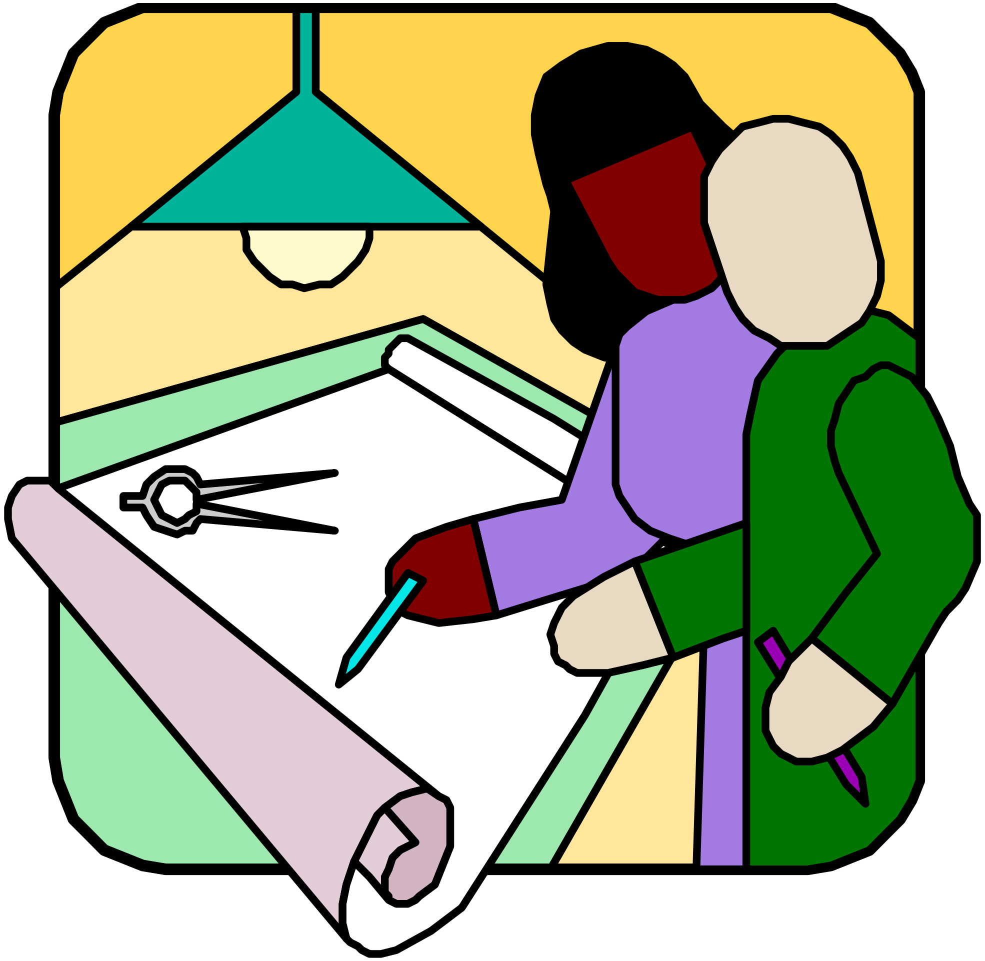
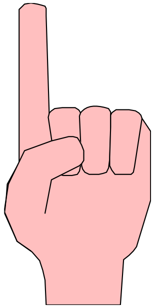
SERDP

IAS Design Paradigm



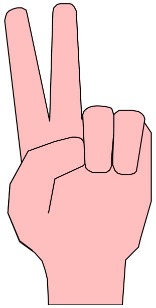
Design Basis and Philosophy

- The most significant factors affecting IAS performance are:
  - Air distribution in the target treatment zone
  - Contaminant distribution relative to the air distribution
  - Contaminant characteristics (composition and properties)



Design Basis and Philosophy

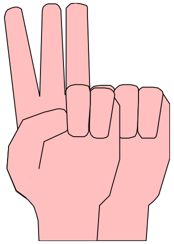
- Given the sensitivity of air distributions to relatively subtle changes in soil structure, it is unlikely that air distributions can be predicted, except in a very gross sense (i.e., highly permeable/homogeneous settings, distinctly layered systems, etc.).
- IAS long-term performance cannot be reliably predicted using data from short-term pilot tests.



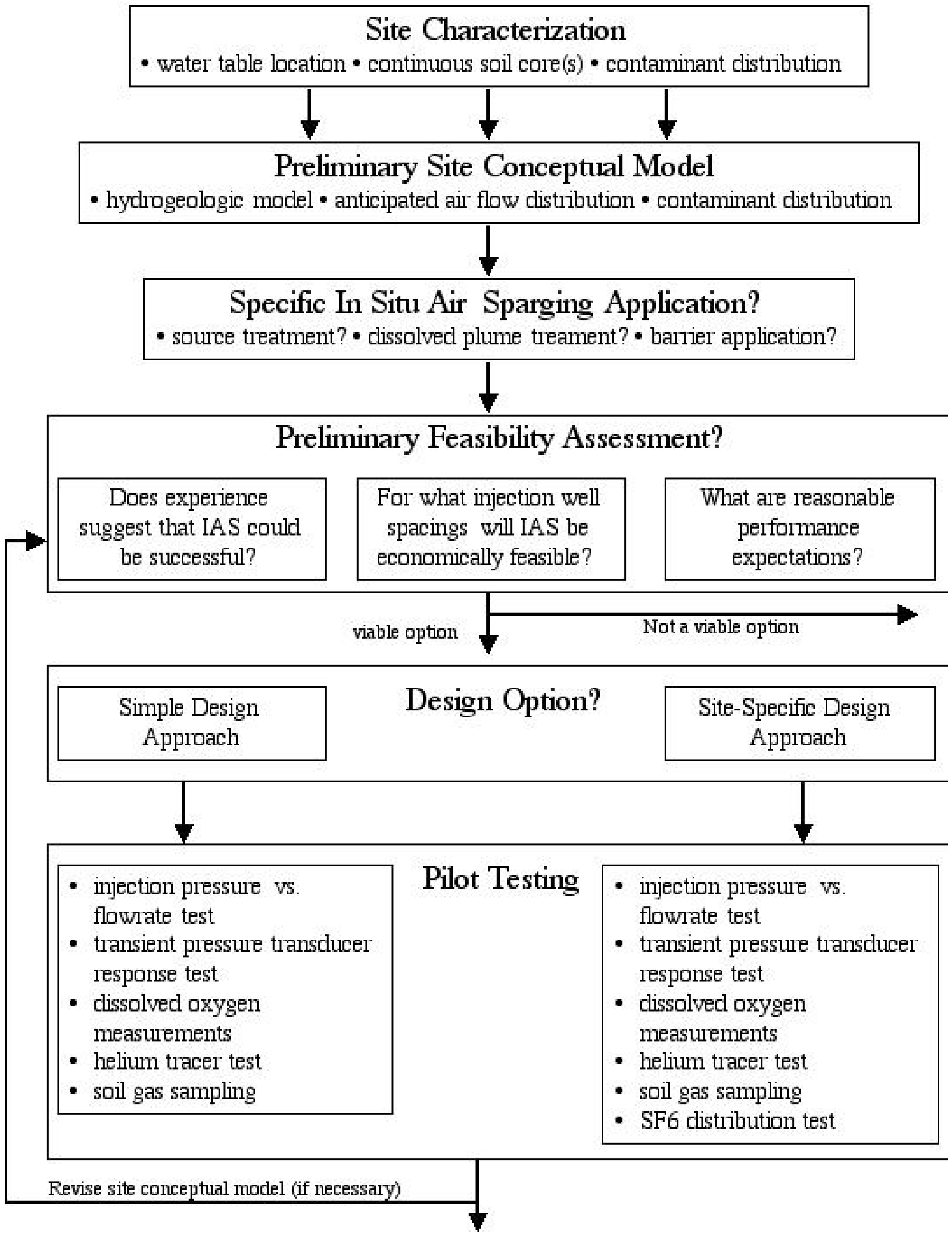
- All other things being equal, remediation performance will be better in settings with higher densities of air channels in the target treatment zone.

Design Basis and Philosophy

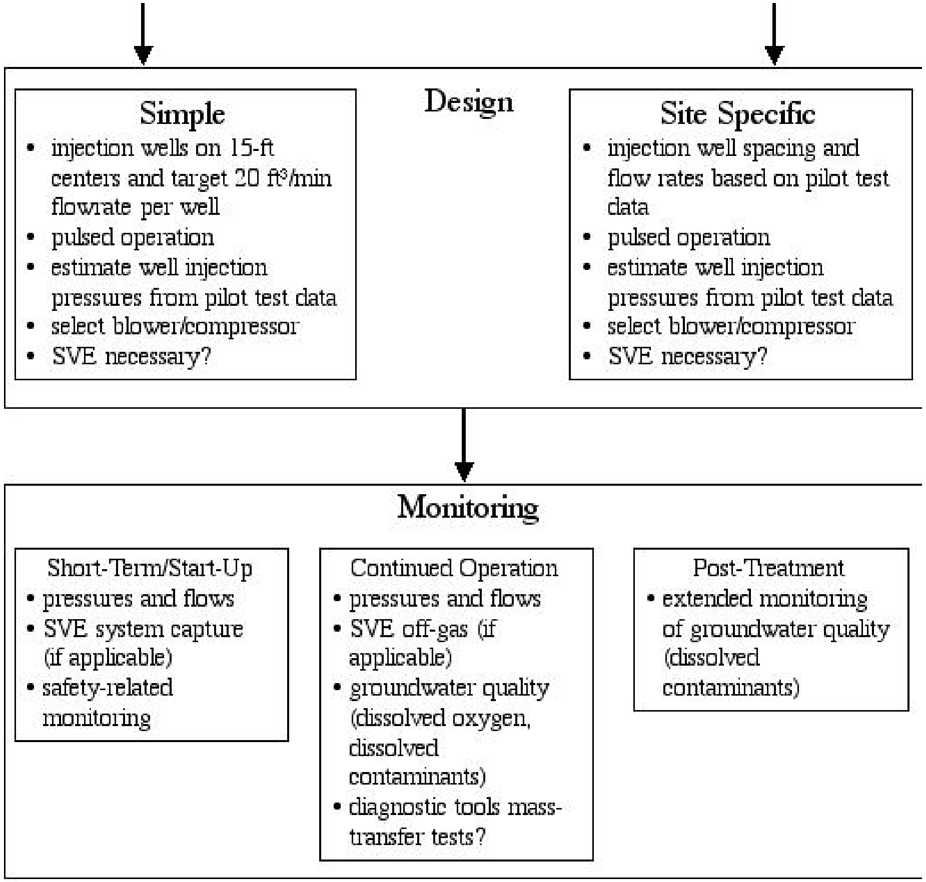
- **Short-term testing should focus on looking for indicators of infeasibility (low flow, poor air distribution, safety hazards, etc.)**
- **Air distributions in the target treatment zone should be characterized during short-term testing and full-scale operation**
- **The degree to which the air distribution is characterized should be balanced by the conservatism in the system design (less characterization = denser IAS well networks).**



Design Paradigm



Design Paradigm



Design Paradigm

- **Unique features - two design paths...**

Design

Simple	Site Specific
• injection wells on 15-ft centers and target 20 ft^3/min flowrate per well • pulsed operation • estimate well injection pressures from pilot test data • select blower/compressor • SVE necessary?	• injection well spacing and flow rates based on pilot test data • pulsed operation • estimate well injection pressures from pilot test data • select blower/compressor • SVE necessary?

- **Wells are cheap in many settings…**
- **Installing air injection wells at minimum spacing (about 15 ft) increases potential for success and compensates for the unknowns...**
- **When the cost of well installation is significant (deep settings, large areas, etc.), then the cost of wells can be reduced by increasing spacing - however, additional air distribution characterization is needed to minimize uncertainty in performance...**

Design Paradigm

- **Unique features - two design paths and two pilot testing options...**

Pilot Testing

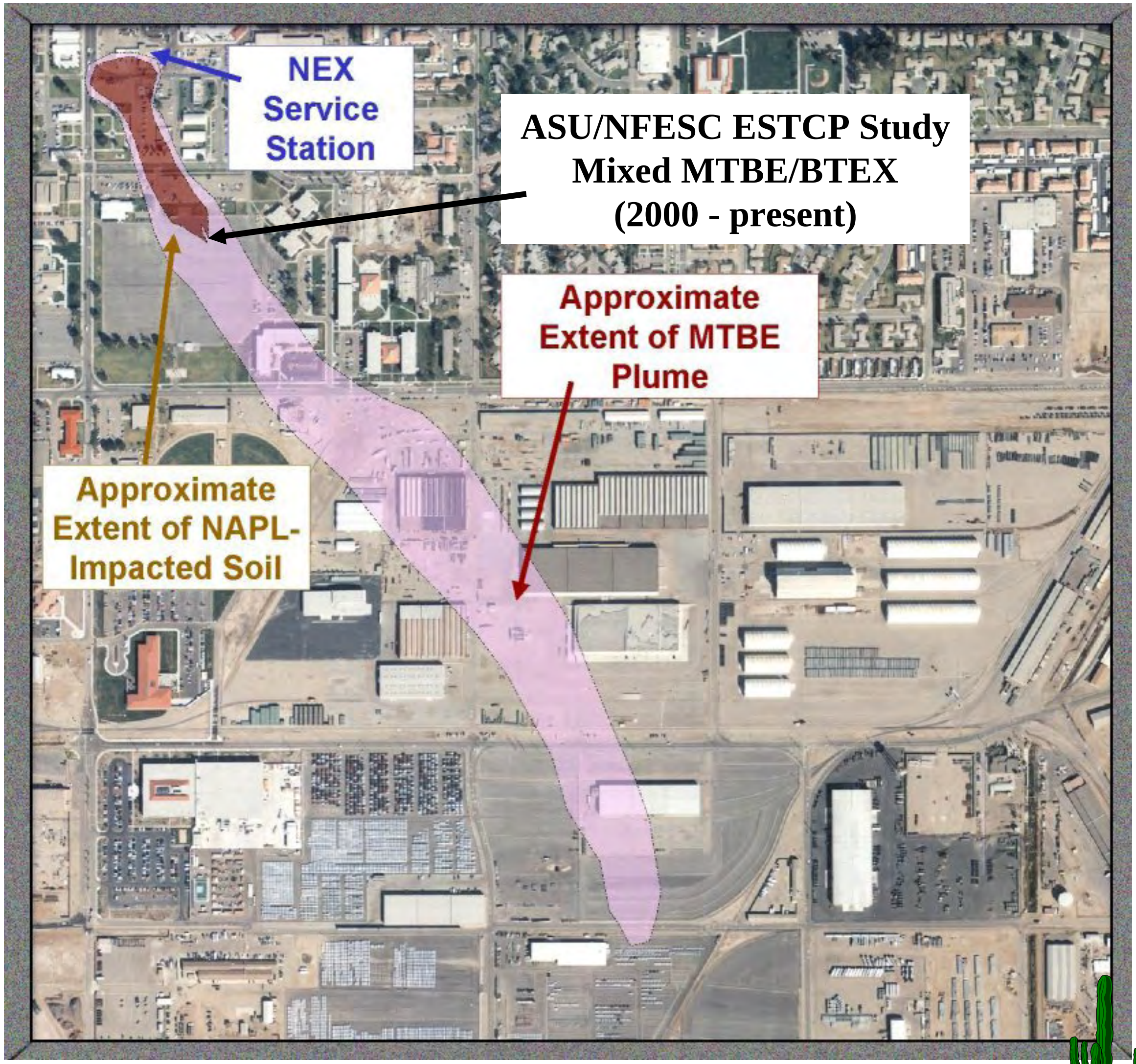
- injection pressure vs. flowrate test
- transient pressure transducer response test
- dissolved oxygen measurements
- helium tracer test
- soil gas sampling

- injection pressure vs. flowrate test
- transient pressure transducer response test
- dissolved oxygen measurements
- helium tracer test
- soil gas sampling
- SF6 distribution test

Full-Scale BioBarrier Demonstration...

ASU/ESTCP Study:

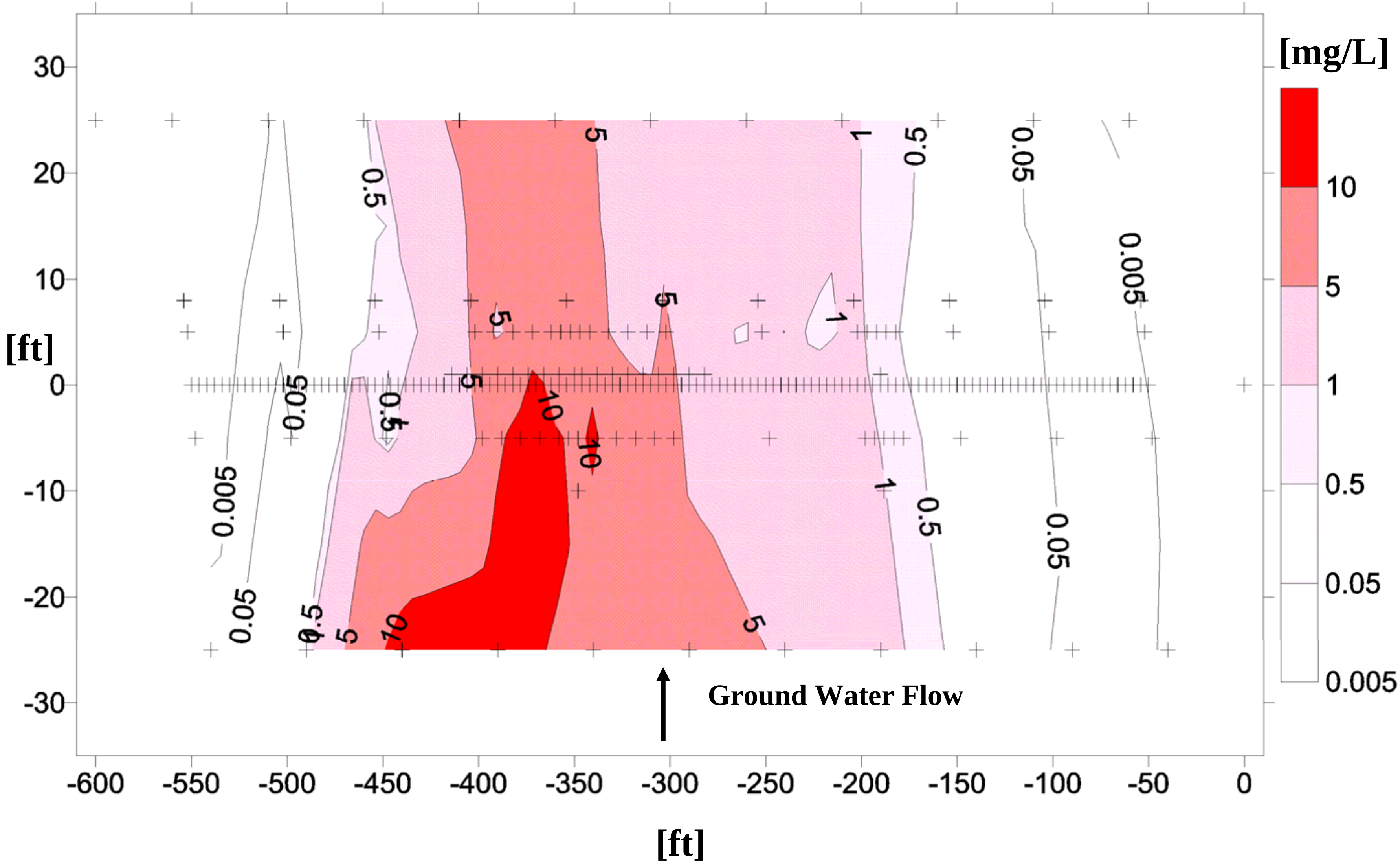
- 500 ft long bio-barrier
- mixed MTBE/BTEX plume
- edge of source zone
- bioaugmentation
- biostimulation
- MC100 and SC100
- oxygen and air
- September 2000 - present



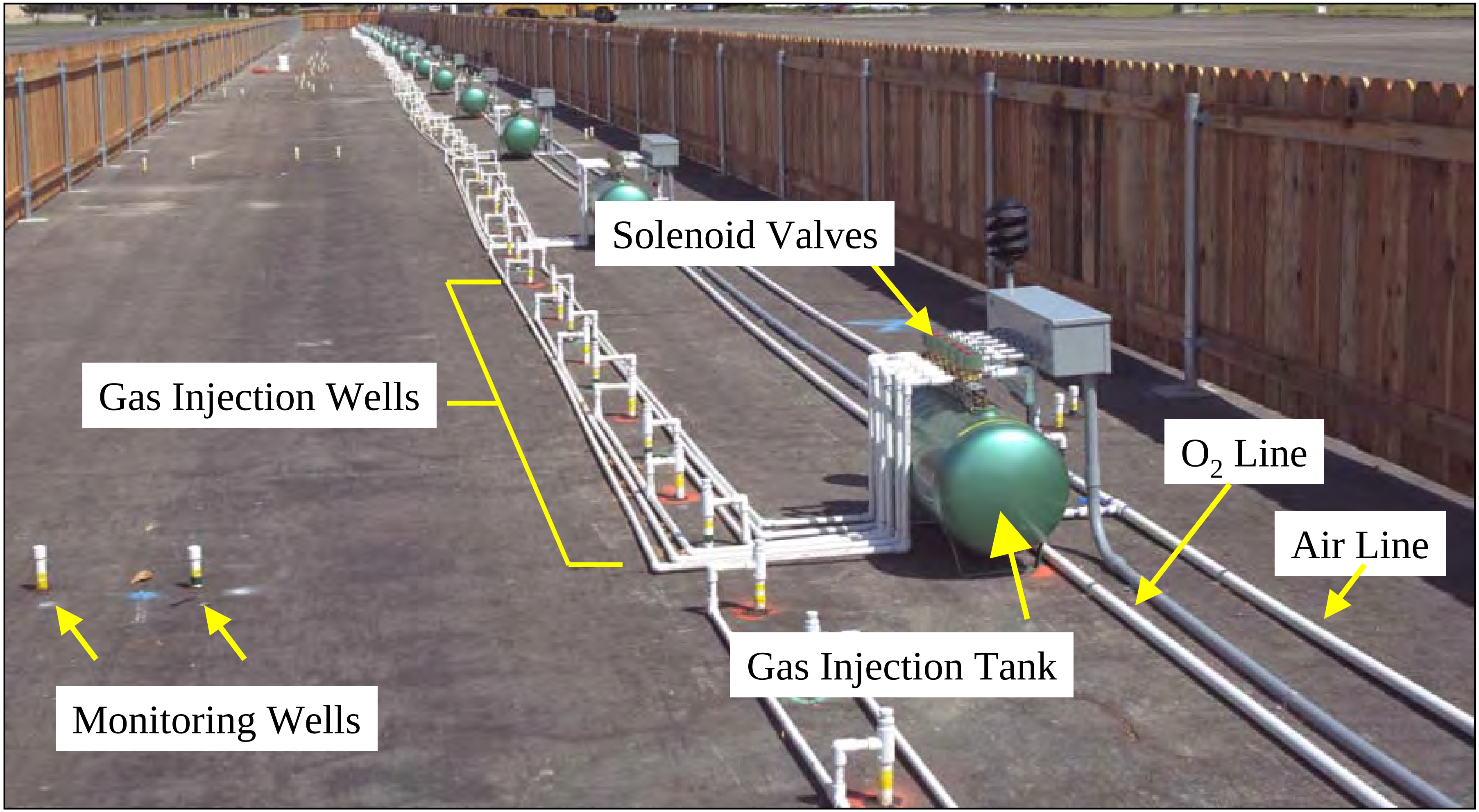
VCNB Port Hueneme, CA

MTBE Distribution

[Shallow Wells - Initial Distribution Before Gas Injection and Inoculation]



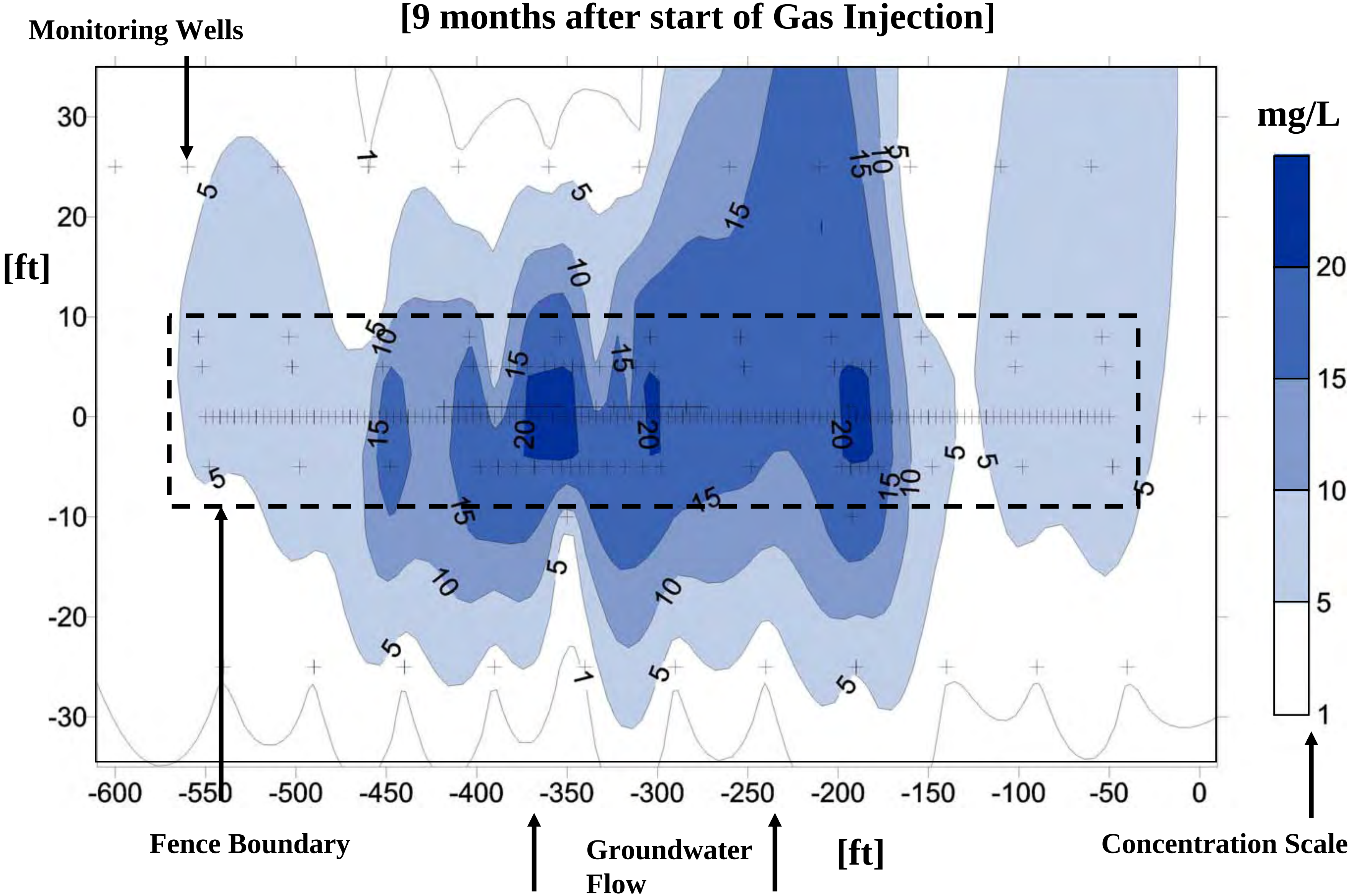
Oxygen Delivery System



Oxygen Generator

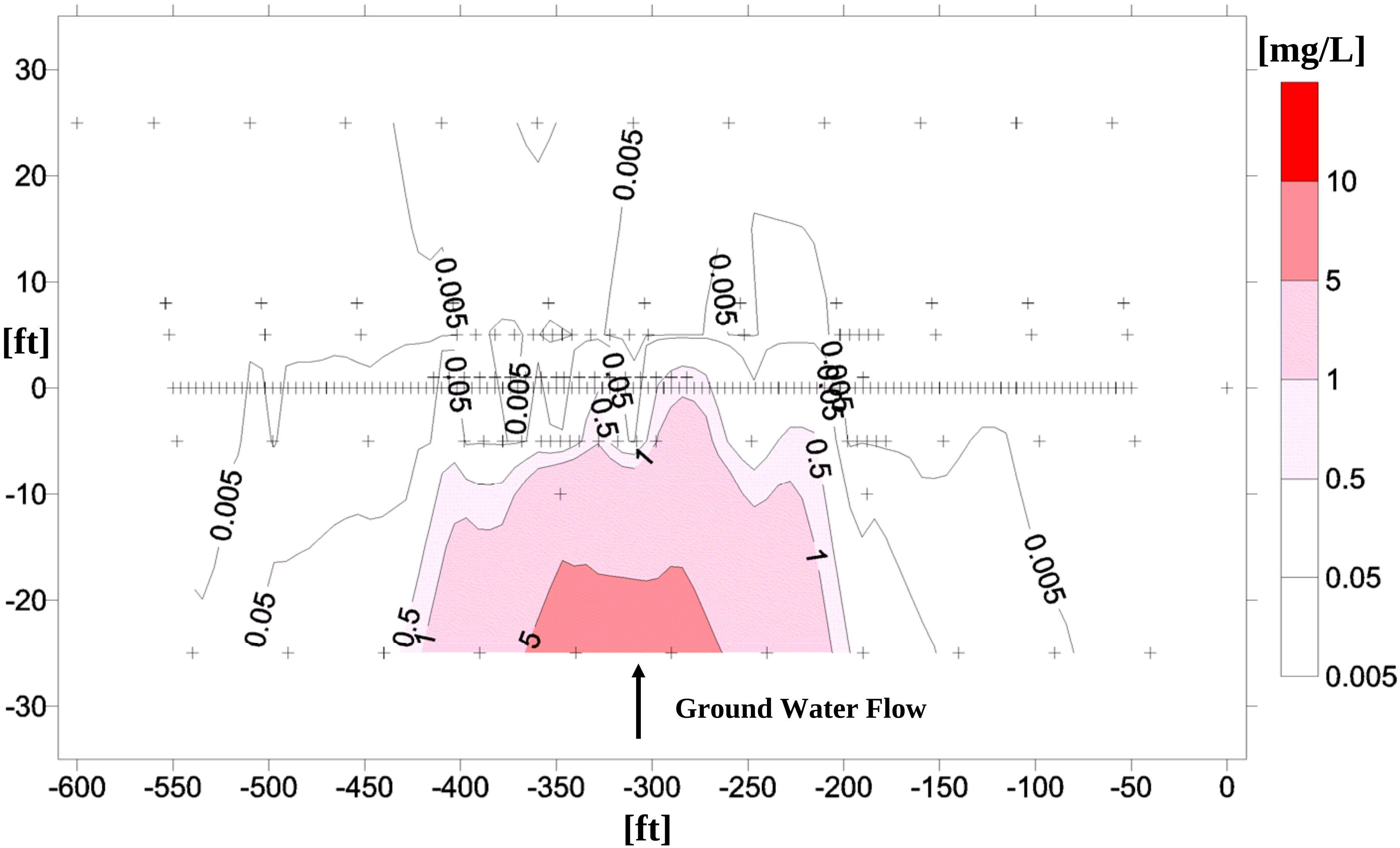
Dissolved Oxygen Distribution

[9 months after start of Gas Injection]

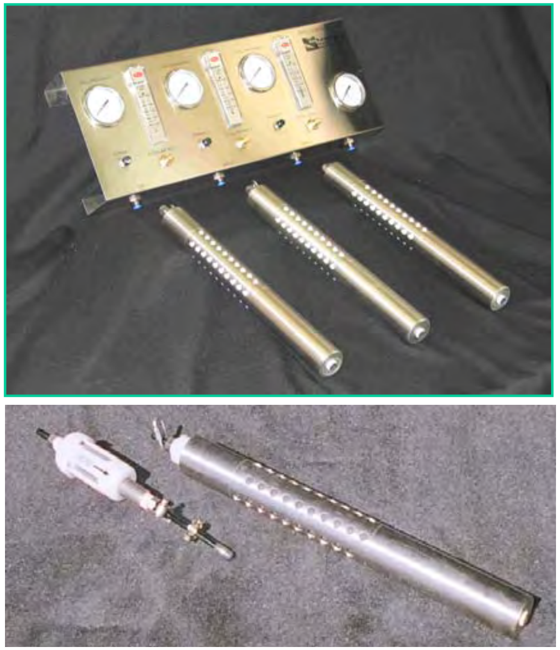


MTBE Distribution

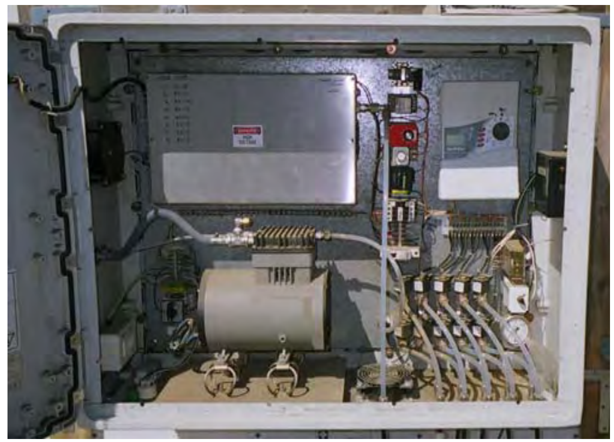
[Shallow Wells - 9 Months After Gas Injection and 7 Months After Inoculation]



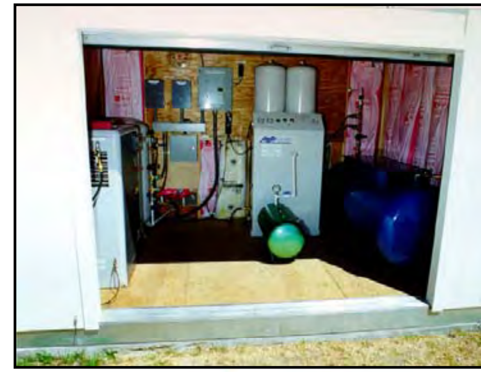
Field Evaluation of Three Commercially Available In-Situ Oxygen Distribution Technologies for Groundwater and Source Zone Treatment

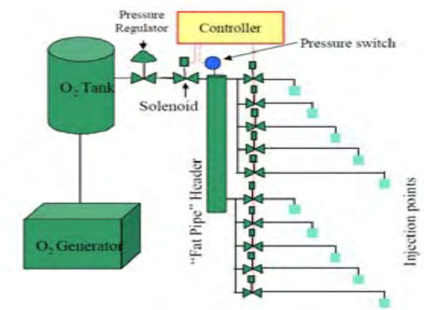


iSOC (in well)



C-Sparge
(special well)





O_2-pulsed Injection System

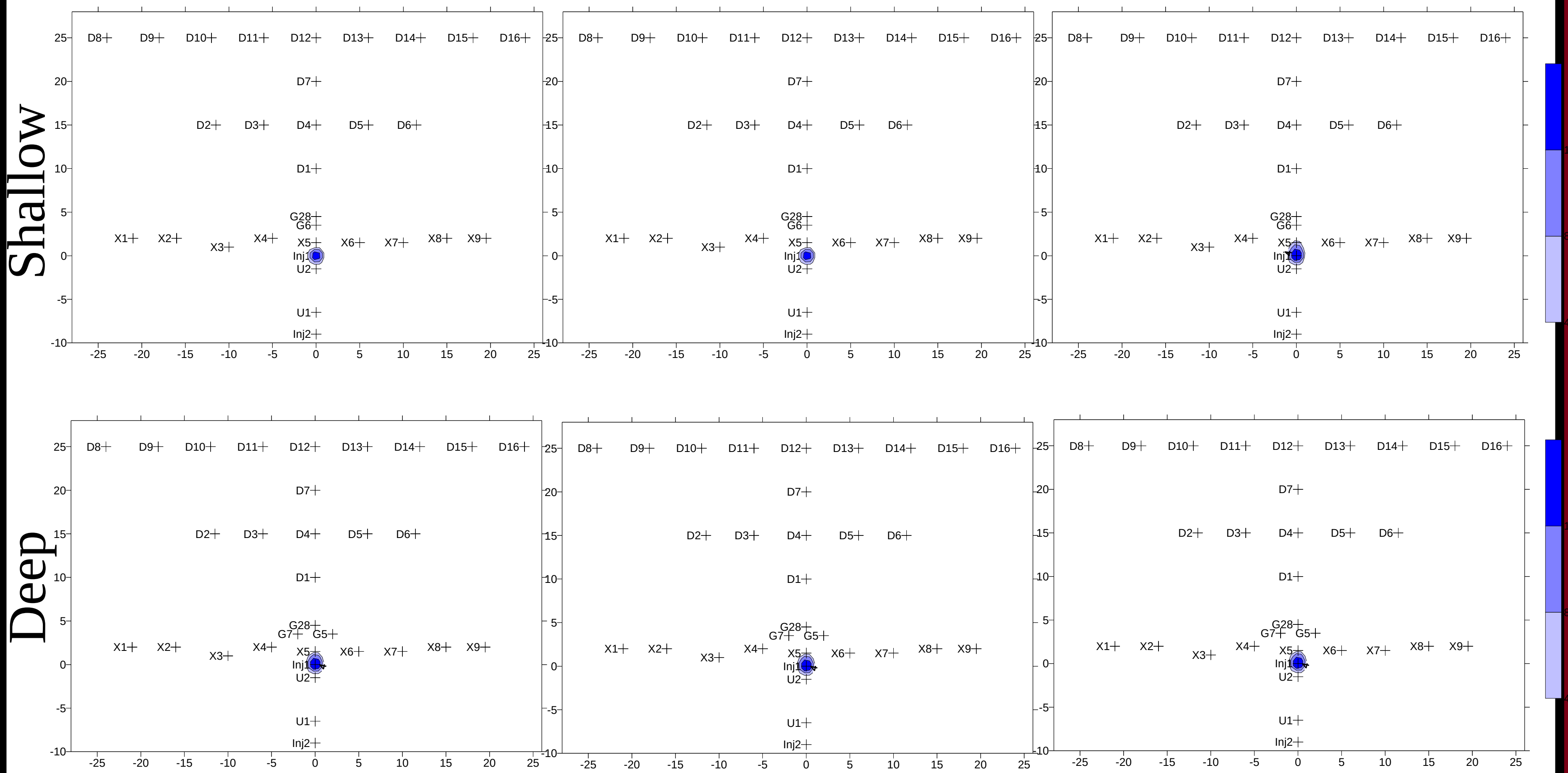
Paul Dahlen, Jennifer Triplett Kingston, and Paul C. Johnson

Arizona State University

Cristin L. Bruce and Gerard E. Spinnler

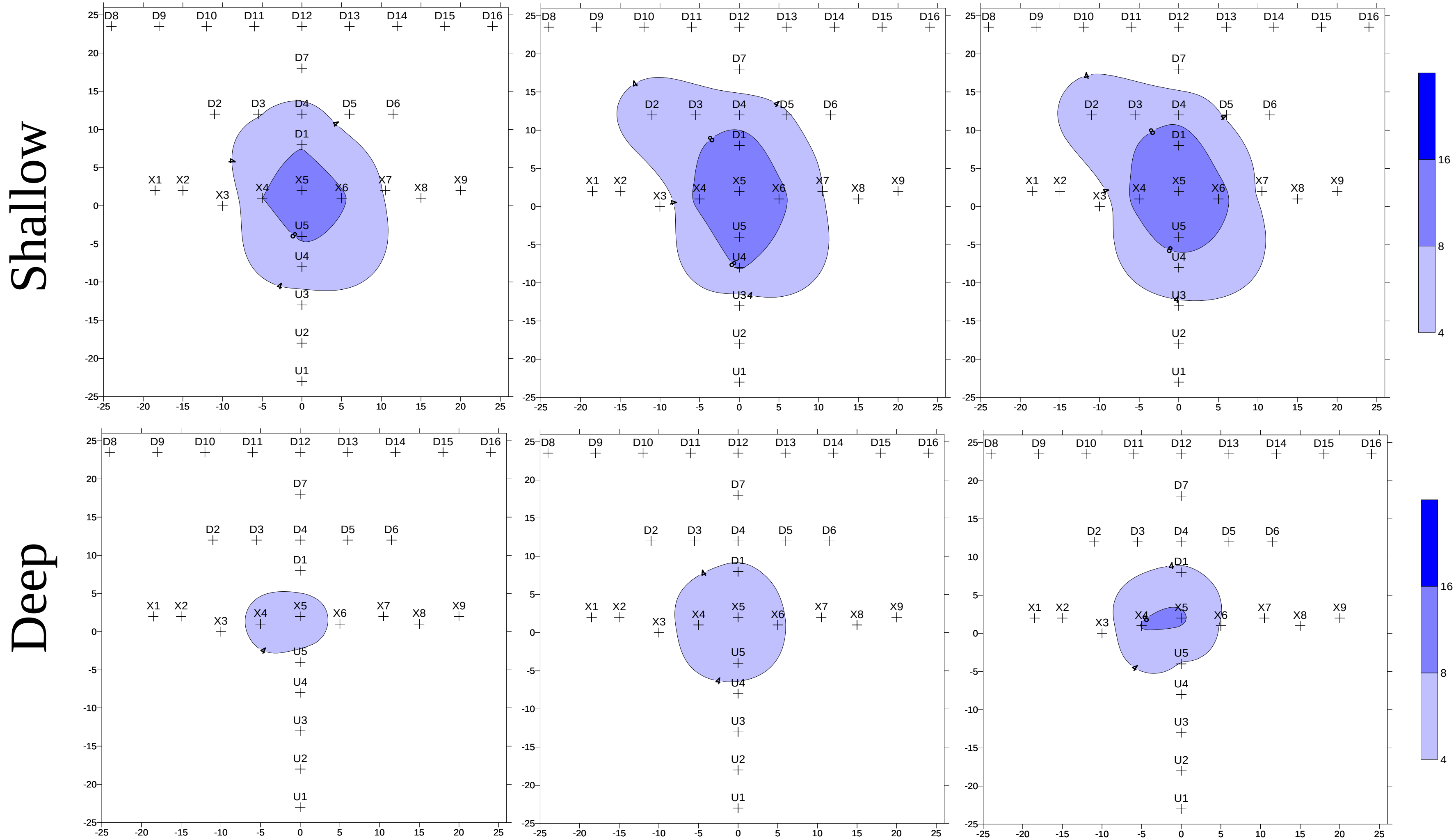
Shell Global Solutions

iSOC O_2 injection - iSOC plot
0.76 ft^3/day (15 ml/min continuous injection as per spec)



12/5/05	1/11/06	2/15/06
4 weeks into injection	8 weeks into injection	12 weeks into injection

C-Sparge ambient air injection – C-sparge plot
264 ft^3/day (2.2 ft^3/min/interval x 10 min x 12/day)



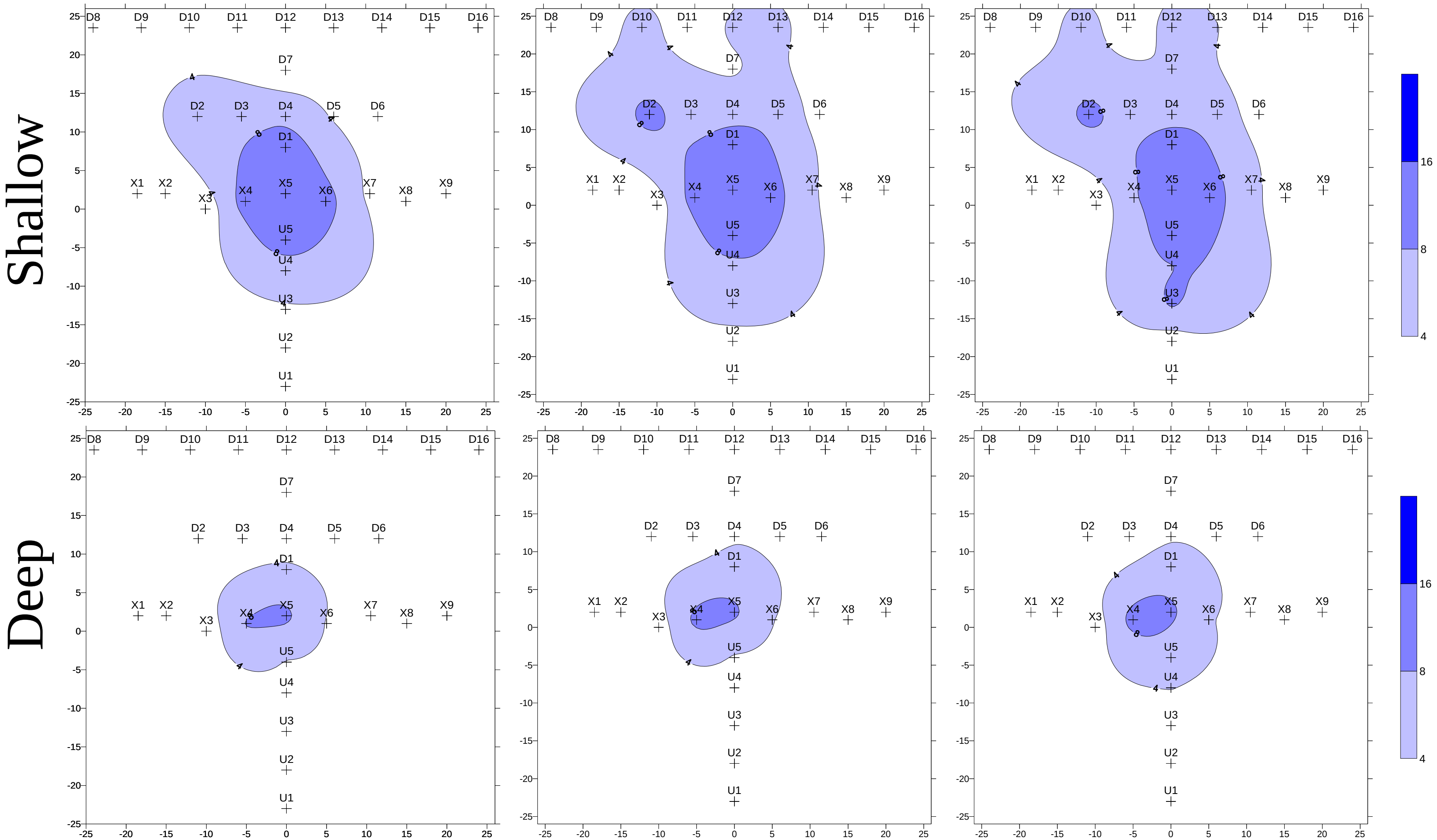
12/5/05
4 weeks into injection

1/11/06
8 weeks into injection

2/15/06
12 weeks into injection

C-Sparge ambient air injection – C-sparge plot

792 ft^3/day (2.2 ft^3/min/interval x 30 min x 12/day)

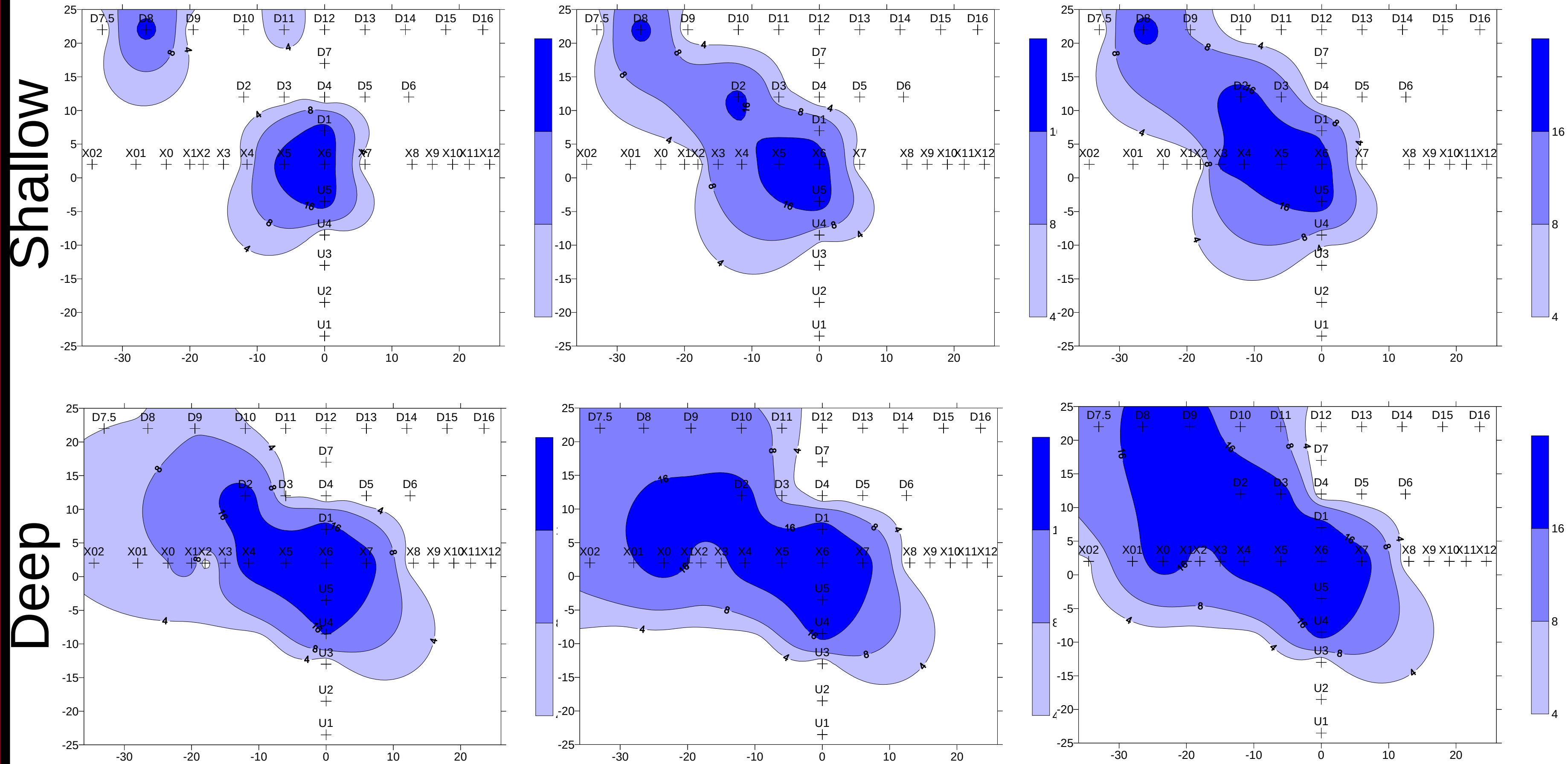


2/15/06
Background

3/30/06
6 weeks into injection

5 /11/06
12 weeks into injection

OPIS O_2 injection - OPIS plot
12 ft^3/day (6 ft^3/interval x 2/day)



12/5/05
4 weeks into injection

1/11/06
8 weeks into injection

2/15/06
12 weeks into injection

Lessons Learned …

- Substantially different oxygen distributions for each technology.

- Oxygen zones appear to be stable and DO NOT appear to propagate in the downgradient direction as advertised by some technology vendors.

- Oxygen dieaway in well-established oxygenated zones takes some time (> 6 weeks). This has implications for remediation system operation and downtime.

- Larger injection volumes (in the range studied for pulsed injection systems and microbubble-based systems) lead to larger oxygenated areas, but the envelope has not been established.