
Biological Degradation and Chemical Reduction To Reduce DNAPL and Dissolved COCs to Turn off an Extraction System

Robert E. Mayer Jr.

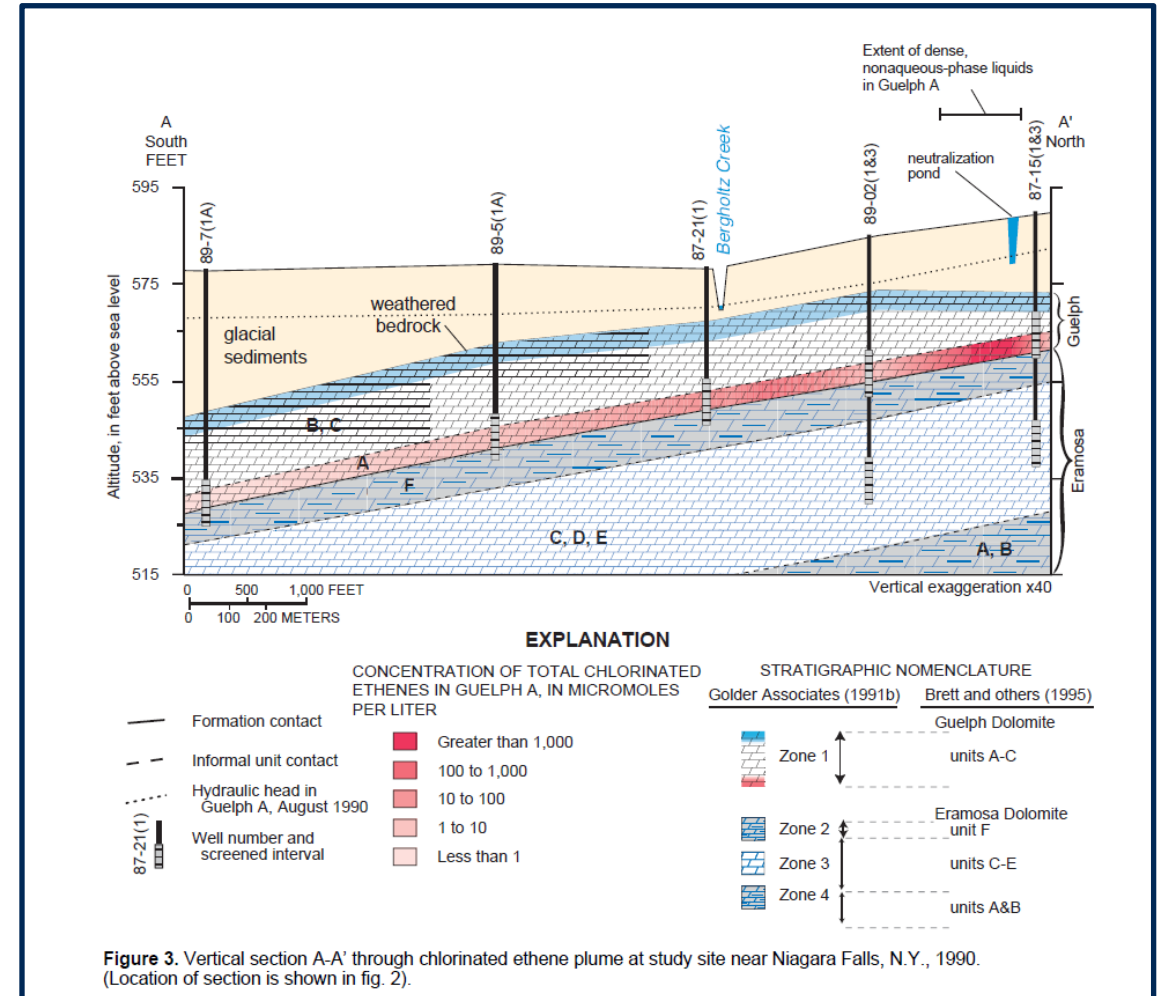
BACKGROUND

- ▶ Site near Niagara Falls, NY
- ▶ The site had been an active research, testing, and manufacturing facility since 1940.
- ▶ TCE and methylene chloride were used in the manufacturing process.
- ▶ A neutralization pond was formerly used for the treatment of waste fluids.
- ▶ The use of the pond was discontinued in 1987



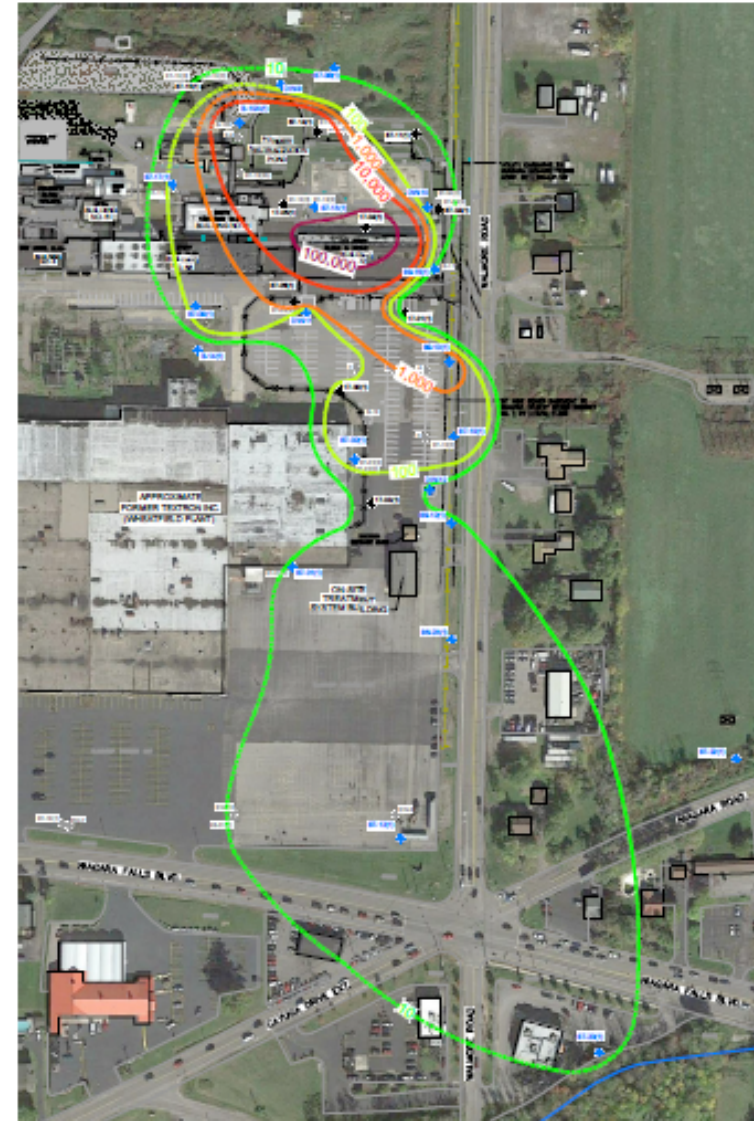
BACKGROUND

► Soils at the neutralization pond were excavated to bedrock; however, the presence of DNAPL and dissolved levels of VOCs have been detected in uppermost bedrock strata.



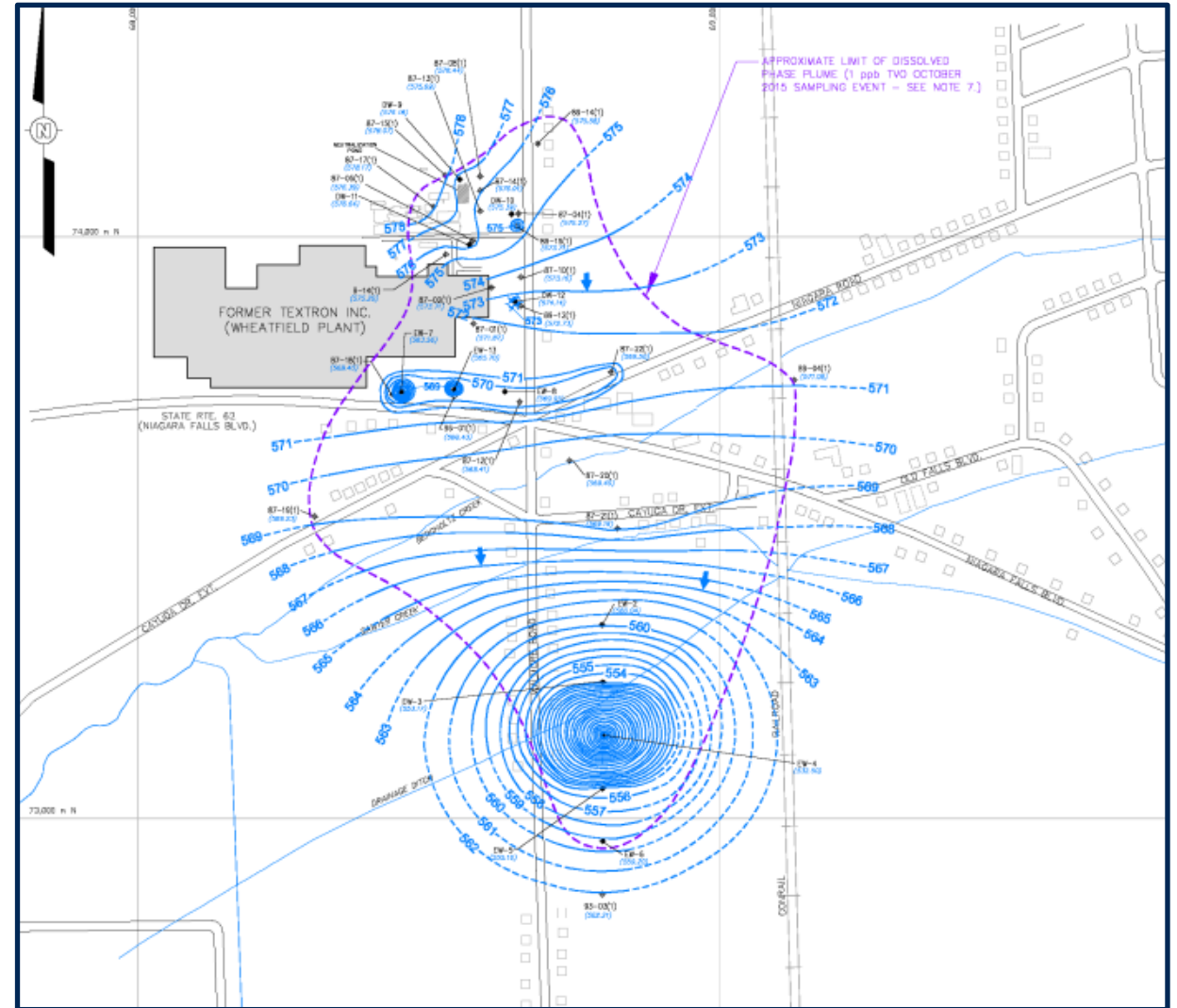
BACKGROUND

- ▶ The DNAPL plume has extended to near 750 feet downgradient of the pond.
- ▶ The dissolved phase VOC plume, including TCE, cis-1,2-DCE, VC and methylene chloride extends approximately 4,000 feet downgradient.



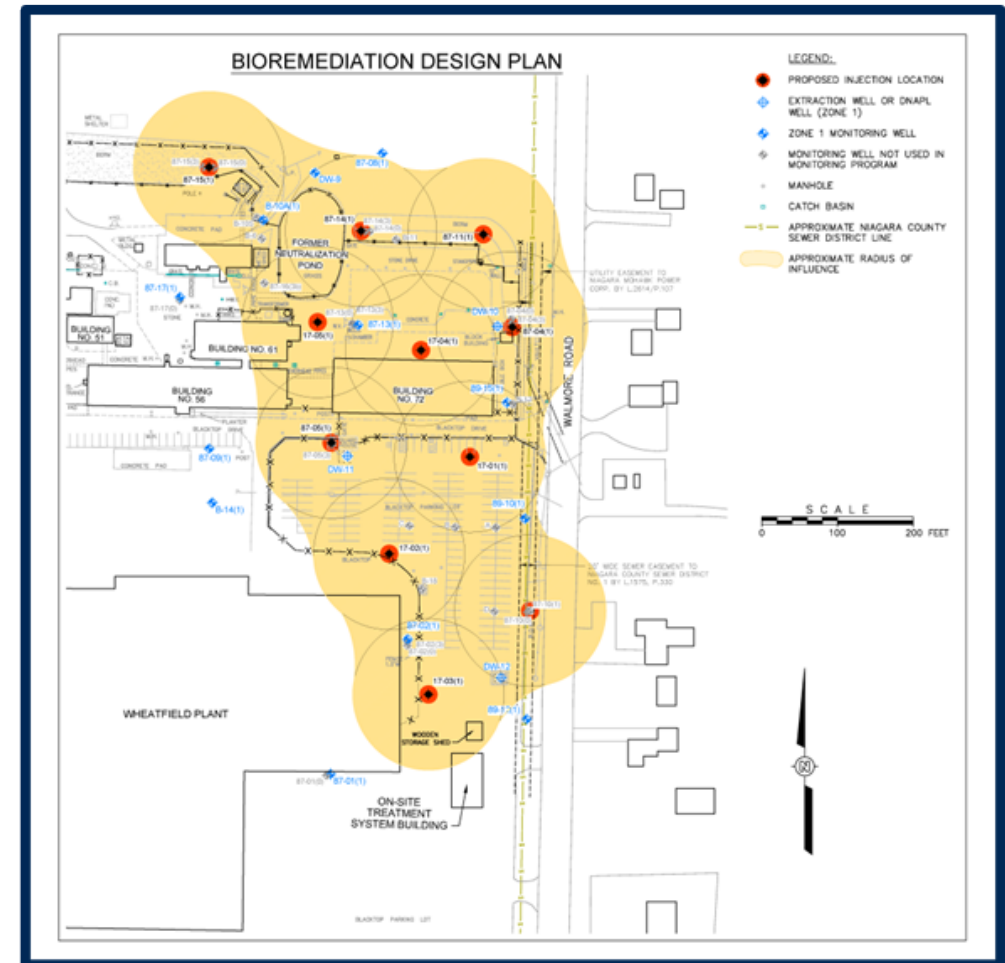
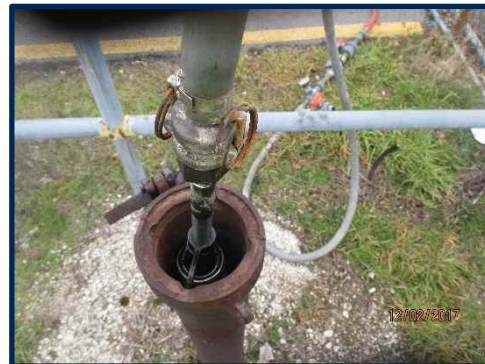
GROUND WATER EXTRACTION

- ▶ The original groundwater remedy included two groundwater recovery systems within the Zone 1 bedrock.
- ▶ Off-site system was turned on in 1993.
- ▶ On-site system was turned on in 1995.



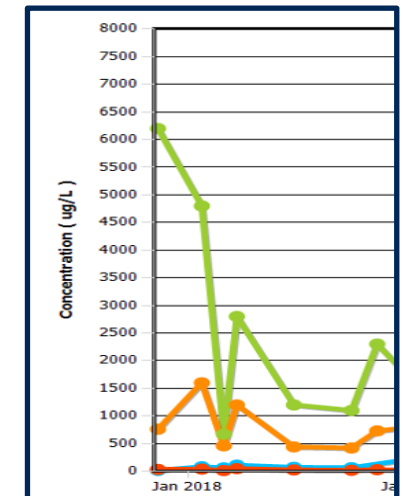
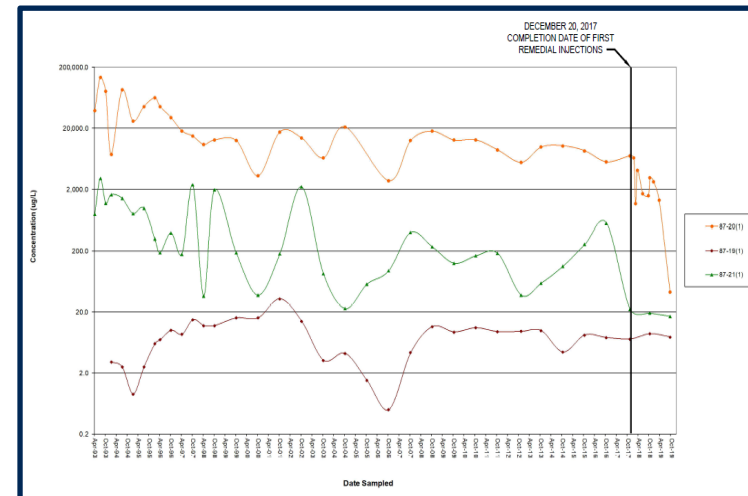
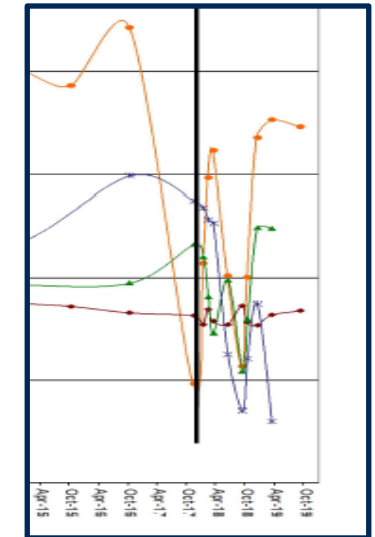
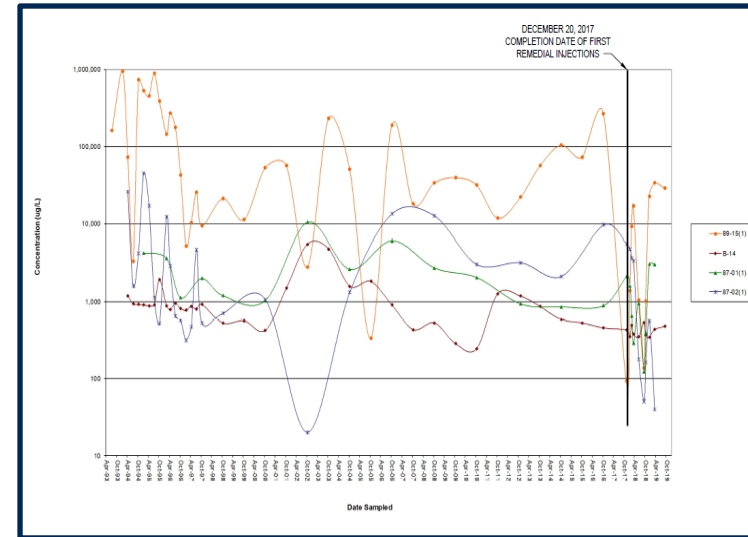
2017 INJECTION – IN-SITU GROUNDWATER PILOT STUDY

- ▶ November 2017 – A bioremediation pilot study was started
 - ▶ 10 Injection Wells
 - ▶ Carbon source using 3DME®
 - ▶ Ferrous iron chemical reducing solution (CRS®)
 - ▶ Bioaugmentation culture SDC-9™



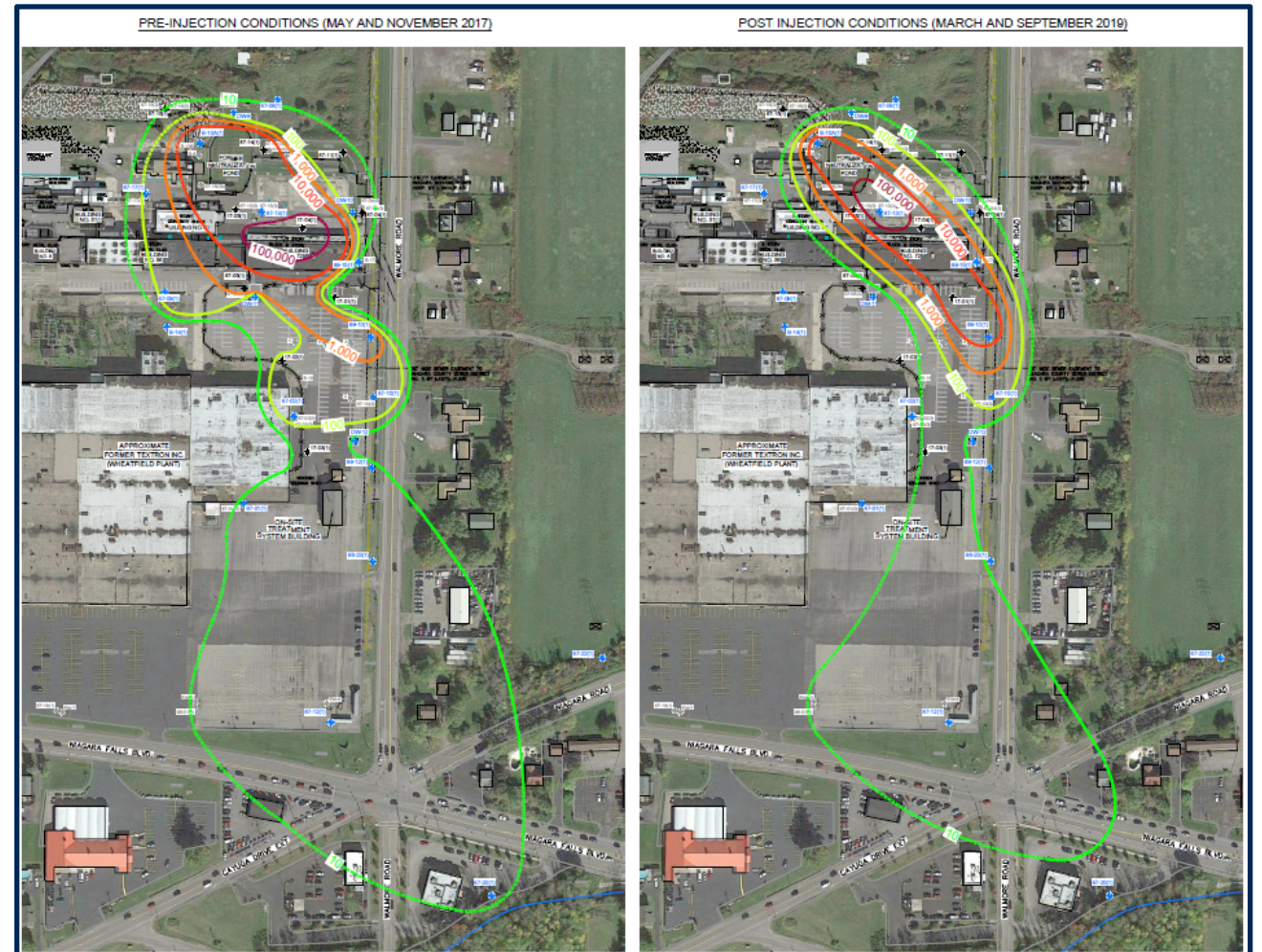
2017 INJECTION

- ▶ Source Area
 - ▶ Initial decreases were observed in most wells.
 - ▶ In the source area, concentrations rebounded.
- ▶ Downgradient Area
 - ▶ Initial decreases were observed.
 - ▶ Concentrations remained low in areas downgradient.



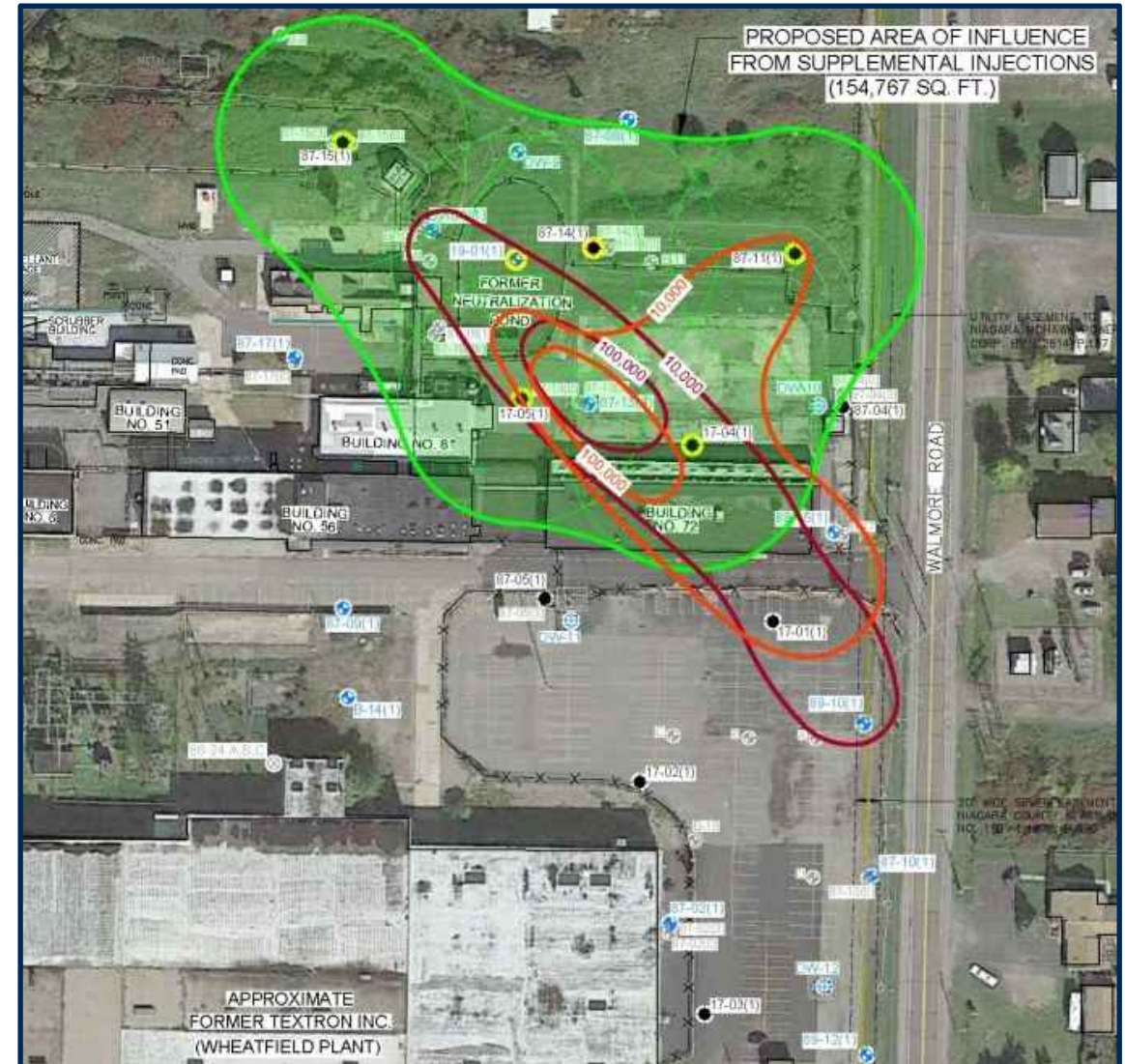
2017 INJECTION

- ▶ Decreases where observed; however, a large amount of mass remains in the source area.
- ▶ Additional Injections were required.



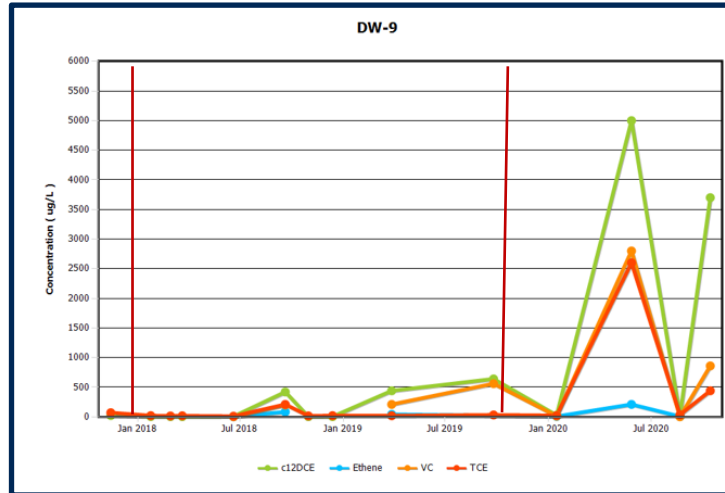
2019 INJECTION - SOURCE AREA INJECTION

- ▶ In October 2019, a focused, in-situ treatment was conducted where the highest concentrations of CVOCs have been detected.
 - ▶ Installed a well in the Neutralization Pond
 - ▶ Elevated levels of total organic carbon were present and additional carbon was not added.
 - ▶ CRS®
 - ▶ MDB-1 and SDC-9™
 - ▶ S-MicroZVI

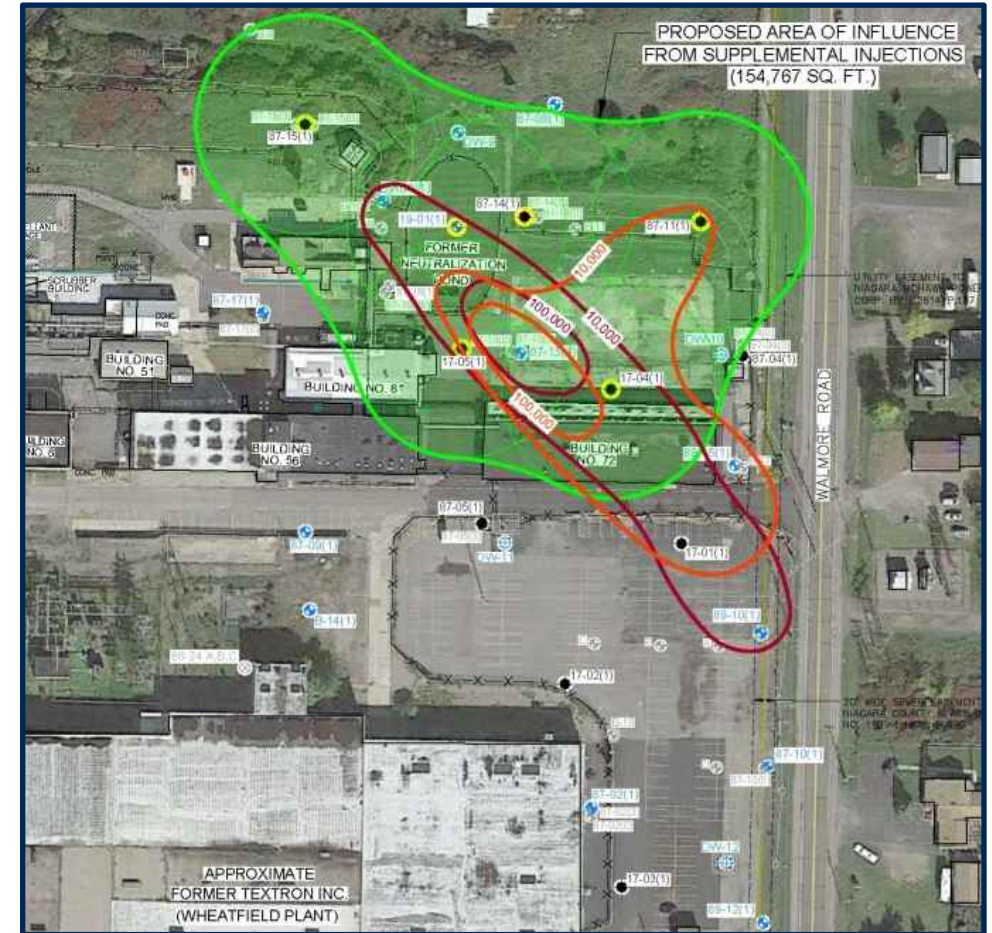
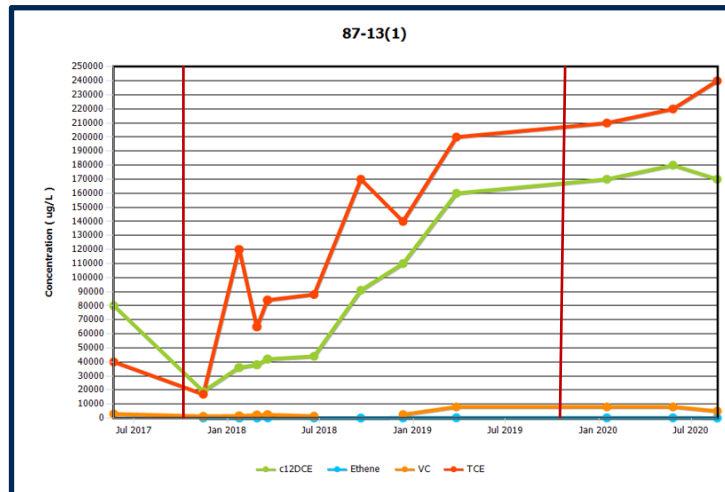


2019 INJECTION - SOURCE AREA

▶ VOC have decreased in injection wells and then rebound was observed.

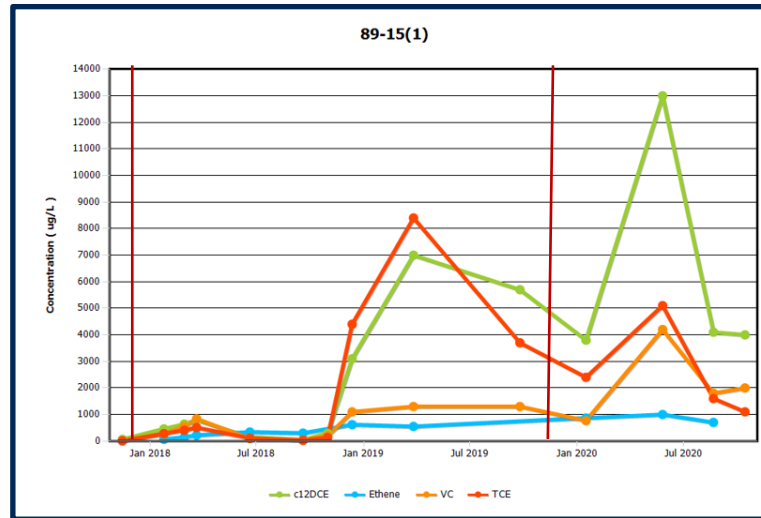
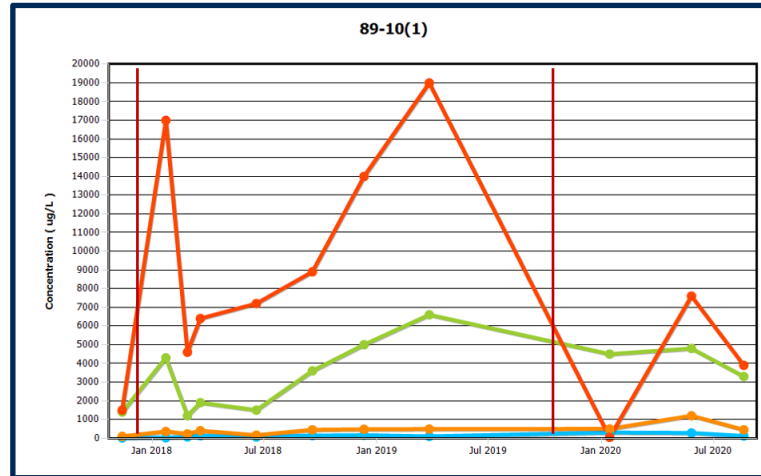


▶ VOCs increased in target well due to significant contaminant mass in groundwater.



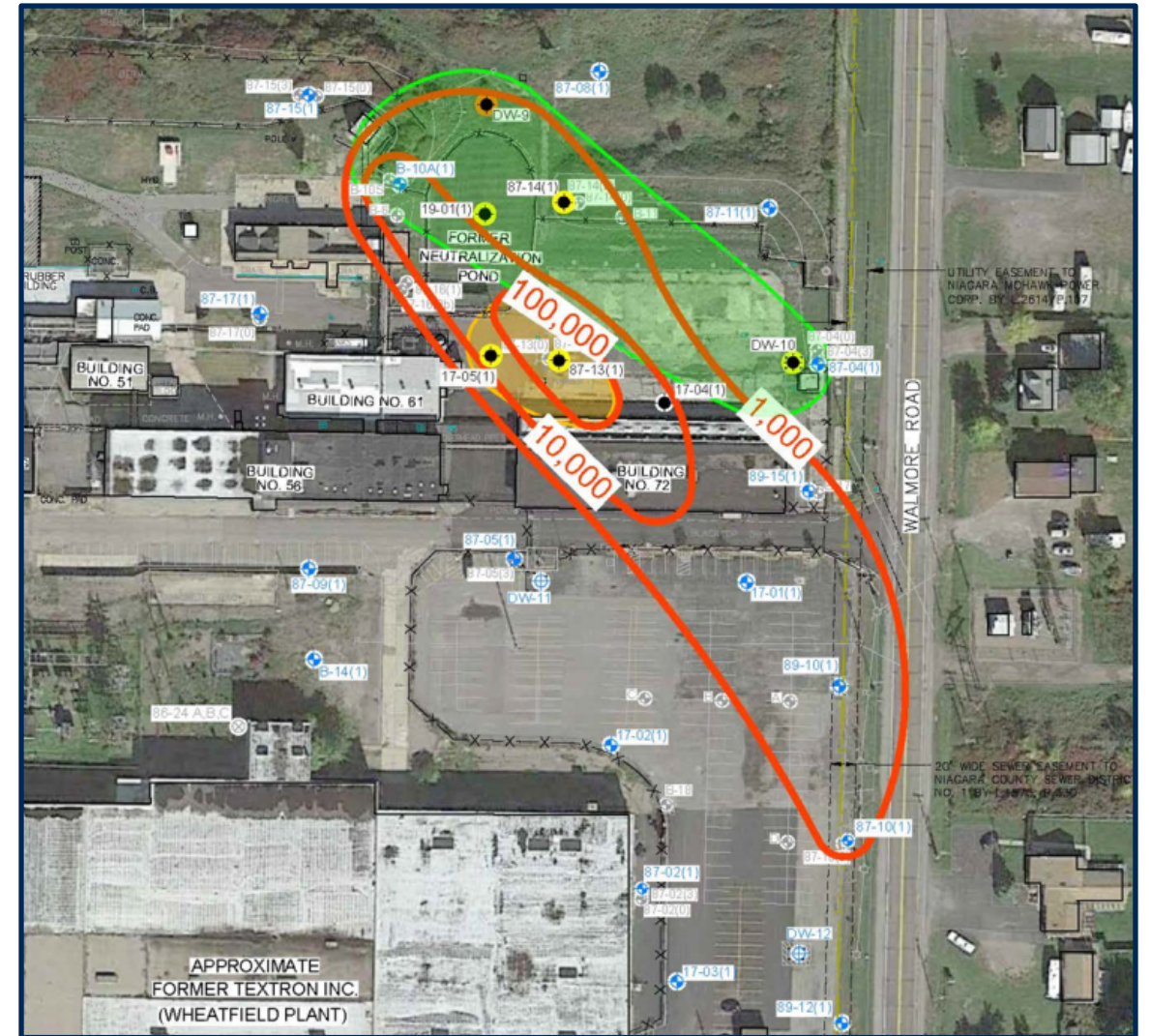
2019 INJECTION - DOWNGRADIENT

- ▶ VOC have decreased in some wells
- ▶ Rebound continues to be observed.



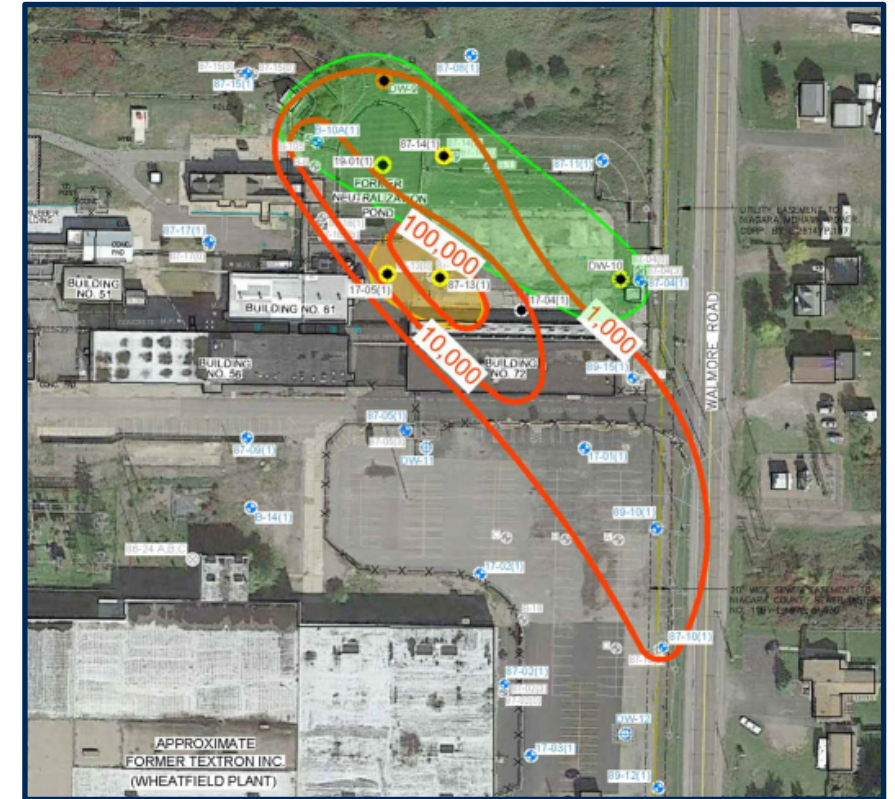
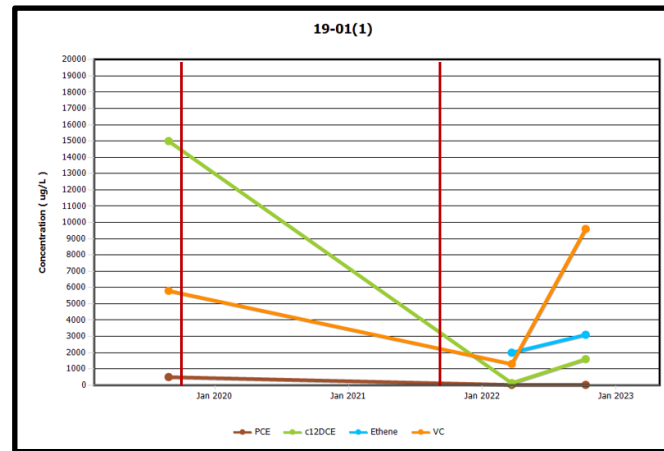
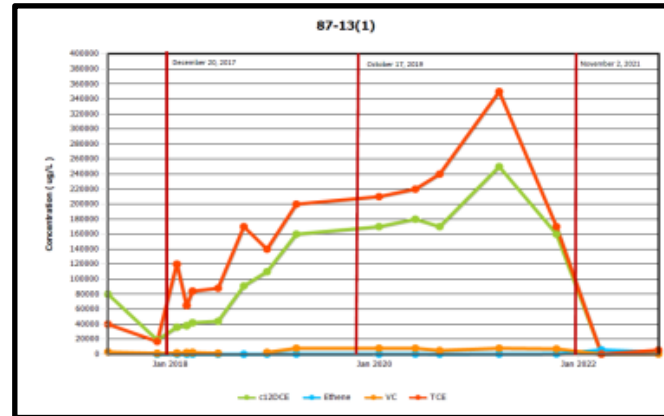
2021 SOURCE AREA INJECTION

- ▶ In November 2021, a second focused injection was conducted.
 - ▶ S-MicroZVI to abiotically reduce concentrations near the former Neutralization Pond
- ▶ In the areas of lower contaminant concentrations:
 - ▶ 3DME® carbon source
 - ▶ SDC-9™ and MDB-1™



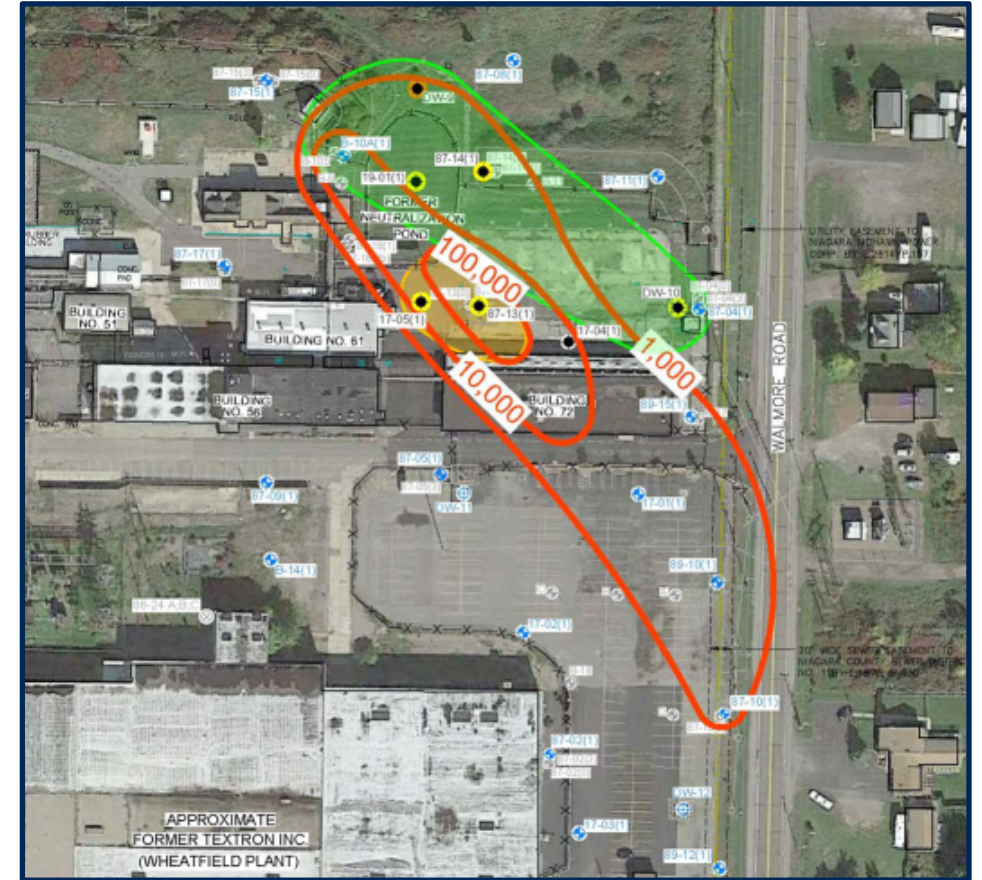
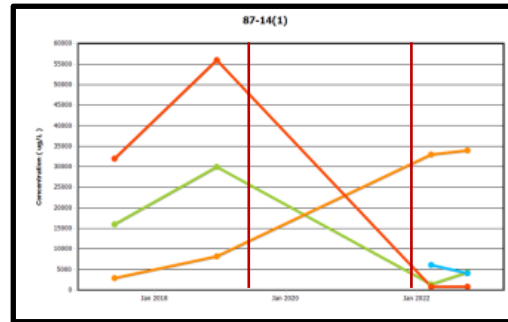
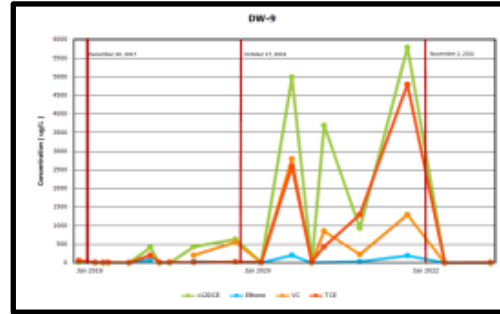
2021 INJECTION – SOURCE AREA S-MICRO ZVI

- ▶ VOC have decreased in injection wells.
- ▶ Additional time is required to determine if VOC levels rebound due to the contaminant mass in this area.



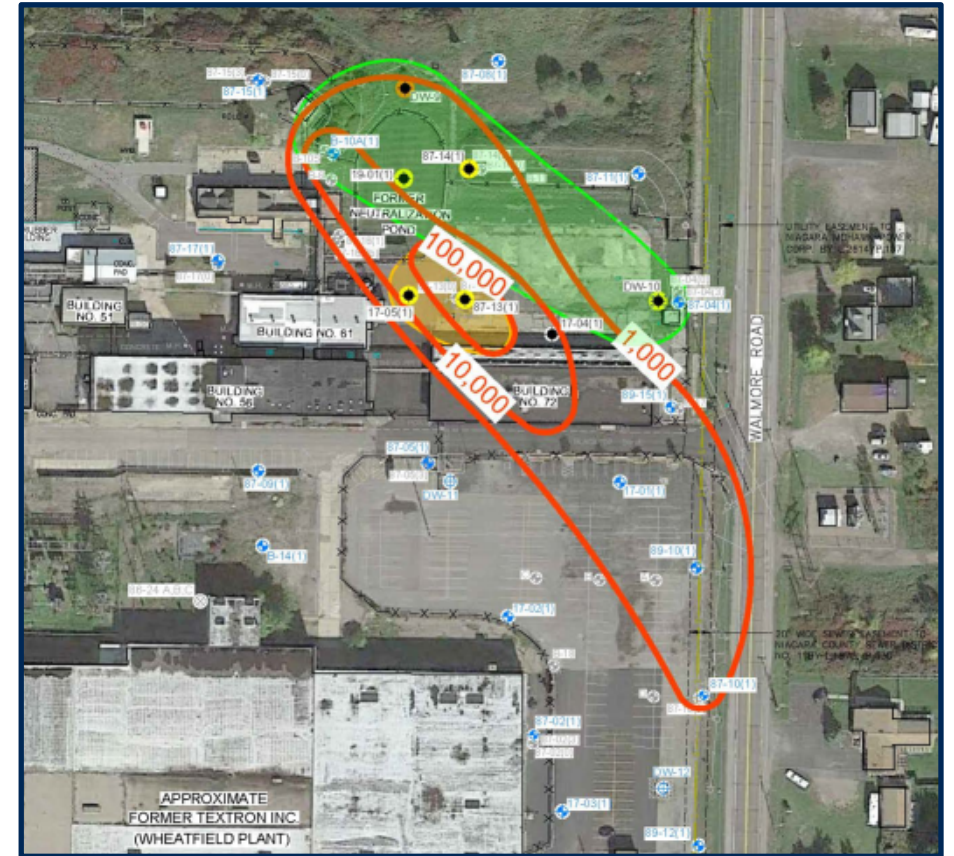
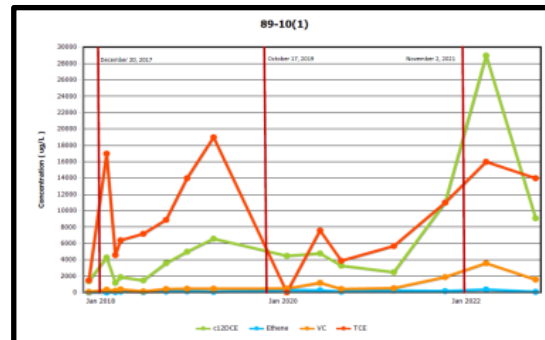
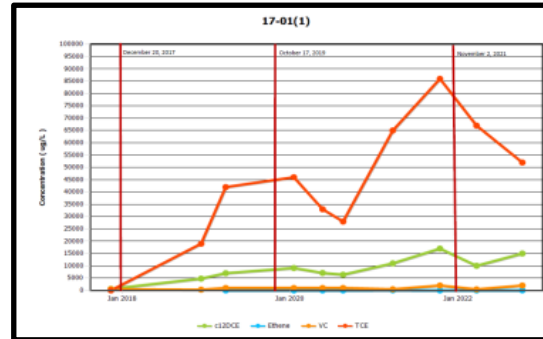
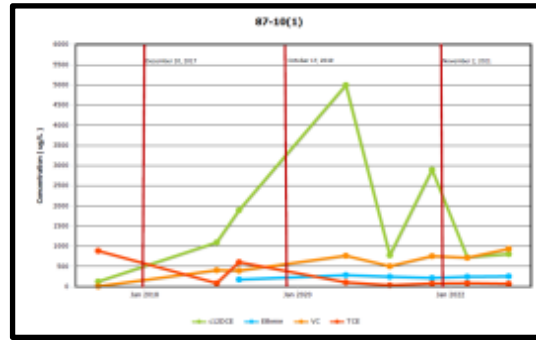
2021 INJECTION – SOURCE AREA BIOREMEDIATION

- ▶ TCE concentrations have decreased.
- ▶ Daughter products (cis-1,2-DCE and VC) are being observed indicating reductive dechlorination is occurring.



2021 INJECTION - DOWN GRADIENT

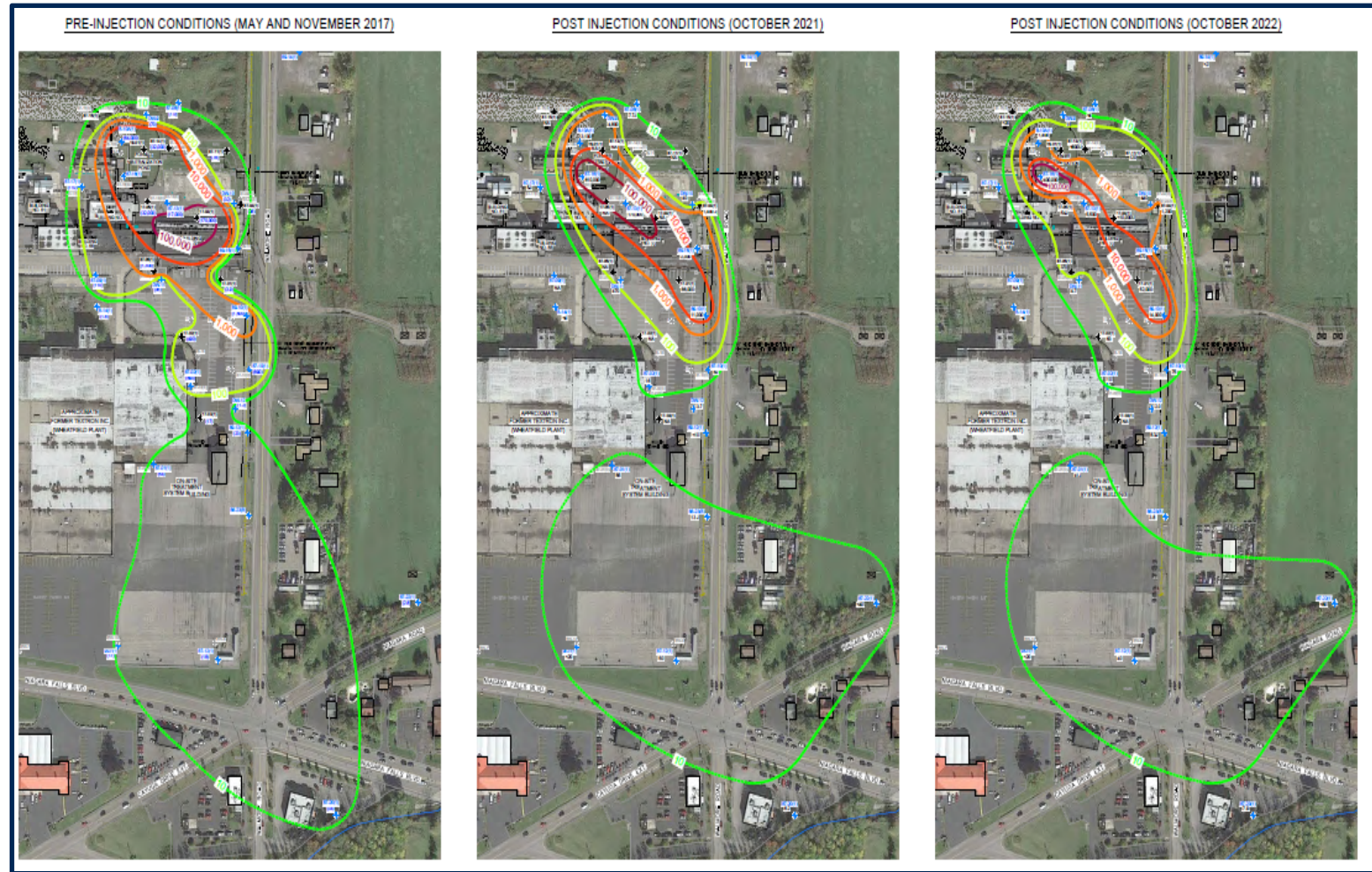
- ▶ VOC concentrations have decreased in some downgradient wells.
- ▶ Significant decreases are still not expected in these areas until elevated levels in the source area are further reduced.



OVERALL TCE REDUCTIONS

- ▶ Decreases in TCE have been observed.

TCE			
Concentration (ug/L)	Pre-Injection Area (square feet)	October 2022 Area (square feet)	Percent Decrease
10	713,810	669,396	6%
100	191,132	163,996	14%
1,000	111,687	73,293	34%
10,000	70,288	29,287	58%
100,000	12,325	3,462	72%



OVERALL ETHENE INCREASES

- Increases in ethene indicate complete reductive dechlorination is occurring.

Concentration (ug/L)	Ethene		
	Pre-Injection Area (square feet)	October 2022 Area (square feet)	Percent Increase
1	867,942	1,556,002	79%
10	658,814	1,171,469	77%
100	10,230	747,852	>100%
1,000	0	70,428	>100%



SITE OPTIMIZATIONS

- ▶ On-site extraction system remains suspended.
 - ▶ Reduced O&M

- ▶ Groundwater Sampling
 - ▶ Reduced frequency
 - ▶ Reduced number of wells

- ▶ Savings of more than \$200,000

	Optimizations			
	2017	2019	2021	2023
On-site Groundwater Treatment Plant	Yes	No	No	No
Off-site Groundwater Treatment Plant	Yes	Yes	Yes	Yes
Approximate Number of Trips to the Site	12	12	3	2
Number of Samples Analyzed per Year	104	72	78	44



CONCLUSION

- ▶ On-site extraction system remains suspended.
- ▶ Abiotic degradation is reducing VOC concentrations in the source area plume.
- ▶ Bioremediation and Biogeochemical degradation is working in the dissolved plume.



OUR COLLABORATIVE TEAM

▶ APTIM

- ▶ Paul Bauer
- ▶ Evan Schlegel
- ▶ Kevin Cronin

▶ Regenesis

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- ▶ Keith Gaskill
- ▶ Brett Hicks



QUESTIONS



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Expect the Extraordinary.