A Comprehensive Evaluation of MNA Mechanisms for TCE and DCE in a Large, Dilute Plume

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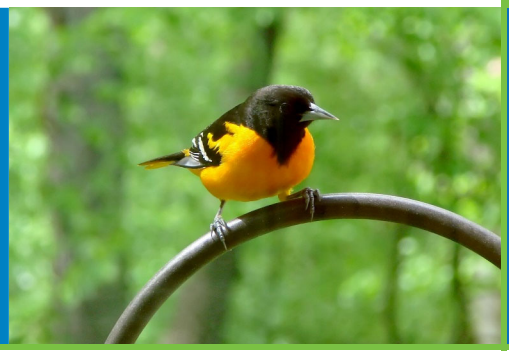
April 17, 2019



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Acknowledgements

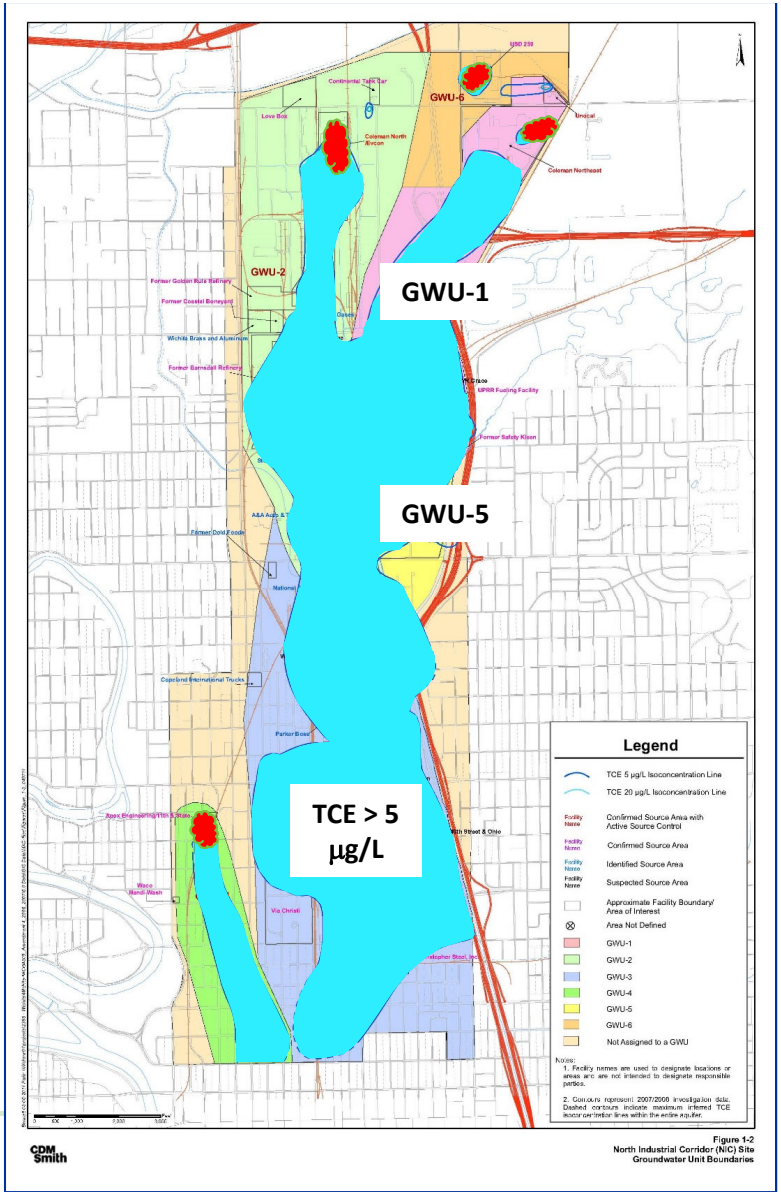
- Dr. Roger Olsen
- Monica Williams
- Dr. Tamzen Macbeth, PE
- Darren Brown, City of Wichita

City of Wichita – North Industrial Corridor (NIC) Site

- Commingled TCE/DCE plume
- Multiple sources

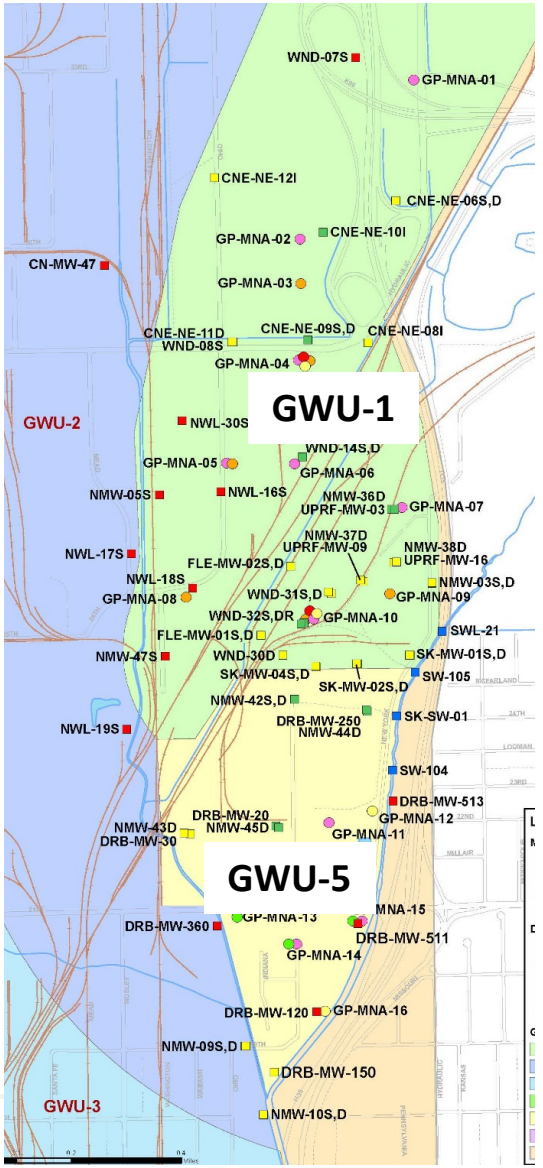
City of Wichita – NIC TCE Plume

- Groundwater units from KDHE corrective action
- MNA study to determine its role for GWU-1
- TCE ACG = 21 µg/L



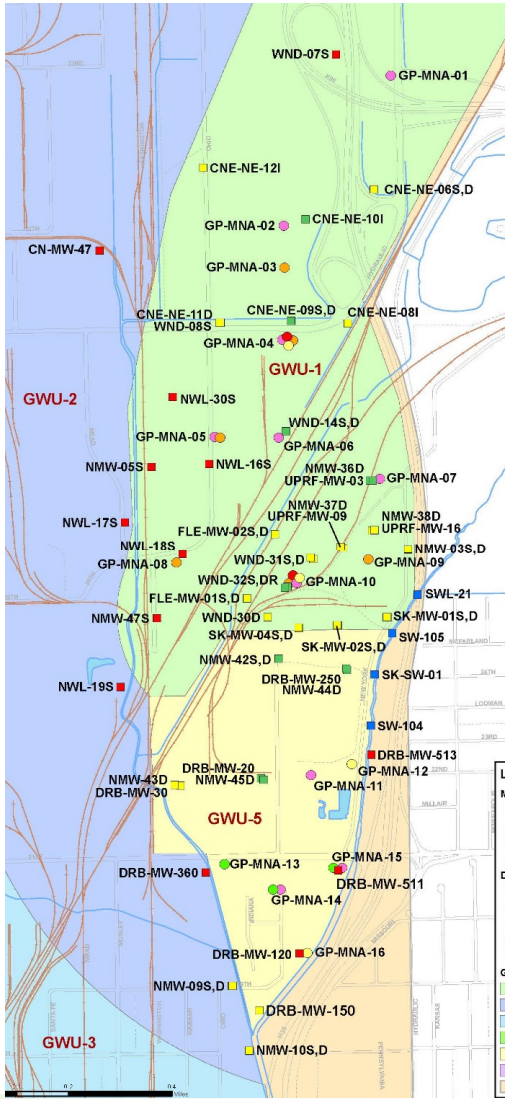
MNA Study

- Features
  - Two comprehensive sampling events
  - Evaluation of reductive dechlorination
  - Evaluation of abiotic degradation
  - Evaluation of aerobic cometabolism activity
  - Overall degradation evaluation (CSIA)
- Goals
  - Evaluate all relevant degradation mechanisms
  - Predict long-term attenuation
  - Provide basis for performance monitoring plan



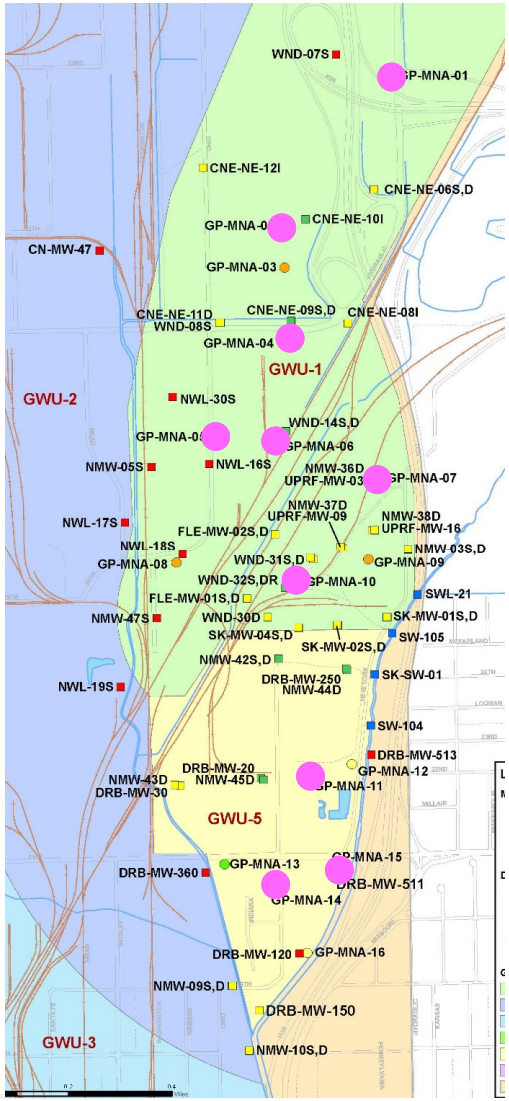
MNA Study

- Two Sampling Events
  - Event 1: 6 months to 1 year after PDA (July 2014)
  - Event 2: 6 months to 1 year after Event 1
  - Spacing between events to aid trend analysis



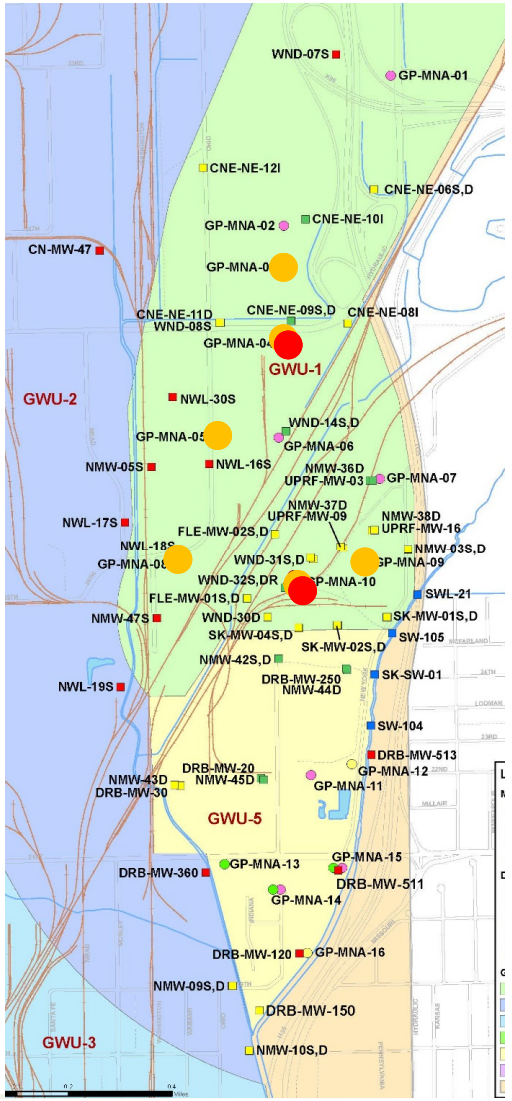
MNA Study Groundwater

- DPT and monitoring wells
  - 36 locations – VOCs (yellow)
  - 21 locations – VOCs + MNA (green)
- Enzyme probes, groundwater – 10 locations (fuchsia)
  - Bacterial enzymes responsible for aerobic cometabolism
- CSIA, groundwater – 10 locations (fuchsia)



MNA Study Soil

- Magnetic susceptibility
  - 6 locations (orange)
  - Electrical conductivity logging to confirm target sample depths
- Total iron (XRF)
- Microcosm samples
  - 2 locations (red)



Hydraulic Gradient

- Southerly in GWU-1
- Turning SE in GWU-5 due to Chisholm Creek

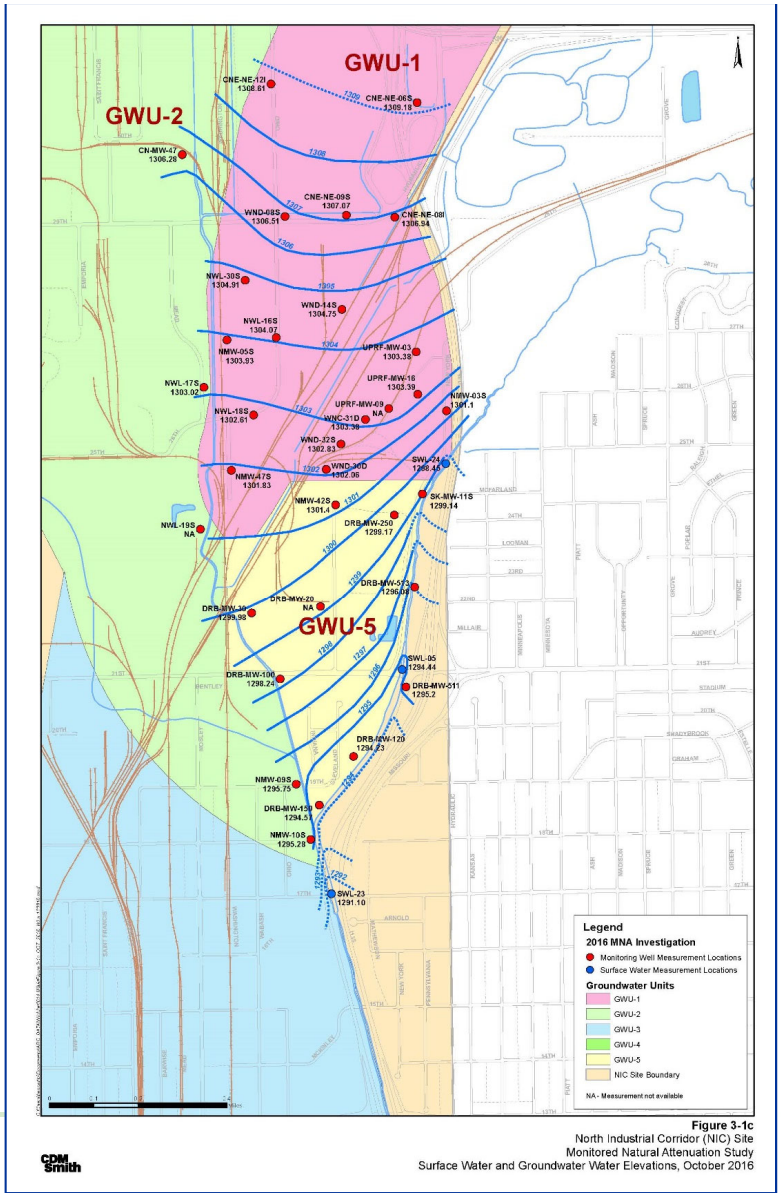


Figure 3-1c
North Industrial Corridor (NIC) Site
Monitored Natural Attenuation Study
Surface Water and Groundwater Water Elevations, October 2016

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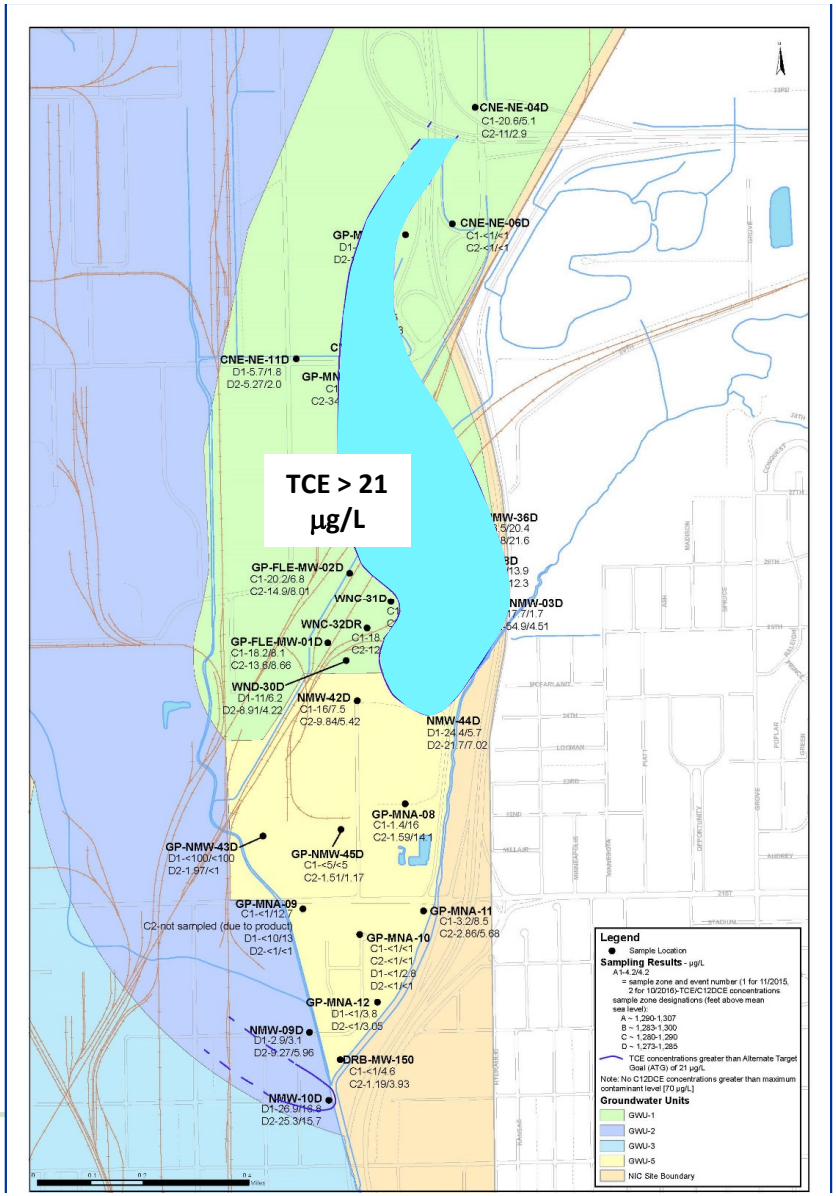
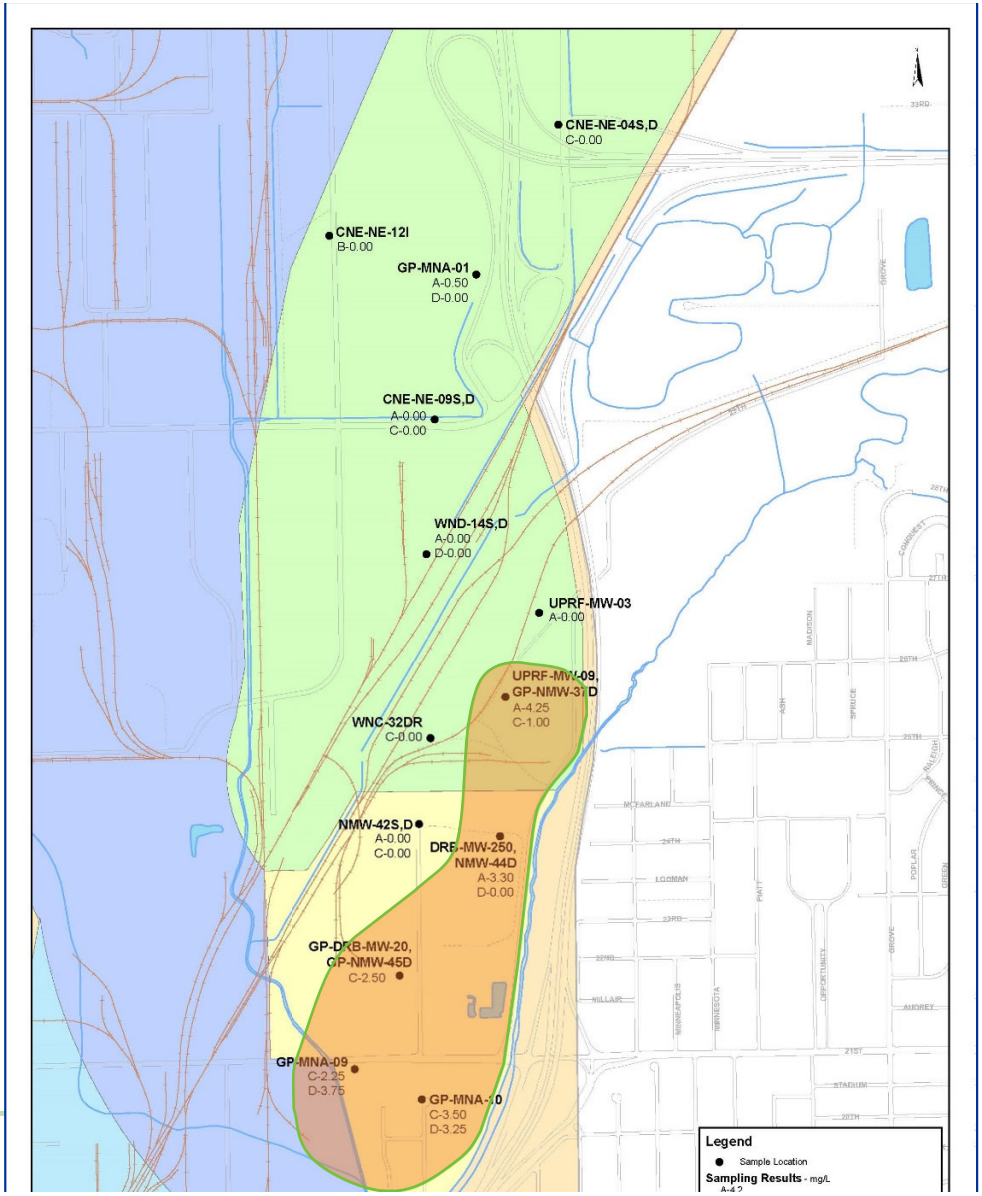
TCE-DCE in Deep Groundwater

- Alternate Target Goal (ATG) for TCE:
  21 µg/L
- Only 3 shallow locations above ATG



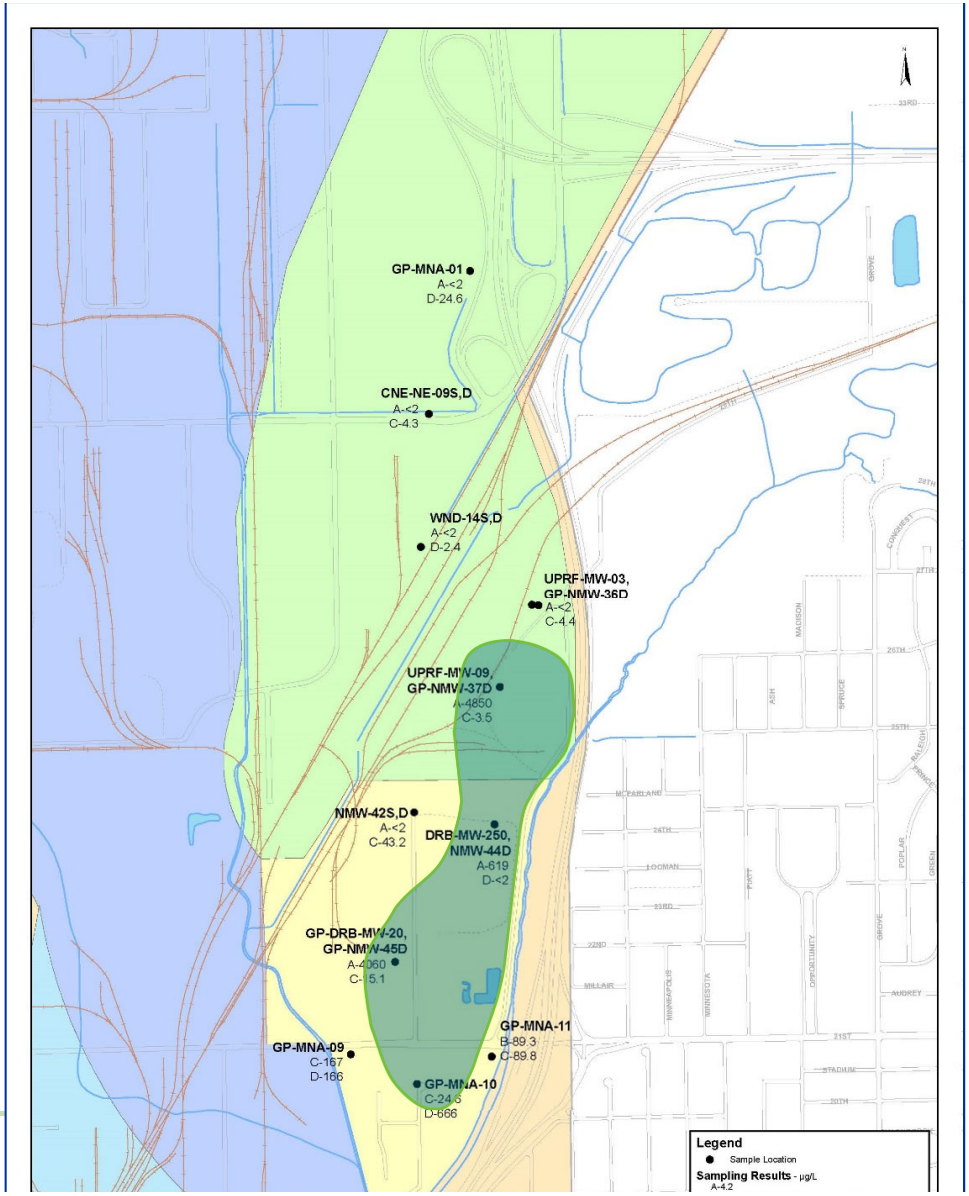
Ferrous Iron

- Ferrous iron > 1 mg/L
- Probably associated with refinery



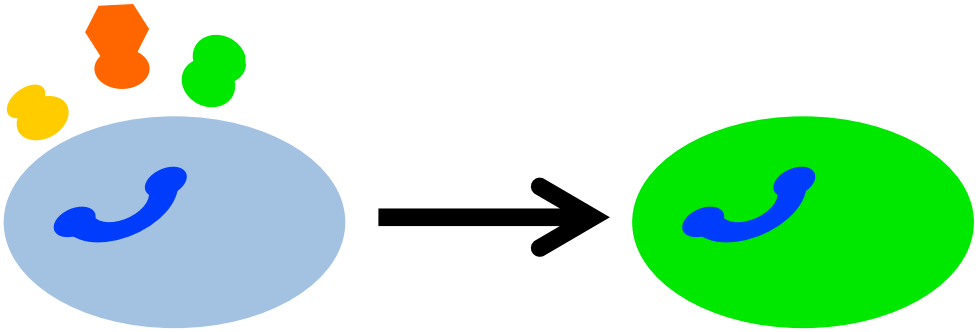
Methane

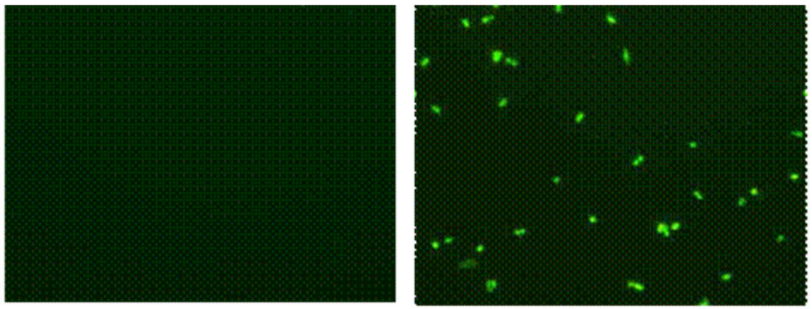
- Methane
  > 0.5 mg/L
- Probably associated with refinery



Aerobic Cometabolism

- Not widely understood
- More difficult to monitor
  - Axial concentration ratios
  - Activity-dependent enzyme probes



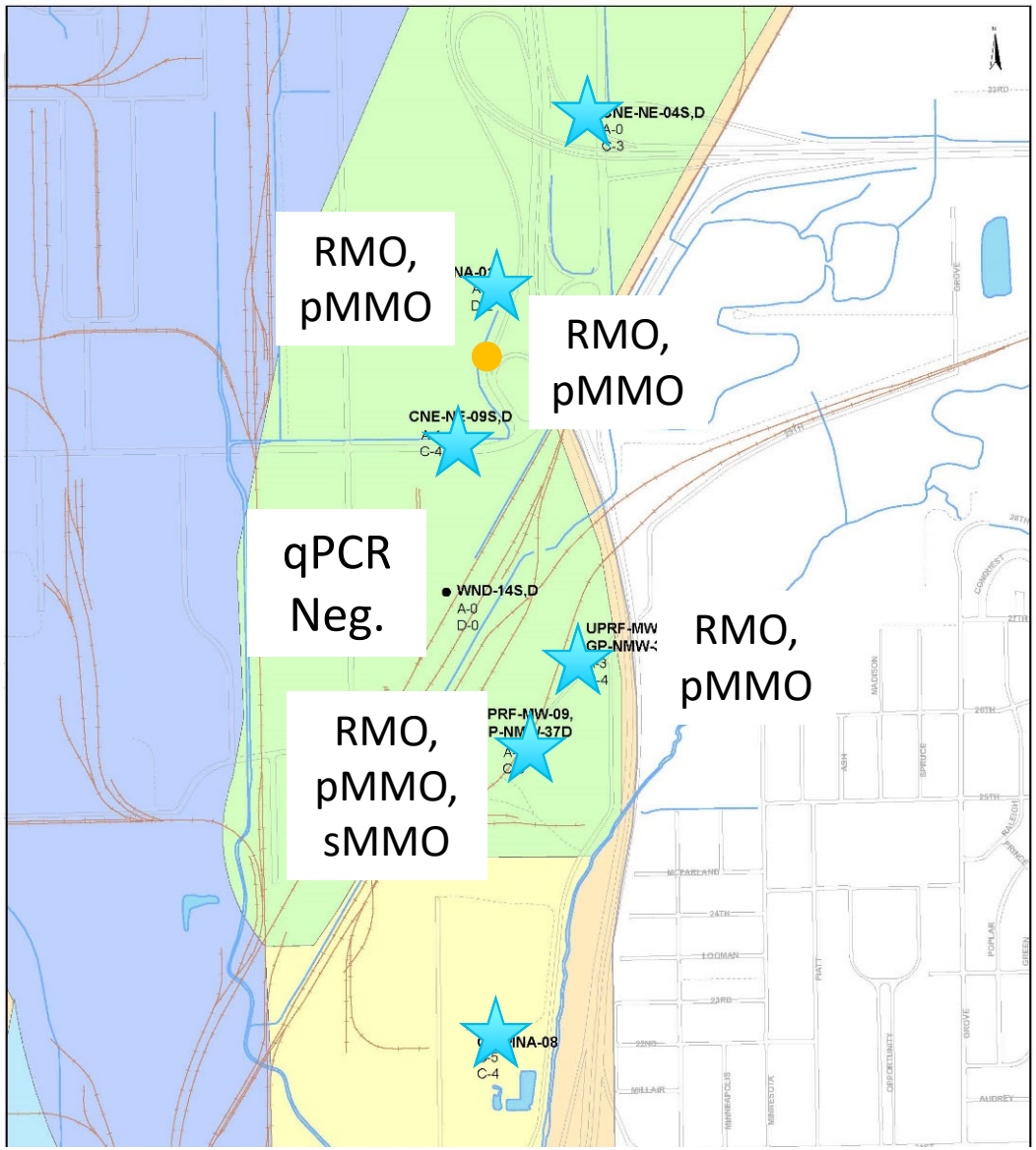


Enzyme probes- negative response

Enzyme probes- positive response

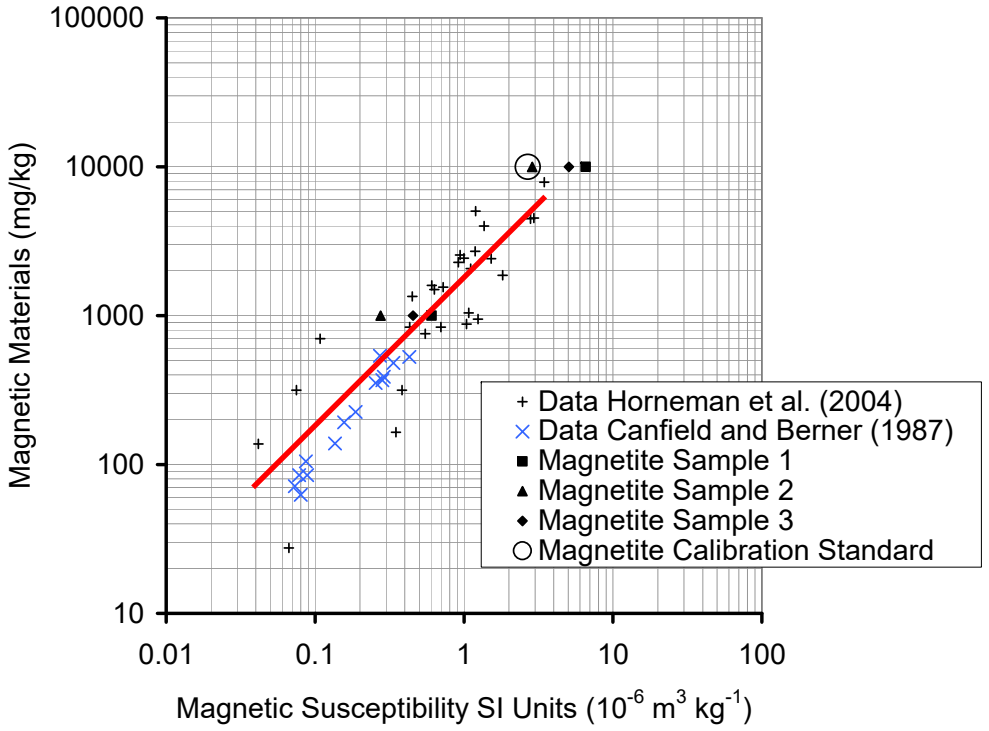
Enzyme Activity Ratings, qPCR

- Moderate to high activity for most of GWU-1 and GWU-5
- Methane and toluene oxygenase enzymes active
  - RMO = ring hydroxylating toluene-3 and -4 monooxygenase



Magnetic Susceptibility

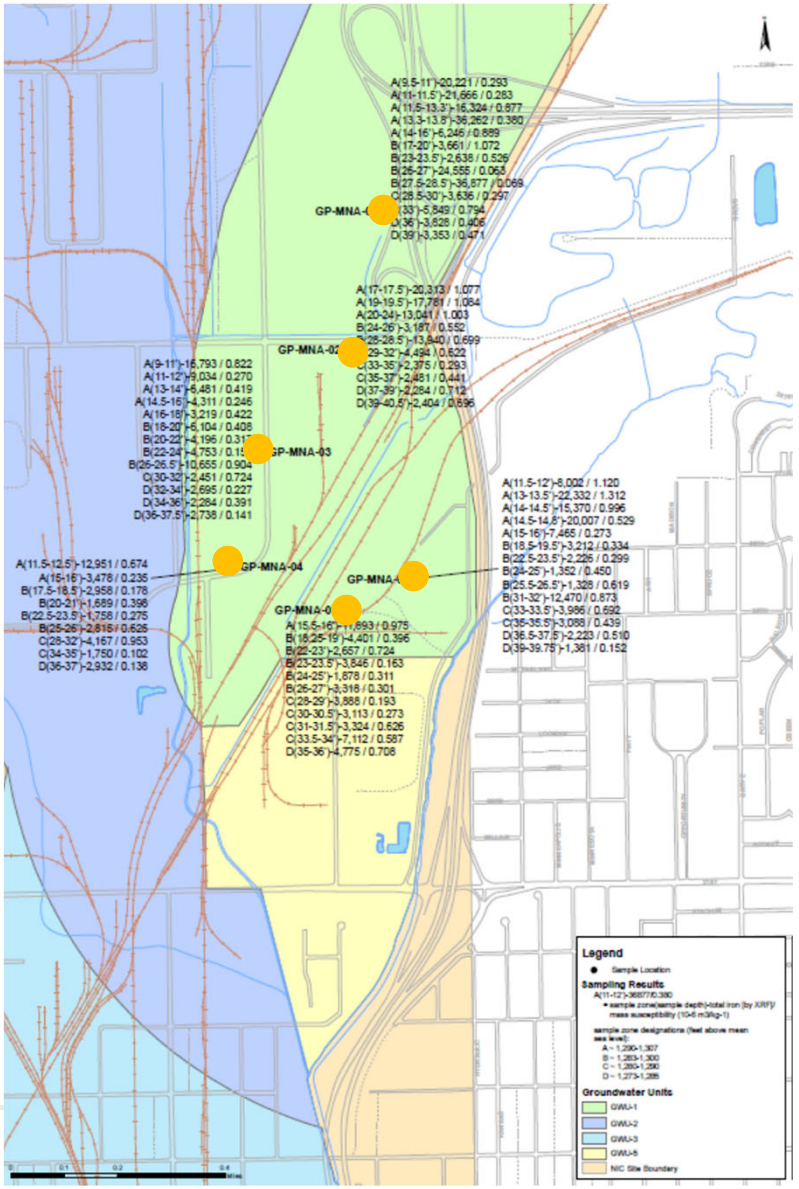
- Indicator of iron minerals (esp. magnetite)
- Material with a magnetic susceptibility of 0.1 to 1.0 X 10^{-6} m^3 kg^{-1} <u>might</u> sustain rates of removal of TCE or *cis*-DCE near 0.3 to 3 yr^{-1} (half-lives between 0.2 and 2 years)



Source: EPA 600/R-09/115 | December 2009 | www.epa.gov/ada; John Wilson, pers. Comm.

Magnetic Susceptibility Results

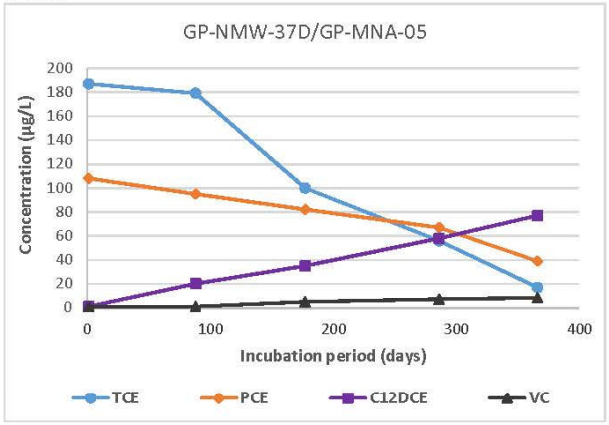
- Six borings, 4 intervals:
  - A: 0.757 E-6 m³/kg
    (0.27E-6 m³/kg to 1.312 E-6 m³/kg)
  - B: 0.427 E-6 m³/kg
    (0.156E-6 m³/kg to1.072 E-6 m³/kg)
  - C/D: 0.464 E-6 m³/kg
    (0.102 E-6 m³/kg to 0.953 E-6 m³/kg)

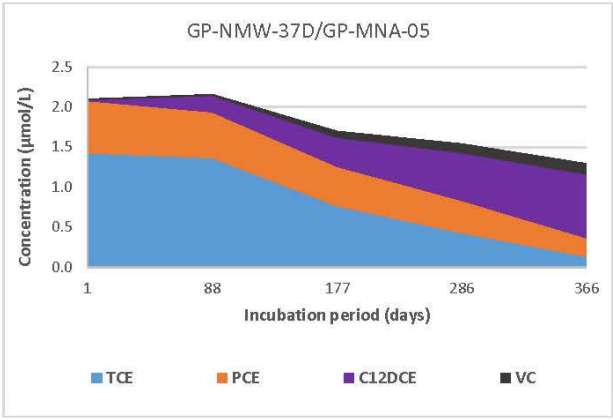


Microcosm Test Results

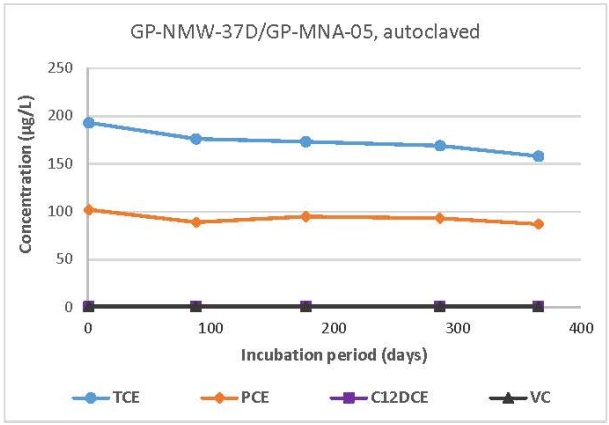
- Reductive dechlorination evident

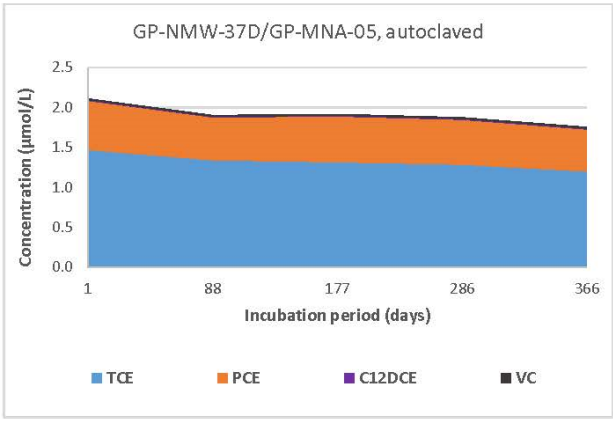
a) Set 1



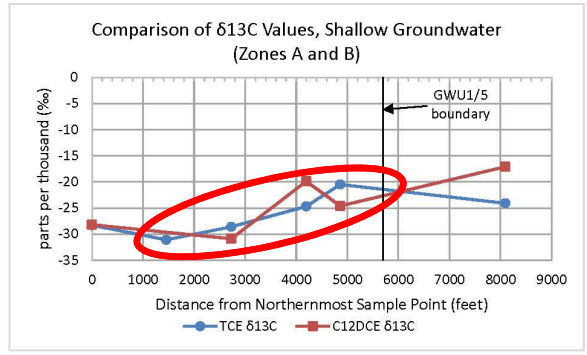


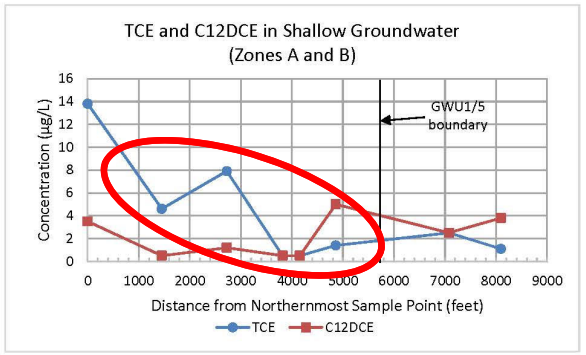
b) Set 2

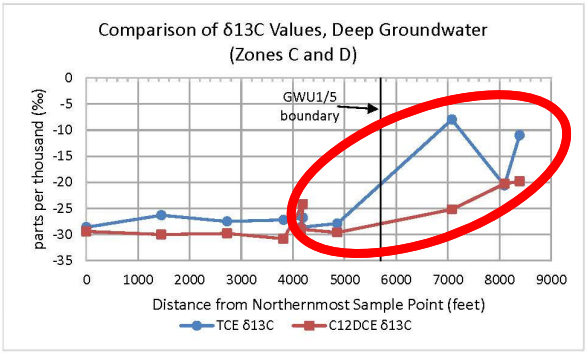




TCE-DCE Concentrations and δ13C Values







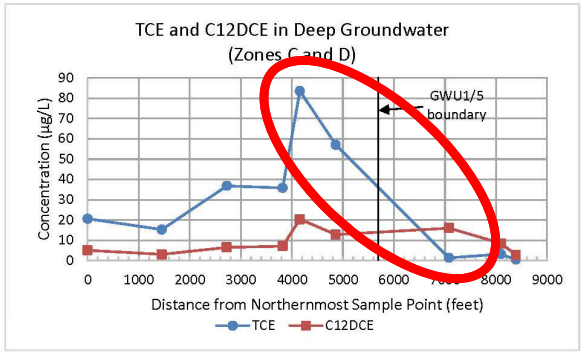
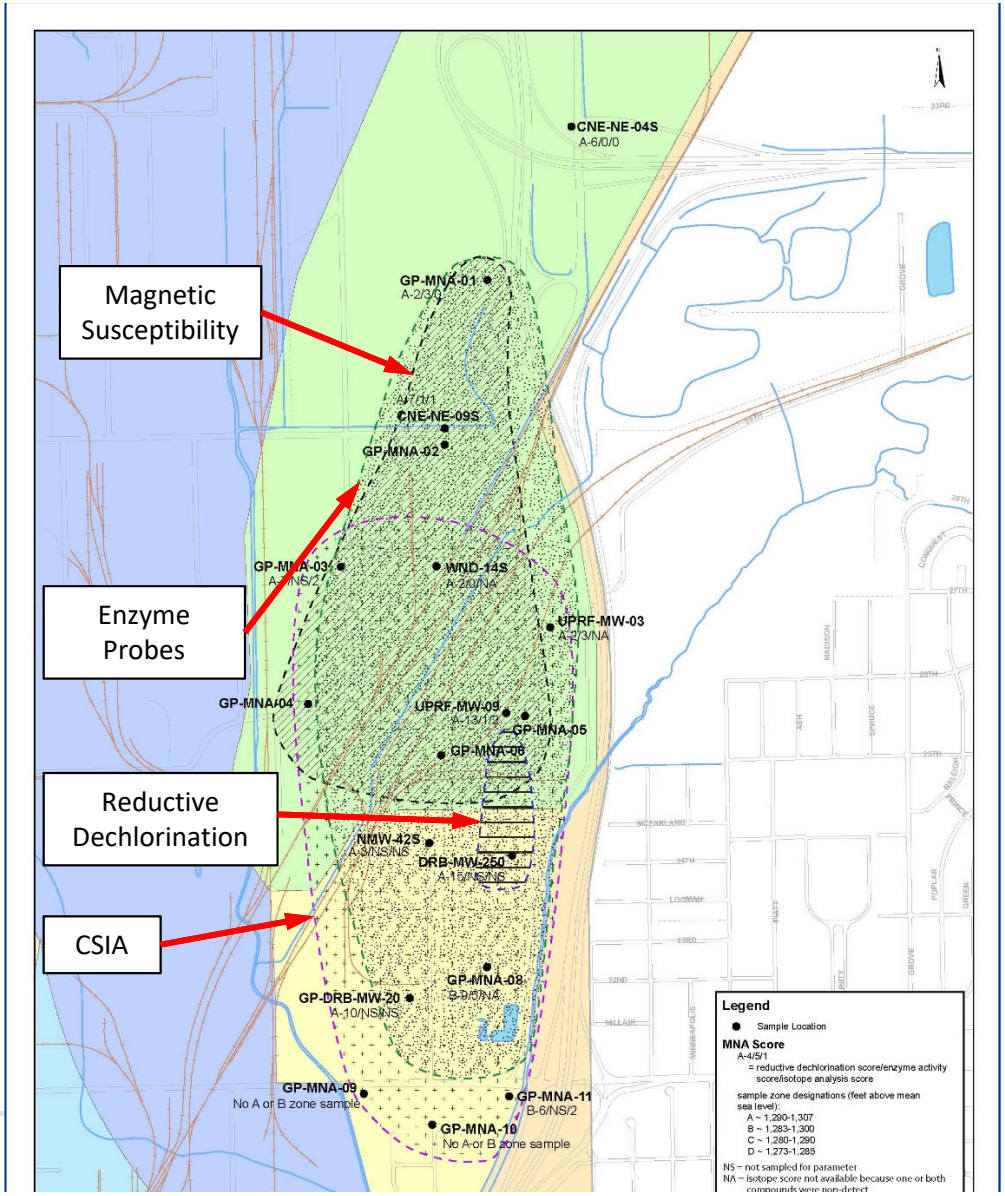


Figure 3-11
North Industrial Corridor Site
GWU1 MNA Study
TCE and C12DCE Concentrations and δ13C Values

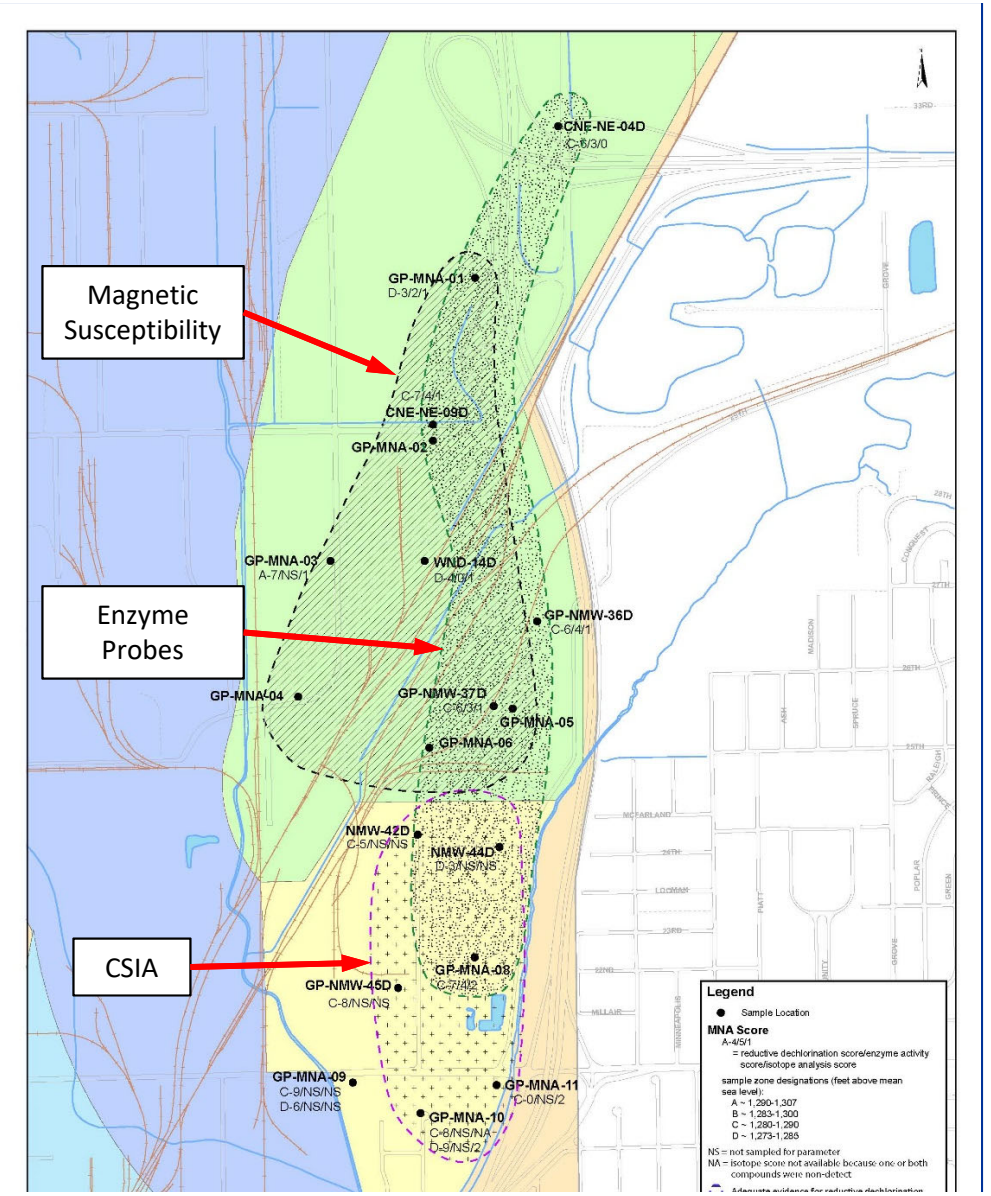
MNA Favorability in Shallow and Intermediate Groundwater

- Most of the shallow zone shows significant evidence for MNA by at least two tools



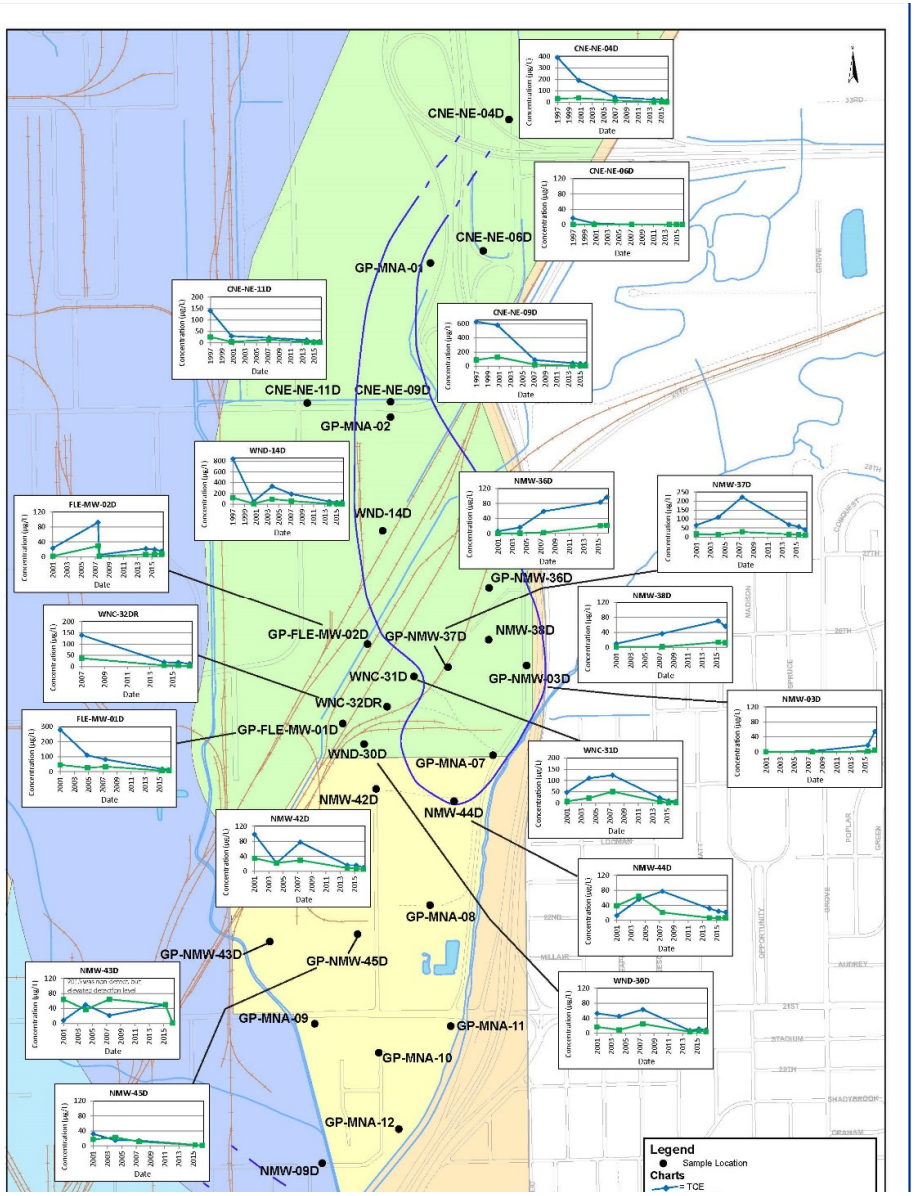
MNA Favorability in Deep Groundwater

- Reductive dechlorination insignificant
- MNA still evident via aerobic cometabolism and potentially abiotic mechanisms



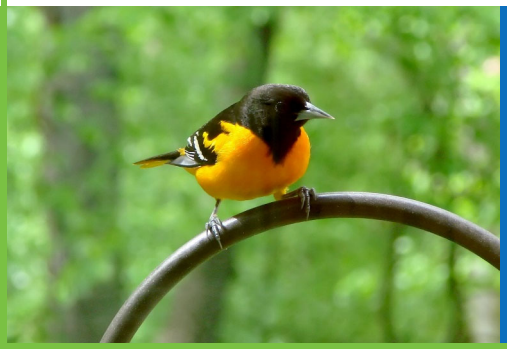
TCE-DCE Time Trends in Deep Groundwater

- Degradation rates estimated in 16 wells
- 10 < ATG
- 5 expected to be < ATG by 2021
- 1 had only 1 year of monitoring, so degradation not apparent



Conclusions

- Multiple lines of evidence needed to confirm degradation
- Reductive dechlorination probably least important mechanism
- MNA approved by KDHE as final remedy for GWU-1
  - Contingency pump and treat system NOT NEEDED



Questions?