NABIR Field Research Center
Oak Ridge, Tennessee

FRC Workshop Tour
September 22, 2003

David Watson (865-241-4749) - FRC Manager
Environmental Sciences Division
Oak Ridge National Laboratory
E-Mail: watsondb@ornl.gov

http://www.esd.ornl.gov/nabirfrc/

Agenda

- **Overview**
  - **NABIR Program and FRC**
  - **Summary of Site Setting**
  - **Description of multi-disciplinary *in situ* bioremediation field research projects**
- **Tour**
  - **Contaminated field plots and field trailer**
  - **Soil lysimeters**
  - **Background Area**

NABIR Objectives

- **To encourage hypothesis-based field and laboratory research on bioremediation of metals and radionuclides the NABIR program has established a Field Research Center (FRC) for NABIR (and possibly EMSP) investigators.**
- **Laboratory studies indicate that bioremediation techniques can be used to transform metals and radionuclides to less mobile forms. Recent *in situ* studies conducted at the FRC confirm that reduction of dissolved Tc and U is possible in the field (see figure 1).**
- **FRC research will lead to new methods of reducing/understanding risks associated with DOE's metals and rads legacy waste.**
- **NABIR's research will be used to help Environmental Managers and other stakeholders fulfill DOE's environmental restoration and long-term stewardship mission.**

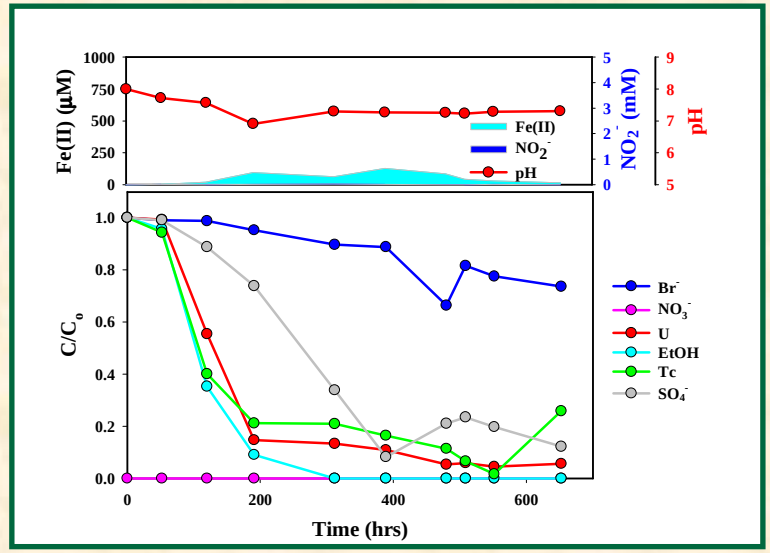


Figure 1. *Results of OSU push-pull test showing removal of U, Tc and nitrate at FRC Area 2 Field Plot due to microbial activity.*

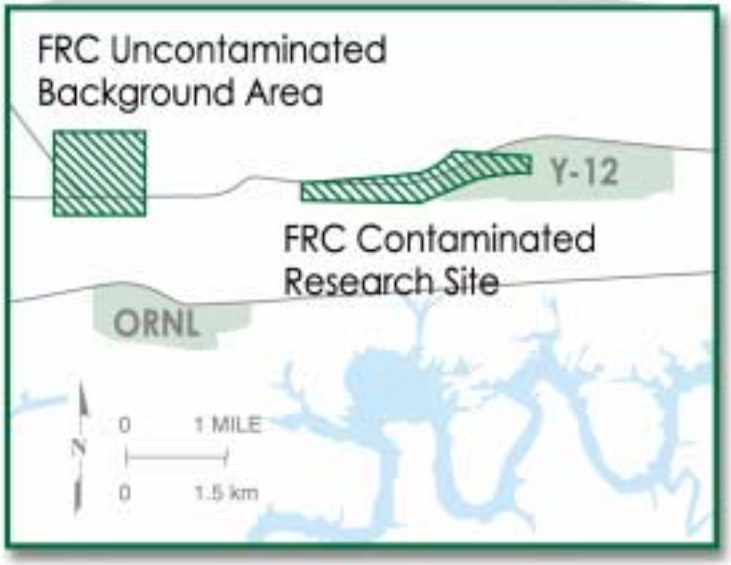
FRC Goals

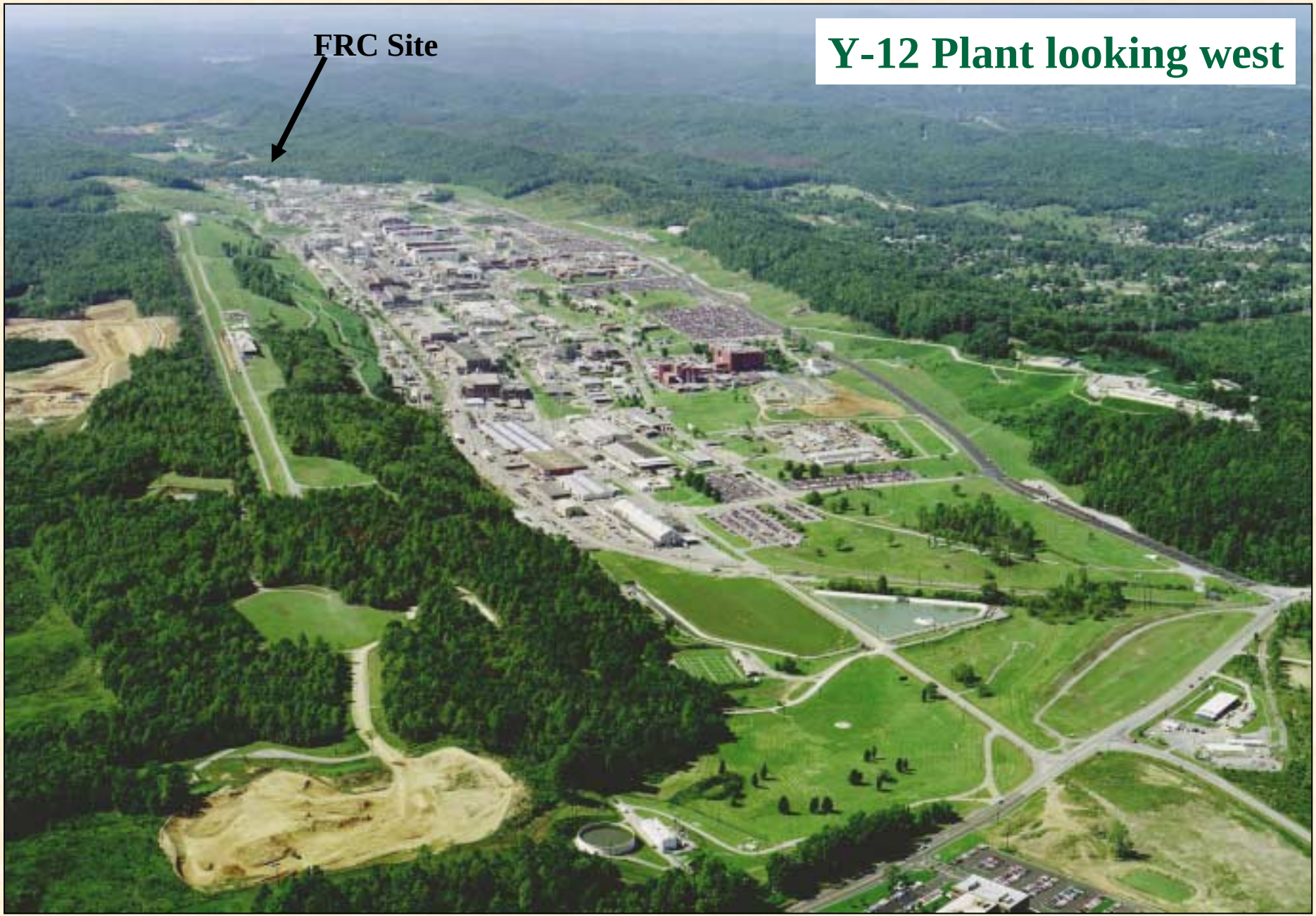
- **Establish field laboratory**
  - **Source of subsurface samples for NABIR investigators**
  - **Evaluation of new characterization and monitoring methods, and predictive approaches**
  - **Intrinsic bioremediation analyses**
  - **In situ accelerated bioremediation research**
- **Site specific benefits to Oak Ridge Environmental Restoration Program**

NABIR FRC Facilities

Glove Bag with 5 ft Airlock at Field Trailer

Drill Rigs



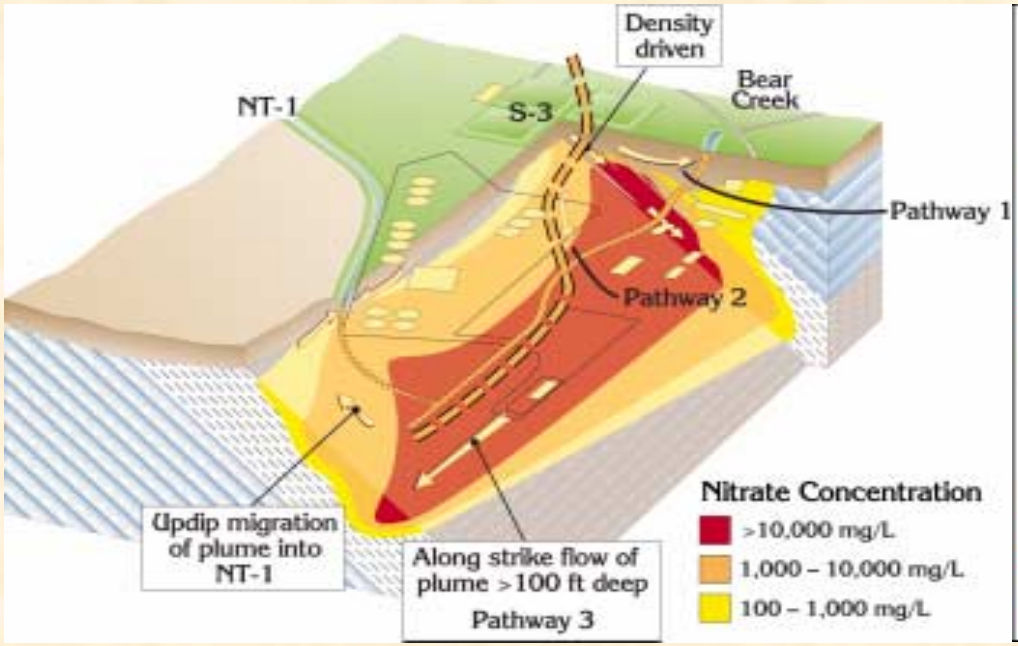

FRC Site
Y-12 Plant looking west

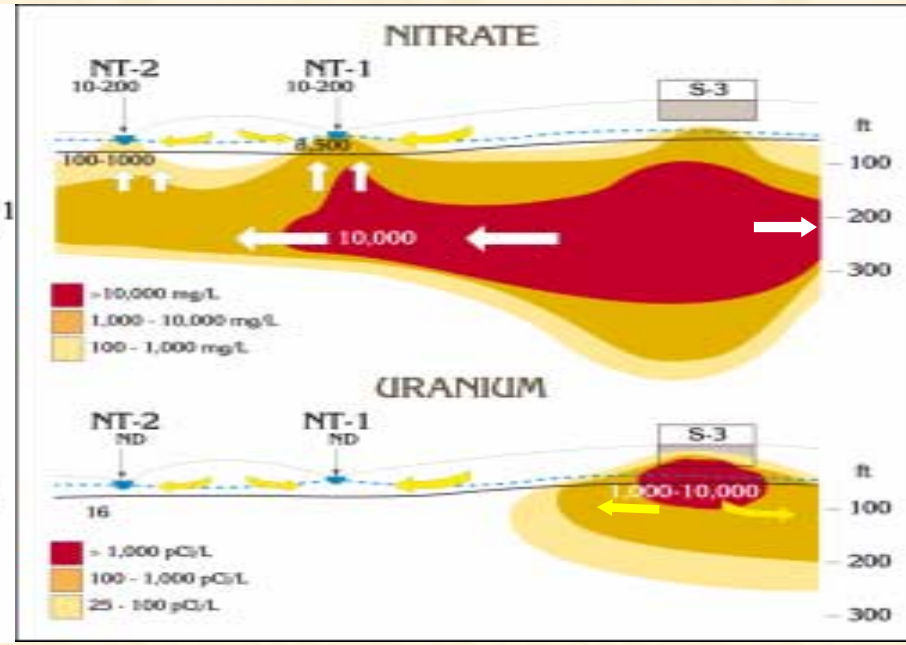
- Operated from 1951 to 1983
- 400 ft x 400 ft x 17 ft deep
- Over 2.5 million gallons waste/year
- Wastes contained nitrate, uranium, Tc-99, metals, VOCs, high TDS, and low pH (<2.0)
- Neutralized in 1984 capped in 1988

Currently a parking lot

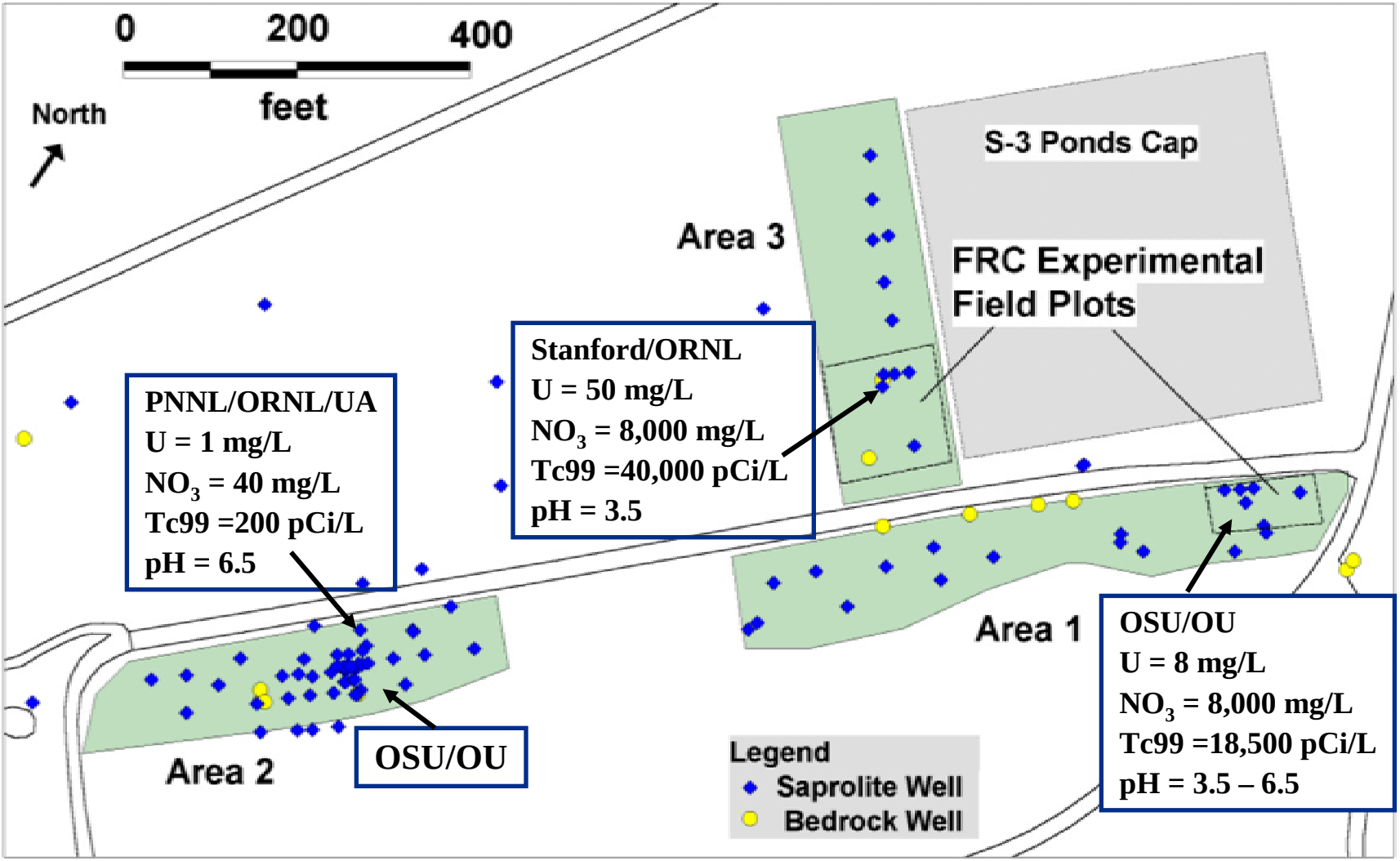
S-3 Disposal Ponds During Denitrification

Conceptual Model of Contaminant Transport at the S-3 Ponds Site





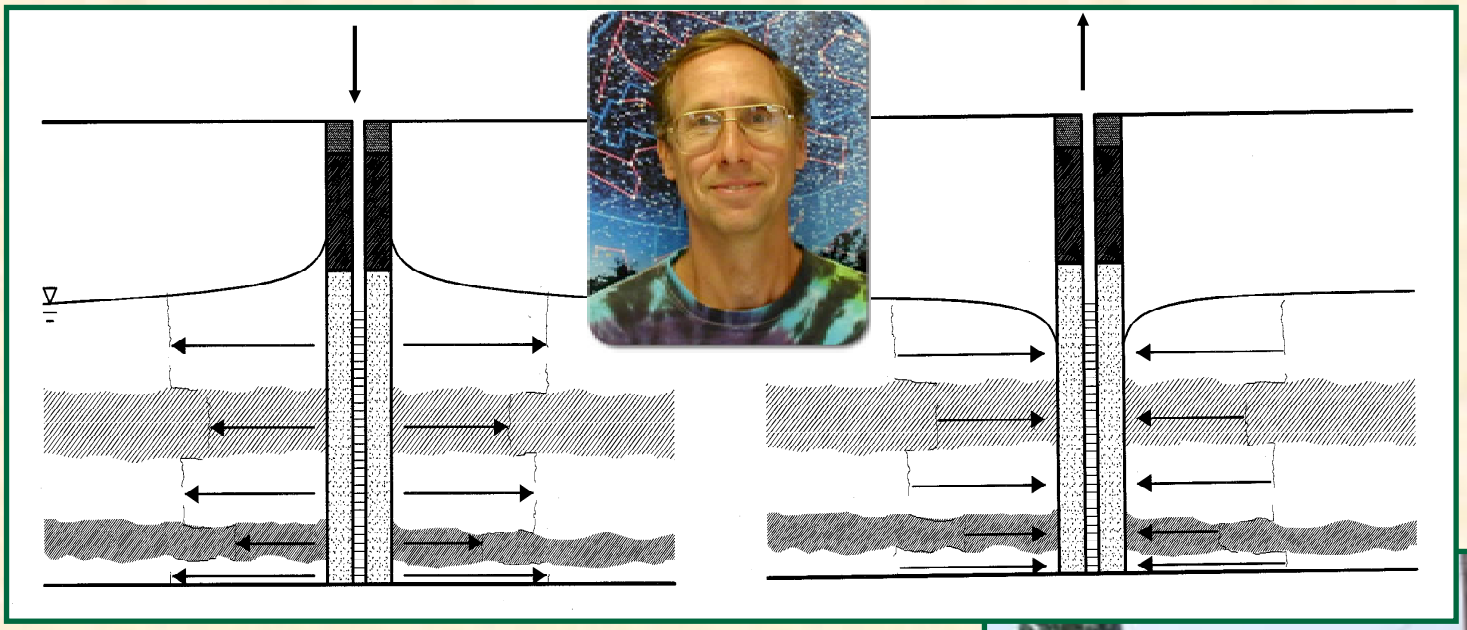
Field Plots in Contaminated Area



Multi-disciplinary in Situ Accelerated Bioremediation Field Research Projects

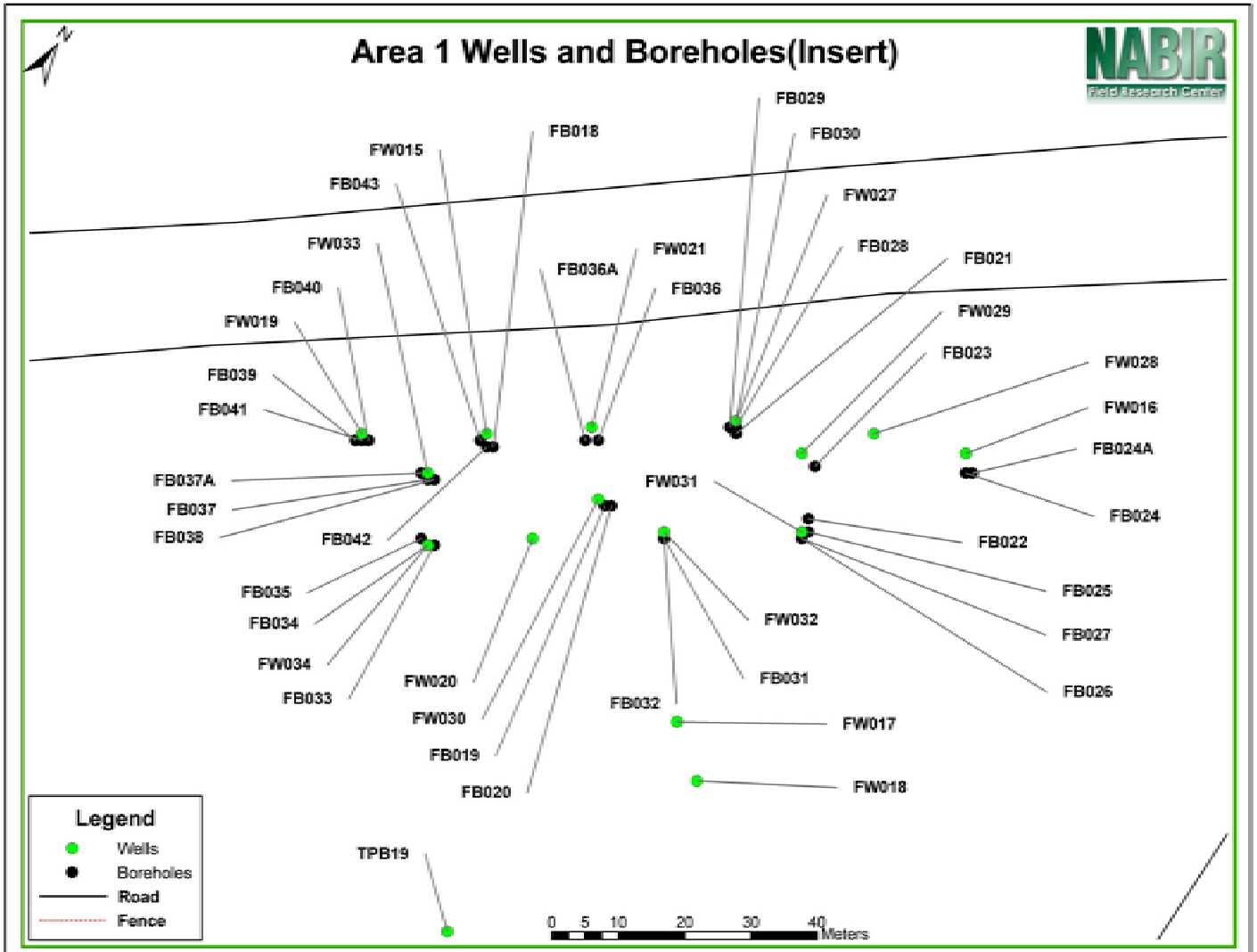
- **In-situ Uranium Reduction Experiments Using Push-Pull Techniques (Oregon State University and Oklahoma University located in Area 1 and 2)**
- **In situ Immobilization of Uranium in Structured Porous Media via Biomineralization at the Fracture/Matrix Interface (PNNL, ORNL, and University of Alabama located in Area 2)**
- **Field-scale Bioreduction of Uranium (Stanford and ORNL located in Area 3)**

OSU/OU Push-Pull test methodology

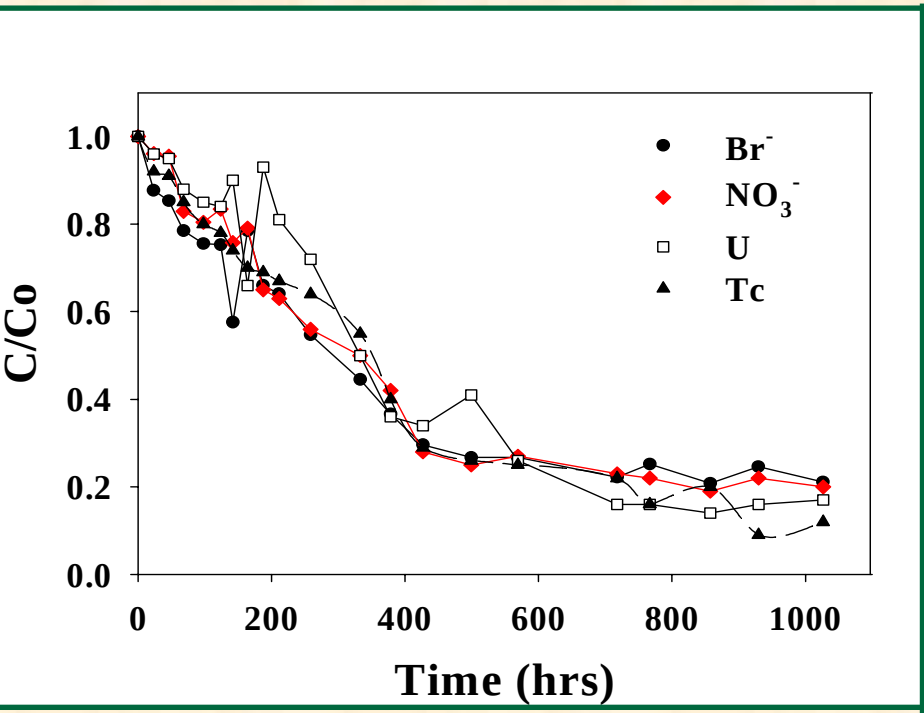


Field push-pull tests (left) injection "push" phase (right) extraction "pull" phase

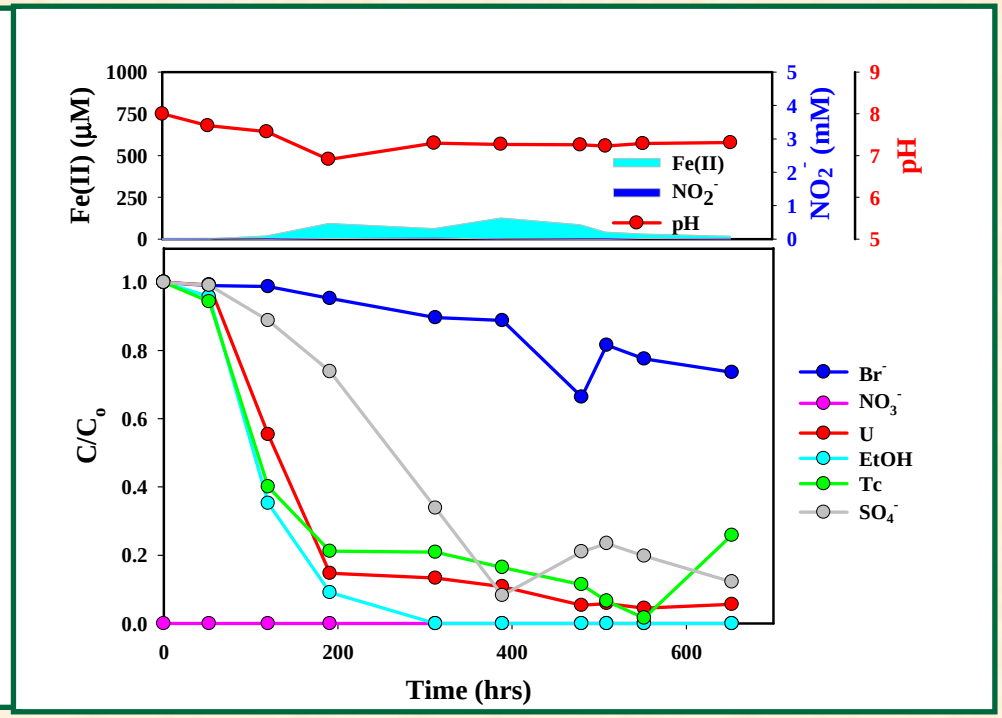
To test for microbial activity, site groundwater is mixed with tracers and nutrients in drums and injected into monitoring wells. Many tests can be run relatively quickly to test hypothesis.


Area 1 Wells and Boreholes(Insert)
NABIR
Field Research Center
FB029
FB018
FB030
FW015
FB043
FW027
FW033
FW021
FB028
FB021
FB036A
FB036
FB040
FW019
FW029
FB023
FB039
FW028
FB041
FW016
FB024A
FB037A
FW031
FB037
FB024
FB038
FB042
FB022
FB035
FB025
FB034
FW032
FB027
FW034
FB031
FB026
FB033
FW020
FB032
FW030
FW017
FB019
FB020
FW018
TPB19
Legend
Wells
Boreholes
Road
Fence
0 5 10 20 30 40
Meters

OSU/OU Push-Pull test results



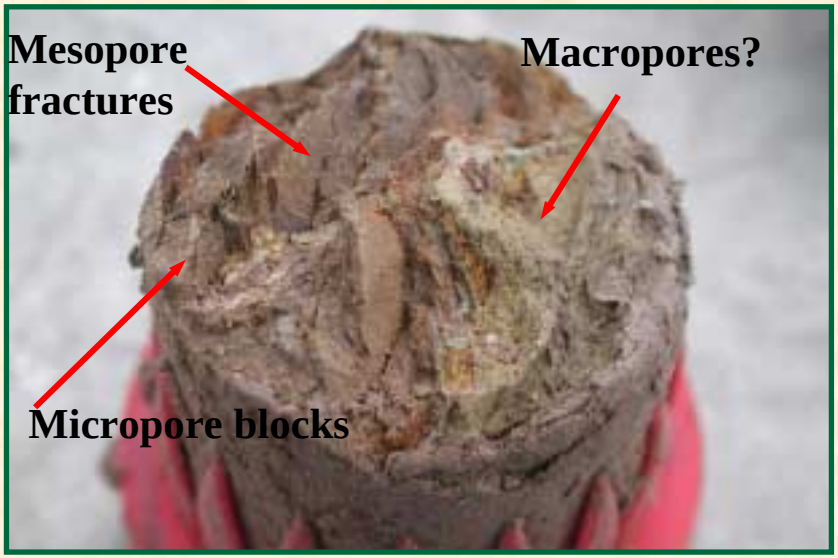
Control well with no electron donor shows no reaction



Simultaneous uranium (U) and technetium (Tc) immobilization during field push-pull tests with addition of electron donor (ethanol)

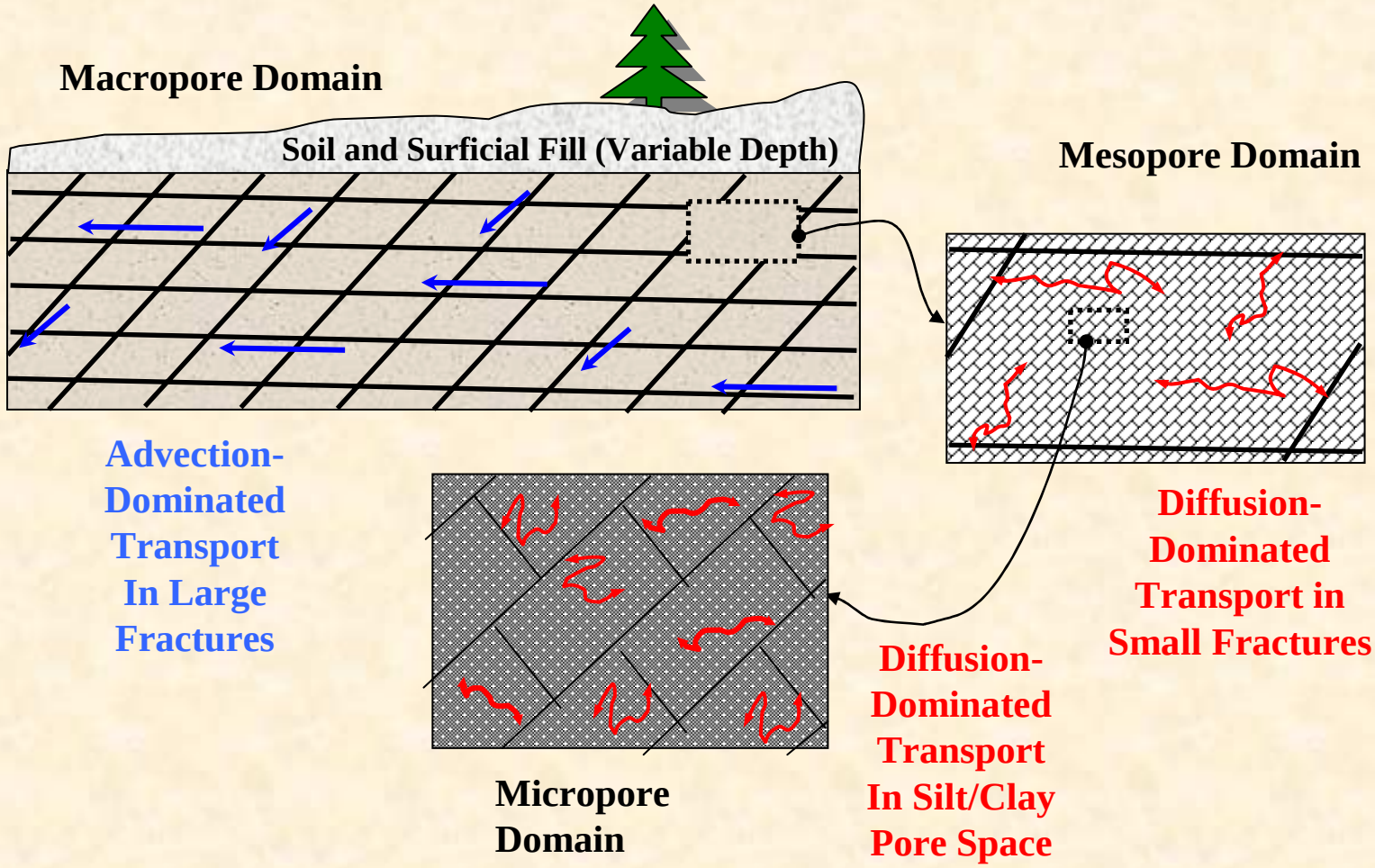
PNNL/ORNL/UA project hypothesis

- **Micropores act as a reservoir for contaminants like uranium and Tc99.**
- **Contaminated groundwater, migrates by diffusion from smaller to larger pores**
- **Microorganisms important for bioremediation are too big to fit in micropores, but small enough to live in mesopores and macropores.**
- **Hypothesis - by stimulating these bacteria in place, uranium can be immobilized in subsurface macropore and mesopore regions. These boundaries will act as localized, distributed semi-permeable barriers that serve to prevent the movement of mobile uranium VI from the micropores to mesopores and macropores.**

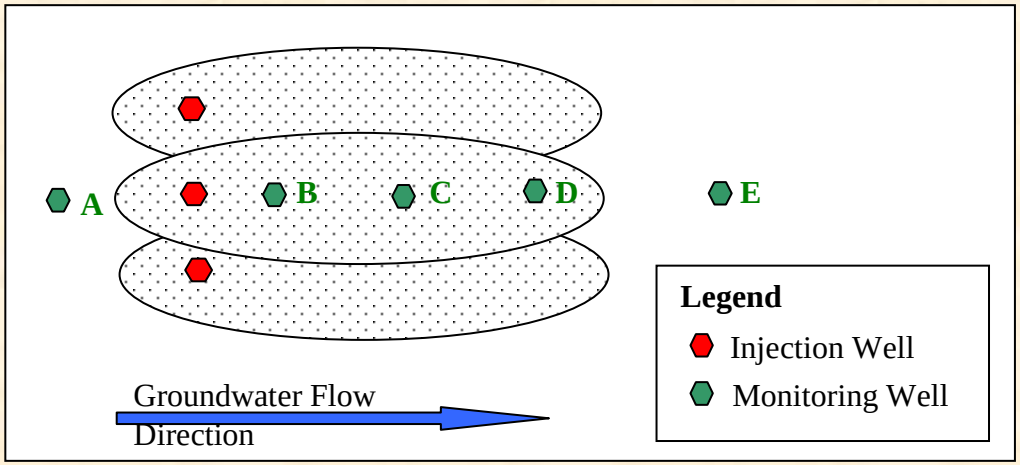


All Pores are not created equal.

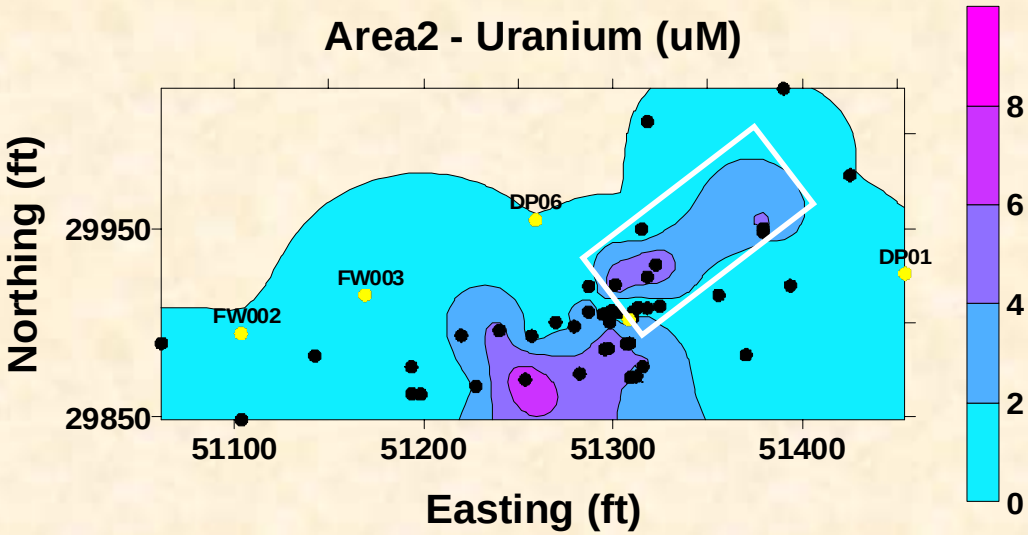
Schematic diagram of three conceptualized pore domains.

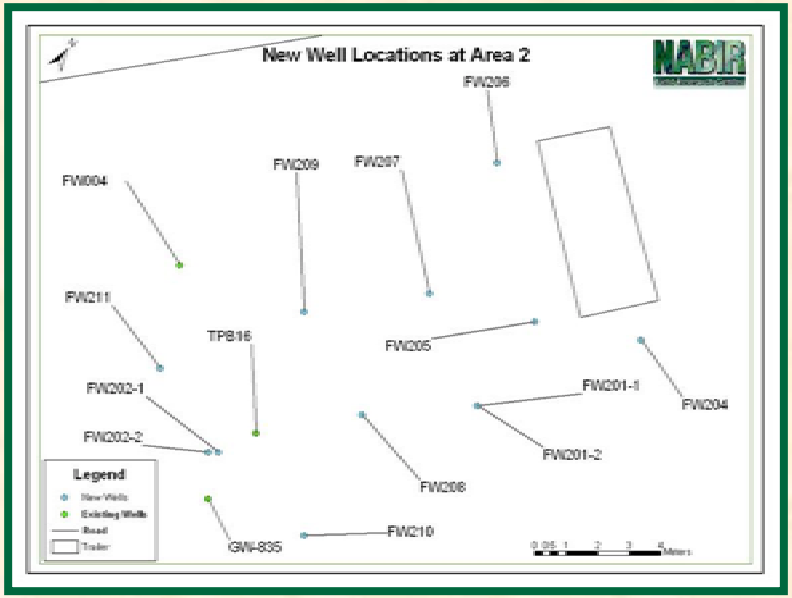


PNNL/ORNL/UA proposed *in situ* experimental design



Schematic diagram of field experimental flow cell (plan view). Dotted zones represent volumes of the aquifer (mobile domain) influenced by injected nutrients.





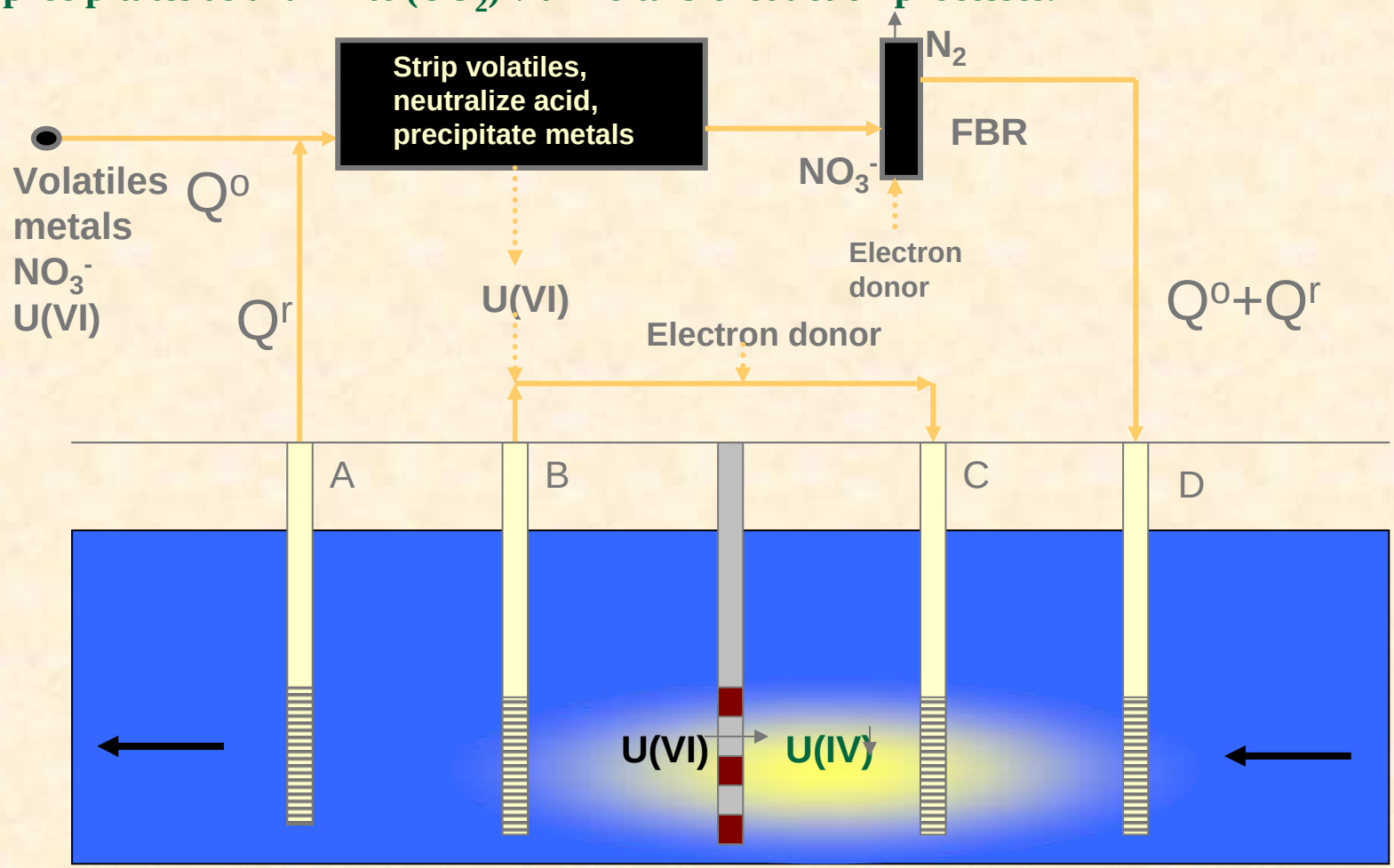
PNNL/ORNL/UA project intact core experiments

Background Area test pit showing:
A) **Remnant bedding structure exposed on test pit wall**
B) **Melanie Mayes of ORNL carving down a waxed saprolite column**
C) **Waxed and epoxy coated saprolite core in PVC casing**

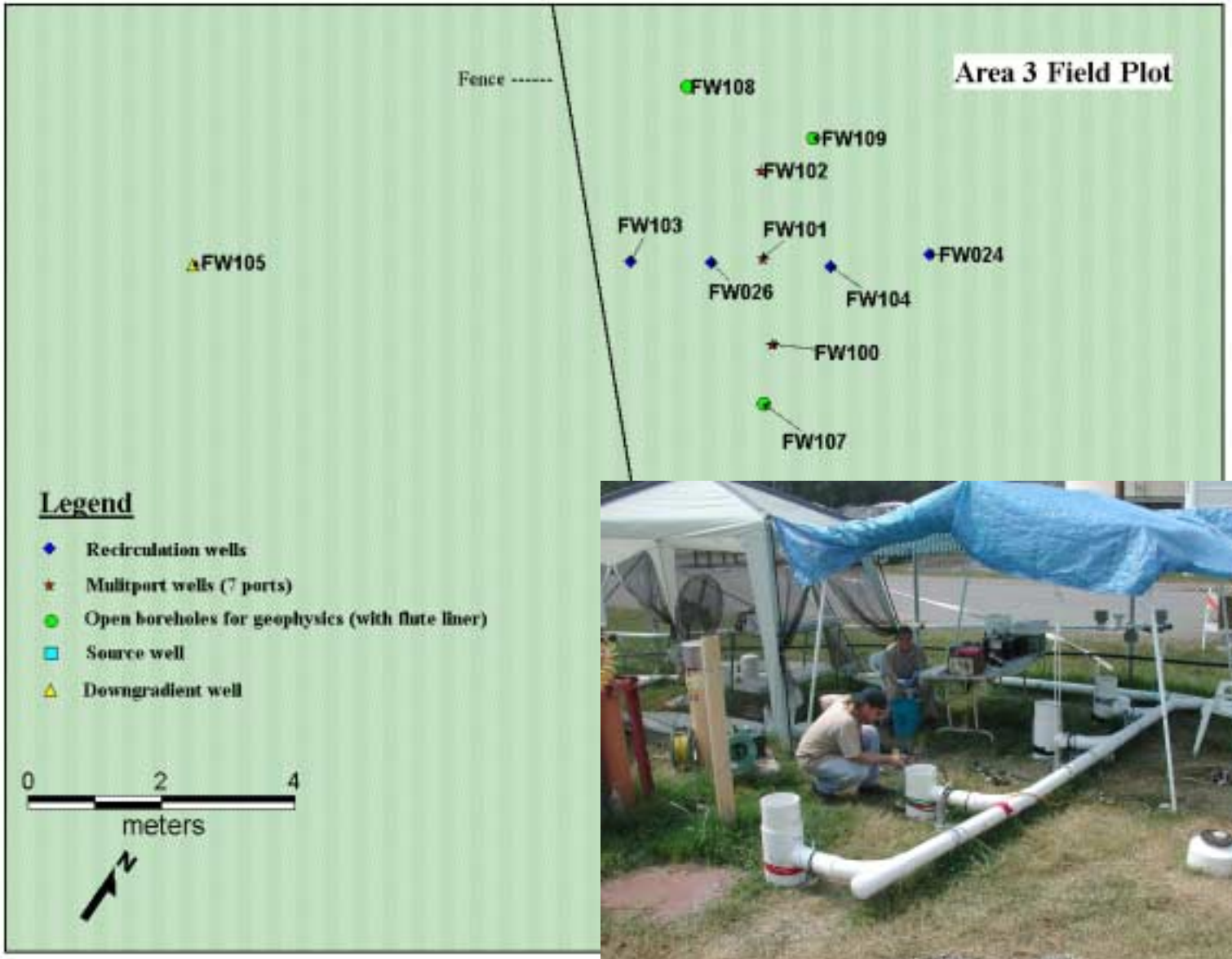
Stanford/ORNL Project U bioreduction strategy

After the hydraulic flow field reaches steady state, electron donor and minimal nutrients will be injected into the inner domain to stimulate microorganisms. Nitrate and toxins are removed from the outer loop.

U(IV) precipitates as uraninite (UO_2) via in situ bioreduction processes.



Stanford/ORNL Field Plot in Area 3



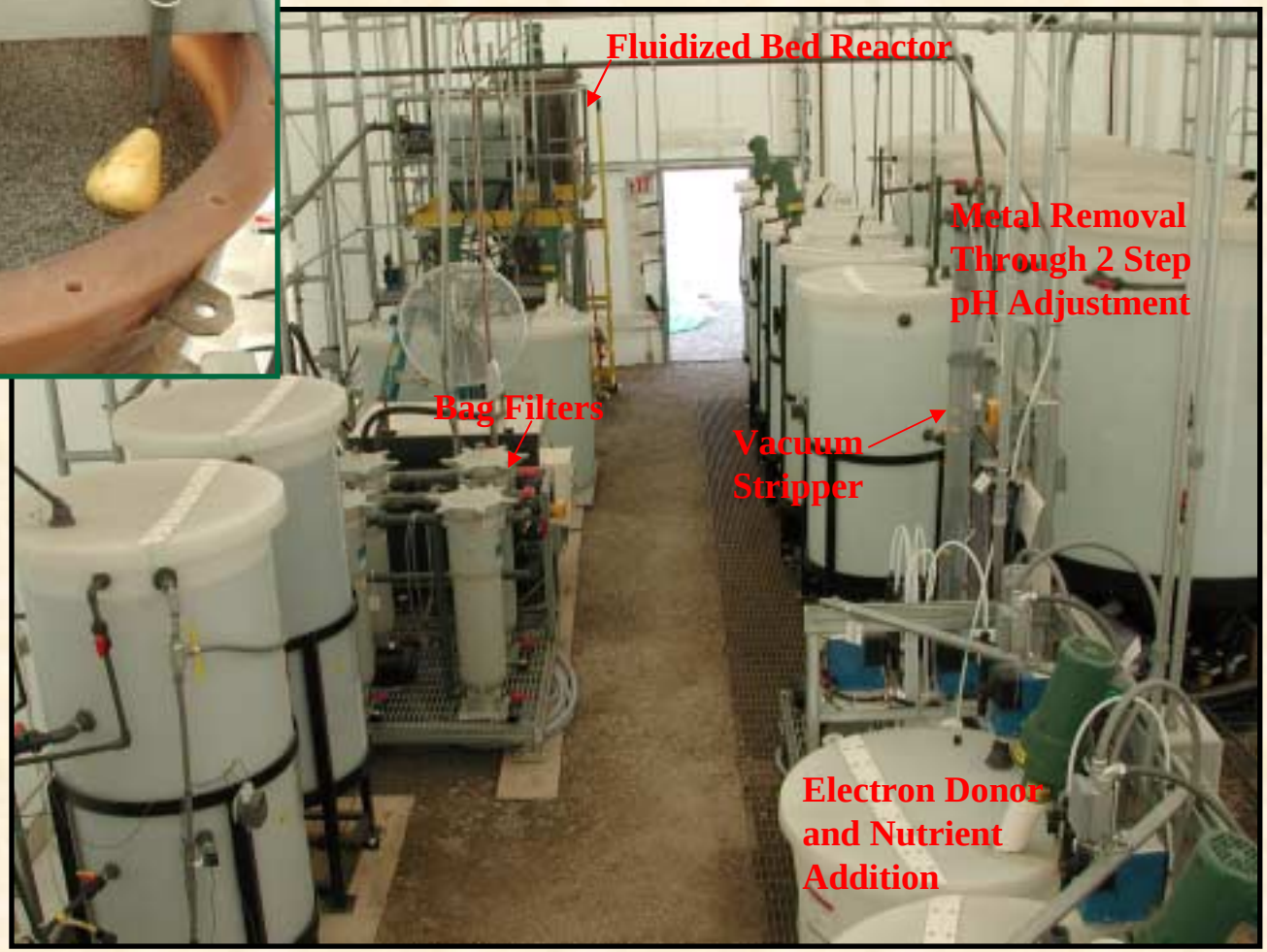
The Big Top
Its Showtime!

Featuring!!!
The Ring Master - Craig Criddle

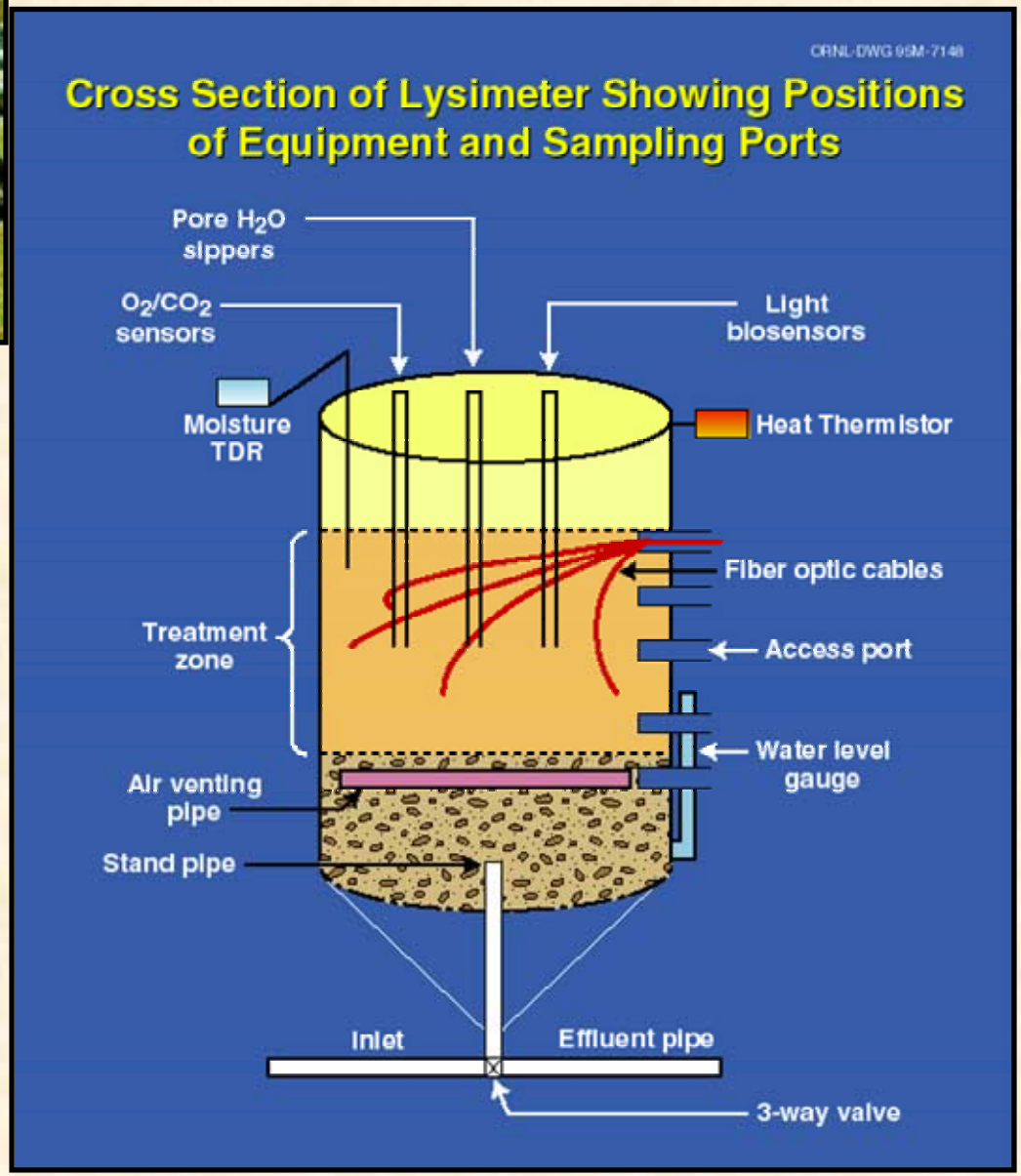
I bet I can jump this baby!
With Phil "Evel Knievel" Jardine

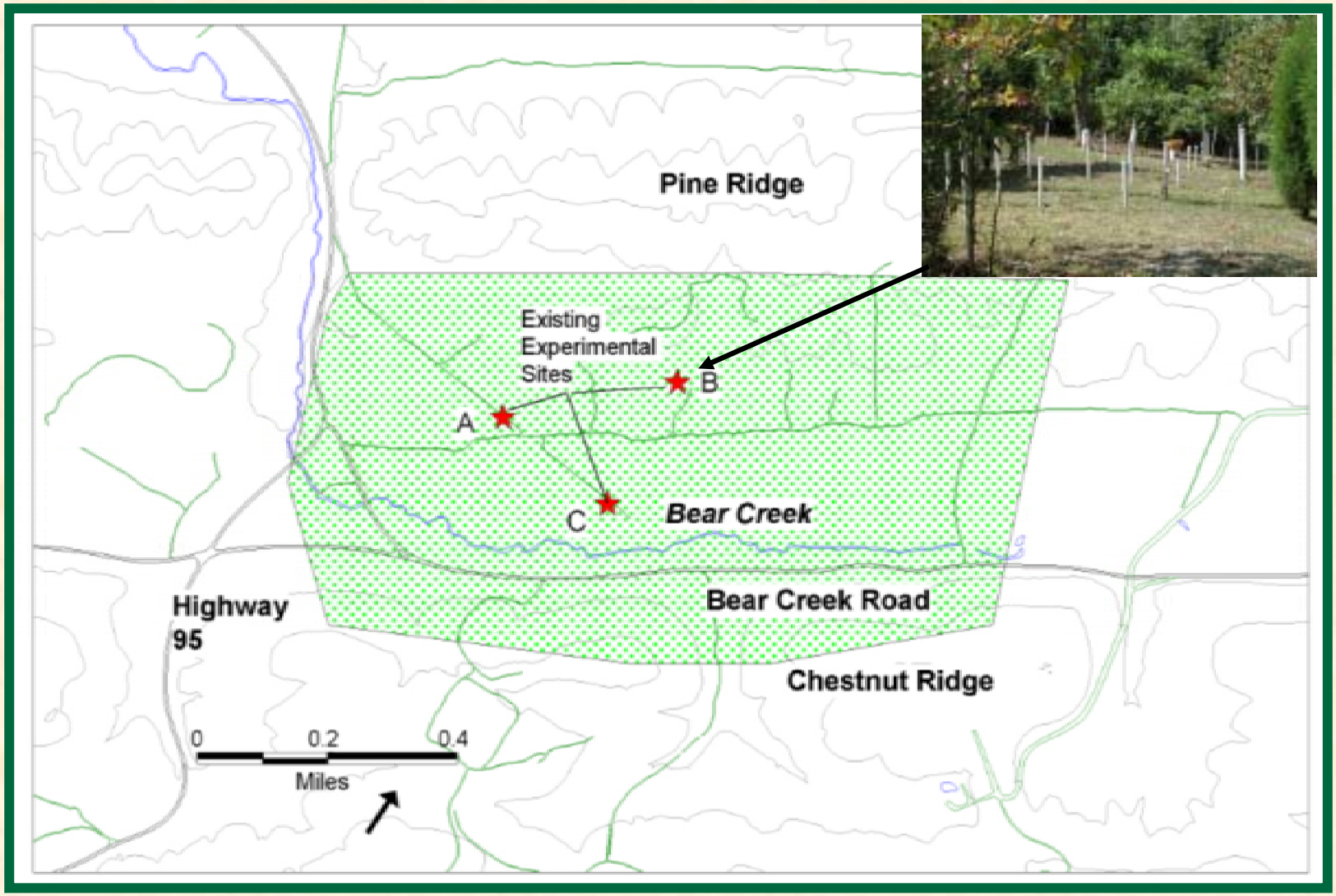
Above ground conditioning

Bubbles in FBR indicating microbial activity is consuming ethanol and removing nitrate



Lysimeters at the FRC



- Twenty Lysimeters
  - 17 large 8’ diameter x 12’ deep
  - 3 small 3’ diameter x 12’deep
- Central core access
- Permitted to test GEMs
- One tank used to test naphthalene degradation

FRC Background Area