







Cosolvent Flushing and Enhanced Bioremediation at a Dry Cleaner Site

By

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Project Funding – State of Florida, EPA-TIO, Florida Center for Solid and Hazardous Waste Management, SERDP (FIBRC-WES)



Brief Cosolvent Flushing History

- Before 1980 Cosolvents theory - Pharmaceuticals
- Mid 1980s Cosolvents used to study transport of hydrophobic compounds in soils
- Early 1990s Cosolvents investigated for remediation
- 1995 First Cosolvent Flood at Hill AFB (Florida)
- 1996 Second Cosolvent Flood at Hill AFB (Clemson)
- 1998 Cosolvent Flood at a Dry Cleaner Site (LFR, Sages)
- 1999 Cosolvent Flood at Dover AFB
- 2001 2nd Cosolvent Flood at Dover AFB (Clemson)
- 2002-3 Full-Scale Flood at Sages (Others?)

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Sages Dry Cleaner Site Jacksonville, Florida

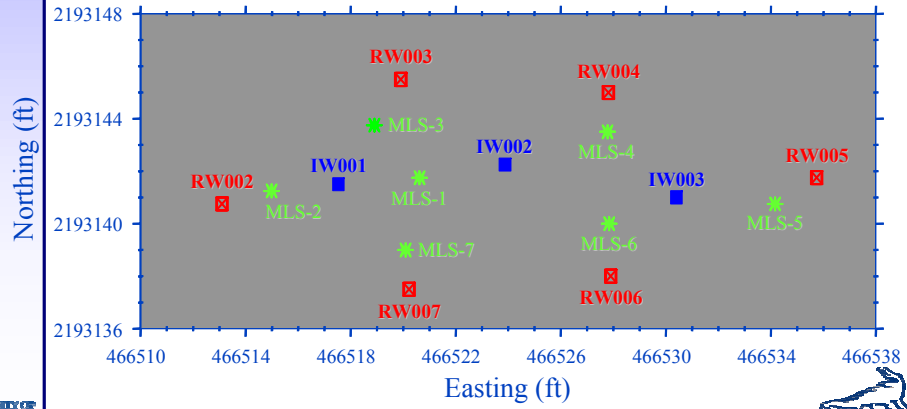


Pilot test at Jacksonville, FL (Sages):

- Dry Cleaner PCE source zone
- 8 to 9.5 m below ground surface
- 7 m long by 3 m wide
- Performance based cores and tracers

Sages Site

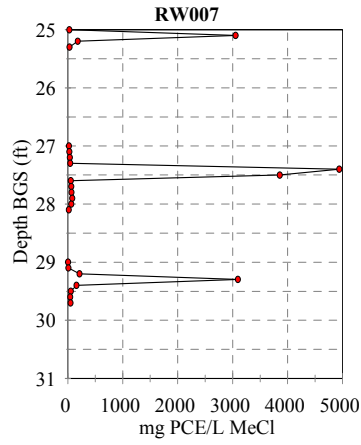
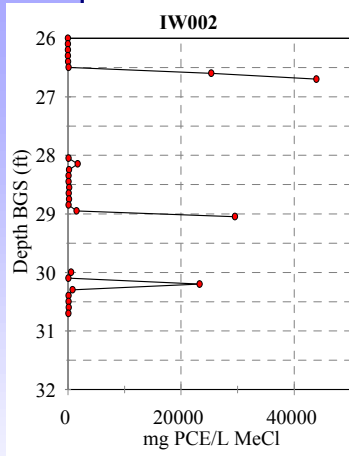
- 3 Injection Wells (IWs)
- 6 Recovery Wells (RWs)
- 7 Multi-Level Samplers (MLSs)



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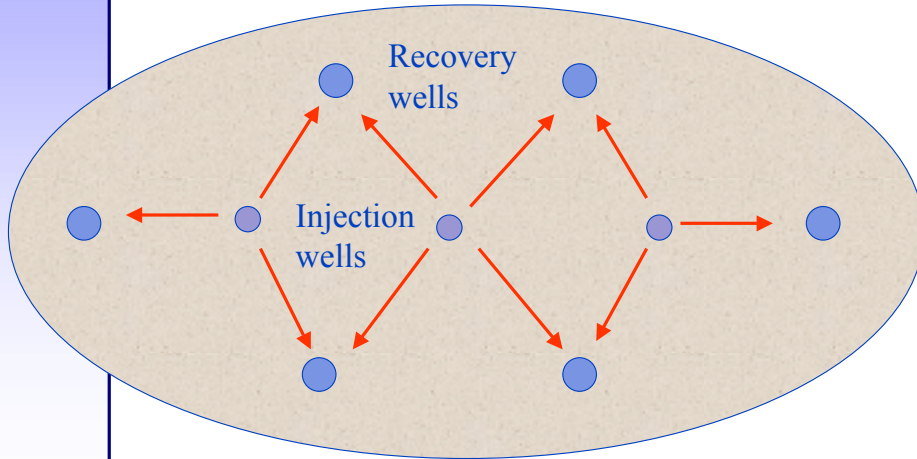
High Frequency Soil Sampling at Sages



Thin lenses of
DNAPL on
minor
permeability
contrasts



Sages Well Layout



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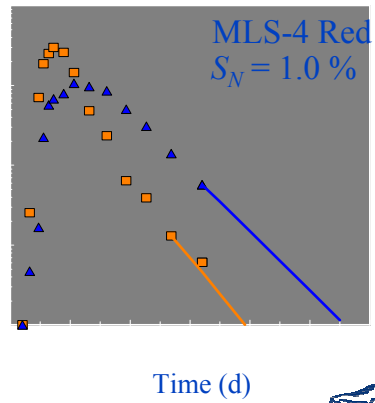
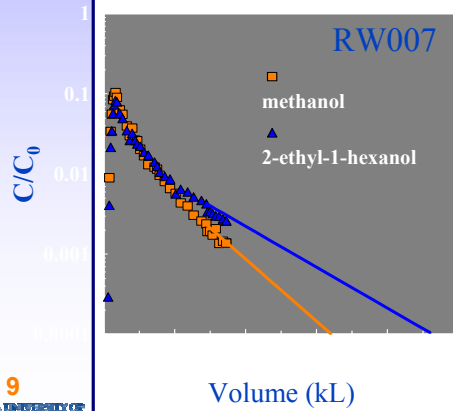


Sages Site

Partitioning Tracer Test:

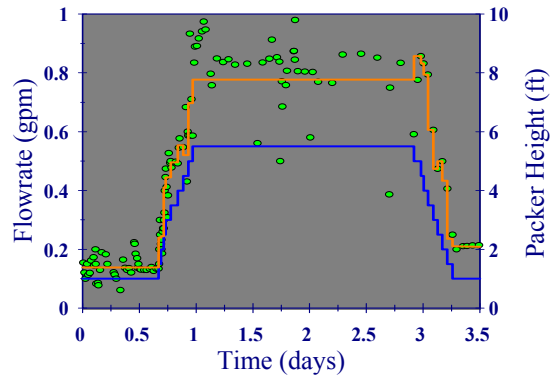
$$S_N = 0.26 \%$$

$$V_{PCE} \approx 50 \text{ L}$$



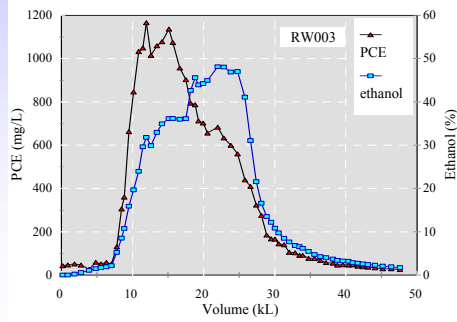
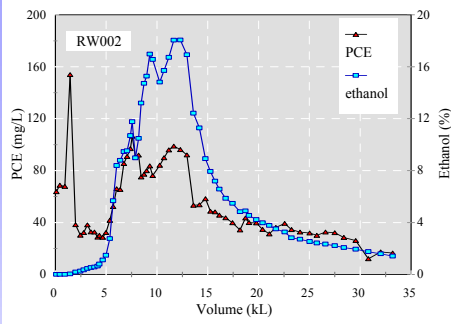
Sages Site

Cosolvent Flushing



95 % consumable grade ethanol

Cosolvent Flushing



**Total PCE
Removed**
67.4 kg
41.5 L

Sages Site

Waste Treatment:
Air Stripping
Macro Porous Polymer (MPP)



Trailer-mounted MPP system



PCE recovered from effluent

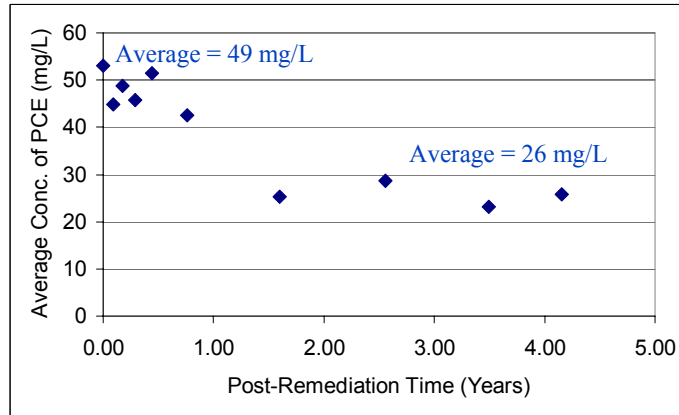
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Summary Results

Cosolvent Extraction:
43 L PCE Removed (Mass Recovery)
~63 % PCE Removed (Partitioning Tracer)
65% Removal based on Soil Core Data

Concentration (or Flux) Reduction in the Source Zone



Mass Reduction = 64% : Flux Reduction = 47%
n = 35 sampling locations

Solvent Extraction Residual Biotreatment (source management)

- Remove more accessible fraction of DNAPL, lower dissolved concentrations/flux. Reduce time/distance needed to meet GW quality objectives.
- Activate reductive bio-transformations in high redox environments.
- Insure supply of e- donor, accelerate process and reduce uncertainty.
- Meet regulatory requirements.

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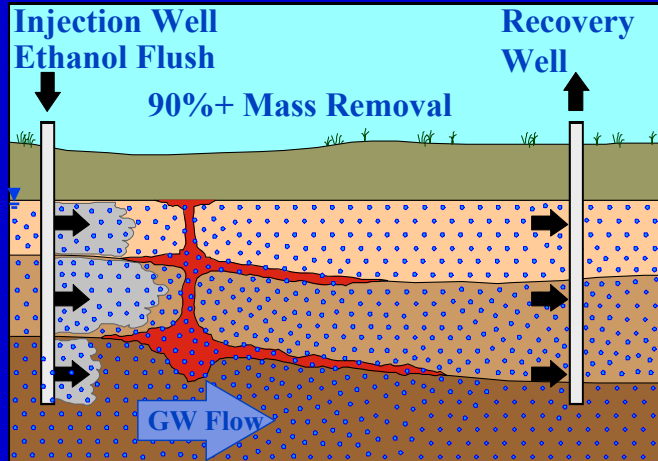
Pre-Cosolvent Flush Site Characterization

- Aerobic Conditions
- Low levels of daughter products (TCE)
- DNAPL contamination identified at 26 to 31 ft. bgs

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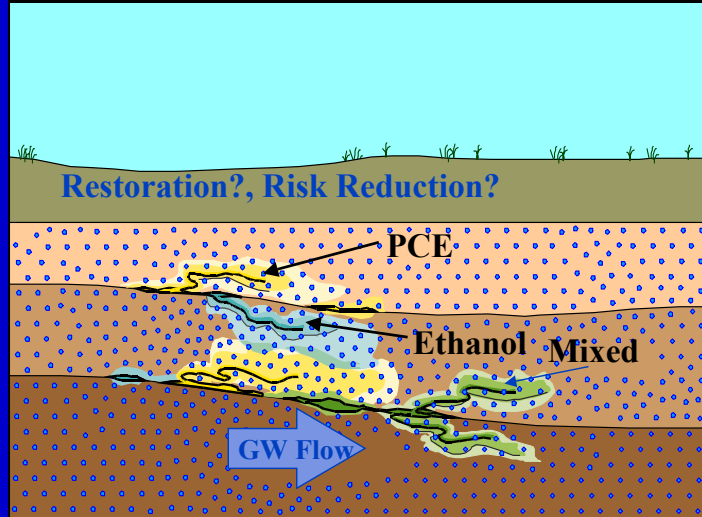
Cosolvent Extraction



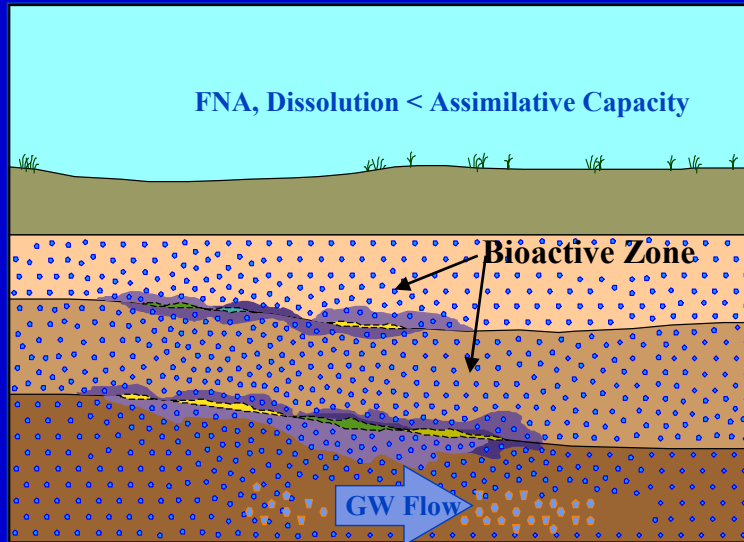
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Residual Contaminants



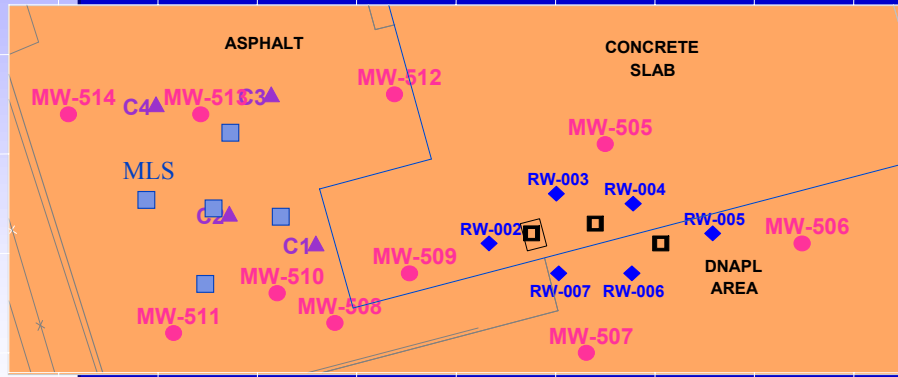
Bioremediation



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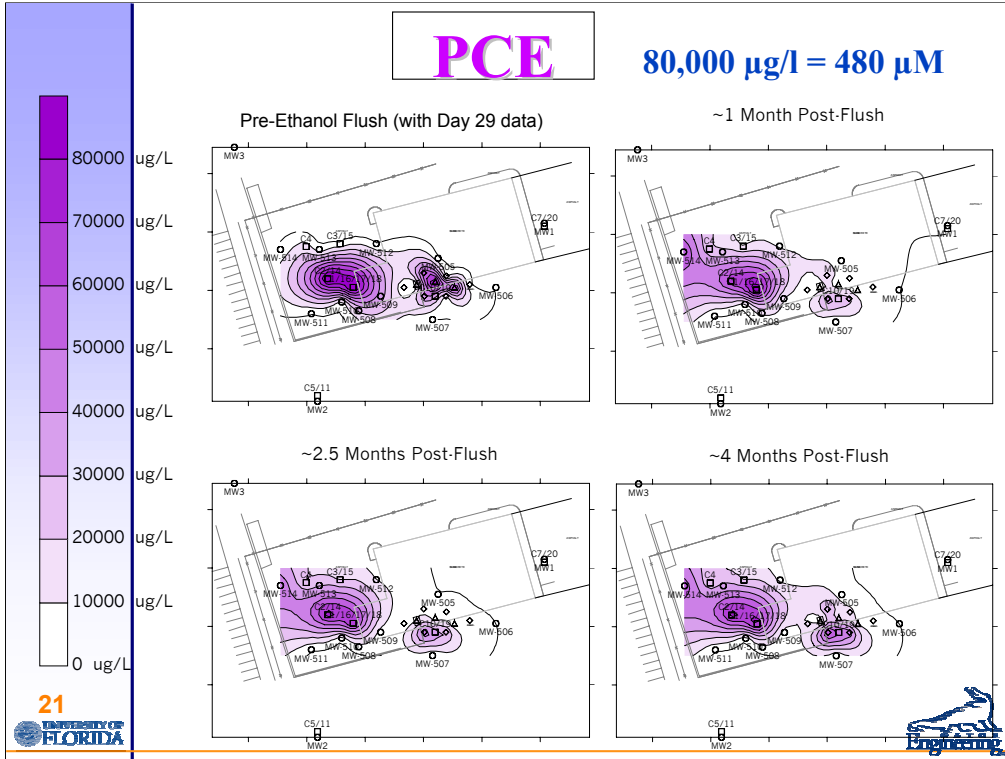


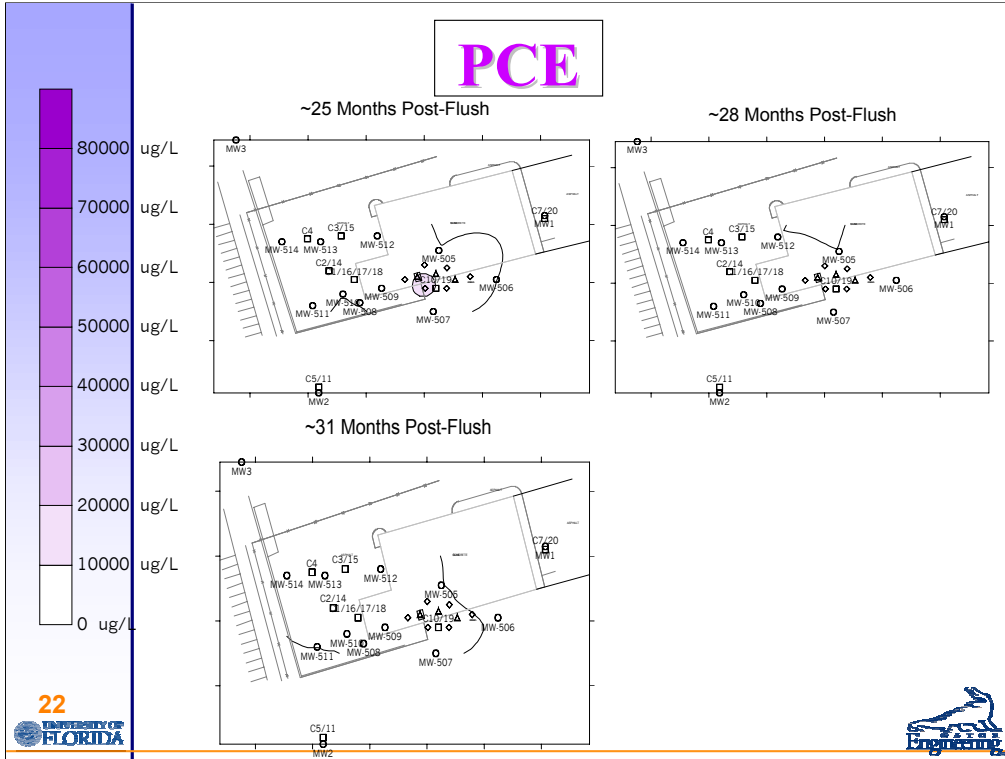
Sage's Dry Cleaner Site Jacksonville, Florida



0 ft. 20 ft. 40 ft. 60 ft. 80 ft.

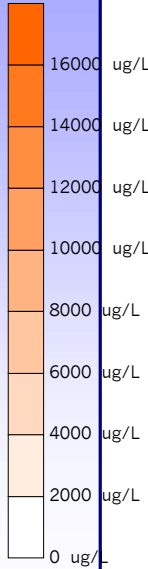




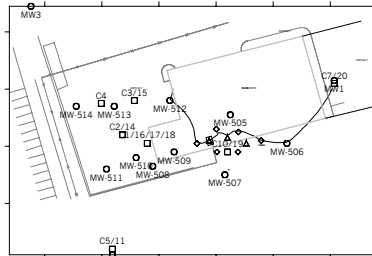


cis-DCE

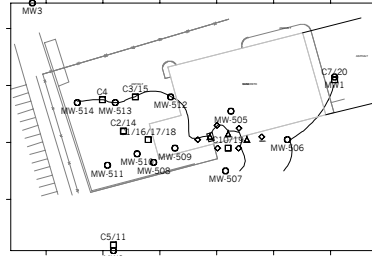
16,000 $\mu\text{g/l} = 165 \mu\text{M}$



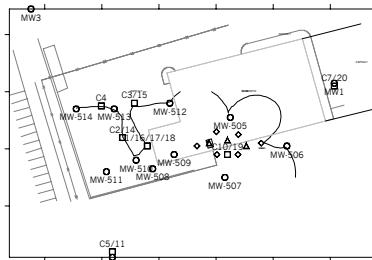
Pre-Ethanol Flush (with Day 29 data)



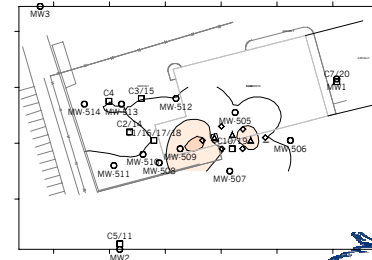
~1 Month Post-Flush



~2.5 Months Post-Flush

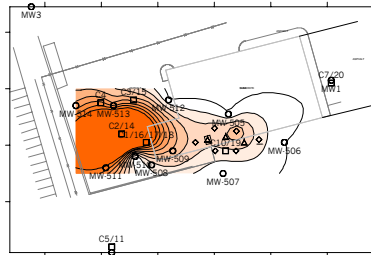


~4 Months Post-Flush

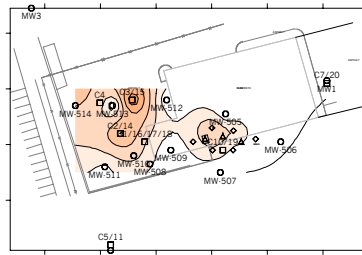


cis-DCE

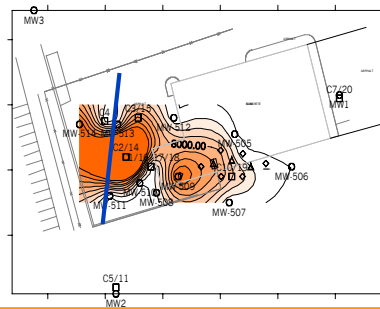
~25 Months Post-Flush



~28 Months Post-Flush

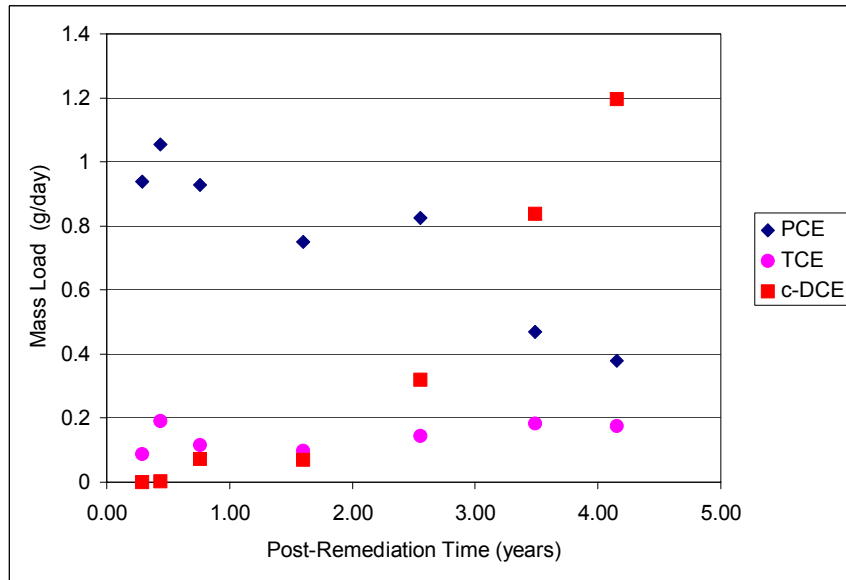


~31 Months Post-Flush



Next look at flux
across a multilevel
sampler transect

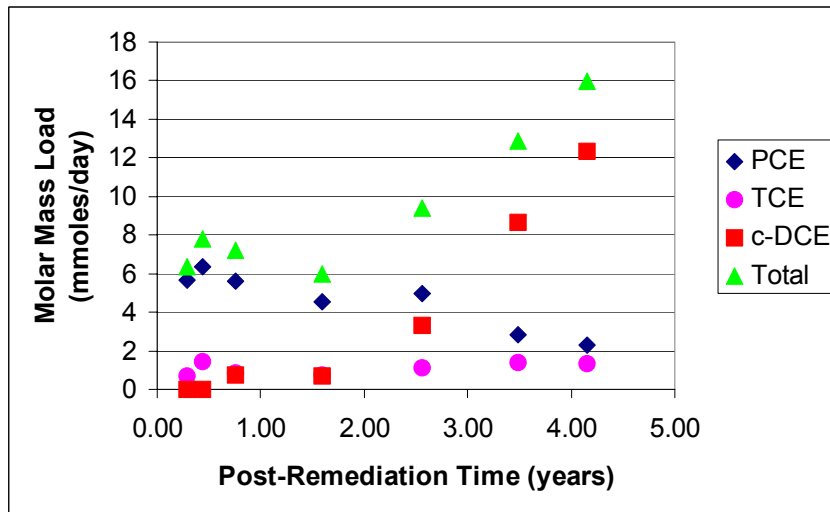
Total Plume Mass Load



25



Molar Based Total Load



Increased mass flux caused by enhanced dissolution?

SUMMARY

Solvent Extraction:

43 L PCE Removed (Mass Recovery)
~64 % PCE Removed

Source Zone Flux

47% reduction in PCE concentration in
the source zone multilevel sampler network

PCE Daughter Product Formation

Significant increase in *cis*-DCE mass

For additional indications of Biological Activity
See the Sages Poster

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What's Next?

Full Scale Remediation at Sages (early 2003)

Monitoring Mass Flux from the
Source Zone and in the Plume?



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