Surfactant Enhanced DNAPL Source Zone Remediation: Results of a Field Demonstration and Implications for Bioavailability

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Research Sponsors

- US EPA Great Lakes and Mid-Atlantic Hazardous Substance Research Center
- Michigan Department of Environmental Quality

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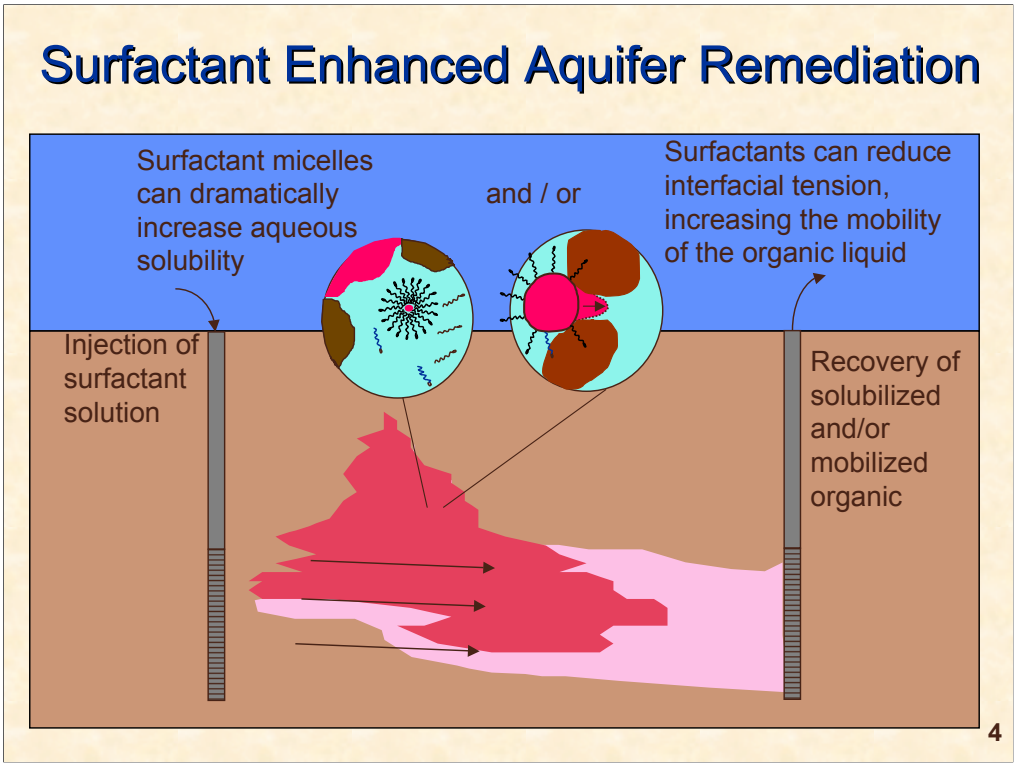
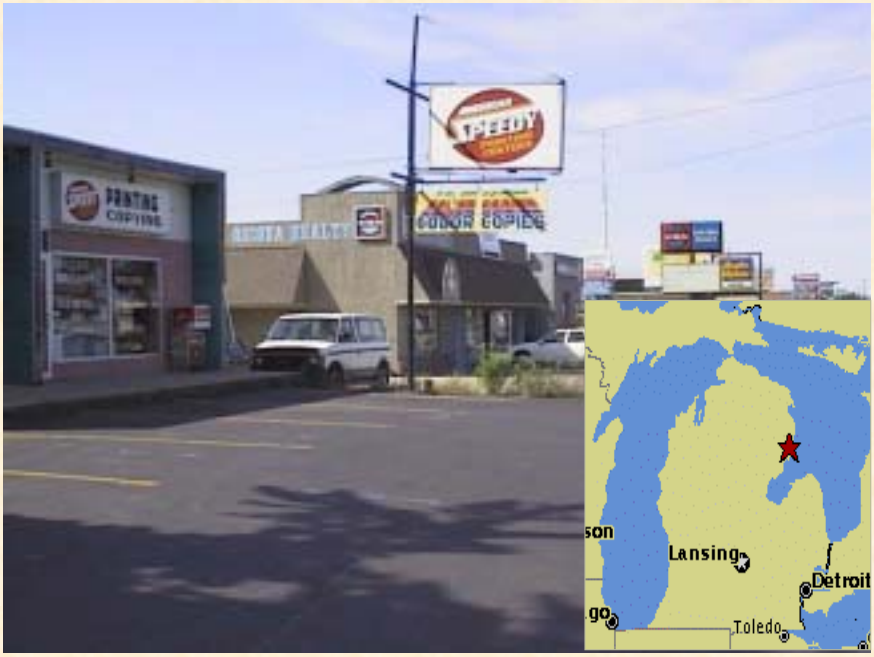


Overview of SEAR – targeted towards removal NAPLs and DNAPLs which are the source regions for contaminant plumes.

Two removal mechanisms: solubilization and mobilization

Bachman Road Site



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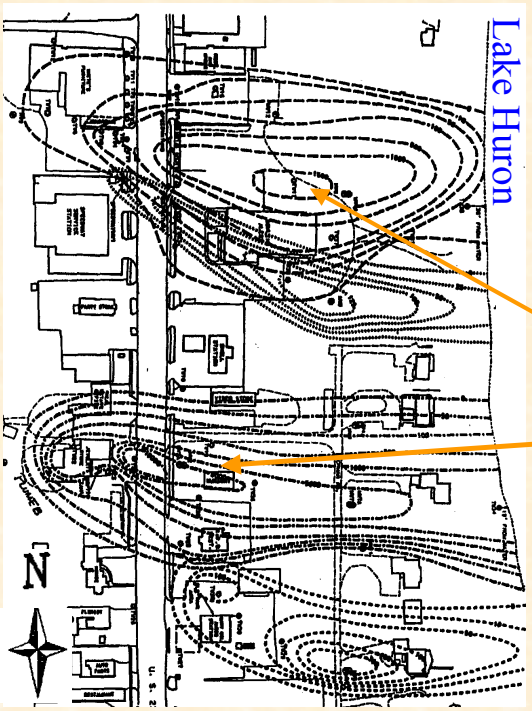

Bachman Road

1994 Contaminant Concentration Contours

Plume A: Halorespiration

Plume B: SEAR (Source Zone)

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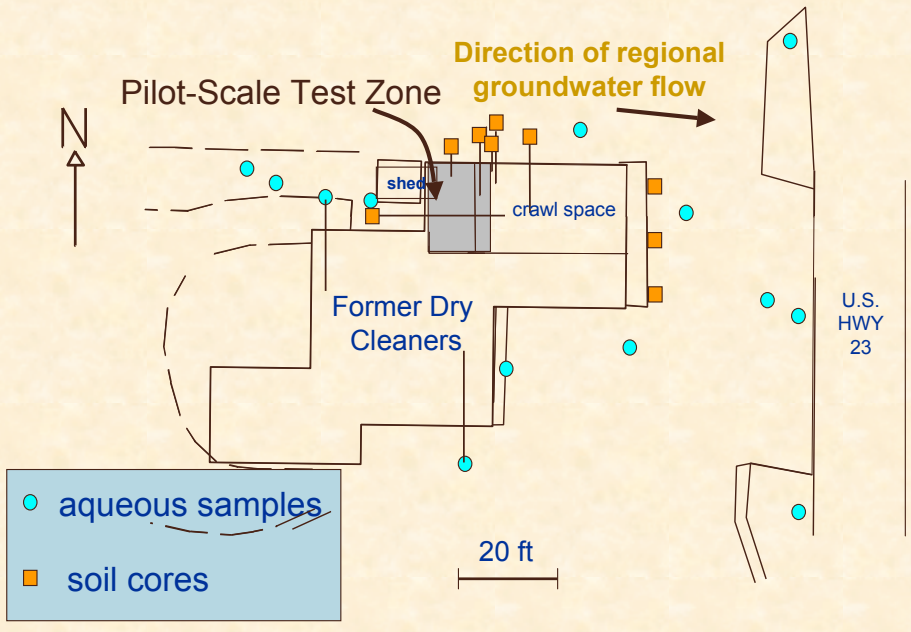
Site Characterization



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PCE Source Area
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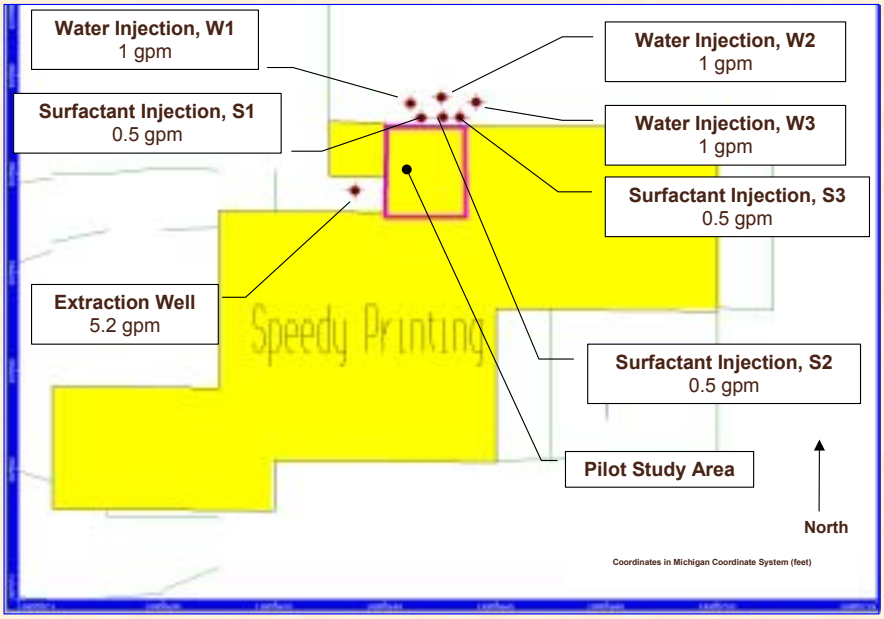
Pilot Test Design



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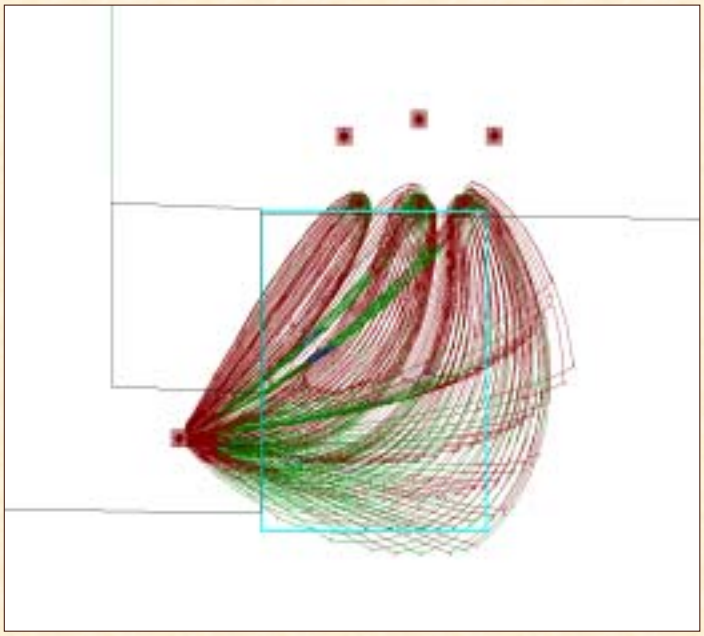
Simulated flowlines (upper layer)



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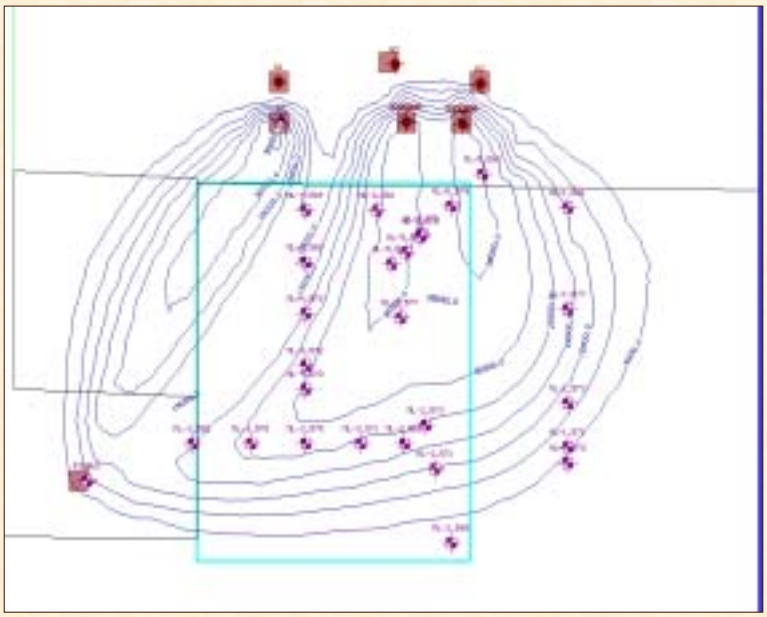
Simulated surfactant concentration (5 days of injection)



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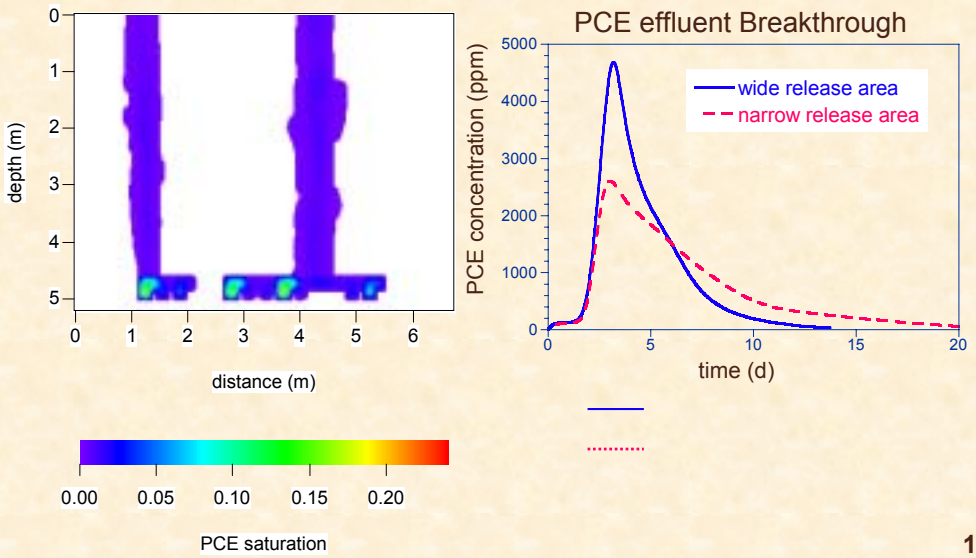
Simulated PCE Distribution and Recovery



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Conclusions from Pre-test Modeling

- Pilot test design should achieve desired sweep
- Even for this relatively homogeneous formation, spatial variability in texture influences mass distribution and remediation efficiency
- NAPL recovery strongly depends upon the hydraulic conductivity distribution and source release history

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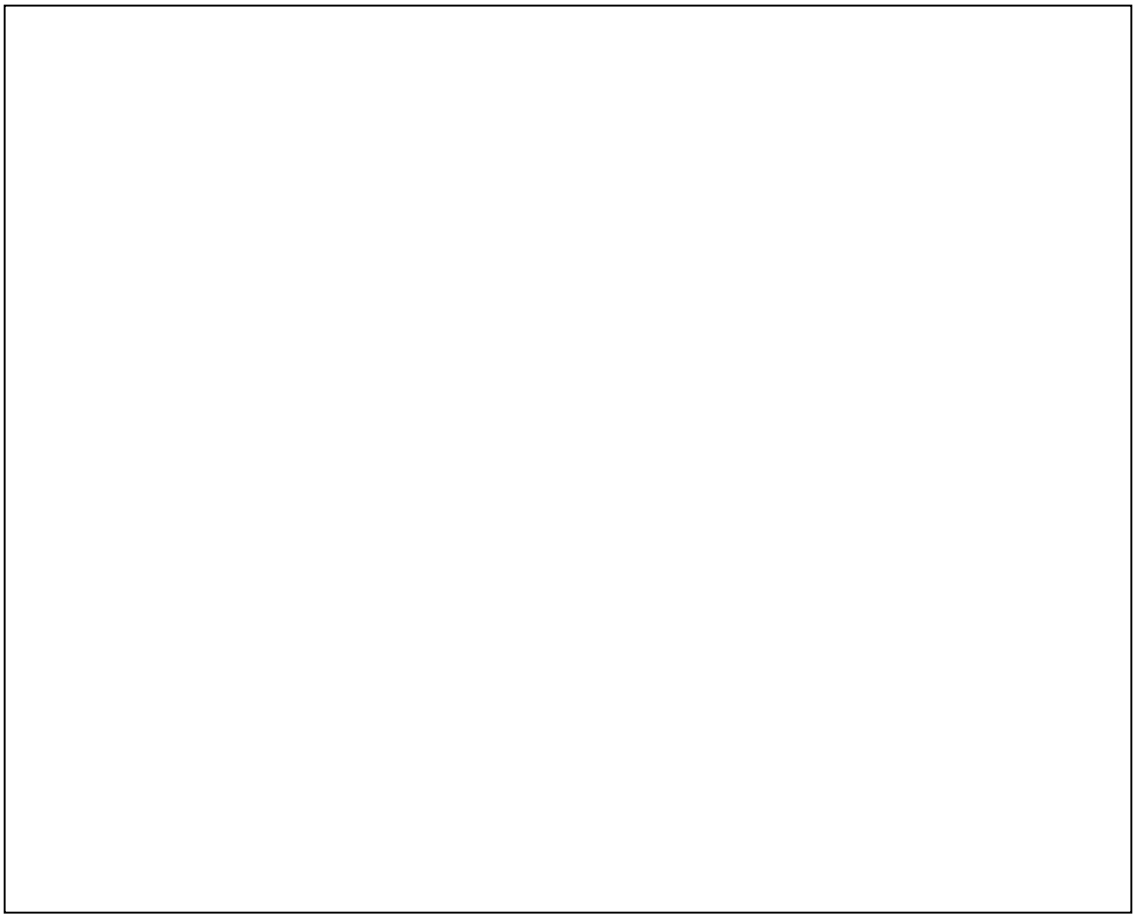

Installation of Multi-level Samplers

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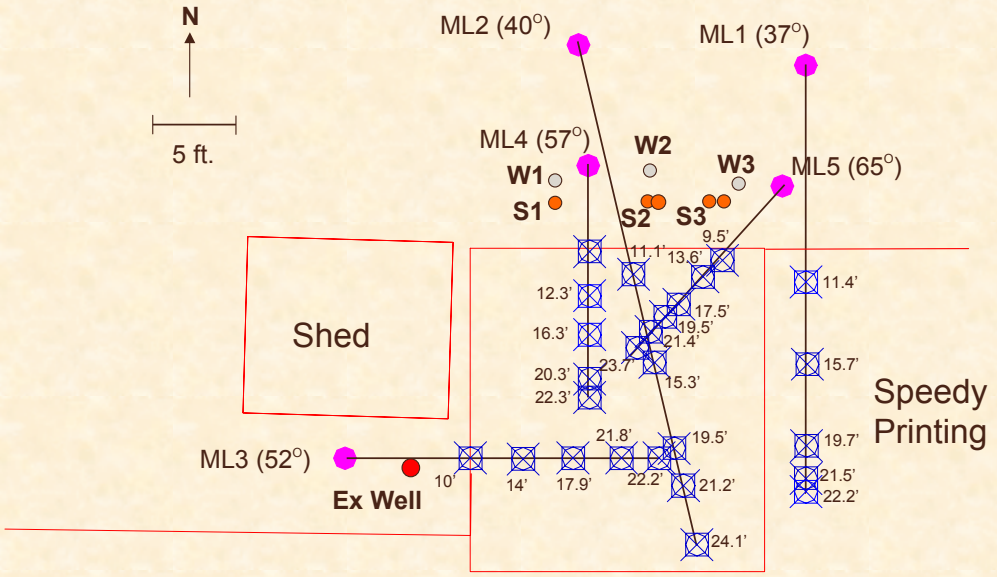
Top View of Multi-Level Monitoring Well

Location of Multi-Level Sampling Points



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Injection Flow Control System

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Injection/Mixing Tanks

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55 Gallon Drums of Tween 80

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Cross-Flow Sieve Tray Air Stripping System

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Sample Collection

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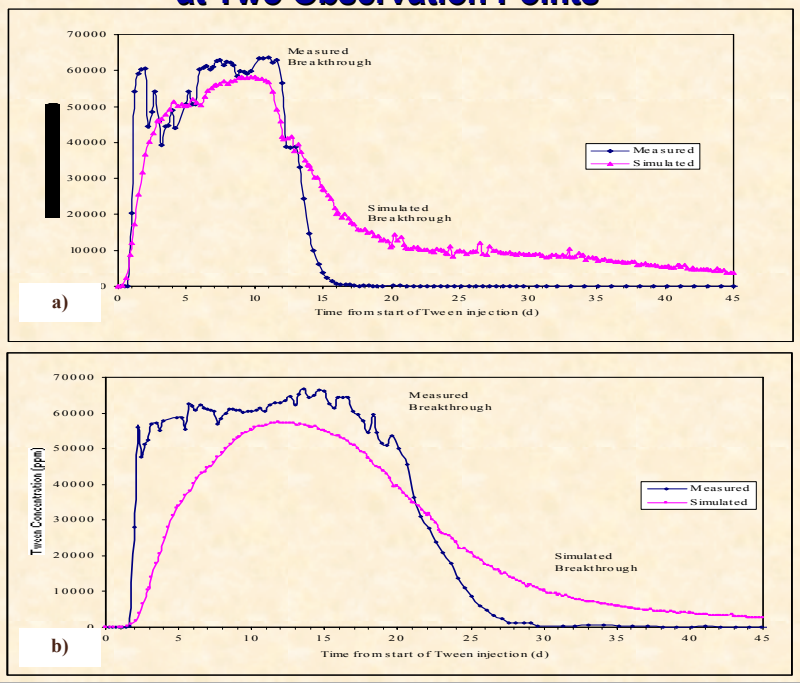
Simulated and Measured Surfactant Breakthrough at Two Observation Points



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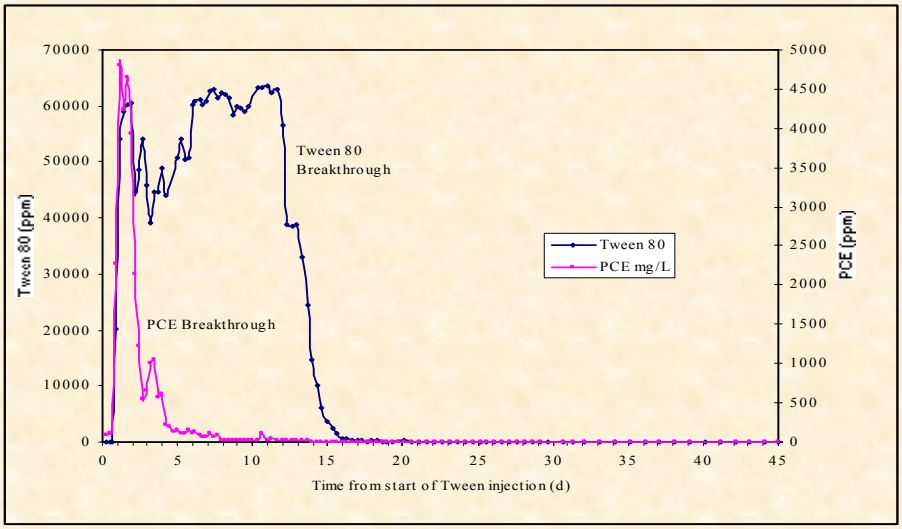
Surfactant Breakthrough and Observed PCE Concentrations (ML5E)



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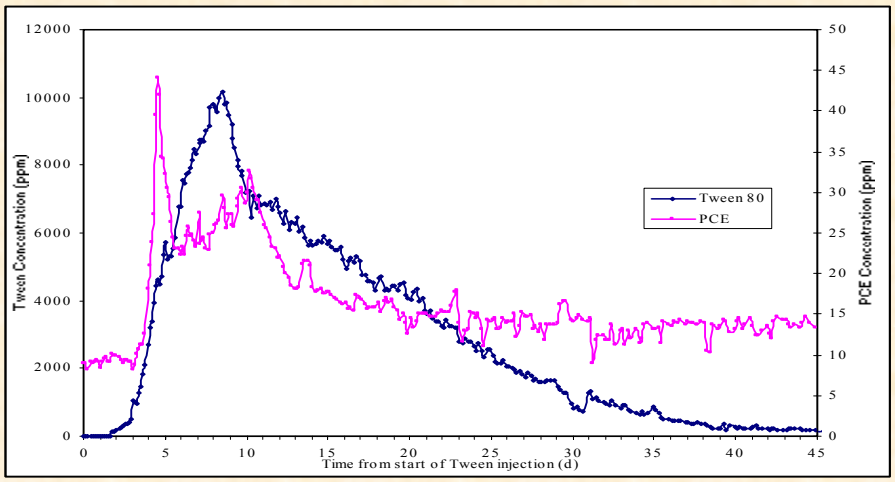
Extraction Well Recovery of Surfactant and PCE



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Source Zone Monitoring (ML5)

(mg/L)

		ML-5A (9.5')		ML-5B (13.6')		ML-5C (17.5')		ML-5D (19.5')		ML-5E (21.4')	
Date	Comments	PCE	Tween	PCE	Tween	PCE	Tween	PCE	Tween	PCE	Tween
6/30/2000	Start of surfactant injection	0.35	NQ<311	45.31	NQ<311	48.00	NQ<311	0.89	NQ<311	98.84	NQ<311
8/15/2000	Last day of SEAR test	NQ<5.14	NQ<90	NQ<5.14	NQ<90	NQ<5.14	NQ<90	NQ<5.14	NQ<90	NQ<5.14	NQ<90
8/29/2000	2 weeks after test	NQ<1	122.23	NQ<1	103.71	NQ<0.63	NQ<90			NQ<0.63	NQ<90
10/10/2000	56 days after test	0.0845	63.72	0.4566	93.96	0.8823	54.13	0.0888	64.93	0.9368	63.87
5/10/2001	270 days after test	0.288	NQ<16	0.052	21.85	0.10	NQ<16	NQ<.015	NQ<16	0.19	NQ<16
11/13/2001	450 days after test	0.0220	NQ<50	0.1700	NQ<50	0.2400	NQ<50	0.0200	NQ<50	0.4000	NQ<50

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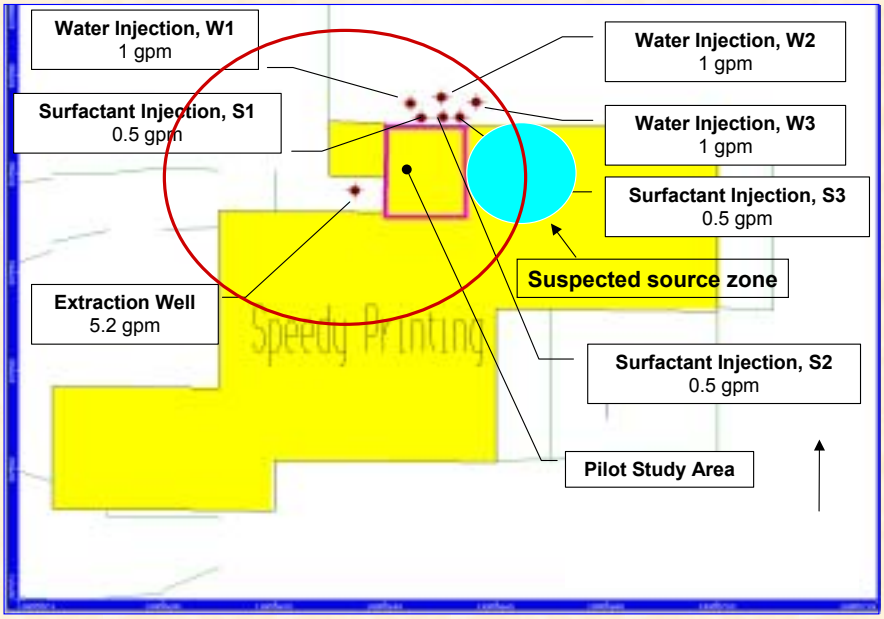
Pilot Test Configuration



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Source Zone Monitoring for Degradation Products (ML5) – Nov 2001

(mg/L)

		ML-5A (9.5')	ML-5B (13.6')	ML-5C (17.5')	ML-5D (19.5')	ML-5E (21.4')
Date	Comments	mg/L	mg/L	mg/L	mg/L	mg/L
11/13/01	Tetrachloroethylene (PCE)	0.022	0.17	0.24	0.02	0.4
11/13/01	Trichloroethylene (TCE)	0.12	0.052	0.031	0.006	0.041
11/13/01	cis - 1.2 - Dichloroethene	0.47	0.57	0.11	0.017	0.12
11/13/01	trans -1.2 - Dichloroethene	NQ<.001	NQ<.001	NQ<.001	NQ<.001	NQ<.001
11/13/01	Vinyl Chloride	NQ<.001	NQ<.001	NQ<.001	NQ<.001	NQ<.001
11/13/01	Tween	NQ<50	NQ<50	NQ<50	NQ<50	NQ<50
11/13/01	acetate (mM)	NQ<0.1	0.49	NQ<0.1	NQ<0.1	NQ<0.1

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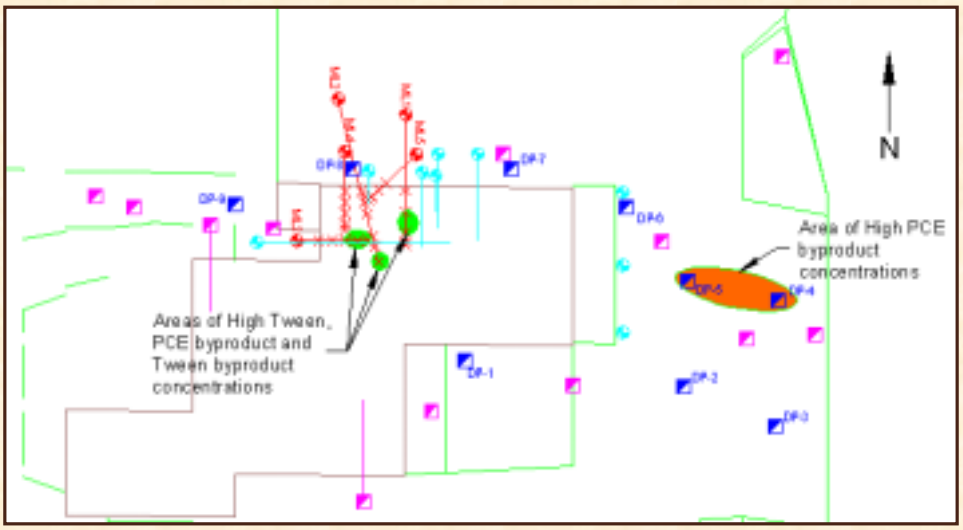
Post Test Characterization

November 2001



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Conclusions

- Breakthrough curves indicate good sweep efficiency within the treatment zone
- 95% of the injected surfactant mass was recovered
- 19 liters of PCE were recovered during test
- Analysis of partitioning alcohols suggest very low saturations within the treatment zone
- Concentration tailing in extraction well suggests additional source area within capture zone
- Source zone concentrations reduced by approximately two orders of magnitude
- Evidence of post-test microbial activity enhancement within residual source zone

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Ongoing Work

- Monitoring of PCE and degradation products
- Further site characterization
- Full-scale SEAR design
- Exploration of feasibility of halorespiration stimulation in treated zone

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References

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