NABIR Field Research Center
Oak Ridge, Tennessee

March 19, 2003 NABIR PI Meeting

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

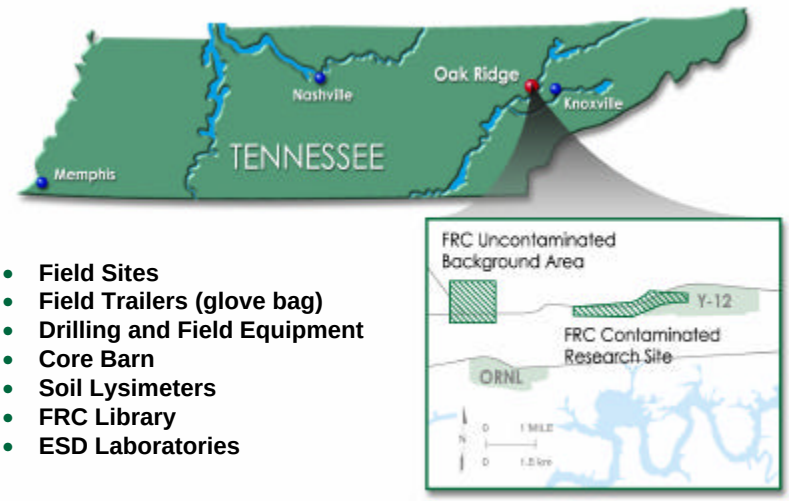
Presentation Outline

- **Objectives**
- **Summary of Site Setting**
- **What's New**
  - **Administrative**
  - **Field Plots and Samples**
- **Update on FRC Characterization**
- **Summary of Upcoming Field work**

FRC Objectives

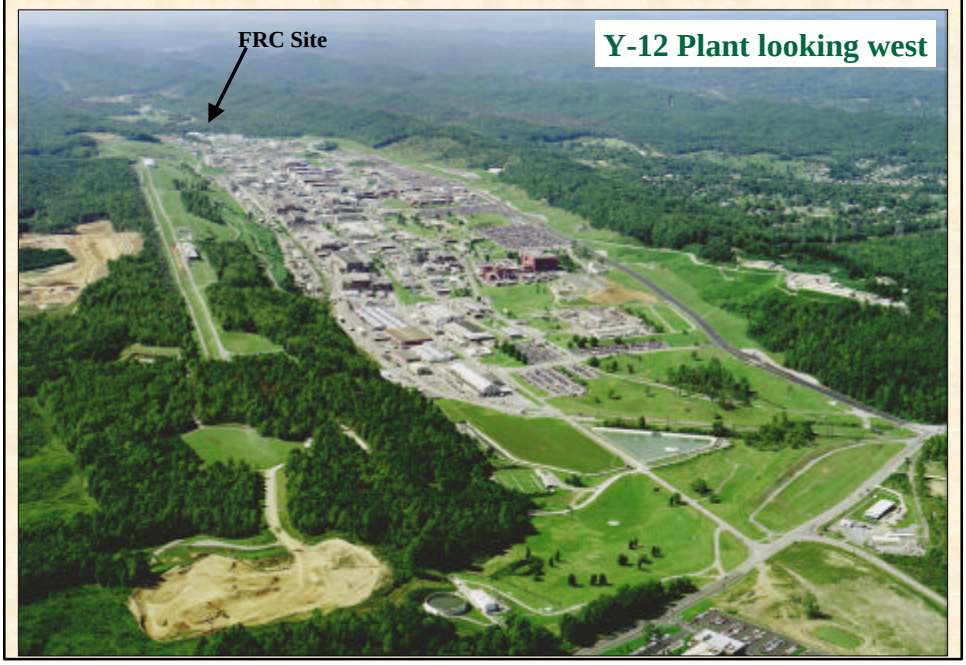
- **Objective - Understand fundamental biogeochemical processes that would allow for the use of bioremediation approaches for cleaning up DOE's contaminated legacy waste sites.**
  - **Source of subsurface samples for NABIR investigators**
  - **Evaluation of new characterization and monitoring methods**
  - **Intrinsic bioremediation analyses**
  - **In situ accelerated bioremediation research**
- **Advantages – Promote coordination and efficient use of resources, and facilitate comparison and integration of data**

NABIR FRC Facilities



- **Field Sites**
- **Field Trailers (glove bag)**
- **Drilling and Field Equipment**
- **Core Barn**
- **Soil Lysimeters**
- **FRC Library**
- **ESD Laboratories**

Field Research Center

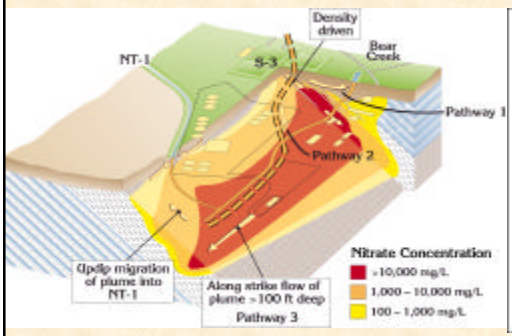


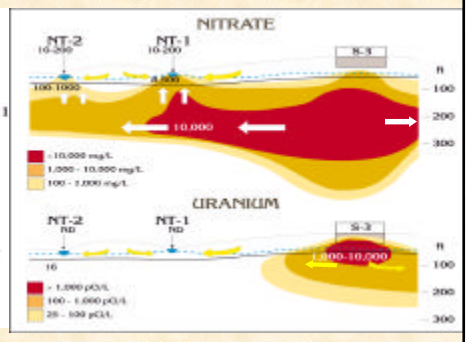
- Operated from 1951 to 1983
- 400 ft x 400 ft x 17 ft deep
- Over 2.5 million gallons waste/year
- Wastes contained nitrate, uranium, Tc-99, metals, VOCs, high TDS, and low pH (<2.0)
- Neutralized in 1984 capped in 1988

Currently a parking lot

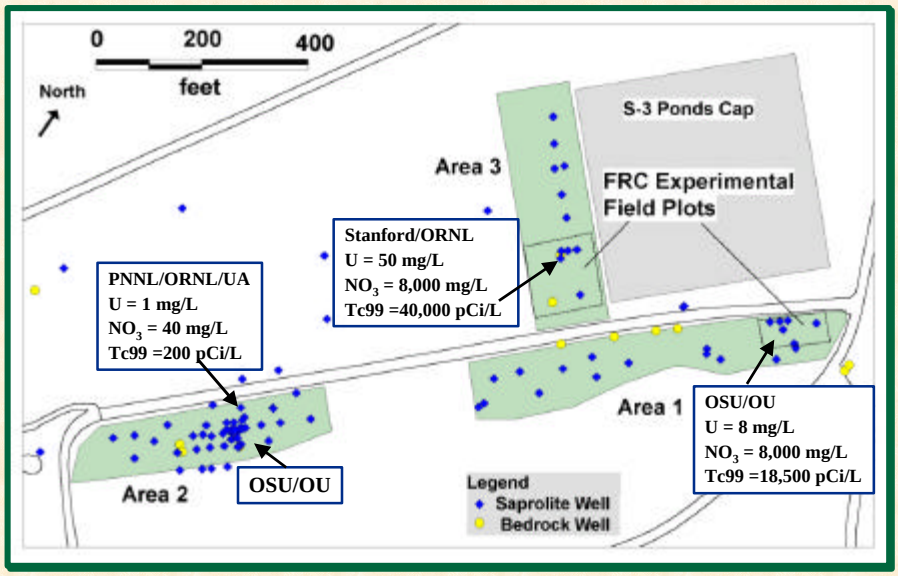
S-3 Disposal Ponds During Denitrification

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





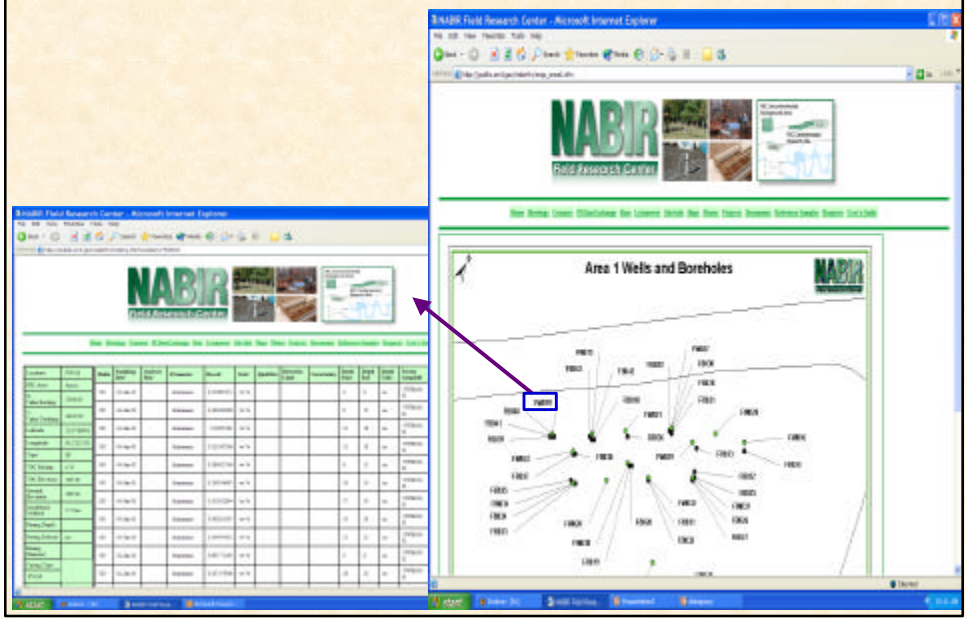
Field Plots in Contaminated Area



What's New - Administrative

- **Table Summarizing PI research on FRC samples revised (available on web)**
- **Website revised to include point and click retrieval of data from site maps**

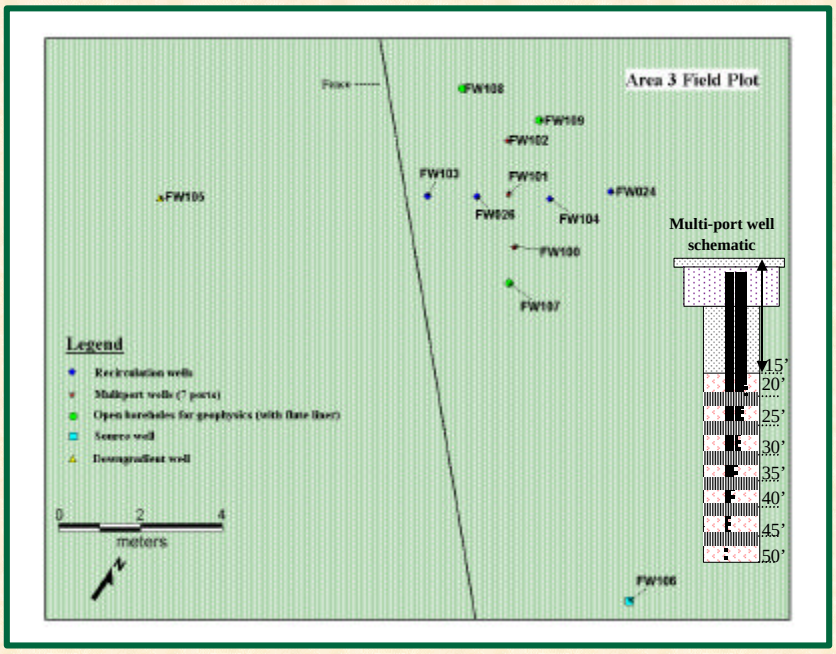
Point and click data retrieval on the FRC Website



What's New – Field plots and Samples

- **Hundreds of groundwater and sediment samples (cores and composites) have been collected and shipped from the background and contaminated site for use by 8 National Labs and 17 Universities**
- **Samples being provided to GTL PIs**
- **Area 3 Field Plot**
  - **Rotasonic coreholes**
  - **Recirculation wells**
  - **Boreholes for geophysics**
- **"Big Top" comes to Area 3**

Stanford/ORNL Field Plot in Area 3

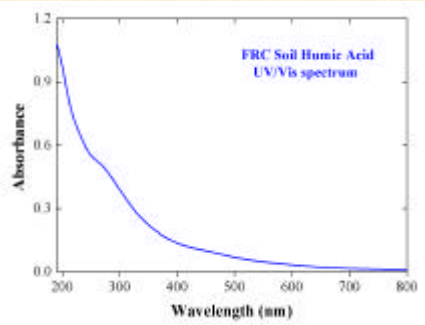


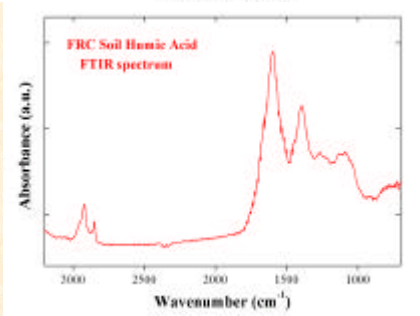
"Big Top" in Area 3 to house bioreactor equipment

Update on FRC Characterization

- **Humics – Background Area forested surface soils**
- **Geophysics**
  - **ORNL seismic and resistivity surface tomography**
  - **LBNL crosswell seismic and radar tomography**
  - **Geoprobe electrical conductivity measurements**
- **Four day and night pumping and tracer test at Area 3 Field Plot**
- **Area 3 rotasonic core**

Background Area Forested Soil Humics





- Extracted, concentrated, and freeze dried
- Spectroscopic characterization
- Contact: Baohua Gu/ORNL

Elemental Composition of Humic Acid

Element	%
C	54.50
O	30.46
H	4.62
N	4.10
S	0.50
Ash	1.86

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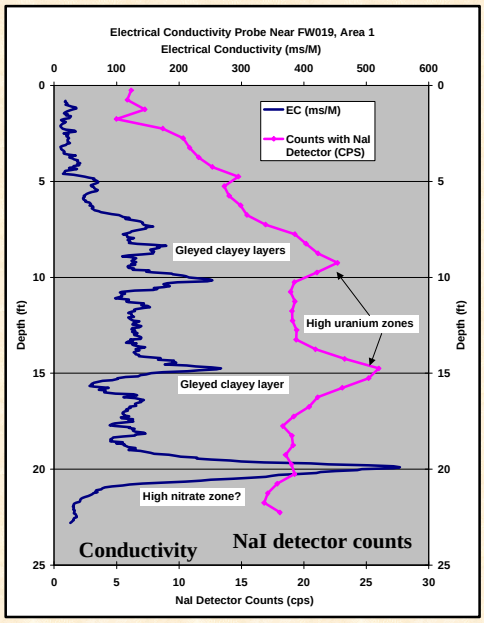

Electrical Conductivity Probing with FRC Geoprobe

- Useful for mapping stratigraphy and high U zones

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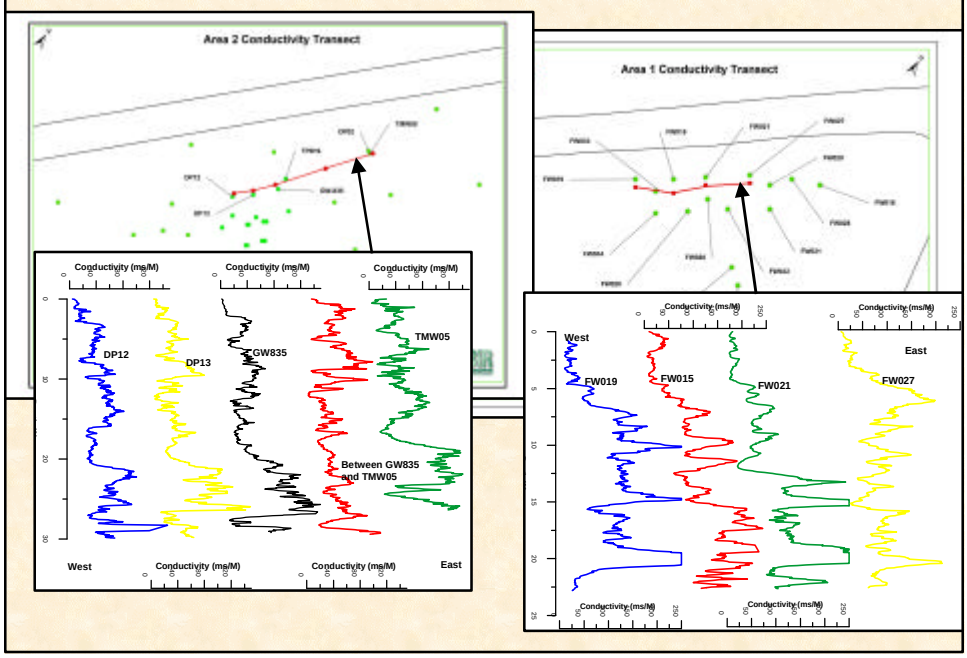
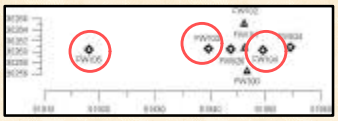
Electrical conductivity Profiling



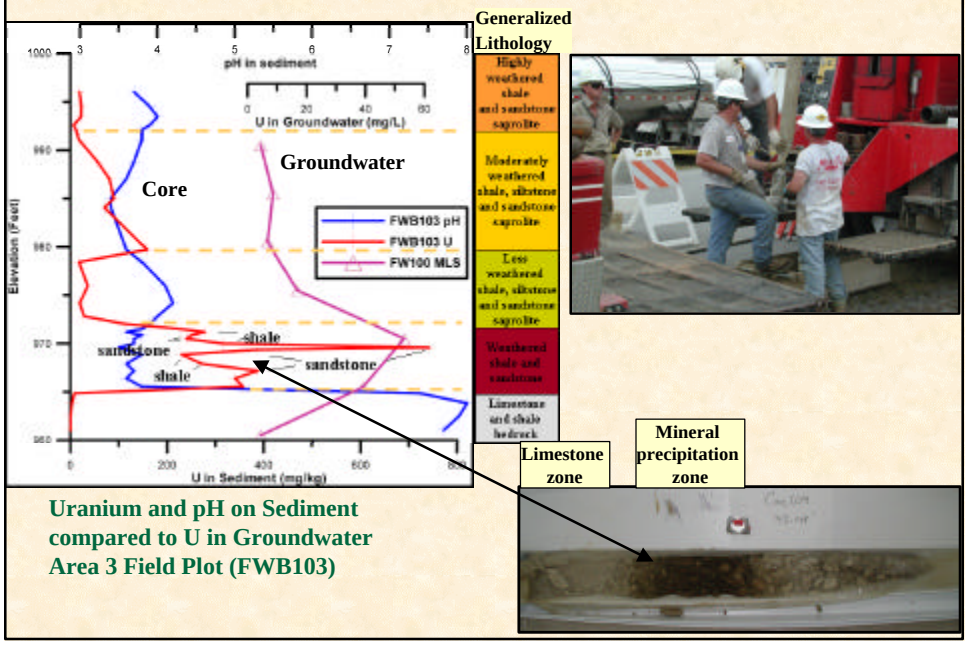
Characterization of FRC Cores

- Three rotasonic coreholes to 15 meters (Area 3 Field Plot)



- Analyses
  - pH
  - Uranium (kpa)
  - Oxalate and CBD extractions (Fe, Mn, Al, Si by ICP)
  - P (fusion/ICP) and S (combustion infrared Leco)
- Mineralogical Analyses
  - Thin sections, SEM, EDX, BES element mapping
  - XAFS (ANL – Ken Kemner and Shelly Kelly)
- Column, sorption and bioreduction studies

Rotasonic drilling in Area 3



Uranium and pH on Sediment compared to U in Groundwater Area 3 Field Plot (FWB103)

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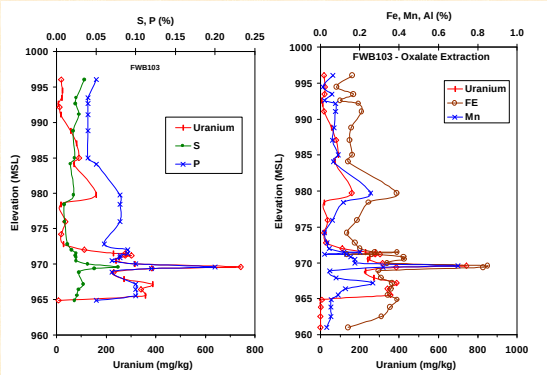
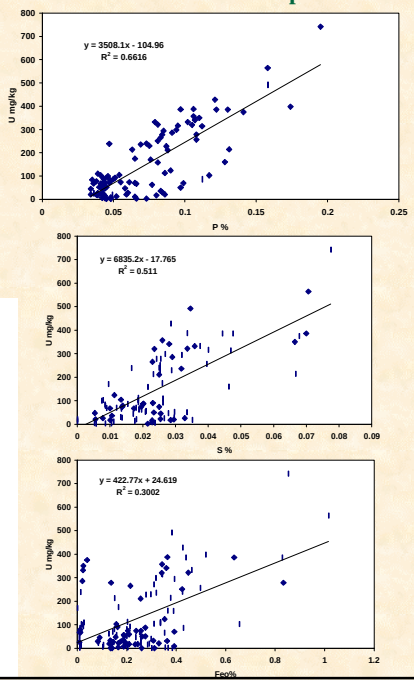
Core Analysis (Fe, Mn, Al, P, S)

- Correlation varies form core to core and between depth intervals
- P is as high as 0.2 %
- P and S are correlated to U

FW103 distribution with depth
- Strong association with U

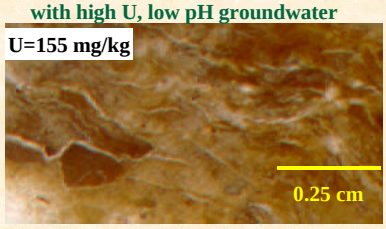


Area 3 and Area 1 samples

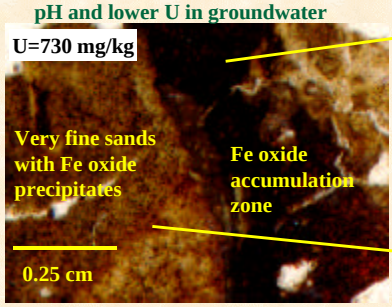


Area 3 Core Mineralogical Evaluations

Overlying Gleyed leached flow zone with high U, low pH groundwater

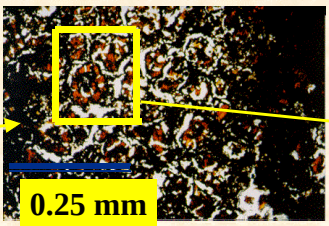


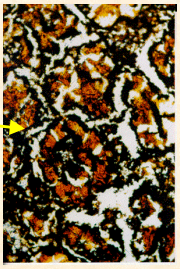
Black precipitate Zone with higher pH and lower U in groundwater

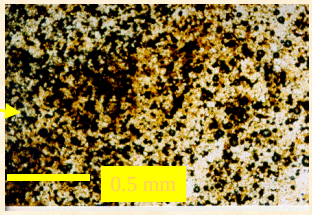


A high U zone was detected in FW100 (Area 3 field site) at a depth of 46'.

XRD results:
Gleyed Zone - Quartz, Vermiculite, Mica, HIV, Ca-feldspar
Black Zone - Quartz, Ca-feldspar, Vermiculite, Mica, Goethite







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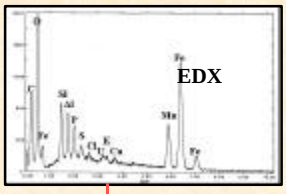
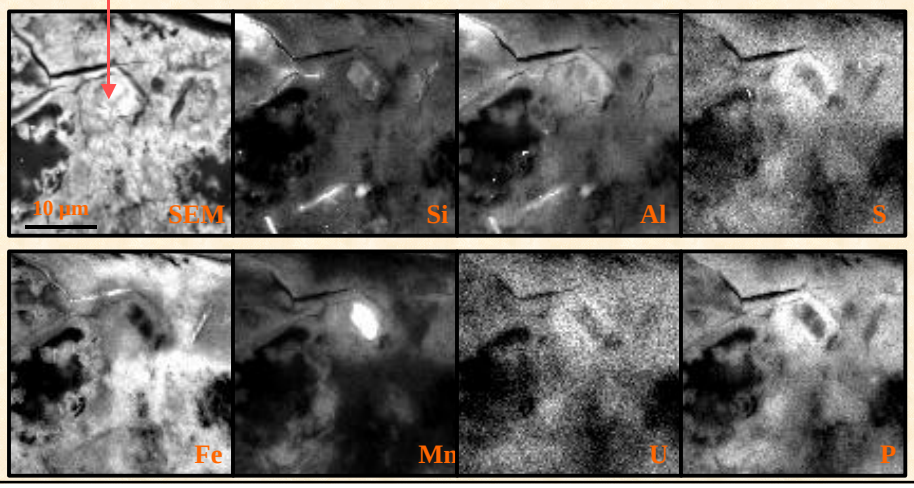
SEM-BSE-Element Mapping of FWB100-06-09 sample Black Rad Zone



U distribution matches P and S distribution



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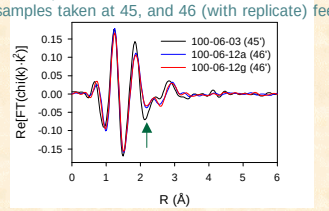
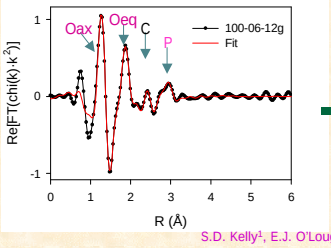
U L_3-edge XAFS data collected from Field Research Center soil samples

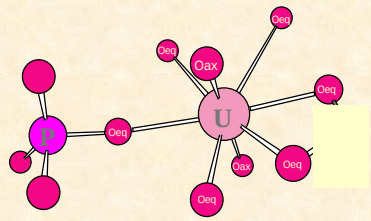
Real part of Fourier transform of data from samples taken at 45, and 46 (with replicate) feet



- Samples collected under anoxic conditions and shipped on ice.
- U XAFS data collected under anoxic conditions at the Advanced Photon Source.
- U in the samples is mostly U(VI).
- U(VI) in all samples is coordinated by two tightly bound axial oxygen atoms and approximately 6 equatorial oxygen atoms.
- Data from 45 feet is different from data taken on samples from 40 and 46 feet. Indicating a different local atomic environment about the U atoms at 45 feet as compared to 40 and 46 feet.
- Model of the data at 46 feet show that U is coordinated by bidentate carbon containing groups and/or monodentate phosporous containing groups.

Real part of Fourier transform of data and model from sample taken at 46 feet





S.D. Kelly[1], E.J. O'Loughlin[1], M.I. Boyanov[1], D. Watson[2], P. Jardine[2], K.M. Kemner[1]

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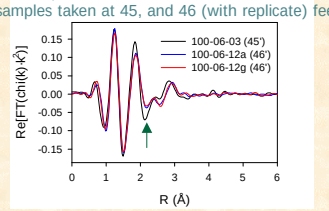

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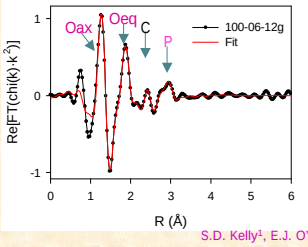

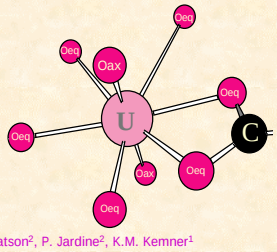

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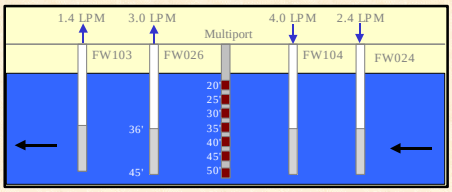
Four Day Pumping and Tracer Test at Area 3 Field Plot - Hydrology

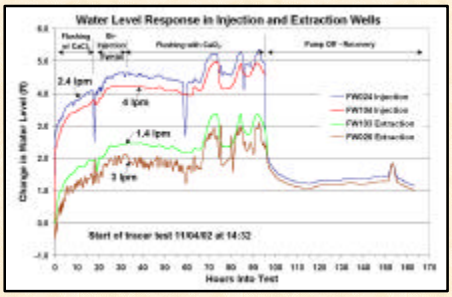
Test Schedule:

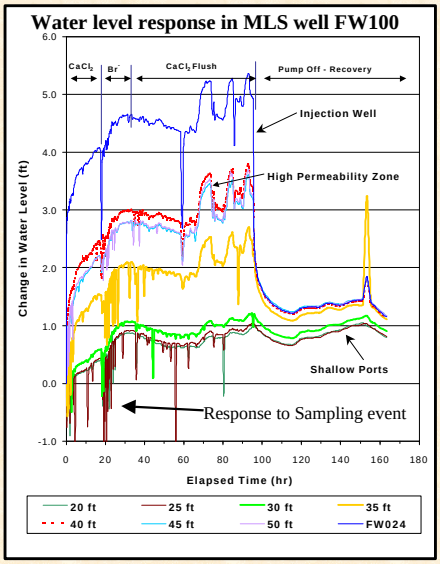
- Hour 0 to hour 18:08: flushing with $CaCl_2$ solution (5mM pH 3.6).

- Hour 18.3 to hour 33:3: injecting 800 mg/L bromide solution in FW104, $CaCl_2$ in FW024.

- Hour 33:3 to hour 96: washing out with $CaCl_2$ solution (5 mM, pH 3.6).

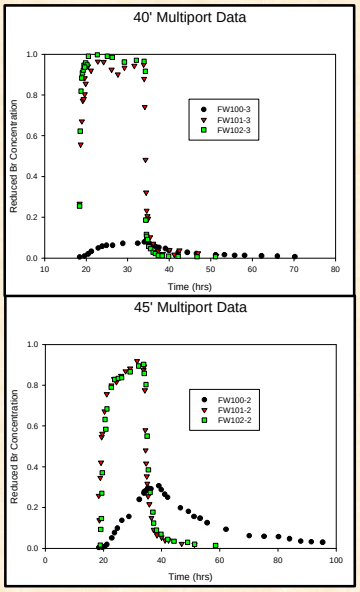




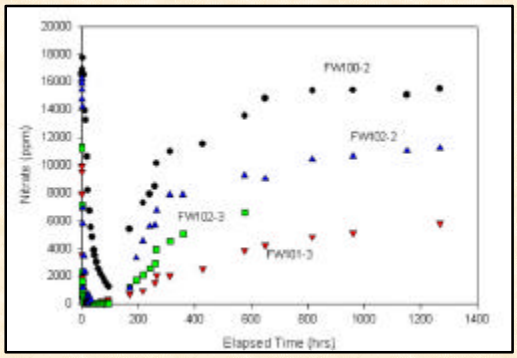


Shallow ports do not respond to test as much as well connected deeper ports (e.g., 40')

Area 3 Field Plot Tracer Test – Tracer break through and flushing



Rapid break through and flushing is observed in deeper well connected zones



However, recovery of nitrate levels is slower in the 40' high permeability zone than the 45' zone possibly due to less diffusion of $CaCl_2$ and Br solution

Upcoming Field Work

- **Characterization of Area 2 field plots**
  - **Coring and well installation**
  - **Geochemical and microbial studies on groundwater and sediment**
  - **Hydraulic studies**
  - **Geophysics**
    - **Geoprobe electrical conductivity**
    - **Surface tomography**
- **Collection of intact cores from Background Area**
- **Push-pull tests Area 1 and 2**
- **Stanford/ORNL system startup - Area 3**

FRC Contributors

- Sample collection, processing, shipping, and analysis – Tonia Mehlhorn, Barry Kinsall, Kenneth Lowe, Mary Anna Bogle, George Houser, Steve Childs, Kirk Hyderand Norman Farrow,
- Geophysics - Bill Doll, Les Beard, Jeff Gamey, and Jacob Sheehan
- Soil Characterization - Debra Phillips and Yul Roh
- Database and website - Craig Brandt, and Susan Holladay
- Regulatory issues - Harry Quarles and Monty Ross
- Geochemistry - Scott Brooks and Philip Jardine
- Microbiology - Susan Pfiffner and Tom Phelps
- Humics- Baohua Gu
- BASIC - Amy Wolfe
- Administrative - Lynda Campbell
- Stanford and ORNL – Craig Criddle, Phil Jardine, Wei-Min Wu, Peter Kitanidis, Mike Fienen, and Susan Hubbard
- OSU/OU – Jack Istok and Lee Krumholz
- PNNL/ORNL/UA – Tim Scheibe, Scott Brooks, Eric Roden
- FRAP – Terry Hazen et. al.
- XAFS – Ken Kemner, Shelly Kelly (ANL)