

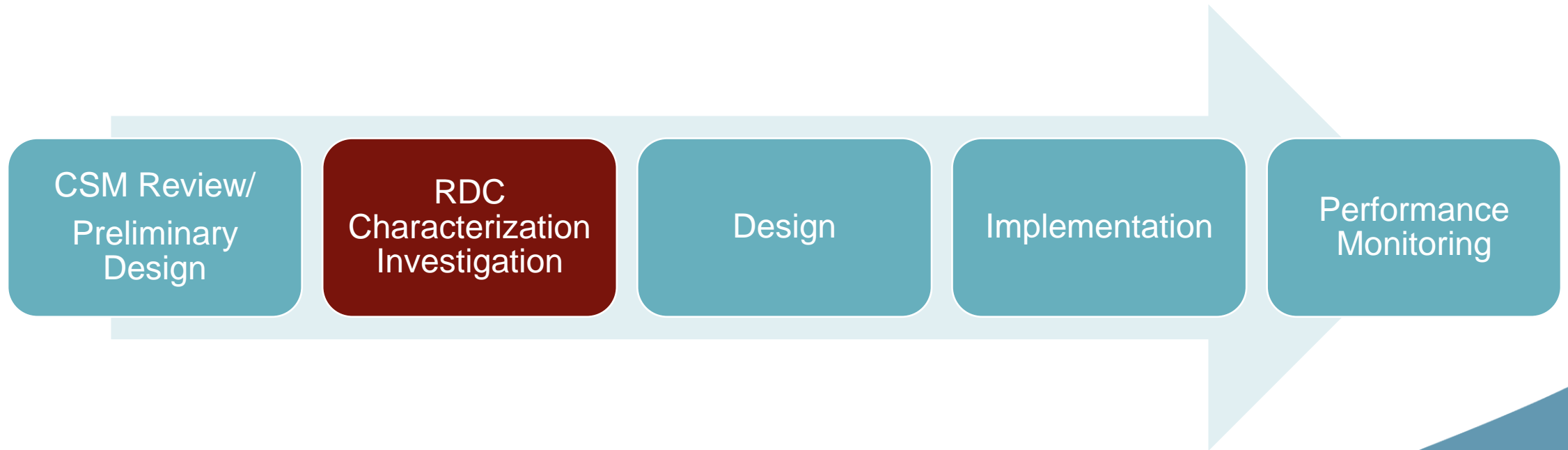


HIGH RESOLUTION SITE CHARACTERIZATION AND BIOREMEDIATION IN FRACTURED ROCK

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Senior Geologist
AST Environmental, Inc.

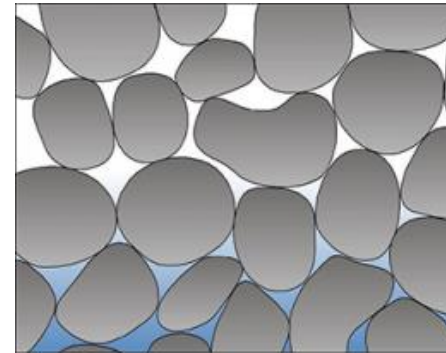
Derek Pizarro
Senior Product Manager
AST Environmental, Inc.

TRAP & TREAT® REMEDIATION PROCESS (THE APPROACH)

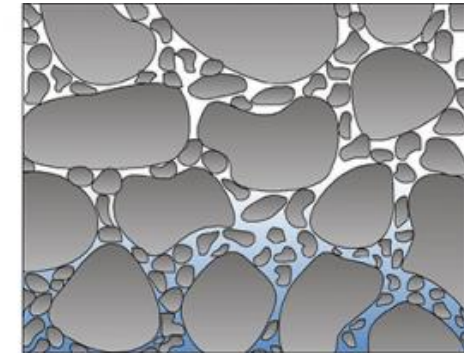


WHAT IS A FRACTURE? WHAT IS A FEATURE?

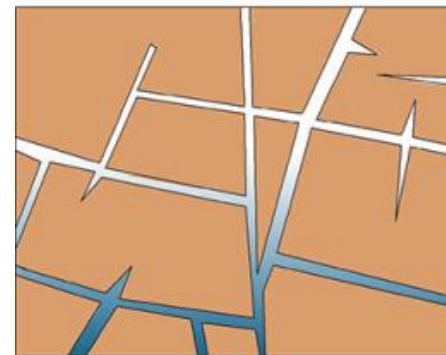
- When associated to caliper logs...
 - Bedding plane separation
 - Joint/Fault
 - Lithologic contact
 - Hydraulic Zones (using our tools)
 - Producing
 - Receiving
 - Erosional Plane
 - Enlargement
 - Drilling-induced feature?
 - Total Porosity vs. Effective Porosity



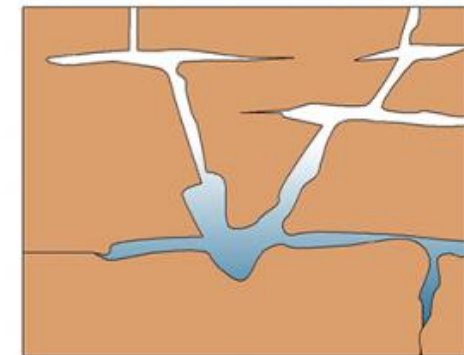
Well-sorted sedimentary material
(Alluvium of the South Platte River)



Poorly sorted sedimentary material
(Dawson, Denver, Arapahoe aquifers)



Fractured crystalline rocks
(Pikes Peak Granite)



Soluble rock-forming material
(Leadville Limestone)

REMEDIAL DESIGN CHARACTERIZATION (RDC)

Surface Geophysics

- 2D Electrical Resistivity
- Seismic

Characterization → Injection Wells

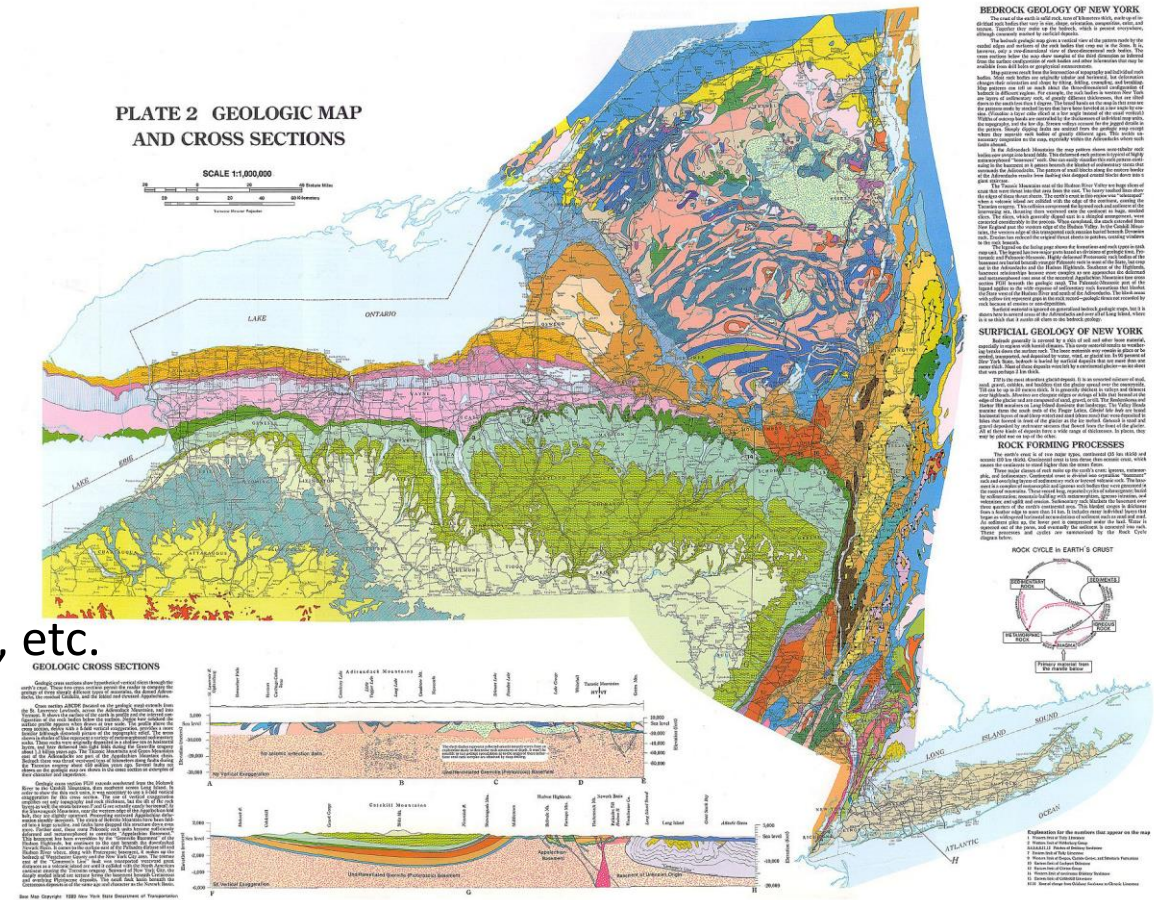
- Open Borehole with surface casing
- Rock Cores – logging and sampling of matrix

Borehole Geophysics

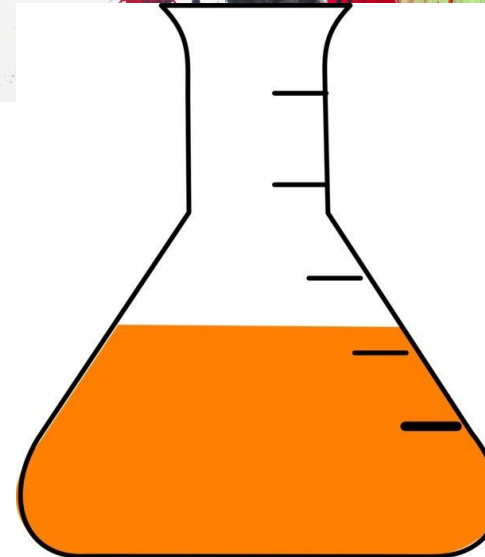
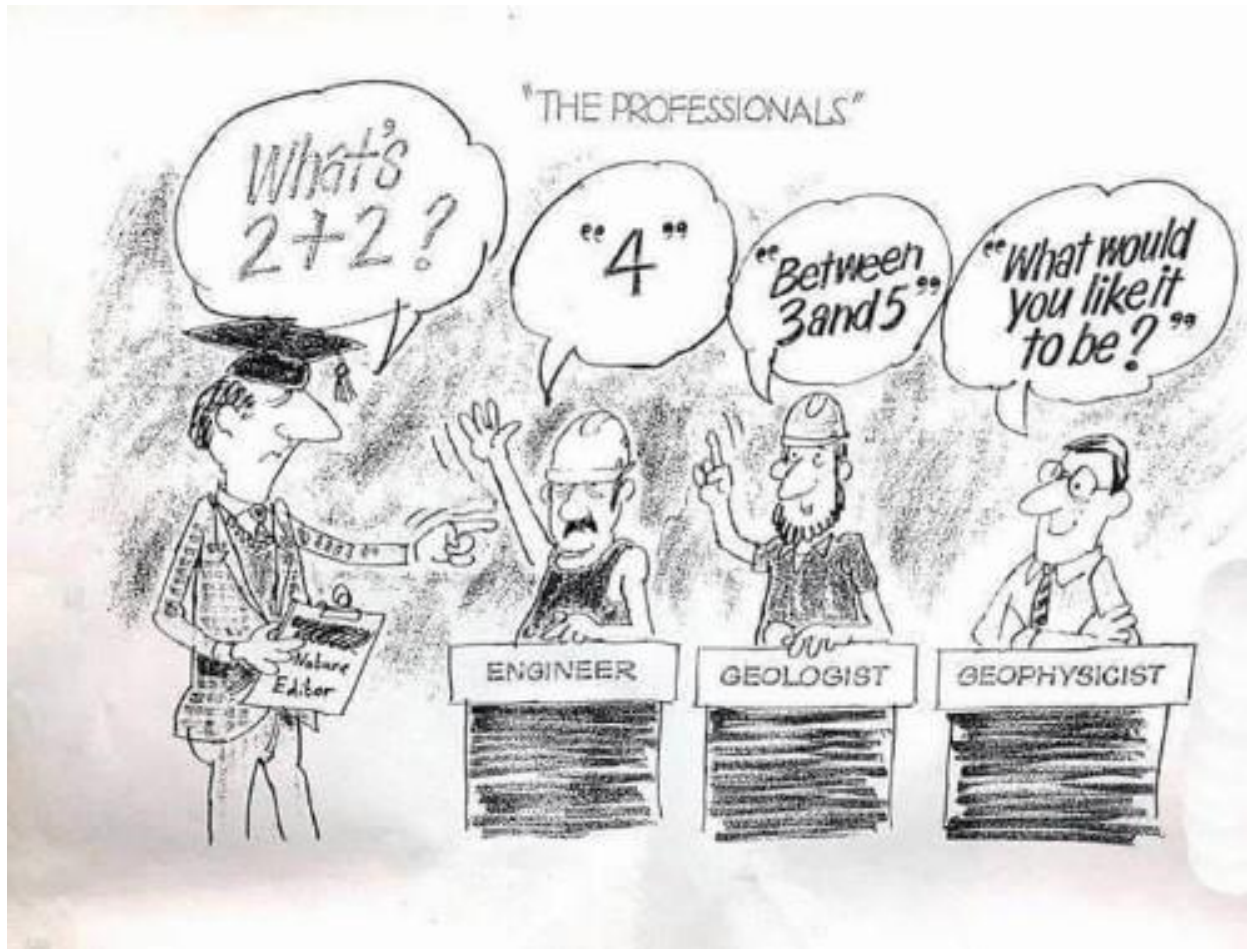
- Caliper, Acoustic Televiwer, Downhole Camera, etc.

Groundwater Characterization

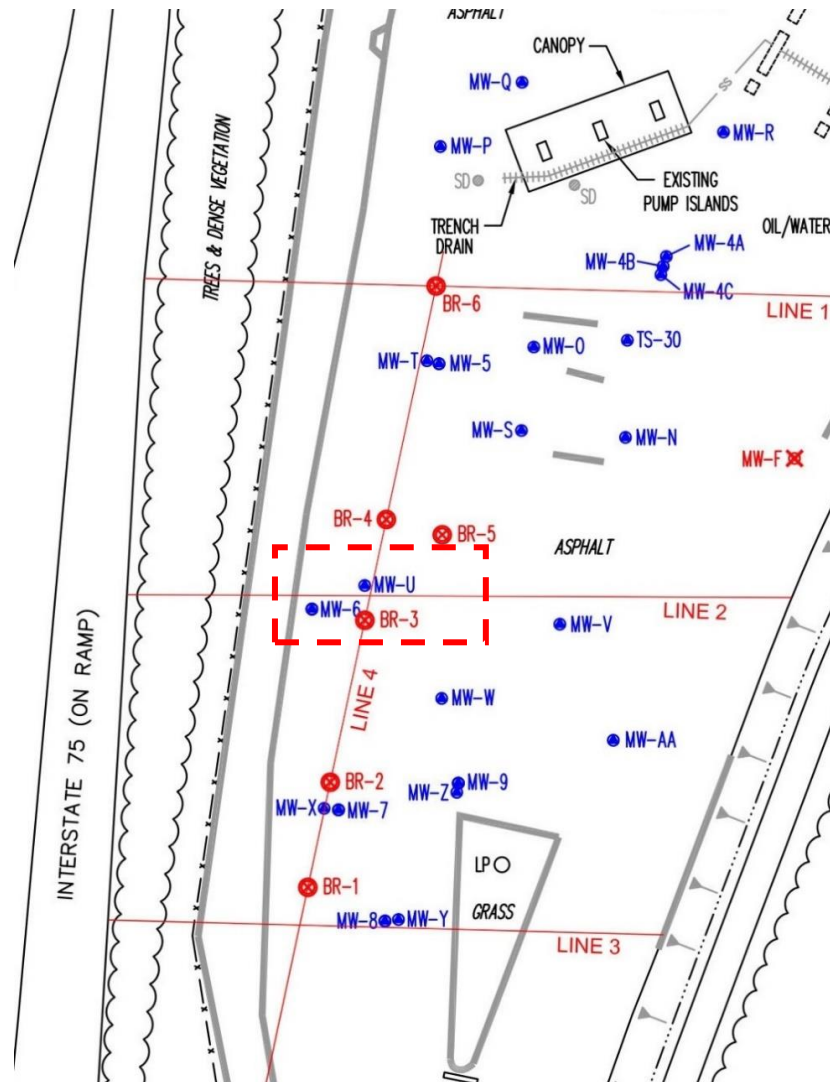
- Pumping Tests
- Discrete Interval Analytical Sampling
- Response Data - Transducers



SURFACE GEOPHYSICS

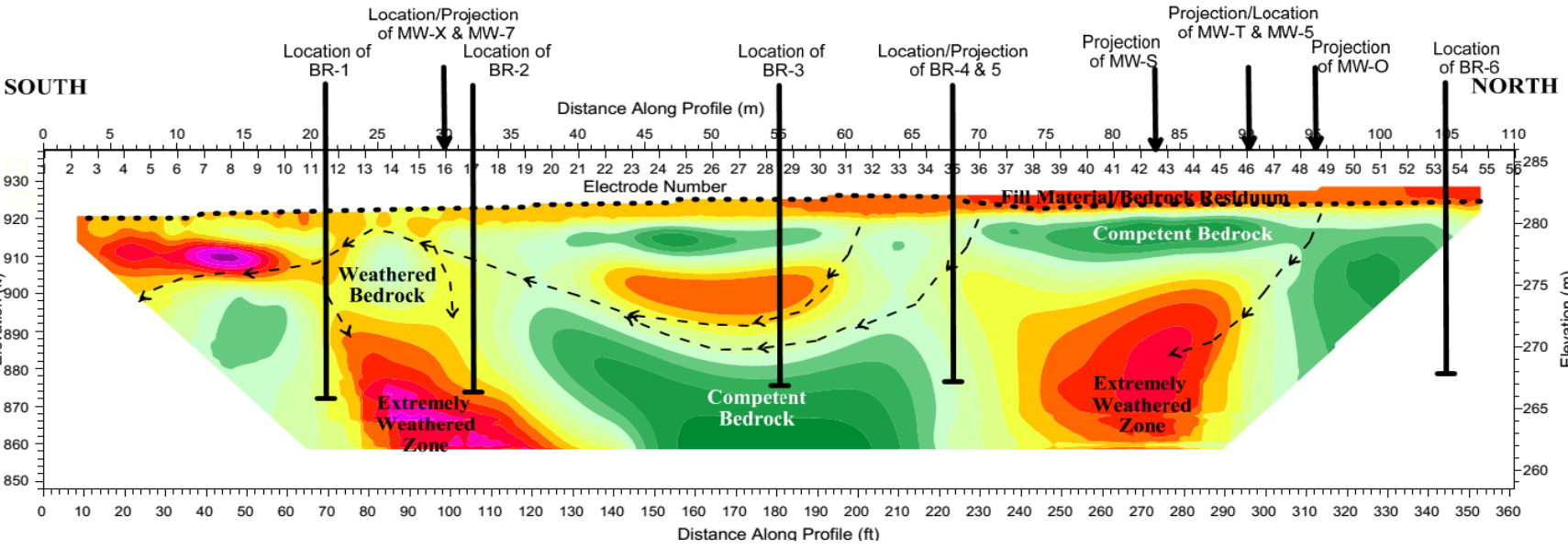
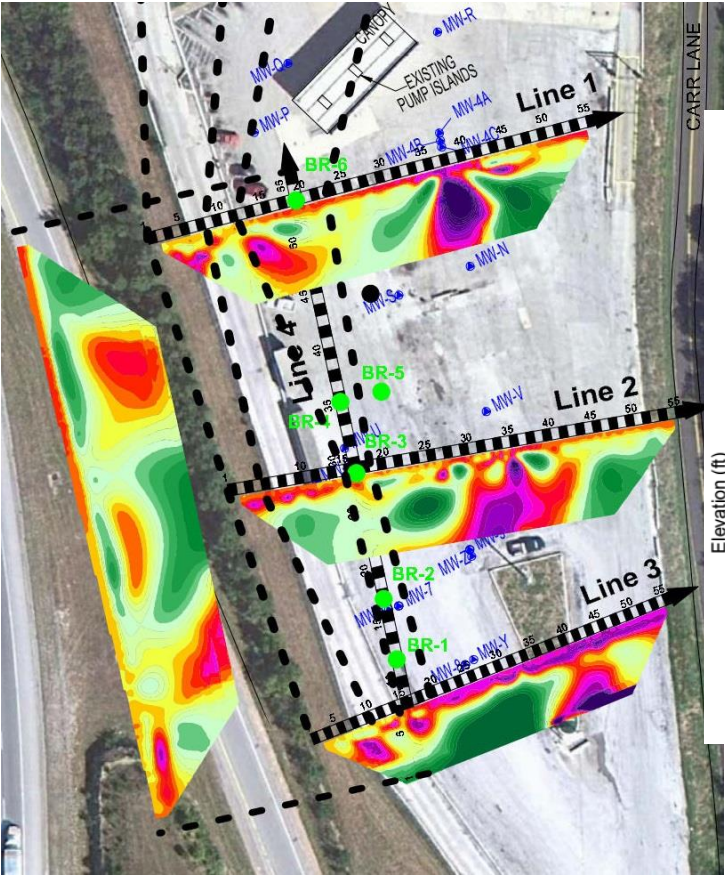



HISTORICAL DATA AND SITE LAYOUT



- Shallow bedrock
- Benzene higher in shallow wells near source
- Highest concentration MW-U – deep screen
- Shallow wells are most impacted further down gradient – MW-7, MW-8

RDC - 2-D ELECTRICAL RESISTIVITY

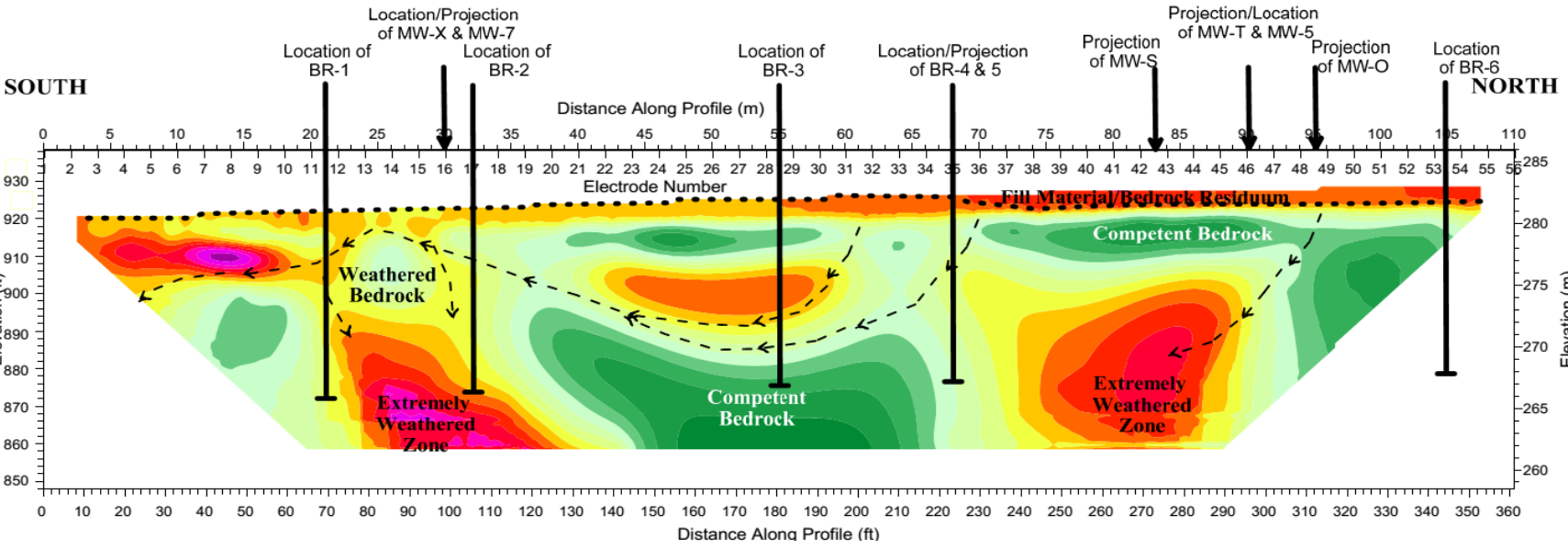
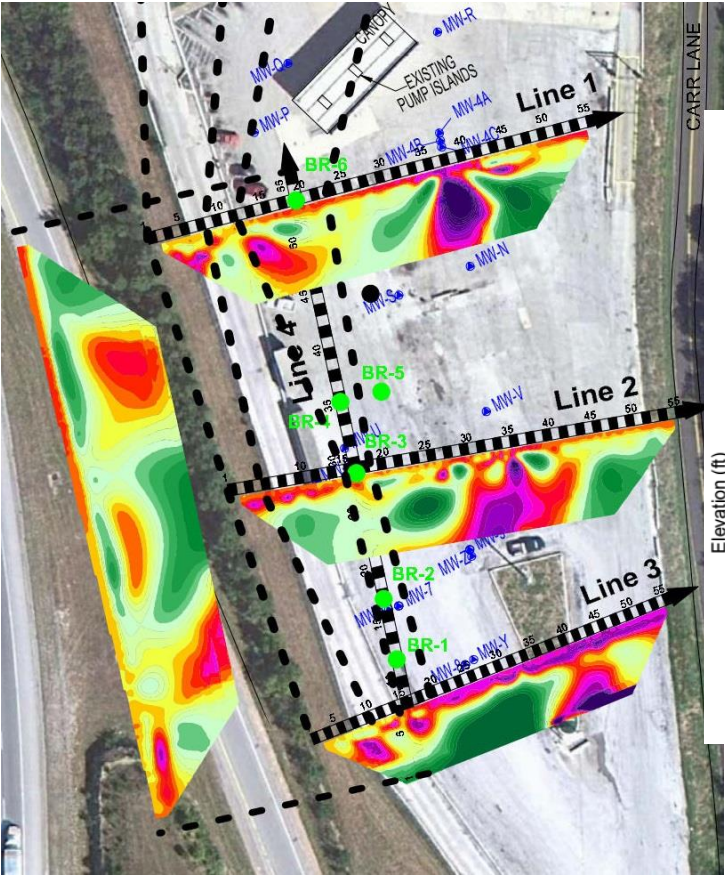




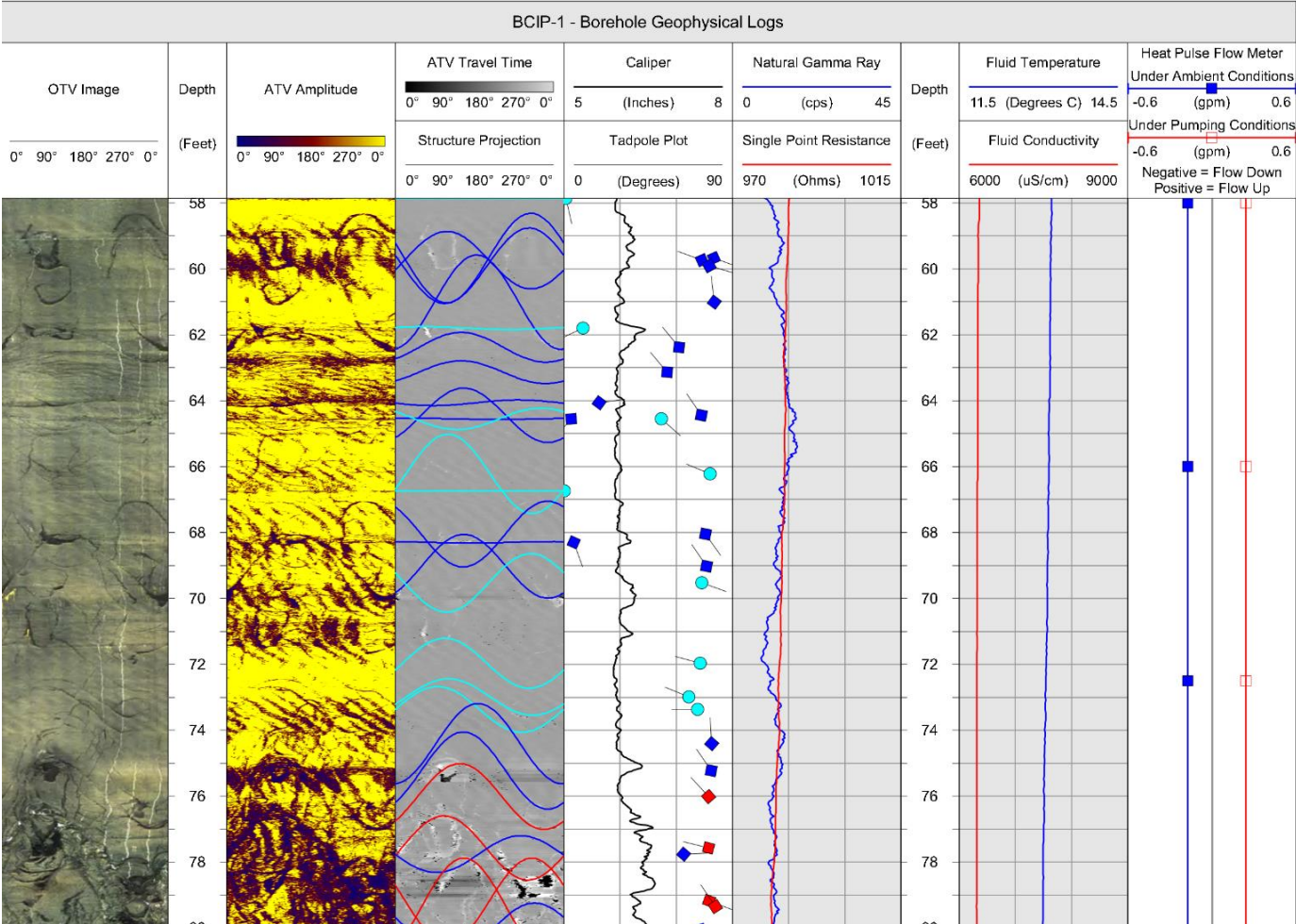
Calloway Creek Limestone

Garrard Siltstone

RDC - 2-D ELECTRICAL RESISTIVITY



RDC - BOREHOLE GEOPHYSICAL LOGS



Standard Details

- 3 arm caliper*
- Natural Gamma
- Resistivity
- Fluid Temperature + Conductivity

Additional Details

- OTV and ATV*
- Heat Pulse Flow Meter

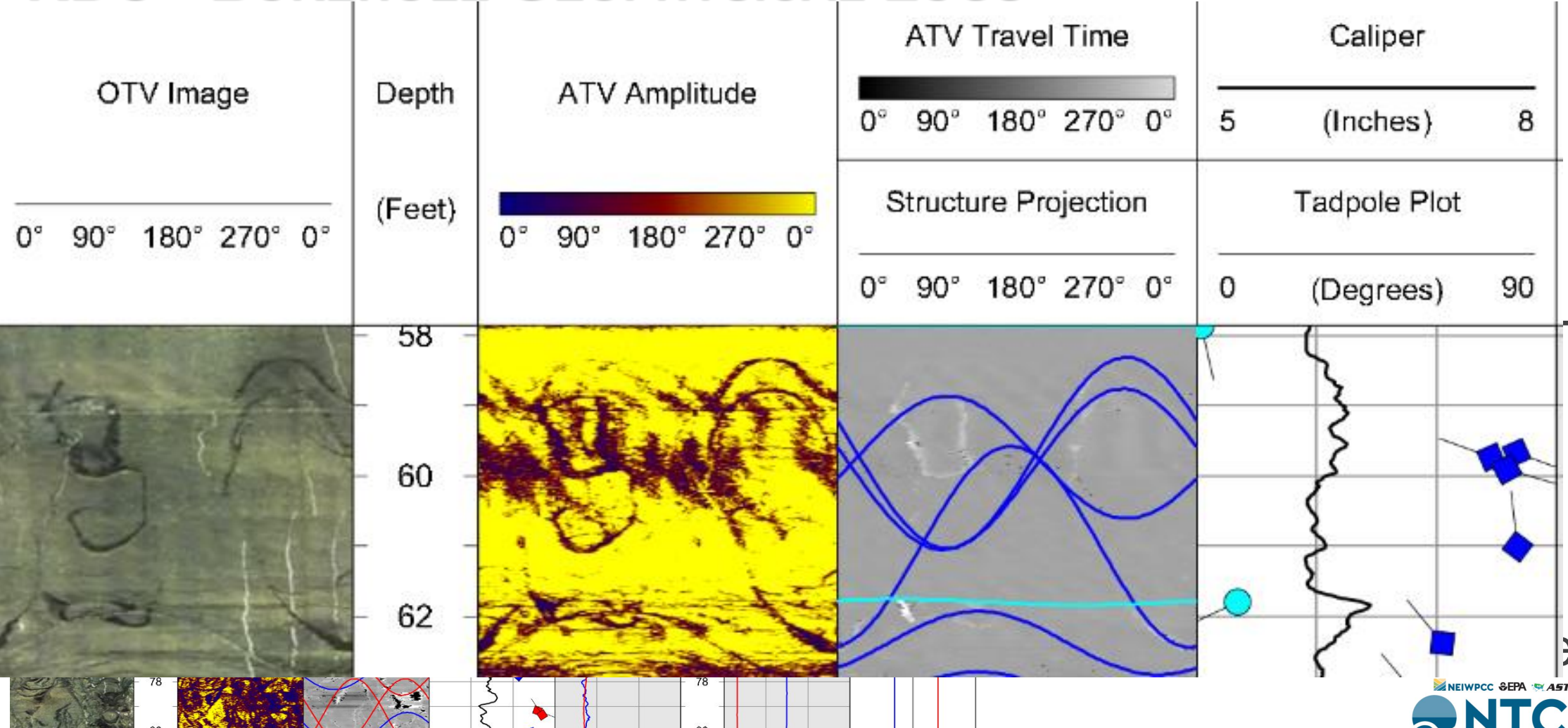
BOREHOLE CAMERA



BOREHOLE CAMERA

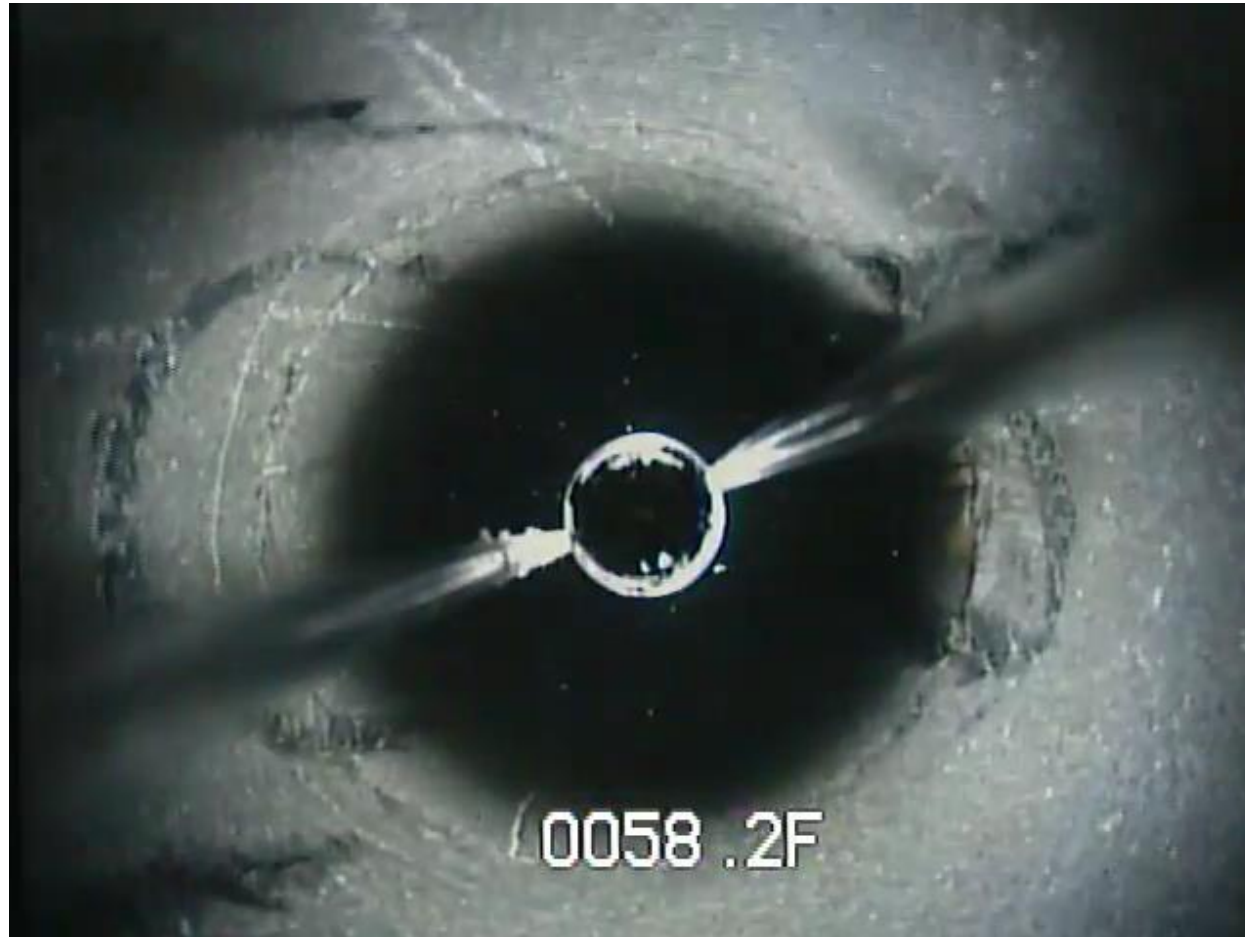


RDC - BOREHOLE GEOPHYSICAL LOGS



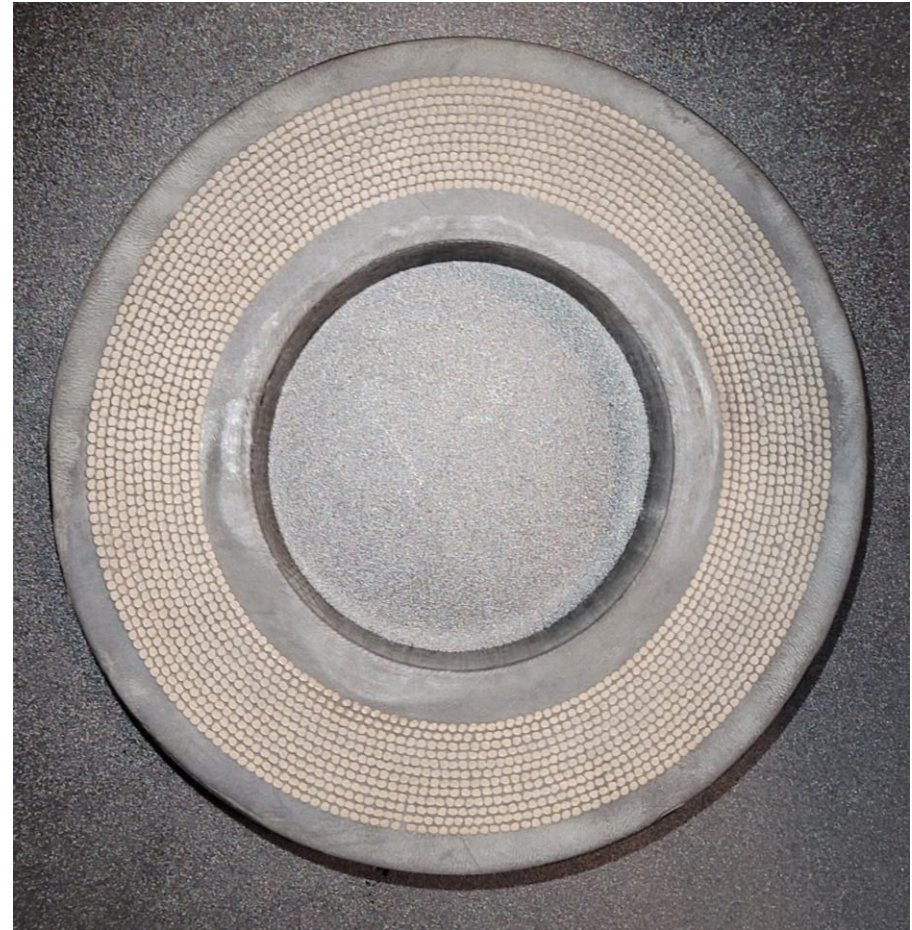
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RDC - DOWNHOLE CAMERA

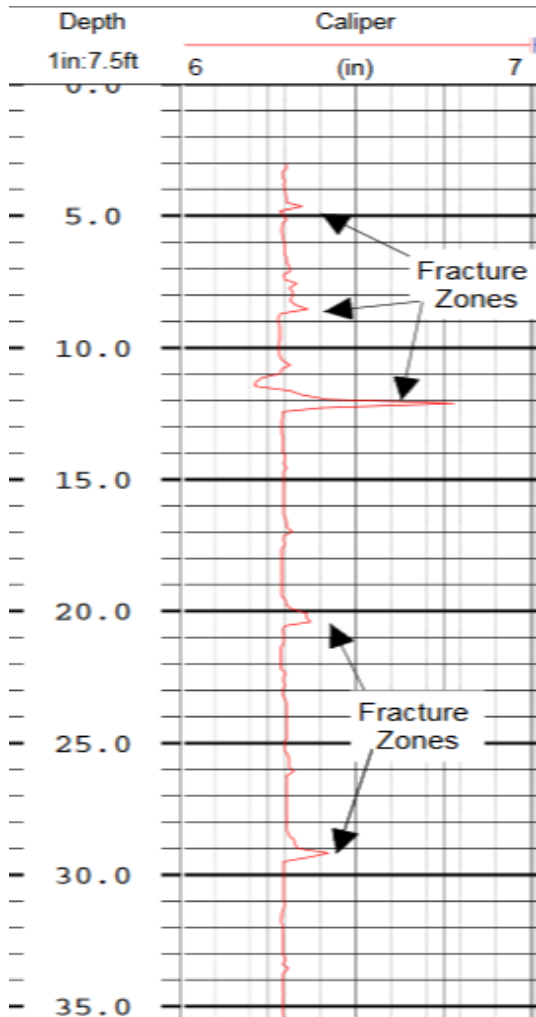


WHAT IS A STRADDLE PACKER?

- Expandable bladder/plug
- Uniform, even inflation
- Open-air high-pressure inflation w/o rupture
- Isolates borehole sections
- Rated for high pressures (ensure seal)
- Sliding element section with O-ring seal
- Long sealing section



RDC – GW CHARACTERIZATION



Aquifer Testing

- Pumping Tests
- Discrete Interval Analytical Sampling
- Response Data – Transducers
- Conventional packer strings make it very difficult to isolate individual features
- Custom Straddle Packer String
 - Pressure transducers
 - Integrated pump
 - Discrete Sampling or injection



ROCK CORES

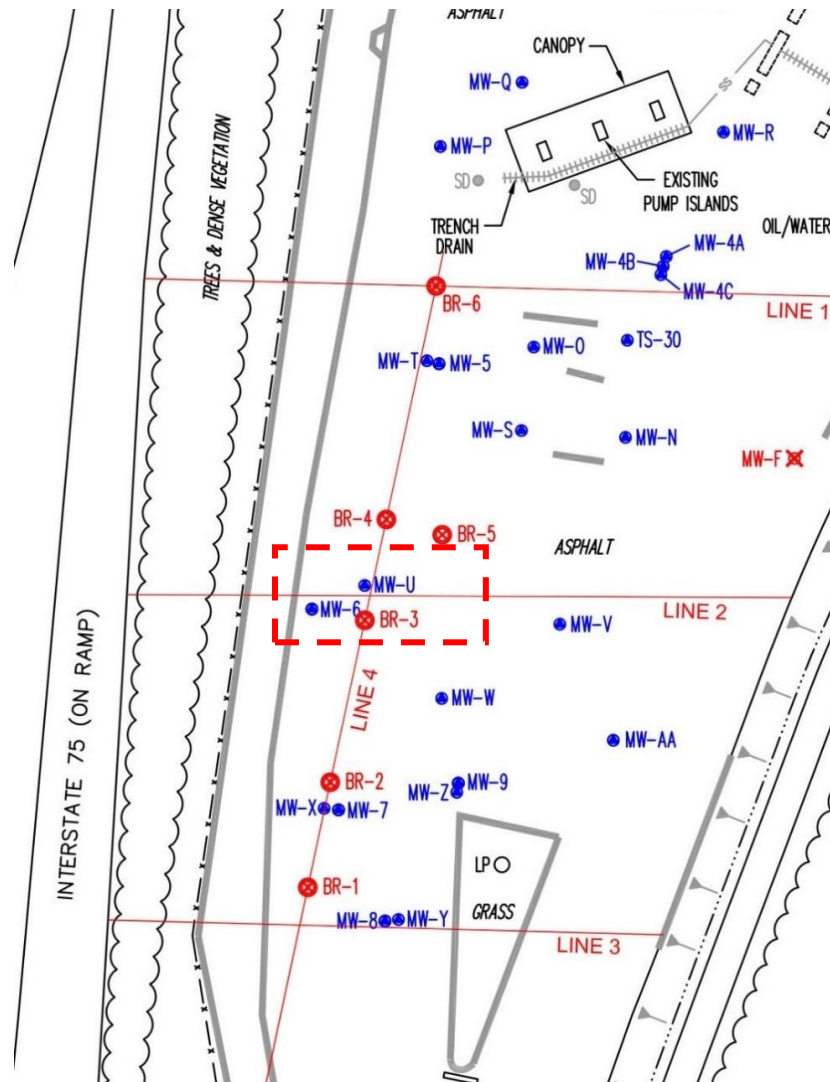


- Structure, texture, and variation in lithology visible in log perspective
- Another level of data to use when updating the CSM
 - Look, touch, hold, etc. what you see in 2D wireline logs or downhole camera display
- Sample Rock Matrix

ROCK MATRIX SAMPLING



HISTORICAL DATA AND SITE LAYOUT



- Shallow bedrock
- Benzene higher in shallow wells near source
- Highest concentration MW-U – deep screen
- Shallow wells are most impacted further down gradient – MW-7, MW-8

ROCK MATRIX SAMPLES VS GROUNDWATER RESULTS

Sample ID. No.	MW-U	MW-U	MW-U	MW-U
Date Sampled	5/2/2013	5/2/2013	5/2/2013	5/2/2013
Sample Depth	12-12.75'	12-12.75'	19.75-20'	22-22.25'
Units	ug/kg	(2nd Sample) ug/kg	ug/kg	ug/kg
MTBE	374 (4)	336 (5)	ND (6)	ND (5)
Benzene	1420 (4)	1390 (5)	ND (6)	16.5 (5)
Toluene	2090 (4)	2580 (5)	ND (6)	7.67 (5)
Ethylbenzene	417 (4)	385 (5)	ND (6)	ND (5)
m/p-Xylenes	1330 (4)	1350 (5)	21.9 (6)	7.46 (5)
o-Xylenes	641 (4)	579 (5)	9.57 (6)	ND (5)
1,2,4-Trimethylbenzene	114 (4)	432 (5)	15.2 (6)	5.04 (5)
Naphthalene	37.7 (4)	118 (5)	ND (6)	ND (5)
TVPH (ppm)	50.8 (2)	46.7 (2.5)	260 (3)	15.8 (2.5)

The highest benzene concentration from adjacent discrete gw sampling was 474 ug/L

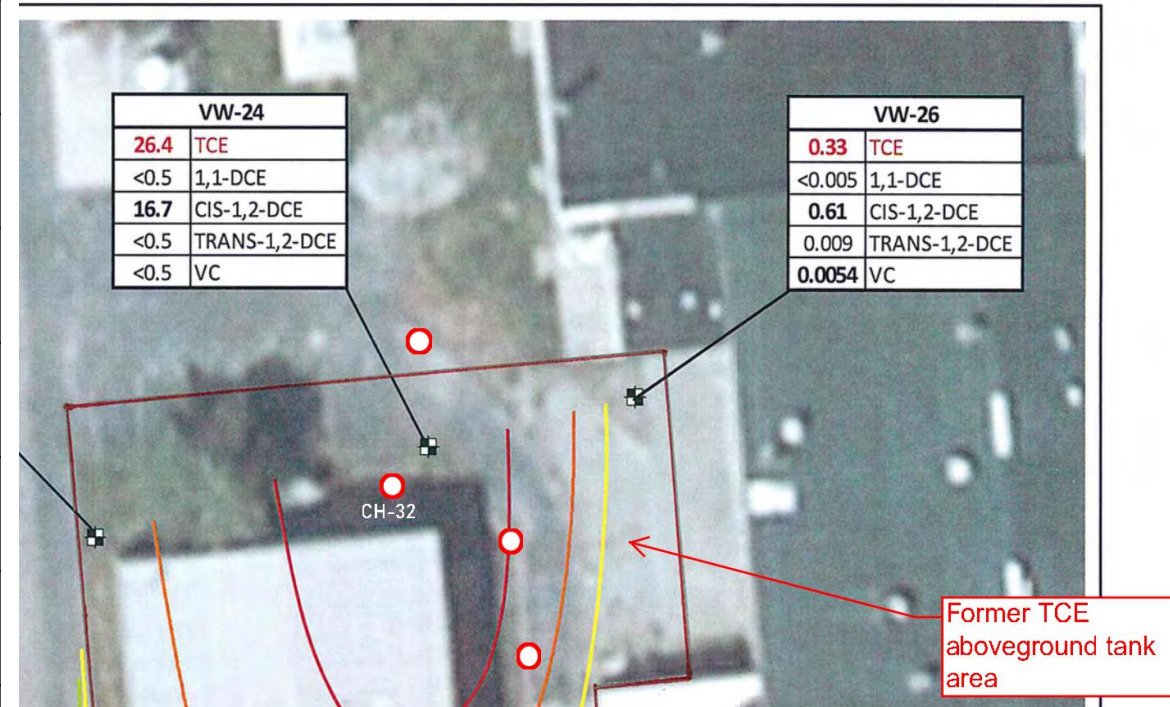
			33.8	Benzene
MW-U	9/17/12	20.86		6.4
	6/29/12	14.27		9.3
	9/15/11	12.50		3.4
	2/18/11	12.35		5.9
	6/30/10	21.0		6.3
	3/19/10	12.24		5.7
	7/7/09	12.32		10
	2/12/09	12.92		1.8
	5/22/08	12.19		2.2
	11/19/03	12.31		3.2
	12/3/02	12.50		0.5
	9/11/02	11.17		0.021
	6/19/02	8.67		0.66
	3/18/02	2.08		0.052
	11/13/01	19.30		0.00066
	8/14/01	10.58		2.8
1/3/01	15.00		0.68	
7/7/99	11.05		0.64	
3/2/98	10.40		4.6	
12/17/97	33.81		0.6	

RDC – Rock Matrix vs Groundwater Concentrations

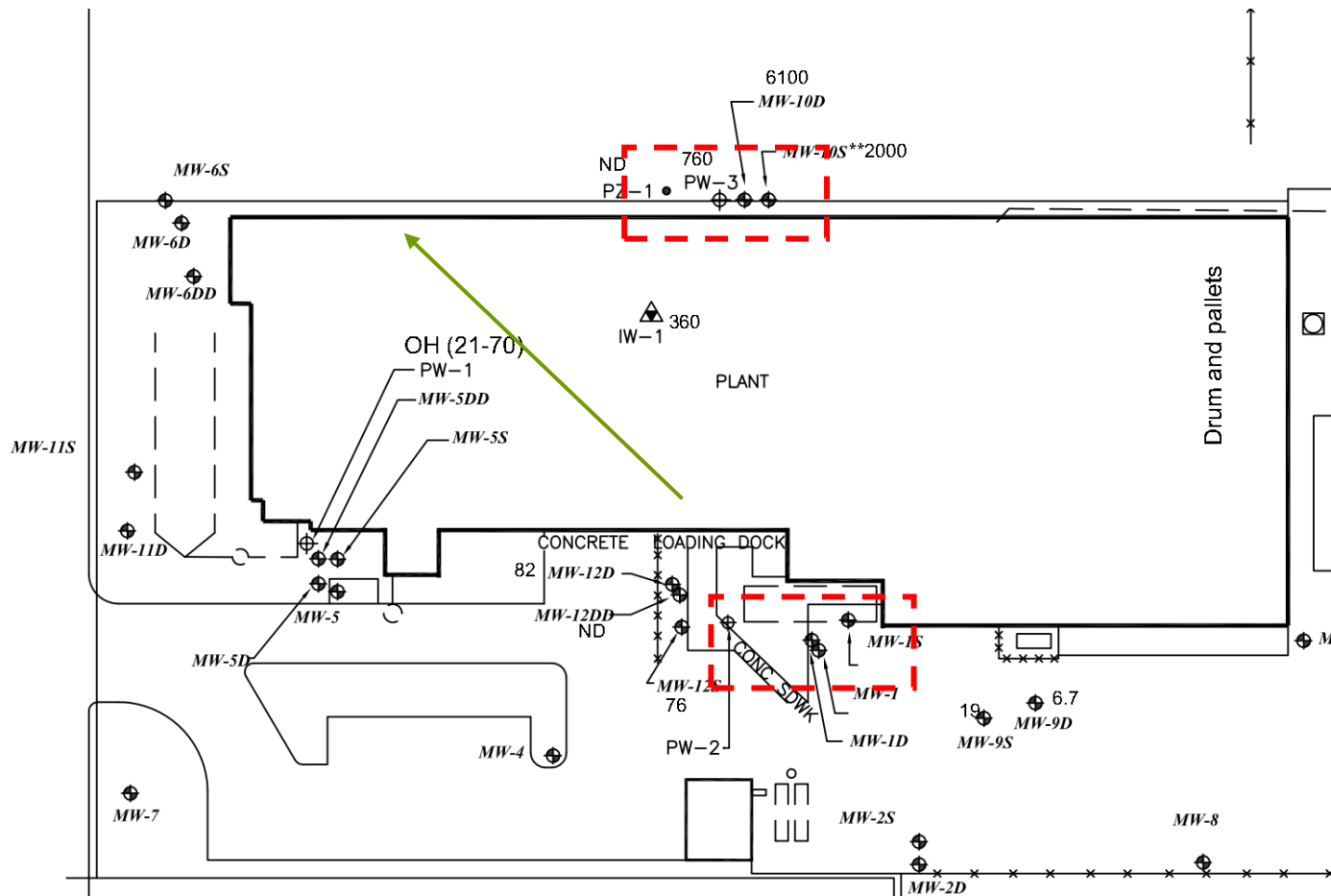


RDC – ROCK MATRIX SAMPLE

CH-32 Discrete Intervals			CH-32	VW-24
Sample Depth	TCE (ug/L)	TCE (ug/Kg)	TCE (ug/L) Water @ 34.80'	TCE (ug/L) Water @ 18.70'
7	Dry	774		
10.6	Dry	4780		
15	Dry	197		
20.6	Dry	25,400		
22.7	Dry	336		
27.4	Dry	78.0	204	26,400

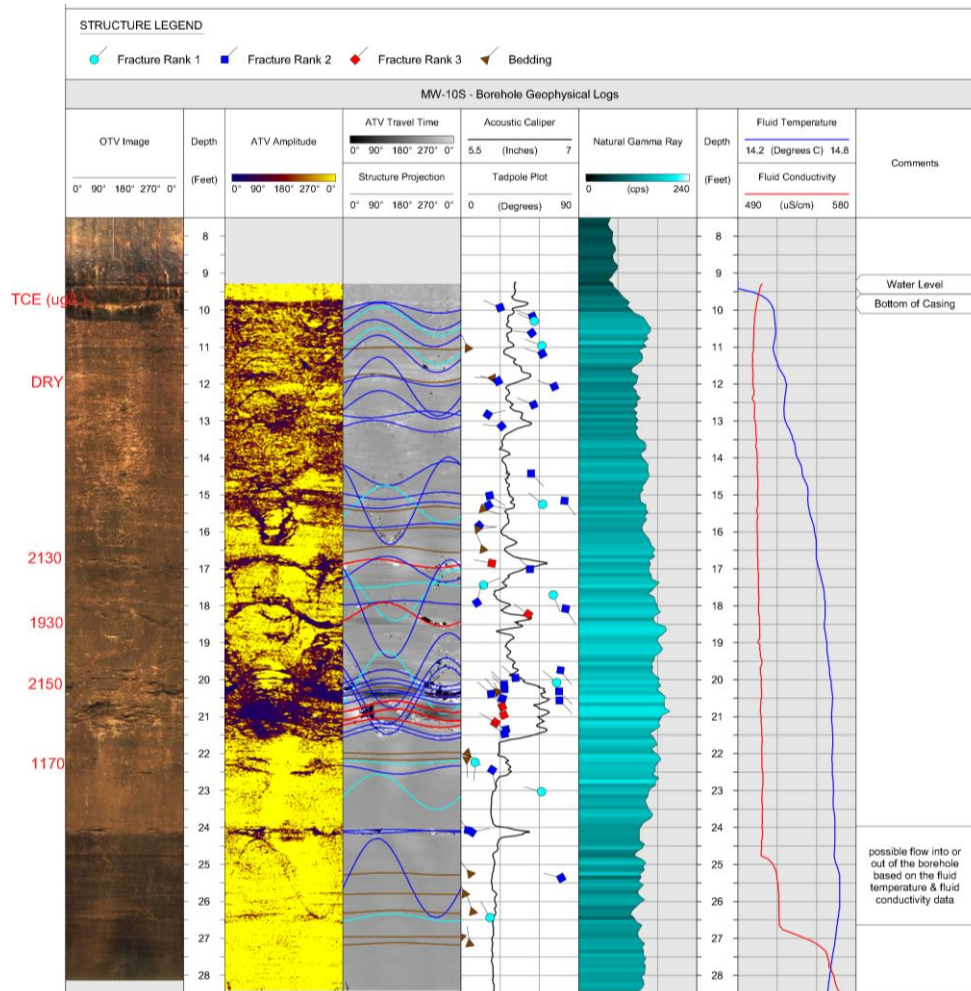


RDC – AQUIFER DISCRETE SAMPLING

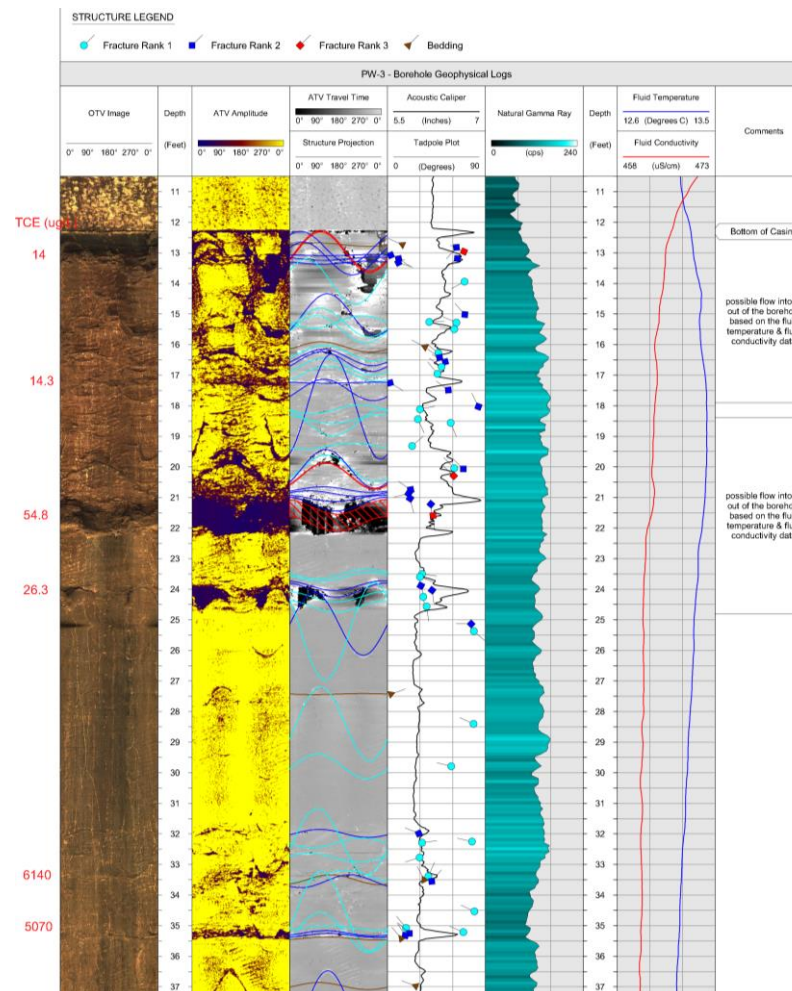


- Multiple potassium permanganate injections completed at PW-1 and PW-2
- Induced flow from PW-3
- No long-term reductions in TCE concentrations

RDC – AQUIFER DISCRETE SAMPLING

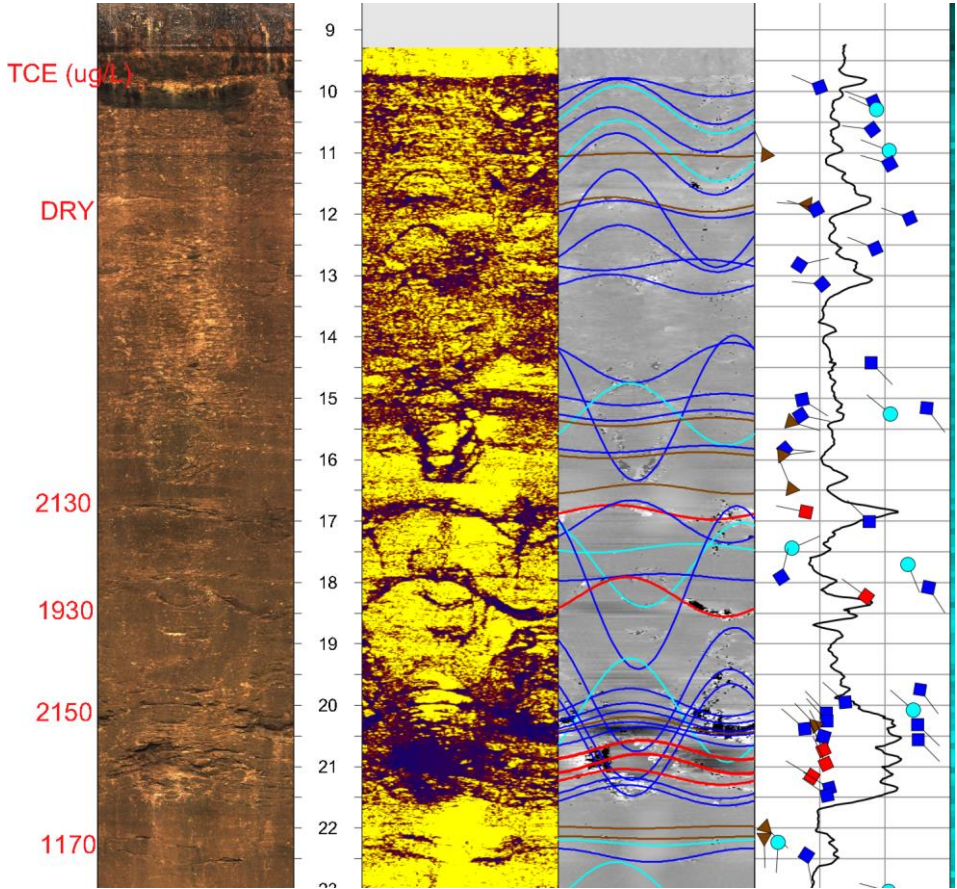


MW-10S

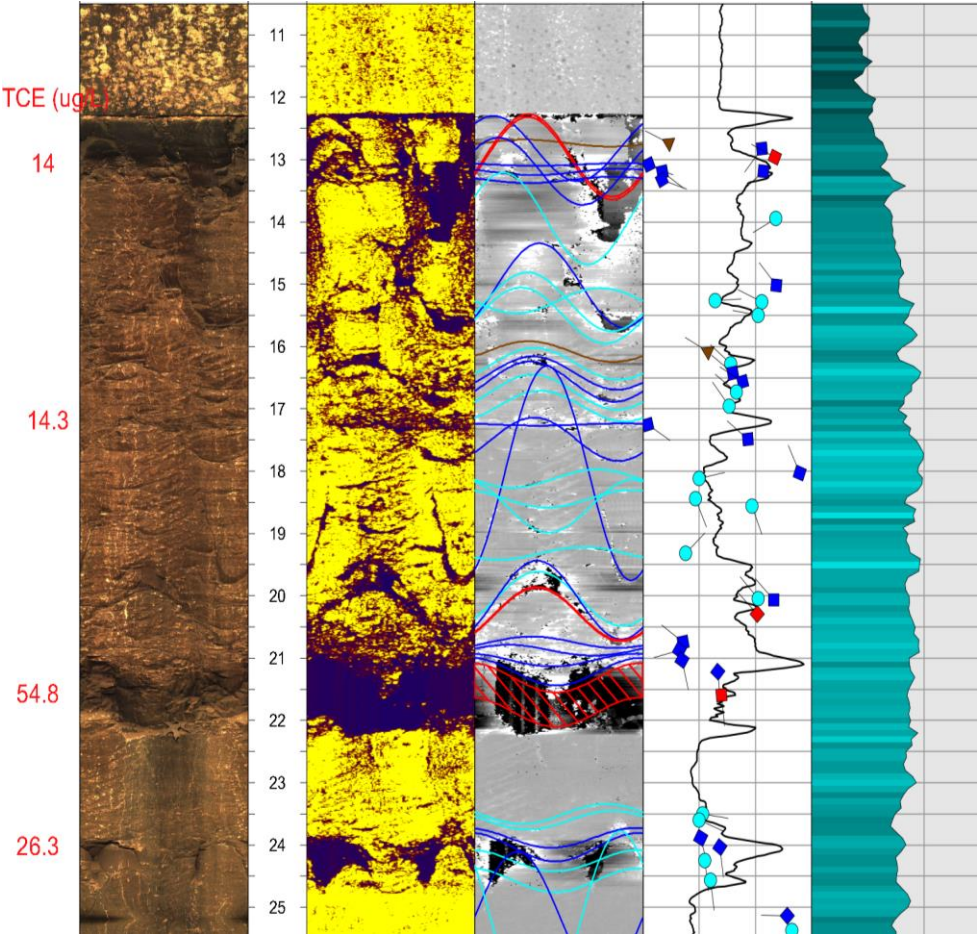


PW-3

RDC – AQUIFER DISCRETE SAMPLING



MW-10S



PW-3

RDC – AQUIFER DISCRETE SAMPLING

RW-4D Sample Intervals

Sample Depth	Benzene (ug/L)	Volume Pumped (g)
41.2	184	5
42.5	300	10 (LNAPL)
43.5	355	10 (LNAPL)
45	371	5
47	443	5
49	619	10
52.5	425	10
53-open	259	10

Sample event agenda twin-track tables

Track 1: Title

7:30AM – 8:30AM	Networking Breakfast Room 000 Hosted by Host Name
9:00AM – 10:30AM	SESSION 1: TITLE HERE Room 000 Presenter Name
10:45AM – 11:45AM	SESSION 2: TITLE HERE Room 000 Presenter Name
12:00PM – 1:15PM	Lunch and Learn: Topic Title Room 000 Hosted by Host Name
1:30PM – 3:30PM	SESSION 3: TITLE HERE Room 000 Presenter Name

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THANK YOU!

Nathan Thacker

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RPI Booth #212