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# Investigation, Design, Construction, and Optimization of a Large-Scale Combined In Situ Thermal Treatment and Enhanced Bioremediation Remedy

DCHWS Seminar, February 12, 2020

# Presenters


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*2020 Design and Construction Issues at Hazardous Waste Sites (DCHWS) Seminar*

# Agenda

1. Site Background
2. Remedial Investigation (RI), Feasibility Study (FS), and Record of Decision (ROD)
3. Pre-Design Field Investigation (PDFI), Pilot Studies, and Preliminary Remedial Design (RD)
4. Value Engineering (VE)
5. Remedial Action (RA) Implementation and Optimization
   - Vapor intrusion (VI) mitigation systems (VIMS)
   - In situ thermal treatment (ISTT)
   - Enhanced reductive dechlorination (ERD)
6. Long-Term Response Action (LTRA)
7. Planned Transition from Federal to State Oversight

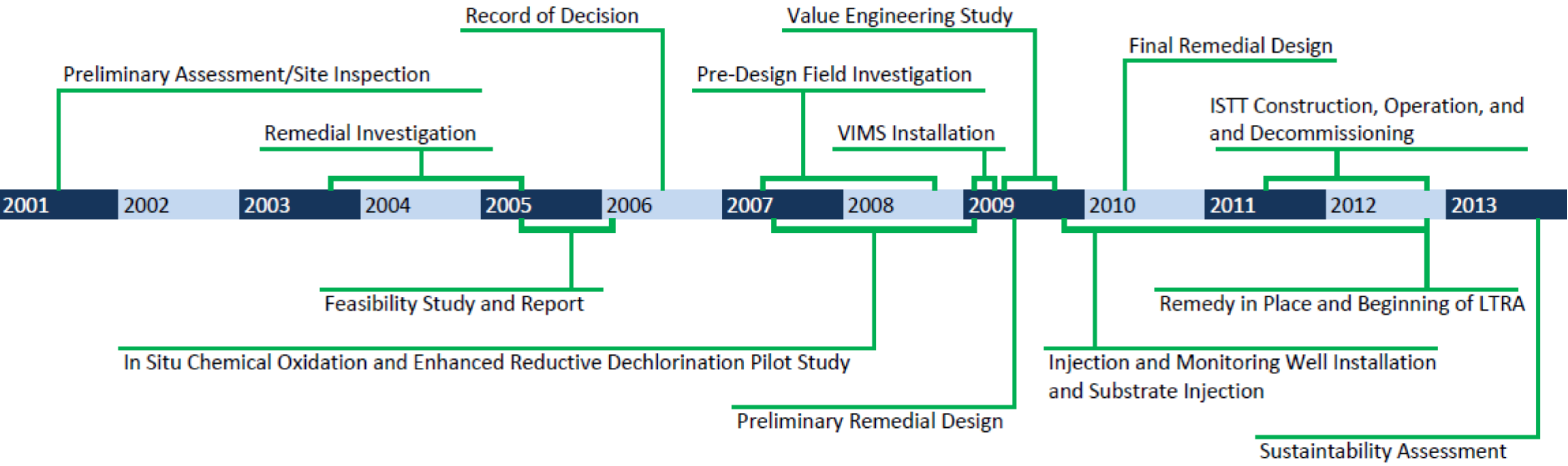
# Site Background

# Site Location


# Site History


- Located in a mixed commercial and residential neighborhood
- In late 1990s, site was identified when chlorinated volatile organic compounds (CVOCs) were found to be commingled with petroleum hydrocarbon plume at gasoline station
- 20-acre and 100-foot-deep CVOC plume
  - Primarily tetrachloroethene (PCE) and trichloroethene (TCE) at concentrations greater than maximum contaminant levels (MCLs)
- Associated with historical dry cleaning operations at the active Holiday Cleaners (since 1969)
- Listed on National Priorities List (NPL) on July 22, 2004
- U.S. Environmental Protection Agency (EPA) committed to achieving Construction Complete milestone by end of FY 2012

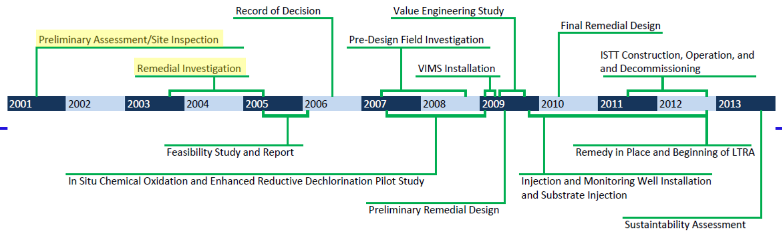
# Site History: Key Milestones from Project Inception to LTRA



# Remedial Investigation (RI), Feasibility Study (FS), and Record of Decision (ROD)

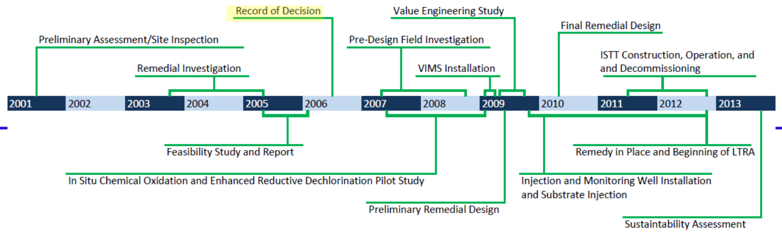
# RI

- 2001 – Preliminary Assessment/Site Inspection (New Mexico Environment Department [NMED] Groundwater Quality Bureau – Superfund Oversight Section)
  - Investigated CVOCs in wells associated with nearby leaking UST investigations
- To meet aggressive schedule, abbreviated RI performed from October 2003 through April 2005; collected soil, soil vapor, and groundwater to:
  - Evaluate nature and extent of CVOCs in soil and groundwater
  - Assess VI risk to accelerate mitigation
  - Begin remedy evaluation process
- Baseline Human Health Risk Assessment (HHRA) completed by EPA; Ecological Risk Assessment (ERA) not required



# FS and ROD

- FS – January 2006
- ROD – June 2006
  - Met critical EPA milestone to have ROD completed in FY 2006
  - Flexible “cafeteria style” ROD included multiple viable technologies to account for uncertainties once the site was fully characterized during the PDFI
  - Lauded by EPA for its flexibility to select from these multiple viable technologies
  - All work performed under one operable unit – OU-1 – but included early deployment of residential VIMS to disconnect this completed pathway



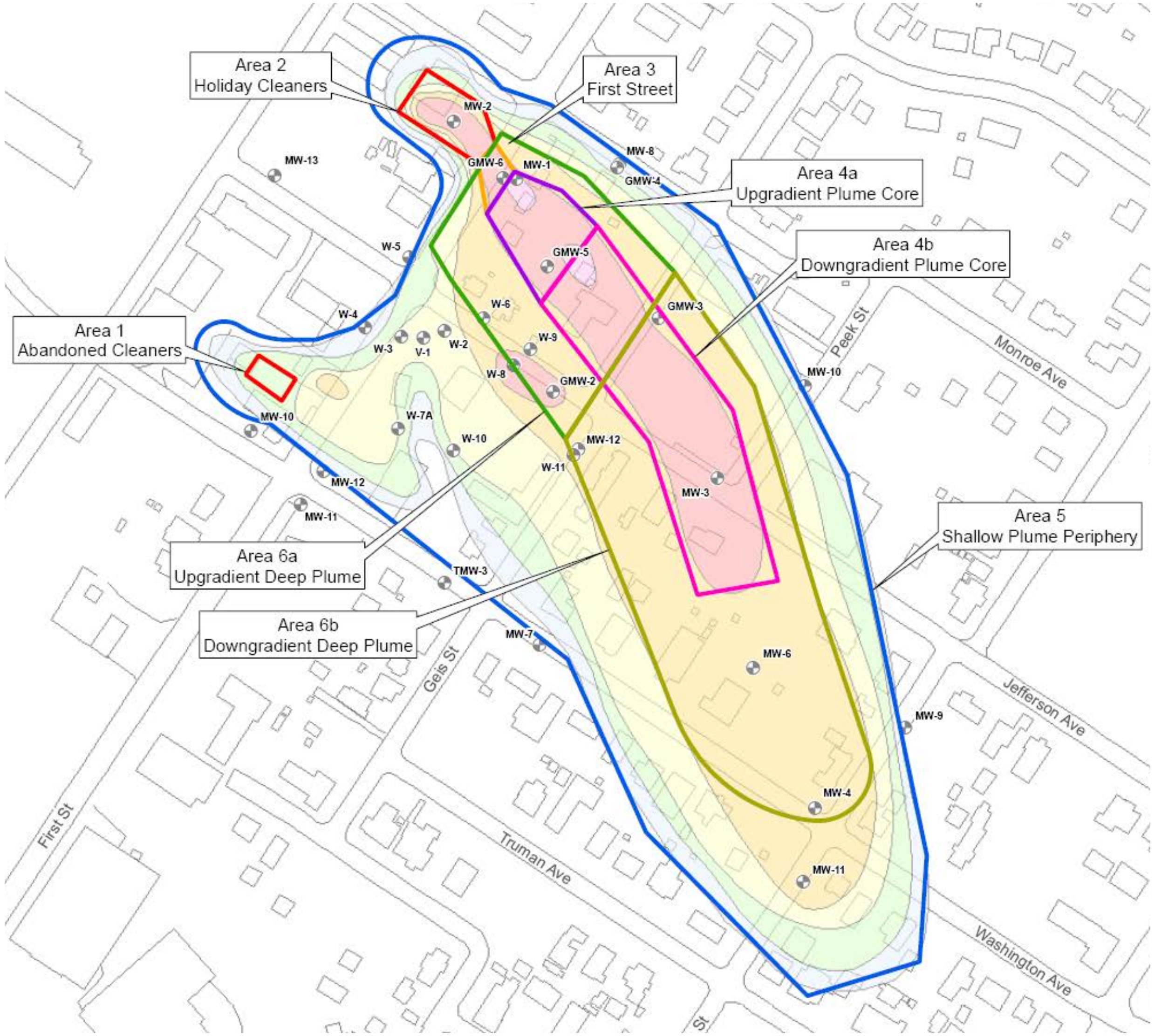
# FS and ROD

Table 19
Cost Summary for Remedial Alternatives

| Remedial Action Component | | | | | | Preferred Remedy Cost |
|---|---|---|---|---|---|---|
| | Alternative Option | | | | | |
| | No Action | Vapor Mitigation System | | | | |
| Indoor Air | $0 | $ 381,661.00 | | | | $ 381,661.00 |
| | Alternative Option | | | | | |
| | No Action | Thermal Treatment | ISCO w/ Follow-On ERD | ERD (Gridded) | | |
| Source Area Treatment | $0 | $ 8,018,000.00 | $ 9,436,000.00 | $ 8,446,000.00 | | $ 8,018,000.00 |
| | Alternative Option | | | | | |
| | No Action | ZVI PRB - Multiple Transects | ISCO w/ Follow-On ERD | ERD (Bio Barriers) | Pump and Treat (1) | |
| Shallow Plume Core & Hot Spot | $0 | $ 5,774,000.00 | $ 6,731,000.00 | $ 1,876,000.00 | $ 13,509,000.00 | $ 6,731,000.00 |
| | Alternative Option | | | | | |
| | No Action | Monitored Natural Attenuation | ZVI PRB - Multiple Transects | ERD (Bio Barriers) | Pump and Treat (1) | |
| Shallow Plume Periphery | $0 | $ 1,901,000.00 | $ 13,926,000.00 | $ 3,273,000.00 | $ 13,918,000.00 | $ 3,273,000.00 |
| | Alternative Option | | | | | |
| | No Action | Monitored Natural Attenuation | ZVI PRB w/ Deep ERD | ERD (Bio Barriers) | Pump and Treat (1) | |
| Deeper Ground Water | $0 | $ 2,037,000.00 | $ 27,732,000.00 | $ 7,222,000.00 | $ 13,799,000.00 | $ 7,222,000.00 |
| | | | | | ***Subtotal of Preferred Alternatives Options*** | $ 25,625,661.00 |
| Project Management | | | | | $ 589,730.00 | |
| Project Planning Documents (Work Plan, Field Sampling Plan, Quality Assurance Project Plan, Health and Safety Plan) | | | | | $ 138,668.00 | |
| Preliminary Design Field Investigation | | | | | $ 1,230,019.00 | |
| Ground Water Sampling Program | | | | | $ 1,383,910.00 | |
| 5-Year Reviews | | | | | $ 240,000.00 | |
| | | | | | ***Subtotal of Required Components*** | $ 3,582,327.00 |
| | | | | | **Total Remedial Action Cost** | $ 29,207,988.00 |

# ROD – Remedial Alternative

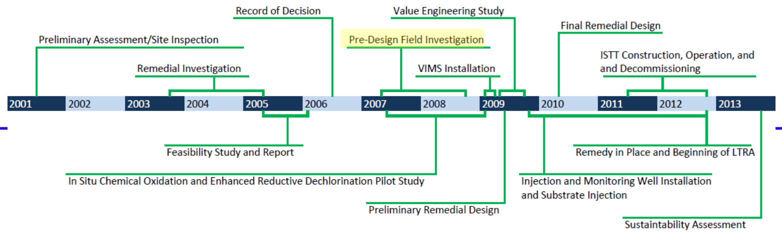
| Area | Approach |
|---|---|
| 1 | ISTT |
| 2 | ISTT |
| 3 | ISTT and in situ chemical oxidation (ISCO) |
| 4a | ISCO |
| 4b | ISCO with follow-on ERD |
| 5 | ERD |
| 6a | ERD |
| 6b | ERD |
| All | VIMS at residences within plume footprint |



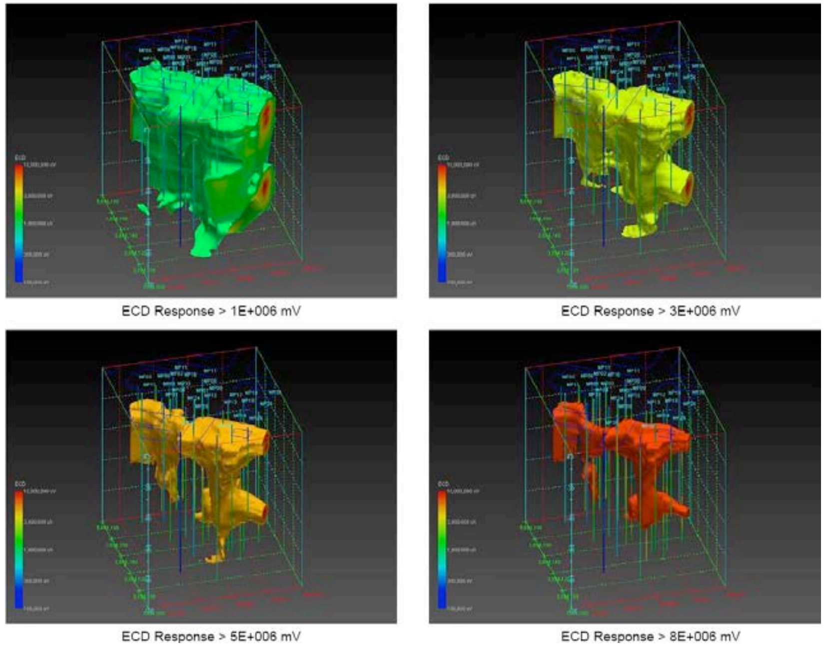
# Pre-Design Field Investigation (PDFI), Pilot Studies, and Preliminary Remedial Design (RD)

# PDFI Objectives and Activities

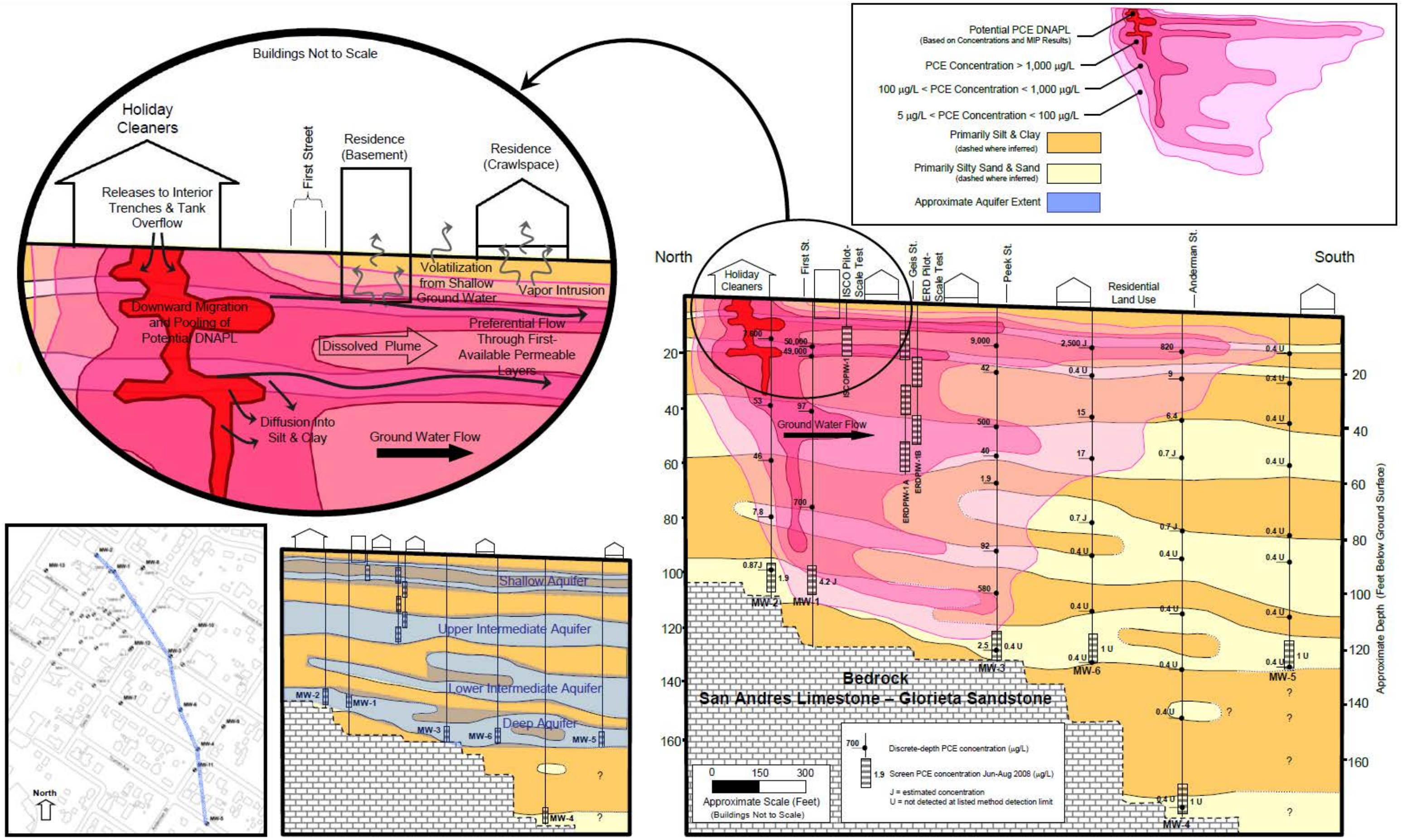
- Key objectives
  - Address site characterization uncertainties that remained following the limited RI investigation
  - Verify/revise the approaches selected in the ROD
- Key activities
  - PDFI – May 2007 to September 2008
    - Groundwater monitoring, soil sampling, a detailed subsurface investigation at two identified source areas, and aquifer testing
    - Additional groundwater sampling and lithologic investigation to map out the previously identified preferential flow pathways
  - Treatability Study – June 2007 to January 2009
    - ISCO
    - ERD



# PDFI Findings - Conceptual Site Model

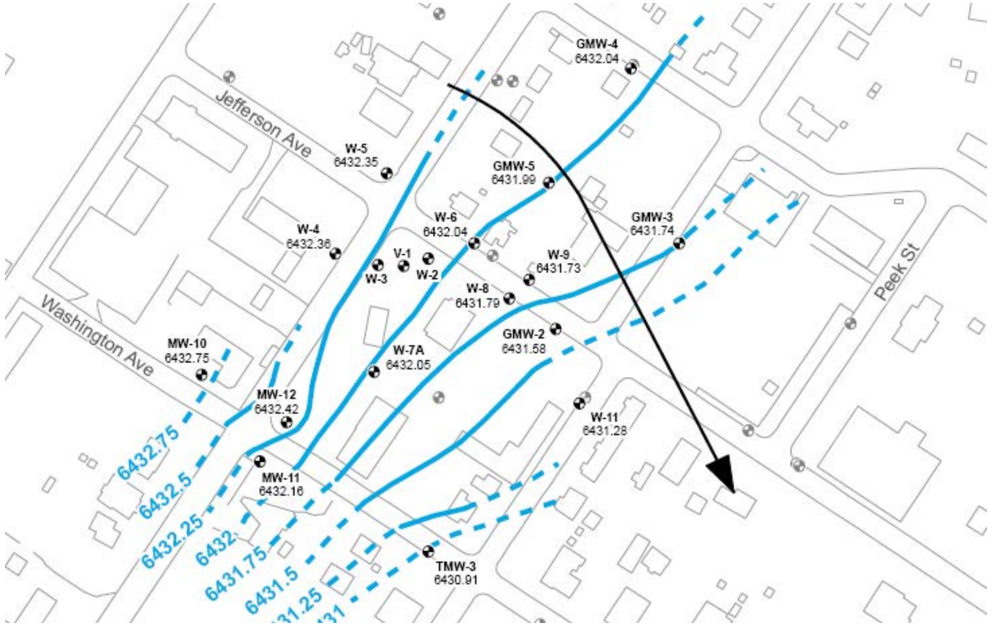


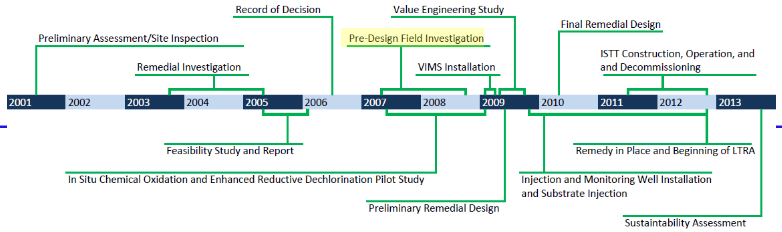

**Membrane interface probe (MIP) output**



# PDFI Findings - Hydrogeology and Site Geochemistry

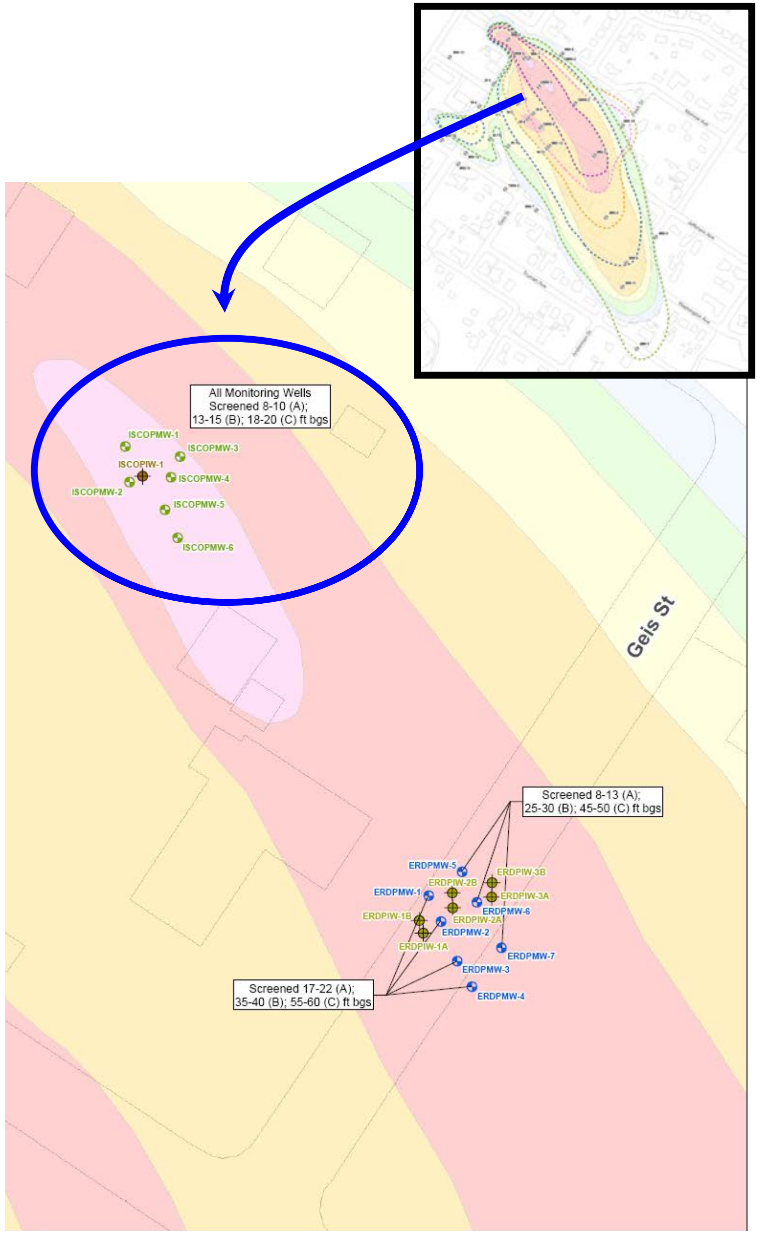
- Site characteristics that influenced remedy selection and design
  - Shallow groundwater
  - Downward vertical gradient
  - Vertical interval-specific velocity that generally decreased with depth
  - Mildly anaerobic geochemical environment
  - Average sulfate concentrations > 1,000 mg/L
  - Elevated dissolved solids (4,000 to 5,000 mg/L) and iron (5 to 20 mg/L)
  - Evidence of reductive dechlorination where the petroleum plume and CVOC plume co-mingled



# ISCO Treatability Study

- Objective
  - Implementability and effectiveness of the proposed ISCO
- ISCO bench-scale test
  - Soil oxidant demand (SOD) analysis
- ISCO pilot-scale test
  - Potassium permanganate (KMnO4) injection at 35 g/L (3.5% solution)
  - 6,526 gallons injected within a single injection well screened from 8 to 20 feet bgs
  - Six monitoring well clusters to assess distribution/ROI, KMnO4 persistence, and CVOC concentration changes over time

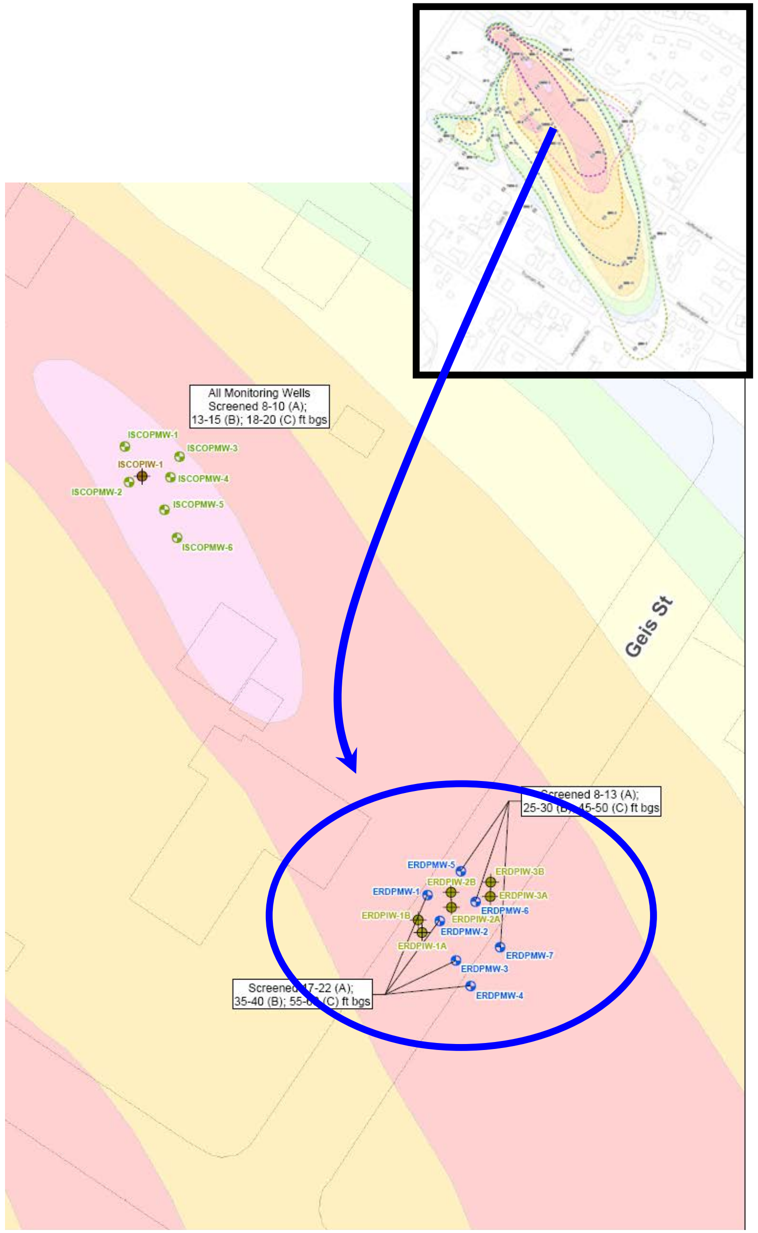


# ISCO Treatability Study – Results

- Injection flow rates – up to 12 gallons per minute (gpm)
- Injection radius of influence (ROI) – 12 feet
- Oxidant persistence – 3 months with limited effectiveness up to 6 months
- Limited volatile organic compound (VOC) destruction
- Limited ORP increase
- Path forward
  - ISCO still considered viable; however…
    - Permanganate concentrations and injection frequency were further evaluated during RD
    - Alternative oxidants (e.g., persulfate) were also considered
    - Two wells screens recommended to address key shallow intervals

# ERD Treatability Study

- Objective
  - Implementability and effectiveness of the proposed ERD
- ERD pilot-scale test
  - 45,000 gallons of 2 percent emulsified vegetable oil (EVO) solution (7,560 pounds of EVO) were injected into the three injection well nests to address the target treatment interval from 10 to 60 feet bgs
  - Seven monitoring well clusters to assess distribution/ROI, TOC persistence, and CVOC concentration changes over time
  - First-order decay rates



# ERD Treatability Study – Results

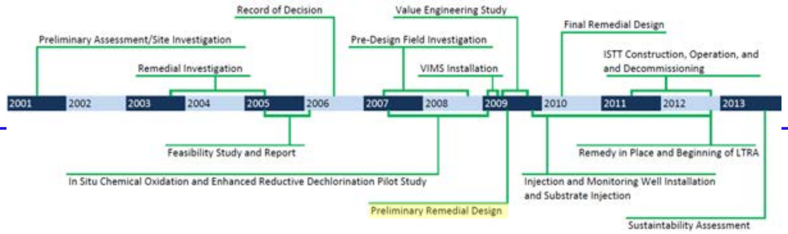
- Injection flow rates – up to 15 gpm (average: 10 gpm)
- Injection ROI – 12 feet
- TOC persistence – adequately reducing conditions
  - Less than -200 millivolts (mV) 24 months post-injection
- Classic ERD VOC destruction patterns
  - Nearly 100% PCE degradation
  - Cis-1,2-dichloroethene (cis-1,2-DCE) and vinyl chloride (VC) production (good molar balance)
  - Microbiology testing results were positive (e.g., *Dehalococcoides* [DHC] concentrations increased by 2 to 4 orders of magnitude)
- *Path forward*
  - ERD considered very effective
  - Two wells screens recommended to address key shallow intervals

# Preliminary RD

- Using the PDFI and Treatability Study results, a preliminary RD was developed for the remedies in the ROD

| Remedy | Area | Present Value Cost |
|---|---|---|
| Soil Vapor Extraction (SVE) | Abandoned Cleaners | $200,000 |
| In Situ Thermal Treatment (ISTT) | Holiday Cleaners | $6,100,000 |
| Monitoring and Injection Well Installation | All | $6,400,000 |
| In Situ Chemical Oxidation (ISCO) applications | Shallow Plume Core | $3,000,000 |
| Enhanced Reductive Dechlorination (ERD) applications | Shallow Plume Core and Plume | $14,700,000 |
| | | **$30,400,000** |

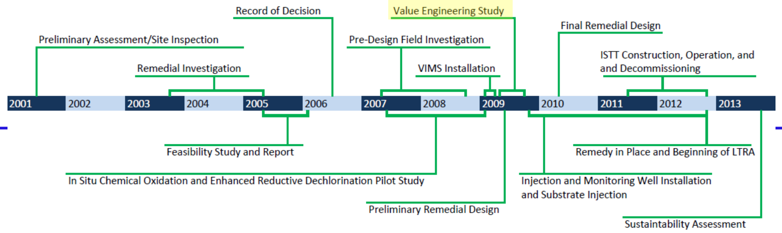
- EPA requested a Value Engineering (VE) Study be conducted to “optimize” the remedy before completing the RD process



# Value Engineering (VE) Study

# VE Study

- Initially developed at General Electric during WWII
- Systematic problem-solving technique involving a thorough analysis of project functions using team dynamics to creatively consider design options
- Public and private organizations often employ VE studies to reduce costs and/or maximize functionality of major construction projects
- Widely used in areas such as defense, transportation, construction, and healthcare, and also on environmental remediation projects



# VE Study Objective

- Value improvement to enhance the project and improve the potential for reducing both the initial cost and the future cost of remediation

$$V = F/C$$

- Facilitate and provide the structure for the process of making informed design decisions
- Identify design concepts that are more cost-effective than the original proposal

# VE Study Participants

- **Full-Time VE Team Members**
  - Certified Value Specialist, VE Team Leader
  - Hydrogeology and ISCO Expert
  - Thermal Remediation Expert
  - ERD Expert
  - Independent Design Review Team Member
- **Agency Representatives**
  - Remedial Project Manager, EPA Region 6
  - Design Review Representative, EPA Headquarters
  - Superfund Oversight Section Program Manager, NMED
  - Superfund Oversight Section Project Manager, NMED
- **Design Team Members**
  - Project Manager
  - Lead Engineer
  - Project Hydrogeologist

# VE Study Methodology

- Information Phase
- Creative Phase
- Analysis Phase
- Development Phase
- Presentation

# Analysis Phase - Passing Ideas

- ⬇ Consider alternative carbon substrate (as compared to the specified EVO)
- ⬇ Soil excavation, monitored natural attenuation (MNA), or ERD via substrate infiltration at Abandoned Cleaners (instead of SVE)
- ⬆ Remove and replace the sewer lateral from Holiday Cleaners
- ⬇ Relocate Holiday Cleaners to a nearby location and demolish the existing structure, in lieu of keeping the Holiday Cleaners open during site remediation under the structure
- ⬇ ISTT for soil from 0 to 40 feet bgs and ERD below
- ⬆ Replace ISTT with ISCO/ERD
- ⬆ Replace ISTT with ERD
- ⬆ Soil excavation instead of ISTT along First Street

⬇ Cost savings ⬆ Cost increase

# Analysis Phase - Passing Ideas (continued)

- ⬇ Use DPT delivery instead of permanent injection wells
- ⬆ Install horizontal instead of vertical injection wells for the shallow plume
- ⬇ Construct one-pass trenches instead of vertical injection wells for the shallow plume
- ⬇ Construct one-pass trenches with active reagent recirculation instead of vertical injection wells for the shallow plume
- ⬆ Expand ISTT system into the shallow plume core; reduce ISCO and ERD areas
- ⬆ Air sparging (AS)/SVE instead of ERD
- ⬇ Implement MNA for portions of the shallow plume periphery
- ⬇ Implement MNA for portions of the deep plume

⬇ Cost savings ⬆ Cost increase

# Analysis Phase - Failing Ideas

- Soil mixing using ISCO or ERD amendments
- Consider alternate remediation through open excavation, AS, soil mixture with zero valent iron (ZVI), surfactant flushing, injection or ZVI
- Sheet pile or slurry wall for physical containment
- Excavation and creation of a stormwater retention pond at Holiday Cleaners
- ISTT in parking lot of Holiday Cleaners, but not underneath building
- Relocate Holiday Cleaners to former Knights of Columbus Hall (“down the street”)
- Solar-powered bioreactors
- Plant trees at the Abandoned Cleaners site for phytoremediation
- Purchase or relocate occupied houses over plume (implement long-term institutional controls)
- AS/SVE in shallow plume core
- Pump and treat groundwater

# Analysis Phase – Ratings

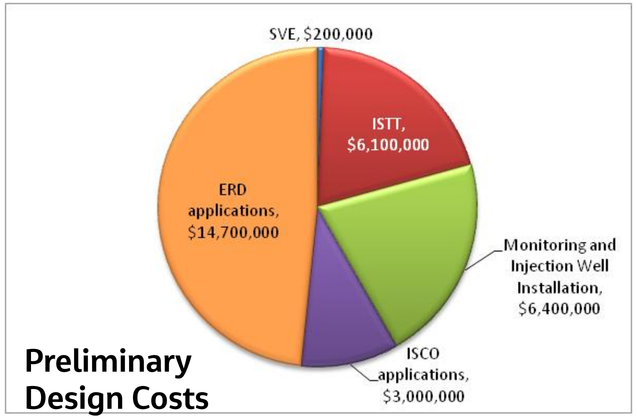
- **Multiple categories**
  - Community
  - Cost
  - Implementability
  - Safety
  - Treatment effectiveness
  - Sustainability
  - Utilities
- **Category weighting factor**
  - Ranges from 1% (utilities) to 49% (treatment effectiveness)
- **Scoring**
  - Priorities and weighting factors selected by the client
    - High (9)
    - Medium (6)
    - Low (3)
  - Scores selected by the team
    - Fully meets (3)
    - Good (2)
    - Acceptable(1)
    - Does not meet (0)

# Development and Presentation Phases

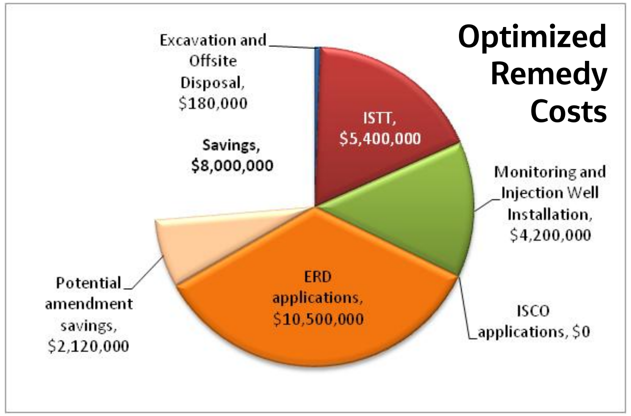
- Economic analysis of proposals to develop initial VE cost estimates
- Detailed technical and economic examination
- Seven of the proposals had the potential to be accepted in conjunction with one another for a maximum potential life-cycle cost saving of $19,500,000
  - About 60 percent of the total life-cycle cost (LCC) estimated in the preliminary RD ($30 to $35 million)
- Total savings from the recommended proposals ranged from $8 to 12 million
  - About 25 to 30 percent of the total LCC

# EPA Endorsed Results

| Area | Description | LCC Savings ($) |
|---|---|---|
| Shallow and deep groundwater plumes | Use alternative carbon substrate(s). | Up to 2,120,000 |
| Abandoned Cleaners | Soil excavation and offsite disposal. | 30,000 |
| Holiday Cleaners | Remove and replace the existing sewer lateral. Excavation and offsite disposal of associated soil. | (110,000) |
| | Relocate and demolish building prior to implementation of thermal treatment. | 810,000 |
| | Reduce depth of thermal treatment and supplement with enhanced reductive dechlorination (ERD). | 340,000 |
| Shallow plume core | Expand thermal treatment to alley between First and Geis Streets. However, use gridded and transect ERD approach in lieu of ISCO with ERD transects. | (130,000) |
| | Use horizontal directionally drilled (HDD) injection wells to deliver carbon substrate underneath existing structures. Supplements vertical well approach. | (590,000) |
| Deep plume | Reduced the number of ERD transects and use MNA elsewhere. | 7,730,000 |
| | **Total** | **10,200,000** |




**Preliminary Design Costs**




**Optimized Remedy Costs**

***100 to 1 return on VE investment of $100,000***

# Pre- and Post-VE Study

| Area | Preliminary Design | VE Study Outcome | Implemented Remedy |
| --- | --- | --- | --- |
| Holiday Cleaners | ISTT from 0 to 80 ft bgs | ▪ ISTT from 0 to 40 ft bgs<br>▪ ERD from 40 to 80 ft bgs<br>▪ Relocate cleaners and demolish existing structure<br>▪ Excavate sewer line and impacted soil; dispose offsite | ▪ ISTT from 0 to 40 ft bgs<br>▪ ERD from 40 to 80 ft bgs |
| Abandoned Cleaners | SVE | ▪ Excavation with offsite disposal | ▪ Long-term monitoring (LTM) |
| Shallow Plume Core (to alley) (< 25 ft bgs) | ISCO with follow-on ERD using biobarriers | ▪ ISTT | **No change from VE** |
| Shallow Plume Core (from Alley) (< 25 ft bgs) | Same as above | ▪ ERD using grid-based application with vertical wells<br>▪ Consider HDD wells<br>▪ Consider alternative carbon substrates | ▪ ERD using grid-based application with vertical wells<br>▪ Consider alternative carbon substrates |
| Shallow Plume Periphery (< 25 ft bgs) | ERD using biobarriers | ▪ ERD using biobarriers | **No change from VE** |
| Deep Plume (> 25 ft bgs) | ERD using 7 biobarriers | ▪ ERD using 3 biobarrier with MNA | **No change from VE** |

# Remedial Action (RA) Implementation and Optimization

# VIMS Summary


- 24 individual systems installed at 15 residential structures
  - Directly above the groundwater plume where concentrations of TCE or PCE in groundwater exceeded 1,000 µg/L, *or*
  - Where indoor air concentrations due to vapor intrusion exceeded a 1 in 100,000 ($1x10^{-5}$) risk level
- Will operate until the groundwater remedy reduces CVOC concentrations such that VI is not occurring; may be getting close at some structures

# VIMS Installation

- Pre-design diagnostic testing, structure assessment, and system design
- System installation
  - Sub-slab depressurization
  - Crawl space submembrane depressurization
  - Crawl space venting
- Used local radon mitigation system installer

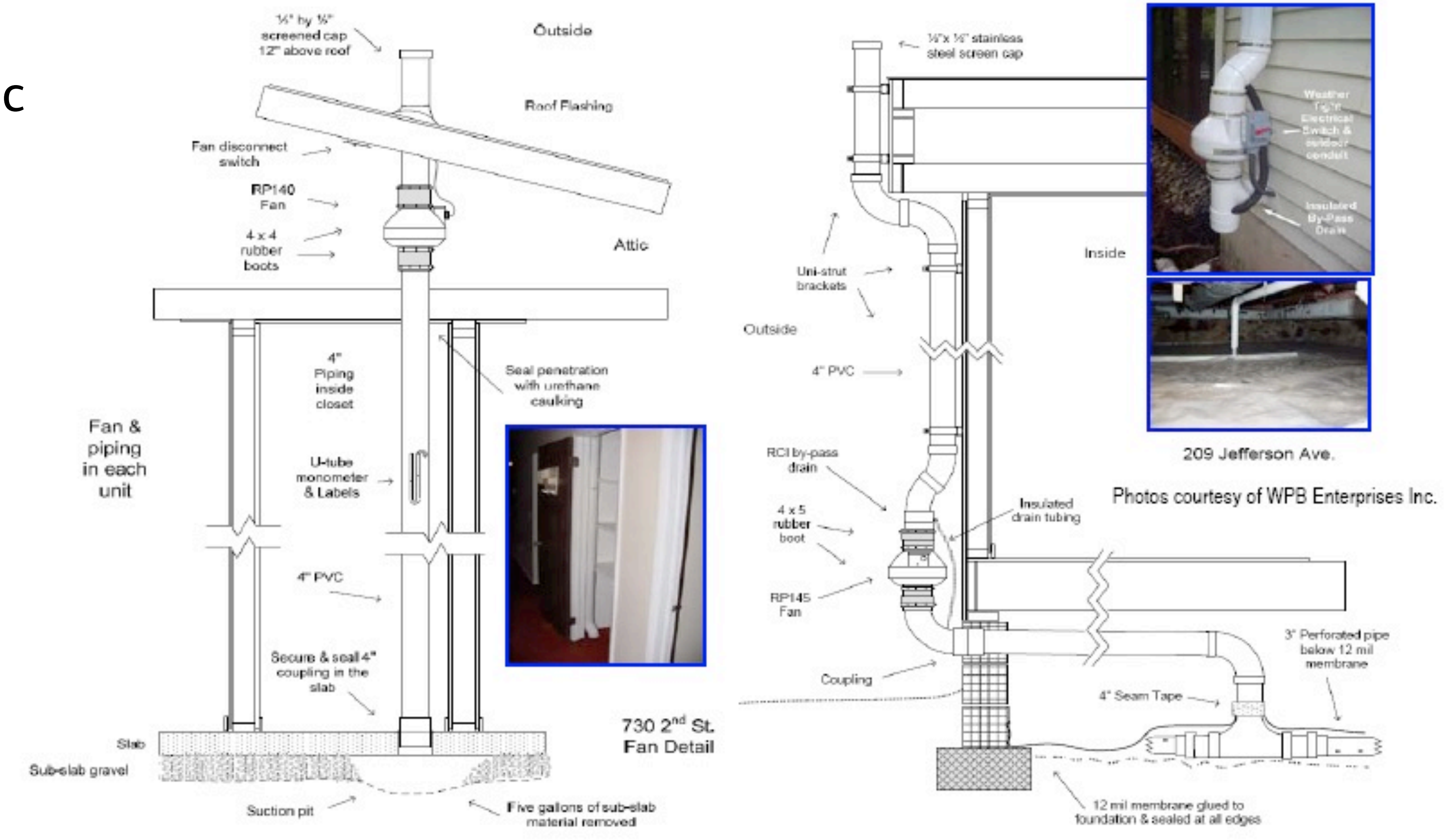


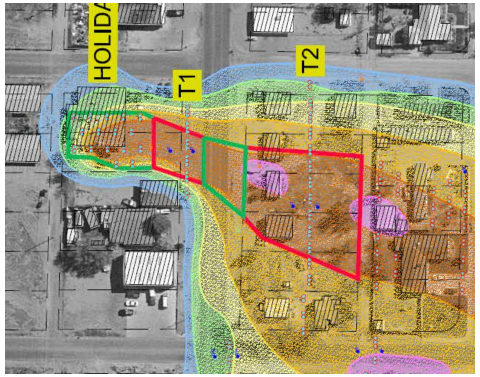

**Figure 2** Typical VIMS Installations: a) Sub-slab; b) crawlspace

# VIMS Challenges

- Operations and maintenance (O&M)
  - Resident keeps fan on and pays for electricity
  - Some owners would turn off fans to avoid paying for electricity to the fans
  - EPA addresses maintenance issues such as fan replacements
- Ambient air quality
- Re-entrainment of fan exhaust from nearby VIMS creates cross-contamination from close VIMS
- Subcontracting challenges – was hard to find qualified subcontractors, easier now but still not in all geographies
- *As remedy progresses – when can VIMS be removed from service?*

# ISTT Summary

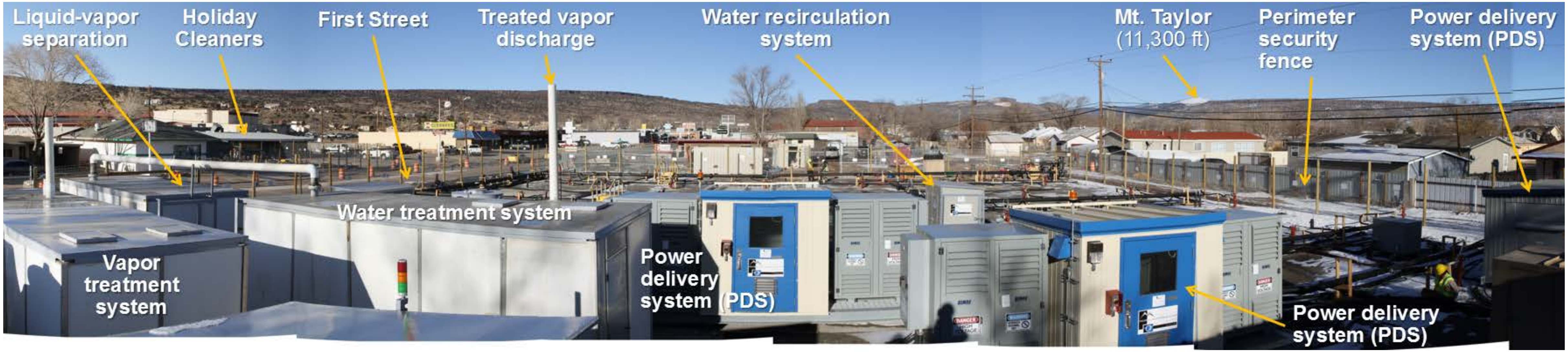
- Treated 0.75 acre to depths of 25 and 40 feet bgs at the Holiday Cleaners source area and the central plume core
- Treated 33,000 cubic yards (CY) of soil and 2,000,000 gallons of groundwater in about 9 months
- The dry cleaners and state roadway remained in service during construction and treatment





# ISTT Challenges

- Active dry cleaning business
- Adjacent structures
- Parking lots
- Active state roadway
- Buried utilities

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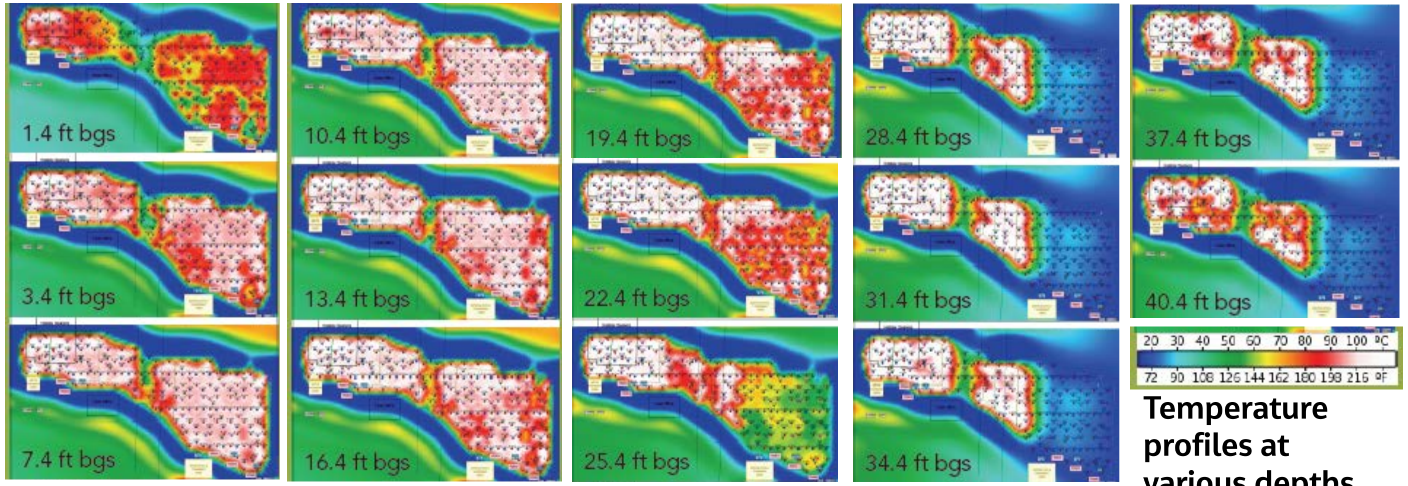


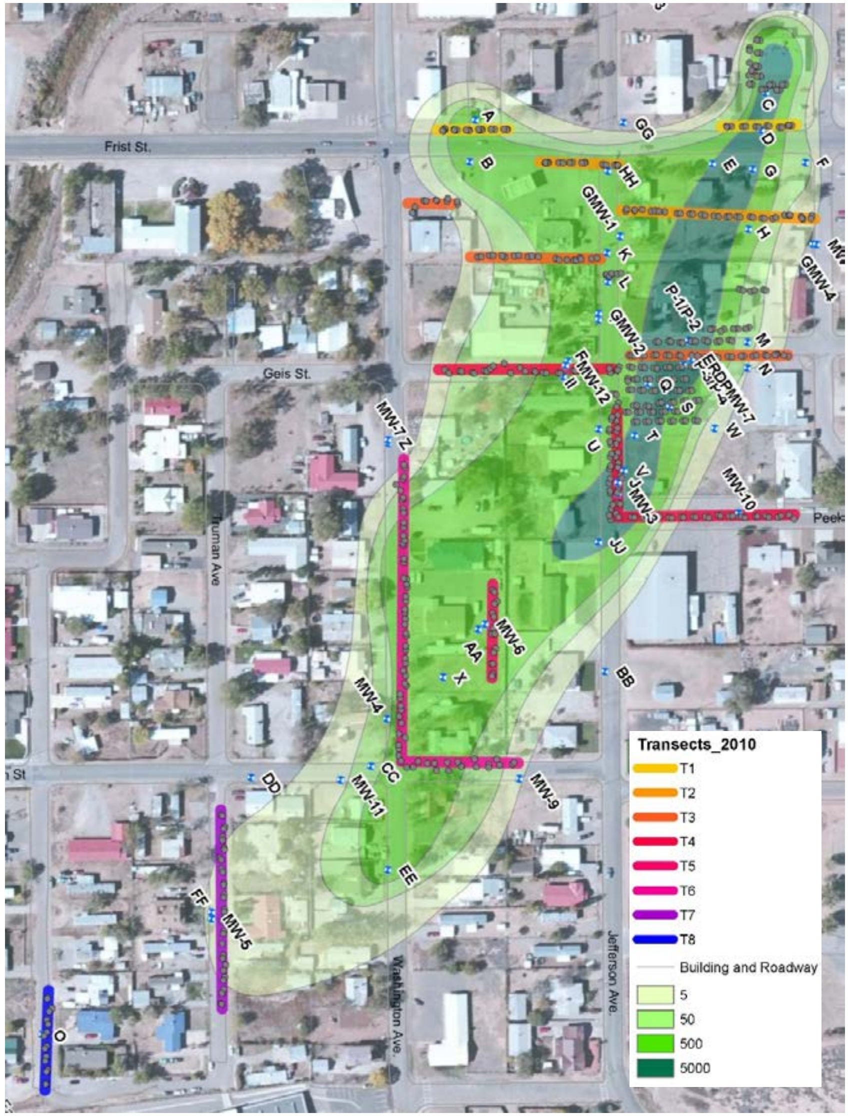

Temperature profiles at various depths

# ISTT Summary – System Shutdown Decision Logic

- RD included provisions to terminate operation before RGs were achieved (because ERD was available as a polishing step)
- Therefore, two performance goals were developed:
  1. Numerical standard
     - Soil RG based on confirmation sampling
  2. Diminishing returns
     - Cumulative energy balance
     - Subsurface temperature response
     - Contaminant mass flow rate
     - Overall system performance

# ERD Summary

- ERD using EVO
- Over 700 injection wells
  - Eight biobarrier transects
  - Gridded area in plume core
- Up to 150 gallons of 3% to 5% EVO solution injected per foot of well screen (during each injection event) using mobile injection equipment
- For the entire 2- to 3-month-long injection event:
  - Up to 750,000 gallons of injection solution
  - Up to 300,000 pounds of EVO
- Reinjection every 18 months with decreasing quantities of substrate solution as the plume collapses
- Up to 20 years of treatment planned in RD



# ERD Optimization during Remedy Implementation

| Element | | Benefit |
|---|---|---|
| 1 | Injection test | Evaluate various screen lengths, ROI, and reduce number of injection wells |
| 2 | Sampling of injection wells during full-scale installation | Refine biobarrier layout |
| 3 | Tracer test during full-scale injection | Confirm radius of injection influence |
| 4 | Use of multiple substrates during full-scale injection | Concurrent evaluation to identify best long-term substrate for site |
| 5 | Partial bioaugmentation during full-scale injection | Assess need for sitewide bioaugmentation |

# ERD Implementation – Challenges

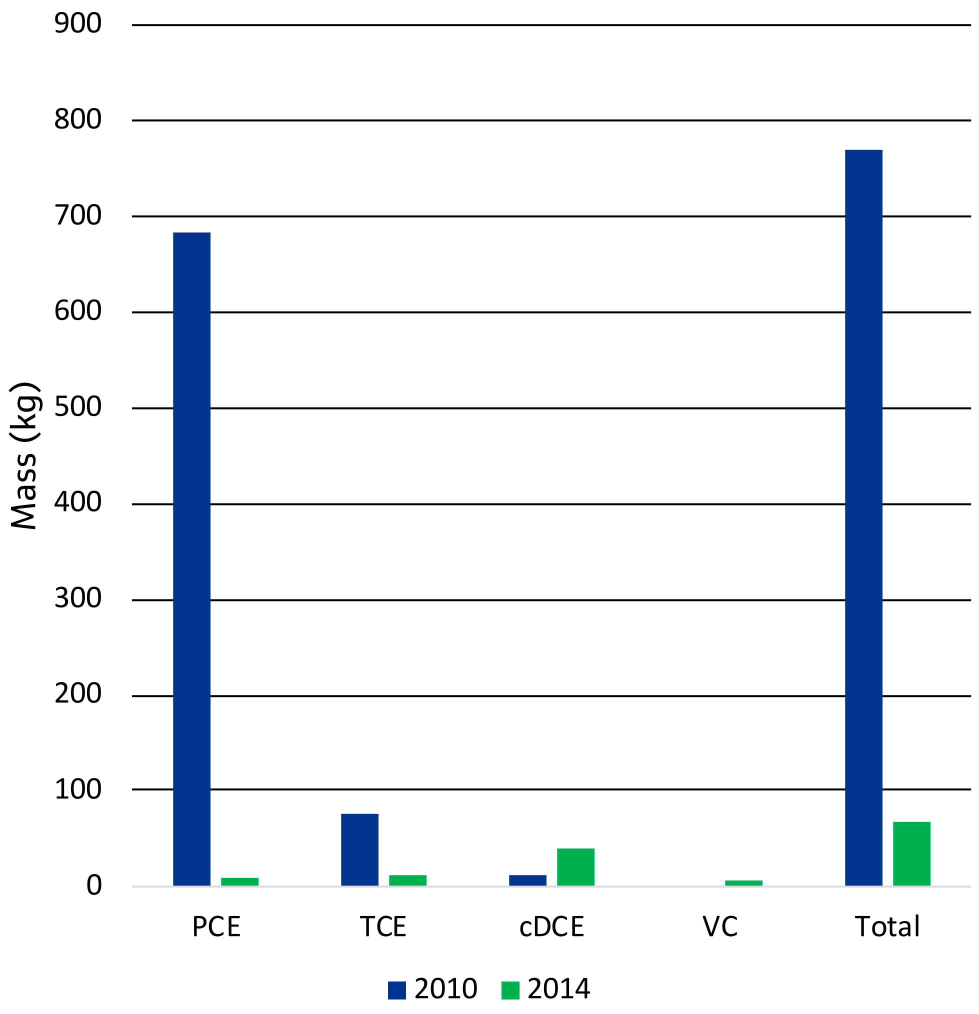
| Element | | Impact and/or Lesson Learned |
|---|---|---|
| 1 | 20-acre plume in active urban area | ▪ Restricted installation of remediation elements to public ROWs<br>▪ Required use of mobile injection units in lieu of more permanent infrastructure<br>▪ Required comprehensive traffic management plan during installation and implementation<br>▪ Inquisitive residents |
| 2 | Stratified lithology | ▪ Required the use of nested wells screens to target specific depth intervals |
| 3 | Compressed (and complex) schedule | ▪ First round of injections completed in four separate mobilizations to work around ISTT and access |
| 4 | Incremental funding | ▪ American Recovery and Reinvestment Act (ARRA) was a key component for accelerating the RA process |
| 5 | Injection of substrate underneath active dry cleaners to address residual source area | ▪ Required use of angled borings after completion of ISTT in shallower depth interval |

# ERD Implementation – Challenges (continued)

| Element | | Impact and/or Lesson Learned |
|---|---|---|
| 6 | Temperatures in high desert setting | • Winter injections necessitated heated storage of substrate and injection trailers and slowed field activities<br>• Mobile injection system had to be temporarily demobilized and stored everyday to avoid freeze-thaw damages |
| 7 | Biogas generation, accumulation, and migration | • Delayed completion of initial round of injections so that the risk could be assessed<br>• Required installation of nearly 50 shallow vapor monitoring points and development of risk management plan to address potential methane and/or hydrogen sulfide generation, migration, and accumulation |
| 8 | Sulfate concentrations up to 5,000 mg/L | • Potential hydrogen sulfide generation<br>• Interference in the reductive dechlorination process and inefficient substrate use<br>• *Benefit included formation of iron sulfides to support abiotic dechlorination* |

# Results through 2014

- Total CVOC mass reduced by more than 90% after approximately 5 years of RA
  - ISTT influence
    - 80% of the decrease
  - ERD influence
    - Dissolved-phase mass outside of the ISTT treatment area decreased by approximately 60% after two injection events
    - 70% of remaining CVOC mass was cis-1,2-DCE or VC
    - Though center of CVOC mass has shifted, the plume footprint remained relatively consistent



# Long-Term Response Action (LTRA)

# Optimization during LTRA

1. Sustainability Assessment
2. Comprehensive TOC Sampling Event
   - Confirm biobarrier longevity assumptions and optimize injection frequency
3. Supplemental Grab Sampling
   - Assess plume geometry data gaps
   - Evaluate contribution of abiotic degradation to VOC reductions
   - Adjust substrate quantities based on VOC results
4. Methane Inhibitor
   - Potential to reduce methane generation from ERD process and optimize substrate use
5. Evaluate Long-Term CVOC Data Trends
   - Reduce sampling frequency at select site monitoring wells
6. Well Redevelopment and New Monitoring Well Installation
7. VIMS O&M and Potential Closure Evaluation

# 1. Sustainability Assessment

- Completed after thermal treatment phase completed
- Use of emulsified vegetable oil has a high embedded water footprint and agricultural runoff impact (due to soybean growth) and potable water use (for delivery)
- Reduced the above environmental impacts and costs by 20% through optimization of EVO delivery volume and frequency

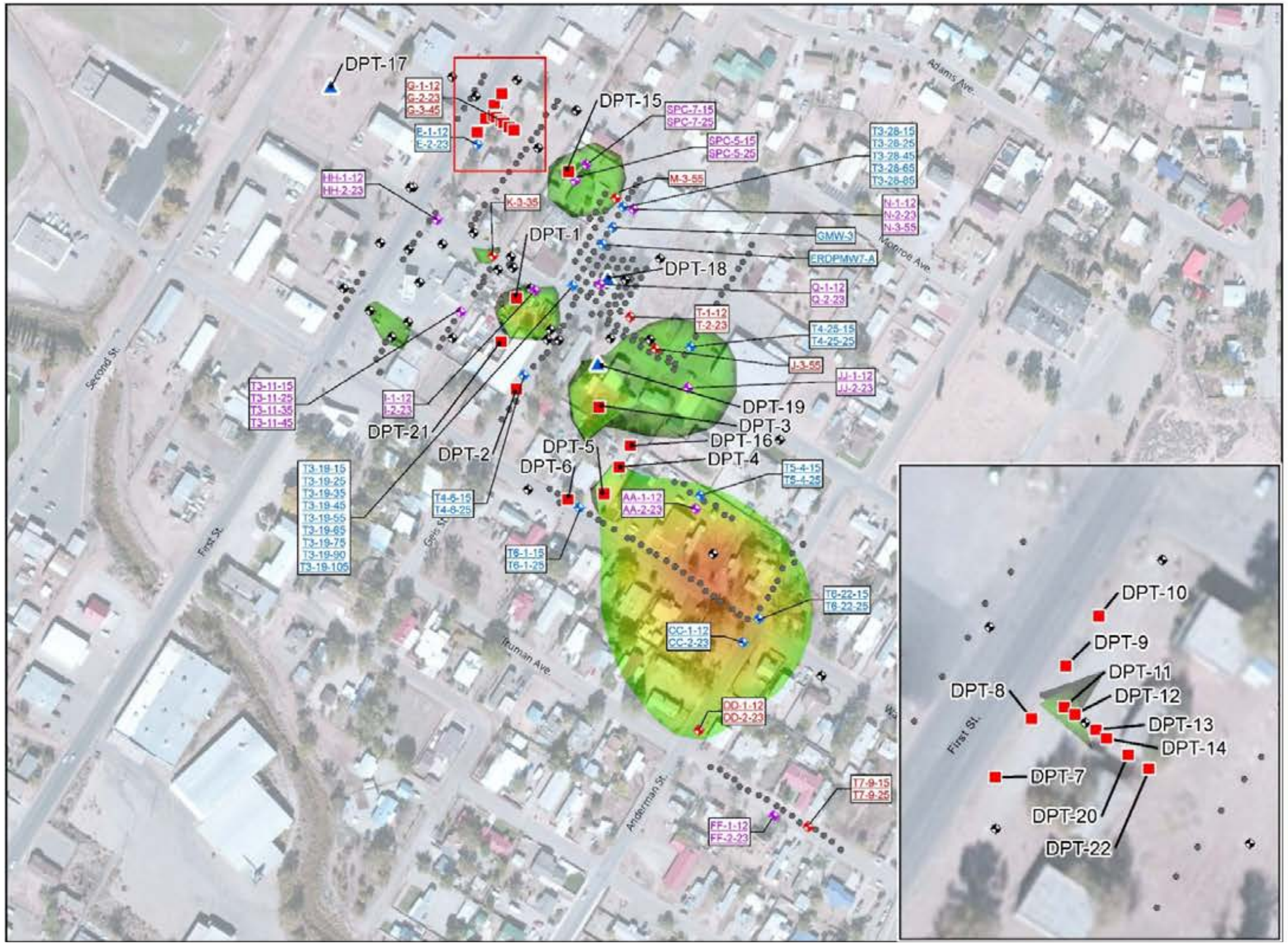
# 2. Comprehensive TOC Sampling Event

| Injection Year | Time Since Injection | TOC Geometric Mean (mg/L) | Number of Injection Wells Sampled in July 2016 |
|---|---|---|---|
| 2015 | 7 months | 570 | 22 |
| 2014 | 26 months | 40 | 8 |
| 2013 | 36+ months | 740 | 3 (all deep) |

- Findings
  - Comparison of 2014 and 2015 injection grouping indicates injection frequency should not exceed 24 months – 18 months is probably still optimal for sustaining peak reduction
  - The persistence of TOC within the deepest portion of injection transect T3 suggests less frequent injections
- 30 monitoring wells also sampled
  - Range = 3 to 130 mg/L; average = 15 mg/L
  - TOC concentrations in monitoring wells are generally adequate for sustaining reducing conditions downgradient of the biobarrier transects

# 3. Supplemental Grab Sampling

- 2016




LEGEND

- Grab groundwater locations
- Abiotic Soil Boring Locations

Monitoring Well Samples

- TOC only
- VOC only
- VOC and TOC
- Monitoring wells
- Injection wells

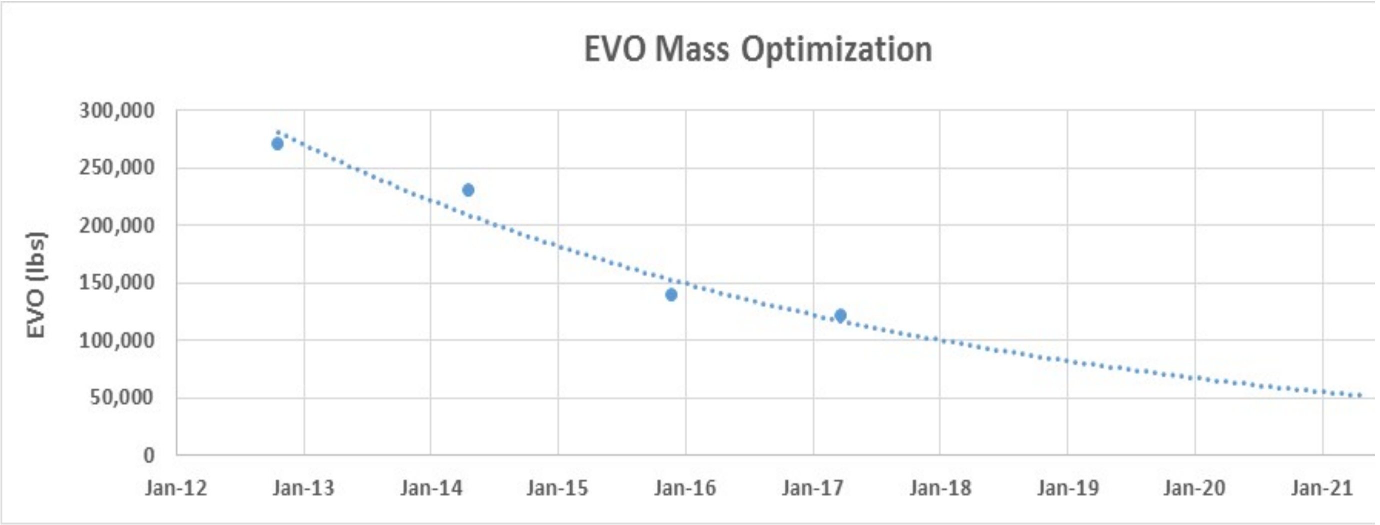
2016 Estimated PCE at Water Table (in µg/L)

- 50-100 µg/L
- 100 - 1000 µg/L
- >1000 µg/L

**Figure 3-2.**
**Remedial Optimization Groundwater Sampling Locations**
2016 Annual Long-Term Response Action Report
*Grants Chlorinated Solvents Plume Site*
*Grants, Cibola County, New Mexico*

# 3. Supplemental Grab Sampling – Injection Optimization

- Complemented permanent injection well network with DPT injections to address recalcitrant areas between transects and where the target substrate volume could not be delivered via injection wells due to well ineffectiveness and/or the local lithology
- Outcome
  - Reduced injections in deeper intervals and on plume periphery
  - Reduced injections in shallow plume core where relatively aggressive approach has resulted in plume collapse




*Substrate use was a key target of optimization due to its GSR influence. Therefore, finding ways to reducing it as efficiently as possible was a key project objective.*

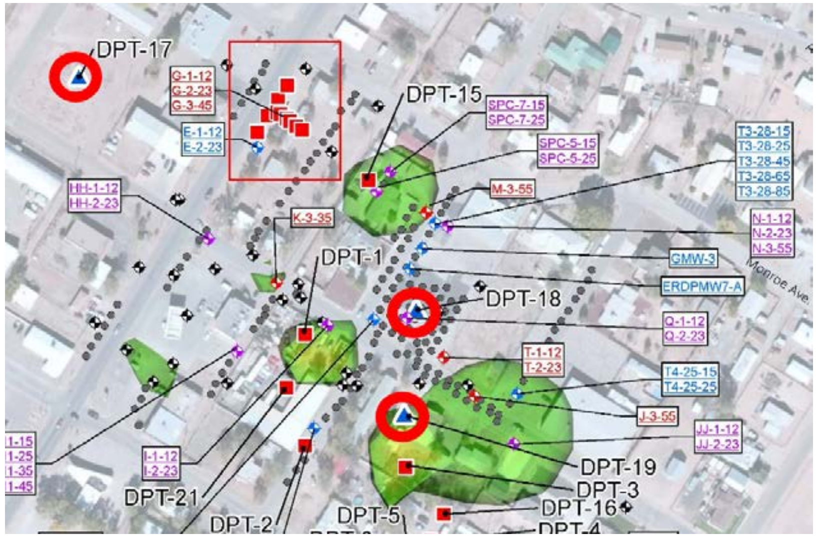
# ERD Optimization – DPT Injections


**Figure 1.**
**Proposed DPT Injection Locations**
*Grants Chlorinated Solvents Plume Site*
*Grants, Cibola County, New Mexico*

*Based on cis-1,2-DCE, which is the most extensive of the remaining CVOCs*

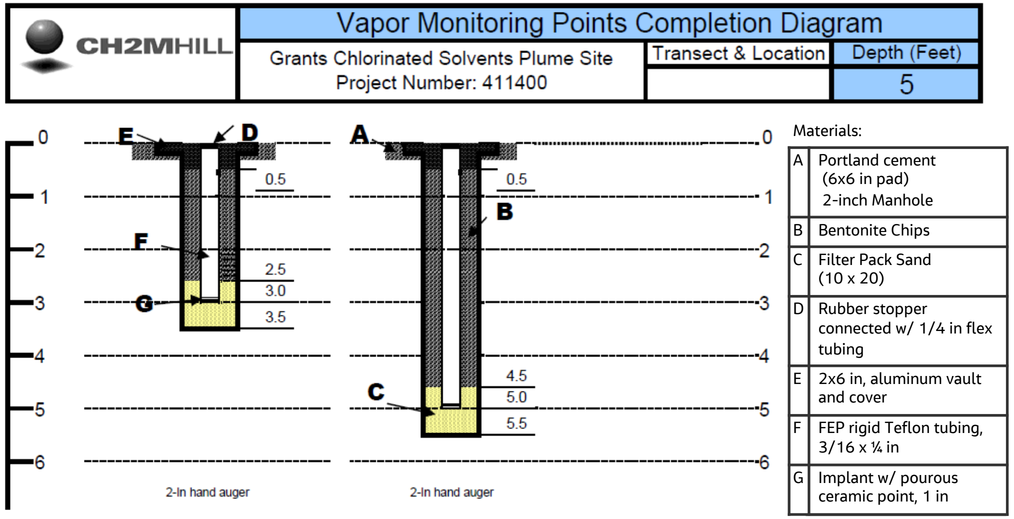
# 3. Supplemental Grab Sampling – Abiotic Degradation Assessment

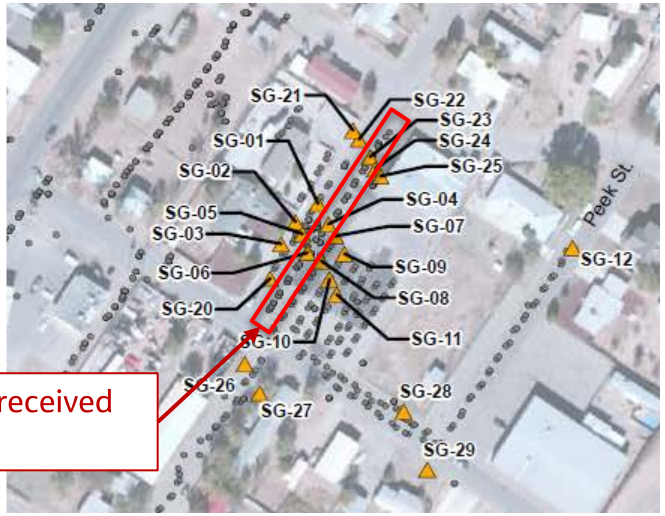
- Abiotic degradation can occur in reducing environments where sulfate concentrations are naturally high, leading to the formation of reactive iron and sulfur minerals
- Assessment approach
  - Soil samples collected via DPT upgradient of the site to establish background conditions and from two locations within the plume
  - Samples collected from 8 to 13, 18 to 23, and 40 to 45 feet bgs
  - Parameters
    - Magnetic susceptibility
    - Acid volatile sulfides
    - Total iron



# 4. Methane Inhibitor

- A commercially available methane inhibitor was added in a pilot test area at wells T3-19 through T3-32
  - Objective is to reduce methane generation and optimize substrate use
- Sampling program
  - Vapor monitoring point pairs (SG) screened from 2.5 to 3.5 and 4.5 to 5.5 feet bgs
  - Monitoring and injection wells
  - Water meter vaults and manholes



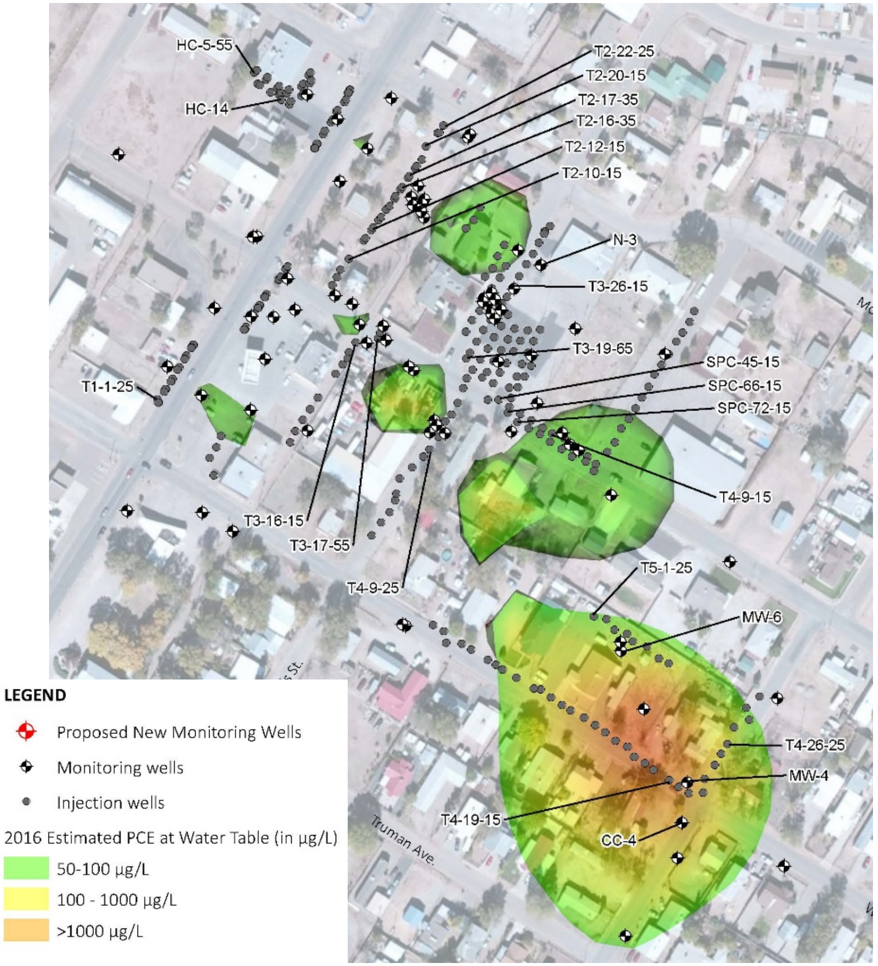

Injection wells that received methane inhibitor

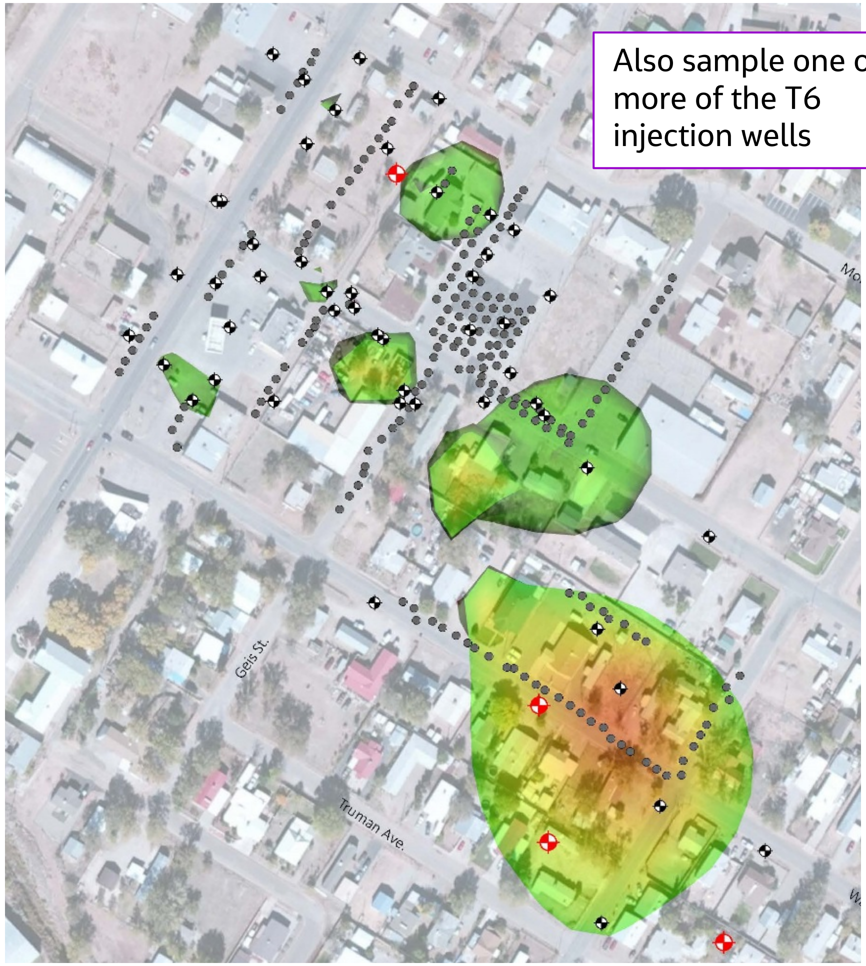
# 5. Evaluate Long-Term CVOC Data Trends

- 120 monitoring wells sampled annually
- VOC concentrations in 18 monitoring wells have been below detection limits since 2013
- VOC concentrations in 37 monitoring wells have been below MCLs since 2013
- Recommended to convert the 37 monitoring wells to a biennial sampling frequency

*By reducing site visits and staff level of effort, this achieved another sustainability benefit*

# 6. Well Redevelopment and New Monitoring Well Installation




Also sample one or more of the T6 injection wells

# 7. VIMS O&M and Potential Closure Evaluation

- Periodic O&M includes confirmation that mitigation fans are turned on and also that they are operating
- Replacement of mitigation fans with same or equivalent units
- Repair to piping, connectors, fittings, hangars, etc., as required
- Evaluation of groundwater plume and remedy progress to identify structures where VIMS can be considered for removal from service
- Recognizing in the evaluation that the dissolved groundwater plume has evolved via in situ biodegradation from a PCE plume to PCE and daughter products, including VC, and that the VIMS may now be required to stay in service due to VC impacts as the plume degradation continues
- Plan is to collect soil gas, subslab soil vapor, and indoor air samples to evaluate the current VI pathway at select structures where the groundwater concentrations have decreased as the remedy has progressed

# VIMS Evaluation – Are they Still Required at all Locations?


**LEGEND**

Vapor intrusion mitigation system locations

2018 Estimated DCE in shallow aquifer (in μg/L)

- 70-100 μg/L
- 100 - 1000 μg/L
- 1000 - 2000 μg/L
- >2000 μg/L

Notes:
DCE = cis-1,2-dichloroethene
μg/L = microgram per liter

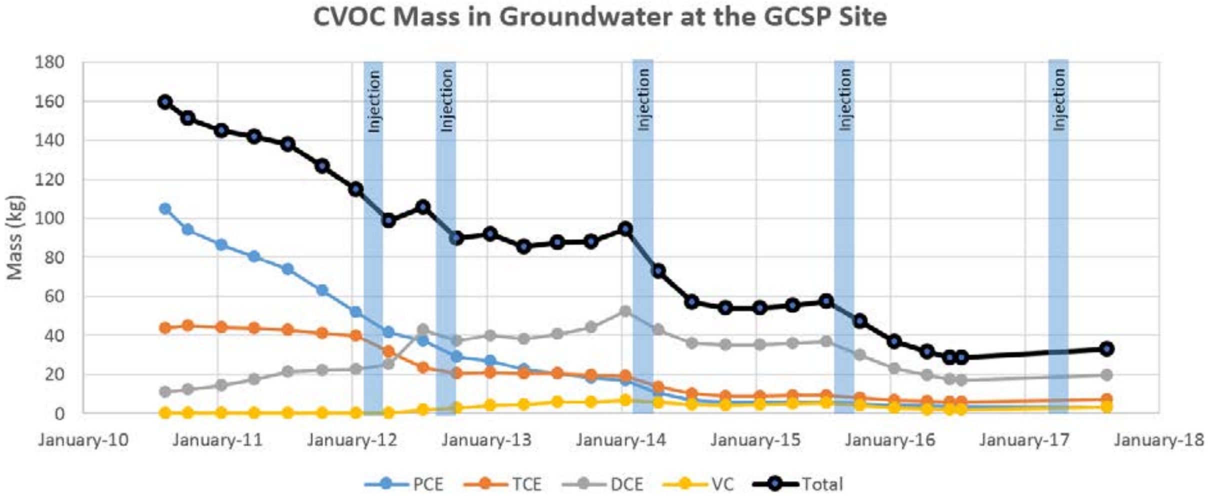
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, Center for Near Eastern Studies/Airbus Defence and Space, United States Department of Agriculture, United States Geological Survey, AeroGRID, Institut Geographique National, and the Geographical Information Systems user community

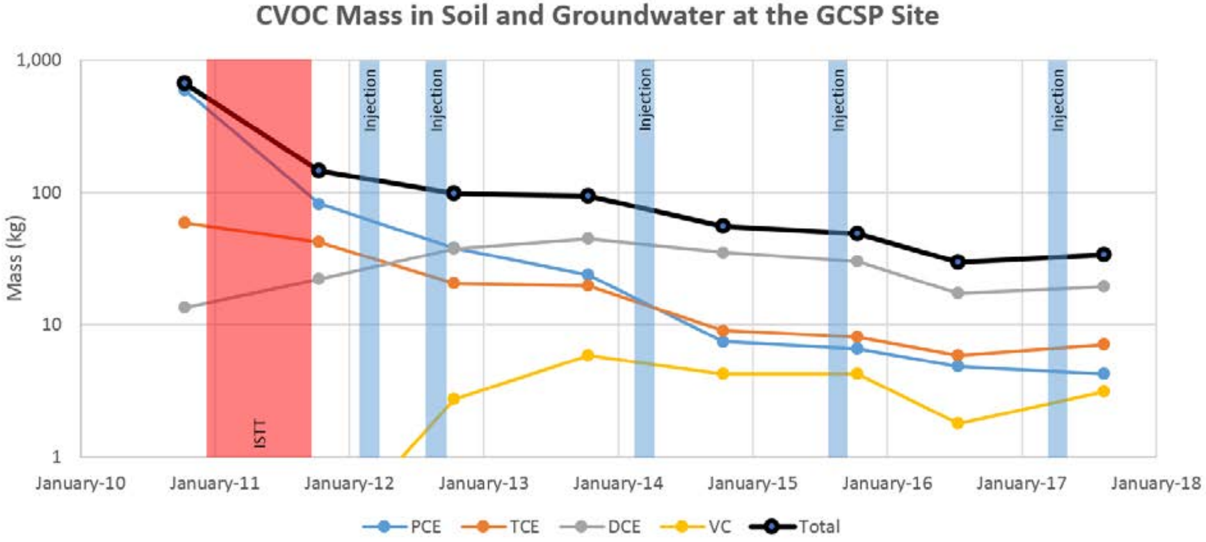
0 50 100 Approximate scale in meters
0 200 400 Approximate scale in feet

**Figure 2-2.**
**Locations of Vapor Intrusion Mitigation System Installations**
2018 Annual Long-Term Response Action Report
*Grants Chlorinated Solvents Plume Site*
*Grants, Cibola County, New Mexico*

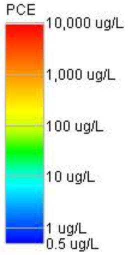
# Results through 2017

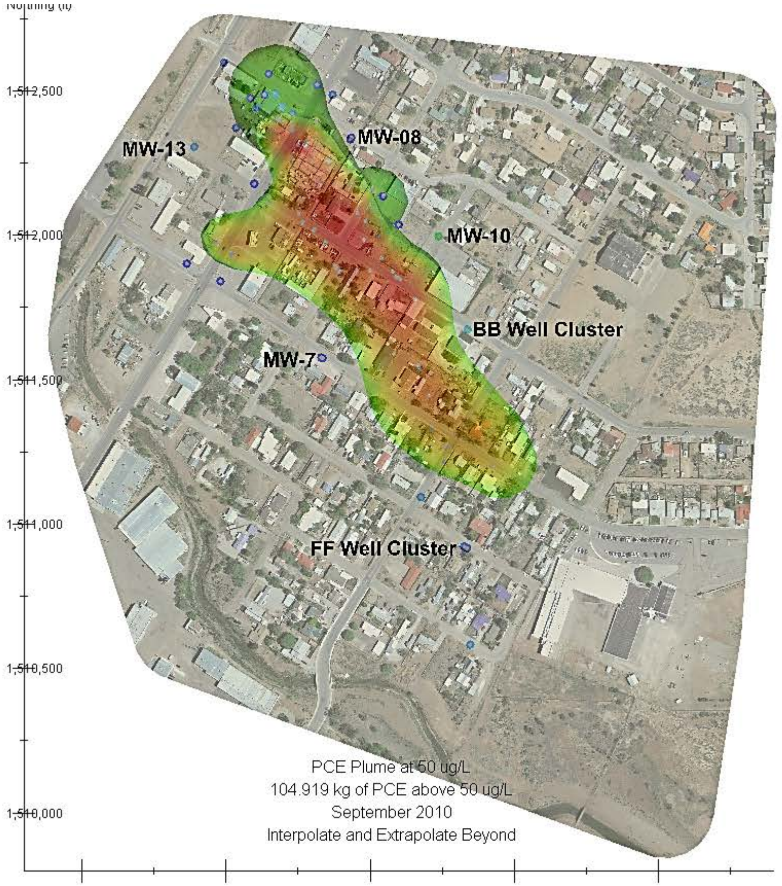
- Total CVOC mass reduced by approximately 95% after approximately 8 years of RA
  - ISTT influence
    - 75% of the decrease
  - ERD influence
    - Dissolved-phase mass outside of the ISTT treatment area decreased by approximately 80% after four injection events
    - Nearly 70% of remaining CVOC mass is cis-1,2-DCE or VC
    - Though center of CVOC mass has shifted, the plume footprint remained relatively consistent



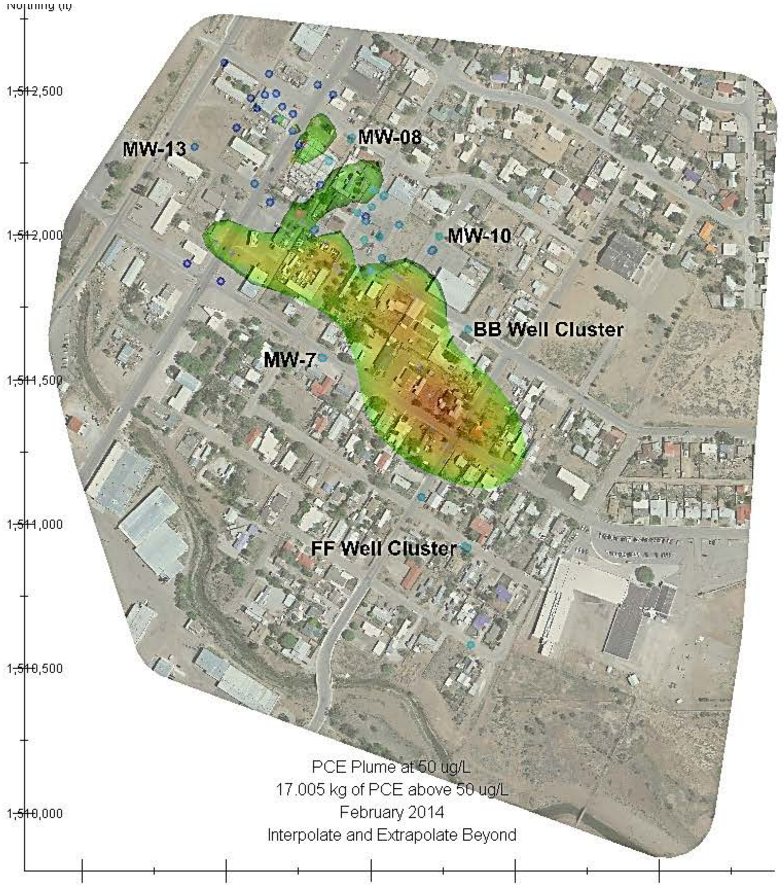



# PCE Plume since Start of Remedy




September 2010

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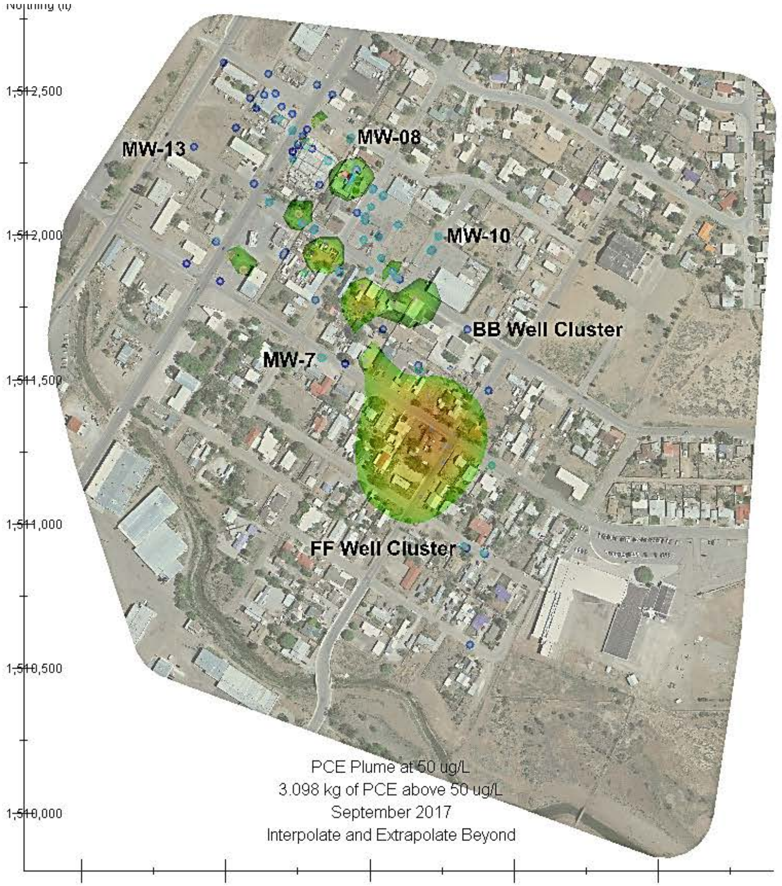
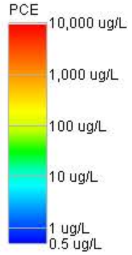
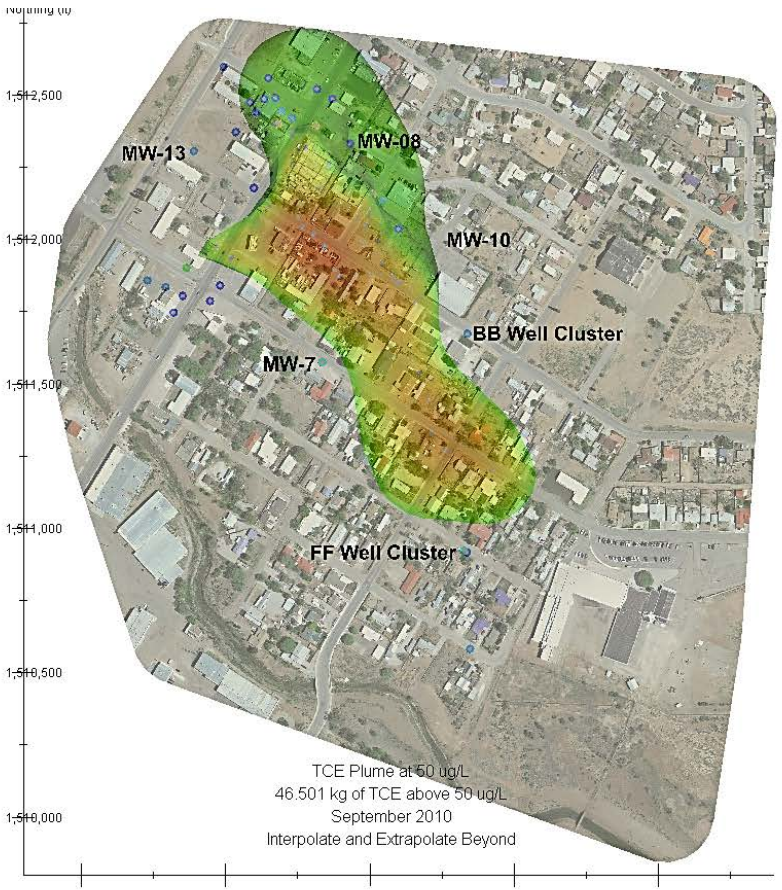



September 2017

# TCE Plume since Start of Remedy

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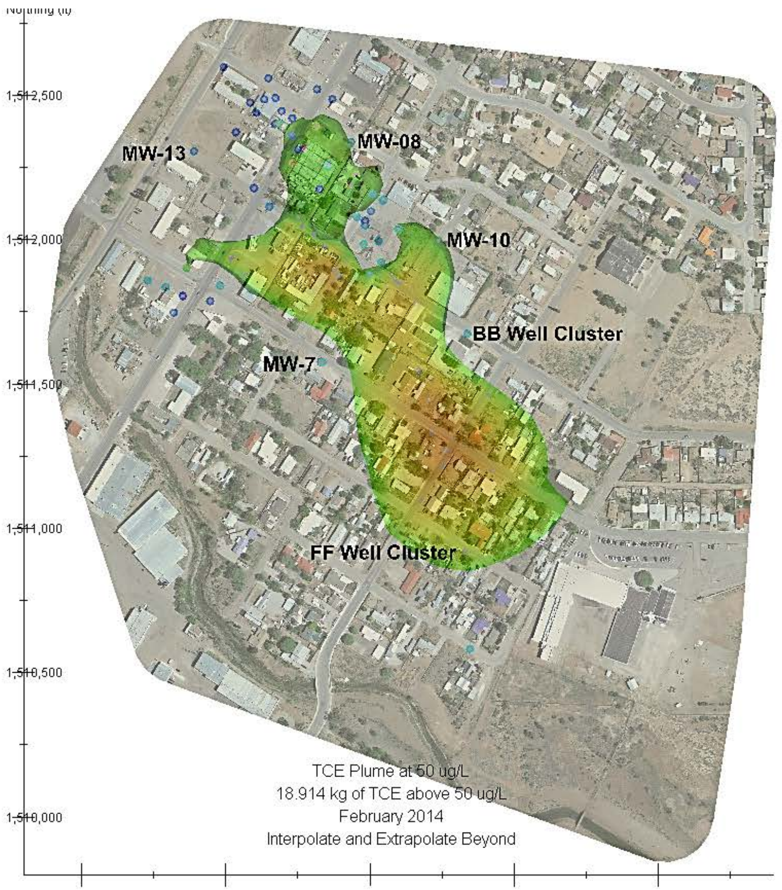


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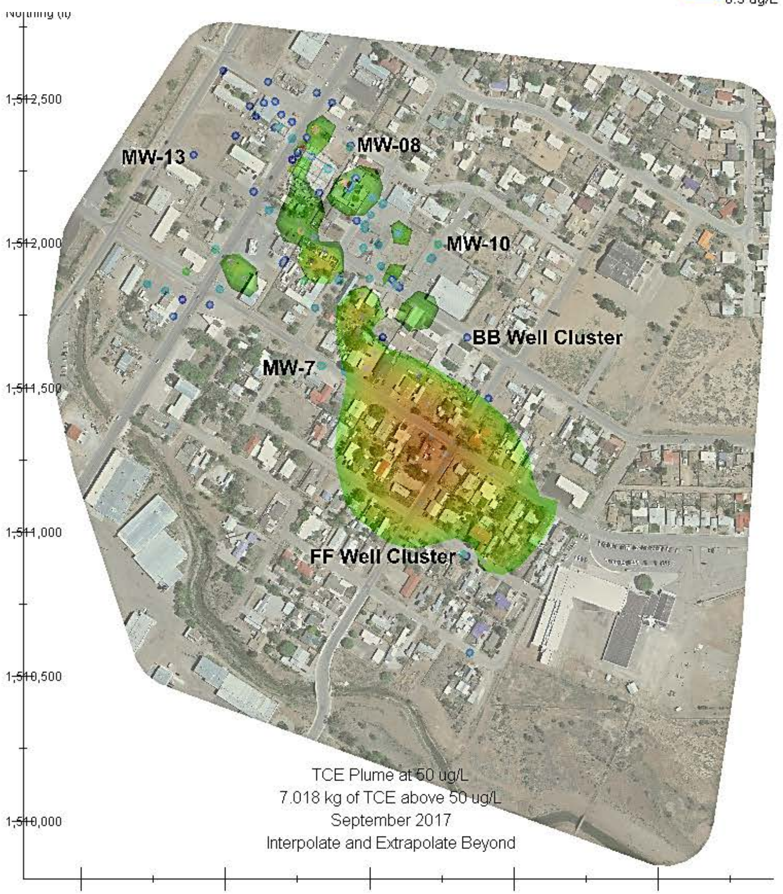
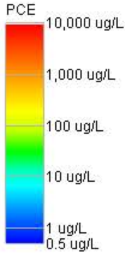
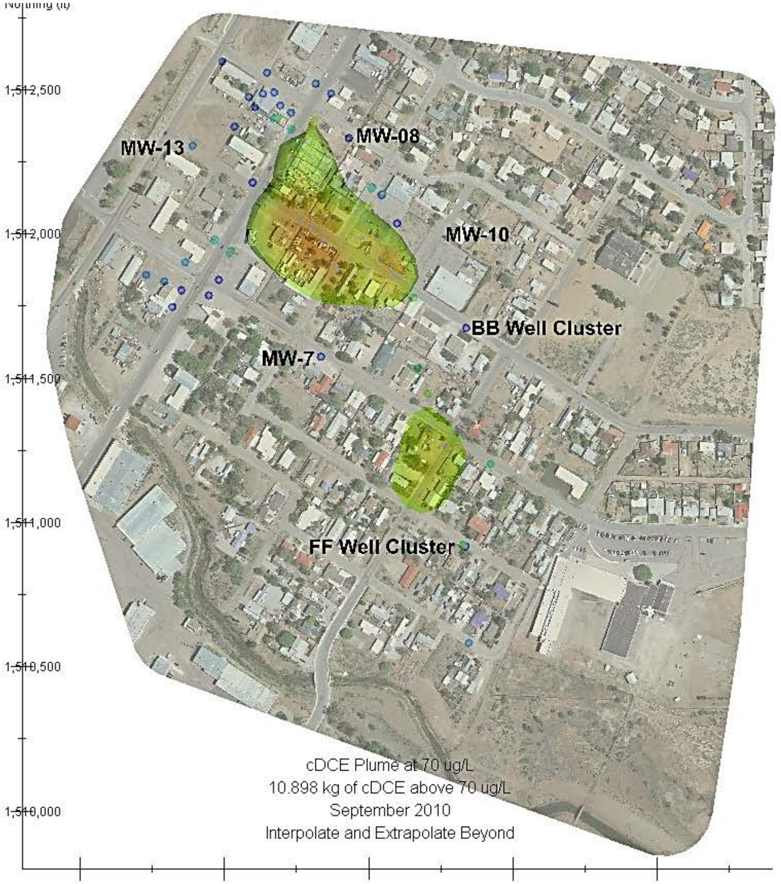



September 2017

# Cis-1,2-DCE Plume since Start of Remedy

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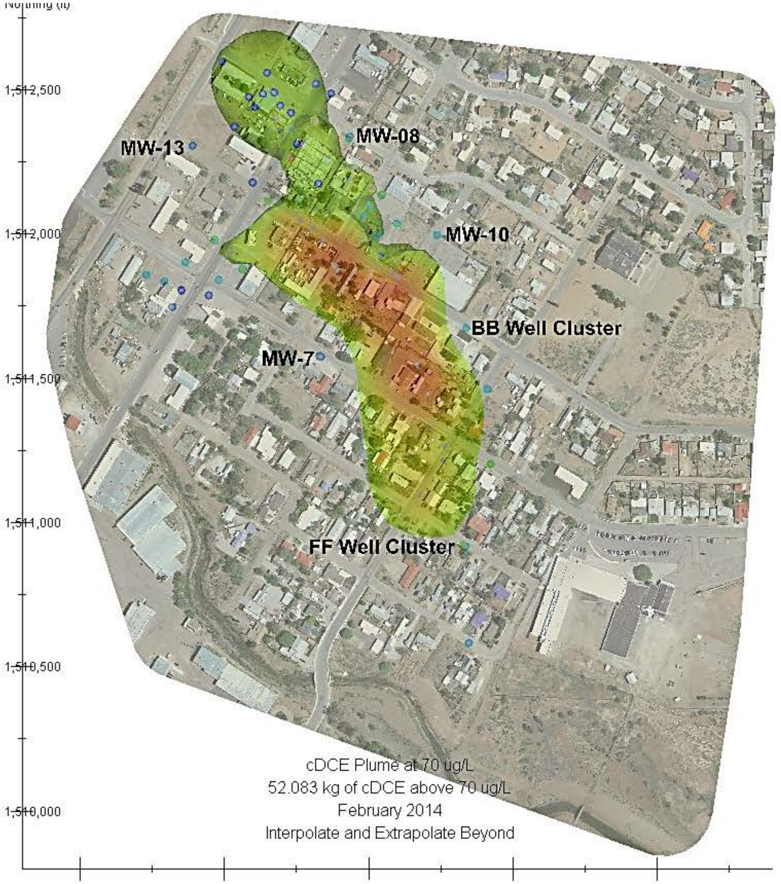


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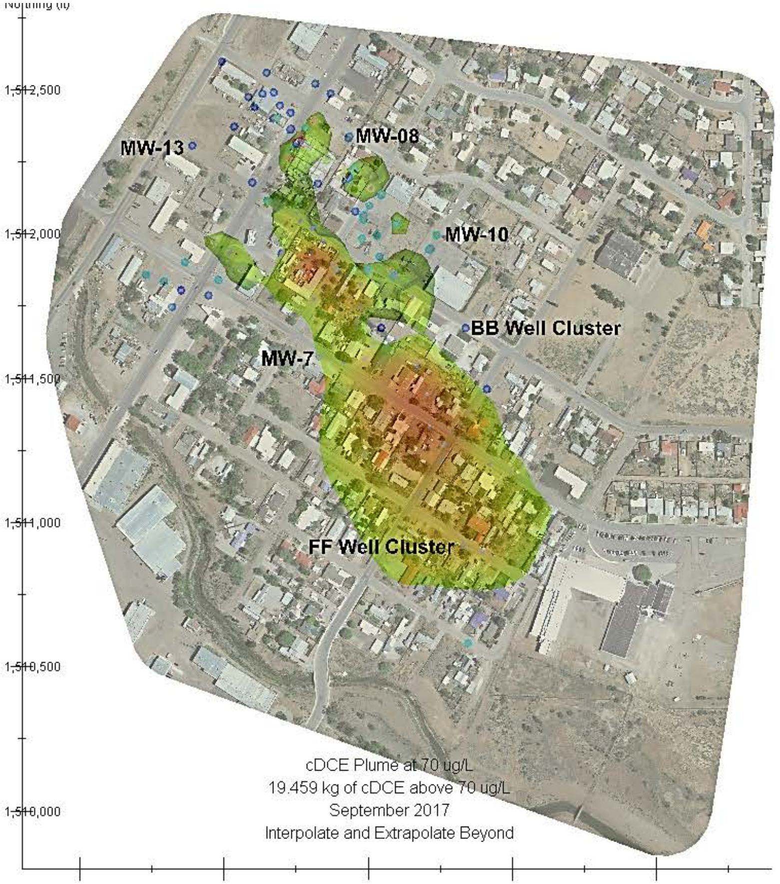
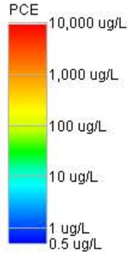
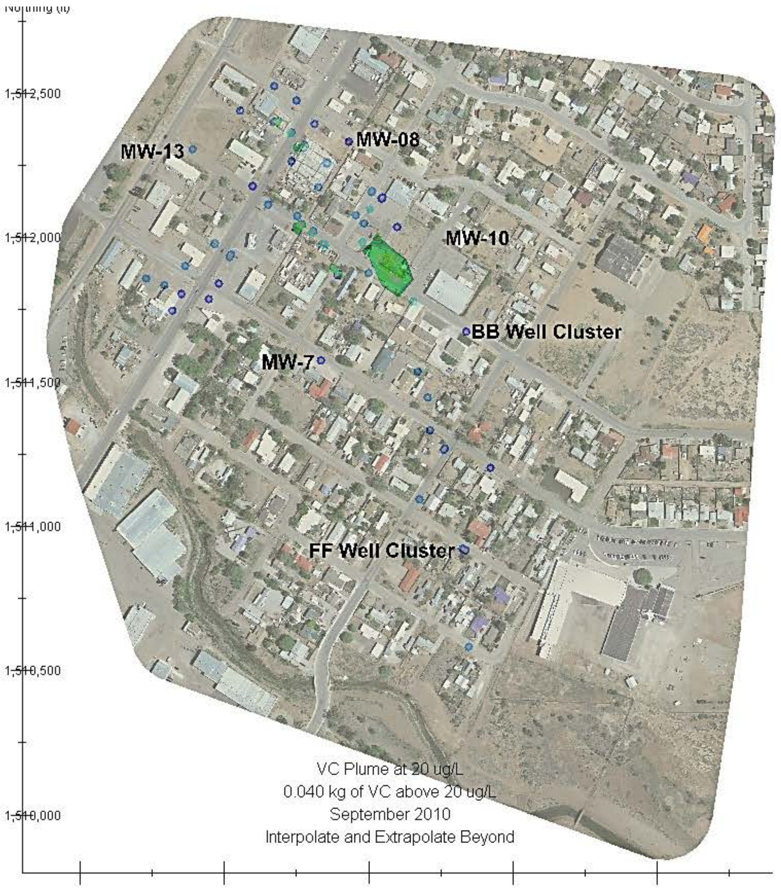



September 2017

# VC Plume since Start of Remedy

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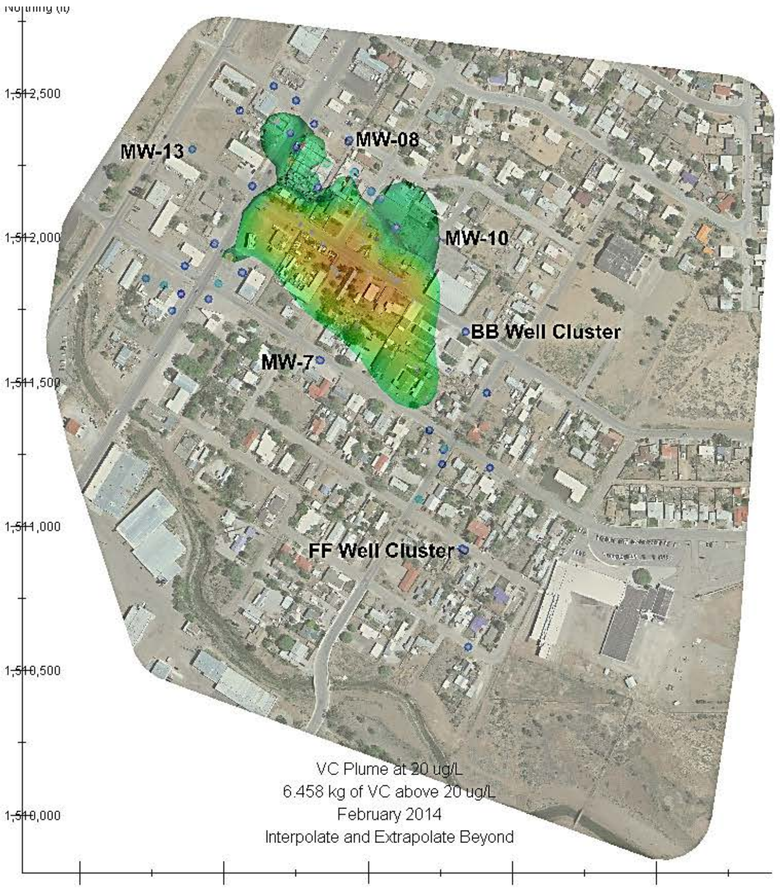


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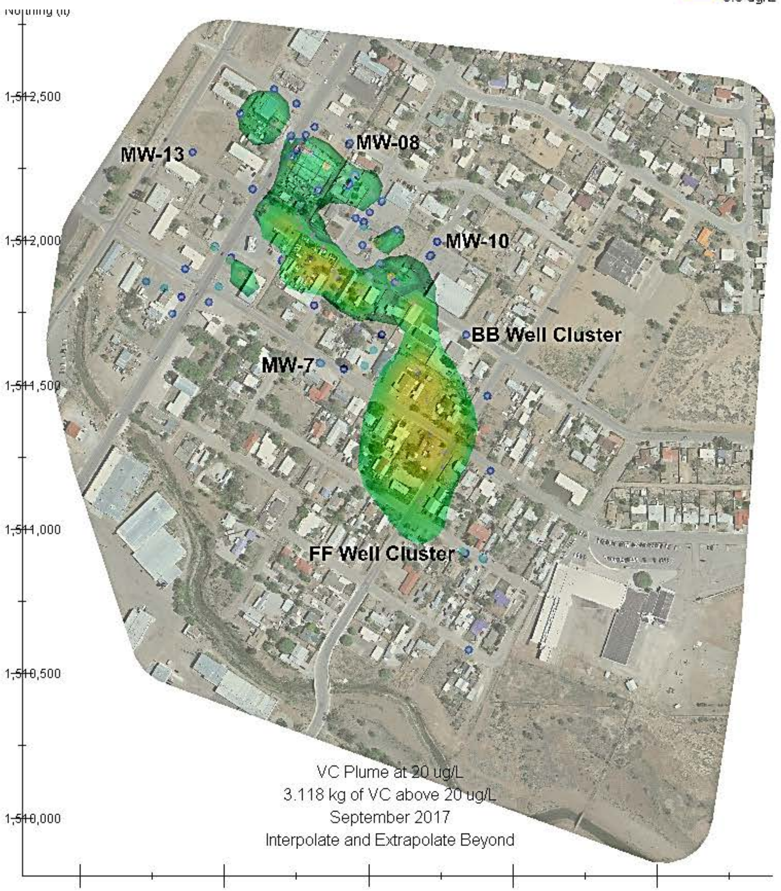


September 2017

- *(show plumes over time in EVS model)*

# RD/RA Successes

- Effectively used cafeteria-style selection process in FS to identify optimal remedy that combined ISTT, ERD, and long-term groundwater monitoring technologies
- Considerable technical and financial benefit to VE Study (second FS)
- Integrated conventional and ARRA funding to accelerate remedy construction
- Implemented ERD primarily within public ROW and used permanent injection wells and mobile injection systems to minimize impact to community
  - Coordinated with local driller to store substrate and trailers
- Installed, operated, and decommissioned ISTT system without disrupting cleaners, state highway traffic, or natural gas line that bisected target treatment zone
  - Required close coordination with city and business owners throughout process
- Achieved Construction Complete in 2012
- Extensively studied and managed risk associated with ERD biogas generation
  - Despite the proximity of receptors, shallow groundwater, considerable methane production, and elevated sulfate concentrations

# Optimization Successes

- Optimization process continuously implemented since preliminary RD
- Monitoring optimization
  - Up to 30% of monitoring wells shifted to sampling every 3 years
  - Remainder sampled annually
- Substrate quantity optimization
  - Fourth injection event used 60% less than the first
    - Includes 365 injection wells; down from nearly 700
  - Fifth injection event expected to include approximately 80% less substrate than the first

- Sequential remedy performance maximized
  - Total CVOC mass at site reduced by 95%
    - 75% percent of mass loss attributed to ISTT
  - Total CVOC mass in ERD areas reduced by 80% after eight years of substrate injections
- Ahead of schedule presented in final RD
  - Optimization efforts completely paid for with realized cost savings
  - Additional life-cycle cost reductions expected with shorter active remediation timeframe as compared to design estimate
  - RD assumed 13 injection events for 20 years of treatment; current data trends suggest 7 to 10 events would be needed to achieve remedial objectives

# Remedy Implementation – Cost Perspective

| | ERD | ISTT | VIMS |
|---|---|---|---|
| Capital cost | $5,000,000 | $10,000,000 | $750,000 |
| Average annual costs | $800,000<br>(current: $400,000) | — | <$10,000 |
| Total costs to date | $10,000,000 | $10,000,000 | $750,000 |
| Mass removed | 200 kg | 550 kg | — |
| Cost per kilogram of CVOC removed | $50,000 | $18,000 | — |
| Target treatment area and volume | 20 acres<br>2,000,000 CY | 0.75 acre<br>30,000 CY | — |
| Cost per CY | $5 | $330 | — |
| Cost per structure | — | — | $50,000 |

# Planned Transition from Federal to State Oversight

# EPA to State Transition

- Current plan to transition LTRA activities from EPA to State of New Mexico in third quarter (calendar) 2020, prior to end of 10-year LTRA period; site will be under LTRA into 2022
- Providing cost and schedule information to EPA so that remaining LTRA and O&M activities can be projected based on the original RD and optimized remedy
- Abandon injection and monitoring wells that are no longer needed
- Enhanced ERD with temporary DPT injection points
- Complete the VIMS evaluation – *Can any be removed from service prior to the transition to the State?*
- Preparing enhanced dashboards
- Re-assess role of MNA as part of remedy
- Logistics of project transfer to State of New Mexico – training on groundwater sampling and injection processes and a project status summary memorandum

# EPA to State Transition

- (show dashboard)

# Thank you

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