ENVIRONMENTAL WORKS

Case Study: Investigation of Chlorinated Solvent Impact in a Drinking Water Aquifer

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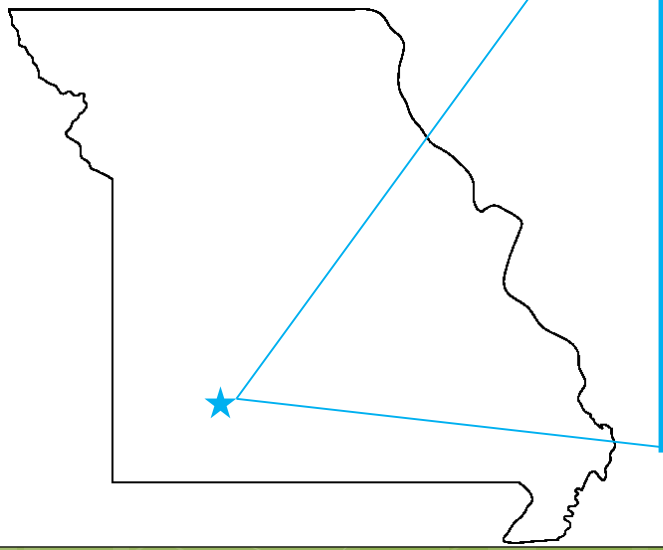
Site Setting and History

- Historical Dry Cleaning Operations
  - Used perchloroethylene "perc" chlorinated solvent (prior to 1985)
- Springfield, Missouri
- Karst Terrain

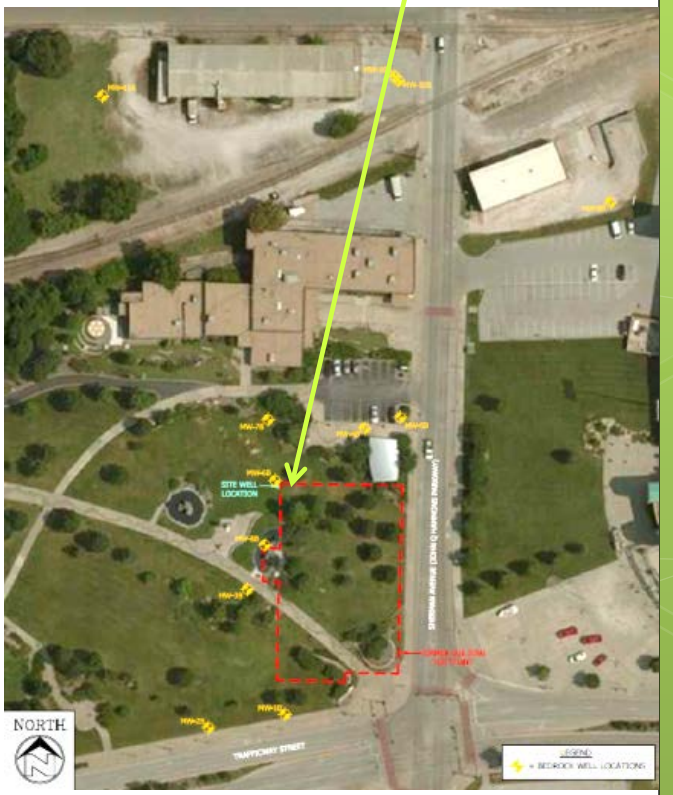


Site Investigation

EWI Objective – Determine extent and evaluate source

- **Soil**: Delineated Onsite

- **Groundwater:**
  - Monitoring Wells – Delineated
    - Open to Shallow Aquifer
    - Chlorinated Solvents Detected:
      PCE, TCE, cDCE, VC
  - Industrial Well Onsite
    - Open to Drinking Water Aquifer (Deep)
    - Chlorinated Solvents Detected:
      PCE, TCE, cDCE, VC



- **Investigation objective:**
  - Could impact from Site be source for Deep impact?

Evaluate Origin of Impact

Tools

- Downhole Camera Survey
- Downhole Geophysical Survey
- Discrete Groundwater Sampling
- Compound Specific Isotope Analysis (CSIA)

Potential Origin

- Well Casing Condition
- Contaminant Distribution
- Potential Migration Pathways
- Carbon/Chlorine Isotope Ratios

Downhole Camera Survey

Objective

- Evaluate/Identify:
  - Well casing
  - Geologic features
  - Discrete sampling points
  - Any staining or other pertinent features

Results

- Obstructions observed in well
- Rehabilitation
- Formation transitions not observed

Downhole Geophysical Survey

Objective: Identify Discrete Sampling Points

Tool	Associated Data	Data Use
Compensated Density	Natural gamma, resistivity, caliper, density	Identify higher porosity, fractures/voids, grout in annular space
Acoustic Televiewer	Fractures, bedding planes, borehole geometry and wall texture	Preferential flow pathways and targeted sampling
EM Flowmeter	Groundwater flow rates, fluid resistivity, fluid temperature	Changes identify higher flow rates and flow pathways

Downhole Geophysical Survey Results

- Selected 10 locations for discrete sampling
  - Potential flow pathways:

  Higher porosity, voids/fractures, bedding planes
- Competent well casing and surrounding grout

Discrete Groundwater Sampling

COC Interpretation at targeted flow paths

- Any natural breakdown/degradation of PCE?

  PCE→TCE →cDCE →VC

- Deep Aquifer Impact Possibilities:
  - Vertical migration from impacted shallow aquifer
  - PCE released directly into industrial well from the surface

- Sampling Methods:
  - Former industrial well
    - Passive diffusion bags (PDBs)
  - Shallow monitoring wells
    - Low flow

ORIGIN IMPACT RESULTS

Discrete Sampling Results

Vertical Migration unlikely

Highest Impact

Surface release unlikely

	Well ID or Depth (ft bgs)	Formation	Sample Date	Tetrachloroethene (PCE) (ug/L)	Trichloroethene (TCE) (ug/L)	cis-1,2-Dichloroethene (DCE) (ug/L)	Vinyl Chloride (ug/L)
	MDNR Default Target Levels			5	5	70	2
Industrial Well PDB Locations	454	Cotter	4/23/2015	4	16.5	7.1	<1
	628	Jefferson City	4/23/2015	4.2	40.6	14.2	<1
	875	Roubidoux	4/23/2015	191	234	27.9	<1
	947	Upper Gasconade	4/23/2015	186	190	28.8	<1
	993	Lower Gasconade	4/23/2015	142	163	30.6	<1
	1,086	Lower Gasconade	4/23/2015	37.4	51.5	33.3	<1
	1,135	Lower Gasconade	4/23/2015	16.8	38.1	26.4	<1
	1,220	Gunter Sandstone	4/23/2015	8.9	18.8	6.1	<1
	IW: 875	Roubidoux	8/11/2015	34.4	62.2	23.5	<1
	IW: 947	Upper Gasconade	8/11/2015	9.5	18.1	6.9	<1
Site Bedrock and Unconsolidated Monitoring Wells	MW-1B	Burlington	7/30/2015	9.7	1.1	2.7	<1
	MW-2B	Burlington	7/30/2015	<1	<1	5.9	4.2
	MW-3B	Burlington	7/31/2015	<1	<1	<1	<1
	MW-4B	Burlington	7/30/2015	1,900	169	385	4.9
	MW-5B	Burlington	7/30/2015	1,240	143	380	9
	MW-6B	Burlington	7/30/2015	76.6	16	125	7.4
	MW-7B	Burlington	7/30/2015	161	29	82.7	<1
	MW-8B	Burlington	7/30/2015	<1	<1	<1	<1
	MW-9B	Burlington	9/24/2015	<1	<1	<1	<1
	MW-10A	Unconsolidated Zone	9/24/2015	9.8	1.8	5.3	<1
	MW-10B	Burlington	12/14/2015	18.5	3.2	12.5	<1
	MW-11A	Unconsolidated Zone	8/7/2015	35.6	6.4	12.4	<1

Degradation?

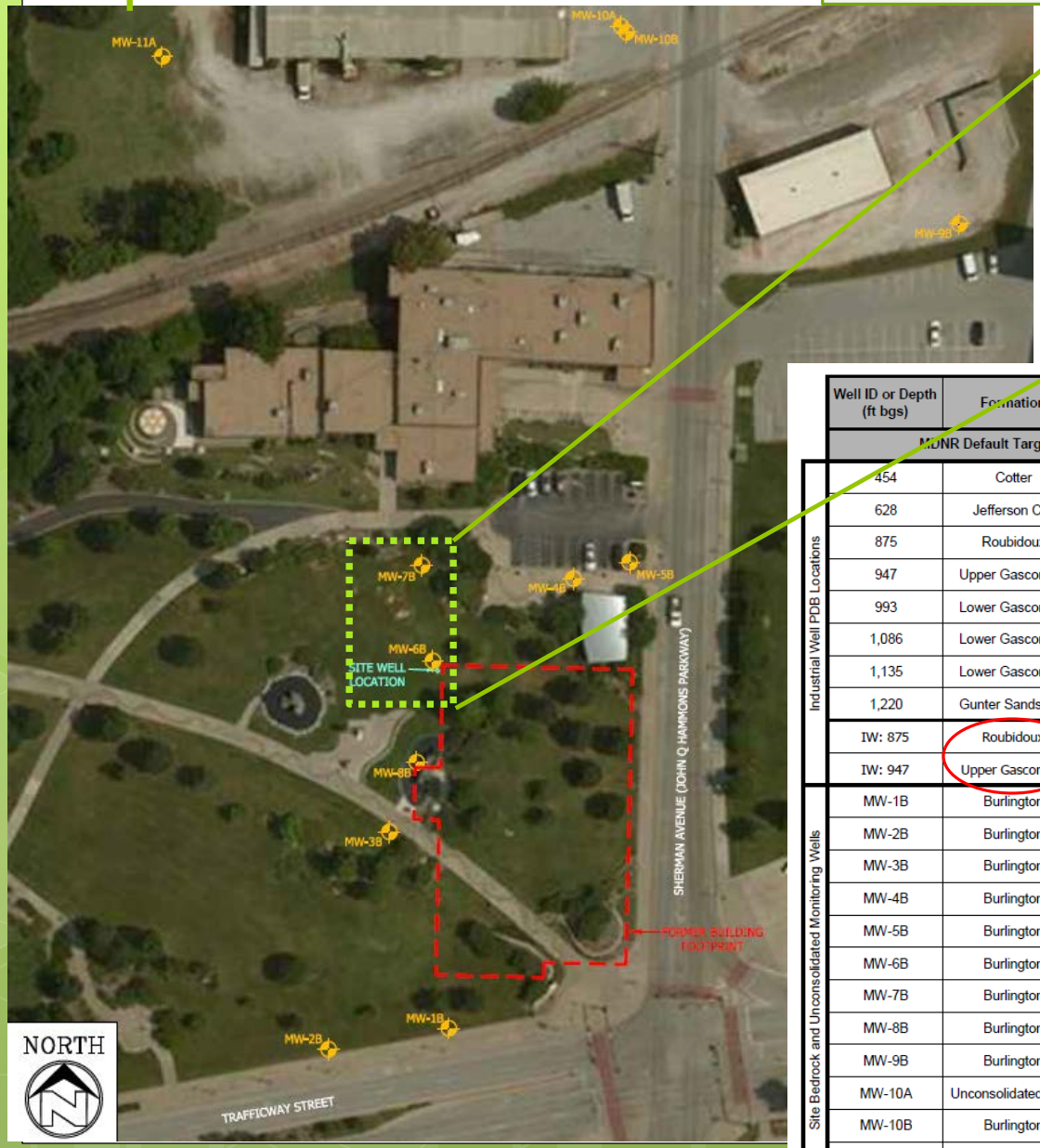
Compound-Specific Isotope Analysis (CSIA)

CSIA – Uses isotopes from carbon, hydrogen and chlorine to evaluate contaminant reduction and relationship between chlorinated compounds

- Former industrial well (Deep) vs. site monitoring wells (shallow)
  - Vertical migration from the shallow to deep aquifer?
  - Direct release into the well from the surface?
  - Not related to historical activities at the Site (off-site source)?
- GW samples collected from each aquifer for CSIA
  - Analysis of VOCs by EPA Method 8260
  - CSIA - 13C/12C and 37Cl/35Cl isotopic ratios for PCE, TCE, and cDCE using gas chromatography-isotopic ratio mass spectrometry (GS-IRMS) techniques.

ORIGIN IMPACT RESULTS

Aquifer Point Selections



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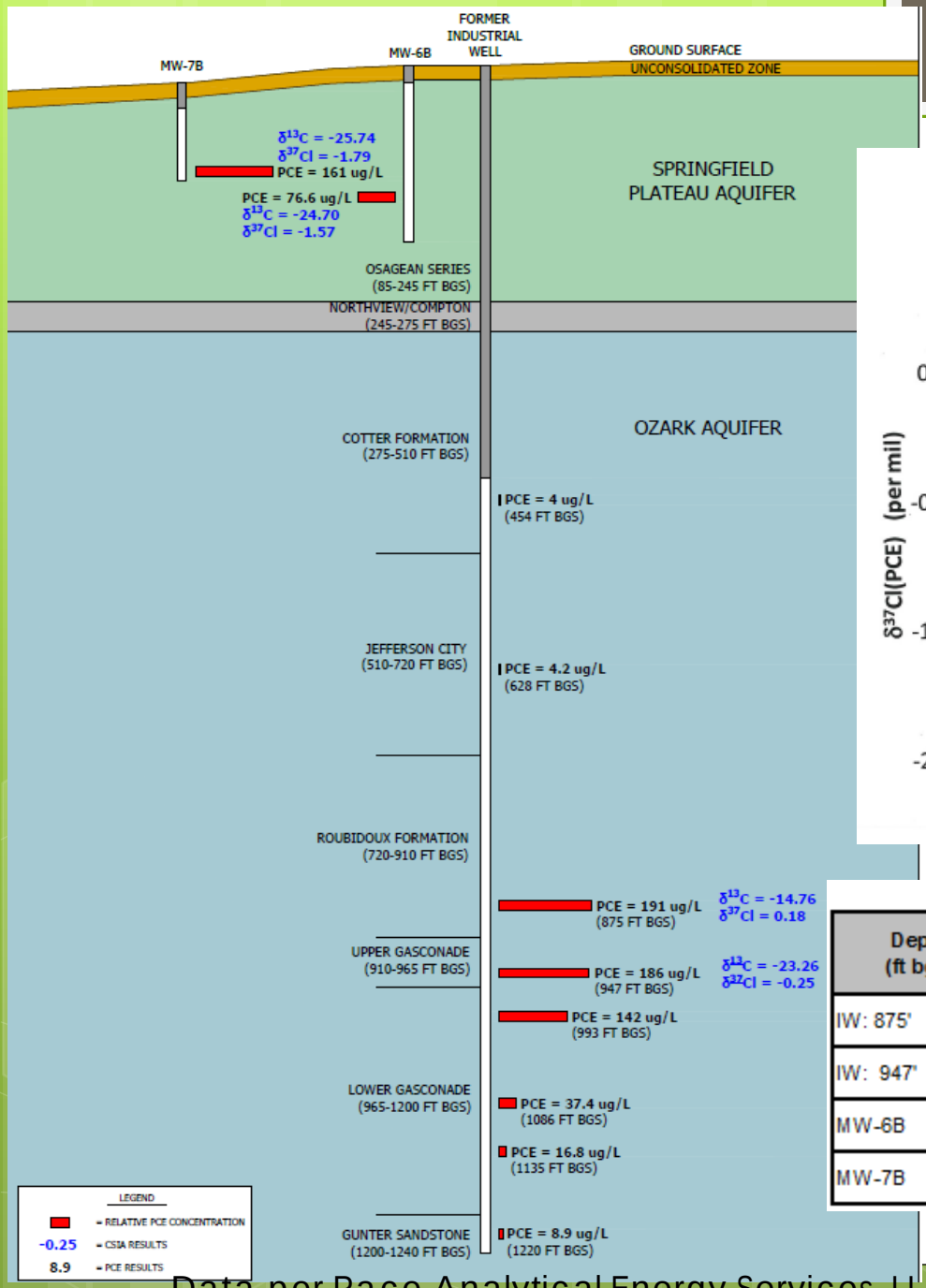
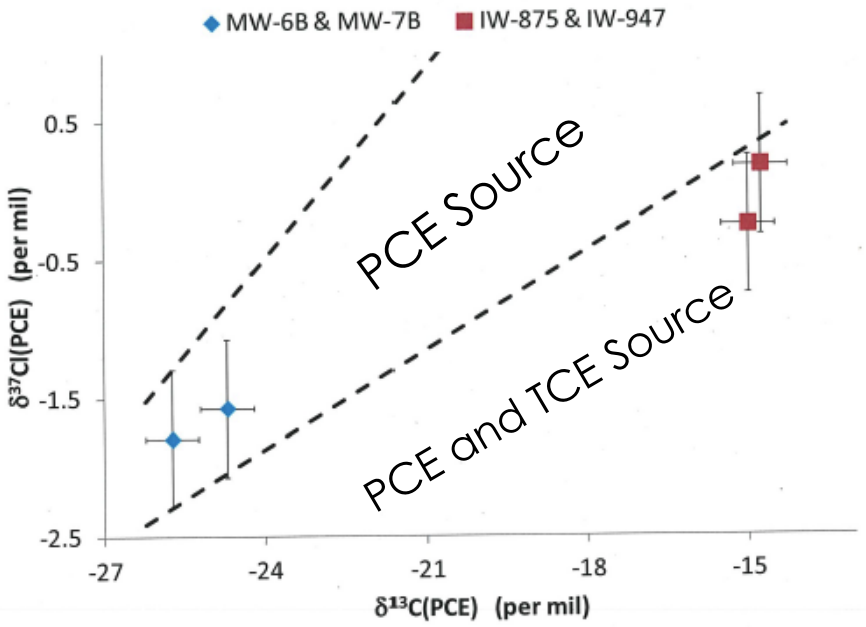
ORIGIN IMPACT RESULTS



CSIA Results



		Carbon Specific Isotope Analysis			
Depth (ft bgs)	Sample Date	δ^{13}C PCE (‰ PDB)	δ^{13}C TCE (‰ PDB)	δ^{37}C PCE (‰ SMOC)	δ^{37}C TCE (‰ SMOC)
IW: 875'	8/11/2015	-14.76	-31.07	0.18	-1.65
IW: 947'	8/11/2015	-23.26	-29.06	-0.25	-1.17
MW-6B	7/30/2015	-24.7	-25.59	-1.57	0.7
MW-7B	7/30/2015	-25.74	-25.98	-1.79	0.93

Data per Pace Analytical Energy Services, LLC (PAES) (Pittsburg, PA) Interpretive Report

Multiple Line Approach

Camera Survey

- Rehabilitation
- Formations identified for discrete sampling points/primary COC migration pathways

Geophysical Survey

- Grout seal/well casing – not compromised
- 10 potential secondary porosity horizons identified

Discrete Sampling

- Highest COC concentrations in center of industrial well
- Vertical migration and surface release unlikely

CSIA Evaluation

- Impact from industrial well (deep) originated from both PCE and TCE sources, not just PCE
- Impact in shallow aquifer originated from PCE source only
- Only 16% chance that PCE within industrial well is related to PCE within shallower aquifer

Conclusions

- COC impact within former industrial well is NOT the result of:
  - Onsite historical activities,
  - Direct release of contaminants from surface,
  - Or vertical migration from shallower impact at the Site
- COC impact within former industrial well is from an off-site source

QUESTIONS