



Long-Term Monitoring at the Sunnyvale Permeable Reactive Barrier: Lessons Learned / Future Expectations

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Site Location

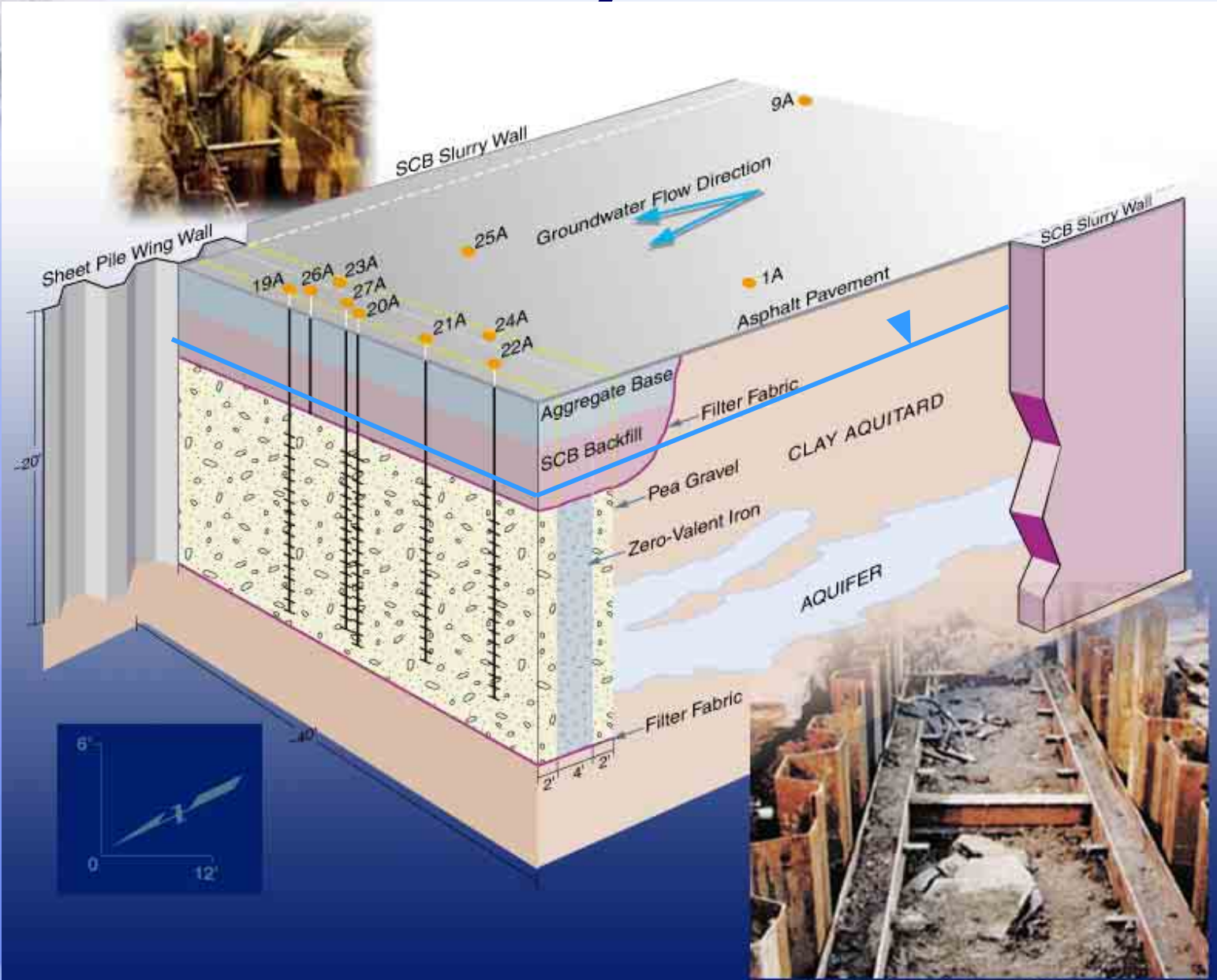


Sunnyvale, California

Site History

- **1983** VOCs detected at the site
- **1986** Source area excavated
- **1987** Groundwater Extraction System installed
- **1991** Zero-valent iron PRB concept identified
- **1992** Lab and pilot test studies for ZVI treatment
- **1993** PRB full scale design and regulatory approval
- **1994** PRB construction November
- **1995** GWS removed - February
- **1997** Hydrogen gas evaluation
- **1999** Five-year effectiveness evaluation completed
- **2000** Passive diffusion bag sampling implemented
- **2002** Hydrogen gas evaluation
- **(2004** Ten-year effectiveness evaluation)

PRB Layout



PRB Design

Wall Thickness

CoC	C_{inf} ($\mu\text{g/L}$)	MCL ($\mu\text{g/L}$)	$N_{t_{1/2}}$ (- -)	$t_{1/2}$ (hr)	t_R (hr)	v (ft/d)	W (ft)
VC	540	0.5	11	3.9	43	1	1.8
cDCE	1415	6.0	8	0.9	7	1	0.3
TCE	210	5.0	6	1.7	10	1	0.4

C_{inf} = influent concentration

$t_{1/2}$ = half-life

$N_{t_{1/2}}$ = number of half-life to achieve MCL

t_R = residence time

v = groundwater velocity

W = required barrier width

PRB Emplacement



PRB Emplacement

Building Constraints and Media Placement



PRB Emplacement

Treatment Section



2 feet

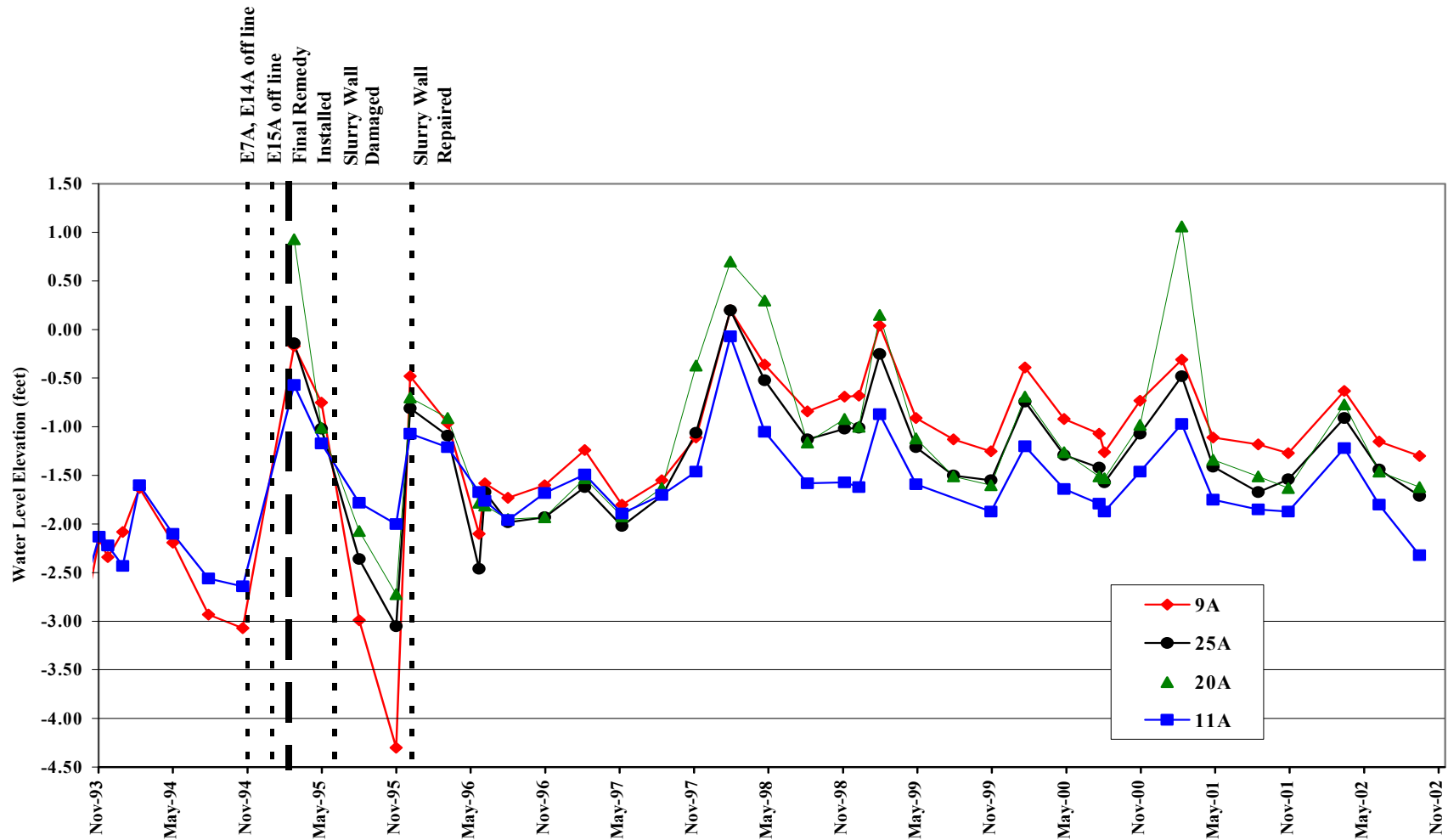
4 feet

2 feet

JEE, 1998

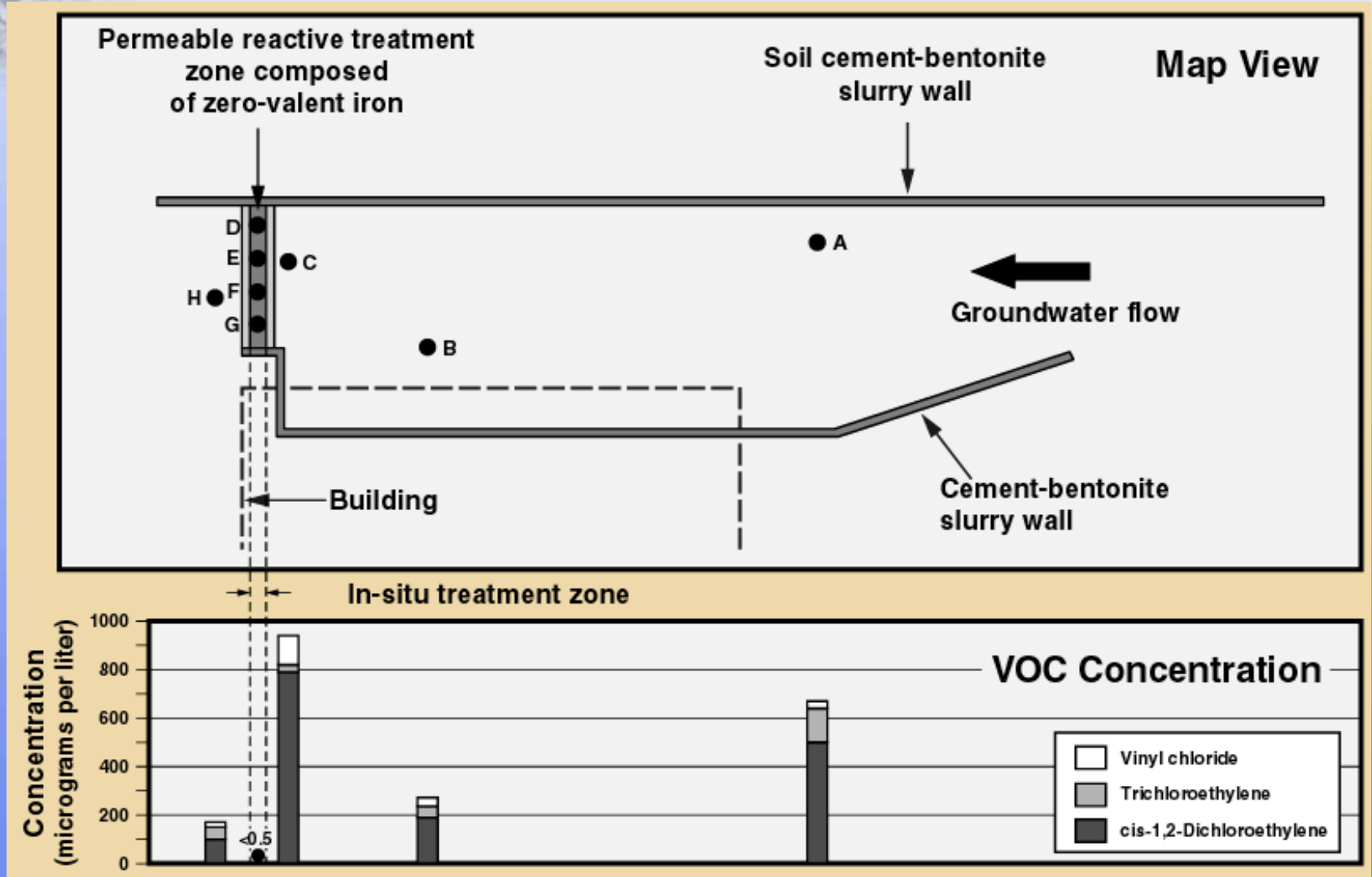
Monitoring

Water Levels



Monitoring

Organic Chemistry

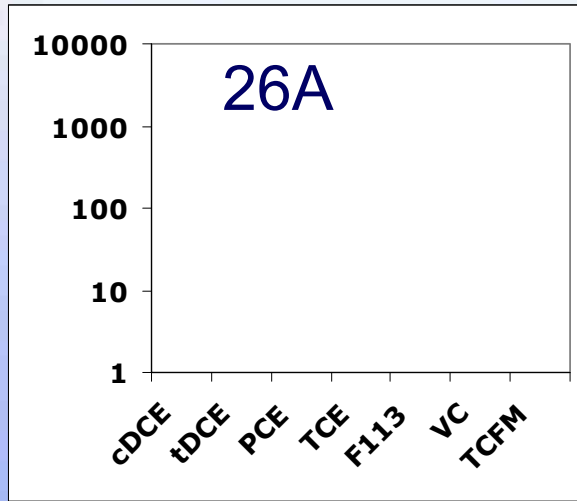


Passive Diffusion Bag Sampler Pilot Test Methods

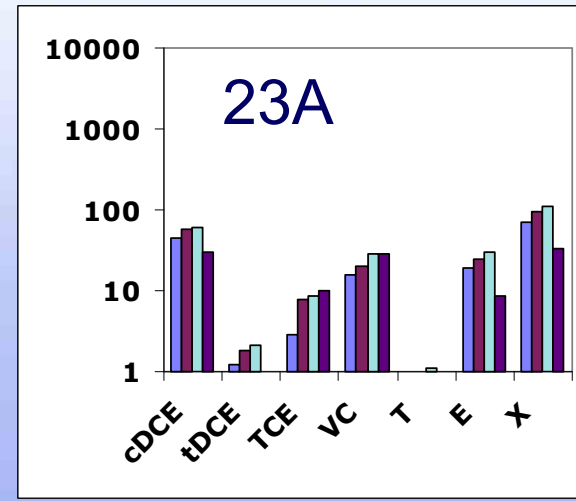


Passive Bag Sampler Pilot Test Results

Low flow purging

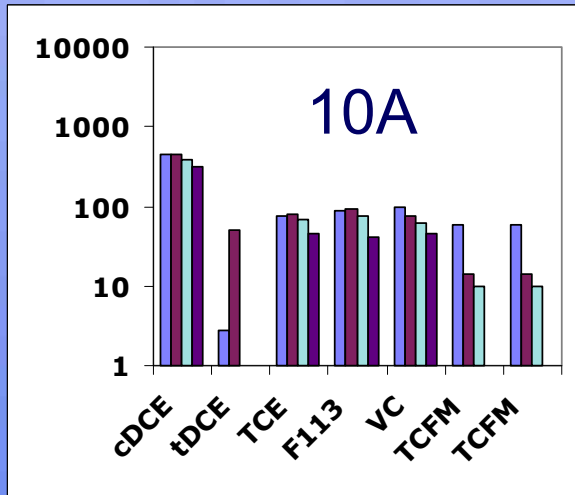


Zero-valent iron



Pea gravel

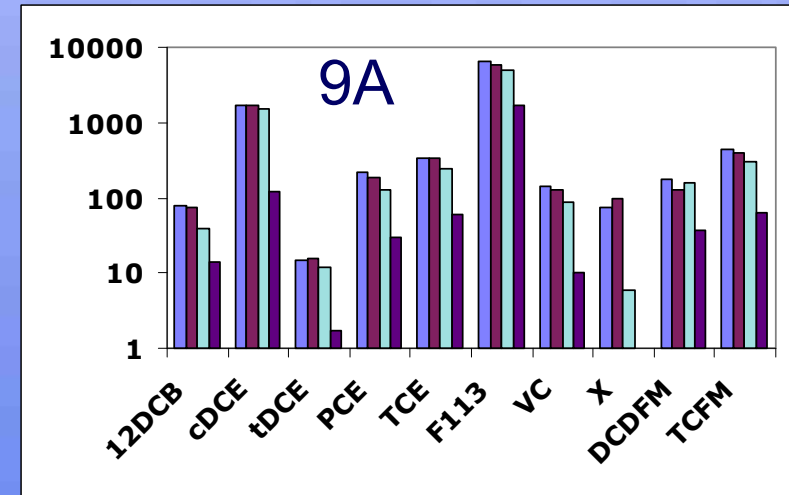
3-casing volume purging



Downgradient



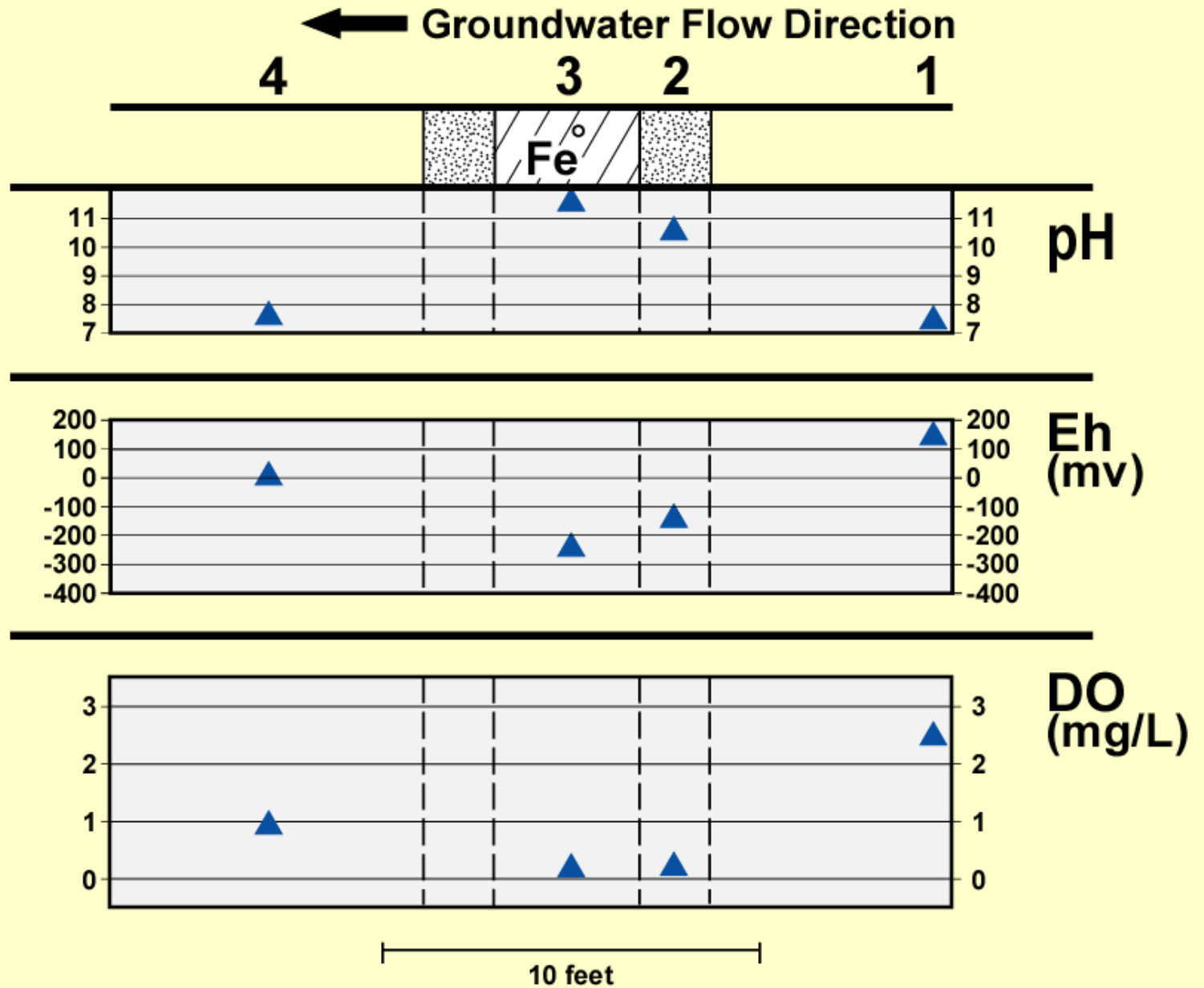
Groundwater flow Direction



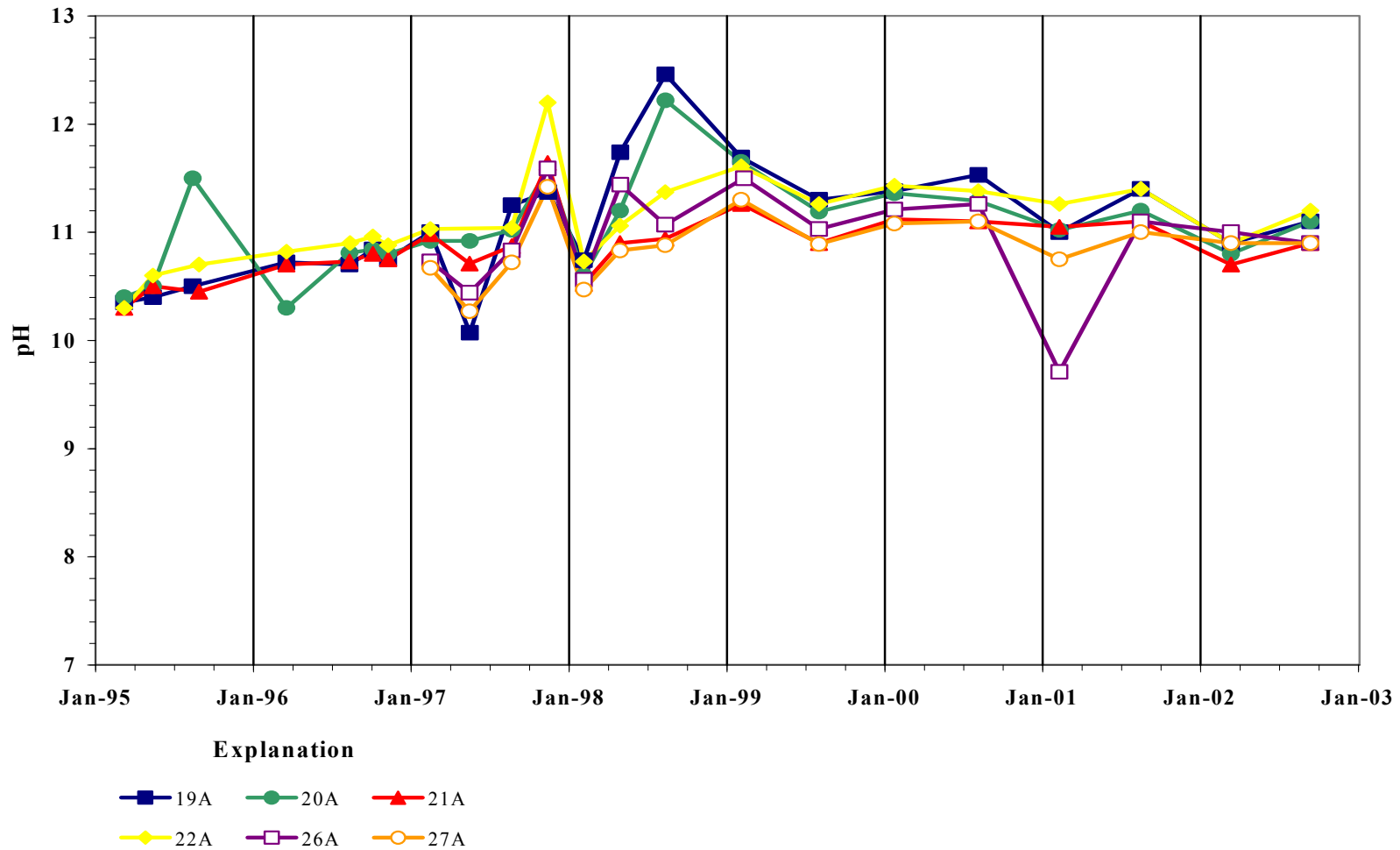
Upgradient

Monitoring

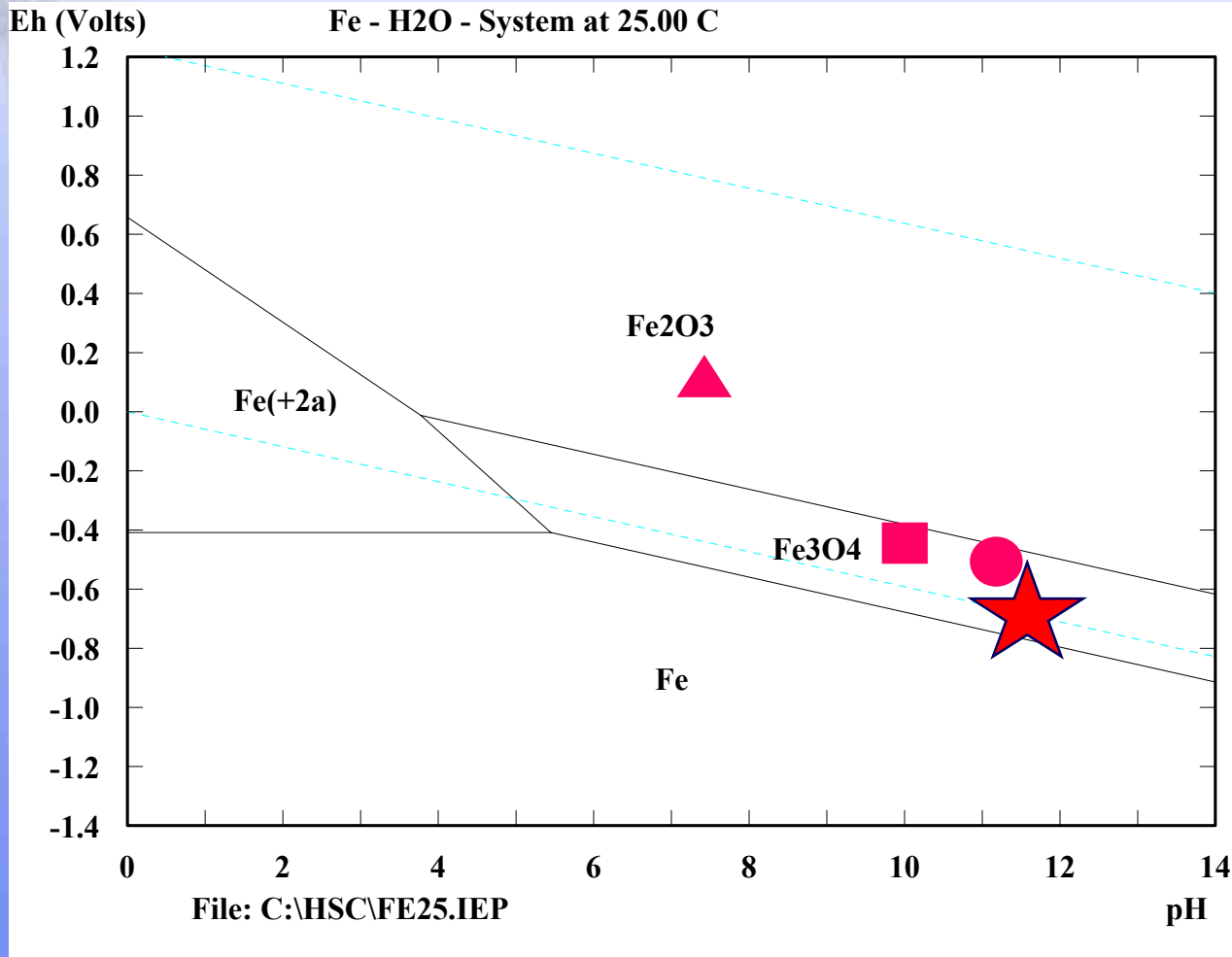
Water Quality Parameters



Trend in pH Conditions



Redox Conditions



Ambient

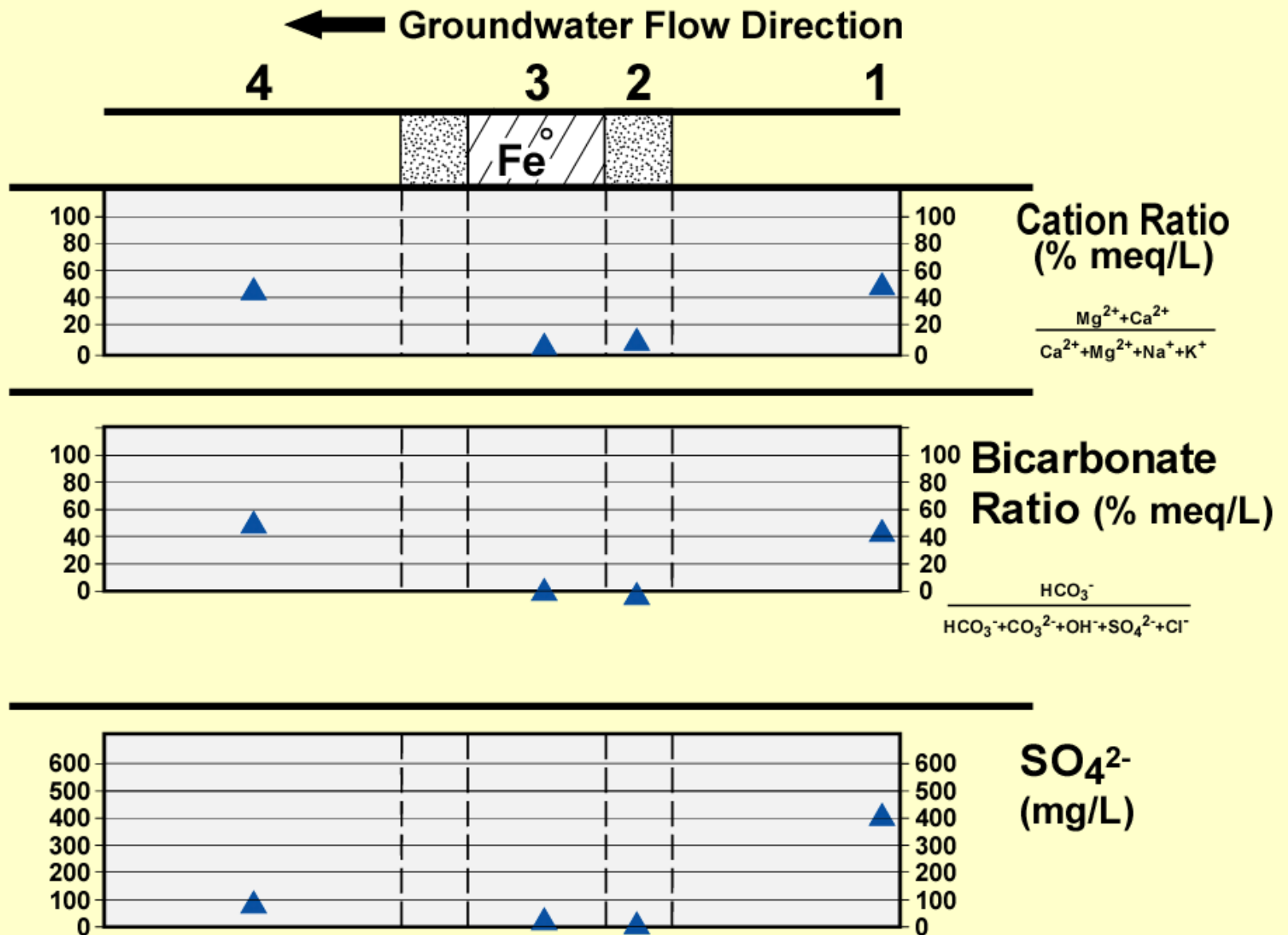
After 1 yr

After 5 yr

After 8 yr

Monitoring

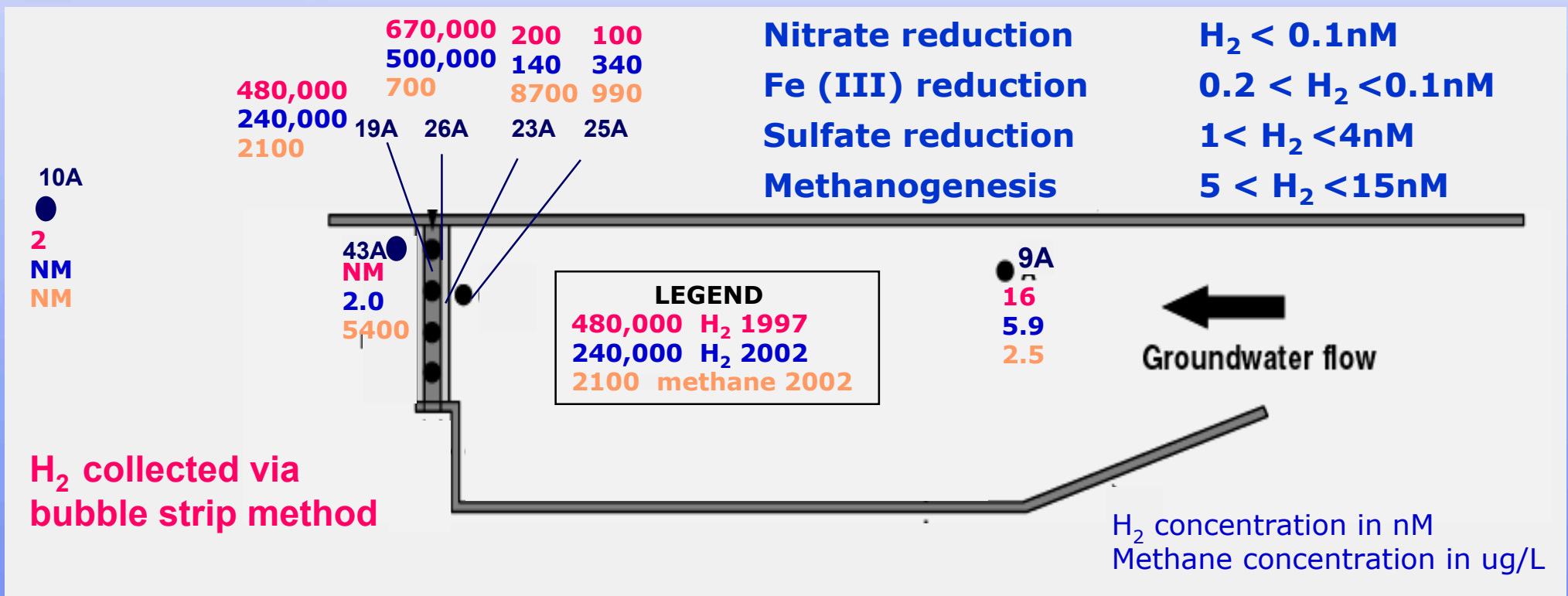
Inorganic Chemistry





Dissolved Gas Monitoring

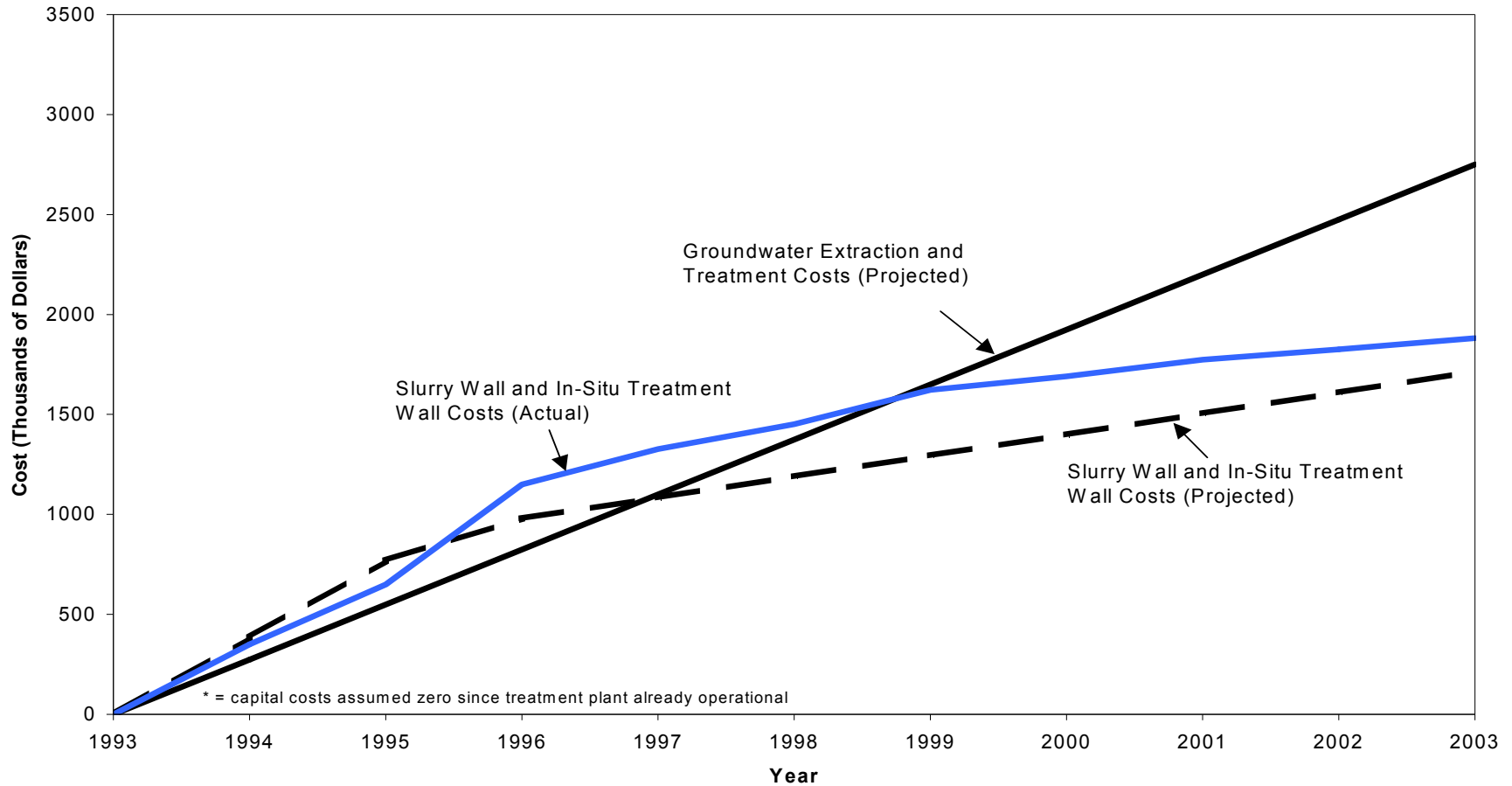
Hydrogen and Methane gas



H₂ Solubility = 1.6 ppm = 0.02 L/L = 800,000 nM

Economic Assessment

Project Costs 1993-CURRENT





Summary of Conditions

- Zero-valent iron PRB is successfully meeting site remediation goals
- PDB sampling provides representative results in Fe-PRB environment
- Hydrogen gas suggests continued reaction
- Methane gas suggests biological activity
- Inorganic data suggests mineralization in PG
- Hydraulic conditions are seasonal



What have we learned

- The PRB concept IS an economical remedy
- Hydraulics are key for design/performance
- H₂ may be useful for periodic monitoring
- The corrosion reaction appears long-lasting
- Mineralization does occur
- PDB sampling works and is representative
- Expect the unexpected



What do we anticipate

- The PRB will remain economical for years
- Treatment viable for several more years
 - at least 10; 10-15 next key period
- H₂ should decrease gradually (?)
- Mineralization should continue
- Season hydraulic variability - non-uniformity
- Continued drift in redox sensitivity?



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