EPA and Groundwater High-Resolution Site Characterization at Superfund Sites

Ben Bentkowski, P.G.

Region 4 Scientific Support Section

Superfund and Emergency Management Division

Groundwater High-Resolution Site Characterization Training

HRSC training course focuses on groundwater characterization and discusses:

(1) the impacts of subsurface heterogeneity on the investigation and cleanup of groundwater and related media,

(2) the need for scale-appropriate measurements and adequate data density, and

(3) the tools and strategies that are available to overcome the impacts of subsurface heterogeneity.

The course addresses eight modules of technical content.

HRSC Technical Modules

1. Defining and explaining the need for and benefits of HRSC
2. Understanding the sources and attributes of subsurface heterogeneity and their impact on hydrogeology, contaminant fate and transport, and source and plume relationships
3. Defining and using scale-appropriate measurements, adequate data density and collaborative data sets
4. Explaining the application of HRSC to the characterization of integrated media, including groundwater, soil, soil vapor, surface water, sediments and bedrock
5. Evaluating potentially applicable tools for subsurface investigations of shallow unconsolidated environments, deep unconsolidated environments, fractured and porous media, and the groundwater and surface water interface
6. Developing effective HRSC implementation and investigation strategies
7. Managing and visualizing HRSC data for decision making
8. Applying HRSC to remedy design, implementation and optimization

Defining Groundwater HRSC

Matches the scale of measurement with the scale of the variability of the property being measured

A subsurface investigation appropriate to the scale of heterogeneities in the subsurface which control contaminant distribution, transport and fate.

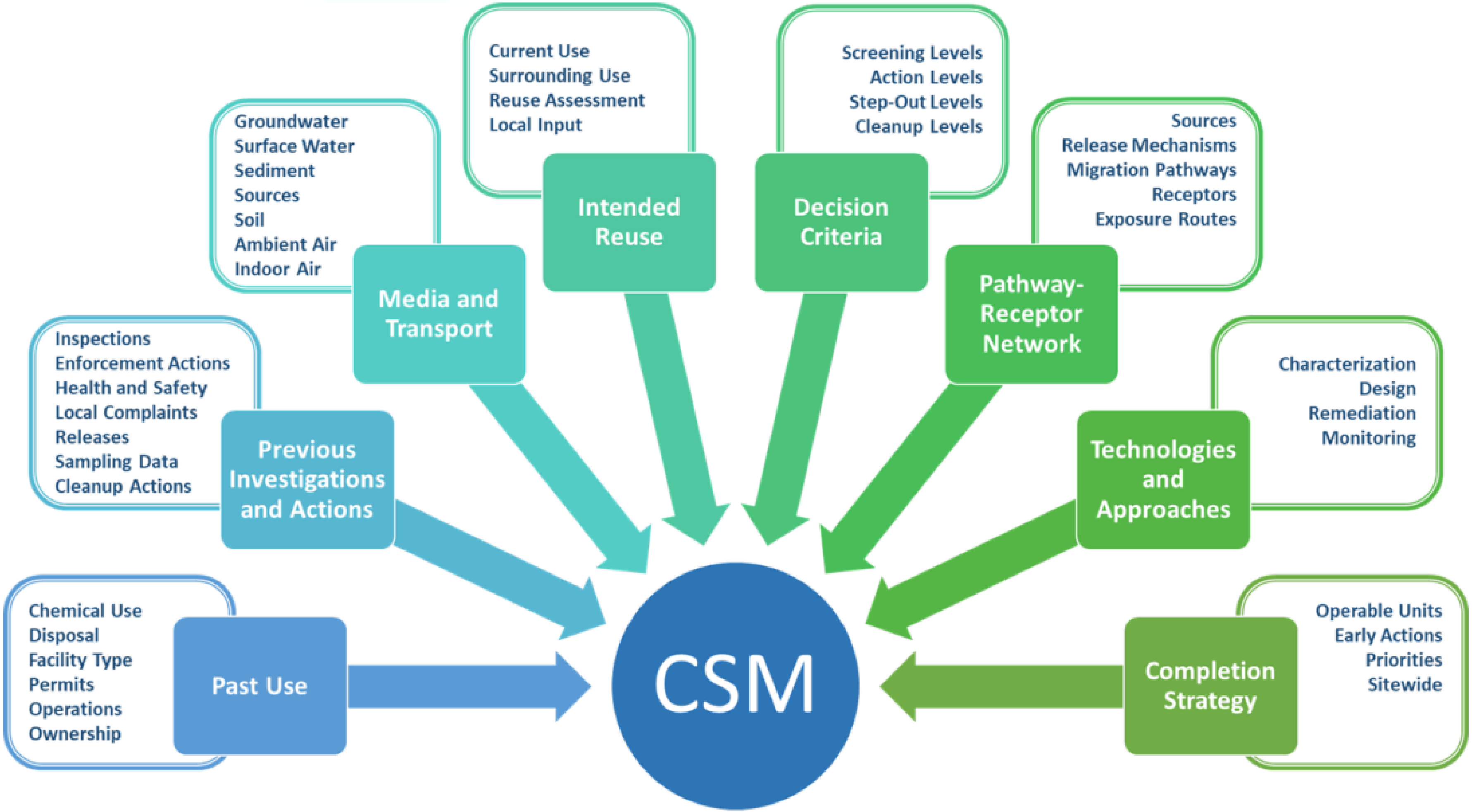
Explaining the need for and benefits of HRSC

A subsurface investigation appropriate to the scale of heterogeneities in the subsurface which control contaminant distribution, transport and fate, and that provides degree of detail needed to understand:

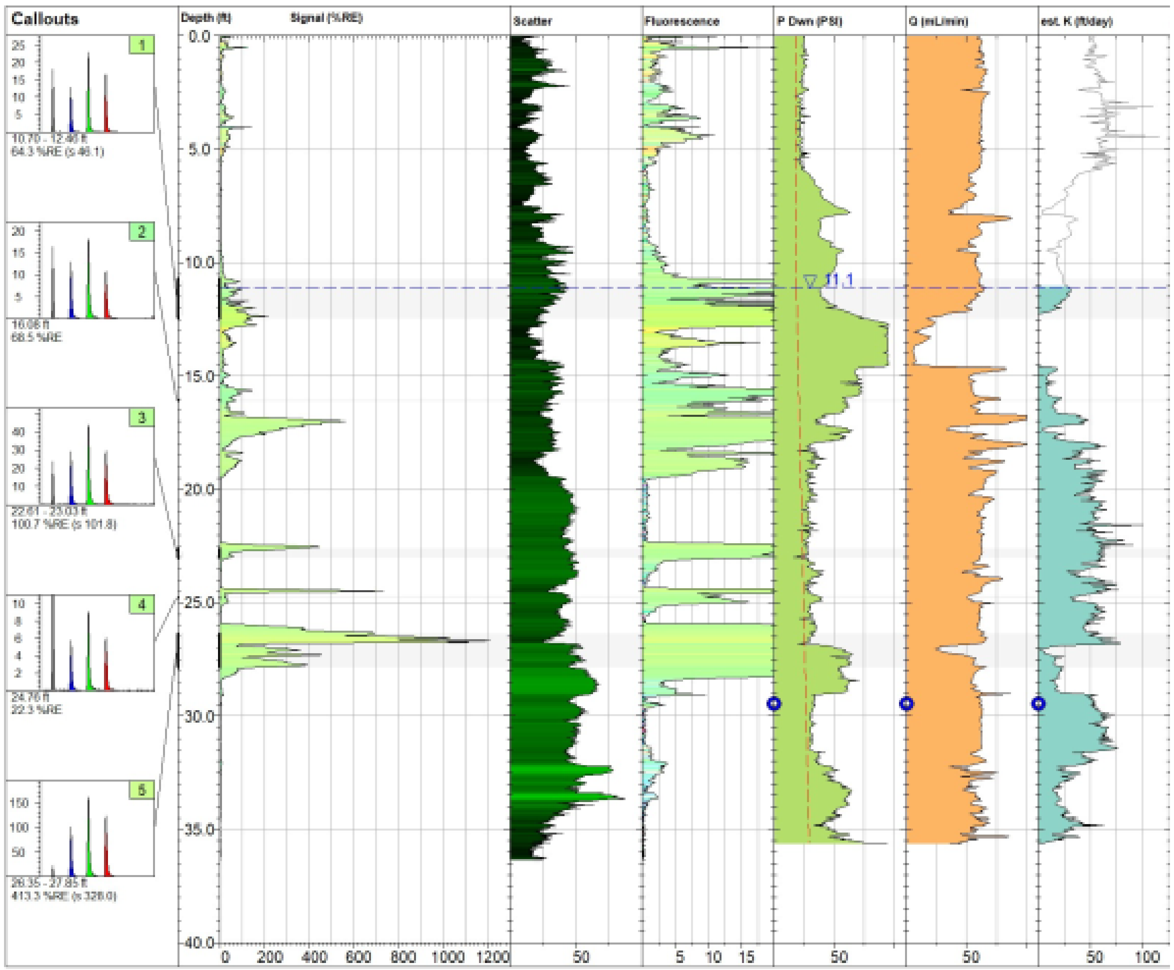
- Exposure pathways
- Processes affecting fate of contaminants
- Contaminant mass distribution and flux by phase and by media (mobile and immobile)
- How remedial measures will affect the problem

Employing Systematic Planning up front and all of this feeds into the Conceptual Site Model.

Dynamic Conceptual Site Model



Understanding the sources and attributes of subsurface heterogeneity

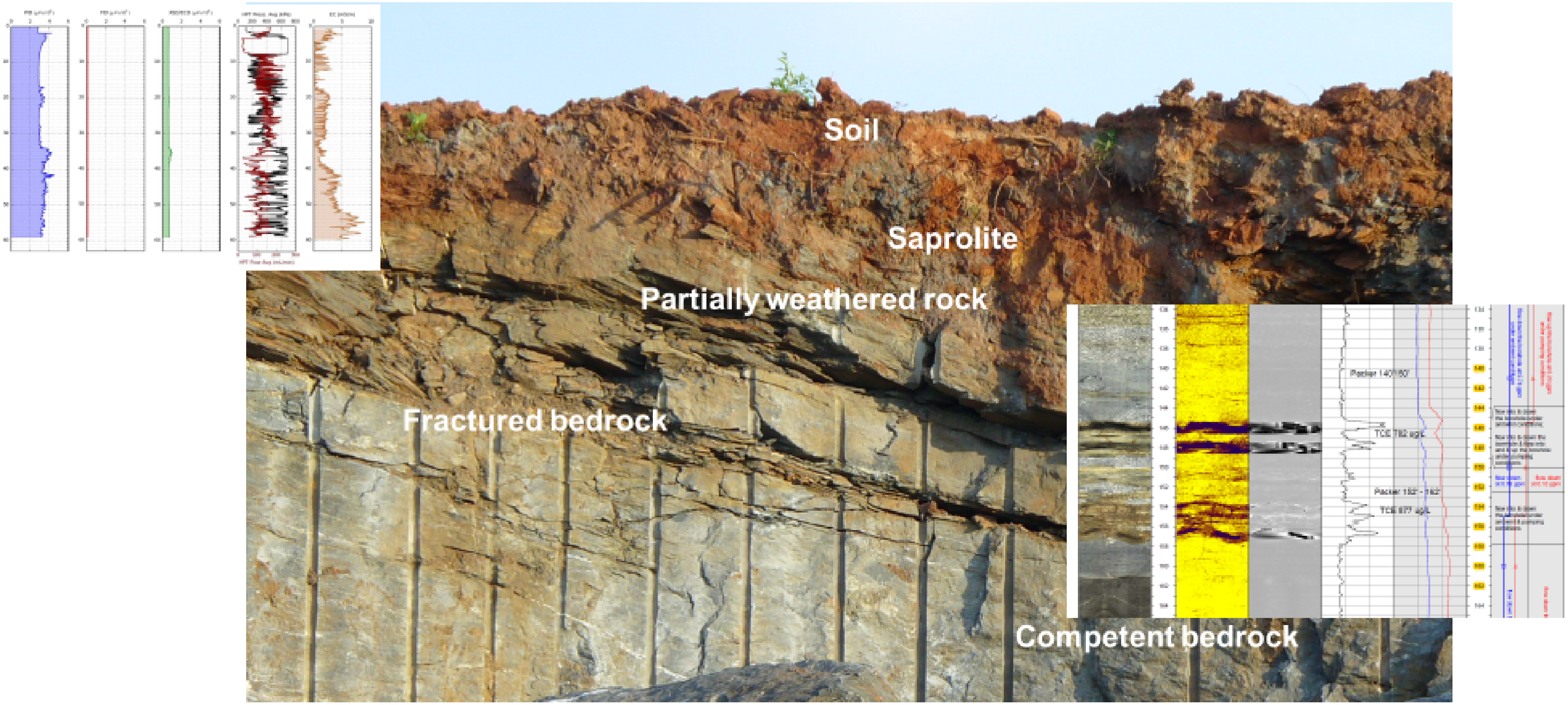


The TARGOST log identifies the creosote DNAPL by the %RE – percent of the standard.

Hydraulic Profile Tool identifies ~grain size and confining layers

High Resolution

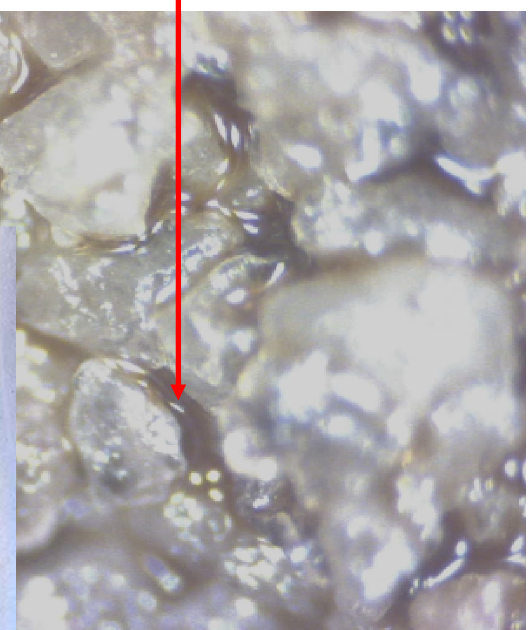
Sources and Attributes of subsurface heterogeneity for Fractured Rock



Defining and using 1)scale-appropriate measurements, 2)adequate data density and 3)collaborative data sets

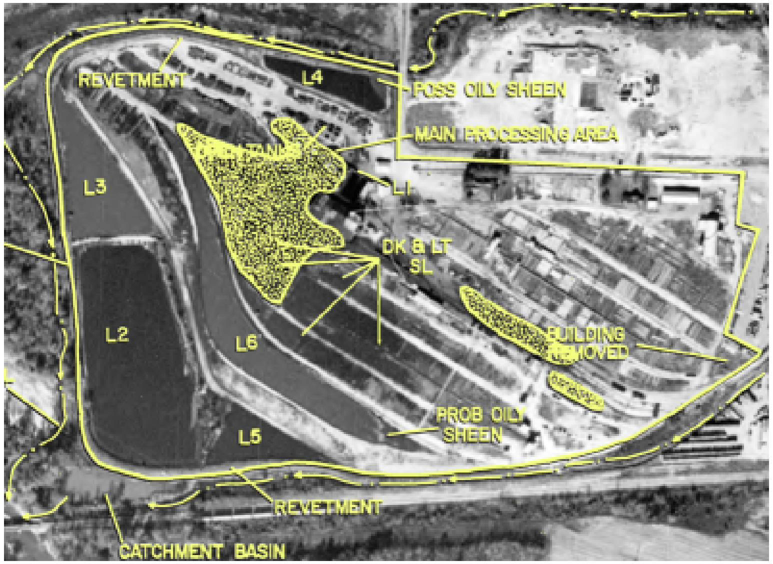
Dramatic creosote saturated sonic core, dripping creosote into a jar.

Residual DNAPL, the real problem – a continuing source to groundwater – and hard to see!



American Creosote Works
Jackson, TN

Tn DOT wants to builds a highway bypass across the SW corner of a former creosote plant, now a Superfund site.



The challenge: remediate the source, residual source and GW underneath the footprint of the road in the next 4-5 years.

American Creosote Works
Jackson, TN - Data Density

The challenge refined: evaluate the existing data, perform field work to fill data gaps, evaluate remedies and submit for funding in 4 months.
What defines the creosote source and residual source sufficiently to specify a volume to be remediated? What lines of evidence combine to identify a volume to treat and perform a cost estimate?


Exhibit 4 TarGOST boring locations.

Lots of TARGOST data, old and new w/ HPT for lithology

Exhibit 5 DPT boring locations.

8 samples for analytical and geotechnical analysis

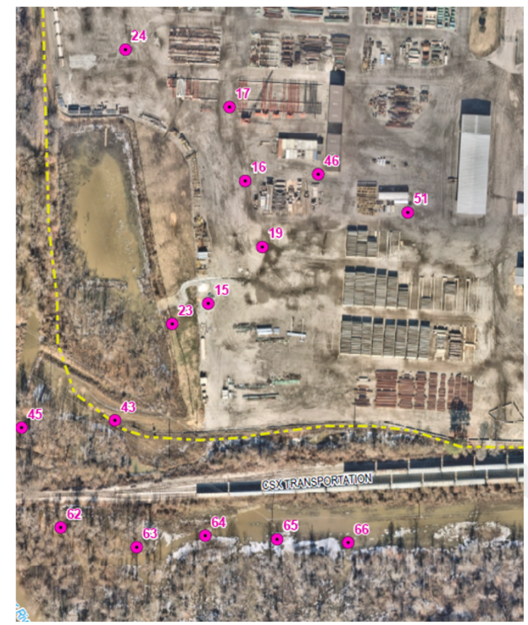
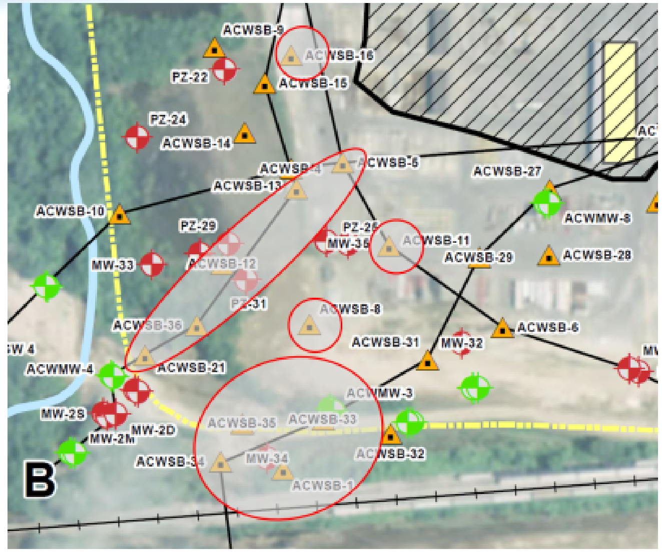


Exhibit 6 CPT boring locations.

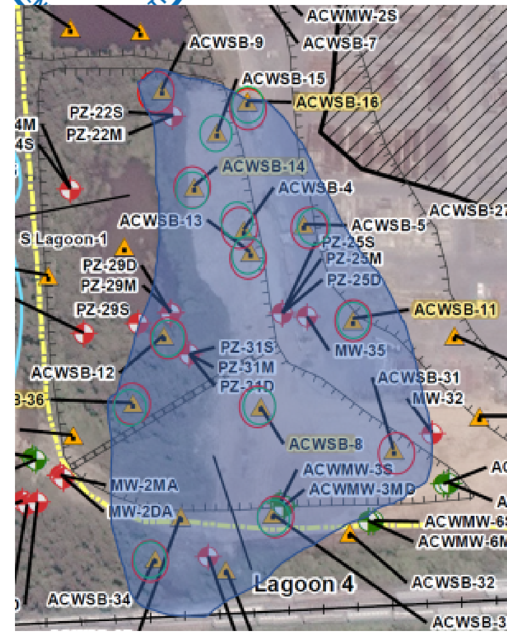
15 new Cone Penetrometer

These three analyses do have remarkable overlap and were used for a GIS analysis to define the treatment footprint ot the NTCRA zone.

#1 These locations exceed the 1% solubility rule for the presence of DNAPL

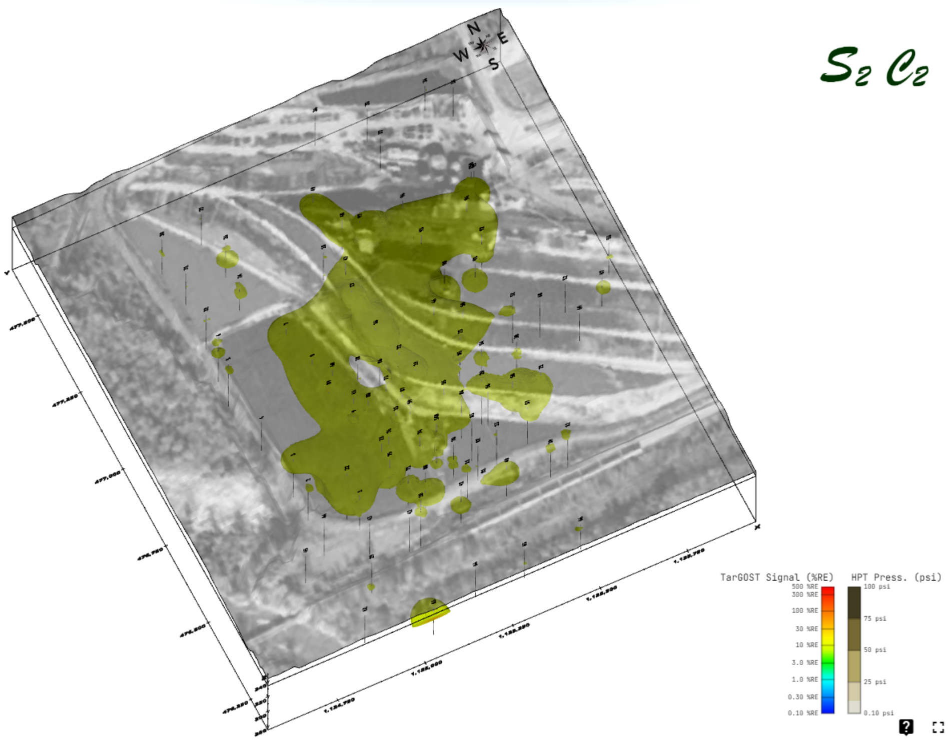


#2 These locations had visual indications of Creosote staining in boring logs or cross sections.

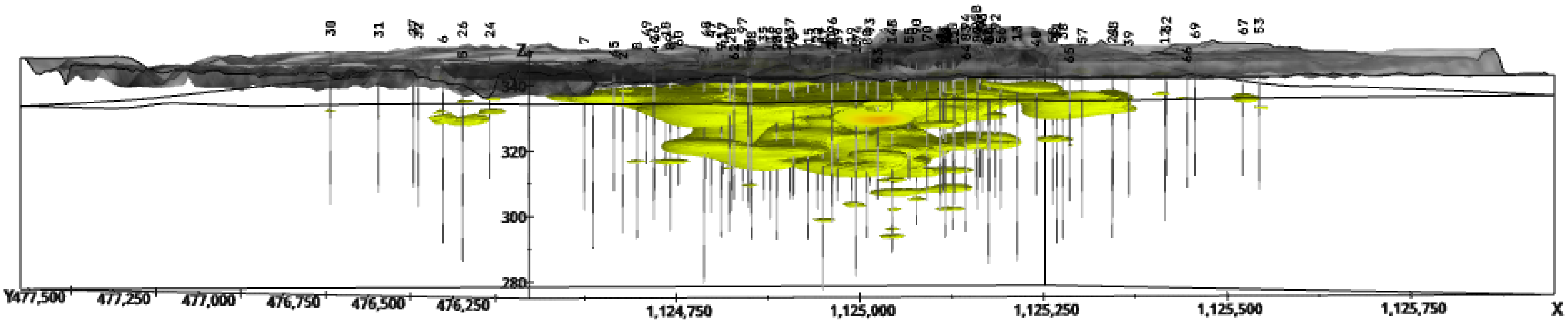


#3 These locations exceed the SSL screening process for leaching GW contamination > the residential RSL, suggested as an upper bound of low-level waste.

American Creosote Works
Jackson, TN



After evaluating eight collaborative data sets, we settled on the 10%RE of the TARGOST as a quantifiable value that could provide a quantified volume for cost calculations.



Explaining the application of HRSC to the characterization of integrated media

This will be covered as part of the project description starting on Slide 16.

Evaluating potentially applicable tools for subsurface investigations

https://asct-1.itrcweb.org/

To select tools to evaluate you will need to provide the following information using the pulldown boxes on the spreadsheet: » **The type of data needed – chemistry** (chemical identification, NAPL presence, contaminant concentration, pH, conductivity, organic content, total organic solids), **geologic** (lithology, stratigraphy, fractures, structural, physical properties), or **hydrologic** (porosity, permeability, flux, groundwater flow, hydraulic conductivity, hydraulic gradient).

» **The type of subsurface – consolidated/bedrock** (cannot penetrate with direct-push platforms) or **unconsolidated.**

» **Data quality needed – quantitative** (for chemistry – concentrations based on standards, for geo or hydro–parameter measurements that are generally repeatable), **semi-quantitative** (measurements that fall within a range), or **qualitative** (an indirect measurement).

» **Data collection characteristics – invasive** (requires a boring or subsurface access) or **non-invasive** (access restrictions, surface cover, topology or other characteristics that may restrict or make access difficult).

ITRC ASCT Selection Tool

Tool	Data Needed				Subsurface/Surface			Data Quality			Data Collection		Additional Info		
	Geology	Hydrogeology	Chemistry	Topography	Consolidated /Bedrock	Unconsolidated	Surface	Quantitative	Semi-Quantitative	Qualitative	Invasive	Non-Invasive	Summary Table	Checklist	Case Study
Direct Sensing													DS_ST	DS_CL	
Membrane Interface Probe (MIP)			X		X[1]	X			X		X				9.1 (9.2)
Optical Image Profiler (OIP-UV, OIP-G)			X		X[1]	X			X		X				9.3
Laser Induced Fluoresence (LIF)			X		X[1]	X			X		X				9.4 (9.5/9.6)
Cone Penetrometer Testing (CPT)	X	X			X[1]	X		X			X				9.7
Hydraulic Profiling (Waterloo[APS] and HPT)	X	X			X[1]	X		X	X	X	X				9.8
Electrical Conductivity (EC)	X		X		X[1]	X			X	X	X				
Flexible Underground Technology (FLUTe)		X	X		X			X	X	X	X				
Borehole Geophysics													BG_ST	BG_CL	
Fluid Temperature			X					X			X				9.9
Fluid Resisitivity			X		X				X		X				9.9
Mechanical Caliper	X				X				X		X				9.9
Optical Televiewer (OTV)	X	X			X				X		X				9.9
Acoustic Televiewer (ATV)	X	X			X				X		X				9.9
Natural Gamma	X				X	X			X		X				9.9
Heat Pulse Flow Meter		X							X		X				9.9
Impeller Flowmeter	X	X							X		X				
Electrical Resitivity			X		X				X		X				9.11
Nuclear Magnetic Resonance (NMR)		X	X		X	X		X			X				9.9
Borehole Video	X				X	X				X	X				9.9
Surface Geophysics													SG_ST	SG_CL	
Electrical Resistivity Imaging (ERI) (Tomography (ERT))	X	X	X		X	X			X	X		X			9.13 (9.10/9.15)
Ground Penetrating Radar (GPR)	X	X			X	X				X		X			9.12 (9.11/9.13)
Multichannel Analysis of Surface Waves (MASW)	X				X	X			X	X		X			9.15 (9.14)
Seismic Reflection	X				X	X			X	X		X			
Seismic Refraction	X				X	X			X	X		X			9.14
Frequency Domain Electromagnetics (FDEM)	X	X			X	X			X	X		X			9.11
Time Domain Electromagnetics (TDEM)	X	X	X		X	X		X	X	X		X			9.16
Remote Sensing													RS_ST	RS_CL	
Visual Spectrum Camera				X			X	X		X		X			9.17 (9.18/9.19)
Multispectral Camera			X				X	X		X		X			9.18 (9.17)
Hyperspectral Camera			X				X	X		X		X			
Thermal/Long-Wave Infra-Red Camera	X	X	X				X	X		X		X			9.18 (9.17)
LiDAR				X			X	X				X			
Water Sampling			X				X	X			X				
Air Sampling			X				X	X			X				9.19

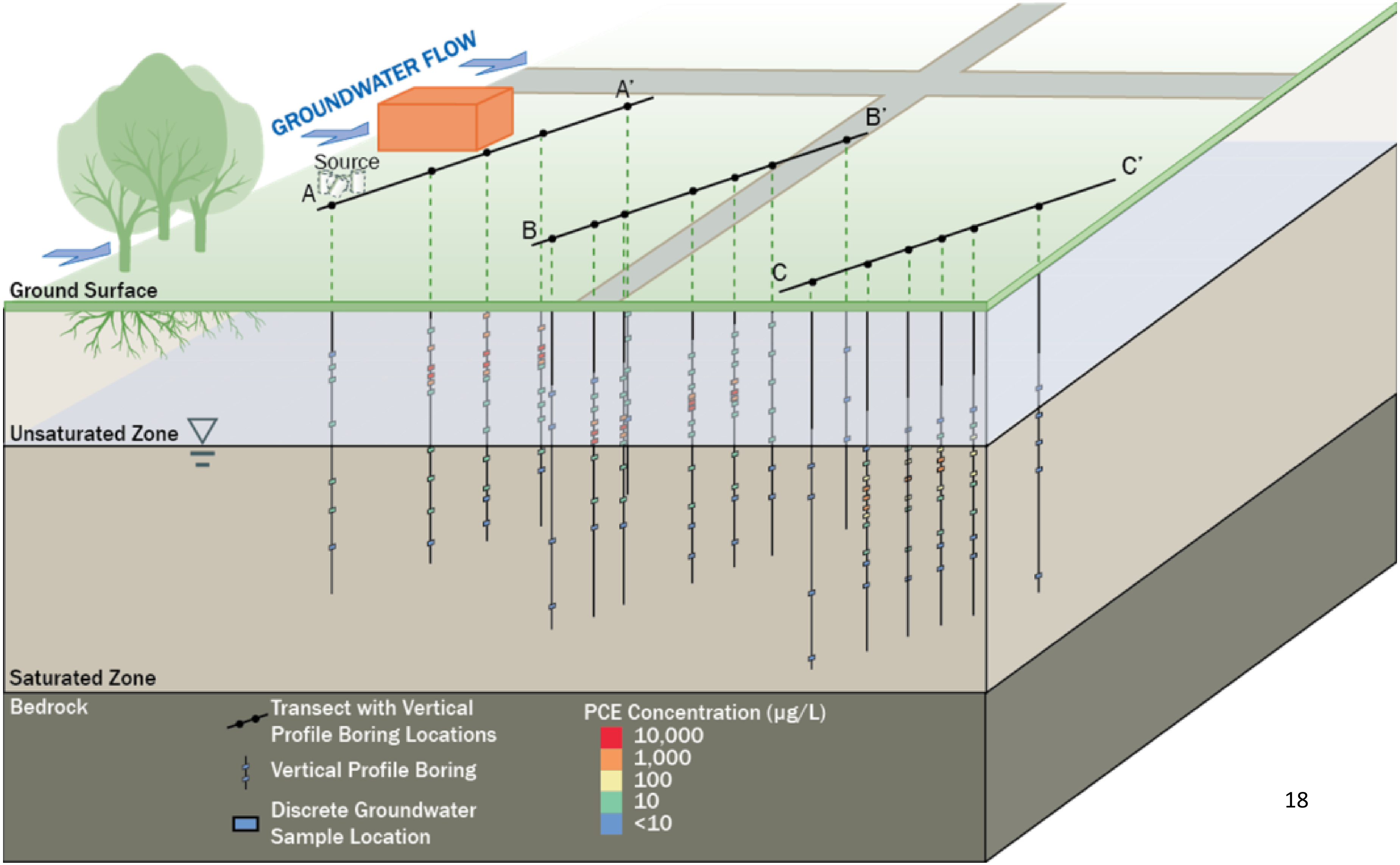
Developing effective HRSC implementation and investigation strategies

- For the attendees, this comes with practice in the course, through going through case studies and then evaluating your own sites.

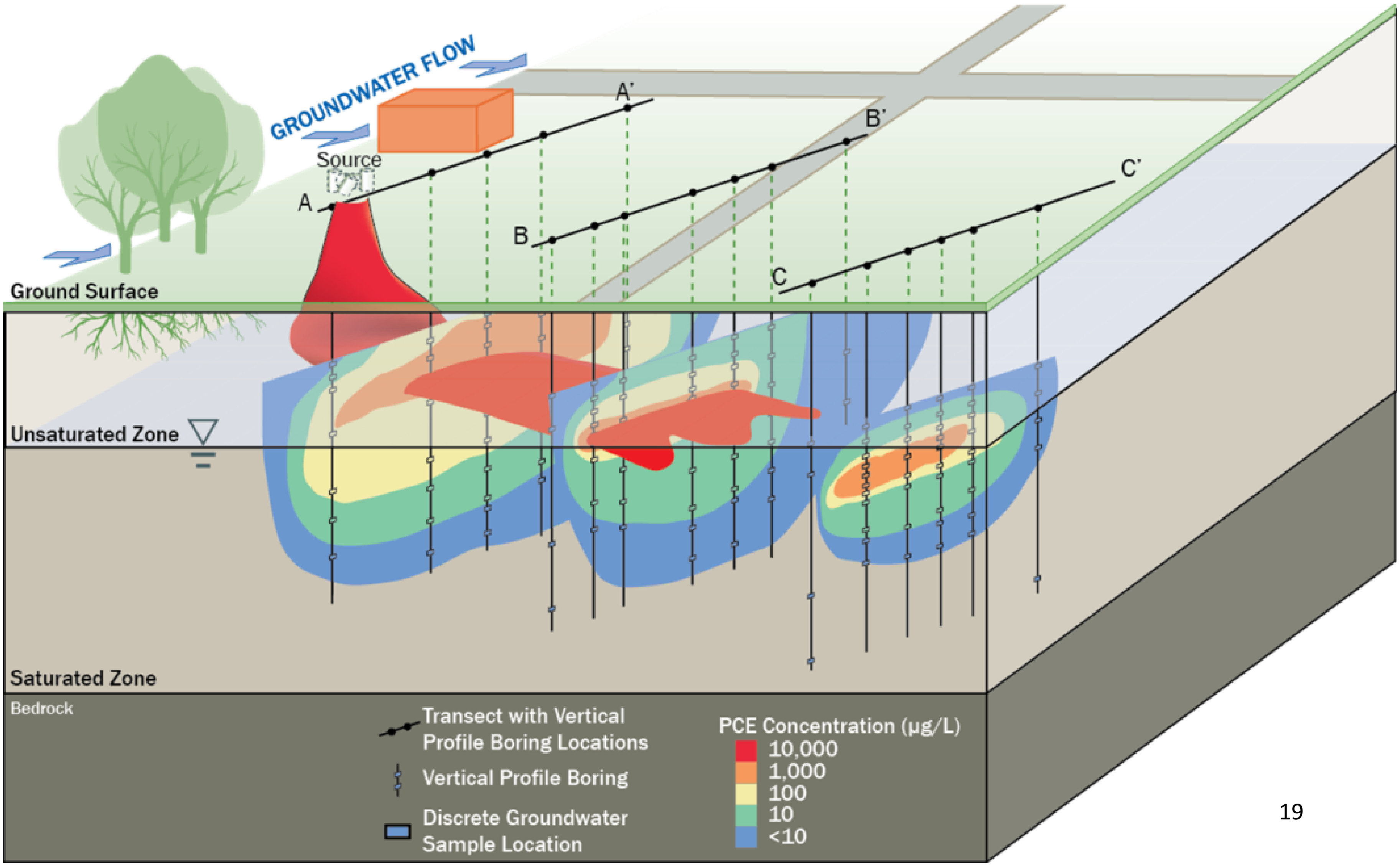
- For more experienced practitioners, these concepts could refine their approach and provide greater confidence/less uncertainty in the conclusions of the investigation.

- What does your CSM say about what you know so far and where are the data gaps? i.e. the ones necessary to fill to make a remedial decision.

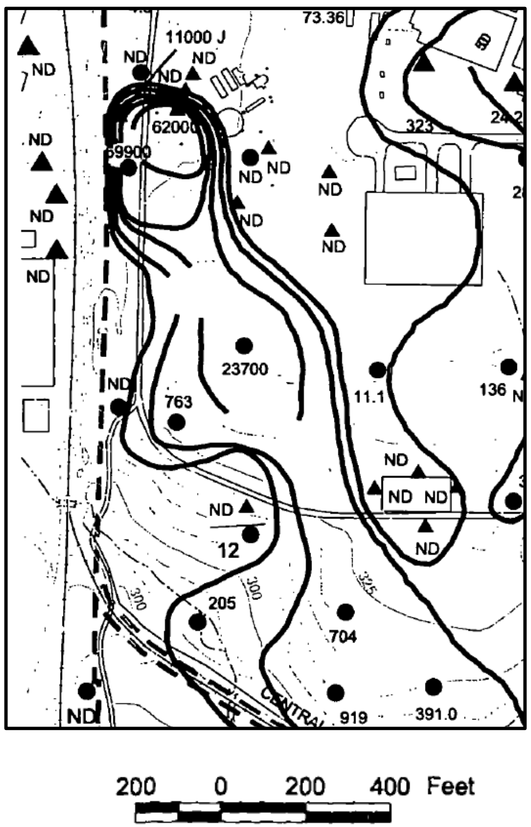
A New or Renewed Investigation



‘Typical Site’ data interpreted

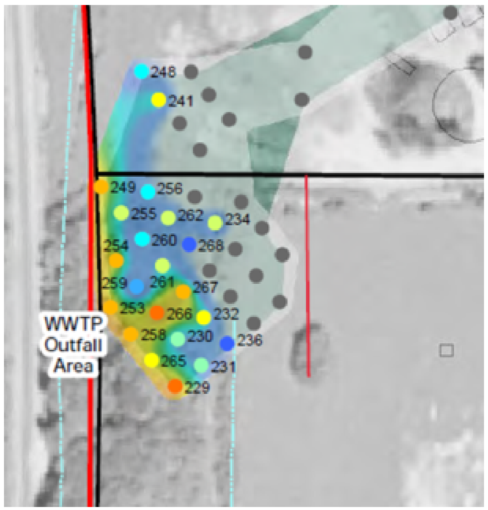


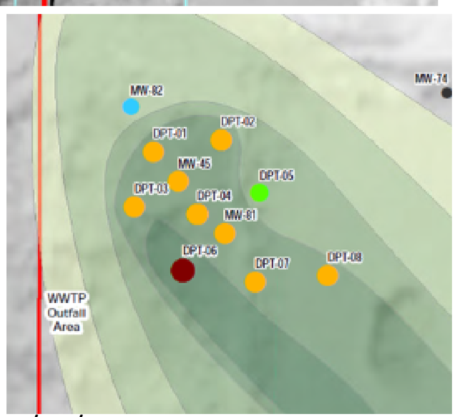
Developing effective HRSC implementation and investigation strategies



- A Superfund Site
- Figure from a 2000 report
- TCE concentrations in ug/L
- 600’ between the two hottest wells and then 600 more feet to the next downgradient well.
- 20 years later, RI is restarted anew following high res practices.

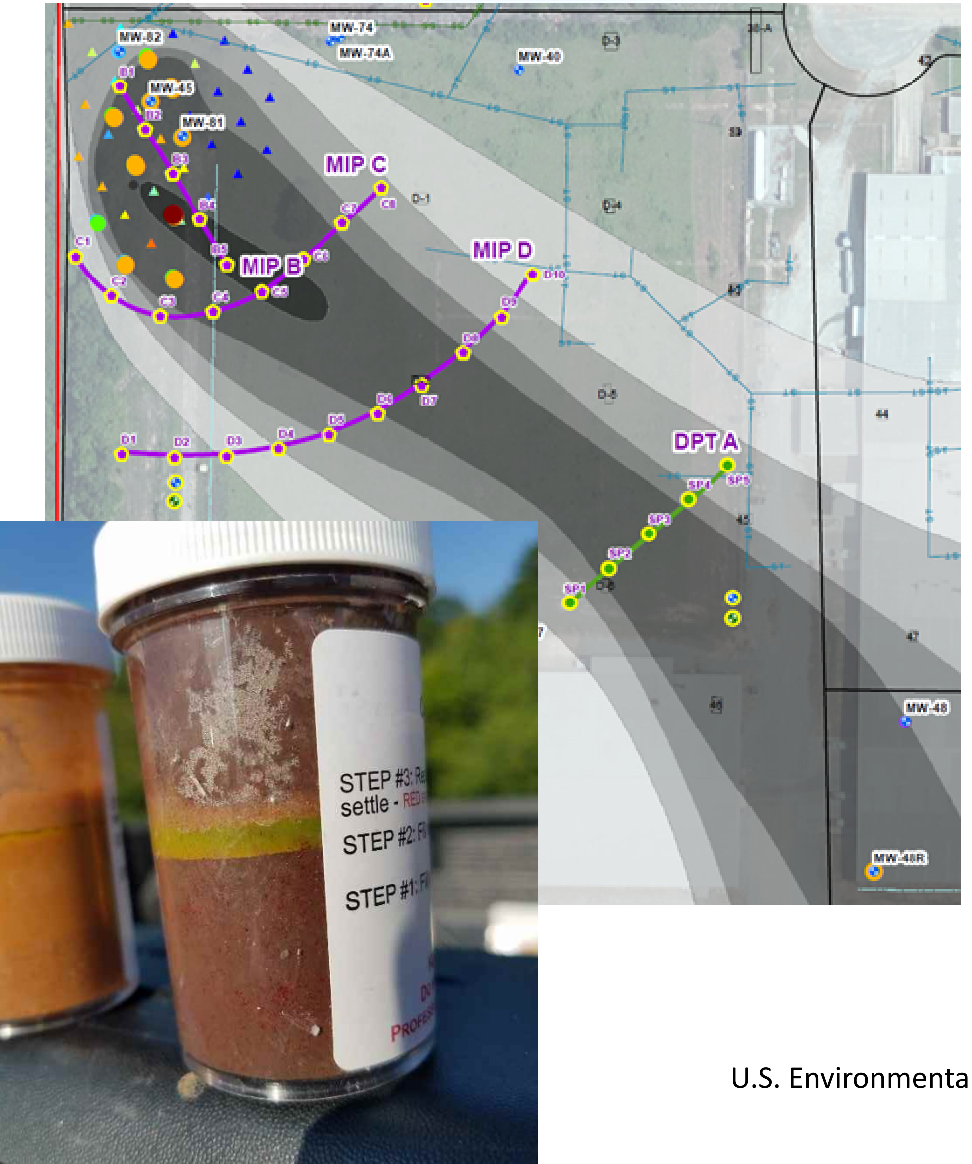
Developed investigation strategies





- High density soil gas surveys in the hot spot, spacing 30’-40’
- 8 Direct push soil samples, 5X at 10’ intervals, 30’ – 50” spacing, max TCE value 240 mg/kg.
- 8 Direct push GW samples, 2 depth intervals, 30’ – 50’ spacing, + 3 MW samples, max TCE value 84 mg/L, same location as max soil value.

Developed investigation strategies

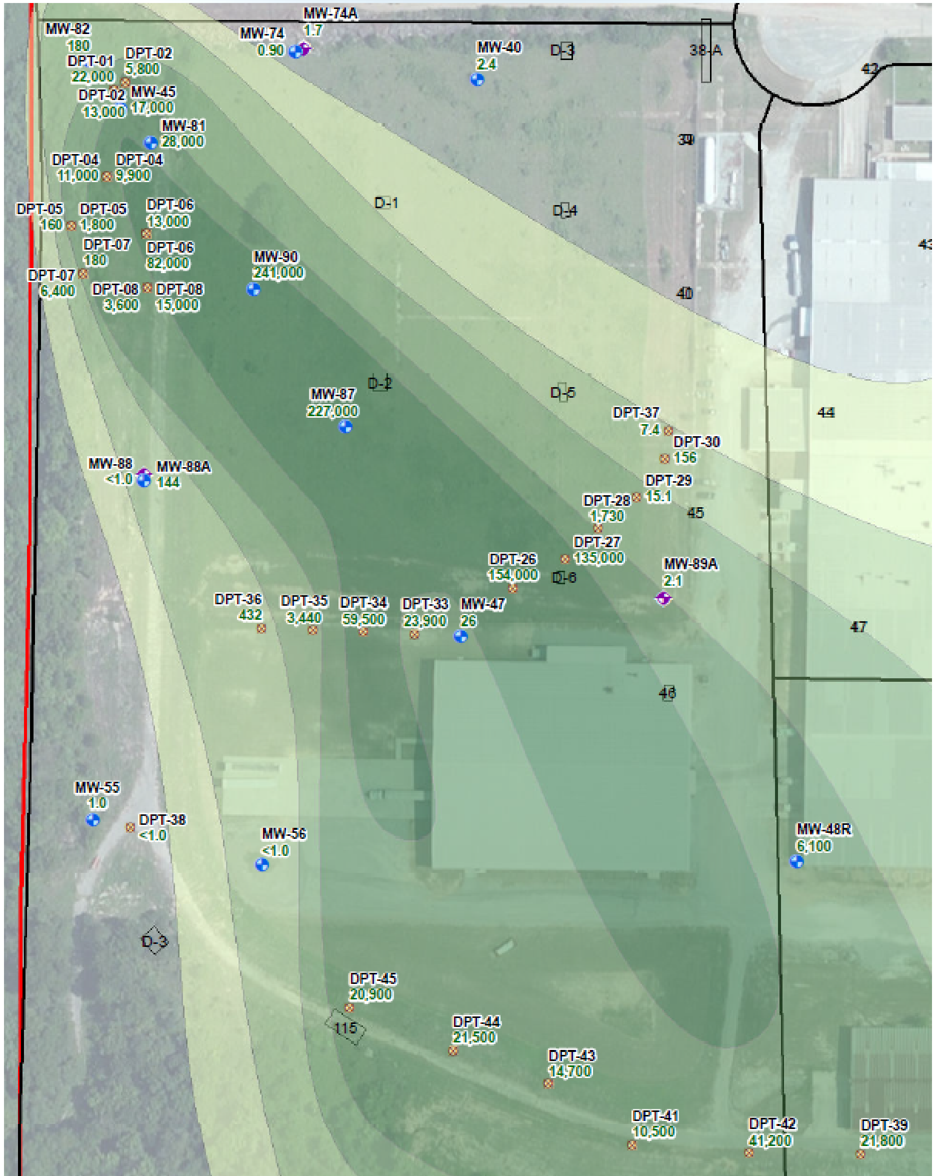


Developed four transects for GW characterization with Membrane Interface Probes and GW sampling.

Did find the core of the plume – see next slide

Sonic core for MW-90 did identify a DNAPL zone with an oil red shake test.

Developed investigation strategies



Subsequent MW installation

MW-90 - TCE @ 241 mg/L, 22% of saturation and

MW-87 - TCE @ 227 mg/L, 20% of saturation

Residual DNAPL - Time to change the CSM to reflect the new high resolution data

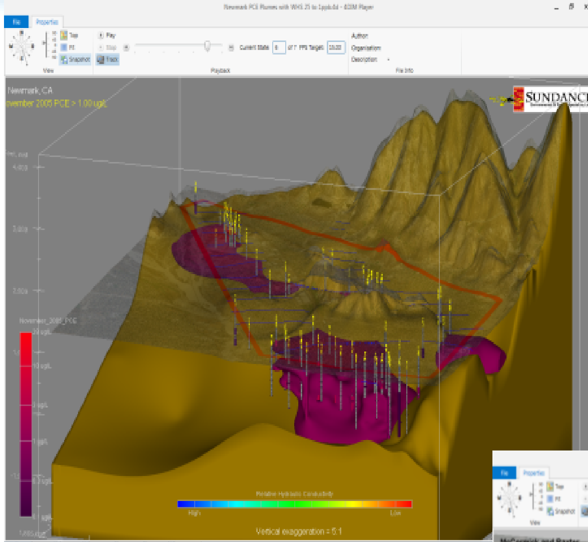
Residual DNAPL is formed at the trailing end of a migrating DNAPL body and typically occurs at saturation of no more than 25% of pore spaces. Pg. 36

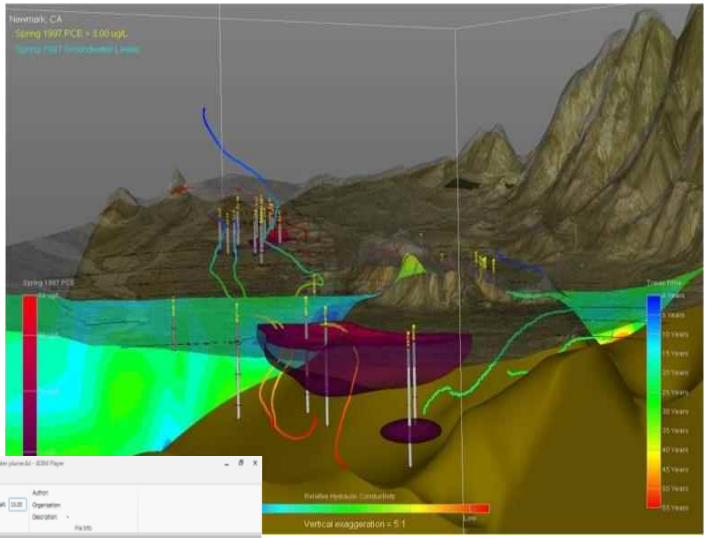
Kueper, et. al., 1993, in Chlorinated Solvent Source Zone Remediation, Kueper, et. al., SERDP/ESTCP, 2014, 713 pgs.

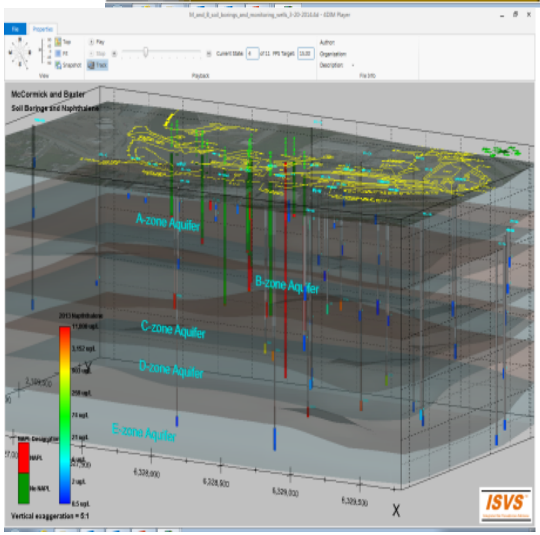
Managing and visualizing HRSC data for decision making

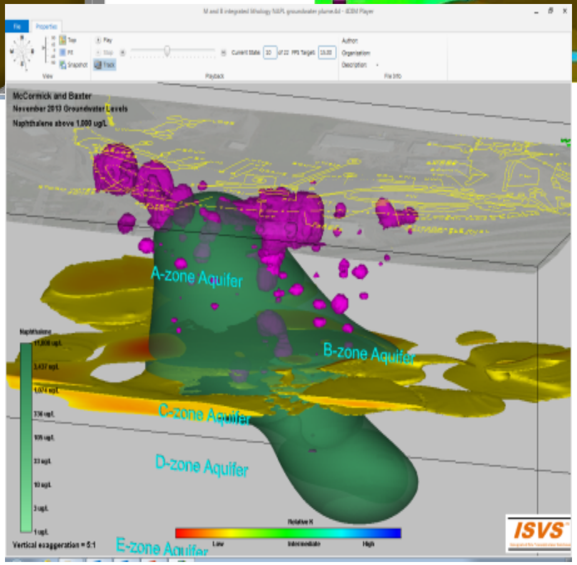
- No body's favorite task to organize all the data but 3D visualization is a strong communication tool. And in order to get that message across, you have to collect and store a LOT of data and in a format and way that it is retrievable by the GIS wizards.
- Data Management Plan
- Assure communication across various platforms and softwares.
- Look how important it was to success of the ACW Creosote Site.

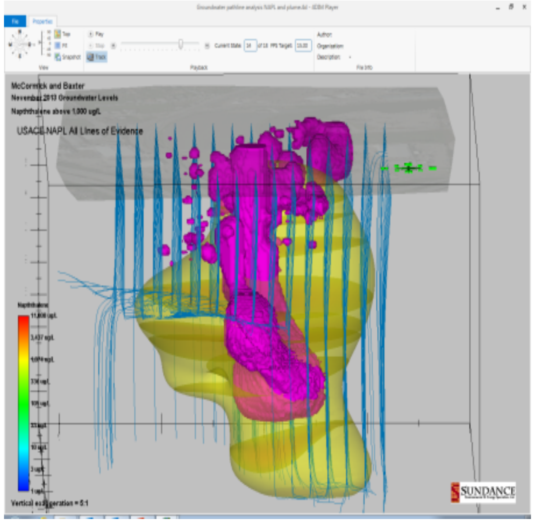
Visualizing HRSC data for decision making



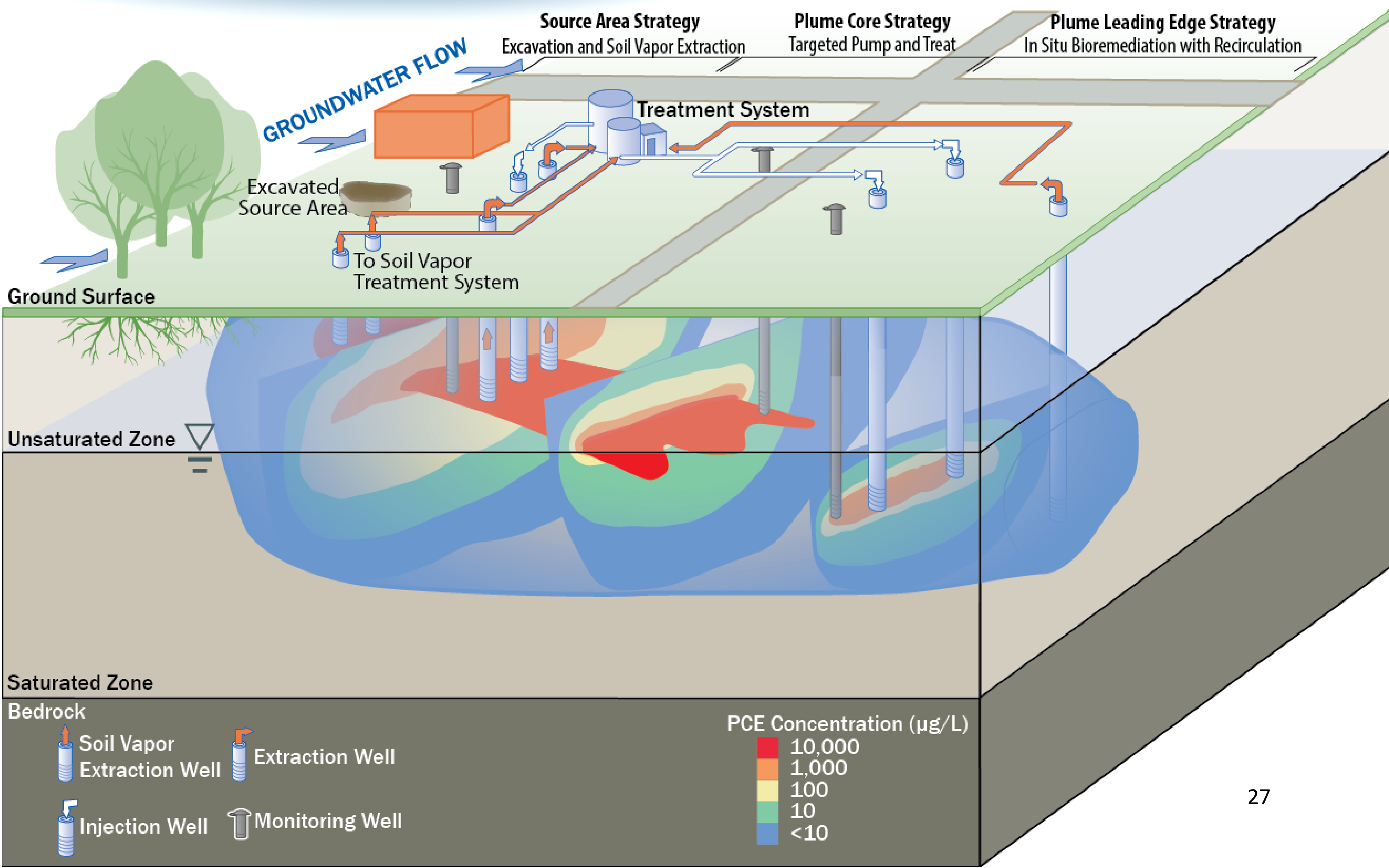








Applying HRSC to remedy design, implementation and optimization



Other HRSC-related courses

- Best Management Practices for Site Characterization Throughout the Remediation Process – CEC
- High Resolution Site Characterization (HRSC): Pragmatic Approaches to Remediation Success – CLU-IN Webinar
- Incremental Sampling – NARPM, CEC and ITRC
- 3D Visualization – NARPM
- Characterization and Remediation of Fractured Rock - ITRC

For more information, visit

- https://clu-in.org/training/
- https://clu-in.org/characterization/technologies/hrsc/
- www.trainex.org (CERCAL Education Center courses)
- www.itrcweb.org
- https://www.serdp-estcp.org

Thanks

Ben Bentkowski, P.G.

Region 4 Scientific Support Section

Superfund and Emergency Management Division

Bentkowski.Ben@epa.gov

470-259-5620