Hanford 300 A IFC

Hanford 300 Area IFC Breakout Session

Multi-Scale Mass Transfer Processes Controlling Natural Attenuation and Engineered Remediation: An IFC Focused on Hanford's 300 Area Uranium Plume

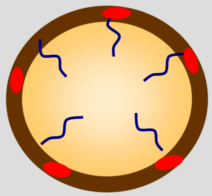
John M. Zachara and IFC Team

Pacific Northwest National Laboratory, Richland, WA 99354

Hanford IFC

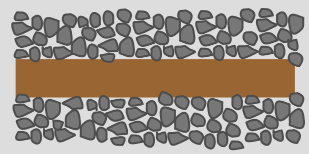
Science Theme *~ Multiscale mass transfer processes influencing sorbed contaminant migration*

micro



grain

macro



facies

<u>Associated Practical Issues</u>

1. Accurate projection of dissipation times for groundwater plumes of sorbing contaminants
   - Sorbing solutes not equal
   - Concentrations at different scales

2. Optimal delivery of remediation reactants
   - Access
   - Kinetic formation and reaction
   - Persistence

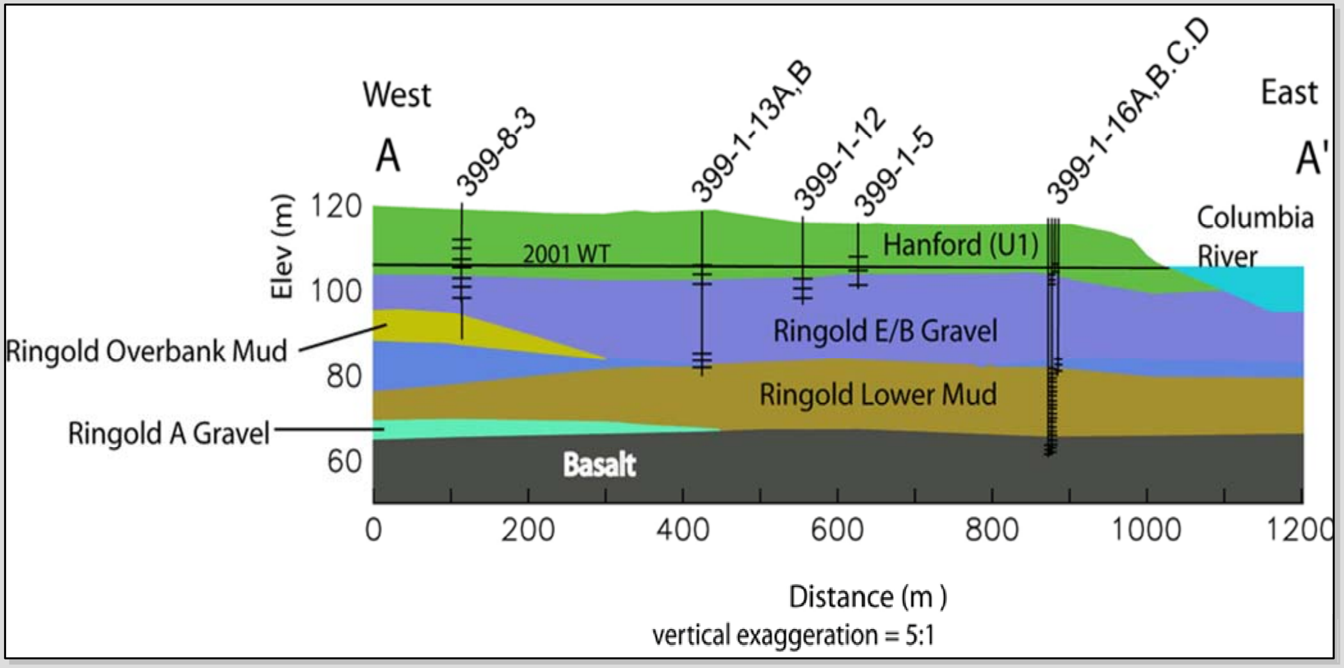
3. Practicality and effectiveness of remediation

Hanford 300 Area in 1962

300 A Waste Streams

- Sodium aluminate (to ~1956)
  - Dissolved Al cladding from rejected fuel assemblies
  - 15% NaOH, Density of 1.5
- Effluents from REDOX and PUREX process development (1944 – 1954)
  - Nitric acid solutions containing uranyl nitrate
- N-reactor fuels fabrication wastes (1978 – 1986)
  - Nitric acid solutions containing U and Cu
- Different grades of enriched U as well as natural and depleted U
- Primary chemical inventory in NPP and SPP
  - 37,000 – 65,000 kg of U; 265,000 kg of Cu

Geological Cross Section

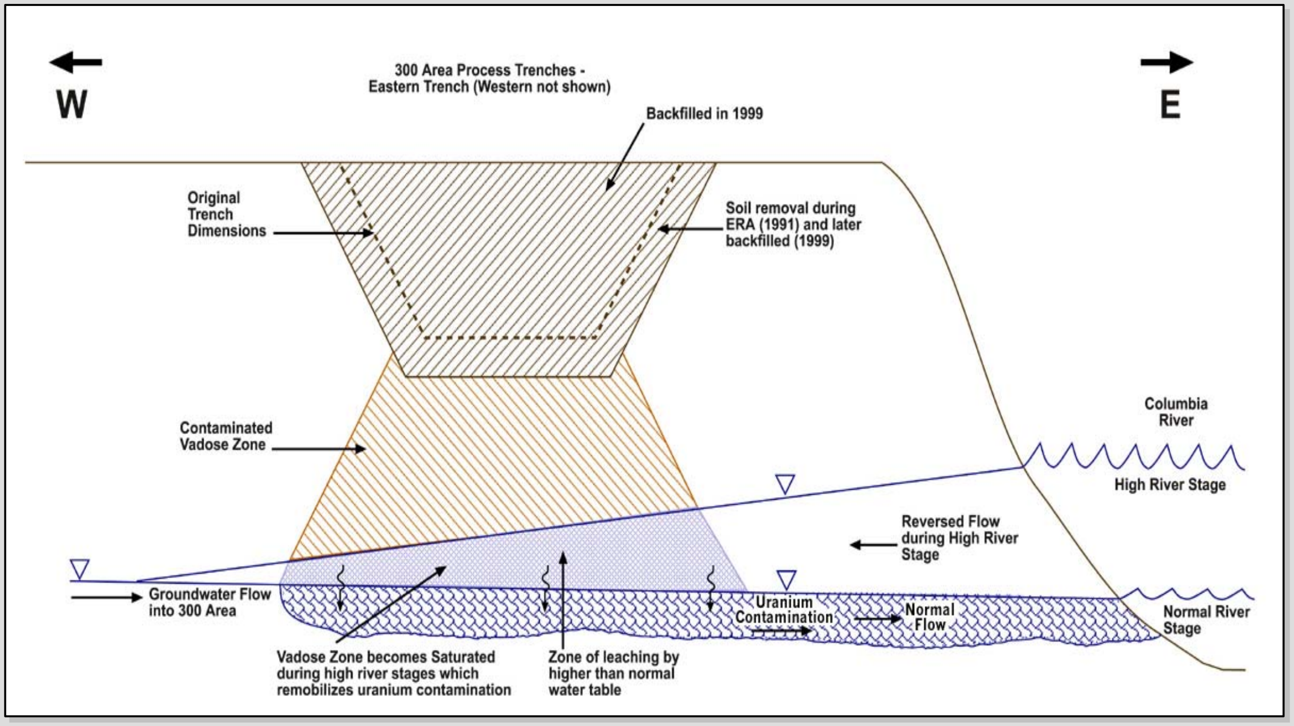


Office of Science
U.S. DEPARTMENT OF ENERGY

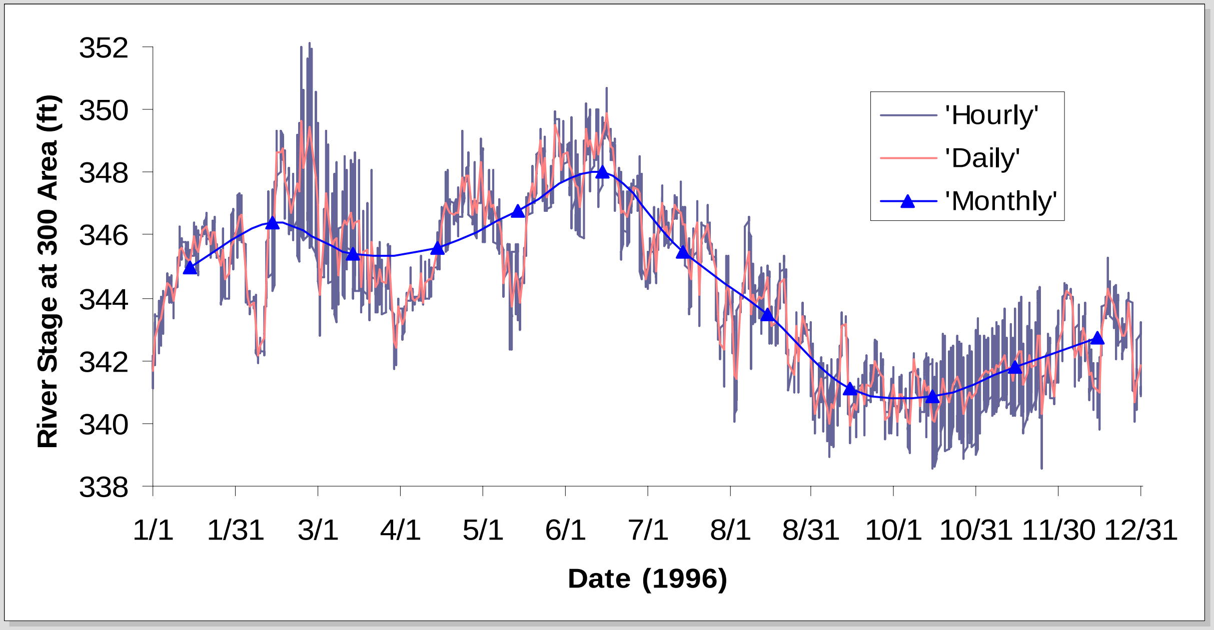
Environmental Remediation Sciences

Pacific Northwest National Laboratory
Operated by Battelle for the U.S. Department of Energy

Vadose Zone Release Model



Hourly, Daily Average, and Monthly Average River Stage at the 300 Area in 1996



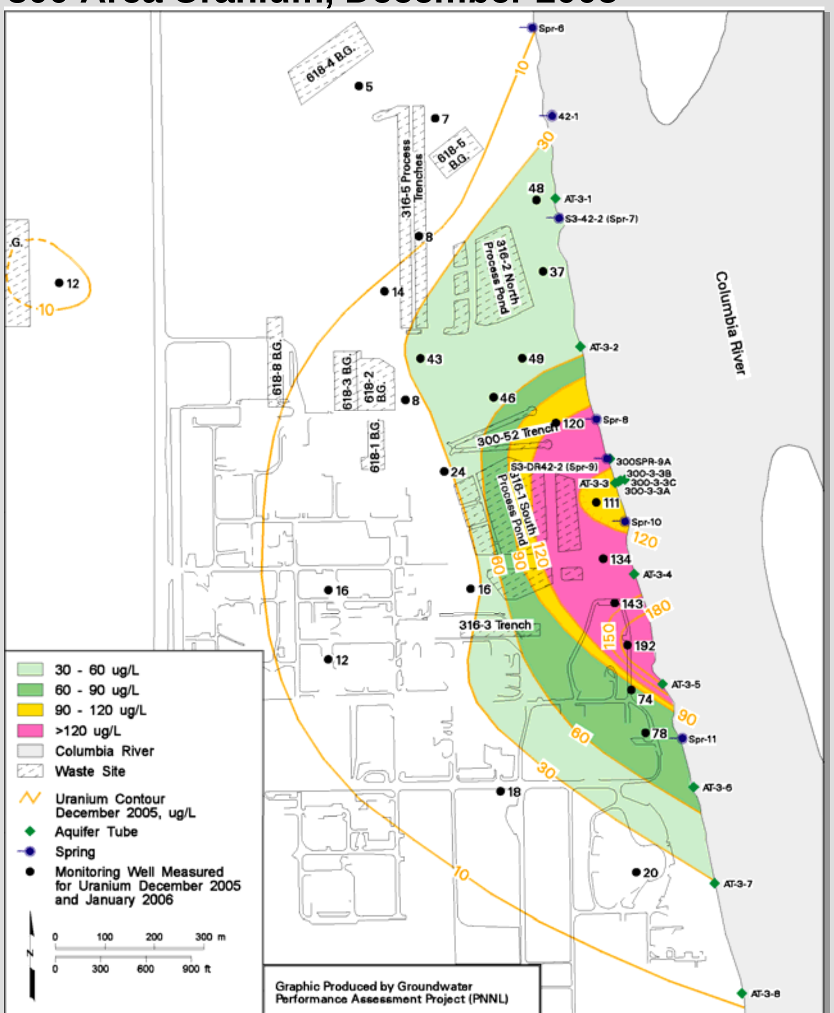
U.S. DEPARTMENT OF ENERGY Office of Science

Environmental Remediation Sciences

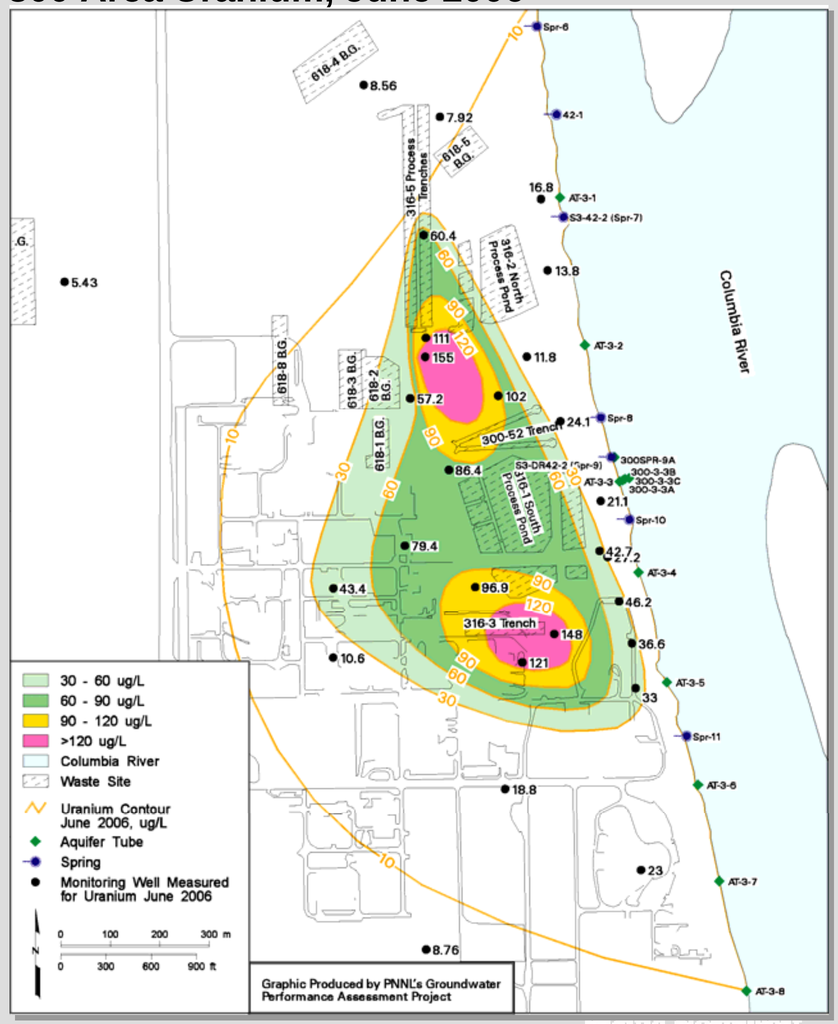
Pacific Northwest National Laboratory
Operated by Battelle for the U.S. Department of Energy

Seasonal Dynamics of 300 A Uranium Plume

300 Area Uranium, December 2005



300 Area Uranium, June 2006



Pacific Northwest National Laboratory
Operated by Battelle for the U.S. Department of Energy

Primary Objectives

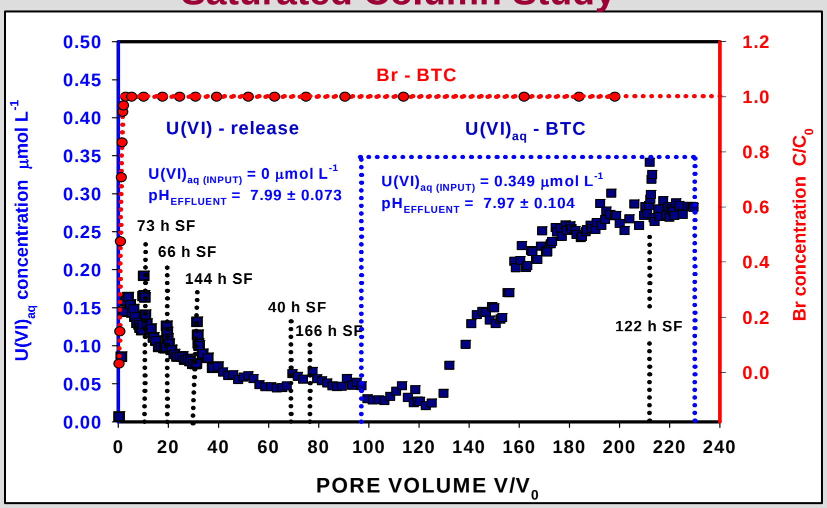
- Quantify the role of mass transfer in controlling U(VI) distribution under various geochemical, hydrologic, and remedial conditions
  - Vadose zone
  - Saturated zone
- Investigate in-situ microbiologic processes that couple with mass transfer to control phosphate barrier performance and longevity
- Create enduring field experimental data sets for model and field-scale hypothesis evaluation
- Test and improve existing models of multi-reaction chemistry and multi-scale mass transfer by comparison to new, robust experimental field data
- Proactively transfer results to site for decision making and remediation

Transport Behavior (Desorption/Sorption) in < 2 mm Sediment is Kinetically Controlled

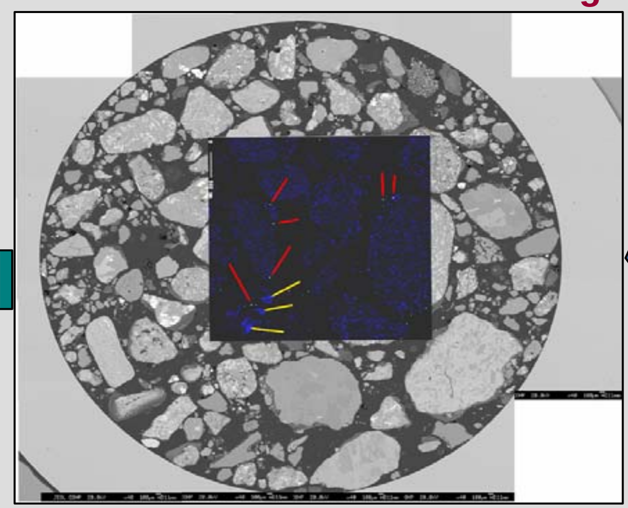
North Process Pond Pit 1 – 14 ft

	Size Range (mm)	Mass Distribution (%)	U_{Total} (nmol/g)
Cobbles			
	> 12.5	74.5	< 22
	2.0 - 12.5	17.2	< 19
Sand			
	1.0 - 2.0	2.64	26
	0.5 - 1.0	2.34	< 18
	0.25 - 0.5	0.78	< 21
	0.149 - 0.25	0.33	37
	0.106 - 0.149	0.19	< 23
	0.053 - 0.149	0.20	< 23
Silt + Clay			
	< 0.053	1.78	125

Saturated Column Study



Electron Microprobe U Abundance Map on Backscattered Electron Image



The release of sorbed contaminant U(VI) and the adsorption of U(VI) from contaminated groundwater both show strong kinetic behavior

(Qafoku et al., 2005; Liu et al., 2007)

Approaches

- Robust 3-D geostatistical characterization of the experimental domain
  - Borehole samples and geophysics
  - geo-, hydro-, chemo-, bio-, and U(VI)-facies
  - Correlative transfer functions with key process-specific parameters
- Field experimental campaigns based on 3 hypothesis at an integrated vadose zone-saturated zone site
  - Well field sufficient to sample heterogeneities
  - Infiltration experiments in vadose zone
  - Passive river stage experiments in capillary fringe
  - Injection experiments in saturated zone
  - Collaborative experiments with EM-20
- Modeling of different types
  - Stochastic-deterministic
  - STOMP, MODFLOW, and FLOTRAN by code originators
  - STOMP as the integrative project code
- Leverage broad data base and other site activities
  - ERSD
  - EM-30, EM-20
  - ASCR
  - NRC

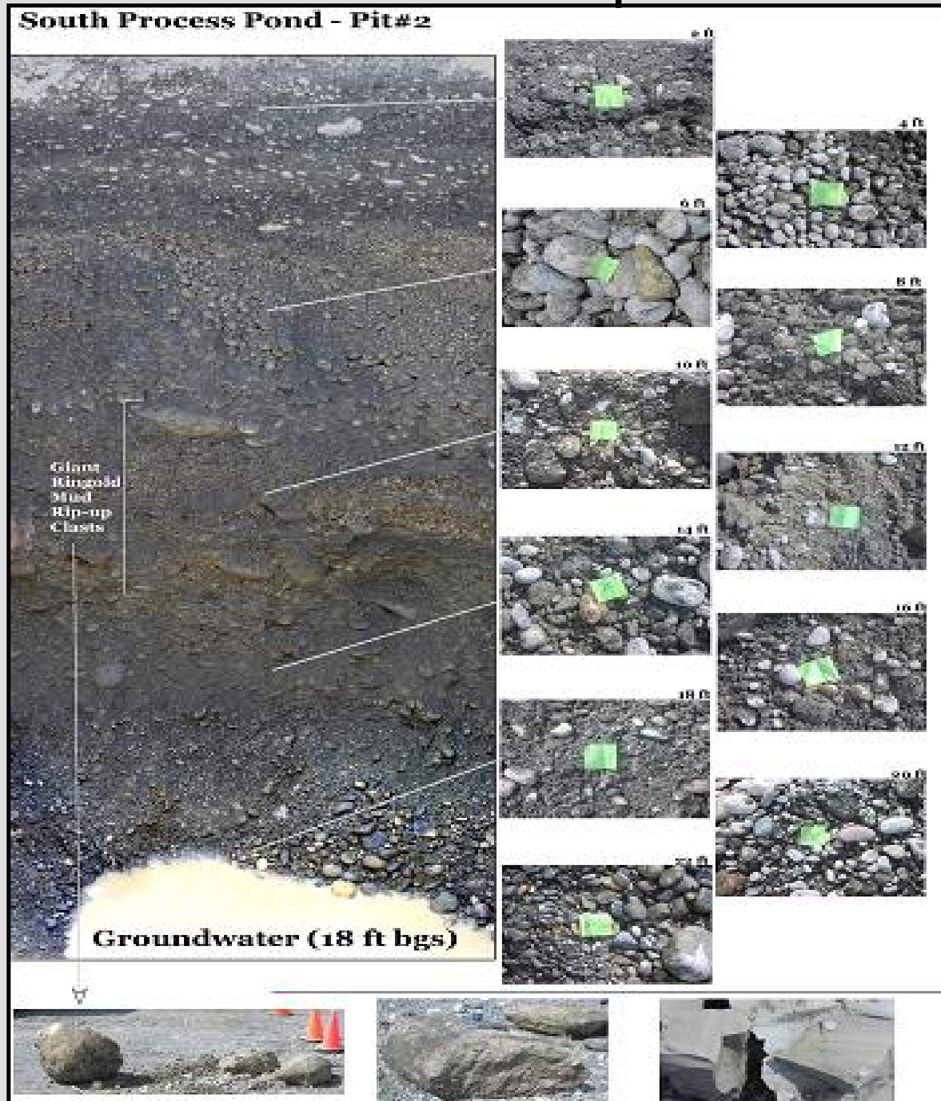
Field Site Design to Exploit Unique Site Attributes

- Variable U concentrations and speciation through vadose zone, capillary fringe, and vadose zone
- Seasonal changes in river stage
  - Groundwater composition
  - Hydrologic gradient, porewater velocity, and flow path trajectory
  - Access to sorbed U in the deep vadose zone and capillary fringe
- Extensive supporting information
  - Geologic, hydrologic, and historic data
  - Lab geochemical information
  - Aquifer hydrologic models
  - EM-20 tracer experiments and well field

North Process Pond and Excavation

The North Process Pond

One of Four Excavations Sampled



Example Opportunities for Collaborative Research

- In-situ adsorption/desorption experiments of various types
- Laboratory to field comparisons
- Evaluation of geophysical methods and inversion techniques
- Mass transfer processes of different types at different scales
- Microbiology of linked groundwater-river systems of low to high transmissivity
- Geologic, hydrologic, geochemical, and biogeochemical modeling of different types
- Microbiology and geochemistry of phosphate amended systems

Materials Available to External Investigators

- Historic U(VI)-contaminated source term materials (limited)
- Contaminated U(VI) vadose zone materials whose geochemical speciation and mass transfer properties have been determined (limited)
- Uncontaminated vadose zone and aquifer sediments from various locations
- Circumneutral site groundwaters with variable U(VI), HCO_3, and Ca concentrations
- Core materials from vadose zone and aquifer experimental plots (TBC, limited)
- Aseptic samples of vadose zone and Hanford and Ringold formation aquifer sediments (TBC, limited)

* TBC = to be collected

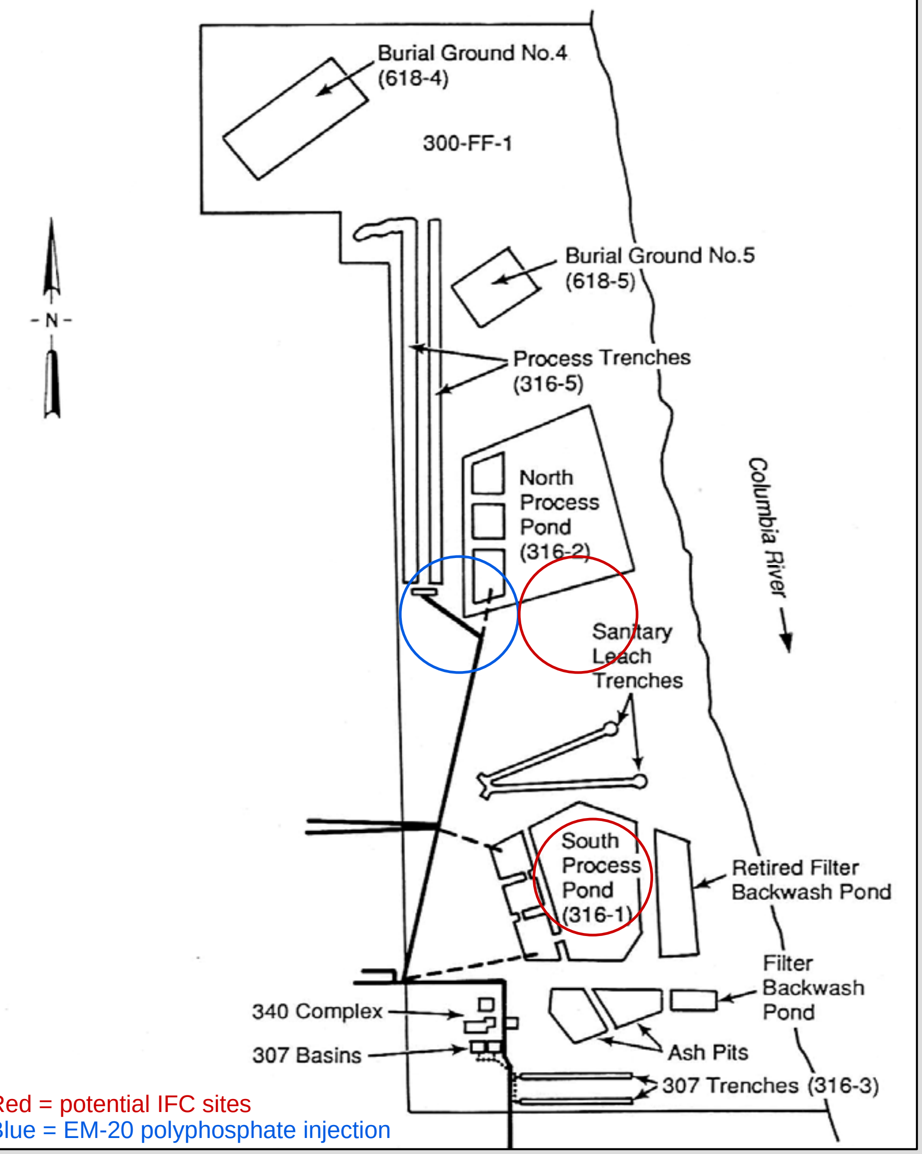
Anticipated Outcomes

- Outstanding, multidisciplinary collaborative effort that significantly advances science
  - Characterization, experiment design, interpretation
  - Basic underpinnings of EM-20 activities
- Enduring and accessible field experiment data sets for hypothesis and model testing
- Improved linked multi-scale mass transfer/biogeochemical models for reactive contaminants
- New conceptual understanding of mass transfer processes at different scales influencing field behavior
  - Desorption, dissolution, dissipation
  - Effective reaction kinetics
  - Contaminant immobilization

Linkage to Site Remediation, Closure and Monitored Natural Attenuation

- Operational model for infusion of DOE science into site remediation and closure decisions
  - Lab to field
  - Concept to application
  - Evaluation and testing of new models and measurement techniques
- 300 A site is representative of Hanford River Corridor locations
  - Applicability of conceptual and numeric models to other locations
- Scientific context for evaluation of remediation strategies and concepts
  - MNA versus active approaches
  - Optimization strategies
  - Expectations for remediation efficiency

The 300-FF-1 Operable Unit



Red = potential IFC sites
Blue = EM-20 polyphosphate injection