Combined Technologies to Address Two Complex Chlorinated Hydrocarbon Sites at a Federal Facility

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Agenda

• Provide facility background
• Present combined technology benefits
• Detail combined technology case studies
  • Selected remedies
  • Exit strategies
  • Ongoing optimizations
Facility Background

- Large federal facility in North Carolina active since 1940s
- CERCLA investigations and remediations underway since mid-1990s
- Nearly 50 active environmental sites
  - Chlorinated solvents
  - Munitions and unexploded ordnance
  - Emerging contaminants
Combined Technologies at Complex Sites

- Achieve distinct remedial objectives in different parts of target treatment area
- Account for varying site characteristics
- Provide flexibility with operations and maintenance
- Clear transition to monitored natural attenuation (MNA)
## Combined Technologies: Case Studies

<table>
<thead>
<tr>
<th></th>
<th>Site #1</th>
<th>Site #2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Historical Operations</strong></td>
<td>Former Dry Cleaning Facility</td>
<td>Former Motor Pool and Defense Reutilization and Marketing Office (DRMO)</td>
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<tr>
<td><strong>Plume Extent</strong></td>
<td>51 acres</td>
<td>50 acres</td>
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<tr>
<td><strong>Depth of Contaminants</strong></td>
<td>180 feet</td>
<td>60 feet</td>
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<tr>
<td><strong>Constituents of Concern (COCs)</strong></td>
<td>Tetrachloroethene (PCE) and daughter products</td>
<td>1,1,2,2-tetrachloroethane (PCA), trichloroethene (TCE), and daughter products</td>
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<tr>
<td><strong>Key Receptors</strong></td>
<td>Residents and industrial users, Downgradient creek</td>
<td>Industrial users, Downgradient creek</td>
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<td><strong>Complicating Site Features</strong></td>
<td>Congested area (buildings, utilities, traffic), Non-aqueous phase liquid (NAPL)</td>
<td>Discontinuous confining unit, Elevated water table, NAPL</td>
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Site #1 Background

• Former Dry Cleaning Facility
• Investigations conducted since 1996 have identified PCE and daughter products in groundwater
  • Concentrations indicative of dense non-aqueous phase liquid (DNAPL), constituting principal threat waste
Site #1 Conceptual Site Model

- PCE originates from former dry cleaning building
- Migrated vertically to underlying clay unit
- Transported via groundwater flow vertically and horizontally to the west
Site #1 Remedial Strategy – Source Area

- DNAPL treatment via Non-time Critical Removal Action (NTCRA)
  - Soil mixing with zero valent iron (ZVI) and bentonite
    - Up to 99.9% reduction of PCE in soil
    - 91-100% reduction of PCE in groundwater

Soil mixing auger at Former Dry Cleaning Facility
Site #1 Remedial Strategy – Dissolved Plume

- Multiple groundwater treatment technologies for remediation of dissolved plume documented in Record of Decision (ROD)
  - Complements plume conditions in direction of groundwater flow
- **Source Area**: Enhanced reductive dechlorination (ERD) via vertical injection wells
- **Deep Dissolved Plume**: In situ chemical oxidation (ISCO) via horizontal directionally drilled (HDD) wells and recirculation
- **Downgradient Area**: Biobarrier via vertical injection wells
Site #1 Exit Strategy

- Milestones for active treatment in near source area (ERD) and deep dissolved plume (ISCO)
  - COCs reduced to active remediation goals
    - Based on protection of downgradient surface water body, as predicted by fate and transport modeling
  - Multiple lines of evidence for switching to MNA are observed:
    - Plume stability
    - Mass reduction
    - Groundwater fate and transport modeling indicates protectiveness of nearest surface water body
    - Sustained favorable geochemical conditions
Site #1 Exit Strategy

• Milestones for active treatment in downgradient plume (biobarrier)
  • COC concentrations are protective of downgradient receptors
  • Aquifer conditions suggest that biodegradation can be maintained naturally; further enhancements not required

• Transition to MNA
  • Until COCs reduced to levels protective of unlimited use / unrestricted exposure

• Optimization to be evaluated as part of Five Year Review process
Site #2 Background

- Former motor pool and DRMO
- Investigations conducted since 1996 have identified 1,1,2,2-PCA, TCE, and daughter products in groundwater
  - Concentrations indicative of DNAPL, constituting principal threat waste
Site #2 Conceptual Site Model

- Contaminants originate from use as motor pool storage yard from 1983 to 2000
- Vertical migration to discontinuous confining unit
- Transported via groundwater flow horizontally to the east towards surface water body
Site #2 Remedial Strategy – Source Area

- DNAPL treatment
    - 48,000 pounds of COCs removed
  - Soil mixing with ZVI and bentonite (2008)
    - 99.7% total COC reduction in soil
    - 92.3% total COC reduction in groundwater
Site #2 Remedial Strategy - Dissolved Plume

- Multiple groundwater treatment technologies for remediation of dissolved plume and surface water documented in ROD
  - Addresses contaminants at different stages of fate and transport
- **Source Area Groundwater:** Air sparging (AS) via vertical and horizontal injection wells
- **Downgradient groundwater:** Permeable reactive barrier
- **Surface water:** in-stream aeration
- **Sitewide:** MNA
Site #2 Exit Strategy

- AS milestones for system shut-down
  - COC reduction to below 100 µg/L within 50 feet of AS wells
  - COC reduction demonstrates asymptotic trends

- PRB milestones
  - Replenishment with emulsified vegetable oil (EVO) based on
    - COC concentrations and trends
    - Oxidation reduction potential (ORP)
    - Available organic carbon
  - Discontinue when COCs in groundwater are reduced to levels protective of unlimited use / unrestricted exposure
Site #2 Exit Strategy
• Surface water aerators
  • Discontinue when COCs in groundwater and surface water are below levels protective of unlimited use / unrestricted exposure
Site #2 Remedial Action Performance

- Air Sparging
  - COC concentrations continue to decline

- PRB
  - COCs are effectively treated
  - Replenished once after 3 years based on depleted TOC measurements

- Aerators
  - COCs continue to be discharged to surface water
  - COCs below surface water standards at most downgradient location

- MNA
  - COC concentrations are generally stable or decreasing

TCE Concentrations in Groundwater (2014 vs. 2016)
Summary

• Benefits of combined technologies
  • Source treatment combined with multiple remediation technologies to effectively address dissolved plumes
    • As demonstrated by two case studies
  • Optimize remedial strategy based on aquifer conditions
  • Minimize time to site closure by addressing multiple remediation objectives concurrently
  • Flexibility with active remediation transition points
Thank you!
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