

Remediation of PFAS

OxyZone® Processes: Bench Scale & Field
Demonstration

NEWMOA Workshop

PFAS in The Northeast: State of Practice & Regulatory Perspectives

May 8 - 10, 2017

Who We Are

A photograph of a small, clear stream flowing over mossy rocks in a lush green forest. The water is slightly turbulent as it flows over the rocks, creating small white rapids. The surrounding trees and foliage are vibrant green, and the overall scene is peaceful and natural.

EnChem Engineering

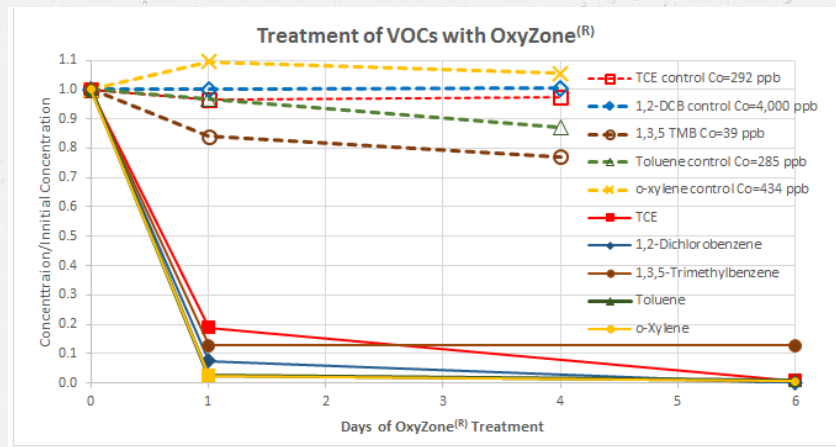
EnChem Engineering, Inc. possesses the underlying technical environmental remediation expertise and effective remediation processes, facilities and staff to solve the most complex emerging contaminant environmental challenges.

We have been a hazardous waste consultant to the U.S. Environmental Protection Agency; the US Air Force and Fortune 500 companies.

OxyZone®

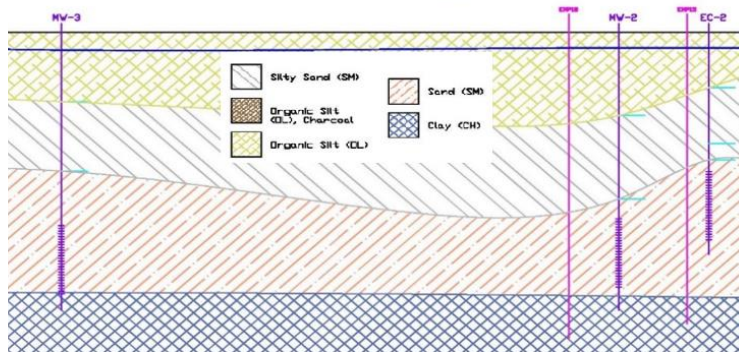
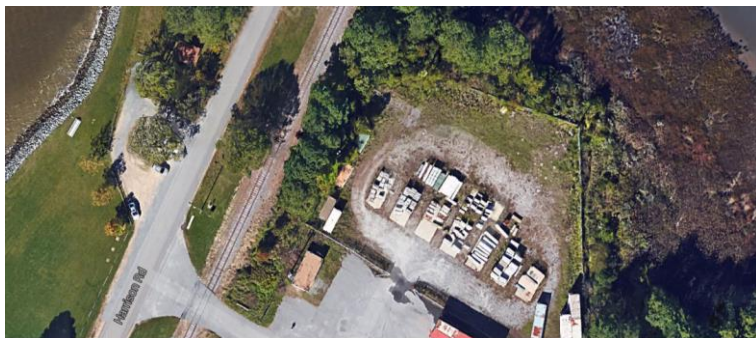


- Patented persulfate-based oxidant mixture
- OxyZone® chemistry generates a mixture of hydroxyl, sulfate, perhydroxyl, and superoxide radical species
- Safe to apply under buildings
- Small site footprint, generation entirely enclosed
- Proven to be effective for in-situ treatment of conventional organic contaminants



Field Demonstration at the JBLE Fire Training Area (FTA) in Hampton, VA

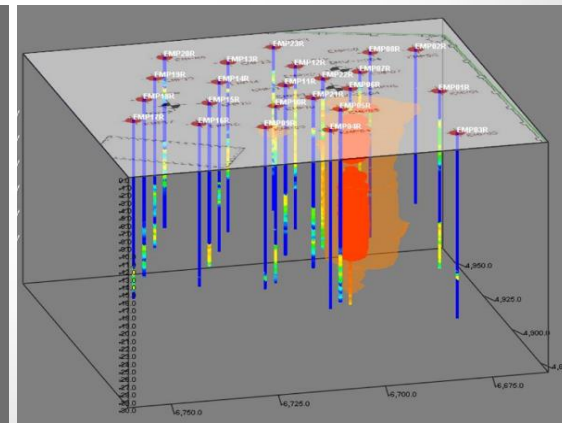
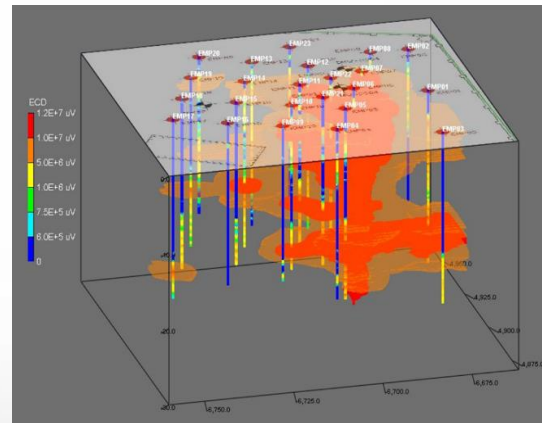
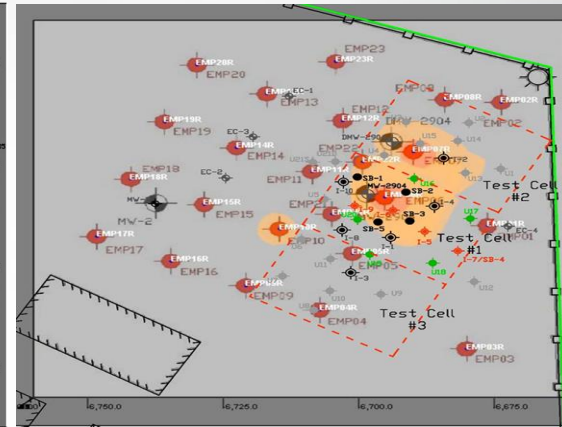
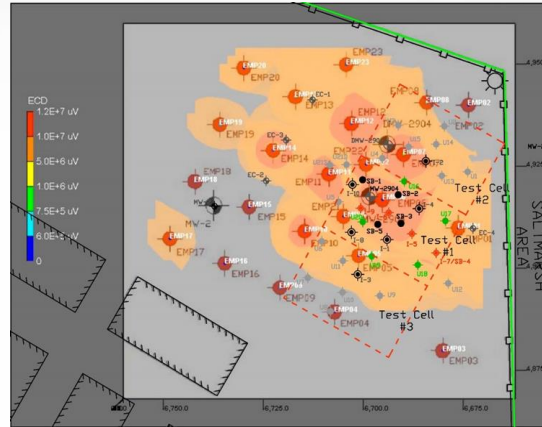
- ▶ Historical military FTA where Aqueous Film-Forming Foam (AFFF) released
- ▶ Complex geology, shallow GW, low GW velocity, tidal influenced
- ▶ Mix of contaminants in site soil & GW at very high concentrations (NAPL)
 - Total Chlorinated solvents (PCE, TCA, DCB): 10 – 250 mg/l
 - Total Petroleum hydrocarbons (BTEX): 0.1 – 5 mg/l
 - Total SVOCs (mostly phenolics): 0.5 – 50 mg/l
 - Total of 9 detected PFAS: 28 – 280 ug/l
 - PFOS (the dominant PFAS): 7 – 200 ug/l



FTA Field Demonstration

Results for Chlorinated VOCs using Membrane Interface Probe (MIPs):

- Significant overall reduction in Chlorinated VOCs
- PFAS concentrations too low to be detected by MIPS

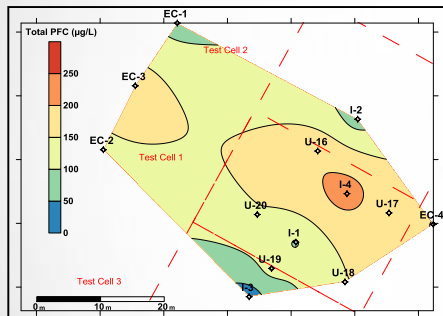


Pre-injection

Post-injection

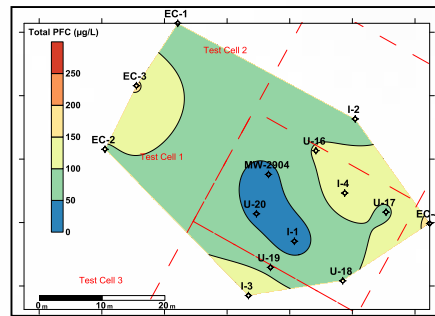
FTA Field Demonstration Groundwater Results for PFAS

April 2013

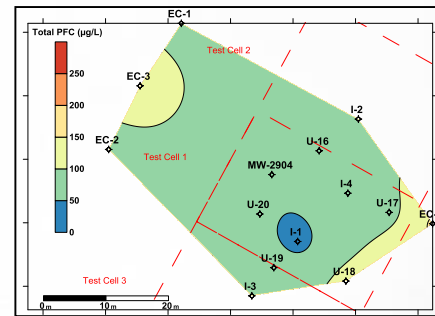


OxyZone®
Injections:
May &
July-August
2013

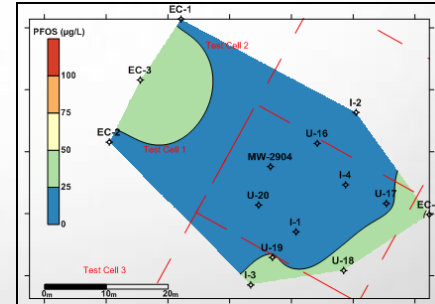
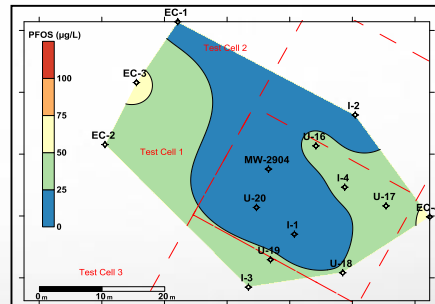
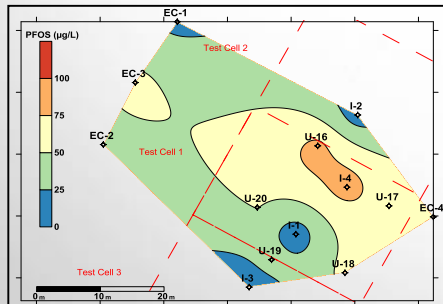
October 2013



February 2014



Total
PFAS



PFOS
only

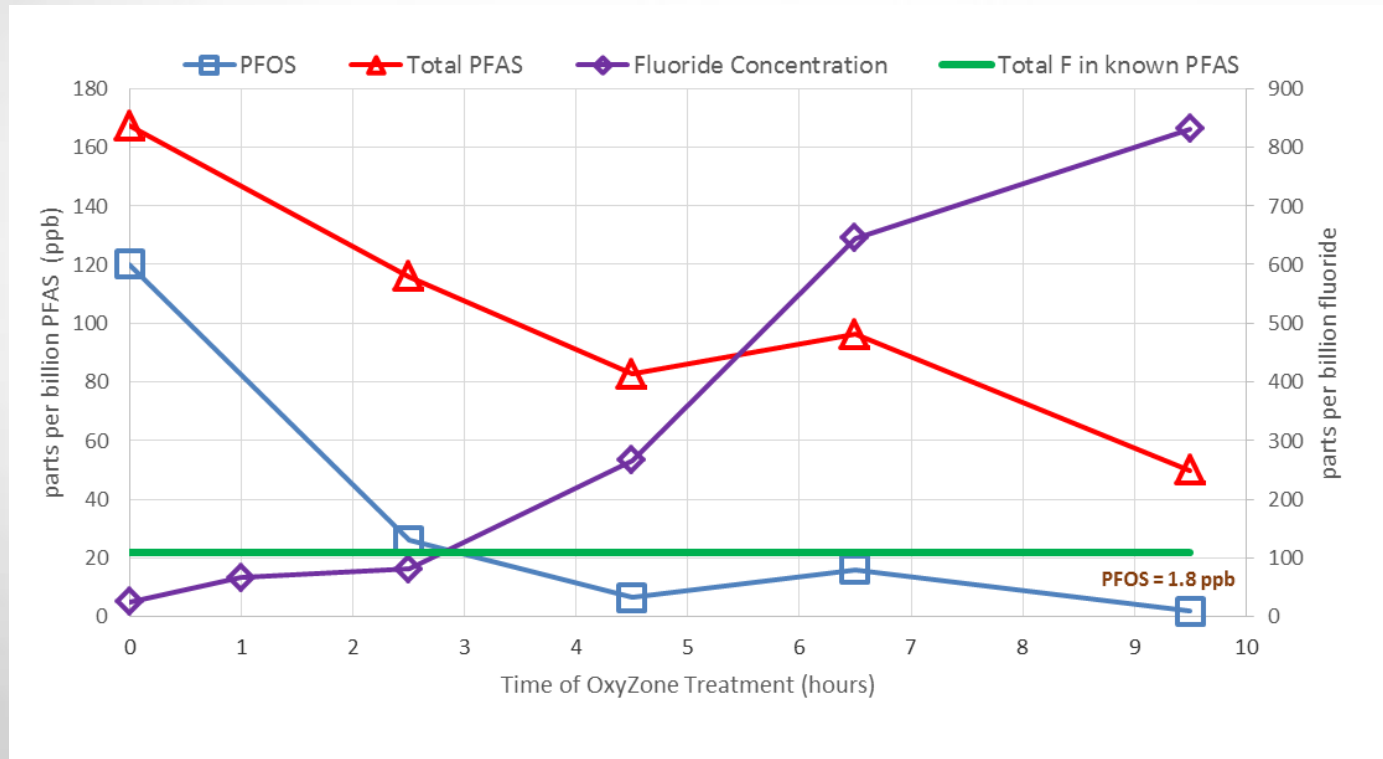
Field Demonstration Treatment Results for PFAS

Overall OxyZone® Impact on PFAS: Lines of Evidence Approach

1. Decrease in total groundwater concentration of PFAS
2. PFOS:
 - highest soil concentration of all (detected) PFAS
 - greatest reduction in groundwater concentration
3. Statistical comparison of wells within Test Cell to those outside Test Cell showed PFAS concentrations decreased within Test Cell, not outside
4. Groundwater concentrations of conservative tracer chloride showed no (dilution) impact from injections

Bench Scale Lab Results:

AFFF Site Contaminated Groundwater – High Undetected PFAS – 750% Fluoride Recovery



PFAS Case Study Results

Field Demonstration

- OxyZone® was selected by the EPA & Air Force for a field demonstration to treat mixed organic contaminants in-situ
- 9 different PFAS were discovered during baseline testing and monitoring
- Groundwater data analysis supported a statistically significant reduction in PFAS concentrations (-21% to -79%) in groundwater, indicating that OxyZone® processes successfully degraded PFAS in-situ in the presence of high concentrations of other organics

Bench Scale Testing

- Up to 99.9% destruction (to less than 0.2 ppb) of PFOS and PFOA
- 80 - 750% defluorination of PFAS organofluorine to fluoride anion

Conclusion

- Results indicate that OxyZone® has the capability to decrease PFAS to very low concentrations, either in-situ or ex-situ.

>99%

Destruction
(to less than 0.2 ppb)
PFOS and PFOA

80-750%

De-fluorination
of PFAS to
fluoride anion

Implementation Options:

Above Ground Reactor For Re-Injection

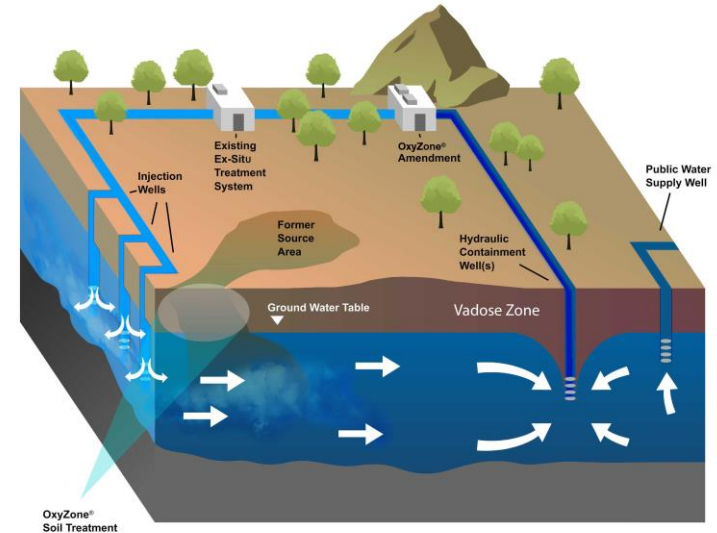
Enclosed Soil Reactor for Vadose Zone Soils

In-Situ Groundwater Recirculation System:

- In-situ OxyZone® treatment of saturated soil and groundwater
- Could supplement existing pump and treatment system

Other Options:

- Horizontal injection wells on plume transect
- Vertical injection wells on plume transect



Typical OxyZone® Treatment Center

Questions? Thank You for your Interest

Raymond Ball, Ph.D., P.E., L.S. P.
EnChem Engineering, Inc.
Office (617) 795-0058 x10
Cell (617)-694-0451
rball@en-chem.com