Successful Closure of a DNAPL Site

Craig A. Cox, CPG, CP
Topics for Discussion

- What is DNAPL and why are DNAPL sites so difficult to close.
- What is DNAPL site closure.
- What is the approach to successful closure.
- Case study of a successful DNAPL site closure.
- Lessons Learned.
What is a DNAPL?

- DNAPL is a “Dense Non-Aqueous Phase Liquid”
- DNAPLs include:
  - halogenated solvents,
  - coal tar and creosotes, and
  - PCB oils.
- Most common form at environmental sites are the halogenated solvents.
Why are DNAPL Sites Difficult?

- Extreme concentration,
- High toxicity,
- Varied migration mechanisms,
- Location of the source, and
- Wetting (residual saturation).
What is DNAPL Site Closure?

- DNAPL site closure is a negotiated truce based on:
  - Setting and meeting realistic expectations,
  - Reducing source strength,
  - Containment, and
  - Risk reduction.

- Requires a prolonged partnership between the site owner, the regulator, and the community.
What is DNAPL Site Closure?

• Relies on:
  – Detailed site characterization activities,
  – Establishing and attaining site-specific alternate concentration limits (ACLs),
  – The likely require use of institutional controls.

• Expensive and time consuming.
Approaching Closure – Step 1

• Prepare for assessment:
  – Develop a Conceptual Site Model (CSM) and a Conceptual Site Exposure Model (CSEM),
  – Develop Data Quality Objectives,
  – Review site history,
  – Get the “Real Story”, and
  – Expect to manage lots of data.
Approaching Closure – Step 2

• Complete an initial assessment:
  – Use screening methods to focus your efforts,
  – Work from the outside – in,
  – Update the CSM and CSEM,
  – Discuss, if possible, your findings and the proposed scope of investigative activities with your regulator.
Approaching Closure – Step 3

• Begin a detailed, phased-investigation to evaluate source strength.
  – Work in 3-dimensions,
  – Collect complete data sets,
  – Establish extent,
  – Don’t disregard certain rules of thumb – DNAPLS can be difficult to locate.

• Establish weight- or volume-based source strength estimates.
Approaching Closure – Step 4

- Establish “Phase-Specific” performance goals to direct remediation:
  - Short-term (mitigation of the immediate risks),
  - Intermediate-term (source depletion and reduction of dissolved load),
  - Long-term (achieve regulatory compliance or risk-based criteria).

- Not necessarily numeric standards.
Approaching Closure – Step 5

- Begin phased remediation effort to meet the short-, intermediate-, and long-term goals.
- Expect to change technologies as your goals change.
- Collect real-time data to document source depletion efforts.
- Collect confirmation samples.
Approaching Closure – Step 6

- Repeat Step 5
- Develop and Implement Post-Closure Care and Monitoring Strategies.
- Establish Institutional Controls.
Case Study

- **Background:**
  - Metal recycler using TCE as a degreaser.
  - Catastrophic release of 500 gallons from a ruptured tank within the facility.
  - Site underlain by glacial till with shallow perched water zones.
  - Regional aquifer lies approximately 100 feet below grade.
  - Heavily industrialized area.
Case Study

- Conceptual Site Model:
  - Unknown quality of TCE affected soils adjacent to the building.
  - Bulk of the TCE trapped beneath the building slab.
  - Sub-slab vadose zone is very thin due to near-surface perched water zone.
  - TCE contained on-site.
  - TCE concentrations decrease with depth.
  - Regional aquifer protected by thick, dense till layer.

Cox-Colvin & Associates, Inc.
Case Study

- Conceptual Site Exposure Model:
  - Potential for site and construction workers to be exposed to TCE in soil through ingestion, dermal contact, and inhalation.
  - Potential for site workers to be exposed to TCE in indoor air through inhalation.
Case Study

- Implement short-term response.
  - Excavation and disposal of affected soils surrounding the building.
  - Excavation of a small drainage swale along the highway.

- Activities reduce the source strength by an estimated 20% (approximately 100 gallons).
Case Study

- Assessment/Investigation
  - Reviewed historic site concentration data in soil and groundwater.
  - Refined the 3-dimension understanding using a Membrane Interface Probe (MIP) and additional soil and groundwater sampling.
  - Established intermediate-term goal of depleting TCE concentrations to below 580 mg/kg (soil saturation limit).
Case Study

• Implement intermediate-term response
  – Two phases of HVDPE and chemical oxidant (potassium permanganate) flooding.
  – Log vapor concentrations in the extracted air stream using an in-line PID.
  – Analyzed TCE concentrations in extracted water prior to disposal.
  – Completed detailed 3-dimensional re-sampling of soil profile after each phase.
Case Study

• Implement intermediate-term response (continued)
  – Used volumetric mapping techniques to evaluate remaining TCE mass in place.
  – Collected additional groundwater data.
• TCE source depleted by an additional 70% (approximately 366 additional gallons, 466 gallons in total).
Case Study

• Risk Assessment
  – Collected and evaluated sub-slab and indoor air samples.
  – Completed risk assessment based on air samples and post-remediation soil and groundwater samples.
  – Hazard index and excess lifetime cancer risk were within acceptable risk ranges.
Case Study

- Implement long-term response
  - Prepared a Post-Closure Care and Monitoring Program.
  - Established deed restrictions prohibiting groundwater use.
  - Established a groundwater ACL of 36,000 ug/l as a predictor of vapor intrusion for a potential future off-site receptor.
  - Monitor groundwater semi-annually and indoor air annually.
Remedy

Cox–Colvin & Associates, Inc.
Remedy

Pre and Post Remediation TCE Concentrations in Soil Between 4 to 7 Feet,
Urico Alloys, Inc.,
Columbus, Ohio

Figure 3-2
Remedy

Pre and Post-Remediation TCE Concentrations in Soil Between 7 to 15 Feet, Urico Alloys, Inc., Columbus, Ohio

Figure 3-3
Lessons Learned

• Use MIP to sneak up on the source.
• Injecting fluids can move the source and provide a false indication of success.
• Document source depletion through extensive sampling efforts.
• Use volumetric mapping techniques to estimate source strength.
• Be flexible in choosing treatment technologies.
• It is possible to remediate tills using HVDPE.
References


