U.S. DEPARTMENT OF ENERGY | OFFICE OF ENVIRONMENTAL MANAGEMENT

Enhanced Attentuation of VOCs in Southern Sector using Humate Amendment via a Recirculation Well

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Technical Briefing to Citizens Advisory Board
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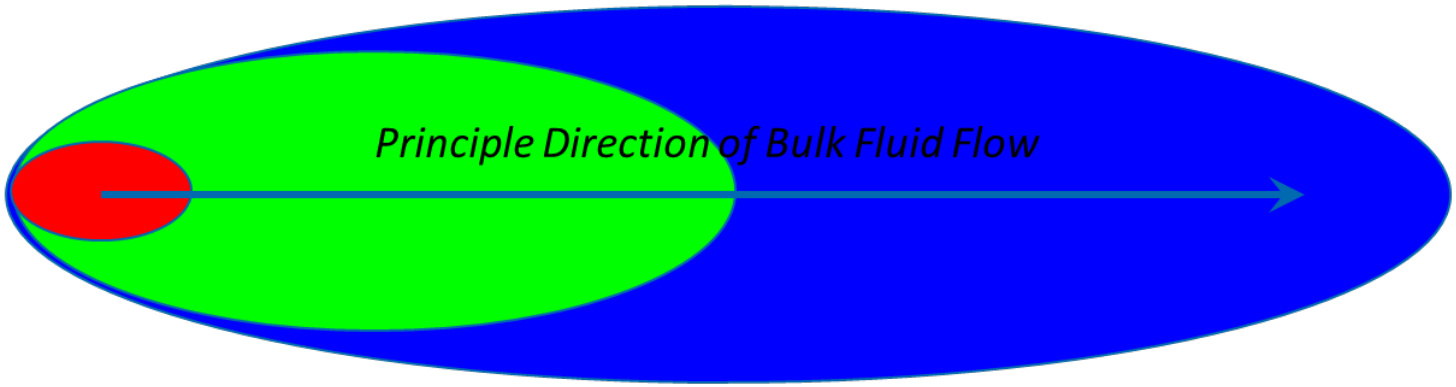
A/M Area Remediation Strategy

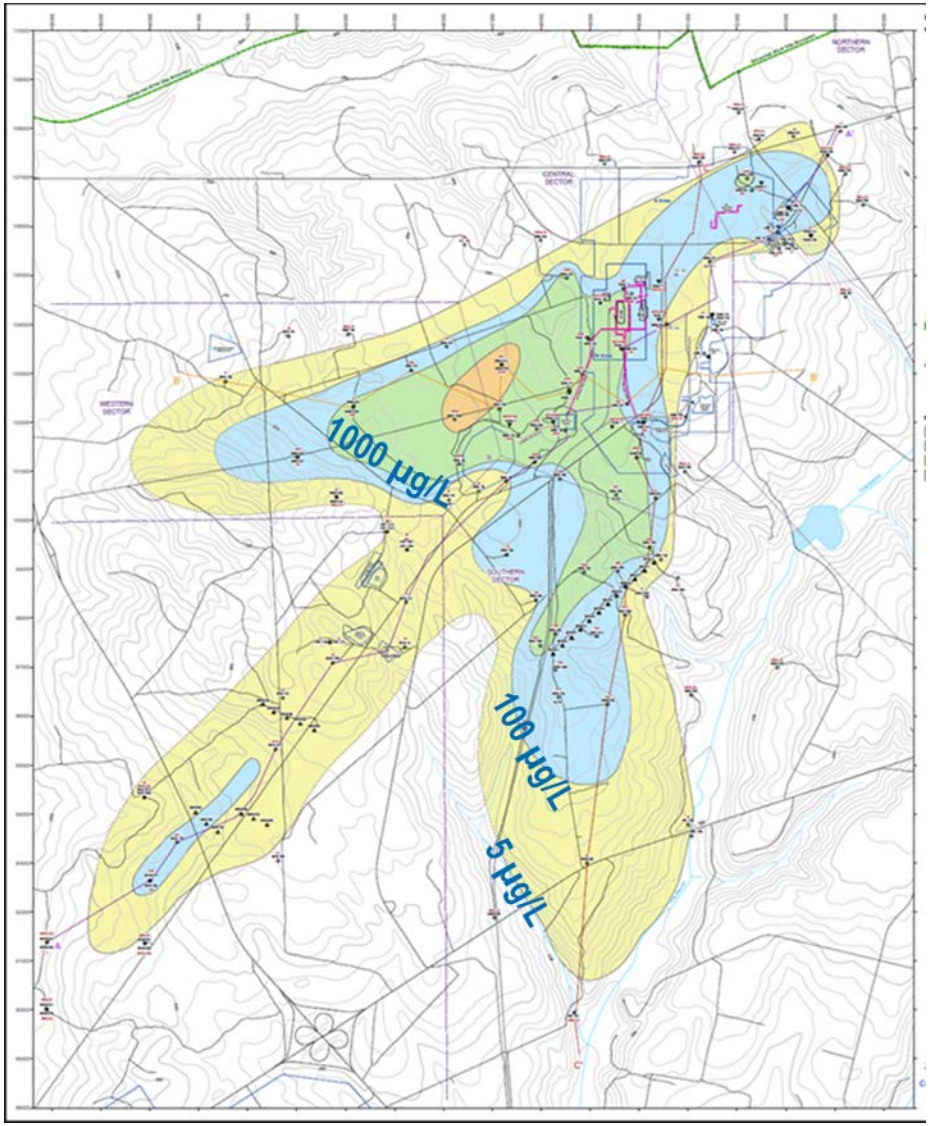
Source Zone → Primary Contaminant Zone → Dilute/Distal Fringe

Source Zone	Primary Contaminant Zone	Dilute/Distal Fringe
Multiple phases High Concentrations	Moderate to high groundwater concentrations	Low concentration above regulatory criteria (MCL)



Aggressive clean-up technologies required to limit long term impacts to aquifers (e.g. heating)	Clean-up technologies required to reduce contaminant mass and spread in aquifers (e.g. recovery well and treatment)	Innovative approaches considering large volume designed to ensure no receptor impact (e.g. enhanced and/or natural attenuation)

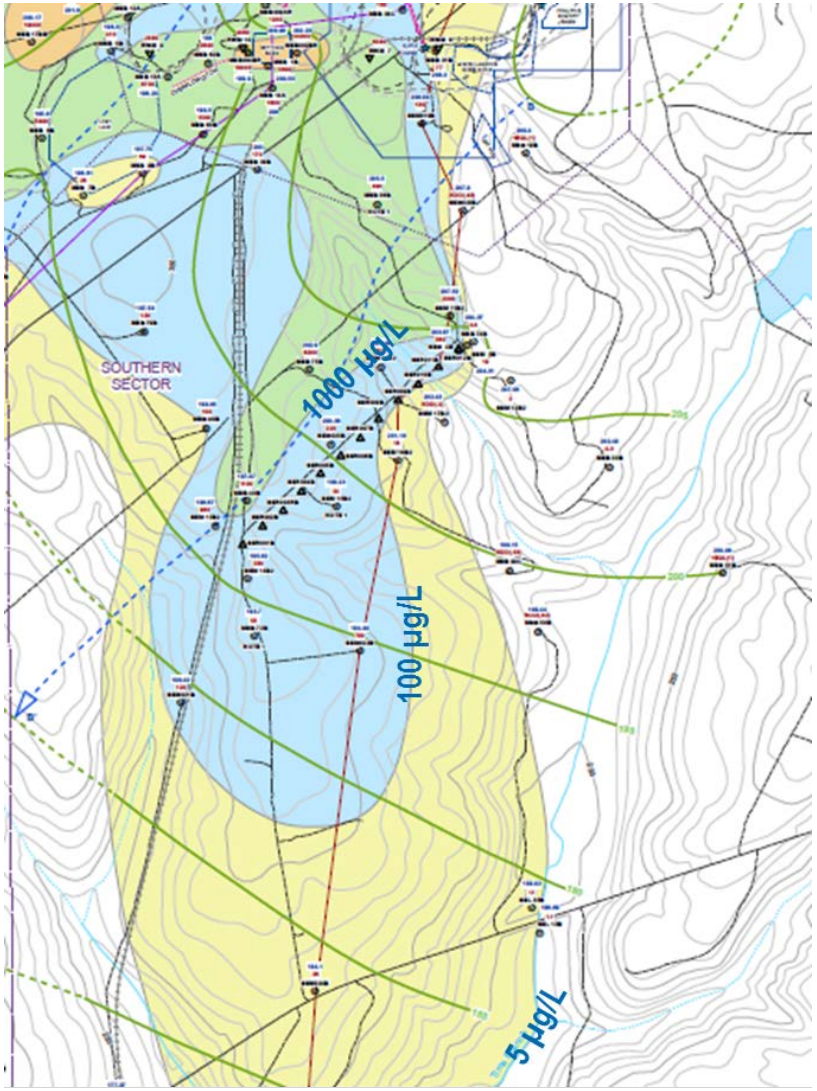
General M-Area Corrective Action Strategy



- Aggressive heating technology at M-Basin and Solvent Storage Tank Area has removed about 500,000 pounds of trichloroethene (TCE) and tetrachloroethene (PCE)
- Residual high TCE and PCE groundwater concentrations in LLAZ require focused treatment to supplement recovery wells.
- 2014 Permit Application Corrective Action Plan (CAP) includes assessment of effectiveness of remediation technologies at the field scale in four areas.
- Results will support technology evaluation in final Corrective Measures Study (CMS)/CAPs for the Southern and Western Sectors.

Southern Sector CAP Strategy

- Previous technology used included recirculation wells that inject air and remove TCE to atmosphere
- Anaerobic (low oxygen) microbial degradation of TCE difficult to implement with high oxygen levels in aquifer
- Aerobic (high oxygen) microbial degradation laboratory study in 2013 shows promise
- Aerobic bioremediation of TCE is a slow process requiring a longer timeframe to evaluate.
- Given long expected residence time of TCE in the aquifer (100+ yrs), enhancing a TCE degradation half life of even 10 years would be significant.



Humate as an Amendment for Enhanced Attenuation

- Background:

  As part of laboratory testing SRNL has been investigating the use of humate as a potential carbon source for enhanced attenuation in the saturated zone of the A/M Area.

- What is Humate?

  Natural organic matter typically used as a soil amendment in organic agricultural applications.

- Initial Results:

  Our results indicate that humate provides an enhanced attenuation mechanism capable of significantly reducing TCE concentrations in the Southern Sector of A/M Area.

- Specific Humate Attenuation Mechanisms we have identified:

  A. Increase of the sorption capacity of the Lost Lake Aquifer sediments.

  B. Carbon source to bio-stimulate the cometabolic, aerobic degradation of TCE.

Specific Humate Attenuation Mechanisms

- Increase the Sorption Capacity of the Lost Lake Aquifer
  - Aquifer sediments in the A/M Area have a naturally low organic carbon fraction:

    $f_{oc} < 0.01\%$

  - The addition of humate will increase f_{oc} and thus increase the sorption (attenuation) of TCE to solid phase (aquifer soil).

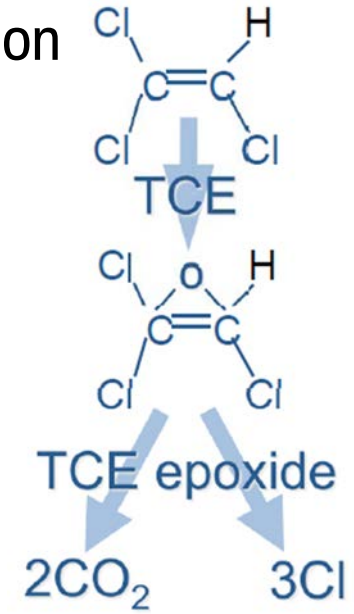
- Serve as carbon source (food) resulting in enhanced attenuation of TCE via aerobic, cometabolic degradation processes
  - What is Aerobic Cometabolic Bioremediation?

    The breakdown of a contaminant by an enzyme that is produced during microbial metabolism of another compound with oxygen.

  - Process requires a suitable carbon substrate.
  - Successful application requires bacteria with proper capabilities.

    These capabilities can be identified using modern microbial tools.

    These tools identify genetic capabilities that produce specific enzymes.



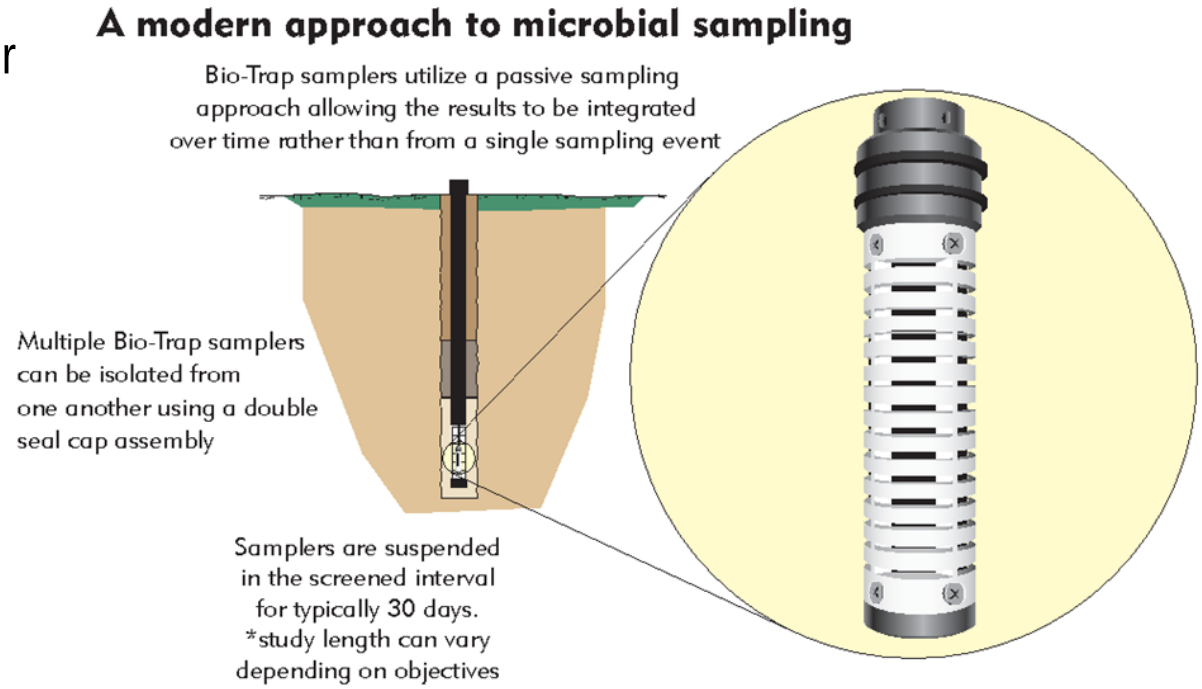
Lab Testing and Results

Characterization of existing microbial communities to see if there are bacteria present that are capable of aerobic degradation of TCE if they grow in response to the addition of humate.

Collect using Use BioTraps® in monitoring wells within 10-ft of the recirculation well.

Baseline deployment in 6 wells for 60-days to determine indigenous community.

Subsequent deployment for 60 days in the same 6 wells using BioTraps® baited with humate.



Lab Testing and Results (con't)

Genetic Testing using DNA identification techniques:

- Quantify the Total Bacterial Biomass in the aquifer
- Identify specific genetic sequences (DNA) related to biological functions that are involved in the aerobic, cometabolic degradation of TCE.

Results:

- The overall Total Bacterial Biomass was within the range for sustained bio-remediation and was not effected by the humate.
- *Indigenous Conditions:* Bacteria that use alkanes and bacteria that use aromatic hydrocarbons for aerobic, cometabolic degradation are present.
- *Humate Amended*: Increased the population density of two types of bacteria associated with aerobic, cometabolic degradation. These bacteria were at levels not detectable without the humate.

Lab Microcosms Testing

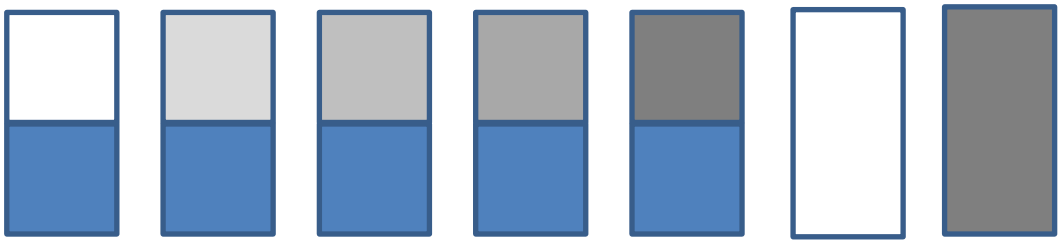
APPROACH: Microcosms were prepared using Lost Lake sediments that were equilibrated in-situ via a monitoring well. This served to inoculate the sediment with indigenous bacteria. Groundwater from these wells were then dosed with various levels of humate to evaluate enhanced attenuation of TCE with time.

t = 0 results used to evaluate abiotic (sorption) processes.

t = 30, 60, 120, 180, 270, 360 days used to evaluate biotic processes.

Summary of Microcosm Variables

Factor		Value/Notes
Humate		Control (< 1 mg/L), Low (25 mg/L), Medium (50 mg/L) , High (100 mg/L), Very High (250 mg/L)
Time		0, 30, 60, 120, 180, 270, 360 days

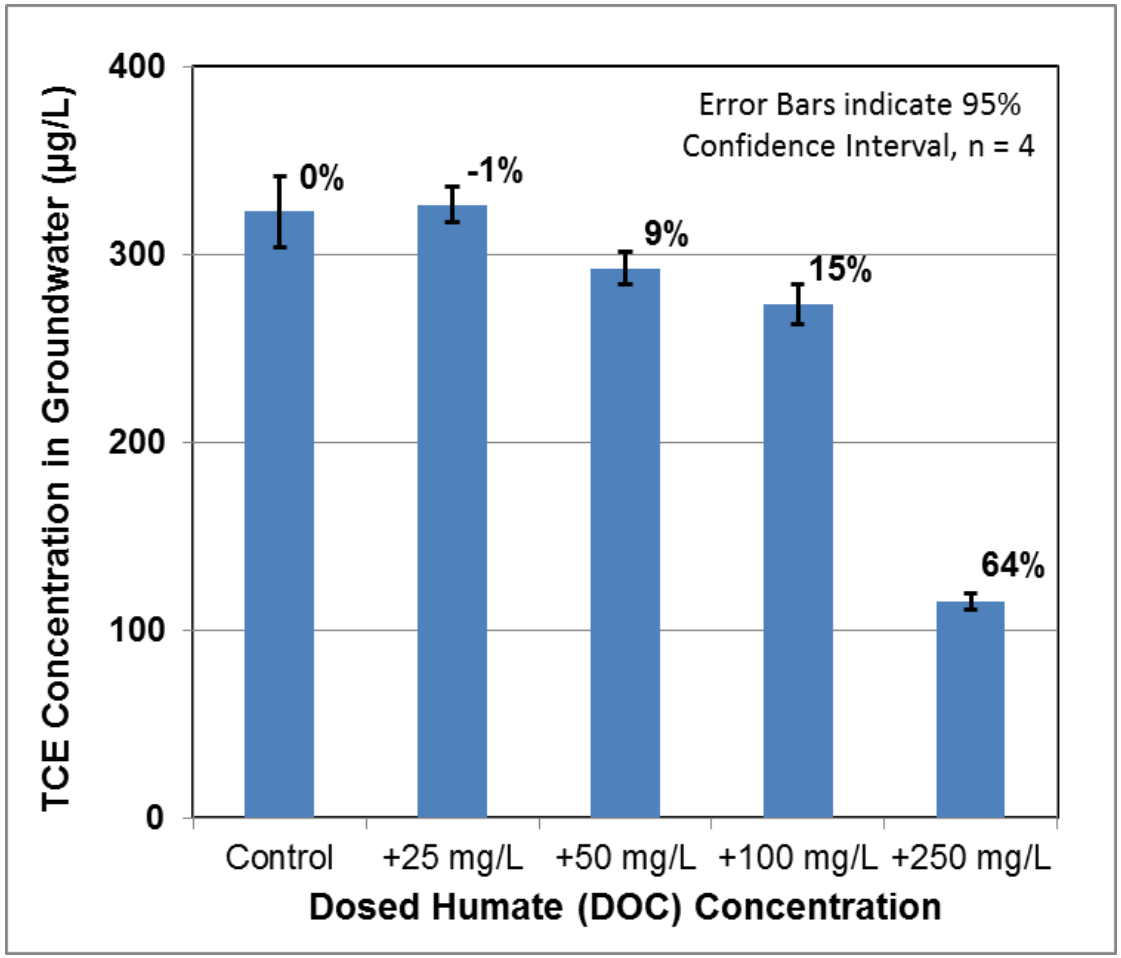


Effects of Humate on TCE sorption (t = 0)

Overall the TCE concentration in the microcosm decreased with increasing humate dose.

Significant reduction in TCE concentration (64%) was observed in groundwater dosed at the highest concentration (250 mg/L) of humate

Thus, addition of dissolved humate should increase sorption of TCE and slow down transport.

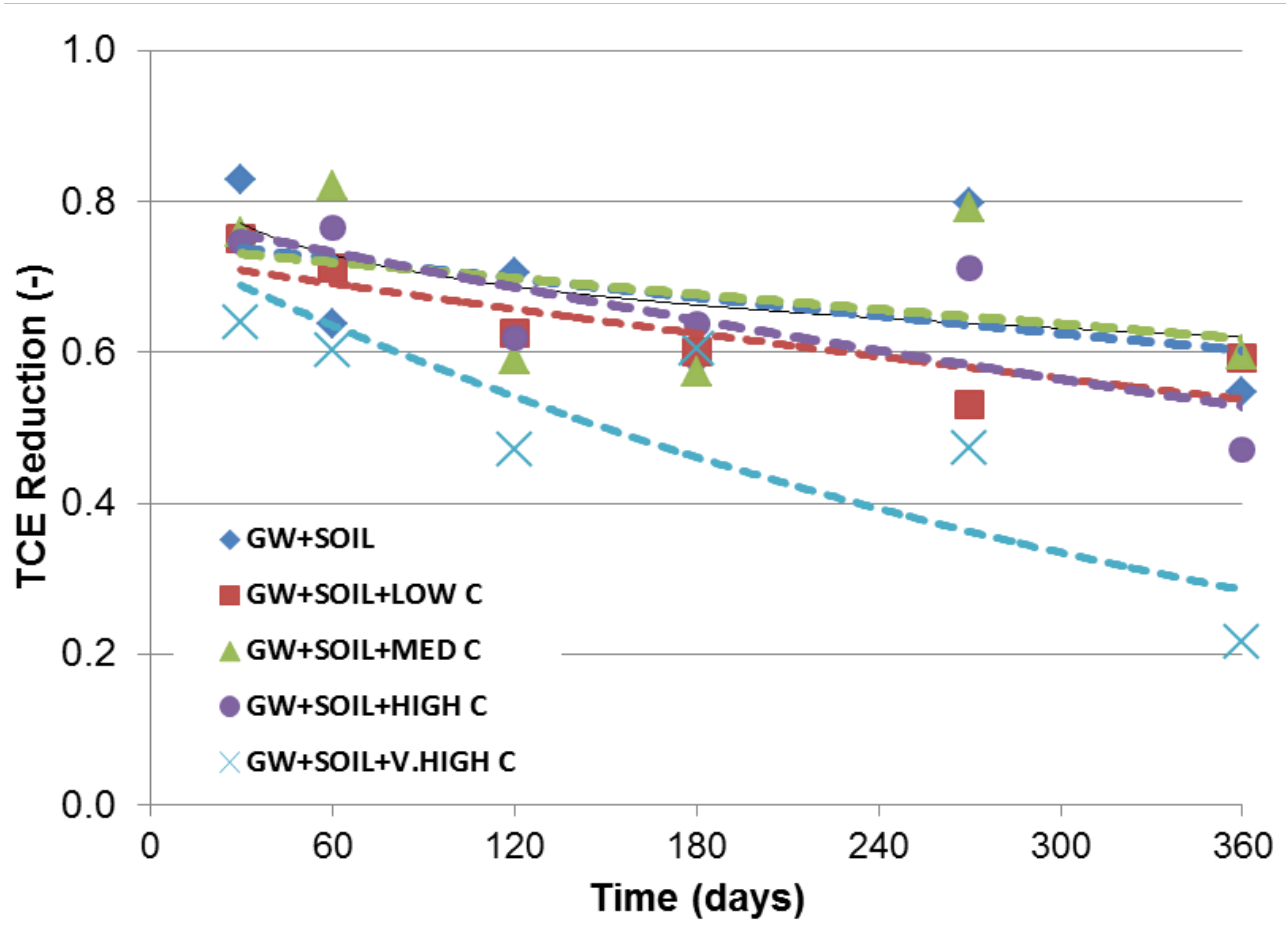


Effect of Humate on the Attenuation of TCE (t > 0)

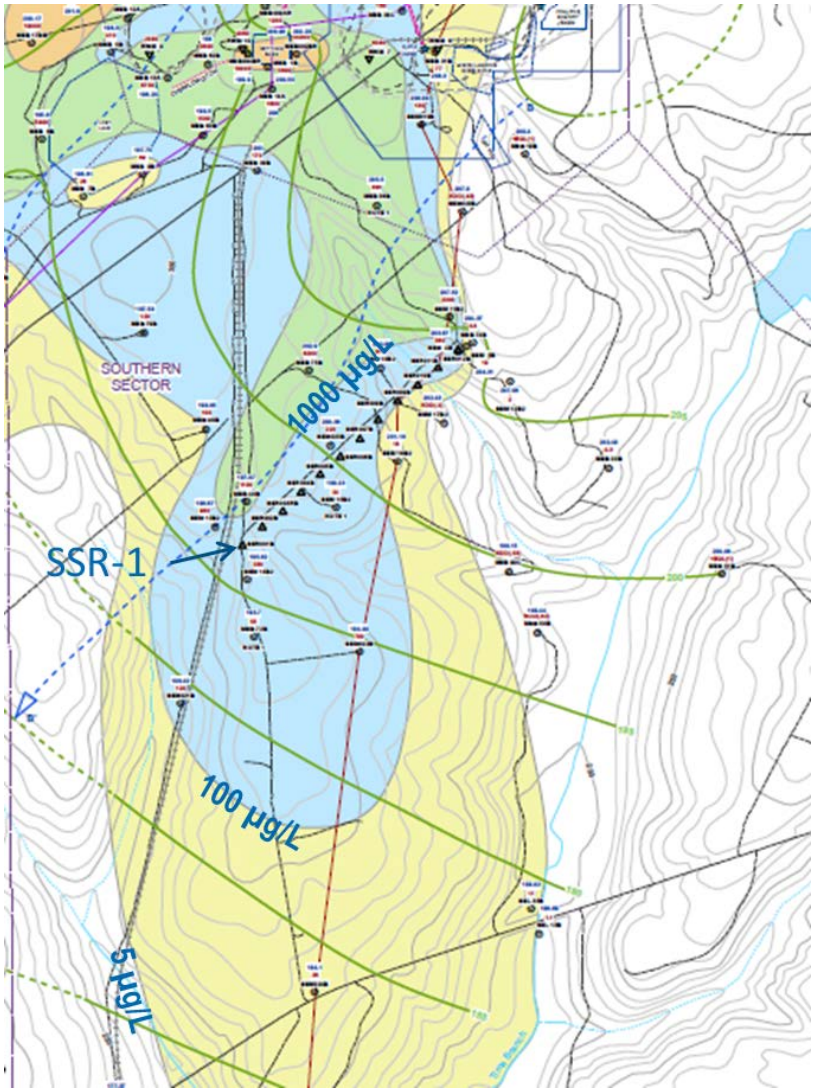
After 1-year total TCE reduction was between 40-80% relative to the controls.

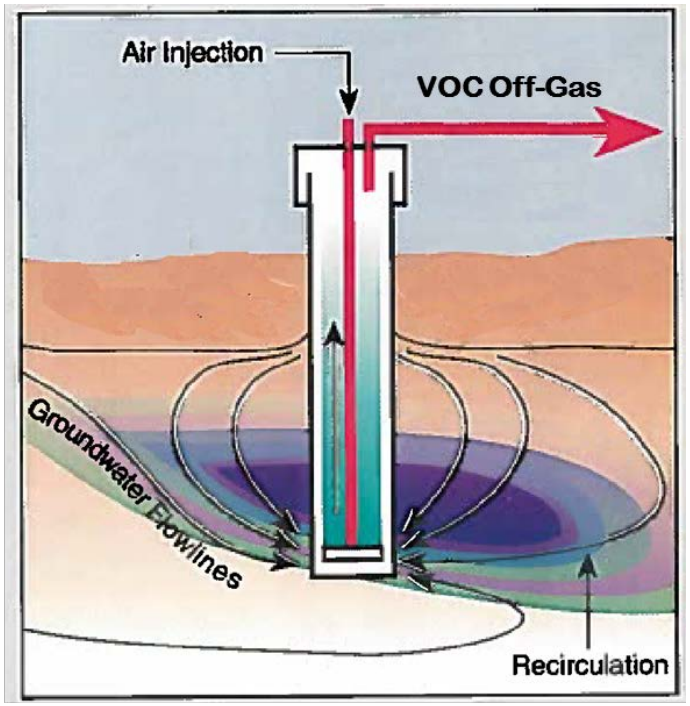
Greatest reduction observed in microcosms having the highest humate level.

Continued long-term evaluation at field scale recommended to quantify the biological half-live of TCE given the long-term time scale related to these processes.



Recirculation Wells in the A/M Area Southern Sector





General Operating Parameters

Size of the Recirculation Cell:
Diameter ~ 240 to 320-ft
Transport Time for 1 cycle:
t ~ 280-days
Recirculation Flow Rate:
Q ~ 30 to 50 gpm

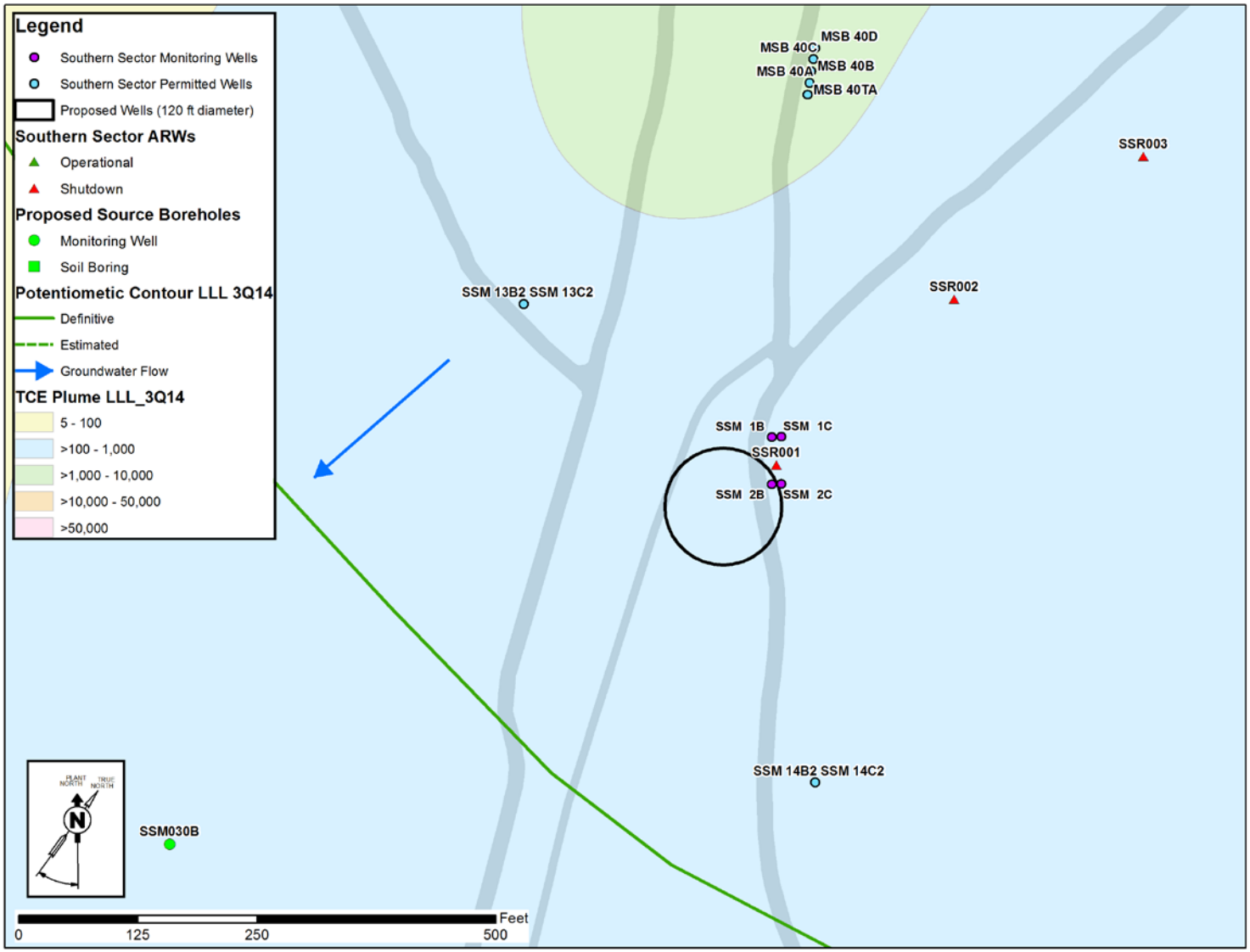
Field Scale Evaluation in the Southern Sector

- Presented lab results and field testing plan to SCDHEC, received approval in December to allow field-testing and performance evaluation using existing recirculation well infrastructure. Will submit details in underground injection permit.

Operational Scheme:

- Continuous addition of dissolved humate, and possibly macro-nutrients, to the aquifer using recirculation well currently in standby to create a 50-ft treatment zone around the well.
- Anticipate up to 29-month injection campaign to increase the humate level in the treatment zone to a target concentration on the order of 80 to 100 mg/L in the aquifer.
- Monitoring and evaluation of field deployment over four years to support February 2021 CMS/CAP for Southern Sector.

SSR-001 Monitoring Layout



Summary

- Understanding that TCE can be degraded by natural bacteria in an aerobic aquifer is a new idea in environmental remediation
- SRNL laboratory studies on the use of humate as a food source to “feed” these bacteria shows promise using our aquifer sediments and also acts to slow down transport of TCE in the aquifer
- Existing recirculation well provides opportunity to distribute humate into aquifer and test effectiveness in the field
- Hope that this technology will provide enhanced attenuation of TCE in the aquifer, thus reducing the overall footprint of the plume and time to reach clean up goals