

Electrically Induced Redox Barriers for Treatment of Groundwater



Presented at the RTDF Permeable Reactive Barrier Action Team Meeting
Albuquerque, New Mexico, October 26, 2004

By

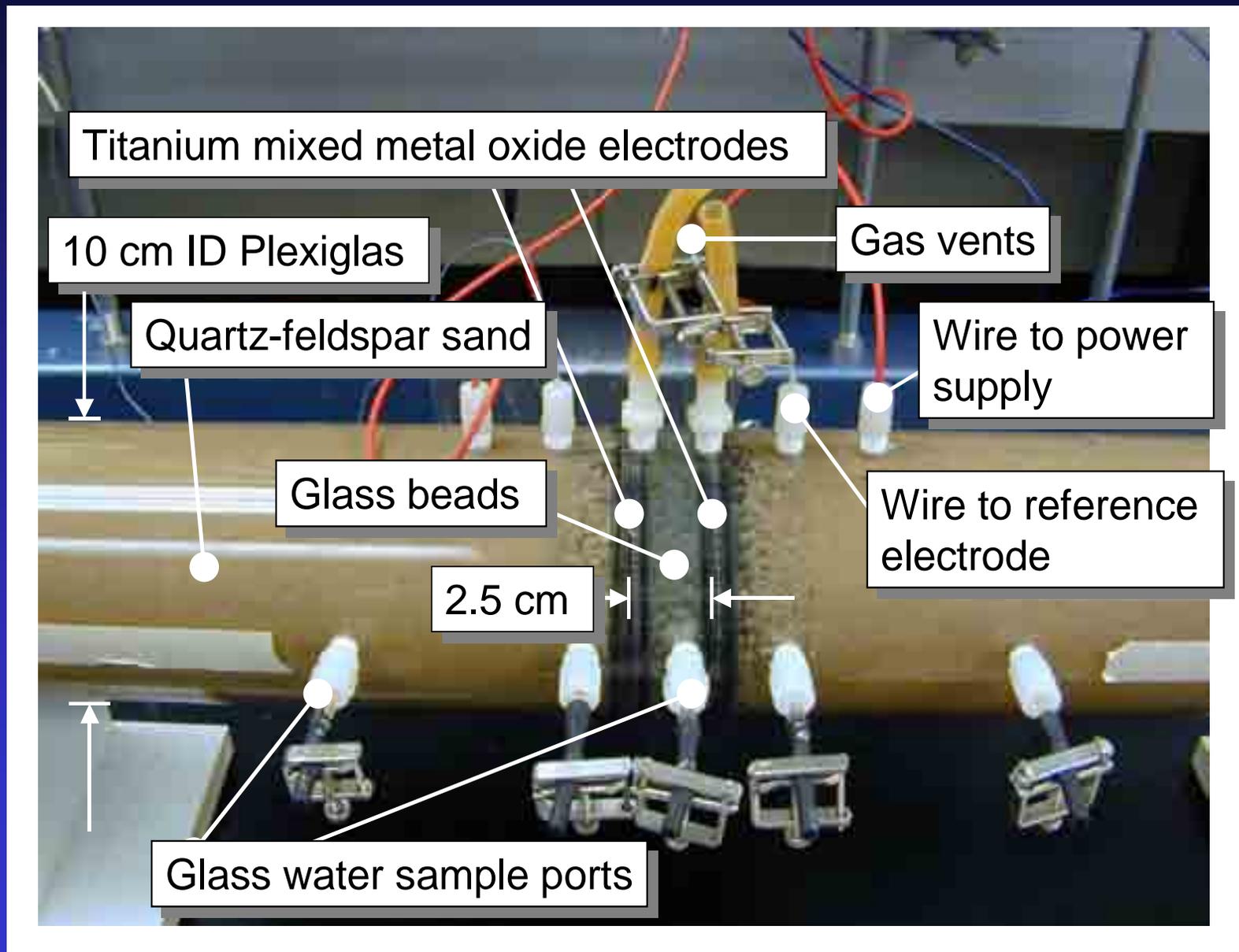
Tom Sale, Matthew Petersen, and Dave Gilbert

Presentation

- Laboratory Results
- Field Results
- Future Plans
- Questions

Flow through electrolytic reactor - e⁻ barriers

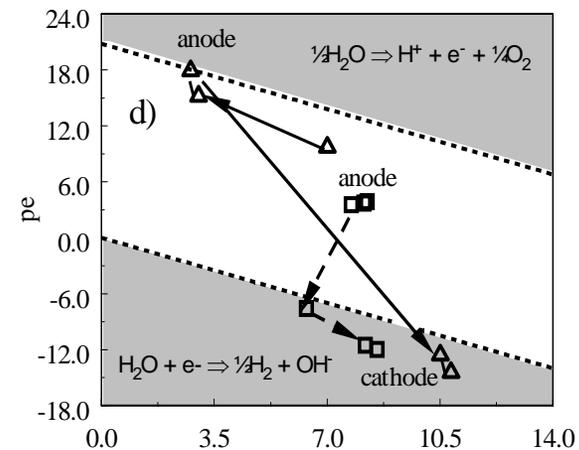
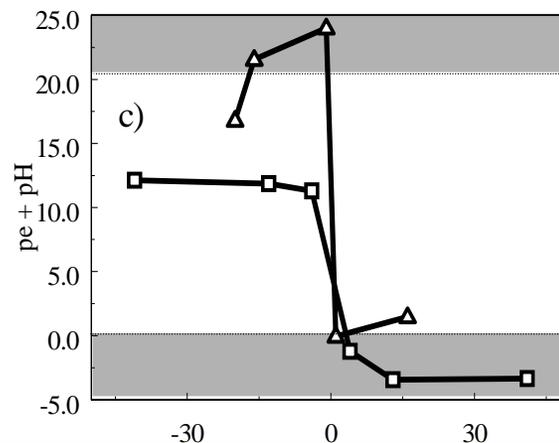
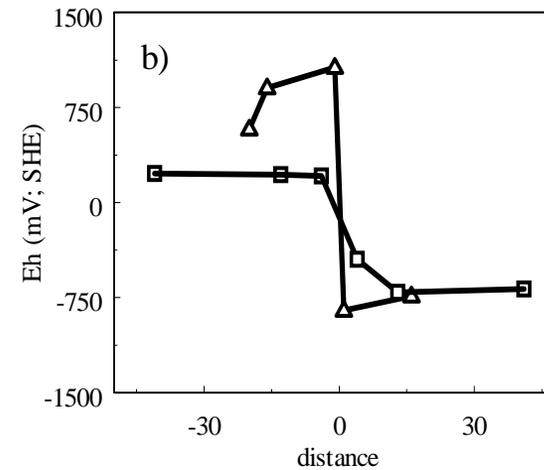
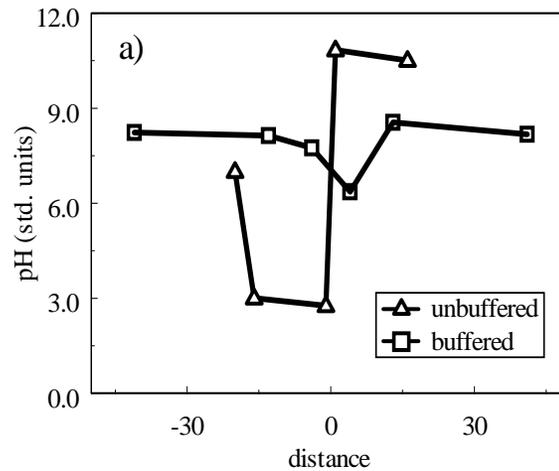
Solvents in Groundwater Research Consortium



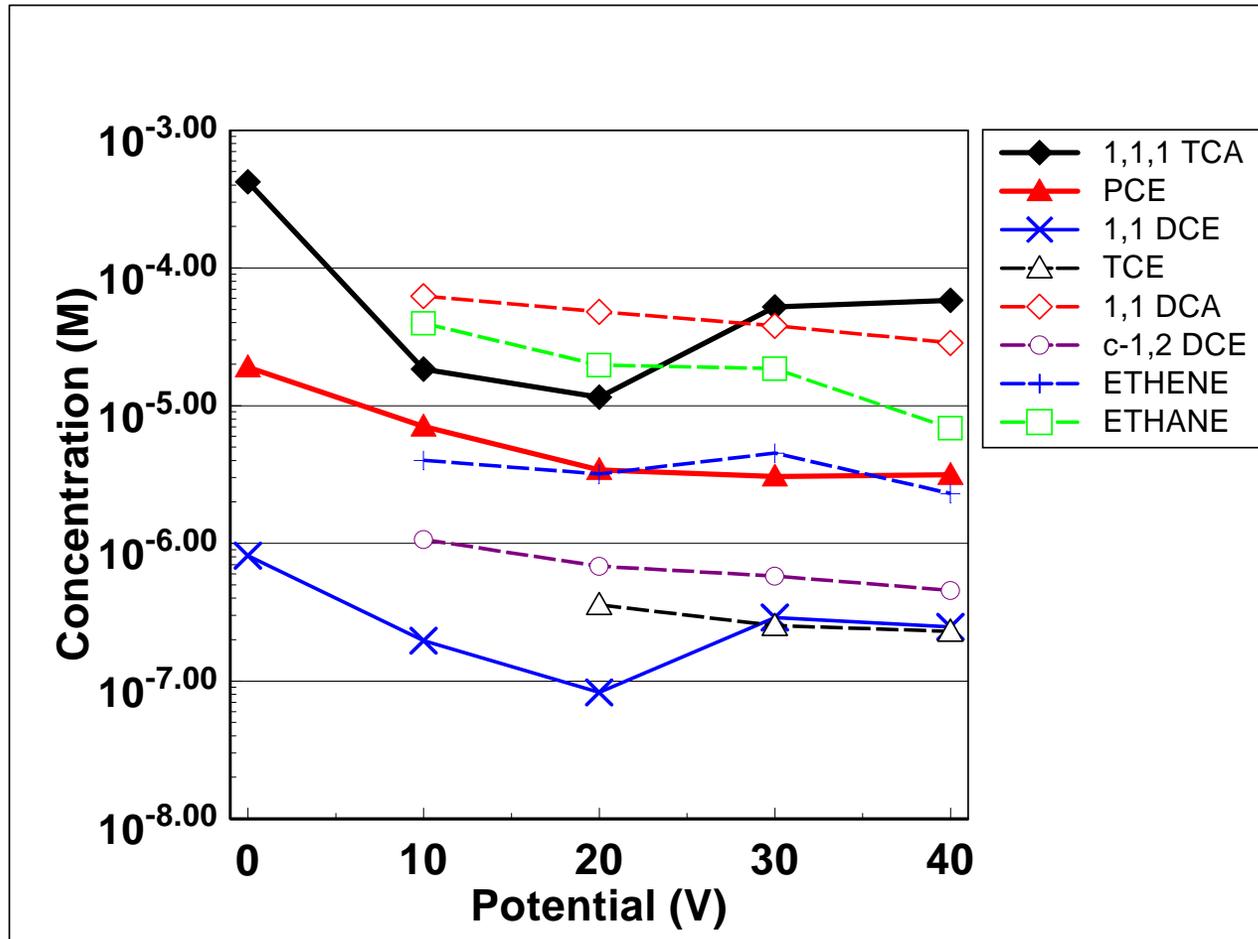


Scanning electron microscope image of a titanium mixed metal anode after 18 months of operation. Actual dimensions are 3 by 4 mm.

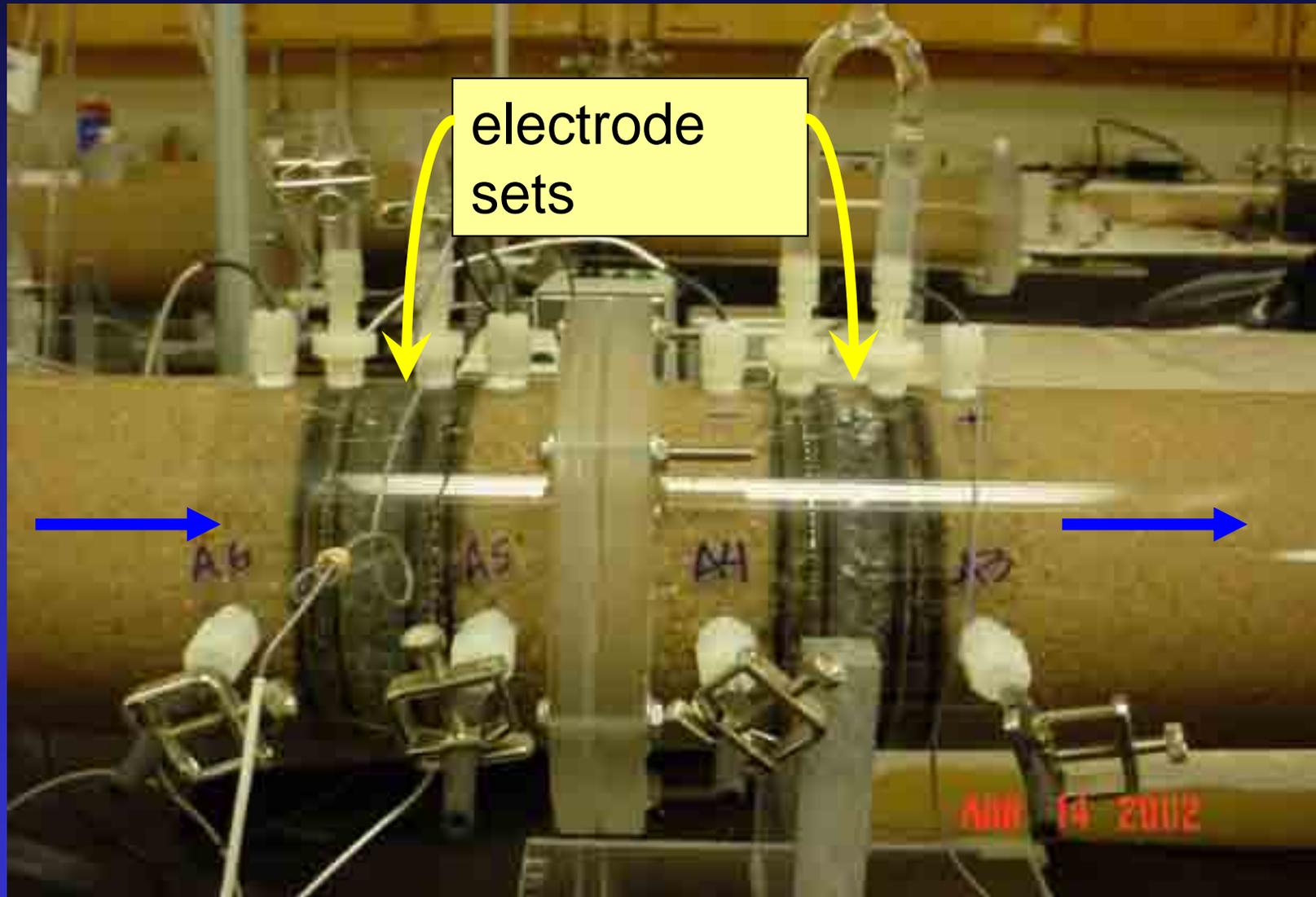
Electrically induced shifts in Eh, pe, and pH



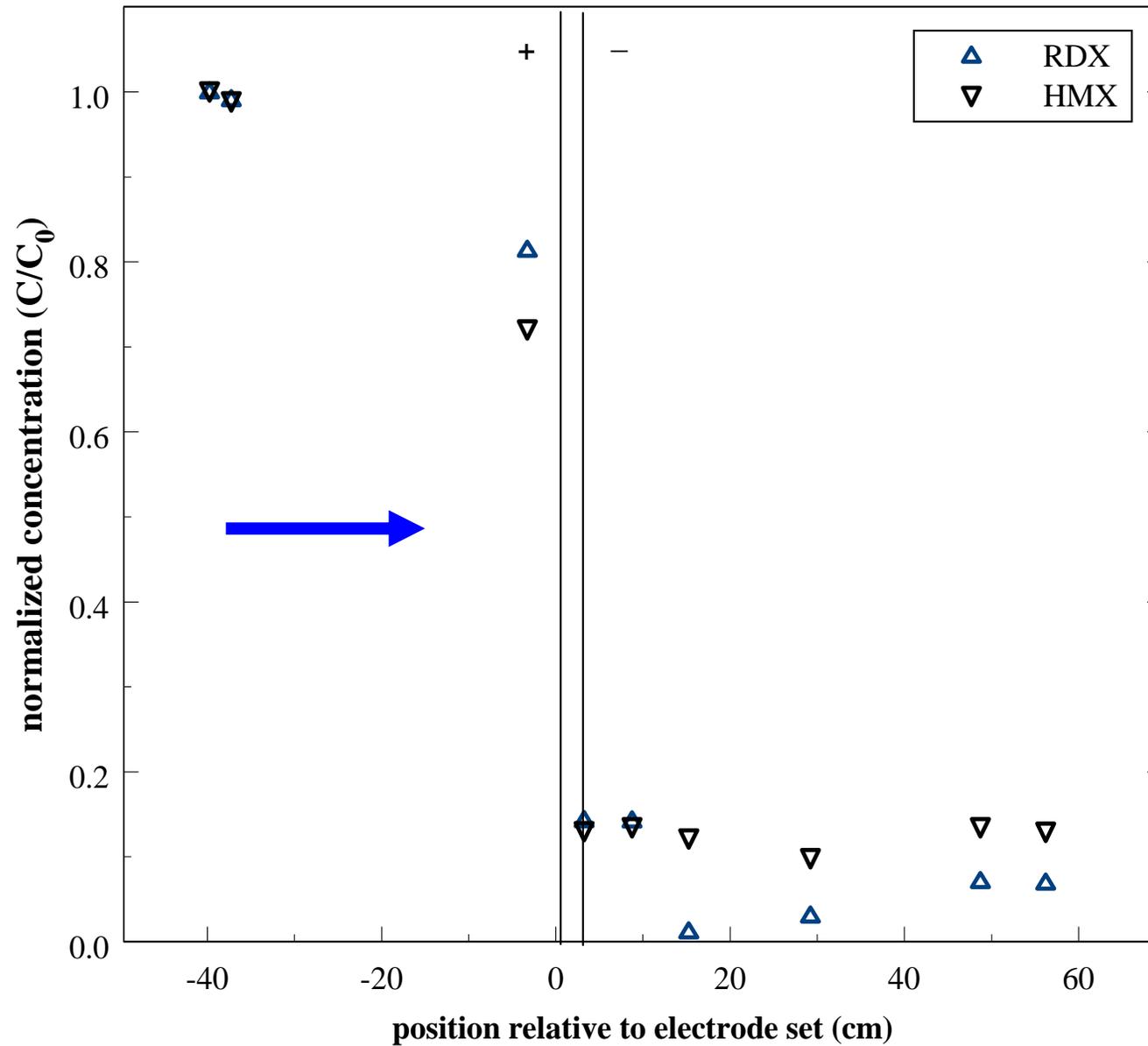
Electrically induced dechlorination as a function of imposed voltage



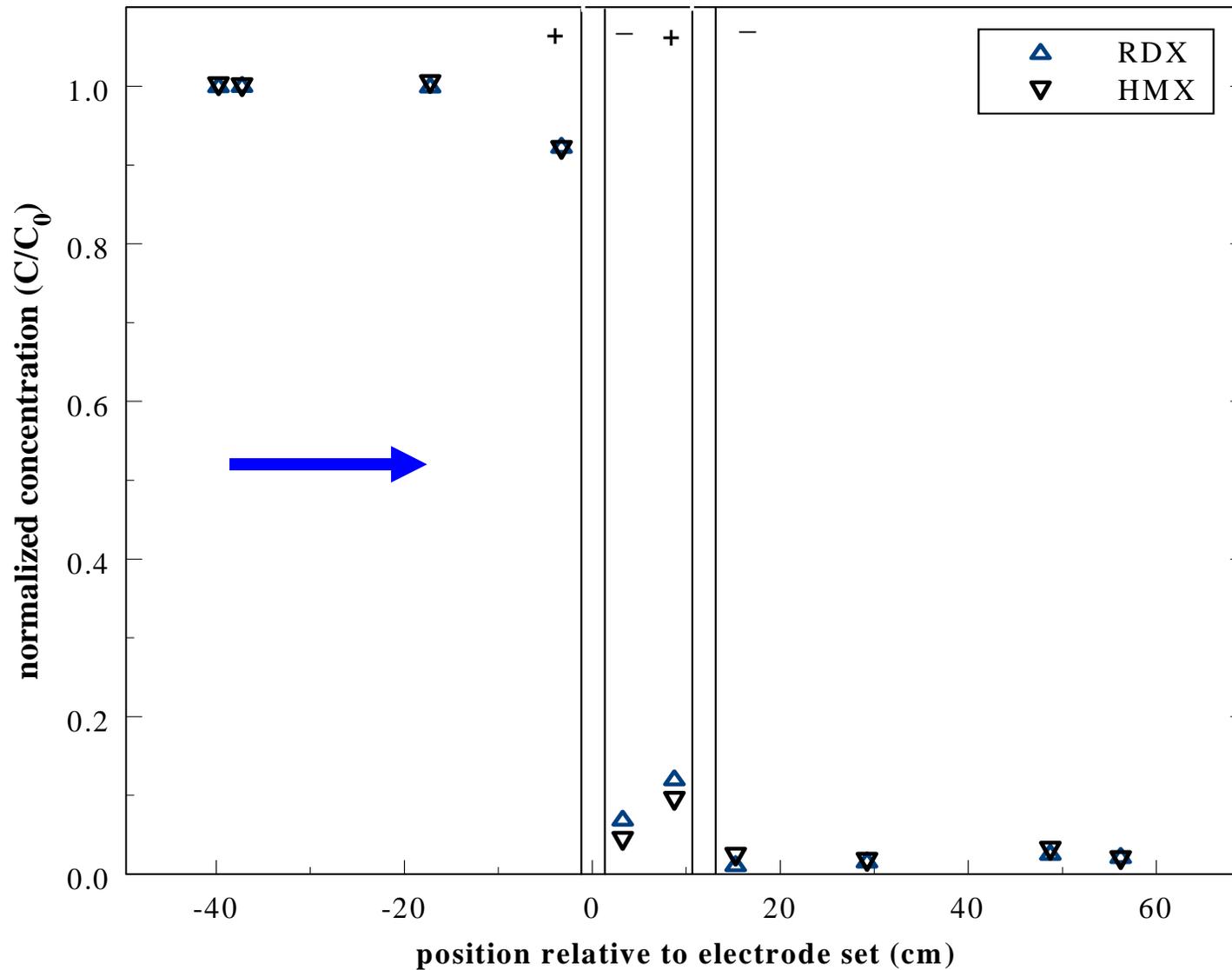
Multiple pass e-barrier



Treatability Studies using RDX and HMX



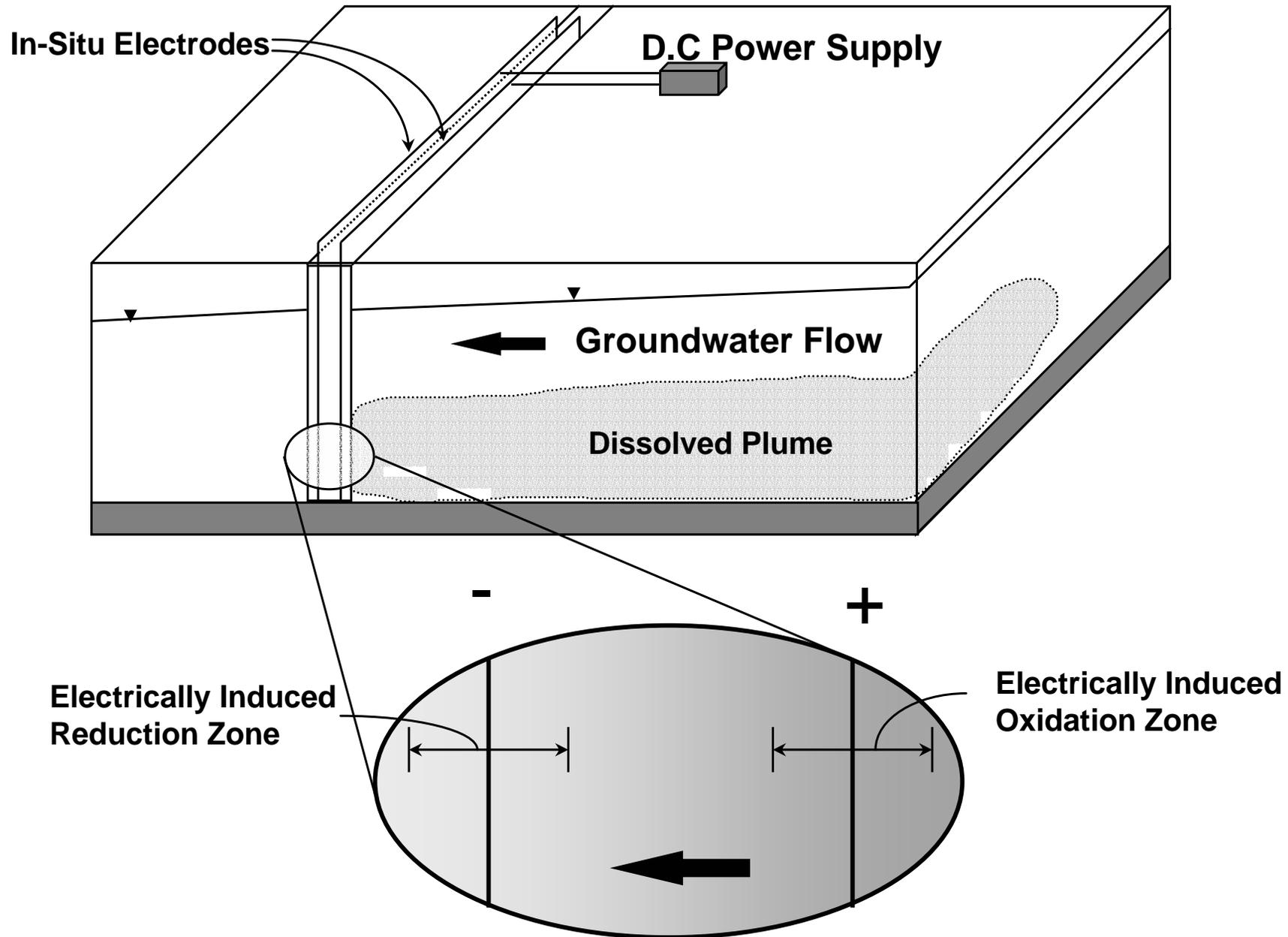
Transformation through two electrode sets RDX and HMX



Motivation for Technology

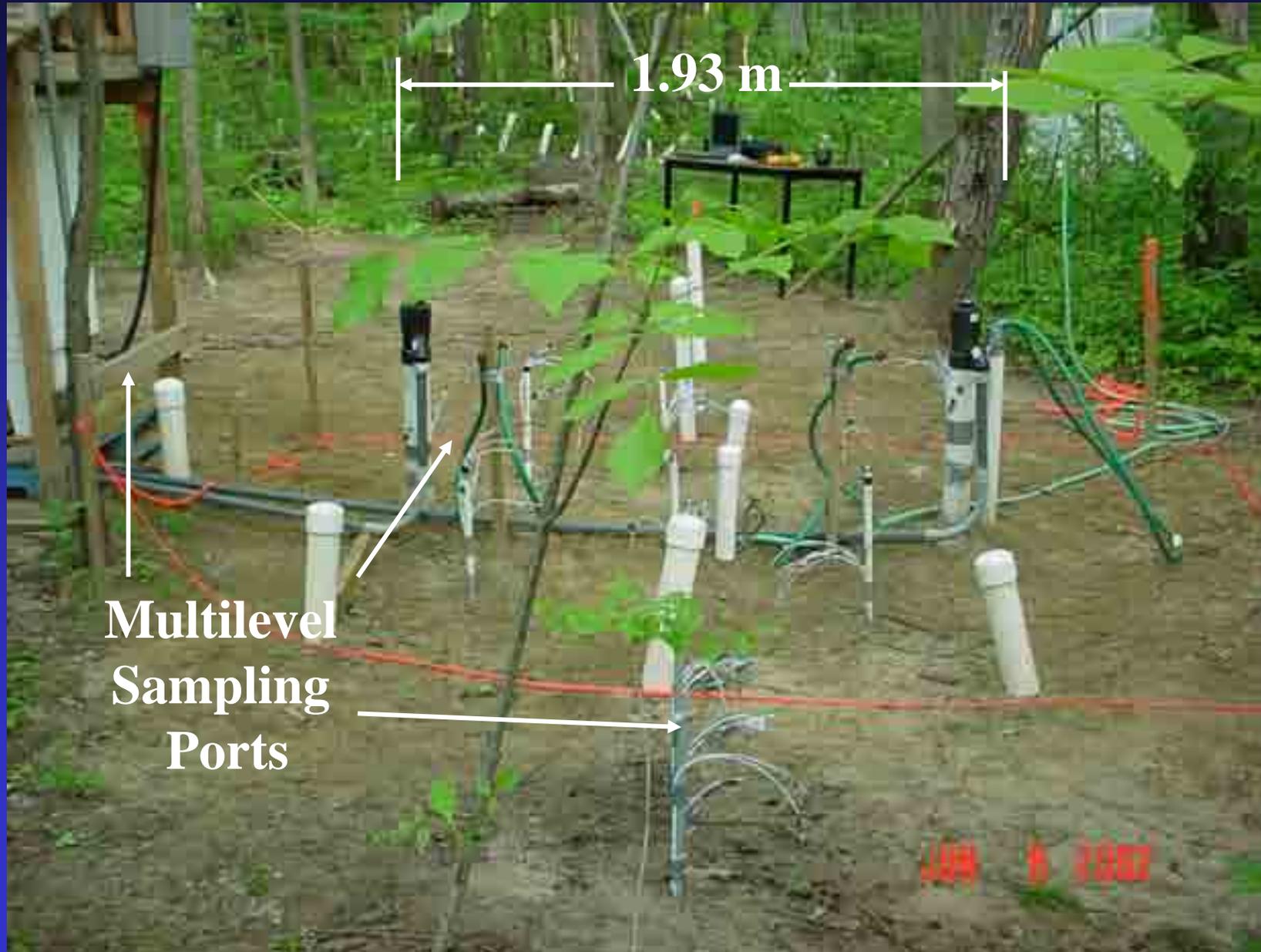
- Treatment controlled by variable applied potential difference
- Includes oxidation and reduction
- Multiple sequences possible
- Precipitate control through polarity reversal
- Low power requirements
- Applicable to many contaminants and mixtures

Field-scale e-barrier concept



4 m² Prototype – Canadian Forces Base Borden, Ontario

University of Waterloo - Matthew Ballaban, Cory Repta,
Colorado State University - Matt Petersen, Ted Van Howland
Solvent in Groundwater Research Consortium



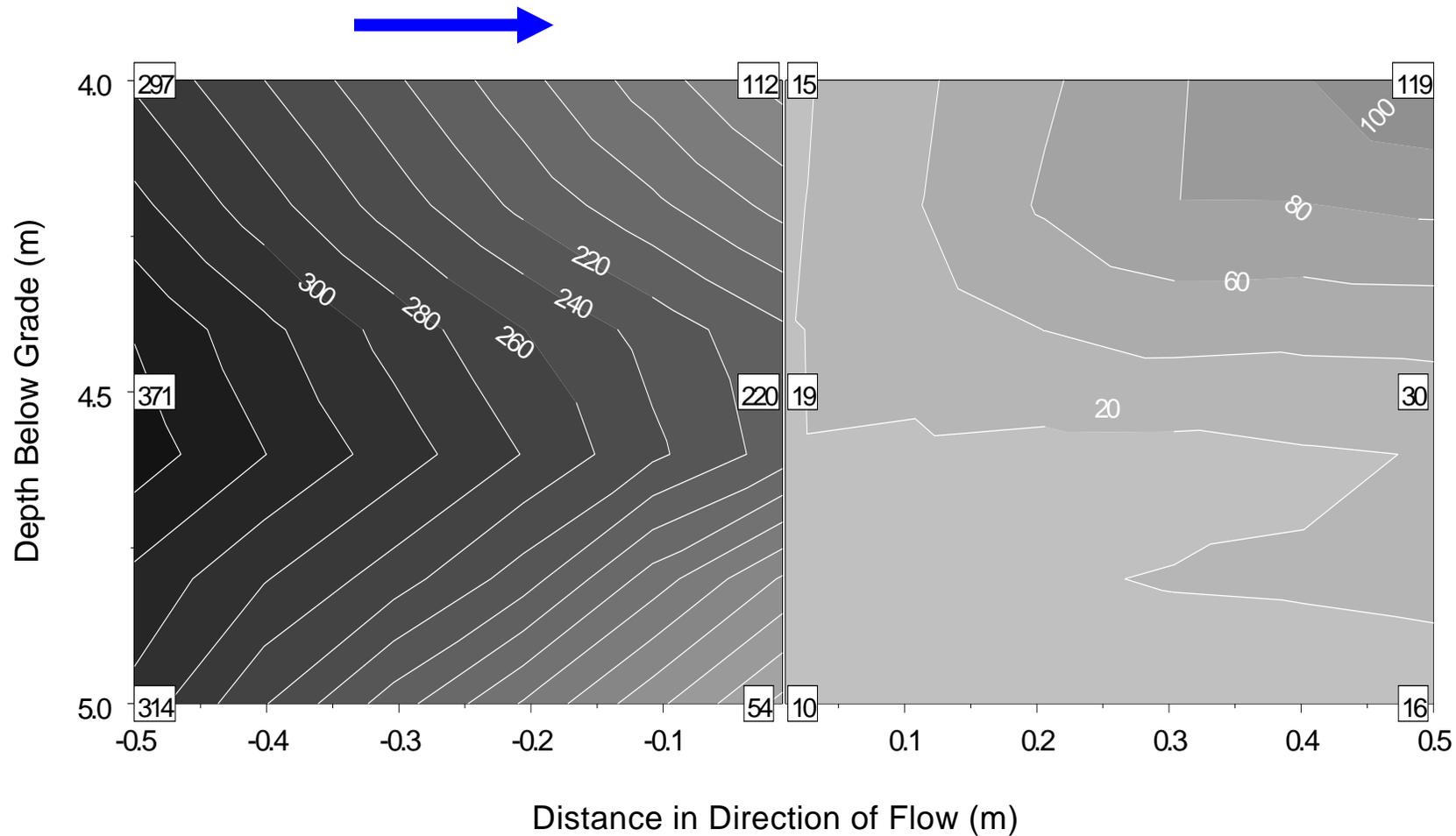
20 m² Field Demonstration – F.E. Warren AFB

Colorado State University - Matt Petersen, Eric Petersen, Katie Compton, Dawn Fairchild, Rob Jackson

ESTCP

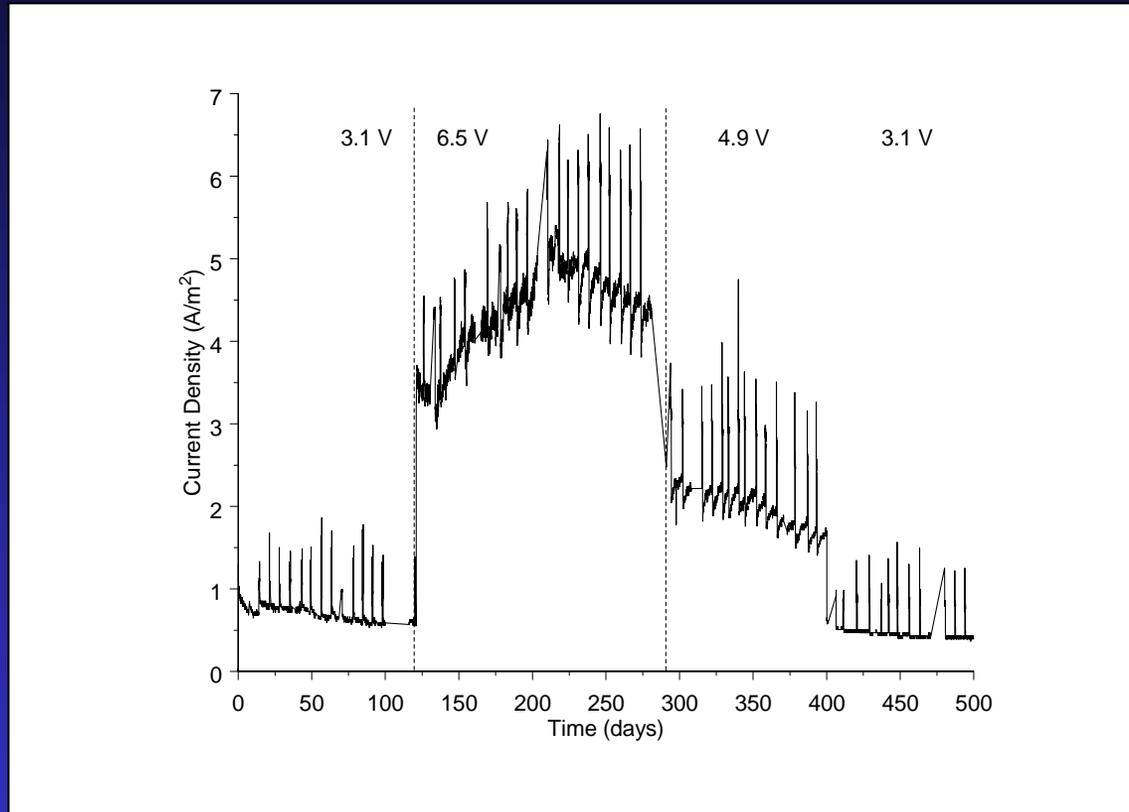


90 to 95% removal of TCE with no intermediates



TCE concentration (ug/L) contour plot along a plane parallel to groundwater flow through the midpoint of the e-barrier.

Current Density



Energy costs of \$0.004 to \$ 0.04 per m^2 -day.

Total power cost during the 18 months of operation is approximately \$110 or an average of \$0.013 / m^2 -day

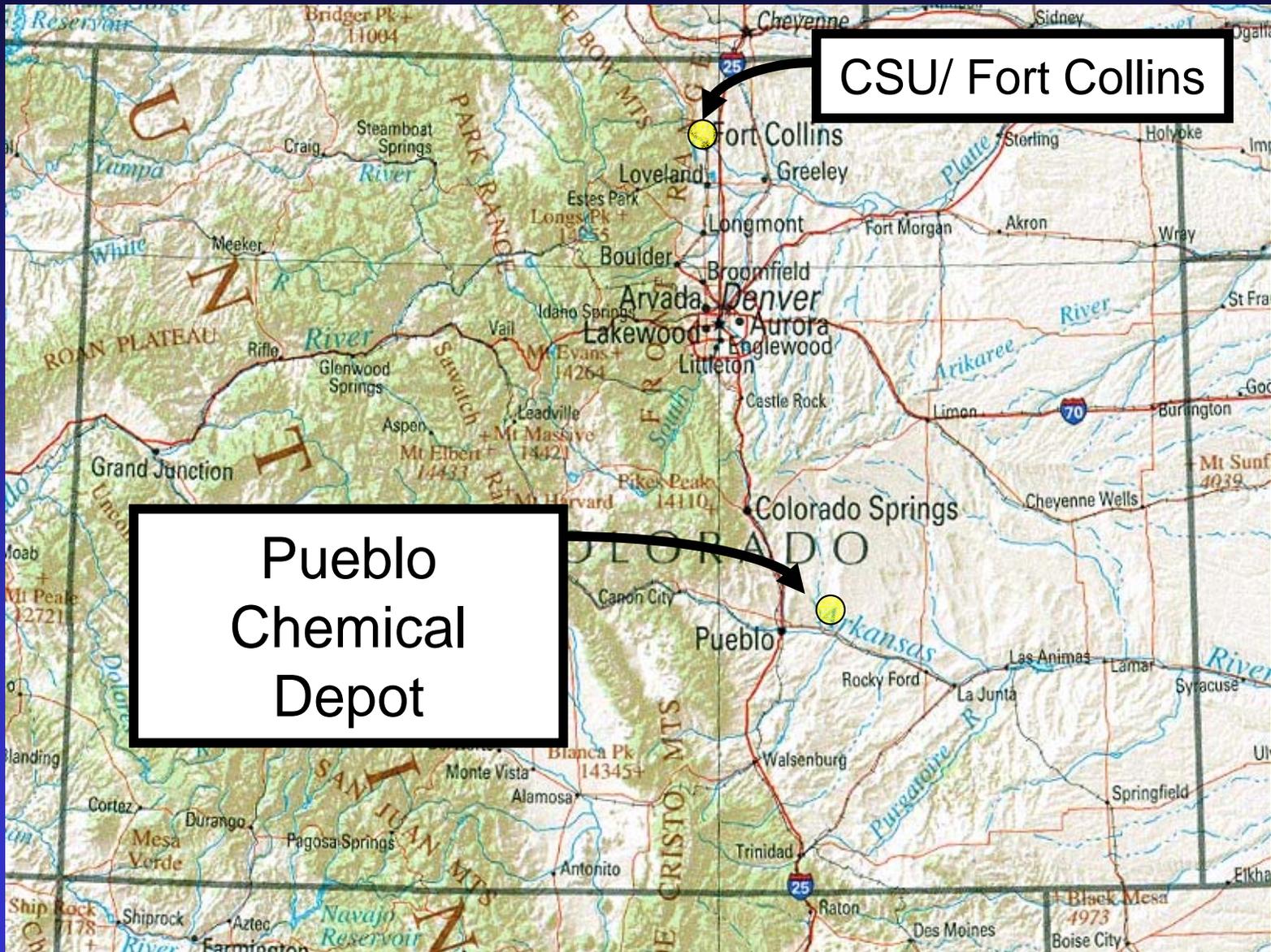
Costs

1. Capital (demonstration) expenses of \$409/ft² of intercepted plume
2. Operation and maintenance (O&M) (demonstration) expense of \$10/ft²/year
4. Cost for full-scale systems are anticipated to be 25 to 50% lower
5. Capital and O&M costs similar to those of current proven technologies for TCE
6. Advantages for contaminants such as energetic compounds

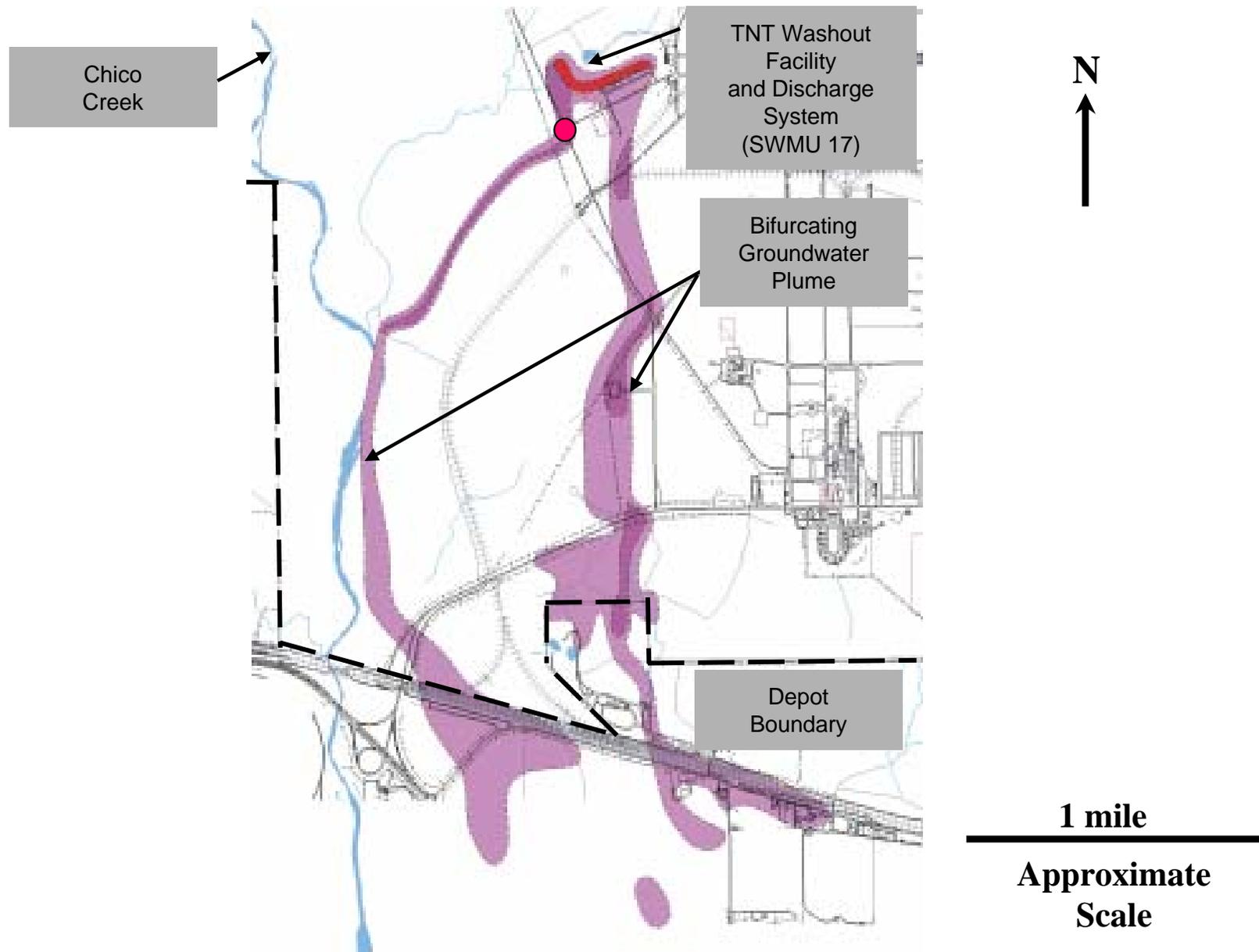
Opportunities for Improvements

- Addition of a fourth electrode
- Advanced instrumentation and control
- Simpler design
- Use of conventional HDPE barrier walls for framing
- Photovoltaic DC power supply

Next Stop ?



Pueblo Chemical Depot



Status

- Former ammunition and material storage center
- Identified for realignment (BRAC)
- Undergoing environmental restoration
- RDX, 2,4-DNT, nitrate
- Existing pump and treat system

Former Washout Pond

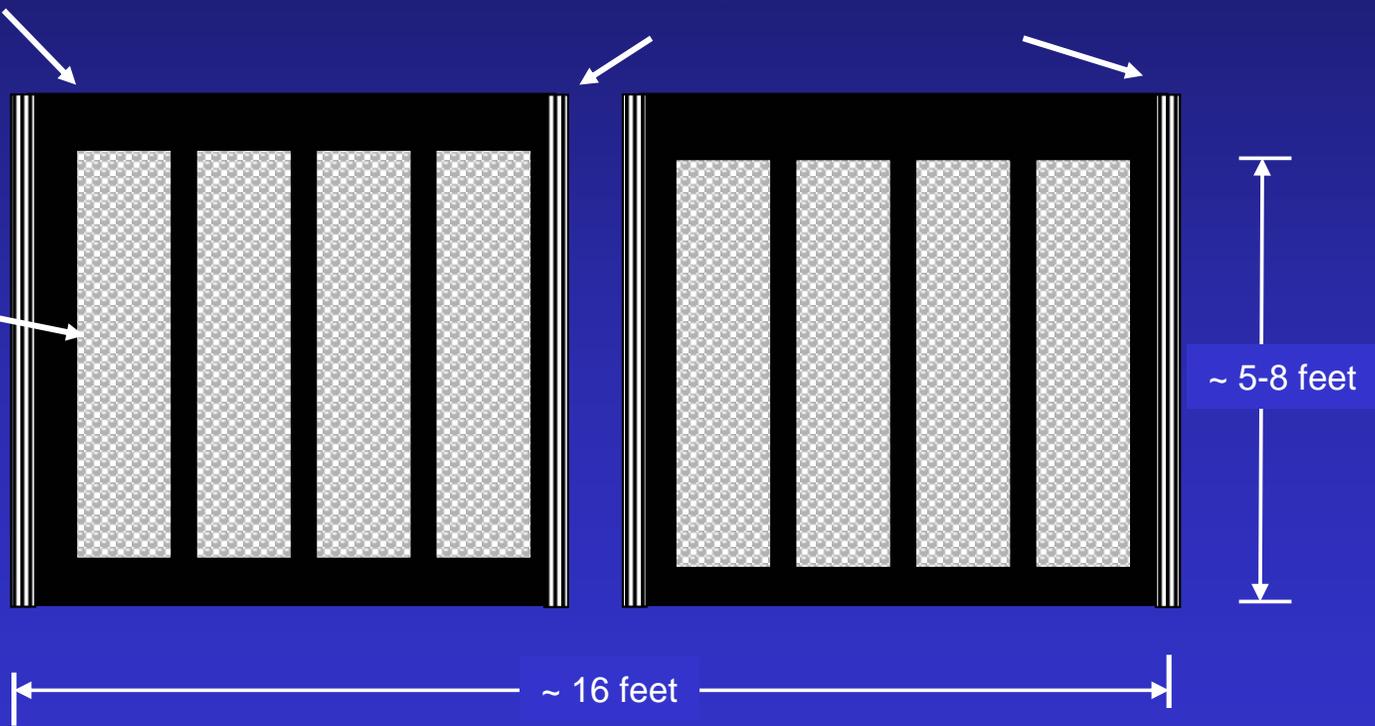


Preliminary Design and Methods

HDPE Barrier Wall Sheeting
as Framing

Interlocks with Hypertite™
Expansive Seals

Active Electrode
Panels



HDPE Sheet Barrier

- Off-the-shelf technology
- Cost - \$20-\$40 foot²
- Better flow control
- Proven installation



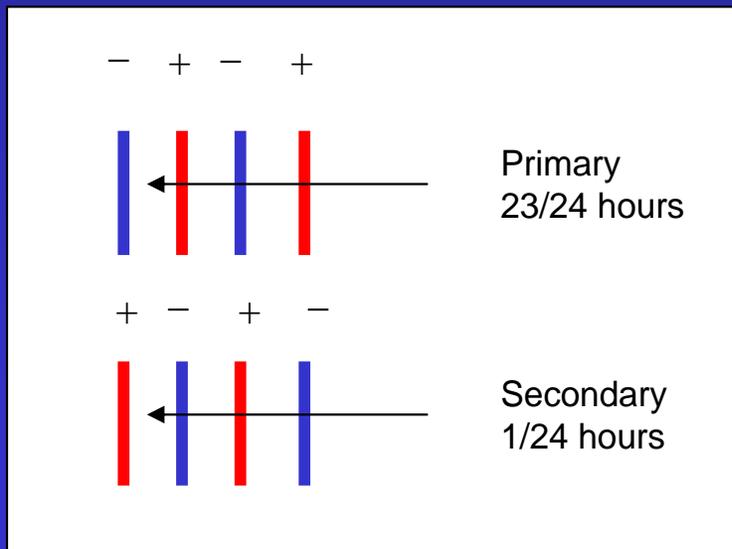
Solar Power

- Cost effective off the shelf systems
- Eliminates need for rectifier and line power
- Well suited to remote locations
- Simpler wiring
- Green solution



Four electrode design

- Ongoing tank studies (USACOE-ERDC)
- Better removal
- Operational flexibility
- Better scale control



Summary of e-barriers status

- 90-99% removal of TCA, TCE, RDX, and TNT with few intermediates
- Construction costs of \$200-400/ft²
- Operation and maintenance cost ~ 10ft²
- Titanium mmo electrodes are durable
- Improved strategies for scale control are needed
- Most promising niches RDX, TCA and mixtures

Acknowledgements

- Solvents-in-Groundwater Research Consortium
- ESTCP
- SERDP
- Army Corps of Engineers