Louis Berger

Lessons Learned During DNAPL Source Zone Remediation

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Background

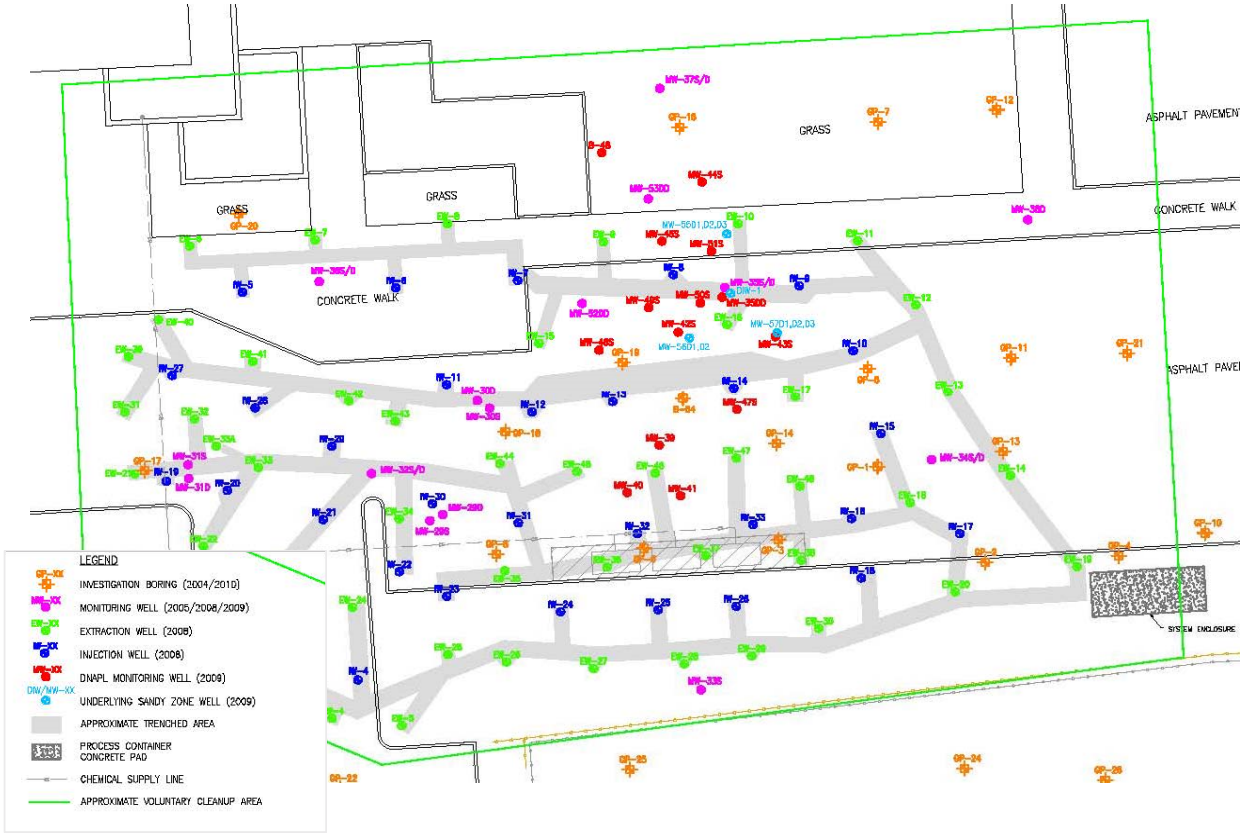
- Former watch factory in Queens, New York
- Chlorinated ethane (TCA) impacts to soil and groundwater
- Leaking USTs and product lines
- Remediation includes:
  - Biostimulation
  - Co-solvent flushing

2006 Remedial Investigation

- **0'-15' bgs** = fill material (brick, wood, concrete, sand)
- **15'-35' bgs** = low permeability (K_H~0.01 ft/day) silt layer
- **35'+ bgs** = fine sands (K_H~0.1 ft/day)
- **DTW** = ~15' bgs, @ ~0.25 ft/year in silt zone
- **Drilling Method** = air rotary and HSA with 2-foot split spoon soil sampler, hydropunch GWS

- Greatest contaminant mass located within silt layer (20'-30' bg)
- TCA up to 420,000 µg/L
- DCA up to 55,000 µg/L
- Area of DNAPL (ganglia formation) is ~4,900 sf
- Area of GW Impacts > 500 ug/L is ~20,000 sf
- Strong evidence of TCA being naturally degraded (DCA and acetic acid present) **led to the biostimulation approach**

Biostimulation System *(started Nov 2008)*



Biosystem includes:

- 48 extraction wells
- 33 injections wells
- Total recirculation flow rate: ~1.5 GPM
- 18 monitoring wells

Challenge #1 – Mobile DNAPL

- Following system startup – DNAPL being captured by 2 of the system's extraction wells
- Resulting in:
  - Retrofitting system with DNAPL knockout vessels
  - Supplemental RI
  - Additional well installations within DNAPL zone to recover NAPL

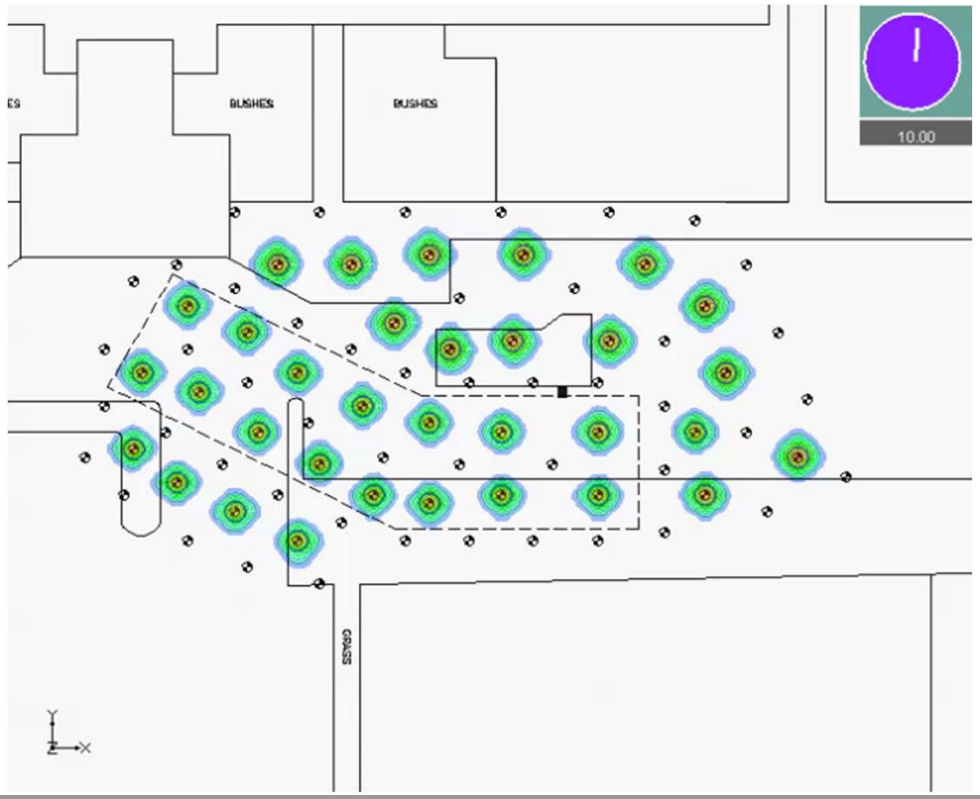
Root cause = **incomplete understanding of the geology's complexity**

which contributed to…

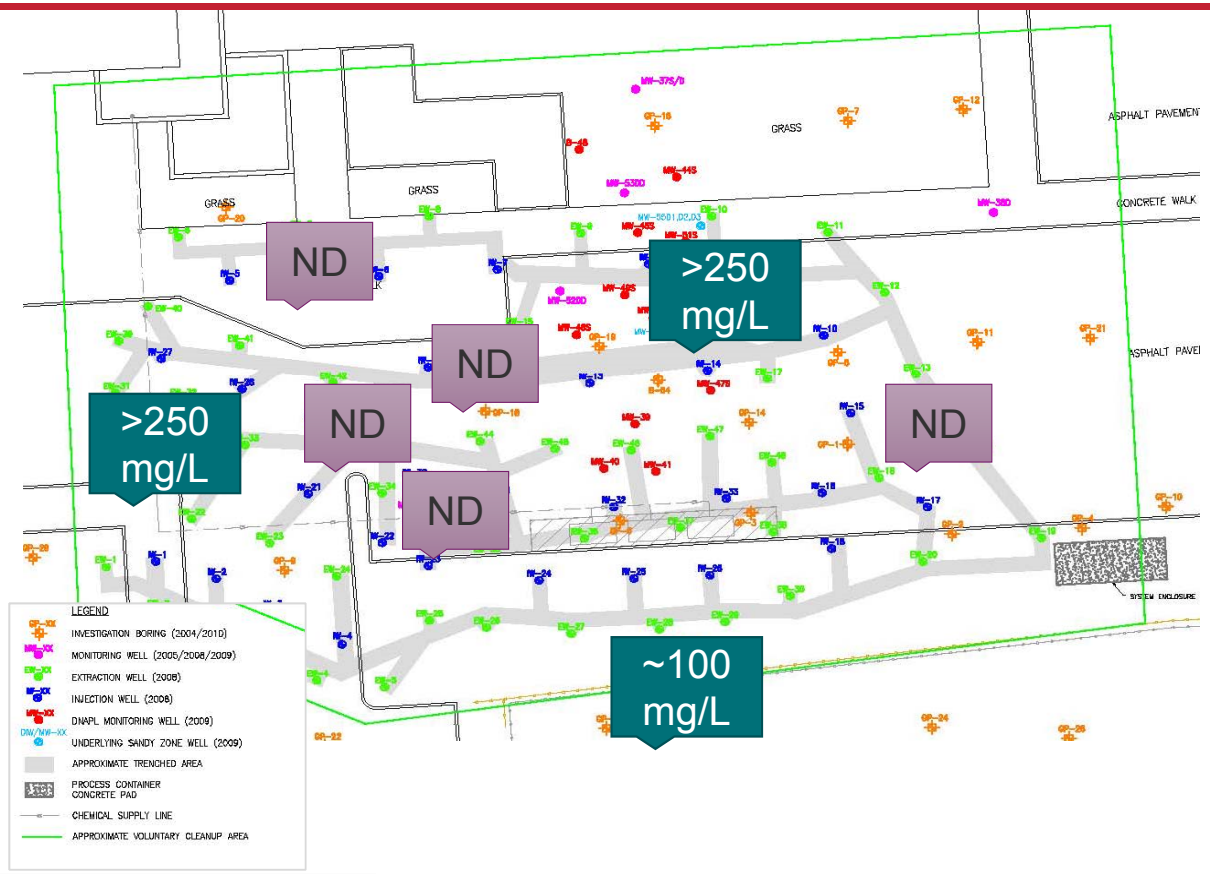
not finding mobile DNAPL

Challenge #2 – Lactate Distribution

- Modeling estimated adequate distribution of lactate after ~70 days
- Full containment of DNAPL/highly impacted groundwater



Challenge #2 – Lactate Distribution (~7 years)



Many MWs remain ND for electron donor (VFAs) after many years of operation

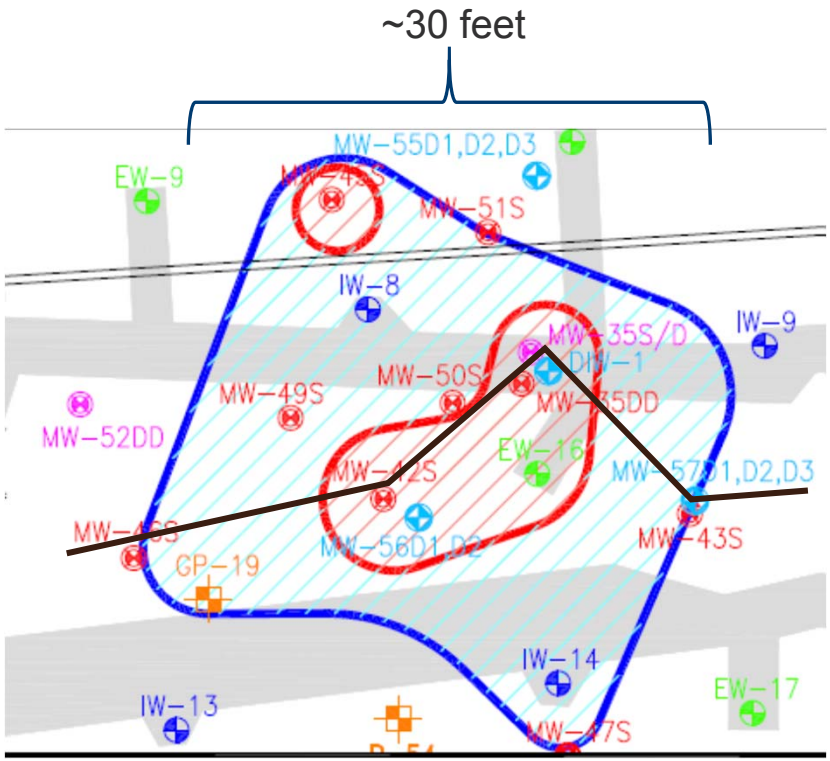
Contributing cause = **geology complexity**

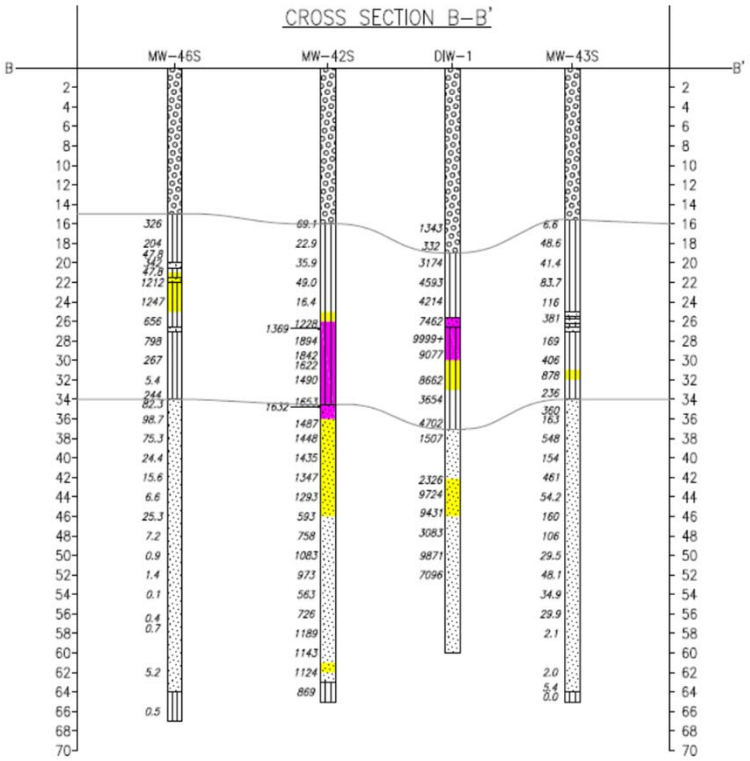
Other reasons include:

- Preferential flow between injection and extraction wells bypassing MWs
- Consumption of electron donor higher than expected

Solution = utilize flexibility in the system to target areas

Supplemental RI (2009)



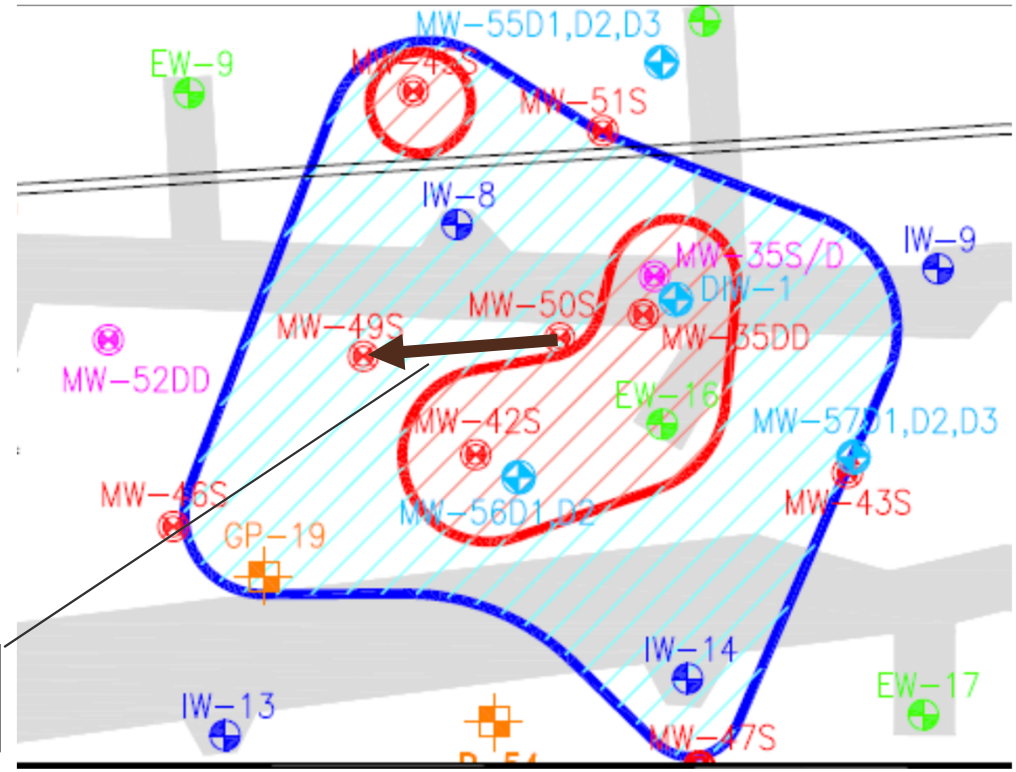


DNAPL investigation tools:

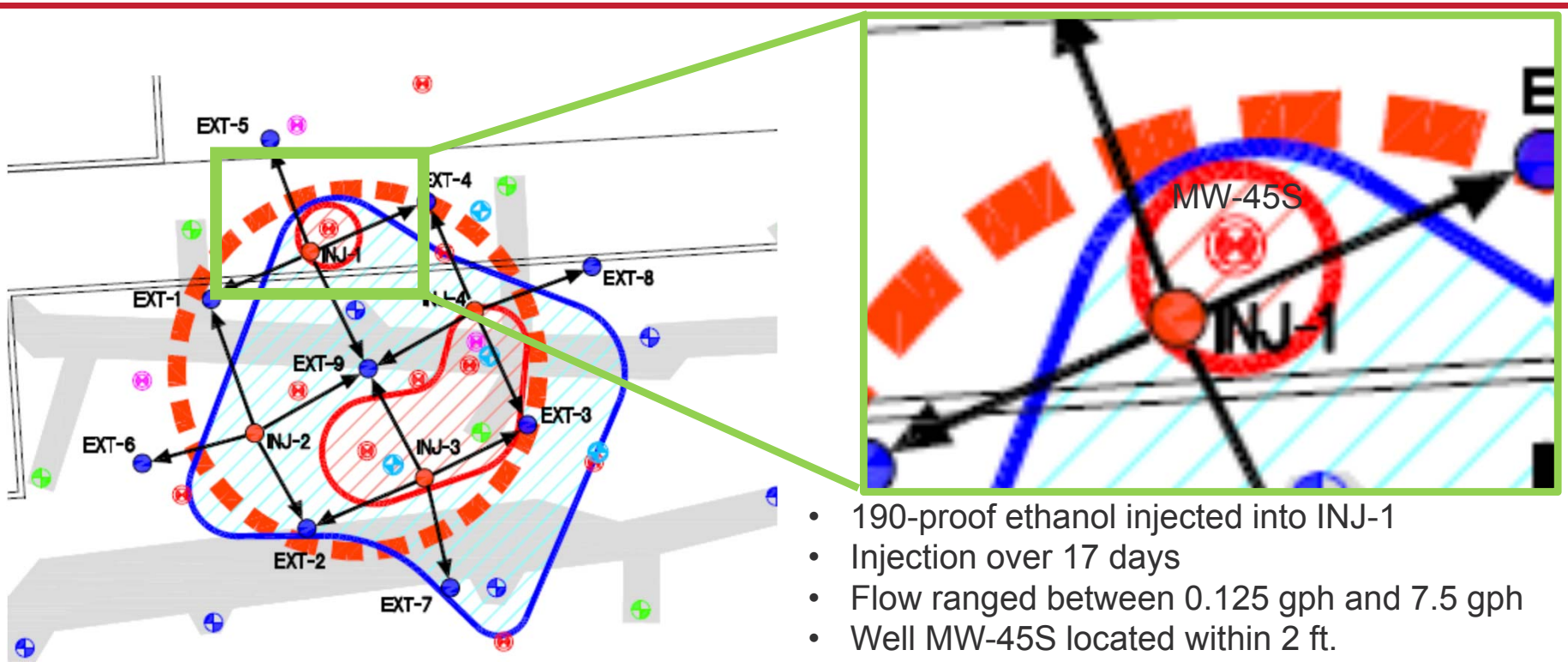
- Soil borings (8)
- Well install (17)
- Visual inspection
- Well pumping
- Lab analysis
- PID readings
- UV screening of soils

Co-Solvent Flushing Development

- Hydraulic conductivity testing (2.07×10^{-1} ft/day)
- Tracer testing (7.7% EP, confirmed connectivity)
- Well field modeling
- Co-solvent bench scale testing (ethanol vs. methanol)
- Evaluation of DNAPL migration



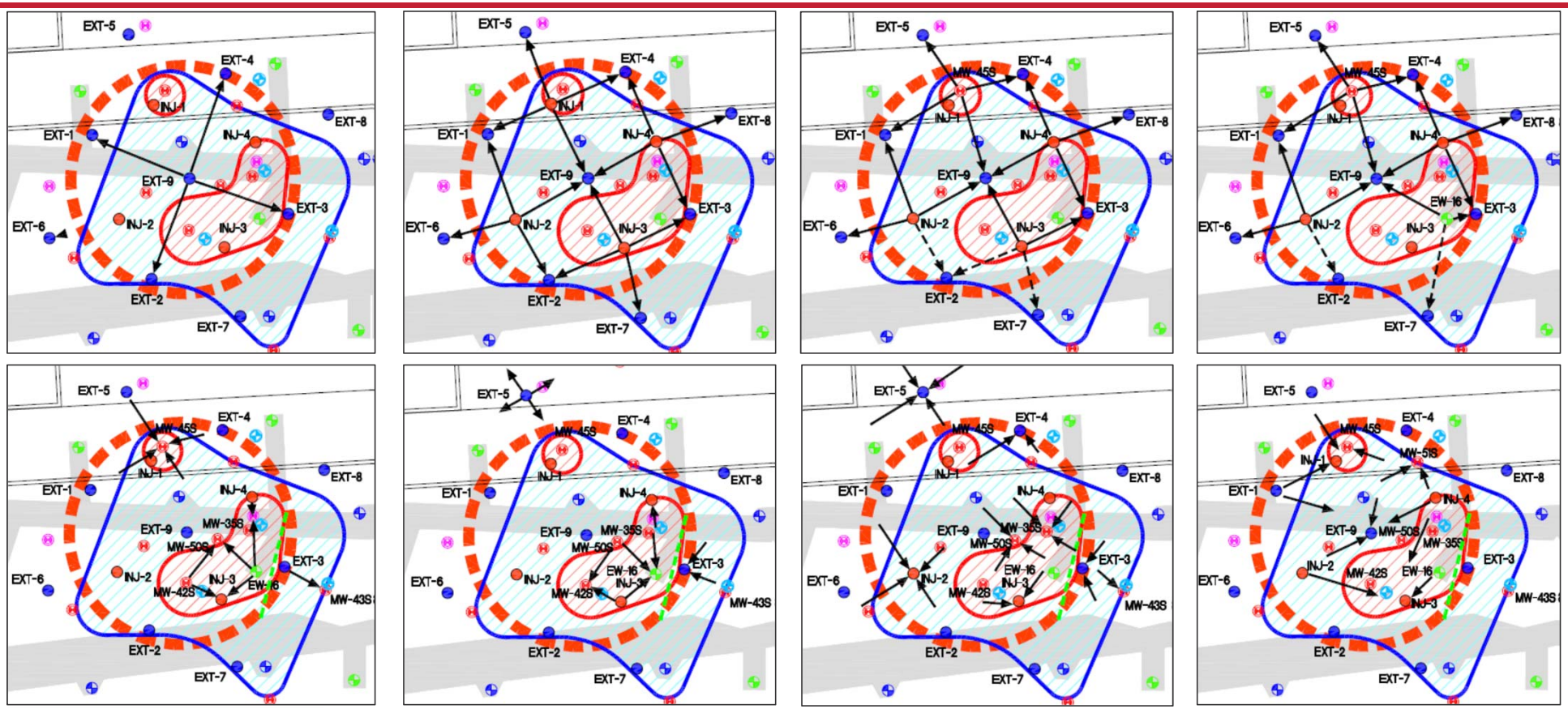
Challenge #3 – Ethanol Distribution



- 190-proof ethanol injected into INJ-1
- Injection over 17 days
- Flow ranged between 0.125 gph and 7.5 gph
- Well MW-45S located within 2 ft.
- **MW-45's ethanol concentration = NON-DETECT!!!**

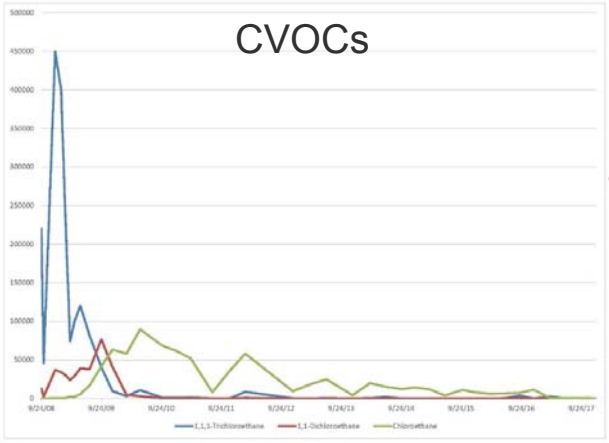
Why??? – geology once again

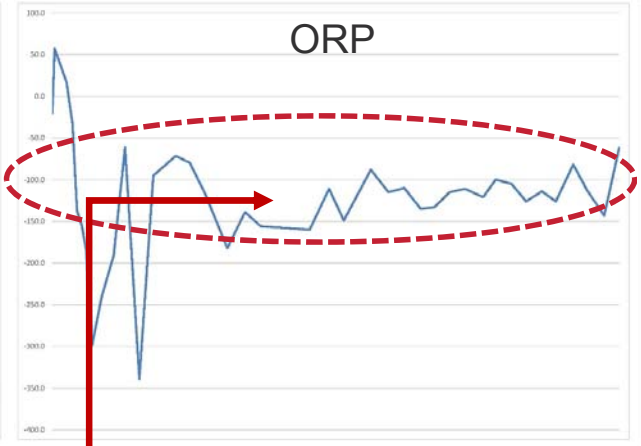
Ethanol Injection Schemes

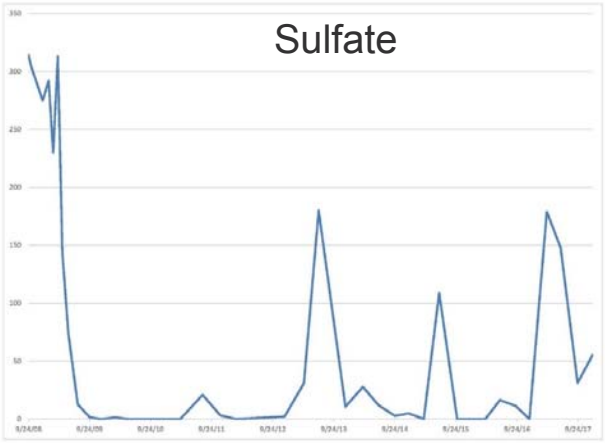


Challenge #4 – Evaluating Biological Activity

MW-33S





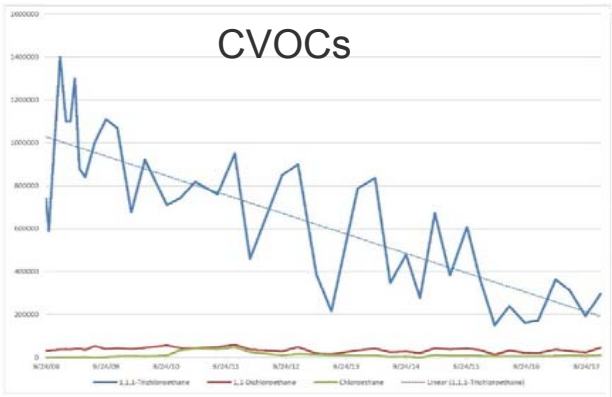


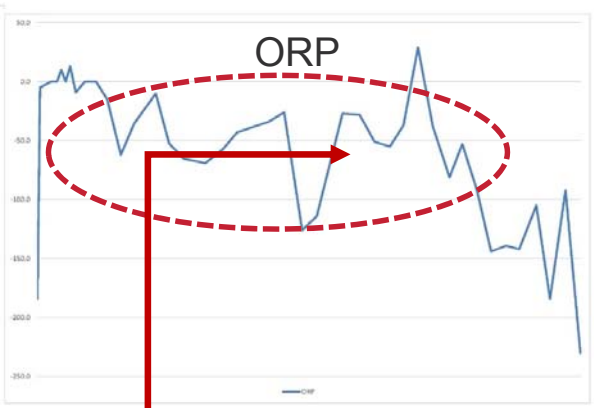
- Classic TCA →DCA →CA
- ORP -100 → -175 eV
- Sulfate ~300 mg/kg → ND

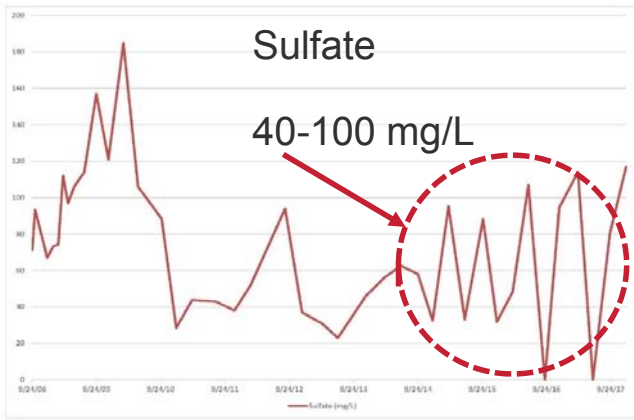
- Electron donor present
- pH ~ 7
- DO < 1 mg/L

Challenge #4 – Evaluating Biological Activity

MW-35S







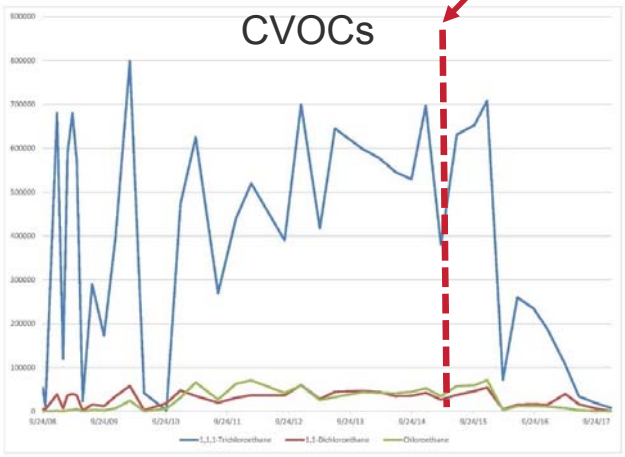
- TCA ~1,400 mg/L → 250 mg/L
- No DCA or CA response
- ORP ~ 0 to -50 eV
- Sulfate remains elevated

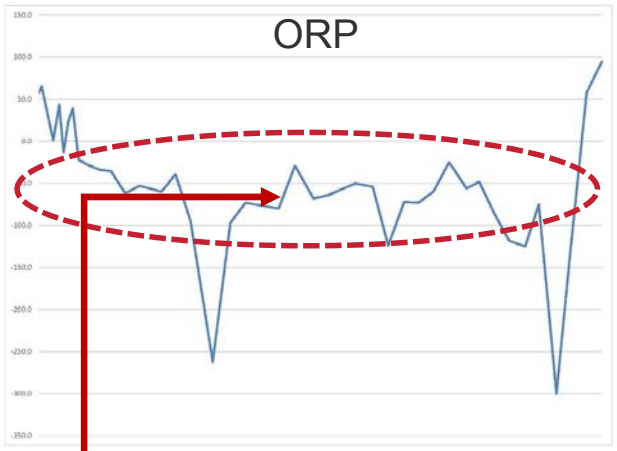
- Electron donor present
- pH ~ 7
- DO < 1 mg/L
- Free hydrogen present

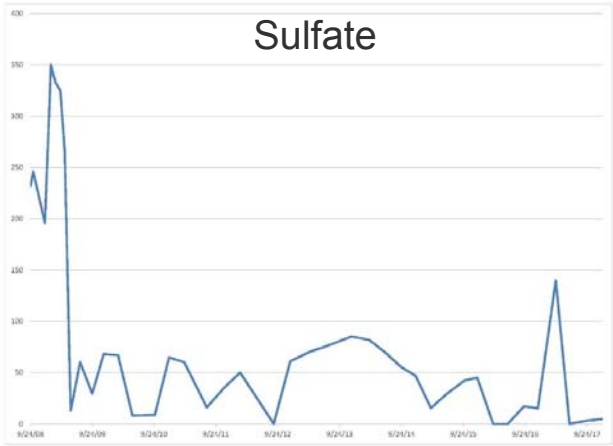
Challenge #4 – Evaluating Biological Activity

MW-31S

Nearby IW switched to EW







- TCA ~800 mg/L → 20 mg/L
- No DCA or CA response
- ORP ~ -50 to -100 eV
- Sulfate ~200 mg/L → <50 mg/L

- Electron donor present
- pH ~ 7
- DO < 1 mg/L
- Free hydrogen present

Lessons Learned

- Don’t Underestimate Your Geology
- Have Flexibility
  - With Your System / Plan
  - Yourself
- Look at ALL Aspects When Evaluating Biological Activity
- Expect Biologically Active and Dead Zones

Questions & Thanks!