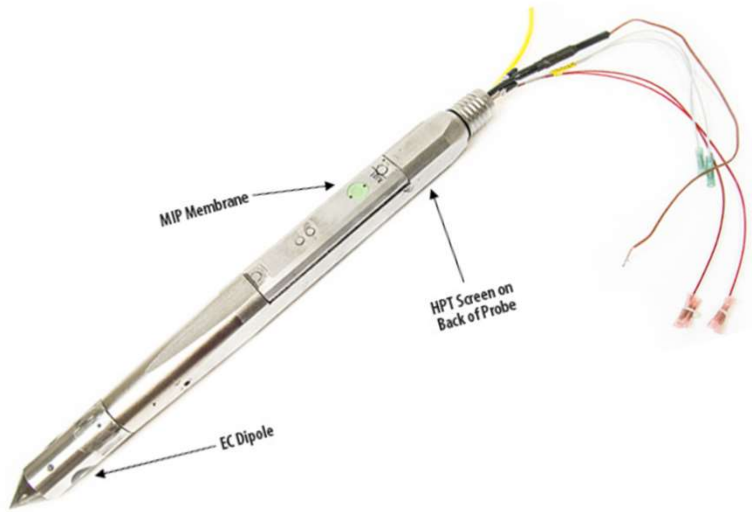
MIP/HPT = **MIHPT**

- Membrane Interface Probe
- Hydraulic Profiling Technology
  - VOCs



# MIP/HPT = MIHPT

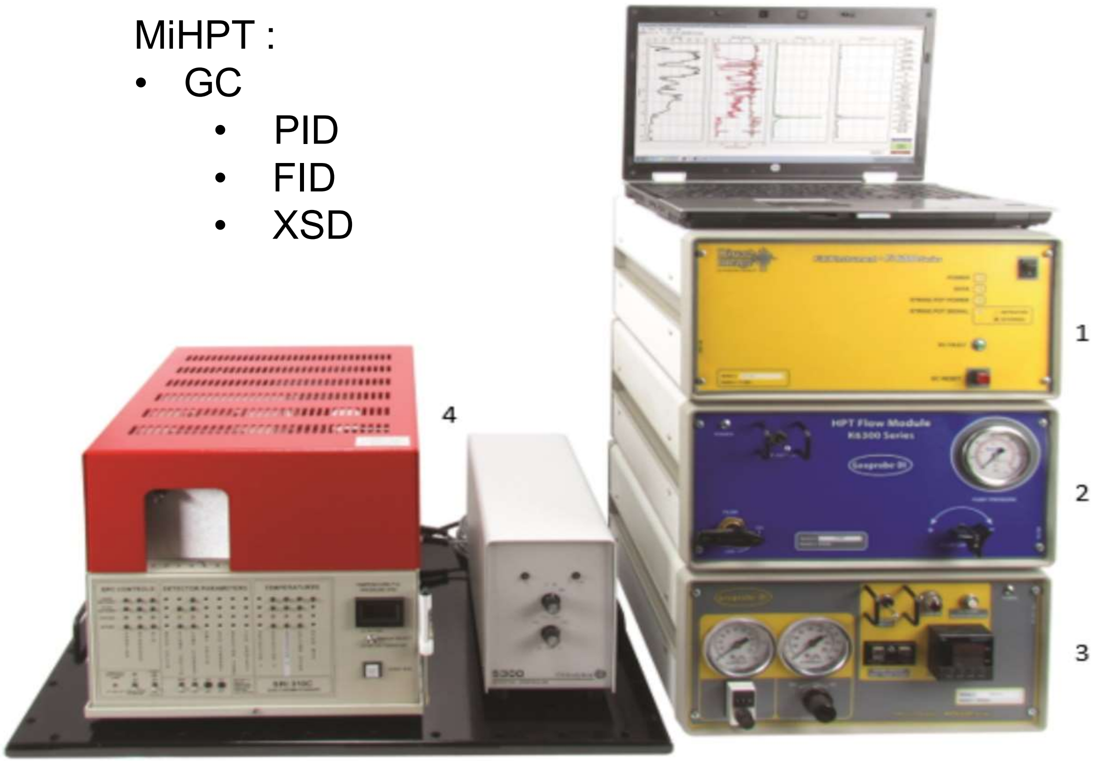
- Heater block – 120C
- Pause 1’ intervals
- VOCs diffuse through membrane
- Carried up to surface

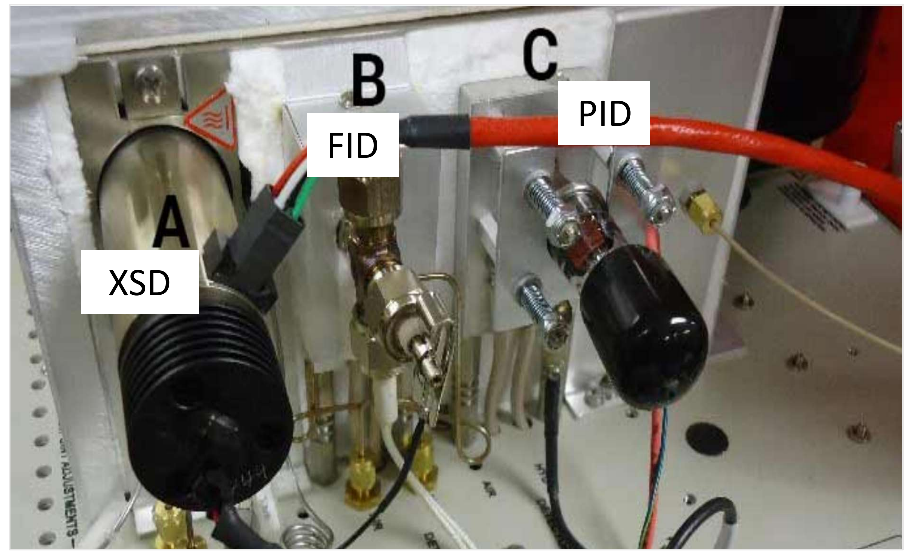



# MIHPT Detectors/Equipment

Detector Equipment inside the Mobile Command Center Units :

MiHPT :
- GC
  - PID
  - FID
  - XSD



# Strategic Optimization with HRSC – Critical for Success / Ensure Accurate Data

1. QC Tests- before & after each boring:
2. SOPs
3. Reviews
4. Trained Specialists Only!!





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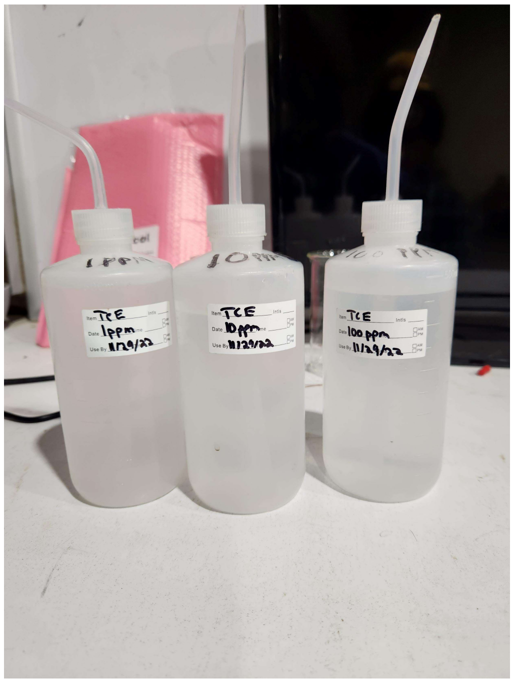
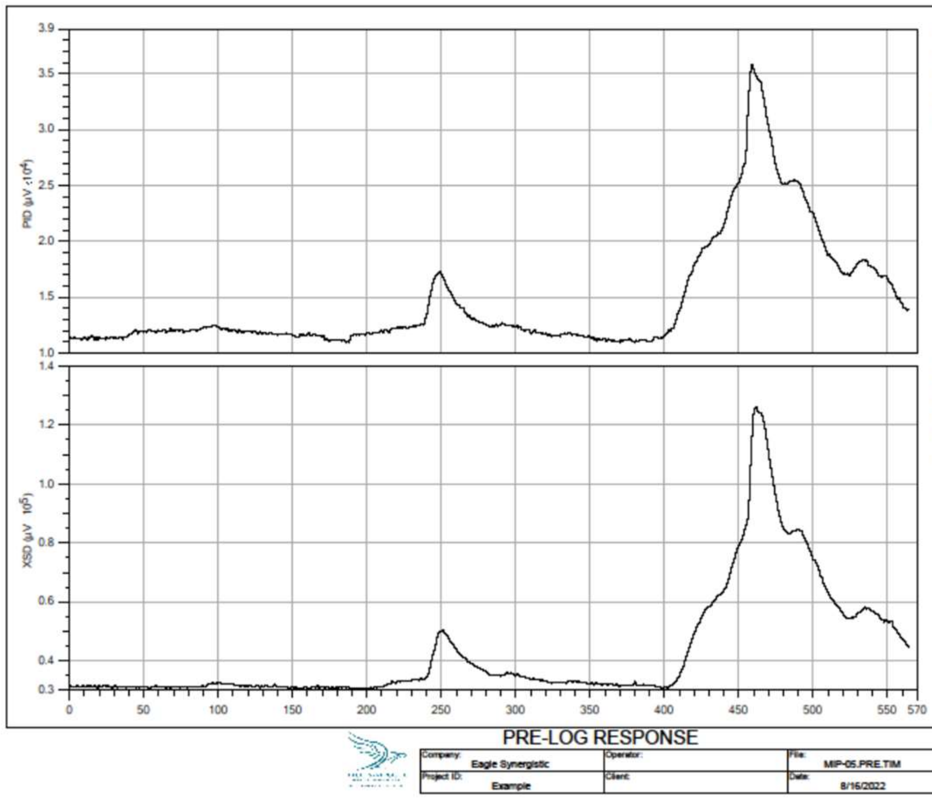
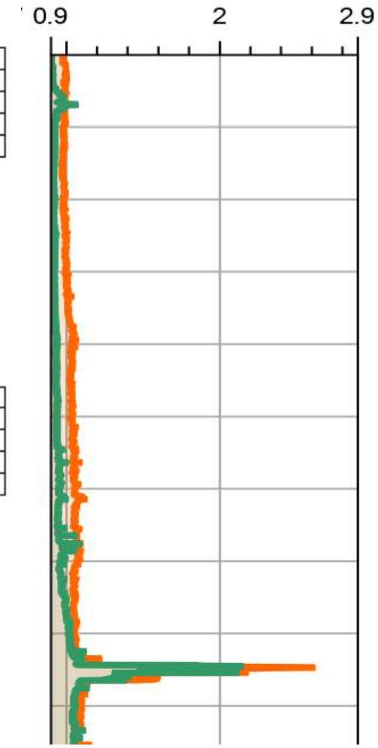
# Response Test



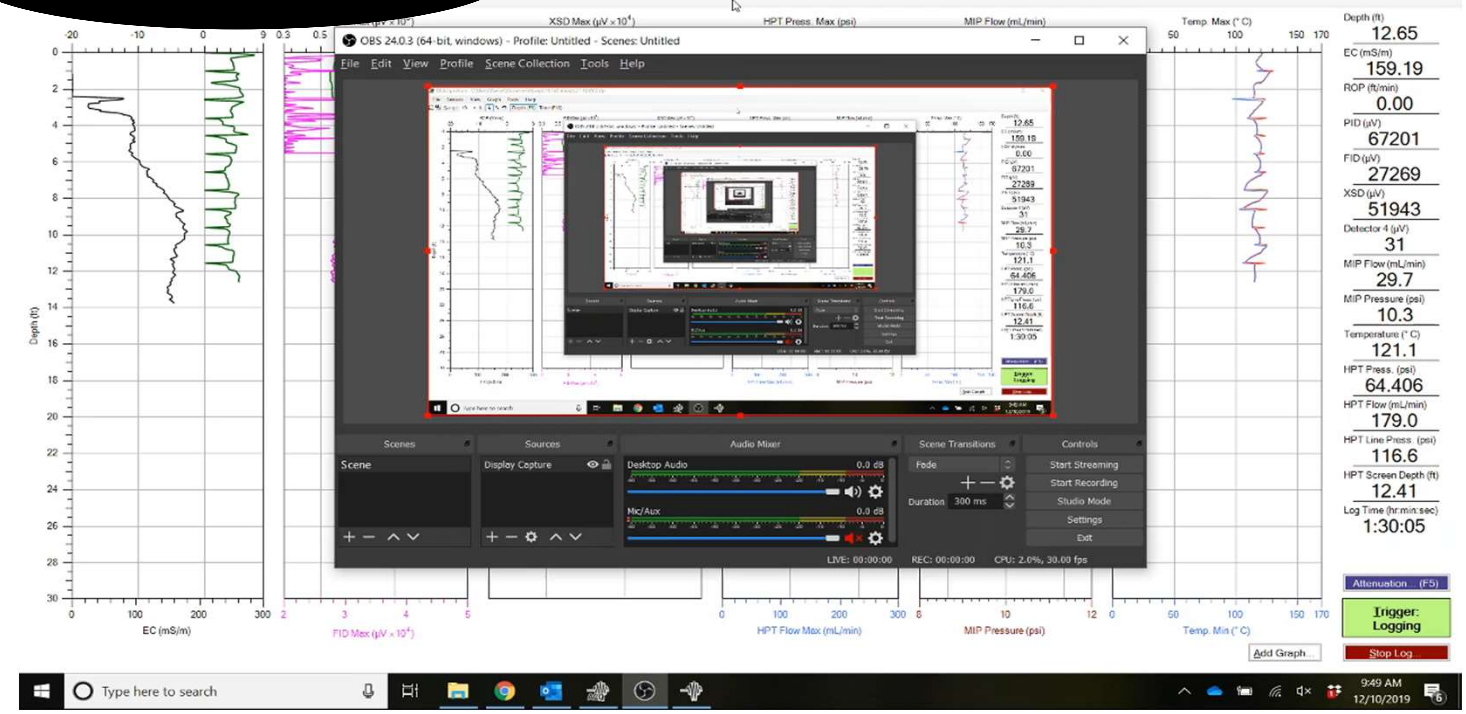



# *Strategic HRSC Investigative Process*– Critical for Targeted Remediation Success

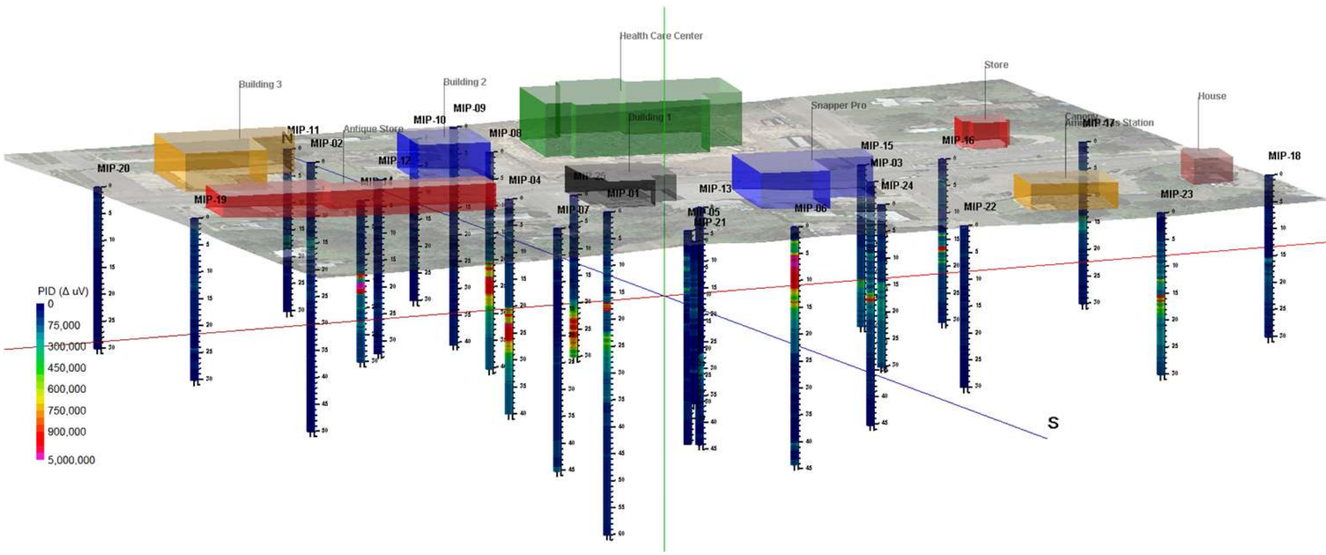
Real Time Logging

Dynamic decisions possible due to real time data!

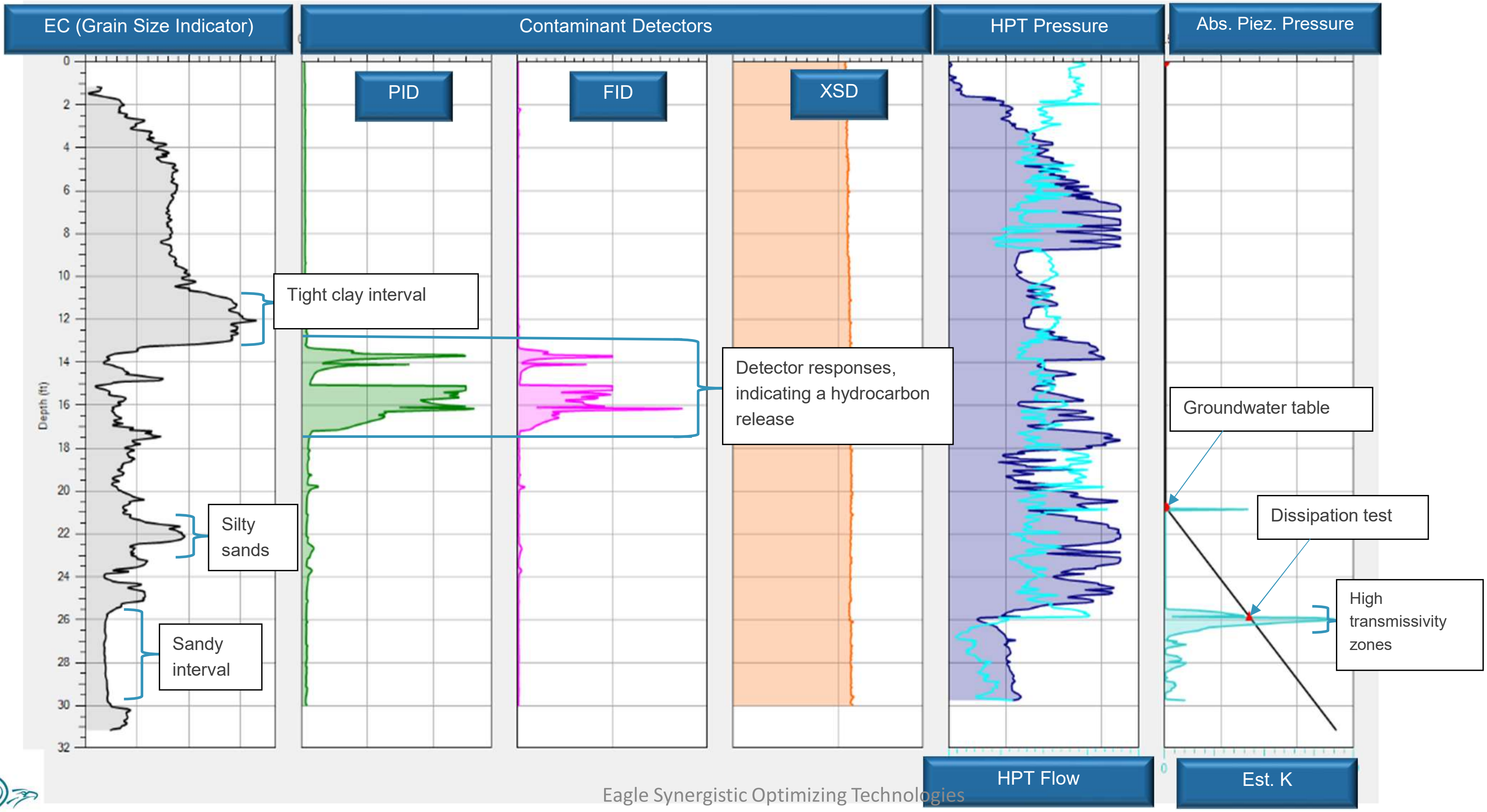


# Case Study 1: MIHPT Borings

- Conducted 25 MIHPT borings in 5 days
- Total of ~1,000 vertical feet logged
- Spanning a 6 block radius

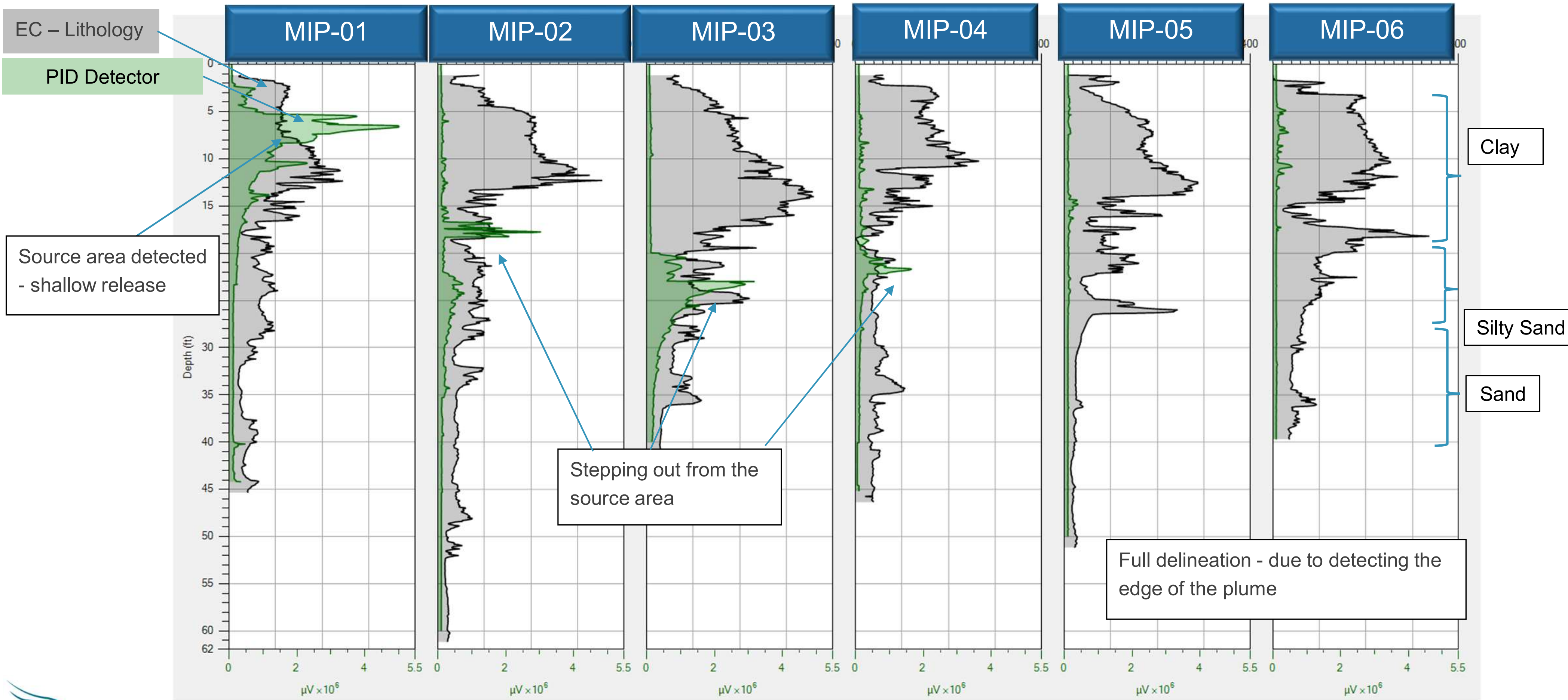


# MIHPT Log



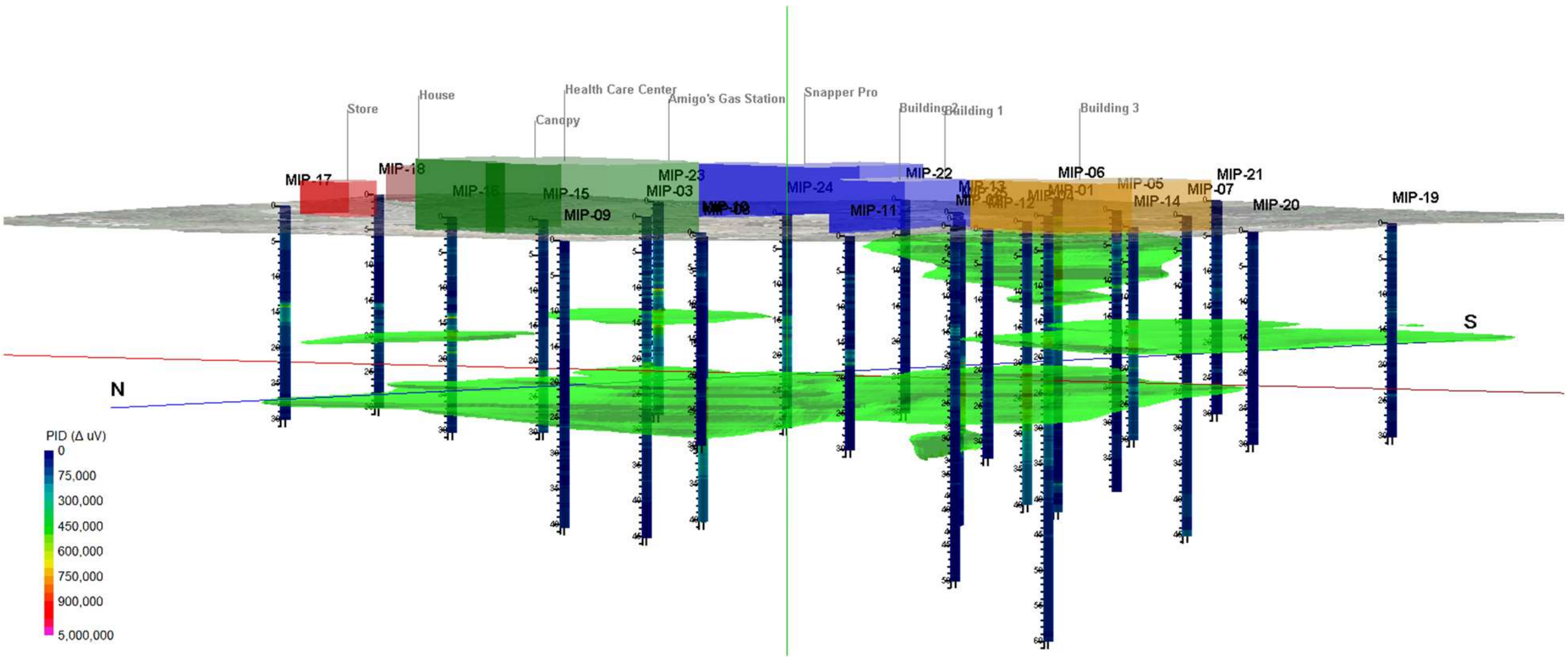
EC (Grain Size Indicator)
Contaminant Detectors
HPT Pressure
Abs. Piez. Pressure
PID
FID
XSD
Depth (ft)
Tight clay interval
Detector responses, indicating a hydrocarbon release
Groundwater table
Dissipation test
High transmissivity zones
Silty sands
Sandy interval
HPT Flow
Est. K

# MIP Log Cross-Sections

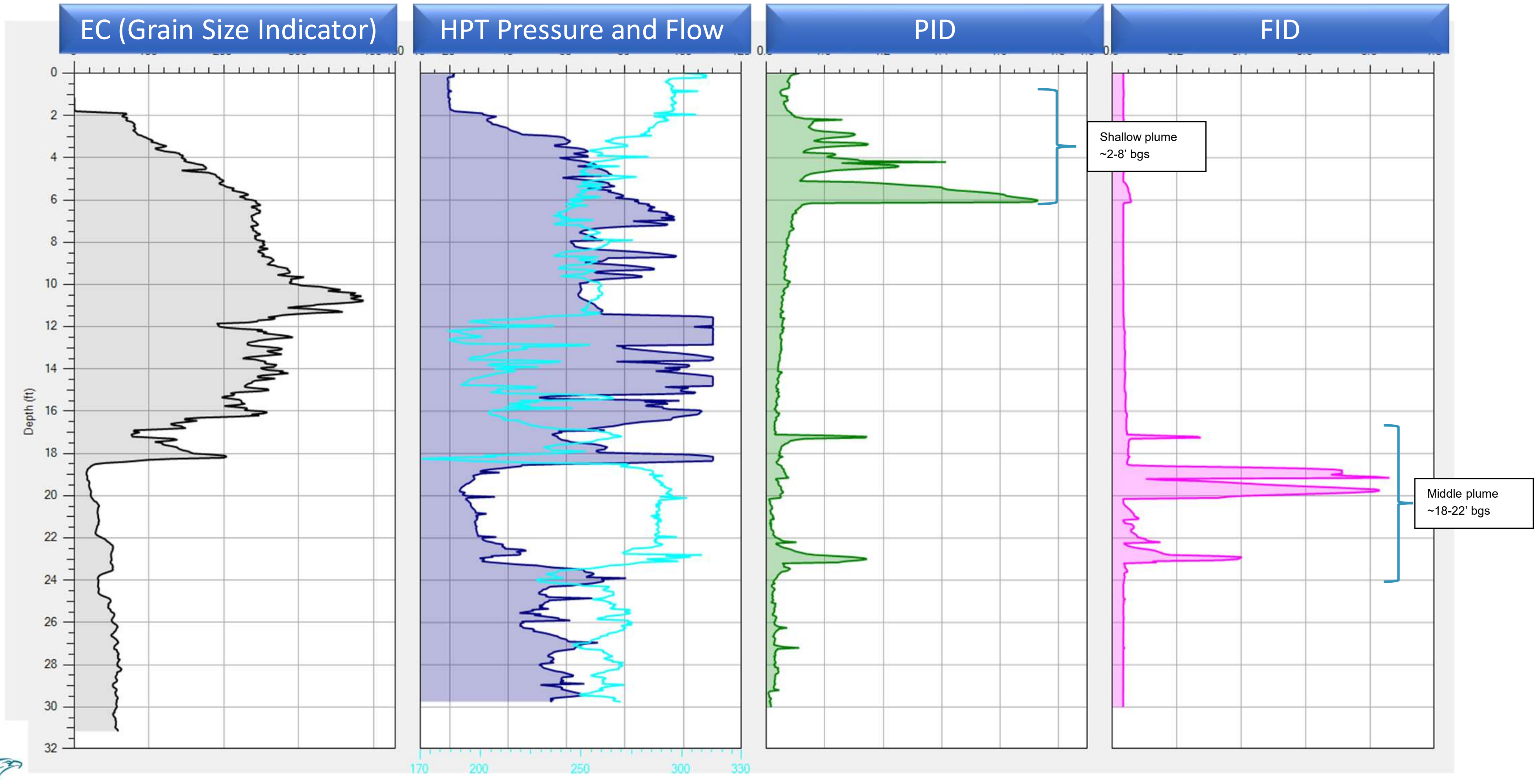


# MIP Model Aerial View

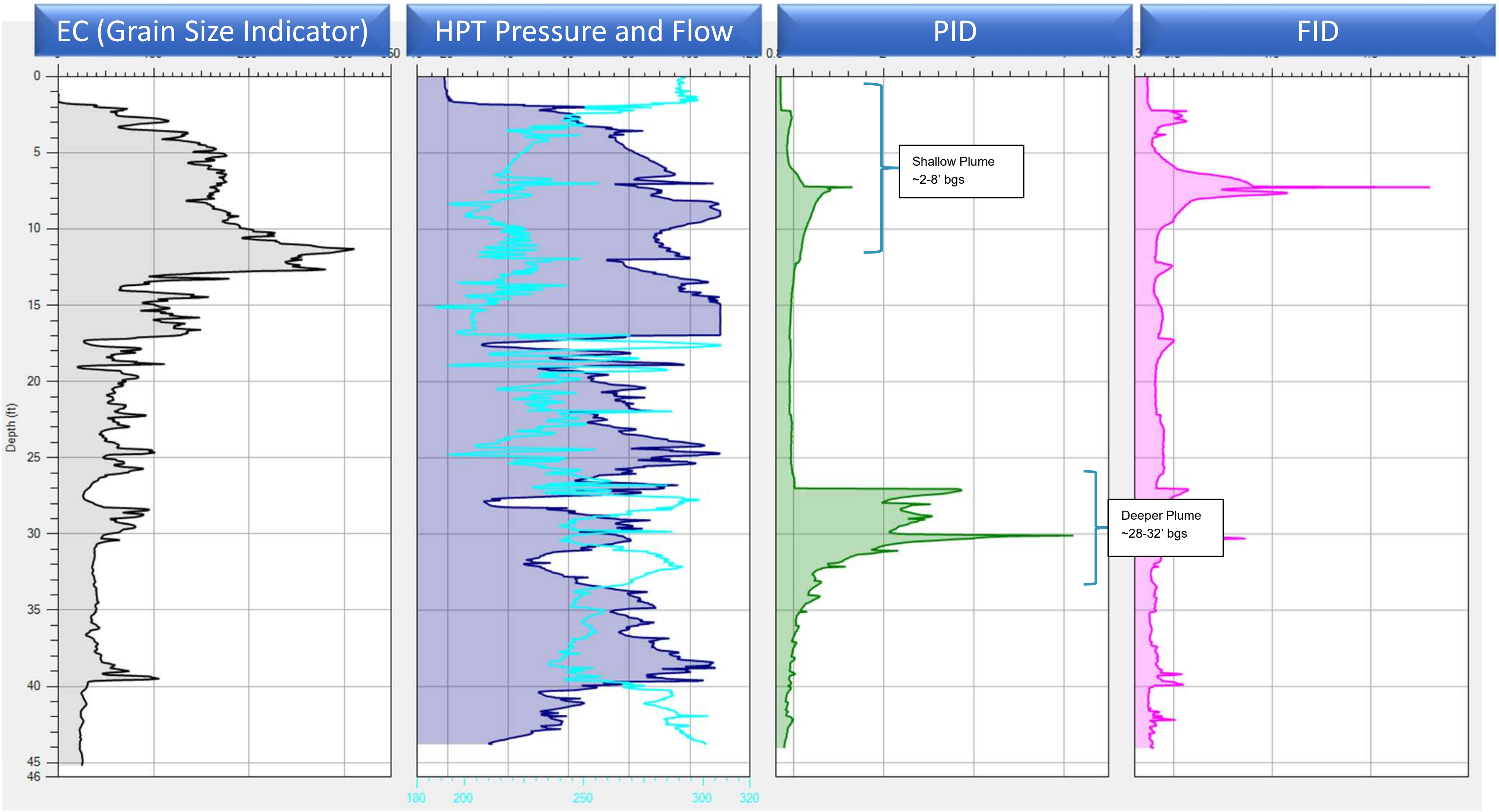
# MIP Model Side Profile



# MIP Showing Two Separate Plumes



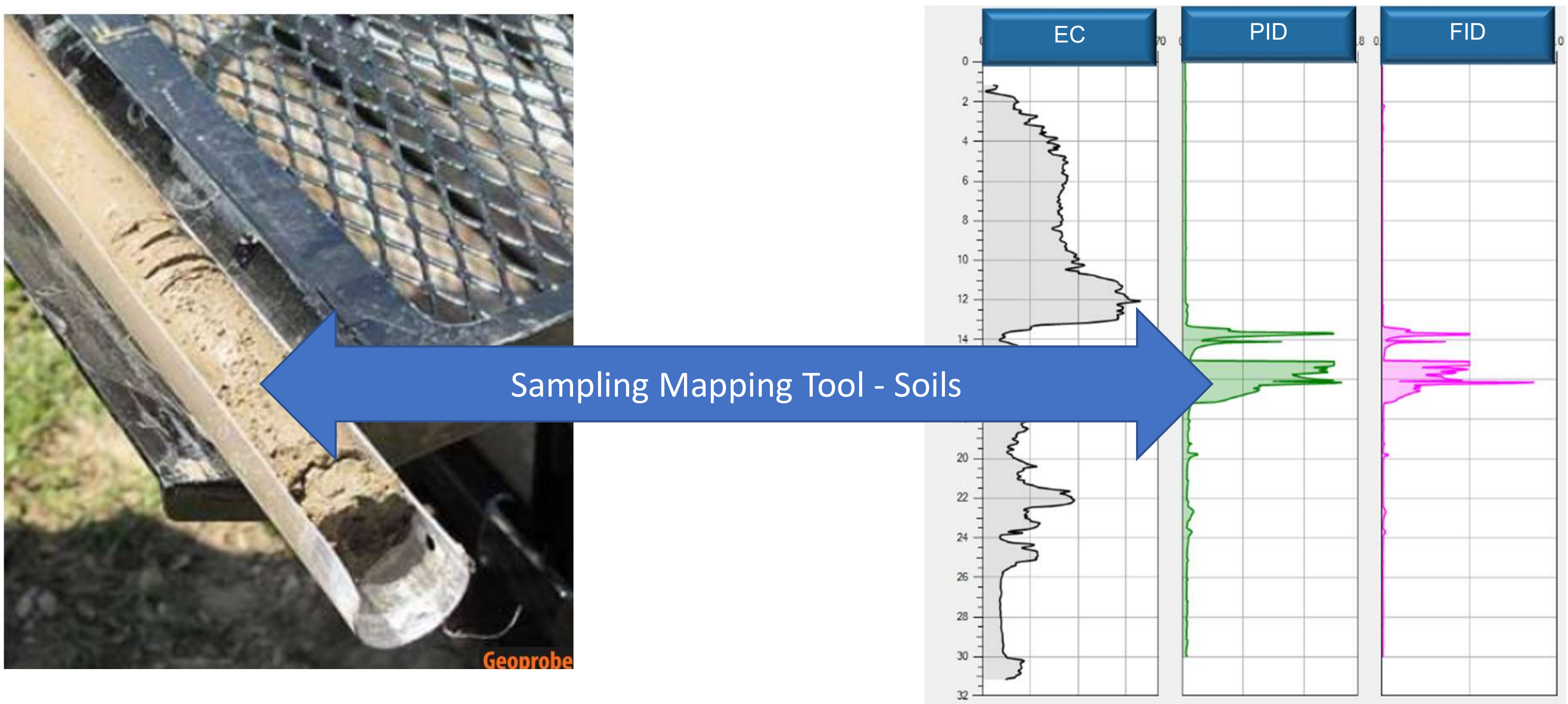
# MIP Showing Two Separate Hydrocarbon Plumes



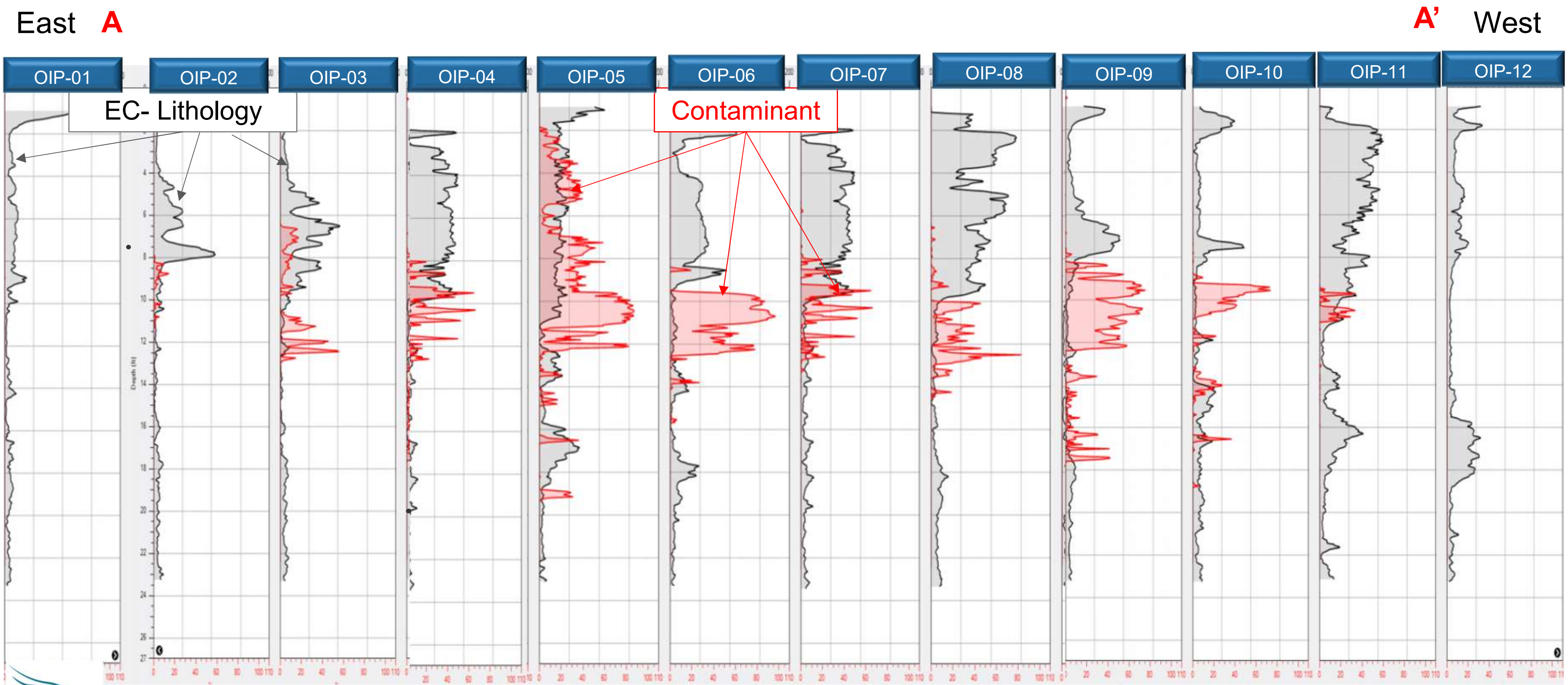
# Understand your HRSC Data - Targeting Discrete HRSC Interval

*Correlation Sampling:*

~10-20% of borings – for semi-quantitative data. Map the discrete points to sample.



# OIP Borings – Daily Cross Sections – 1 Day



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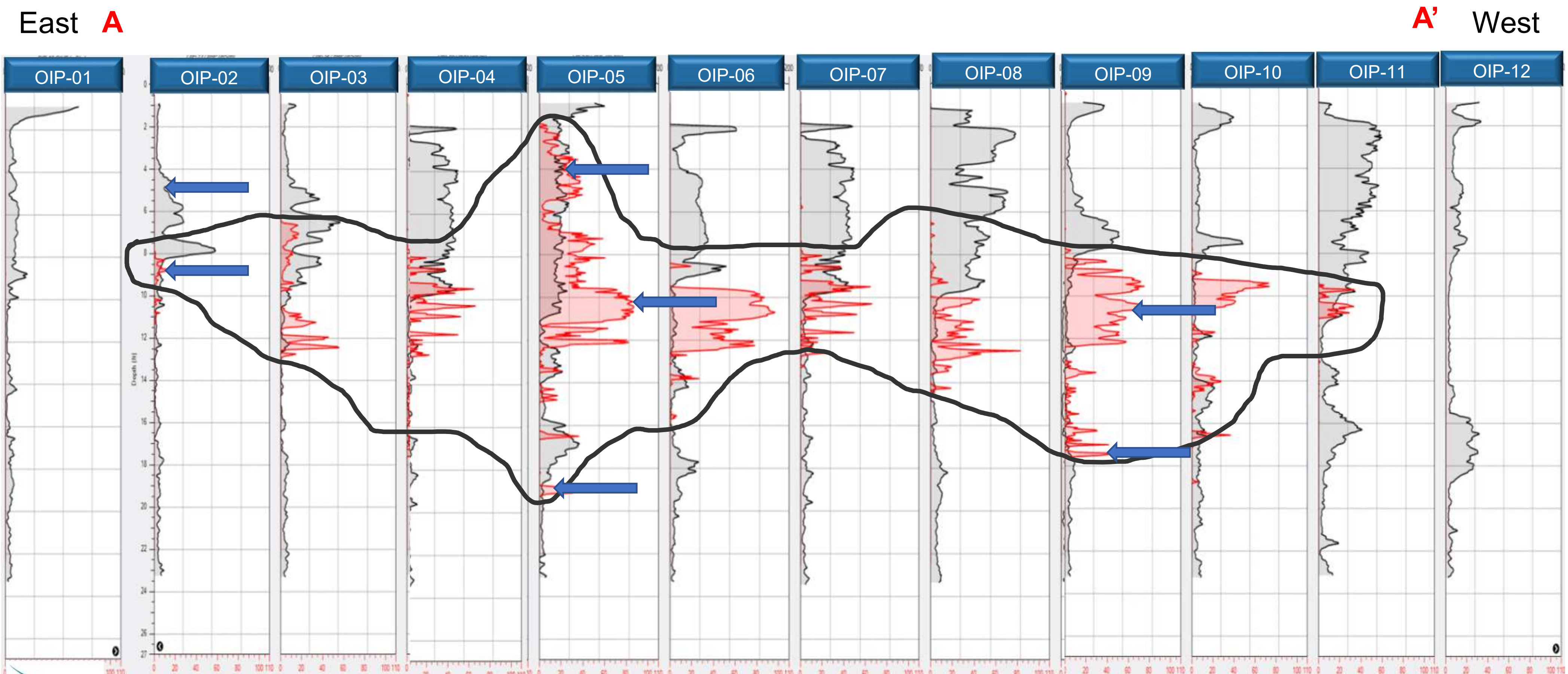
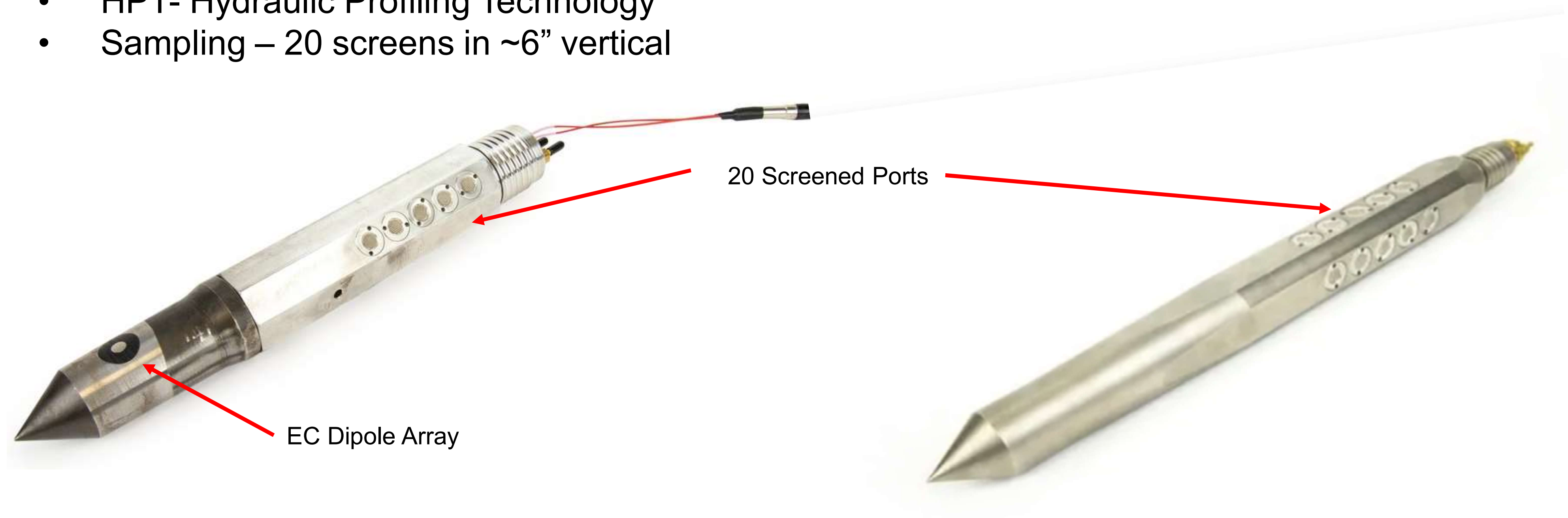
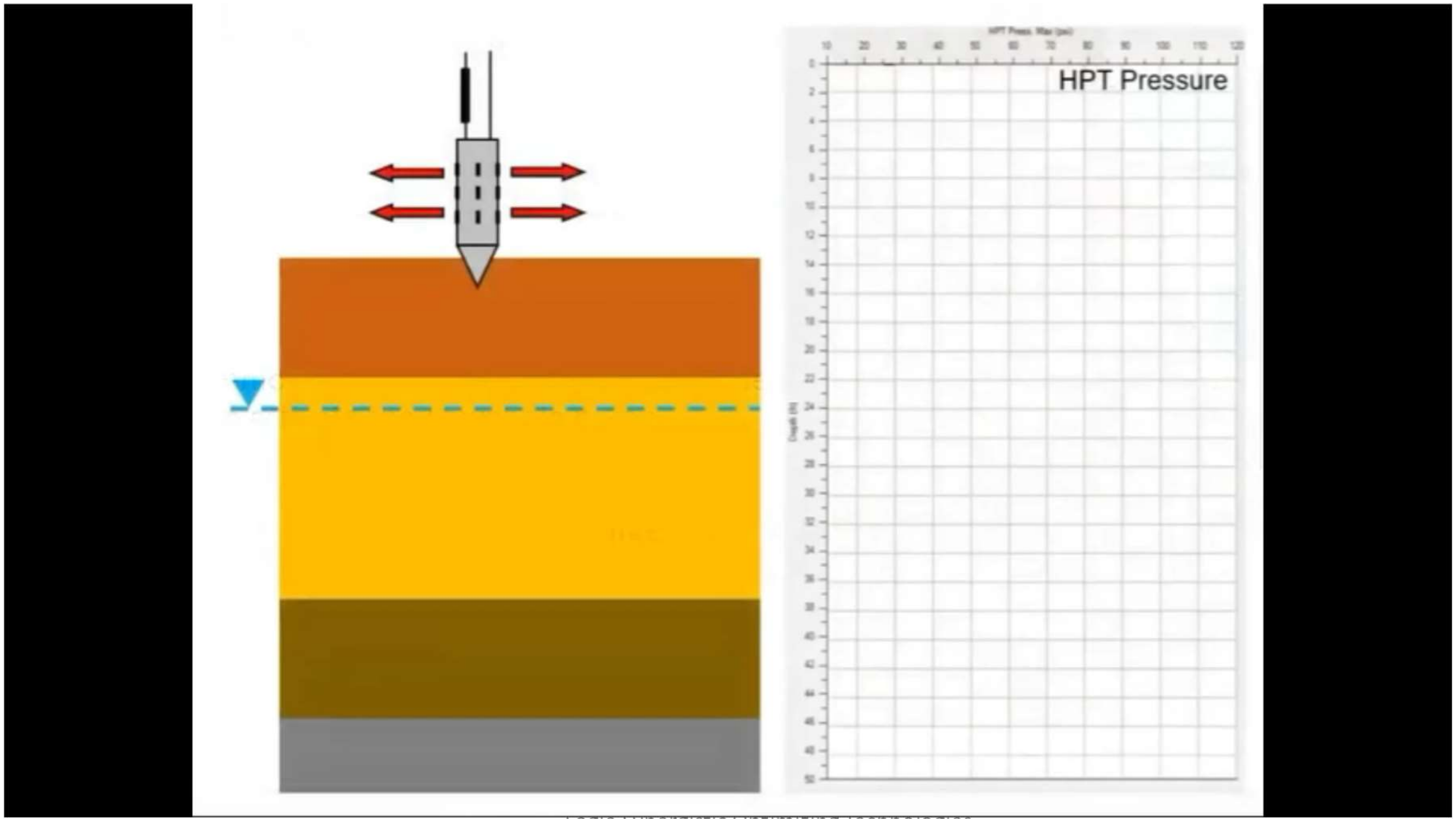


# Overview of GW Sampler/Profiler Technology – 1.75 & 2.25

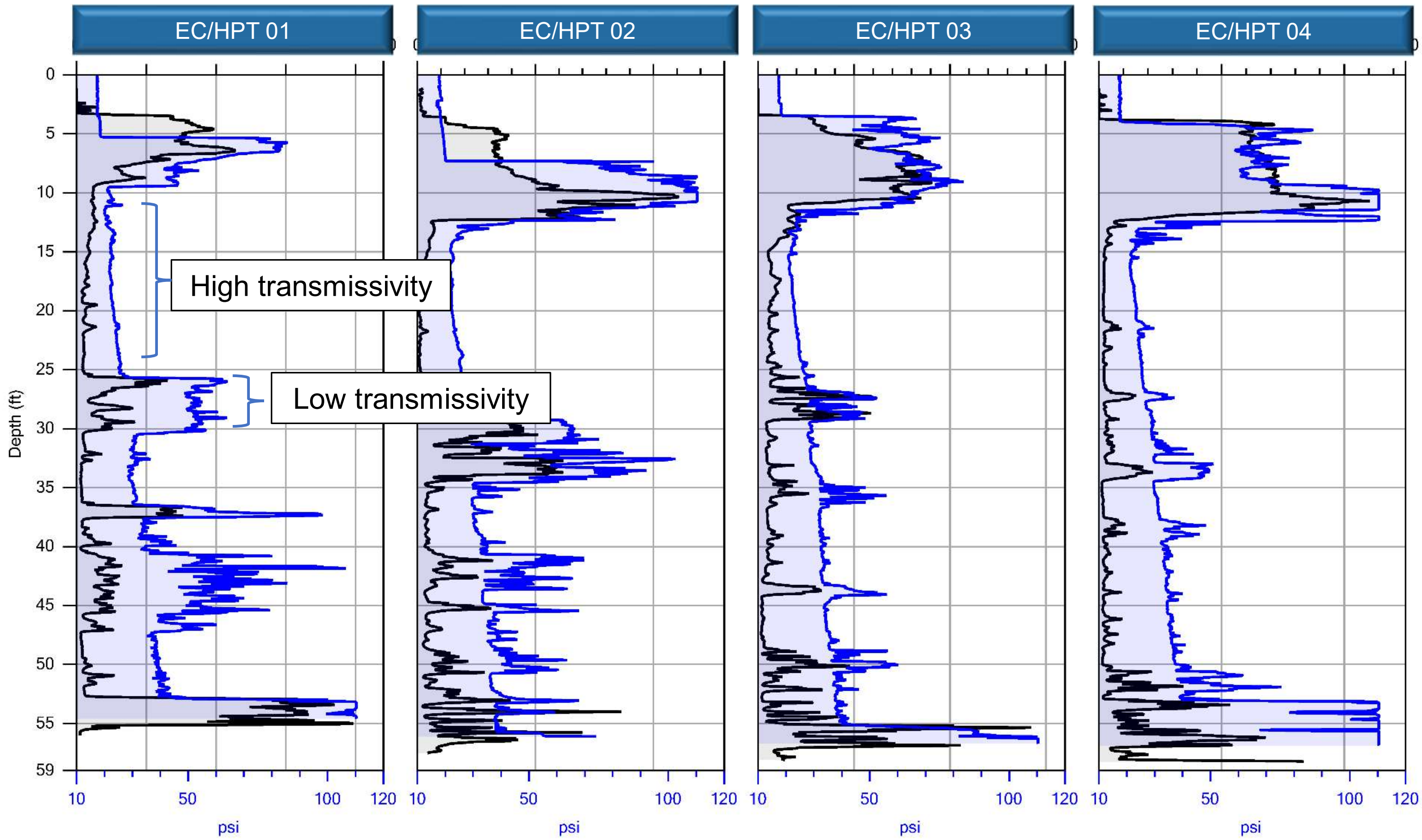
- EC- Electrical Conductivity
- HPT- Hydraulic Profiling Technology
- Sampling – 20 screens in ~6” vertical



# GW Profiler/Sampling

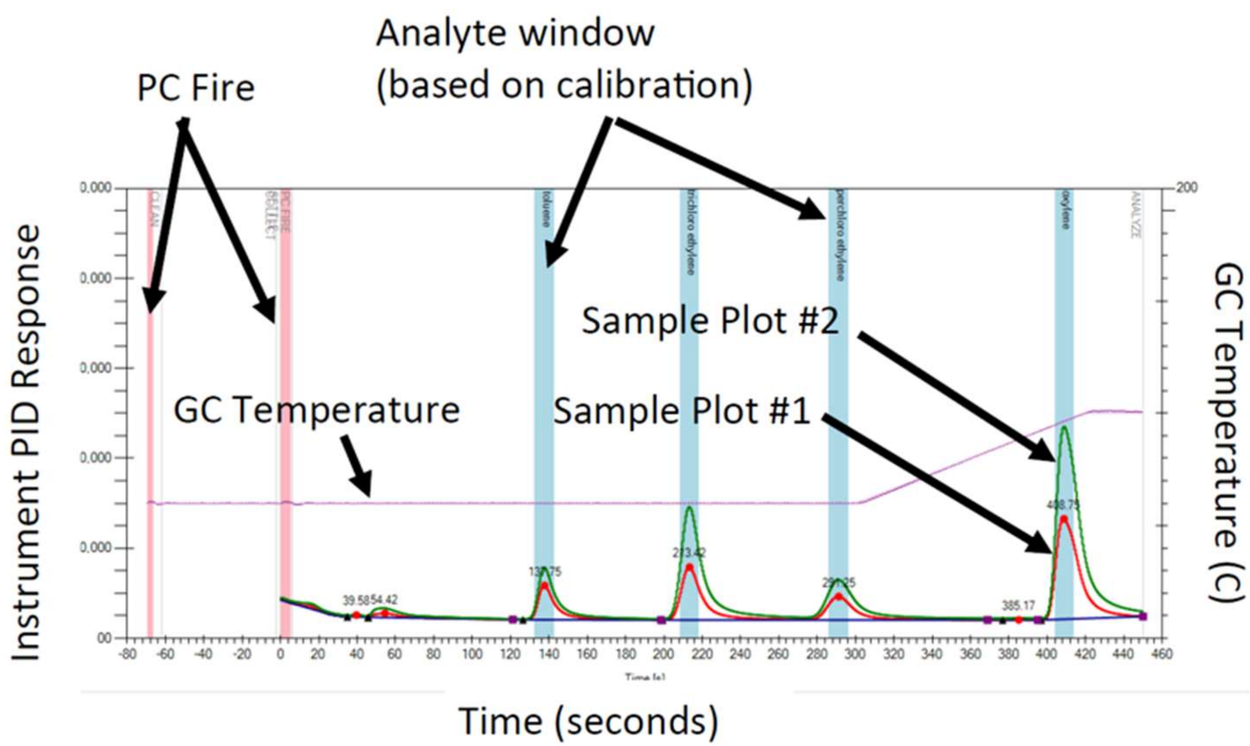
# GWS Site Investigation: Cross Sections



# Additional Optimizing Technology!

Lab Grade Portable GC

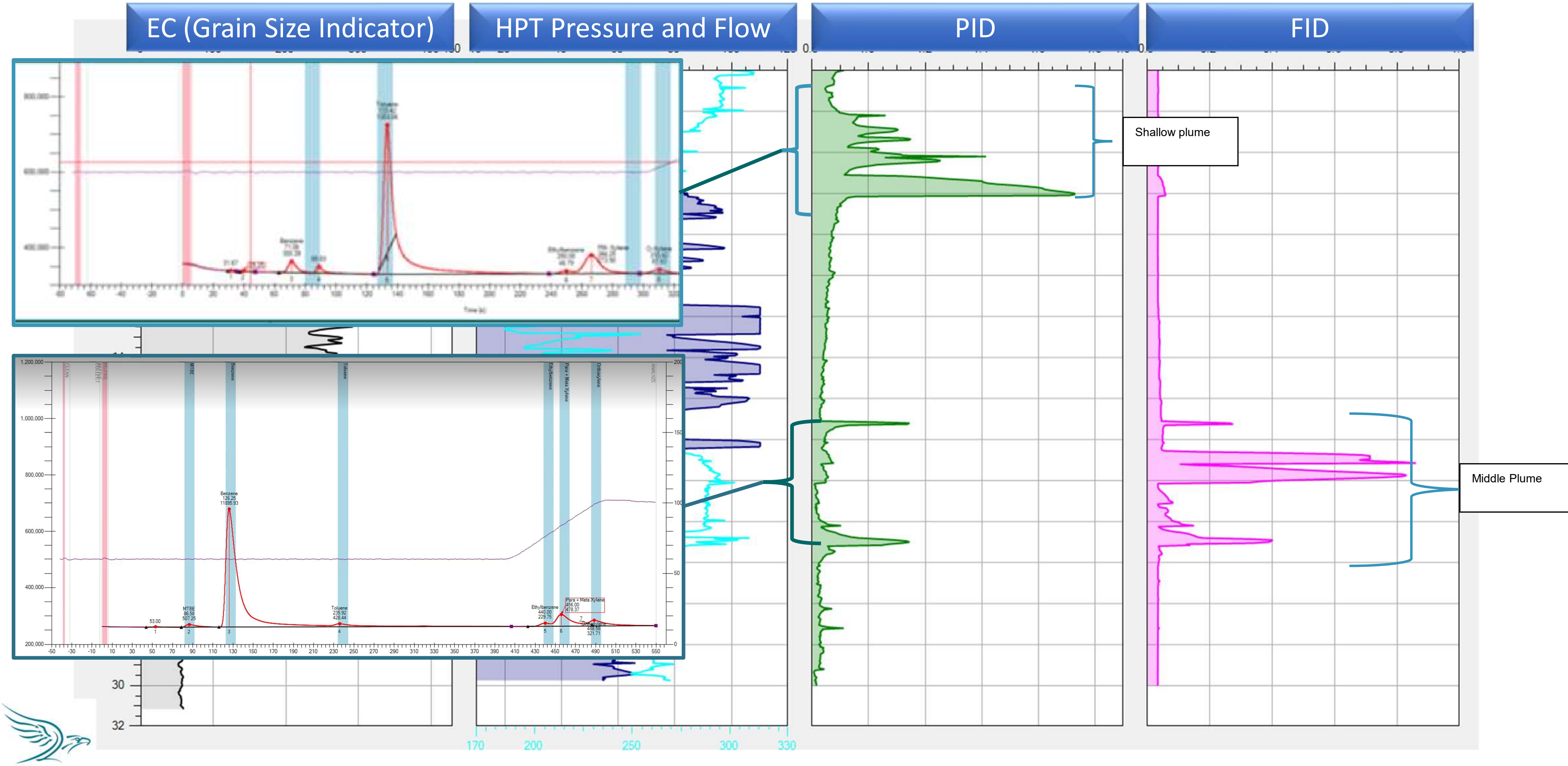
- Real Time
- On Site



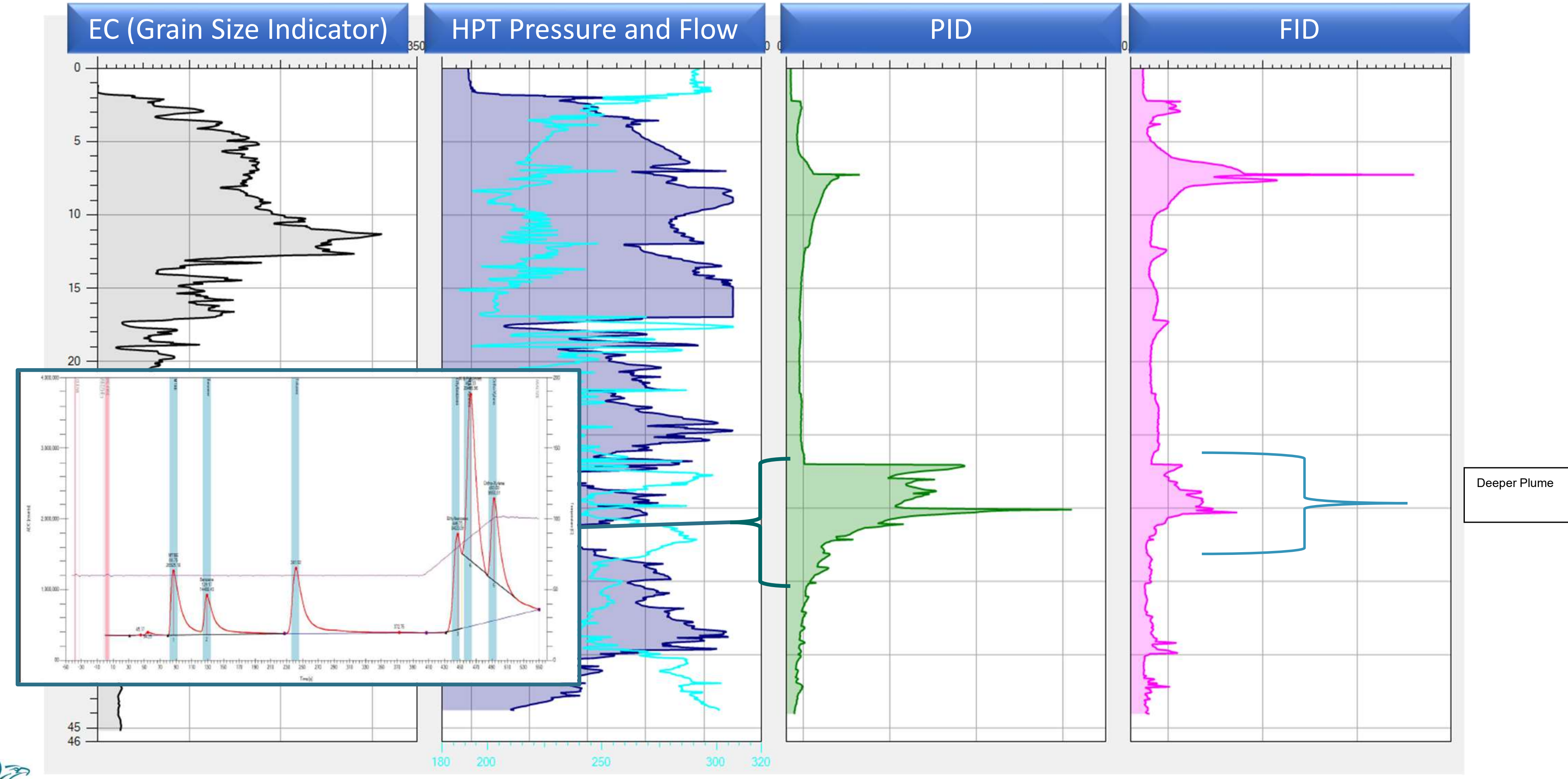
# Detectable Chemicals

| | | |
|---|---|---|
| 1,1-Dichloroethene | 75-35-4 | 10.0 |
| 1,2,4-Trichlorobenzene | 120-82-1 | 9.0 |
| 1,2-Dibromoethane | 106-93-4 | 10.4 |
| 1,2-Dichlorobenzene | 95-50-1 | 9.1 |
| 1,3-Dichlorobenzene | 541-73-1 | 9.1 |
| 1,4-Dichlorobenzene | 106-46-7 | 9.0 |
| 1,4-Dioxane | 123-91-1 | 9.2 |
| 1-Propanol | 71-23-8 | 10.2 |
| 2-Butanone (MEK) | 78-93-3 | 9.5 |
| 2-Chloroethanol | 107-07-3 | 10.5 |
| 2-Hexanone | 591-78-6 | 9.4 |
| 2-Pentanone | 107-87-9 | 9.4 |
| 2-Picoline | 109-06-8 | 9.4 |
| 2-Propanol | 67-63-0 | 10.2 |
| 4-Methyl-2-pentanone | 108-10-1 | 9.3 |
| Acetone | 67-64-1 | 9.7 |
| Acrolein | 107-02-8 | 10.1 |
| Allyl alcohol | 107-18-6 | 9.6 |
| Allyl chloride | 107-05-1 | 10.1 |
| Benzene | 71-43-2 | 9.2 |
| Benzyl chloride | 100-44-7 | 9.1 |
| Bromoacetone | 598-31-2 | 9.7 |
| Bromodichloromethane | 75-27-4 | 10.6 |
| Bromoform | 75-25-2 | 10.5 |
| Bromomethane | 74-83-9 | 10.5 |
| Carbon disulfide | 75-15-0 | 10.1 |
| Chlorobenzene | 108-90-7 | 9.1 |
| Chlorodibromomethane | 124-48-1 | 10.6 |
| Chloroethane | 75-00-3 | 10.0 |
| Chloroprene | 126-99-8 | 8.8 |
| Crotonaldehyde | 4170-30-3 | 9.7 |
| Dibromomethane | 74-95-3 | 10.5 |
| Diethyl ether | 60-29-7 | 9.5 |
| Diisopropyl ether (DIPE) | 108-20-3 | 9.2 |
| Epichlorohydrin | 106-89-8 | 10.6 |
| Ethanol | 64-17-5 | 10.6 |
| Ethyl acetate | 141-78-6 | 10.0 |
| Ethyl tert butyl ether | 637-92-3 | 9.4 |
| Ethylbenzene | 100-41-4 | 8.8 |
| Ethylene oxide | 75-21-8 | 10.6 |
| Iodomethane | 74-88-4 | 9.5 |
| Isobutyl alcohol | 78-83-1 | 10.1 |
| Isopropylbenzene | 98-82-8 | 8.8 |
| Methacrylonitrile | 126-98-7 | 10.3 |
| Methyl methacrylate | 80-62-6 | 9.7 |
| Methyl tert-butyl ether | 1634-04-4 | 9.2 |
| m-Xylene | 108-38-3 | 8.6 |
| Naphthalene | 91-20-3 | 8.1 |
| n-Butanol | 71-36-3 | 10.0 |
| Nitrobenzene | 98-95-3 | 9.9 |
| n-Propylamine | 107-10-8 | 8.8 |
| o-Toluidine | 95-53-4 | 7.4 |
| o-Xylene | 95-47-6 | 8.6 |
| Propargyl alcohol | 107-19-7 | 10.5 |
| p-Xylene | 106-42-3 | 8.5 |
| Pyridine | 110-86-1 | 9.3 |
| Styrene | 100-42-5 | 8.4 |
| t-Butyl alcohol | 75-65-0 | 10.3 |
| Tetrachloroethene | 127-18-4 | 9.3 |
| Toluene | 108-88-3 | 8.8 |
| trans-1,2-Dichloroethene | 156-60-5 | 9.7 |
| Trichloroethene | 79-01-6 | 9.5 |
| Vinyl acetate | 108-05-4 | 9.2 |
| Vinyl chloride | 75-01-4 | 10.0 |
| β-Propiolactone | 57-57-8 | 9.7 |

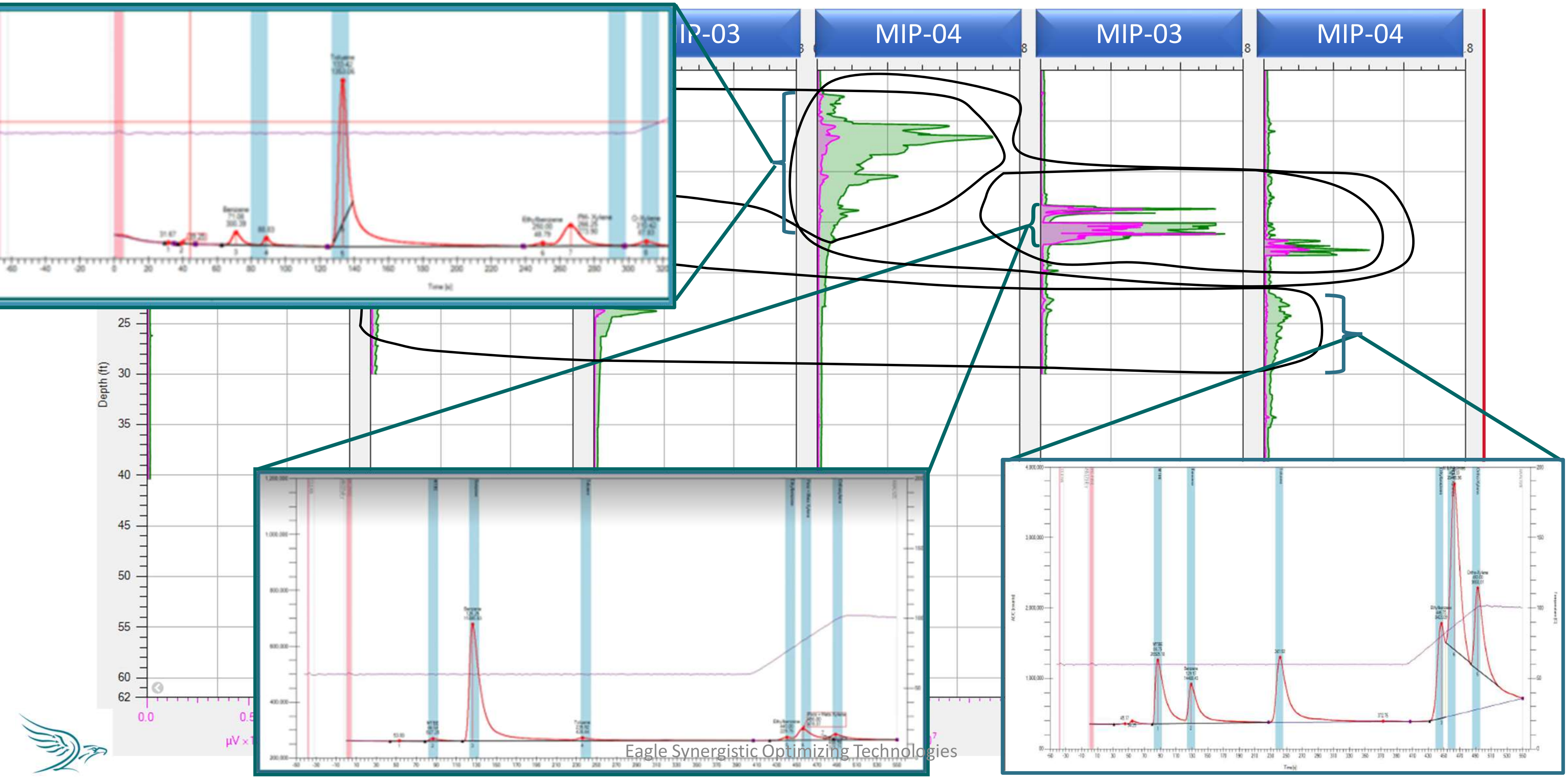
# MIP Showing Two Separate Plumes



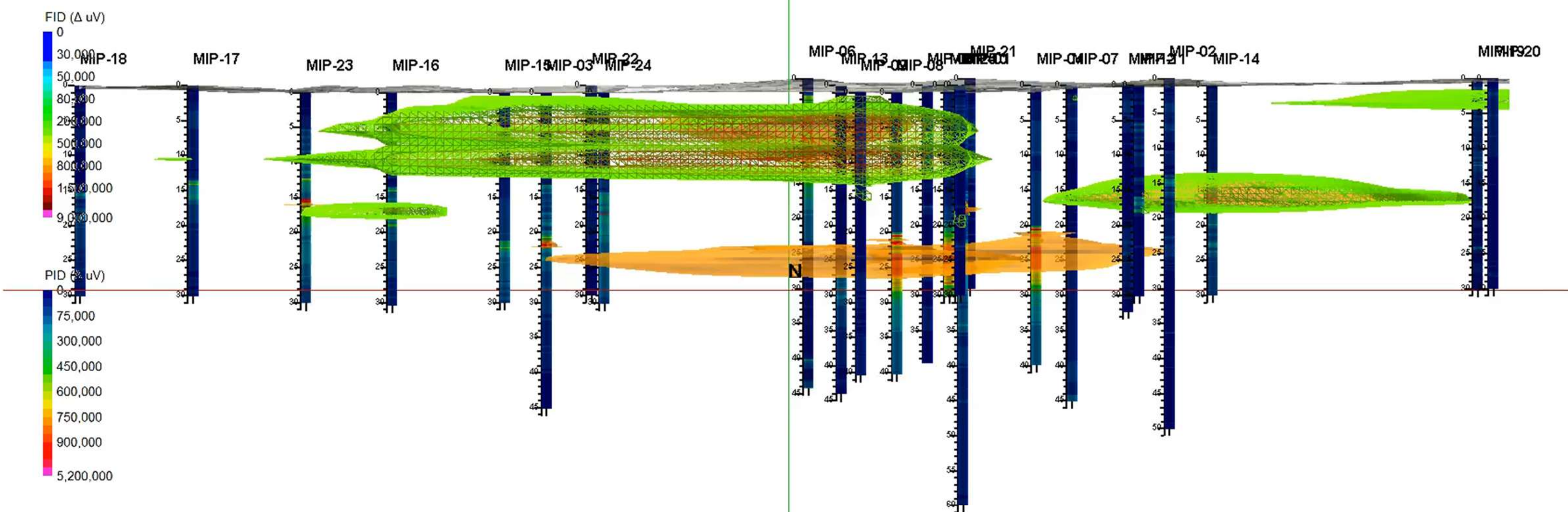
# MIP Showing Two Separate Hydrocarbon Plumes



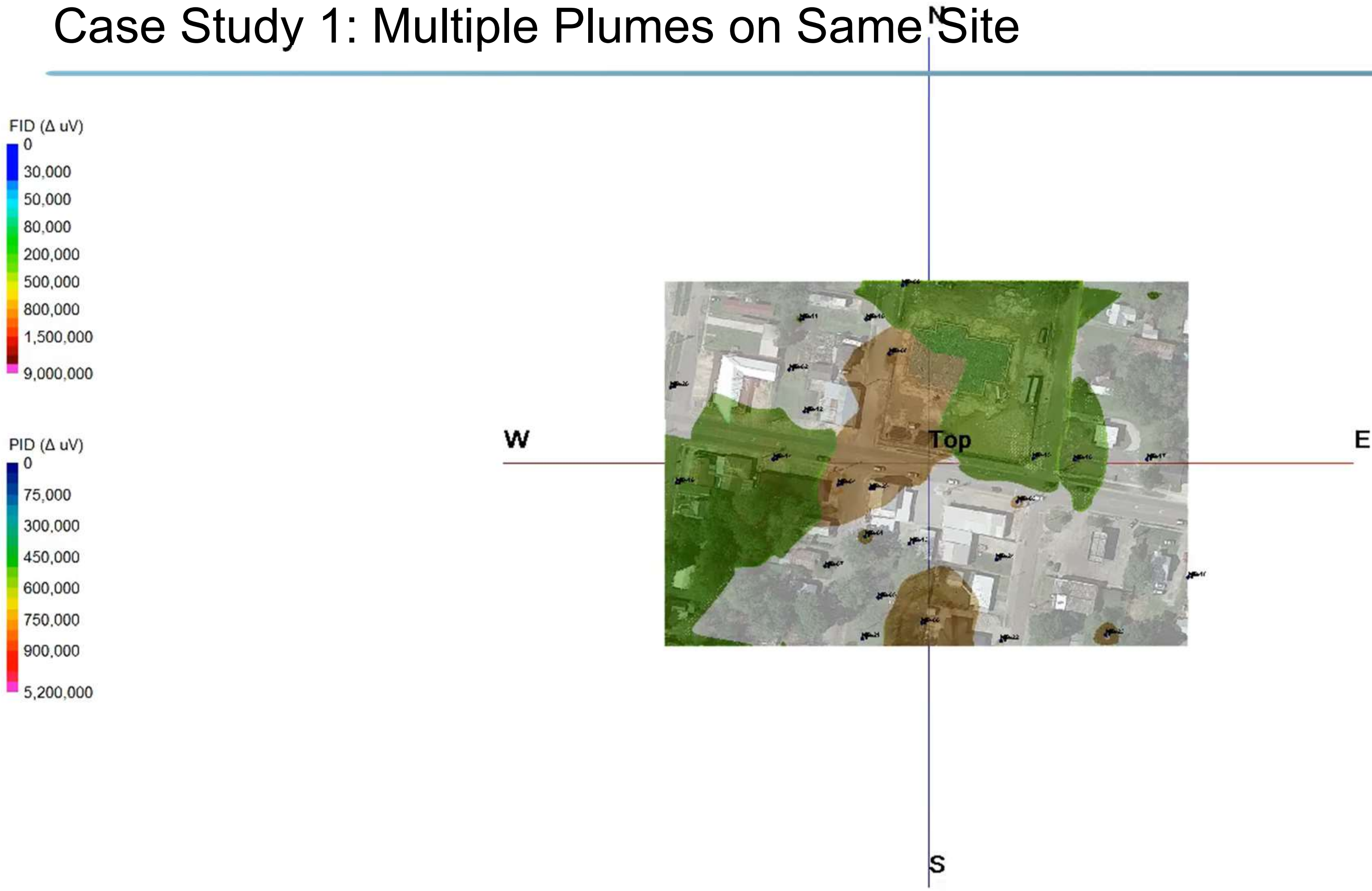
# Comingled Plume



# Case Study 1: Multiple Plumes on Same Site

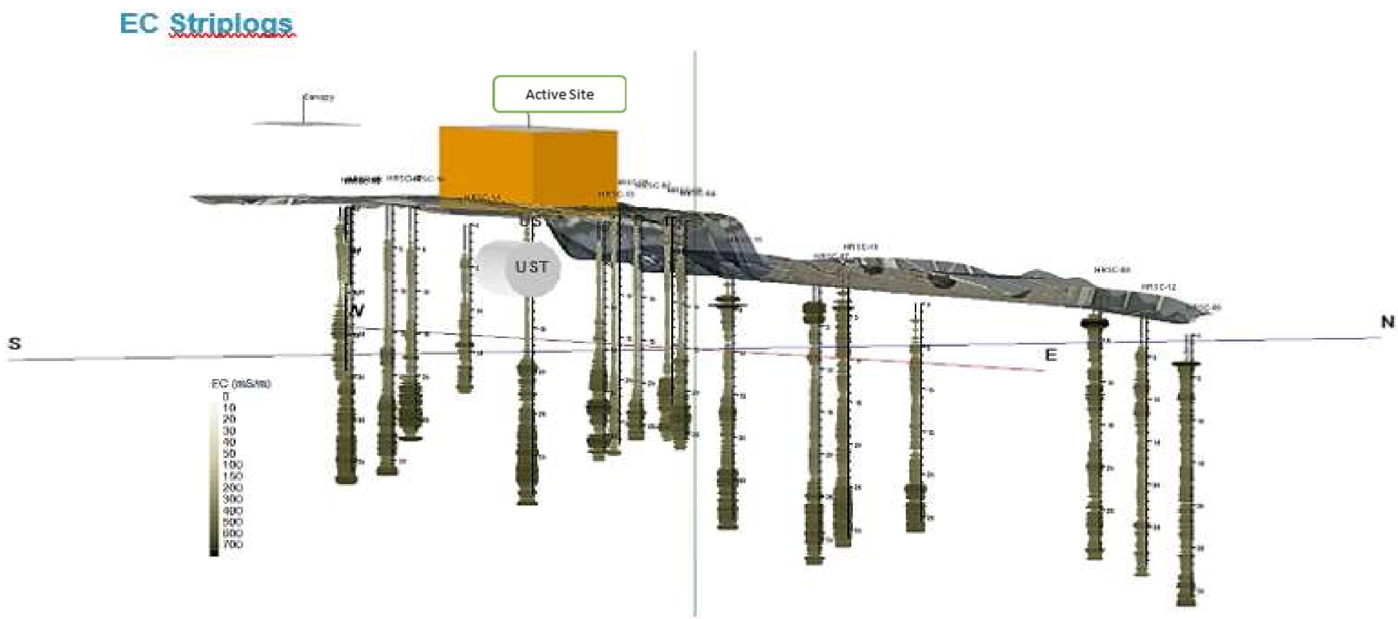


# Case Study 1: Multiple Plumes on Same Site



# Case Study 2:
# 3D Modeling Visualization
# &
# Discrete Soil Samples – Helped Client to Define Risk Level Plume

# Strategic Optimization with HRSC

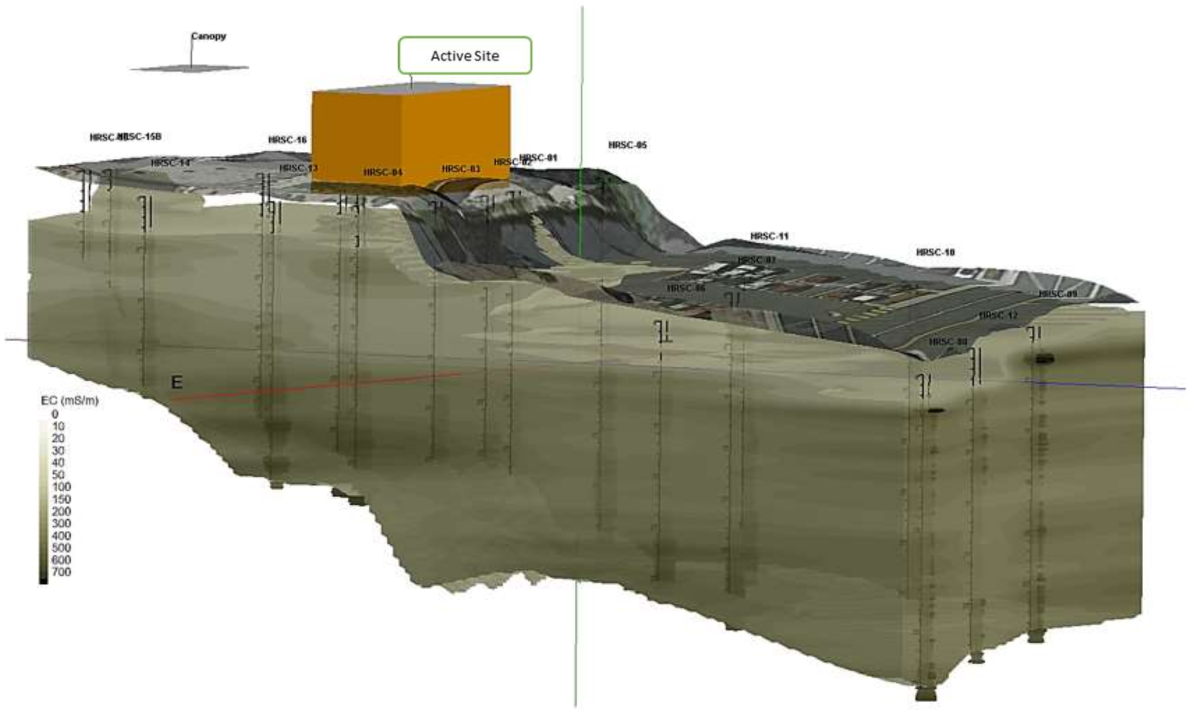



Electrical Conductivity:

- 18 Boring Locations
- The darker/thicker areas of the striplogs indicate higher EC values and correlate with the color legend
- East-West indicated by the red axis
- North-South indicated by the blue axis

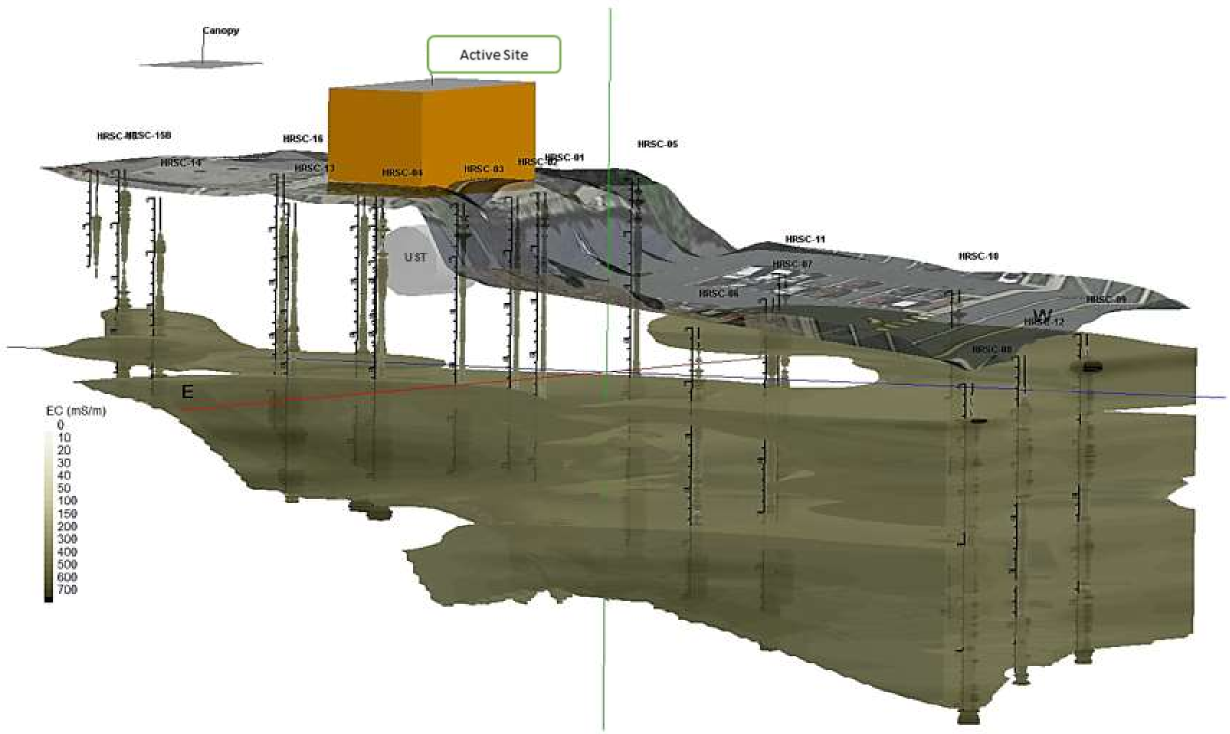
# Strategic Optimization with HRSC

## EC Solid Block Models



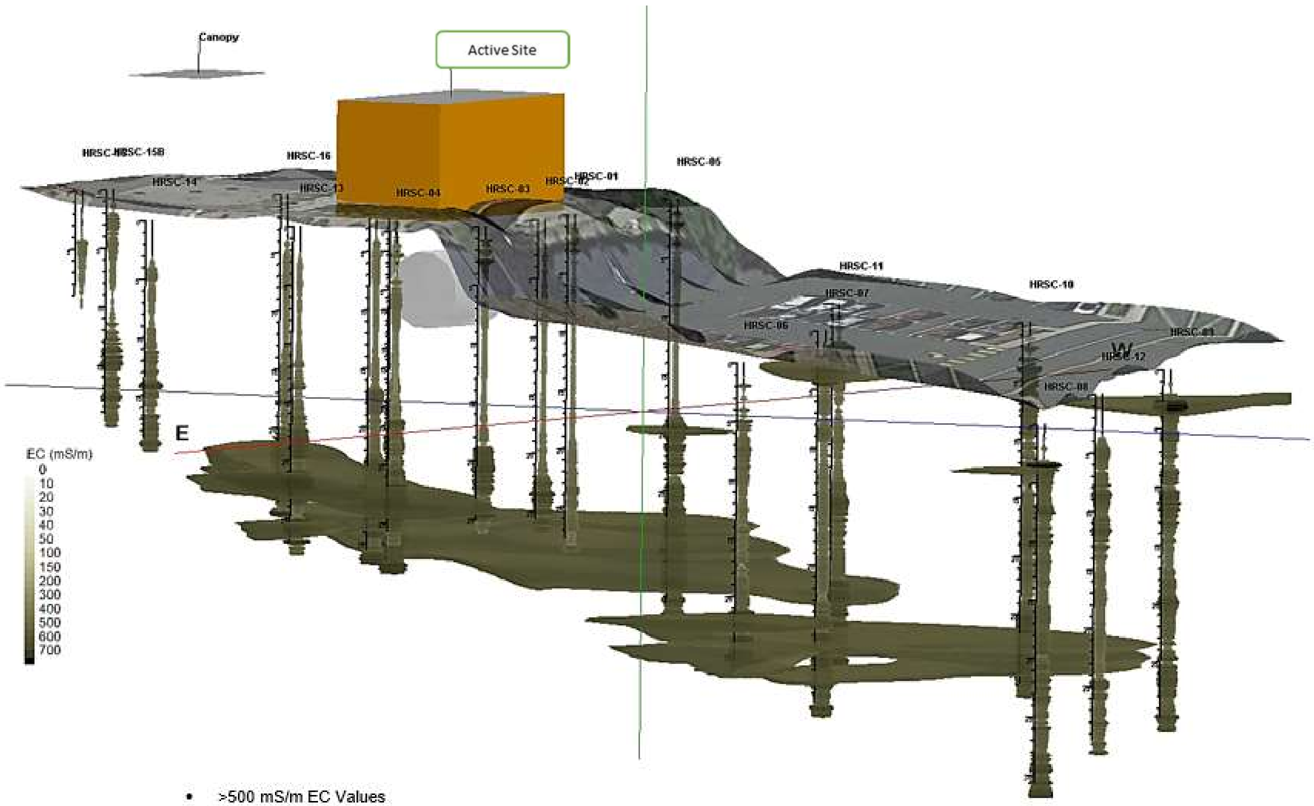

- >100 mS/m EC Values
- Lighter colors are lower EC values generally indicating coarser, more permeable lithology

# Strategic Optimization with HRSC



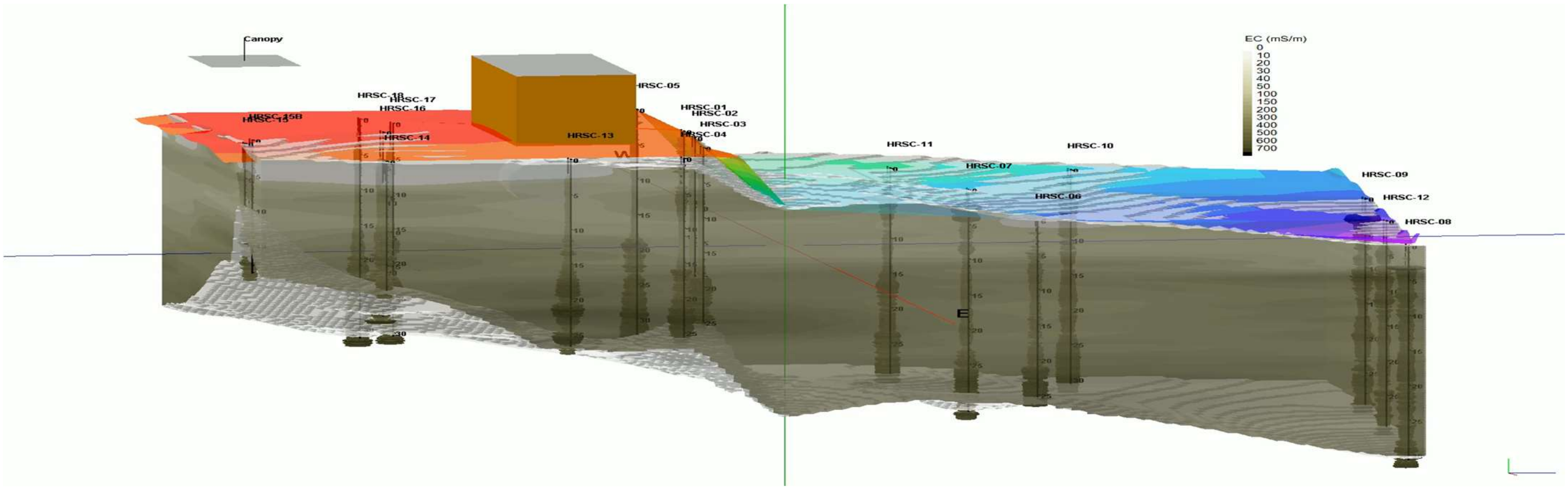

- >300 mS/m EC Values
- Lighter colors are lower EC values generally indicating coarser, more permeable lithology

# Strategic Optimization with HRSC

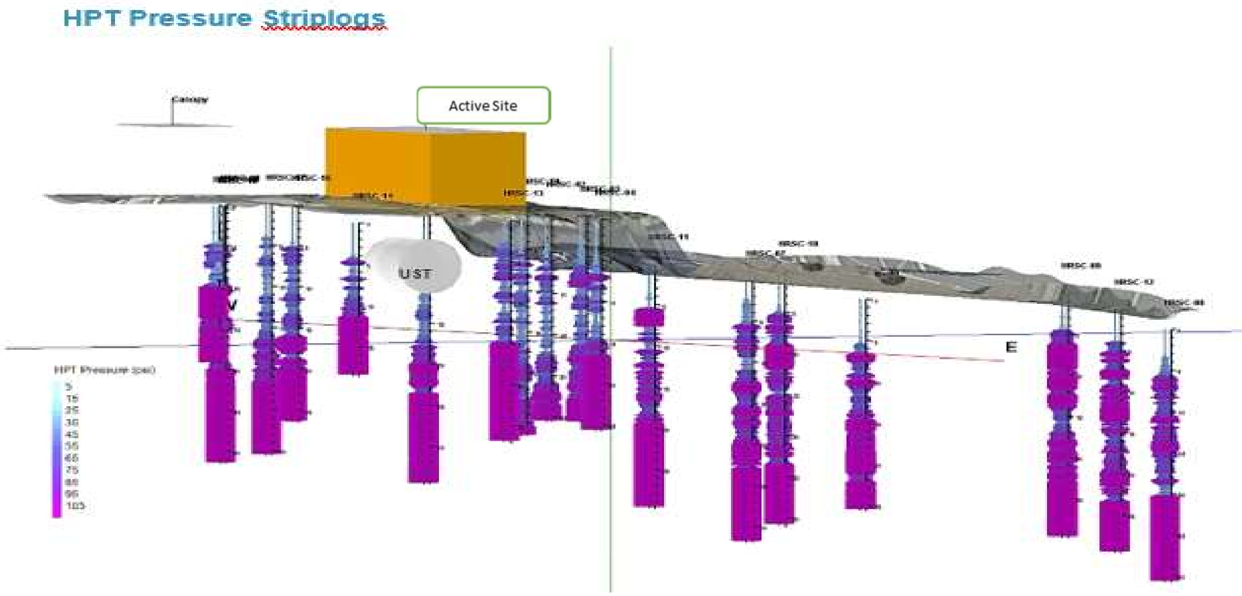



- >500 mS/m EC Values
- Lighter colors are lower EC values generally indicating coarser, more permeable lithology

# Strategic Optimization with HRSC



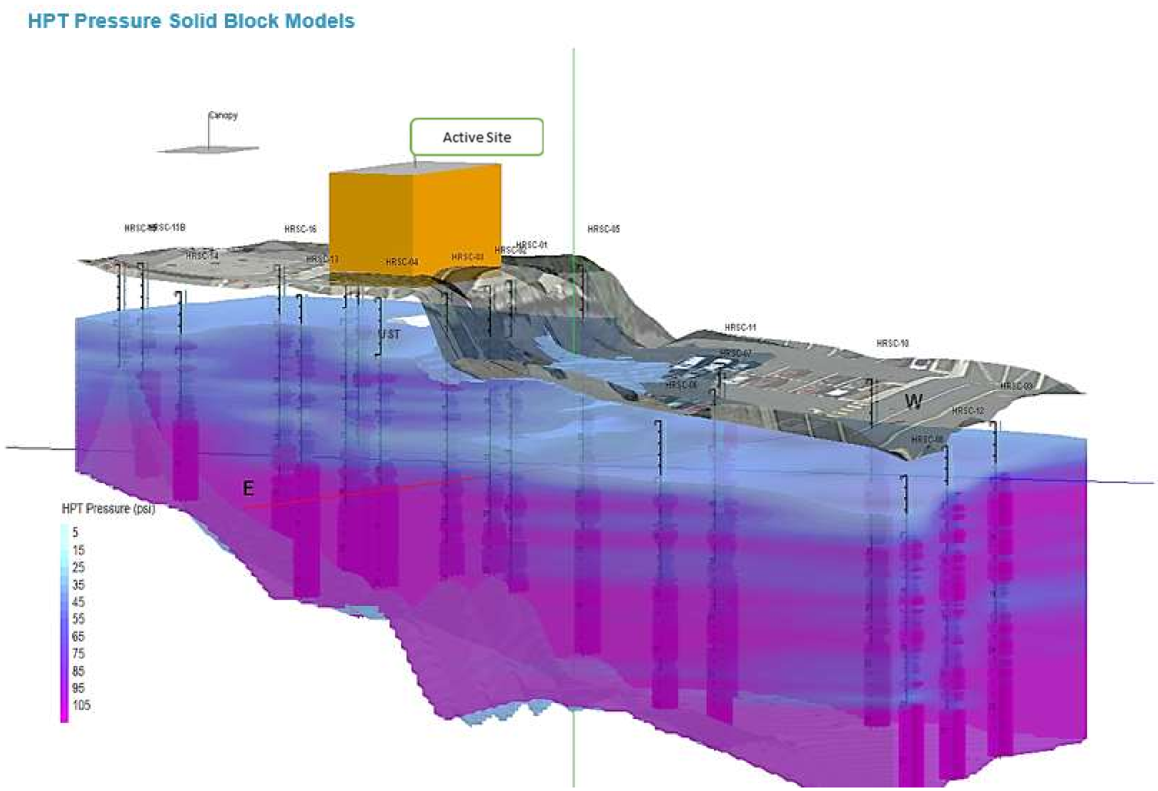
# Strategic Optimization with HRSC



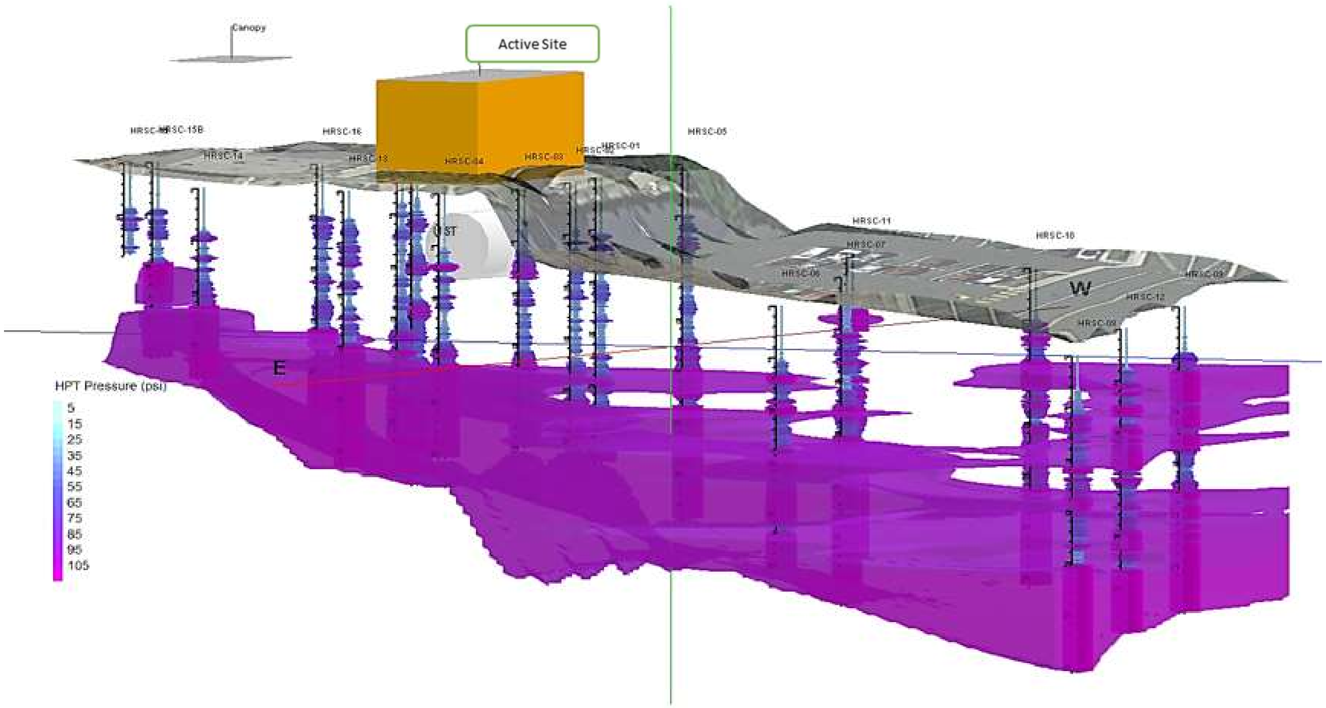

HPT Pressure (psi)

- 18 boring locations
- East-West indicated by the red axis
- North-South indicated by the blue axis
- Higher HPT pressure indicated by dark blue to pink colors and thicker striplogs
- Higher HPT pressure generally indicates finer grained, lower permeability or "tighter" zones and often trends with EC.

# Strategic Optimization with HRSC

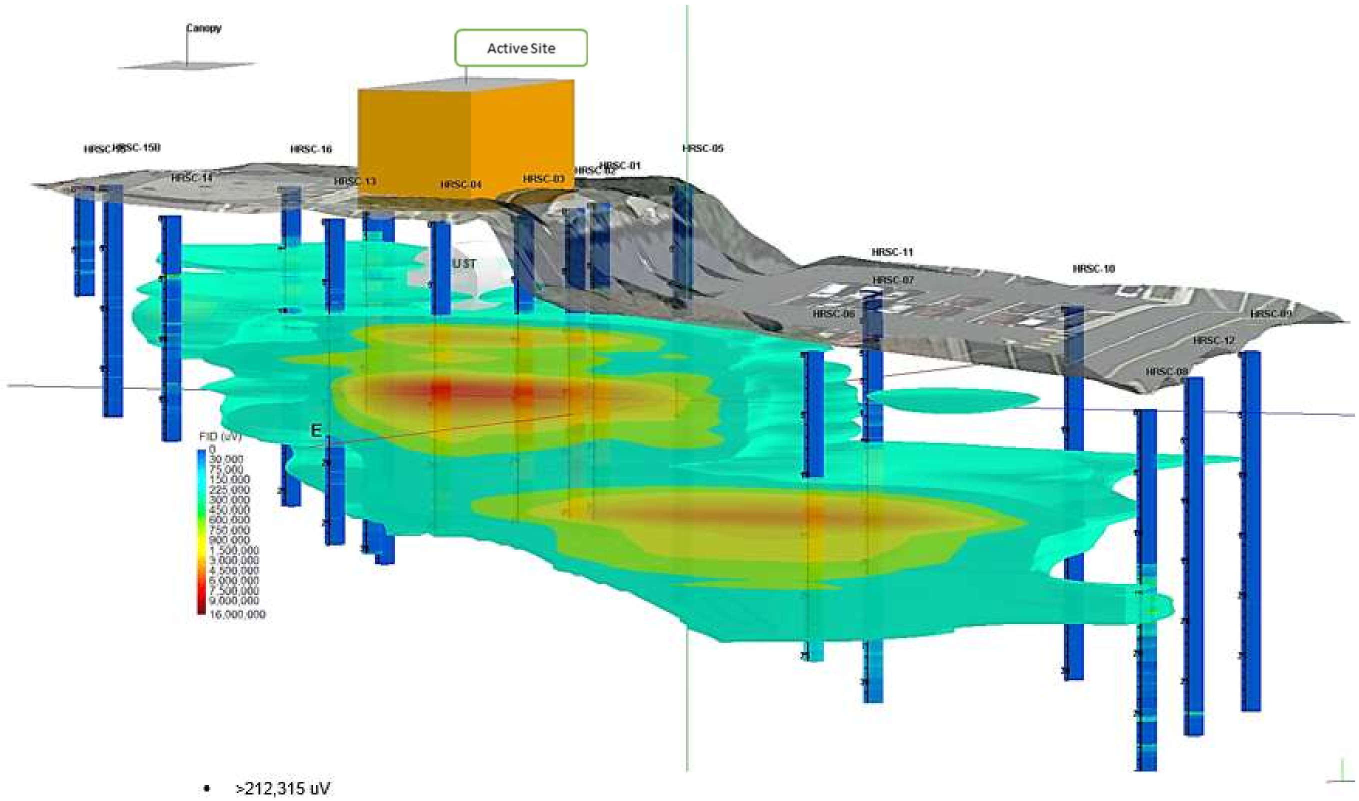


# Strategic Optimization with HRSC

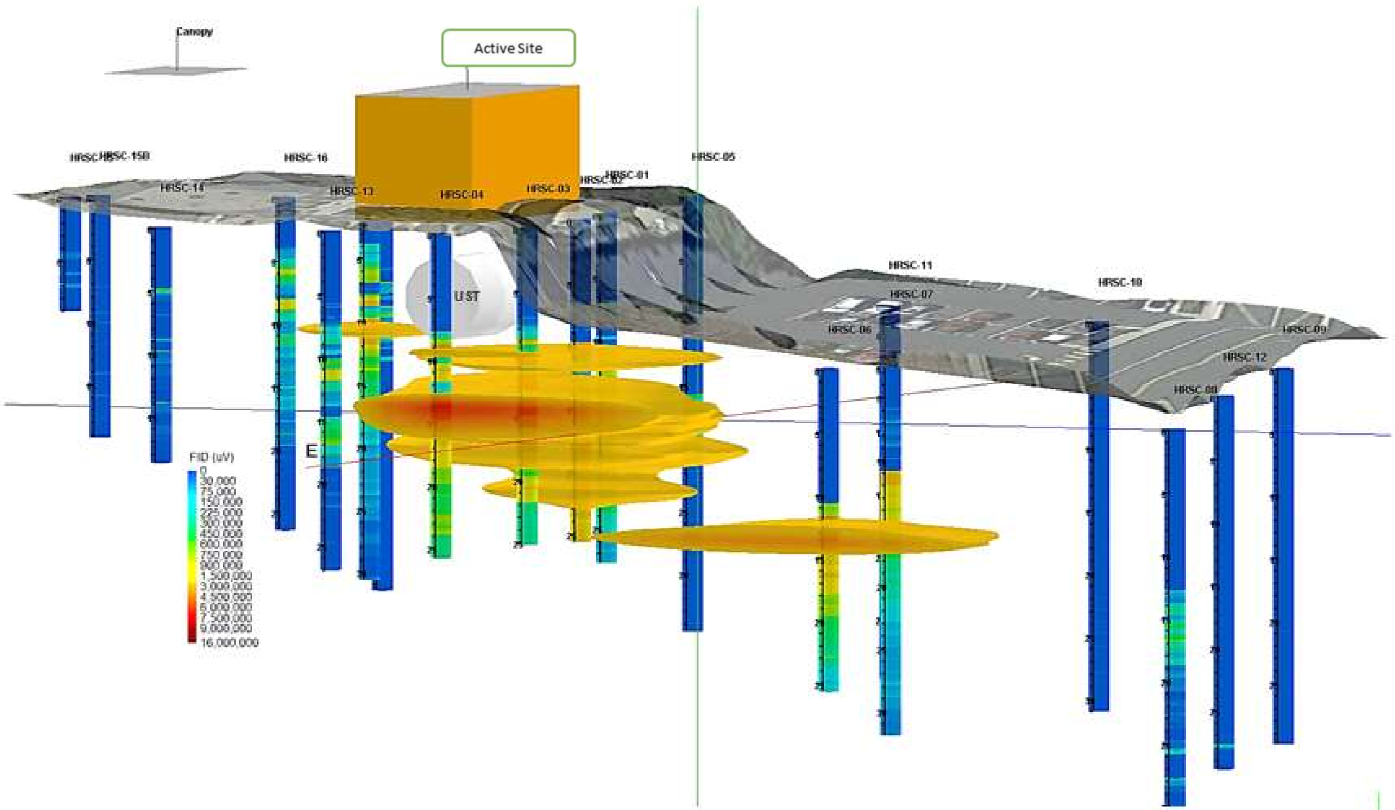



- >100 psi HPT values

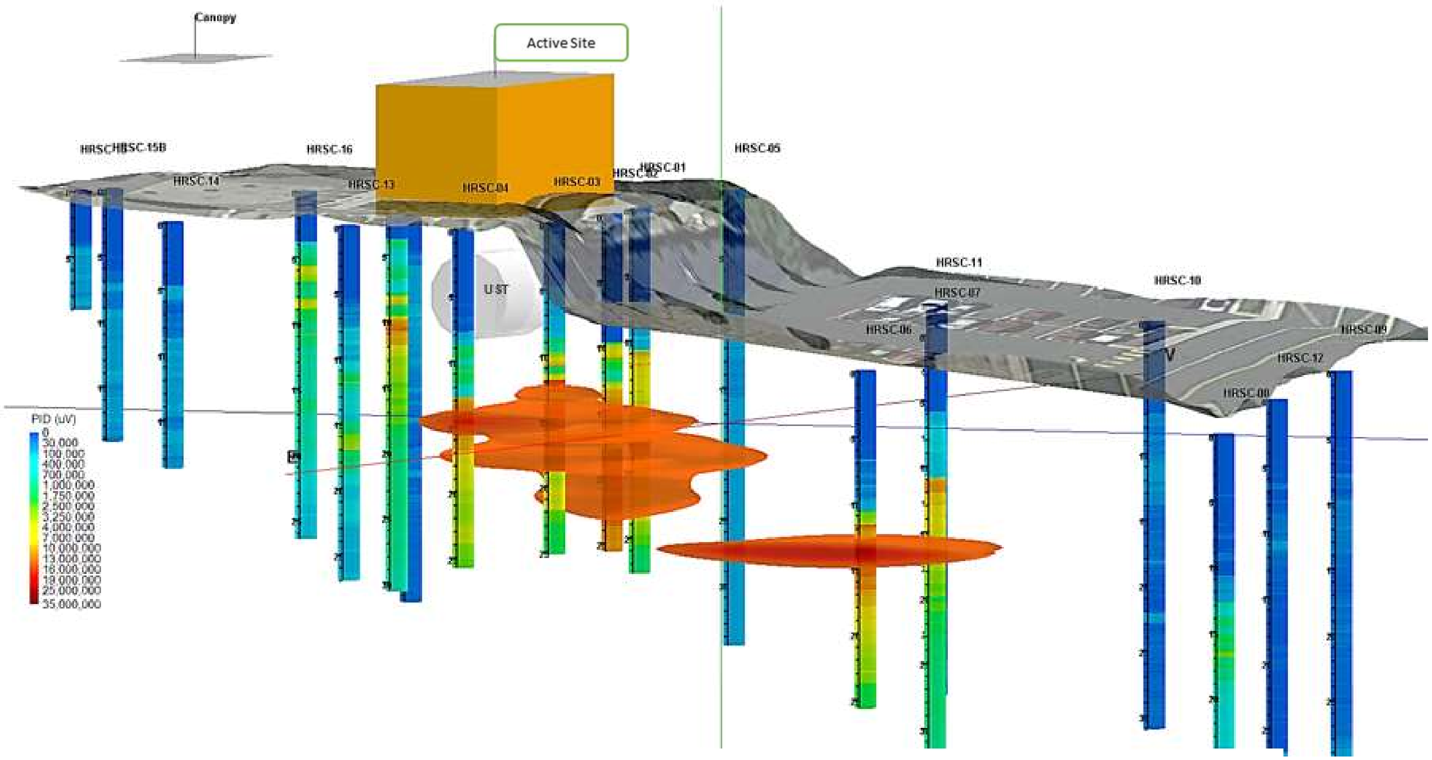
# Strategic Optimization with HRSC



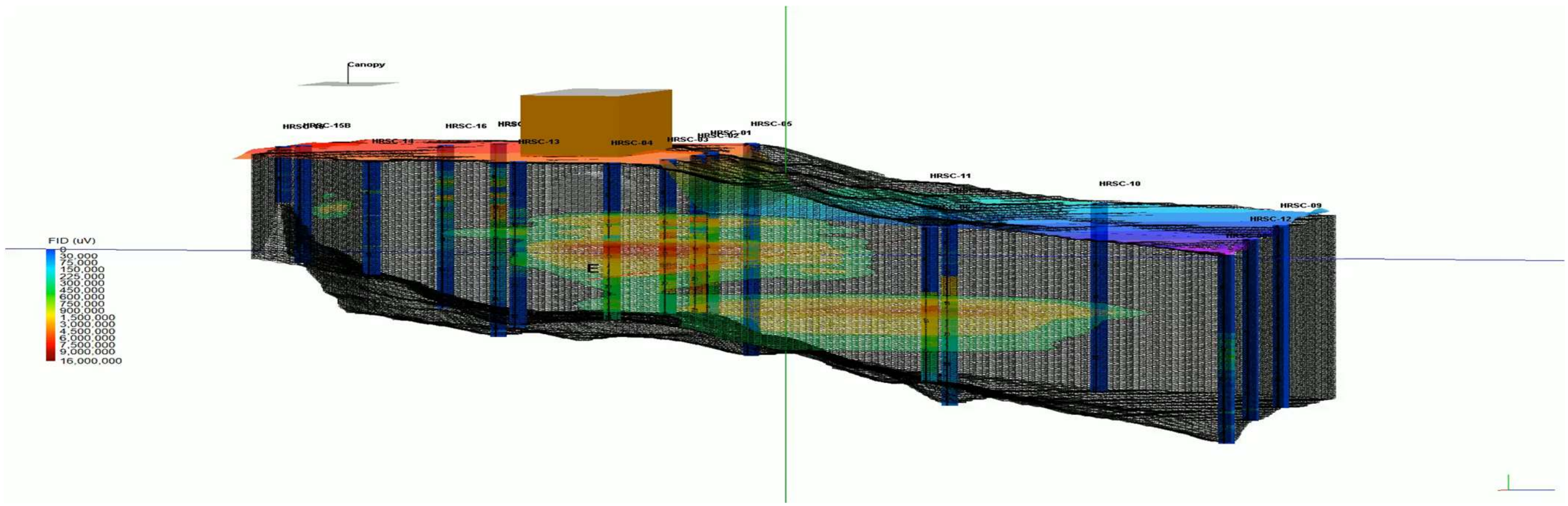
# Strategic Optimization with HRSC



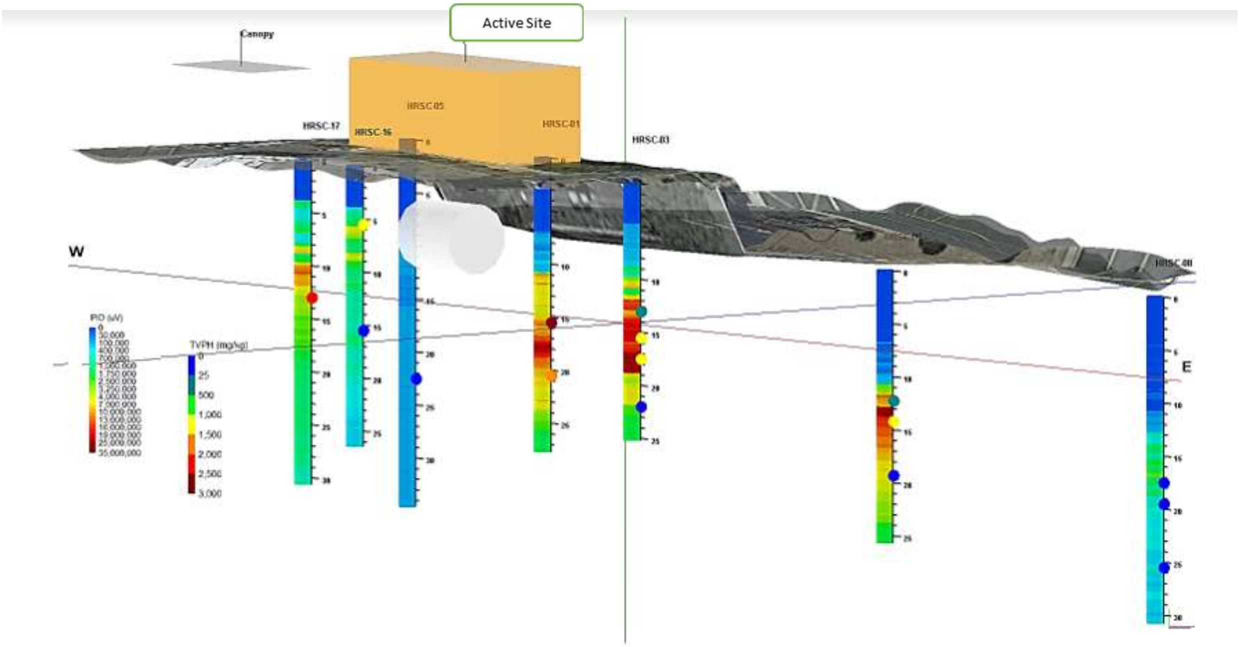
# Strategic Optimization with HRSC



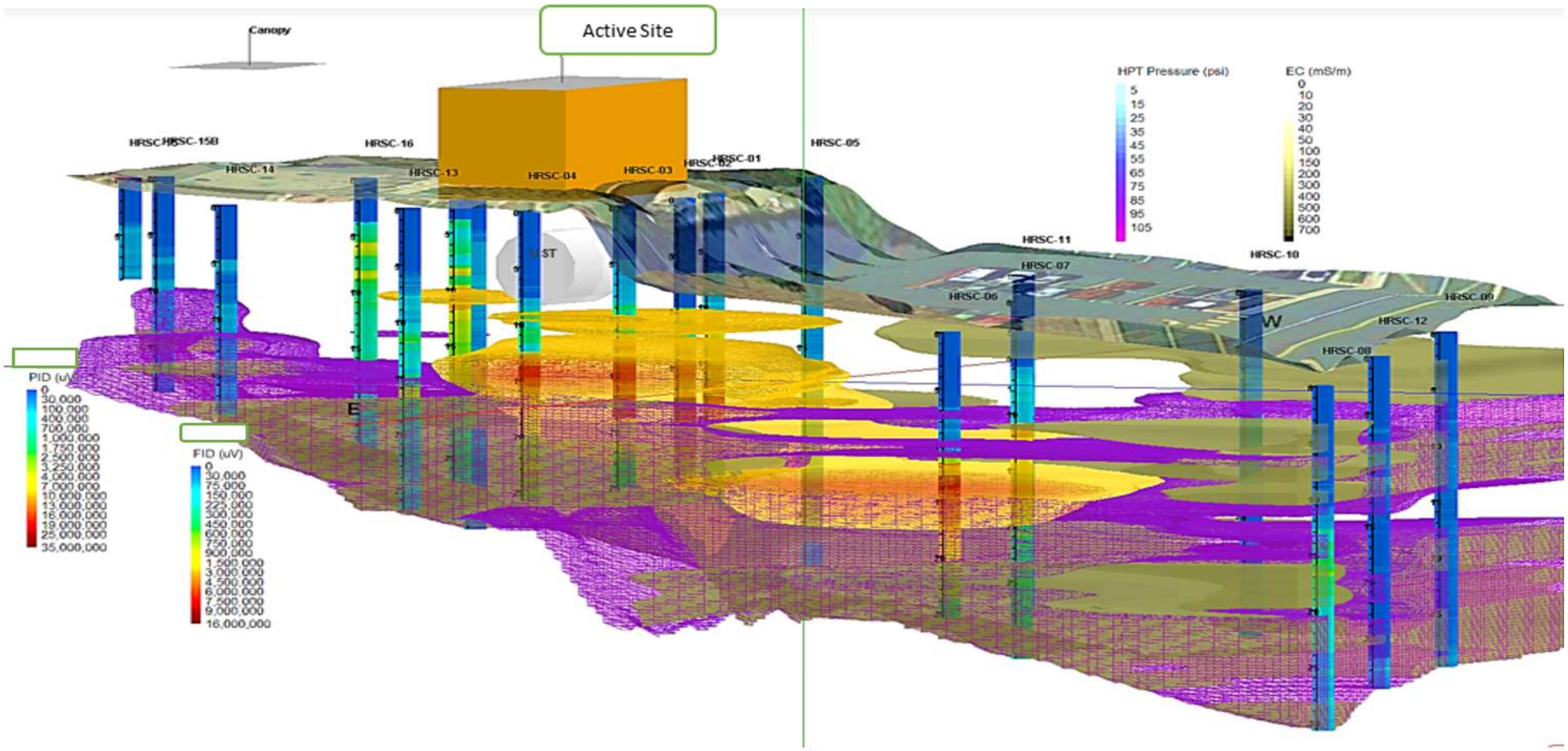
# Strategic Optimization with HRSC



# Strategic Optimization with HRSC

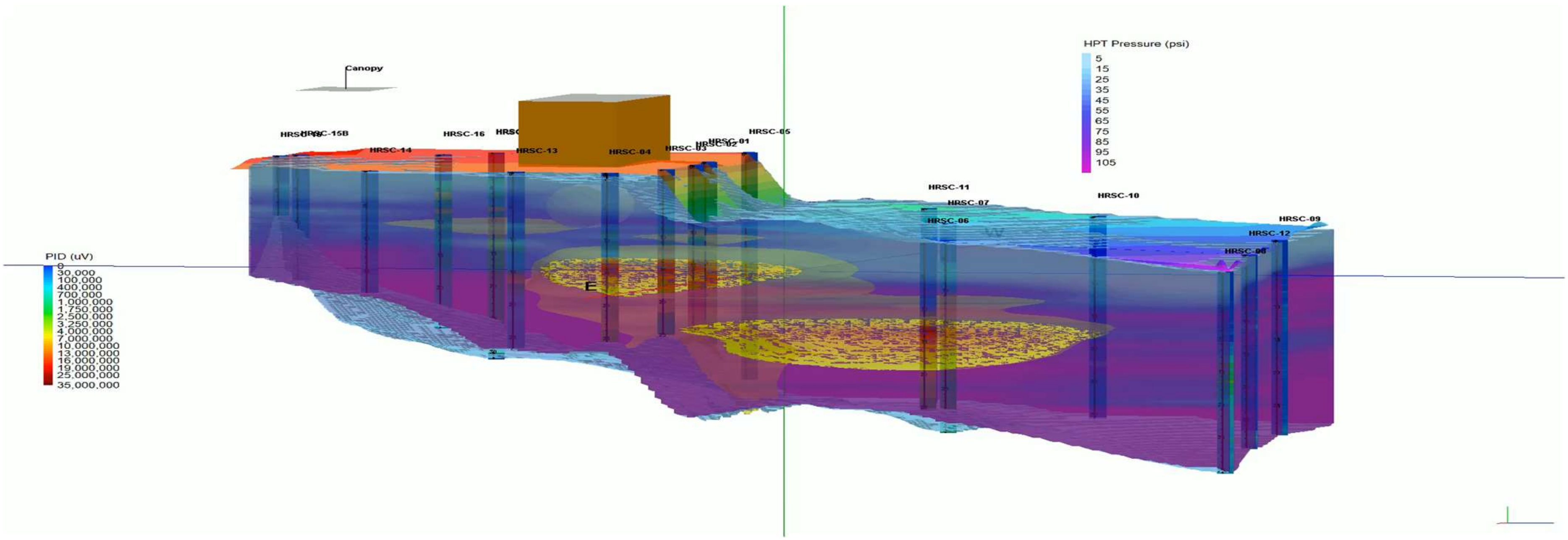


# Strategic Optimization with HRSC

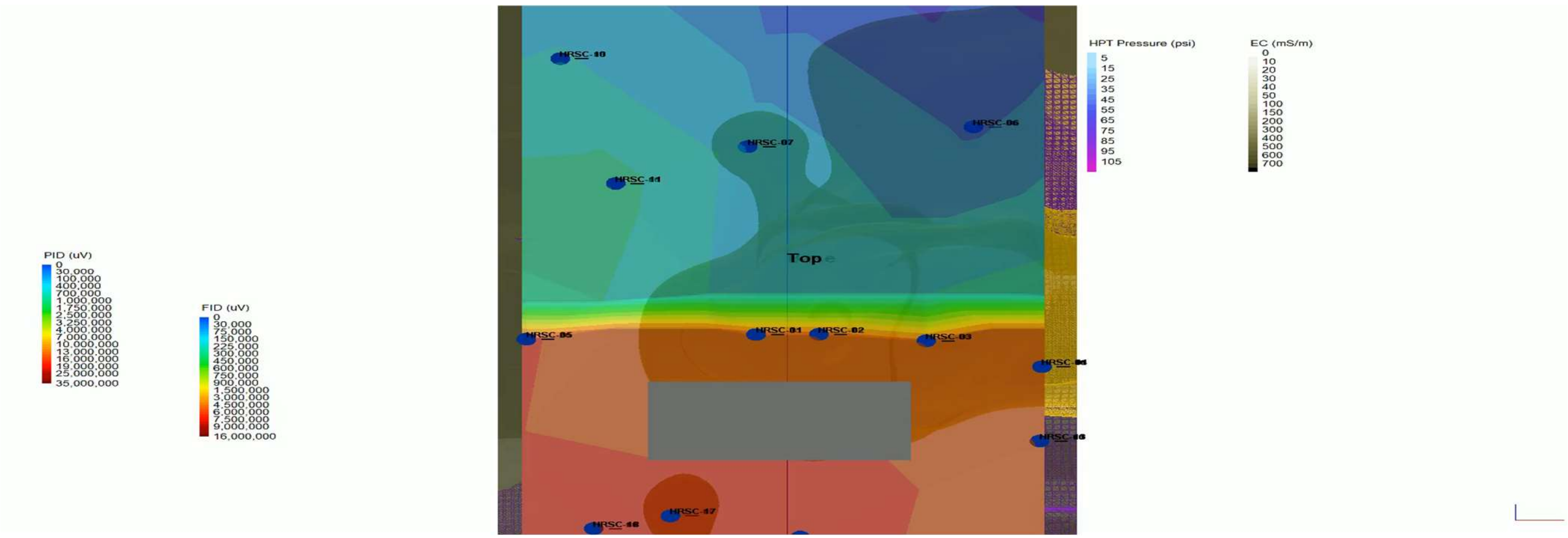



- EC >351 mS/m
- HPT Pressure >91 psi (wired mesh)

# Strategic Optimization with HRSC



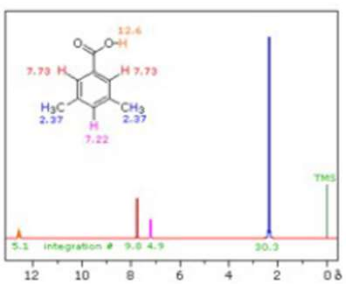
# Strategic Optimization with HRSC



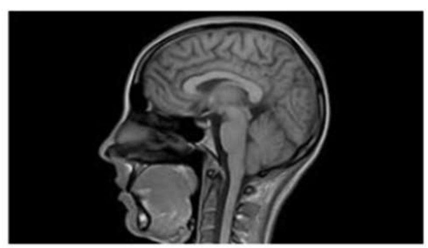
# Nuclear Magnetic Resonance (NMR) Overview

# NMR Applications

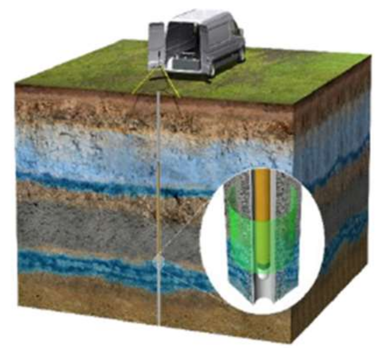
## Organic Chemistry

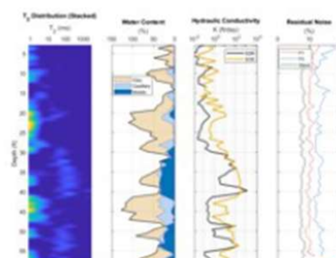



## Medical MRI



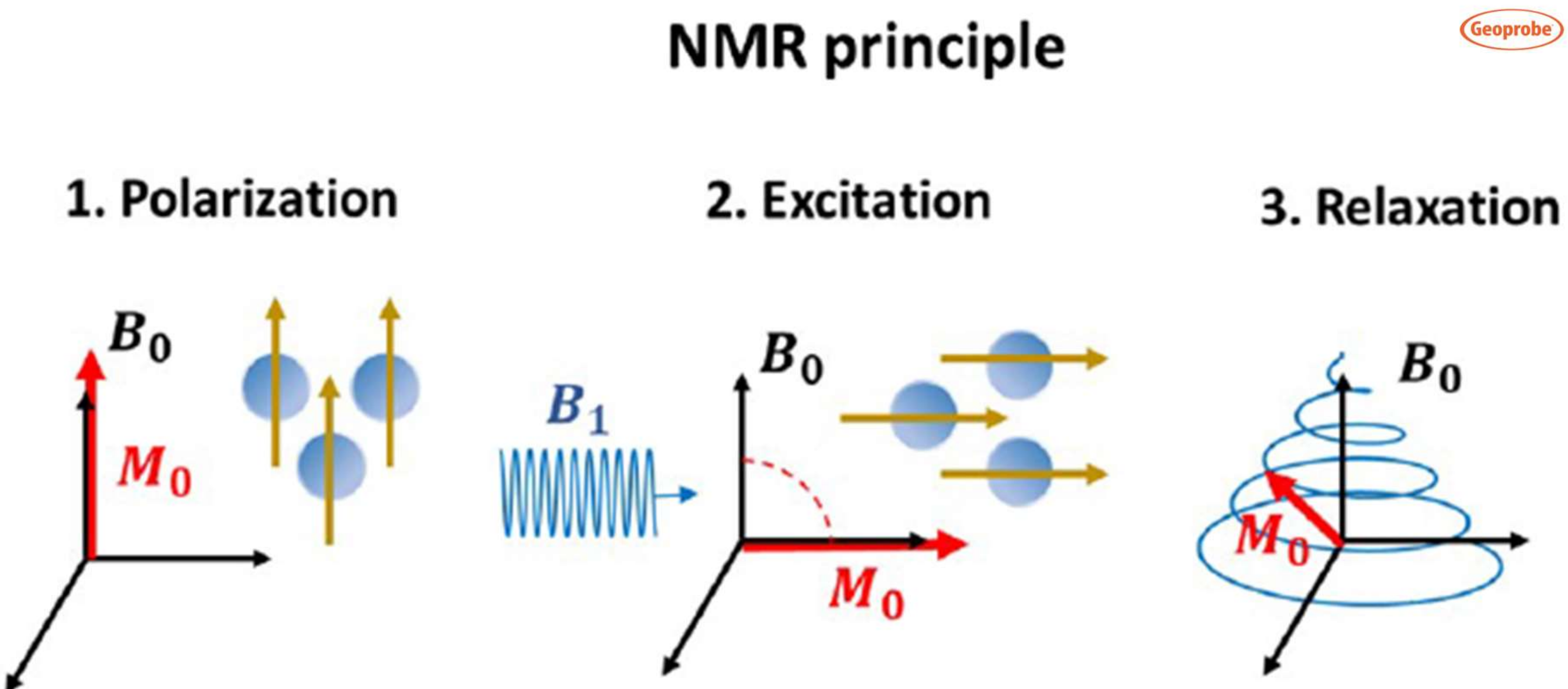
## NMR Geophysics





Geoprobe

# NMR — How does it work?

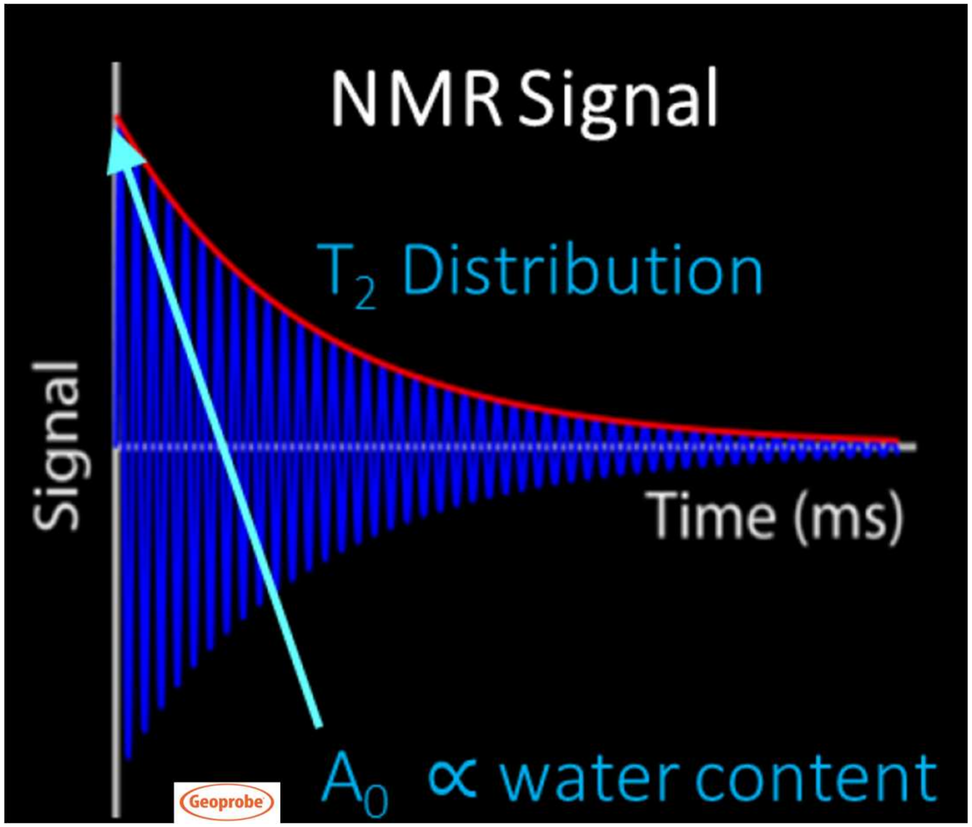



Hydrogen protons align to magnetic field

Protons are excited to a higher energy state

Hydrogen relax back to equilibrium

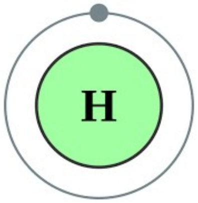
# NMR — What does it measure?




$A_0$ = initial amplitude of the signal

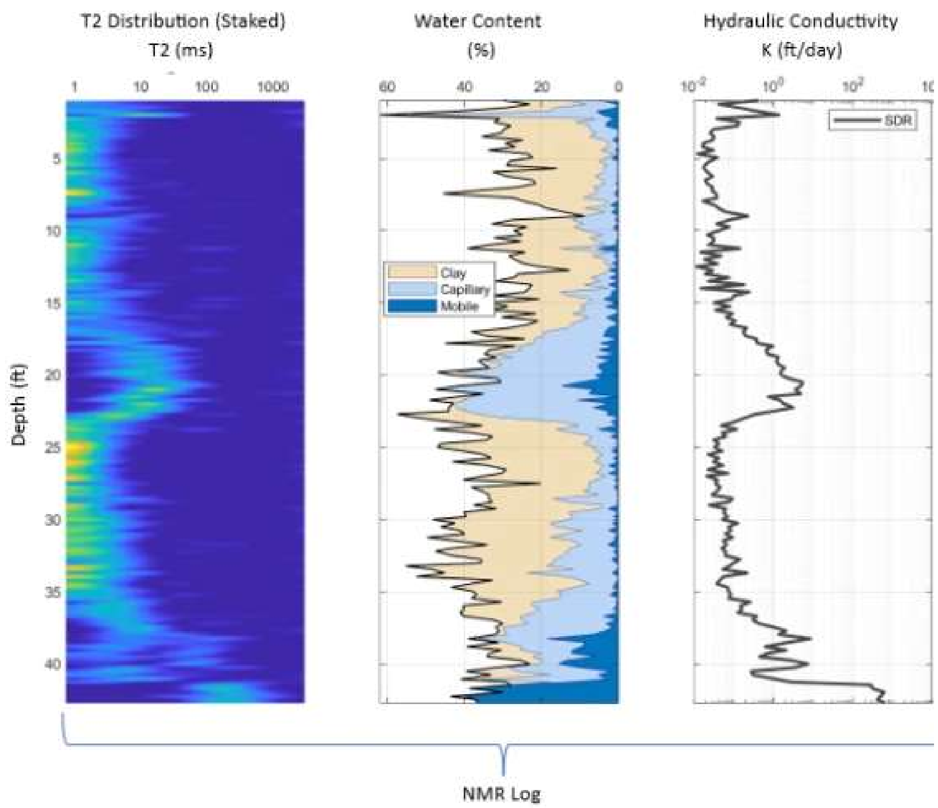
NMR signal

Hydrogen




% water content

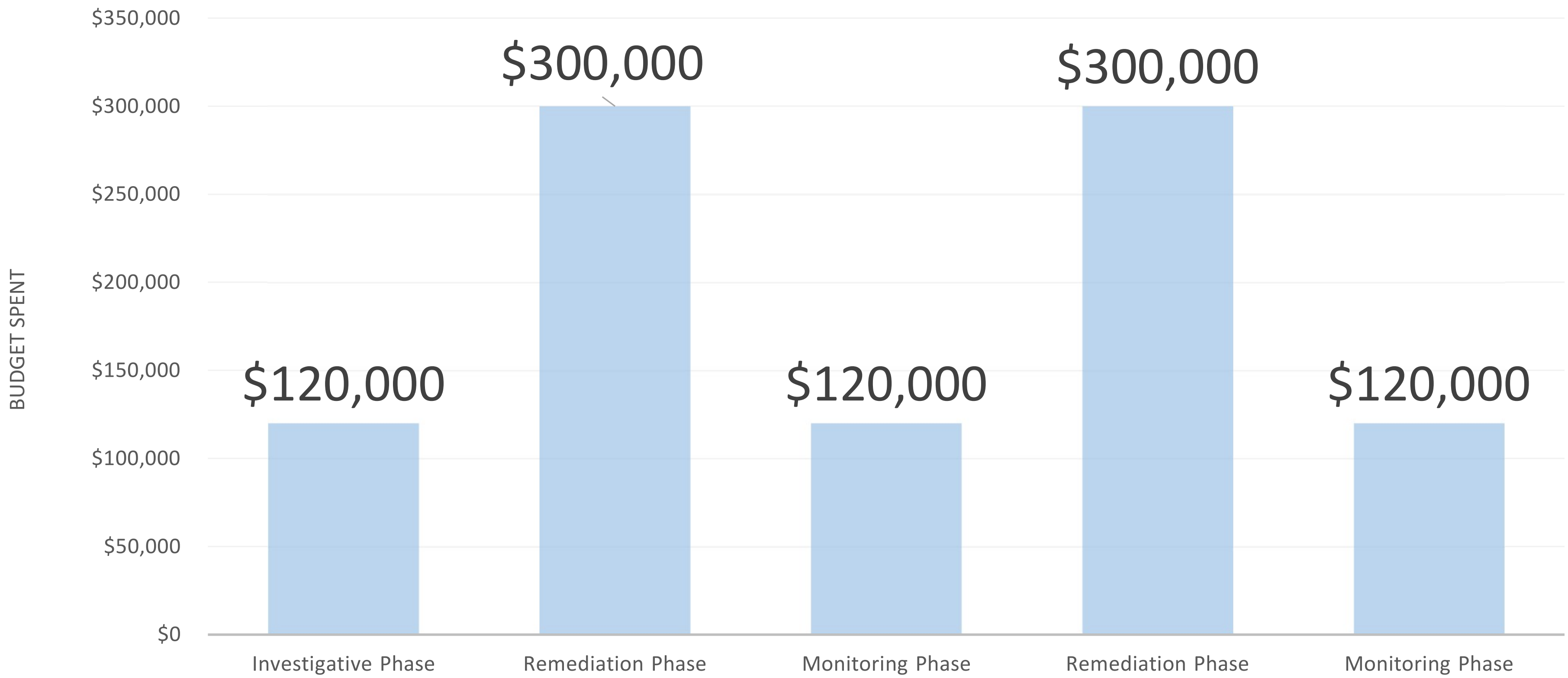
# NMR — What does it measure?



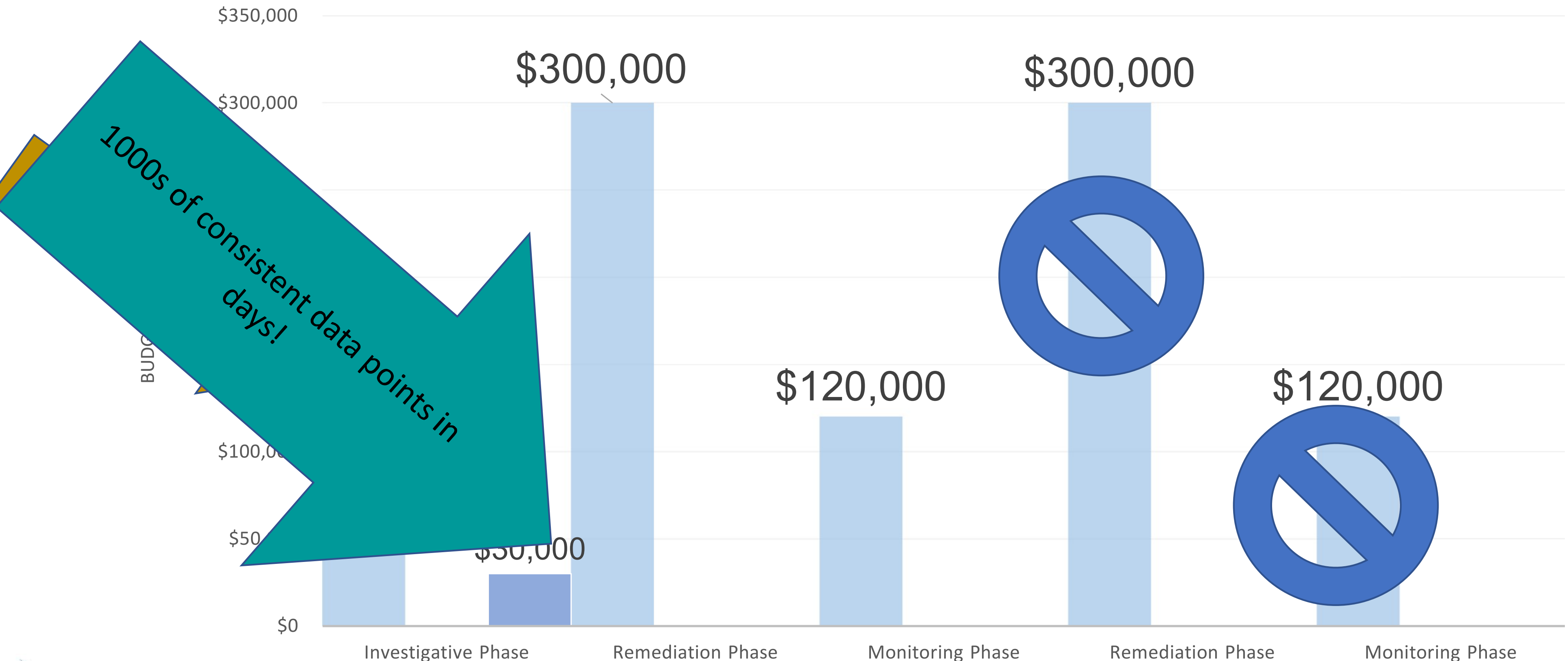
# *Is HRSC worth the time and funds?*

# *Cost (Investment) vs Benefits*

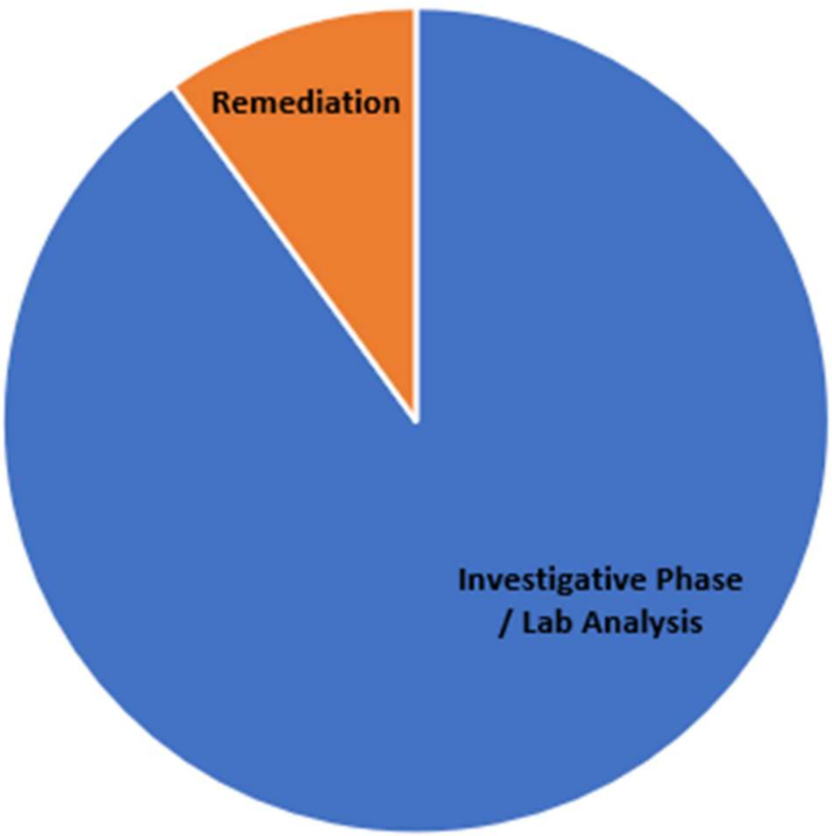
# Cost Benefit Analysis for HRSC – Small Site



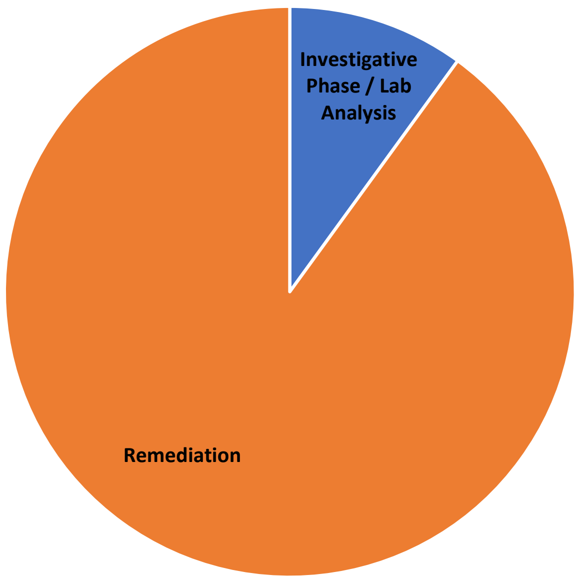
# Adding HRSC Into the Equation

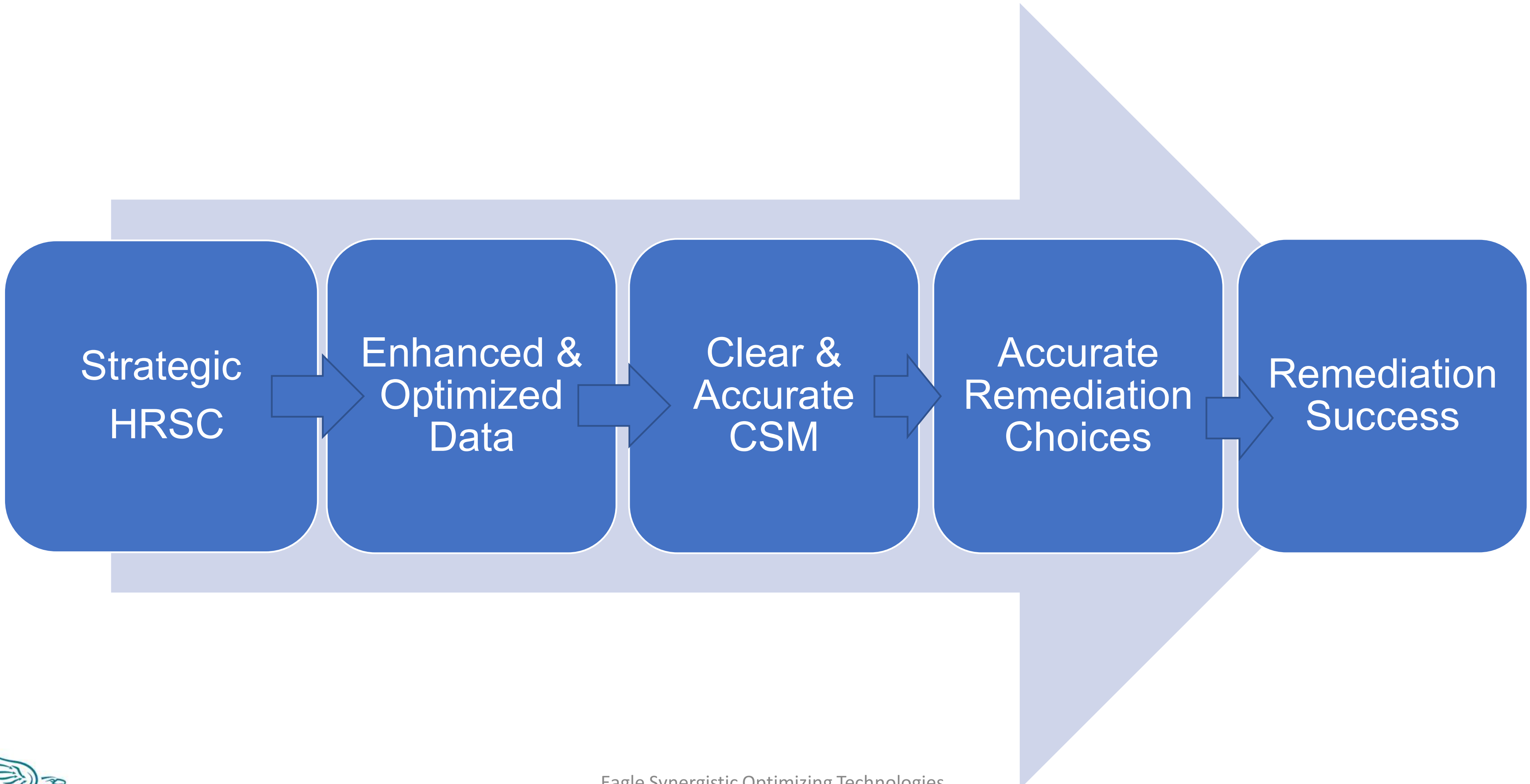


# Time and Cost Benefit Analysis for HRSC




Adding HRSC Into the Equation




Strategic HRSC
Enhanced & Optimized Data
Clear & Accurate CSM
Accurate Remediation Choices
Remediation Success

EAGLE SYNERGISTIC
OPTIMIZING TECHNOLOGIES, LLC.

# THANK YOU!

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President, PG

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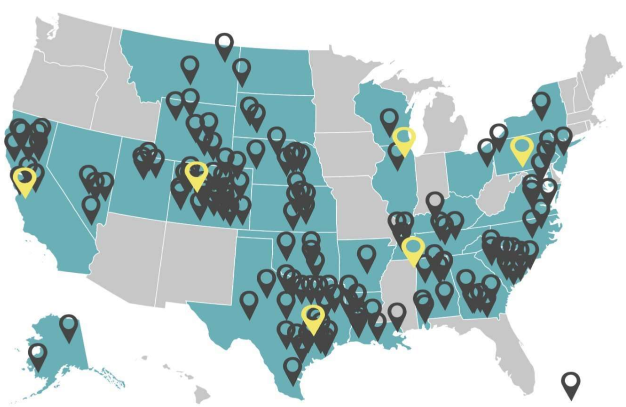

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