

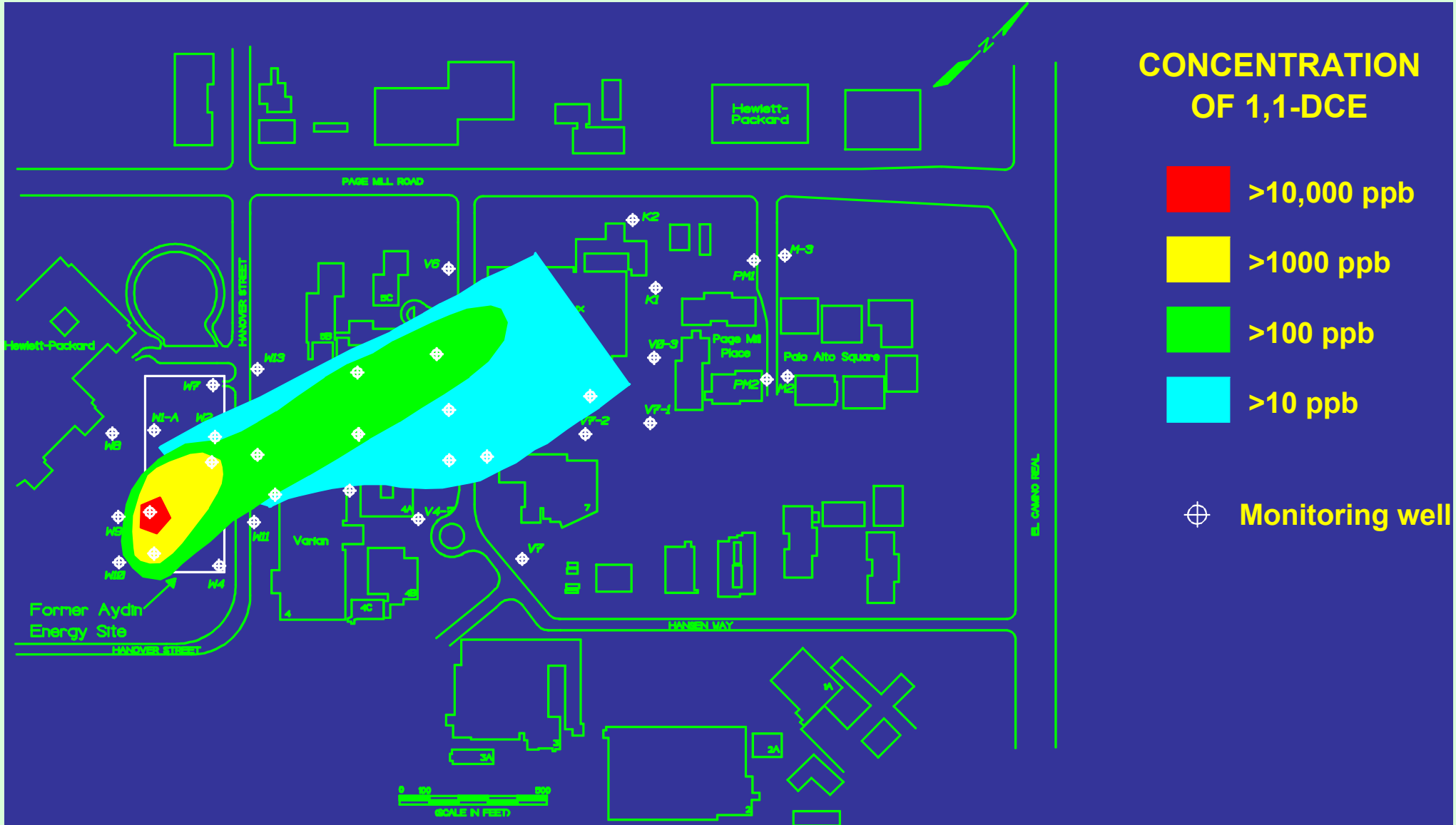
Lecture 10

Soil vapor extraction, air sparging, and soil flushing

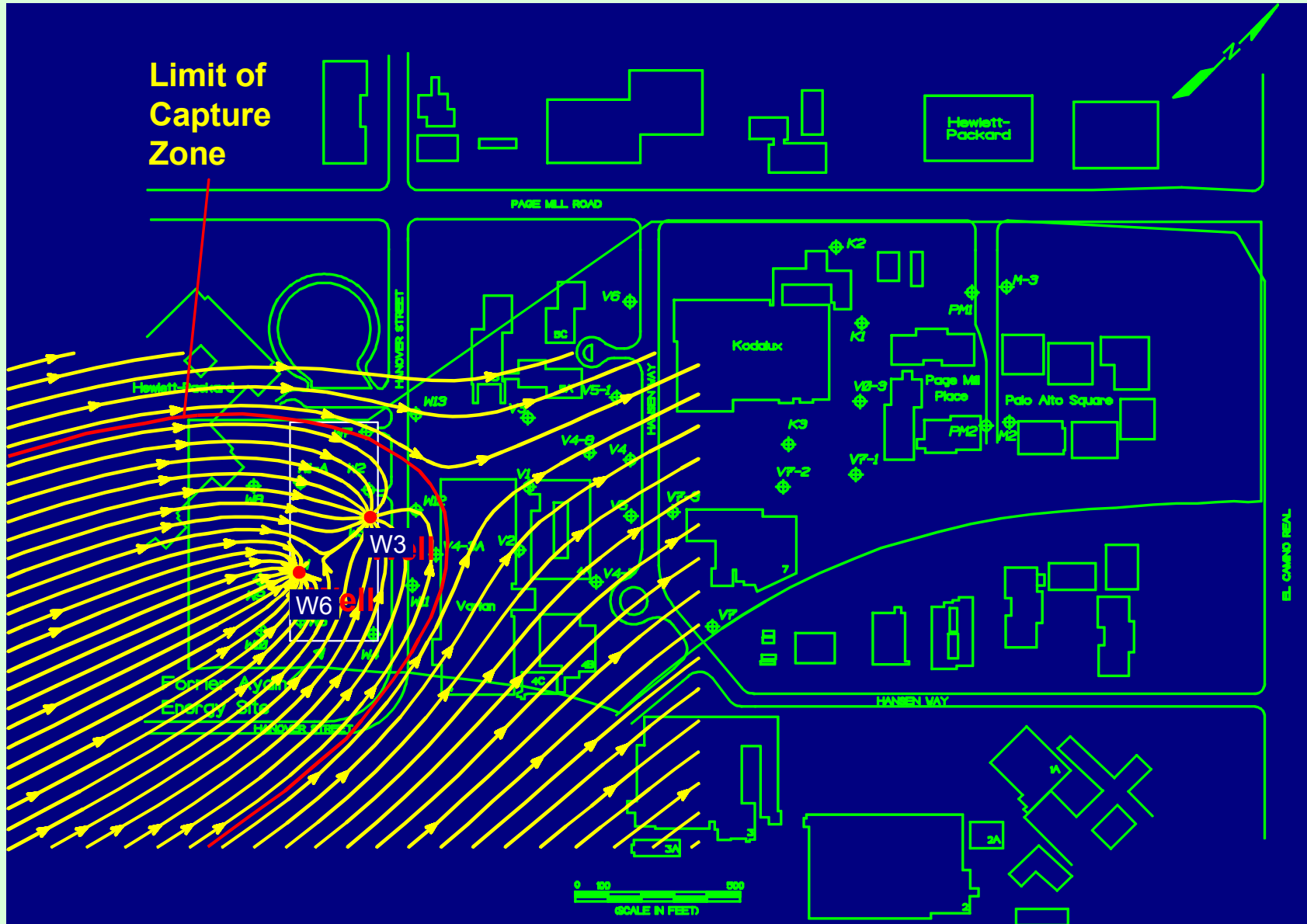


Air stripper in Acton, MA. It is installed on an Acton public supply well affected by the W.R. Grace Superfund Site. Image courtesy of Peter Shanahan.

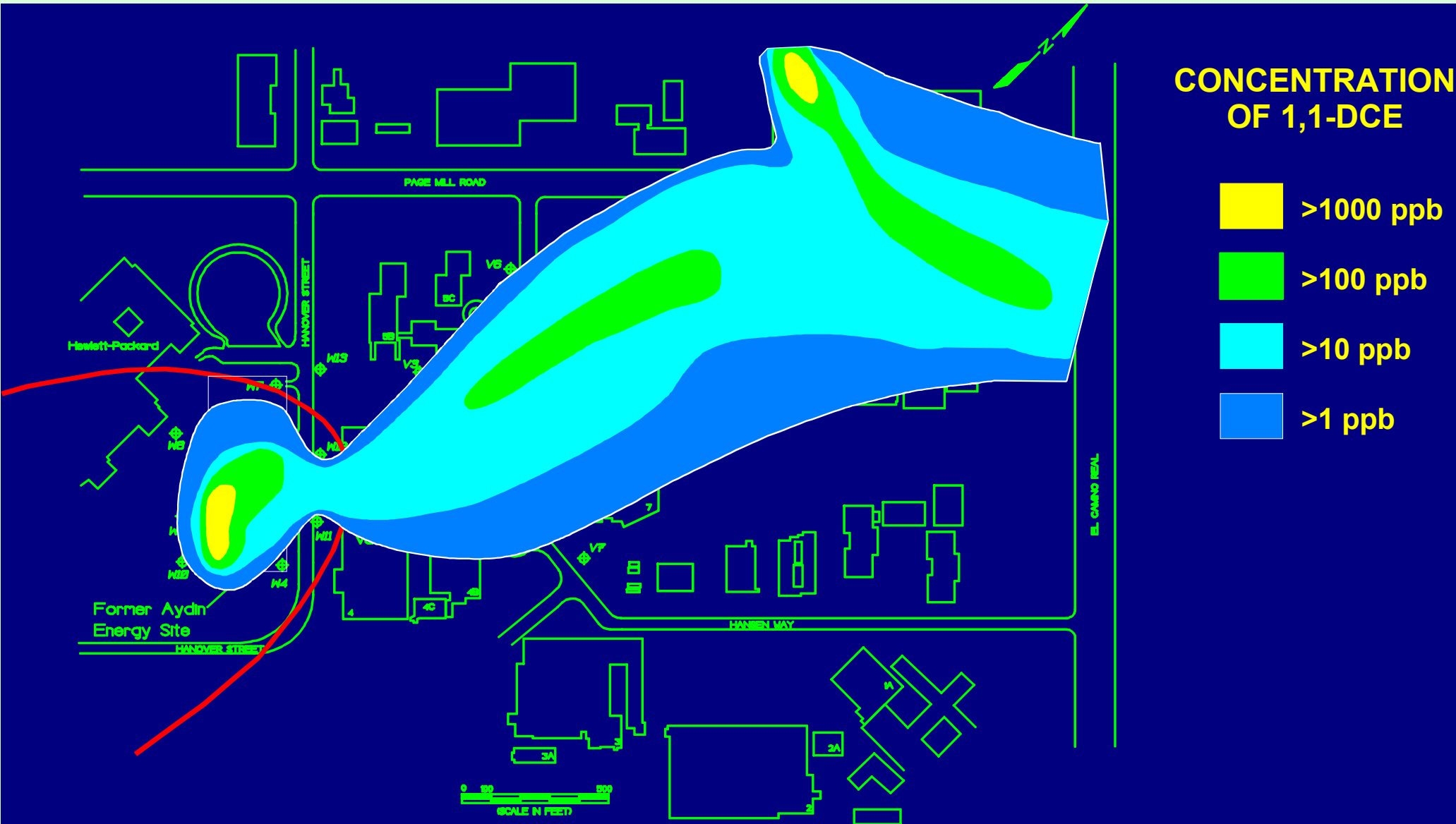
1,1-DCE Plume in Palo Alto, California



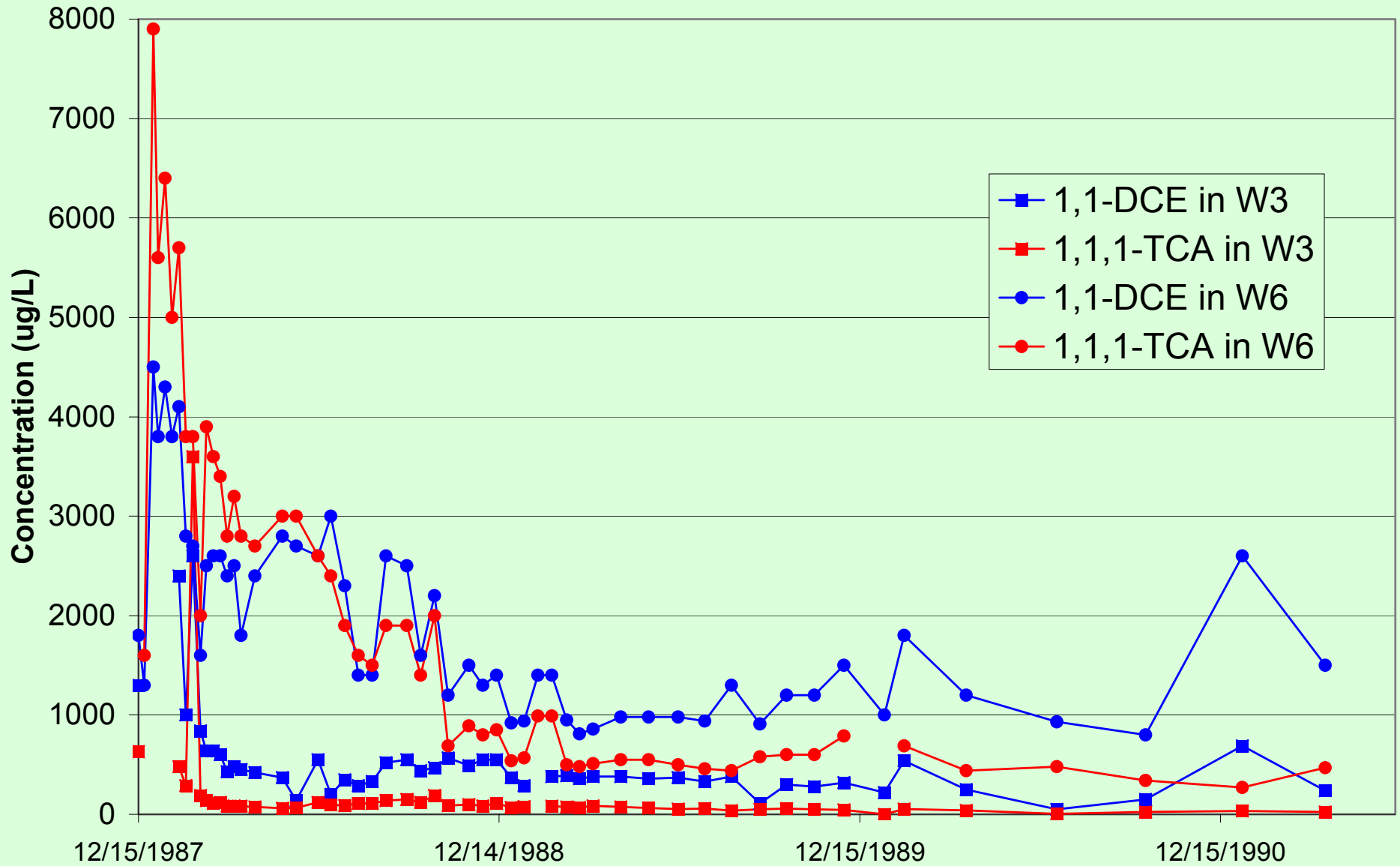
Capture Zone Model



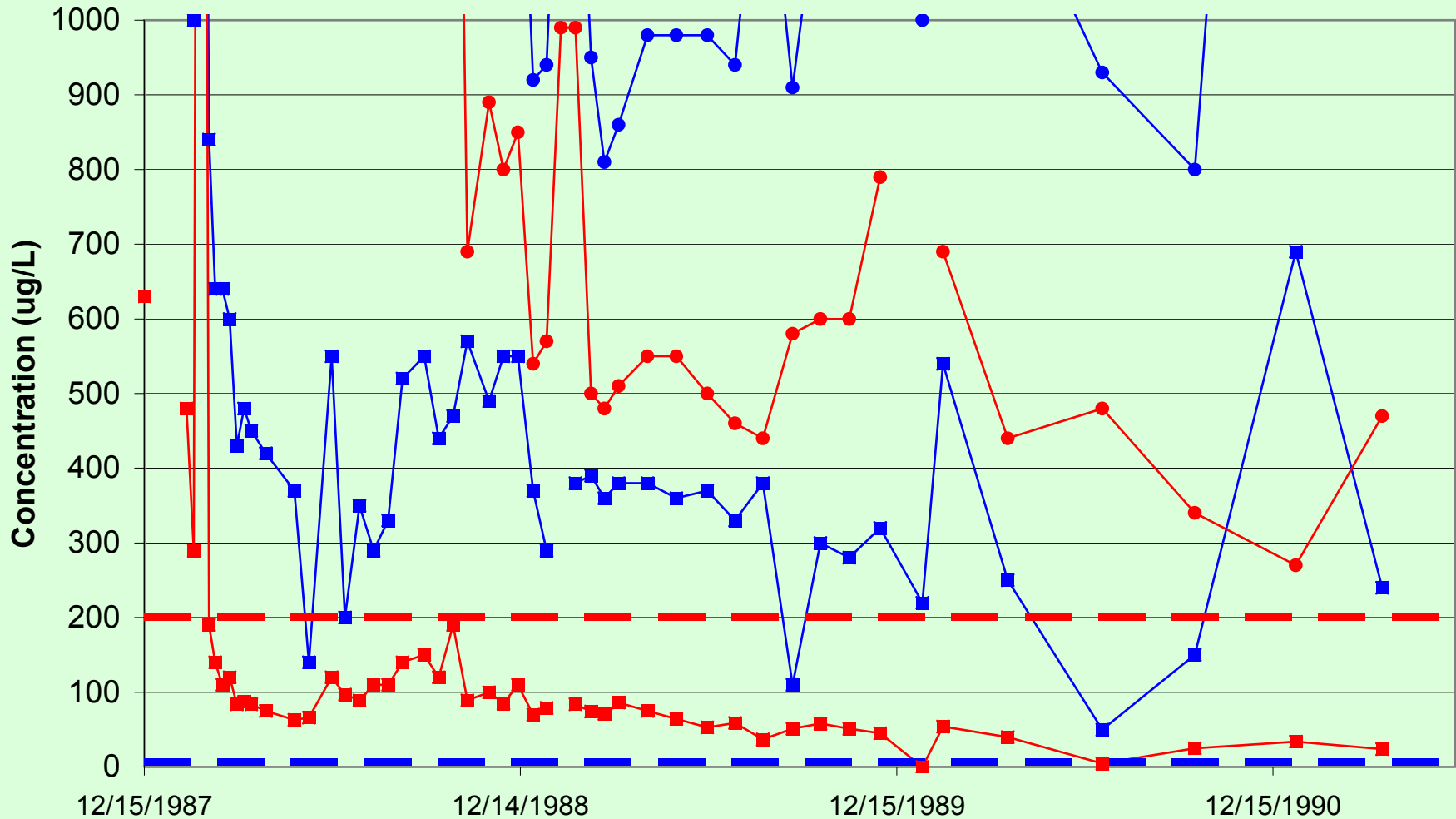
Plume after Pump and Treat Starts



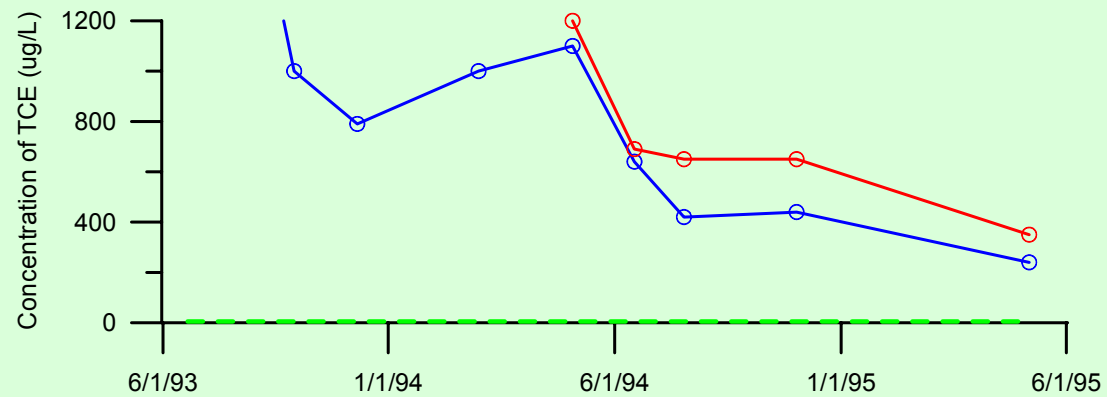
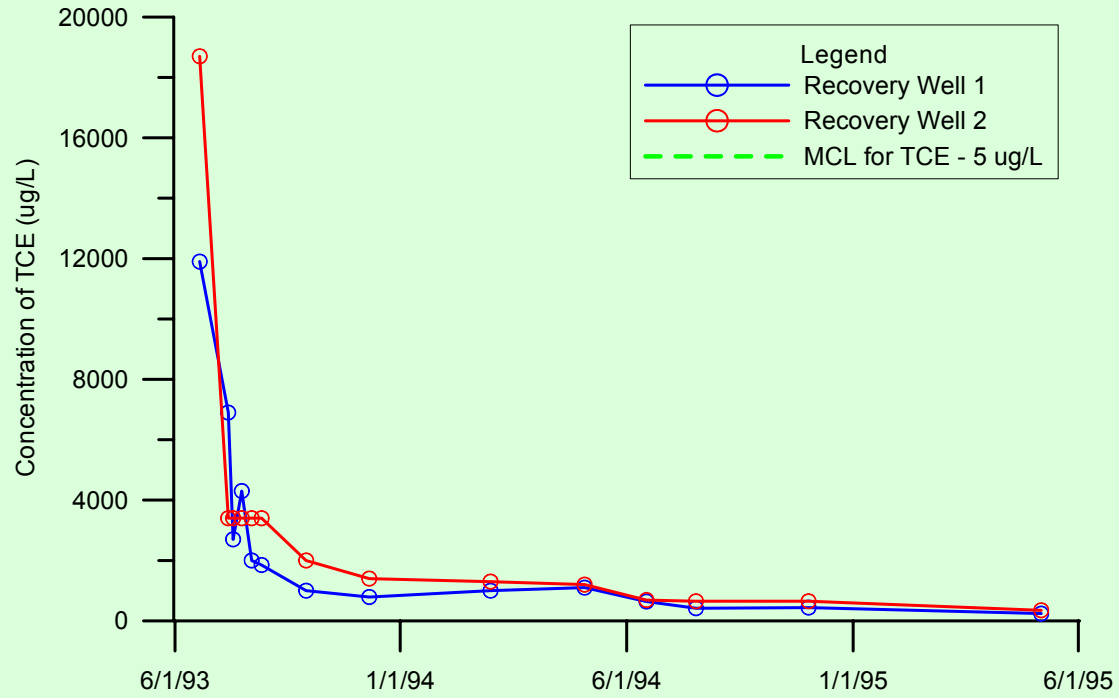
Concentrations in Withdrawal Wells



Concentrations in Withdrawal Wells



Concentrations in Pump and Treat Recovery Wells at manufacturing facility, Hutchinson, Kansas



Historical Recognition of Limitations of Pump & Treat

- 1989 – Articles in Ground Water and ES&T question pump and treat remediation
- 1989 – EPA review finds only 1 out of 19 systems reached cleanup goals
- 1991 – EPA holds seminars on DNAPLs
- 1992 – EPA issues “Estimating Potential for DNAPLs at Superfund Sites”
- 1993 – EPA issues “Technical Impracticability” guidance
- 1994 – National Research Council study finds 69 out of 77 systems did not reach cleanup

Figure 5. Selection of P&T for Superfund Remedial Actions (FY 1986 - FY 1999)

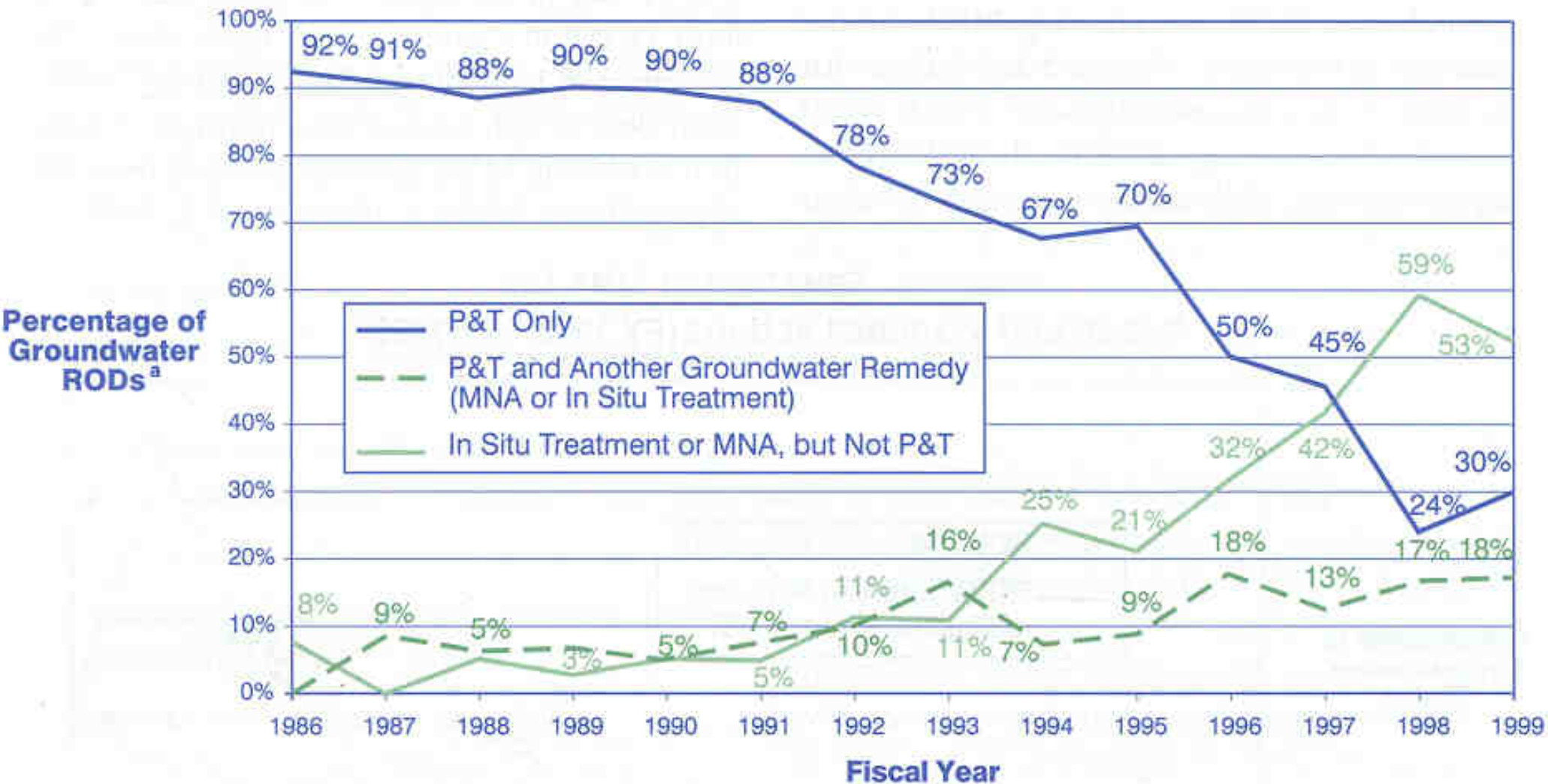
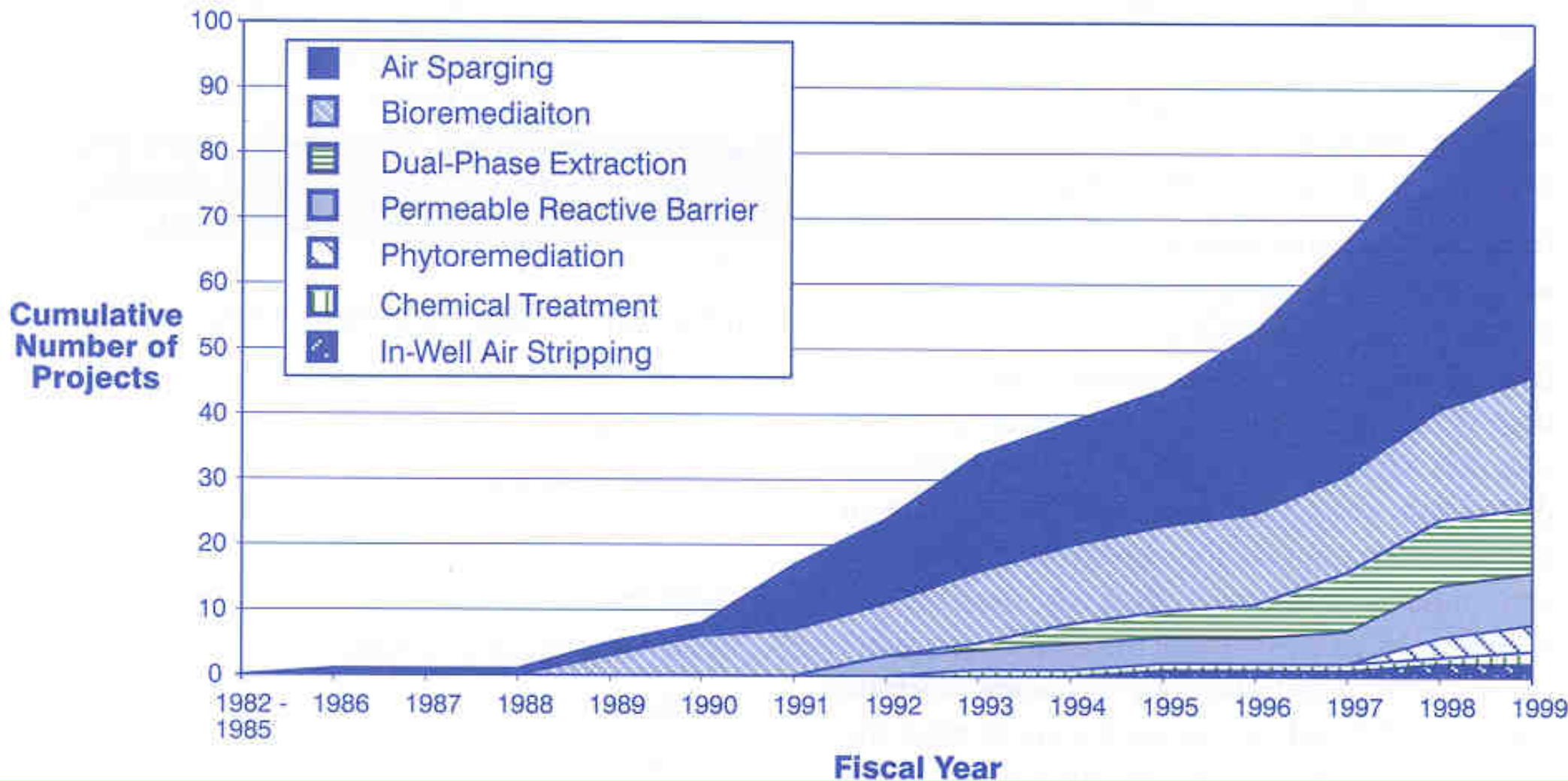
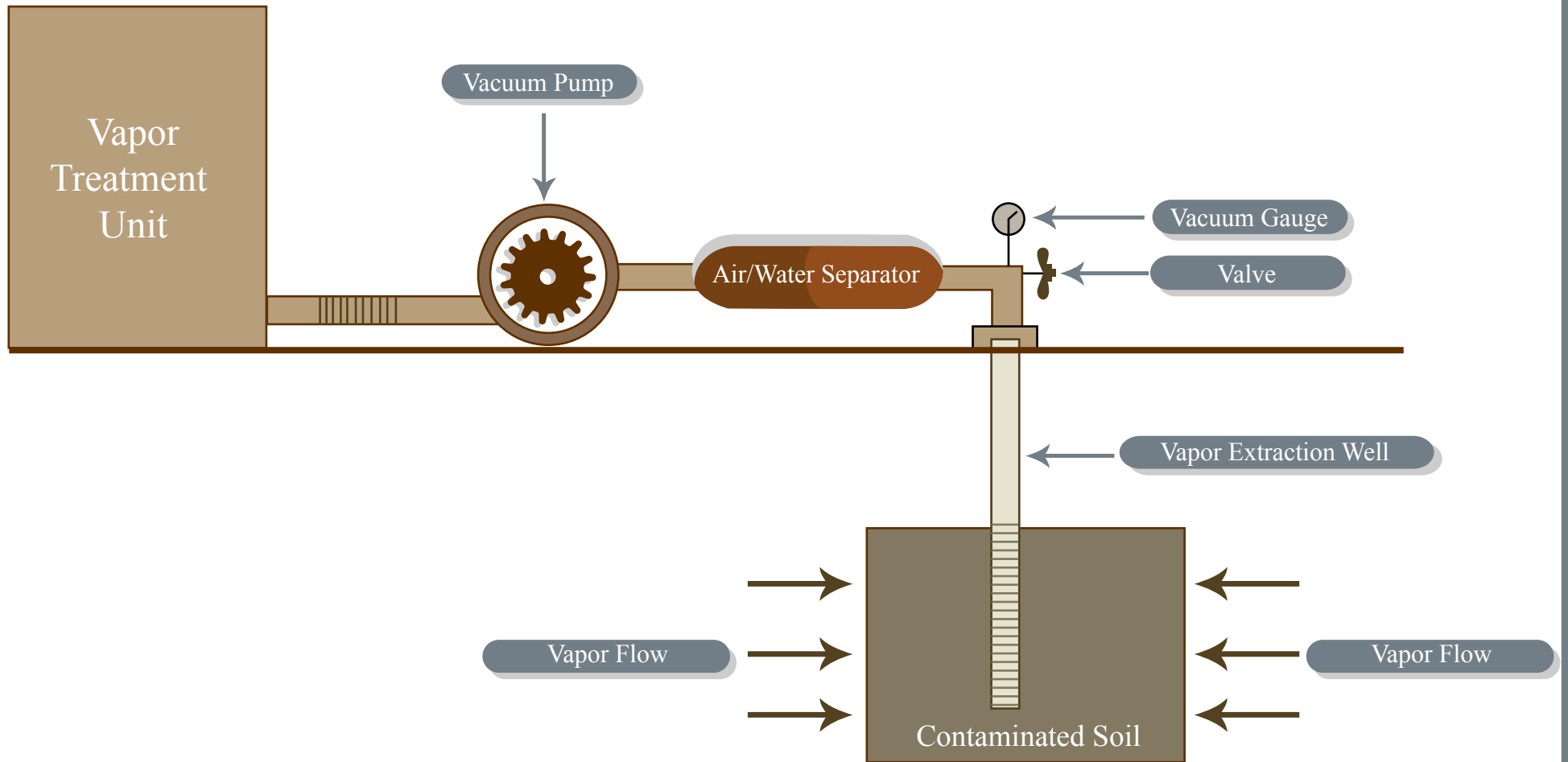


Figure 10. Superfund Remedial Actions: Cumulative Trends for In Situ Groundwater Treatment Technologies (FY 1982 - FY 1999)



Soil Vapor Extraction (SVE)



Adapted from: Hansen Web Design, February 23, 2003. *Environews*. U.S. Army at Badger Army Ammunition Plant. Baraboo, WI.
<http://www.badgeraap.org/environews/envmarapr99g.htm>. Accessed February 27, 2003.

SVE System

See image at the Web site of Wayne Perry, Inc.,
Soil Vapor Extraction Systems,
<http://www.wpinc.com/remedy/remedy30.html>
Accessed May 11, 2004.

SVE Vapor Treatment

See image at the Web site of Environmental Support Technologies, Inc., Vapor Extraction Vent Testing and Treatment Systems, <http://www.est-inc.com/vapext.htm>
Accessed May 11, 2004.

SVE Instrumentation and Controls

See image at the Web site of Applied Hydrology Associates, Inc., Soil Vapor Extraction, Air Sparging, and Bioventing.

<http://www.appliedhydrology.com/soil.htm>

Accessed May 11, 2004.

Paulsboro, NJ Oil Terminal

See image at the Web site of Environmental Satellite, Paulsboro, New Jersey.

http://www.paulsboroterminal.com/agrave.asp?get=/Paulsboro_Pipeline/Fall_1999/gis_diagram

Accessed May 11, 2004.

Paulsboro SVE System

See image at the Web site of Environmental Satellite, Paulsboro, New Jersey.

http://www.paulsboroterminal.com/agrave.asp?get=/Paulsboro_Pipeline/Fall_2000/Treating_the_Vapors

Accessed May 11, 2004.

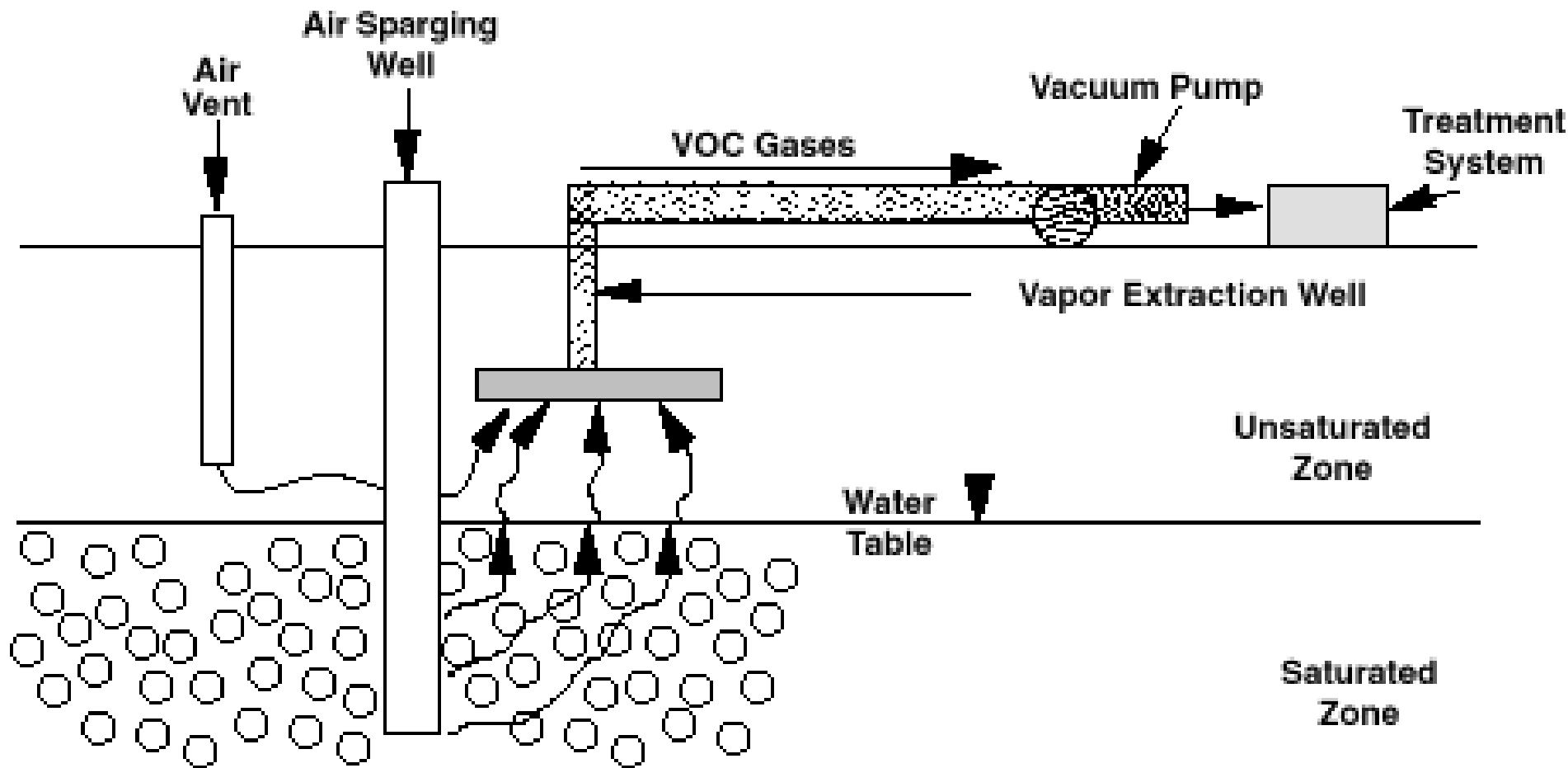
SVE System - Paulsboro

See image at the Web site of Environmental Satellite, Paulsboro, New Jersey.

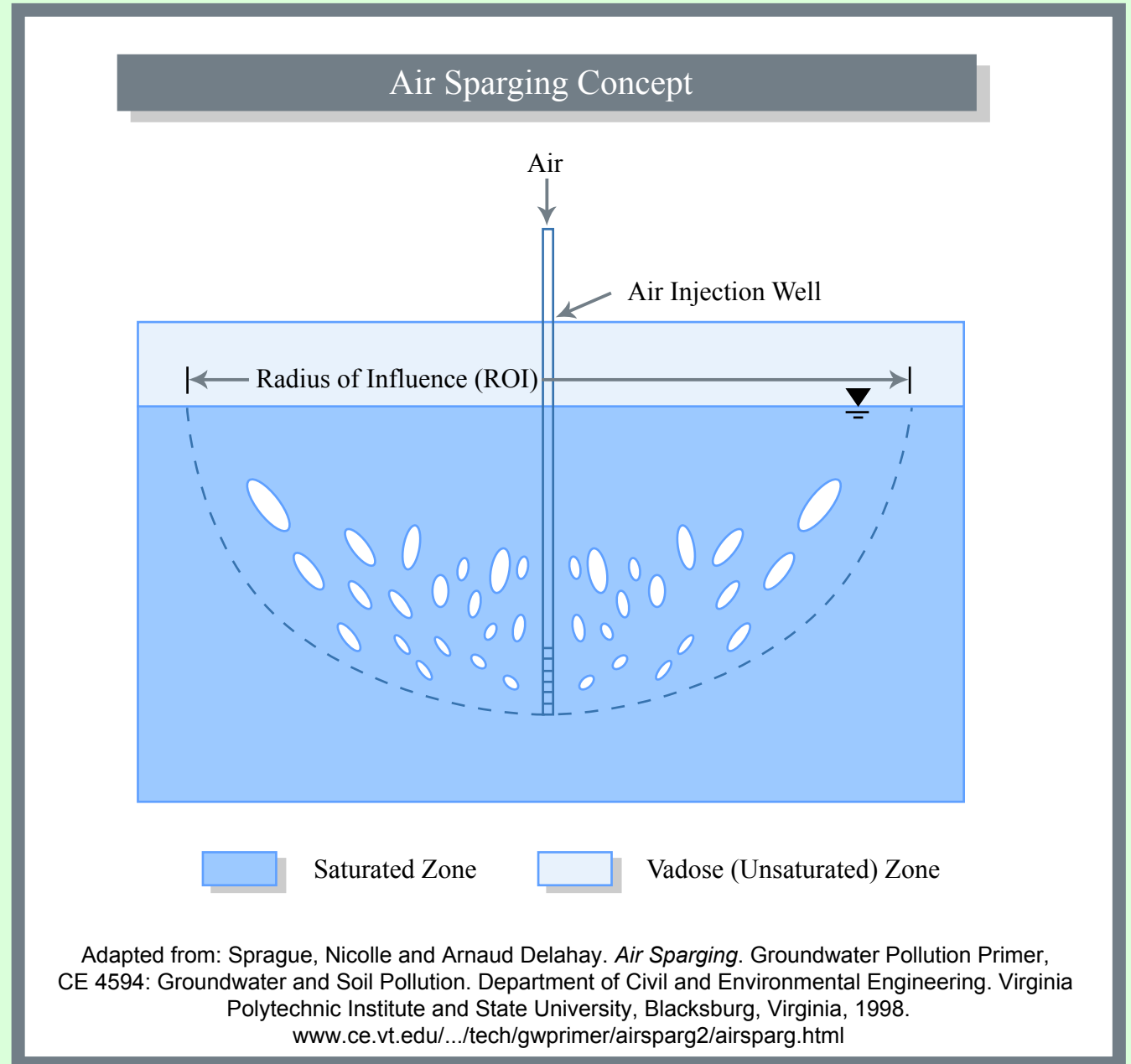
http://www.paulsboroterminal.com/agrave.asp?get=/Paulsboro_Pipeline/Fall_2000/The_SVE_System_at_the_Paulsboro_Terminal

Accessed May 11, 2004.

Air Sparging & SVE



Air Sparging Concept



Moderate Air Injection

See Figure 7 in: Ji, W., A. Dahmani, D. P. Ahlfeld, J. D. Lin and E. Hill, 1993.

"Laboratory study of air sparging: air flow visualization." *Ground Water Monitoring and Remediation*, Vol. 13, No. 4, Pp. 115-126.

High Air Injection – Uniform Medium

See Figure 8 in: Ji, W., A. Dahmani, D. P. Ahlfeld, J. D. Lin and E. Hill, 1993.

"Laboratory study of air sparging: air flow visualization." *Ground Water Monitoring and Remediation*, Vol. 13, No. 4, Pp. 115-126.

High Air Injection – Mixed Medium

See Figure 11 in: Ji, W., A. Dahmani, D. P. Ahlfeld, J. D. Lin and E. Hill, 1993.

"Laboratory study of air sparging: air flow visualization." *Ground Water Monitoring and Remediation*, Vol. 13, No. 4, Pp. 115-126.

Stratified Medium Setup

See Figure 13 in: Ji, W., A. Dahmani, D. P. Ahlfeld, J. D. Lin and E. Hill, 1993.

"Laboratory study of air sparging: air flow visualization." *Ground Water Monitoring and Remediation*, Vol. 13, No. 4, Pp. 115-126.

Moderate Air Injection – Stratified Medium

See Figure 16 in: Ji, W., A. Dahmani, D. P. Ahlfeld, J. D. Lin and E. Hill, 1993.

"Laboratory study of air sparging: air flow visualization." *Ground Water Monitoring and Remediation*, Vol. 13, No. 4, Pp. 115-126.

Air Sparging Microview

See Figure 7a in: Elder, C. R. and C. H. Benson, 1999. "Air Channel Formation, Size, Spacing, and Tortuosity During Air Sparging." Ground Water Monitoring and Remediation, Vol. 19, No. 3, Pp. 171.

**Low pressure →
discontinuous air passage**

See Figure 7b in: Elder, C. R. and C. H. Benson, 1999. "Air Channel Formation, Size, Spacing, and Tortuosity During Air Sparging." Ground Water Monitoring and Remediation, Vol. 19, No. 3, Pp. 171.

**High pressure →
continuous air passage**

Air Sparging – Bubble Movement

See Figure 5 in: Roosevelt, S. E. and M. Y. Corapcioglu, 1998. "Air bubble migration in a granular porous medium: Experimental studies." *Water Resources Research*, Vol. 34, No. 5, Pp. 1131-1142.

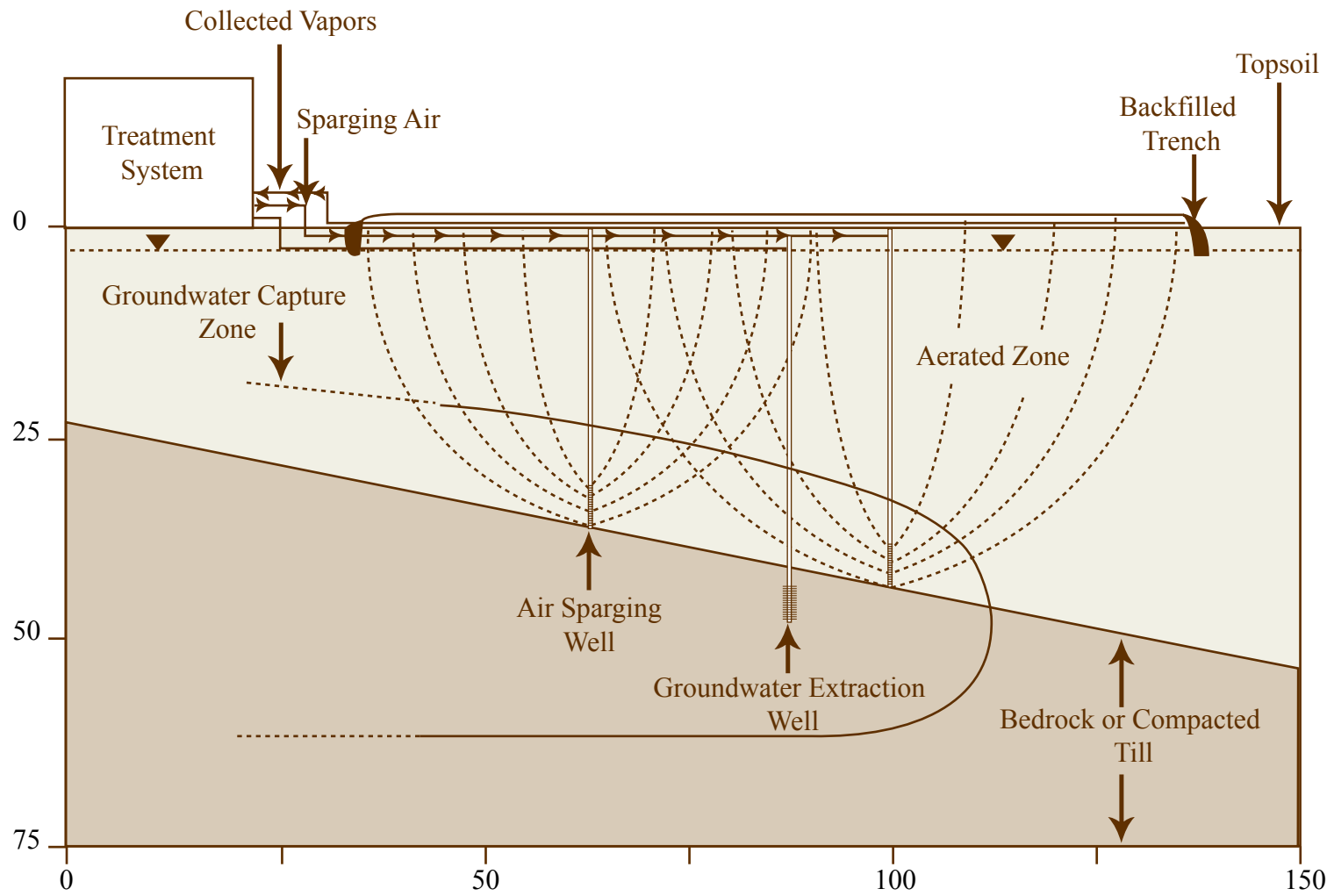
Air Sparging Conceptual Models

See Figure 12 in: Clayton, W. S., 1998. "A Field and Laboratory Investigation of Air Fingering During Air Sparging." *Ground Water Monitoring and Remediation*, Vol. 18, No. 3, Pp. 134-145.

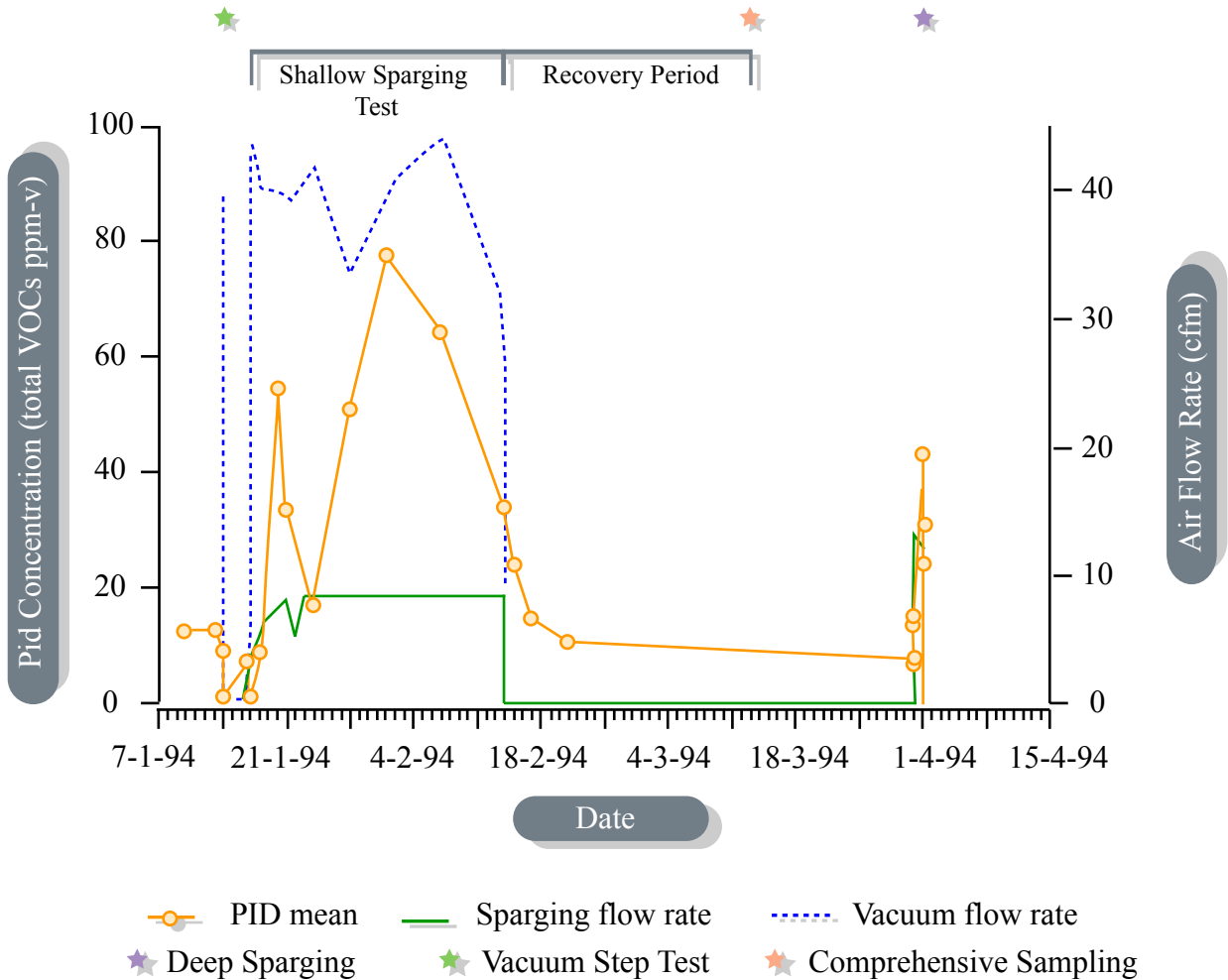
Woburn Wells G&H Superfund Site, Massachusetts

Source: Environmental Protection Agency, Region 1,
Waste Site Cleanup & Reuse in New England,
http://www.epa.gov/ne/superfund/sites/wellsgh/42364_TOC_Text.pdf. Accessed May 11, 2004.

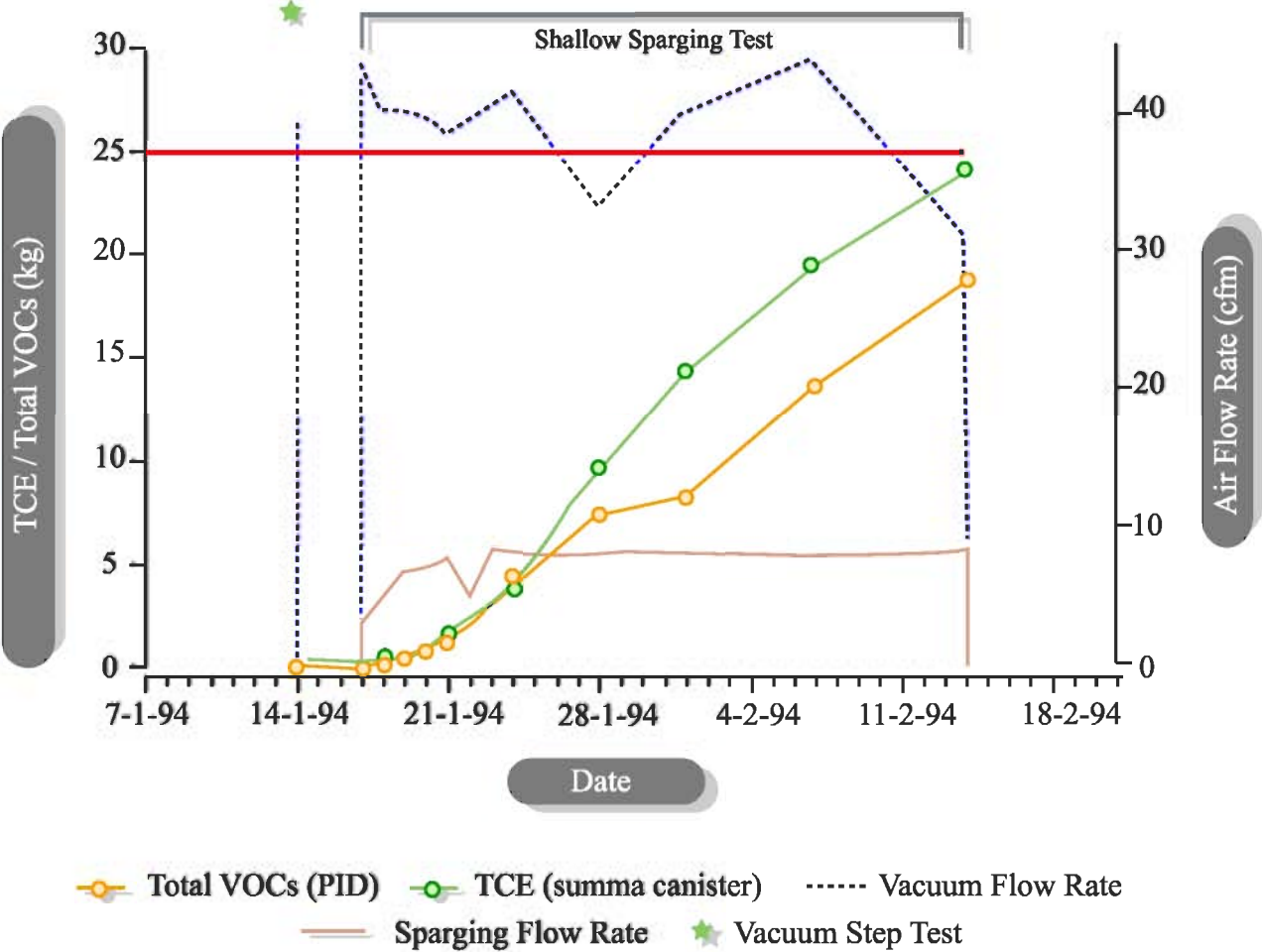




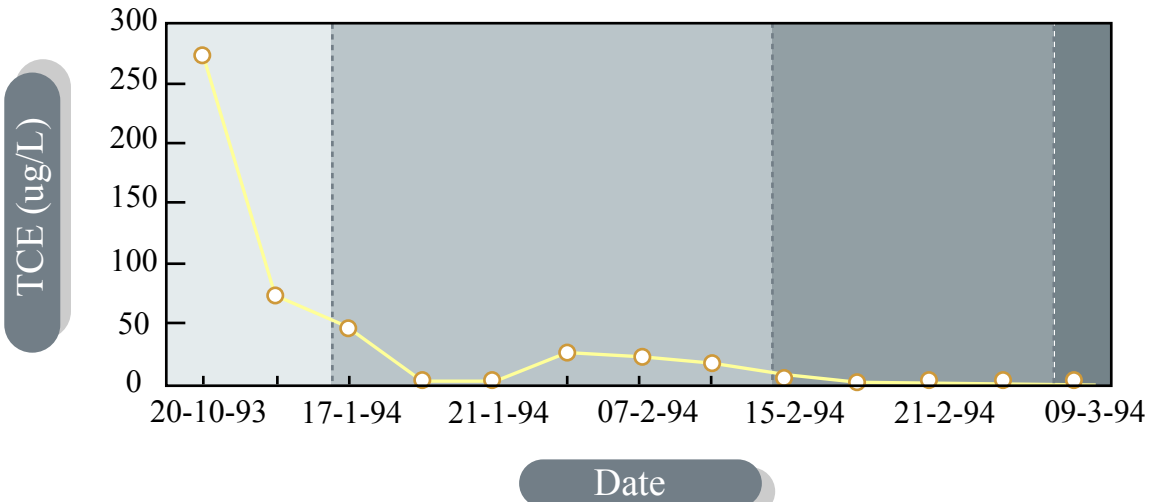
Pid Concentrations-Vapor Probes Inside Pilot Cell (Screened 0'-2')



Cumulative Recovery- TCE/Total VOCs (kg)



NP-1D, Groundwater-TCE



NP-2S, Groundwater-TCE

