

Ferox Plus is a synergistic mixture of Ferox ZVI reactive iron powders and emulsified vegetable oil which:

- » Increases the reaction efficiency of both the direct beta-elimination and reductive dehalogenation pathways
- » Comes in a site-ready format that is easy to inject
- » Is an effective and efficient in-site chemical reduction amendment.

## SITE BACKGROUND

Former Dry Cleaner

Contamination source

- » An estimated 70 to 150 gallons of tetrachloroethylene (PCE) discharged when a valve on a dry cleaning machine malfunctioned

Site Geology

- » Jurassic-Triassic Passaic Formation composed of red-brown to gray shale, mudstones, siltstones and sandstones

## SITE CHALLENGES

Post-pilot study sampling indicated significant reductions in PCE and TCE. However, there was a significant increase in lesser chlorinated daughter products (DCE) observed at concentrations exceeding mass of PCE and TCE present, suggesting treatment occurring outside current well network.

An in situ microcosm study was conducted to evaluate potential for biodegradation of COCs and whether biostimulation or bioaugmentation would enhance reductive dechlorination

- » Confirmed Dehalococoides and vinyl chloride reductase genes at high concentrations
- » Volatile fatty acids indicative of electron donor addition also detected

## PILOT STUDY

A pilot study was initiated to assess the treatment effectiveness of zero valent iron (ZVI) on the Contaminants of Concern (COCs).

Selected approach

- » Ferox Flow ZVI reactive iron powder
  - > Fine grade
  - > Designed for source area and hot spot treatment. Easily suspended and injectable by DPT
- » Pneumatic fracturing

Following one year of post injection sampling, a full scale remedial approach was selected, utilizing Ferox Plus ZVI reactive iron powder and a carbon source, to facilitate biological treatment of the remaining contamination.

## INJECTION BY THE NUMBERS

Full-Scale Approach

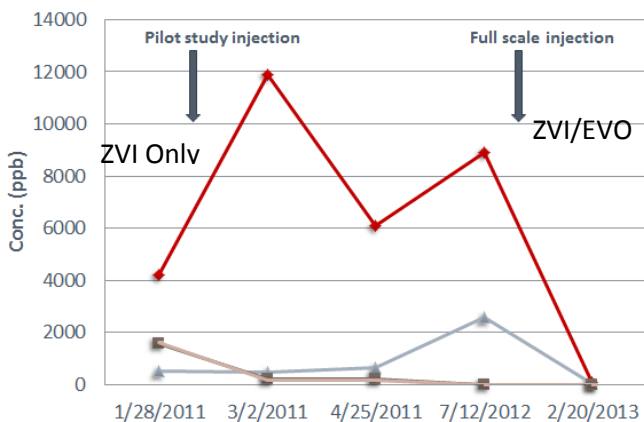
- » 14,200 gallons of Ferox Plus
  - > Ferox Flow ZVI reactive iron powder = 28,000 lbs.
  - > SRS®-SD 60% EVO = 4,730 lbs.
- » 10 open boring bedrock injection points (Packer/Nozzles)
- » 0.53% w/w Soil/Amendment

## FULL SCALE RESULTS

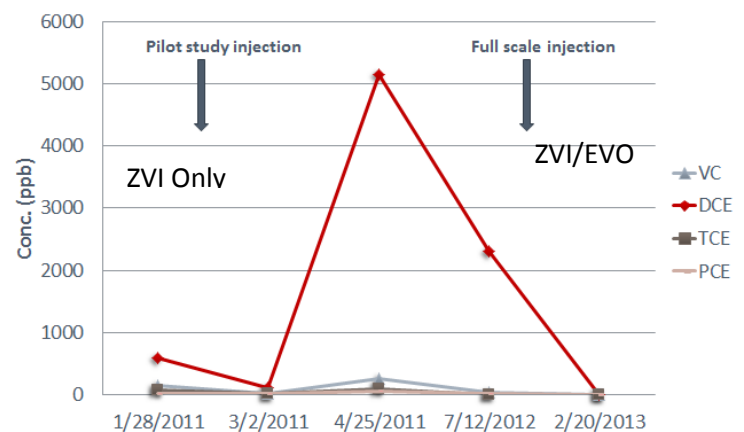
Post injection sampling showed nearly complete degradation of the COCs

- » 99% and 96% reduction in VC for source wells MW-11 and MW-12, respectively
- » Greater than 99% reduction in DCE also observed with no formation of VC
- » Down gradient shallow well (GEI-1) also showed significant reductions
  - > Greater than 99% reduction in VC and DCE
  - > No accumulation of VC
- » The pH in the two source area wells (MW-11/MW-12) observed to decrease following the full scale injections

### Well Sample Data—MW11



### Well Sample Data—MW12



## CONCLUSIONS

The synergistic interaction between ZVI and carbon facilitates the more direct reduction pathway via beta elimination, as demonstrated in the weathered rock and overburden wells. This conclusion is further supported by the reduction in pH, suggesting the catalytic properties generated from the ZVI and carbon resulted in the production of atomic hydrogen.

- » Indicated from the absence of increases in pH in wells MW-11 and MW-12 that results from hydroxyl formation produced from iron corrosion reactions according to iron corrosion chemistry
- » Reduction reactions involving atomic hydrogen results in the production of hydrogen ion, which can neutralize the hydroxyl ions produced from the corrosion of iron
- » Further confirmed by the complete degradation of DCE and VC with no evidence of sequential reductive dechlorination or accumulation of VC