Using Remedy Implementation Information to Guide Remedy Optimization

Federal Remediation Technology Roundtable Meeting

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Outline

- Hanford Case Study Site Description
- Conceptual Site Model (CSM) Elements of Remedy Selection
- CSM Refinement: Input from Remedy Implementation and Performance Assessment
- Identified Remedy Optimization Targets
- Optimization Study Approach and Adaptive Site Management
Hanford Site Groundwater Units
Historical Hanford Processes

- Manufacture Fuel Elements
- Irradiate Fuel Elements
- Chemical Separations
- Plutonium Finishing

[Map and images of Hanford Site operations]
Carbon tetrachloride (CCl₄) disposed of in three nearby locations

Large groundwater mound spread CCl₄ in the groundwater (10-square-kilometer plume, over 50 meters thick)

Early action of Soil Vapor Extraction (SVE) removed 80,000 kilograms; no continuing source

No dense nonaqueous phase liquid (DNAPL) below water table

Groundwater mound has dissipated; groundwater flow rate is slow

Groundwater concentrations 1,000 times the remedial action objective (RAO); natural attenuation occurs, but plume is too concentrated and large for passive-only remedy

Radionuclide and inorganic co-contaminants are present
**200-ZP-1 OU Conceptual Site Model (cont.)**

- **Historic groundwater mound:** Broad plume spread multiple directions
  - Addressed by SVE

- **Approx. 75 m**
  - Ringold Lower Mud
  - No DNAPL

- **Approx. 50+ m**
  - Window to lower part of aquifer
  - Ringold A
  - Ringold E
Conceptual Site Model – Remedy Selection

- RAO to restore aquifer
- Source addressed by SVE and no DNAPL present
- Large plume with co-contaminants difficult for in situ remediation
- Pump-and-treat (P&T) systems can effectively diminish plumes; difficulty in reaching RAO
- If plume is diminished, natural attenuation can reach RAO
- Remedy applies P&T with transition to Monitored Natural Attenuation (MNA)
- Anticipated 25 years of P&T and 100 years of MNA to meet RAO based on Feasibility Study CSM
  - CCl₄ distribution – uncertainty in mass (collect data during remedy)
  - Attenuation rate – uncertainty est. 41–290-year half-life (implement study)
Began operations in 2012

- 33 Extraction Wells located within carbon tetrachloride plume
- 35 Injection Wells on the outer edges of the highest concentration area
Implementation and Performance Data

3-D plume mapping
- Monitoring well concentrations
- Extraction/injection concentrations
- Characterization depth profile concentrations
- Extraction mass removal rate compared to predicted mass removal rate
Hydraulic data

- Water levels
- Capture analysis

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<td>16%</td>
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<th>Percent of Plume Area Contained</th>
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Implementation and Predictive Modeling

Monitor
1. Concentrations (MW and EW)
   - Primary COCs – DS #1, DS #2
   - Transformation products – DS #4
2. Water levels – DS #1, DS #6
3. Water quality and biogeochemical indicators (pH, DO, dissolved iron, chlorides) and selected WASH-1/DV-1 contaminants (at selected locations) – DS #3, DS #5
4. P&T effluent (IW) concentrations
   - COCs – DS #1, DS #2
   - Water quality – DS #3, DS #5
   - Other constituents – DS #3

Calculate
1. Aquifer
   - Capture zone
   - Plume for each COC
   - Mass in aquifer for each COC
2. Well
   - Capture zone for each EW
   - EW mass extracted for each COC
   - COC and other constituents
   - Mean, LCL, UCL – Long-term trends and statistics
   - For the IWs, capacity and performance trends

Predict
1. Update model as needed for operational configuration changes
   1. Aquifer
      - Capture zone and flow paths
      - Plume contours/mass over time
      - Mass extraction profile
   2. Well
      - Capture zone (EW)
      - Mass extraction profile (EW)
      - Concentration profile (MW/EW)

Report
1. Aquifer
   - Plume changes consistent with lower or higher mass estimate?
   - Trends consistent with meeting 25-year or less performance goal?
2. Well
   - Mass removal at IEs consistent with lower or higher mass estimate?
   - EW and MW trends consistent with meeting 25-year or less goal?
   - EW and MW/DF trends indicate zone of persistence (potential source) or inconsistent with predicted capture zone?
   - EW and MW data for environmental conditions within acceptable zone?
3. Causes for uncertainties and factors inhibiting remediation
4. 290 West P&T operating conditions, optimization, and performance issues that relate to plume remediation performance
5. Address DS questions (Section A6)

Optimize
1. Adjust for progress and efficiencies
2. Address performance issues (e.g., IW capacity) or sources
   1. Model configuration updates
   2. P&T modifications
      - Change EW and IW flow rates
      - Adjust well network
      - Add, remove, alter wells for plume extraction
      - Change well configuration to address sources
      - Modify the P&T facility
3. Monitoring network
   - Add/remove wells
   - Different monitoring frequency
4. Consider hot spot treatment

Are concentrations amenable to MNA achieved?

Evaluate P&T
Shutdown, Rebound Studies
Challenges Identified

- More CCl₄, including more below the Lower Mud Unit (Ringold A) than understood during the feasibility study (FS)
  - Total within FS uncertainty but higher than baseline estimate
  - Ringold A 25% versus 12% of total
- Characterization is planned to define the extent of contaminants of concern in Ringold A and its hydraulic properties
Challenges Identified (cont.)

- Abiotic degradation of CCl₄ (hydrolysis) is slower than FS assumption
  - 630 versus 41–290-year half-life
  - Previous information extrapolated from high temperature
  - Data at site-specific temperature shows lower rate (6-year study)

- Currently studying other degradation mechanisms at the site
Evaluation of CCl₄ Information

- Need more intensive mass removal during the P&T period to enable transition to MNA
- May need more MNA time
- Need more information in the Ringold A to assess the best approach
Nitrate Considerations

- Sufficient nitrate may have been removed from Ringold E to stop active biological treatment and start transition to MNA as identified in the record of decision (ROD)
  - Blending during P&T
  - Natural attenuation after P&T
- Suspending biological treatment would:
  - Enable more efficient approach for increasing \( \text{CCl}_4 \) treatment capacity
  - Eliminate operational difficulties associated with biofouling in wells
Contaminants of Concern – Mass Removed, 2012 through 2018

200 West Pump & Treat
Cumulative Mass Removed July 2012 to December 2018

- Nitrate as Nitrogen: 438,105 kg (965,865 lbs)
- Carbon Tetrachloride: 15,122 kg (33,339 lbs)
- Uranium: 530 kg (1,169 lbs)
- Chromium: 512 kg (1,130 lbs)
- Trichloroethene: 66 kg (148 lbs)
- Technetium-99: 748 g (1.65 lbs)
Approximately 40% of Operations and Maintenance cost is due to nitrate treatment.

Biofouling issues with wells would decrease significantly with removal of FBRs/MBRs.

Limits flow through the system
Optimization Study Rationale

- Evaluated six years of 200 West P&T operation data
- Current remedy as designed is projected to be insufficient for meeting remedial action objectives due to
  - Larger mass of CCl$_4$ in the aquifer
  - Slower degradation rate
- Important to consider remedy optimization for CCl$_4$ because it is the most significant risk driver; unlike other contaminants, its concentration is up to 1,000 times greater than the RAO
Optimization Study Plan

- Suspend biological treatment for specified amount of time and gather data on contaminant behavior in the aquifer.
- Treatment capacity for CCl₄ will be increased with an additional air stripper and expanded well network.
- Intended to be an iterative process of data evaluation and decision-making.
- Once sufficient data is collected and evaluated, the site and regulators will work together to determine if the remedy needs to be changed.
  - Will consider if RAOs and timeframes listed in ROD can be achieved.
  - No intent to change cleanup levels.
EPA Support for Optimization

- September 2012: EPA released a *National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion*.
  - Envisions the application of optimization concepts throughout all phases of the remedial process
- Systematic site review at any phase of the cleanup process to:
  - Identify opportunities to improve remedy protectiveness, effectiveness and cost efficiency
  - Facilitate progress toward completion of site work
Adaptive management is a formal and systematic site or project management approach centered on rigorous site planning and a firm understanding of site conditions and uncertainties. This technique, rooted in the sound use of science and technology, encourages continuous re-evaluation and management prioritization of site activities to account for new information and changing site conditions. A structured and continuous planning, implementation and assessment process allows EPA, states, other federal agencies, or responsible parties to target management and resource decisions with the goal of incrementally reducing site uncertainties while supporting continued site progress.

EPA Memo, Broaden the Use of Adaptive Management, July 2018