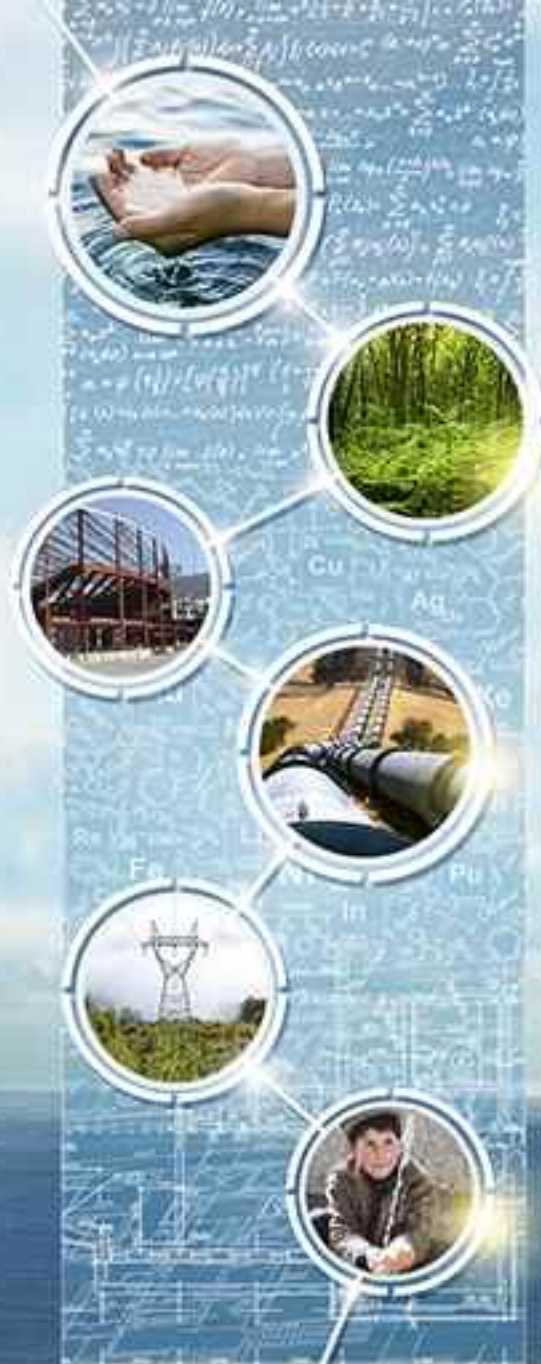




Fast Kinetics In Situ Chemical Oxidation Treatment of a PCE Source Area with Sodium Persulfate Activated with Hydrogen Peroxide

June 4, 2024

Presenter: Angel Cuellar



Presentation Outline

- Pilot Study Objectives
- Site Characterization Summary
- Amendment Mixing and Delivery
- Performance Monitoring Plan
- Performance Monitoring Results
- Pilot Study Conclusions

Pilot Study Objectives

- Test an approach to deliver an aggressive In-Situ Chemical Oxidation (ISCO) amendment to a tetrachloroethylene (PCE) source area
- Evaluate if ISCO can decrease PCE concentrations below the Michigan Department of Environment, Great Lakes, and Energy's (EGLE) Groundwater Surface Water Interface Criteria (GSI) criteria
- Collect data required to complete a full-scale design



Site Characterization Summary

- Agricultural products manufacturing facility of nozzles, spray guns and valves since 1940s
- Operated until early 1990s
- Property had one building totaling 6,500 square feet and located on a 0.5-acre parcel
- Beginning in 1990, various environmental investigations identified several volatile organic compounds (VOCs), including PCE and daughter products at concentrations exceeding one or more of the generic cleanup criteria in soil and groundwater.

[illegible]

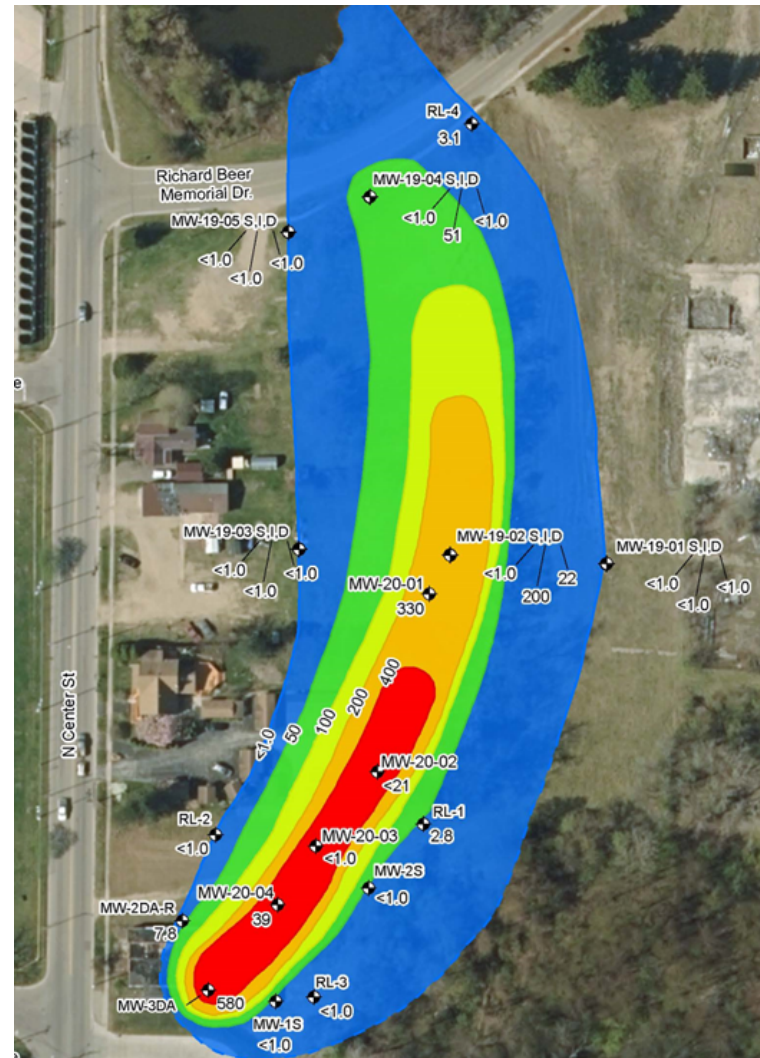
Site Characterization Summary

- Regional Geology is glacial outwash sands and post-glacial alluvium
- Previous Interim Actions included:
 - Soil Vapor Extraction/Air Sparge with 10 to 20 vertical wells
 - In-Situ Chemical Reduction (ISCR) Pilot Study
 - Unsaturated Source Area Excavation

Site Characterization Summary

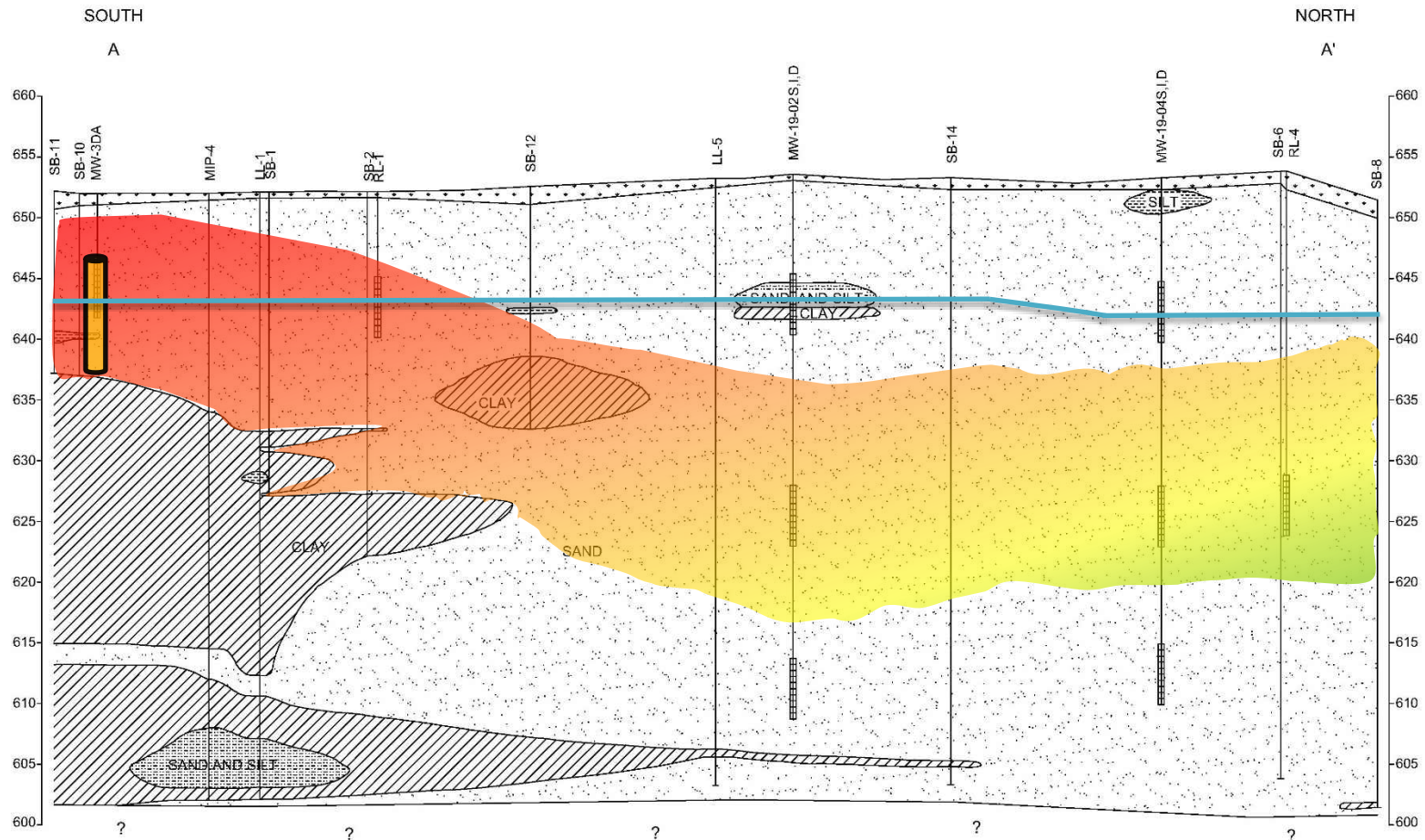
- The areal extent of the impacted groundwater plume exceeding Remedial Objectives is approximately 120 feet wide and 660 feet long discharging to the Black River
- The groundwater flows to the north and has an average groundwater flow velocity of 0.84 feet per day or 309.7 feet per year determined by FluxMeters

2022 Baseline VOCs



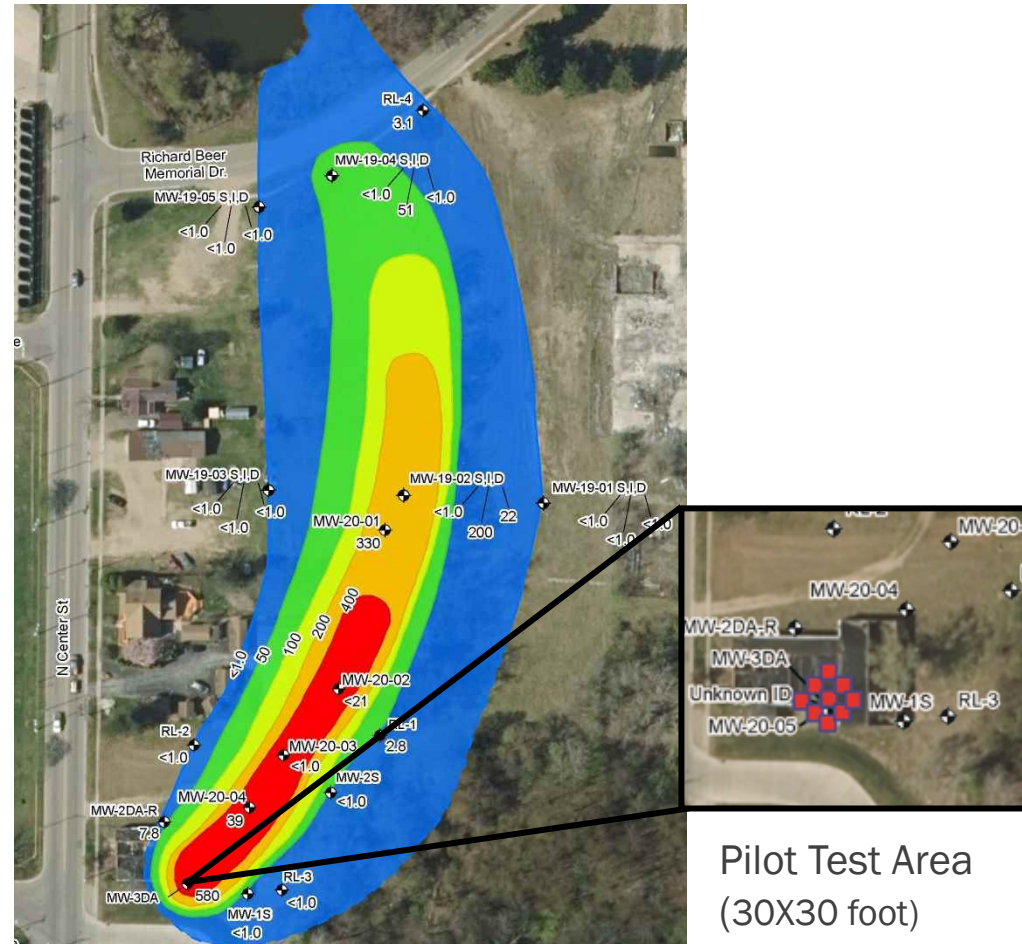
Site Characterization Summary

Cross-Section



Amendment Mixing and Delivery

- Nine, 1-inch polyvinyl chloride injection wells
- 10-foot, 0.010" mill slot screens
- The target treatment depth was approximately 6 to 16 feet below ground surface (bgs) with groundwater at 7.46 feet bgs
- 15-foot grid spacing over 900-square foot to ensure adequate subsurface distribution assuming a targeted radius of 8 feet.



Amendment Mixing and Delivery

- Sodium persulfate activated with 34 weight % hydrogen peroxide was selected due to the fast kinetics needed to oxidize the contaminants before the high groundwater flow velocity transported the amendment away from the source area
- The source water for the amendment mixing was municipal water delivered to the site by tanker truck



Amendment Mixing and Delivery

- The amendment solution was mixed to manufacture's specifications:
 - 980 pounds of sodium persulfate
 - 2,000 pounds of 34 weight % hydrogen peroxide
 - 2,230 gallons of water
 - 2,450 gallons of amendment solution per injection point
- A diaphragm pump with a 550-gallon mixing tank was used to distribute the amendment solution with an average injection rate of approximately 14.3 gallons per minute and average injection pressure was 35.8 pounds per square inch
- Injections were completed over a 5-day period



Amendment Mixing and Delivery

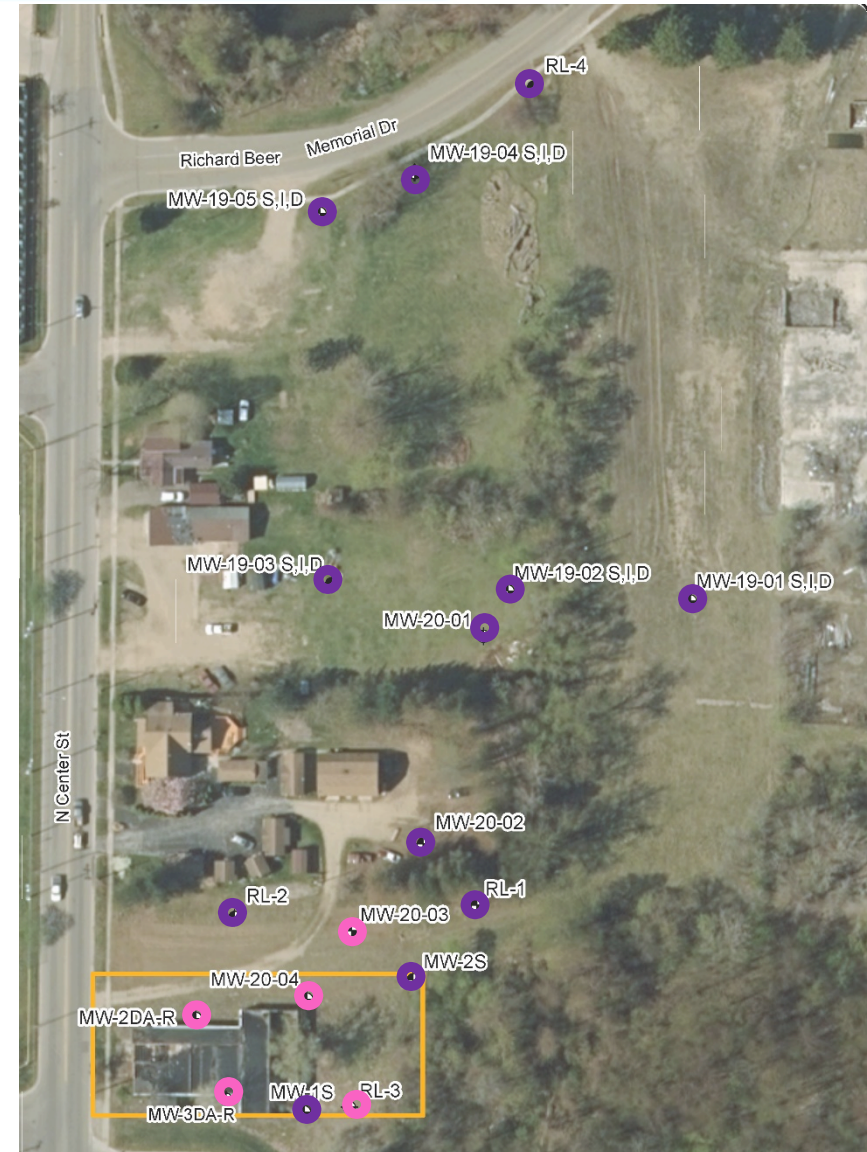
- Field testing included groundwater geochemical monitoring of:
 - sodium persulfate field test kits
 - pH,
 - Oxidation-Reduction Potential (ORP), and
 - specific conductance



Target area persulfate test kit during injections

Performance Monitoring Plan

- The performance monitoring included 27 wells for VOCs with five of the wells for ISCO performance parameters:
 - Sodium Persulfate Field Test
 - Dissolved Sodium
 - Sulfate



Performance Monitoring Results

Target Well		Baseline	Post Injection			
MW-3DA-R		10/12/2022	1/19/2023	5/16/2023	7/19/2023	10/24/2023
pH	S.U.	7.54	5.77	6.03	5.94	6.13
ORP	mV	-10.7	202.4	122.0	290.3	231.9
Specific Conductance	ms/cm	3.017	2.519	1.691	3.928	3.395
Sodium Persulfate	mg/L	0	28-35	4.2	21	NS
Dissolved Sodium	mg/L	400	400	190	450	400
Sulfate	mg/L	30	800	67	510	580
Cross Gradient		Baseline	Post Injection			
MW-2DA-R		10/12/2022	1/19/2023	5/16/2023	7/19/2023	10/24/2023
pH	S.U.	7.17	7.05	7.01	7.01	7.14
ORP	mV	75.3	10.6	184.7	58.9	101.6
Specific Conductance	ms/cm	0.676	0.935	0.885	1.489	1.093
Sodium Persulfate	mg/L	0	0-0.7	1.4	0	NS
Dissolved Sodium	mg/L	41	48	50	140	97
Sulfate	mg/L	32	30	33	30	28

Performance Monitoring Results

Cross Gradient		Baseline	Post Injection			
RL-3		10/12/2022	1/19/2023	5/16/2023	7/19/2023	10/24/2023
pH	S.U.	7.17	7.09	6.69	6.51	6.73
ORP	mV	-135.7	-192.3	-105.9	-89.9	-3.9
Specific Conductance	ms/cm	5.087	4.433	4.053	7.092	4.137
Sodium Persulfate	mg/L	0	0.7-1.4	0	0-0.7	NS
Dissolved Sodium	mg/L	620	560	560	1100	610
Sulfate	mg/L	50	90	310	750	340
Down Gradient		Baseline	Post Injection			
MW-20-04		10/12/2022	1/19/2023	5/16/2024	7/19/2024	10/24/2023
pH	S.U.	7.16	6.59	6.39	6.28	6.40
ORP	mV	142.7	4.2	245.3	220.1	54.0
Specific Conductance	ms/cm	0.952	1.028	1.931	1.684	0.623
Sodium Persulfate	mg/L	0	0-0.7	>70	49-56	NS
Dissolved Sodium	mg/L	110	110	200	180	39
Sulfate	mg/L	19	16	250	190	38

Performance Monitoring Results

Target Well		Baseline	Post Injection				
MW-3DA-R		10/12/2022	1/19/2023	5/16/2023	7/19/2023	10/24/2023	4/15/2024
PCE	µg/L	420	30	36	22	66	27
TCE	µg/L	ND	2.8	3.3	ND	2.4	2.2
cis-DCE	µg/L	ND	1.1	1.6	ND	3.6	3.9
VC	µg/L	ND	ND	ND	ND	ND	ND
Cross Gradient		Baseline	Post Injection				
MW-2DA-R		10/12/2022	1/19/2023	5/16/2023	7/19/2023	10/24/2023	4/15/2024
PCE	µg/L	11.0	8.7	7.6	12	14	7.3
TCE	µg/L	ND	ND	ND	ND	ND	ND
cis-DCE	µg/L	ND	ND	ND	ND	ND	ND
VC	µg/L	ND	ND	ND	ND	ND	ND
Cross Gradient		Baseline	Post Injection				
RL-3		10/12/2022	1/19/2023	5/16/2023	7/19/2023	10/24/2023	4/15/2024
PCE	µg/L	1.6	2.4	2.1	2.1	2.2	ND
TCE	µg/L	1.7	1.8	1.7	2.4	1.4	ND
cis-DCE	µg/L	4.1	3.7	1.9	1.7	1.9	5.2
VC	µg/L	ND	ND	ND	ND	ND	ND

Performance Monitoring Results

Down Gradient		Baseline	Post Injection				
MW-20-04		10/12/2022	1/19/2023	5/16/2023	7/19/2023	10/24/2023	4/15/2024
PCE	µg/L	29	26	30	25	8.9	14
TCE	µg/L	2.1	5.2	1.3	1.9	8.3	6.9
cis-DCE	µg/L	ND	ND	1.5	ND	1.7	1.6
VC	µg/L	ND	ND	ND	ND	ND	ND
Down Gradient		Baseline	Post Injection				
MW-20-02		10/12/2022	1/18/2023	5/16/2024	7/19/2024	10/24/2023	4/15/2024
PCE	µg/L	6.3	ND	NS	4.0	4.4	3.3
TCE	µg/L	3.8	ND	NS	3.6	4.5	6.7
cis-DCE	µg/L	7.0	1.2	NS	8.0	4.2	6.2
VC	µg/L	4.0	2.6	NS	5.7	3.2	1.5

- Successfully injected ISCO amendment into the shallow impacted interval.
- Sodium persulfate field test kits demonstrated achievement of the target radius of influence
- Aggressive fast kinetics ISCO applied decreased the source area concentrations
 - PCE was reduced from 420 µg/L to 27 µg/L in a key well; 94% reduction from baseline
- No full-scale implementation is needed because the pilot study achieved the remedial objective to decrease concentrations in the source area below GSI criteria prior to discharging into the Black River



Thank You!

Angel Cuellar

Program Manager

angel.cuellar@tetrattech.com