CH2MHILL®

Environmental Services Business Group

Integrated Approach to the Remediation of Chlorinated Organic Compounds in Low Permeability Soils – A Field Study

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Site Information

- Chemical production plant in Southwestern Ontario, Canada, in operation from 1940's to 2009.

- 322 acres of property prepared for closure through a combination of *insitu* and *exsitu* remediation.

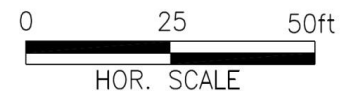- Volatile Organics Compounds present in the subsurface for over 60 years.

Where *Insitu and Exsitu* Remediation Were Applied
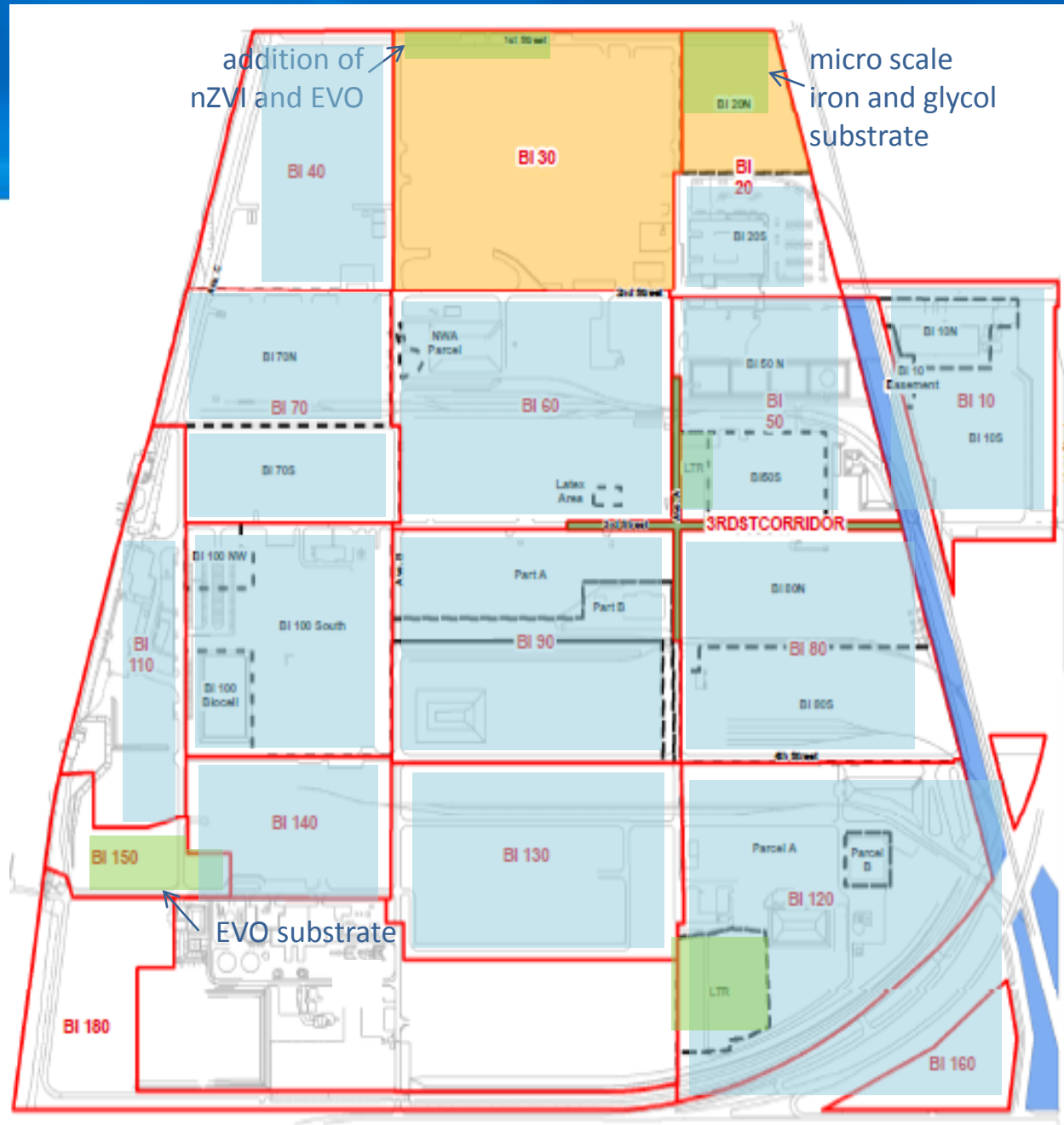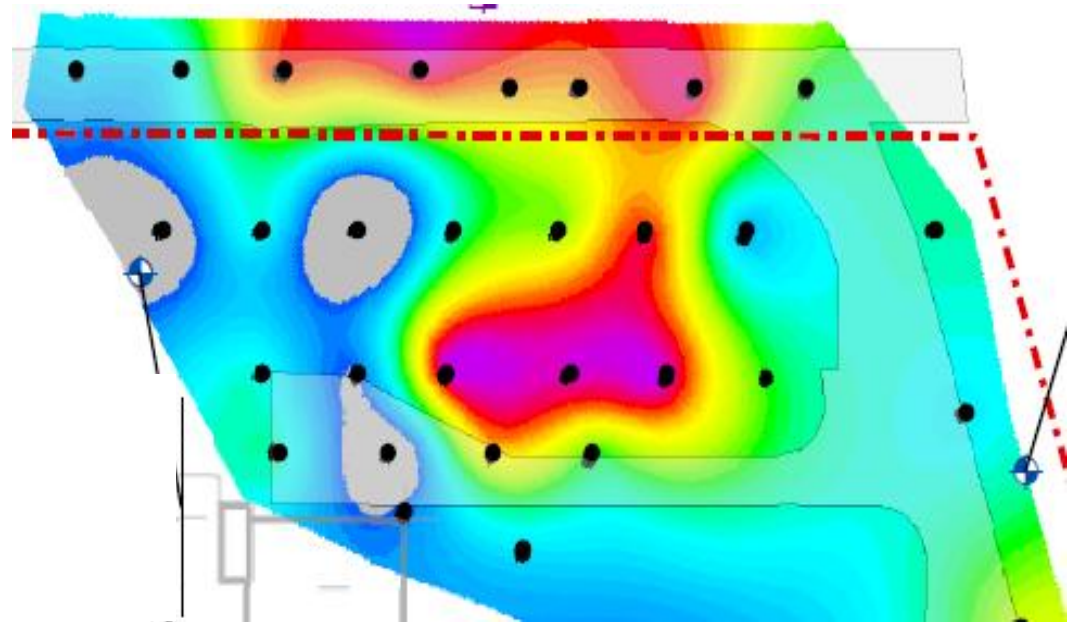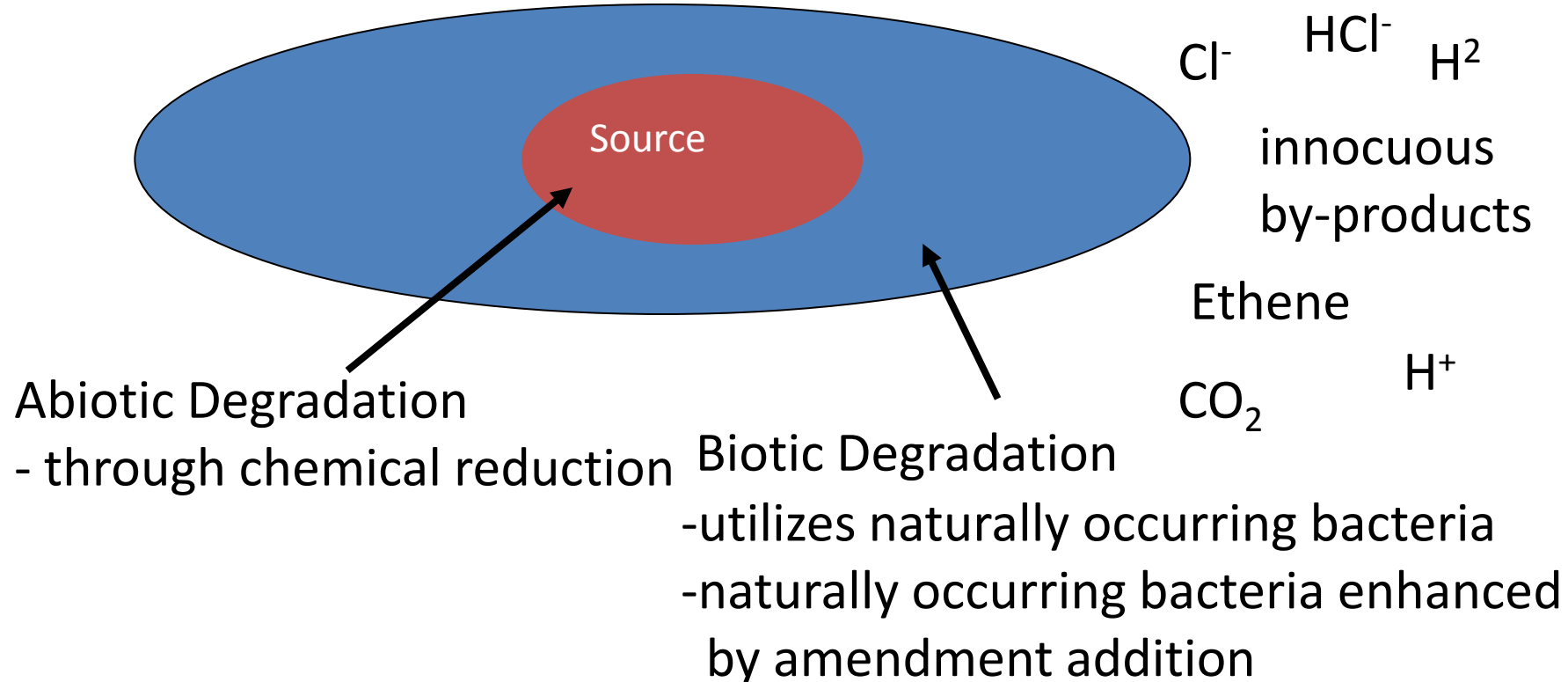
Block 20 Conceptual Site Model
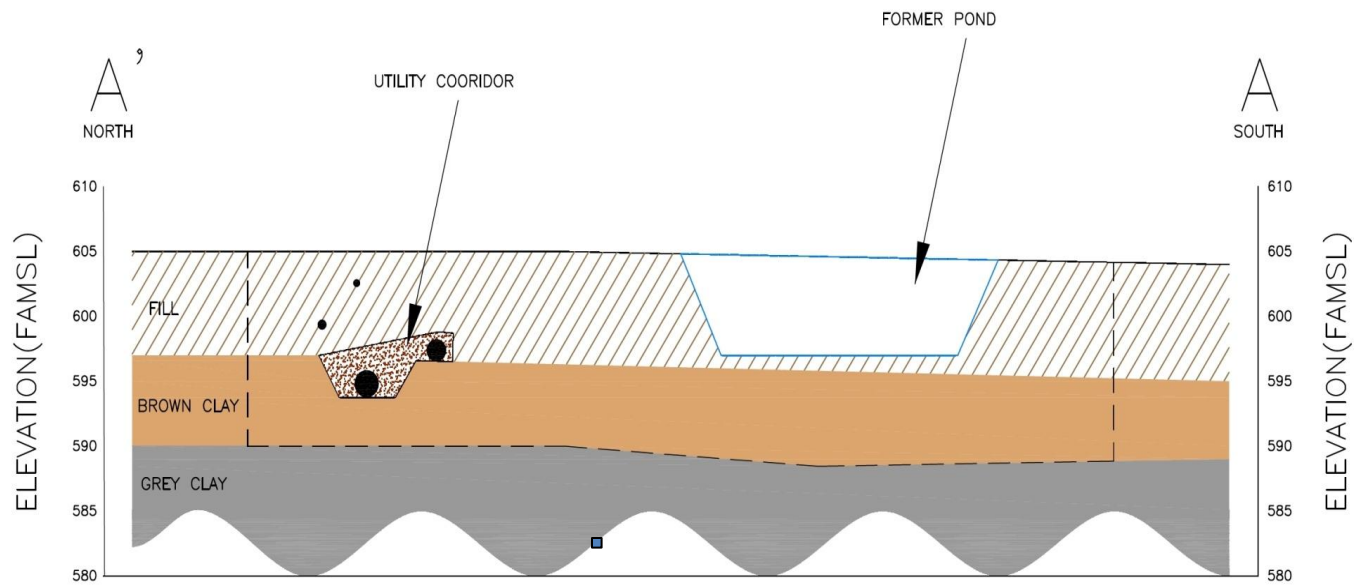
Design of Remedial Strategy

- Reach target concentrations in 5 – 7 years
- Must be cost effective based on volume of soil to be treated (22,000 cubic yards)
- Selected amendment must be able to treat DNAPL and dissolved phase contamination in soil and groundwater
- Amendment application technology must be able to treat low permeability soils

Conceptual Model For Contaminant Reduction

Cl^- HCl^- H^2

innocuous by-products

Ethene

CO_2 H^+

Abiotic Degradation
- through chemical reduction

Biotic Degradation
-utilizes naturally occurring bacteria
-naturally occurring bacteria enhanced by amendment addition

Amendment Application Technology – Fracture and Injection

Amendment Composition
- Macroscale Zero Valent Iron for propant (20/40)
- Microscale Zero Valent Iron (LT80/120)
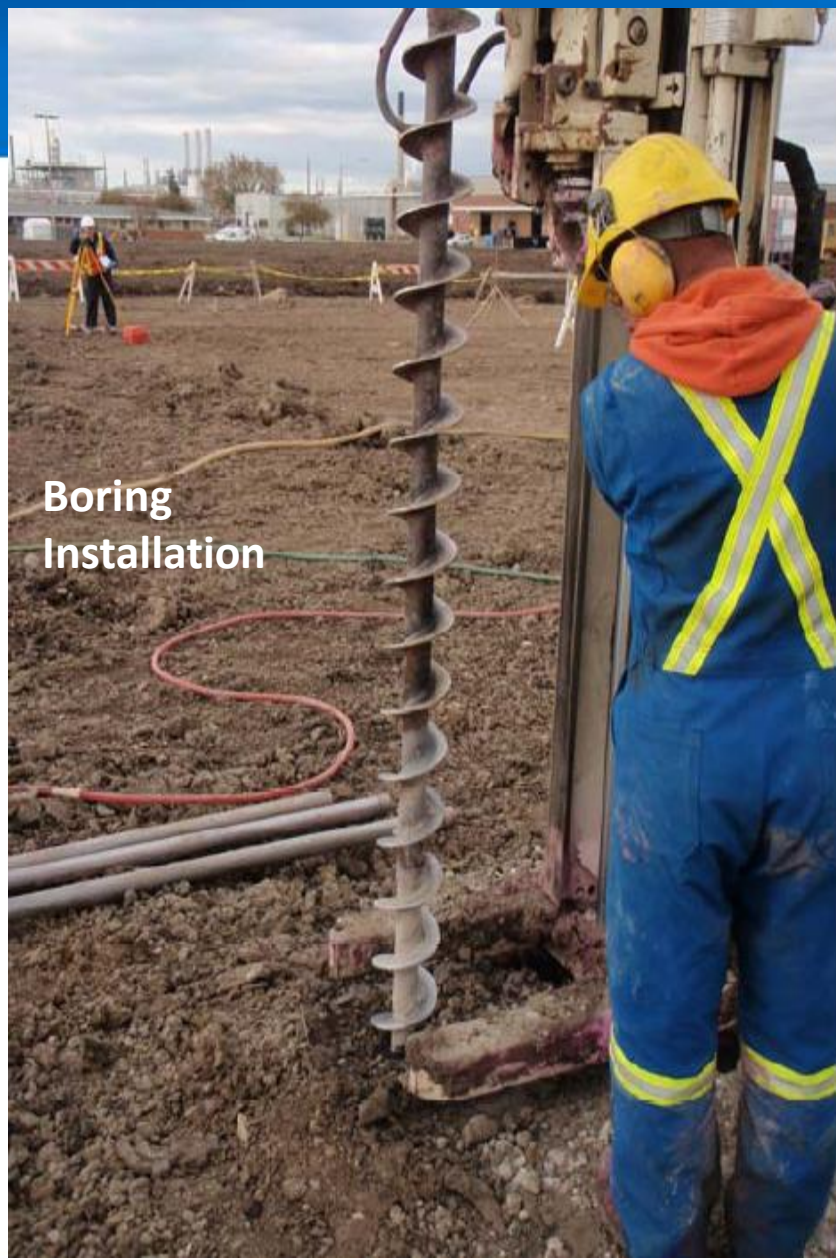- Microscale emulsified Zero Valent Iron
- Guar
- Glycol

Injection Point

Ground Surface

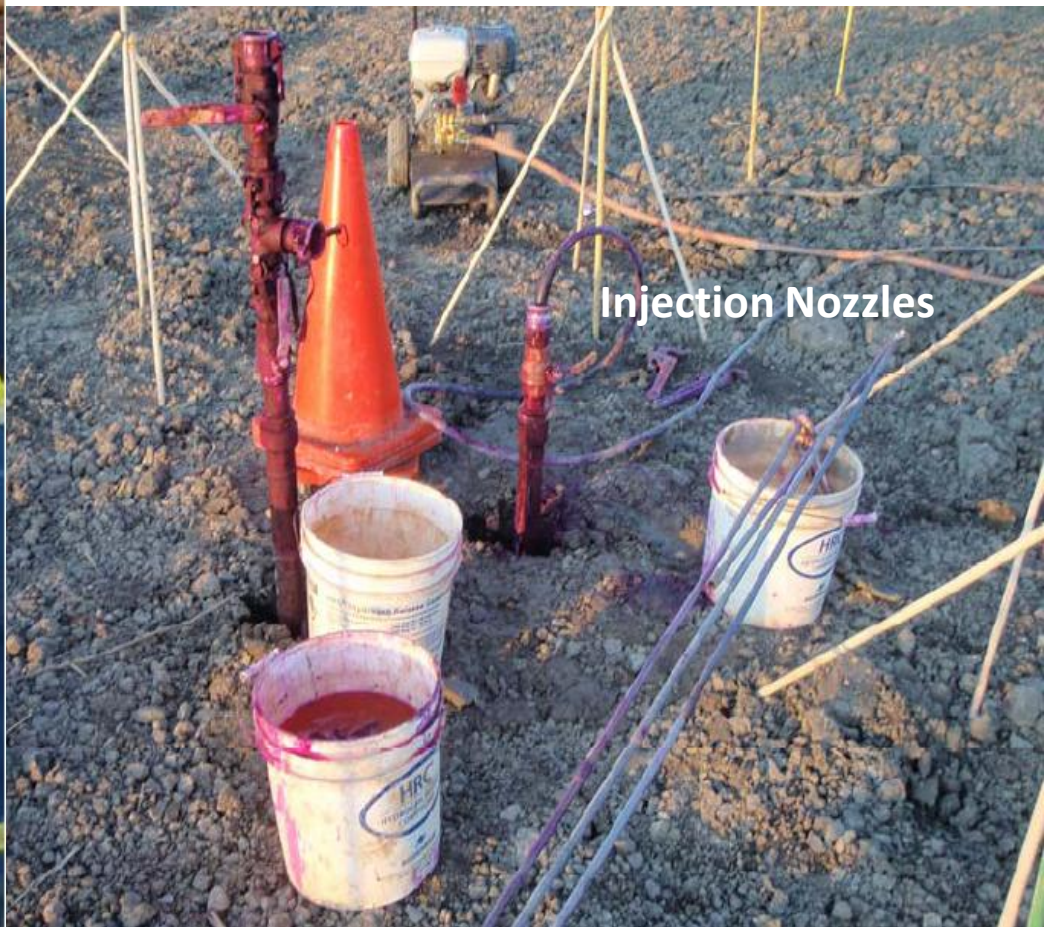Treatment Zone
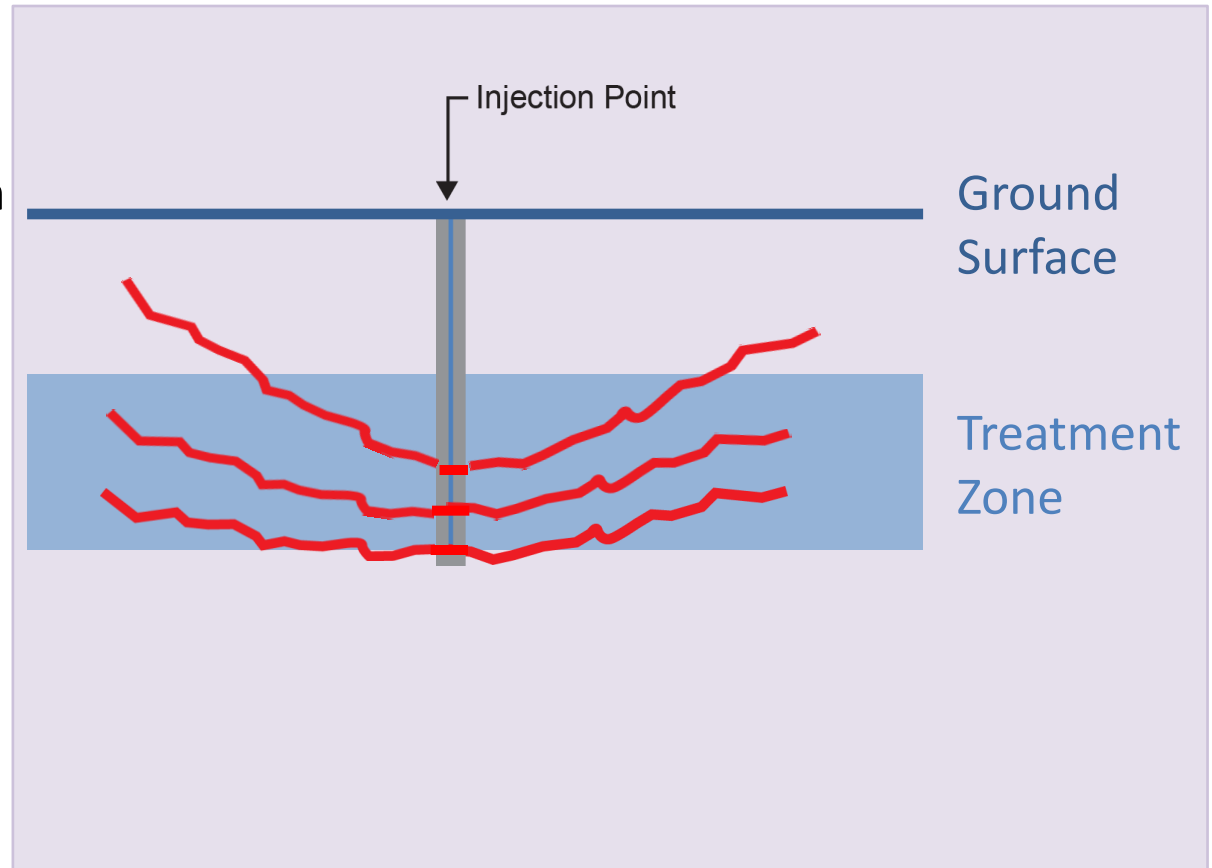
Remedial Design Layout
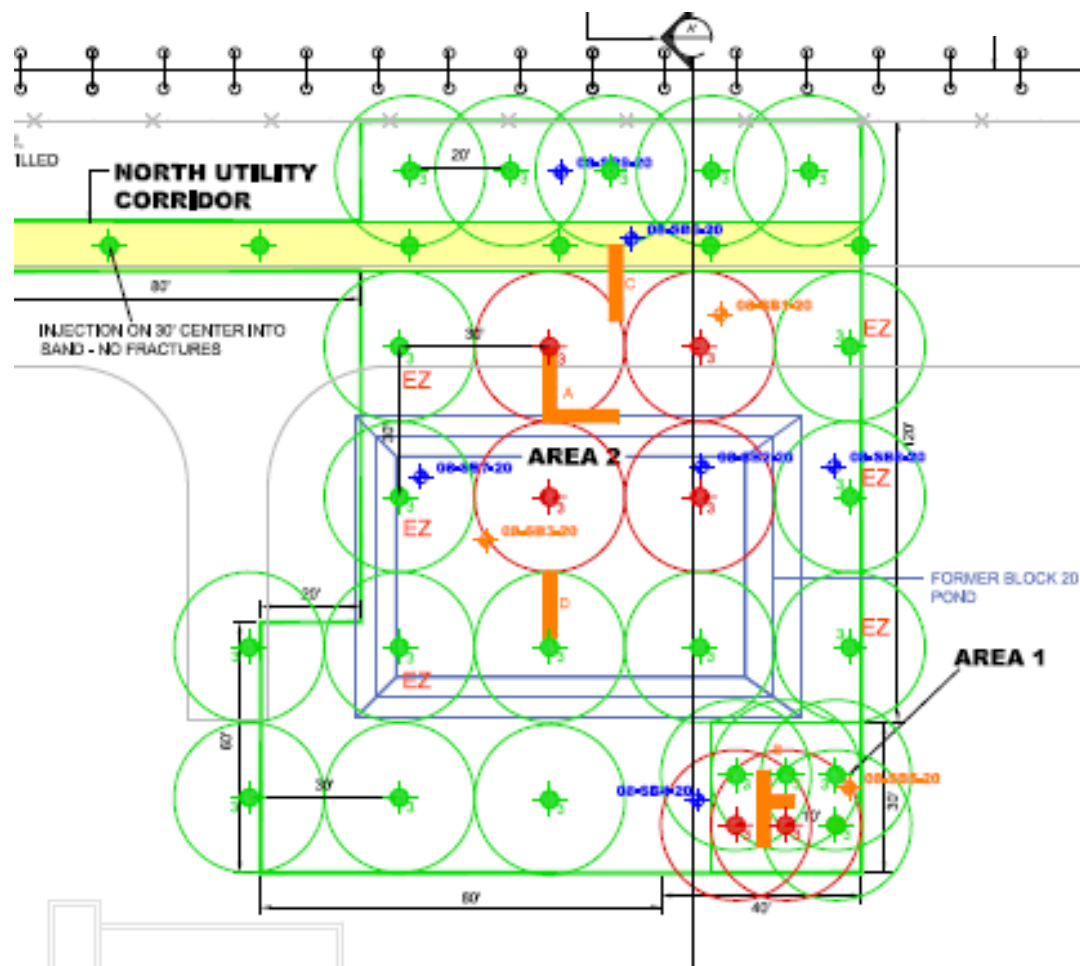
Amendment Volumes

- 2,300 lbs Iron per fracture
- 168,000 lbs Total iron injected
- Average of 234 gal of Injectate material (Guar, Water, and Glycol) per Fracture
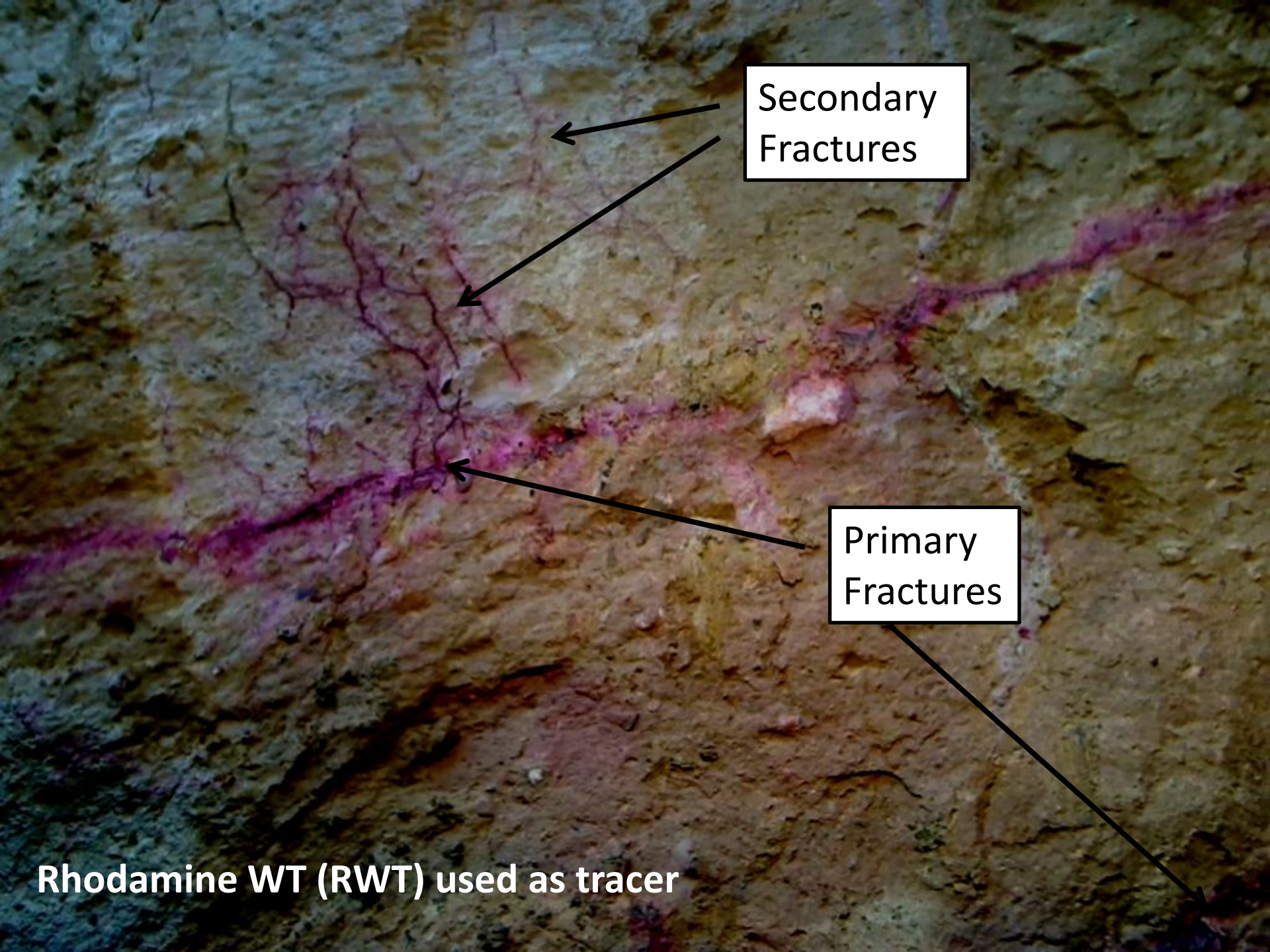- 16,457 gal of Injectate total

Boring Installation

Injection Nozzles

Each location had 3 fracture depths, each finished with a 1" PVC temporary well

Secondary Fractures

Primary Fractures

Rhodamine WT (RWT) used as tracer

20 feet from Injection point

Confirmation Test Pits
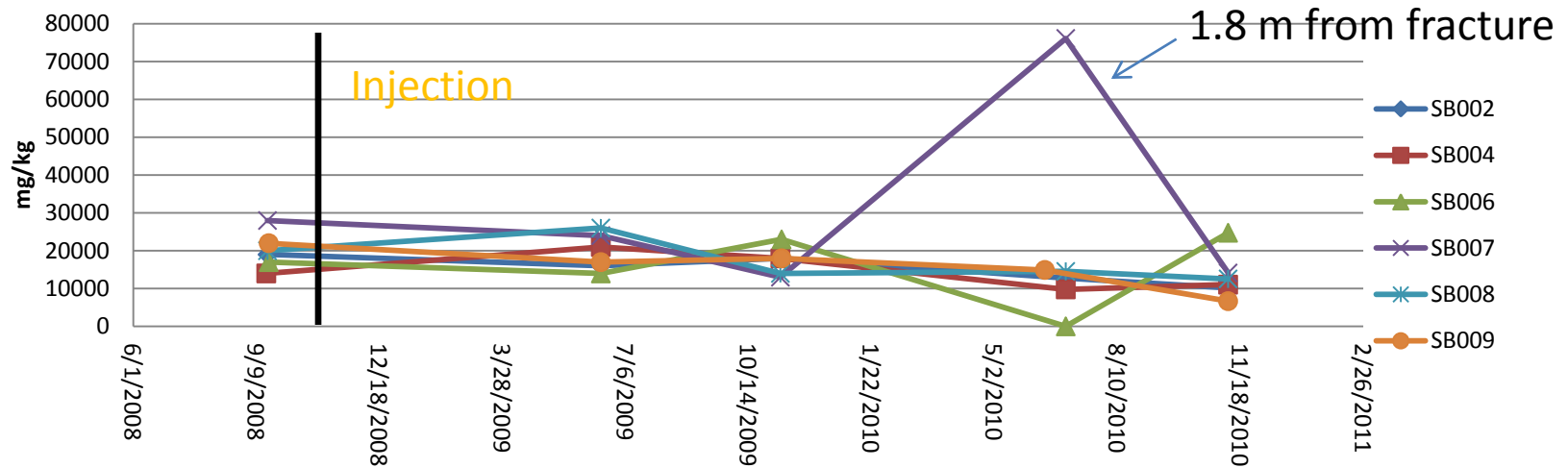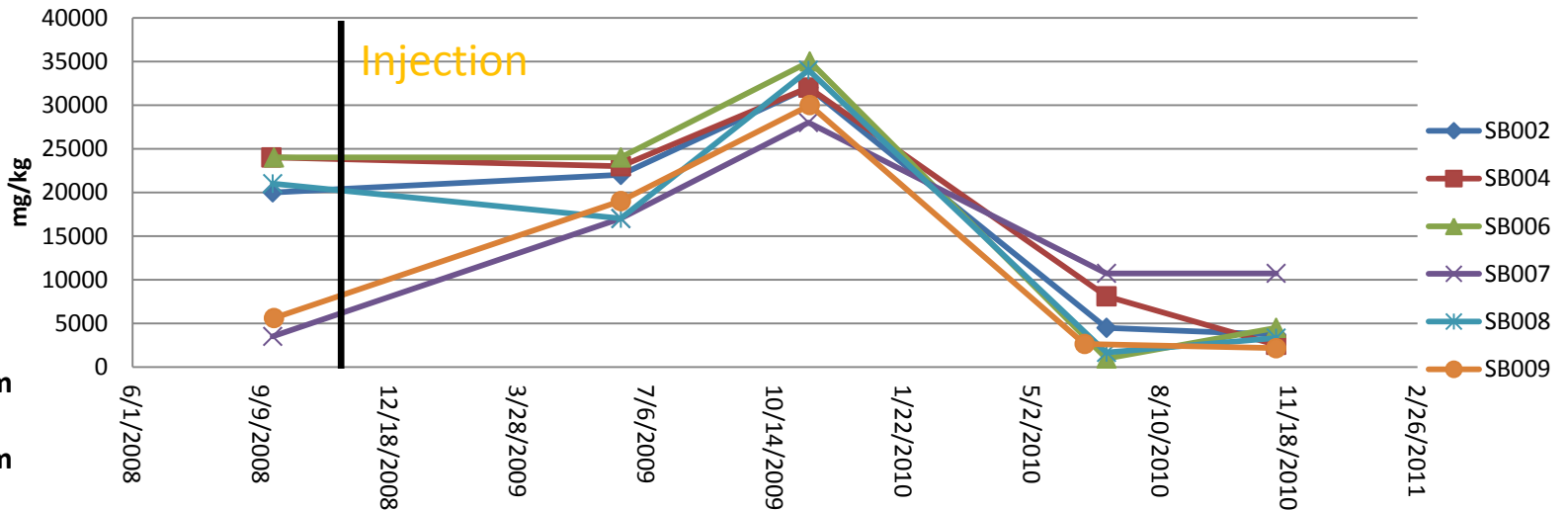
10 feet from Injection point

Primary Fracture

Soil

Iron

TOC

SB002 – 1.95 m
SB004 – 3 m
SB006 – 3.15 m
SB007 – 1.8 m
SB008 – 2.1 m
SB009 – 4.35 m

Groundwater

Total Iron
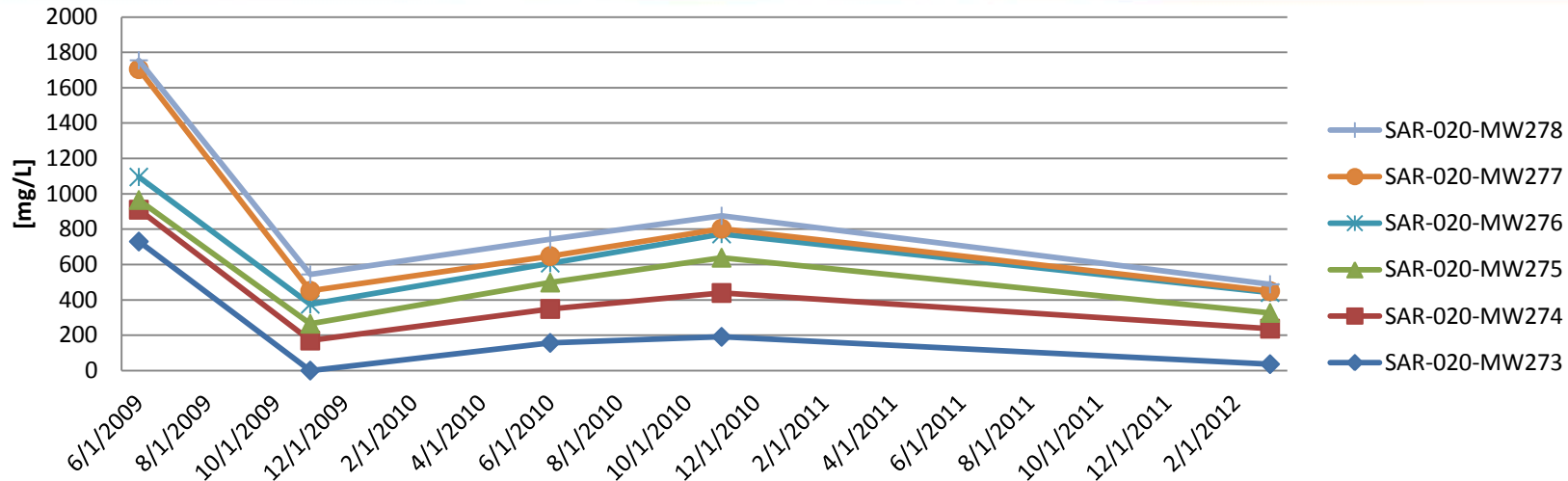
Total Organic Carbon
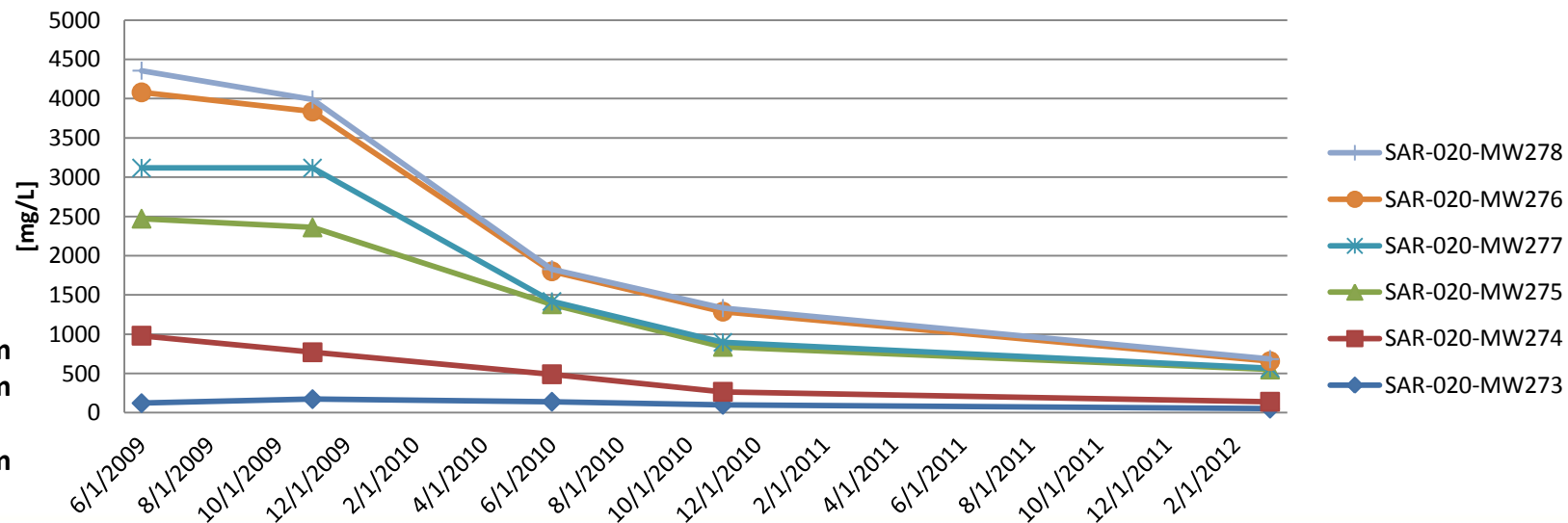
MW273 – 4.35 m
MW274 – 3.15 m
MW275 – 1.8 m
MW276 – 1.95 m
MW277 – 2.1 m
MW278 – 3 m

MW274 – 3.15 m from Fracture

U of G Data Collection Steps

Step 3. Sample removal from core

Step 2. Core logging and inspection

Step 1. Core vertical hole

Step 5. Sample Preparation by Shaking

Step 6. Aliquot extraction

Step 6. Sample analysis by GC

Step 7. Results and analysis

Evidence of Dechlorination Adjacent to ZVI-filled Fractures
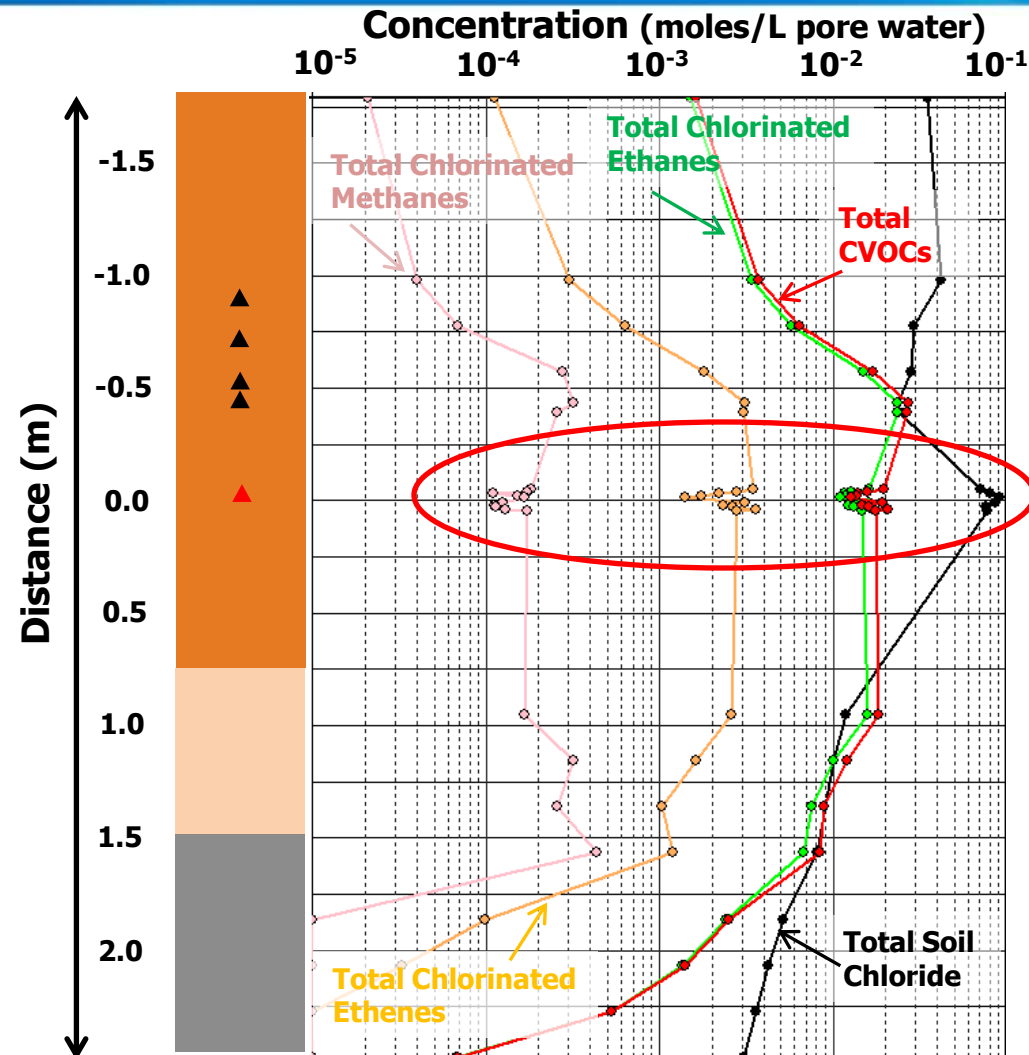
Soil Chloride at UG 2-2

- ☐ **Increase in chloride adjacent to the fracture**

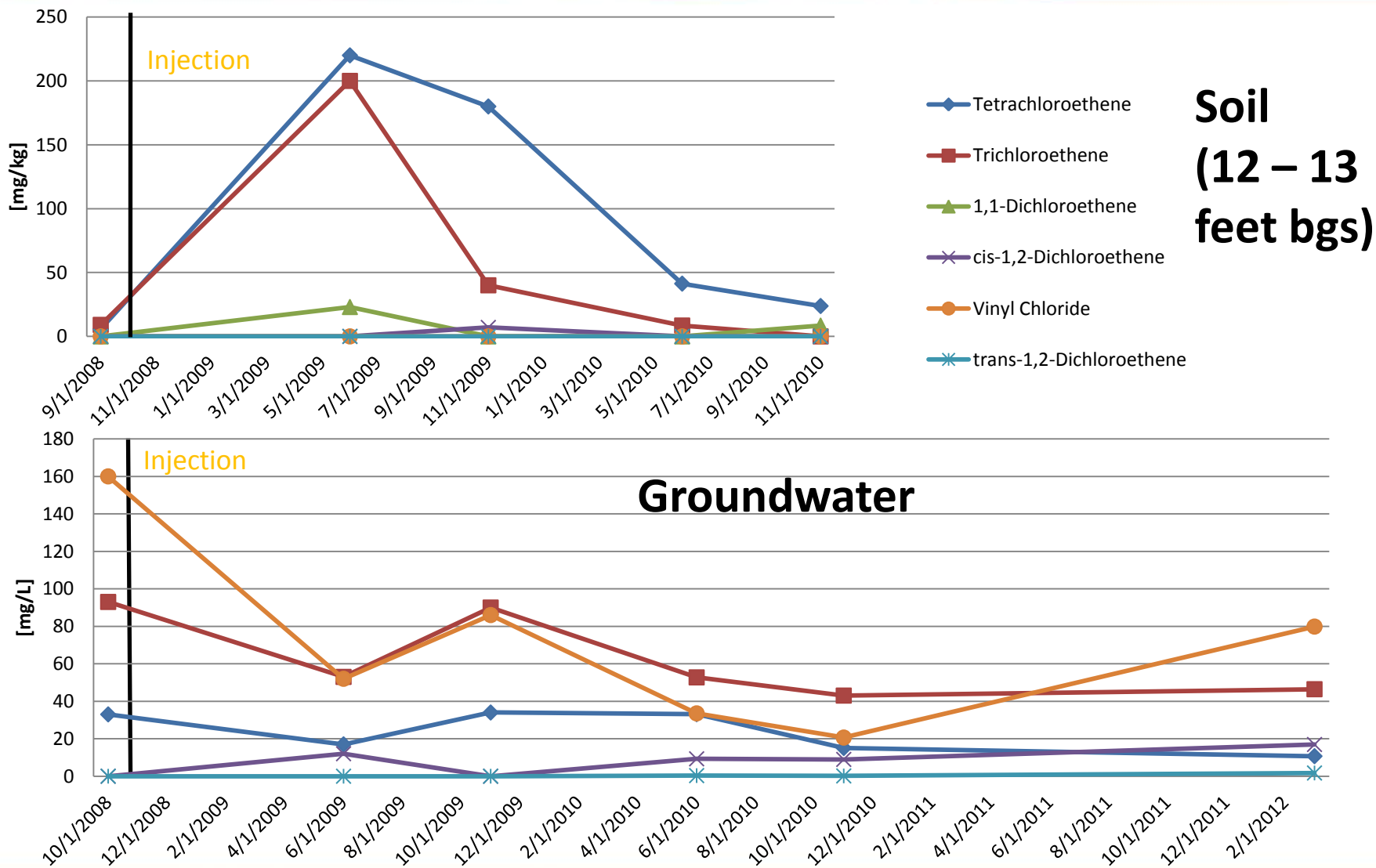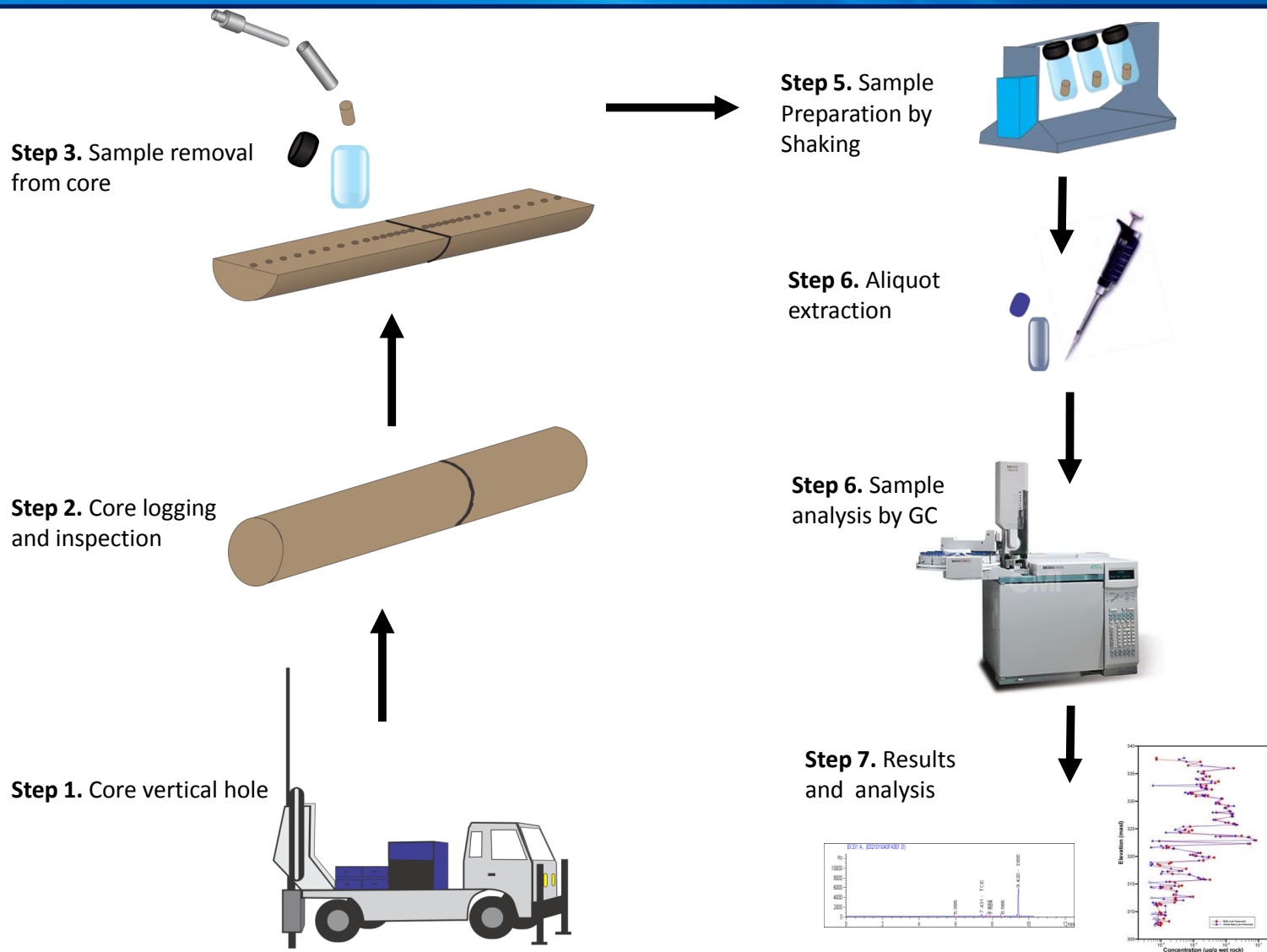- ☐ **Corresponding decrease in CVOC concentrations**

Legend:
- 🟧 Brown Weathered Clay
- 🟧 Transition Zone
- ⬜ Grey Unweathered Clay
- 🔺 Induced Fractures
- 🔺 Natural Fractures

Chart labels: Concentration (moles/L pore water); Distance (m); Total Chlorinated Methanes; Total Chlorinated Ethanes; Total CVOCs; Total Chlorinated Ethenes; Total Soil Chloride

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Results

- Iron was successfully added to the subsurface through the F&I work and has resulted in the destruction of some CVOCs

- Amendment detected throughout a 20 to 30 foot radius from the injection point and secondary fractures visible up to 12 inches vertically from the primary fractures

- Organic carbon was successfully added to the subsurface and has been utilized for biodegradation as indicated by increases in biodegradation end products.

- Dechlorination is occurring, however the influence into the bulk of the media may be limited

Lessons Learned

- Baseline sampling should be collected before and immediately after injections to account for minor mobility and changed conditions created by the pressures of injections

- Diffusion into the clay matrix will be a slow process, but is occurring

- Groundwater results are indicative of processes occurring in soils, but can not be directly correlated to concentration reductions in soils, but is useful as a less expensive screening option

- Samples at 6 month intervals may not have great value for a large scale project, one to two year sampling intervals are sufficient , with groundwater sampling used to indicate timeframe for soil sampling

Acknowledgements

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Questions?