



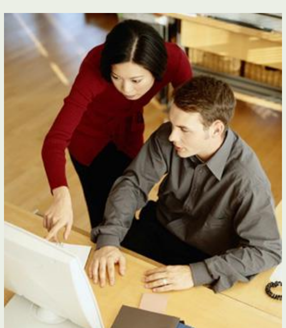

Data Use, Management and Visualization

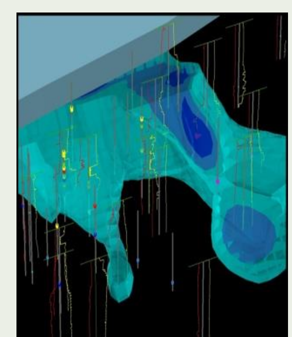
EPA
United States
Environmental Protection
Agency

Thanks to:
Steve Dyment, U.S. EPA ORD
Seth Pitkin, Stone Environmental

Module Overview

- ♦ Maximizing the use of existing data
- ♦ Obtaining collaborative data through HRSC
- ♦ Managing the increased amount of data from HRSC
- ♦ Visualizing the data
- ♦ HRSC planning checklist



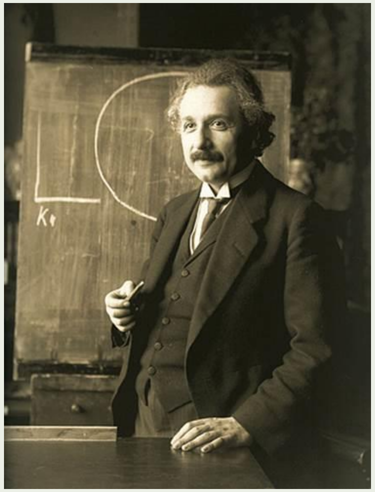


Maximizing the Use of Data

- **Plan for effective use of data in dynamic work strategy**
  - » Identify stakeholders and engage them
  - » Identify core technical team
  - » Conduct systematic planning activities
- **Compile and evaluate historical Information**
  - » Basis for development of the preliminary CSM
- **Identify data quality objectives including statistical evaluations**
- **Agree to project communications plan**

Historical Information Compilation and Evaluation

- **Review existing site investigation work plans, reports, data**
  - » Effectively support decision-making (Know your knowns, unknowns)?
  - » Data type and quality, measurement scale vs. heterogeneity?
- **Evaluate historical and regional information**
  - » Facility operations, online data reports, aerial photos
  - » Topographic maps, meteorological data
  - » Nearby sites, wells, borings



'The more I learn, the more I realize I don't know.'

– Albert Einstein

Historical Information Compilation and Evaluation

- **Develop Preliminary CSM**
  - Geologic, hydrogeologic, hydrologic and analytical data
  - Media of interest, contaminants of potential concern (COPC)
  - Receptors, pathways
- **Identify regulatory information**
  - Agency contacts, relevant guidance,
  - Applicable or Relevant and Appropriate Requirements (ARAR)
- **Evaluate other site documentation of significance**
  - Include regulatory review comments, responses, and other information

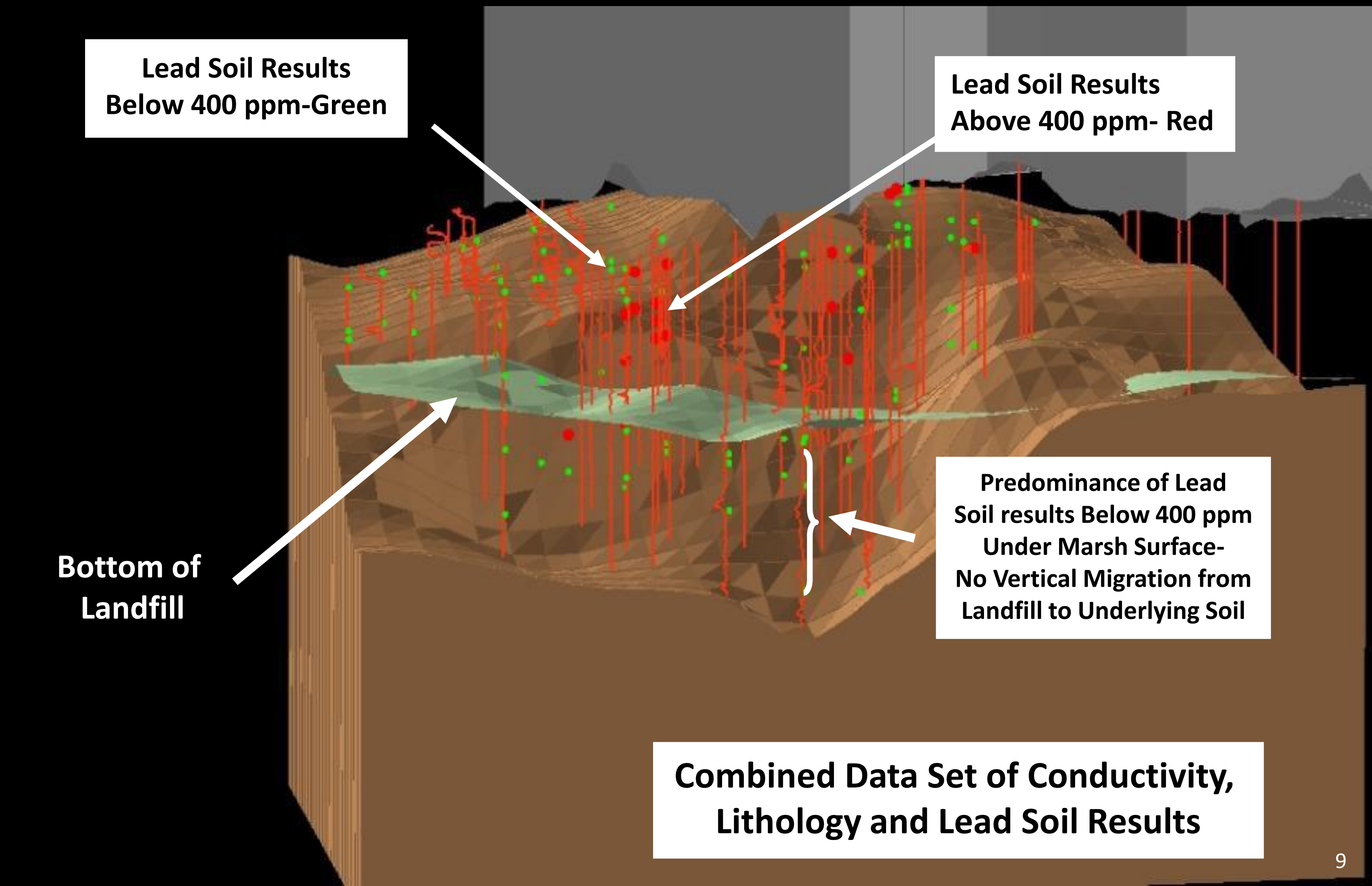
Project Communications Plan

- **Establish lines of communication for the team**
  - Communicating results and interpretation of data is essential to building stakeholder consensus
- **Establish "what, how, when" for communications among team members**
- **Decide when CSM updates should be distributed**
  - Maps, graphs, and diagrams
  - Visualizations
  - Cross-sections
- **Communication options**
  - Dedicated project websites
  - Web meetings and webinars
  - Conference calls

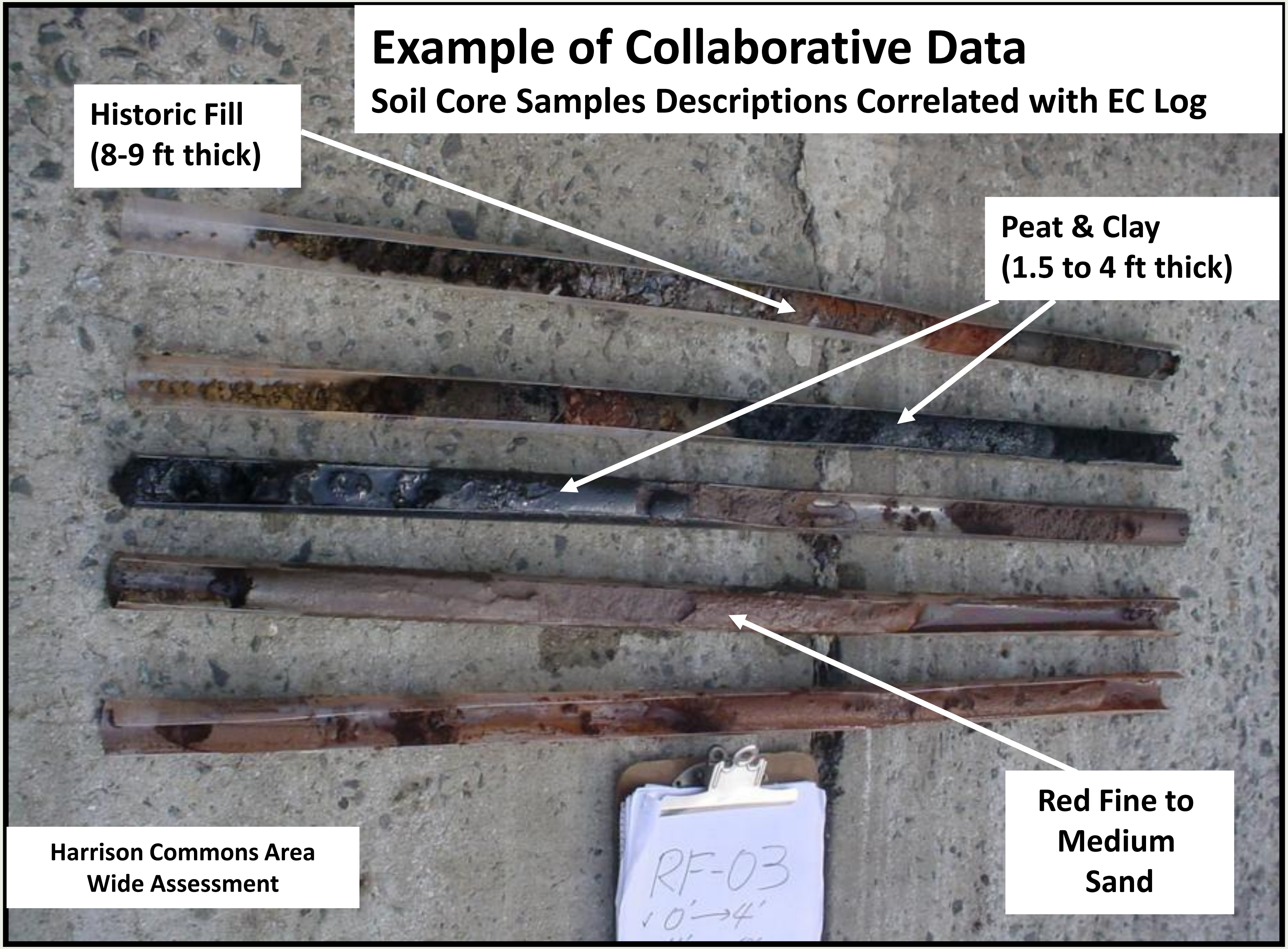
Collaborative Data

- **Different methods for same analyte or suite of analytes**
- **Multiple lines of evidence = "weight of evidence"**
  - Control project and site decision uncertainties
  - Revises decision criteria in response to data
- **One method provides information for when another is required or beneficial**
- **Control multiple error sources**
  - Sampling design, matrix, prep, analytical
- **Result: increased confidence in the CSM; better decisions, better remedy implementation**
  - Characterization of chemistry and physical attributes with adequate data density

Example of Collaborative Data Set



Example of Collaborative Data
Soil Core Samples Descriptions Correlated with EC Log



Collaborative Data Sets Address Analytical Spatial, and Sampling Uncertainties

The Missing Link

Collaborative data sets and high-resolution also critical for <u>geologic and hydrogeologic</u> information

- Not just analytical concept

- In fact, geologic and hydrogeologic context is critical for effective remedy design

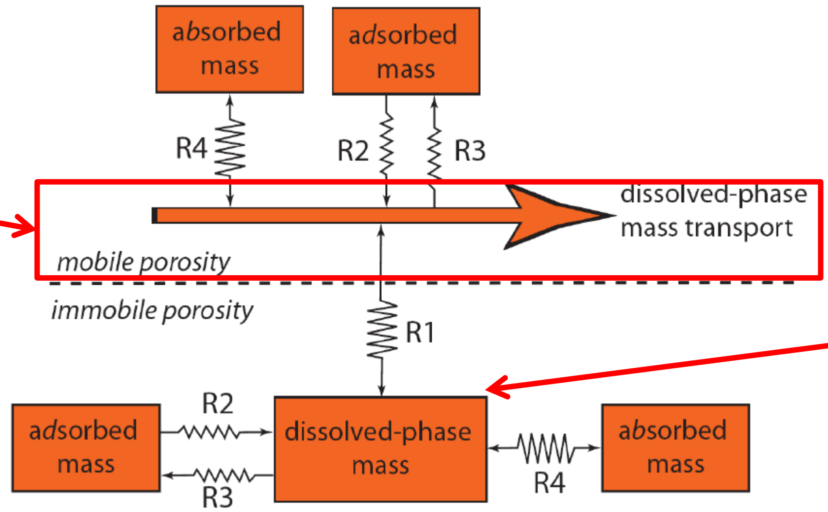
Collaborative Data Sets

The Missing Link

High-resolution geologic/hydrogeologic information.

A Multi-Compartment Model of Solute Transport

Mass that "moves" and what monitoring wells see



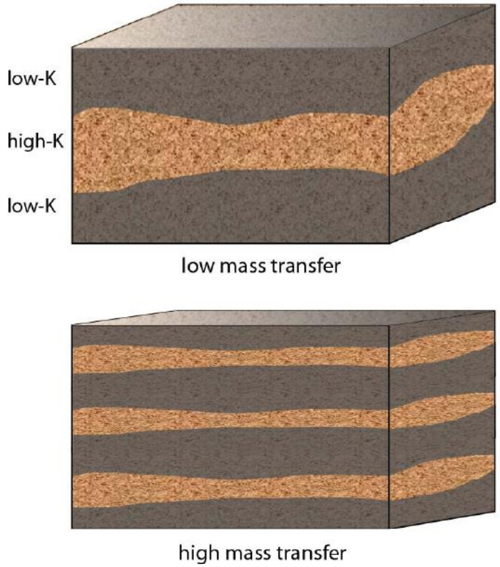
Back diffusion causes challenges like rebound and long cleanup times

Aquifer Matrix Challenges

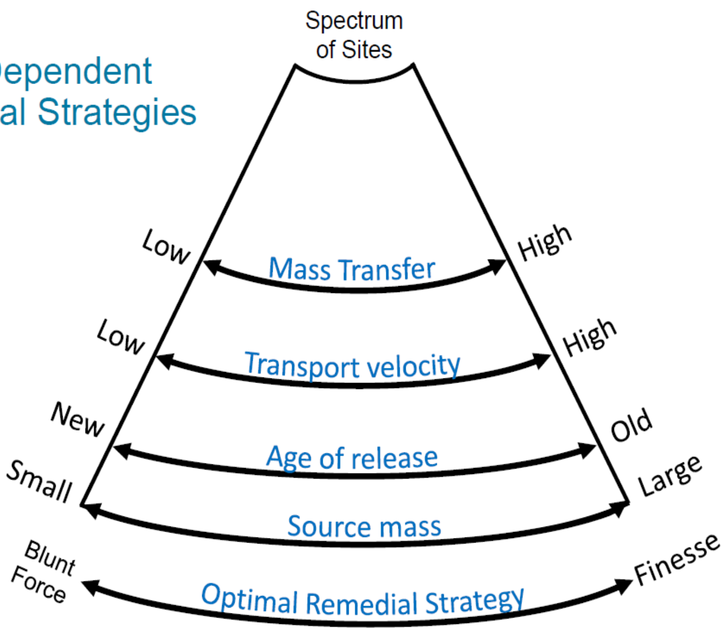
Two aquifer blocks with equal:

- Average hydraulic conductivity
- Mobile porosity
- Groundwater transport velocity

In the high-mass-transfer geometry, the rate of diffusive migration into the low-K zones is approximately 10-fold greater than for the low-mass-transfer case.



Scale-Dependent Remedial Strategies



Courtesy of Fred Payne- Arcadis

ARCADIS

The Big Picture: Data Flow & Tools

QA/QC

Collect Data

Scriblets
Forms II Lite
R5 EDD,SEDD
Field tools (eg XRF)

Field Data

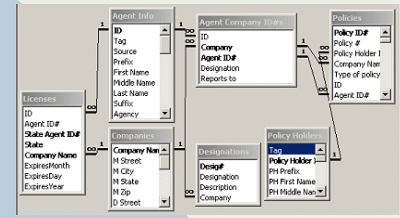
Laboratory Data

Store Data

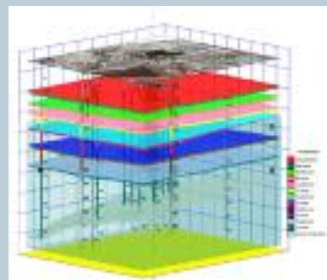
Process Data

Field Database (e.g., Scribe)

Regional Data Repository (WQX/STORET, EQuIS)



Database



CSM Life Cycle Evolution

Make Decisions

EVS/MVS
MAROS
F/S Plus
FIELDS Tools
VSP
SADA
DST Matrix

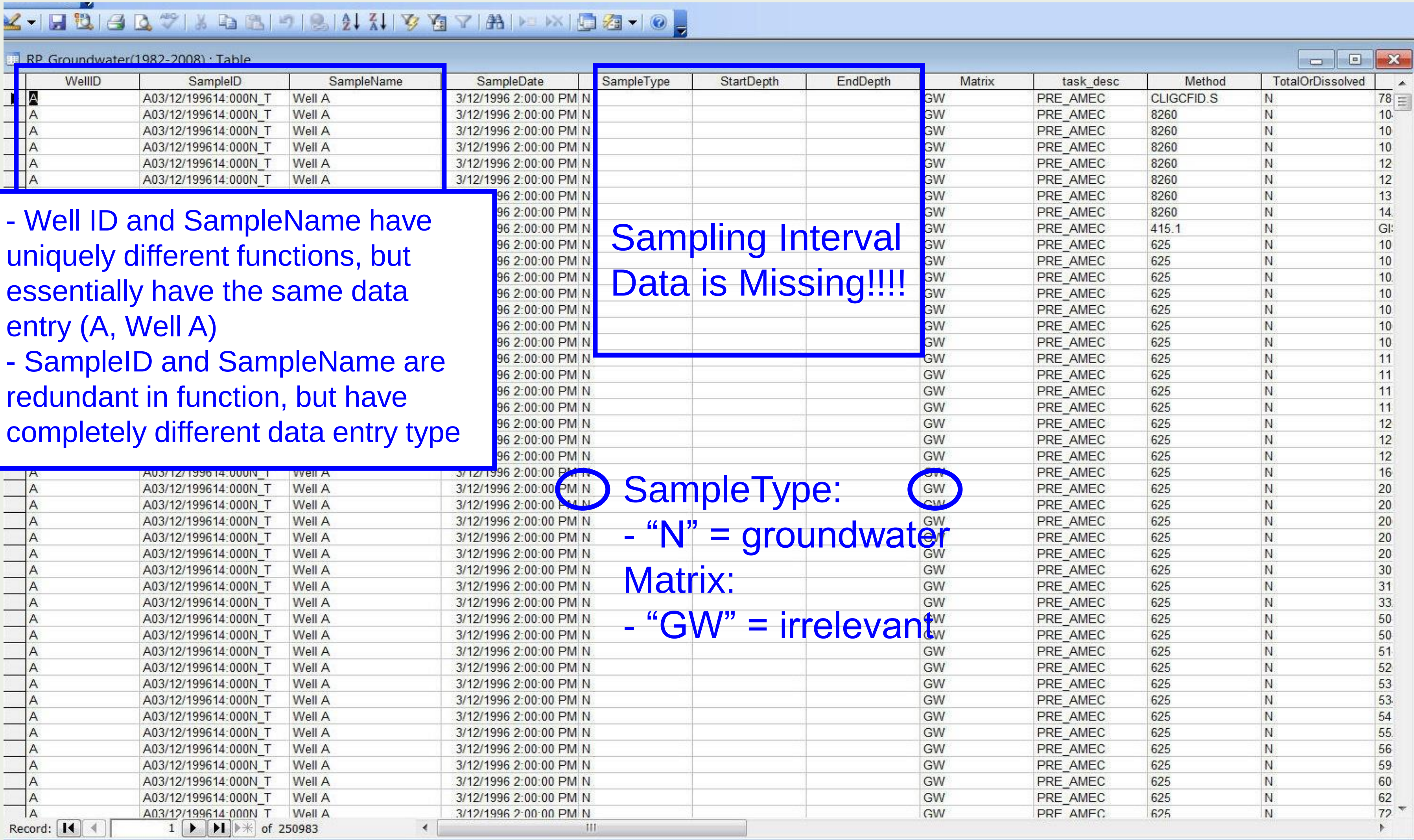
Decision Support Tools
Data Visualization Tools

Communicate

Scribe.net
EPA OSC Website
Quickplace
Collaboration Pages
Web Conferencing

Distance Collaboration

Limitations of Electronic Databases



HRSC Relies on Effective Data Management, Assessment, and Visualization Strategy

- **HRSC relies on the acquisition of large amounts of high-density collaborative data, and this data must be**
  - Stored, processed, interpreted, visualized, and communicated in near real-time
- **DMAs and upfront planning are key – take a test drive**
  - Large amounts of data can get unruly quickly
    - direct sensing probes acquire 10 to 100+ data points per foot
  - DMAs can be used to test the plan for collecting, analyzing, interpreting, visualizing, and communicating data from the real-time measurement technologies to be used

Data Management, Assessment, and Visualization Process

- **Tool Export Format**
  - Database Programs with Real-Time QC
- **Visualization and Decision Support Tools**
  - 3- and 4-D Mapping
  - Software Programs
- **Interpretation**
  - Communication
  - Decision-Making

Why 3-D, Why Now?

- ♦ Computer processor, software improvements (Moore's Law)
- ♦ Beneficial for developing a more realistic CSM
- ♦ Matches well with dense data sets from HRSC
- ♦ Improves communication and outreach
- ♦ Integrates multiple data types into unified representations
  - » 2-D visualizations have limited capability to integrate chemical, geologic, and hydrogeologic information
- ♦ Emphasis on high quality characterization in support of remedy selection, design and optimization

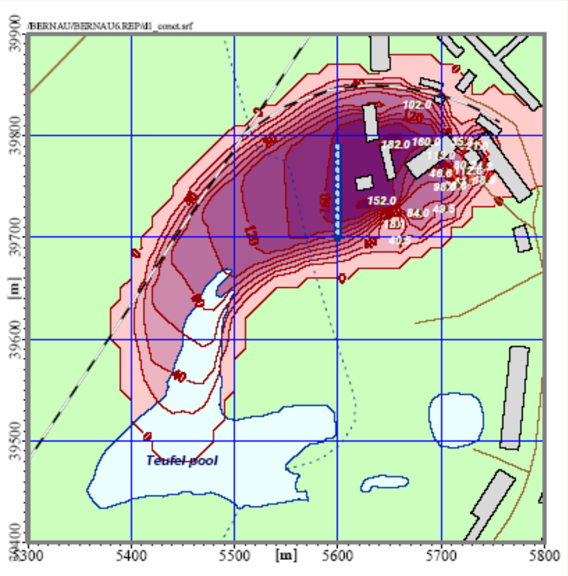
Data Interpretation

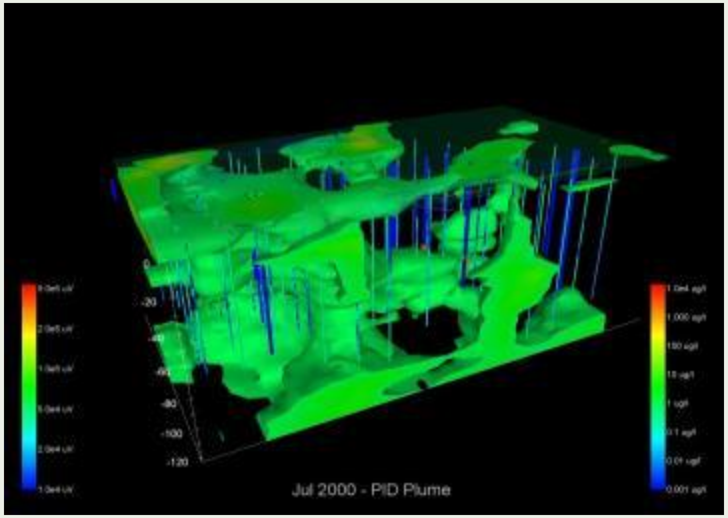
- **Separating data from interpretation**
  - Data should lead the approach
    - Identify variables
    - Evaluate relationships of variables
    - Identify key drivers
  - Strive for spatially correct correlations
  - Expand DQOs from focus on analytical quality to consider uncertainty of spatial and temporal variations
- **Addressing "outliers"**
  - Outliers provide insights into sampling procedures and CSM
  - Few cases where throwing out data makes sense
  - Justification needs more basis than "because its an outlier"

Data Visualization Tools

- ♦ **Tools are available for visualizing and evaluating subsurface data in 2-D and 3-D**

Typical 2-D map of plume based on 7 wells

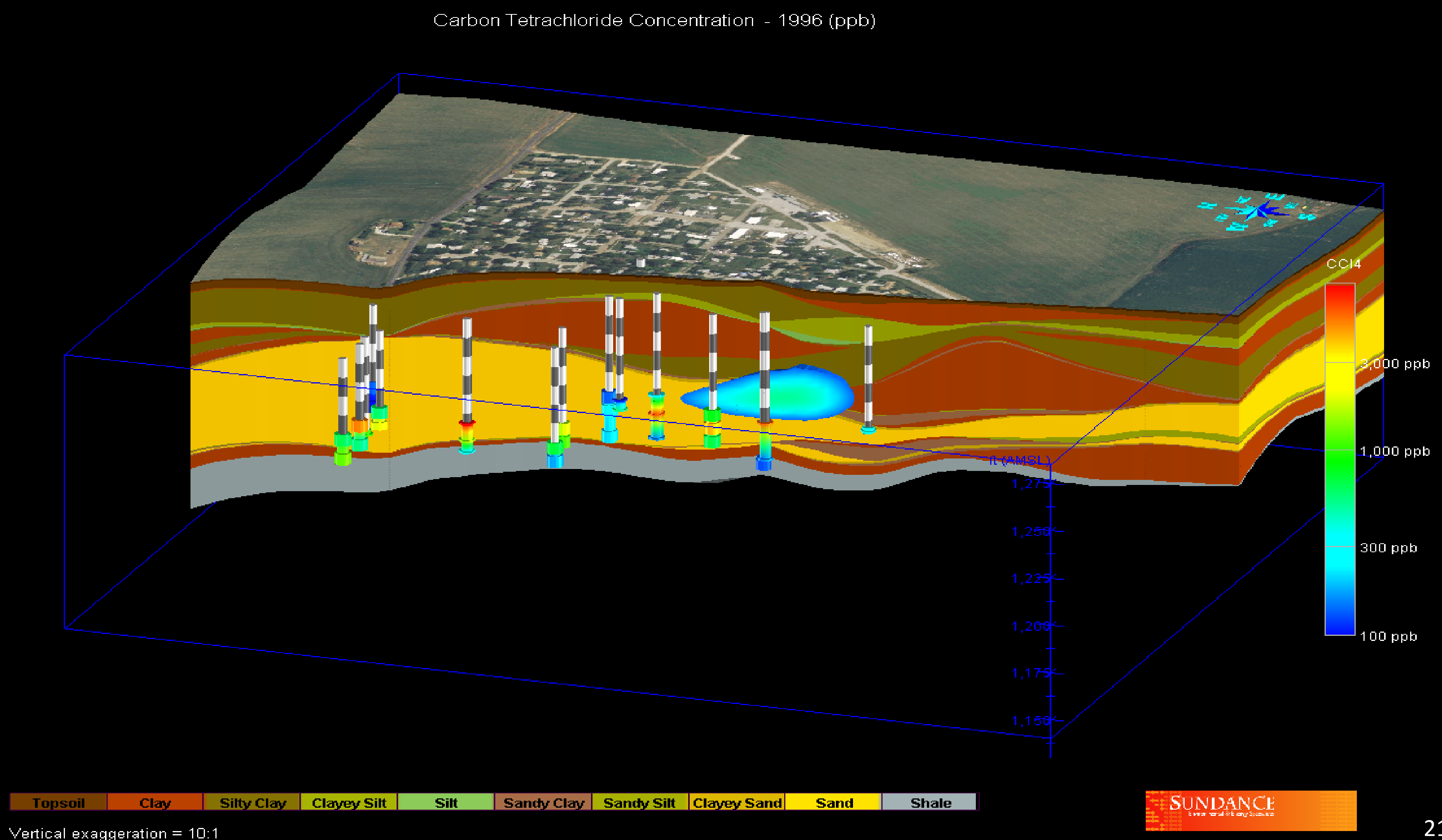




3-D plume visualization based on over 50 sampling locations

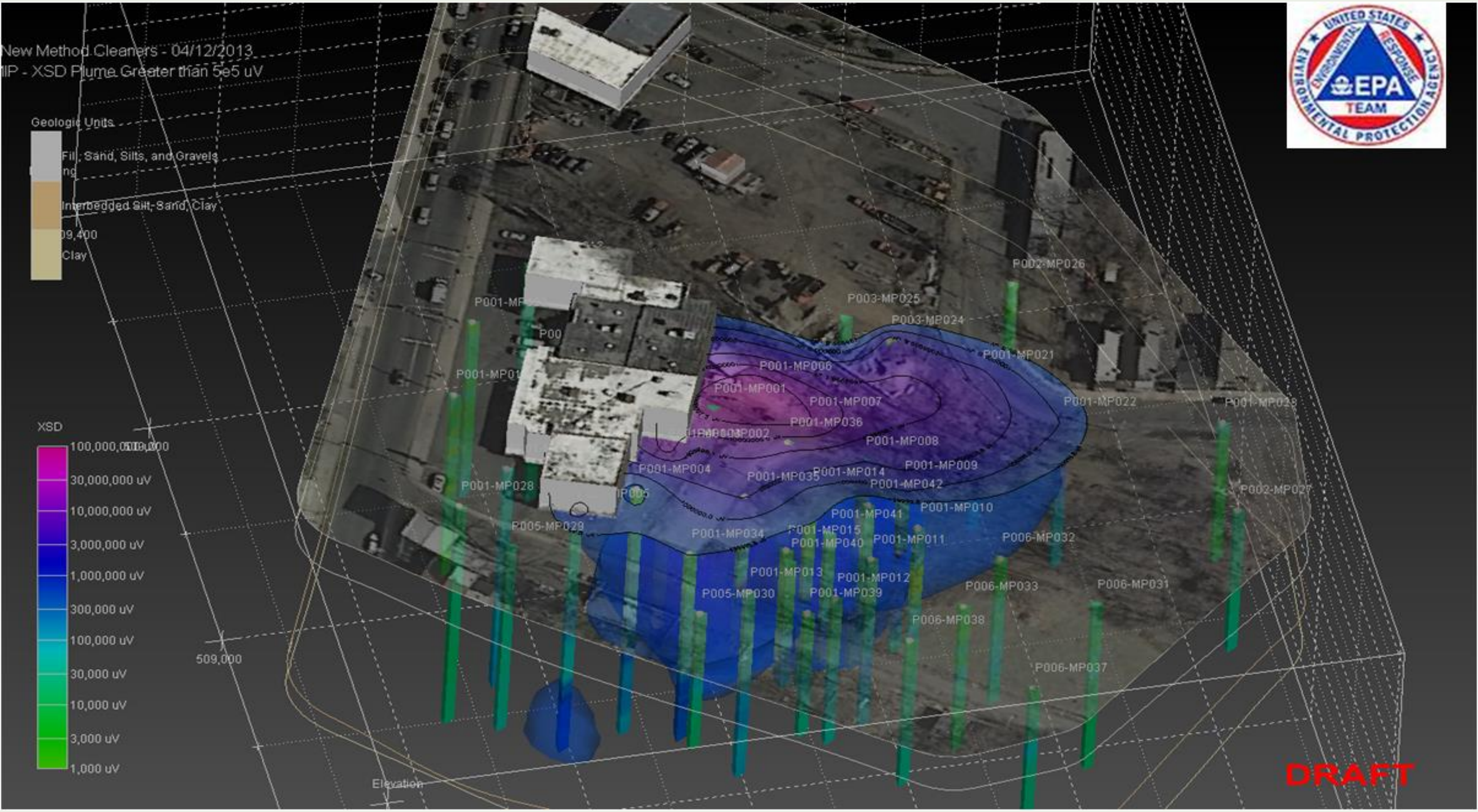
- ♦ **Estimate distributions, volume, mass, and behavior over time in high resolution (4-D)**

Dynamic Visualizations for Groundwater Results Over Time (4-D) for Chlorinated Solvents



SUNDANCE

Visualization of MIHPT Delineation
PCE Site – Visualization Updated Daily – Day 10



Two Types of Software for Environmental Data Reconstruction/Visualization

- **Geographic Information Systems (GIS)**
  - Examples – Google Earth Pro, ArcGIS, RockWorks™
  - Map (2-D) view of information
  - Useful in looking at data distributions and details of some data sets
  - Does not allow analysis of data with depth or elevation changes
  - Prerequisite to running of most 3-D programs
- **3-D and 4-D data reconstruction and visualization programs**
  - Examples – EarthVision®, EVS/MVS, GMS, RockWorks™, ArcGIS 3D analyst
  - Allows analysis of environmental data as a function of space (3-D) / time (4-D)
    - e.g., hydrogeology, bedrock, vadose/saturated zone distributions, sampling protocols – discrete intervals versus lengthy well screens, source to plume linkages
  - Important differentiation in types of data analysis produced by different programs
    - Geostatistical versus subjective correlations
    - Flexible (accepts all site data) versus fixed program structure

What is 3DVA?

- Geostatistical visualization and analyses
  - Statistics applicable to space and time
  - Collaborative data (multiple lines of evidence)
  - Three (space) or four (time or data as variables) dimensions
- 3DVA Framework
  - Places data in a spatially accurate grid based on geographic coordinates and elevations for each data point
  - Uses data kriging (geostatistics) to generate spatial/temporal data distributions and patterns
  - Enables synthesis of collaborative data in a holistic, integrated manner
  - Provides variety of tools that enable rigorous site analysis in easy to understand, 3-D formats

3DVA is…
- More than just ‘a picture’ – it’s a data analysis platform
- Interpolation of actual data – not predictive modeling
- Support all project stages – not just for characterization
- Cost effective – it can be low cost with very high ROI

Why Use 3DVA? *To end the Zombie Data Apocalypse!*

- **What are Zombie Data?**
  - Underutilized data that may be key to achieving site closure
- **Zombie Data are Everywhere**
  - Reams of data in appendices and files
  - Outlier data randomly removed from future use
  - One-time CSMs placed on the shelf and never seen again
  - Multitudes of reports that never lead to site completion
  - More and more zombie data being created every day

- **How to Resurrect Zombie Data?**
  - "Maximize the value of existing data"
  - Use 3DVA to maximize data value

3-D Visualization and Analysis Process

- **Clarify Project Goals**
  - » Identify specific questions to be answered
- **Manage Data**
  - » Address acquiring, reviewing, processing, importing
- **Develop Component Databases and Visualizations**
  - » Components include geologic, hydrogeologic, and chemical
- **Develop Integrated Visualizations**
  - » Integration of components with calibration and outlier checks
- **Analyze Visualizations**
  - » Assess what 3-D visualizations depict
- **Present Conclusions and Recommendations**
  - » Inform stakeholders and recommend next steps

Questions?

Case Studies

EPA
United States
Environmental Protection
Agency

Overview

- **Case studies**
  - Groundwater HRSC use at sites that have already undergone a traditional investigation
  - Compare the CSM from a traditional investigation with the CSM from an HRSC investigation
  - Show how HRSC can be used for sources also

Acknowledgement

- **Case studies are being used by courtesy of:**
  - Environmental Resource Management (ERM)
  - Stone Environmental, Inc.
  - SulTRAC

Case Study 1

United States
Environmental Protection
Agency

Background

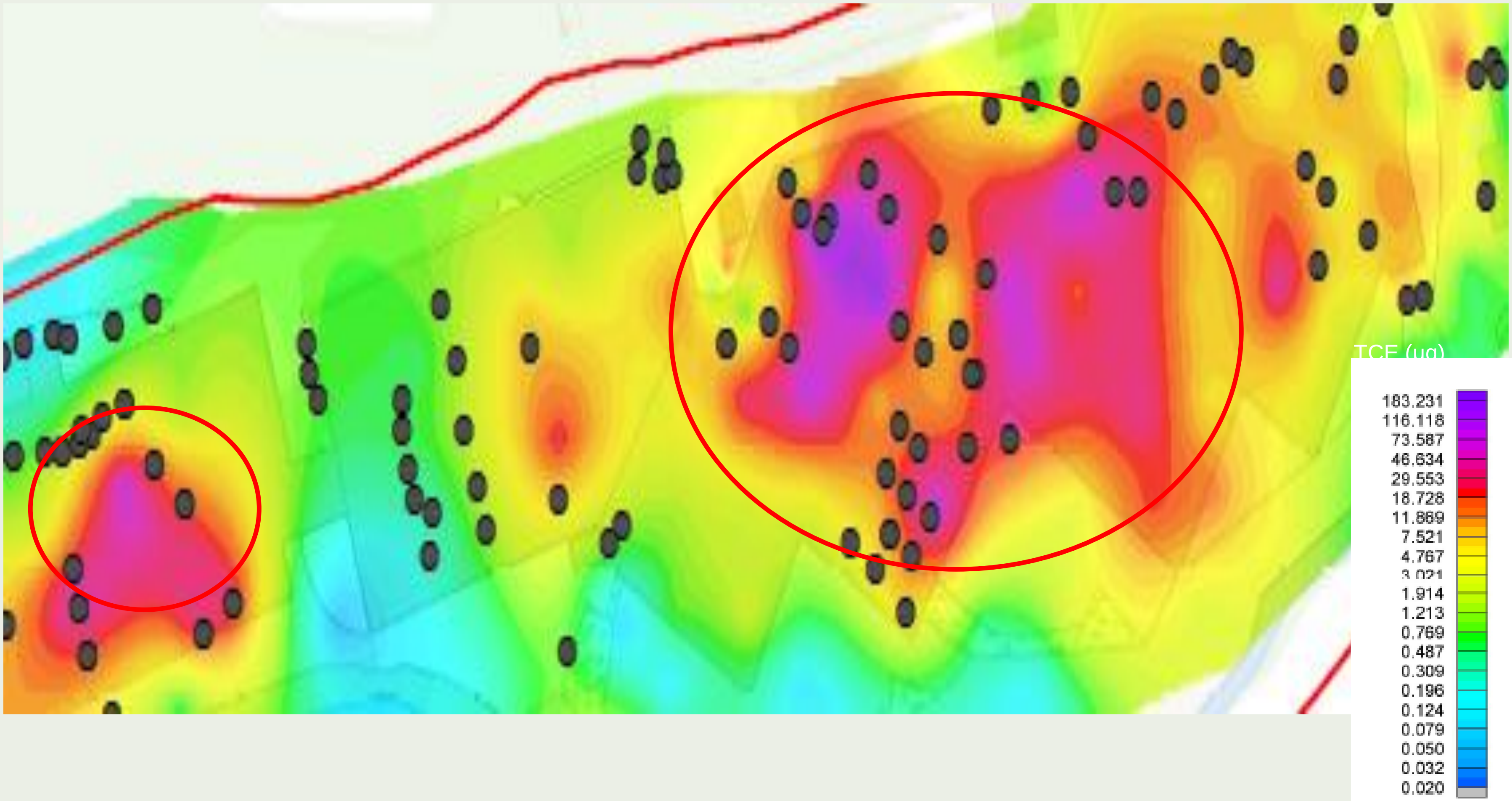
- **The site was previously subjected to considerable traditional site investigation (borehole drilling, limited monitoring well installation), which produced an initial Conceptual Site Model:**
  - Geological sequence of Fill (1 m), Alluvium (3 m), shale (thickness unknown)
  - Significant impact to soil due to historical use of TCE
    - Presence of significant concentrations of degradation compounds cis-1,2-dichloroethene and vinyl chloride in groundwater (both up to 20 mg/L)
  - Area of impact not fully defined either laterally or vertically
  - Anticipated that shale may form a low permeability barrier to inhibit vertical solvent migration, although fracture flow was not understood

(continued)

Background

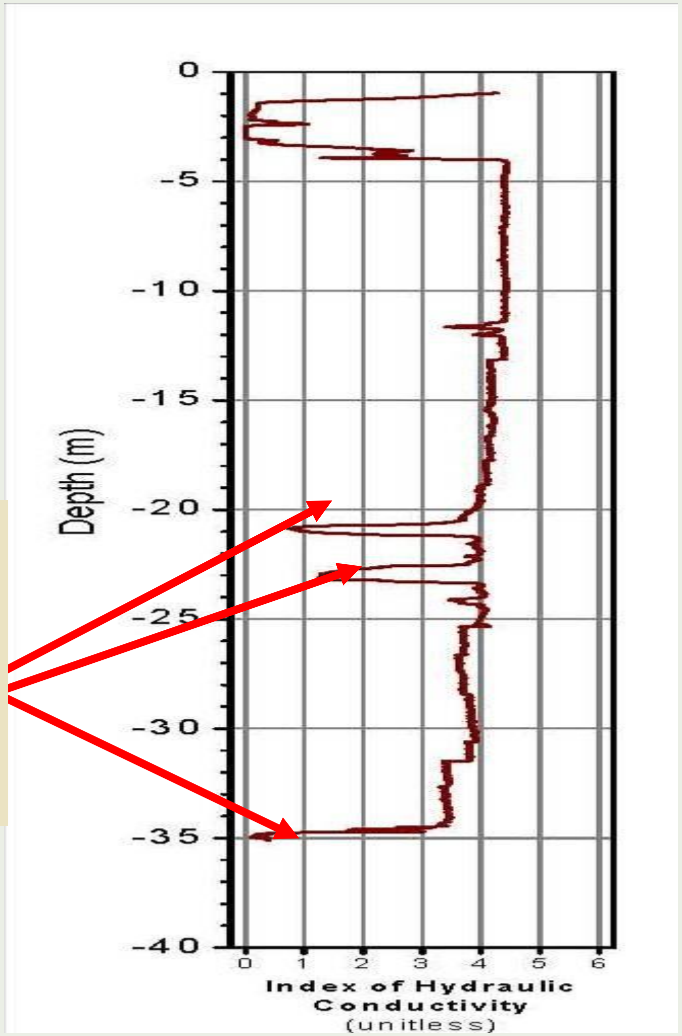
- **Remediation of the site was required and a long term solution was initially envisaged. To achieve this objective, the geometry of the plume needed to be understood. ERM therefore used a variety of HRSC techniques, including:**
  - Gore Sorber™ Survey at 155 locations (largest survey of its type in the UK)
  - Waterloo^{APS} ™ Investigation (Alluvium/shale) – 100+ groundwater VOC samples collected
- **HRSC approach carried out in accordance with Triad principals to collect collaborative data set**
- **Sustainability a key focus at both site investigation and remediation stage (SuRF UK Framework)**

Gore Sorber™ Results



Waterloo^{APS}™ Investigation

Targeted DNAPL sampling above low K horizon



Rock Core Investigation Rationale

- **The investigation defined impact within the Alluvium and upper margins of the shale, but revealed that significant VOC impact was present within the weathered shale, where samples could be collected**
- **Therefore to assist with the remediation strategy development, ERM recommended additional detailed contaminant assessment of the bedrock matrix via a CORE$^{DFN™}$ investigation as part of a Discrete Fracture Network (DFN) investigation approach developed by Beth Parker (University of Waterloo, University of Guelph)**

Rock Core Investigation Scope

- Completion of 19 rock coring locations to a depth of between 11m bgl and 22m bgl. Total of circa 200m of rock core recovered
- All boreholes were photographed, structurally logged and selected samples screened with a Photoionization Detector (PID)
- Samples tested on-site for VOCs and in off-site laboratory for physical property analysis (TOC, porosity, moisture content and bulk density)
- Wells installed into each borehole to enable assessment of groundwater flow direction and dissolved phase concentrations within the bedrock
- Initial locations selected based on areas of previously determined greatest groundwater impact. Subsequent locations and finally drilled depth based on progressive real-time assessment of the data during the field work

Sample Collection Process

Above: shale core sampling

Above: shale core

Above and Left: Rock crushing, with decontamination equipment above

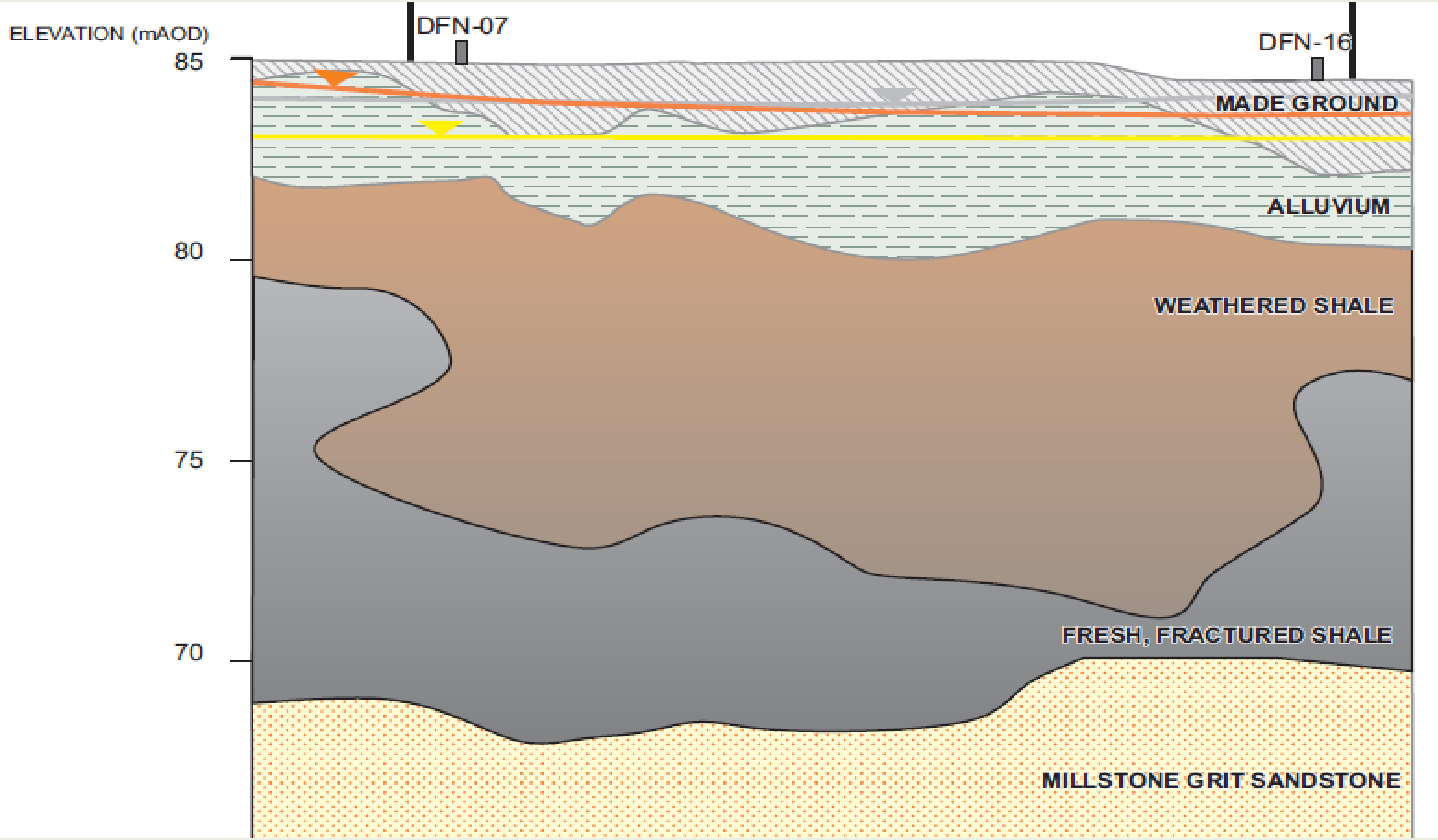
On-site Laboratory Analysis

On-site laboratory analysis of pore water concentrations using Microwave Assisted Extraction

- MAE was then used to extract VOCs from the rock core into methanol
- Concentrations were measured in the methanol extract (by GC/MS)
- The entire process took <90 minutes (compared to circa 5 weeks if this analysis was undertaken via traditional methods)
- Circa 450 rock core samples were tested for VOCs in a period of 15 days

On-site Laboratory

Geology

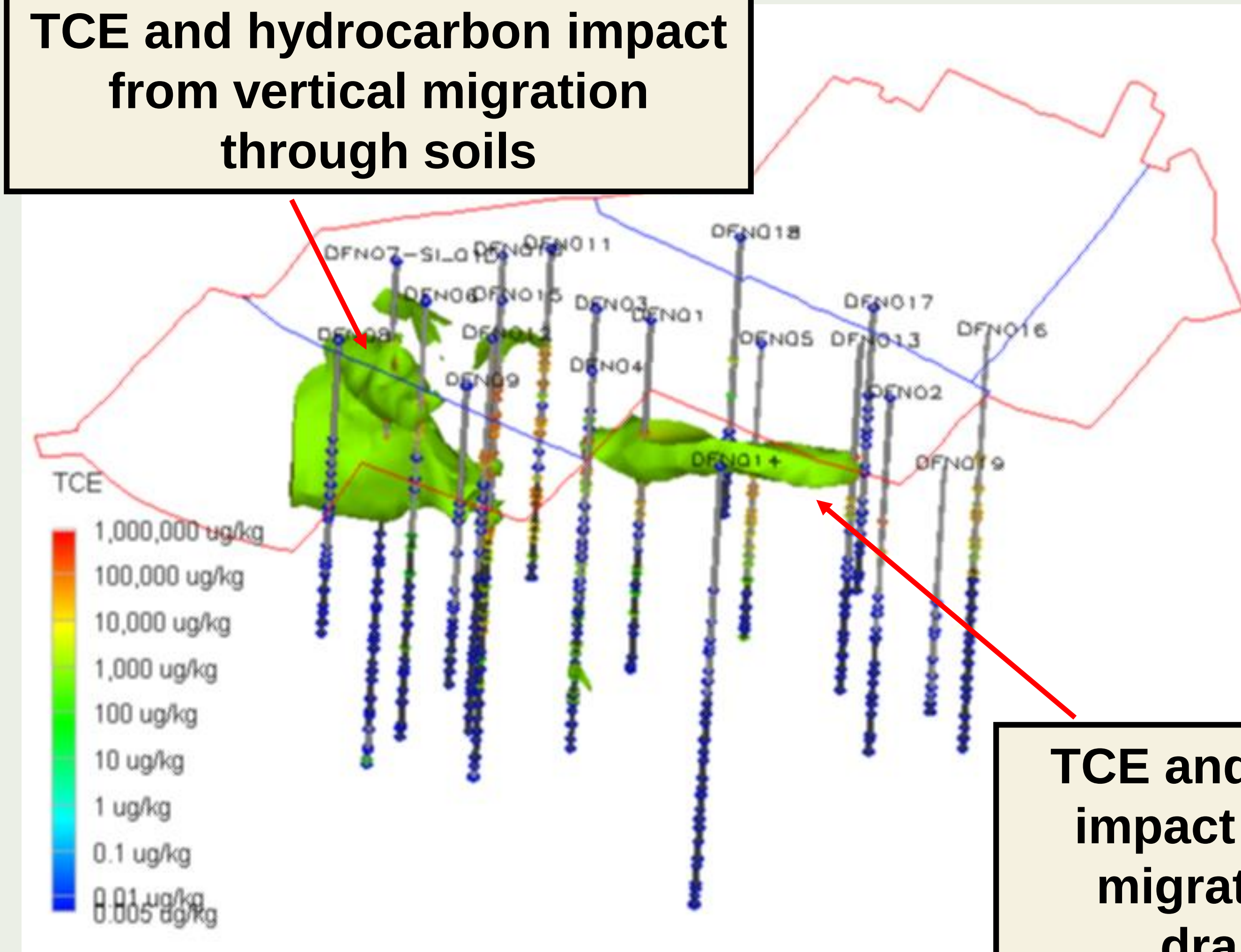

ELEVATION (mAOD)
85
80
75
70
DFN-07
DFN-16
MADE GROUND
ALLUVIUM
WEATHERED SHALE
FRESH, FRACTURED SHALE
MILLSTONE GRIT SANDSTONE

Hydrogeology

- ♦ **Groundwater flow direction confirmed in shale**
- ♦ **Both Alluvium and shale are in hydraulic continuity and form a confined aquifer beneath the site**
- ♦ **Permeability of shale is relatively high – up to 9.5m/d. Higher than would be anticipated for this lithology and is likely to be due to the affects of the weathering**
- ♦ **Ecological receptors – nearby river (lateral) and sandstone aquifer at depth (vertical)**

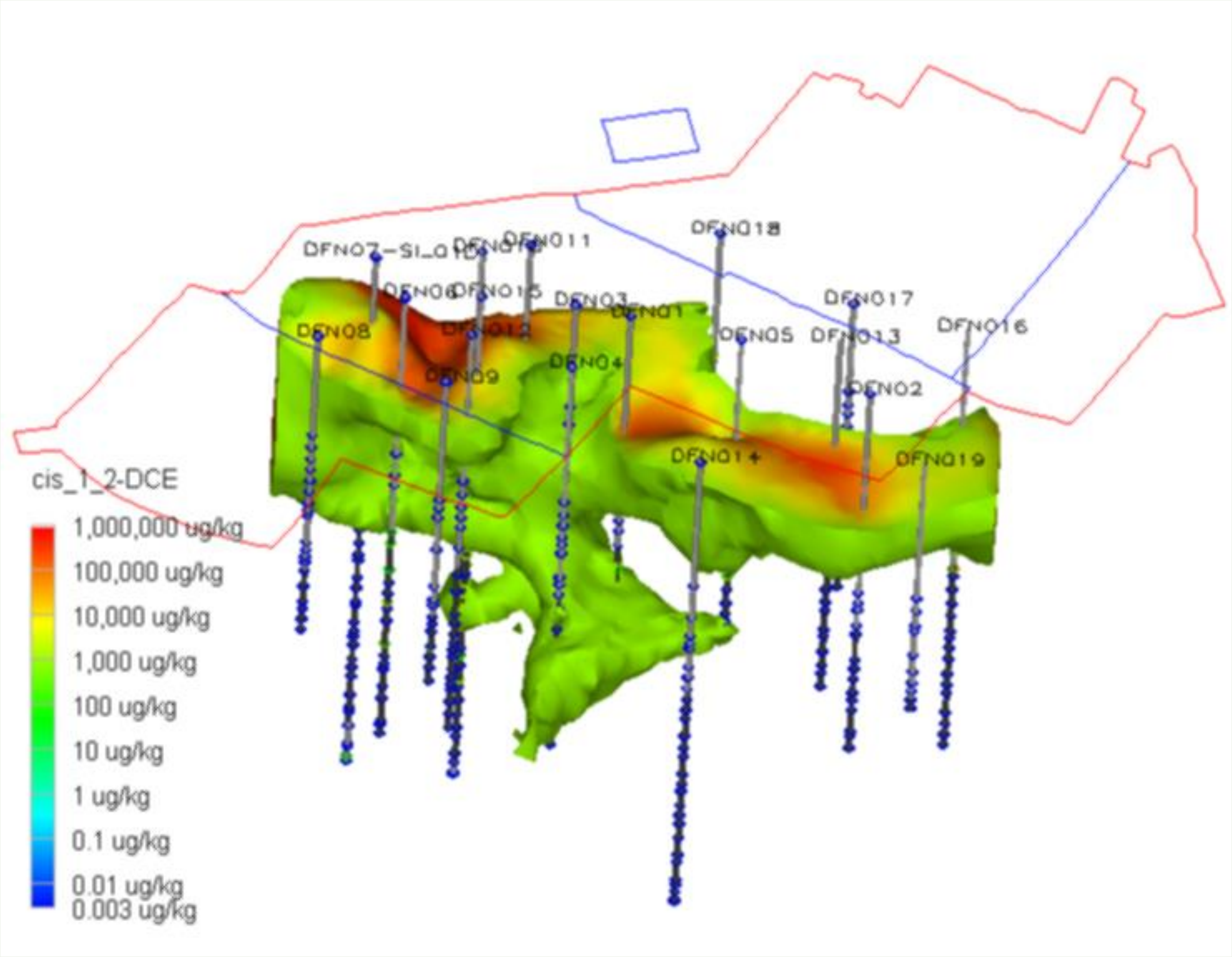
Pore Water Contaminant Distribution – TCE

TCE and hydrocarbon impact from vertical migration through soils

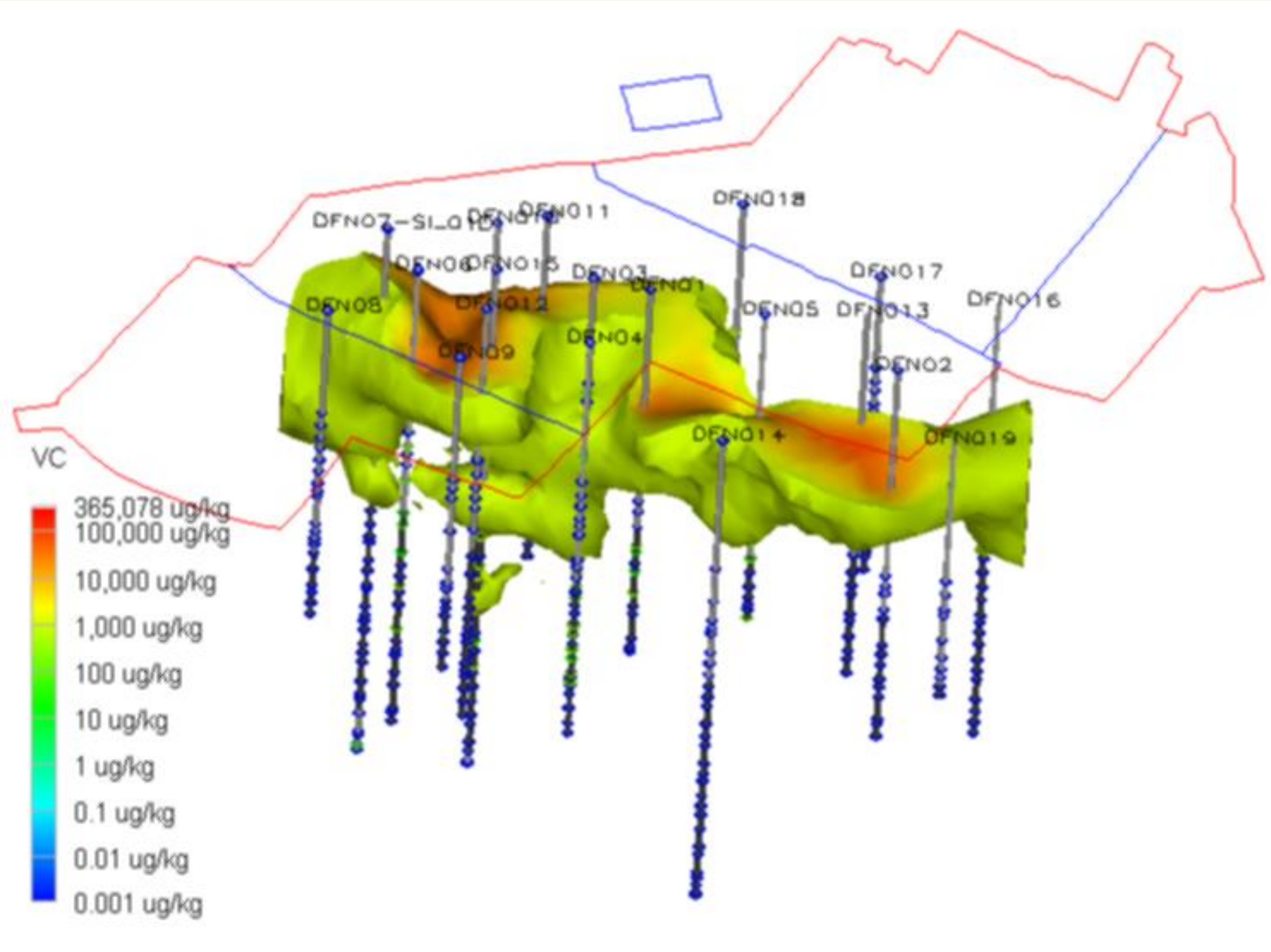


TCE and hydrocarbon impact from vertical migration through drainage run

Pore Water Contaminant Distribution – Cis-1,2-DCE



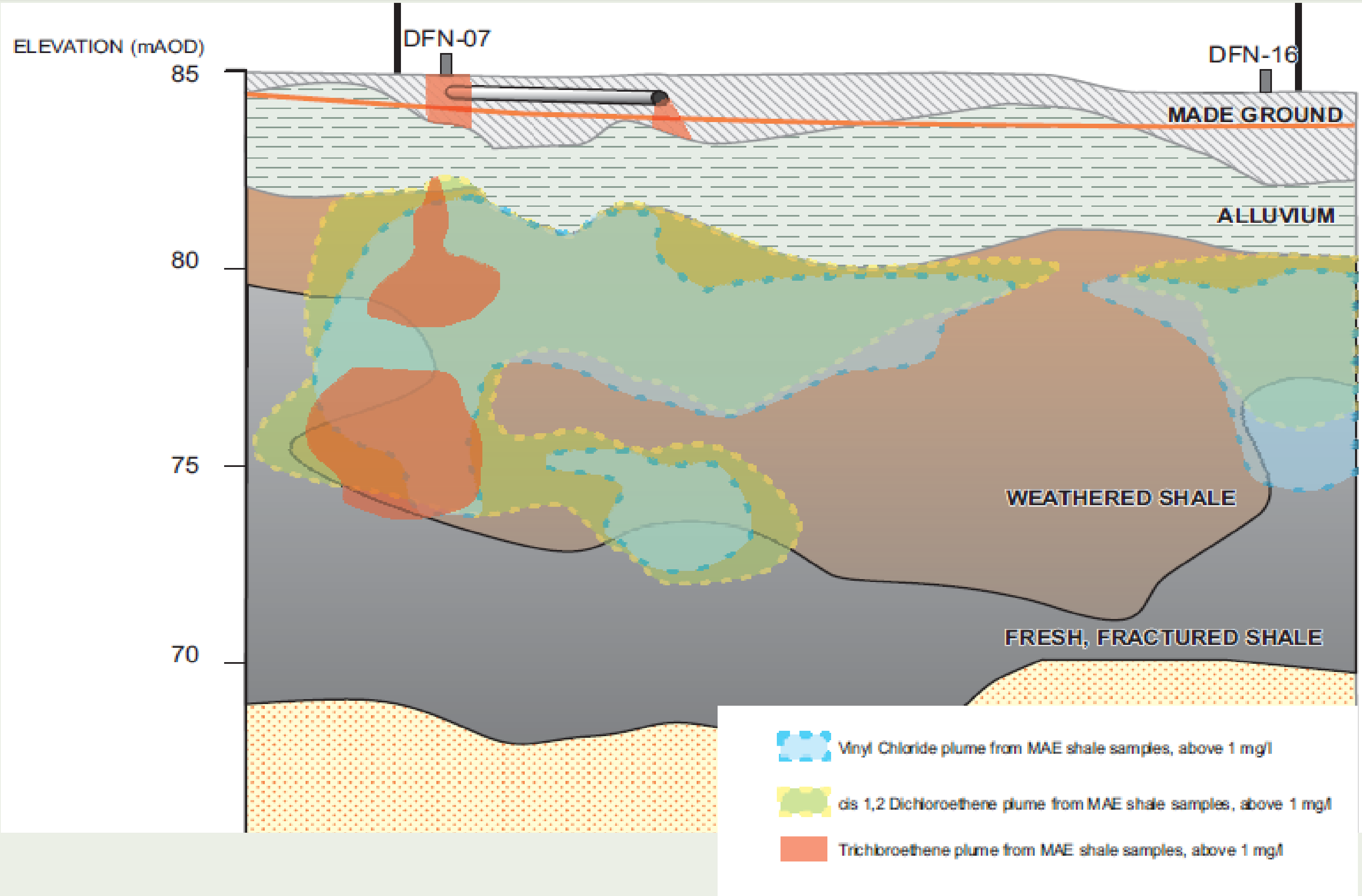
Pore Water Contaminant Distribution – Vinyl Chloride



Groundwater Sampling Results

- Results showed a majority of the contaminant mass was sorbed within the rock matrix. This is a typical reflection of contaminant mass distribution within bedrock
- Groundwater concentrations significantly lower than in pore water (again typical for bedrock). No obvious trends between pore and groundwater ratios
- Slow diffusion of impact from the rock matrix into dissolved phase likely to be on-going

Refined Conceptual Site Model



Sustainability Measurement Results

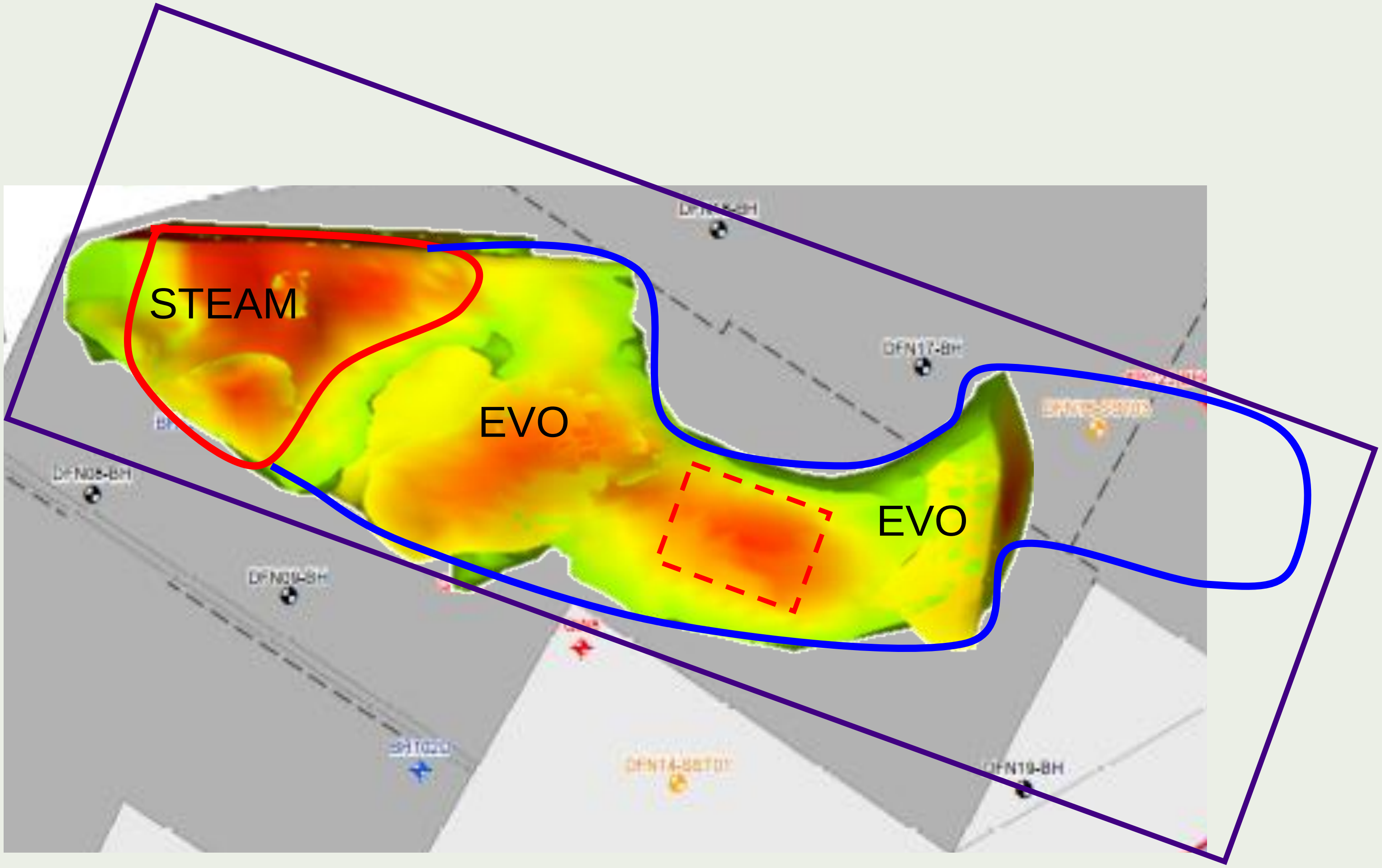
- To assess the impact of using innovative site characterization approaches on the carbon footprint of the investigation, an estimate of the footprint that would have resulted with conventional techniques was calculated for comparative purposes.
- Using conventional techniques to obtain a similar level of site characterization detail would have potentially resulted in a carbon footprint of 33.1 tonnes CO_2e; this significantly exceeds the actual total emitted of 22.7 tonnes CO_2e.

Travel	19.9 t CO_2e	(60%)
Accommodation	6.0 t CO_2e	(18%)
On site energy use	4.7 t CO_2e	(14%)
Materials	2.3 t CO_2e	(7%)
Material Deliveries	0.1 t CO_2e	(0%)
Site wastes	0.0 t CO_2e	(0%)
Water	0.2 t CO_2e	(0%)
TOTAL	**33.1 t CO_2e**	

Summary

- Three HRSC techniques (Gore Sorbers, Waterloo$^{APS™}$ and CORE$^{DFN™}$ Investigation) applied on-site in both drift and solid rock deposits to collect a collaborative data set in accordance with Triad investigation principals. Shown to be an efficient process for developing robust conceptual site models.
- Over 700 sample locations
- First application of the CORE$^{DFN™}$ rock core technique for bedrock in the UK
- More sustainable site investigation approach than traditional investigations, along with numerous other cost, time, safety and technical benefits. Also benefits at the remediation stage (performance certainty, reduced treatment zone and effort focused on greatest mass.

HRSC to Define Remedial Treatment Area and Techniques

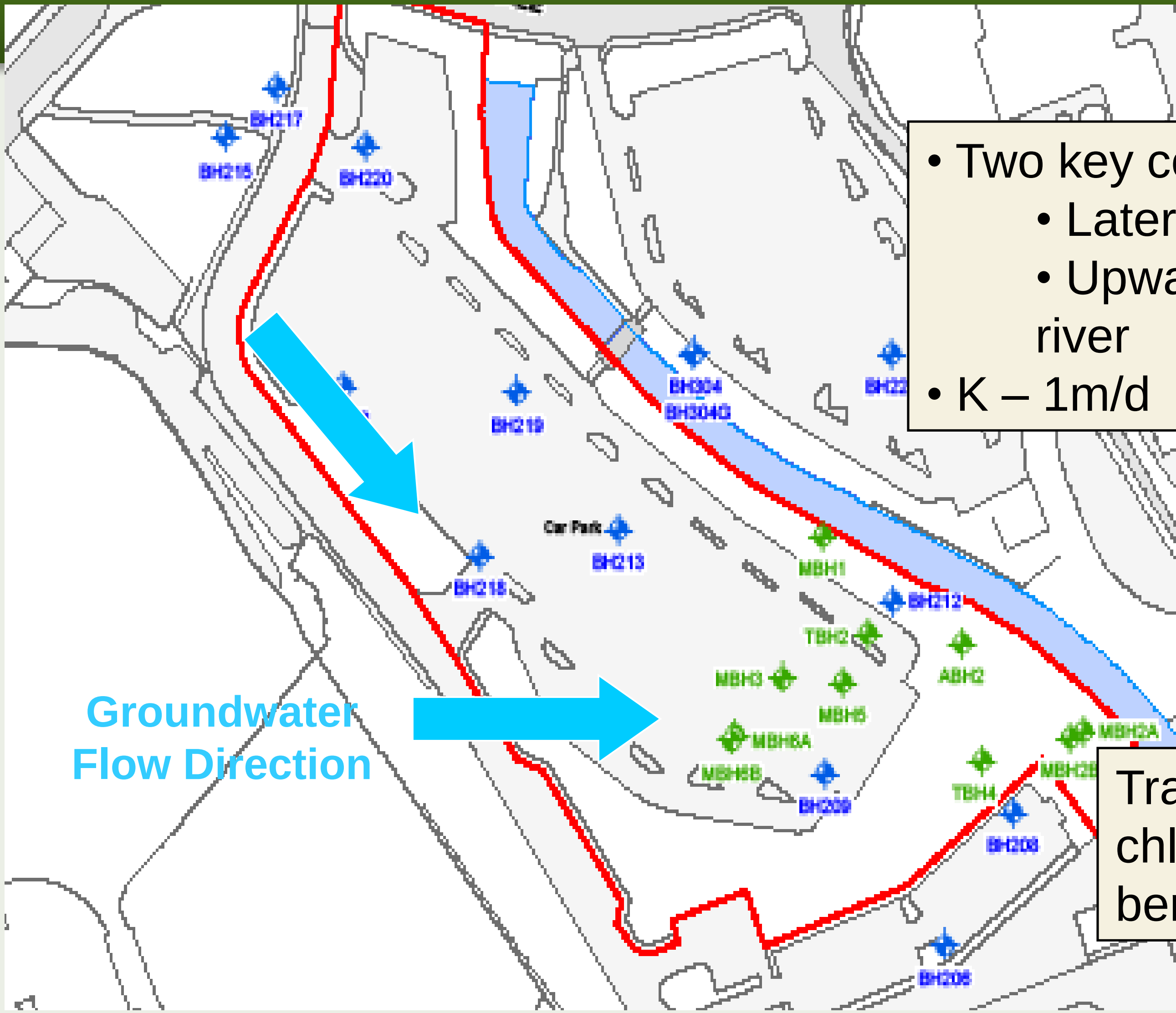


Case Study 2

United States
Environmental Protection
Agency

Site Overview

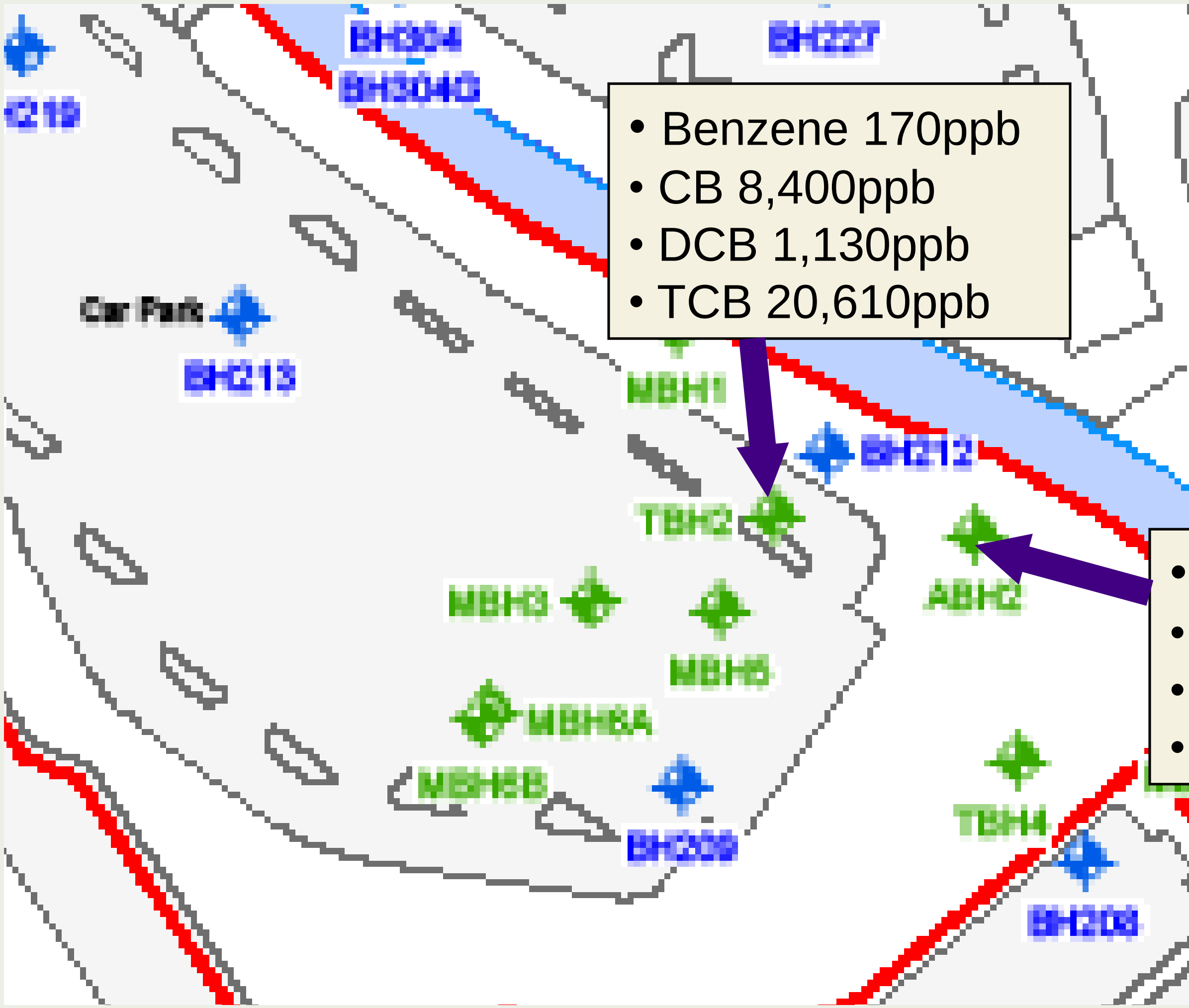
- **Former industrial site in northern England**
- **Historic use of chlorinated benzenes**
  - (TCB, DCB, CB)
- **DNAPL presence suspected**
- **Previous investigation and remediation undertaken by others using traditional techniques (soil borings, well installation, soil excavation)**
- **Geology: Made Ground underlain by sands/gravels/ clays. Sandstone bedrock at depth (circa 15-20m bgl)**



- Two key components:
  - Lateral flow to river
  - Upward Gradient near river
- K – 1m/d

Trace levels of chlorinated benzenes in river

Previous Groundwater Sampling Results



- Benzene 170ppb
- CB 8,400ppb
- DCB 1,130ppb
- TCB 20,610ppb

- Benzene <10ppb
- CB 94ppb
- DCB 77ppb
- TCB 40ppb

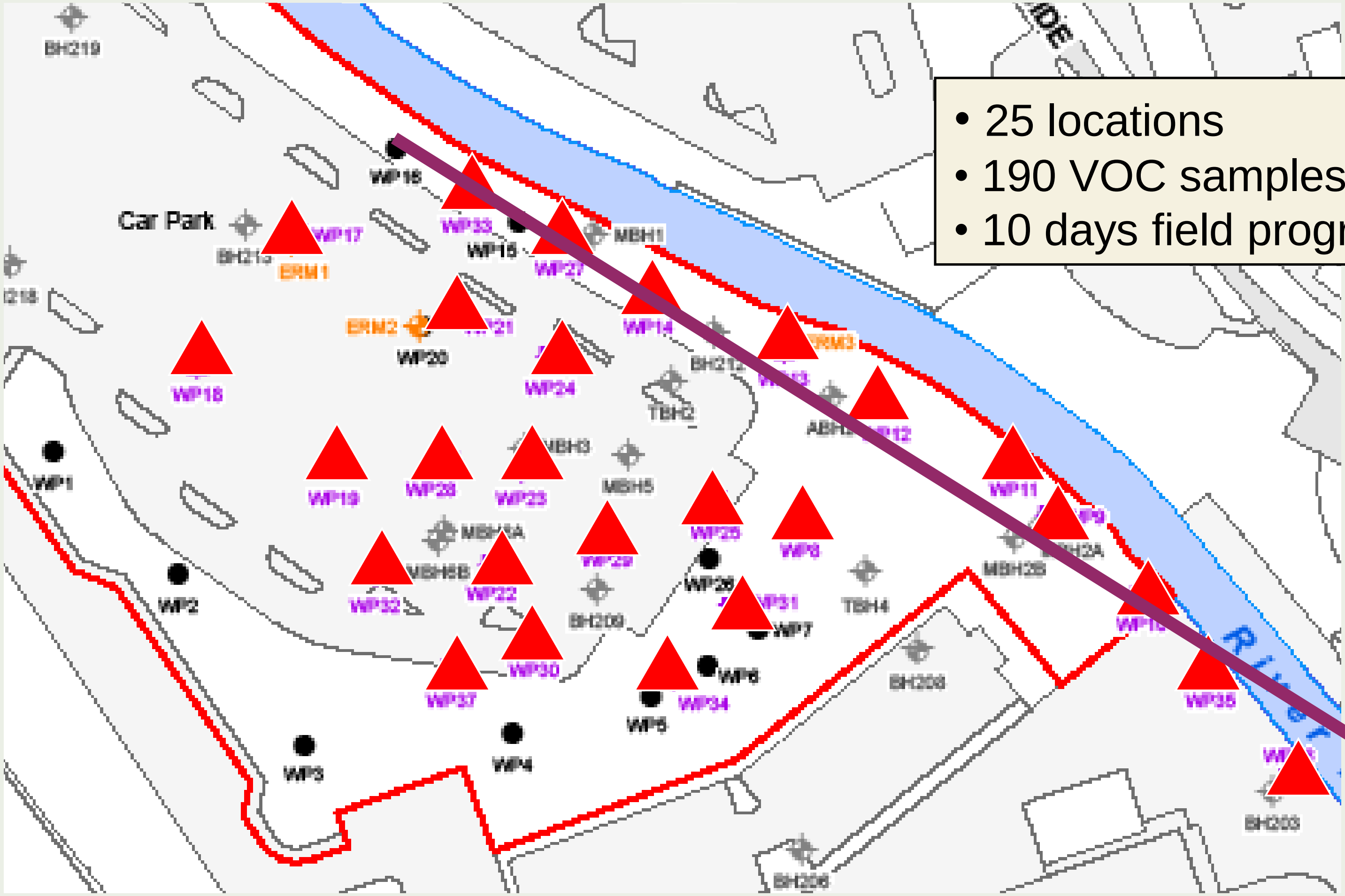
variable screen placement in wells

DNAPL suspected but not identified

Groundwater Investigation Objectives

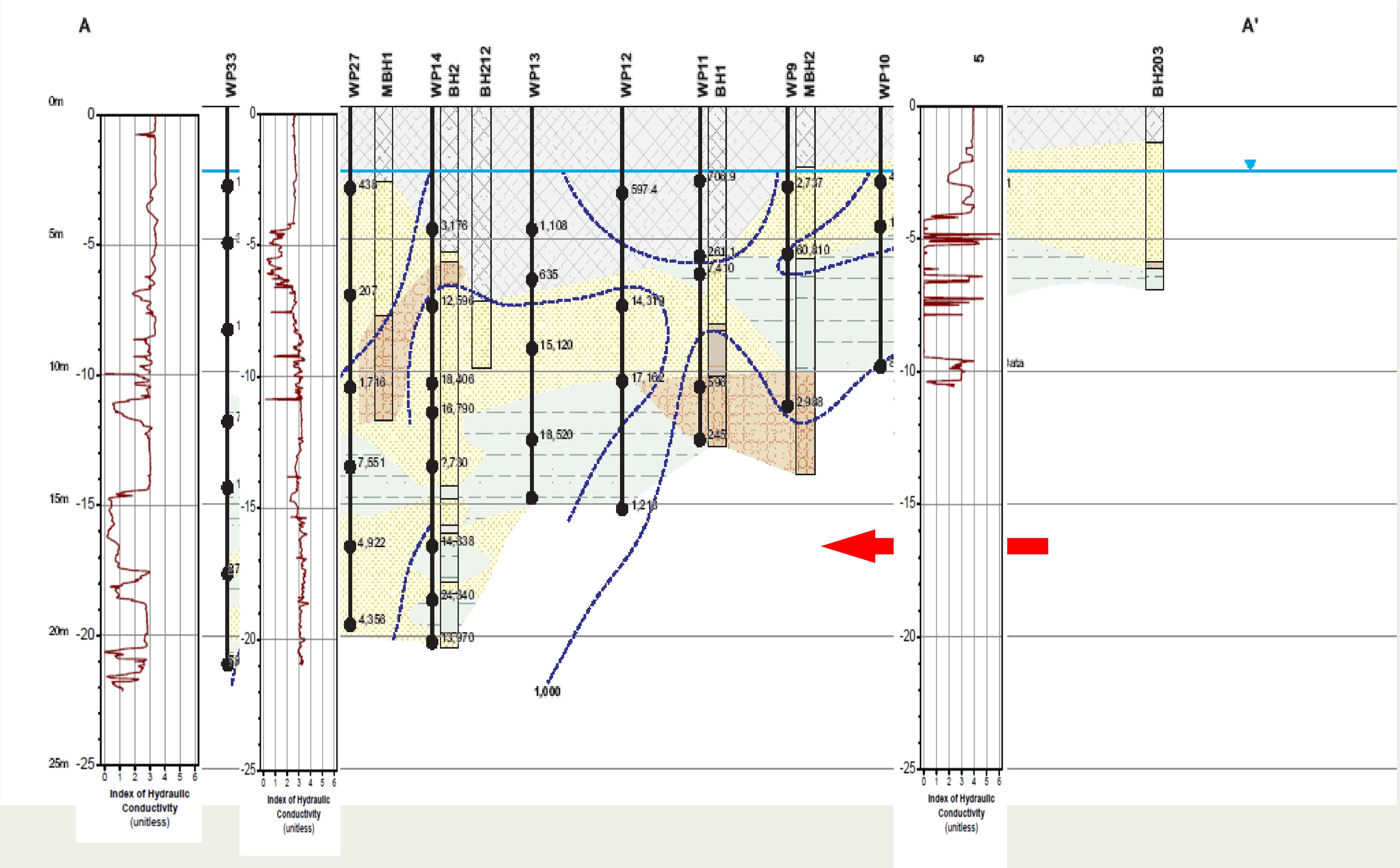
- **Waterloo$^{APS™}$ investigation undertaken to refine incomplete Conceptual Site Model, specifically:**
  - » Evaluate linkages between shallow groundwater and river
  - » Define lateral and vertical extent and magnitude of groundwater treatment zones required for subsequent remediation works

Waterloo^APS™ Location Plan

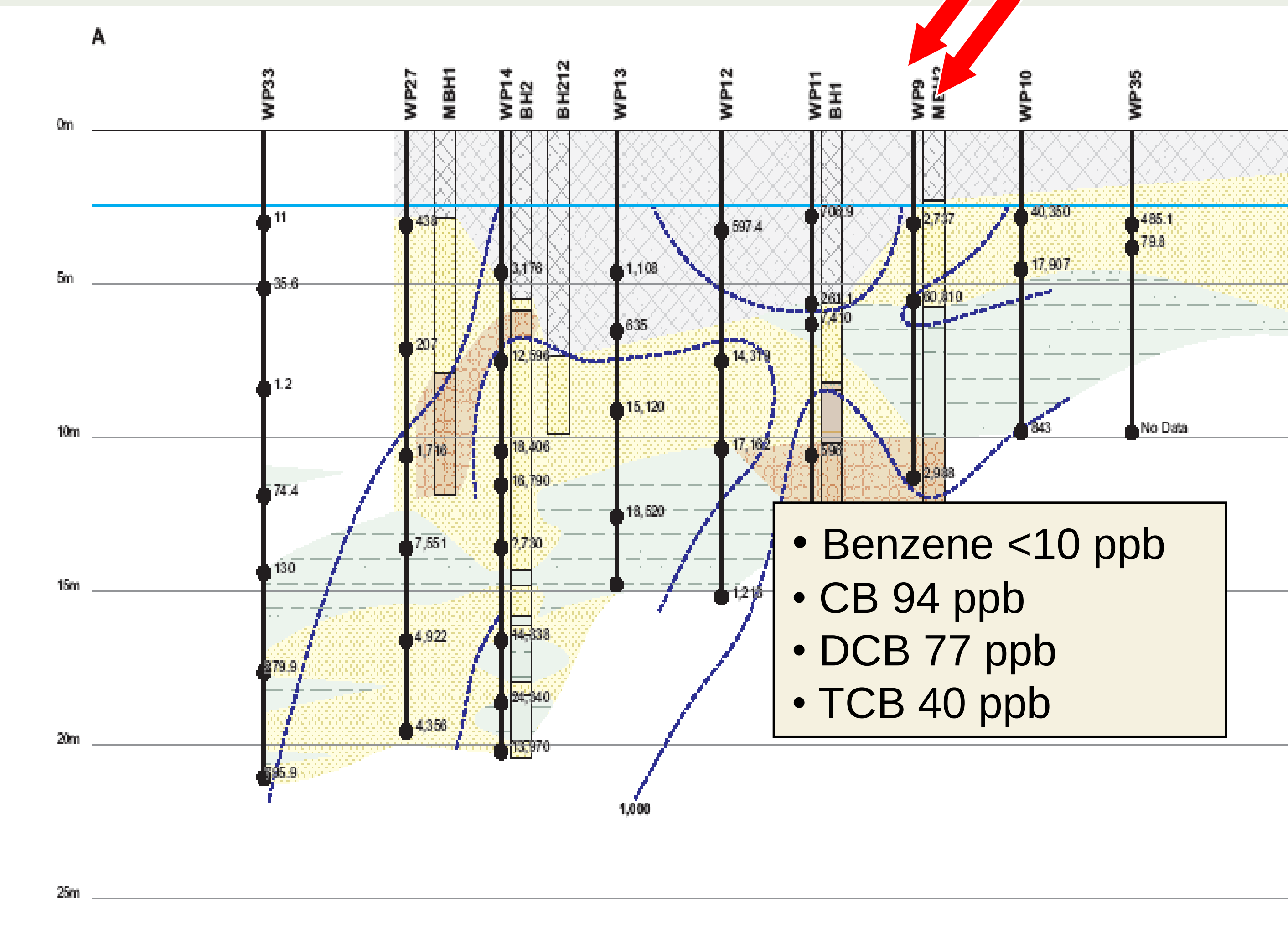


- 25 locations
- 190 VOC samples
- 10 days field program

Cross Section North to South



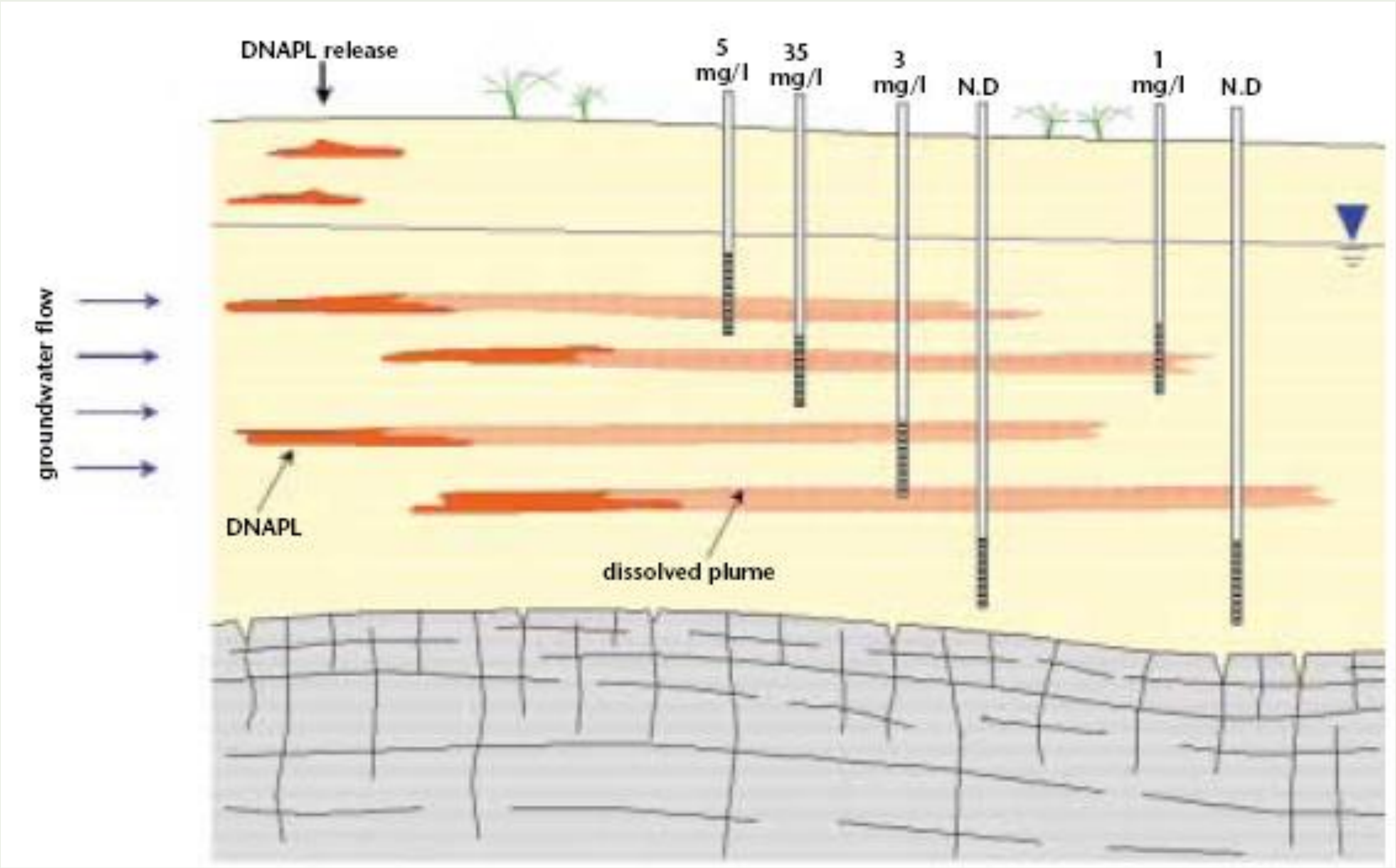
Traditional Well Versus Waterloo^APS™ Sampling



- Benzene <10 ppb
- CB 94 ppb
- DCB 77 ppb
- TCB 40 ppb

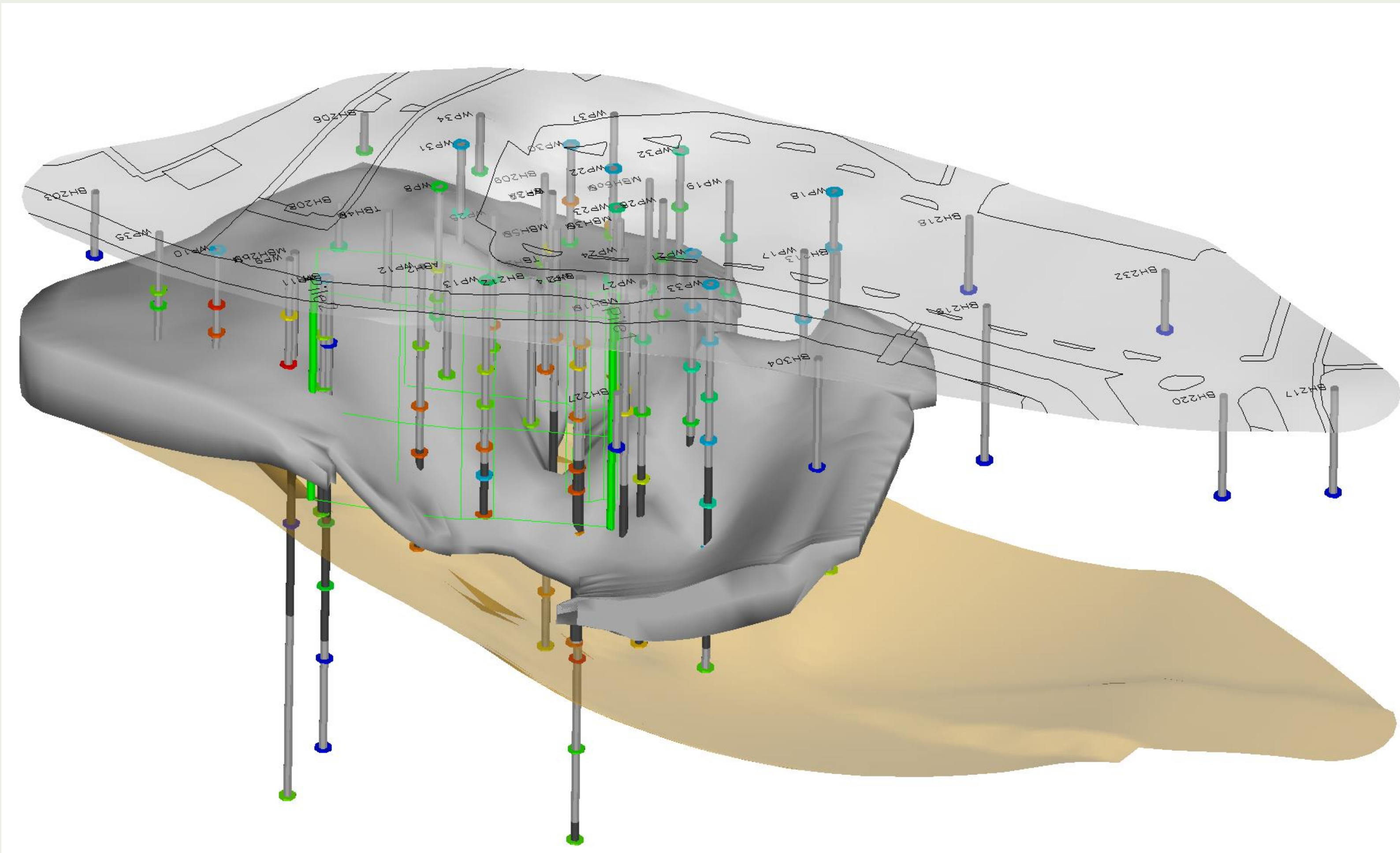
(continued)

Traditional Well Versus WaterlooAPS™ Sampling



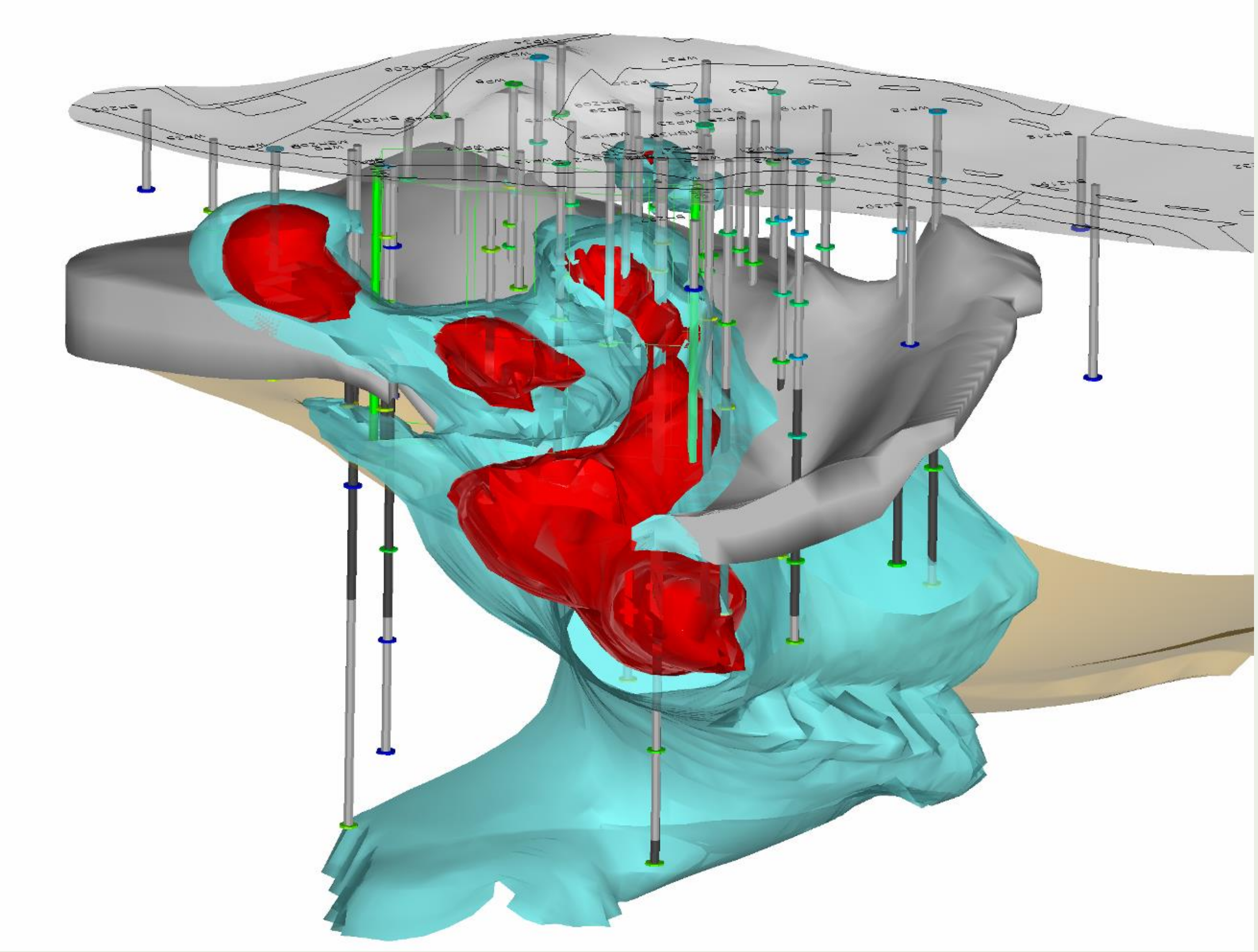
Environment Agency, 2003

EVS Output



(continued)

EVS Output



Heterogeneity rules (even in "homogenous" geology)

Source area contaminant mass above low K zones

Plumes migrate in high K zones

Waterloo^APS™ Benefits

- ♦ **Improve delineation and hence confidence**
- ♦ **Equivalent costs using traditional methods would have been greater**
- ♦ **Data quality more robust (smaller sampling interval showed higher and more representative concentrations)**
- ♦ **Cost savings on remediation by being able to focus effort on the areas that really need it**

Conclusions

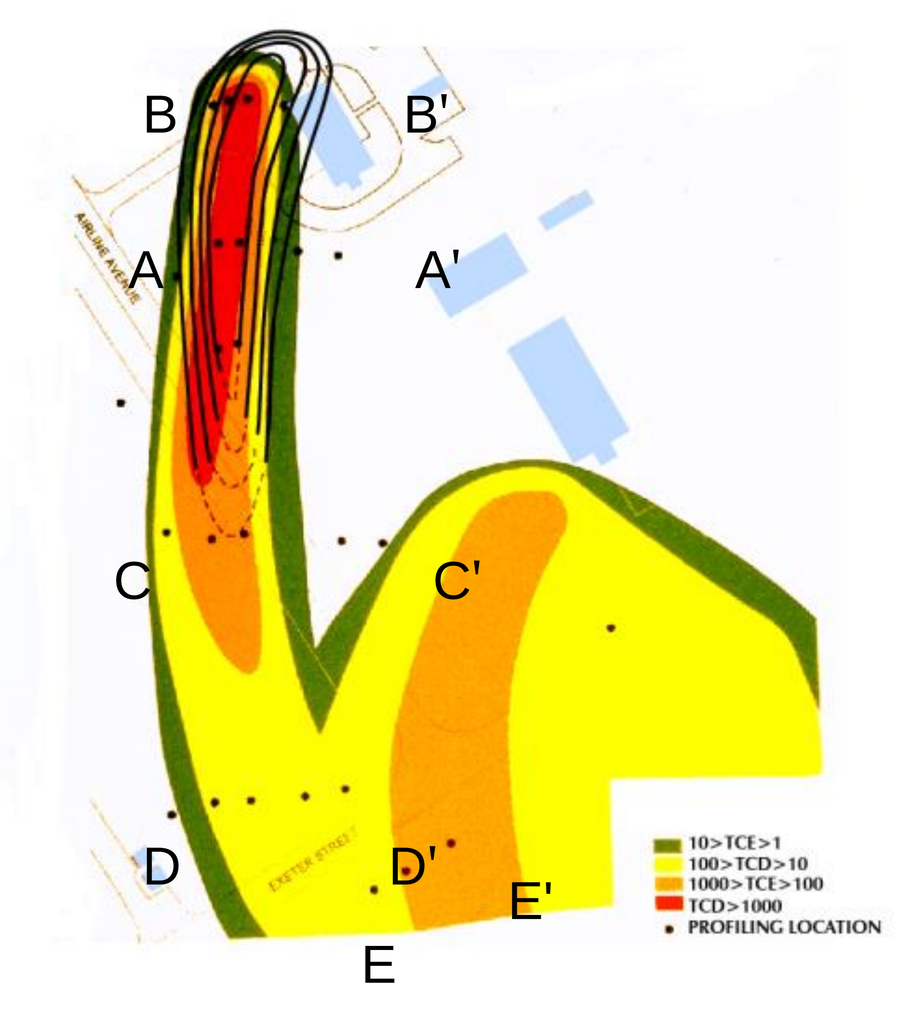
- Use of Waterloo$^{APS™}$ for 10 days = 190 VOC samples
- Significant advance of CSM
- Robustness of CSM led to greater regulatory confidence with respect to validation scheme for subsequently completed remediation
- Only the second time Waterloo$^{APS™}$ equipment used in the UK – likely future increase in use

Post Remediation

Case Study 3

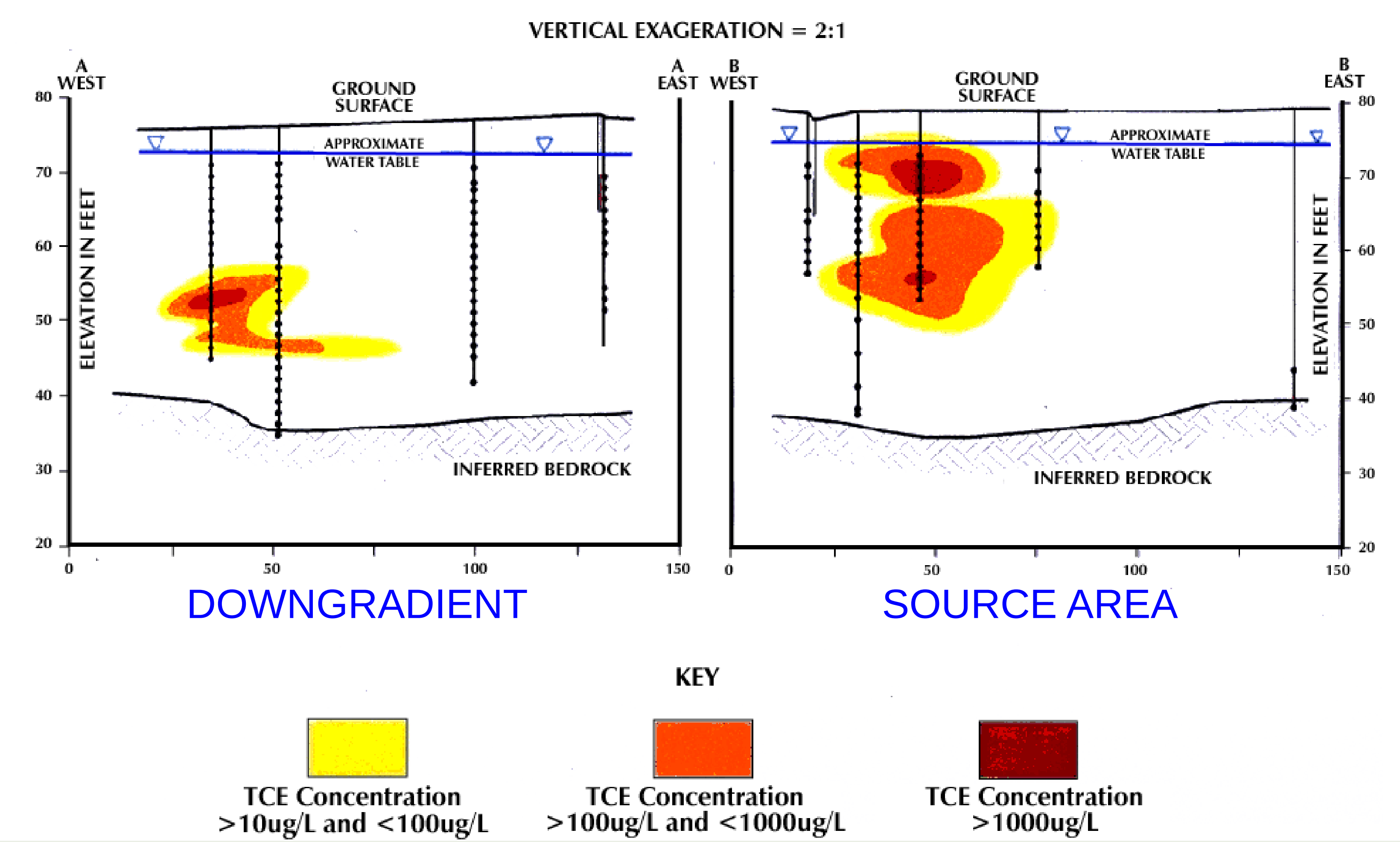
United States
Environmental Protection
Agency

Transect Case Study: Secondary Groundwater Plume Characterization, Pease AFB, NH

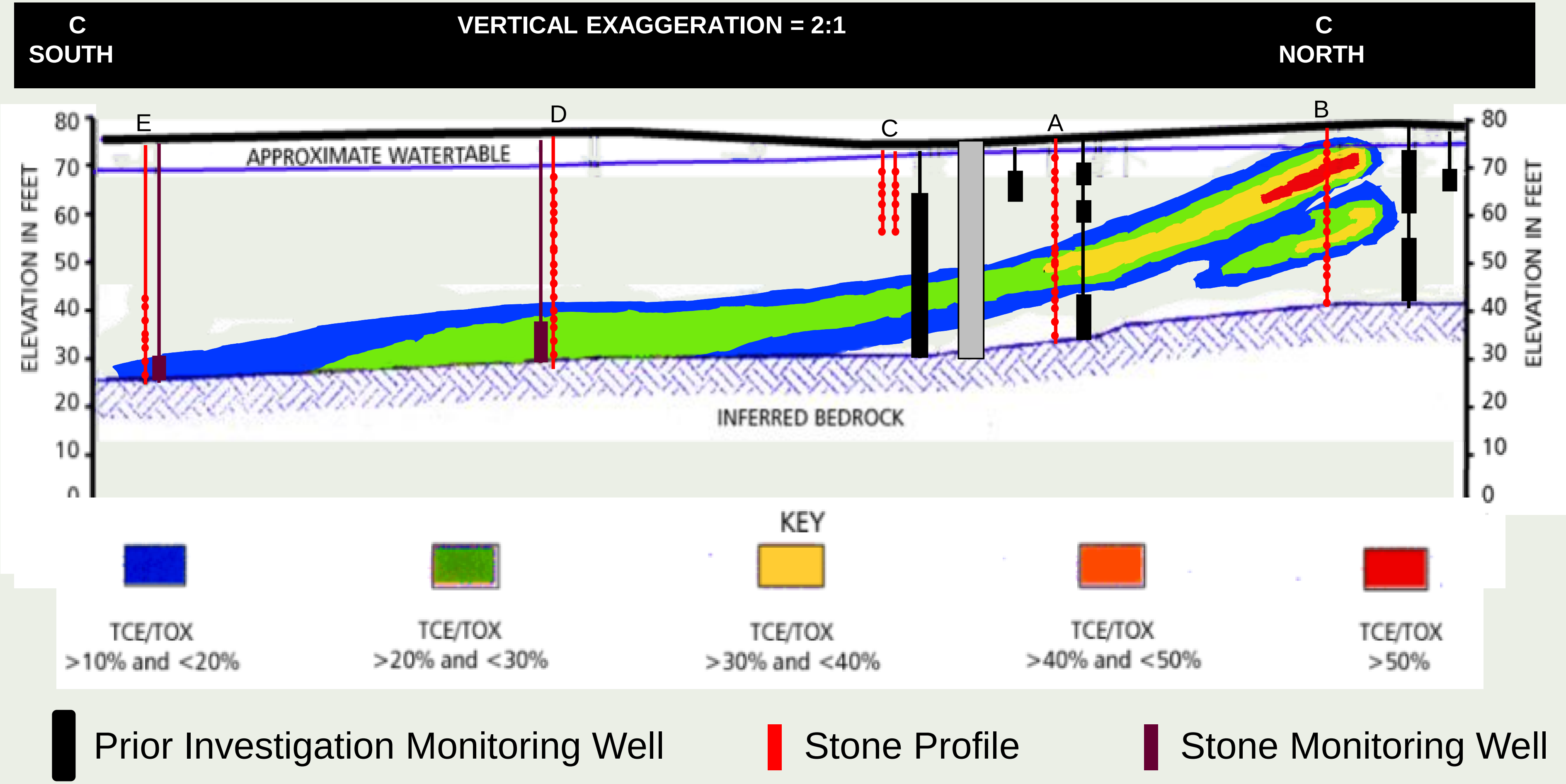


- **VOC and POL release site**
- **VOCs potentially affecting two bedrock supply wells**
  - » Concern over DNAPL in bedrock
- **Prior monitoring well investigation did not accurately characterize the plume**
  - » Defined as "short plume"
- **5 Modified Waterloo Profiler transects performed normal to plume axis**
  - » A - A' = Downgradient of source
  - » B - B' = Through source area
  - » C - C' / D - D' / E - E = Downgradient plume delineation

Profiler Cross Sections Showed TCE Plume was Sinking with Distance from Source



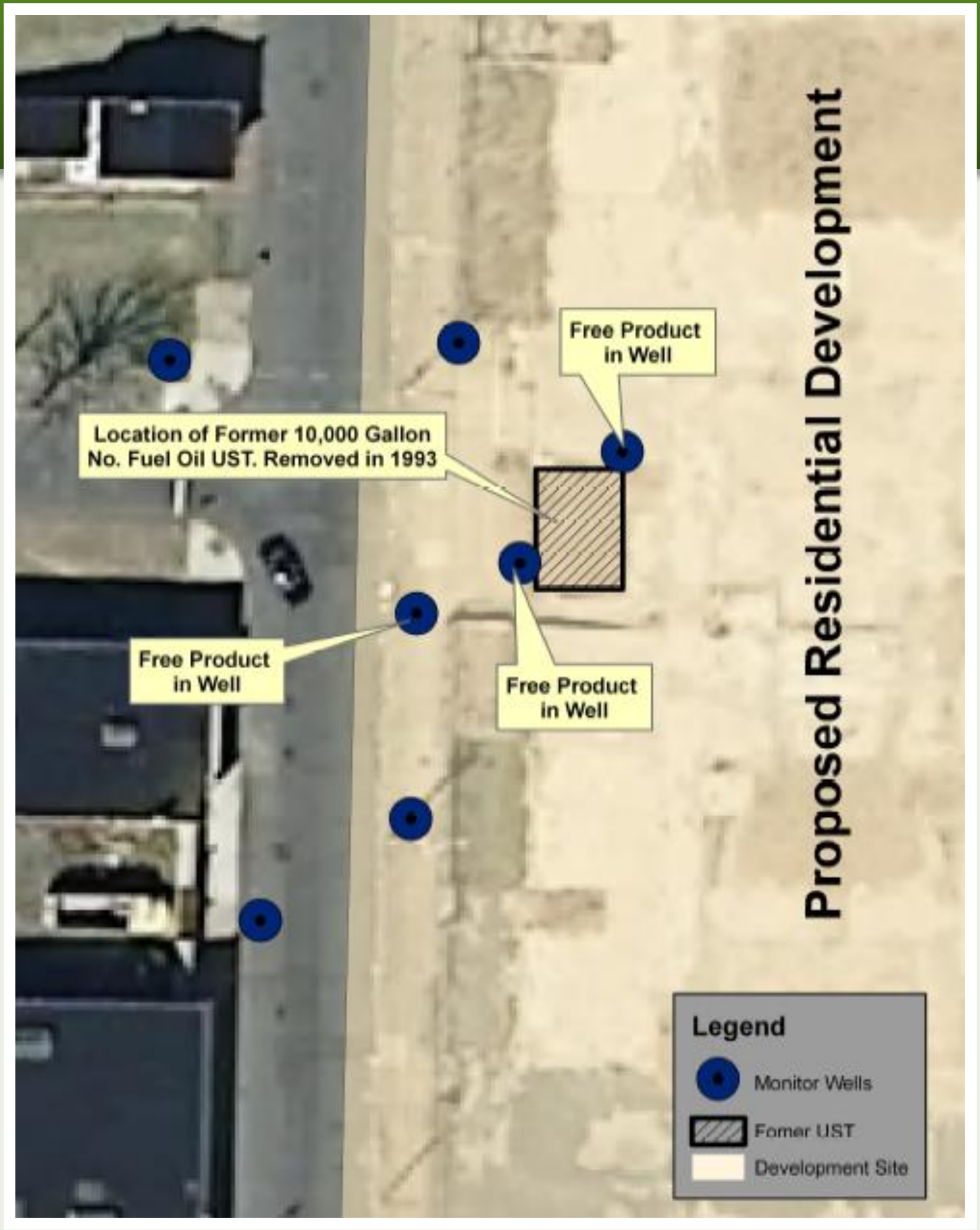
Vertical Profiling vs. Monitoring Well



Case Study 4

United States
Environmental Protection
Agency

Case Example of Delineation of TPH Impacts from UST Release Using Collaborative Data Sets and Imaging

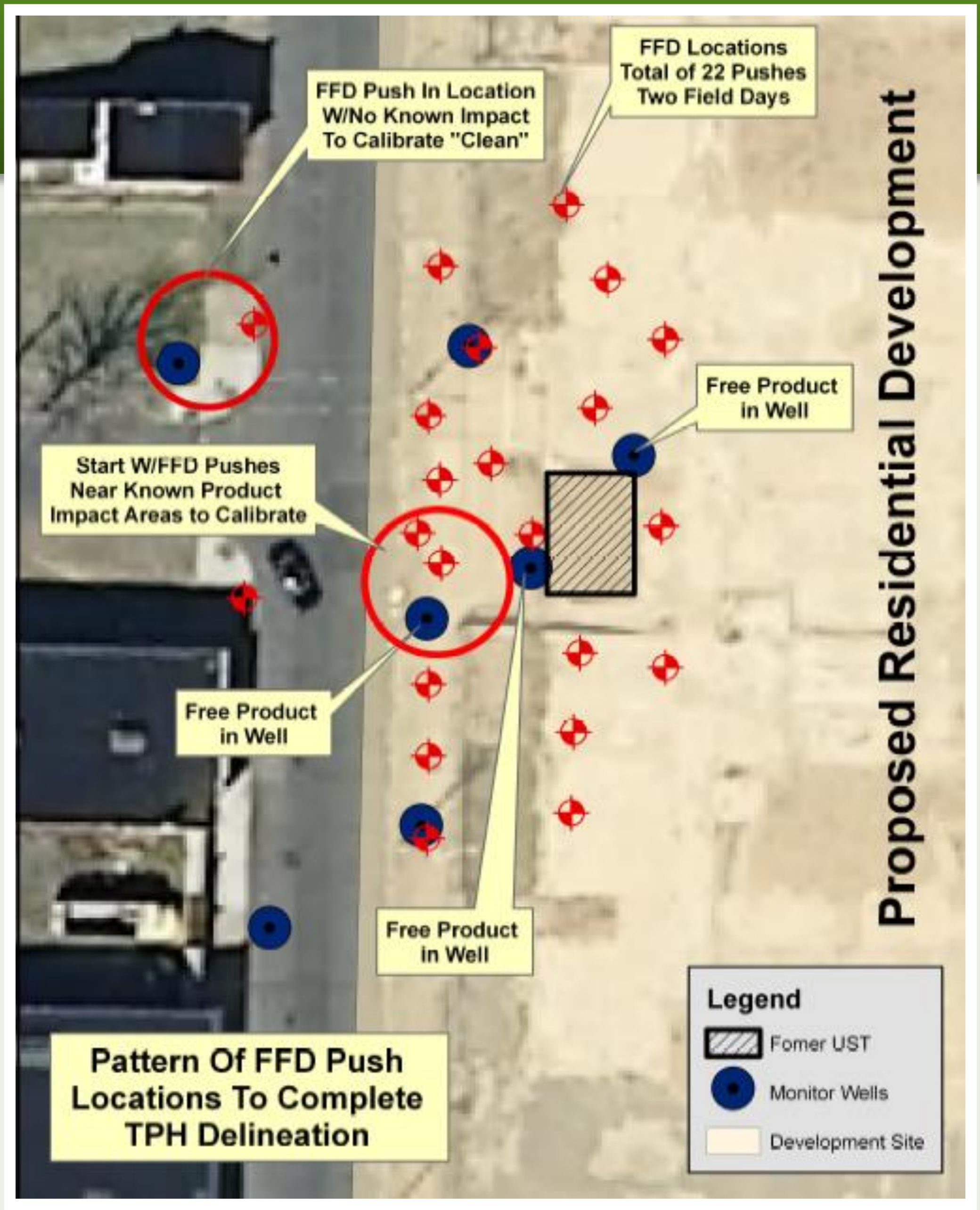


- Proposed residential development on former school site
- 10,000 gallon heating oil UST leaked released No. 2 Fuel Oil (1993)
- Limited SI consisting of MWs indicated free product in 3 wells in 2000
- Objective: Delineate TPH impact zone and define core impact area for the purposes of remediation

Delineation of Petroleum Hydrocarbon Impacts in Soil Caused By UST Release

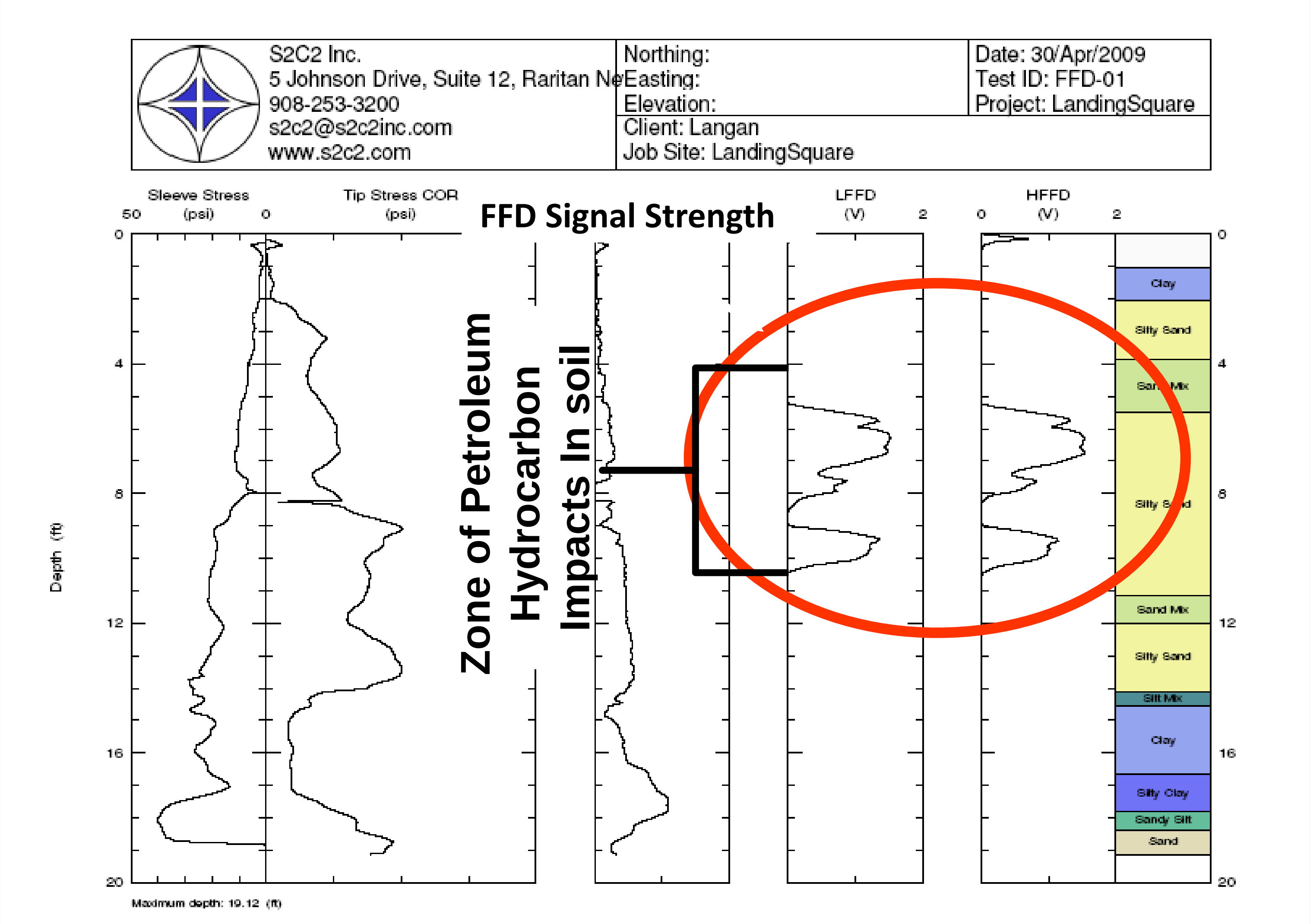
- **Petroleum hydrocarbons in soil delineated using an FFD**
  - Employs UV light source to locate TPH
- **Locations of depth-discrete soil and groundwater samples were selected based on FFD Logs**
- **Data sets were imaged using ArcGIS 3-D Imaging Software to depict impact zone**
- **Visualization used to support remedial action design**

FFD Pushes Used to Delineate Extent of Impacts

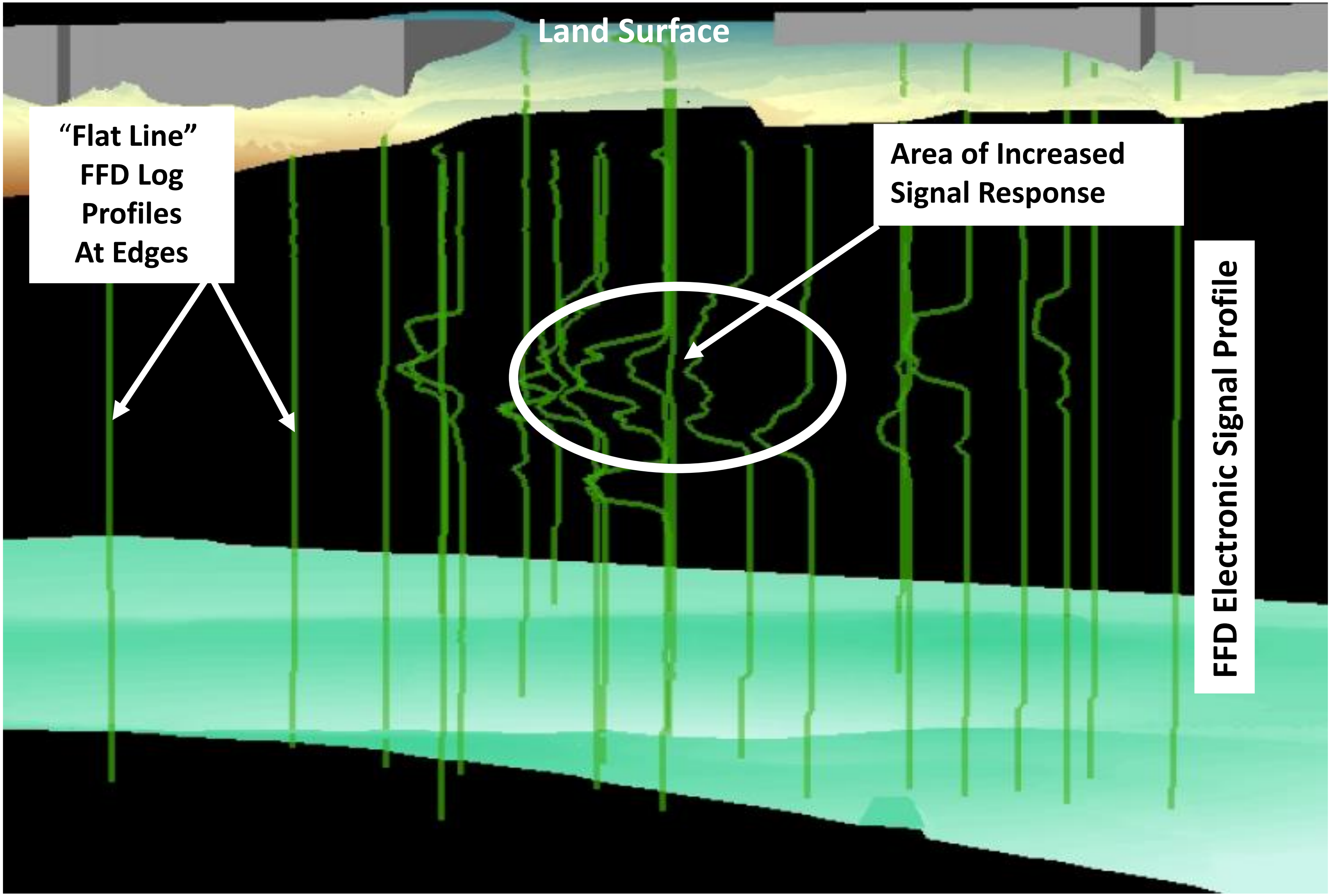


- ◆ Begin at locations of known highest TPH impact or free product in well
- ◆ Test instrument response
- ◆ Next "go to" location with little to no TPH impact
- ◆ Perform dynamic field based "step outs" to instrument "flat line"
- ◆ When FFD shows no response ("Flat Line") confident TPH below 100 ppm

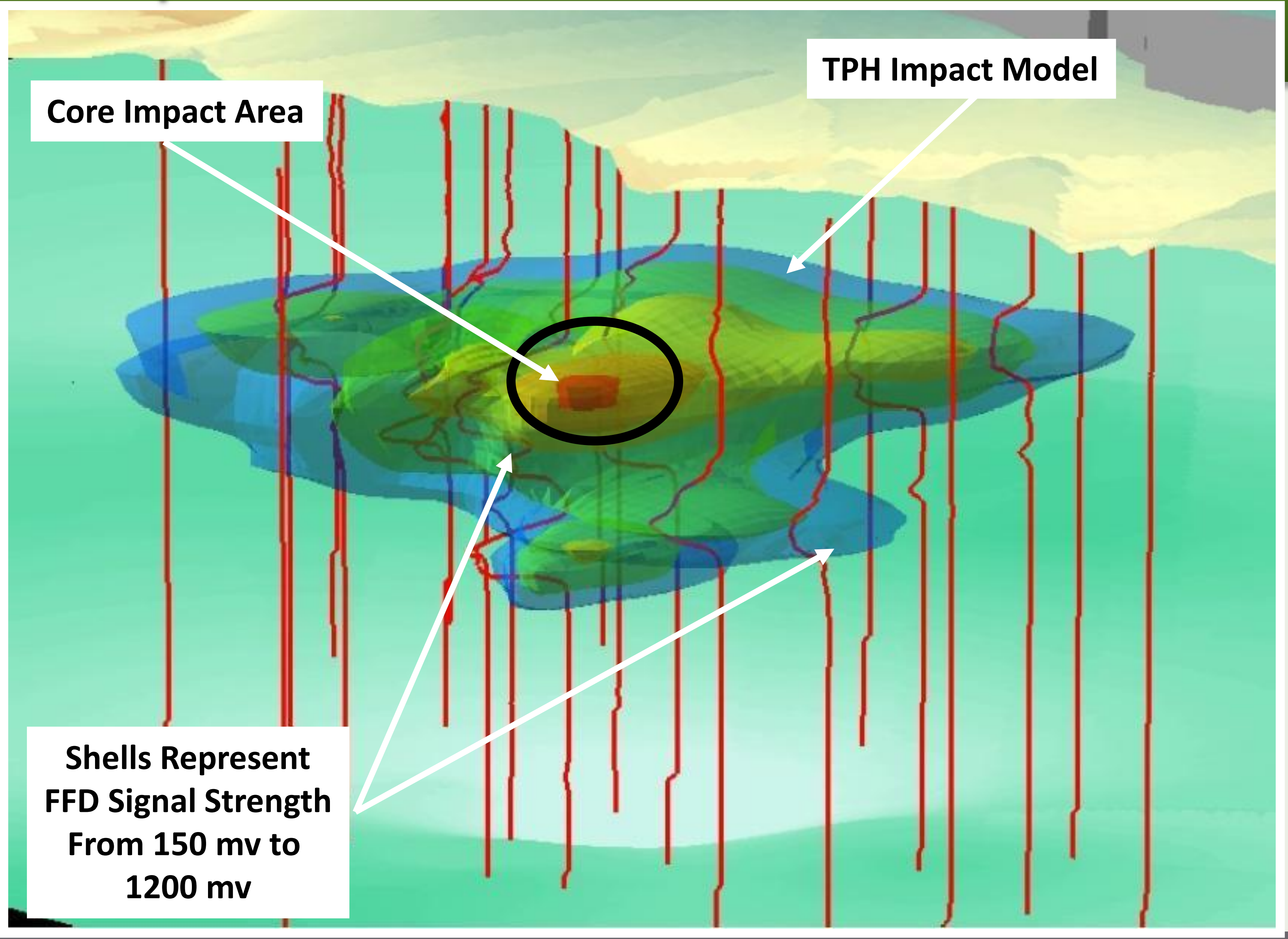
Typical FFD Log



FFD Log Profiles Hung From Surface in 3-D Visualization

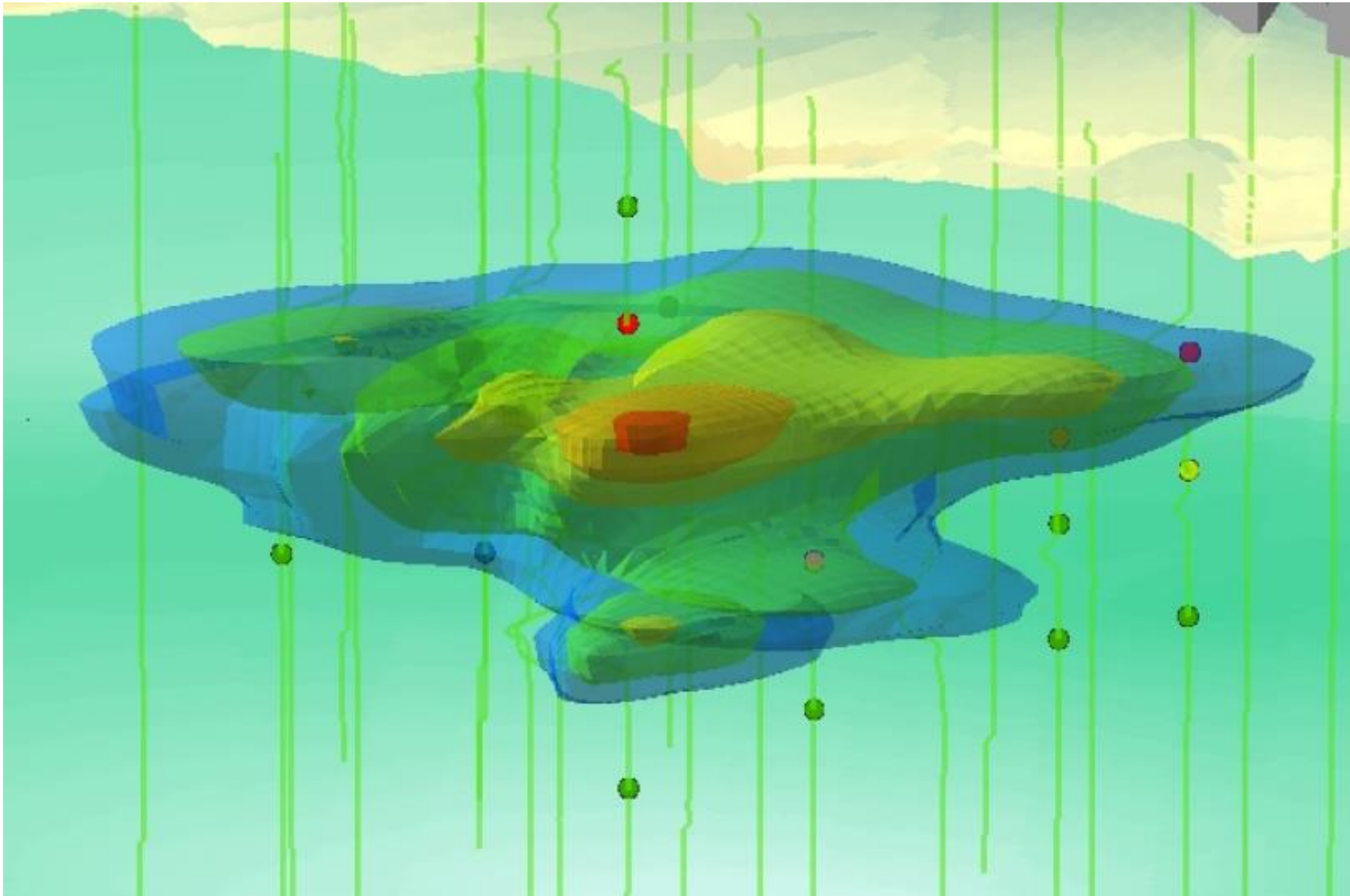


TPH Impact Area 3-D Visualization Built From FFD Profiles

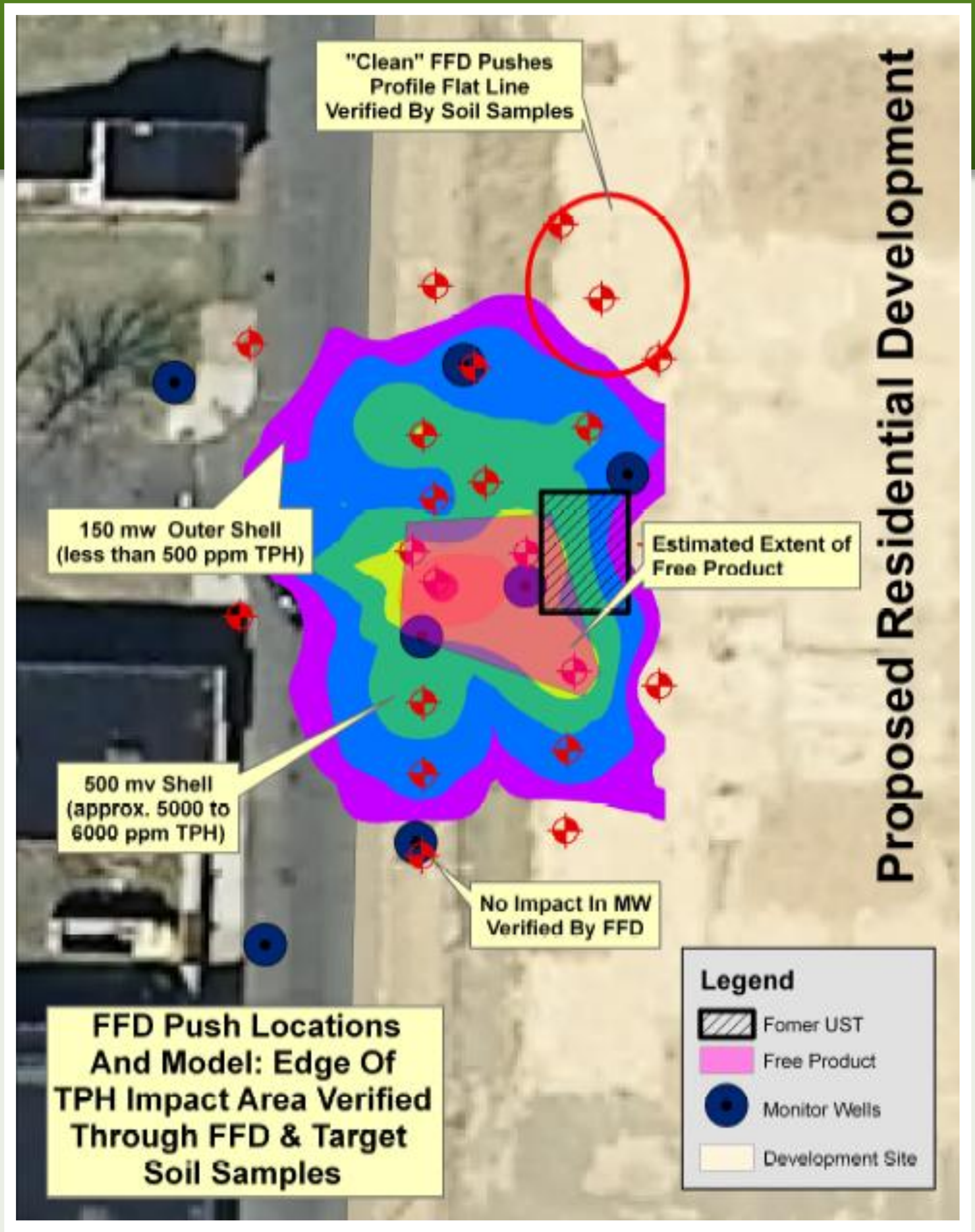


Soil Sample Collected Pre-Determined Interval Based on Systematic Planning

FFD Profiles, TPH 3-D Visualization and Soil Sample TPH Results Merged to Show Collaborative Data Set and Demonstrate Delineation

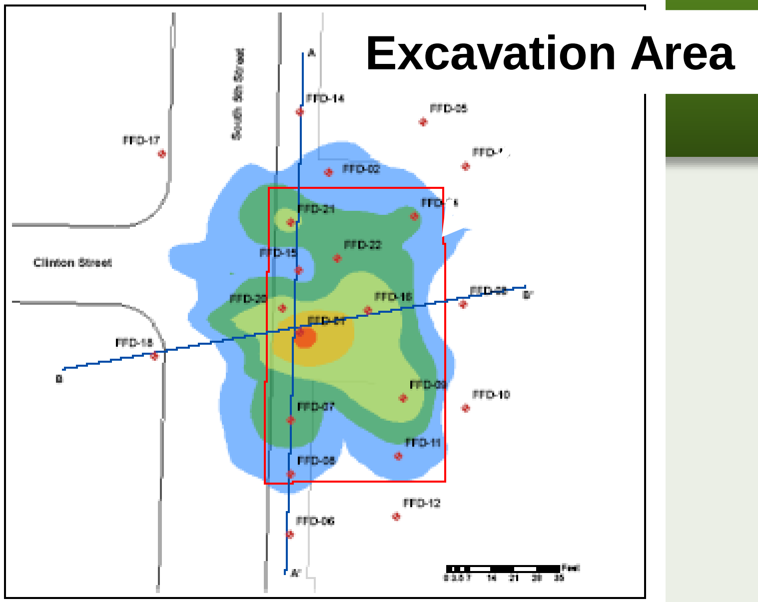


TPH Impact Area Delineated

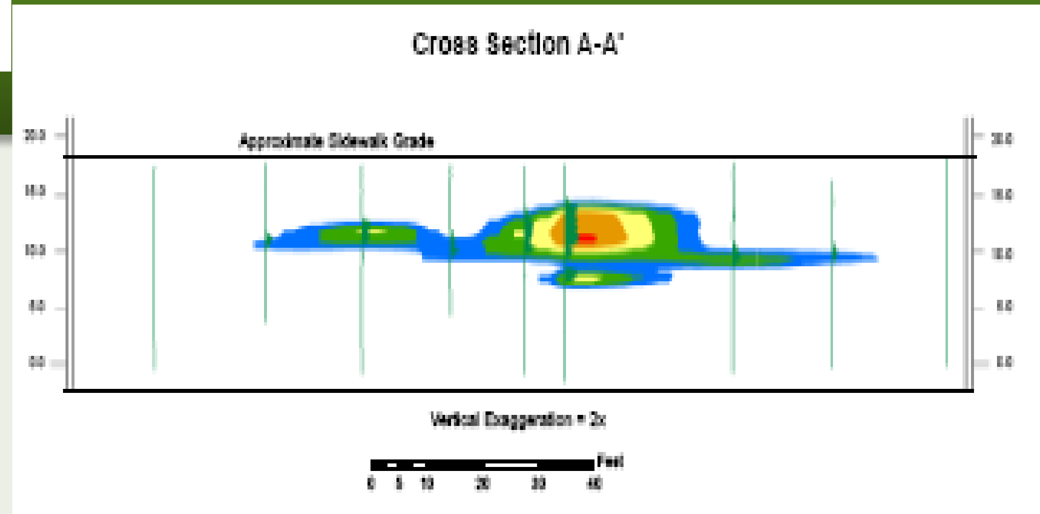


- Extent of TPH Impacts Verified Through Collaborative Data Set and Visualization
- Various cleanup options can be quickly evaluated:

1. Total removal to beyond 150 mv shell
2. Removal to extent of 500 mv shell which correlates with approx. 5-6,000 ppm TPH
3. Free product/core impact area removal for maximum risk reduction benefit

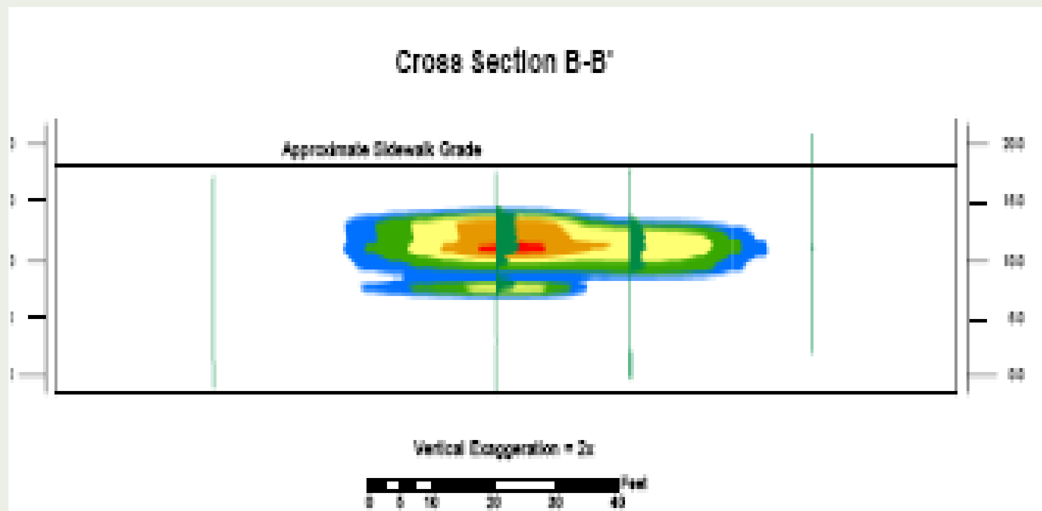


Fuel Fluorescent Detector (FFD)
Model Results - Plan View



Engineering Analysis

Cross Sections Showing Distribution of Fuel Impacts and Location of Excavation Area



Case Study 5
New Carlisle Landfill

United States
Environmental Protection
Agency

New Carlisle Landfill Site

- **Background**
  - » Former landfill closed in the early 70's
  - » Accepted hazardous and non-hazardous waste
  - » Primary COC is vinyl chloride
  - » Public well contaminated
  - » Ohio EPA completed previous assessment work from 2004 through 2006 with two large sampling events

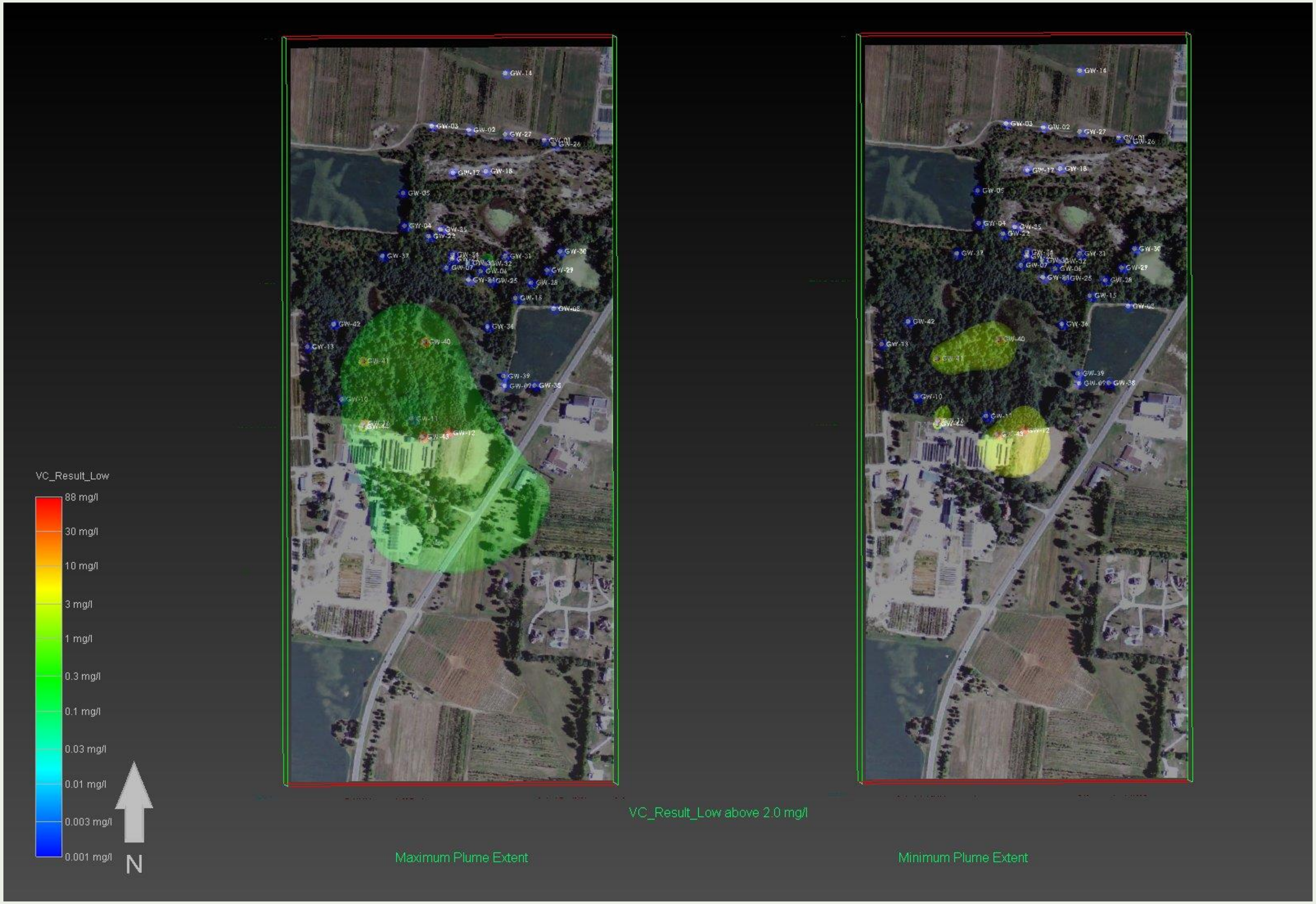
Project Approach

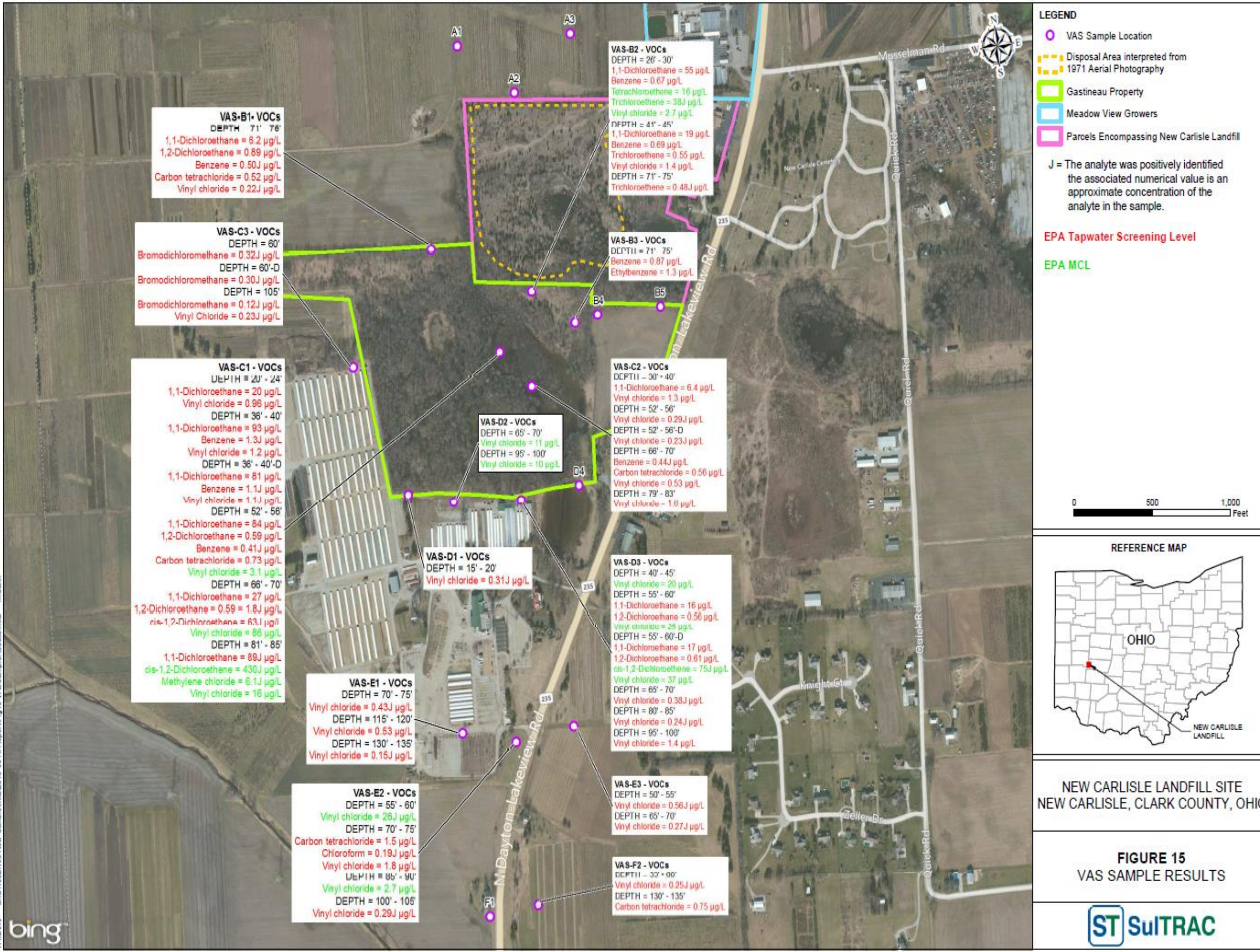
- **Use existing data to update CSM before planning additional investigations**
- **Use 3DVA to depict existing data**
  - Obtain stakeholder buy-in on existing CSM
    - EPA
    - State of Ohio
  - Use updated CSM to identify data gaps and guide development of investigation approach

Investigative Approach

- **Transect-based vertical aquifer sampling**
  - One transect upgradient to confirm no contaminant movement to the north
  - Series of transects downgradient to bound vertical, horizontal, and longitudinal extent of the plume
- **Approach to sampling in each borehole of transect**
  - Use of direct push technology to 80 feet and use of sonic from 80 feet to 200 feet
  - Generally collecting a groundwater sample every 10 feet above and below known plume
  - More dense sample collection (less than every 10 feet) in the known location of the plume

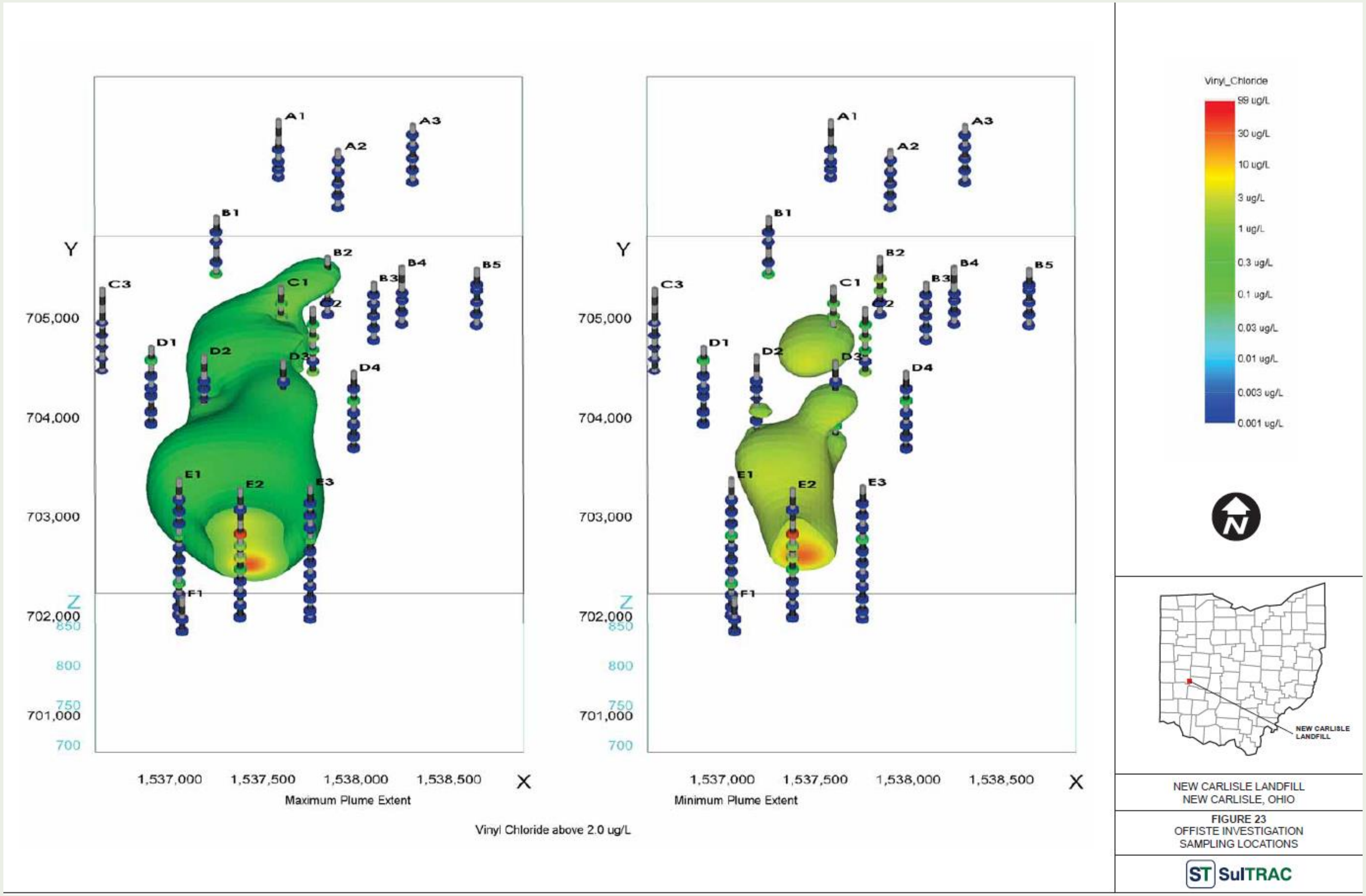
Ohio EPA Data MVS Output





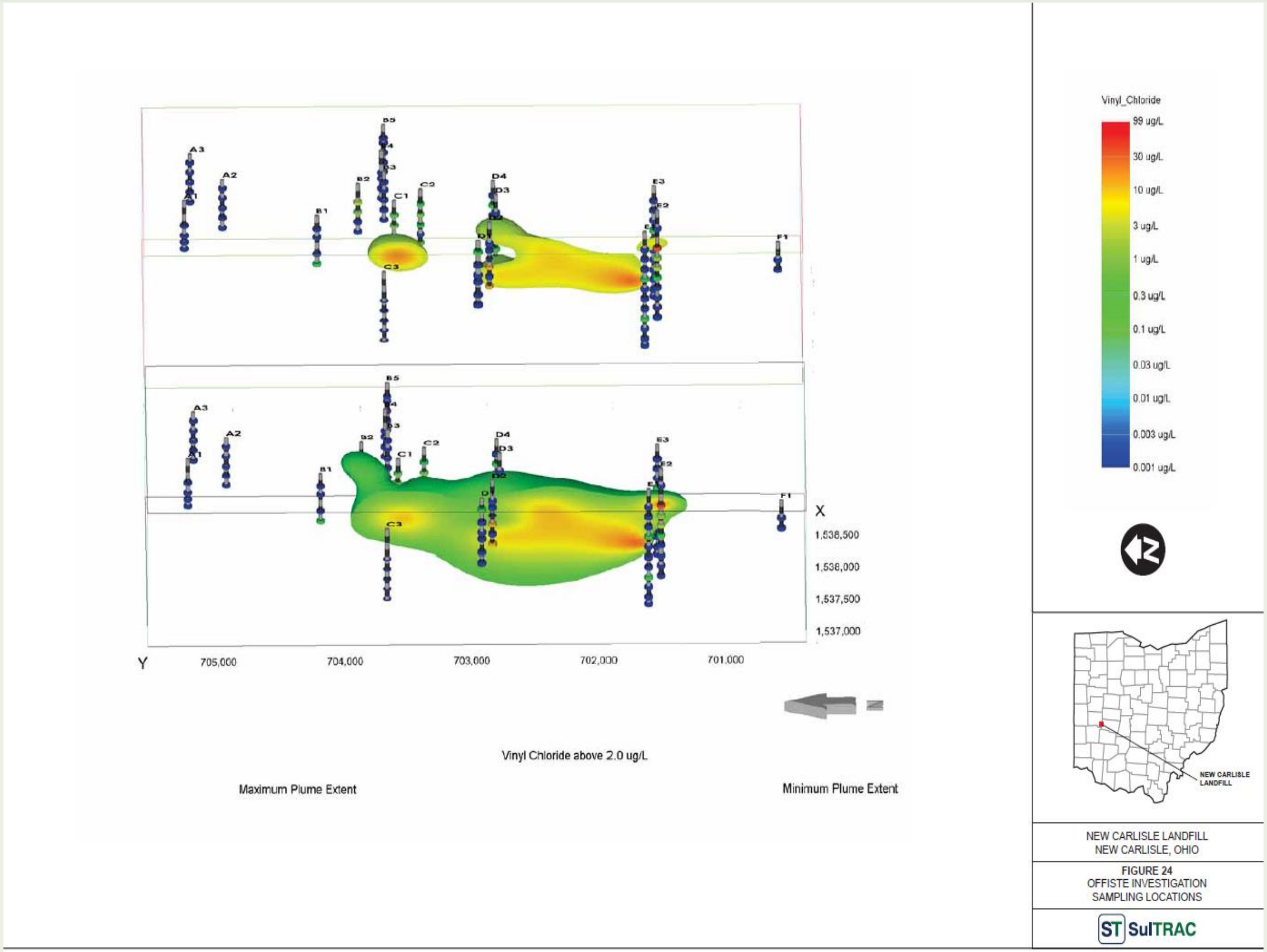
VAS-B1- VOCs
DEPTH = 71' - 76'
1,1-Dichloroethane = 6.2 µg/L
1,2-Dichloroethane = 0.89 µg/L
Benzene = 0.50J µg/L
Carbon tetrachloride = 0.52 µg/L
Vinyl chloride = 0.22J µg/L
VAS-C3 - VOCs
DEPTH = 60'
Bromodichloromethane = 0.32J µg/L
DEPTH = 60'-D
Bromodichloromethane = 0.30J µg/L
DEPTH = 105'
Bromodichloromethane = 0.12J µg/L
Vinyl Chloride = 0.23J µg/L
VAS-C1 - VOCs
DEPTH = 20' - 24'
1,1-Dichloroethane = 20 µg/L
Vinyl chloride = 0.96 µg/L
DEPTH = 36' - 40'
1,1-Dichloroethane = 93 µg/L
Benzene = 1.3J µg/L
Vinyl chloride = 1.2 µg/L
DEPTH = 36' - 40'-D
1,1-Dichloroethane = 81 µg/L
Benzene = 1.1J µg/L
Vinyl chloride = 1.1J µg/L
DEPTH = 52' - 56'
1,1-Dichloroethane = 84 µg/L
1,2-Dichloroethane = 0.59 µg/L
Benzene = 0.41J µg/L
Carbon tetrachloride = 0.73 µg/L
Vinyl chloride = 3.1 µg/L
DEPTH = 66' - 70'
1,1-Dichloroethane = 27 µg/L
1,2-Dichloroethane = 0.59 = 1.8J µg/L
cis-1,2-Dichloroethene = 63J µg/L
Vinyl chloride = 86 µg/L
DEPTH = 81' - 85'
1,1-Dichloroethane = 89J µg/L
cis-1,2-Dichloroethene = 430J µg/L
Methylene chloride = 6.1J µg/L
Vinyl chloride = 16 µg/L
VAS-E1 - VOCs
DEPTH = 70' - 75'
Vinyl chloride = 0.43J µg/L
DEPTH = 115' - 120'
Vinyl chloride = 0.53 µg/L
DEPTH = 130' - 135'
Vinyl chloride = 0.15J µg/L
VAS-E2 - VOCs
DEPTH = 55' - 60'
Vinyl chloride = 26J µg/L
DEPTH = 70' - 75'
Carbon tetrachloride = 1.5 µg/L
Chloroform = 0.19J µg/L
Vinyl chloride = 1.8 µg/L
DEPTH = 85' - 90'
Vinyl chloride = 2.7 µg/L
DEPTH = 100' - 105'
Vinyl chloride = 0.29J µg/L
VAS-D2 - VOCs
DEPTH = 65' - 70'
Vinyl chloride = 11 µg/L
DEPTH = 95' - 100'
Vinyl chloride = 10 µg/L
VAS-D1 - VOCs
DEPTH = 15' - 20'
Vinyl chloride = 0.31J µg/L
VAS-B2 - VOCs
DEPTH = 26' - 30'
1,1-Dichloroethane = 55 µg/L
Benzene = 0.67 µg/L
Tetrachloroethene = 16 µg/L
Trichloroethene = 38J µg/L
Vinyl chloride = 2.7 µg/L
DEPTH = 41' - 45'
1,1-Dichloroethane = 19 µg/L
Benzene = 0.69 µg/L
Trichloroethene = 0.55 µg/L
Vinyl chloride = 1.4 µg/L
DEPTH = 71' - 75'
Trichloroethene = 0.48J µg/L
VAS-B3 - VOCs
DEPTH = 71' - 75'
Benzene = 0.87 µg/L
Ethylbenzene = 1.3 µg/L
VAS-C2 - VOCs
DEPTH = 30' - 40'
1,1-Dichloroethane = 6.4 µg/L
Vinyl chloride = 1.3 µg/L
DEPTH = 52' - 56'
Vinyl chloride = 0.29J µg/L
DEPTH = 52' - 56'-D
Vinyl chloride = 0.23J µg/L
DEPTH = 66' - 70'
Benzene = 0.44J µg/L
Carbon tetrachloride = 0.56 µg/L
Vinyl chloride = 0.53 µg/L
DEPTH = 79' - 83'
Vinyl chloride = 1.0 µg/L
VAS-D3 - VOCs
DEPTH = 40' - 45'
Vinyl chloride = 20 µg/L
DEPTH = 55' - 60'
1,1-Dichloroethane = 16 µg/L
1,2-Dichloroethane = 0.56 µg/L
Vinyl chloride = 28 µg/L
DEPTH = 55' - 60'-D
1,1-Dichloroethane = 17 µg/L
1,2-Dichloroethane = 0.61 µg/L
cis-1,2-Dichloroethene = 75J µg/L
Vinyl chloride = 37 µg/L
DEPTH = 65' - 70'
Vinyl chloride = 0.38J µg/L
DEPTH = 80' - 85'
Vinyl chloride = 0.24J µg/L
DEPTH = 95' - 100'
Vinyl chloride = 1.4 µg/L
VAS-E3 - VOCs
DEPTH = 50' - 55'
Vinyl chloride = 0.56J µg/L
DEPTH = 65' - 70'
Vinyl chloride = 0.27J µg/L
VAS-F2 - VOCs
DEPTH = 85' - 90'
Vinyl chloride = 0.25J µg/L
DEPTH = 130' - 135'
Carbon tetrachloride = 0.75 µg/L
A1
A2
A3
B4
B5
D4
F1
Musselman Rd
Quick Rd
N Dayton-Lakeview Rd
Knight Ct
Zeller Dr
235
bing
LEGEND
VAS Sample Location
Disposal Area interpreted from 1971 Aerial Photography
Gastineau Property
Meadow View Growers
Parcels Encompassing New Carlisle Landfill
J = The analyte was positively identified the associated numerical value is an approximate concentration of the analyte in the sample.
EPA Tapwater Screening Level
EPA MCL
0
500
1,000
Feet
REFERENCE MAP
OHIO
NEW CARLISLE LANDFILL
NEW CARLISLE LANDFILL SITE
NEW CARLISLE, CLARK COUNTY, OHIO
FIGURE 15
VAS SAMPLE RESULTS
ST SulTRAC

MVS Output

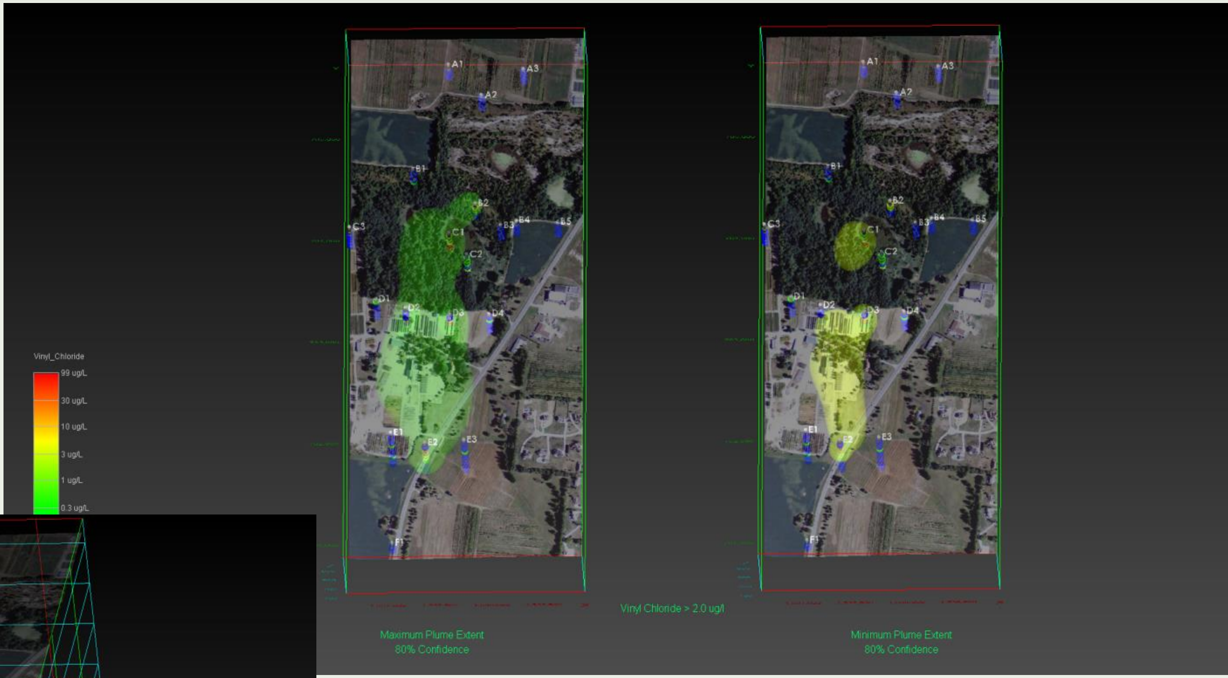


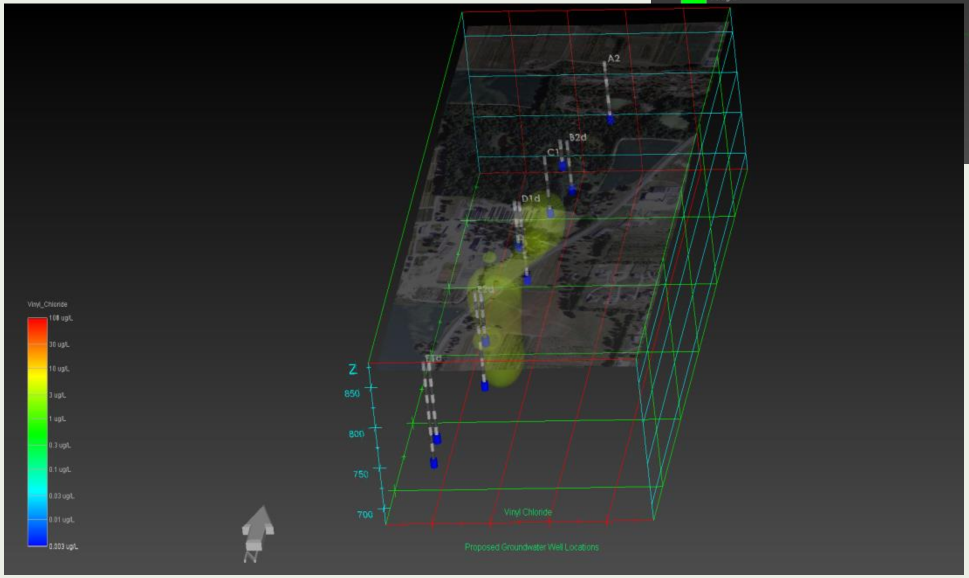
Y
705,000
704,000
703,000
702,000
701,000
850
800
750
700
1,537,000
1,537,500
1,538,000
1,538,500
X
Maximum Plume Extent
Minimum Plume Extent
A1
A2
A3
B1
B2
B3
B4
B5
C1
C3
D1
D2
D3
D4
E1
E2
E3
F1
Vinyl Chloride above 2.0 ug/L
Vinyl_Chloride
99 ug/L
30 ug/L
10 ug/L
3 ug/L
1 ug/L
0.3 ug/L
0.1 ug/L
0.03 ug/L
0.01 ug/L
0.003 ug/L
0.001 ug/L
N
NEW CARLISLE LANDFILL
NEW CARLISLE LANDFILL
NEW CARLISLE, OHIO
FIGURE 23
OFFISTE INVESTIGATION
SAMPLING LOCATIONS
ST SulTRAC

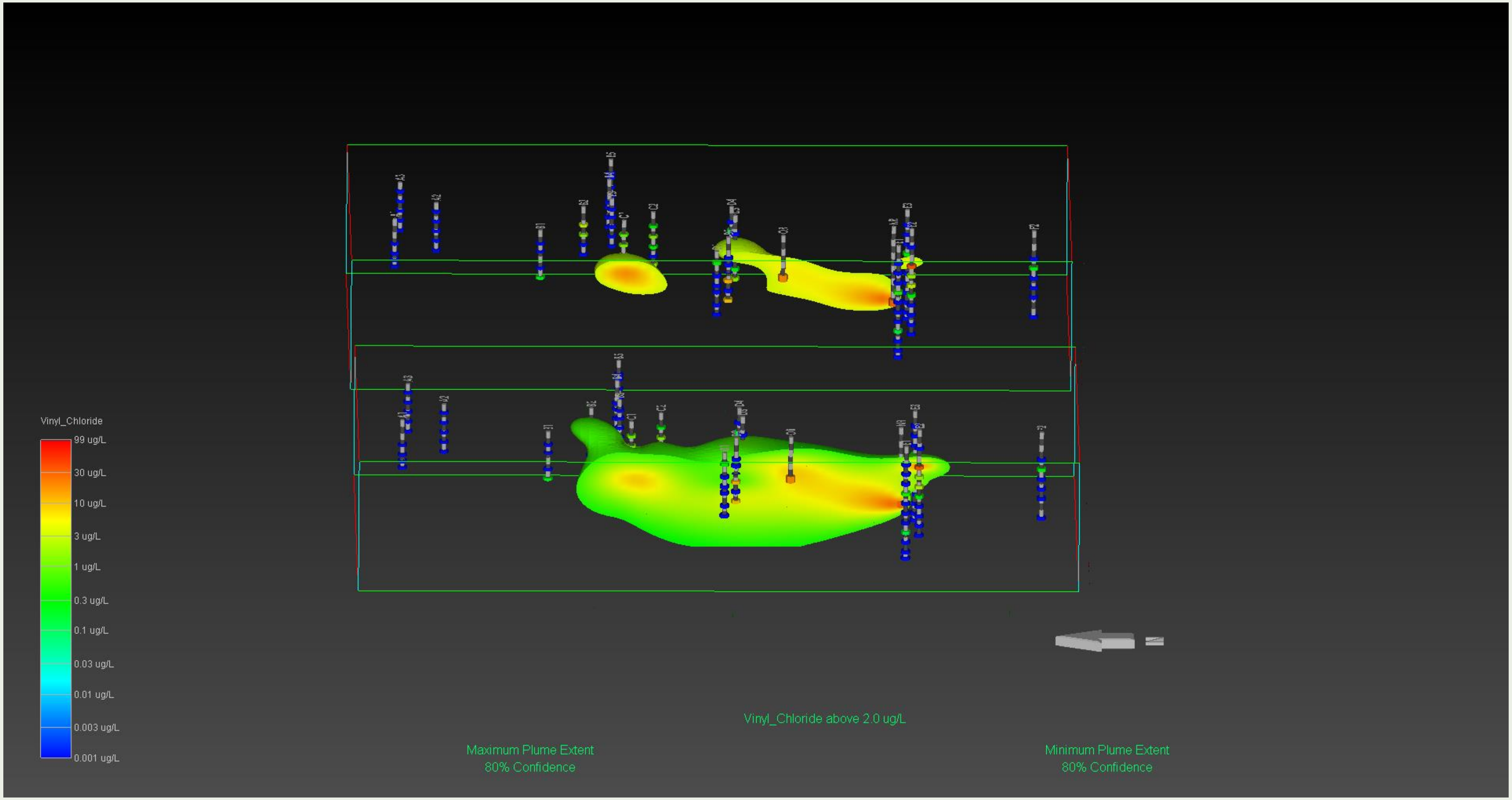
MVS Output



Vinyl_Chloride
99 ug/L
30 ug/L
10 ug/L
3 ug/L
1 ug/L
0.3 ug/L
0.1 ug/L
0.03 ug/L
0.01 ug/L
0.003 ug/L
0.001 ug/L
X
1,538,500
1,538,000
1,537,500
1,537,000
Y
705,000
704,000
703,000
702,000
701,000
Vinyl Chloride above 2.0 ug/L
Maximum Plume Extent
Minimum Plume Extent
NEW CARLISLE LANDFILL
NEW CARLISLE LANDFILL
NEW CARLISLE, OHIO
FIGURE 24
OFFISTE INVESTIGATION
SAMPLING LOCATIONS
ST SulTRAC


Vinyl_Chloride
99 ug/L
30 ug/L
10 ug/L
3 ug/L
1 ug/L
0.3 ug/L
Vinyl Chloride > 2.0 ug/l
Maximum Plume Extent
80% Confidence
Minimum Plume Extent
80% Confidence


A2
B2d
C1
D1d
Z
850
800
750
700
Vinyl Chloride
Proposed Groundwater Well Locations


Vinyl_Chloride
99 ug/L
30 ug/L
10 ug/L
3 ug/L
1 ug/L
0.3 ug/L
0.1 ug/L
0.03 ug/L
0.01 ug/L
0.003 ug/L
0.001 ug/L
Vinyl_Chloride above 2.0 ug/L
Maximum Plume Extent
80% Confidence
Minimum Plume Extent
80% Confidence

Conclusion

- **Transect based sampling was chosen based on previous Ohio EPA data used with MVS**
- **Ultimately MVS saved time and money**
- **Tetra Tech was able to define the VC plume both horizontally and vertically**
- **Able to see connection between plume and irrigation wells**

Case Study 6

United States
Environmental Protection
Agency

Site Overview

Groundwater Plume

Subsurface Materials Encountered

- ♦ **Sand and gravel with interbedded and laterally discontinuous clay and silt layers**
- ♦ **Clay and silt layers are of variable thickness and occur at varying depths**

Groundwater Flow

- The shallow zone has been relatively consistent over time and is generally southeastward and roughly parallel to the river with a flow component towards the river in one area suggesting that pumping in the deep portion of the aquifer east of the river may influence flow in the shallow zone west of the river
- The deep zone has also been relatively consistent over time and is generally southeastward and roughly parallel to the river with a more pronounced flow component towards the river indicating that pumping in the deep portion of the aquifer east of the river influences flow in the deep zone west of the river

Data Gaps

Investigation results from the RI indicate that the nature and extent of contamination has been generally defined with the following data gaps identified:

- ♦ **Additional information is needed to identify sources of contamination**
- ♦ **Additional information is needed to better define where the plume is migrating under the river**
- ♦ **The horizontal extent of shallow soil contamination detected in industrial areas has not been fully delineated**
- ♦ **Physical and geochemical parameter information is needed to develop, evaluate and select remedial alternatives**
- ♦ **Vapor intrusion information is needed at some locations not previously sampled**

Proposed Investigation Approach

The scope of the proposed investigation includes a combination of high resolution site characterization (HRSC) and "traditional" sampling activities:

- ♦ **Further characterizing potential source areas using HRSC and direct-push drilling methods**
- ♦ **Evaluating potential secondary source areas within groundwater plume hot spots potentially associated with contaminants sorbed to fine grained materials using HRSC**
- ♦ **Obtaining indoor air samples near suspected source areas not previously sampled during the RI using traditional sampling methods**
- ♦ **Obtaining other soil and groundwater data to address data gaps associated with defining extent of soil contamination and evaluation of potential remedial alternatives using traditional sampling methods**

HRSC Investigation Scope

The HRSC investigation will use real-time field methods to optimize sample collection and site characterization at:

- ♦ **Suspected source areas, including the original suspected points of origin of the chlorinated VOC plumes**
- ♦ **Downgradient locations where residual VOCs may be sorbed to fine-grained subsurface materials acting as ongoing “secondary” sources of groundwater contamination**

HRSC Investigation Methodology

The HRSC techniques to be used include using a membrane interface probe (MIP) and a Waterloo Profiler Sampling System. The advantages of this approach include:

- ♦ **Using real-time field methods to optimize sample collection and site characterization in suspected source areas**
- ♦ **Obtaining a higher density of investigation data at the suspected source areas**
- ♦ **Allowing flexibility to select initial sampling locations and step-out from initial locations, as necessary based on real-time information**
- ♦ **Minimizing the number of samples collected for laboratory analysis**

Investigation Sequence

Step One: Consists of a MIP investigation designed to identify locations and horizons within the suspected source areas, and adjacent downgradient areas, that contain elevated levels of total VOCs

Step Two: Consists of HRSC groundwater profiling to collect compound-specific data in order to establish lateral and vertical contaminant profiles

Proposed MIP Approach

Proposed Waterloo Approach

Summary

- HRSC being incorporated in the investigation to further identify sources of contamination
- Approach uses MIP in combination with Waterloo groundwater profiling and mobile laboratory
- Sampling approach allows for flexibility to maximize benefit of real-time technologies
- Real-time methodology combined with a flexible approach will result in scale-appropriate data
- Desired outcome of the HRSC investigation is to determine whether original source material (NAPL) exists or whether there are locations where residual VOCs may be sorbed to fine-grained subsurface materials acting as ongoing “secondary” sources of groundwater contamination
- Refining the conceptual site model will be used during the remedy evaluation and selection phase in the FS

Disclaimer

- Information presented in this presentation represents the views of the author(s)/presenter(s) and has not received formal U.S. EPA peer review.
- This information does not necessarily reflect the views of U.S. EPA, and no official endorsement should be inferred.
- The information is not intended, nor can it be relied upon, to create any rights enforceable by any party in litigation with the United States or any other party.
- Use or mention of trade names does not constitute an endorsement or recommendation for use.