Drilling **N**ot **A**ble (to find) **P**recise **L**ocation of **S**olvents

NEWMOA Workshop

Characterizing Chlorinated Solvent (DNAPL) Sites

Presented By

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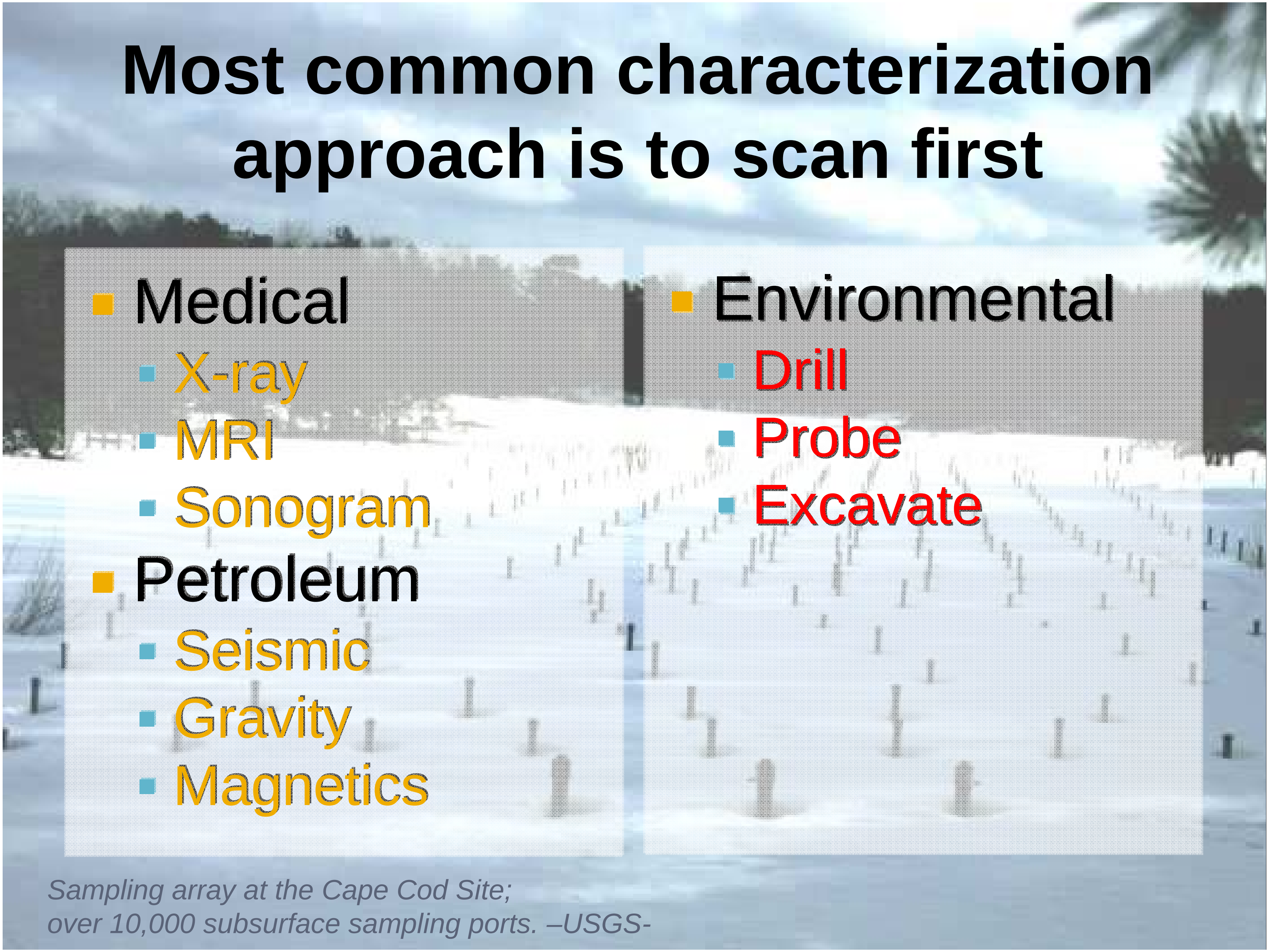
Today's Discussion Points Regarding DNAPL Site Characterization

- Conventional site characterization methods are not providing complete & cost effective site characterization; a new tool is available to help (i.e., high resolution ERI)
- Review reasons why wells/borings alone are not sufficient to characterize DNAPL sites
- Discuss new paradigm of NAPL source behavior in subsurface developed by use of high resolution ERI (GeoTrax SurveyTM)
- Review Case Studies - EPA, States, consultants, have demonstrated that high resolution ERI (GeoTrax Survey™) works to locate NAPLs in subsurface
- Better site characterization → Better Project Results

DOC SAID HE COULD GIVE YOU A CAT SCAN
BUT HE WANTS TO TRY IT THIS WAY FIRST!

Most common characterization approach is to scan first

- Medical
  - X-ray
  - MRI
  - Sonogram
- Petroleum
  - Seismic
  - Gravity
  - Magnetics
- Environmental
  - Drill
  - Probe
  - Excavate



Sampling array at the Cape Cod Site;
over 10,000 subsurface sampling ports. –USGS-

Typical Site Characterization Problems

- Costly Investigations
  - Few useful data points (low data density)
  - Too much “interpretation” between data points
- No continuous “picture” of the subsurface
- Site impacts with no known source
- Over/under design and inefficient O&M
- Is the site really clean following remedial action?

Why don't we "scan" first?

1. Cost
2. Social limitations (3rd Party scanning?)
3. Previously difficult to effectively scan
   - Lots of "noise"
     - Pipes
     - Disturbed ground
   - Most contaminants geophysically "invisible"
     - Non-magnetic
     - Low density contrast
     - Non-conductive to highly non-conductive

Characterize my DNAPL problem…

1. I put an organic cocktail into the ground with many possible constituents
2. I don't know <u>when</u> or exactly <u>where</u>
3. My subsurface property distribution is unknown
4. Biodegradation is occurring at some rate
5. I may have added a few things….

What is Electrical Resistivity Imaging (ERI)?

- Based on
  - DC resistivity techniques (>100 yrs old)
  - computing/electronics power (<10 yrs old)
- Instead of 10’s of data, collect thousands (high data density)
- Geological digital photography
- Provides high resolution map of electrical properties of the subsurface

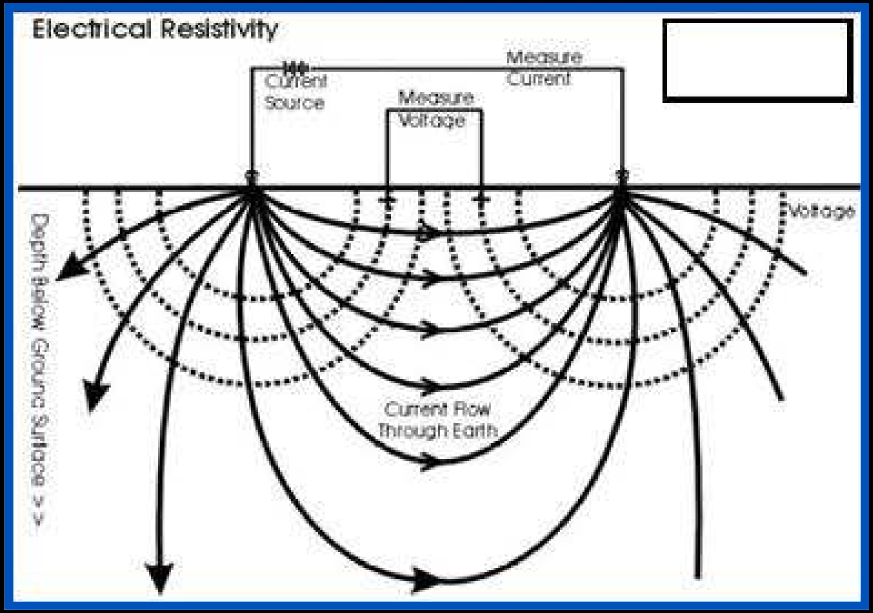
How ERI Works – “Setting Up The Camera”

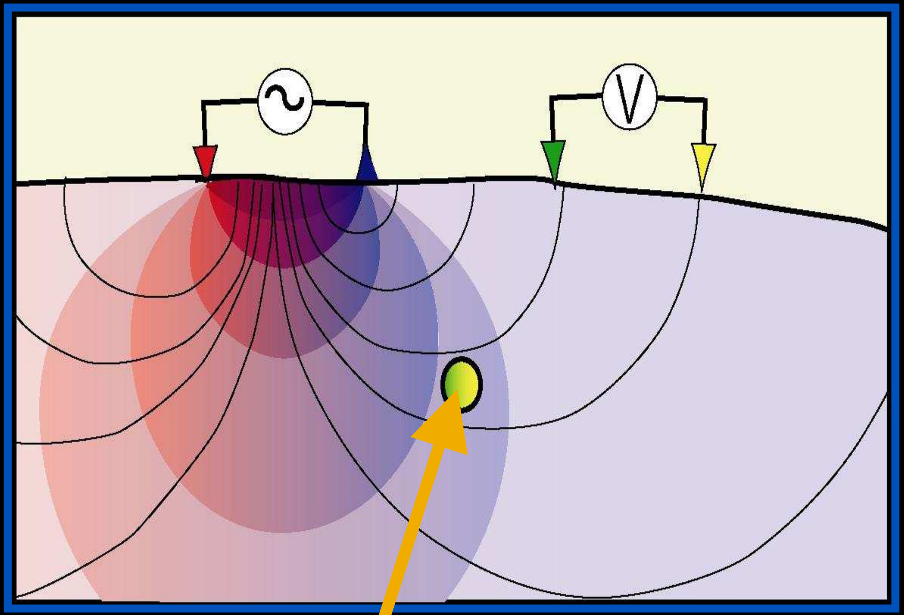
- **56 Electrode Stakes (3/8-inch diameter) Hammered Into Ground**
- **Geophysical Cables Attached to Electrode Stakes**
- **Data Collection Starts (~1-2 Hours; Site Dependent)**

Take Only Pictures…Leave Only “Footprints”!

How ERI Works – "Taking the Picture"

Four Electrodes Yield One Measurement Data Point ("pixel")

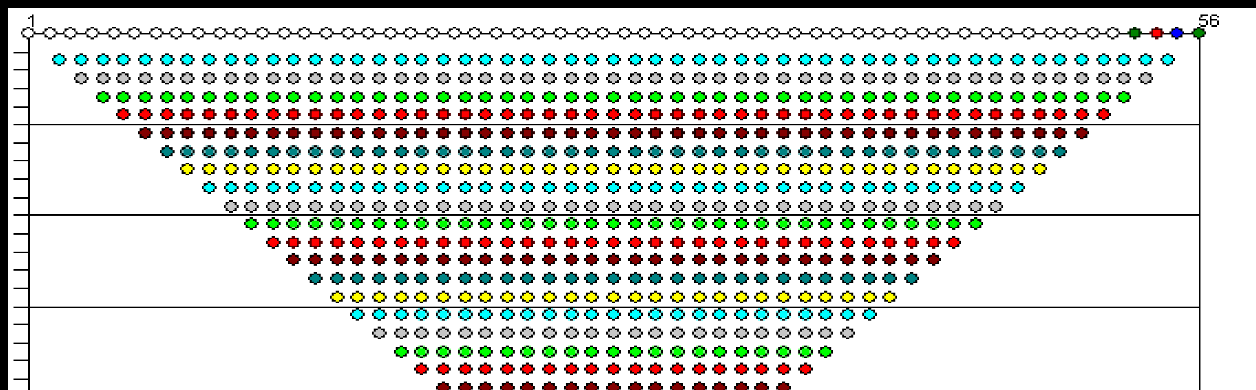




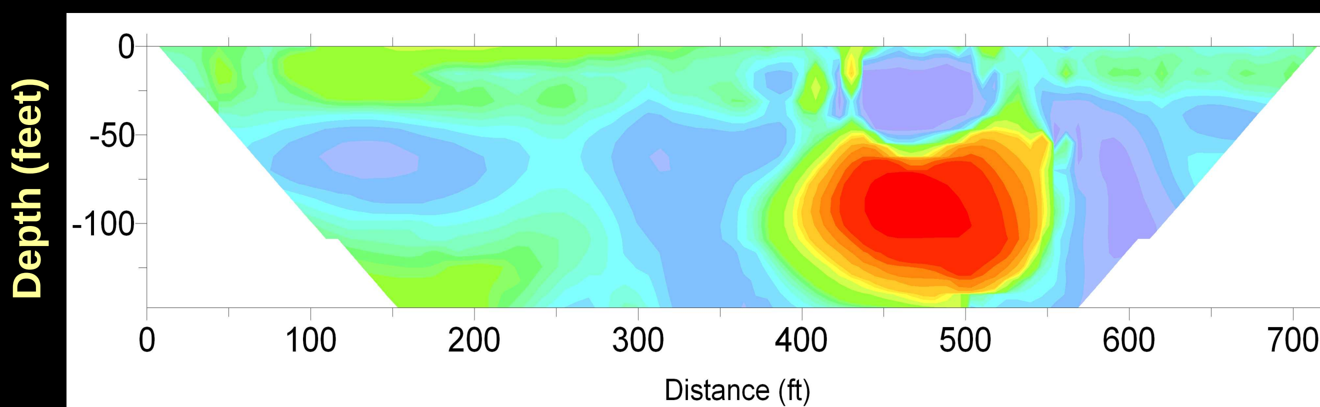
One Data Point or "Pixel"

How ERI Works – "Developing the Film"

Iterative Measurements Yield Matrix of Data Points or "Pixels"

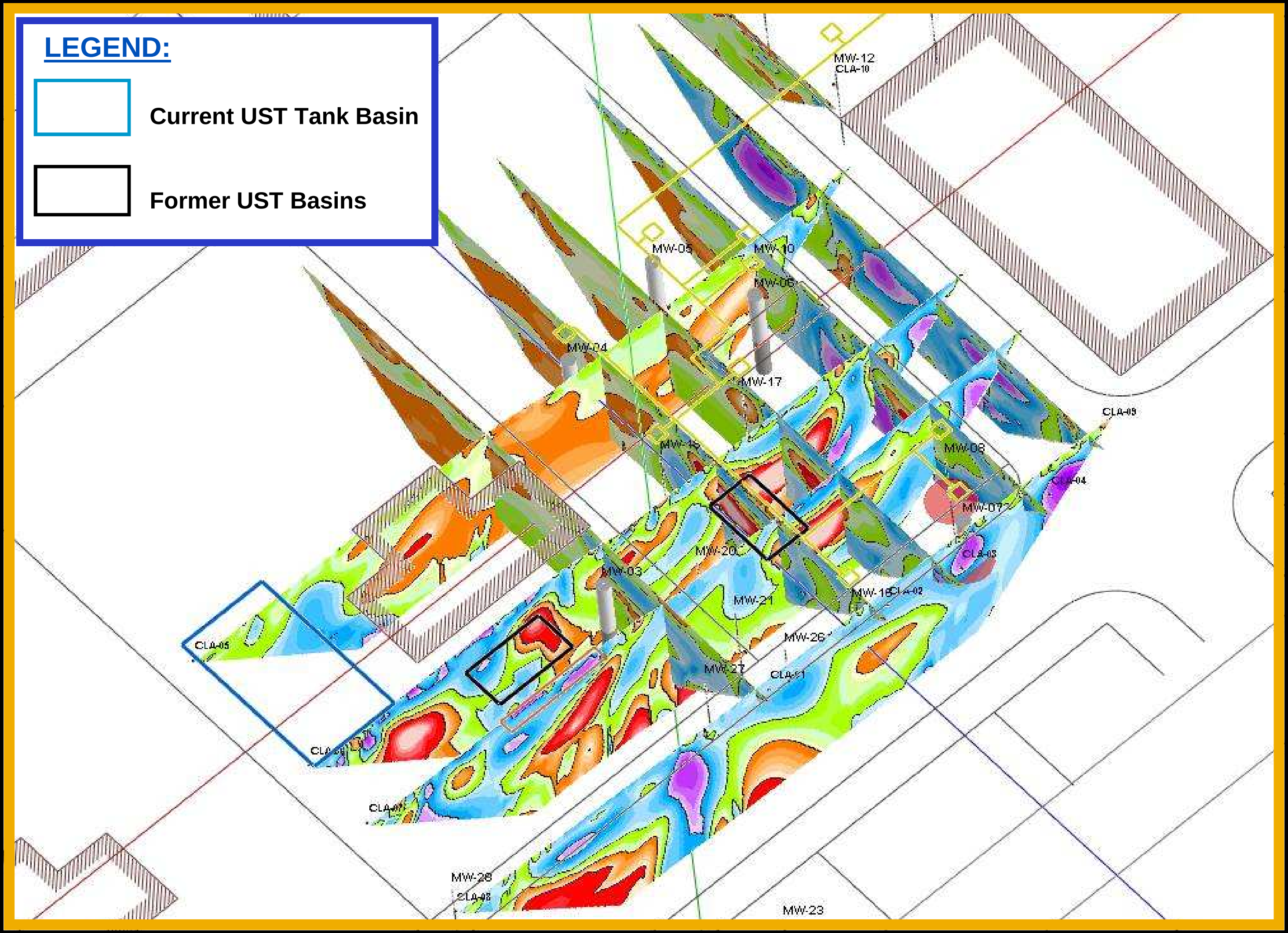


Proprietary Software Generates Subsurface 2-D Image from Data Set



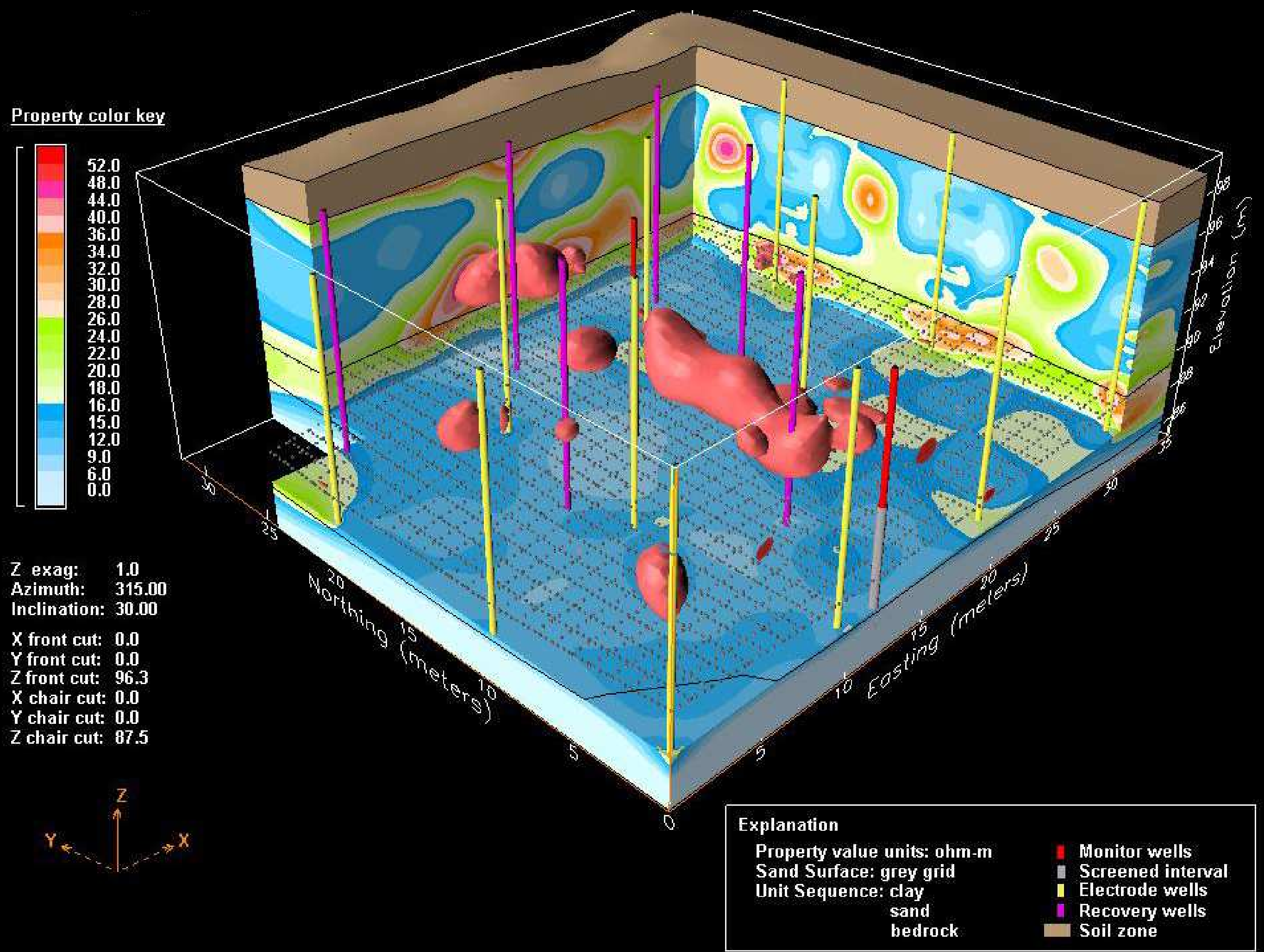
A Kilopixel Digital Camera Taking Electrical Picture of Subsurface

How ERI Works – Viewing the "Pictures"



ERI Output – 2-D Data "Fences" in 3-D Space

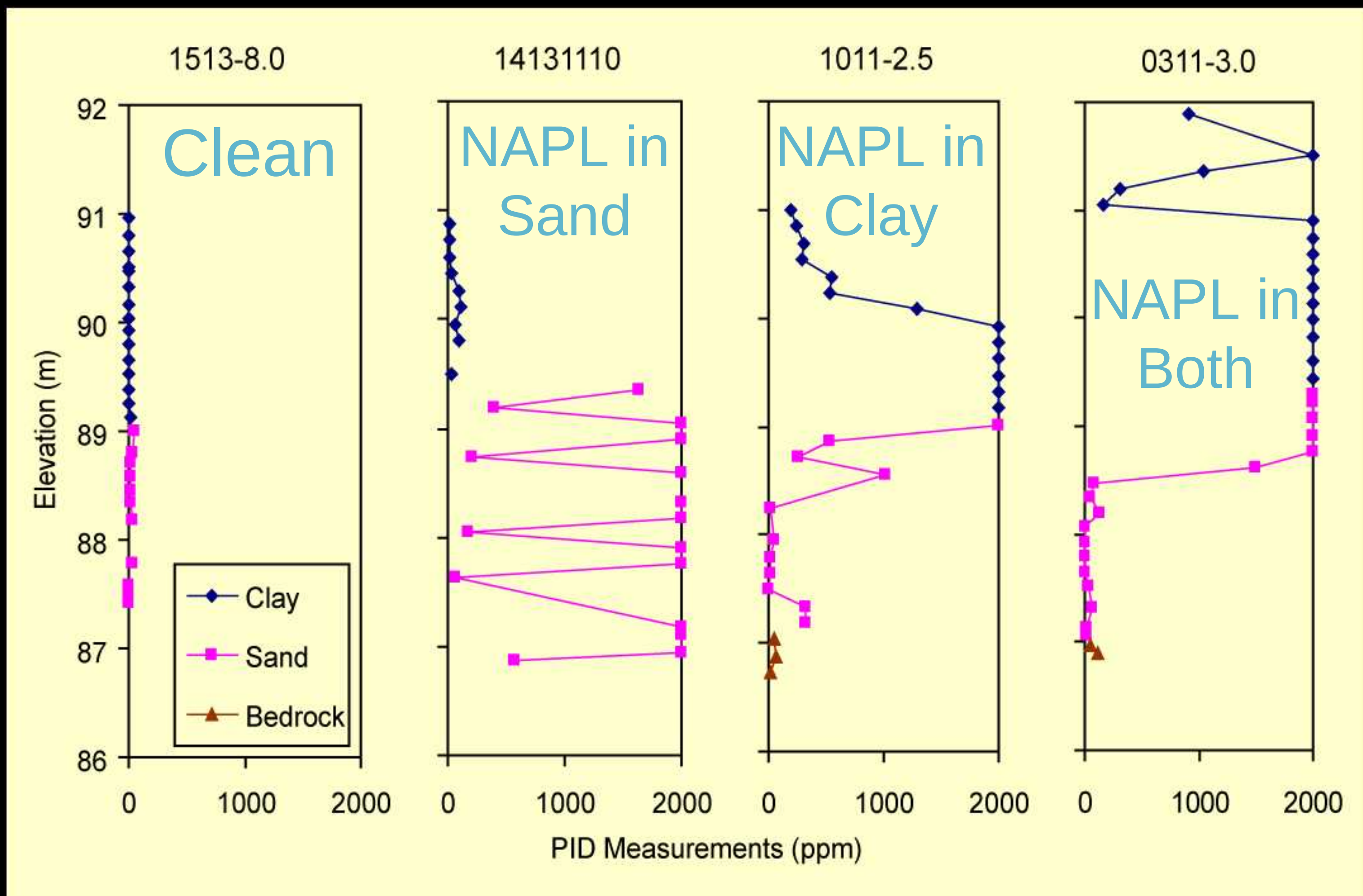
How ERI Works – Viewing the "Pictures"



3-D ERI Model Output – Enid, OK

What would you like the Enid Site conceptual model to be?

(all cores within 60 feet of each other)



Why didn't we do this before?

Technological Progression

- Data acquisition now 100x faster than 1990
- Data processing now <u>350x</u> faster than 1990
- Images were not "drillable"
  - OSU/Aestus created dramatically improved images
  - Images can "see" resistive subsurface targets others can't

Aestus Proprietary Supplemental Field Equipment

Proprietary OSU/Aestus Data Acquisition Algorithms

Standard Electrical Resistivity Techniques

Proprietary OSU/Aestus Data Reduction/ Processing

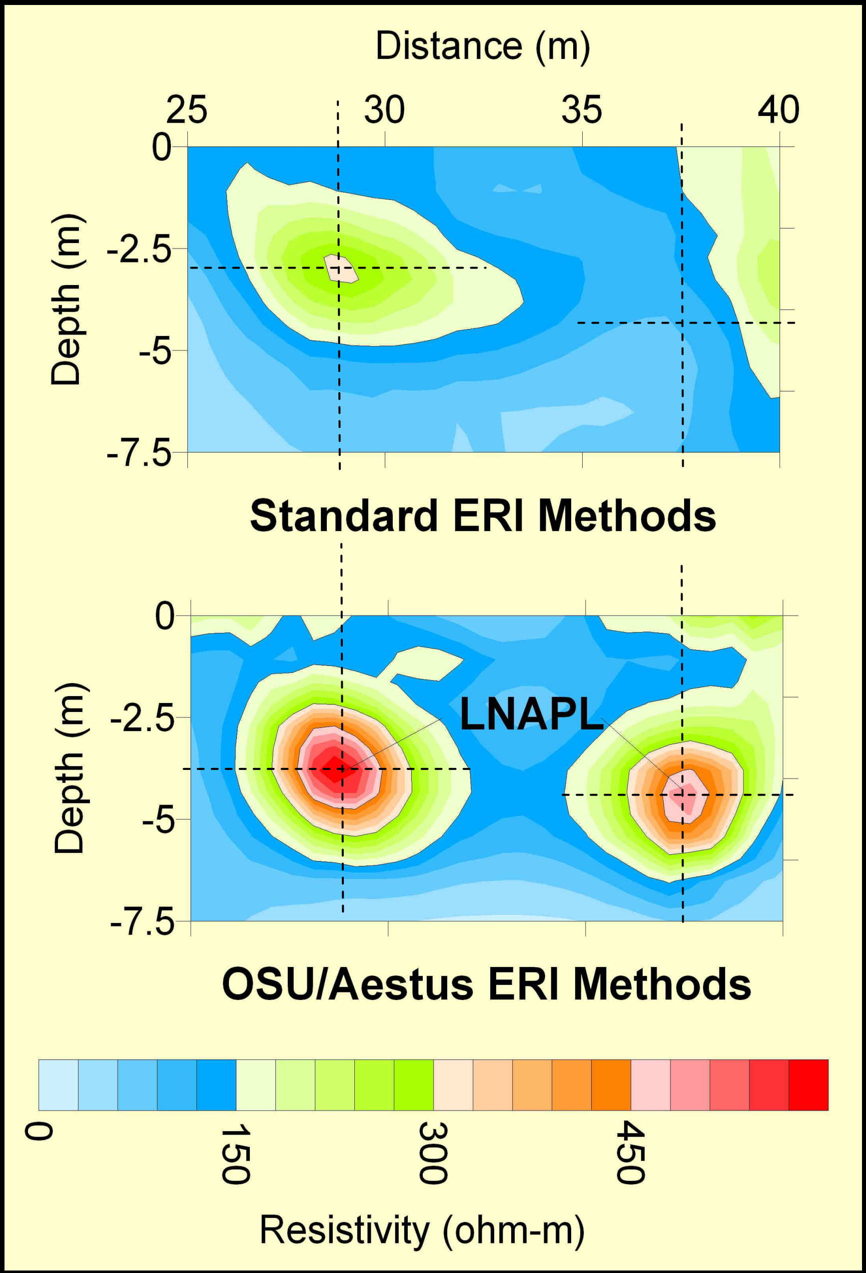
High Resolution Subsurface Image

That is “Drillable”

Technological Comparison

- X Standard ERI methods barely able to detect "blob" with the highest concentration of LNAPL detected on this site
- X Second LNAPL "blob" does not show up using standard ERI

- ✓ OSU's/Aestus' ERI Methods detect both LNAPL "blobs" present
- ✓ Image shows concentrations in a semi-quantitative manner
- ✓ Images are "Drillable"

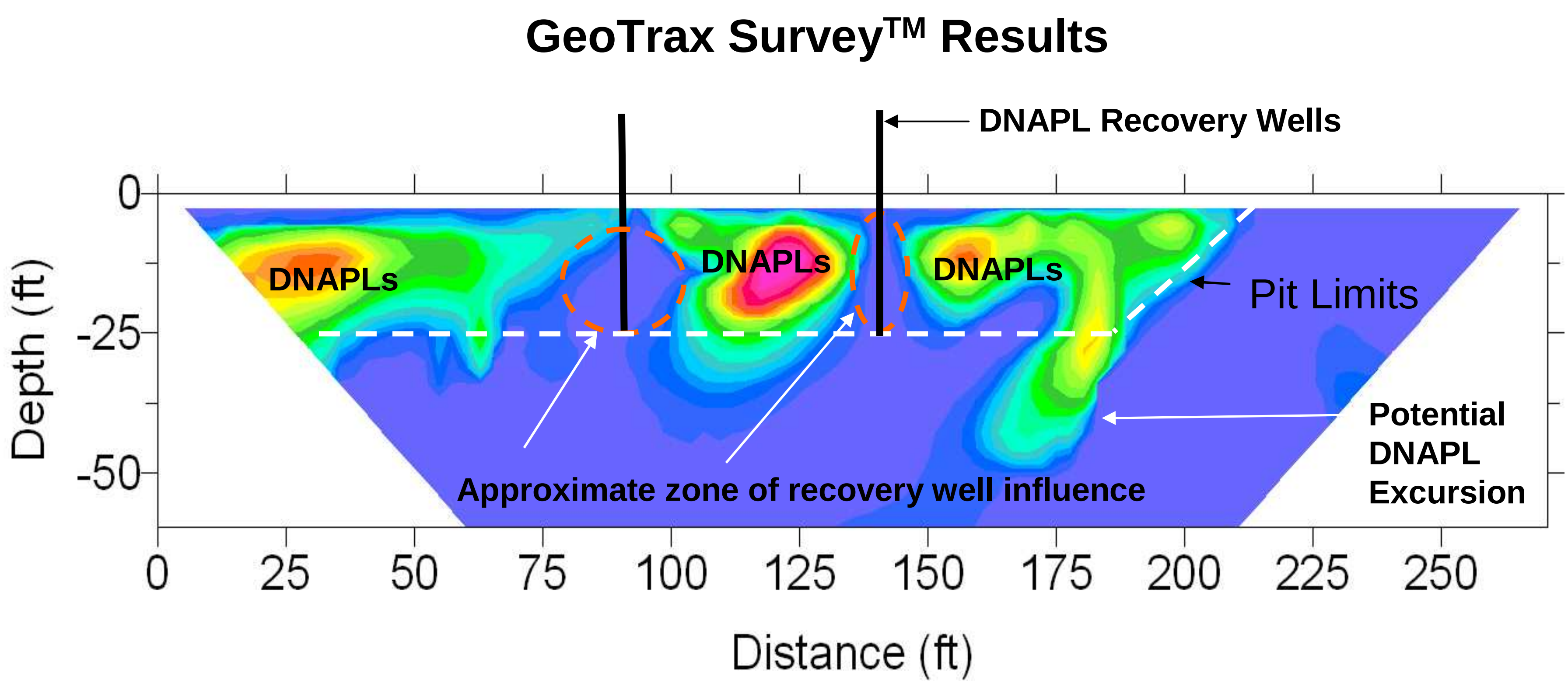


** Confirmation Drilling Data Collected by EPA;*
nages from Golden, OK Site Case Study

Why has it been so hard to understand your site?

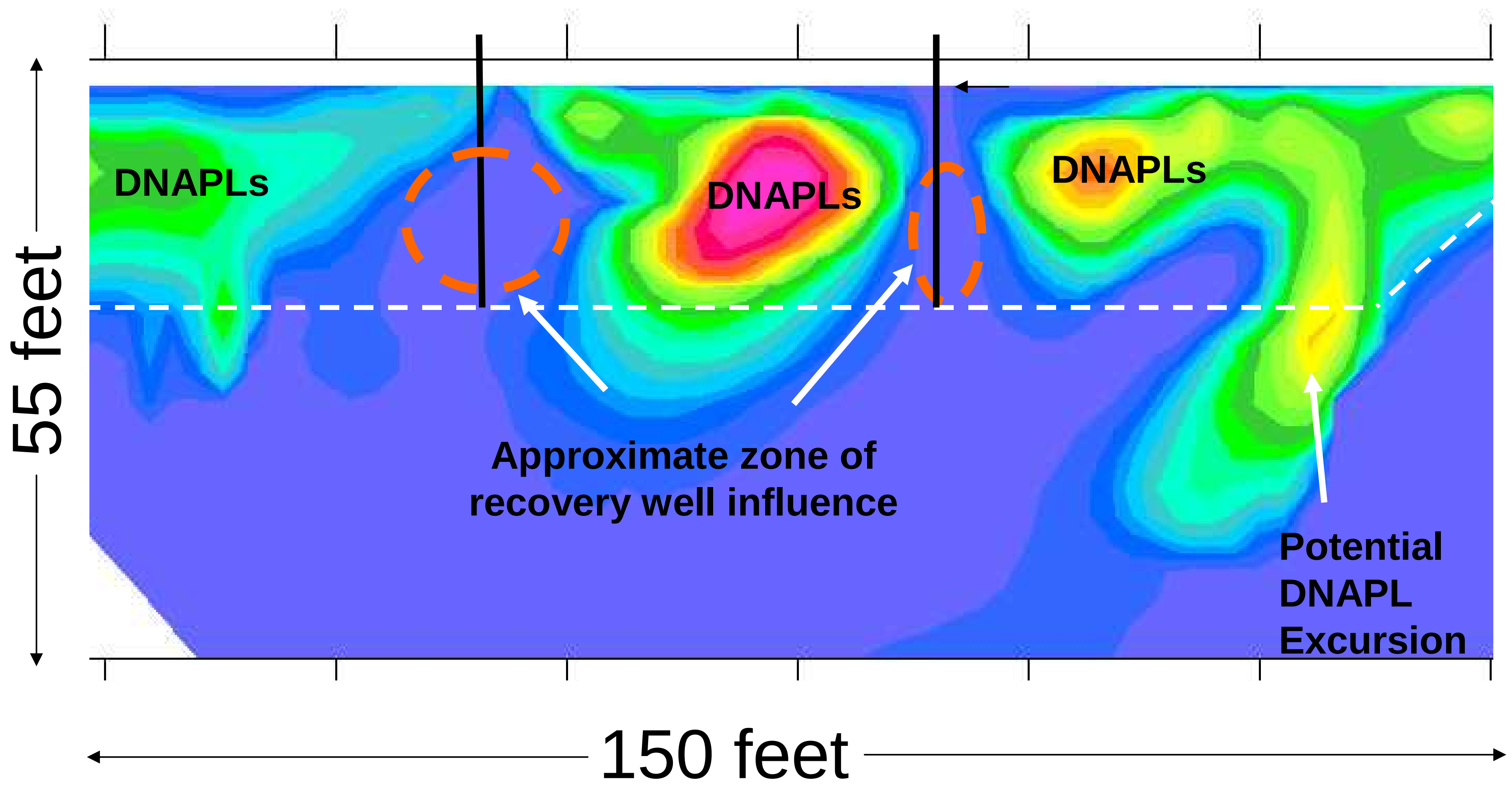
- Wells do not provide a good estimate of subsurface conditions at DNAPL sites
- No site imaged with this ERI technique has shown a uniform layer with a "thickness" of DNAPL – occurs as discontinuous "blobs"
- Well data should be viewed differently depending on well function, well construction, and whether pre- or post-remediation

DNAPLs at Landfill Waste Pit

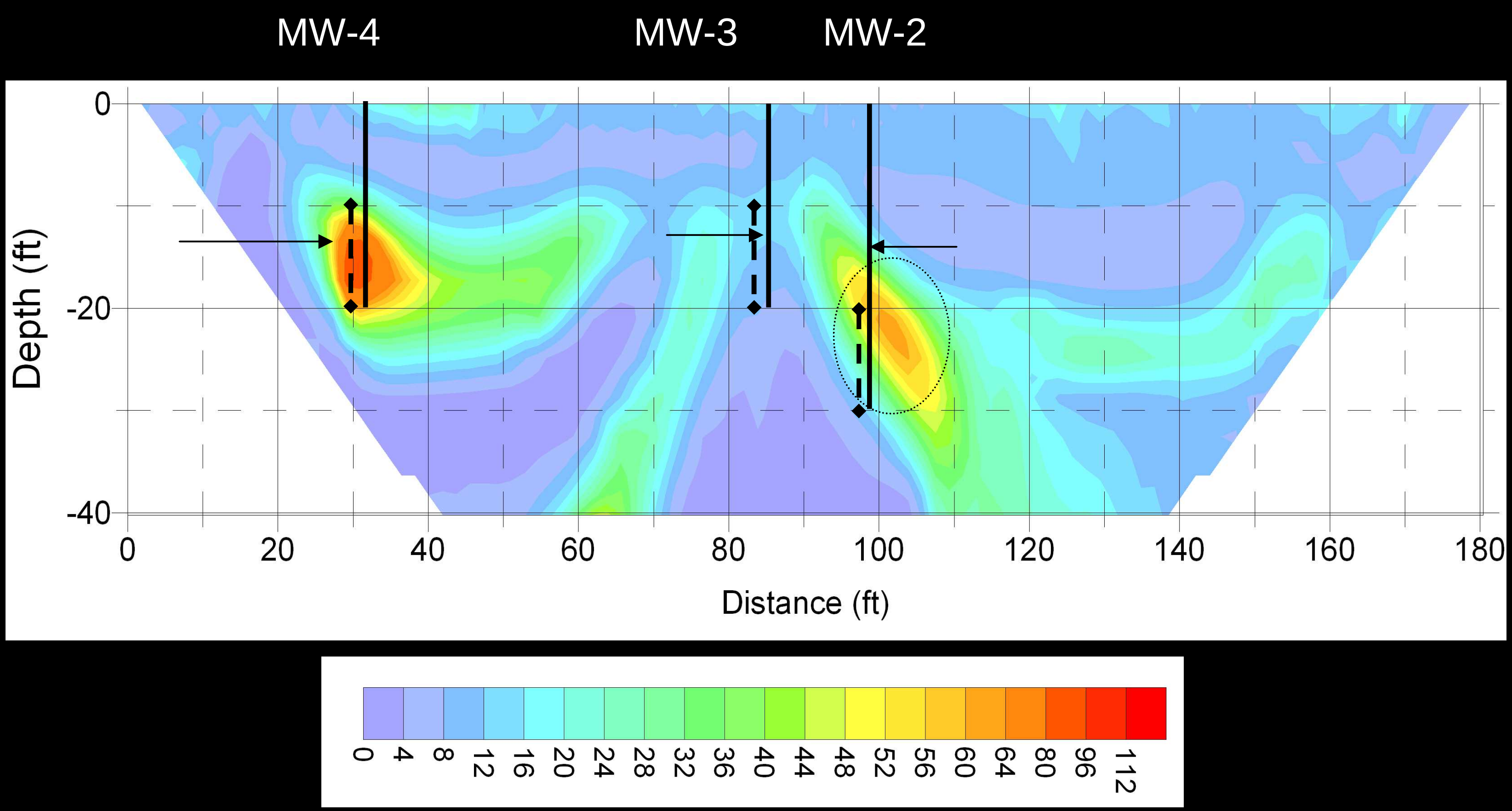


At the time the image was taken, wells were “clean”

DNAPLs at Landfill Waste Pit - Zoomed

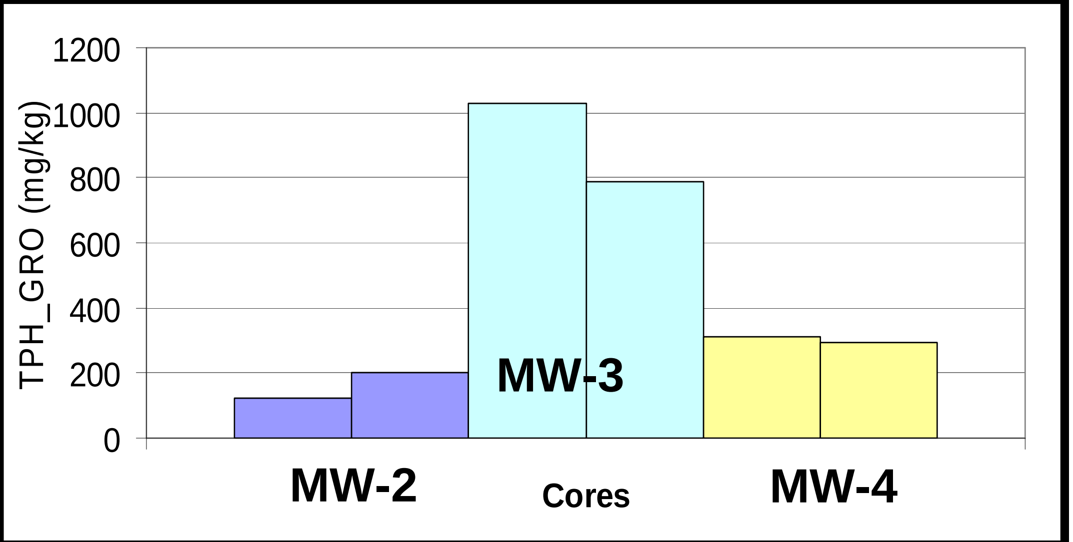


Dept. of Health/Human Services Building - Hobart, OK



(Aestus, August 2004)

Dept. of Health/Human Services Building - Hobart, OK



Core Data - detects high total petroleum hydrocarbon concentrations

Monitoring Well	Date	Depth to Product (ft)	Product Thickness (ft)
MW-2	9/1/04	NP	0
	11/11/04	NP	0
	10/11/05	NP	0
MW-3	9/1/04	NP	0
	11/11/04	NP	0
	10/11/05	NP	0
MW-4	9/1/04	NP	0
	11/11/04	NP	0
	10/11/05	NP	0

Well Data - all were non-detect,
No apparent problem

(Secor, August 2004)

Some references that demonstrate problems with monitoring LNAPL using only wells

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Now, in general…

- Wells provide a limited picture of the subsurface
- ERI provides a great tool to allow sites to be better characterized; ERI is not a magic bullet as confirmation data is required to calibrate images
- Because DNAPL distribution is discontinuous, the total volume estimated using ERI is typically much less than estimates using only well data
- Visual tools provide increased ability to understand sites and communicate to project stakeholders

Why do you need confirmation borings?

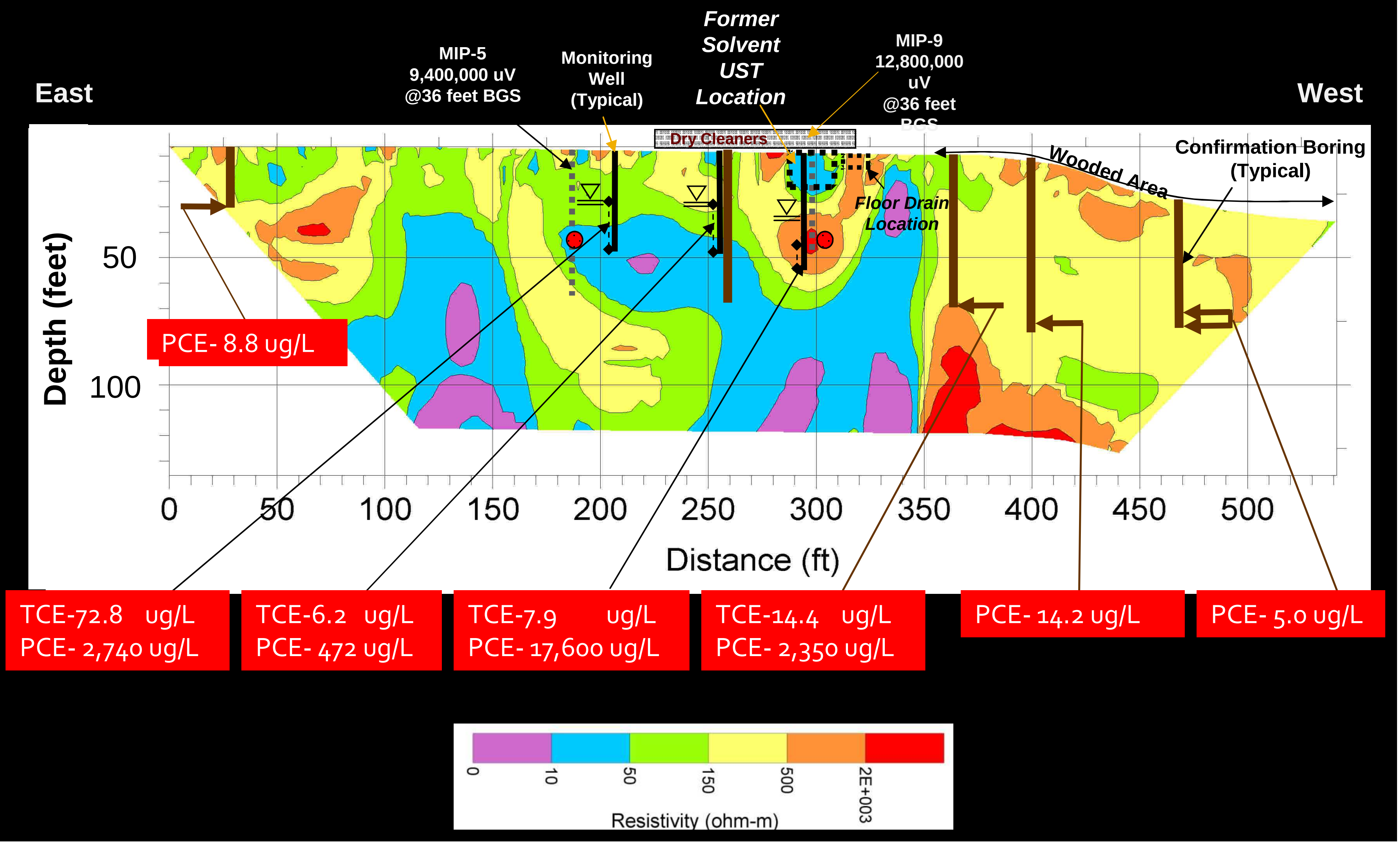
- Every site is different- there are infinitesimal combinations of lithology, pore fluids, pore structure, contamination, and previous remediation attempts.
- We don’t have a “magic” resistivity scale that categorizes every site.
- Images MUST be calibrated in order to provide the best interpretation.

Case Studies

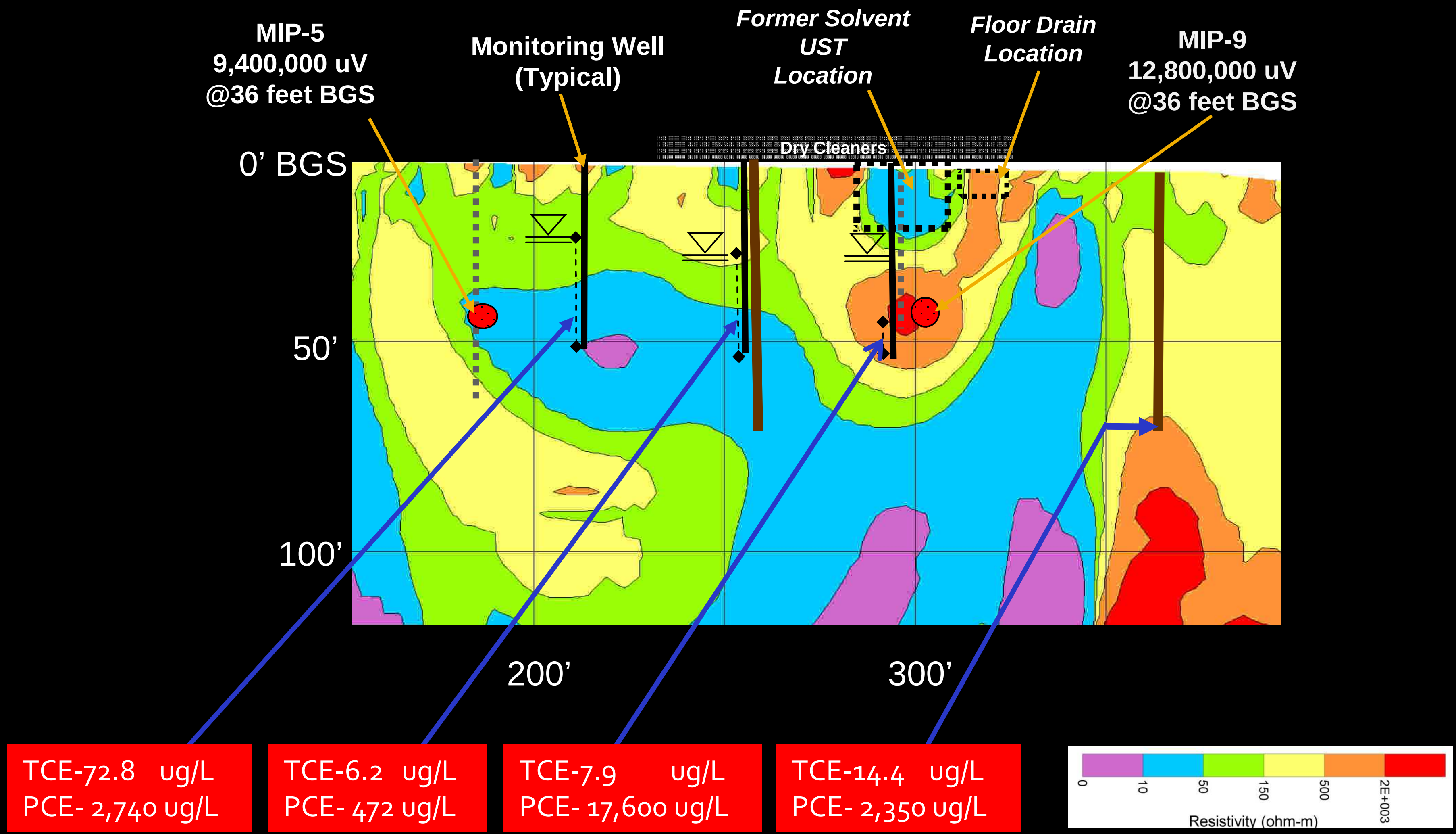
Locating DNAPLs in Hard Rock Geology Using GeoTrax Survey™ Subsurface Imaging

Dry Cleaners Site – PCE and TCE

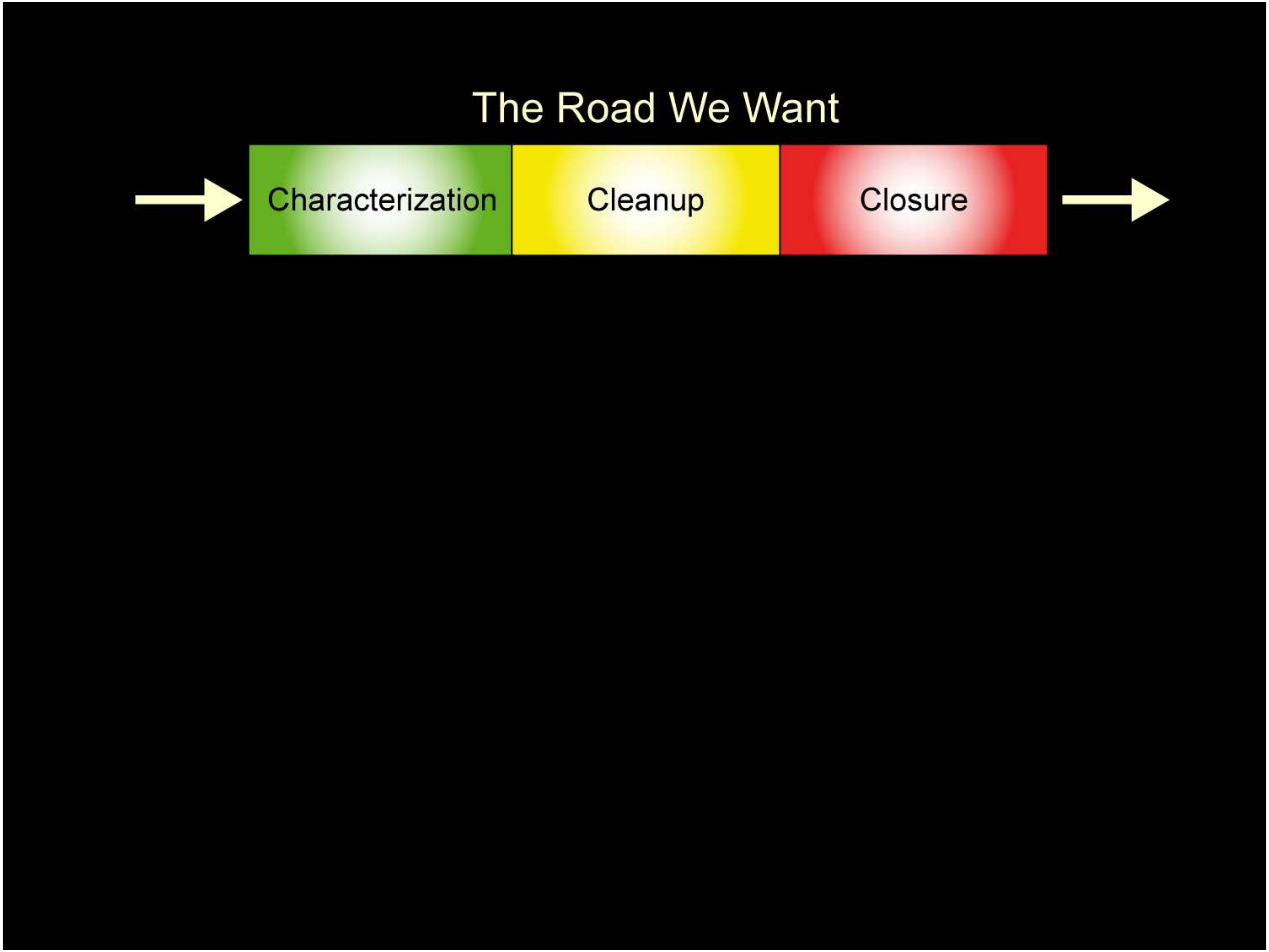
Case Study - Dry Cleaner Site with TCE & PCE in Sands/Clays Overlying Bedrock

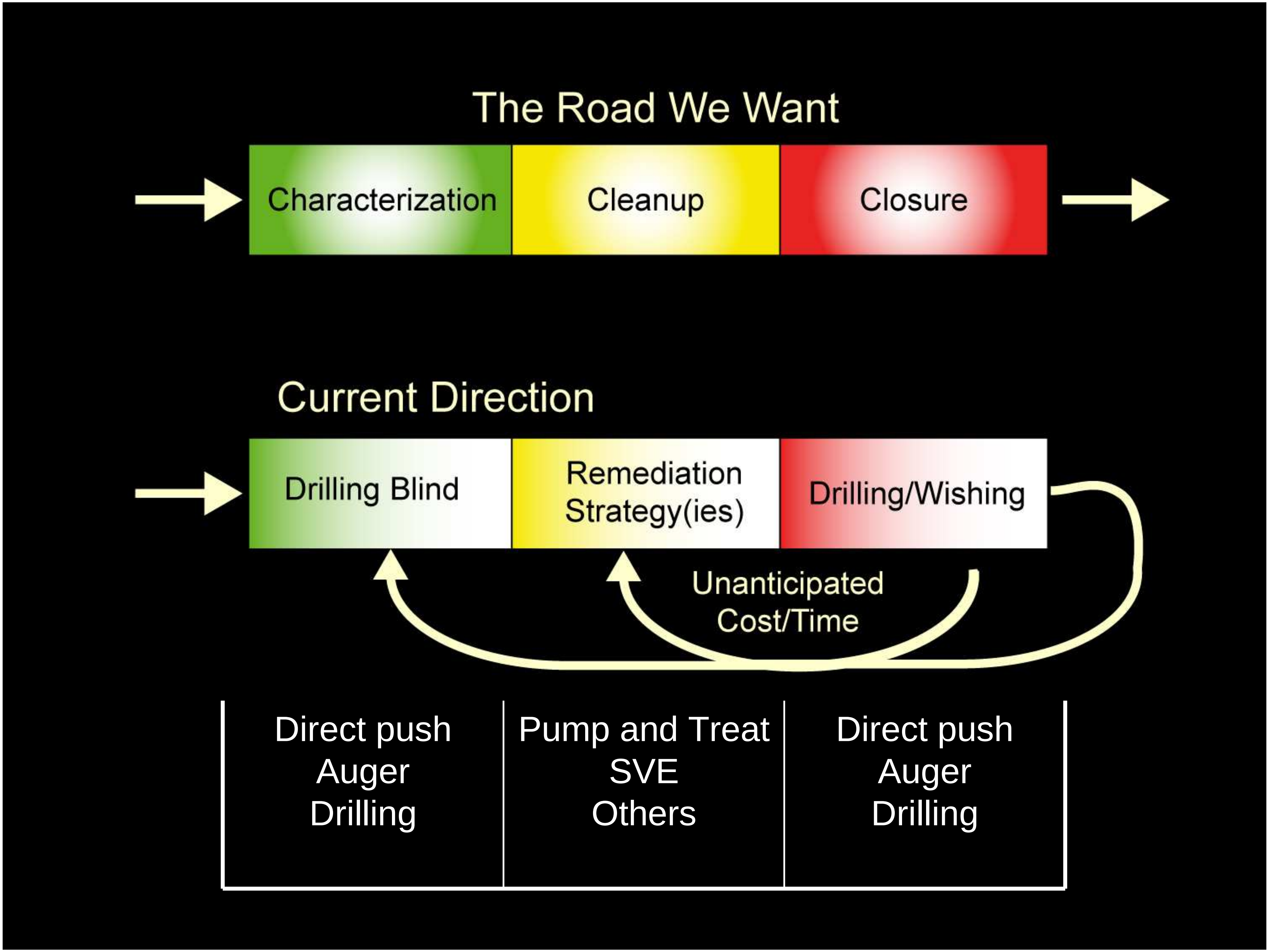


Case Study - Dry Cleaner Site with TCE & PCE in Sands/Clays Overlying Bedrock - Zoomed



Groundwater Sampling Results


The Road We Want
Characterization
Cleanup
Closure


The Road We Want
Characterization
Cleanup
Closure
Current Direction
Drilling Blind
Remediation Strategy(ies)
Drilling/Wishing
Unanticipated Cost/Time
Direct push
Auger
Drilling
Pump and Treat
SVE
Others
Direct push
Auger
Drilling

The Road We Want

Possible Direction

High Res. ERI w/ confirmation drilling	Direct heating Surfactant Flush Dig and Haul Others	High Res. ERI w/ confirmation drilling

Moral of This Story:

Stop Drilling Blind!

THANK YOU!
Questions?

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