Utilizing Electrical Hydrogeology to Create More Meaningful Conceptual Site Models (CSMs)

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Aestus

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Executive Summary

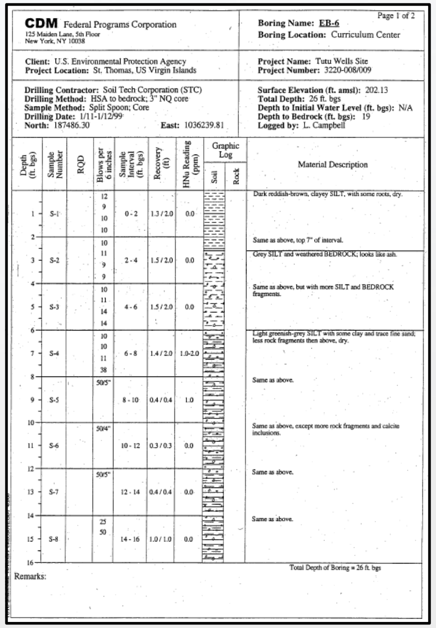
I. What is the Industry Standard for Data Density?

II. Increasing Data Density with Electrical Hydrogeology

III. Case Study: DNAPL in fractured rock

IV. Benefits of Electrical Hydrogeology

The Common Approach to CSM Development



CDM Federal Programs Corporation
125 Maiden Lane, 5th Floor
New York, NY 10038

Page 1 of 2
Boring Name: EB-6
Boring Location: Curriculum Center

Client: U.S. Environmental Protection Agency
Project Location: St. Thomas, US Virgin Islands

Project Name: Tutu Wells Site
Project Number: 3220-008/009

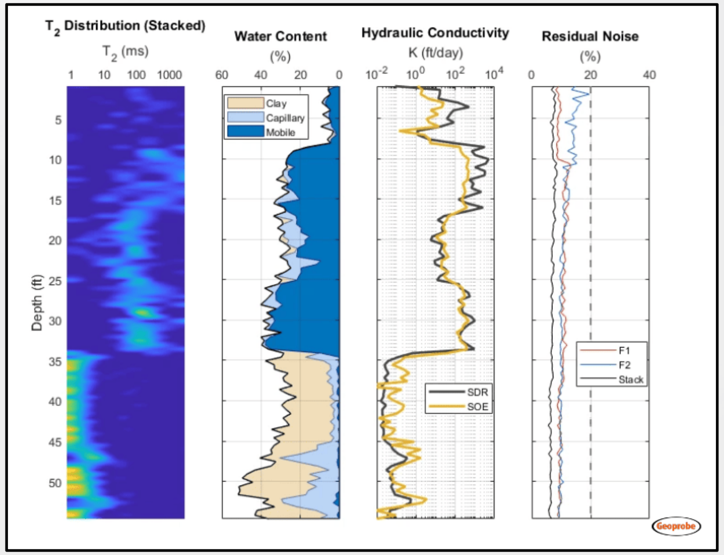
Drilling Contractor: Soil Tech Corporation (STC)
Drilling Method: HSA to bedrock; 3" NQ core
Sample Method: Split Spoon; Core
Drilling Date: 1/11-1/12/99
North: 187486.30 **East:** 1036239.81

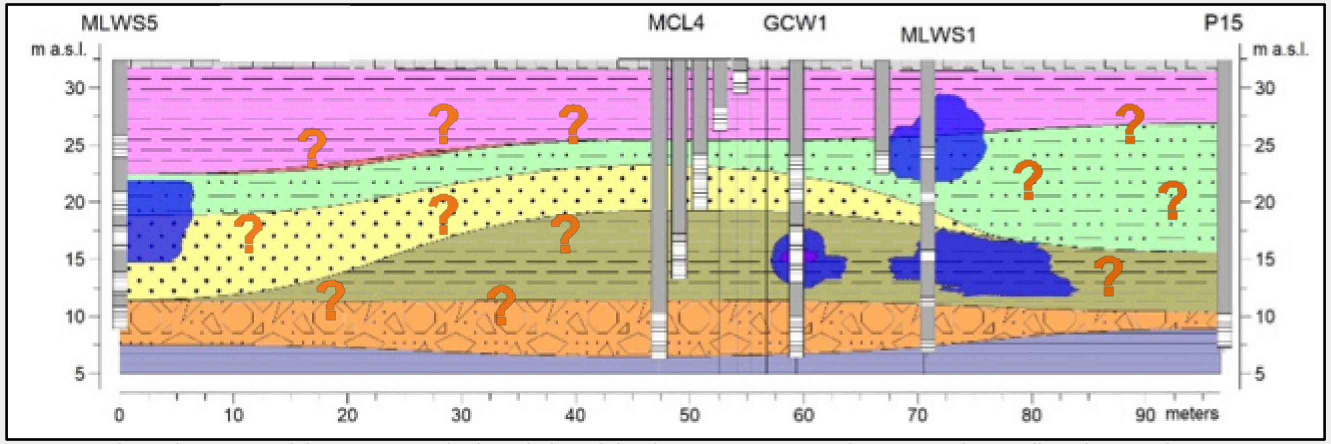
Surface Elevation (ft. amsl): 202.13
Total Depth: 26 ft. bgs
Depth to Initial Water Level (ft. bgs): N/A
Depth to Bedrock (ft. bgs): 19
Logged by: L. Campbell

Depth (ft. bgs)	Sample Number	RQD	Blows per 6 inches	Sample Interval (ft. bgs)	Recovery (ft)	HNu Reading (ppm)	Material Description
1	S-1		12 9 10 10	0 - 2	1.3 / 2.0	0.0	Dark reddish-brown, clayey SILT, with some roots, dry. Same as above, top 7" of interval.
3	S-2		10 11 9 9	2 - 4	1.5 / 2.0	0.0	Grey SILT and weathered BEDROCK; looks like ash.
5	S-3		10 11 14 14	4 - 6	1.5 / 2.0	0.0	Same as above, but with more SILT and BEDROCK fragments.
7	S-4		10 10 11 38	6 - 8	1.4 / 2.0	1.0-2.0	Light greenish-grey SILT with some clay and trace fine sand; less rock fragments then above, dry.
9	S-5		50/5"	8 - 10	0.4 / 0.4	1.0	Same as above.
11	S-6		50/4"	10 - 12	0.3 / 0.3	0.0	Same as above, except more rock fragments and calcite inclusions.
13	S-7		50/5"	12 - 14	0.4 / 0.4	0.0	Same as above.
15	S-8		25 50	14 - 16	1.0 / 1.0	0.0	Same as above.

Total Depth of Boring = 26 ft. bgs

Remarks:





Ciampi et al, 3D dynamic model empowering the knowledge of the decontamination mechanisms and controlling the complex remediation strategy of a contaminated industrial site,Science of The Total Environment,V 793,2021

Limited Datasets In 3D Are Still Limited

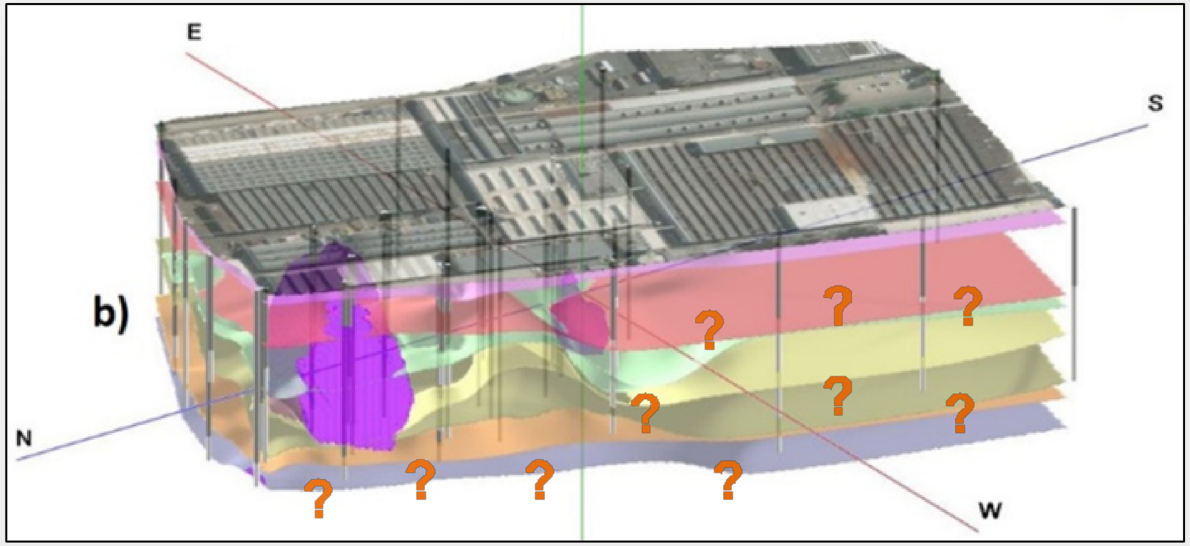
- Modelling software typically used for interpolating sparse data
- Does not solve low data density problem

Site Area: 120,000 m^2

56 boreholes/wells to ~30 m

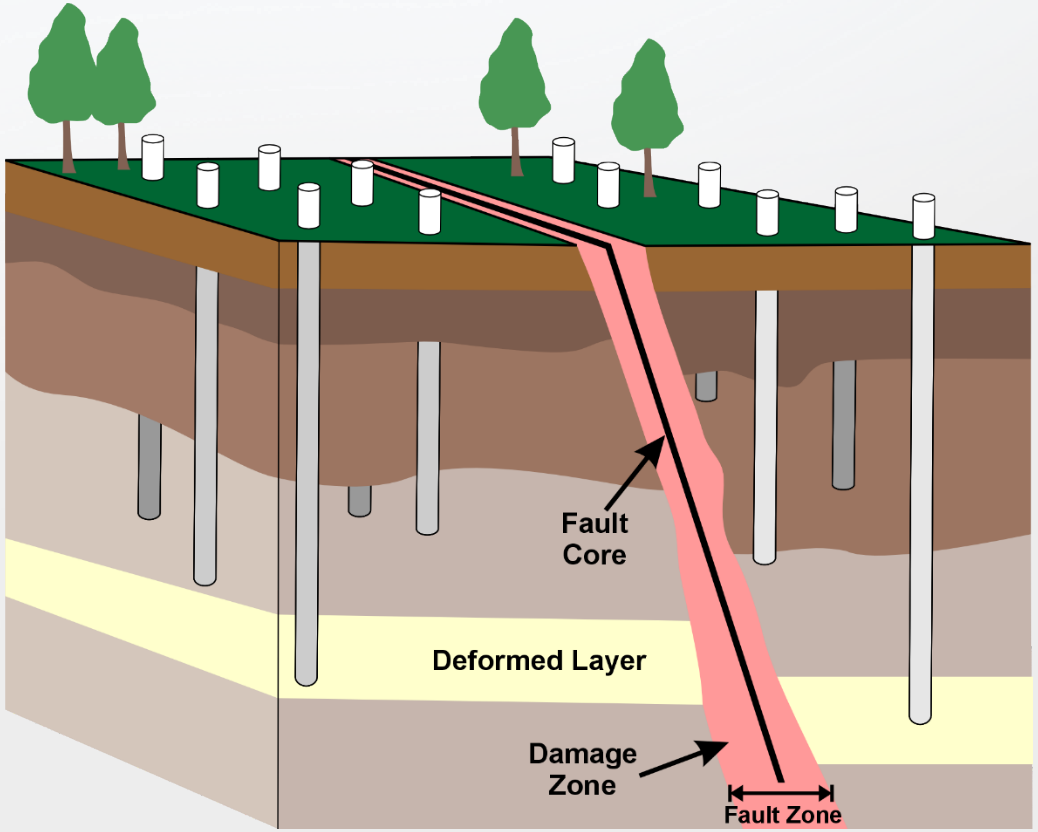
106 piezometers

<u><1% of 3D domain is sampled</u>



Ciampi et al, 3D dynamic model empowering the knowledge of the decontamination mechanisms and controlling the complex remediation strategy of a contaminated industrial site, Science of The Total Environment, V 793,2021

Vertical Data Inherently Limited



- "You can't find a line with a stick"
- CSMs typically built from limited number of vertical wells
- Attempting to comprehend large volumes of the subsurface based on small discrete samples
- *Limited information about subsurface conditions leads to failed remediation attempts*

Brief Overview of Scan First Approach

Defined Process to Integrate Data Sets

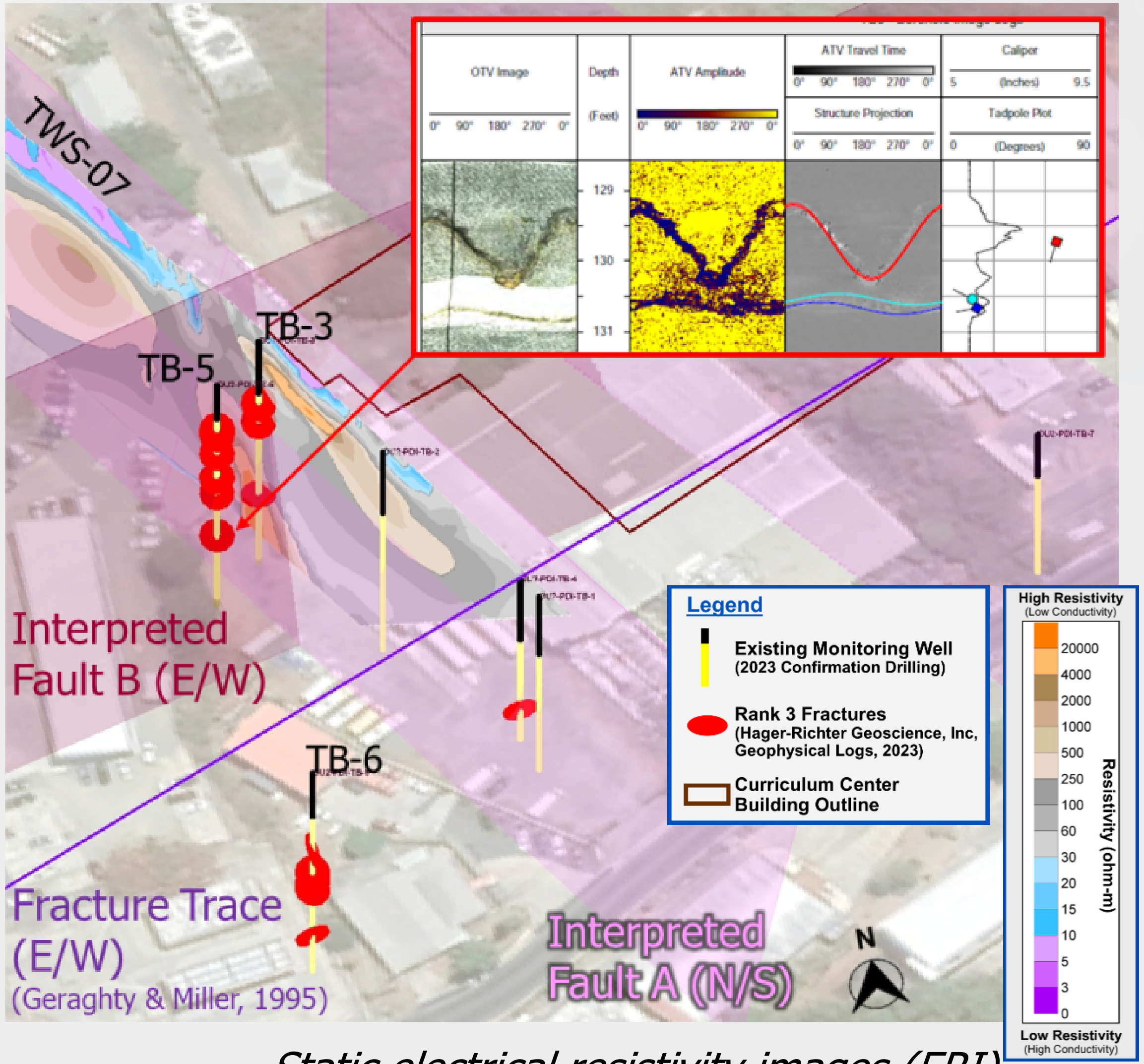
Traditional Hydrogeology

+

Electrical Imagery/Visualization/
Targeted Drilling

=

Electrical Hydrogeology



Static electrical resistivity images (ERI)

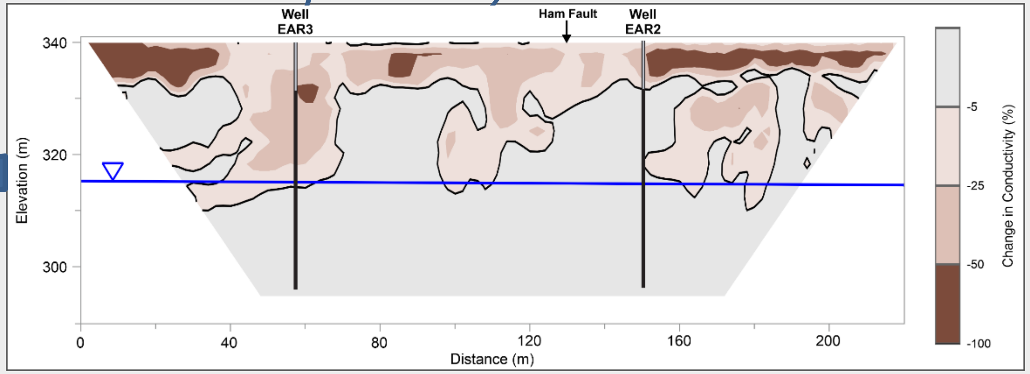
Monitoring Sites with "Planes" Instead of "Lines"

Monitor with a well
(<1 m of subsurface laterally)

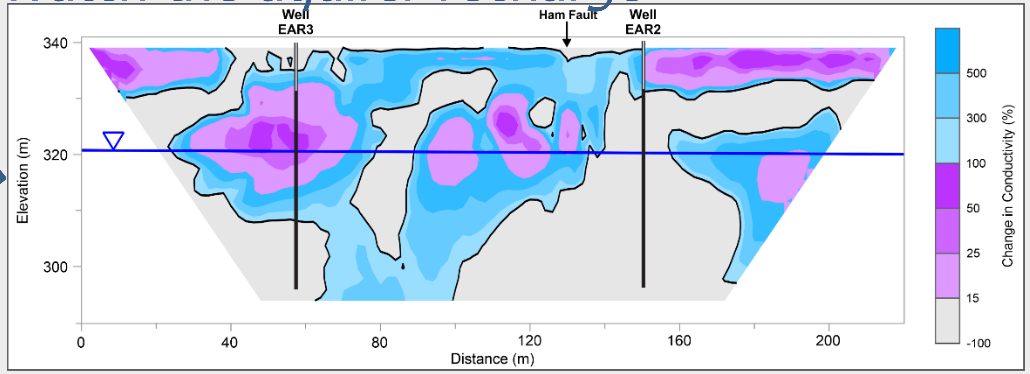
Or

Monitor a Plane
(~220 m of subsurface sampled)

Watch the aquifer dry



Watch the aquifer recharge

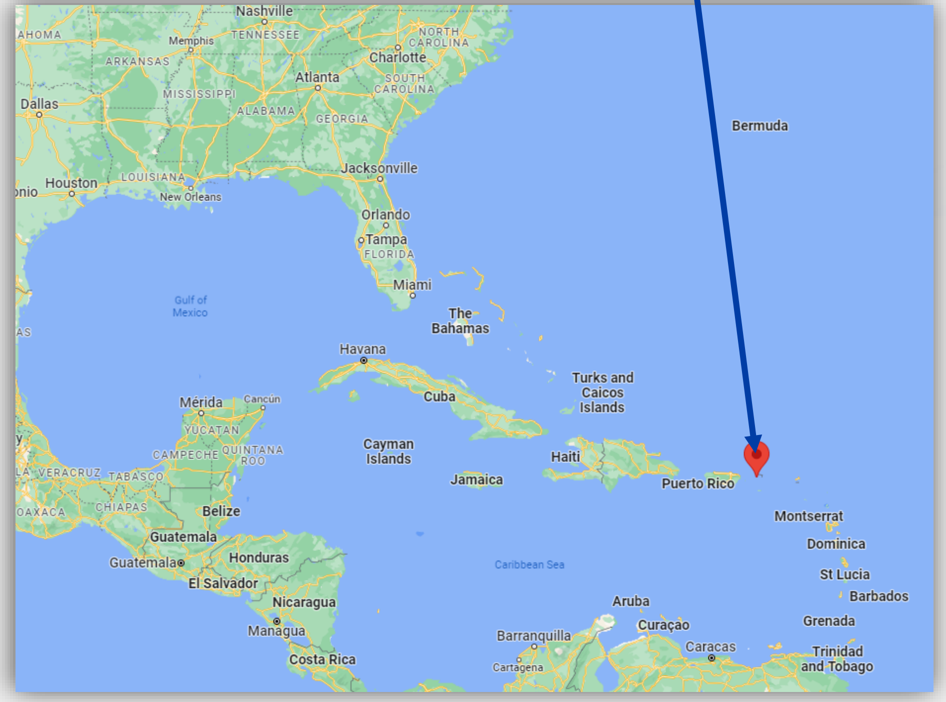


Temporal electrical resistivity images (TERI)

EPA Superfund Site, Tutu Wellfield

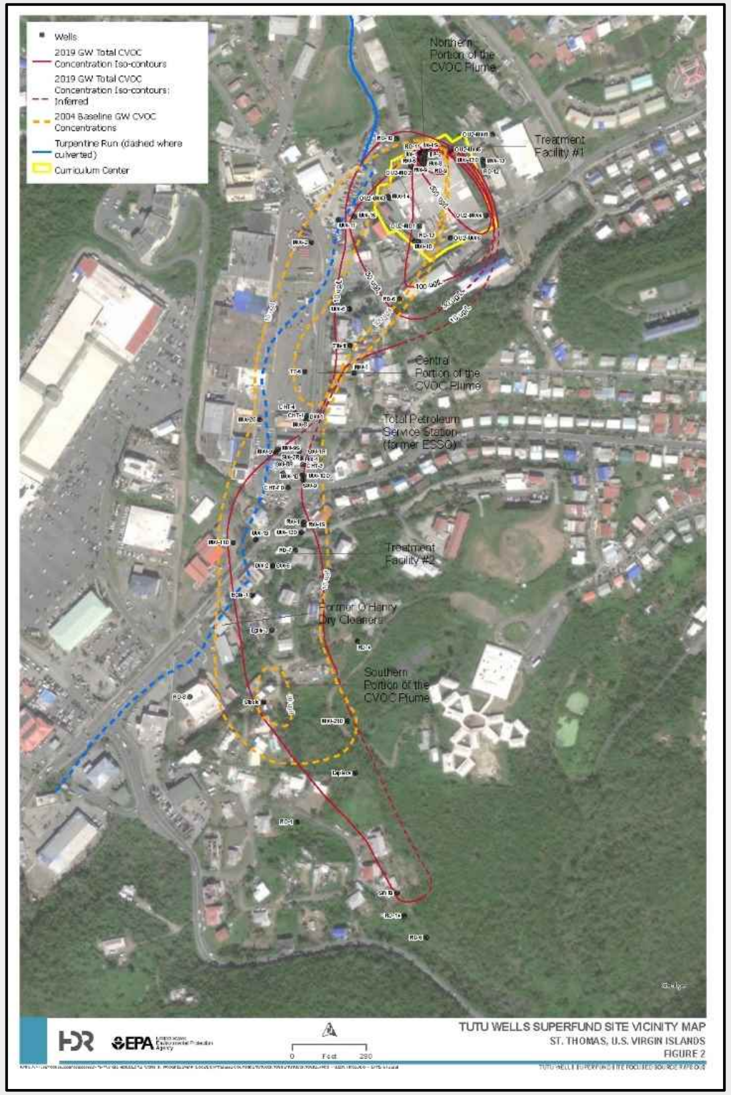
- Location: St. Thomas, US VI
- Geology: fractured, volcanic bedrock
- Source: PCE
  (manufacturing facility w/ dry cleaner)
- Problem: source zone still not fully delineated

Tutu Wellfield
Superfund Site



Site History

- Multiple investigations at the source area since 1987
- GW impacted with CVOCs as deep as ~140′ BGS
- Fractured igneous bedrock site
- GW flow to southwest
- SVE & groundwater extraction and treatment system began in 2004



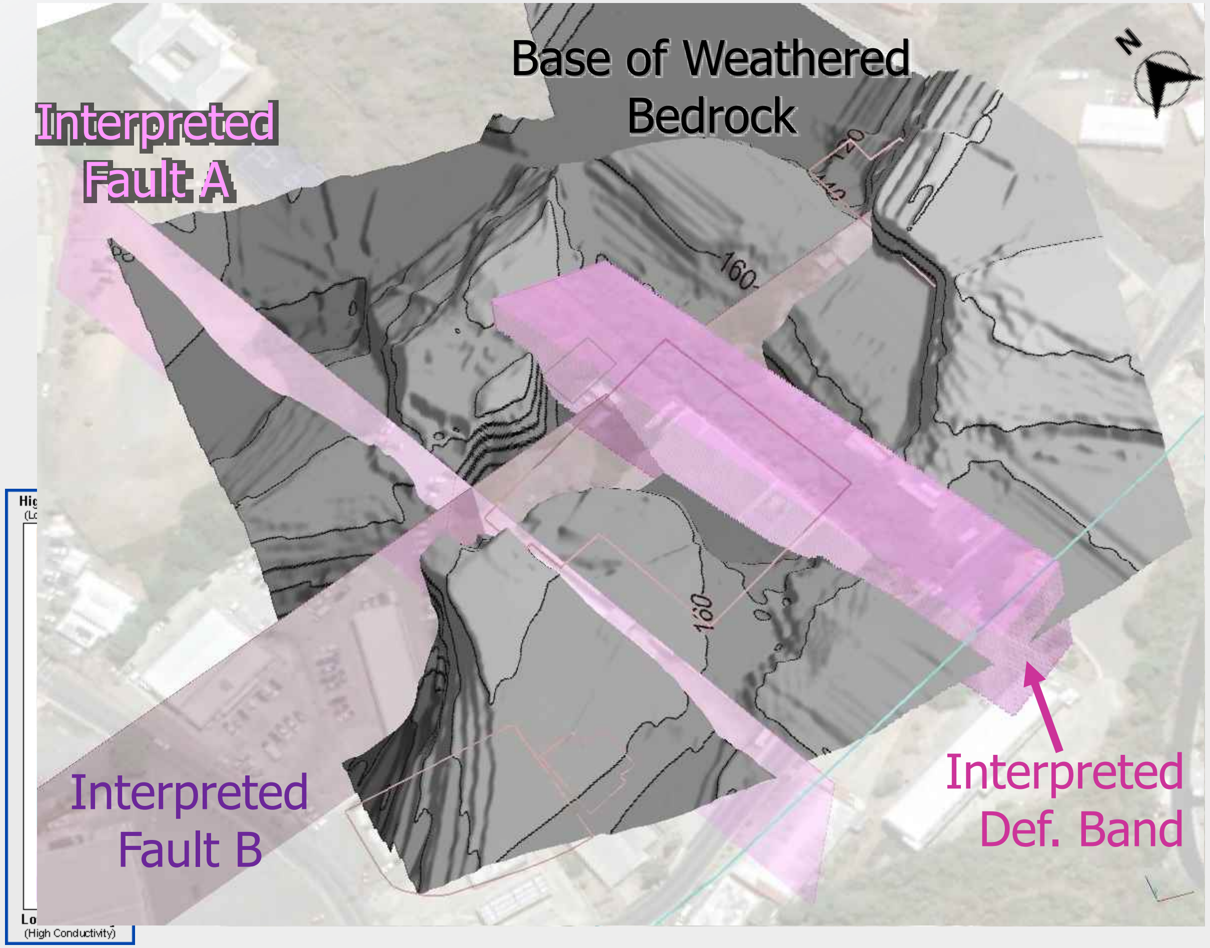
2019 CVOC Groundwater Plume Map by HDR

Island Site Logistics

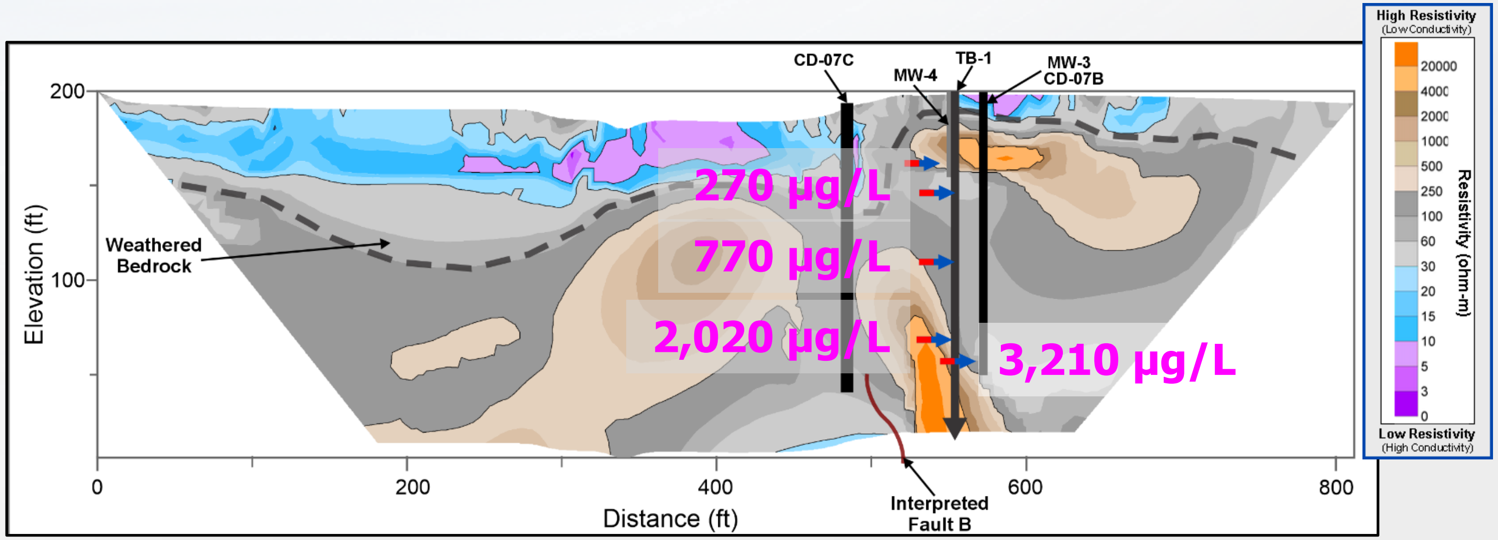
Key Hydrogeologic CSM Updates

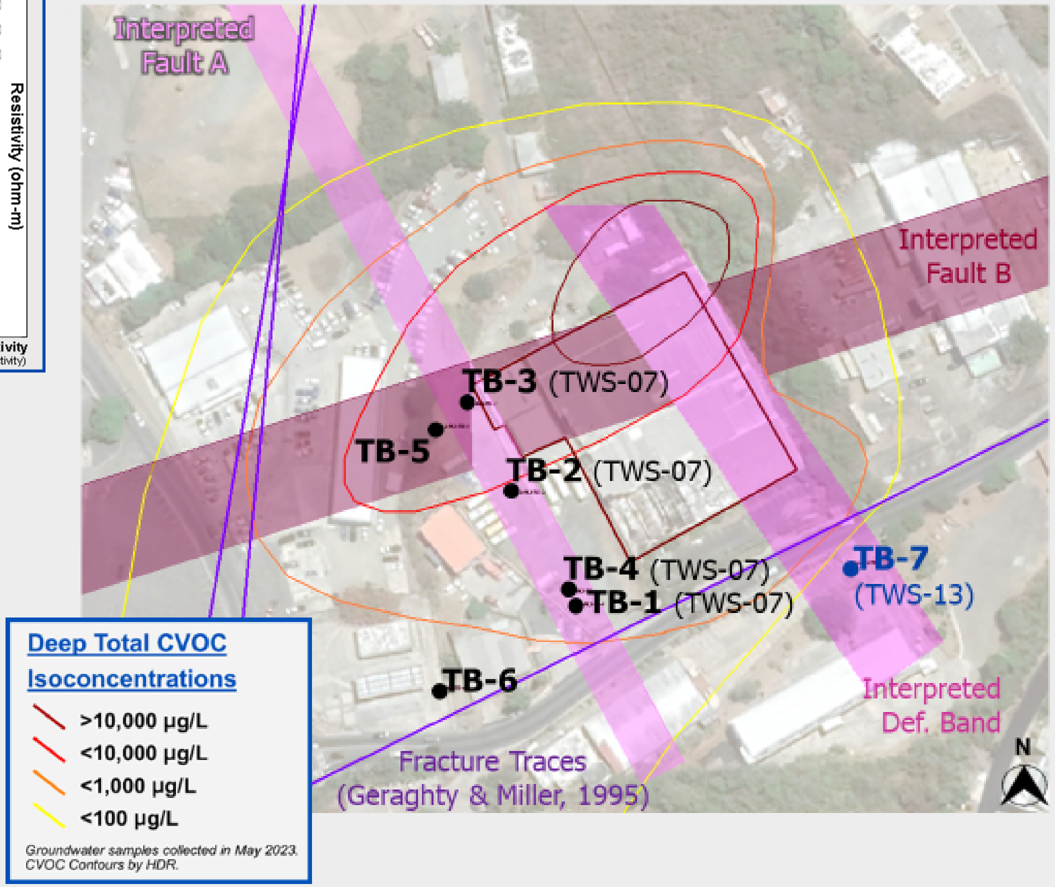
Delineating preferential flowpaths

- ✓ GeoTrax Electrical Imagery / Two faults
- ✓ Existing boring/well data / Deformation band
- ✓ Team of "electrical interpreters" / Modeled bedrock surface



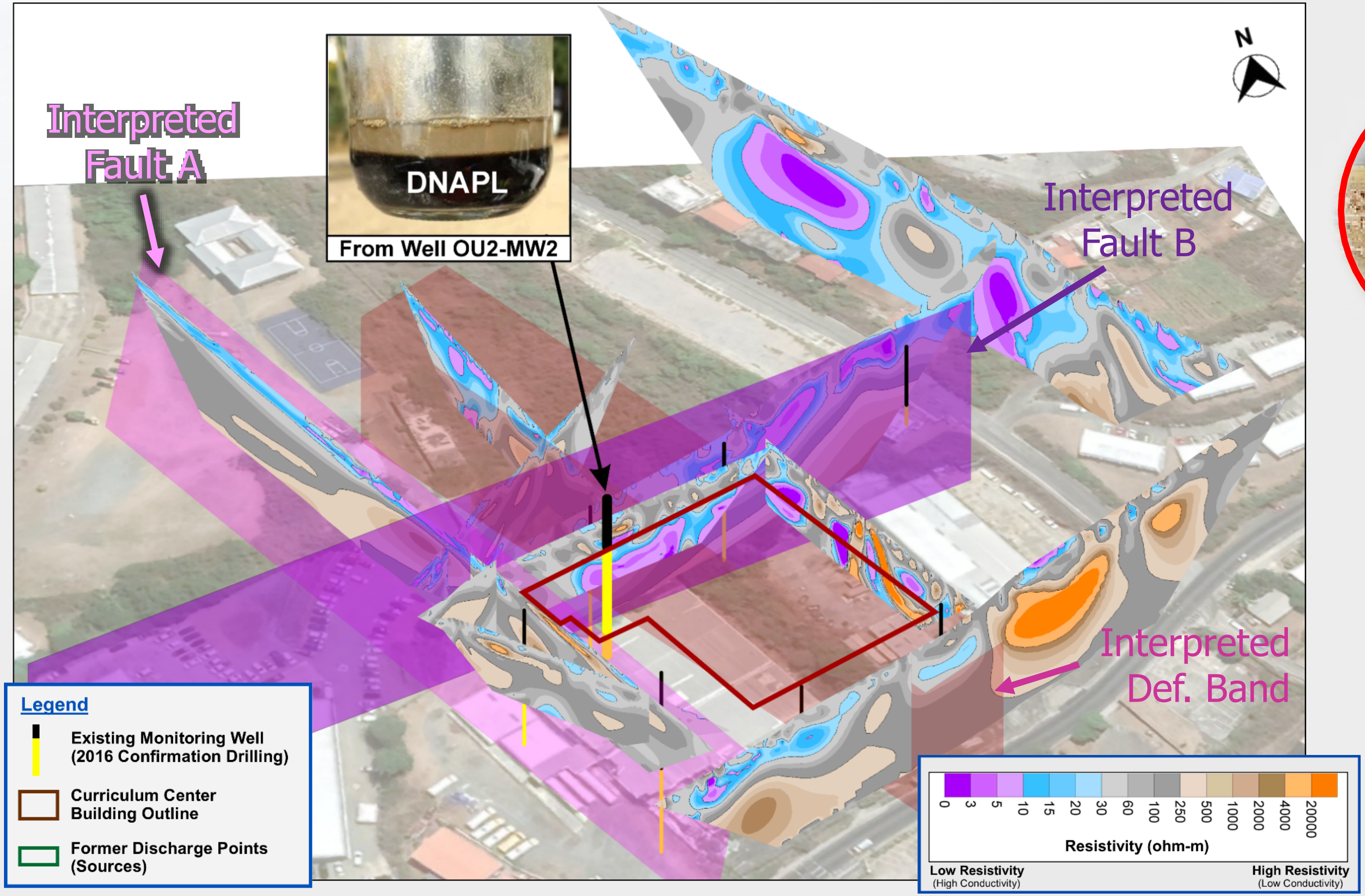
Confirmed Geologic Features





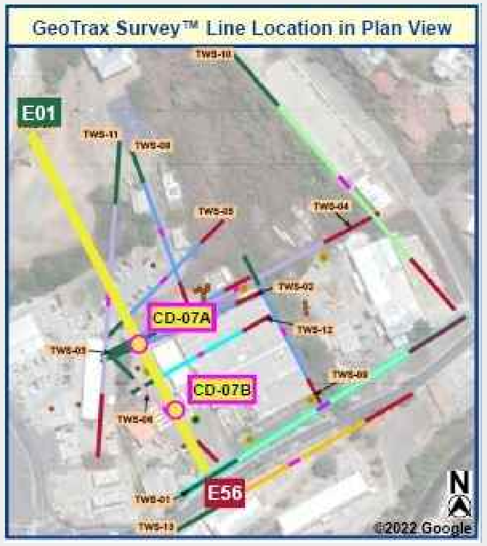
- Increased data density enables discovery of key geologic features
- Delineating these features informs contaminant distribution and migration

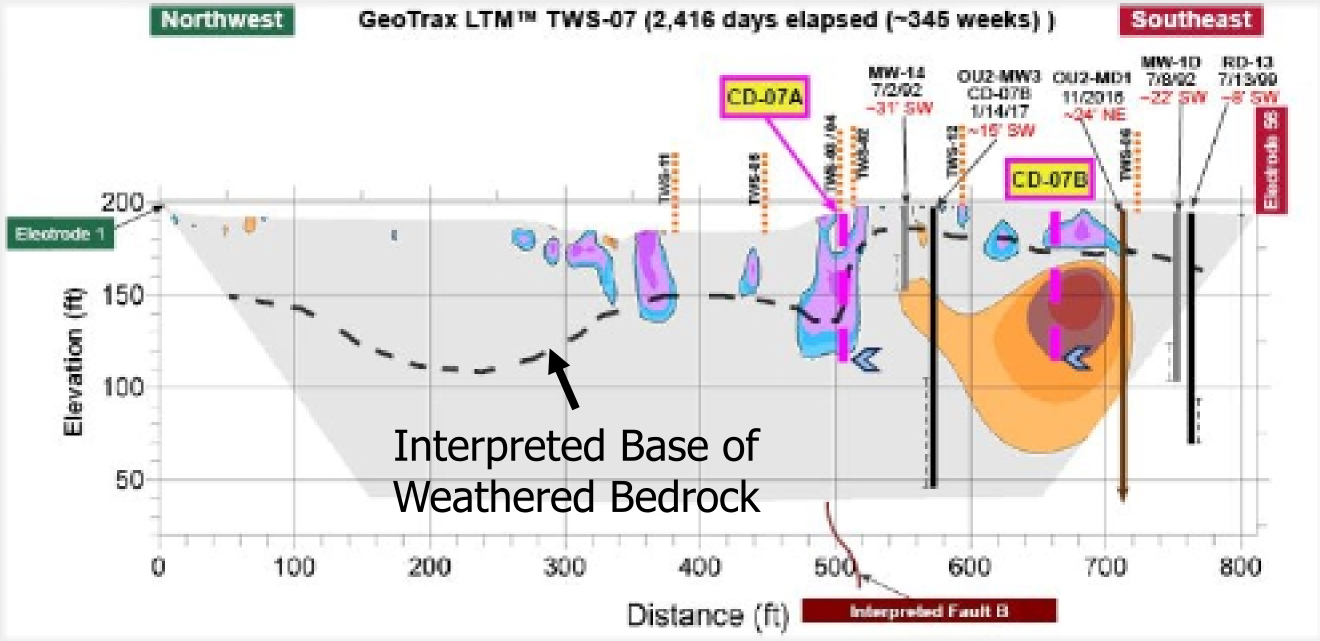
Using Electrical Imagery to Target Drilling

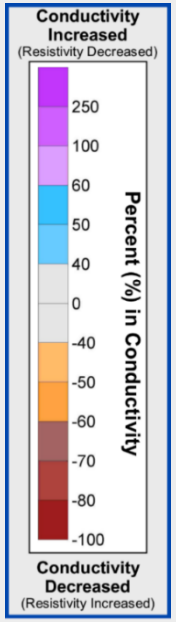


Benefits of Temporal Imaging

- Assessment of changes above/below weathered bedrock surface (how is fault functioning?)
- Changes above weathered bedrock indicate where flux occurring
- Provided valuable insight for remediation team







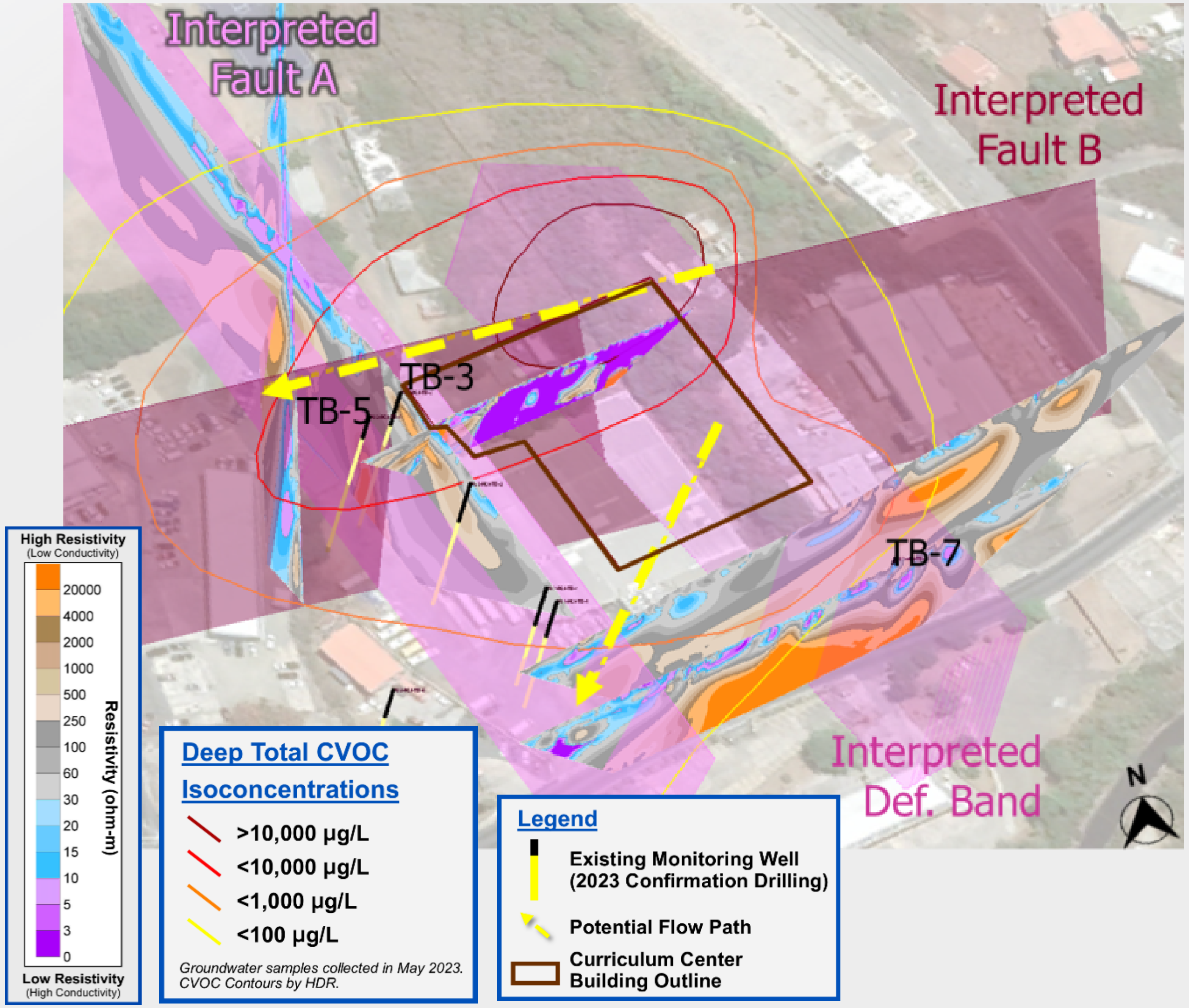
Advantages to Utilizing Electrical Hydrogeology

- ✓ Targeted drilling located previously unknown DNAPL source zones
- ✓ GeoTrax Survey™ effectively imaged key geologic structures
- ✓ Preferential contaminant migration pathways delineated
- ✓ HDR Proj. Manager: *Without Aestus' GeoTrax CSM+™ process and integral subsurface imaging data, we would not have been able to fully characterize the fractures, faults, and deformation zone where most of the groundwater flow and contaminant migration is occurring on our site. These results allowed us to target monitoring and extraction wells in the high-flow pathways so that remediation can be more effective.* – Demetrios Klerides, P.E., BCEE, Senior Project Manager / Professional Associate at HDR, Inc

CSM based from electrical imagery integration being used to guide on-going site characterization and remedial design

Building CSMs via Electrical Hydrogeology

- CSM built on field data, not interpolation
- Doesn't rely solely on vertical tools
  - Borings/Wells are ineffective
  - Base of site often undefined
- Up-leveling your data density at any stage adds significant value
- Temporal monitoring (2D planes) of subsurface changes informs remediation efforts



***Goal:** Focused remediation in less time at lower cost*

When Should You Scan First?

- On bedrock sites
- Where flow paths are highly preferential and difficult to target with borings
- Traditional methods cannot be used (e.g. through buildings or rugged terrain/environments)
- Multiple remedies have been attempted in the past and regulatory goals are still not being met
- Thermal remediation being considered

Acknowledgements

- EPA Region 2
- HDR, Inc.
- Aestus Field Team
- Aestus Interpretation & Visualization Team

QUESTIONS?

Thank you for your time!

<u>Contact Us to Learn More:</u>

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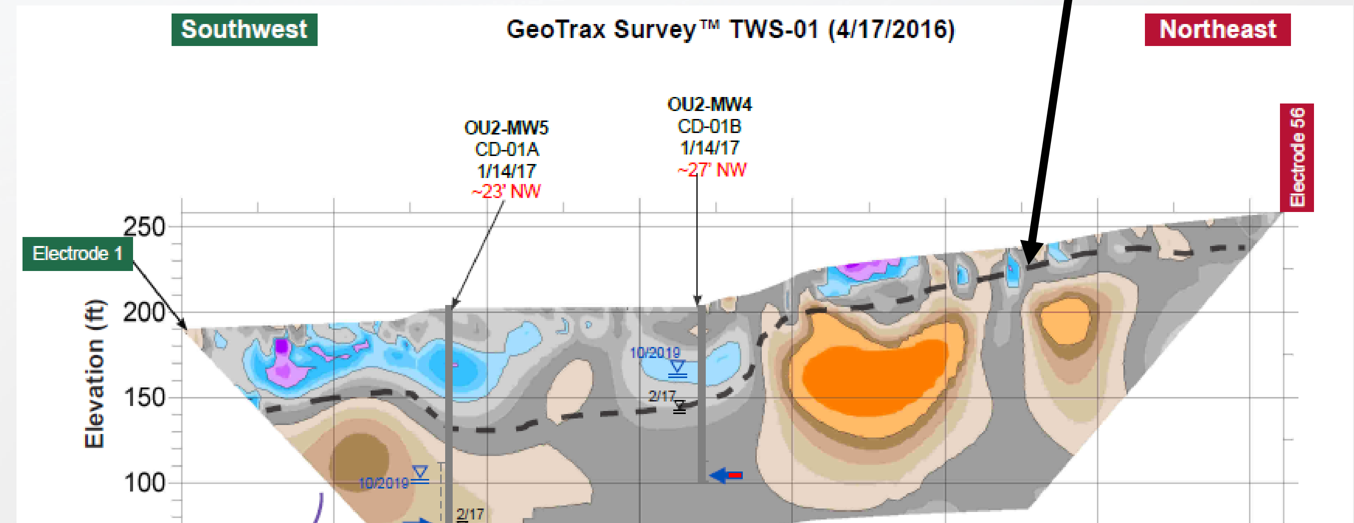
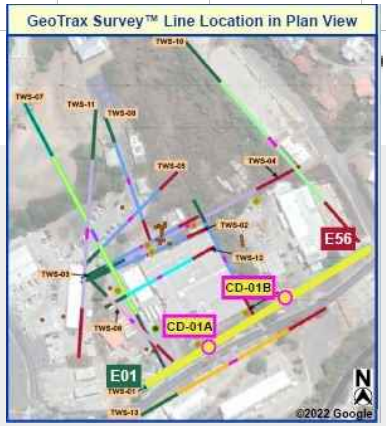
Aestus

III. Case Study: DNAPL in Igneous Bedrock

Interpreted Geologic Features

Interpreted Base of Weathered Bedrock
(100 ohm-m contact)





Legend

Curriculum Center Building Outline

Potential Flow Path

Total CVOCs Contours

1,000 µg/L

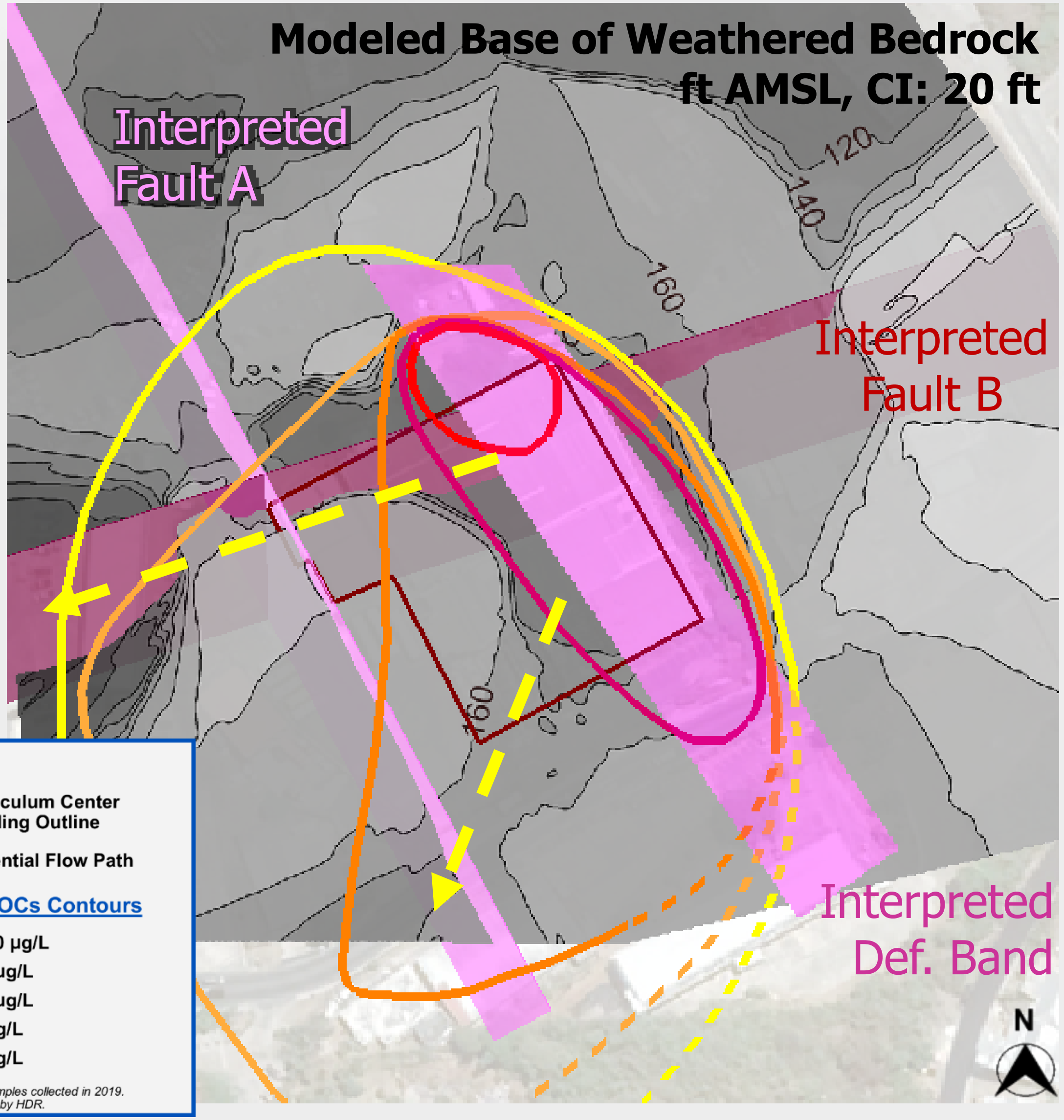
500 µg/L

100 µg/L

30 µg/L

10 µg/L

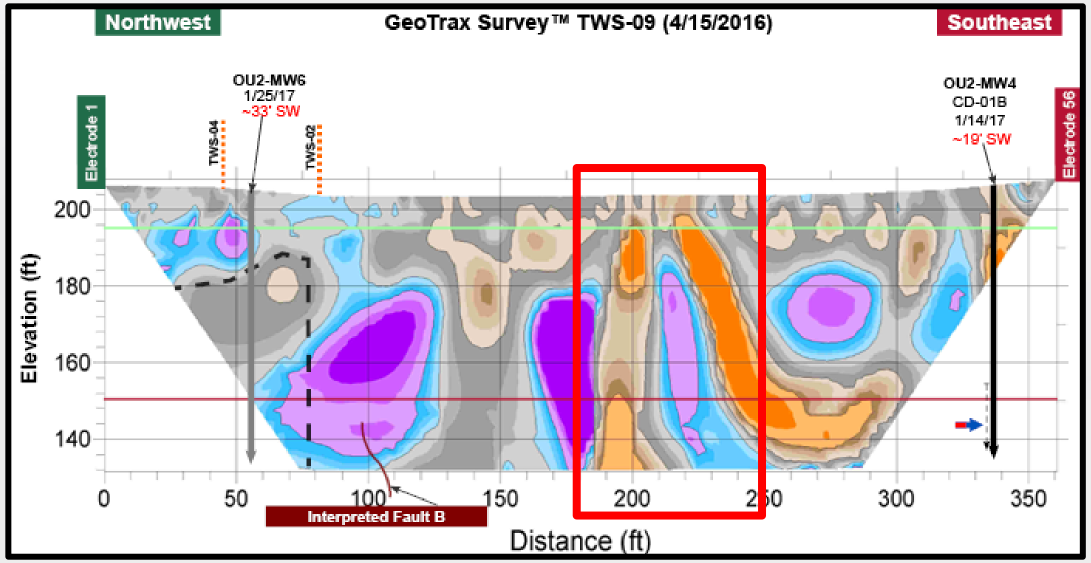
Groundwater samples collected in 2019. CVOC Contours by HDR.

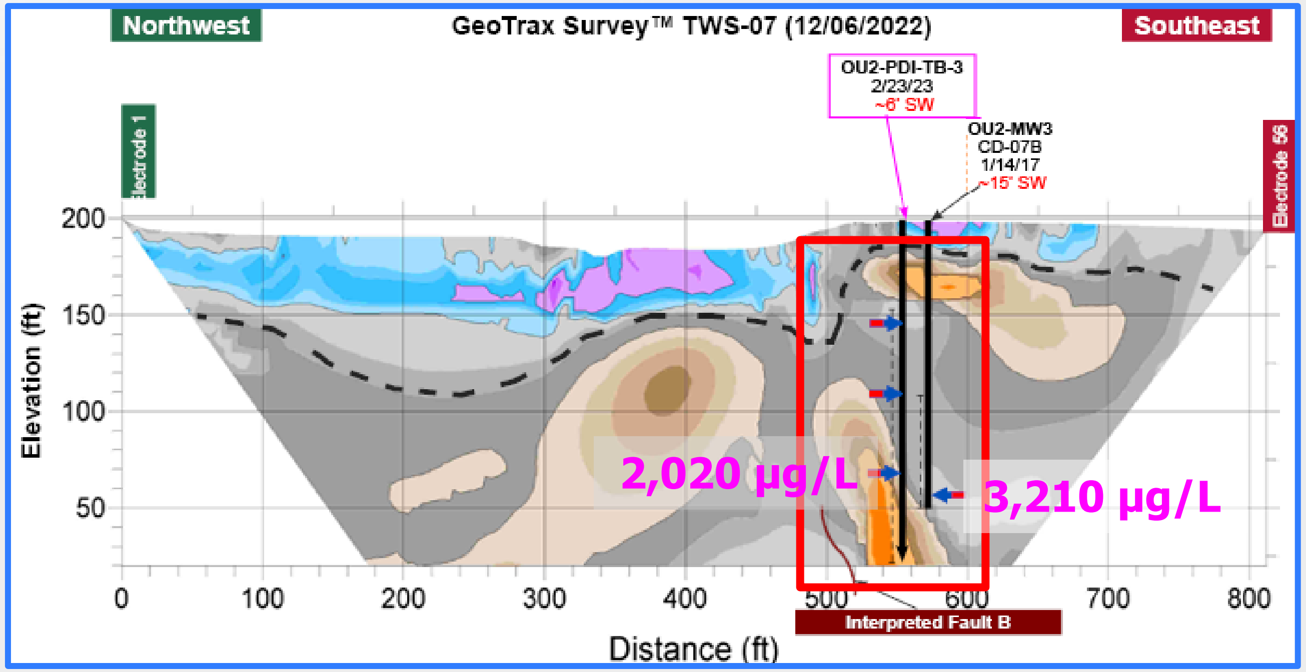


III. Case Study: DNAPL in Igneous Bedrock

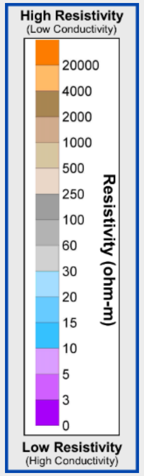
Confirmed Geologic Features

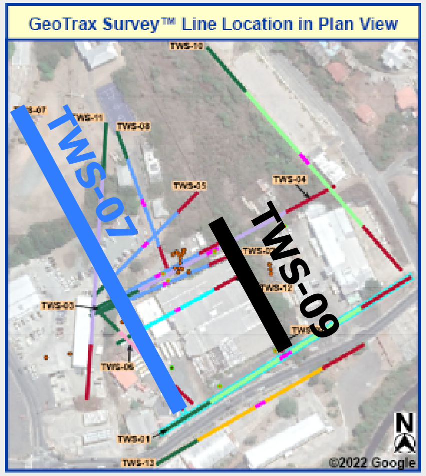
Impacted target on TWS-07 (2022) similar to electrical resistors on TWS-09 (2016)



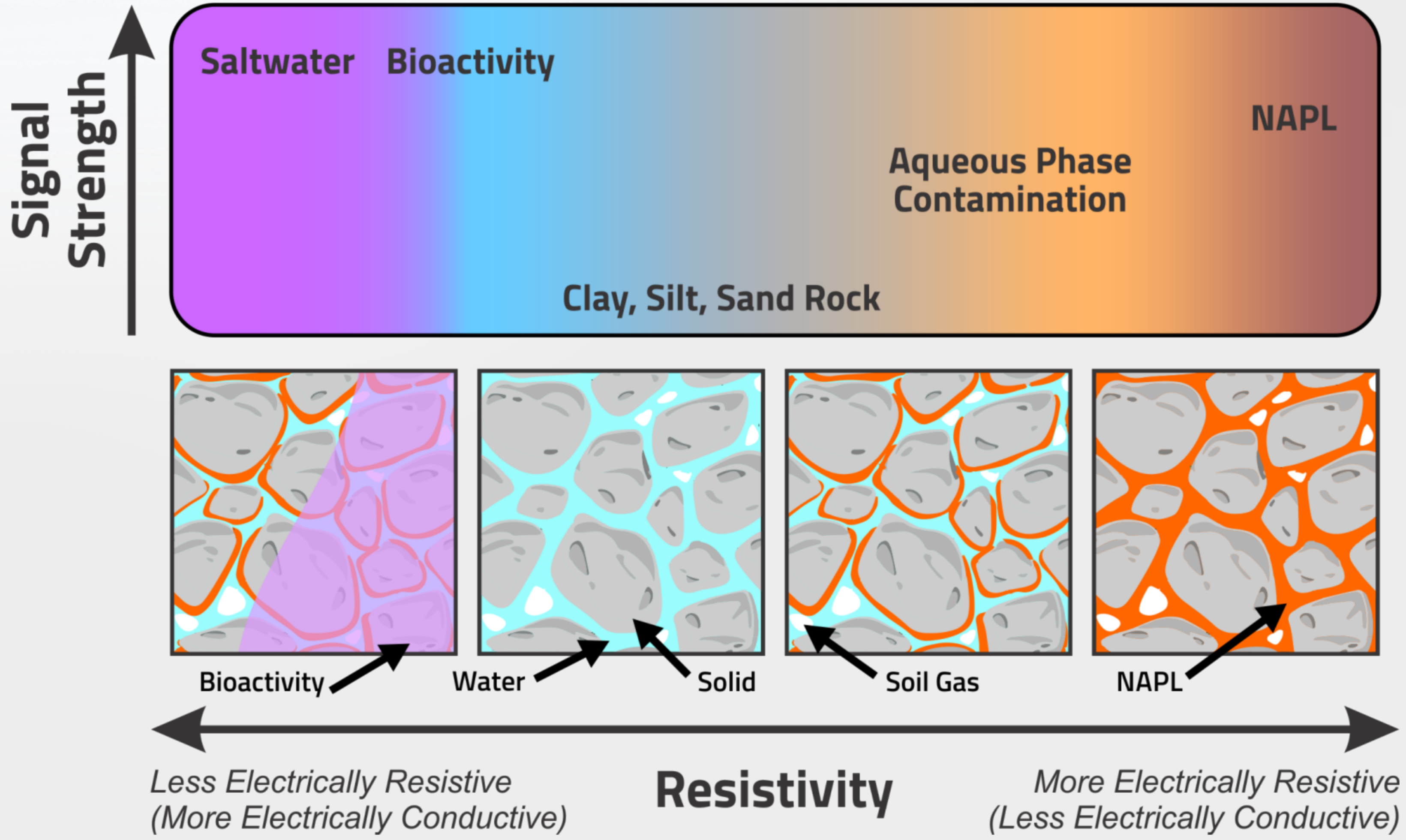


PCE
(May 2023)

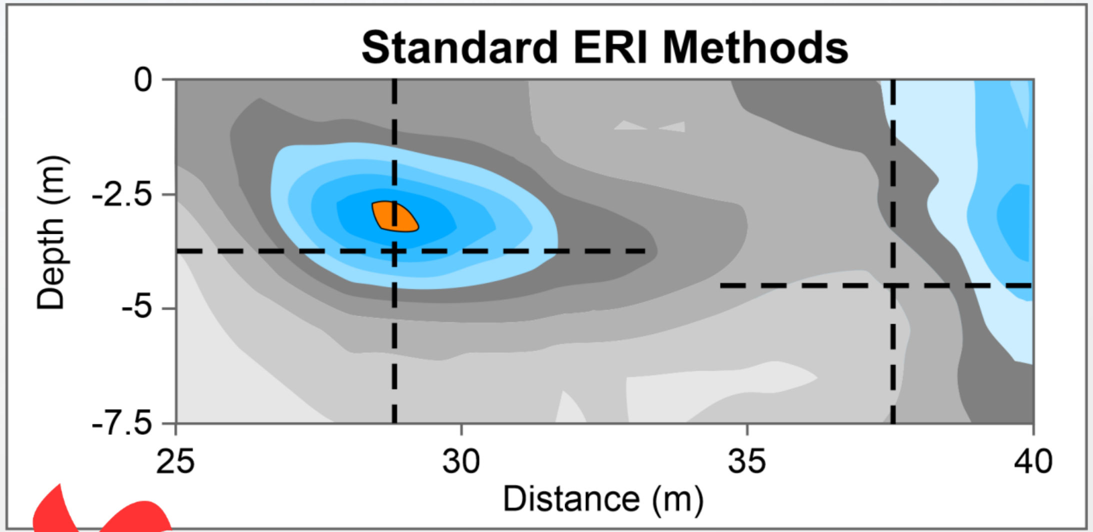


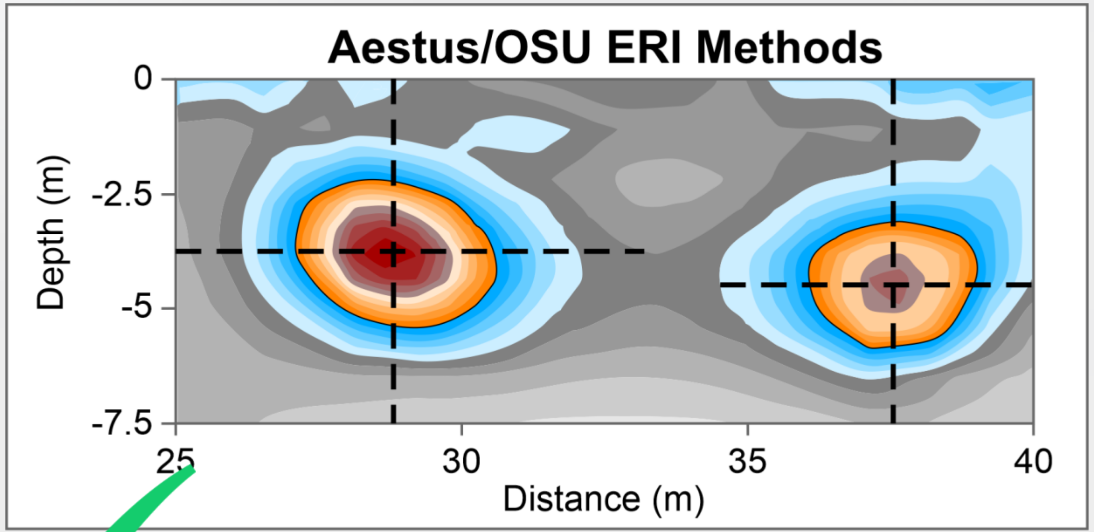


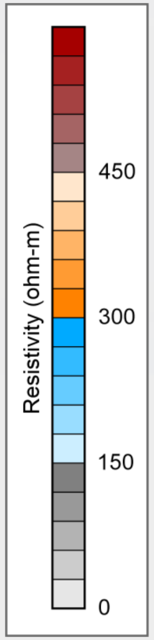
Typical Electrical Properties
Environmental Sites



Picture This: Traditional ERI vs GeoTrax Survey™







Standard ERI

Aestus GeoTrax Survey™

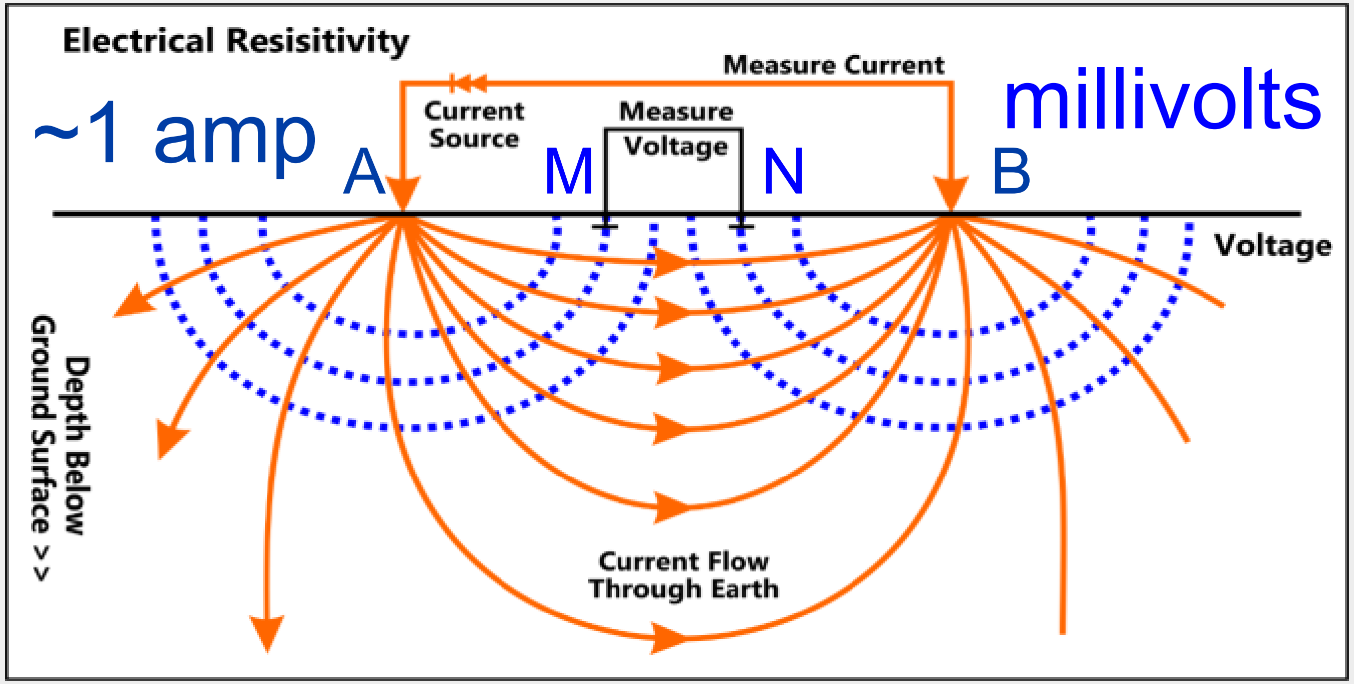
Confirmed by EPA Ada Lab
Drillable Image
Halihan et al, 2005

Same equipment

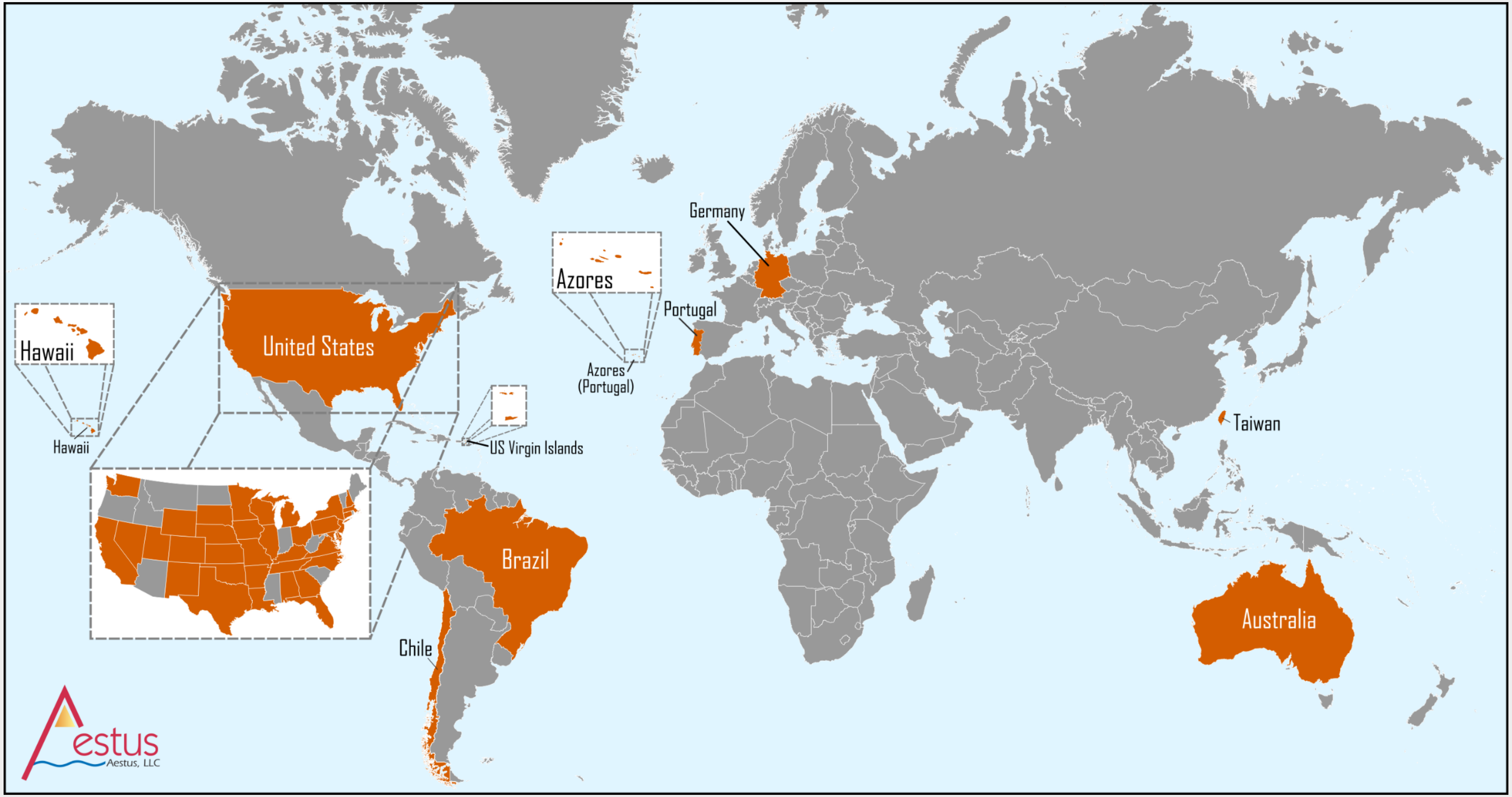
Same transect line

Electrical Resistivity Imaging (ERI) Measurements

- Measurement: electrical potential from applied current
- 4 electrodes yield 1 data point "pixel"
- Result: electrical resistivity distribution



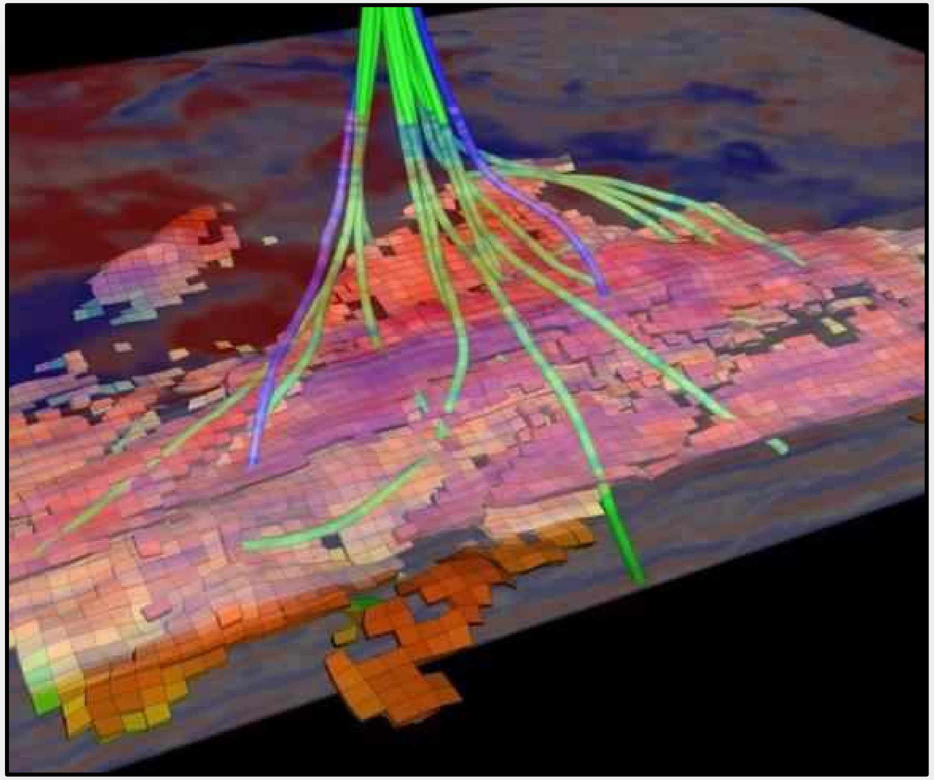
Where in the World is Aestus?



Scan and Target Approach: Aligning with Other Industries

X-ray of Skull

nydailynews.com

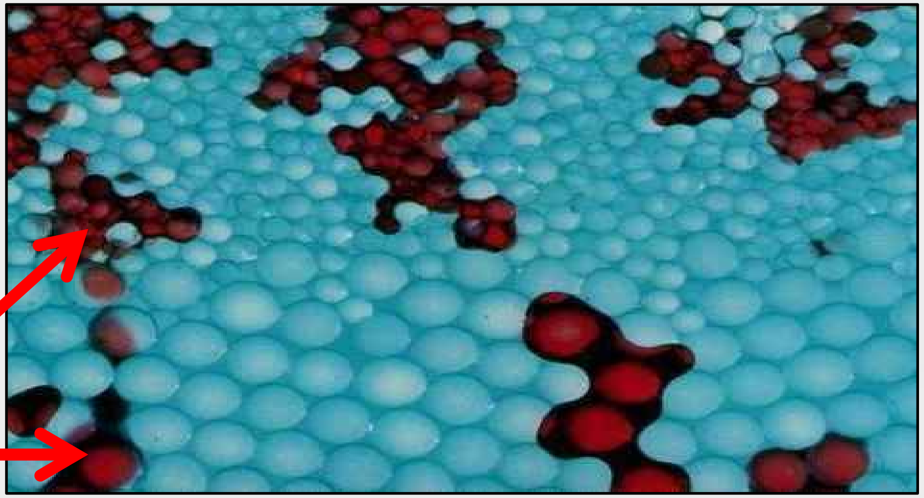


3-D Seismic North Sea

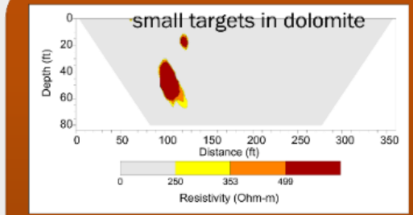
dgi.com

Unweathered NAPL Impacts

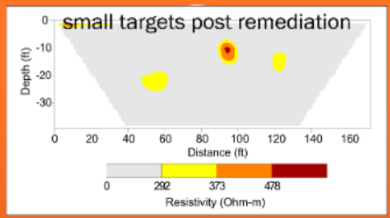
Resistive signatures of NAPLs (liquid resistors) dependent on NAPL composition and solubility



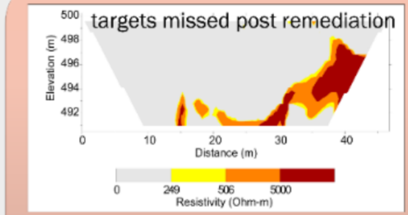
NAPL in pore space



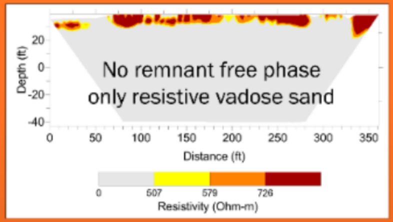
PAHs in Dolomite



Gasoline in Silty Clay



PCE In Silty Sand



TCE in Sand

Relative Solubility

	PAHs in Dolomite	Gasoline in Silty Clay	PCE In Silty Sand	TCE in Sand
Relative Solubility	1	7.5	8	54
Solubility	20 mg/l	150 mg/l	160 mg/l	1070 mg/l

Reason for Bioactivity Detection

"Nanowires"

(Electron Microscopy)