Differentiating CVOCs in Bedrock and Alternate Remediation Criteria - Rationale and Regulatory Concurrence

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• **Challenge:** Comingled CVOC plumes in industrial areas difficult to differentiate, and complex in bedrock.

• **Goals:**
  • Differentiate sources of CVOCs in groundwater
  • Apportion responsibility and remediation targets

• **Approach:**
  • Develop and refine a robust Conceptual Site Model
  • Apply a logical and iterative process
  • Validate with empirical data
  • Engage and collaborate with regulators
  • Proactively accept actual responsibility
**Site**: Petrochemical research and development facility

**Setting**: Mixed use area in New Jersey

**Geology**: Limited connectivity between overburden and bedrock; fracture controlled and supply well-influenced groundwater flow

**Chemicals**: Petroleum Hydrocarbons & CVOCs (multiple sources)
SITE HISTORY
SITE GEOLOGY

Overburden Soil
- Fill material, silt, and clay
- ~ 3 to 18 feet thick
- Overburden thickness increases from North to South
- Average GW depth ~ 8 to 10 feet
- Limited hydraulic connectivity with bedrock

Bedrock – Passaic (Brunswick) Formation
- Red / gray shale and sandstones
- Weathered zone up to 40 feet thick
- Dips NW ~ 5 to 12 degrees
- Extensional fractures dip SE ~ 70 to 80 degrees
- Groundwater flow along strike
- Hydraulic connectivity of wells along strike
Environmental investigation began in the early 1990s at the site.

Multiple areas of concern identified:
- ASTs (current/former)
- USTs (current/former)
- Hazardous materials storage / handling areas
- Process piping

Multiple phases of investigation

CVOCs identified in bedrock during sampling of the onsite supply well
- Initially assumed to be from onsite source(s)
POTENTIAL ONSITE SOURCES OF CVOCS

- **Soil**: Max TCE = 0.1 mg/kg
- **Overburden GW**: Max TCE = 9 µg/L
- **Bedrock GW**: Max TCE = 2,700 µg/L

*N* - SUPPLY WELL

- UST Location

SUPPLY WELL

1,000 ft

**SE**

**SW**

**NE**

**NW**
BR-25D
- Installed to delineate CVOCs in bedrock at the NE site boundary
- Highest concentrations of CVOCs onsite
- Triggered evaluation of offsite sources

Basis for suspected source(s) of CVOCs in bedrock:
- Release history
- CVOCs in soil and/or groundwater
- Location relative to the site (along strike)

Potential offsite sources identified:
1. Manufacturer of insulating materials
2. Plastics extrusion facility
3. Commercial drycleaning service
CVOCs in bedrock originated at the drycleaning facility

- Documented releases of PCE at the drycleaning facility
  - Concentrations in soil and groundwater were up to 2 orders of magnitude higher than those onsite
- Apparent transport of CVOCs from drycleaning facility toward the SW
  - Facilitated by operation of the onsite supply well
  - Operations at the drycleaning facility coincided with operation of the site supply well

<table>
<thead>
<tr>
<th>Year</th>
<th>DRYCLEANING FACILITY</th>
<th>DRYCLEANING FACILITY (New Ownership)</th>
<th>PLASTICS EXTRUSION</th>
<th>SITE SUPPLY WELL OPERATION</th>
<th>INSULATION MANUFACTURER</th>
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<td>2010</td>
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Concentration gradient and weathering gradient from the drycleaning facility toward the southwest

**Regulator Touch Point:** Agency asserted potential onsite contribution; In-person technical review meeting held
Conceptual Site Model refined based on meeting with regulatory agency:

- Agreed upon a comingled plume condition
- Comparison of CVOCs inside and outside of the comingled plume to determine contributions from each potential source
  - Within the comingled plume – Attributed to migration from the drycleaning facility
  - Outside of the comingled plume – Attributed to onsite source(s)
- Impacts from offsite may extend farther to the SW
  - Comingled plume was terminated just south of the supply well as a conservative approach.
- *TCFM / DCFM release as ‘tracer compounds’?

*Regulator Touch Point: Considered, evaluated, and ruled out TCFM / DCFM as tracers – consensus achieved
• Seven classes of CVOCs (27 compounds) analyzed in groundwater:

  - **Chlorinated ethanes**: 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,1-dichloroethane, 1,2-dichloroethane, chloroethane and ethane

  - **Chlorinated ethylenes**: Tetrachloroethylene, trichloroethylene, 1,1-dichloroethylene, cis-1,2-dichloroethene, trans-1,2-dichloroethene, vinyl chloride and ethylene

  - **Carbon tetrachloride**: Carbon tetrachloride, chloroform, methylene chloride and chloromethane

  - **Chlorofluorocarbons**: 1,1,2-Trichloro-1,2,2-trifluoroethane, trichlorofluoromethane and dichlorodifluoromethane

  - **Chlorobenzenes**: 1,2,3-Trichlorobenzene, 1,2,4-Trichlorobenzene, 1,4-dichlorobenzene, 1,2-dichlorobenzene and chlorobenzene

  - **Chloropropanes**: 1,2-Dichloropropane

  - **Chlorination byproduct**: Bromodichloromethane
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17 CVOCs: ND, <GWQS, or no GWQS = No remediation required
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- **Chlorination byproduct**: Bromodichloromethane

4 CVOCs: ND or <GWQS outside of comingled plume = No remediation required (no onsite source)
### DETERMINATION OF ONSITE CONTRIBUTION OF CV OCS TO BEDROCK

<table>
<thead>
<tr>
<th>Class of CV OCS</th>
<th>Compound</th>
<th>GWQS (µg/L)</th>
<th>Maximum Onsite Concentration (µg/L)</th>
<th>Maximum Overburden Concentration (µg/L)</th>
<th>Maximum Bedrock Concentration (µg/L)</th>
<th>Onsite Contribution to Bedrock Groundwater (µg/L)</th>
<th>Offsite Contribution to Bedrock Groundwater (%)</th>
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<tbody>
<tr>
<td>Chlorinated Ethanes</td>
<td>1,2-DCA</td>
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<td>Vinyl Chloride</td>
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</table>

**ONSITE CONTRIBUTION (%)** | **OFFSITE CONTRIBUTION (%)**
ALTERNATIVE REMEDIATION CRITERIA

- 1,2-DCA
- TCE
- Cis-1,2-DCE
- VC
- PCE
- 1,1-DCE

Concentration (µg/L)

- GWQS
- Max Concentration
- Alternative Remedial Goal
• Comingled CVOC plumes exist at the site
• Onsite supply well likely entrained contamination from offsite sources
• CVOCs in bedrock within the comingled plume mostly attributed to migration from offsite sources
  • Contribution from onsite and offsite sources has been quantified
• TCFM / DCFM may not be reliable ‘tracer compounds’ in this case
• *Continuing engagement with regulatory agency

*Regulator Touch Point: Technical consultation meeting – reconcile Remedial Action Permit with CSM, approach and agreements
Logical reasoning is just as important as empirical data in cases of comingled plume conditions.

Face-to-face dialogue between clients, consultants and regulators is a highly effective means of resolving complex technical issue.

Engagement with the regulatory agency throughout the project is key. Not just a one-time event, or at the time of report submittal.
QUESTIONS