INVESTIGATION AND REMEDIATION STRATEGIES FOR A DNAPL IMPACTED SITE IN STRATIFIED SOILS

Christopher Reiss
Overview

- DNAPL Intro
- Case Study: DNAPL Site History
- Field Investigation Program
- Pilot Testing program
- Results and Partial RAP
- Completed RAP
- Summary
INTRO: DNAPL Difficulty

- Requires more complex delineation
Case Study: Chemical Company
Warehouse Facility Site
Case Study: Chemical Company

Warehouse Facility Site

- Located in an industrial area
- Borders paper shredding company, warehouse, and a Creek
- Current operations include receiving, storage and shipping of chemicals, food additives and plastic pellets
Case Study: Chemical Company
Warehouse Facility Site

Creek

Shredding company

Adjacent warehouse
Case Study: Chemical Company

Contamination History

- Many gallons of PCE were released in 1984 from a sabotaged tankcar during former use as chemical handling facility.

- PCE pool likely flowed into rail ballast, building footings and overland via drainage topography.
Case Study: Chemical Company

Early Cleanup Measures

- Excavation zone
- Excavation zone II
- PCE collection trenches
Case Study: Chemical Company

Arrival of SEACOR…

- SEACOR was retained to supervise the installation of monitor wells by Company’s original consultant based out of California.

- Company decides to retain local SEACOR office as service level from original consultant declines due to distance ( = ‘Client’ )
Case Study: Chemical Company

Property Politics

Client acquired the site in 1992 from ‘Former Owner’ assuming responsibility for on-site impacts.

Former Owner remained responsible for the off-site impacts.

Off-site wells were installed which showed evidence of growing impact.
Case Study: Chemical Company

Property Politics II

- Negotiations with all parties and local Regulator proposed a ‘Joint Investigation’ to confirm the contaminant distribution
- Joint Investigation was performed by SEACOR and the ‘Consultant’ (Former Owner’s consultant) in the summer of 2002
Case Study: Joint Investigation

SEACOR & Consultant

- Fourteen locations drilled in nests of three
- Consultant installed seven off site nests and SEACOR installed seven on site
- 2” PVC nests consisted of a well at 22’ (7m), 45’ (14m) and 65’ (20m)
Case Study: Joint Investigation

Typical Site Stratigraphy

- 1-2 m of clay Silt fill
- Shallow Zone: clay Silt (to approximately 25’)
- Middle Zone: sandy Silt (to approximately 45’)
- Lower Zone: sandy Silt (to approximately 65’)

![Diagram showing the stratigraphy](image-url)
Case Study: Joint Investigation

Location, location, location…

High PCE Soil Concentrations:

- Mainly in upper clay-silt zone, in visible silt seams at ~15-17’
- Some contamination at mid sandy silt zone
- Trace concentrations in the lower sandy silt zone
- Bad wells: 403, 404, 405, 408, 412 & 413 (up to 300 ppm)
Case Study: Pilot Test

Proposed Pilot Test

- SEACOR proposed installing 2” extraction and radius monitoring wells to test each zone’s response to VEMPE in turn

- Extraction wells installed in each Zone with 2m, 4.5m and 7m radius monitoring wells
Case Study: Pilot Test

The System:

- Skid-mounted, 25 hp liquid ring vacuum pump unit
- Header line of 4” PVC ran from unit to each extraction well
- Liquid and air streams were collected and tied into existing remediation room air stripper and GAC
Case Study: Pilot Test

The System:

Pilot Test Well Spacing and Vacuum Schedule

<table>
<thead>
<tr>
<th>Zone</th>
<th>Test Type</th>
<th>Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Zone</td>
<td>high vac</td>
<td>15.5&quot; Hg</td>
</tr>
<tr>
<td></td>
<td>medium vac</td>
<td>12.5&quot; Hg</td>
</tr>
<tr>
<td></td>
<td>passive</td>
<td>0&quot; Hg</td>
</tr>
</tbody>
</table>

| Upper Zone| high vac    | 17" Hg   |
|           | medium vac  | 12" Hg   |
|           | low vac     | 8" Hg    |

| Middle Zone| high vac    | 19" Hg   |
|            | medium vac  | 12" Hg   |
|            | passive     | 0" Hg    |
Case Study: Pilot Test

The Extraction Well:

- Modular well head coupled via 2” Cam-locks and could be moved to each test location
- Portable separator to measure air and water flow at well
Case Study: Pilot Test Results

Upper Zone Results (12-22’ Screen):

- High, Medium and Low vacuum (17, 12 and 8” Hg) were run at this depth with extreme cold and shut down delays
- Excellent PCE removal (product observed in drop lines during start-up)
- 2.4 kg of PCE removed in 7300 l groundwater (5 l/day average pump rate)
- 350 kg of PCE removed in the vapour stream (290 g/hour average PCE removal rate)
Case Study: Pilot Test Results

Upper Zone Results (12-22’ Screen):

- Overall drawdown and vacuum response was erratic due to shutdowns and a ‘utility trench’ nearby.

![Graph showing change in groundwater elevation - 22’ Zone]
Case Study: Pilot Test Results

Upper Zone Results (12-22’ Screen):
- Initially, all local monitor wells responded
- Once vacuum reached the trench, only drawdown and vacuum were observed in 22’_4.5F and 22’_7
Case Study: Pilot Test Results

Mid Zone Results (30-45’ Screen):

- High, Medium and Passive (no vacuum) were run at this depth (19, 12 and 0” Hg)
- Minor PCE removal but smoother operation
- 1.3 g of PCE removed in 2819 l groundwater (80 l/day average pump rate)
- 57 g of PCE removed in the vapour stream (0.07 g/hour average PCE removal rate)
Case Study: Pilot Test Results

Mid Zone Results (30-45’ Screen):

- Drawdown response very good (over 25m)
- Vacuum response noted between 2 and 4.5m

CHANGE IN GROUNDWATER ELEVATION - BRENNTAG PILOT TEST 30-45’ ZONE

DATE

Change in Groundwater Elevation (m)

-7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7
Case Study: Pilot Test Results

Deep Zone Results (50-65’ Screen):

- High, Medium and Passive (no vacuum) were run at this depth (17, 12 and 0” Hg)
- Fourteen locations drilled in nests of three
- Minor PCE removal (limited analytical confirmed)
- 0.8 g of PCE removed in 1016 l groundwater (36 l/day average pump rate)
- Low mass in vapour stream similar to Mid test
Case Study: Pilot Test Results

Deep Zone Results (50-65’ Screen):

- Drawdown response between 4.5 and 7m
- Vacuum showed negligible response at 2m
Case Study: Operational Issues

1) Extreme Cold

- January 2003 had record cold weeks with the monthly average low at –22°C and windchills driving that to the –40’s

- Expansion of the 2” extraction well to the 4” header under vacuum caused freezing of the wellhead to well head with additional heater

- Even with the heating panel on, the inlet separator froze in the LRVP unit if the unit shut down for any length of time
Case Study: Operational Issues

1) Solution:

- Additional heater installed in unit
- Insulated well head cover built with piped warm air from unit air-stripper blower (stripper not used) as well as tech-cable ran to well head with additional heater
- Solenoid valve installed to apply vacuum to well for 1 minute, then open and allow flow for 20 seconds (and repeat)
2) Extraction of Product

- Initial removal of high concentrations and observable separate-phase PCE ate through flow meter

- High vapour concentrations also caused H & S issue in existing Remediation Room (treatment)
Case Study: Operational Issues

2) Solution:

- Flow meter removed until concentrations dropped in liquid stream
- Depth measurements of existing collection tank in site Remediation Room were taken and volumes calculated manually
- Overhaul of leaking components, stripper and associated piping
Case Study: Partial RAP

Pilot Test Post Mortem

- The Consultant did not support the VEMPE test results in the Upper zone soils due to the lack of drawdown at 2m

- The Consultant was impressed with the Mid zone results

- Hydraulic conductivity testing of select wells was performed by both consultants to evaluate the option to control Mid zone impacts and replace the partially effective collection trenches
Case Study: Partial RAP

k Testing Results…

- k’s averaged in the order of 10-7 m/s for Mid zone
- This appeared inconsistent with Pilot Test observations

<table>
<thead>
<tr>
<th>Soil Unit</th>
<th>Upper Zone</th>
<th>Mid Zone</th>
<th>Lower Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aprx. Screen Interval</td>
<td>3.5 - 6.5 m</td>
<td>7.5 - 10.5 m</td>
<td>16 - 19 m</td>
</tr>
<tr>
<td>Average k (Hvorslev):</td>
<td>2.08x10^{-8}</td>
<td>2.03x10^{-7}</td>
<td>2.51x10^{-7}</td>
</tr>
</tbody>
</table>
Case Study: Partial RAP

Hydraulic Control Well Pilot (H-well)

- Two 4” PVC H-wells were installed at the property line (H-1 and H-2)
- Pumping tests revealed low k values again, but more evidence of drawdown influence
Case Study: Partial RAP

Hydraulic Control Wells Installed

- Eight more H-wells were installed at the property line (H-2 to H-10)
Case Study: Partial RAP

More k Testing...

- The Consultant requested the testing of each individual H-well for k

- Testing was performed in 2 stages, every other well and then the alternate set

- Results again showed low k values, but observed evidence of influence in H-well midpoints and well nests
Case Study: Partial RAP

Test Results

Chart 1: Head Drawdown in Neighboring Well Nests, November 2004

Chart 2: Head Drawdown in Neighboring H-Wells, June 2005

Summary Table

<table>
<thead>
<tr>
<th>Well</th>
<th>K, m/s</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2004</td>
</tr>
<tr>
<td>H2</td>
<td>5.80E-09</td>
</tr>
<tr>
<td>H4</td>
<td>1.38E-08</td>
</tr>
<tr>
<td>H3</td>
<td>1.75E-09</td>
</tr>
<tr>
<td>H5</td>
<td>1.09E-09</td>
</tr>
<tr>
<td>H6</td>
<td>7.03E-09</td>
</tr>
<tr>
<td>H1</td>
<td>5.28E-09</td>
</tr>
<tr>
<td>H7</td>
<td>3.17E-09</td>
</tr>
<tr>
<td>H8</td>
<td></td>
</tr>
<tr>
<td>H9</td>
<td></td>
</tr>
<tr>
<td>H10</td>
<td>1.02E-09</td>
</tr>
</tbody>
</table>

Average: 4.88E-09
Case Study: Partial RAP

- Confidence gained for dissolved phase impact control in Mid zone soils at the property line (via H-well system)

- Focus turned to perceived source areas and evidence of product migration (seams observed at OW-403)

- Additional BH’s drilled between well nests confirmed more small, PCE-saturated seams between 15-18’ and evidence of product
Case Study: Complete RAP

- Former owner and Consultant required excavation as part of whole on-site RAP

- SEACOR wished to remove source zone via VEMPE

- Compromise agreed on whereby SEACOR proposed a ‘strip excavation’ adjacent to property line to depth of Mid zone soils (6-7m)
Case Study: Complete RAP

**RAP Objectives**

- Address migration of PCE off-site in Mid zone soils
- Control and recover DNAPL in preparation for Risk strategy for dissolved phase impacts
Case Study: Complete RAP

RAP Overview

1) Excavation of Upper Zone at Property Line

2) Hydraulic Control of Mid Zone at Property Line

3) VEMPE of Source Areas and Residual PCE in Upper Zone
Case Study: Complete RAP

1) Excavation
Case Study: Complete RAP

2) Hydraulic Control

Immediate control of off-site migrating groundwater via ten, 4" wells (H-Wells) along property boundary (already installed) in the Mid zone. All fluids will be controlled and removed by VEMPE and transferred to existing treatment system. Current system based on 10m and 20 m ROI.
Case Study: Complete RAP

3) VEMPE Product Recovery

- Placement of VEMPE lines in existing utility trench and trench pumping wells
- Additional VEMPE wells installed as required by observations made during excavation
- Product mass recovery monitored in fluids separator as well as vapour treatment stream
- Extraction points based on a preliminary ROI of 10m
Case Study: Summary

The Successful Approval

- Multiple field tests with cooperative observation
- Use of in-house and external DNAPL experts
- Made use of the excavation ‘requirement’ to further impede PCE migration

All components of RAP were approved by Client, Former Owner and Consultant …

APPROVED BY LOCAL REGULATOR!
Case Study: Summary

Schedule

- H-wells already installed
- Excavation phase to start winter 2005
- System I and II commissioning to follow in spring 2006

THANK YOU