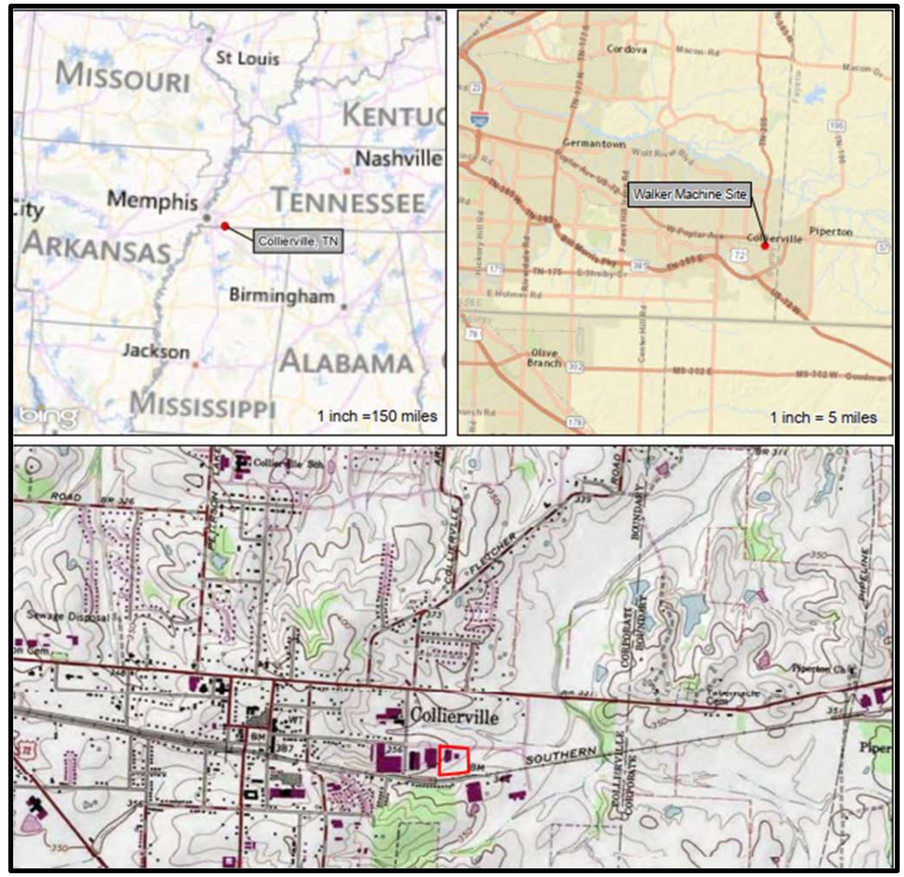
Post-Remedial Design Remedy Optimization to Reduce Life Cycle Costs and Remediation Timeframes at a Superfund Site

Mike Perlmutter, PE
Jacobs

EPA
SAME
DCHWS
Design and Construction Issues at Hazardous Waste Sites
March 4 – March 6, 2026

Agenda

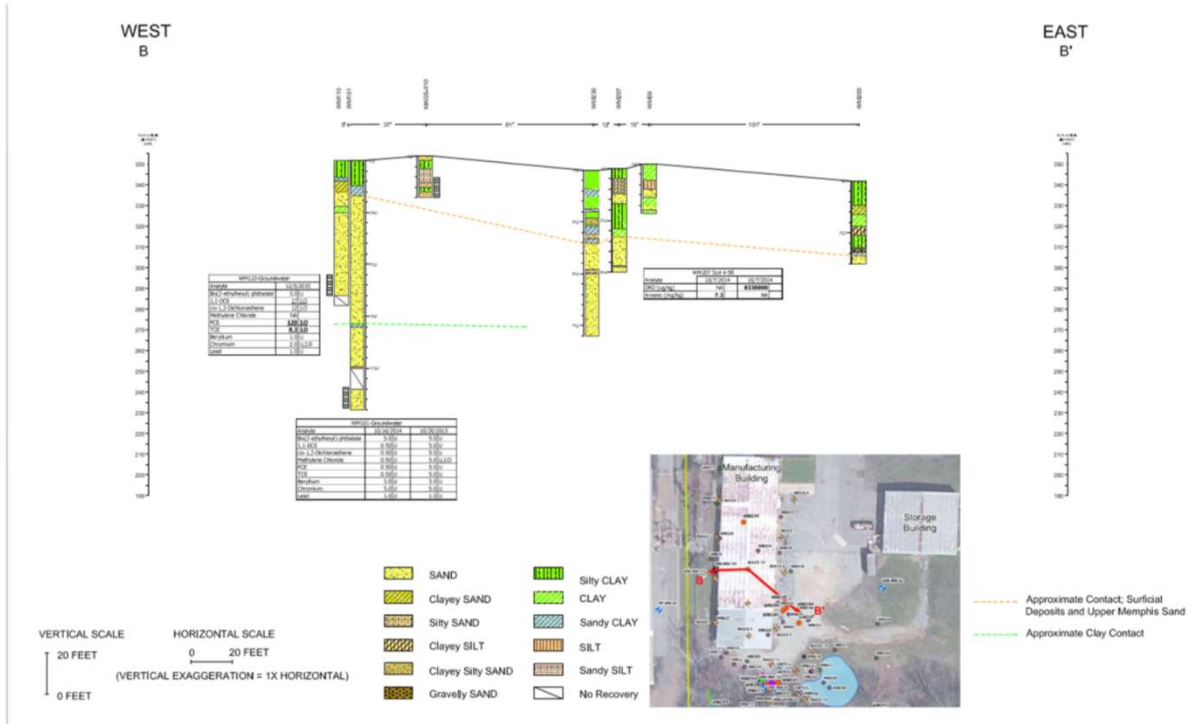
- Site background
- Remedial design (RD)
- Optimization 1
- Optimization 2
- Soil data gap investigation and conceptual site model (CSM) reconsideration
- Optimization 3
- Remedy implementation and further optimization
- Summary



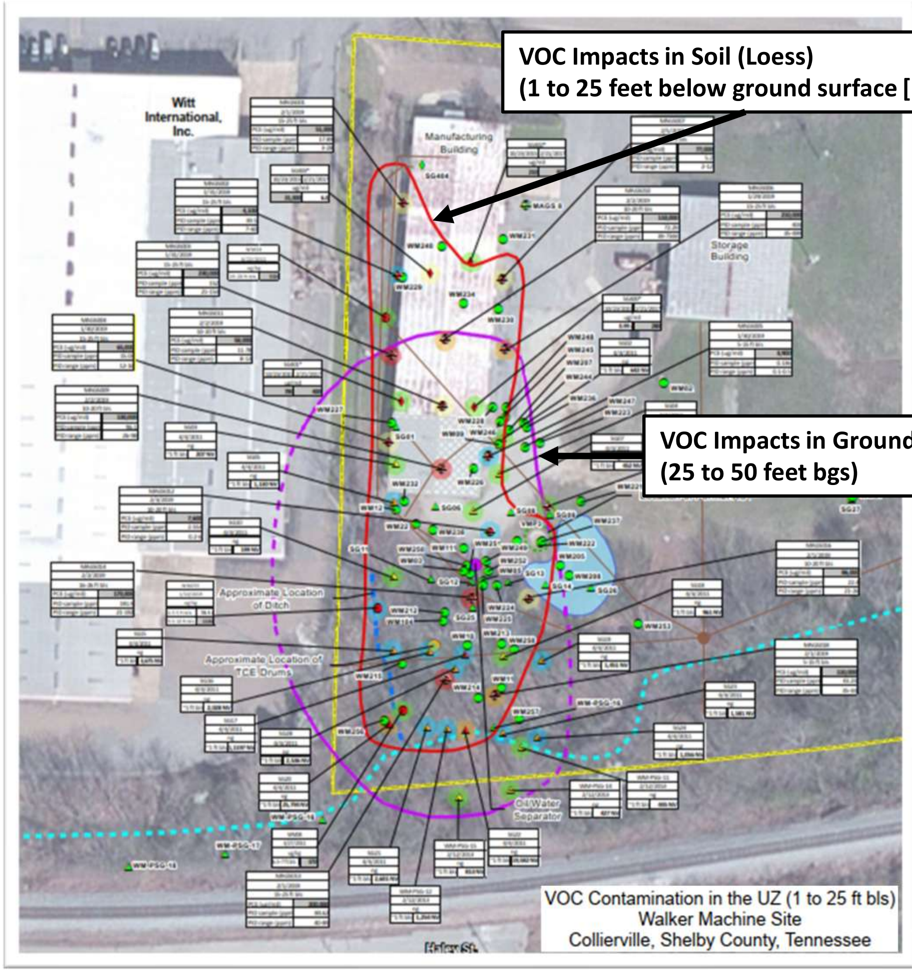
Site Background

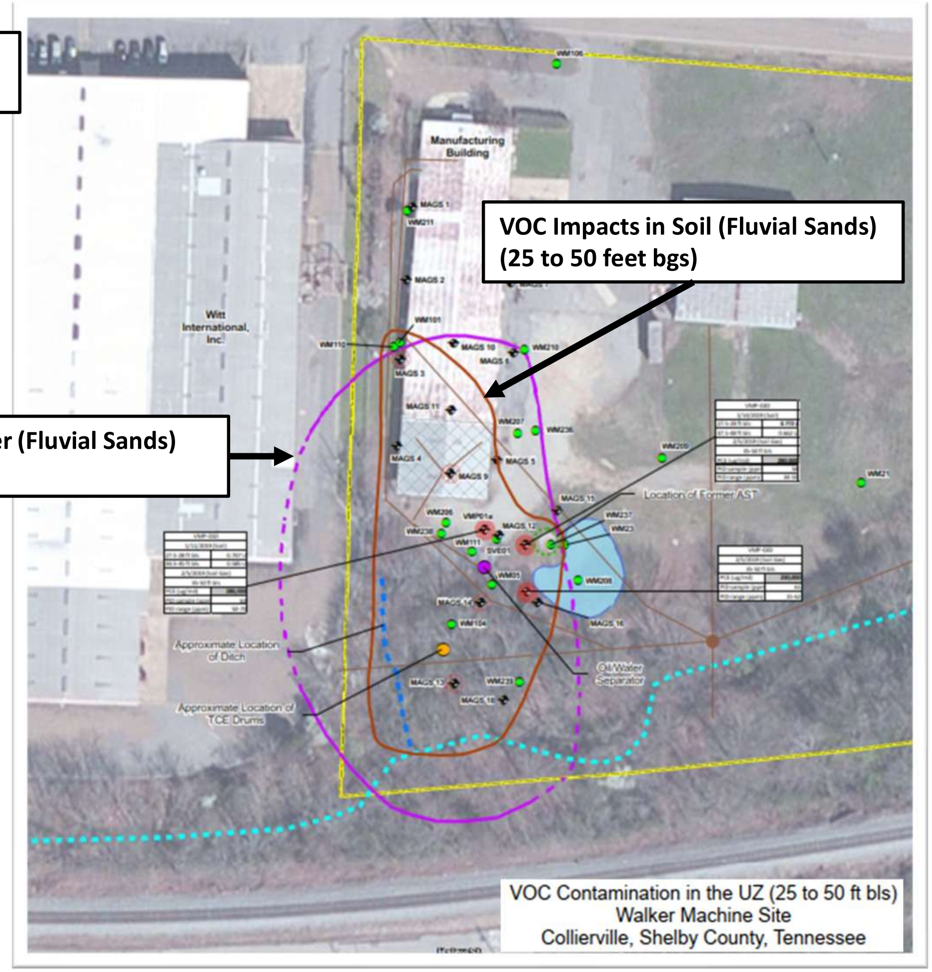
- Walker Machine Products, Inc., east of Memphis, Tennessee, fabricated metal products from the 1960s until about 2002
- Based on the operational history and Remedial Investigation (RI) results, the contaminants of concern (COCs) are:

	GW	Soil	Air
Tetrachloroethene (PCE)	●	●	●
Trichloroethene (TCE)	●	●	●
Cis-1,2-dichloroethene (DCE)	●	●	
1,1-DCE	●	●	
1,1-Dichloroethane	●		
carbon tetrachloride	●		
Methylene chloride	●		
chloride	●		
1,4-Dioxide	●		



GW = groundwater


VOC Impacts in Soil (Loess)
(1 to 25 feet below ground surface [bgs])
VOC Impacts in Groundwater (Fluvial Sands)
(25 to 50 feet bgs)
Witt International, Inc.
Manufacturing Building
Storage Building
Approximate Location of Ditch
Approximate Location of TCE Drums
Oil/Water Separator
VOC Contamination in the UZ (1 to 25 ft bls)
Walker Machine Site
Collierville, Shelby County, Tennessee


VOC Impacts in Soil (Fluvial Sands)
(25 to 50 feet bgs)
Manufacturing Building
Witt International, Inc.
Location of Former AST
Approximate Location of Ditch
Approximate Location of TCE Drums
Oil/Water Separator
VOC Contamination in the UZ (25 to 50 ft bls)
Walker Machine Site
Collierville, Shelby County, Tennessee

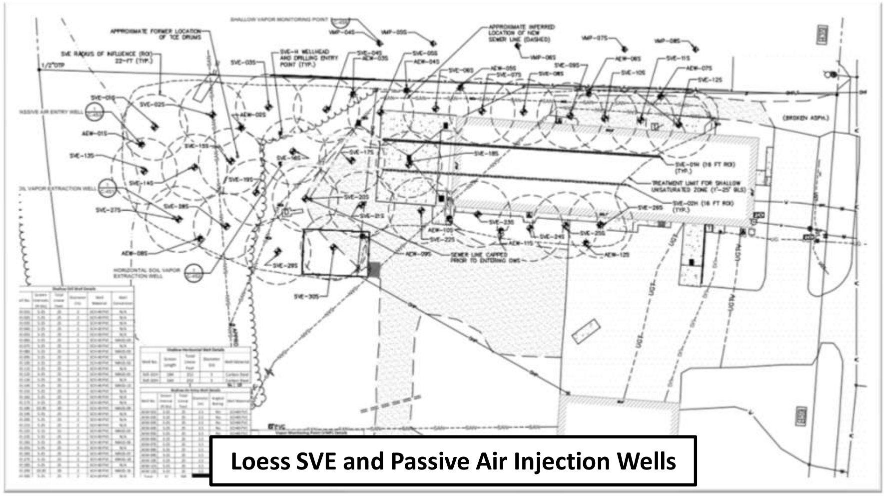
Remedial Action Objective (RAO) Summary

Media	RAO
Air	Prevent human exposure to COC contaminated indoor air at concentrations that pose an unacceptable risk
	Prevent and/or minimize indoor air impacts under current and reasonably anticipated future land use
Soil	Reduce COC source mass in soil
	Reduce or eliminate the long-term leachability of COCs from soil
Groundwater	Prevent and/or minimize the groundwater plume expansion
	Prevent human exposure to COCs in groundwater until remedial goals have been achieved
	Restore groundwater to serve as a potential drinking water source

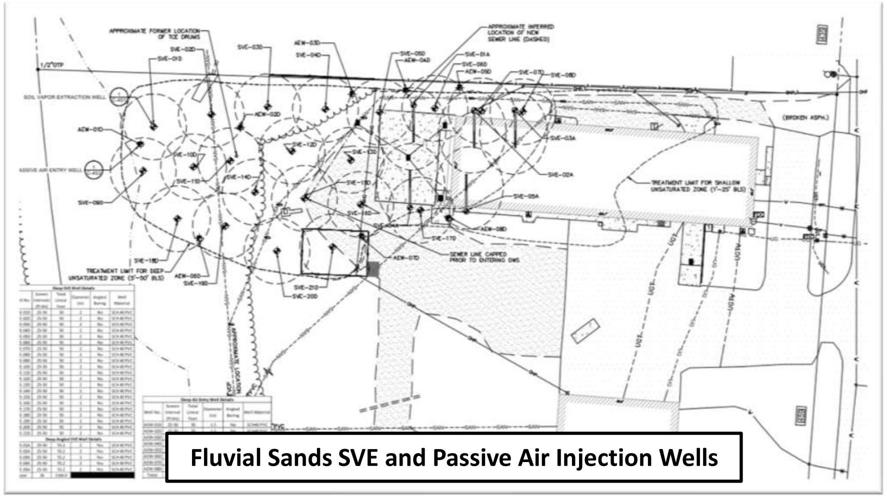
Vapor intrusion mitigation system (VIMS) installed for Walker Building as interim measure

Remedial Design

- Soil and debris excavation from multiple areas
- Soil vapor extraction (SVE)
  - 30 vertical wells screened in the Loess
  - Two horizontal directionally-drilled (HDD) wells with 160- to 180-foot-long screens installed in the Loess beneath the building
  - 21 vertical and five angled wells screened in the Fluvial Sands
- Passive air entry
  - 12 vertical wells screened in the Loess
  - Eight vertical wells screened in the Fluvial Sands



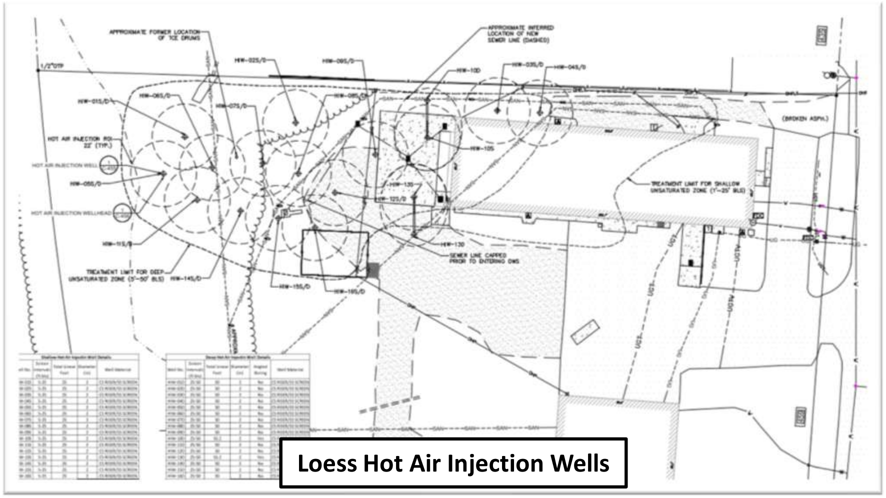
Loess SVE and Passive Air Injection Wells

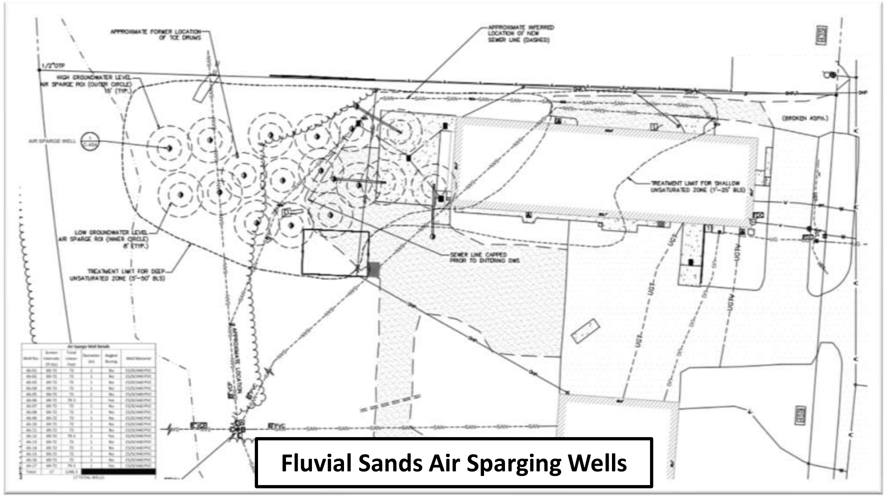


Fluvial Sands SVE and Passive Air Injection Wells

Remedial Design

- Hot air injection
  - 16 vertical wells screened in the Loess
  - 16 vertical and two angled wells screened in the Fluvial Sands
- Air sparging (AS)
  - 14 vertical and three angled wells screened in the saturated Fluvial Sands

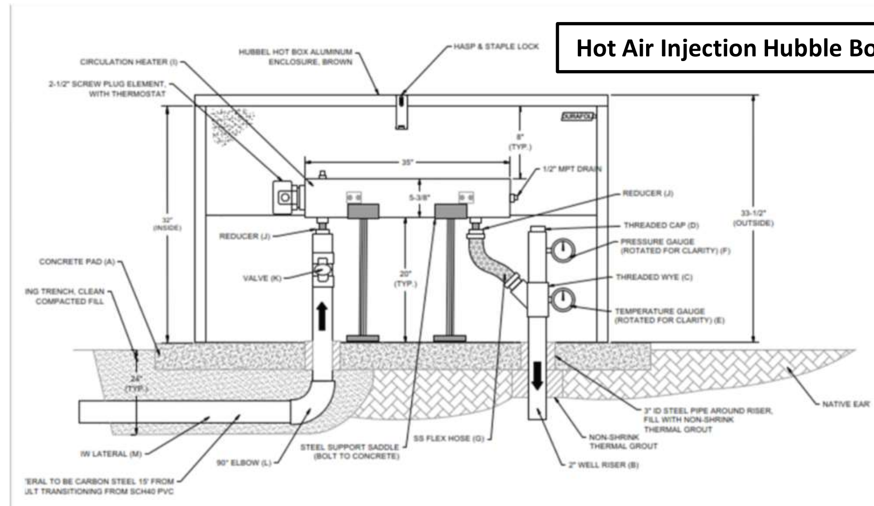




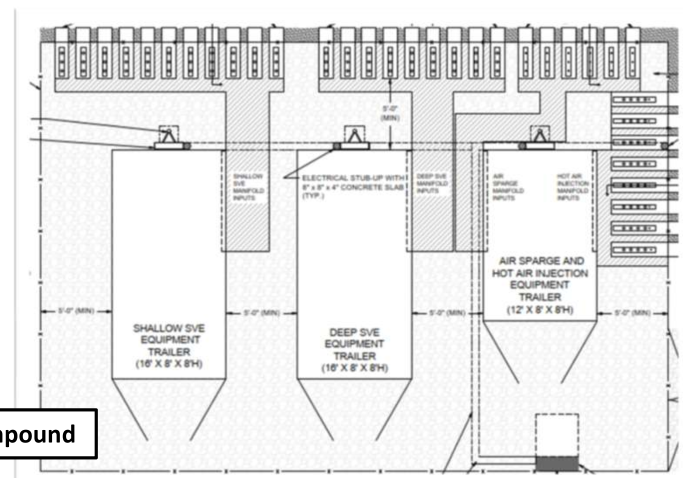
Remedial Design

- Remediation equipment
  - 34 Hubble boxes for heating equipment
  - Loess SVE equipment trailer
  - Fluvial Sands SVE equipment trailer
  - AS and hot air injection equipment trailer

- **Initial phase of Remediation Environmental Services (RES) contract was to optimize the RD prior to construction**



Hot Air Injection Hubble Boxes

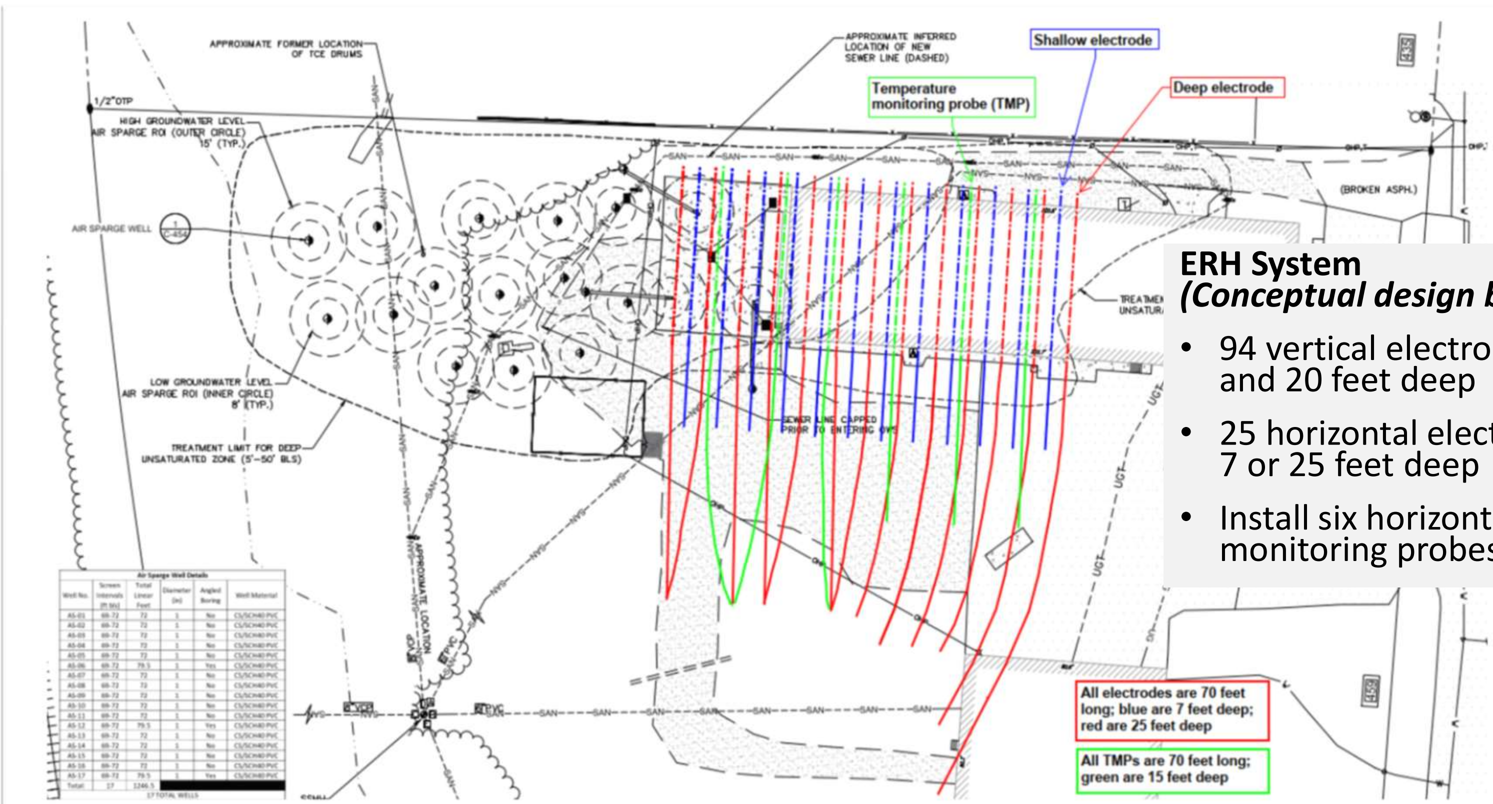


Remediation Compound

Optimization 1 Recommendations

- Change thermal enhancement portion of the remedy from hot air injection, SVE, and passive air entry to electrical resistance heating (ERH) in the loess
- Replace vertical fluvial AS wells with horizontal directional drilled (HDD) AS wells
- Update remediation systems accordingly

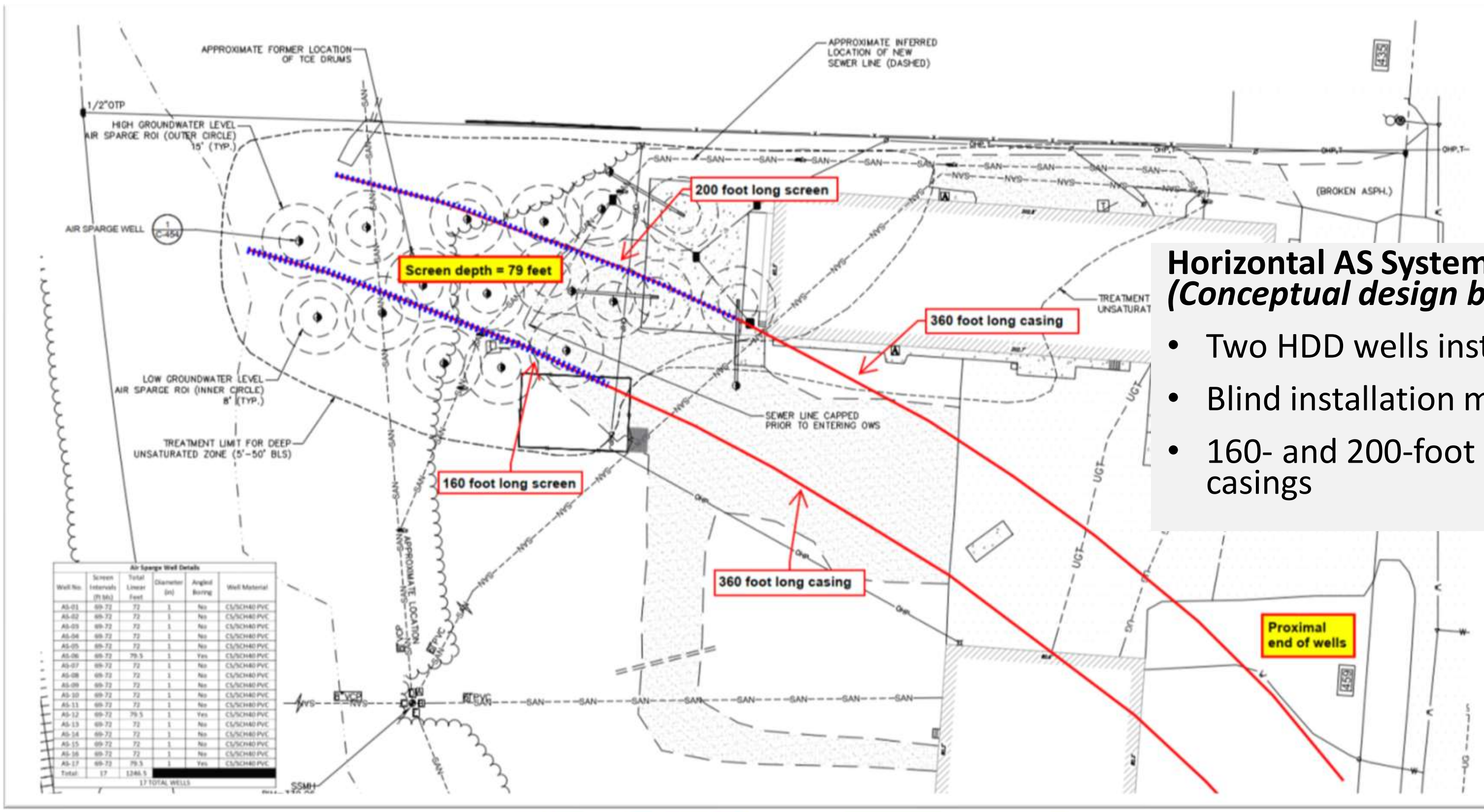
Optimization 1 Components



ERH System
(Conceptual design by TRS)

- 94 vertical electrodes on 20-foot centers and 20 feet deep
- 25 horizontal electrodes (70 feet long) at 7 or 25 feet deep
- Install six horizontal temperature monitoring probes

Optimization 1 Components



Horizontal AS System
(Conceptual design by Ellingson-DTD)

- Two HDD wells installed to 79 feet bgs
- Blind installation method
- 160- and 200-foot screens with 360-foot casings

Optimization 1 Benefits

- Achieves the RAOs (though it deviates from the RD)
- ERH improves heating in loess, increases treatment certainty, and reduces the time to achieve treatment goals by two years
- Reduces vertical drilling locations and conveyance piping while also allowing the AS system to be installed (if needed) after the impacts of the vadose zone remedies are evaluated
- Optimizes the remediation systems

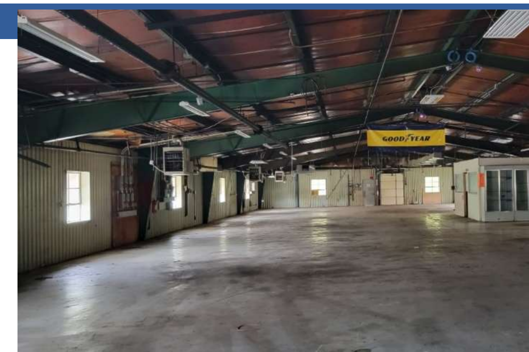
- **Conclusion from EPA**
  - Cost increase of $3 million could not be justified
  - Interested in replacing the vertical AS wells with HDD AS wells and delaying implementation pending vadose zone treatment
  - Interested in refining the extent of the target treatment zone

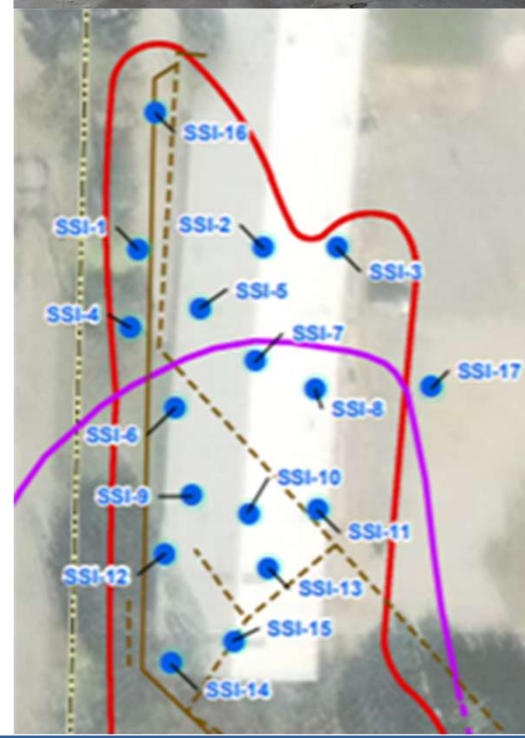
Optimization 2 Recommendations

- Perform a soil data gap investigation
- Use HDD AS wells in lieu of the vertical AS wells
- Optimize the hot air injection and SVE system for the Loess
- Optimize the remediation equipment

Optimization 2 Components

- Advance 12 soil borings beneath the building and awning, and five soil borings adjacent to the building and collect samples at 5-foot intervals for volatile organic compound (VOC) analysis
- Reduce remediation equipment from three trailers to two shipping containers
- Use positive displacement (PD) instead of rotary claw blowers for the Loess and Fluvial Sands SVE and Loess hot air injection systems
- Use a rotary screw compressor instead of a rotary claw pump for the Fluvial Sands AS system
- Replace above-grade Hubble boxes with in-well thermal conductance heaters to heat injected air and surrounding formation and use steel for all Loess air injection and extraction wells
    - ***Conceptual design by TRS***





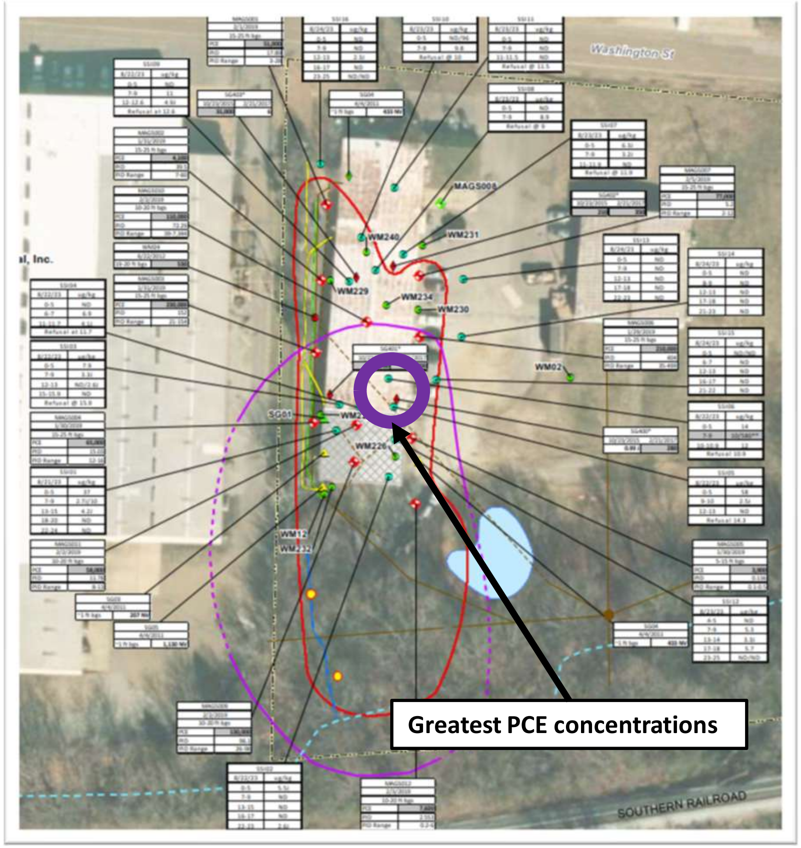
Optimization 2 Benefits

- Reduces projected costs by $100,000 and….
- More closely aligns with RD (as compared to Optimization 1)
- Refines the target treatment zone in the Loess
- Accelerates the construction schedule by reducing the vertical drilling program and deferring the installation of the HDD AS system
- Reduces the remediation system footprint, electrical consumption, and operations and maintenance ()
- Improves energy transfer from each air injection well to the loess to promote solvent removal, facilitation of drying and desiccation of the loess to improve efficacy of the injection process, and heating flexibility

- **Conclusion from EPA**
  - Proceed with the soil investigation
  - Revisit other recommendations after the soil data has been analyzed

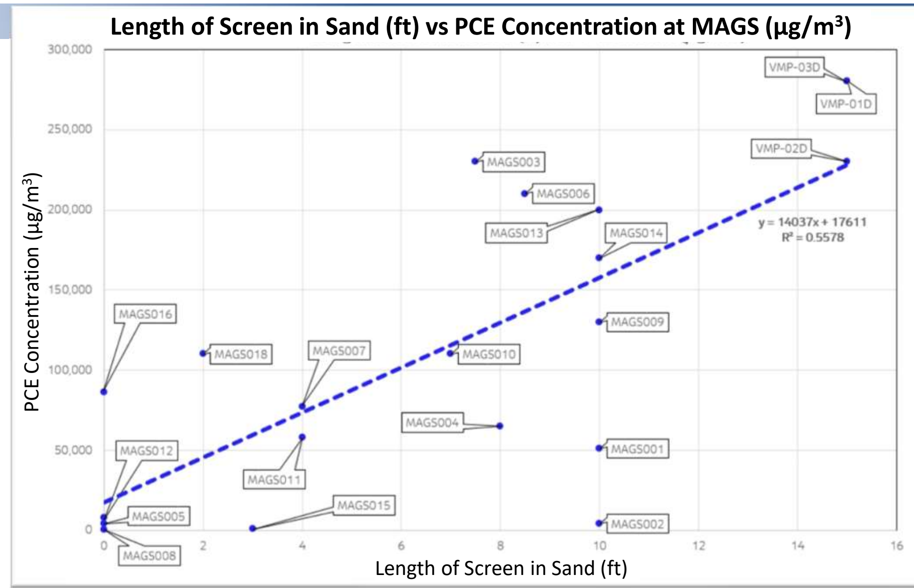
Soil Sampling Results

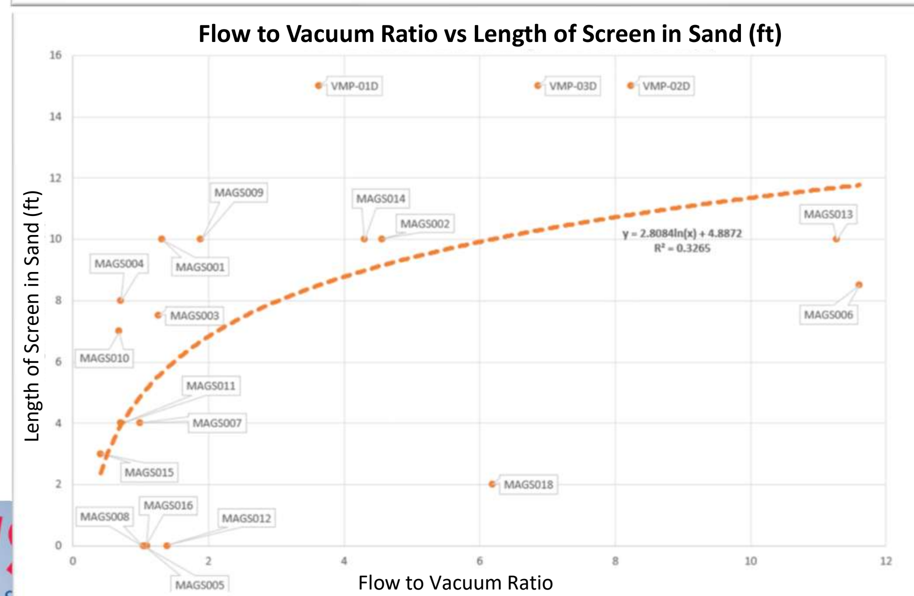
- PCE concentrations in soil ranged from less than detection limits to 580 micrograms per kilogram (µg/kg); most were less than 100 µg/kg
- Negligible photoionization detector (PID) response across all borings
- Results were not indicative of residual source material in Loess



CSM Reconsideration

- Greatest membrane interface probe (MIP) responses from pre-design site characterization were below the Loess
- During pre-design site characterization, modified active gas sampling (MAGS) was used as a surrogate for soil sampling due to access constraints
    - MAGS is essentially a short-term SVE test with flow, vacuum, and soil vapor sampling
- MAGS screens are partially to mostly located below the Loess; therefore, results are likely indicative of the Fluvial Sands rather than the Loess
- Overall, greatest PCE concentrations in soil are only about 10x the remedial goal





Optimization 3 Recommendations

- Eliminate remediation infrastructure for the Loess (revisit exceedances in soil and soil vapor after operating Fluvial Sands SVE; consider targeted remedy as needed)
- Implement Fluvial Sands SVE and AS
- Consider HDD in lieu of vertical AS wells
- Optimize the remediation equipment

Optimization 3 Components

- Install vertical SVE and AS wells with steel casings and screens (to allow for thermal treatment in the future)
  - Or replace vertical AS wells with two HDD AS wells installed after SVE system operates
- Collect soil samples during SVE and AS well installation to verify updated CSM
- Use two trailers for the SVE and AS systems
  - One PD blower for the SVE system
  - One rotary screw compressor for the AS system
- Maintain VIMS
- Collect soil samples from Loess when Fluvial Sands SVE system COC mass removal is asymptotic to evaluate whether exceedances persist and address as necessary

Optimization 3 Benefits

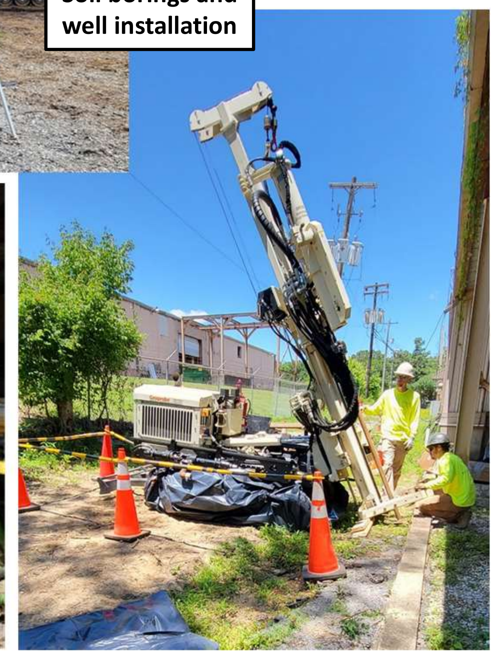
- Simplifies remedial strategy, reduces life cycle costs, and reduces time to achieve remedial goals
- Consistent with the RD, but focuses treatment on areas with most contaminant mass
- Further optimizes the remediation systems
- **Conclusion from EPA**
  - Install vertical AS wells with steel casing (instead of HDD AS wells)
  - Otherwise, implement remedy per Optimization 3

Remedy Implementation

Soil borings and well installation

Soil excavation

Conveyance piping installation



Remedy Implementation


Remediation trailers


Granular activated carbon vessels


Remediation compound and AS/SVE wells

Remedy Implementation Optimization

- Conducted vacuum radius of influence (ROI) versus vapor extraction rate assessment during SVE system start-up to optimize initial operation
  - Vacuum ROI was 40 feet at 20-30 cubic feet per minute (cfm) per SVE well and 90 feet at 50 cfm per SVE well; larger ROI than expected during the design
  - Began steady state operation at 20-30 cfm at 40 to 80 inches of water per SVE well based on results
- Conducted ROI versus air injection rate assessment during AS system start-up to optimize initial operation
  - Began steady state operation at 3 cfm at 4 to 5 pounds per square inch based on results
- Initial COC mass recovery rate = 0.5 to 1 pound per day
  - Supports pivot away from thermal treatment
- Used SVE well-specific PID readings and air extraction rates to identify where COC removal was greatest and focused operation at most productive SVE wells
- Operation ongoing

Remedy Optimization Summary

	Optimization 1 – Major Technology Modification	Optimization 2 – Refine Target Treatment Area and Remedial Design	Optimization 3 – Simplify Remedial Approach
Key Component	Proposed ERH in Loess and HDD AS wells	Soil investigation, revised heating strategy, and optimized remediation equipment	Eliminated Loess remediation; focused SVE/AS on Fluvial Sands based on updated CSM
Benefit	Greater treatment certainty	Smaller Loess treatment zone, improved constructability, and more efficient heat transfer	Treatment aligned with contaminant mass distribution
Cost and Schedule Impact	Approximately $3M capital cost increase with minimum 2-year reduction in treatment duration	Approximately $100K cost savings and accelerated construction schedule	Lower lifecycle costs and shorter time to achieve RAOs
Outcome	EPA did not approve; select concepts retained	EPA approved soil investigation	EPA approved (with vertical AS wells)

Overall Result

Data-driven optimization avoided unnecessary thermal treatment, reduced capital and costs, and expected to shorten the remediation timeframe while maintaining RAO compliance

Thank you!

Mike Perlmutter, PE

mike.perlmutter@jacobs.com