Case Study: Ferox ZVI Reactive Iron Powders

SITE BACKGROUND

Chlorinated VOCs—including PCE, TCE, and their associated daughter products—were detected in groundwater at a large manufacturing facility.

The facility had operated for 50 years as a machine shop where parts were degreased by a variety of solvents.

No source zone or DNAPL was found during investigation, but detected concentrations of chlorinated VOCs in groundwater ranged between 100 and 500 ppb, and exceeded applicable remediation criteria established by the state. The site had multiple areas of concern that had to be addressed.

Site Geology

- PRB area: dominated by slightly fractured siltstone at depths
- Low-lying area: silt deposits and groundwater less than 1 ft. bgs.

SITE CHALLENGES

The presence of low permeability geologic materials and multiple areas of concern required a variety of treatment options. A treatment was needed that could be in place for greater than 10 years.

One area had contaminants in a fractured bedrock. Another area had contaminants from 0 to 15 bgs, moving along an outfall and beneath a swampy area.

In both areas, the goals were to eliminate offsite migration and increases in vinyl chloride.

REMEDIAL APPROACH

A two phased approach was used to construct permeable reactive barriers (PRB) within the fractured bedrock, and treat the low-lying area with a combination of pneumatic emplacement and DPT injections.

Selected approach for the PRB:

- Ferox PRB ZVI reactive iron powder
  - Designed to be injected as a slurry for dissolved phase contaminants
  - Medium to coarse grade
  - Emplaced by a combination of pneumatic and hydraulic fracturing

Selected approach for the low-lying treatment area:

- Ferox Flow and Ferox Target ZVI reactive iron powder
  - Designed to be injected as a slurry for dissolved phase contaminants
  - Medium and fine grade
  - Emplaced by a combination of pneumatic and DPT Injection

INJECTION BY THE NUMBERS

Phase I: PRB

- 15 injection boreholes
- 104,000 pounds of Ferox PRB ZVI reactive iron powder injected into the bedrock with a loading rate of ~0.5% w/w (ZVI to soil)

Three separate reactive zones were established within the bedrock with the goal of eliminating offsite migration of chlorinated VOCs in groundwater.

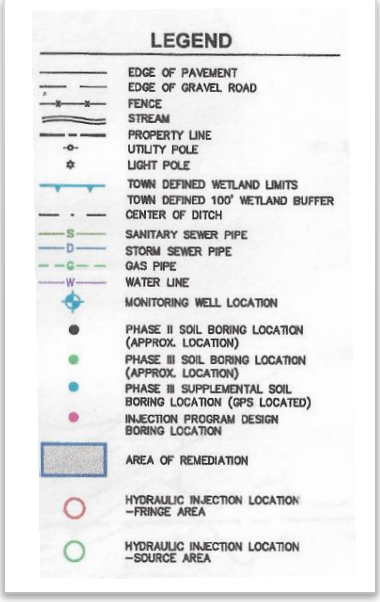
Phase I: PRB cont.

Bedrock is typically encountered at the injection sites between 5 to 20 feet below grade and consists of a moderately soft siltstone that was intensely fractured near the surface of competent rock with fracture intensity decreasing with depth.

Injection zones ranged from 20 to 35 feet belowground surface to 7 to 35 feet. The radius of influence for each injection location was estimated to be 30 to 40 feet.

Phase II: Low-Lying Area

- 150 injection points used to treat a 2 ft. interval from 3 to 15 ft. bgs.
- 50,000 lbs of Ferox Flow and 14,000 lbs. of Ferox Target ZVI reactive iron powders injected into two distinct regions (low-lying silty area and fringe area) and two distinct vertical treatment zones (deep and shallow) --*Table 1 on the following page summarizes the loading rates of ZVI in the various zones.*



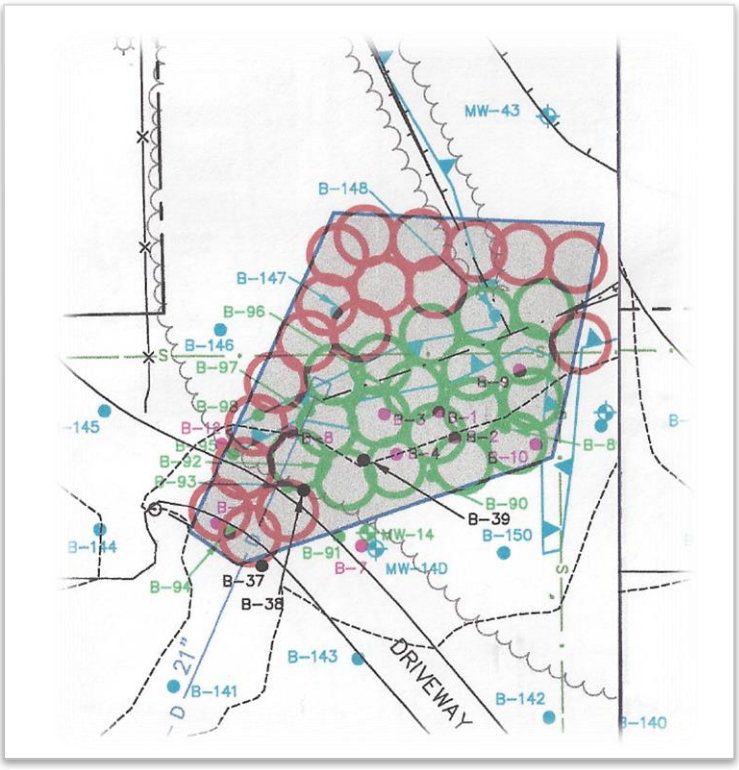


Figure 1: Deep Injections

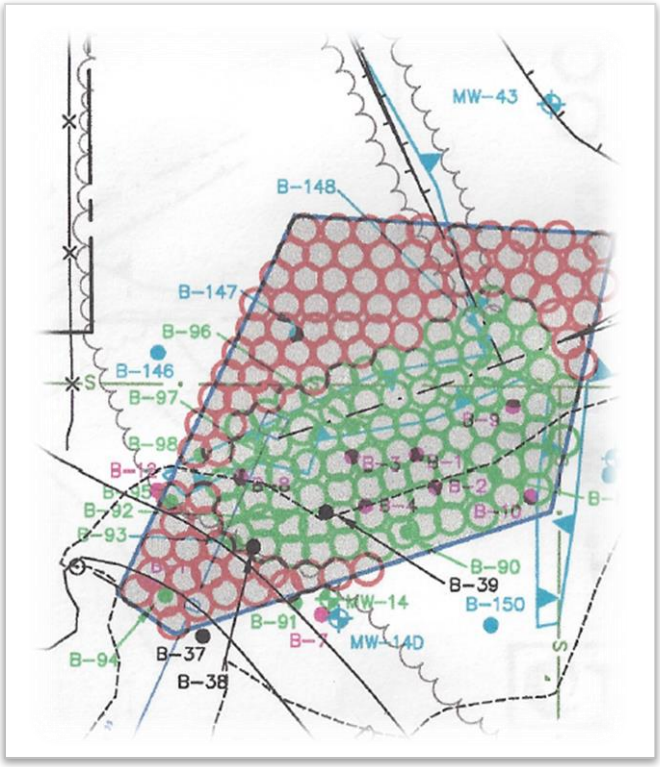


Figure 2: Shallow Injections

Phase II: Low-Lying Area cont.

A combination of DPT injection and pneumatic fracturing/emplaced injection were used to install the treatment material. For the hydraulic injections, Hepure supplied a pumpable ZVI reactive powder.

Daylighting of ZVI to surface during injections was minimal, but where it occurred, it indicated a radius of influence at or beyond 10 feet.

Table 1: Summary of Loading and Distribution of Hepure's ZVI Reactive Iron Powders

Zone	Points	Depth	Intervals	ZVI Dosage
Deep Low-Lying Zone	15 pts	9-15 ft bgs	2 int	667 lbs per interval
Deep Fringe Zone	15 pts	9-15 ft bgs	2 int	400 lbs per interval
Shallow Low-Lying Zone	60 pts	3-9 ft bgs	2 int	166 lbs per interval
Shallow Fringe Zone	60 pts	3-9 ft bgs	2 int	100 lbs per interval

CONCLUSIONS

Groundwater monitoring at both treatment areas results indicate significant decreases in PCE, TCE, and other daughter products within the injection zones following the treatment.

Additional data was collected from down-gradient wells located offsite to determine the effectiveness of the treatment in achieving remedial goals. Results used to evaluate the effectiveness of the remediation included groundwater quality parameters, cVOC, and breakdown products.

A detailed analysis of the impacts of pneumatic fracturing and the use of Ferox PRB, Ferox Flow and Ferox Target ZVI reactive iron powder to satisfy the various treatment needs and installation obstacles resulted in :

- Decreases in PCE, TCE, and daughter products in the treatment zone
- No transient increase in vinyl chloride
- No offsite migration
- No further remedial action needed
- Sustainable remediation system in place