PNNL-SA-60453

INTRODUCTION

John M. Zachara and IFC Team

Pacific Northwest National Laboratory, Richland, WA 99354

http://ifchanford.pnl.gov

Meeting Objectives

- Project status
- Well field and monitoring system
- Characterization
- Database
- Field experimental plans and schedule
- Modeling strategy
- Participant interactions
- Publication targets

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

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Environmental Remediation Sciences

IFC Project Meeting
April 29-30, 2008

IFC Project Team

Project Manager:
John Zachara, *PNNL*

ERSD Program Manager:
David Lesmes, DOE-HQ

Field Site Manager:
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Hanford Site Steward:
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Project Team:

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Jim McKinley, *PNNL*
Mark Rockhold, *PNNL*
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Vince Vermeul, *PNNL*
Roelof Versteeg, *INL*
Andy Ward, *PNNL*
Chunmiao Zheng, *U. Alabama*

Collaborations

EM-40

Remediation and Closure Science Project (RACS, Freshley) - Conceptual and numeric reactive transport models to support remediation

EM-20

Polyphosphate Treatability Studies (Vermeul) - Field scale remediation concept to reduce groundwater U(VI)<MCL

ERSD

"Role of Microenvironments and Transition Zones in Subsurface Reactive Contaminant Transport ". PNNL Scientific Focus Area (Bolton)

"Microscale Metabolic, Redox, and Abiotic Reactions in Hanford 300A Subsurface Sediments." (Beyenal)

“Geophysical Characterization and Monitoring Strategies for Quantifying Hydrologic Transport processes in the Hanford Hyporheic Corridor”. (Slater)

SBIR

"A New High-Resolution Method for the Characterization of Heterogeneous Subsurface Environments: Providing Flow and Transport Parameters via the Integration of Multi-Scale HydroGeophysical Data." (Bussod)

ERSD Field Research Executive Committee (FREC)

Provides review, oversight, and guidance to ERSD on 3 IFC's

Comments on Hanford IFC

- Extent of multi-level depth monitoring*
- Implications of high groundwater flow velocities (~ 50' d) and frequent head changes*
- Capability to measure/estimate fluxes from higher concentration sources at water table or stratigraphic boundaries*
- Development of a flexible database used by all project participants is critical. Make sure it works.
- Time-lapse experiments using new well-field will result in unique and valuable data.
- Develop publication plan.

300 A U Plume/Hanford IFC

- Complicated history, hydrology, and geochemistry; unknown microbiology
- Enigmatic U behaviors, no validated conceptual model for U persistence and resupply
- Numerous research participants, many new findings, few real answers
- Hanford IFC science and plans
  - Flexible and responsive to evolving information
  - Based on most comprehensive current understanding

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

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

FY08 Activities

Oct Nov Jan Feb Mar Apr May Jun July Aug Sept

Website development | Website operation →

Permits and permissions

Experimental site-selection, set-up, and infrastructure

Design of well field and monitoring system | Well drilling |

| In-situ characterization

| Ex-situ characterization

| Field experiment infrastructure

| Evaluations and testing of new characterization methods

IFC- Data baae; Historic data, 5708, new data | (website linkage) new data

Interpretational stochastic data (UCB) | (modeling plan) implementation

Improvements in microscopic models and parameter (w/SFA, EM-40, ERSP)

The 300-FF-5 Operable Unit

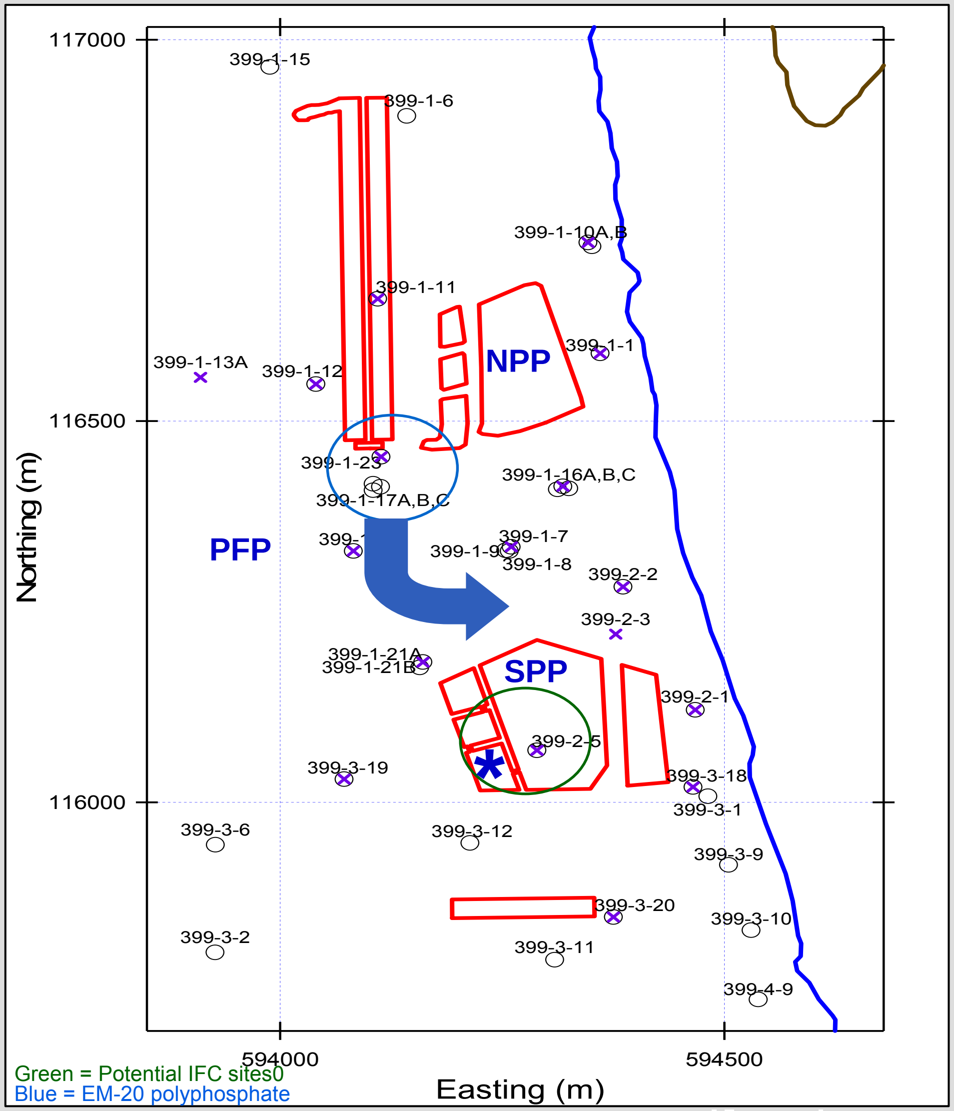
Locations of CERCLA monitoring wells (open circles) and wells instrumented for automated hourly measurements (purple dots)

- water levels
- temperature
- EC

IFC site selection strongly dependent on polyphosphate plume trajectory

- Model projections performed
- Continuous monitoring initiated around SPP to improve the hydrologic model

Field Site Location in WMA 300-FF-5



Surface Geophysical Surveys

- Involved data collection using range of instruments –hand carried or in contact with surface
- Quantitative spatial information to characterize features controlling transport
  - Sedimentary (and other) facies
  - Soil type (surface charge, CEC)
  - Pore size distribution
  - Hydraulic characteristics
- Quantitative temporal information to characterize flow and transport processes
  - Pore-water conductance
  - Temperature

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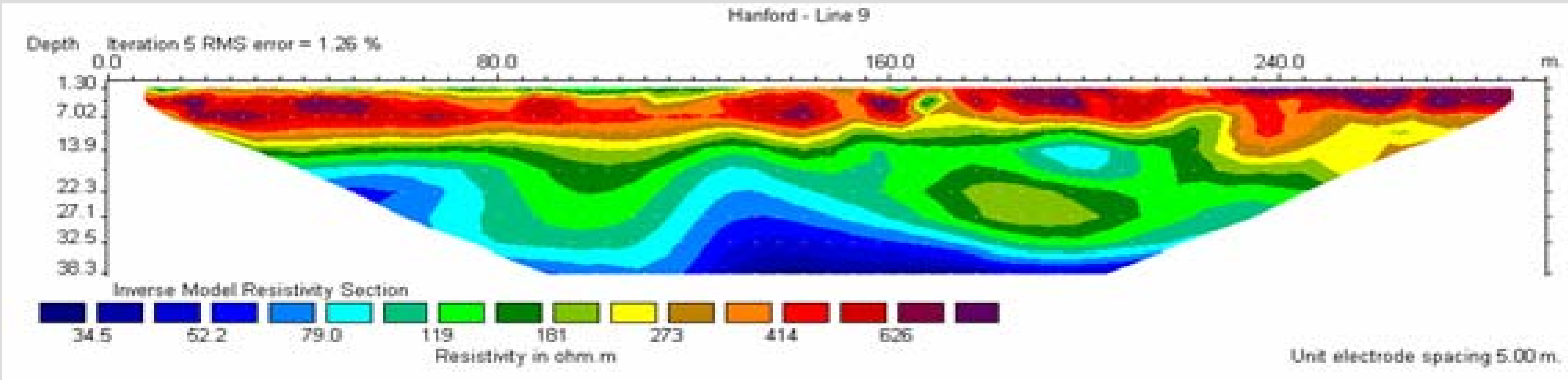
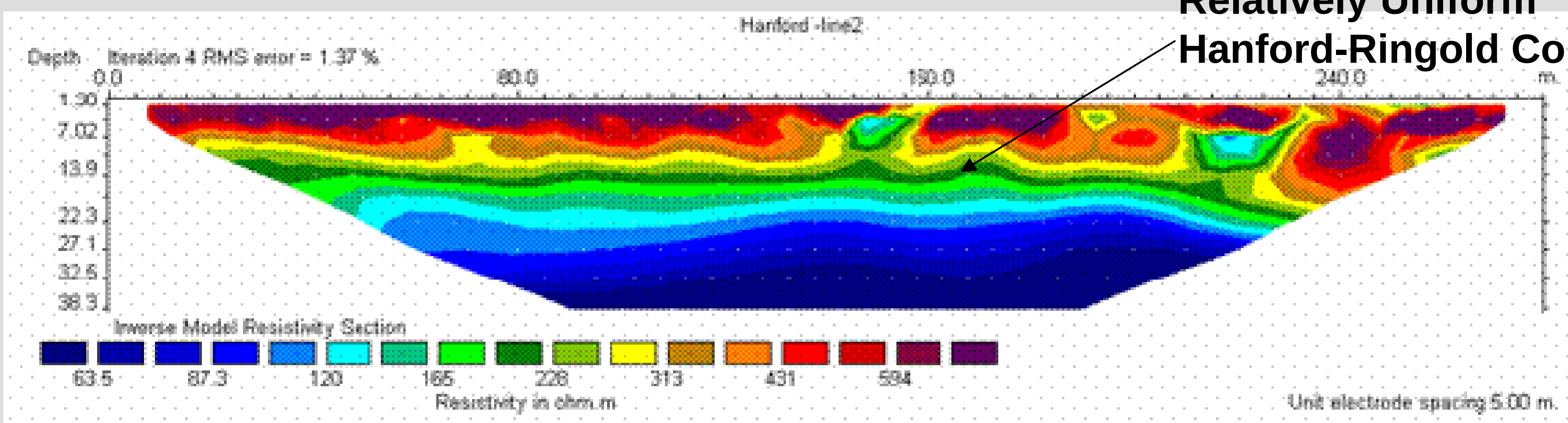
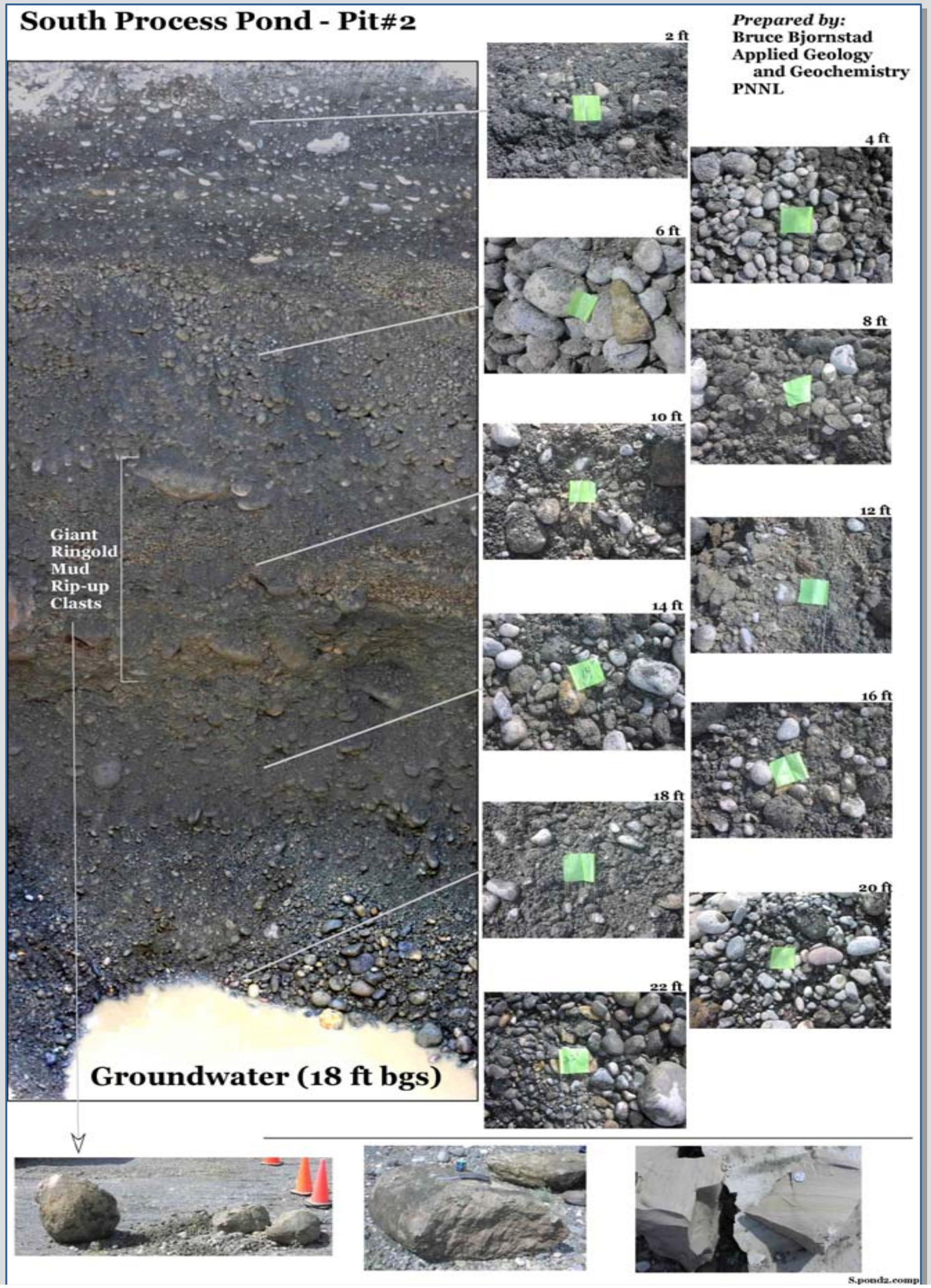
IFC Experimental Site- South Process Pond



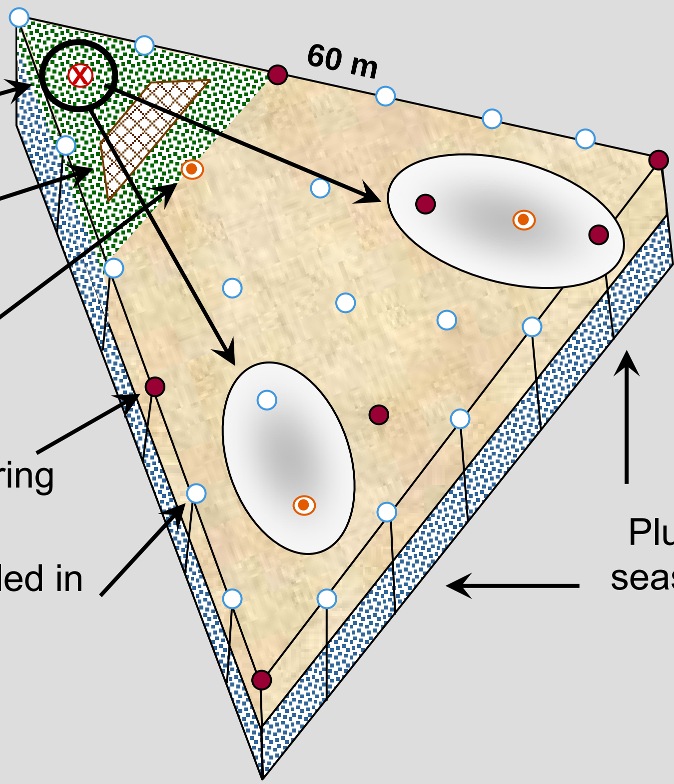
Relatively Uniform Hanford-Ringold Contact



South Process Pond – Pit #2



The Hanford IFC Experimental Domain



- A geostatistical model that correlates U concentration, reactivity, facies properties, and permeability will be established from geophysical logging and direct measurements.
- Injection experiments of ~1.0 x 10^5 gallon will be performed in the 6 m saturated zone under different seasonal gradients.
- Passive experiments will exploit natural gradients
- Continual water level monitoring at 12 locations to provide necessary hydrologic linkages.

Surveyed and Staked IFC Well-Field Awaiting Drilling

Drilling, Sampling, and Well-Completion Information for 35 New IFC Wells

New IFC Wells

Type	# Wells	Preferred Drill Method	Total Depth (ft)	Borehole Diameter	Screen	Screen Interval (ft)	Proposed Sampling	Total # samples/well	Total # samples	Comments
ERT-instrumented/gw monitoring *without* core collection	18	cable tool or sonic	58	8"	4" PVC	31-56	Grab samples every 2 ft	29 grab samples*	464 grab samples*	sandpack below 10' depth; one well to be used as saturated-zone injection well
ERT-instrumented/gw monitoring *with* core collection	7	sonic	58	8"	4" PVC	31-56	4 holes continuous core in 0.5 ft lexan liners within 5-ft long, min. 4-in ID split spoon;	12 split spoons or 58, 1-ft lexan liners;	84 split spoons or 406, 1-ft lexan liners;	continuous core (min 4" OD); sandpack below 10' depth
							3 holes collected in 2-ft long sections of lexan, approximately the same diameter as the core barrel OD, at surface (i.e. grab samples)	29, 2-ft core samples	203, 2-ft core samples	
3-well cluster (multi-level) gw monitoring	3 clusters	cable tool or sonic	37, 46, 57	8"	4" PVC	30-35, 42-44, 53-55	Grab samples every 2 ft	66 grab samples/cluster*	198 grab samples*	ERT on deep (56 ft) well only (sandpack below 10' depth)
Deep characterization; gw monitoring	1	sonic	~180	8"	4" PVC	60-140	~60 ft of core collected in lexan liners, from five intervals (30-35', 50-70 ', 95-100', 122'-132 ft', and 170 ft to TOB); grab samples every 2 ft between core runs		Up to 12, 5-ft split-spoon segments; 60 grab samples	Continuous screen to test groundwater across redox boundaries in Ringold Formation
Total wells	35						*collected at surface by emptying core barrel into 5 gal. buckets or capped lexan liners (if collected by the sonic method use 2-ft long sections of lexan, approximately the same diameter as the core barrel OD)			

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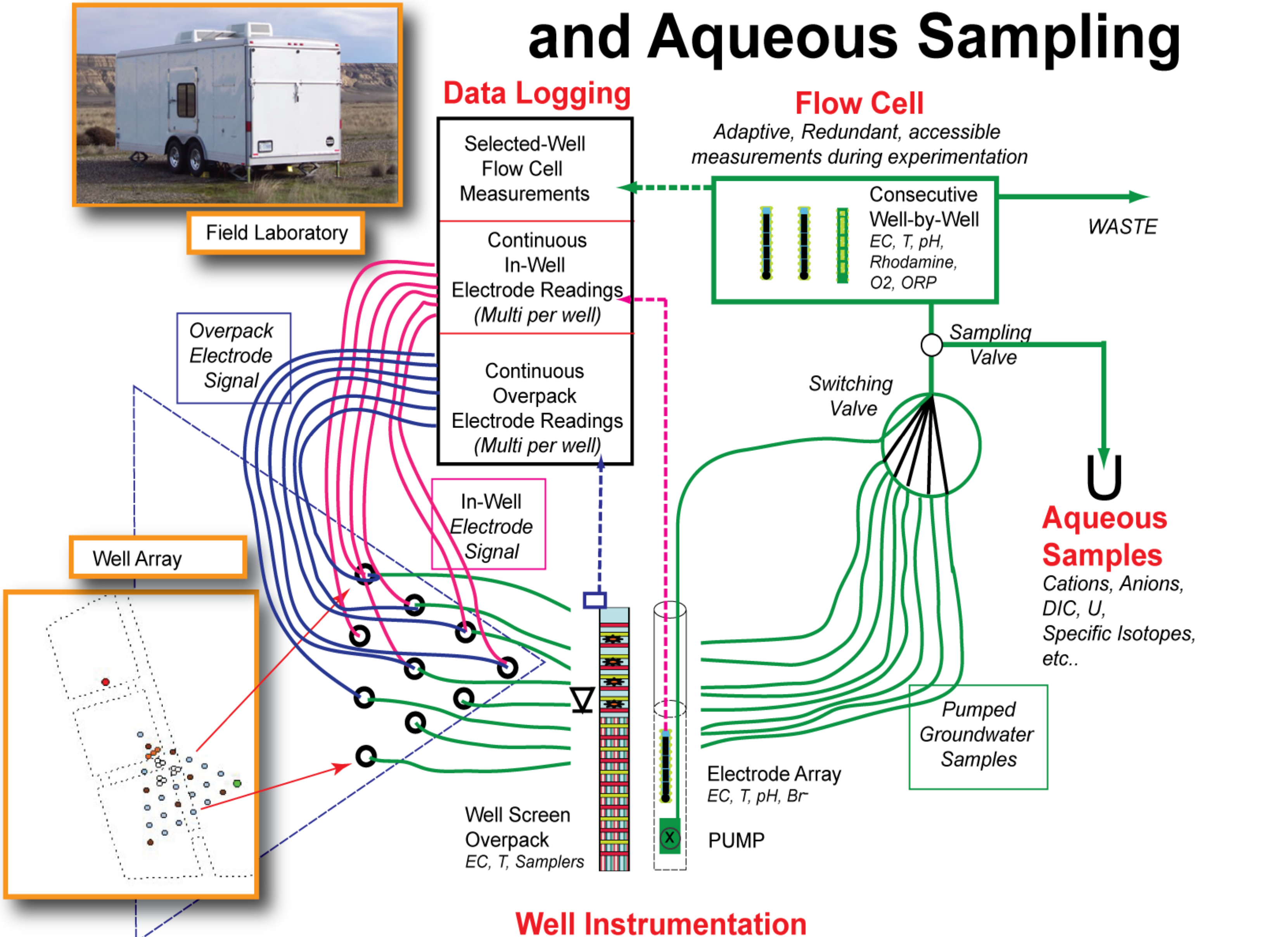
Field Electrode Measurements and Aqueous Sampling



Monitoring Instrument Calibration and Well Assembly has Begun to Support April-May Installation

- QA/QC plan defines calibration needs, testing requirements, and documentation.
- All monitoring equipment has been received. Testing and assembly underway for ~1 month.
- Thermistor and ERT electrode string, and their in-well locations require pre-assembly for rapid field deployment.

Thermistor calibration

Templates established for each well type defining spacings and locations for thermistors and ERT electrodes →

Thermistor string and housing

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Instrumented Well Strings Ready for Deployment

Major IFC Research Objectives in FY 09

- Complete and implement multi-investigator IFC modeling plan
- Perform two temperature tracer studies
- Complete MLS well characterization, and initiate passive biogeochemical experimentation during periods of head change
- Integrate geologic, geophysical, and hydrophysical characterization measurements of various kinds into site geostatistical and hydrologic models
- Begin assembly of site U(VI) reaction model based on IFC, SFA, ERSD, and RACS/EM40 research
- Perform two U(VI) injection tracer experiments (+U, -U, high/low water)
- Begin development of collaborative IFC/SFA microbiologic research plan based on results from the HRDCB
- Initiate publication program

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Characterization ~ At Least a 2 Yr Effort

Objective is a 3-D hydrogeostatistical model of domain and identification of critical scales

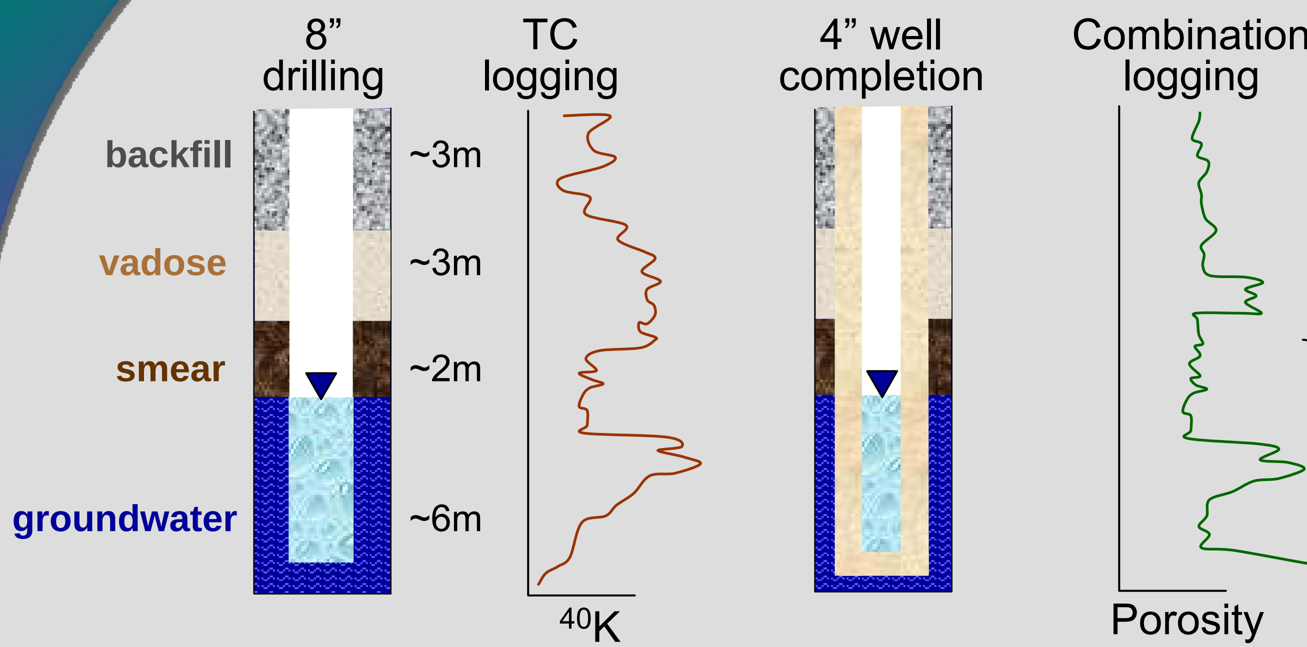
- Tiered approach through first 4 injection experiments
  - Described through plan
  - Maximize useful knowledge gain
  - Support a field-scale reactive transport model
- Based on experimental and interpretational need
  - Obvious beginnings; augmented as knowledge expands
  - Focused on formation, facies, and pore scales

<u>Types</u>

- Physical, hydrologic, geochemical, microbiologic
  - In-situ (borehole, aquifer)
  - Ex-situ (laboratory)

Characterization Strategies

Geophysical measurements to classify facies

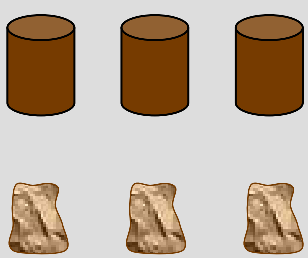


Various correlations of lab measured properties with geophysical measurements → 3D model

~600 Field Samples

core samples

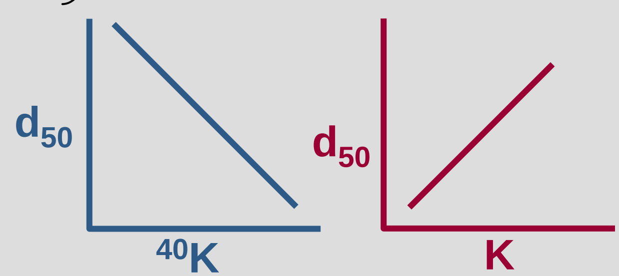
grab samples



Laboratory Measurements

50-400 samples

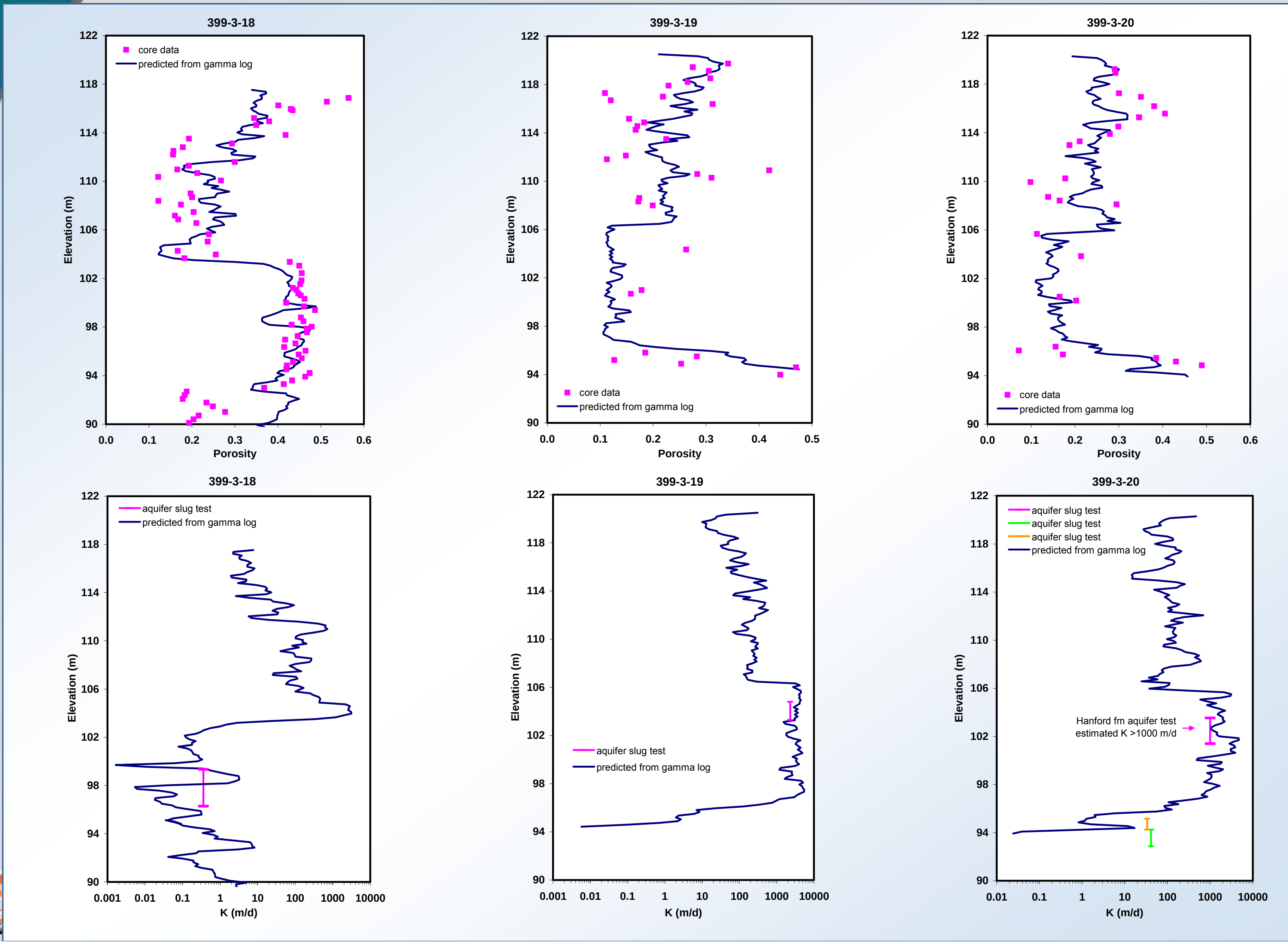
- standard
- derived
- specialized



Well Logs and Correlations

- Gamma logs
  - Spectral gamma (K-40) and total gamma correlate with fines (silt+clay, grain size.). Used to estimate hydraulic properties. Ratios of K-U-T may correlate with mineralogy and lithology.
- Neutron moisture logs
  - Correlated with water content and texture in the vadose zone (not useable for saturated zone). Used with pedo-transfer functions and scaling methods to estimate hydraulic properties and textural zones.
- Lithodensity/Porosity logs
  - Correlate with wet density, which depends on porosity or water content. If water content is known, density can be used to estimate porosity. Variations in lithodensity below water table correlate with porosity.
- Induction and Resistivity logs
  - Borehole resistivity logs provide “point” measurements for vertical control and improved use of cross-hole ERT measurements.
- Combination logs
  - Easier to delineate facies with multiple logs.
  - Contributions of fluids and solids to bulk resistivity can be determined if resistivity and lithodensity/porosity logs are available.
  - Combination of resistivity, neutron moisture, lithodensity/porosity measurements can allow for unambiguous determination of porosity.

Observed and Predicted (from gamma logs) Porosity and Hydraulic Conductivity Profiles



Basis for Characterization – A Field Scale Reactive Transport Model

U Transport Experiments

Groundwater hydrology →   ← **River hydrology**

+U   x → y → z

-U   x → y → z

ΔAC   x → y → z

$$\theta\frac{\partial C_i}{\partial t}+(1-\theta)\rho_s\sum_{k=1}^{M}\frac{\partial q_i^k}{\partial t}=\theta D\frac{\partial^2 C_i}{\partial x^2}-\theta v\frac{\partial C_i}{\partial x},\ i=1,2,\ldots,N$$

$$\rho_s\frac{\partial q_i^k}{\partial t}=\alpha_k\rho_s(S_i^k-q_i^k),\quad i=1,2,\ldots,N;\ k=1,2,\ldots M$$

$>SOH + UO_2^{2+} + H_2O = >SOUO_2OH + 2H^+$

$>SOH + UO_2^{2+} + CO_3^{2-} = >SOUO_2HCO_3$ $q = -K\nabla H$

Geochemistry				Hydrology				
$[U]_{total}$	$P_E(q)$	$P_{MT}(\alpha)$	$AC(q)$	PSD(K)	PVD(Θ,K)	K(ν)	H	i
L	L	L/F	F	L	L/F	L/F	F	F

P = reaction parameter, L = laboratory, F = field, AC = aqueous chemistry, PSD = particle size distribution, PVD = porosity, K = hydraulic conductivity, H = head, i = infiltration

Initial Characterization (Tier 1)

- Vadose zone characterization interval (13’-25’)
  - 5 sampling points/well location for Tier 1 lab properties (~30 samples)
  - 15 samples for θ/K relationships

- Saturated zone characterization interval (25’-56’)
  - 6 sampling points/well location for Tier 1 lab properties (~174 samples)
  - Electromagnetic borehole flowmeter (EBF) measurements every 30 cm
  - Limited constant rate injection tests (~8 wells)
  - 8 h passive MLS deployments in 6-8 wells (@ 2 seasons)
  - Non-reactive tracer experiments (salt, temperature)

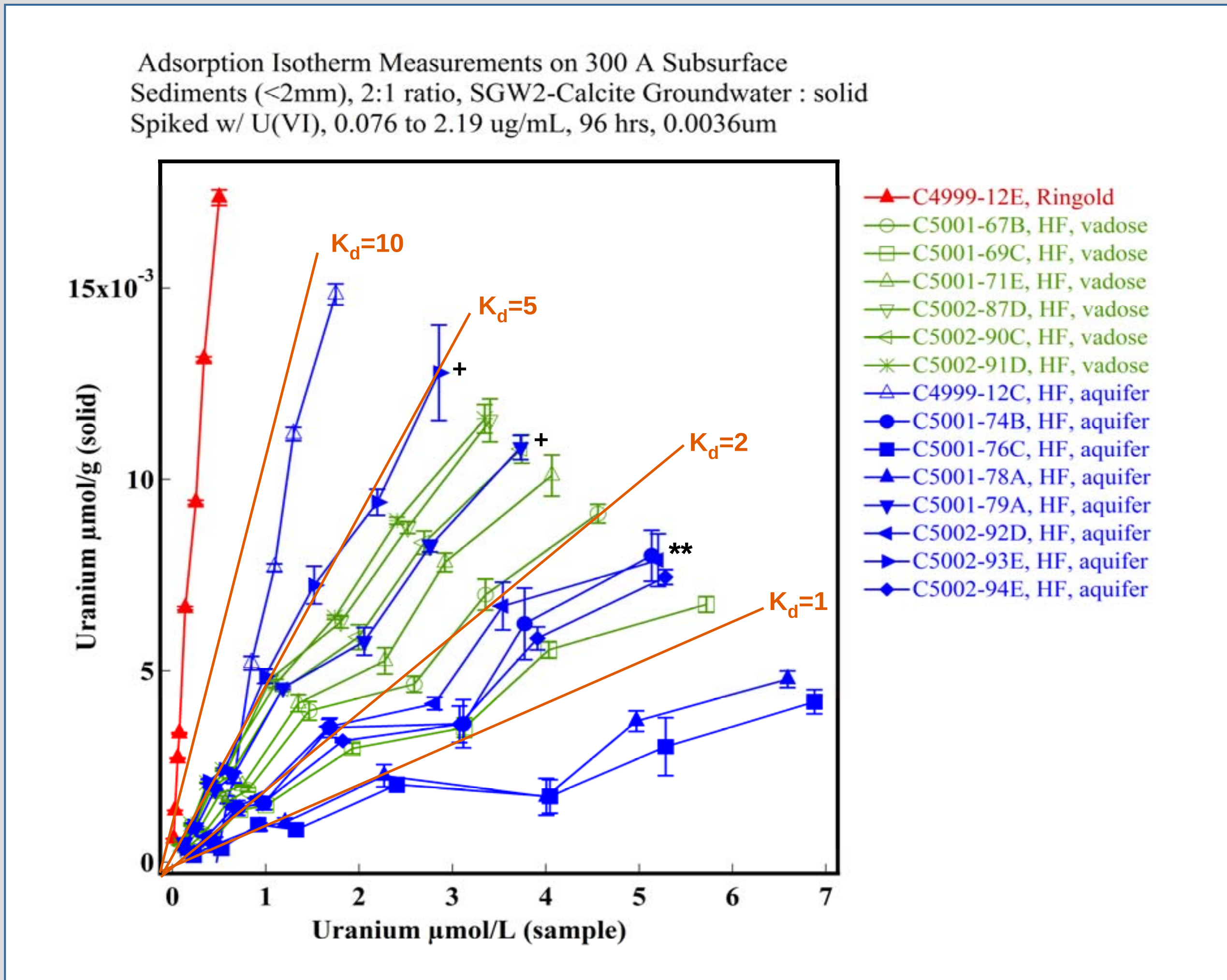
- Tier 1 lab properties

  U_T, P_E, P_M, psd, pvd, K_{sat}, K_Θ

Weak-Acid Extractable U(VI) from C5708

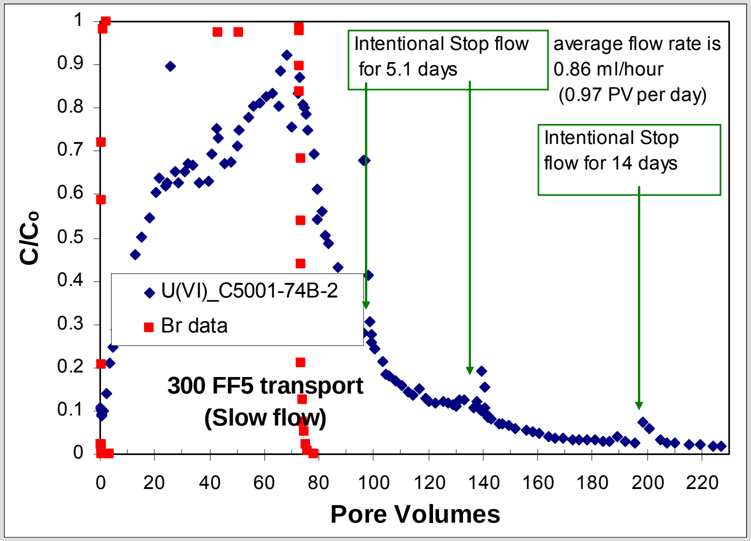
Formation	Notes	Depth (ft)	U(μg/g)
BF		4.5-7	3.4
HF	vadose zone injection depth	15-17	1.03
		20-22	1.24
		23.5-26	3.09
	smear zone	28-31.5	5.17
	water table	32-33	3.29
	upper screen	33.8-36.8	0.99
	middle screen	40.8-42.8	0.93
		45-47	0.64
	lower screen	49.5-51.5	0.56
RF	C.W. upper screen	55-56	1.43
	C.W. lower screen	73-75	0.58
		74-76	0.57

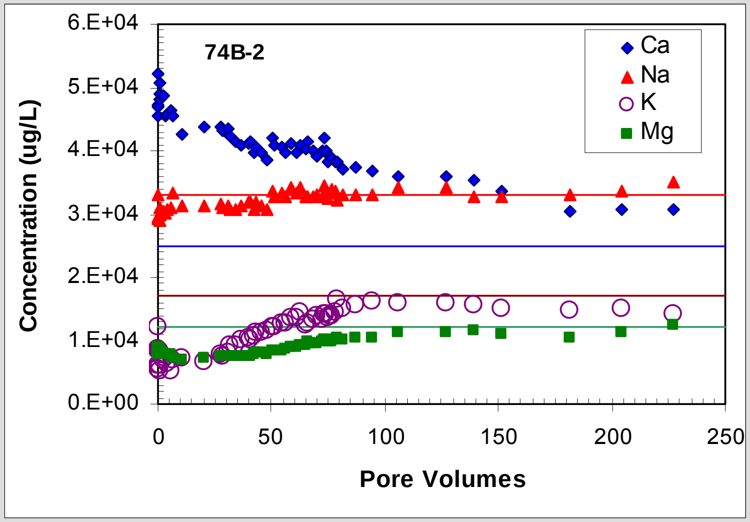
U(VI) Adsorption Isotherms on Uncontaminated 300 A Vadose Zone and Aquifer Materials from LFI Cores



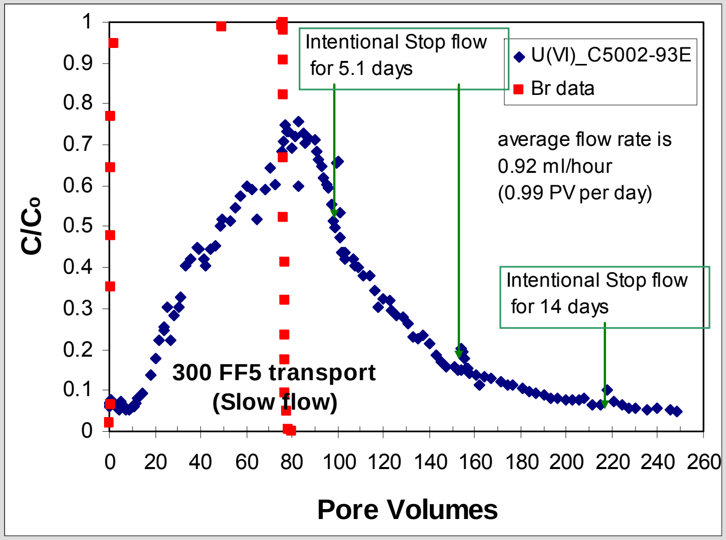
* K_d for whole sediment ≈ K_d (2 mm)/10

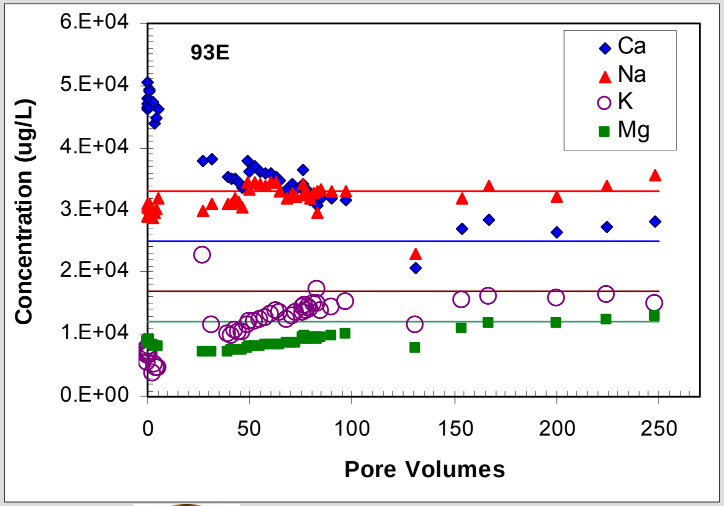
U(VI) Column Experiment of Hanford Gravel C5001-74B





U(VI) Column Experiment of Hanford Gravel C5001-93E





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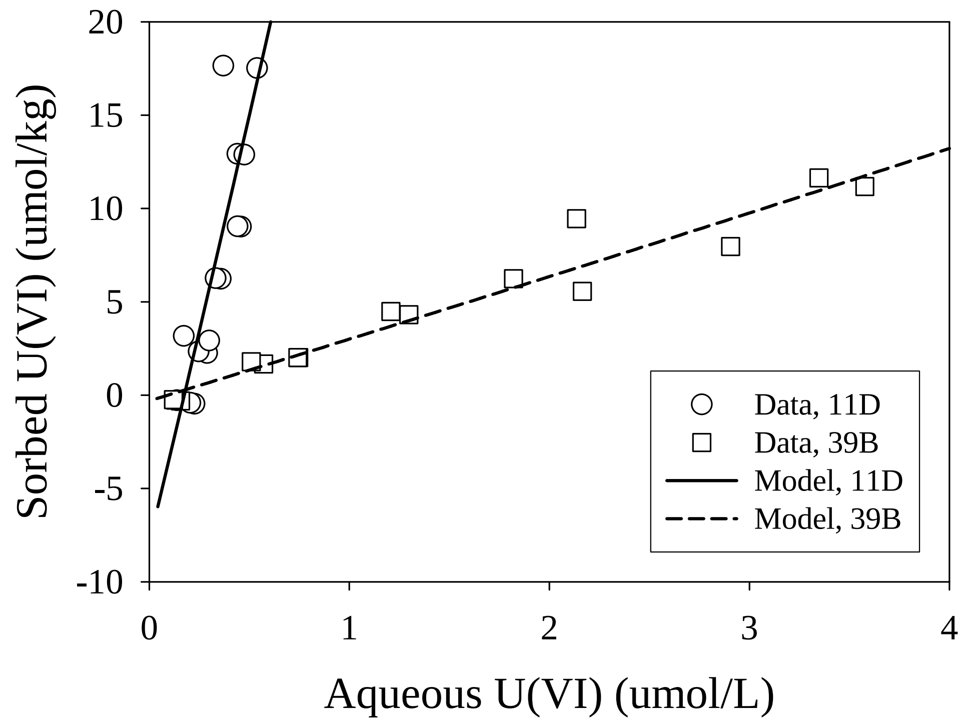
U(VI) Isotherms on Capillary Fringe Sediments of Similar Mineralogy



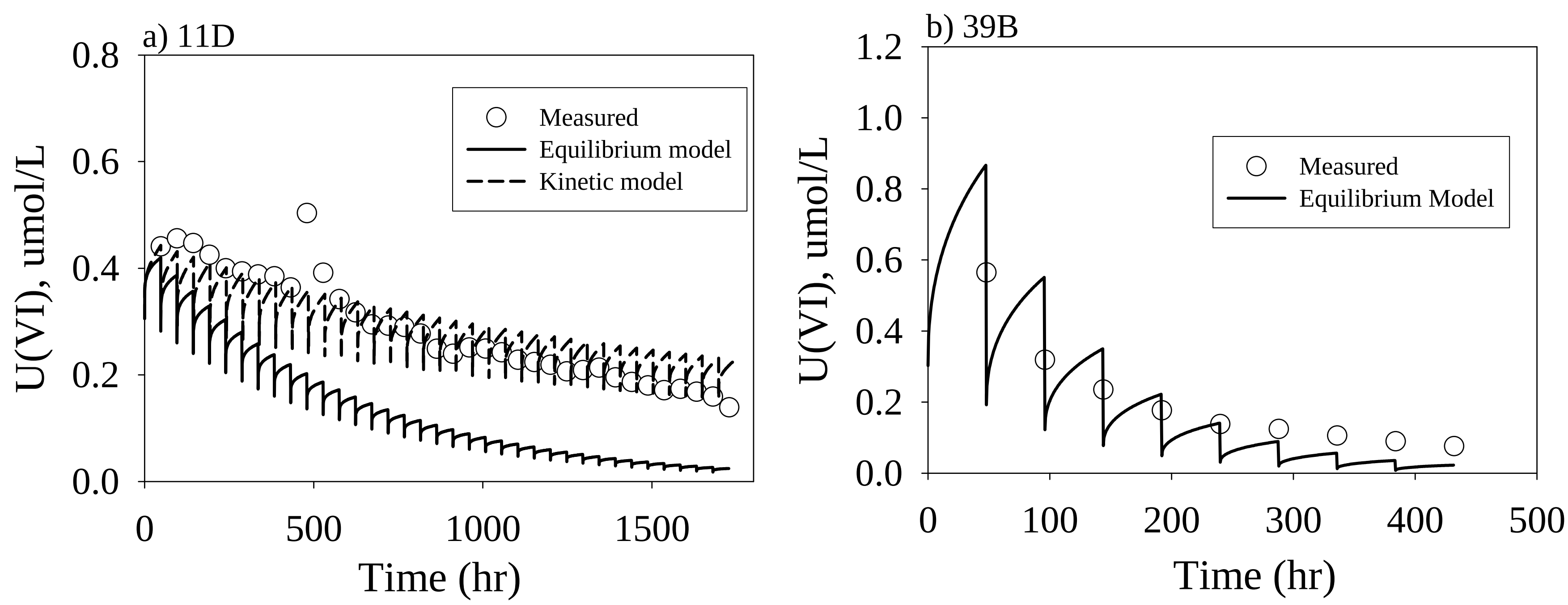
The Distribution Ratio and Solid Phase Properties

	U(VI) K_d (<2.0 mm)	Silt & Clay	SA	Extractable Fe(III) HAHCl	AmOx	DCB
	(mL/g)	(mass %)	(m^2/g)	(μmol/g)		
SPP2-18' bgs	9.23±5.87	7	14.3	19	48	77
NPP2-16' bgs	82.5±48.3	30	23.6	41	91	158

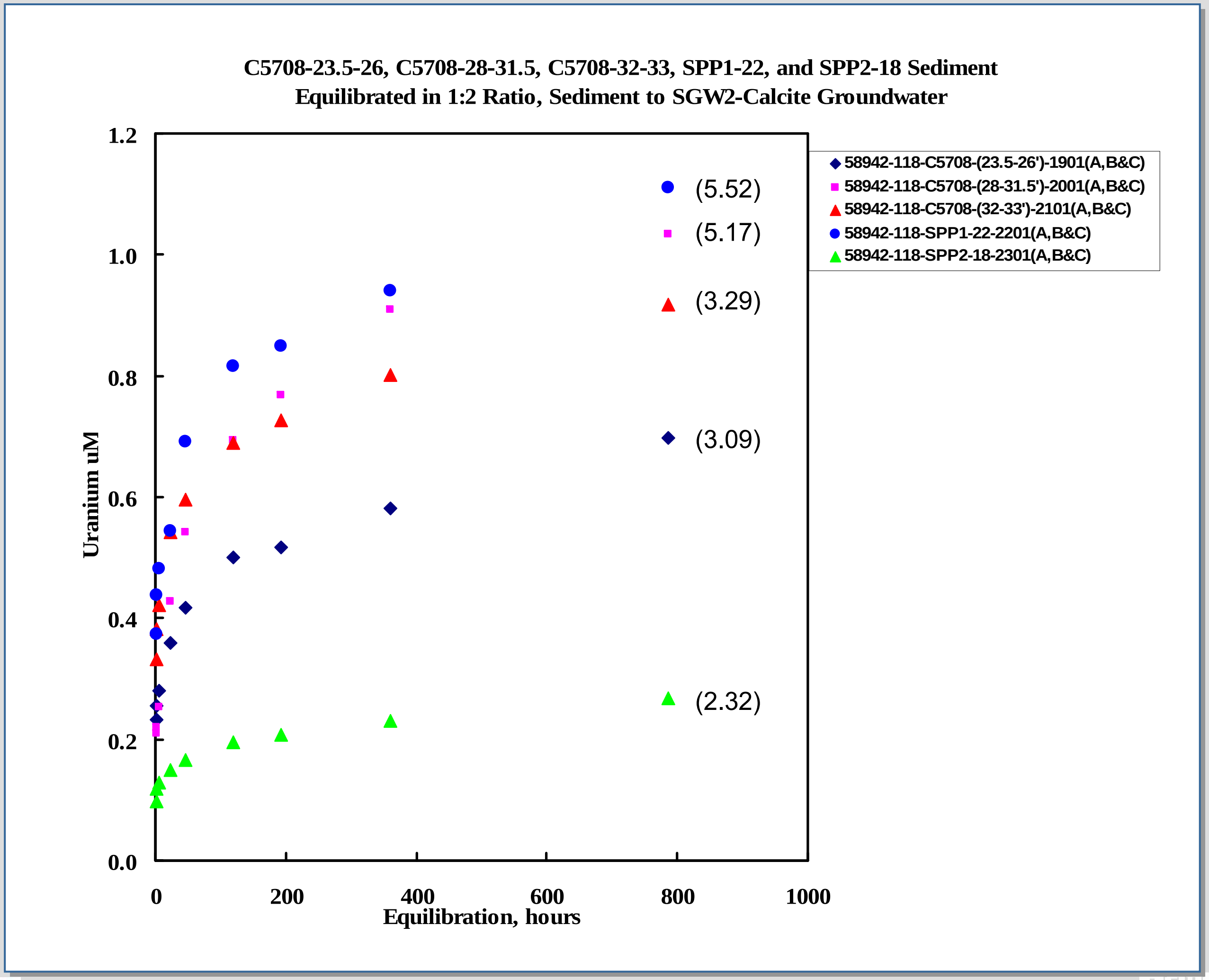
XRD Estimated Mineral Composition of Clay Fraction

	SPP2-18' bgs	NPP1-16' bgs
	(%)	(%)
Clinochlore	29	42
Muscovite	27	30
Montmorillonite	34	20
HIV	7	5
Feldspar & quartz	3	3

Batch Kinetic Desorption Behavior from Capillary Fringe Sediments



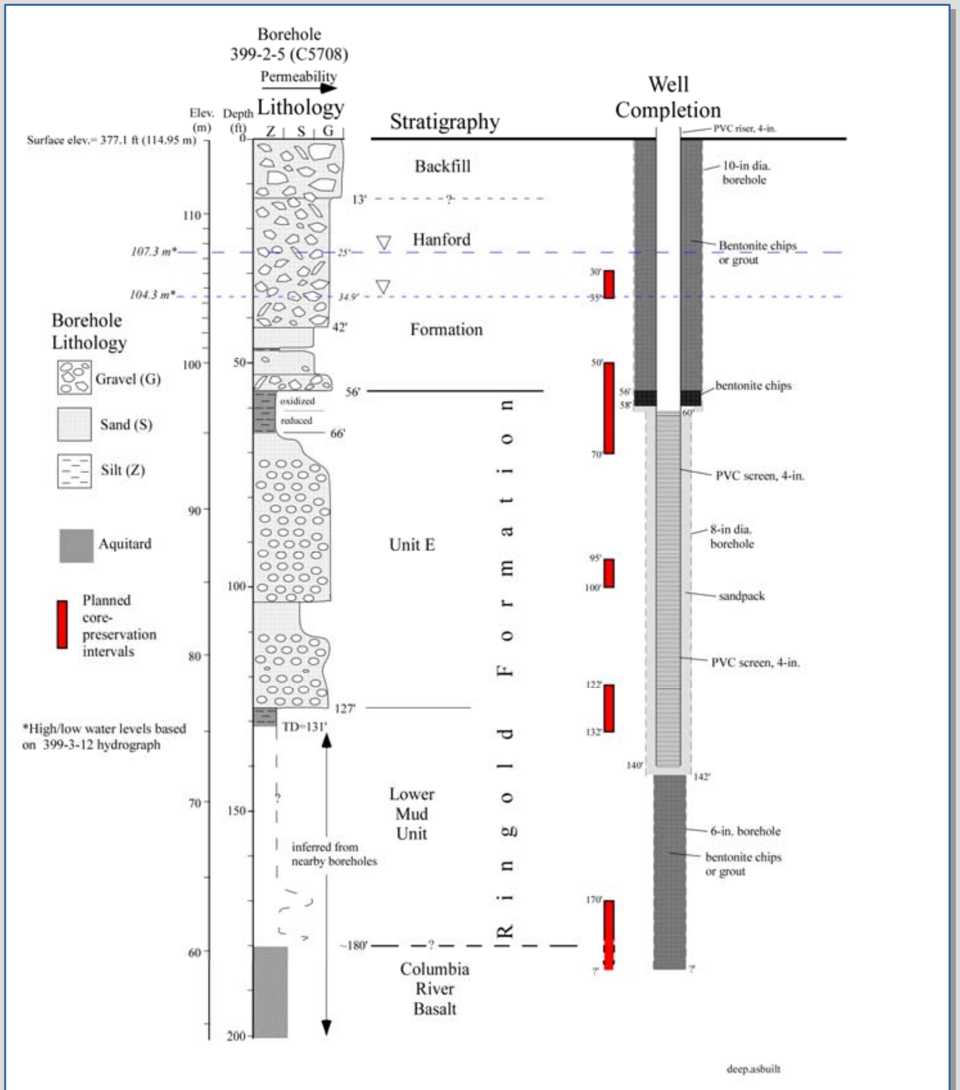
U(VI) Desorption from SPP Sediments in Synthetic Groundwater



Deep Characterization Borehole

- Approximately 150' in depth to sample water-saturated Ringold Formation
- Major focus is microbiological characterization (aspectic sampling)
- To be drilled and analyzed in collaboration with (shared support from) evolving PNNL SFA focused on microenvironments and transition zones
- Located along east margin of IFC experimental site
- Will allow passive biogeochemical and mass transfer studies within Ringold transition zones
- Possible evaluation of diffusive mass transfer from the Ringold as a U source

As-Built Diagram for the Deep Characterization Well



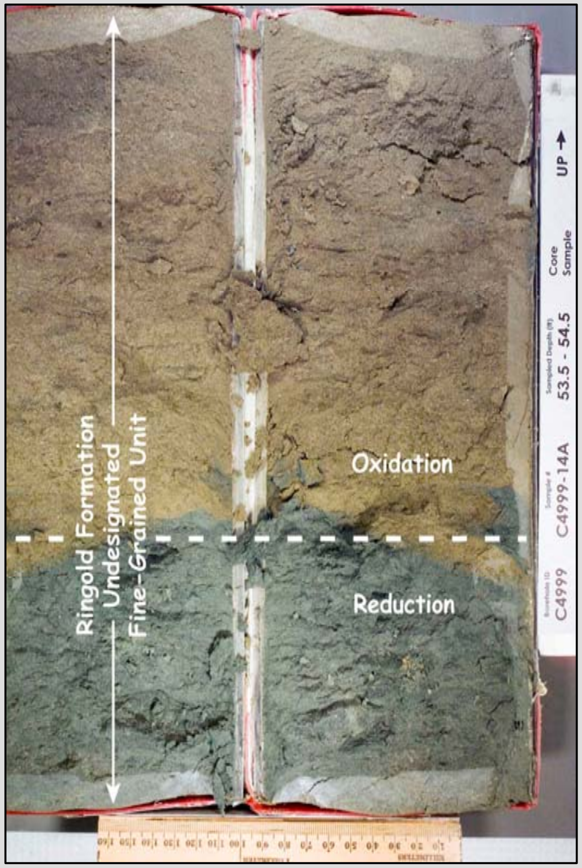
Microbiological Characterization of IFC Sediments

- IFC to support core collection, logging, and well installation. PNNL SFA to support microbiologic characterization and study.
- Enable development of microbial component of IFC research

Objectives

- Determine biomass and phylogenetic diversity
- Metal reduction/oxidation behavior and chemoheterotrophic catabolism
- Numbers and functional diversity of key organism groups that influence U or Tc
- Functional potential of key microbial isolates to transform U and Tc and involved mechanisms
- Basis for understanding biogeochemical processes across transition zones that collect contaminants

Transition Zones in the 300 A Unconfined Aquifer



Microbiologic Characterization of Deep Borehole Sediments

- Microscopic
  - Direct counts (w SYTO and PI) and active cells (TDR)
- Culture independent
  - Phylogenetic diversity/richness
  - Real time PCR for specific functional groups
  - Phylo & functional gene arrays (Geochip)
- Culture dependent
  - Liquid MPN's with various TEA's
  - Filter based cultivation
  - Isolation & characterization of representative cultures
- Activity analysis
  - Targeted incubations w/ radiolabeled substrates

Experimental Campaigns

<u>Issues</u>

- Tracers (identity, concentration, mixtures)
- Injection strategy (i.e., volumes, duration, phasing)
- Water composition (isotopics, major/minor ions)
- Microbiologic perturbations

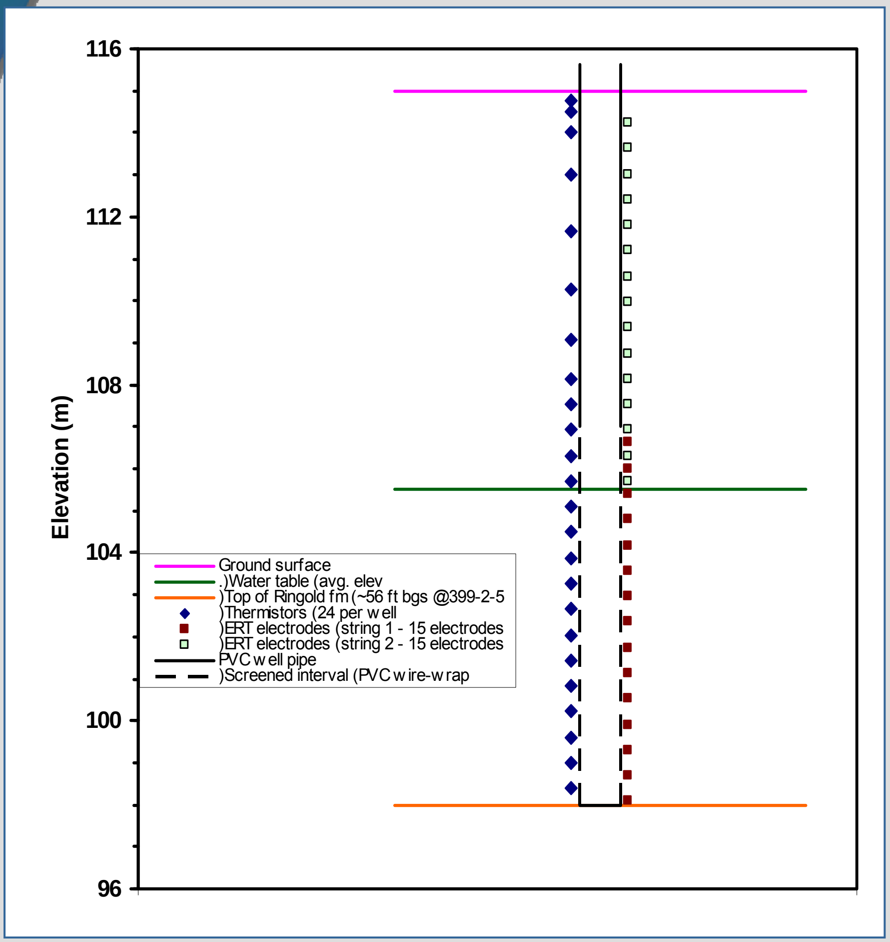
FY08 – FY09

- Non-reactive tracers (Br, D_2O, PFBA)
  - High/low river stage
- ΔT injection
  - High/low river stage
  - Microbiologic issues
- -U, +U injection
- Passive U migration

IFC Experiments

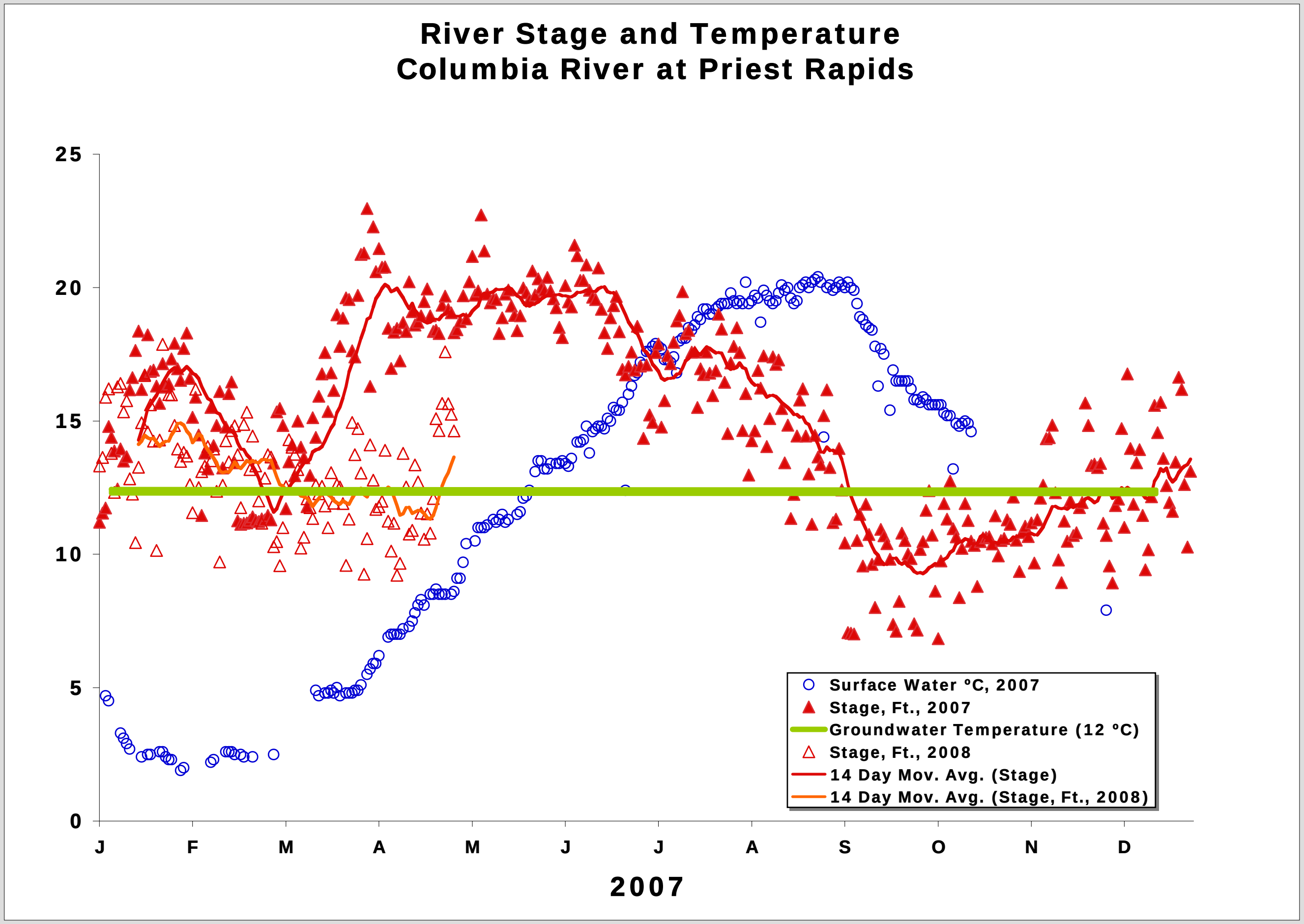
- U(VI) concentration dynamics within the groundwater plume
  - Scale–dependent mass transfer involved in forward (adsorption), backward (desorption), and steady-state (isotopic exchange) reaction processes in flow paths with different trajectories and residence times
    - Injection experiments with varying HCO_3 and U(VI) concentrations, and U(VI) isotopic ratios
    - Passive experiments follow vadose zone pulses, or inland riverwater – groundwater gradients
- U(VI) fluxes from the vadose zone
  - Scale-dependent mass transfer, geochemical kinetics (adsorption/desorption) and water pathway effects on U(VI) fluxes to groundwater
    - Infiltration experiments with varying water application rates, volumes, and composition (pH, HCO_3, Na/Ca)
    - Passive experiments to explore rising and falling water table effects on U(VI) solubilization and release from lower vadose zone
- Optimized and sustained remediation strategies
  - Evaluate role of mass transfer and microbiological processes on different forms of phosphate used to precipitate and immobilize U
    - Injection experiments with polyphosphate, Ca-citrate/PO_4^{3-}, organic P with HCO_3
    - In collaboration with EM-22 and team

Schematic of ERT / Monitoring Wells



- Electrodes spaced at 60 cm (2 ft)
- Electrode length approx 10 cm (4 in)
- Electrode material 316 stainless steel
- Single wire connections to electrodes
- Wires run on outside of PVC well pipe
- Thermistors placed between electrodes
- Wire wrap PVC from 106-98 m elevation
- Tube capped at bottom
- Well head ~0.6 m (2 ft) above ground
- Central connector/DAQ box at top of wellhead
- Heat dissipation unit (HDU), time-domain reflectrometry (TDR) probe and porous cup solution sampler at multiple depths on 5 wells around infiltration site

Temperature and Flow Contrasts



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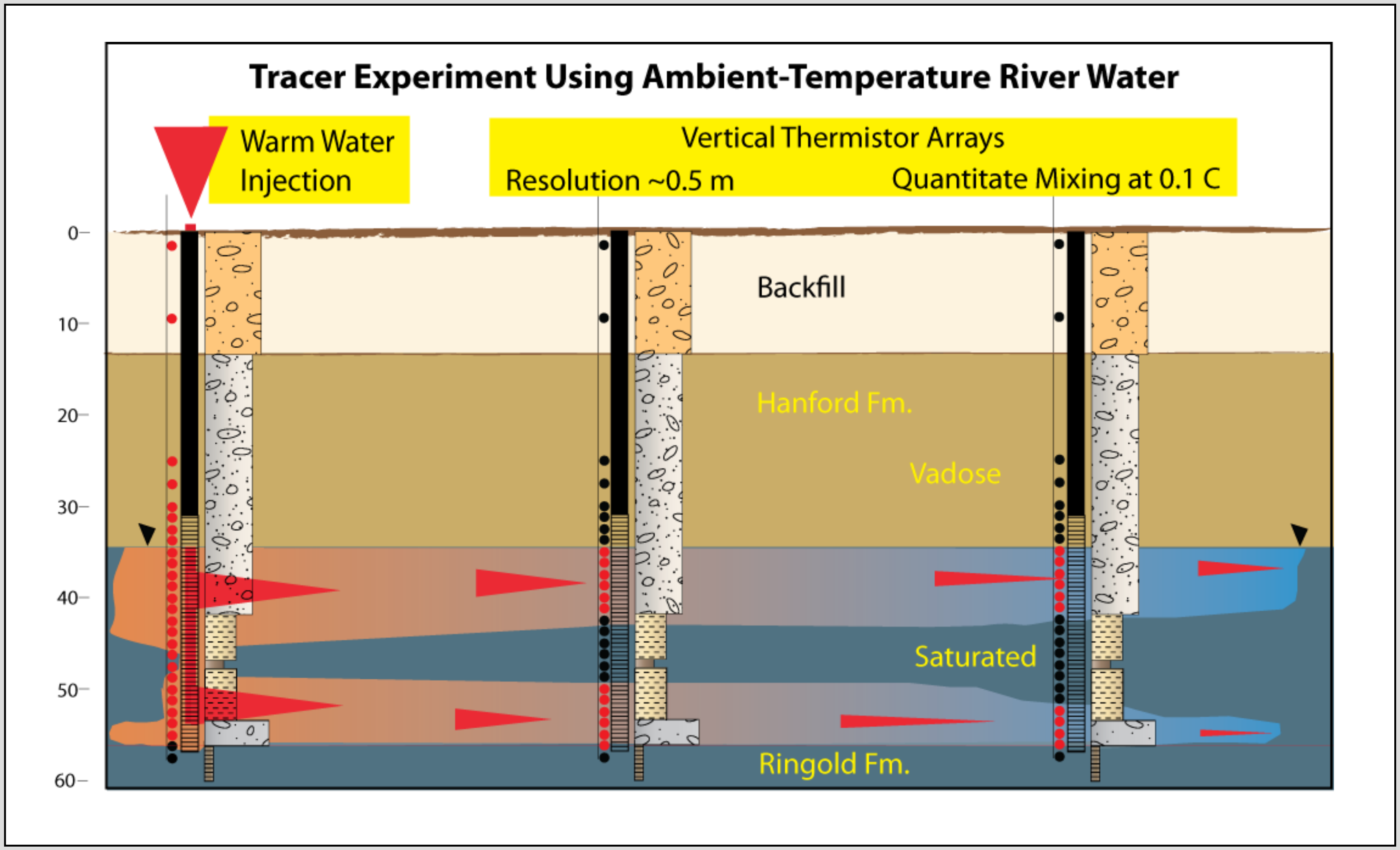
Defining Heterogeneities in Hydrologic Properties and Flow



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Operated by Battelle for the U.S. Department of Energy

Multi-Level Sampler (MLS) for Depth-Discrete Groundwater Sampling

- The MLS for 4” wells uses tiers of diffusion cells to collect depth-discrete water samples every 2”
- Baffles “seal” well bore every 12”
- 8 h required for equilibration
- Sorbents and other materials can be added

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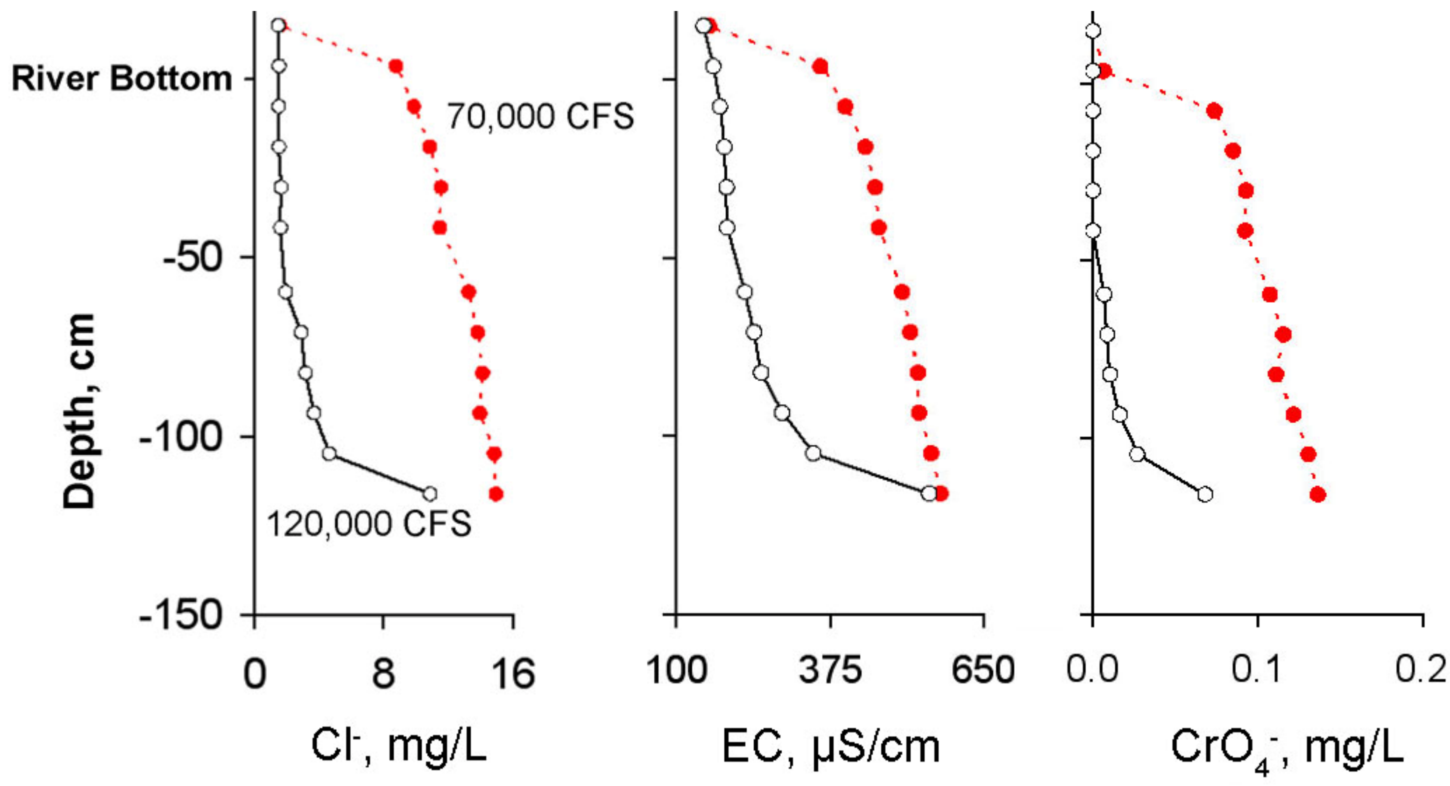
MLS Results for Hyporeic Zone Near 100D



Groundwater Composition and Uranium Speciation

	618-5 Pit 1 (26 Feb, 03)	618-5 Pit 1 (29 May, 03)	618-5 Pit 2 (26 Feb, 03)	SPP Pit 1 (19 Apr, 03)	SPP Pit 2 (19 Apr, 03)	NPP Pit 1 (26 Apr, 03)	NPP Pit 2 (26 Apr, 03)	Range
pH	7.71	8.11	7.80	7.83	8.04	7.83	7.88	7.71 - 8.11
Ionic Strength (mmol/L)	7.5	8.2	7.5	3.5	4.9	5.2	6.3	3.5 - 8.2
Cations (mmol/L)								
Ca	1.31	1.17	1.24	0.60	0.90	1.01	1.14	0.60 - 1.31
K	0.16	0.20	0.16	0.07	0.09	0.07	0.06	0.06 - 0.20
Mg	0.58	0.49	0.56	0.21	0.28	0.34	0.40	0.21 - 0.58
Na	1.34	2.65	1.53	0.77	0.95	0.84	1.14	0.77 - 2.65
Anions (mmol/L)								
Cl^-	0.84	1.21	0.76	0.14	0.36	0.36	0.39	0.14 - 1.21
NO_3^-	0.42	0.53	0.40	0.36	0.40	0.29	0.43	0.29 - 0.53
Inorg. C	2.47	2.71	2.41	1.20	1.70	2.02	1.58	1.20 - 2.71
SO_4^{2-}	0.69	0.76	0.85	0.35	0.43	0.47	0.88	0.35 - 0.88
Si_{Total}	0.57	0.59	0.55	0.28	0.39	0.32	0.23	0.23 - 0.59
U (µmol/L)	4.96	1.39	1.82	0.30	0.36	0.30	1.07	0.30 - 4.96
Species	(%)	(%)	(%)	(%)	(%)	(%)	(%)	
$UO_2(CO_3)_2^{2-}$	5.8	2.8	5.4	22.0	6.2	7.1	7.3	
$UO_2(CO_3)_3^{4-}$	3.5	5.0	4.0	6.5	4.7	4.0	3.9	
$Ca_2UO_2(CO_3)_3^0$	90.6	92.2	90.5	70.4	88.9	88.7	88.6	
P_{CO2}	-2.559	-2.912	-2.656	-2.971	-3.035	-2.754	-2.913	

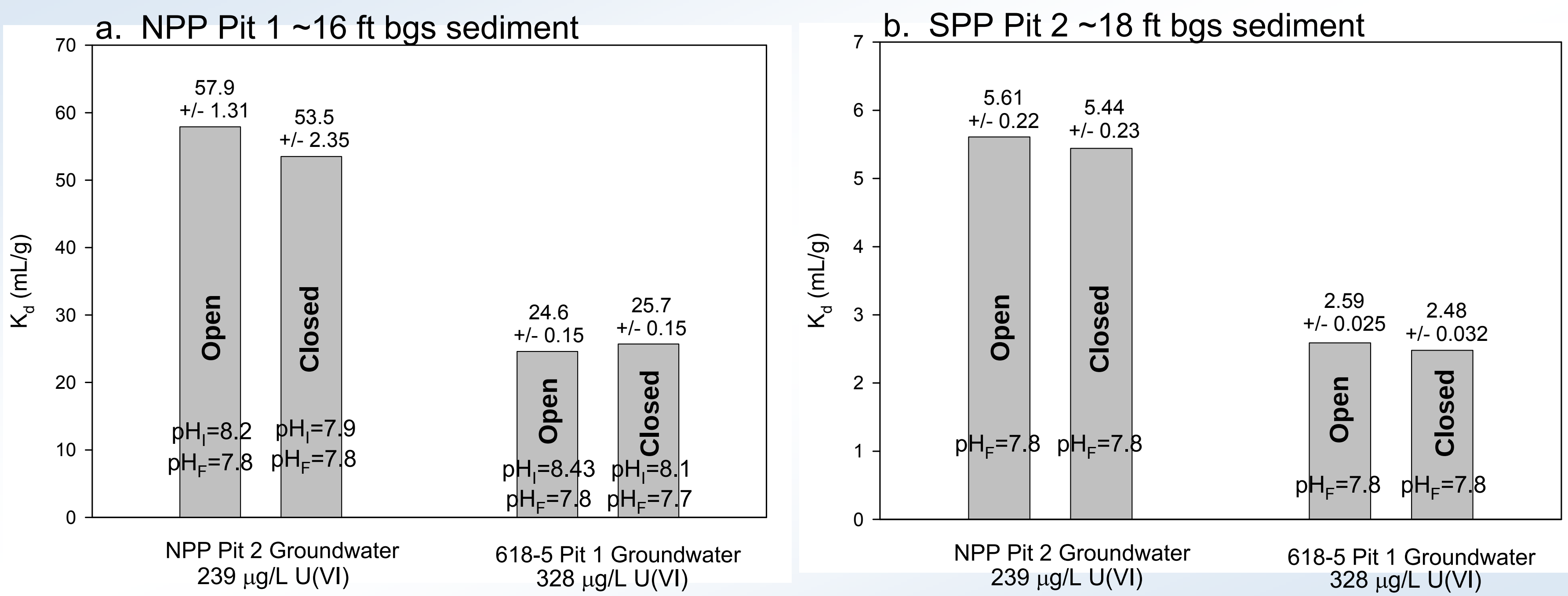
U(VI) Adsorption on 300 Area Sediments from Different Groundwaters

	Inorganic C (meq/L)	K_d (mL/g) 1-Day Contact: SPP Pit 2 (18 ft bgs)		K_d (mL/g) 1-Day Contact: NPP Pit 1 (16 ft bgs)		K_d (mL/g) 7-Day Contact: SPP Pit 2 (18 ft bgs)		K_d (mL/g) 7-Day Contact: NPP Pit 1 (16 ft bgs)	
GW 1	2.02	10.8	(0.02)	61.3	(0.12)	8.67	(0)	63.7	(0.26)
GW 2	1.70	13.2	(0.06)	83.2	(2.58)	9.51	(0.40)	85.6	(2.64)
GW 3	1.20	30.5	(3.97)	168	(7.08)	19.0	(1.76)	178	(7.38)
GW 4	2.41	11.3	(5.68)	33.9	(7.22)	14.6	(7.46)	37.8	(8.07)
GW 5	1.58	2.28	(0)	82.6	(12.8)	3.31	(0.30)	89.7	(13.6)
GW 6	2.47	2.22	(1.32)	30.5	(14.5)	2.82	(1.77)	33.5	(15.7)
GW 7	1.70	ND	ND	85.7	(17.5)	6.76	(1.96)	89.3	(17.7)

GW 1 = NPP pit 1 groundwater (58154-139); 71.4 ppb U; pH 8.29
GW 2 = SPP pit 2 groundwater (58154-132); 84.8 ppb U; pH 8.28
GW 3 = SPP pit 1 groundwater (58154-133); 70.7 ppb U; pH 8.12
GW 4 = 618-5 pit 2 groundwater; sampled 2-26-03 (58154-97-3); 433 ppb U; pH 8.43
GW 5 = NPP pit 2 groundwater (58155-17); 247.3 ppb U; pH 8.22
GW 6 = 618-5 pit 1 groundwater; sampled 2-26-03 (58154-97-4); 1181 ppb U; pH 8.30
GW 7 = SPP pit 2 groundwater spiked to ~250 ppb U; 324 or 269 ppb U; pH 8.29 or 8.08

( ) = The labile U is not considered.

Effect of Groundwater Degassing on U(VI) Distribution Ratio



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Site Management Status

- Received approval from DOE Richland Operations for use of the 300 Area for the IFC May 2007
  - Cultural and ecological reviews completed August 2007
  - NEPA categorical exclusion granted September 2007
- Underground Injection Control permit submitted to Washington State Department of Ecology (Ecology) February 2008
- Controlling documents completed and available on web site (http://ifchanford.pnl.gov/documents)
  - Field Site Management, Health and Safety, QA/QC, Communications Plans
- Processing requests for sample materials submitted by ERSP investigators
- Washington State Waste Discharge Permit ST4511 in place for injections
  - Work with Ecology staff to ensure compliance of injections with permit (e.g. tracer concentrations

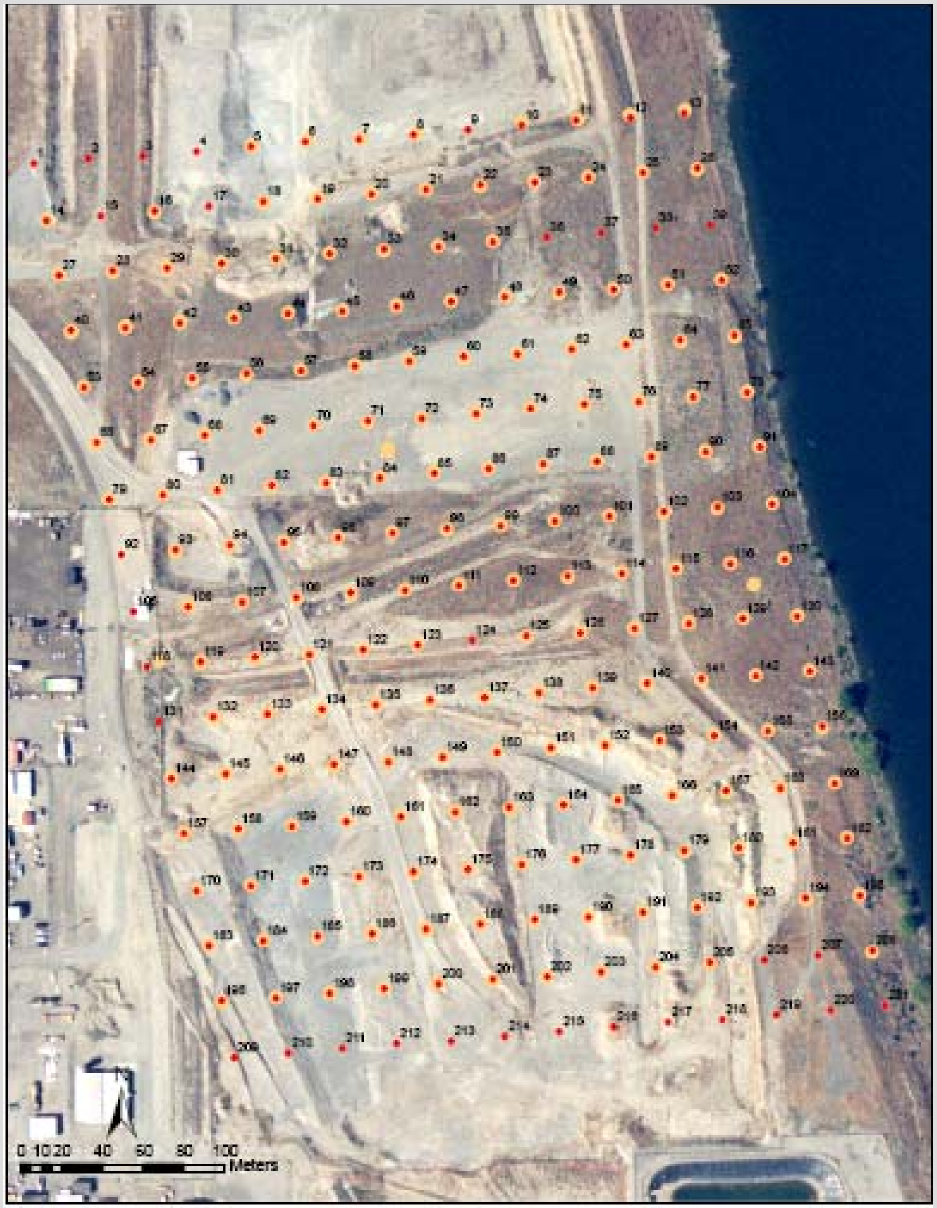
300 A IFC Infrastructure

- Site selection completed October 2007
- Drilling specifications document completed December 2007 and provided to Fluor Hanford (FH)
  - IFC wells located and staked
- Well drilling contract in Fluor Hanford Procurement
  - Excavation permit issued, drill bids received, two finalists selected
  - Drilling pad constructed
  - Start date in late April
- Field office trailer and sample storage containers in place
- Power now being installed at field site

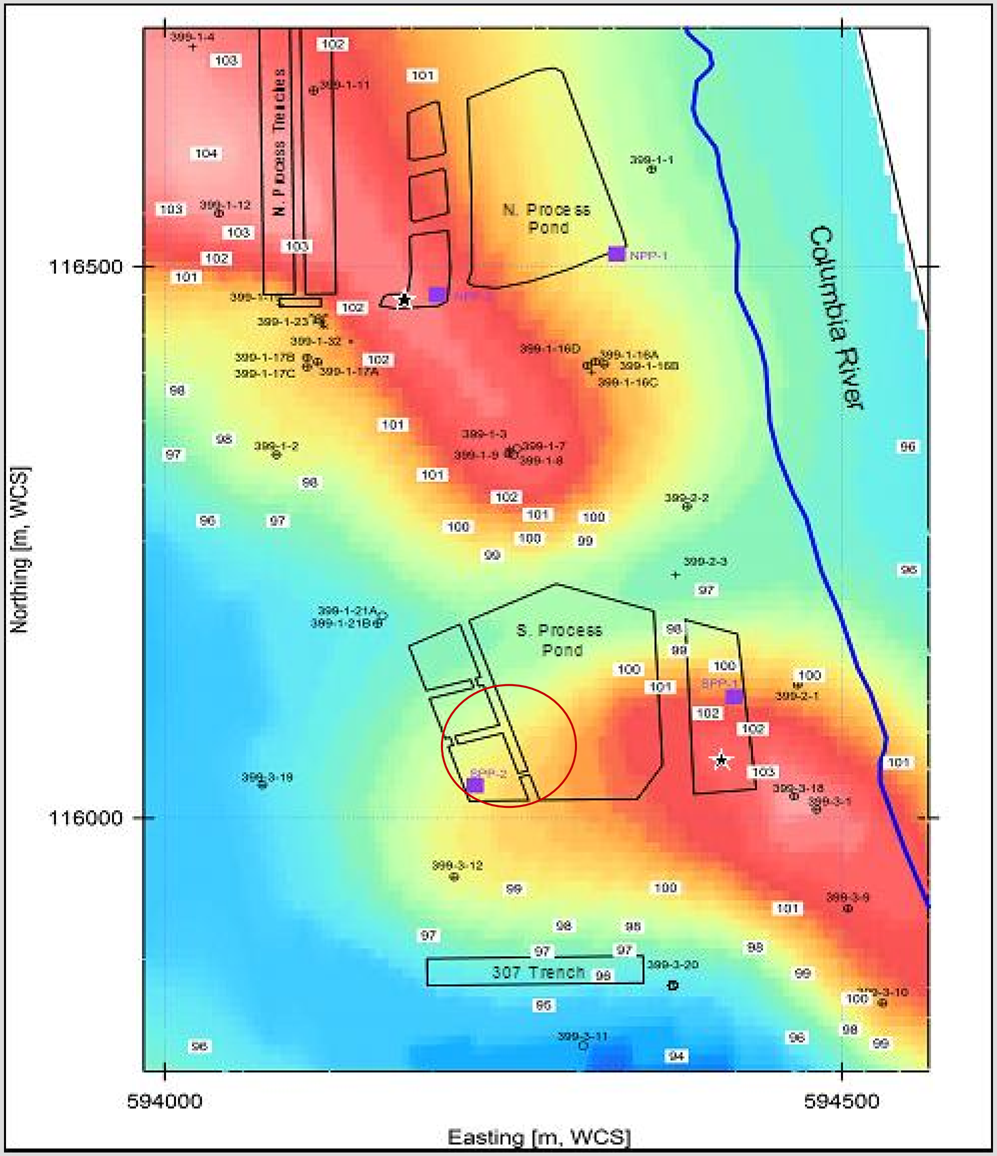
Criteria for Site Selection

- Seasonal changes in [U] ~ 2; [U]max > 50 ppb; no organic contaminants
- Proximate to previous excavations for which significant laboratory and characterization data exists
- Maximal amount of fines in saturated zone
- Near but out of the zone of influence of the EM-20 polyphosphate injection experiment
- Saturated zone thickness (Hanford formation) of 2-3 m
- Relatively flat Hanford-Ringold contact to minimize vertical gradients
- Located within coverage domain of existing groundwater monitoring domain
- Site location (and experiment timing) to allow relatively slow and predictable travel times

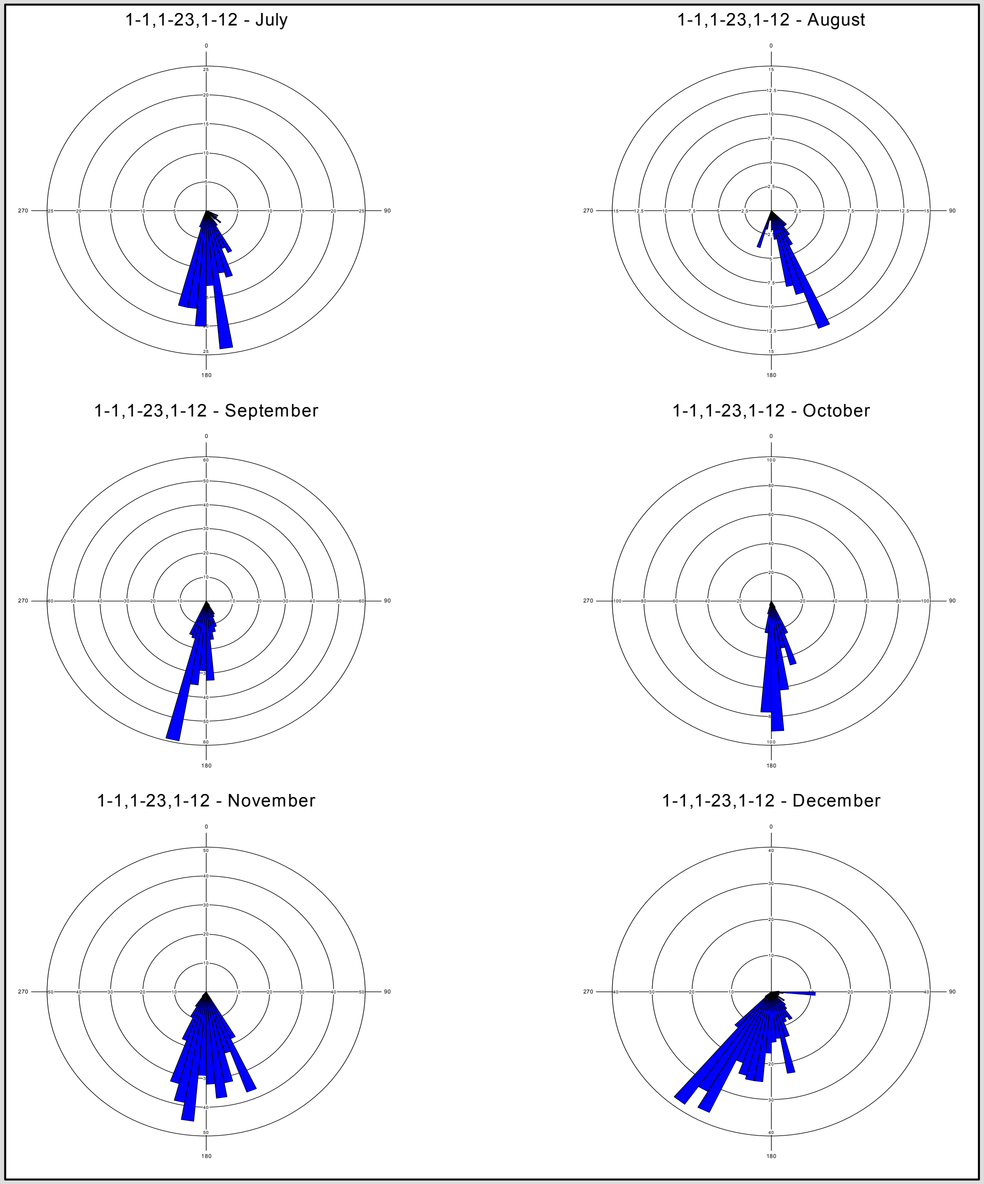
Geophysical Lines for Initial Characterization and Site Selection



Shaded Relief of Hanford Ringold Contact



Seasonal Changes in Groundwater Flow Vectors



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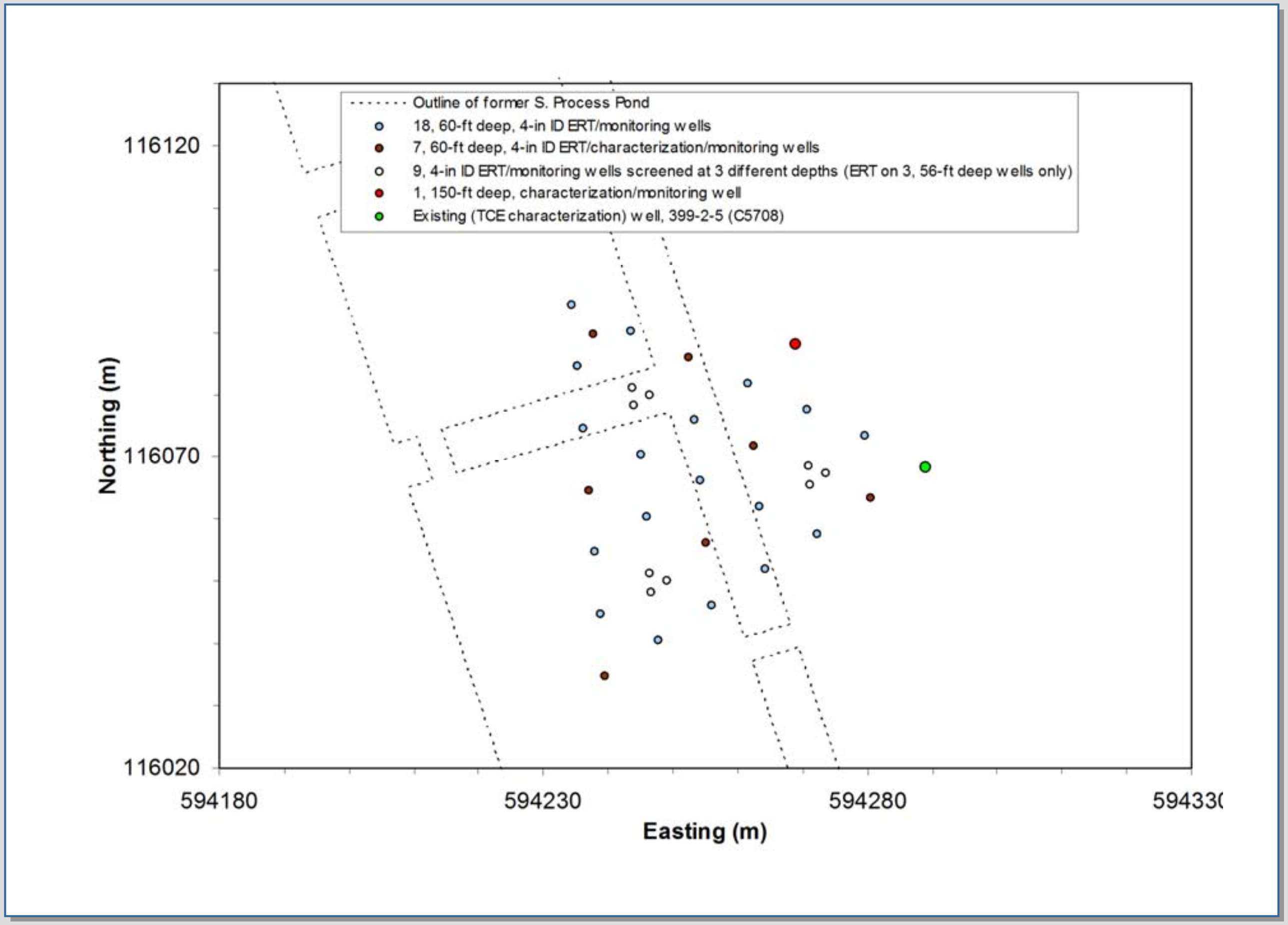
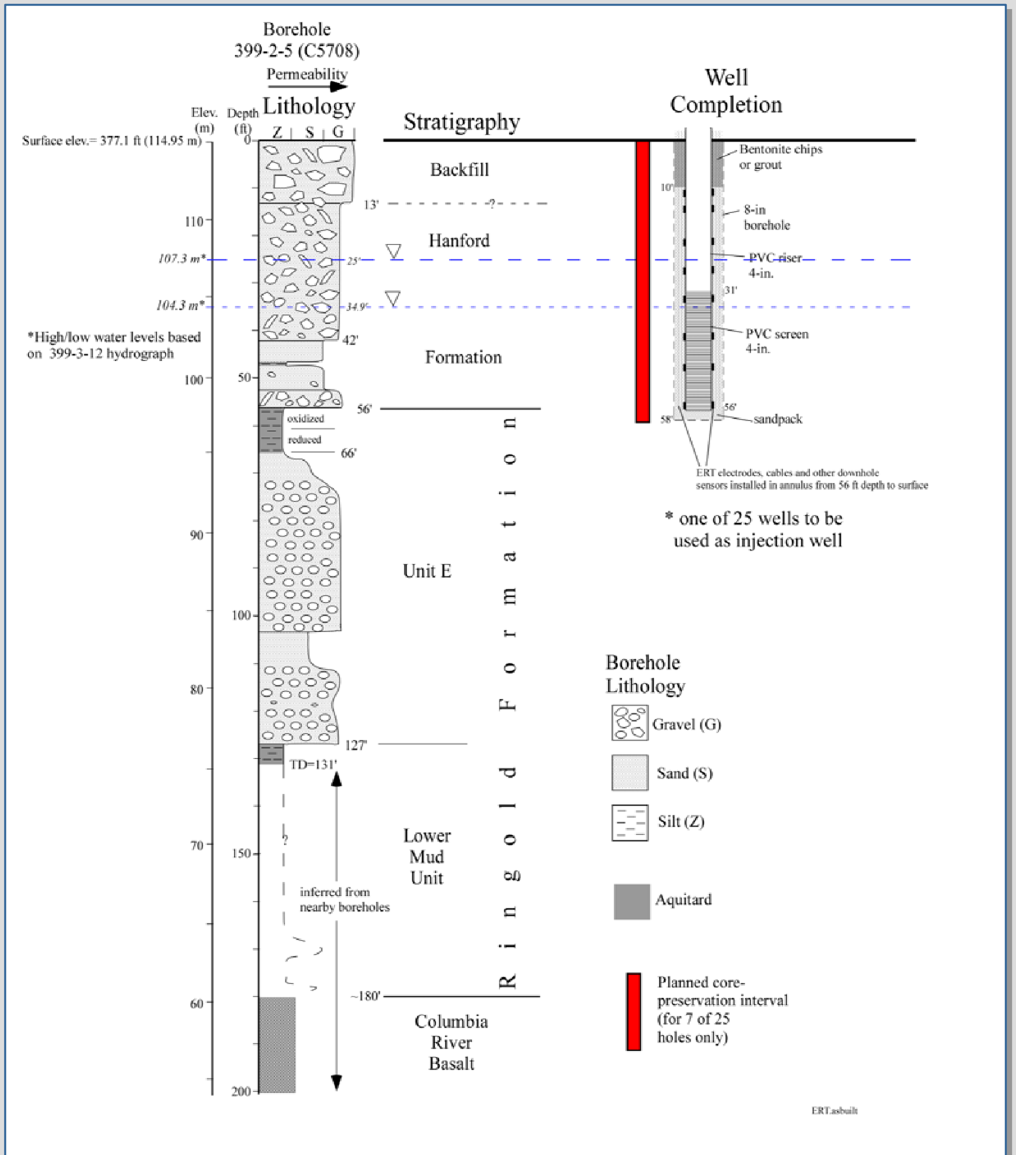
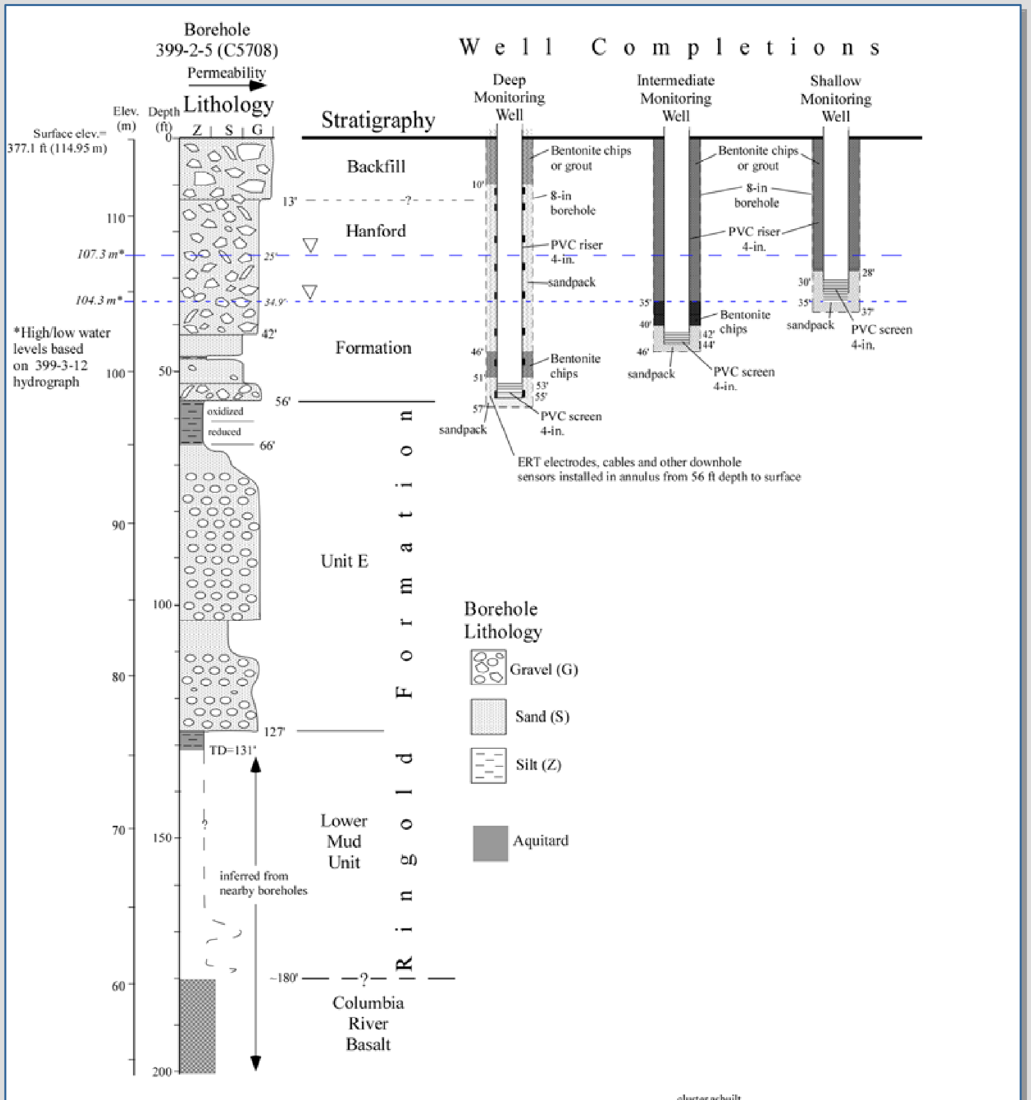
Layout of Hanford 300 Area IFC Well Array



As-Built Diagram for ERT-Instrumented, Groundwater-Monitoring Wells (25*)



As-Built Diagram for Multi-Level, Groundwater Monitoring Well Clusters (3X3)



Installation of Thermistors and ERT Electrodes on Well String

Issues of Vertical Resolution in Groundwater/Plume Monitoring

- Vertically resolved GW sampling difficult because of travel times and water volumes involved
- Given regulations and sediment properties, individual wells completed over distinct depth intervals are required for ML sampling. Three of these are included in the IFC well field.
- Degree/impacts of vertical heterogeneity (K, properties, etc.) will be assessed in characterization activities by seasonal
  - EBF measurements (all wells)
  - MLS geochemical sampling (~6 wells or more if necessary) (poster)
  - Cold/warm river heat tracer studies (poster)
- Large water quality variations monitored by ERT

Materials Available for ERSD Researchers

Existing

- Historic, highly contaminated sediments from process ponds (small masses available)
- Excavation samples from the vadose zone at two locations in the North Process Pond (NPP) and two locations in the South Process Pond (SPP). Samples contain various U(VI) speciation states, including adsorbed, precipitated, and surface complexed phases (variable sample masses are available).
- Uncontaminated vadose zone and aquifer sediments from the EM-40 Limited Field Investigation (LFI)
- Low-level contaminated samples from SPP C5708

To be Collected in Jan - Feb

- Becker-hammer grab samples from monitoring well installation in the Hanford formation screened to < 2 cm (~ 100 samples saved for ERSD researchers)
- 4" continuous sonic core samples from 7 characterization boreholes in Hanford sediment (~ 75-100' saved for ERSD researchers)
- 4" continuous sonic, aseptic core samples from one -150' characterization borehole through the Hanford and Ringold formations (select sample aliquots and undisturbed cores will be saved for ERSD researchers)

Other

- An excavation will be opened below backfill (~15 ') to allow bulk sample collection and in-situ structural analysis

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

K_d Estimation for "*In-Situ*" 300 Area Sediments

Basic Data

SPP2-18', K_d (< 2.0 mm) = 9.24 ± 5.87 mL/g

NPP1-16', K_d (< 2.0 mm) = 82.5 ± 48.3 mL/g

F = .917 (> 2.0 mm)

I-F = .083 (< 2.0 mm)

K_d Estimation [*Cantrell, Serne, and Last (2002)*]

K_{dgc} = (I-F) K_d < 2.0 mm + (F) 0.23 K_d < 2.0 mm

SPP2-18', $K_{d(gc)}$ = 1.94 (0.73 – 4.43)

NPP1-16', $K_{d(gc)}$ = 24.2 (10.1 – 38.4)

K_{dgc} = (I-F) K_d < 2.0 mm

SPP2-18', $K_{d(gc)}$ = 0.76 (0.27 – 1.25)

NPP1-16', $K_{d(gc)}$ = 6.84 (2.84 – 10.85)