

# Adaptive Strategies for *In Situ* Treatment of Shallow and Deep PCE Plumes in Interbedded Geology

Presented by

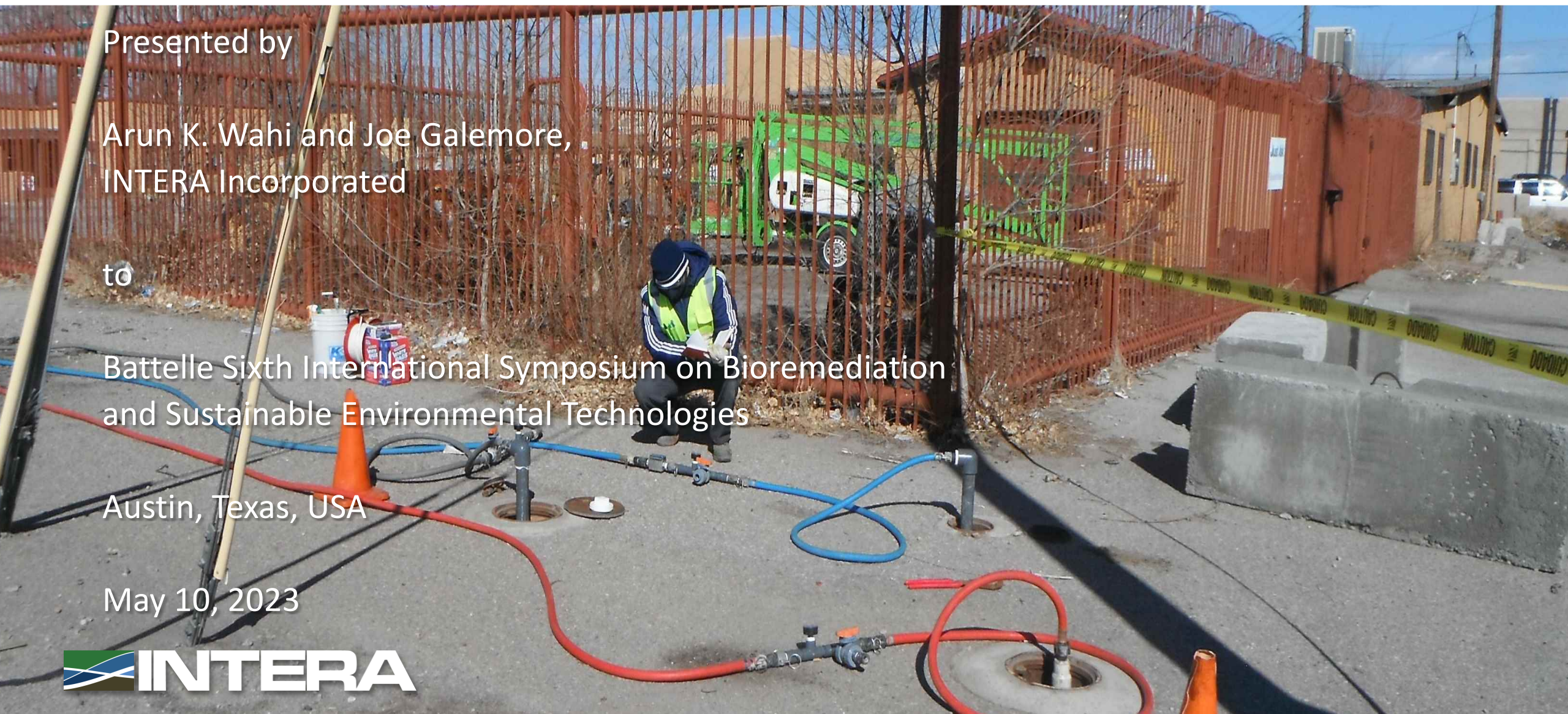
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INTERA Incorporated

to

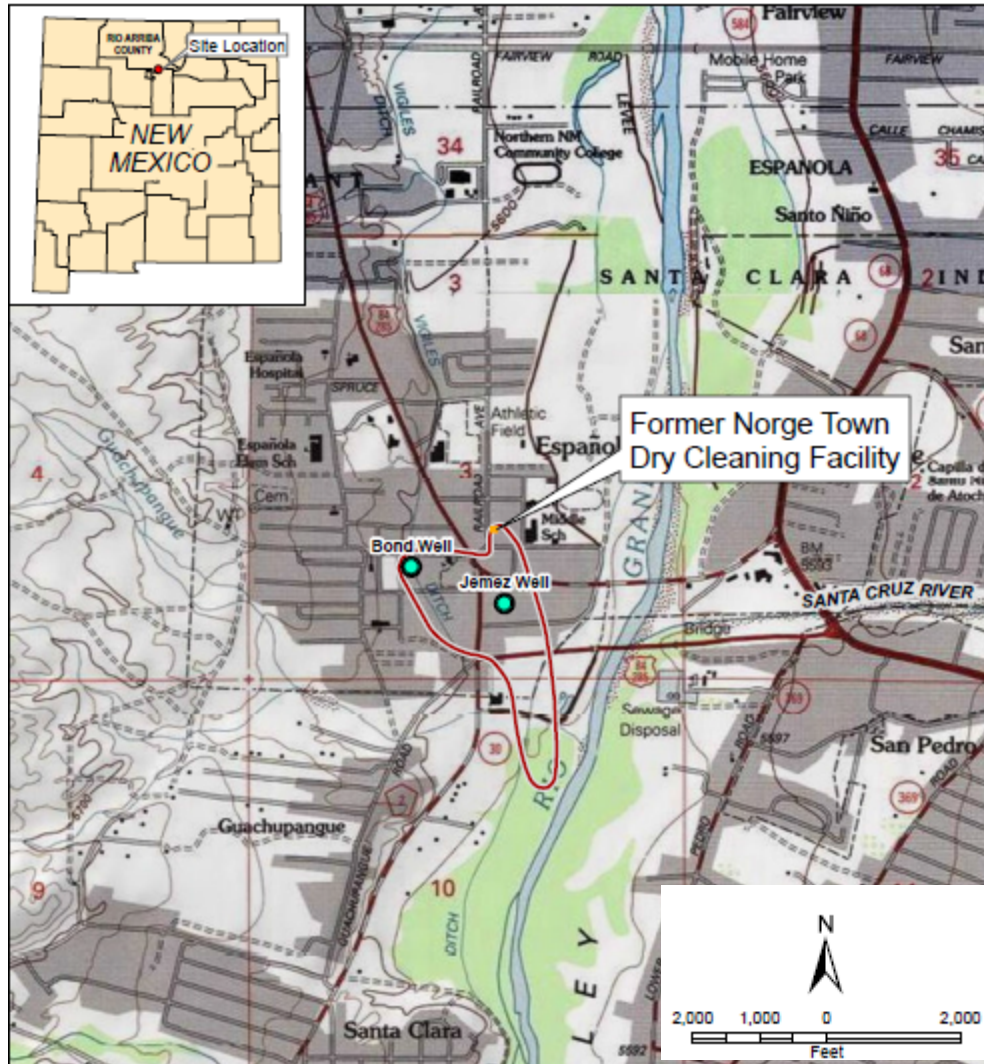
Battelle Sixth International Symposium on Bioremediation  
and Sustainable Environmental Technologies

Austin, Texas, USA

May 10, 2023



# North Railroad Avenue Plume Superfund Site



- Two City of Española municipal wells shut down in 1989-1990 after detecting PCE and TCE
- Investigated by New Mexico Environment Dept. (NMED), US Environmental Protection Agency (EPA), and contractors
- Source traced to dry cleaning facility
- PCE plume in groundwater covered 58 acres
- Up to 260 feet deep, likely affected by historical pumping of supply wells
- Listed on National Priorities List 1999
- Remedial Investigation, Feasibility Study, and Record of Decision 2001
- Pilot Testing 2007
- Explanation of Significant Differences 2008

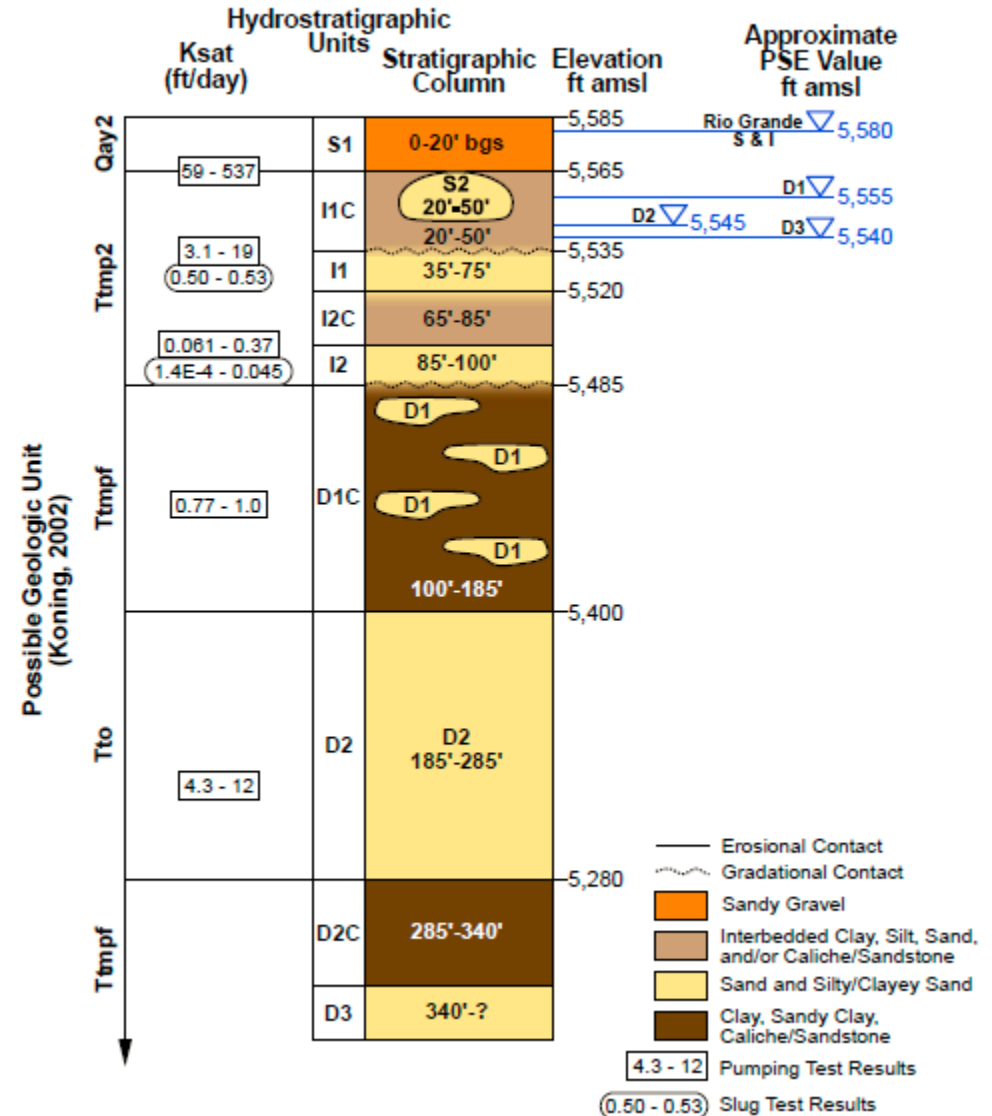
Topo Source: ESRI ArGIS Online

Contour interval = 20 feet

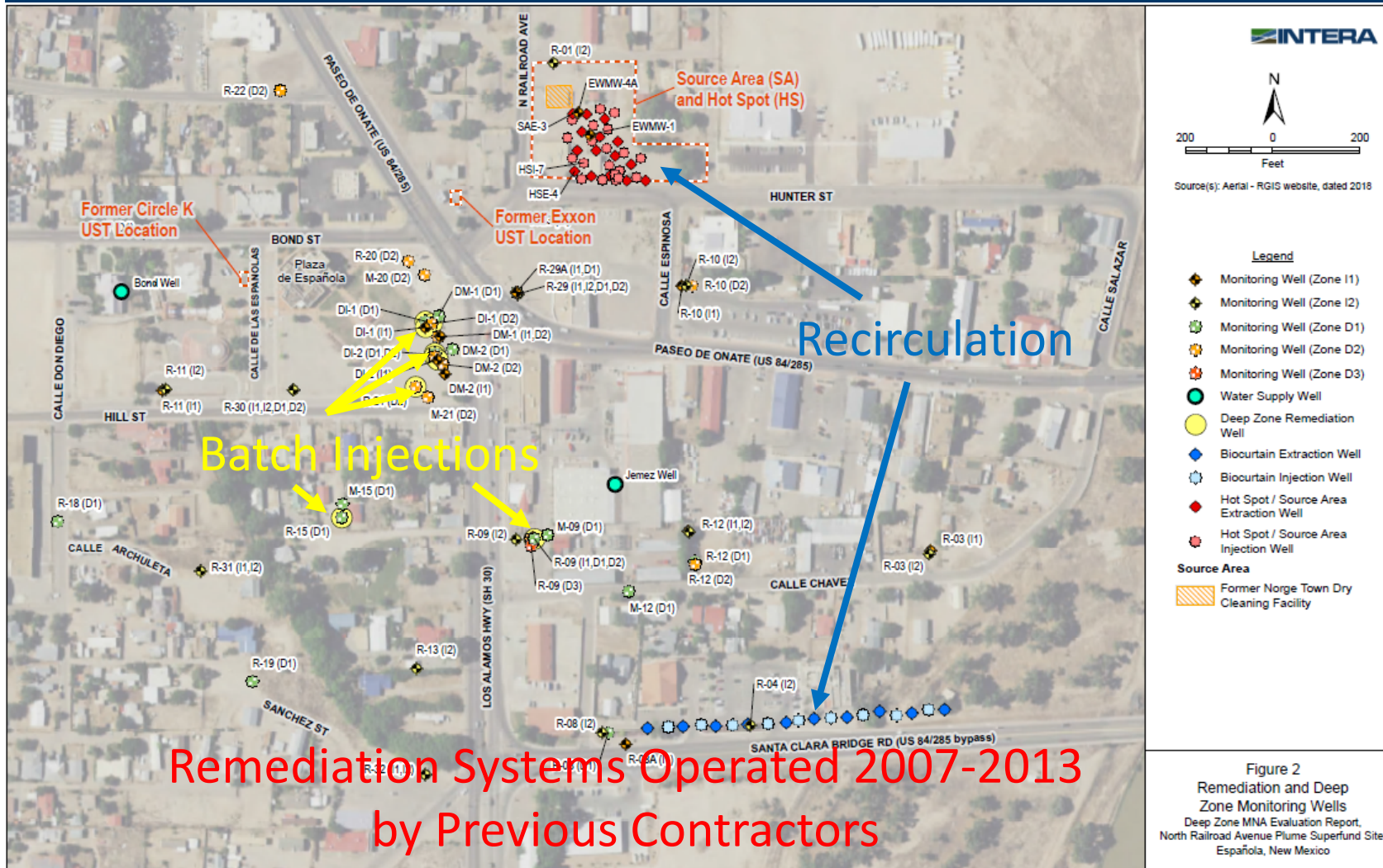
 Historical Areal Extent of NRAP Chlorinated Solvent Plume


# Generalized Hydrostratigraphic Column

- Six coarse-grained hydrostratigraphic units (HSUs) contaminated
- Four fine-grained HSUs isolate downgradient transport pathways vertically and laterally, can cause back-diffusion near the source area



# Objectives

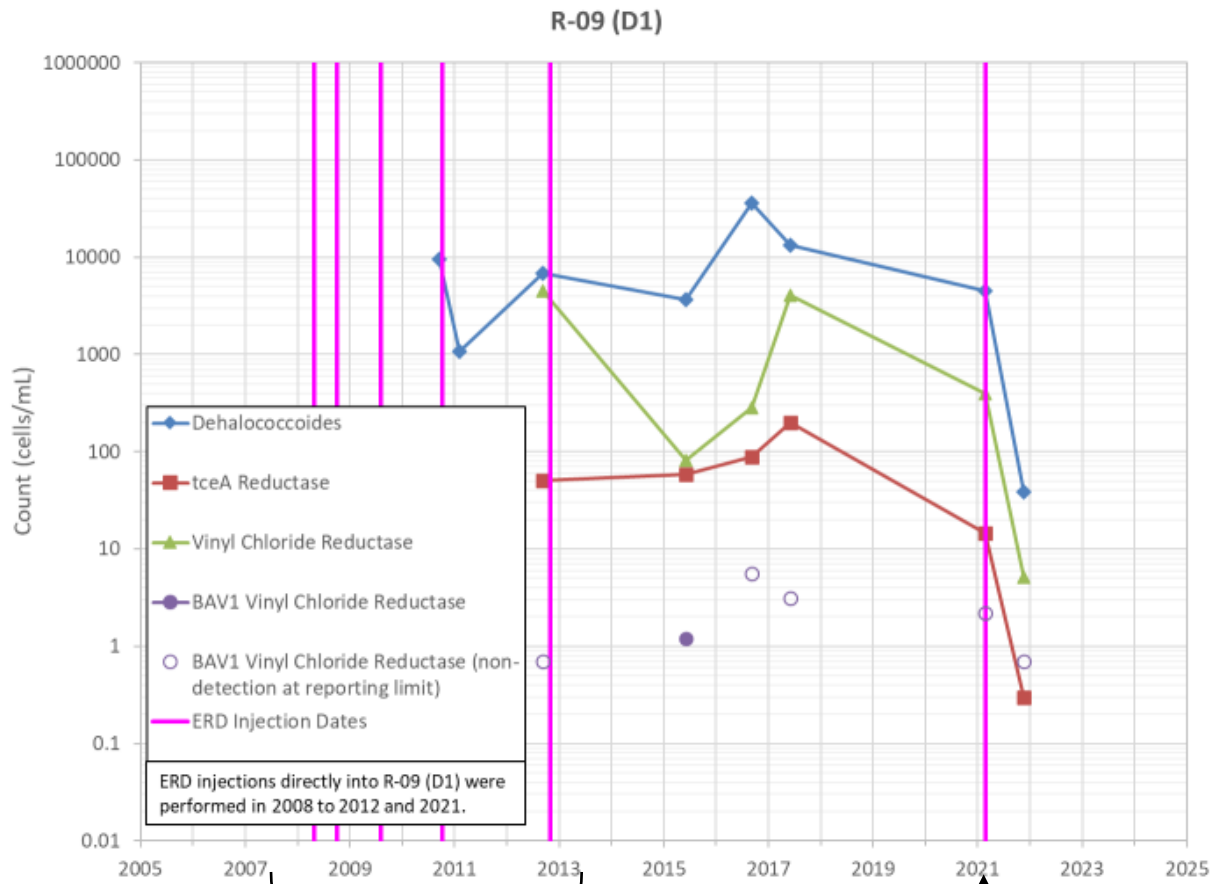


  
 Figure 2  
 Remediation and Deep  
 Zone Monitoring Wells  
 Deep Zone MNA Evaluation Report,  
 North Railroad Avenue Plume Superfund Site,  
 Española, New Mexico

1. Prevent Human Exposures
  - Discontinued use of Bond and Jemez wells
  - Restrictions on new wells, use of existing domestic wells
  - Treatment of shallow groundwater plume, biocurtain upgradient from river
  - Indoor air and soil vapor monitoring
2. Achieve Source Control
  - Source area (SA) and hotspot (HS) treatment systems
3. Limit Migration
  - Biocurtain (BC) and deep zone (DZ) treatment wells
4. Destroy Contaminant Mass
  - Fracture-enhanced injection wells in SA fine-grained zones
  - Continued DZ injections

# Response of Deep Zone Bacteria to Amendment Injections for Enhanced Reductive Dechlorination

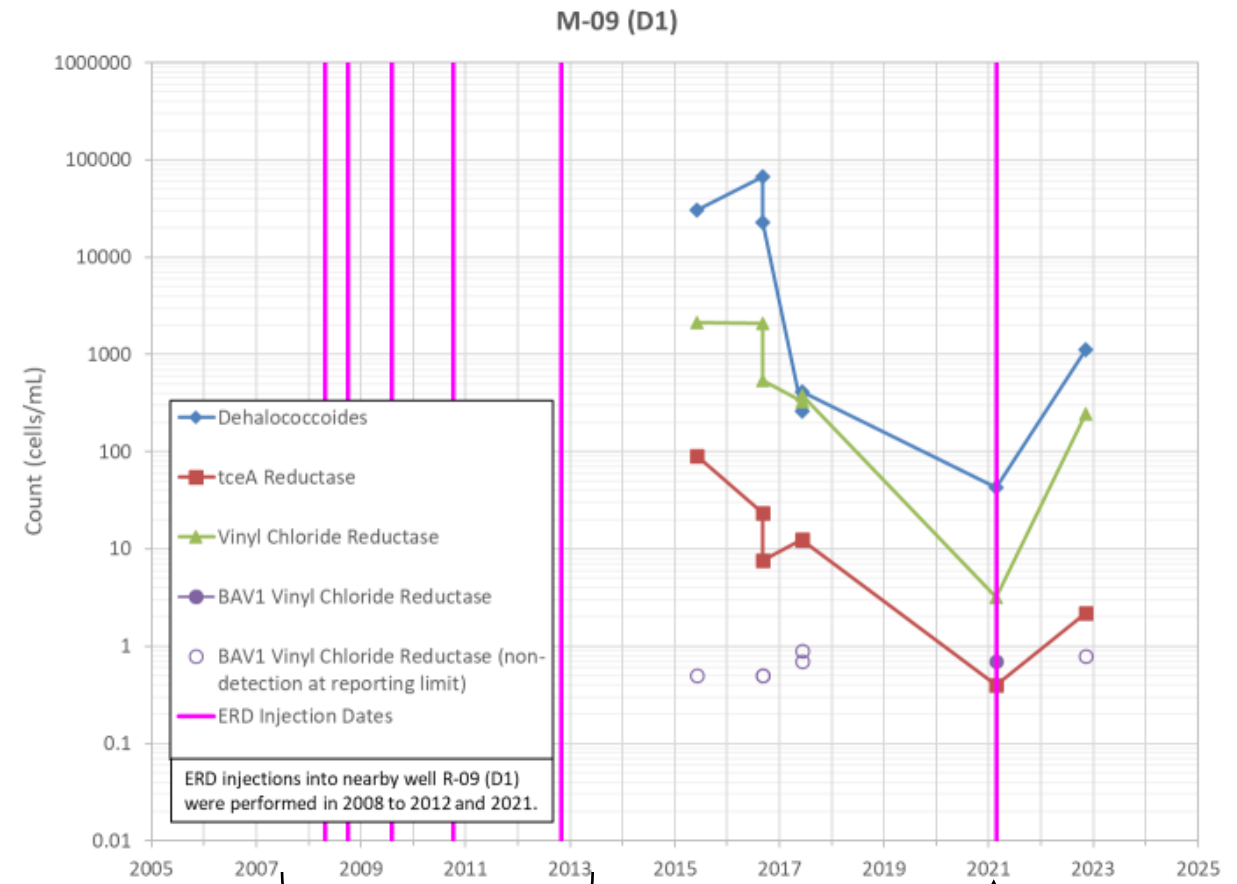
## Injection Well



Emulsified Vegetable Oil (EVO),  
lactate, nutrients

3DME<sup>®</sup>, CRS<sup>®</sup>

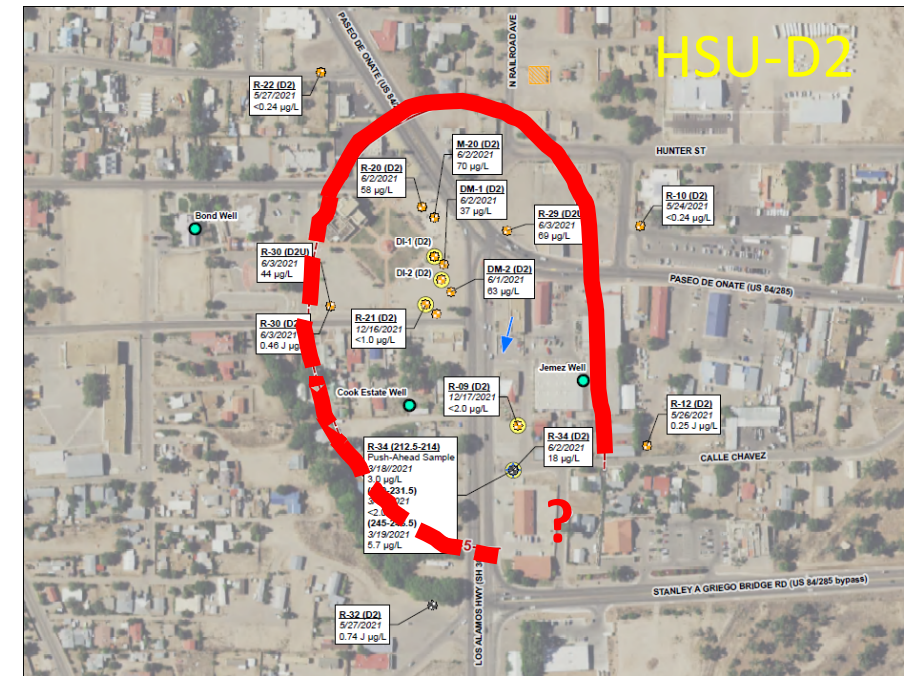
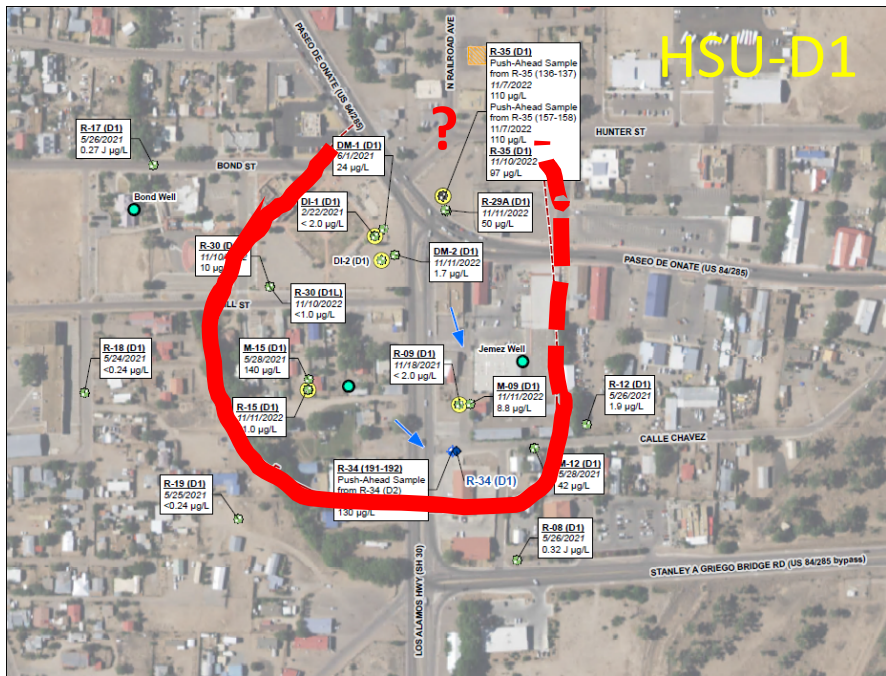
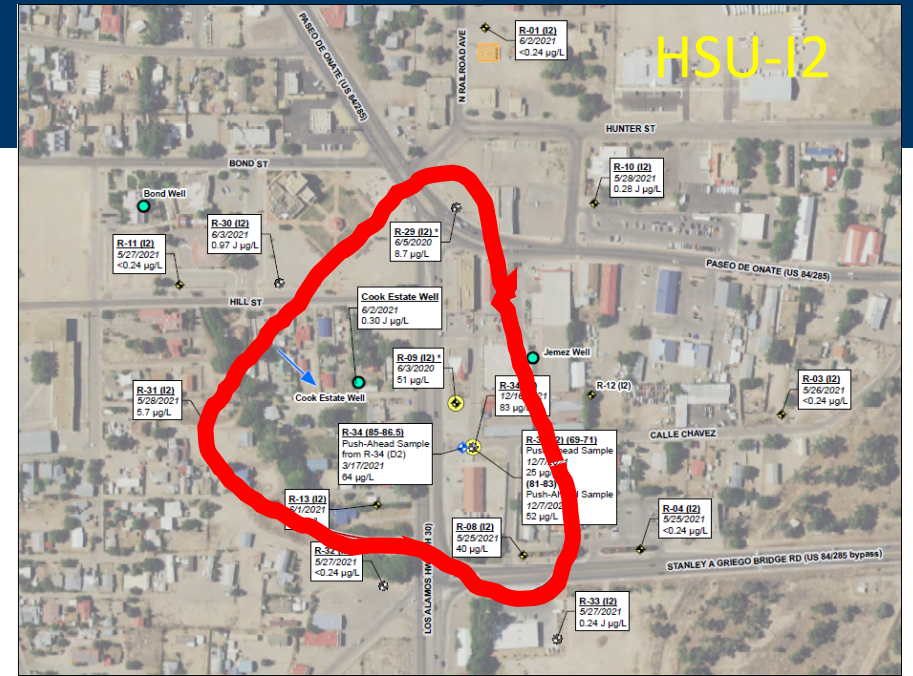
## Nearest Monitoring Well



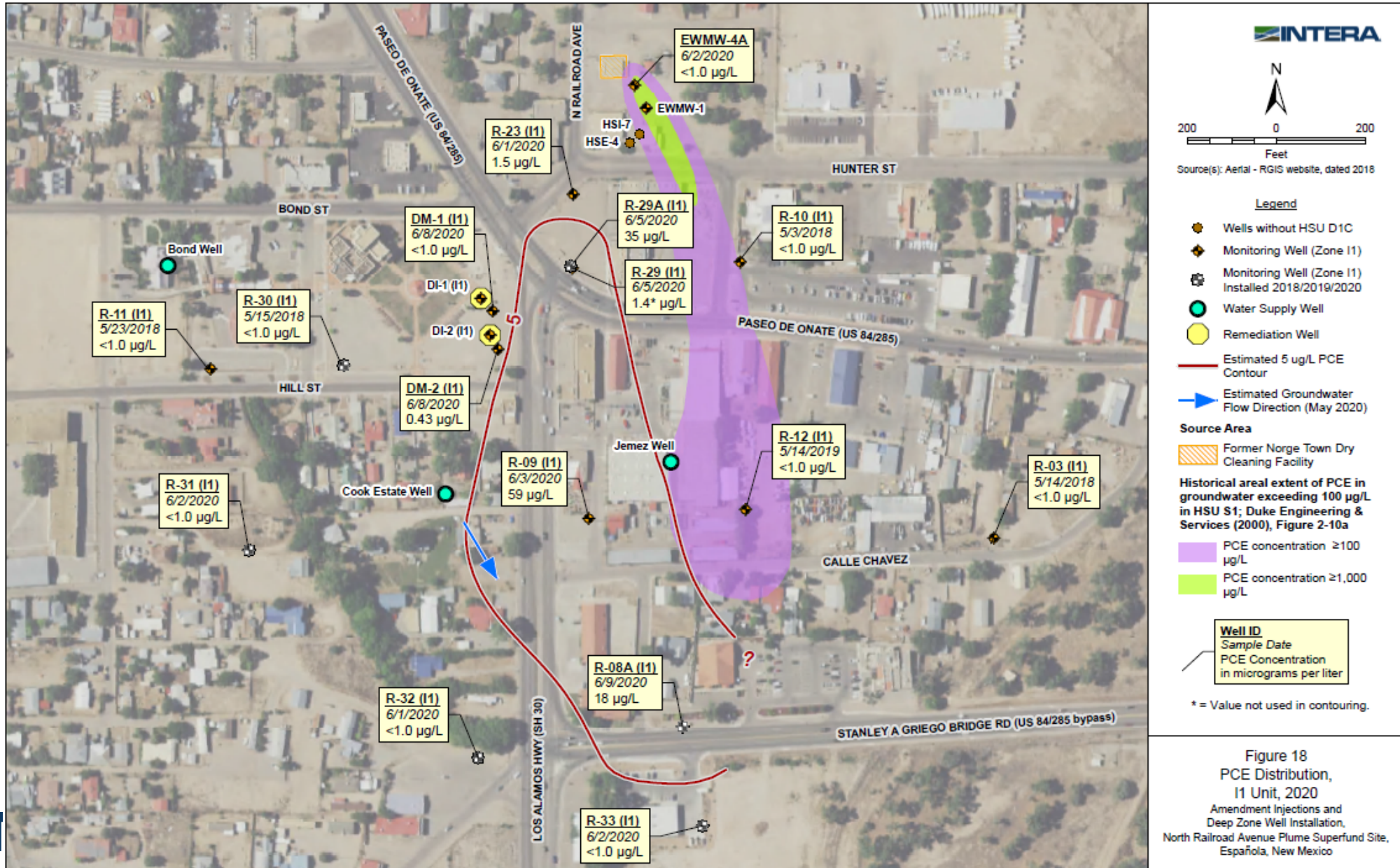
Emulsified Vegetable Oil (EVO),  
lactate, nutrients

3DME<sup>®</sup>, CRS<sup>®</sup>

# PCE Plumes in Deep Zone, 2021



# Transport from Shallower to Deeper HSUs Likely Depended on Historical Pumping by Supply Wells and Geologic Controls



# Conceptual Site Model Update Using Environmental Sequence Stratigraphy

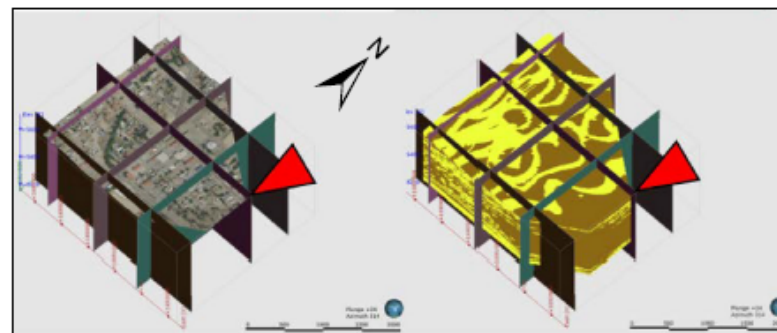
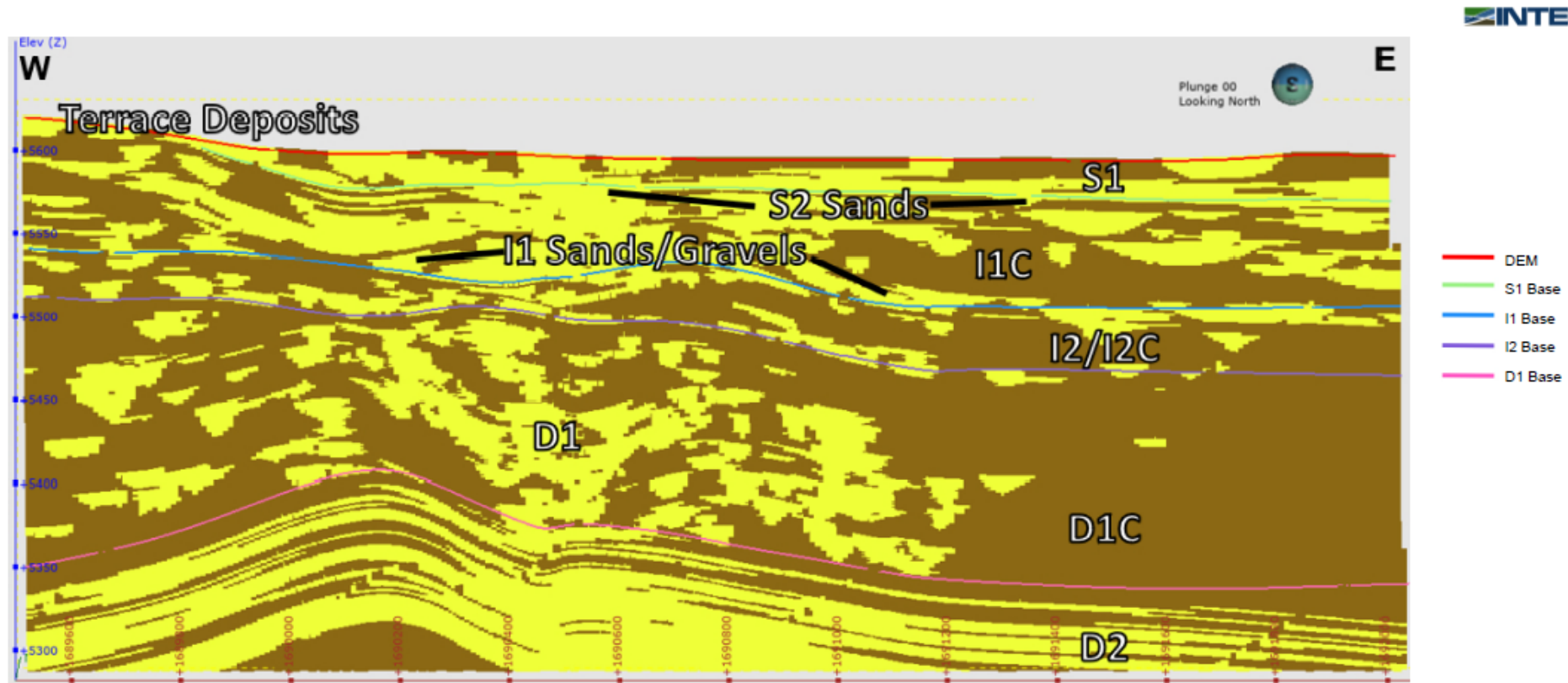


Figure 10a  
Central East-West Cross Section  
Conceptual Site Model Update  
North Railroad Avenue Plume Superfund Site,  
Española, New Mexico



# Hypothesized “Stacked Sand Boundaries” May Explain Water Level Anomalies



# Natural Attenuation May Not Be Adequate to Limit Migration in Deep Zone

## 2018 MNA Evaluation (Five Years After Last EVO Injections to Deep Zone)

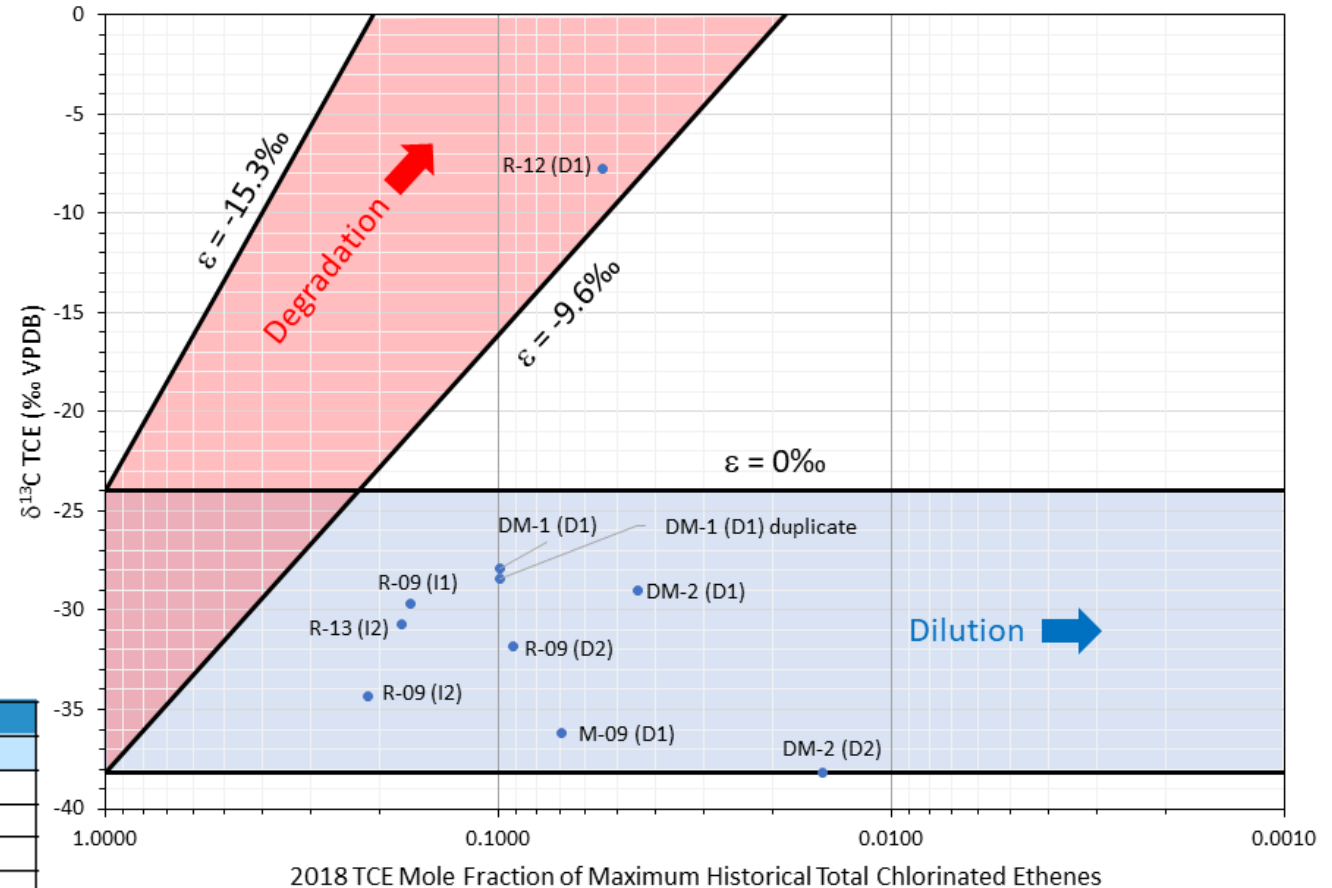
- Timeseries analysis
- Redox parameters
- qPCR
- CSIA
- Fate and transport calculations

## 30-Year Travel Distances Estimated Using BIOCHLOR

Zone	Well	PCE		TCE	
		With Sorption	No Sorption	With Sorption	No Sorption
D-2	R-09	< 2500 ft	< 4500 ft	< 100 ft	< 100 ft
D-1	M-09	< 450 ft	< 700 ft	< 350 ft	< 500 ft
I-1	R-08	< 1000 ft	< 1650 ft	< 400 ft	< 400 ft
I-2	R-08	< 70 ft	< 100 ft	< 50 ft	< 50 ft

Environmental Protection Agency, United States, 2000. BIOCHLOR Natural Attenuation Decision Support System User's Manual Version 1.0. National Risk Management Research Laboratory, Cincinnati, Ohio, EPA/600/R-00/008.

TCE Carbon Isotopes vs. Fraction of Maximum Chlorinated Ethenes

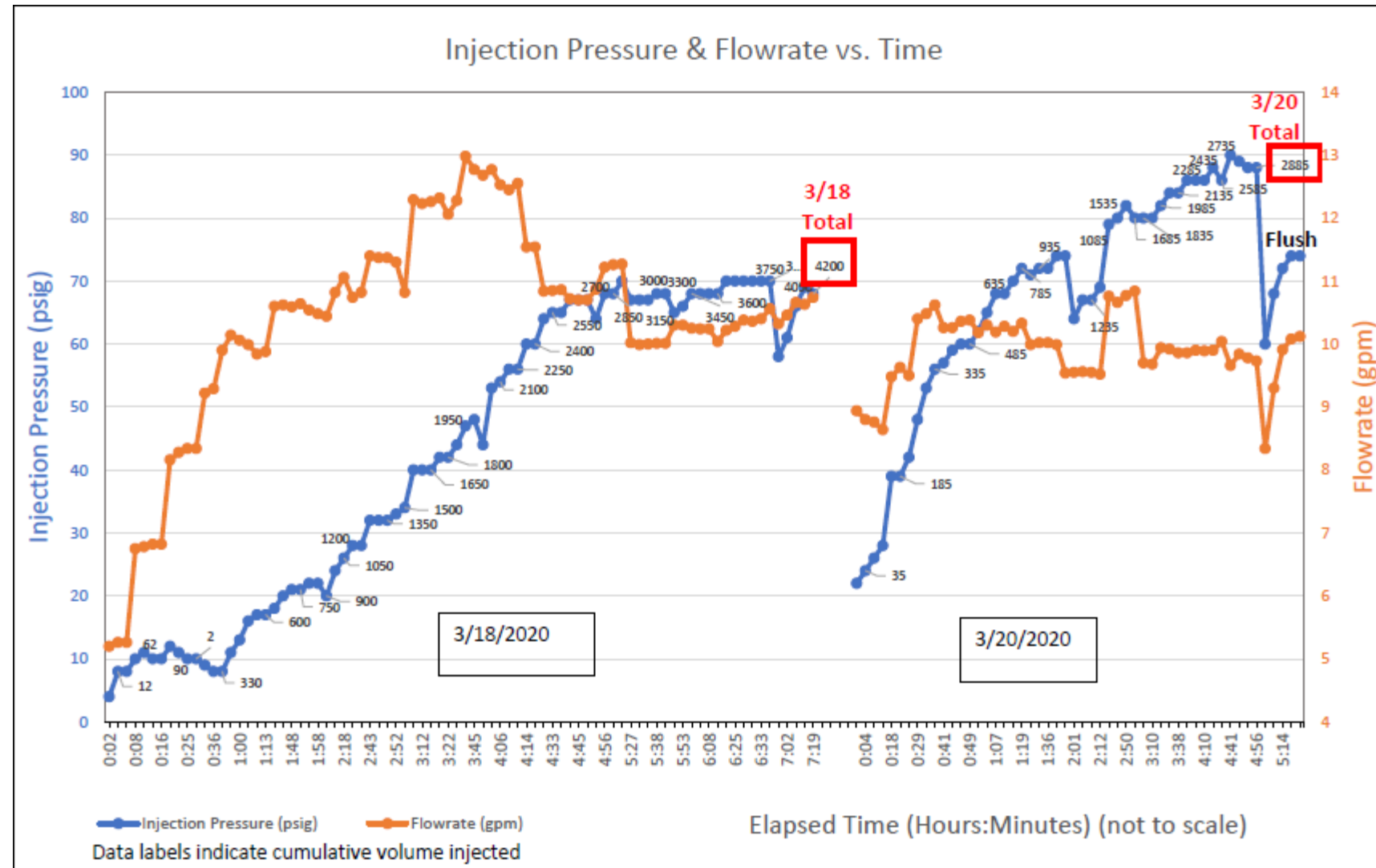


Wilson, J.T., 2012. An Approach to Organize and Interpret Compound Specific Isotope Analysis Data at Chlorinated Solvent Sites. Groundwater Resources Association of California GRACast Web Seminar, September 18, 2012.

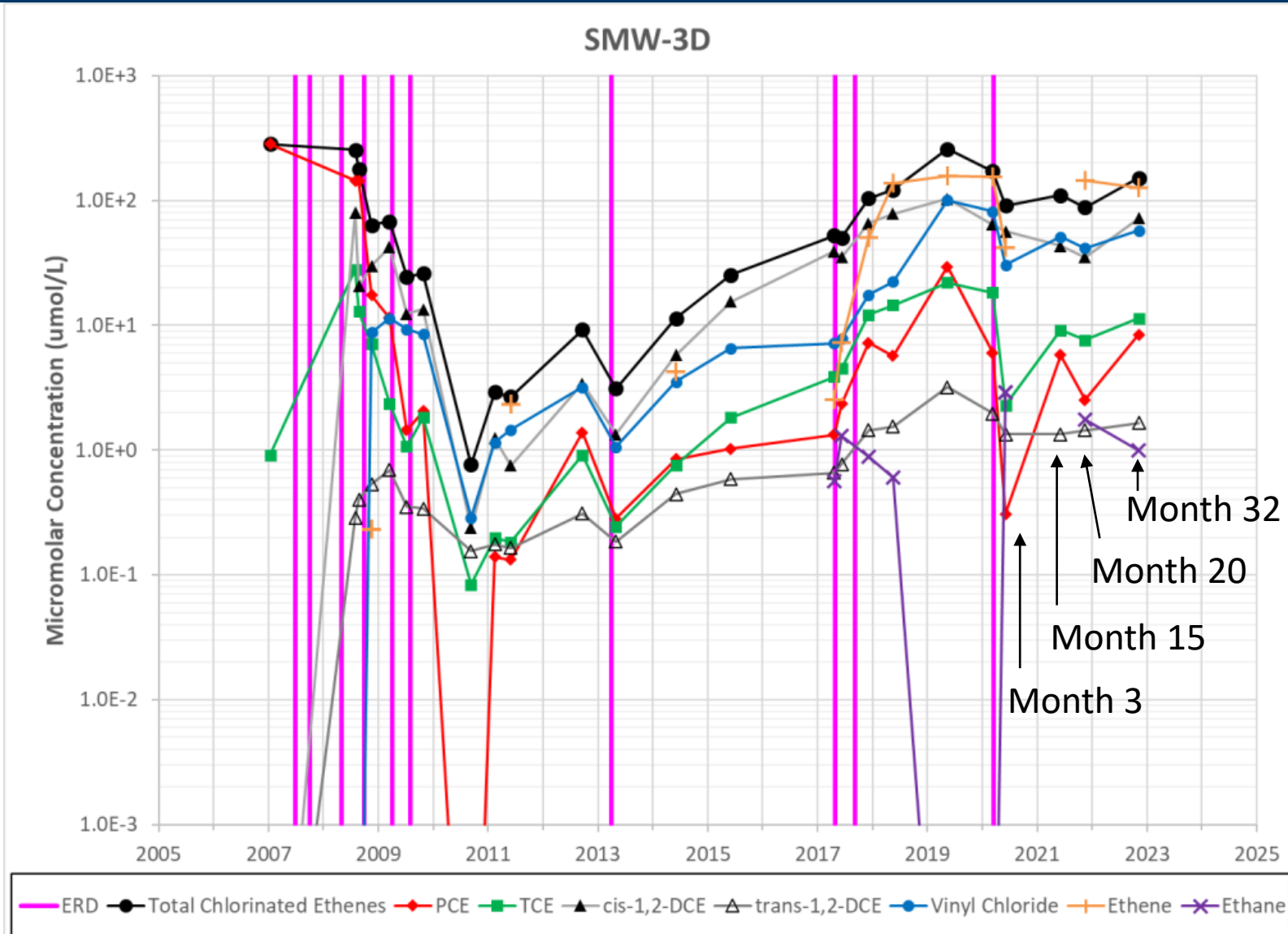
# 2020 Pilot Test of Alternative Amendments



3DME<sup>®</sup> and S-MicroZVI<sup>®</sup> or CRS<sup>®</sup> mixed with water and injected under pressure



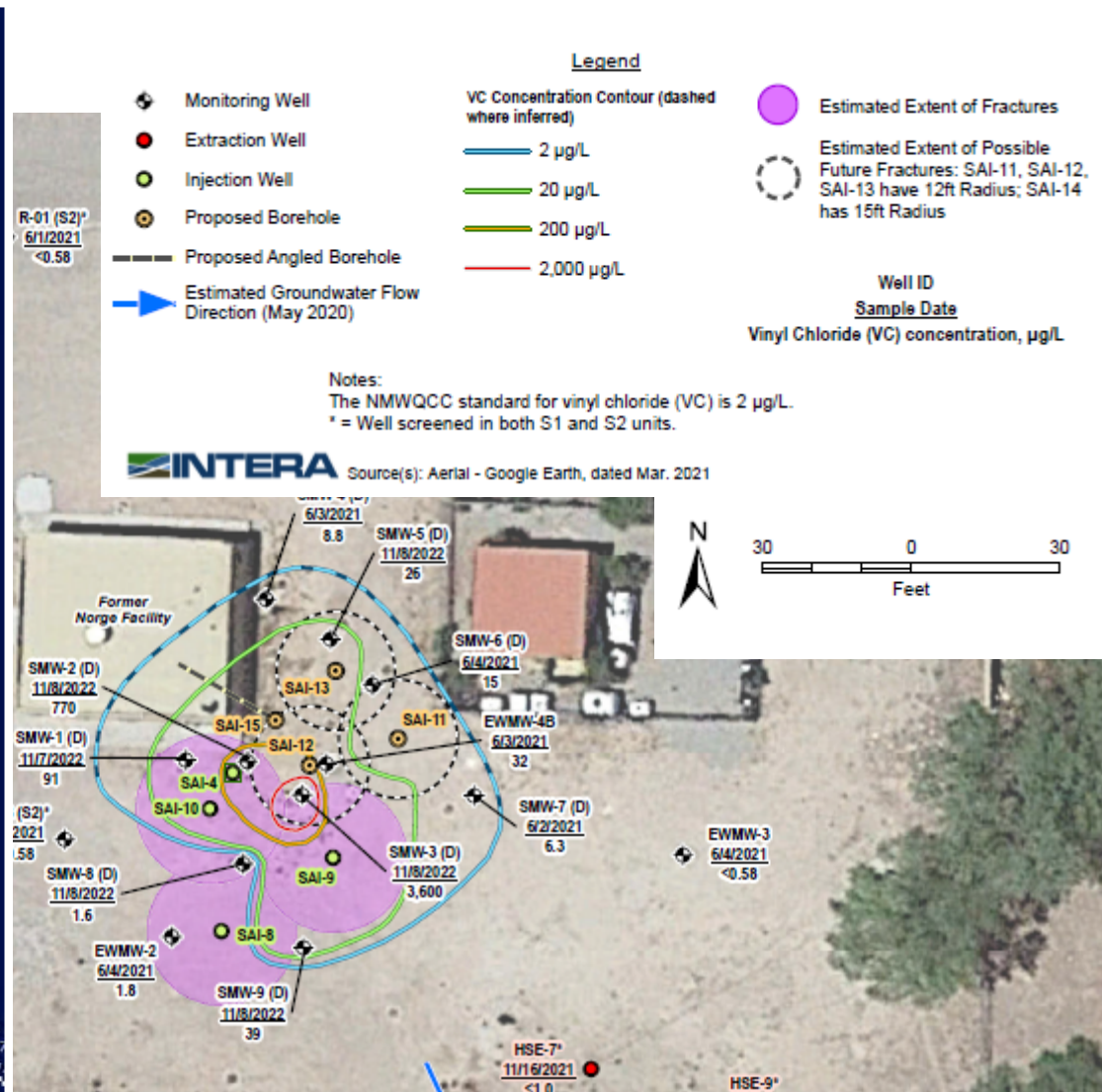
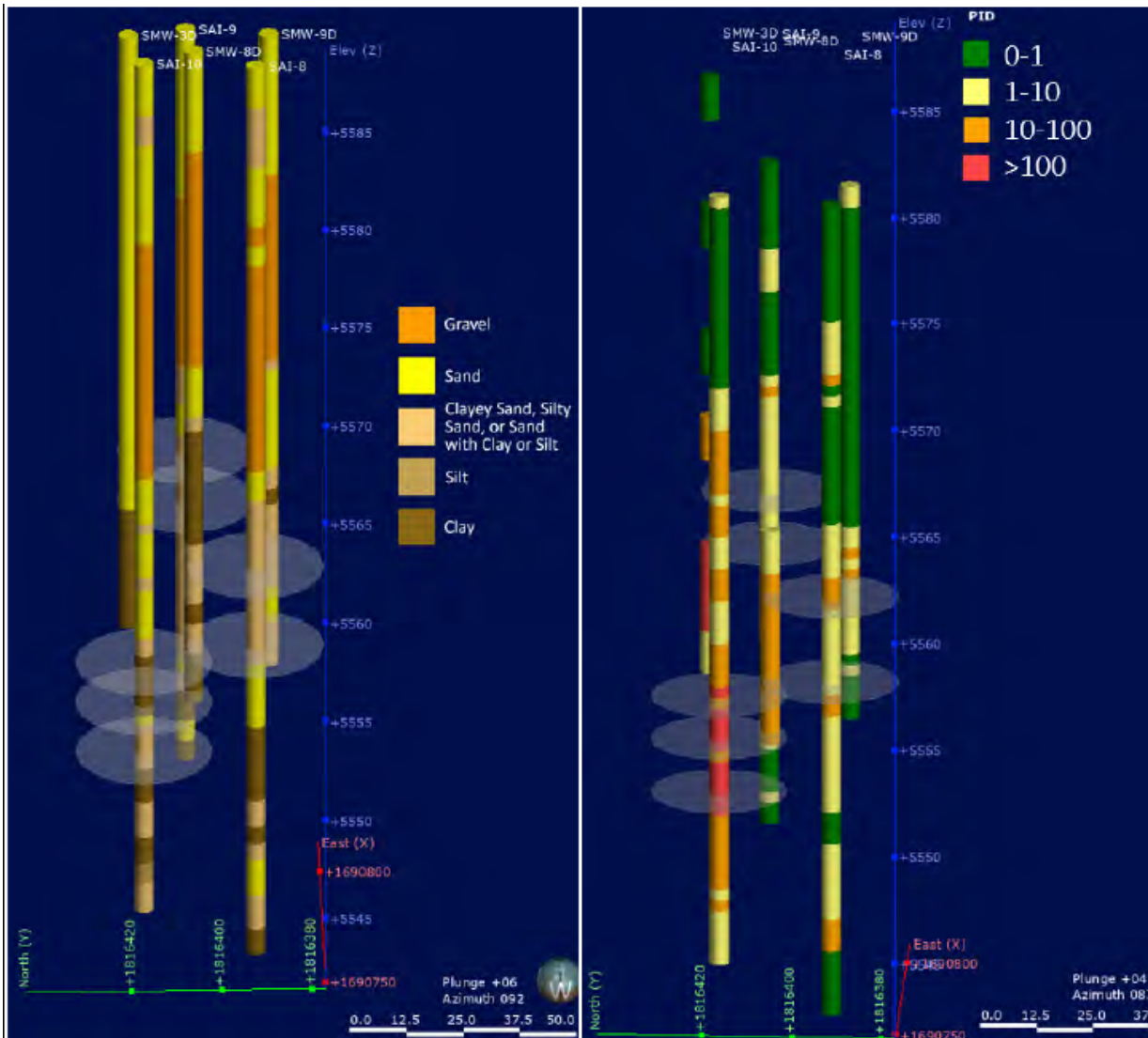
# Response of Source Area Contaminants to Enhanced Reductive Dechlorination



- 2007-2013: Recirculated Emulsified Vegetable Oil (EVO)
- 2017: EVO to targeted injection points/wells 2017
- 2020: 3DME<sup>®</sup> and S-MicroZVI<sup>®</sup> injected into fracture-enhanced wells just downgradient



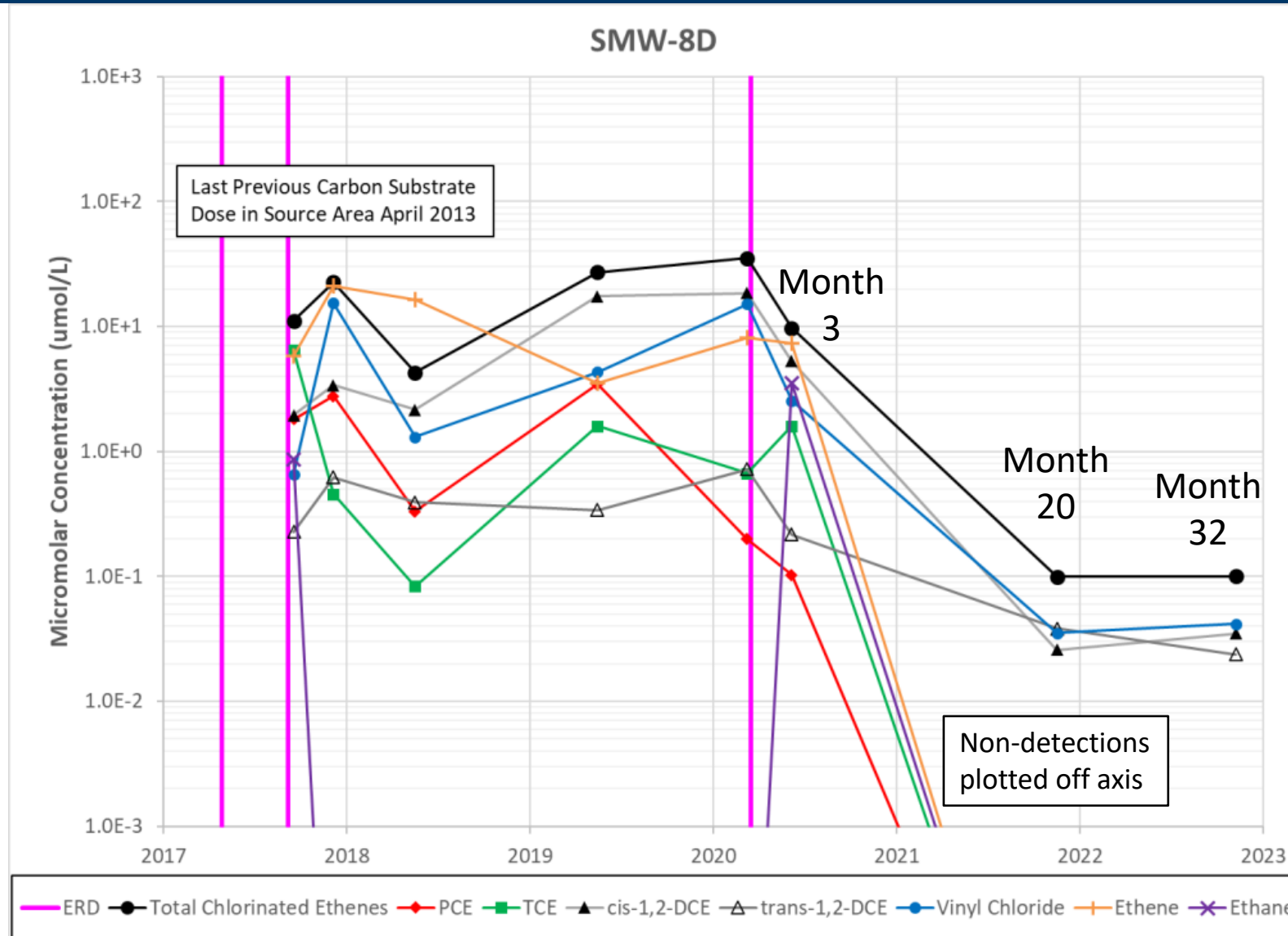
# Fracture Enhanced Wells Distribute Amendments to Residual Contamination in Fine-Grained Zones in Source Area



Lithology looking East

PID data looking East

# Response of Source Area Contaminants to Enhanced Reductive Dechlorination



# Summary of Results

- Recirculating EVO caused plume retreat in the shallow HSUs.
  - Downgradient PCE concentrations decreased from  $>1,000 \mu\text{g/L}$  to  $<5 \mu\text{g/L}$ .
- A fine-grained zone near the source causes back-diffusion.
- Fracturing the clays and injecting 3DME<sup>®</sup> and S-MicroZVI<sup>®</sup> reduced contaminant concentrations, with no rebound in the center of the treatment area 32 months later (rebound occurred peripherally).
- More deep wells, the alternative amendments, and higher injection pressures show promise for better distribution in the deep HSUs than earlier EVO injections.