

Remediation Technology Symposium (RemTech) 2012

Enhanced Bioremediation of Chlorinated Solvents in Fractured Media



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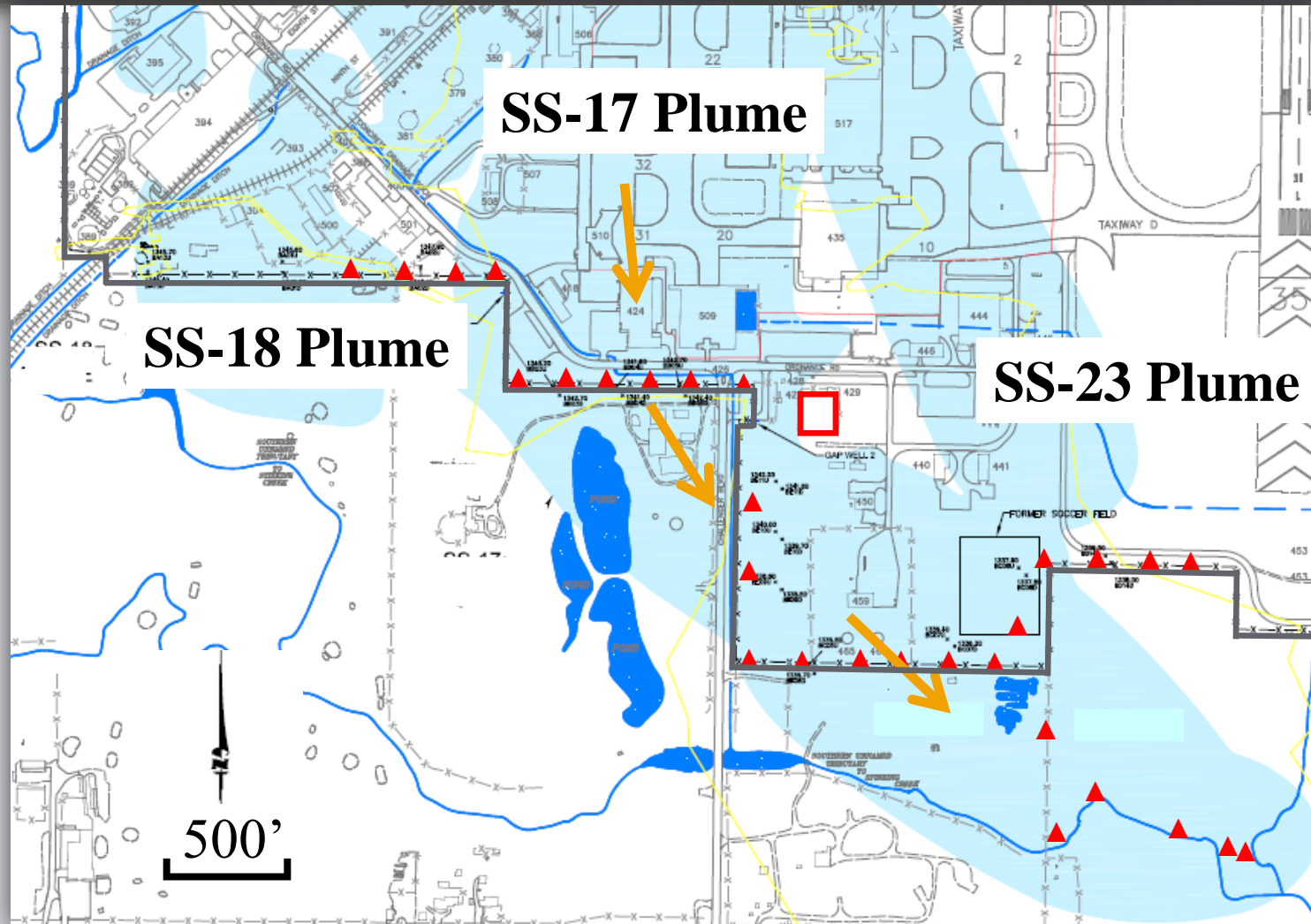
Acknowledgements

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Overview

- Site Description / Problem Statement
- Remedy Objectives
- Remedy Implementation - Substrate Injection
- Performance Monitoring
- Conclusions

Altus Pre-Biowall Overview (2003)



Biowall System Install

- 5,800 linear feet of biowall installed to 35 ft bgs in 2005
- Biowall backfill:
 - cotton burrs (11%)
 - bark mulch (42%)
 - sand (47%)
- Upper and lower horizontal wells installed in biowall segments

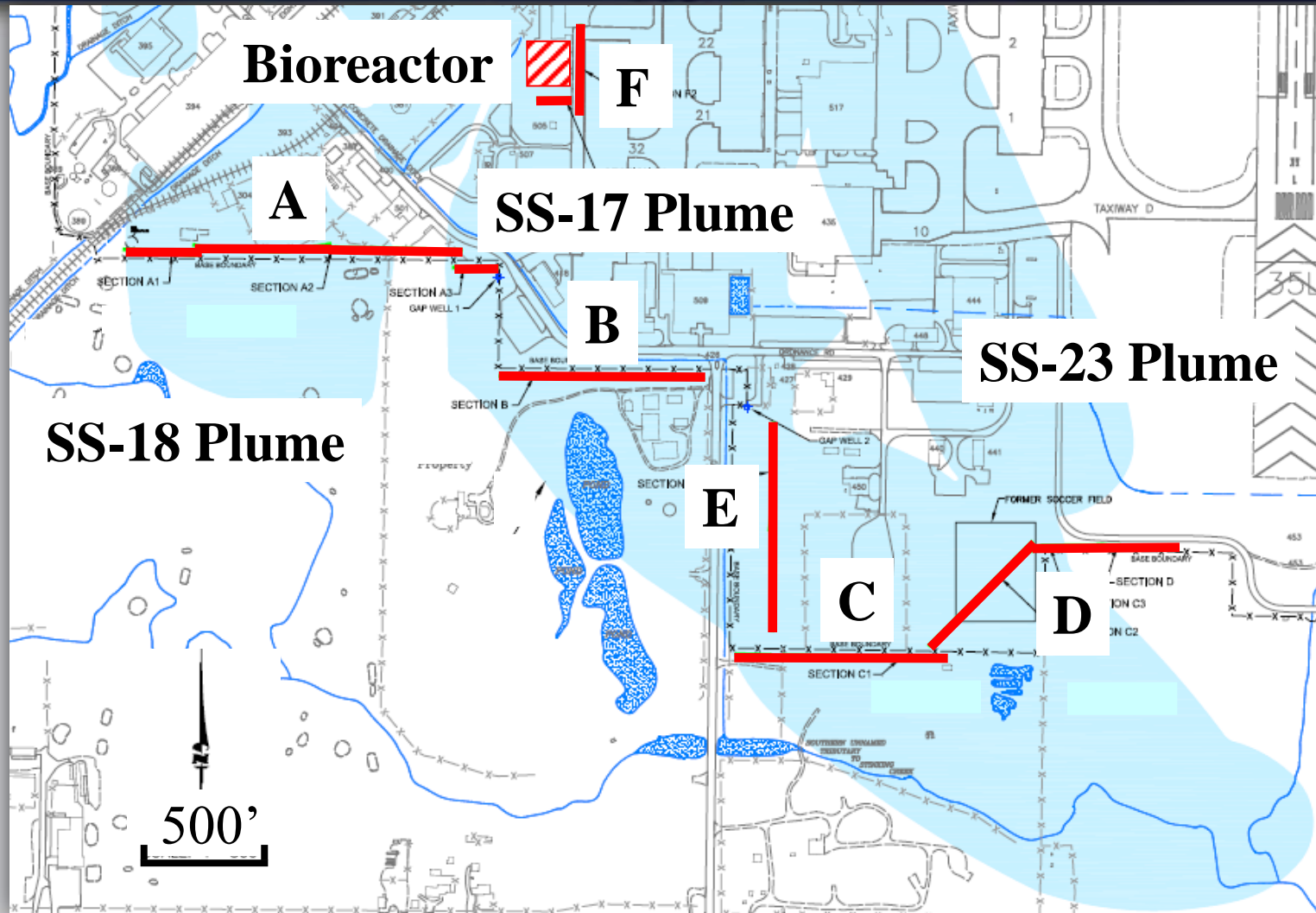


Bioreactor System Install - 2007

- 10,000 yd excavation to a depth of 35' bgs
- Backfill similar to biowalls
- Recirculation system installed to extract water from downgradient and re-inject into bioreactor



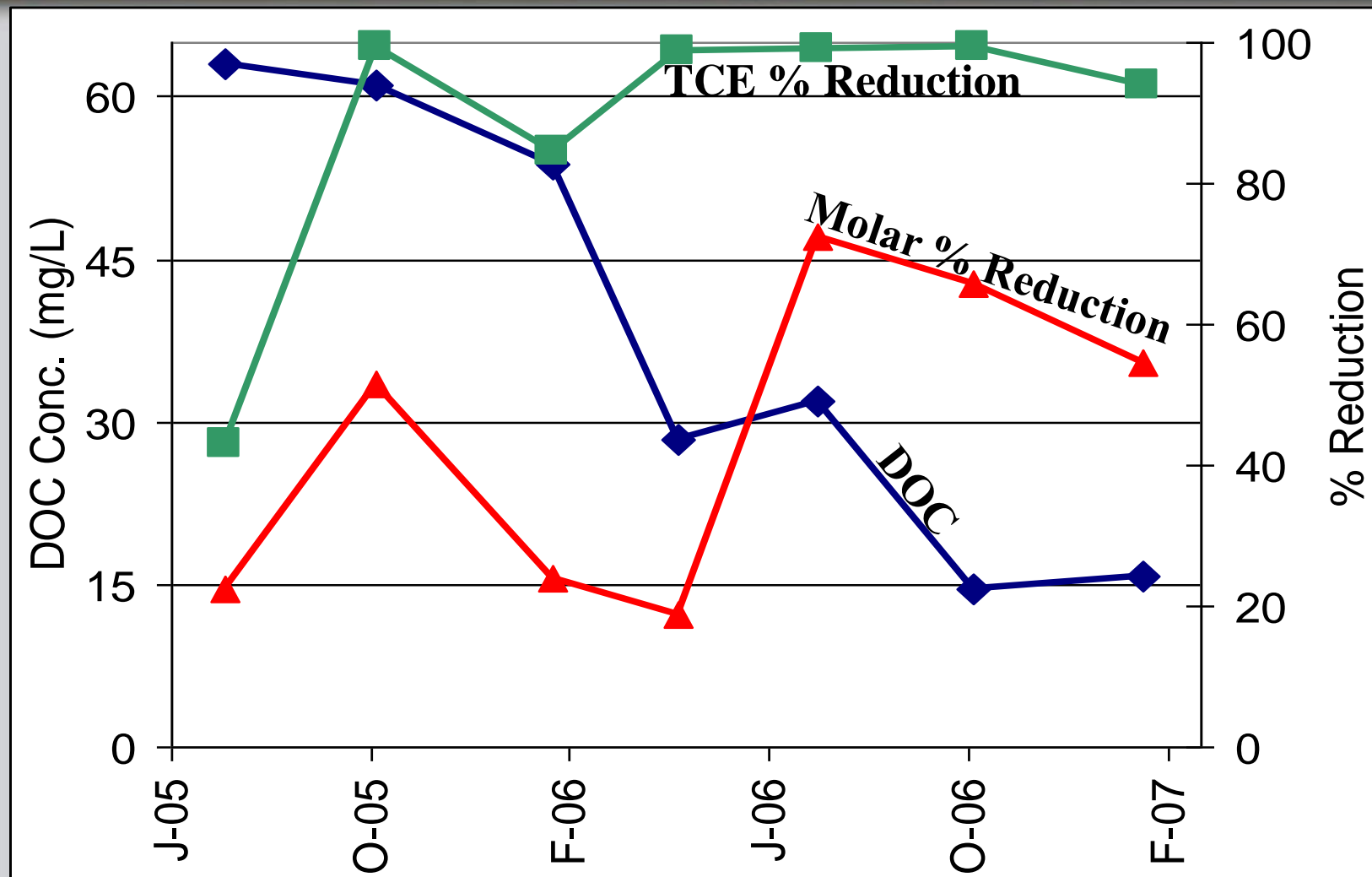
Altus Biowall System Overview



Bio System Results 2005 - 2007

	Percent Reduction (as of 2007)		
	TCE	Total Molar	Toxicity
Segment A	89%	70%	71%
Segment B	98%	94%	93%
Segment C	86%	27%	25%
Segment D	79%	36%	69%
Segment E	95%	18%	3%
Segment F	98%	92%	89%
Average	97%	85%	77%

Bio System Results 2005 – 2007



Bio-System Refresh - 2008

- A total of 811,280 pounds of soybean oil were emulsified in the field with 1,006,500 gallons of groundwater
- Groundwater extraction, substrate mixing, and re-injection of emulsion was conducted in one continuous operation
- A total of 1,200,000 gallons of fluid were injected between June and October 2008

Bio-System Refresh - 2008

- Soybean oil was delivered in 21 bulk loads of neat oil

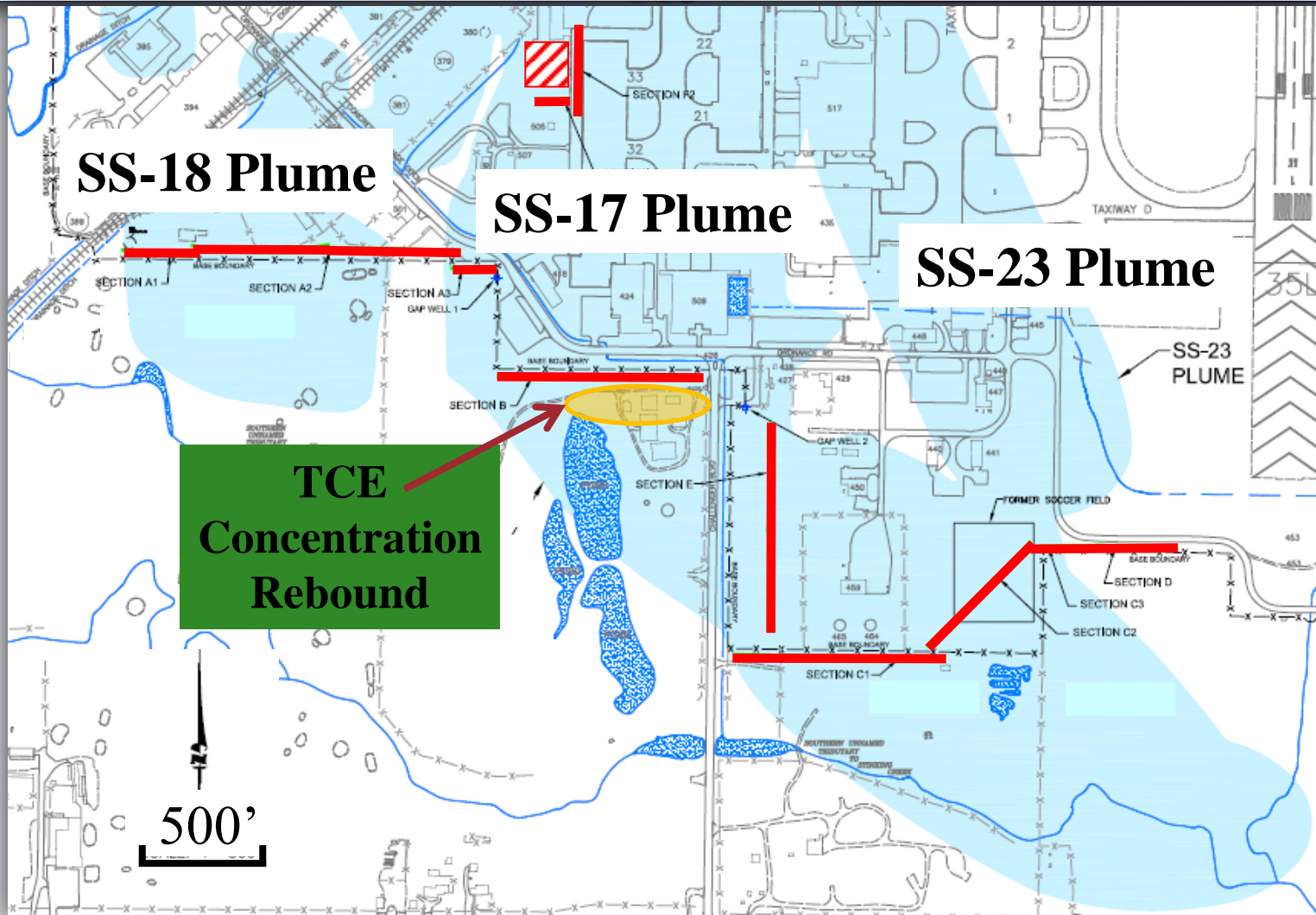


- Injection was completed over 4 months of 24 / 7 operation

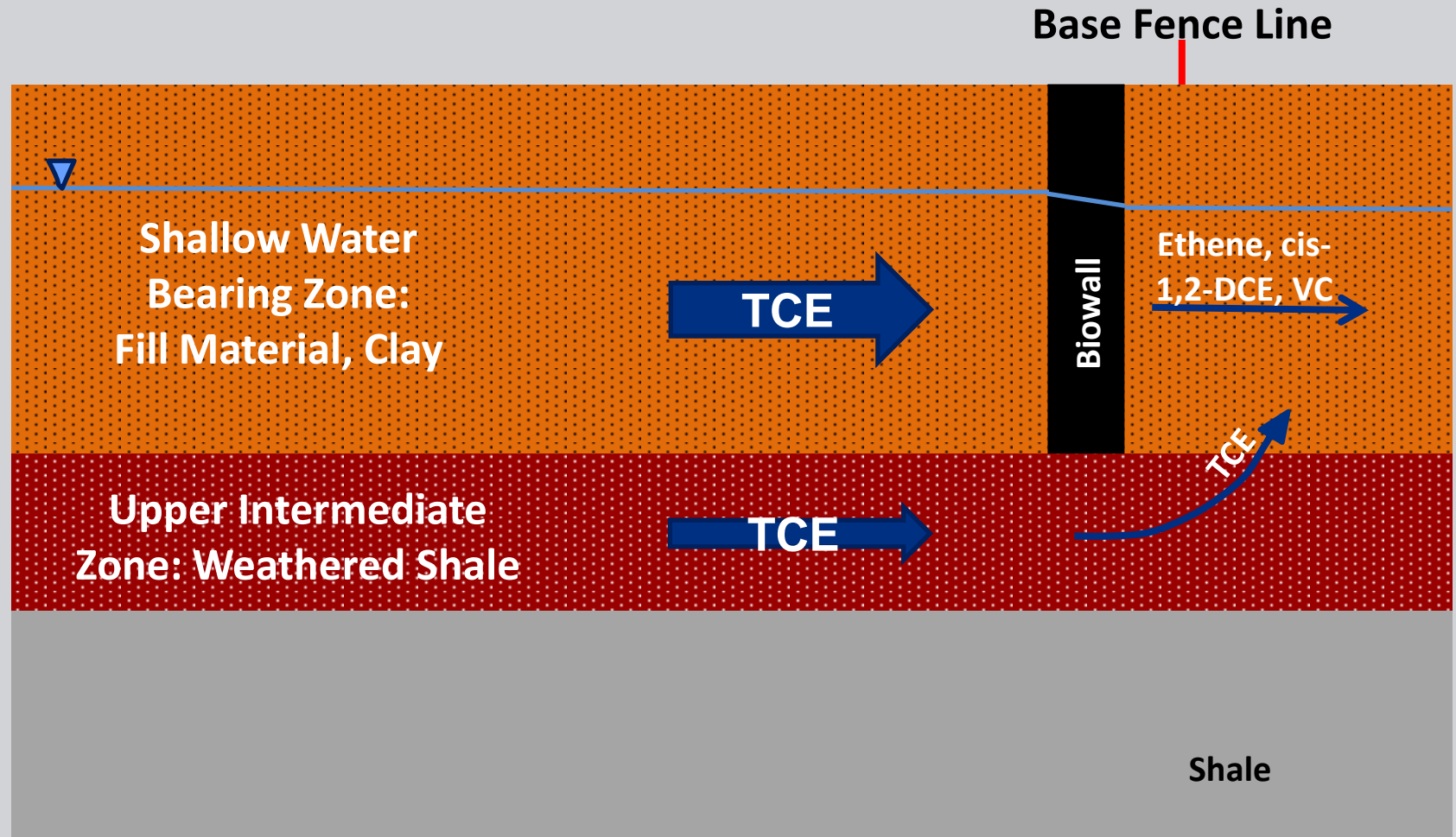
Bio-System Performance 2008 - Current

	Percent Reduction (as of 4/2012)		
	TCE	Total Molar	Toxicity
Segment A	98%	89%	91%
Segment B	100%	99%	98%
Segment C	99%	90%	93%
Segment D	99%	90%	85%
Segment E	99%	95%	93%
Segment F	99%	99%	98%
Average	99%	94%	93%

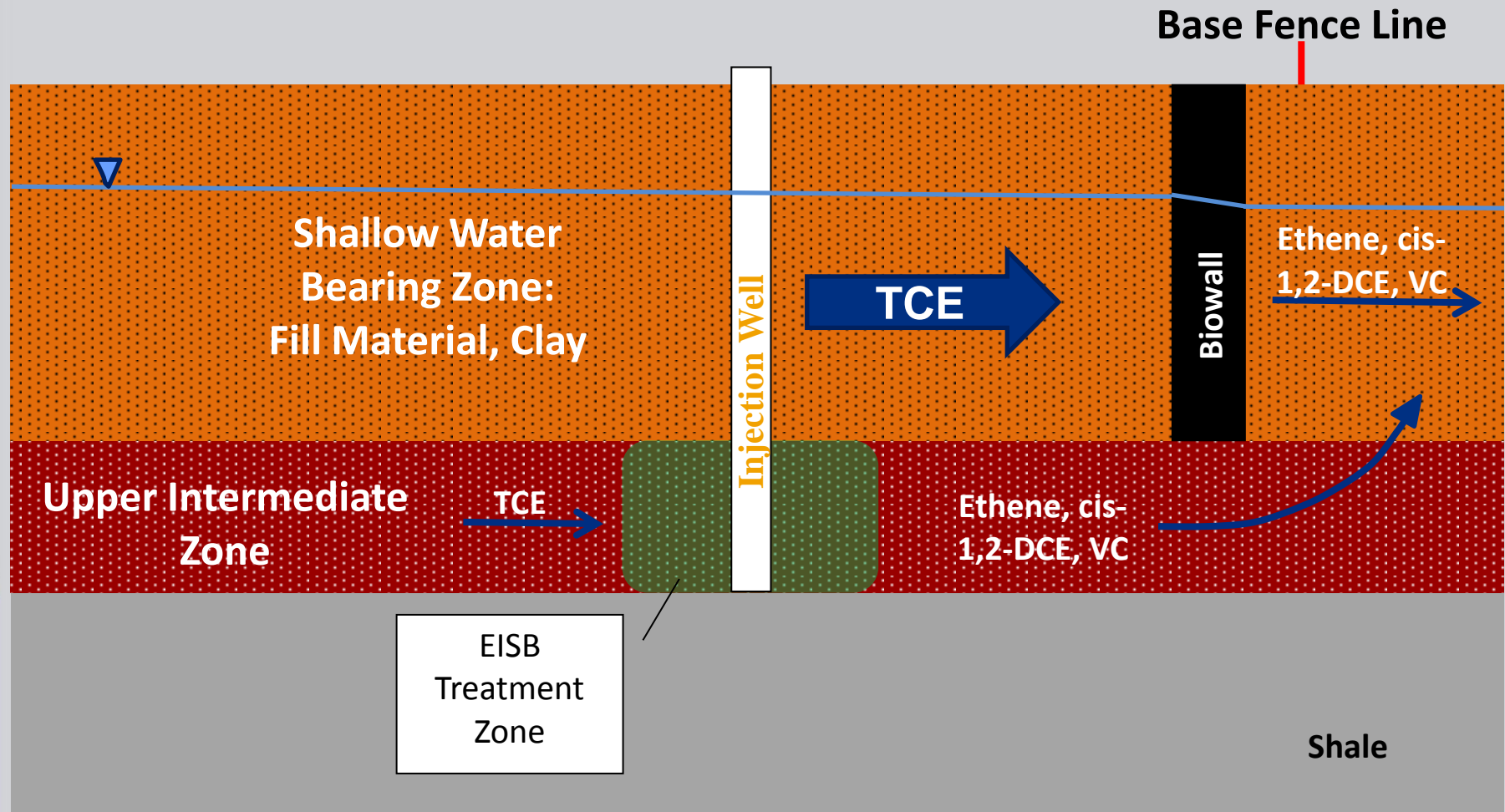
Altus Biowall System Overview



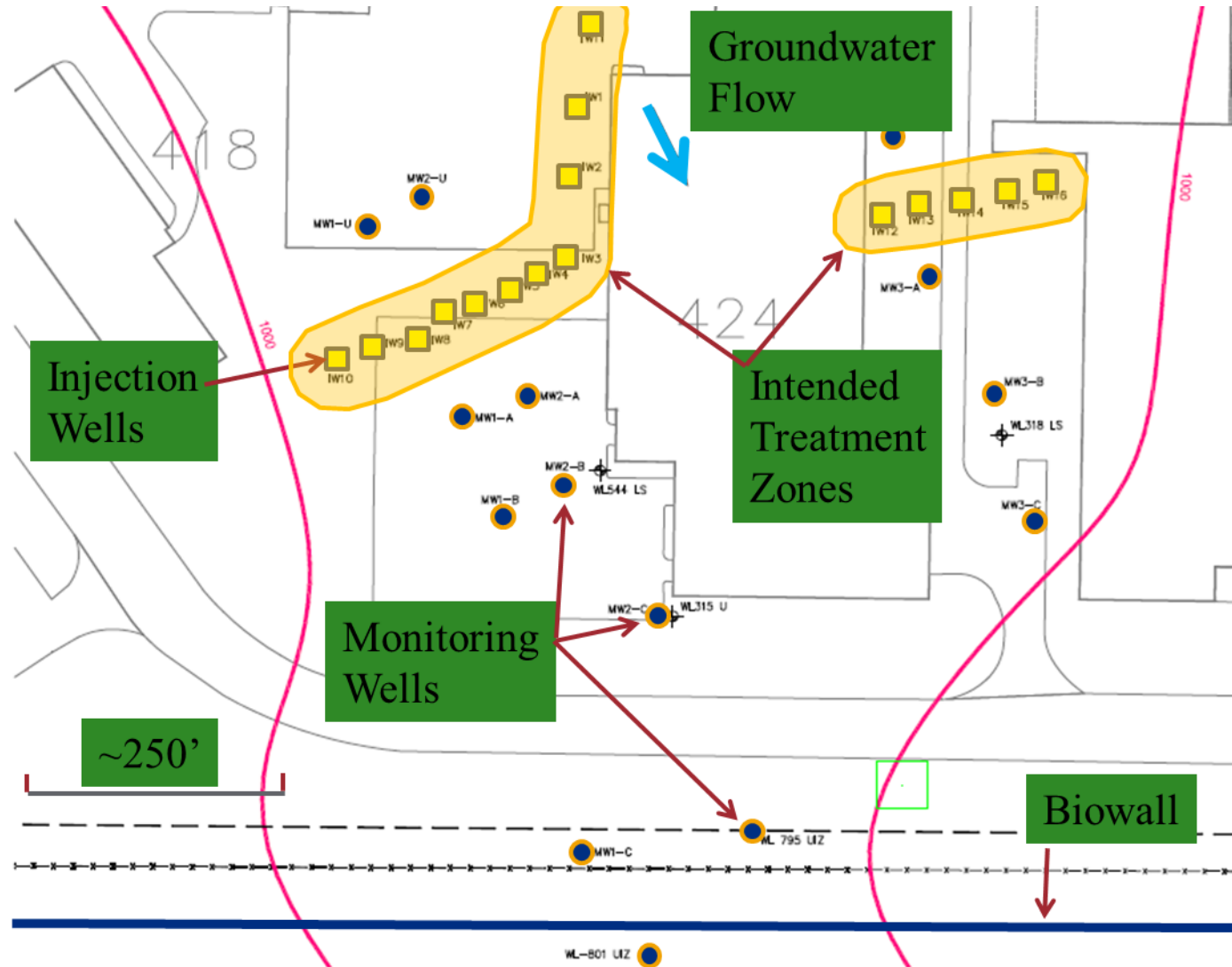
Altus SS-17 Cross Section



Altus SS-17 Cross Section



SS-17 Intermediate Zone Application

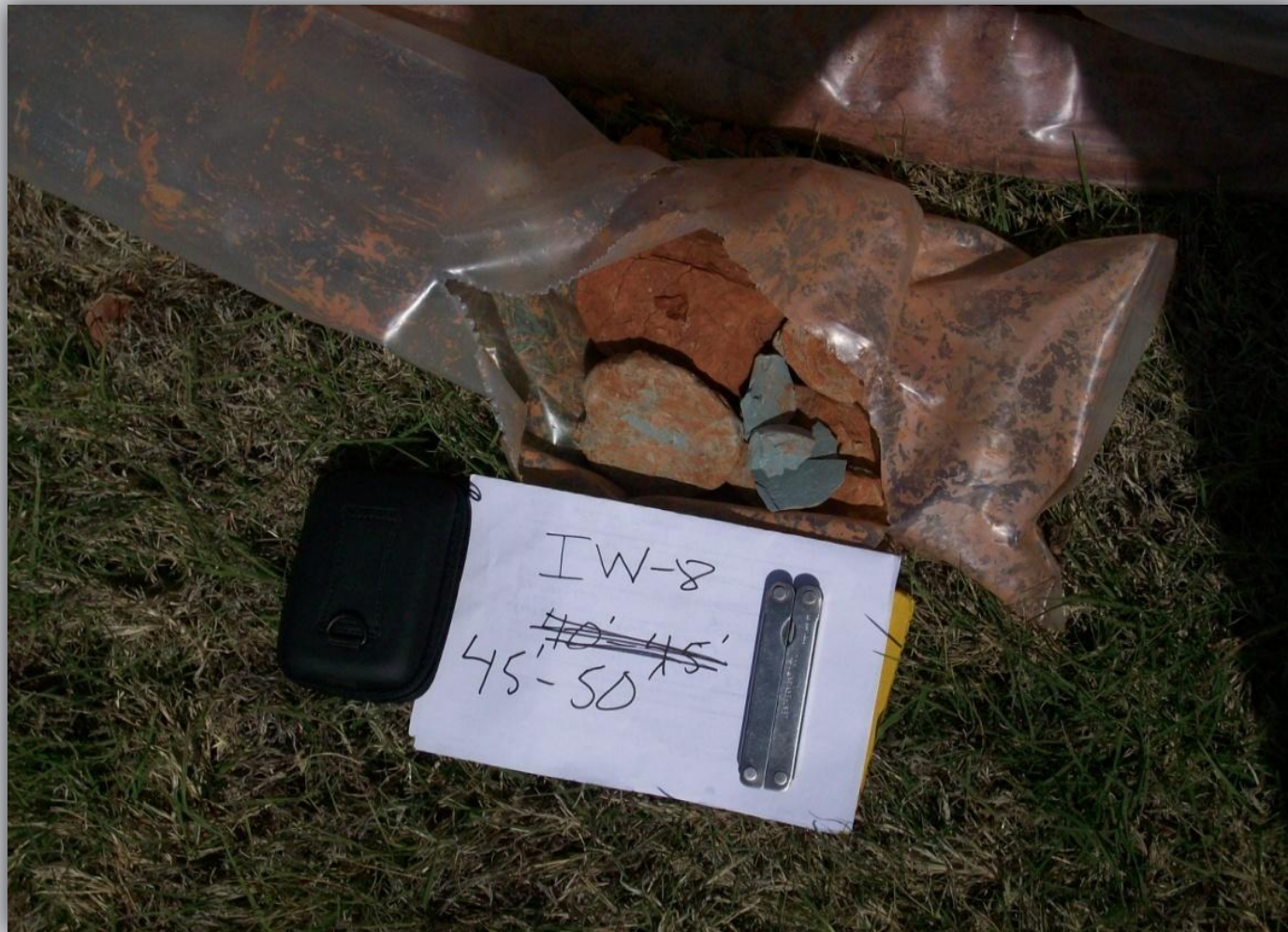


Well Installation

- Well Installations
 - 16 injection wells on 20' spacing
 - 12 monitoring wells upgradient and downgradient from treatment area
- Wells installed using roto sonic drilling



Well Installation



Well Installation



Substrate Injection

- Injections conducted July 2008
 - 6,102 gallons soy bean oil
 - 93,828 gallons total injection including make-up water
- Trailer-mounted mixing/injection system for field emulsification
- Injection completed through recirculation



Performance Monitoring

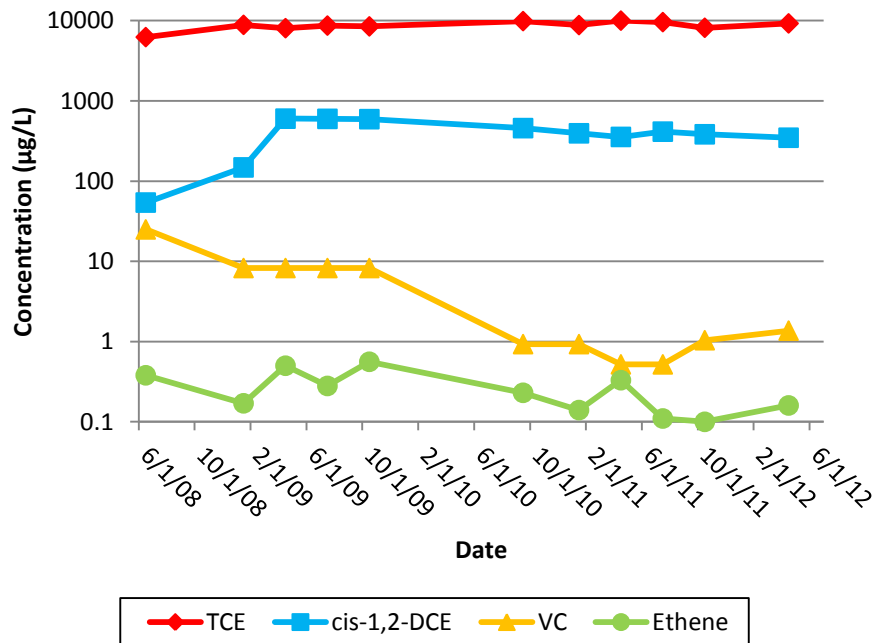
- Baseline monitoring
June 2008
- Performance Monitoring
 - Quarterly for year 1
 - Semi-annually for years 2, 3, and 4



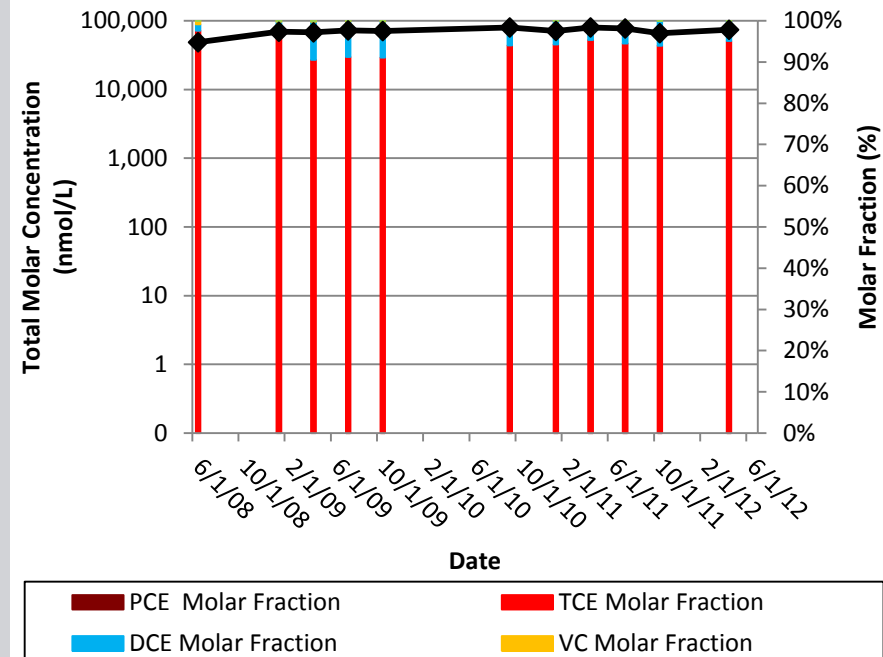
Performance Monitoring

Upgradient Wells MW1-U, MW2-U, MW3-U

MW2-U



MW2-U

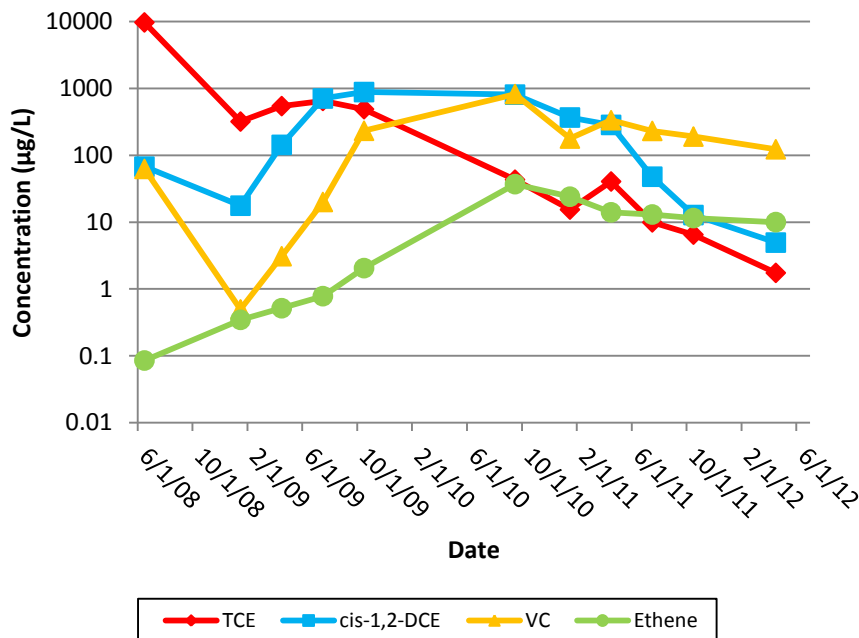


- Chlorinated ethenes are in the form of TCE
- Upgradient wells unimpacted by treatment

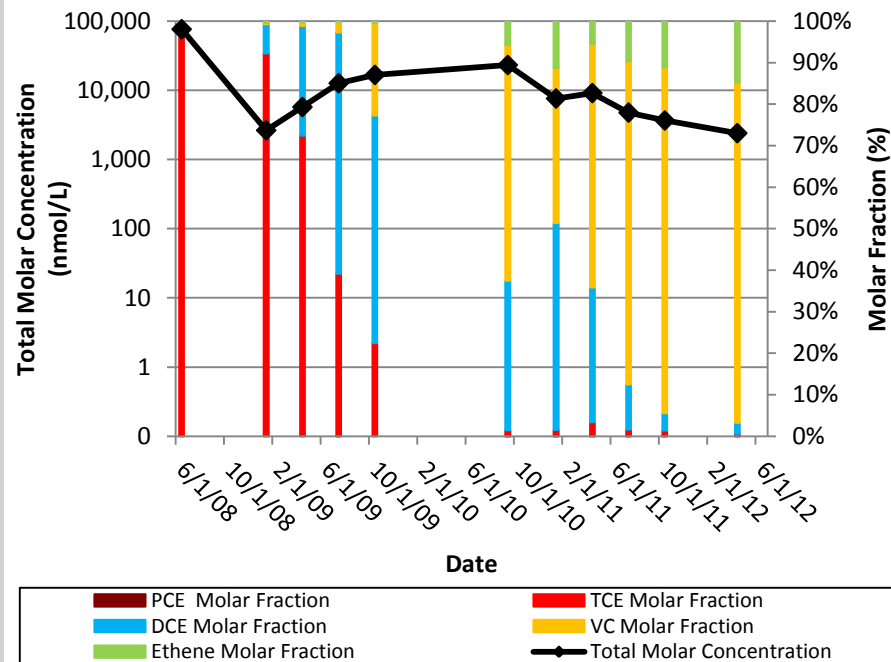
Performance Monitoring

Injection Wells I5, I8, I13

IW5



IW5

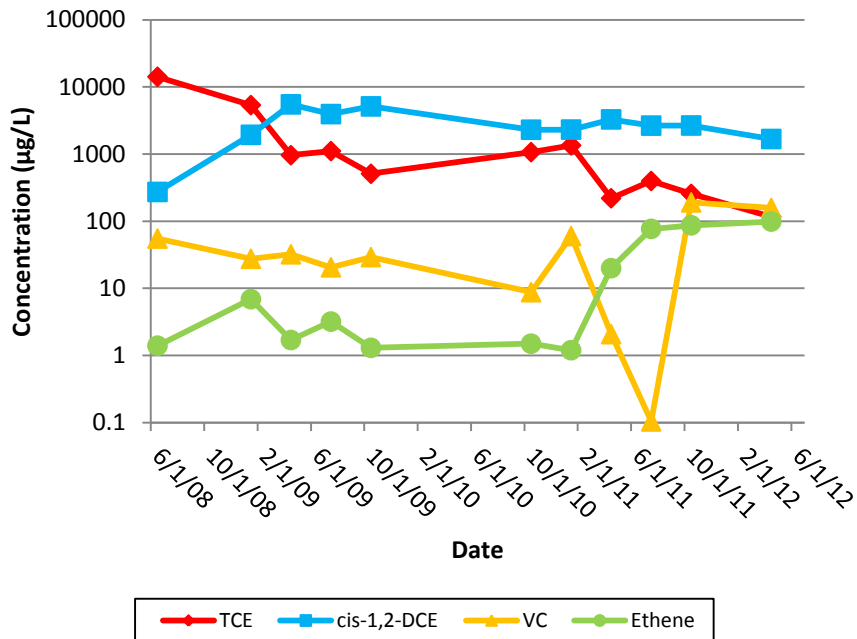


- TCE being dechlorinated VC / ethene
- Total molar concentration decreased by 97%

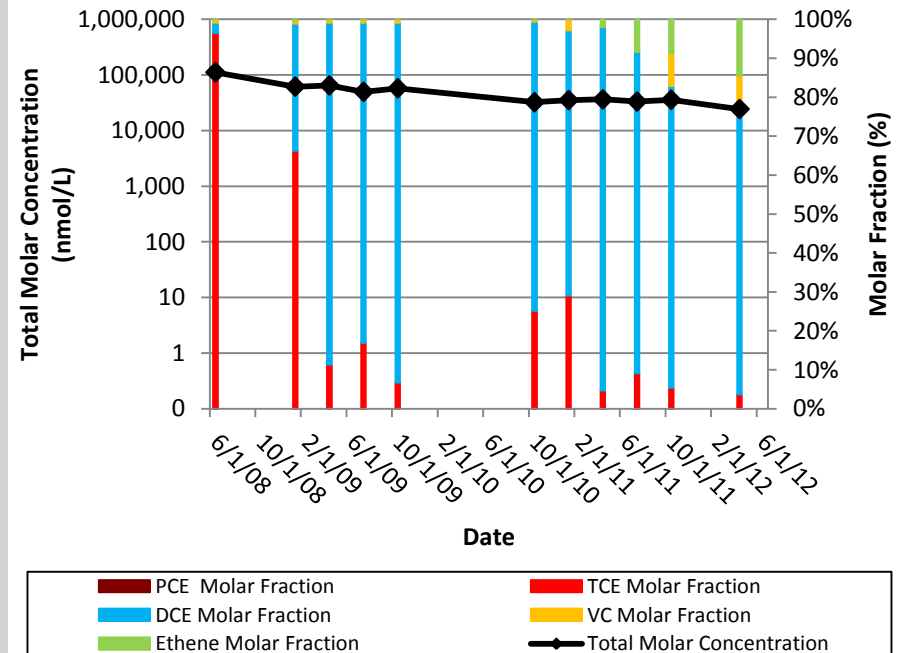
Performance Monitoring

Downgradient Wells MW1-A, MW1-B, MW2-A, MW3-A (75' downgradient)

MW3-A



MW3-A

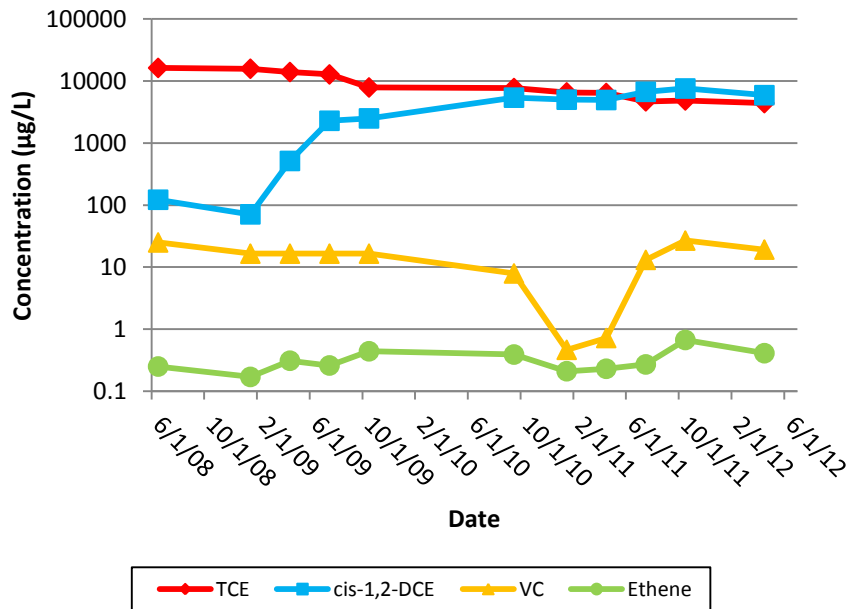


- TCE dechlorinated primarily to DCE + some VC / ethene
- Total molar concentration decreased by ~75%

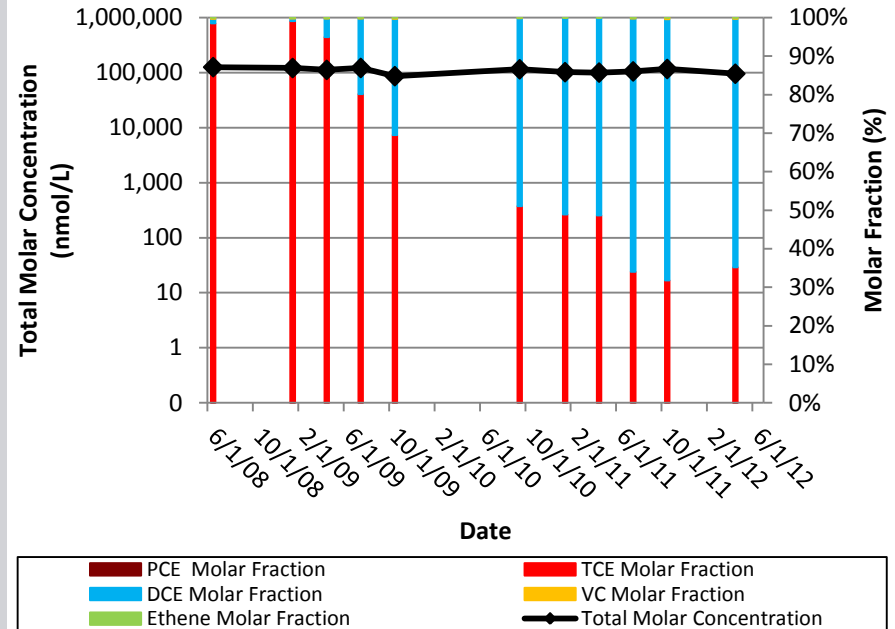
Performance Monitoring

Downgradient Wells MW2-B, MW2-C, MW3-B (150' downgradient)

MW2-B



MW2-B

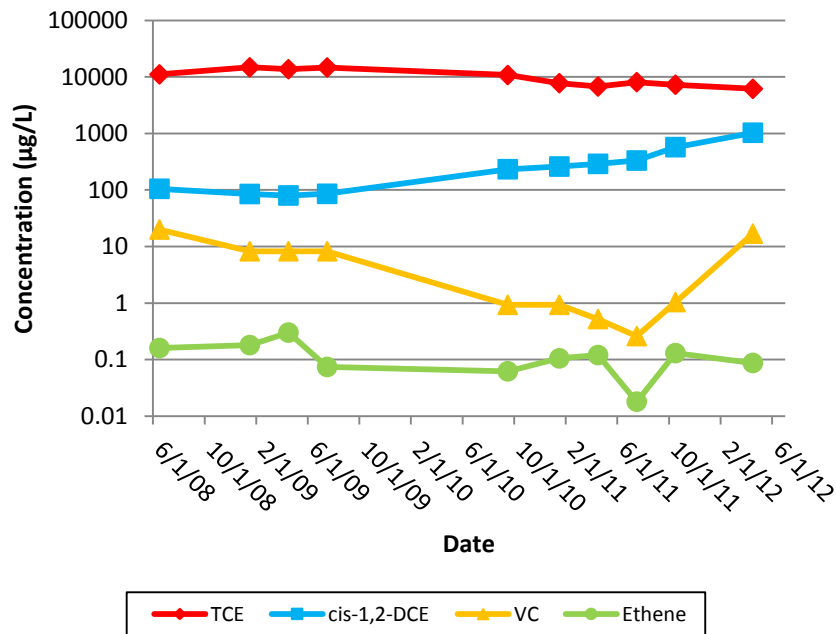


- Total molar concentrations decreased by ~20%
- 50 – 70% of TCE transformed to DCE and VC
- Some ethene

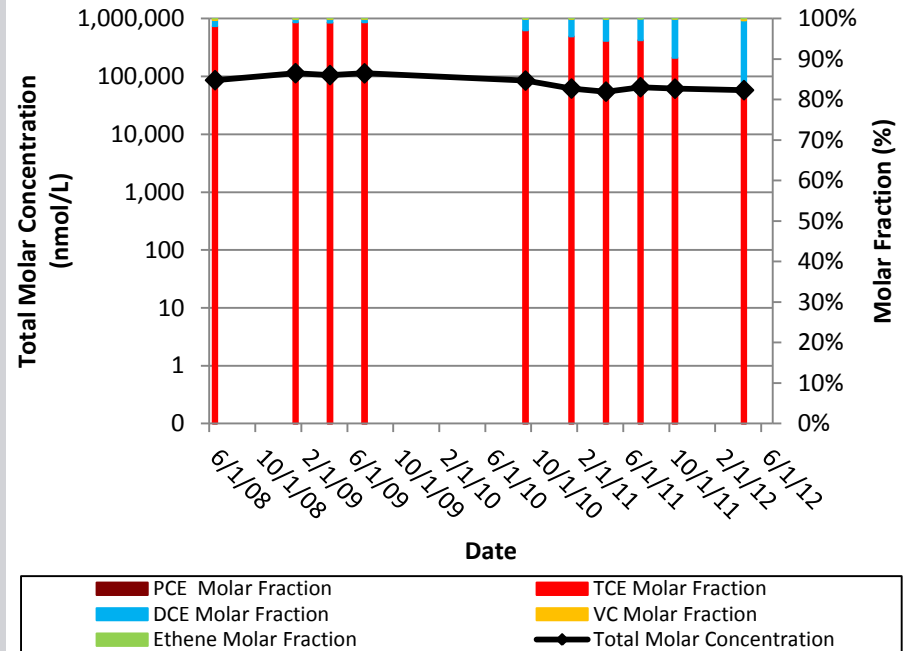
Performance Monitoring

Downgradient Wells MW1-C, MW2-C, MW3-B (260' downgradient)

MW1-C



MW1-C



- Total molar concentrations decreased by ~10%
- Increasing DCE and VC concentrations

EISB Performance Summary

- Background point
- ~97% molar reduction and complete conversion to ethene
- ~75% molar reduction with conversion to DCE, VC, and ethene
- ~20% molar reduction with conversion to DCE, VC



Conclusions

- Substrate emulsion was successfully emplaced in fractured rock aquifer to form a PRB
- Substrate continues to maintain reducing conditions and stimulate dechlorination ~4+ years after injection despite high sulfate loading
- Significant molar concentration reductions within treatment areas and up to ~200' downgradient of injection area



Questions and Discussion

- Thank you for attending