Comparison of Active Remediation Rates and Natural Attenuation Rates for TCE In Groundwater

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Introduction

- This Site represents a facility with over 30 years of investigation, soil/groundwater remediation and groundwater monitoring.
- Site conditions had improved substantially as a result of the site work and the question remained what is the appropriate course of action going forward.
- Groundwater quality monitoring data demonstrates that groundwater quality is improving as fast, if not faster, outside the capture area of the P&T system versus within the capture.
Background

- Site Setting/Geology/Hydrogeology
  - Overburden (weathered shale) to ~9–15 ft bgs
  - Bedrock below 9–15 ft composed of Triassic Newark Group (shales, siltstones, and argillites)
  - Shallow bedrock aquifer (to approx. 80 feet depth):
    - Numerous but small fractures/partings, low K and low yield
  - Deep bedrock aquifer below approx. 80 feet depth):
    - Few but large fractures, high K and high yield
  - Aquifer is anisotropic with higher K along strike, lower K perpendicular to strike
Background

- Contamination discovered in 1979
  - Small waste solvent tank
- Numerous wells installed to define area in 1980
  - 18 shallow over burden wells
  - 19 bedrock wells
- Highest groundwater contamination reported at \(~60,000\) ug/l TCE in bedrock groundwater in 1980
Source Removal
- Waste solvent tank excavated in 1980 (tank tested tight, releases associated with over fills)
- 225 cubic yards of soil excavated and treated (1981 and 1982)
- Shallow groundwater extracted and treated on a batch basis (1982 to 1983)
Background

- Long Term Remedial Action
  - Groundwater P&T system began operation in 1986 in source area
  - Maximum TCE groundwater concentration when P&T system initiated was ~350 ug/l
  - System remained active until 2010
Background

- Site was listed as CERCLA site in 1989
- RI conducted in 1998
  - Investigation of source area soils revealed a maximum concentration of TCE in soil of ~5 ug/kg
  - One additional well (cluster) installed
  - Maximum TCE concentration in groundwater reported was 320 ug/l
Background

- ROD issued in 2004
  - Required implementation of a chemical oxidation remedy for “source control” and expansion of P&T system
- Independent of the ROD, the P&T System was expanded in 2004 to include two additional wells that reported TCE > 100 ug/l (but less than 300 ug/l)
To address the requirements of the ROD, a Pre-Design Investigation (PDI) was completed in 2008 to evaluate how to implement the remedy

- 19 additional bedrock wells installed
- No residual source materials found

PDI Concluded:
- Chemical Oxidation not justified given the absence of any residual source materials
- Continuing P&T not warranted
- MNA recommended remedy
Background

- What you’re left with:
  - A site that was investigated in ~1980
  - Source removal completed in 1982
  - Groundwater remediation began in 1982
  - Continuous P&T began in 1986
  - P&T expanded in 2004
  - No residual source materials or DNAPL
  - Dilute groundwater plume in bedrock (avg. TCE concentration of ~ 40 ug/l)
  - 30 years of groundwater quality from a number of wells, both within and outside the influence of the pumping well(s)
Evaluation of the Effectiveness of P&T

- In order to evaluate the effectiveness of the P&T system going forward, the 30 years of groundwater quality data was evaluated.
  - Linear interpolation using Microsoft Excel.
  - Statistical analysis via the Mann–Kendall trend analysis (via ChemStat).
- Slope and trend of the data for groundwater within the capture zone of the pumping wells were compared to slope and trend for groundwater outside the capture zone of the pumping wells.
Slope and Trend Analysis

- For wells that were in close proximity to the source area, only the data collected after the source removal work was completed was evaluated to reduce the bias in the data.
  - The data used included data from the initiation of the full time P&T system in 1986.
- For the wells that were not in close proximity of the source area, all data was used.
Slope Analysis (Linear Interpolation)

- 27 wells were determined to have sufficient data for analysis.
  - Up to 62 data points were available over almost a 30 year period.
- Results of the Linear Interpolation:
  - 25 of the 27 wells indicated a negative slope in the linear interpolation.
  - 17 of the 25 wells with negative slopes were wells that were not in the capture zone of the pumping wells over the time frames evaluated.
TCE Concentrations at A-3 Over Time

\[ y = -0.0015x + 56 \]
TCE Concentrations at W-15 Over Time

$y = -0.0945x + 2951.9$
Trend Analysis

- Results of the Mann–Kendall trend analysis:
  - 27 wells were evaluated for trend
  - 20 wells reported a negative “S” statistic, which indicates a downward trend
  - 6 wells reported a positive “S” statistic
  - 1 well reported an “S” Statistic of 0
<table>
<thead>
<tr>
<th>Well ID</th>
<th>Data Evaluation Time Period</th>
<th>TCE Concentration Range (μg/L)</th>
<th>Number of Samples</th>
<th>Graphical Slope (μg/L)</th>
<th>Graphical Slope Trend</th>
<th>Calculated Mann-Kendall &quot;S&quot; Statistic</th>
<th>Probability of &quot;S&quot; Statistic or Calculated Z-Value (95% Confidence)</th>
<th>Comparison Probability of Statistically Significant Trend?</th>
<th>Evidence of Statistically Significant Trend</th>
<th>Within Inferred &quot;Recovery Well&quot; Capture Area?</th>
<th>Comment</th>
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<tbody>
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<td>Evidence of Statistically Significant Trend?</td>
<td>Within Inferred Recovery Wall Capture Area?</td>
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</table>
Trend Analysis

- For the wells that reported a negative S statistic, 10 wells were determined to have “statistically significant” downward trends.
  - Statistically significant at 95% confidence.
- Of these 10 wells with statistically significant trends:
  - The slope of the trend ranged from 0.00015 ug/l/day to 0.0946 ug/l/day (i.e., rate of decrease of TCE).
  - Four of these 10 wells were within the capture zone of the pumping wells, and 6 were outside the capture zone.
Slope and Trend Analysis

- For wells that reported a positive S statistic, none of the trends were observed to be statistically significant.
- In general, wells with a limited amount of data did not show statistically significant trends, but wells with extensive data did show statistically significant trends.
Result for Well within Capture Zone

TCE Concentrations at W-1 Over Time

\[ y = -0.0055x + 252.14 \]
Result for Well outside Capture Zone

TCE Concentrations at RW-1 Over Time

\[ y = -0.0095x + 558.96 \]
Comparison of slopes

- The rate of decrease of TCE concentration for a well within the capture zone of the P&T system was ~0.0055 ug/l/day.
- The rate of decrease of TCE concentration for a well outside the capture zone of the P&T system was ~0.0095 ug/l/day.
Conclusion

- The rate of decrease of TCE concentration in groundwater was as great, if not greater, in areas outside the capture zone of the P&T system as within the capture zone of the P&T system.
- Based on this information, the P&T system was shut off in late 2010 to begin a MNA study.
- The results from two quarters of groundwater monitoring have demonstrated no rebound in groundwater quality in the monitoring wells.