

Treatment of a Chlorinated Ethene Plume using Different Biological Amendment Mixtures to Reach Site Closure

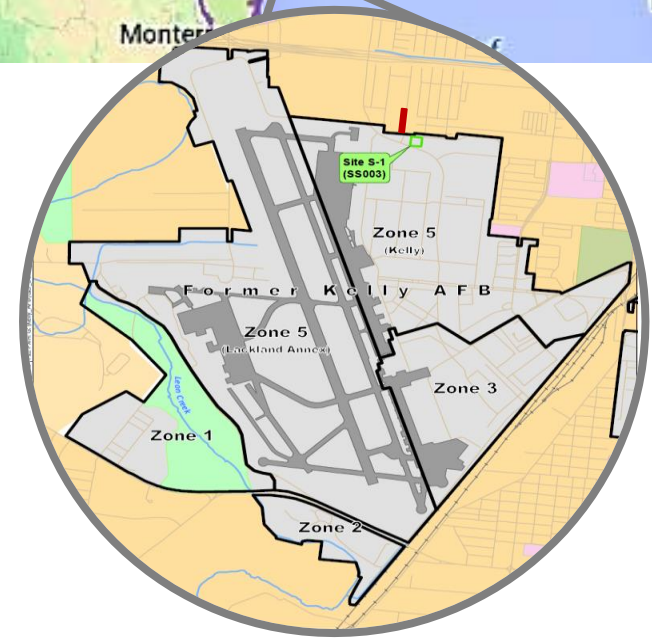
Sowmya Suryanarayanan

Praveen Srivastav, PhD, P.G., Susan Watson P.E.,
Robert E. Mayer & Allen Willmore, P.G.

24 May 2017



- Site Background
- Remedial Design
 - Approach
 - Implementation & Outcome
- Remediation Progress
- Conclusion



Former Kelly AFB

Plume

- Off-base residual plume in the vicinity of businesses & homes

- Unknown source

Primary COCs in GW

- PCE, TCE, cis-1,2-DCE & VC

Lithology

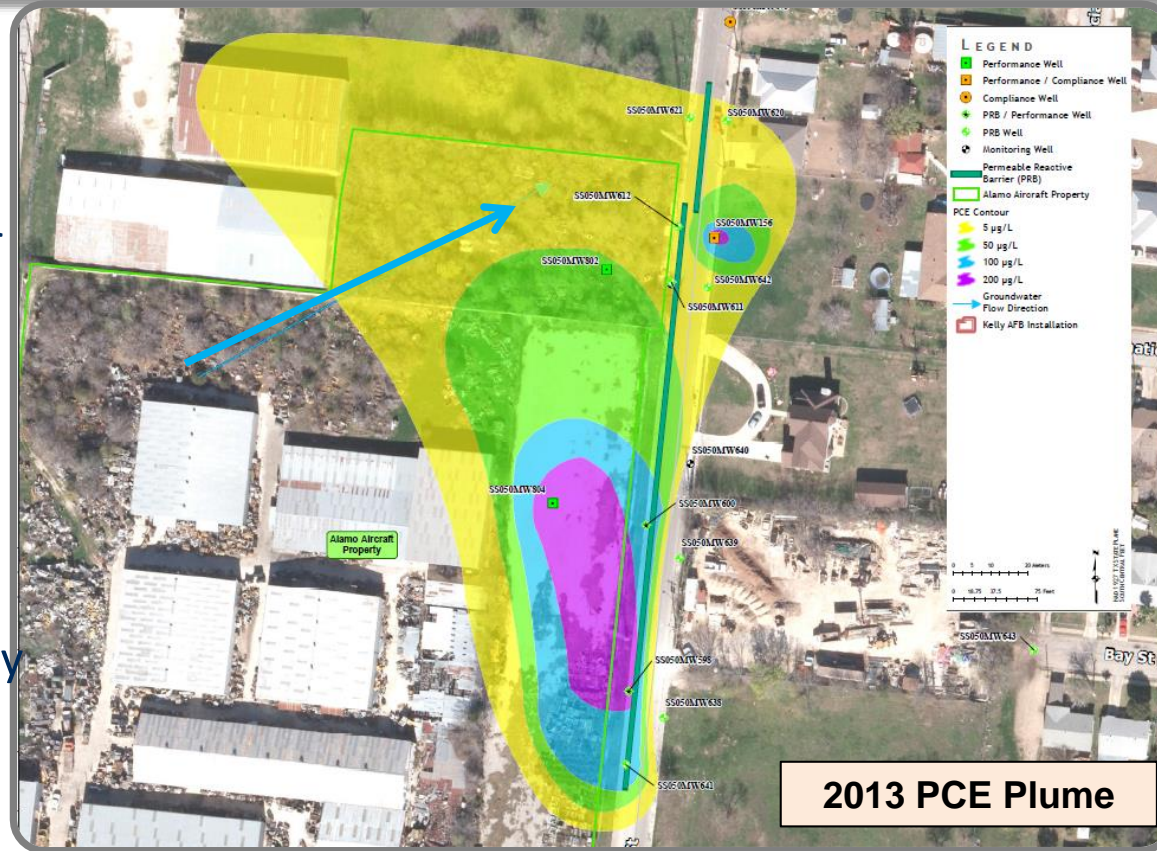
- clay, silt, clayey gravel, clayey fine sandy gravel underlain by Navarro clay

- DTW: 25 to 30 ft bgs

- Shallow aquifer; not a drinking water source

Past Remedial Actions

- ZVI PRB installed in 2 phases (southern part in 2004 & northern part in 2005)
- Monitored Natural Attenuation





- Work conducted under a PBR
- Goal selected for this site is site closure in 2020
- To attain goal, groundwater protection standard (GWPS) (based on MCLs) must be attained by 2017
- Remediation Approach is in situ bioremediation to address the chlorinated ethene plumes



2013 Conditions

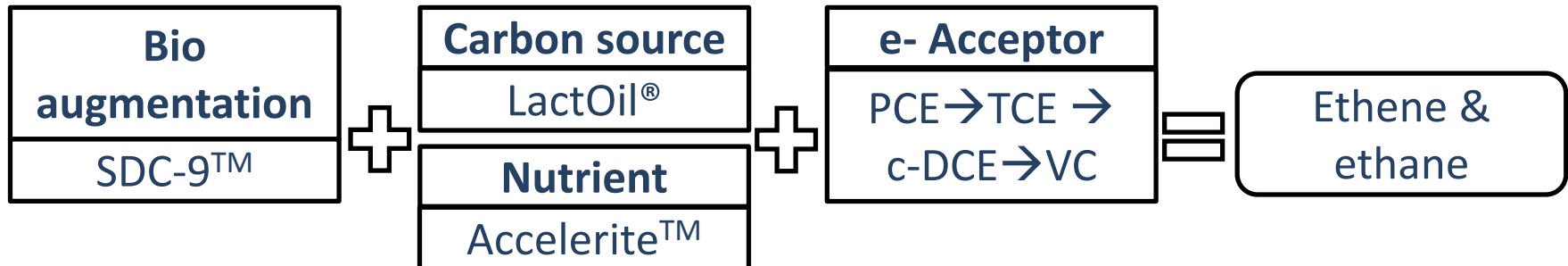
- Existing ZVI PRB
- Aerobic
- Low micro-biota
- High COCs upgradient of PRB

Challenges

- Physical obstructions
- Hard lithology
- Large spread of COCs
- Site access at private off-base property

Round I (Sep 2013): Approach

- Upgradient biological treatment to complement abiotic iron of the PRB
- Biowalls using injection points

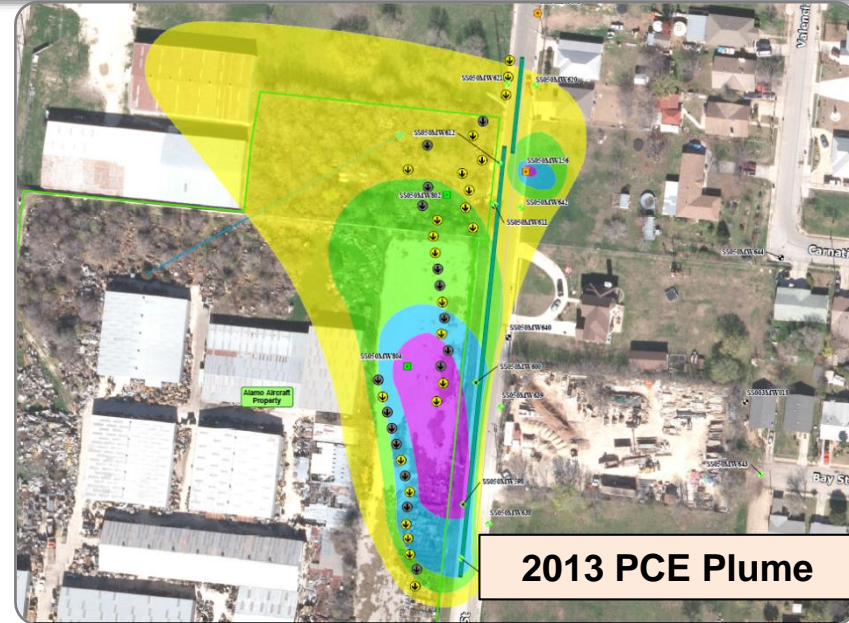


Implementation (Sep 2013)

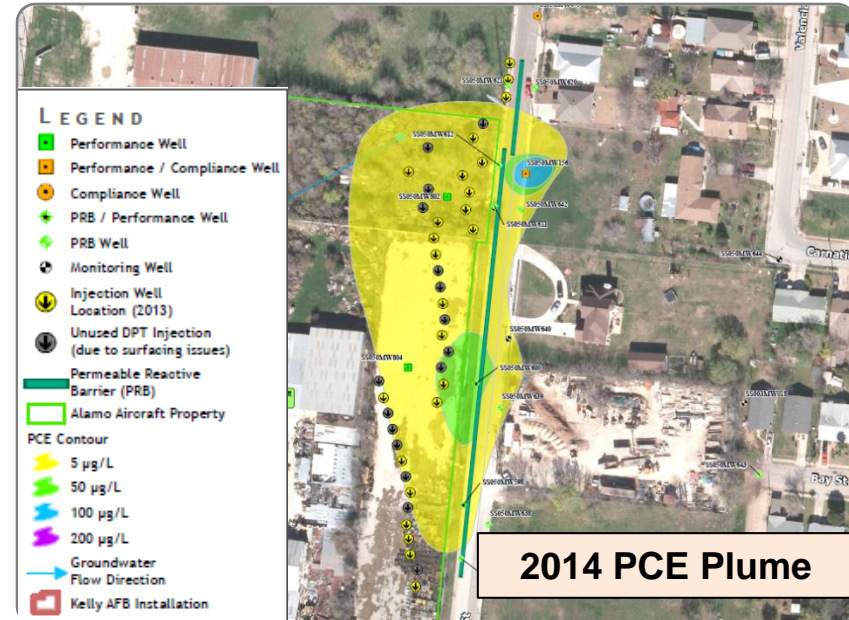
- 40 point biowall installed perpendicular to GW flow as injection points
 - Auger rig
 - DPT injection rods
 - Cost Effective
- Bioaugmentation: SDC-9™
- Carbon Source: LactOil®
 - 35% ethyl lactate (rapid carbon source)
 - 35% oleaginous material (long term donor)
- Microbial Nutrient: Accelerite™ Vitamin B12 and other micronutrients

Outcome (Apr 2014)

- Concentrations reduced
- Surfacing at many points
- Concentrations remain above GWPS



2013 PCE Plume



2014 PCE Plume

LEGEND

- Performance Well
- Performance / Compliance Well
- Compliance Well
- PRB / Performance Well
- PRB Well
- Monitoring Well
- Injection Well Location (2013)
- Unused DPT Injection (due to surfacing issues)
- Permeable Reactive Barrier (PRB)
- Alamo Aircraft Property

PCE Contour

- 5 µg/L
- 50 µg/L
- 100 µg/L
- 200 µg/L

→ Groundwater Flow Direction

■ Kelly AFB Installation



2014 Conditions

- Existing ZVI PRB
- Aerobic
- Low micro-biota

Challenges

- Surfacing
- Insufficient COC reduction downgradient of PRB

Round II (Nov 2014): Approach

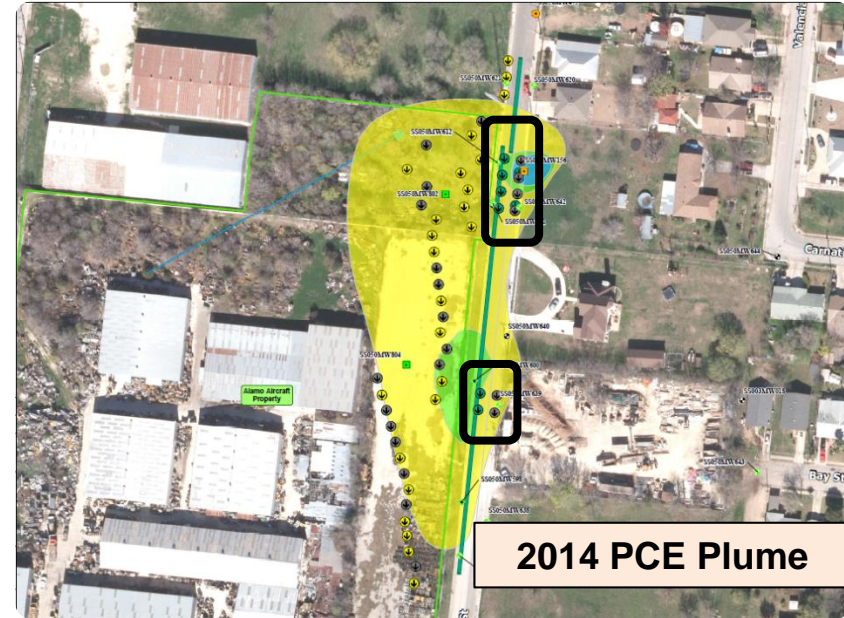
- Downgradient biological treatment to complement abiotic iron of the PRB
- Grid injections using inflatable packers

Implementation (Nov 2014)

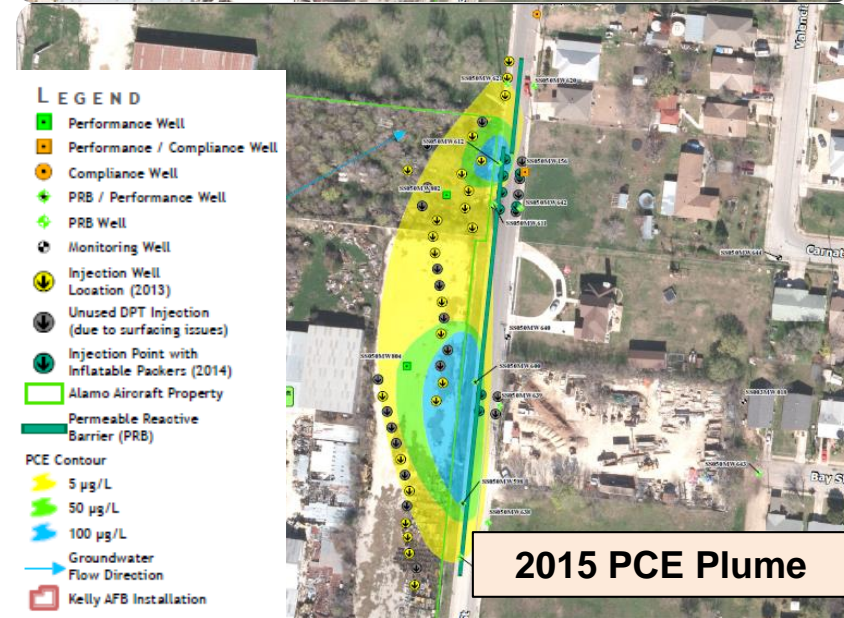
- 12 injection points installed as a grid
- Inflatable packers used to reduce surfacing
 - Auger rig
 - DPT injection rods
 - Cost Effective
- Bioaugmentation: SDC-9™
- Carbon source: LactOil®
- Microbial nutrient: Accelerite®

Outcome (Apr 2015)

- Concentrations reduced to below the GWPS downgradient of PRB
- Rebound in COCs concentrations upgradient of PRB



2014 PCE Plume



LEGEND

- Performance Well
- Performance / Compliance Well
- Compliance Well
- ⊕ PRB / Performance Well
- ⊕ PRB Well
- ⊕ Monitoring Well
- ⊕ Injection Well Location (2013)
- ⊕ Unused DPT Injection (due to surfacing issues)
- ⊕ Injection Point with Inflatable Packers (2014)
- ▭ Alamo Aircraft Property
- ▬ Permeable Reactive Barrier (PRB)

PCE Contour

- Yellow: 5 µg/L
- Green: 50 µg/L
- Blue: 100 µg/L

- Groundwater Flow Direction
- ▭ Kelly AFB Installation

2015 PCE Plume



2016 Conditions

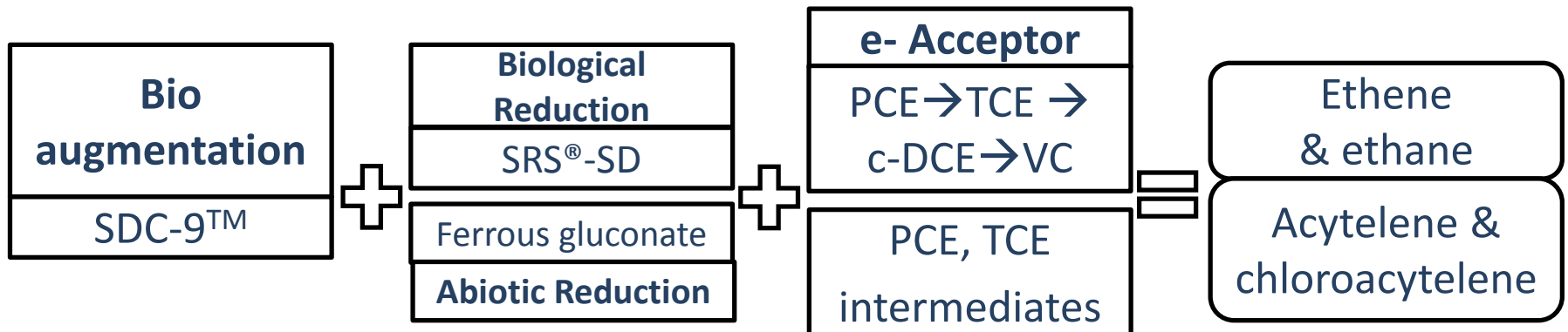
- Existing ZVI PRB
- Aerobic
- Low micro-biota

Challenges

- Rebound in COCs upgradient of PRB
- Site Access
- Time to Site Closure

Round III (Apr 2016): Approach

- Injection Wells
- Upgradient addition of iron
- Upgradient Biological treatment

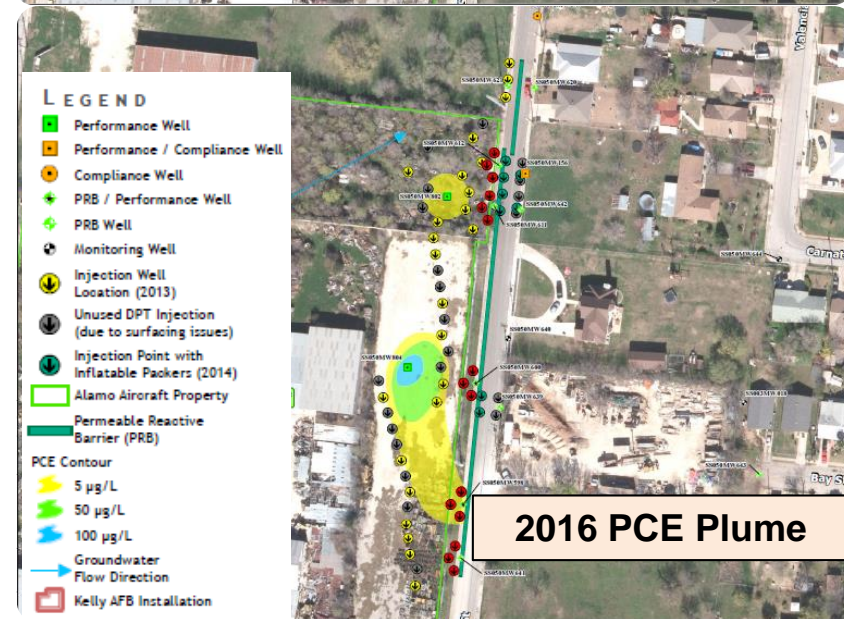
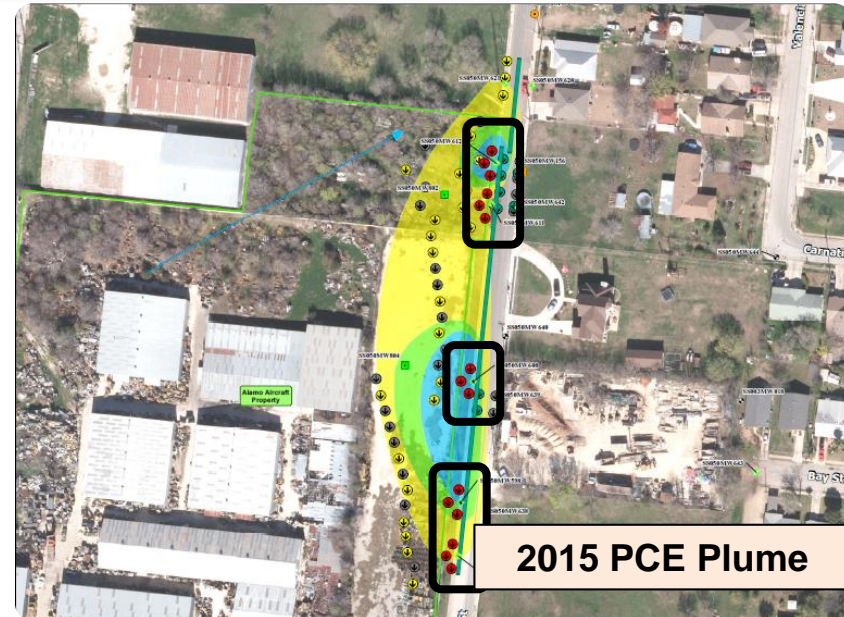


Implementation (Apr 2016)

- 15 injection wells installed as a grid
 - Future Re-injections
 - Less Surfacing
- Bioaugmentation: SDC-9™
- Carbon and Iron source: SRS®-SD
 - Custom made mix
 - Small droplet EVO
 - Ferrous gluconate
 - Microbial nutrient
 - Abiotic chemical reduction using ferrous iron to produce reduced minerals coupled with anaerobic bioremediation for treatment of COCs

Outcome (Jun 2016)

- Concentrations reduced
- Concentrations further upgradient of the PRB remain above GWPS



- LEGEND**
- Performance Well
 - Performance / Compliance Well
 - Compliance Well
 - PRB / Performance Well
 - PRB Well
 - Monitoring Well
 - Injection Well Location (2013)
 - Unused DPT Injection (due to surfacing issues)
 - Injection Point with Inflatable Packers (2014)
 - Alamo Aircraft Property
 - Permeable Reactive Barrier (PRB)
- PCE Contour**
- 5 µg/L
 - 50 µg/L
 - 100 µg/L
 - Groundwater Flow Direction
 - Kelly AFB Installation



2016 Conditions

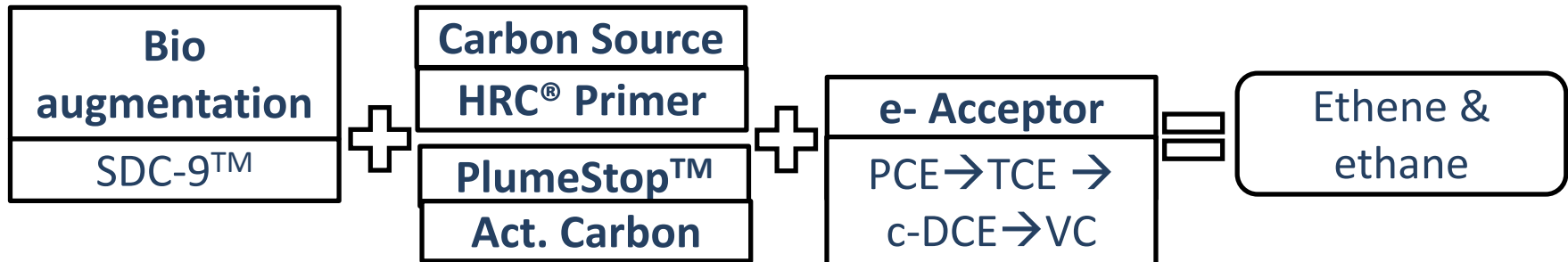
- Existing ZVI PRB
- Aerobic
- Low micro-biota

Challenges

- Site Access
- Insufficient reduction of COCs
- Time to Site Closure

Round IV: Approach

- Focused upgradient biological treatment using activated carbon
- Bioaugmentation
- Injection Wells

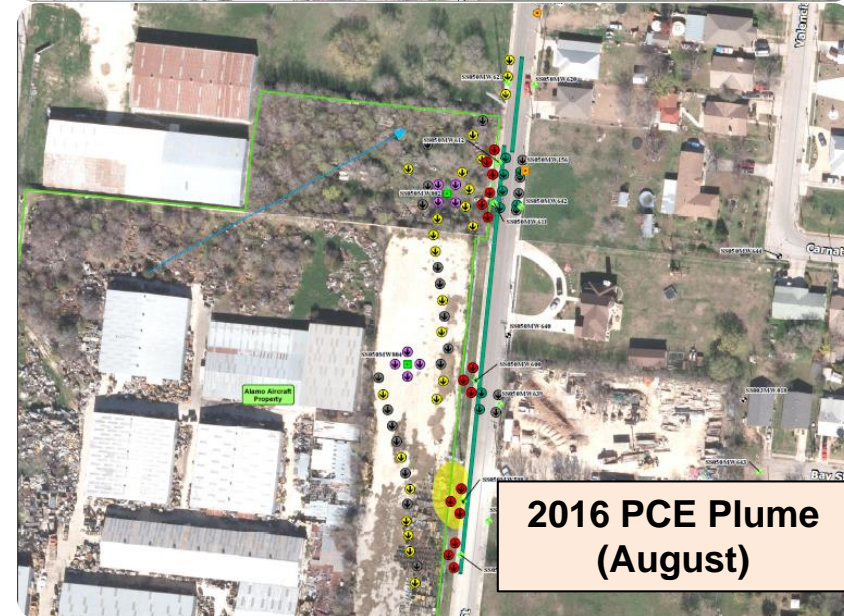
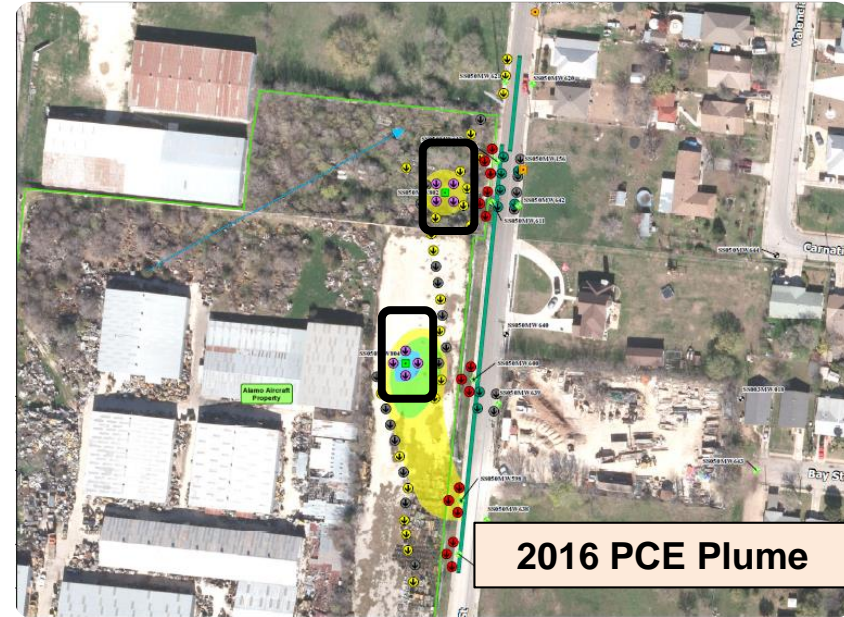


Implementation (Jul 2016)

- 8 injection wells installed as a grid
- Injection wells for future reinjections
- Bioaugmentation: SDC-9™
- Activated Carbon: PlumeStop™
 - Sorbs contaminants, removing them from mobile phase
 - Provides high surface area favorable for microbial growth
- Carbon source: HRC® Primer
 - Electron donor
 - Co-applied with PlumeStop™

Outcome (Aug 2016)

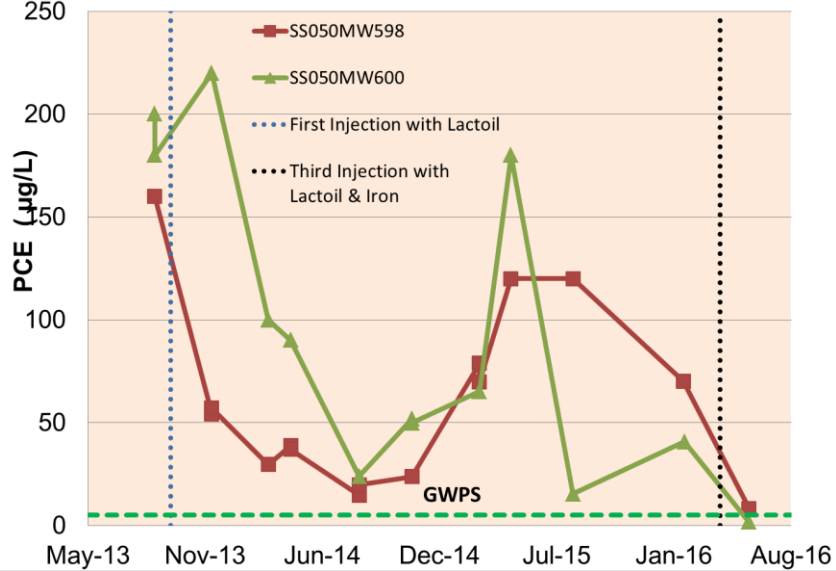
- Concentrations reduced to below the GWPS in majority of wells



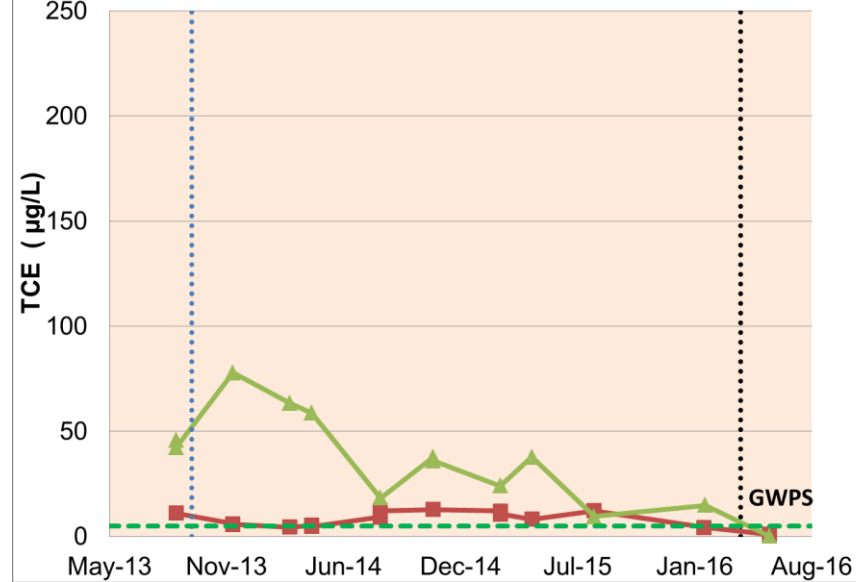


Remediation Progress (LactOil® and Iron)

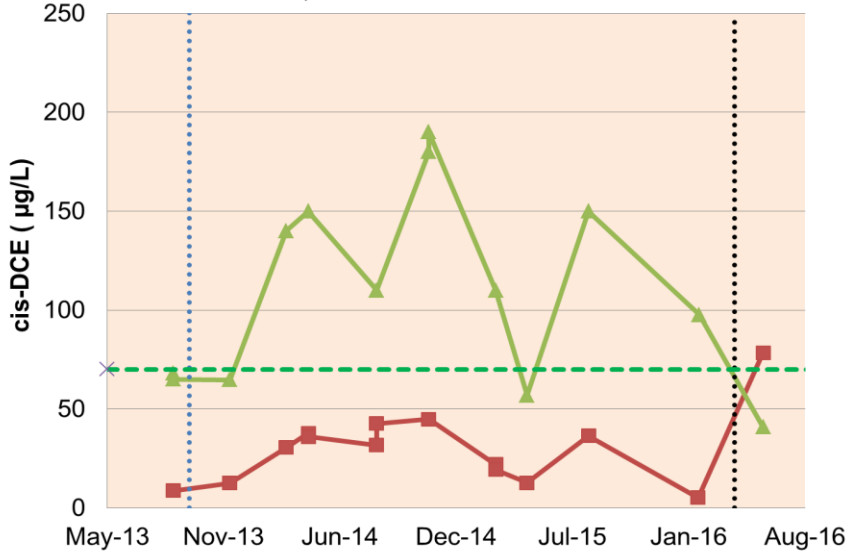
PCE Concentration Trend



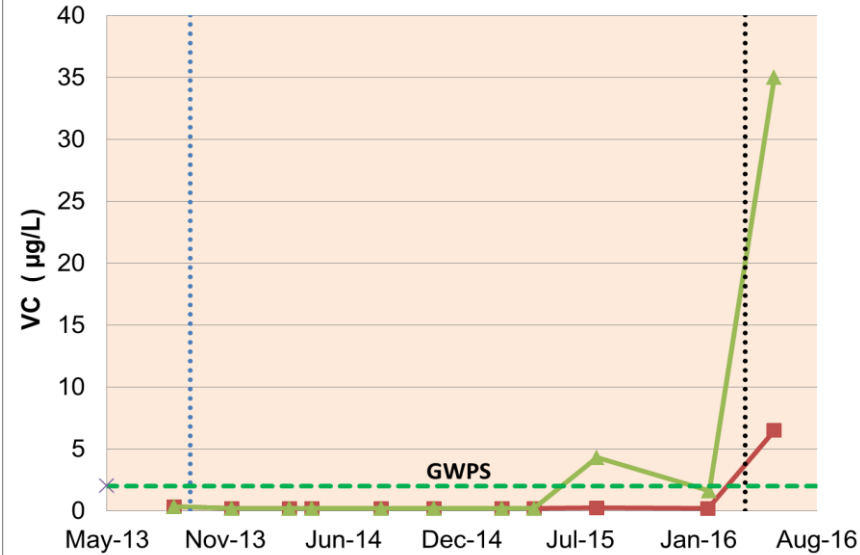
TCE Concentration Trend



cis-1,2-DCE Concentration Trend



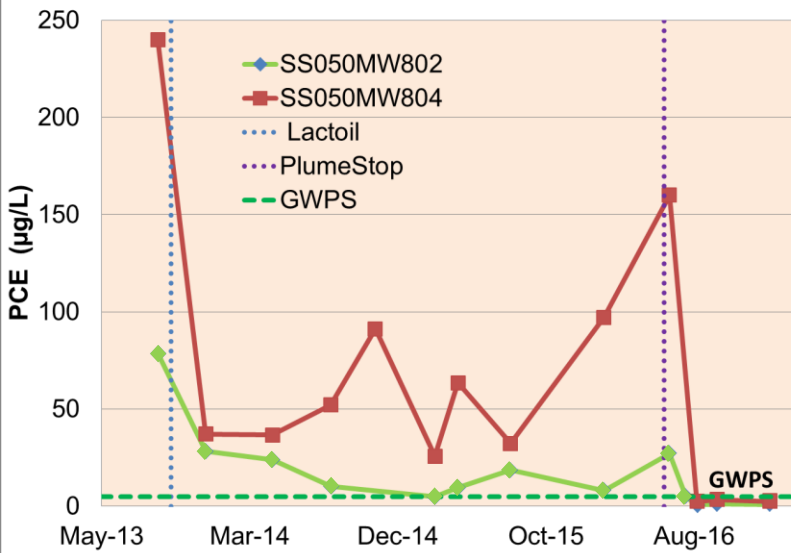
VC Concentration Trend



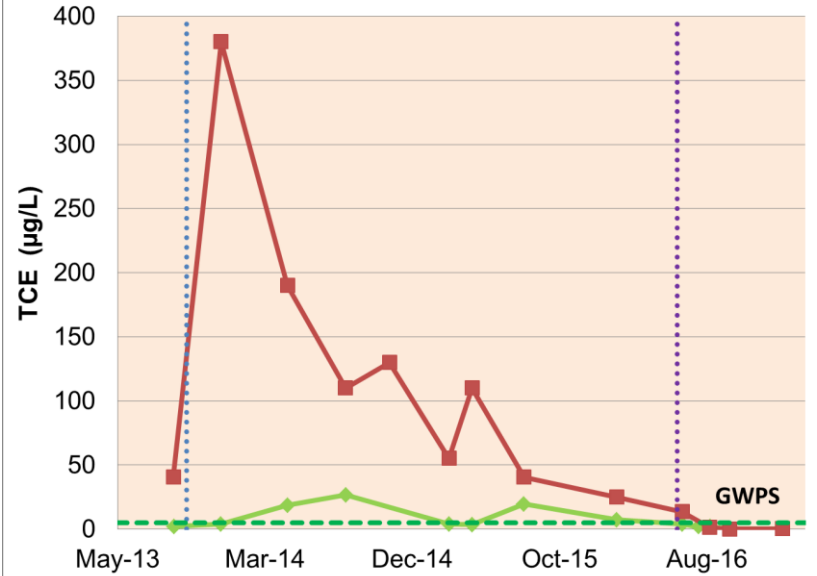


Remediation Progress (PlumeStop™ & HRC)

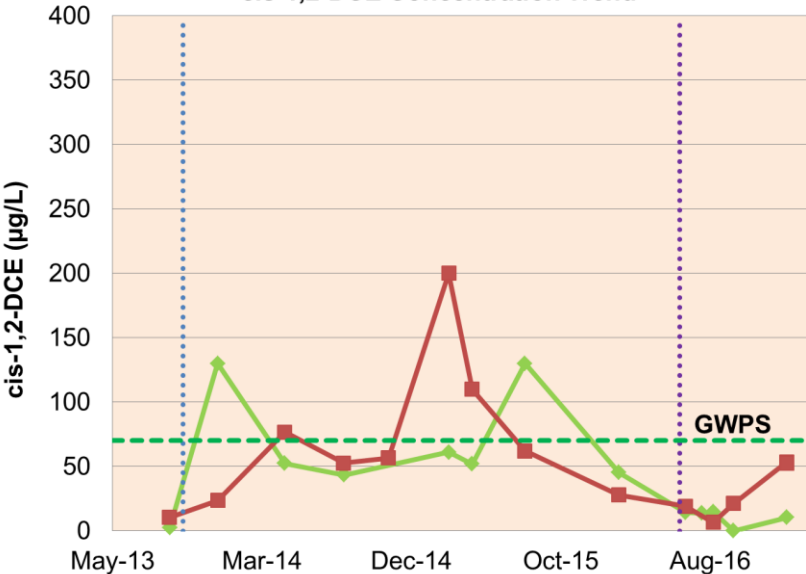
PCE Concentration Trend



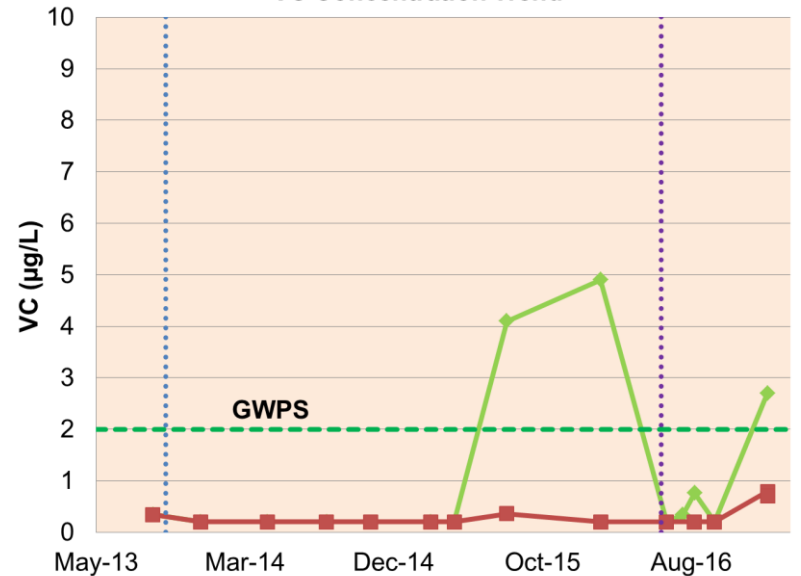
TCE Concentration Trend

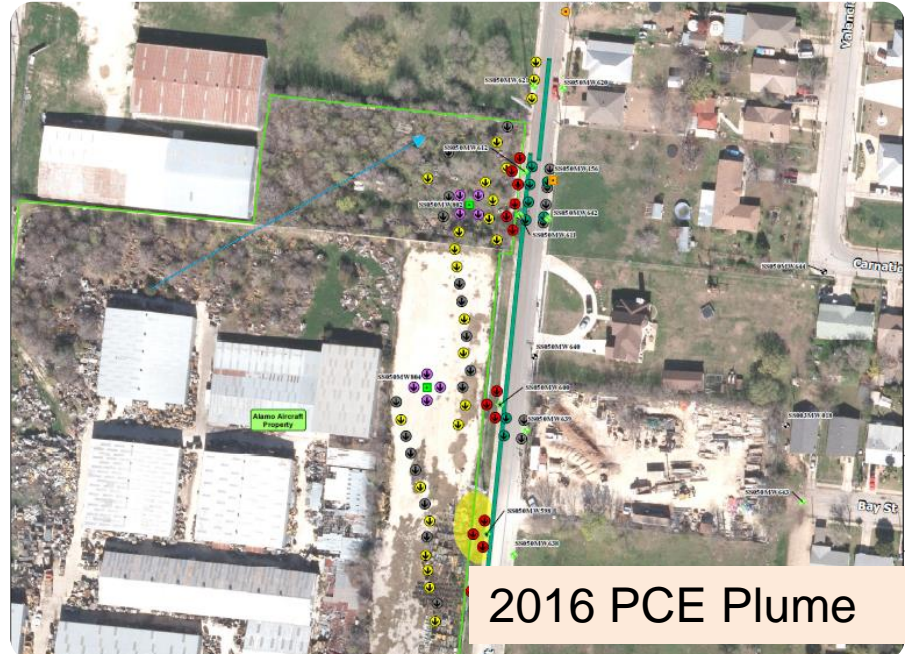
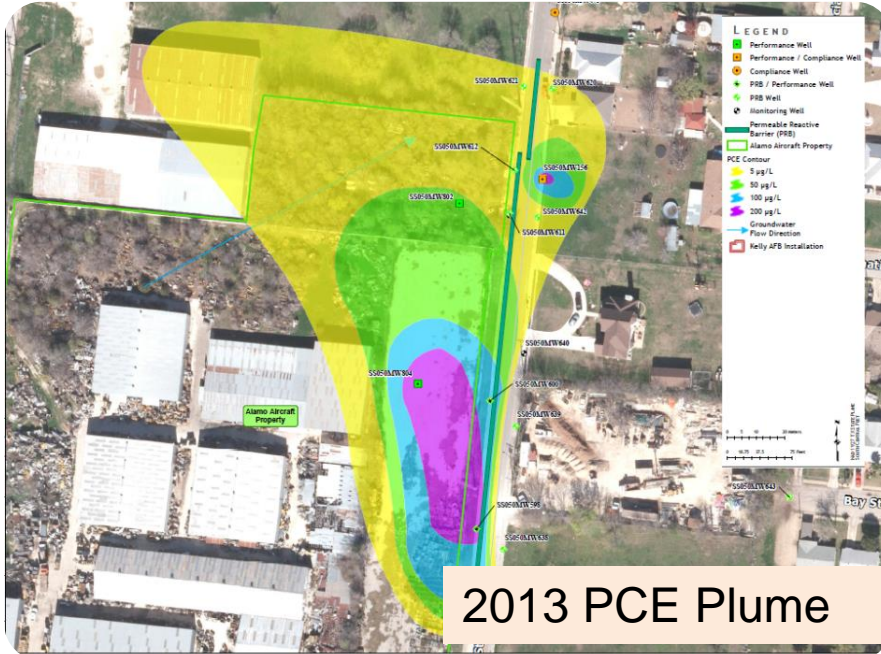


cis-1,2-DCE Concentration Trend



VC Concentration Trend





- PCE plume has reduced to below GWPS (except for localized spot)
- TCE concentrations reduced below the GWPS at all monitoring wells
- VC and cis-1,2-DCE above GWPS at 3 monitoring wells
- CB&I conducted reinjections in March 2017 in areas above GWPS
- CB&I will continue monitoring the site for reduction in COCs

Thank You!



A special thanks to my project team

Praveen Srivastav, Allen Willmore, Andy Callahan, Susan Watson, Rob Mayer & Matthew Mikulin

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