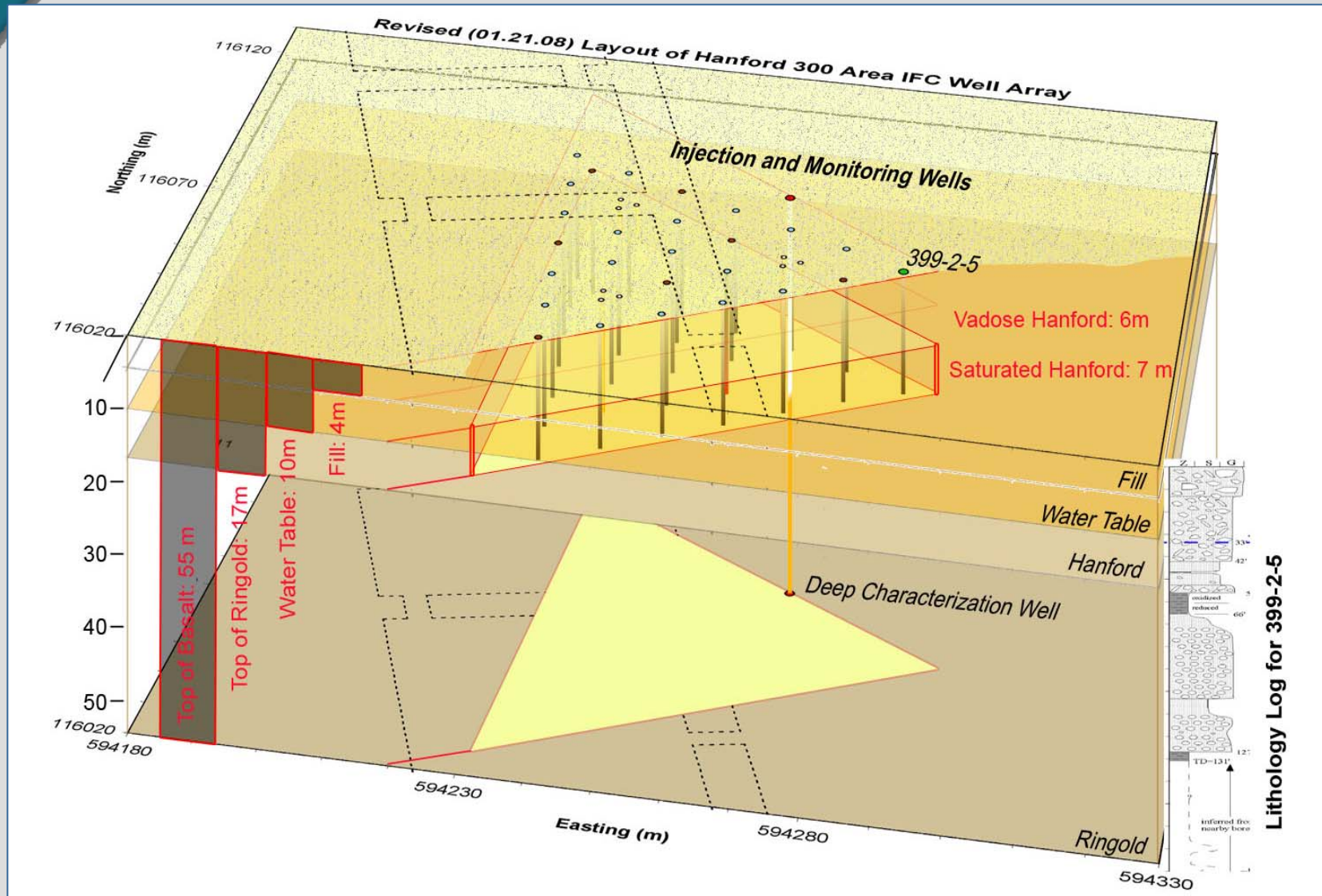


Well-Field Installation, Sampling Plan, and Monitoring System Update

Bruce Bjornstad
Jim McKinley

3-D View of IFC Site and Well Array

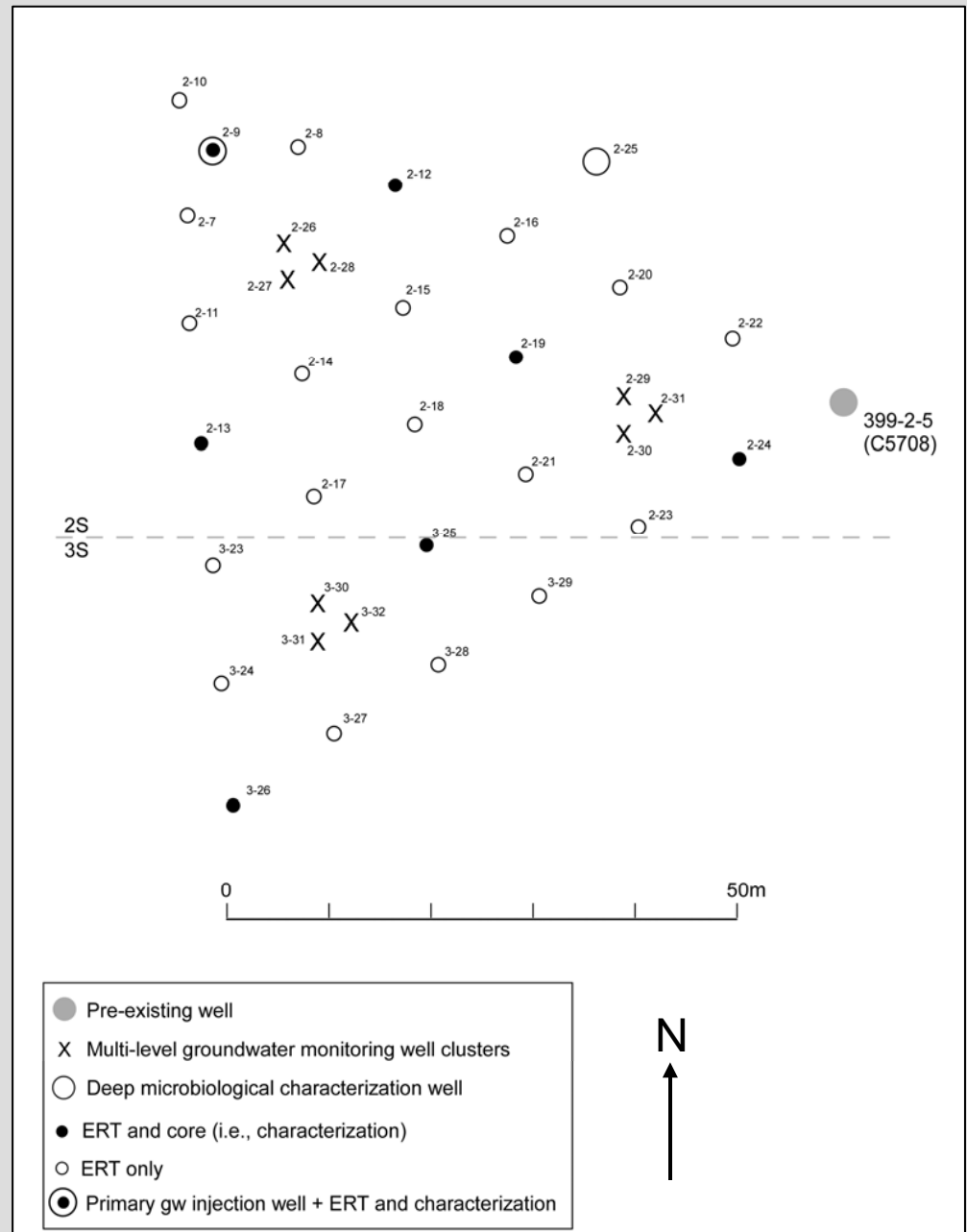


36 Wells in Array by Type

Wells designed to fulfill two or more purposes

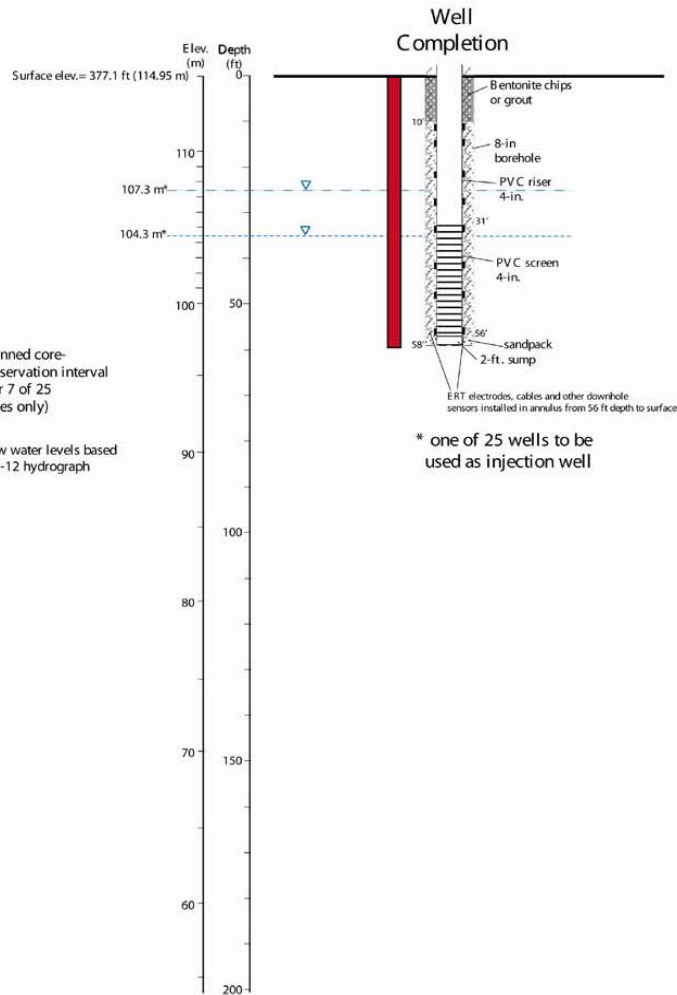
- Groundwater monitoring
- Downhole instrumentation
- Geologic samples for physical, chemical, and microbiological characterization
- Injection experiments

One well (399-2-5) previously installed

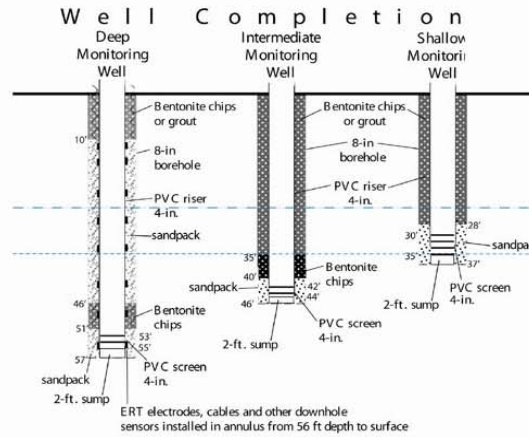


Three Well Types

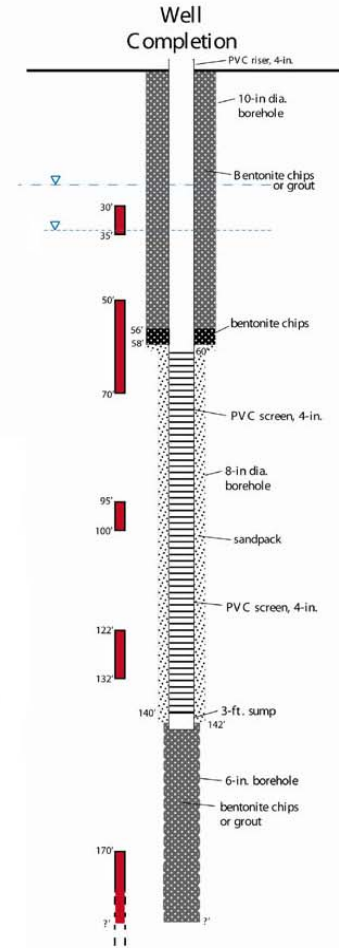
ERT-Instrumented
Groundwater-Monitoring Wells (25*)



Monitoring Well Clusters
(3 X 3)



Deep Characterization Well
(1)



Staked IFC Wells and Well Pad



Resonant-Sonic Drill Method

- ▶ All 35 new wells
- ▶ Fastest and most effective method for obtaining intact core from wide variety of unconsolidated sediments
- ▶ Minimal formation/aquifer disturbance



Drill rig



Fine-textured core



Coarse-textured core

Planned Geologic Sampling*

▶ Intact Core Samples (C)

Continuous core collected downhole in 1-ft-long lexan liners; capped at surface

7 Wells

~385 capped liners



▶ Bulk Grab Samples (G)

Continuous core collected in core bags at surface – transferred to covered 2-gal. plastic buckets at ~2-ft intervals

27 Wells

~700 buckets



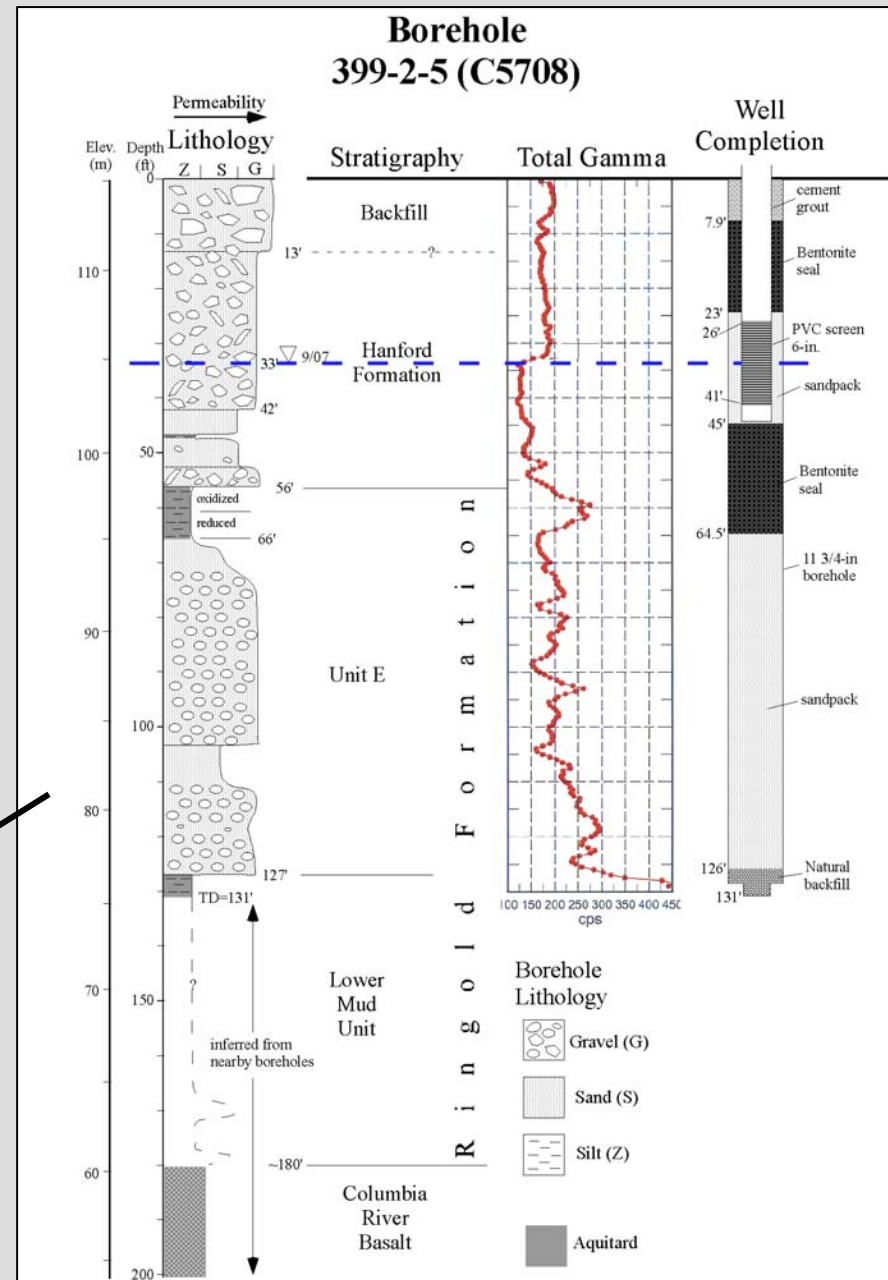
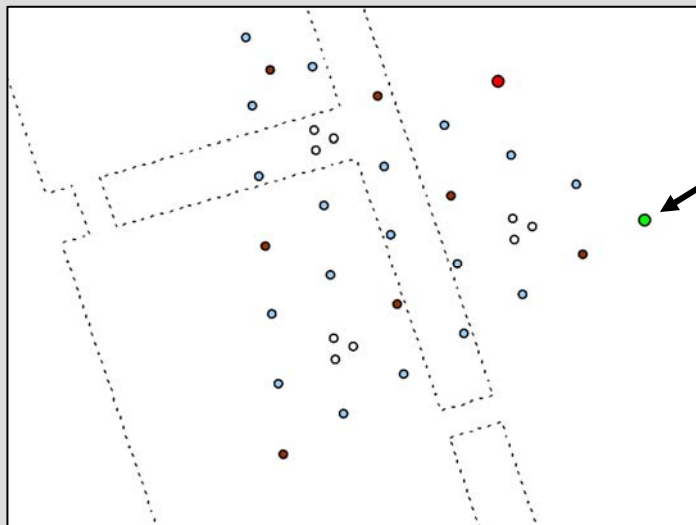
One well (Deep Microbiology Characterization) a combination of alternating intact core (50 liners) and bulk grab (~65 bucket) samples

***all collected via sonic coring method**

Total # geologic samples
≈ 1200

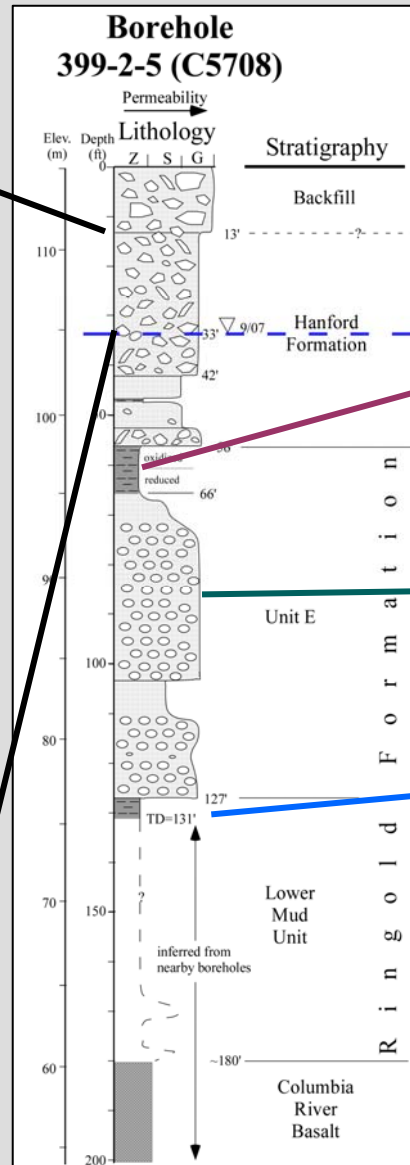
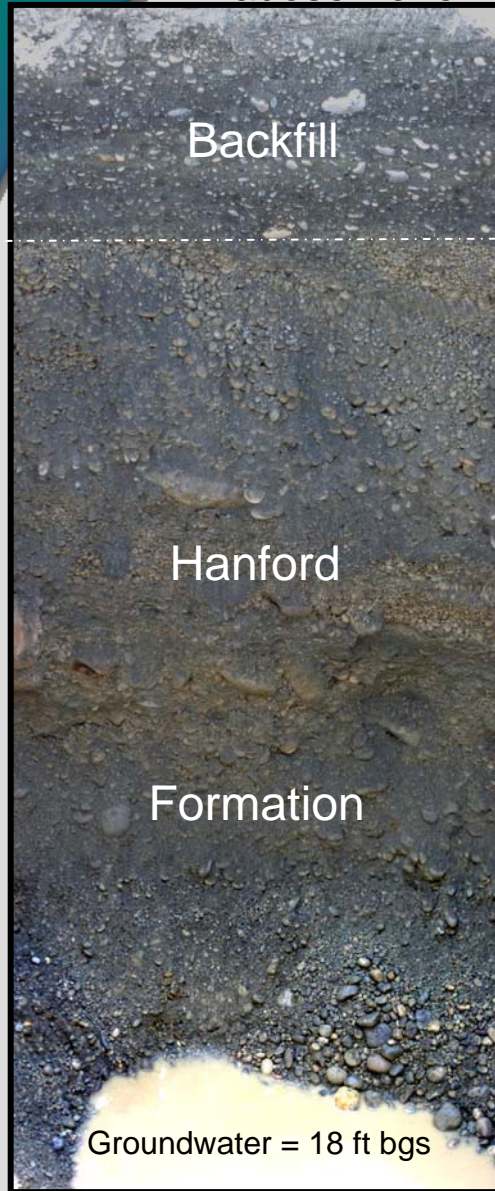
Reference Stratigraphy and Hydrogeology

from Borehole 399-2-5 along eastern boundary of well array

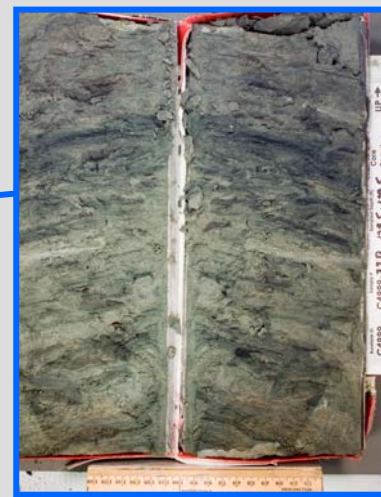
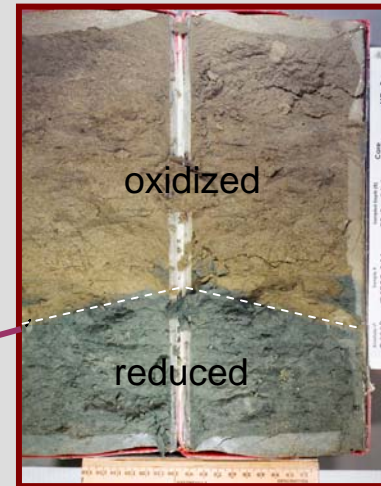


Strata Beneath South Process Pond

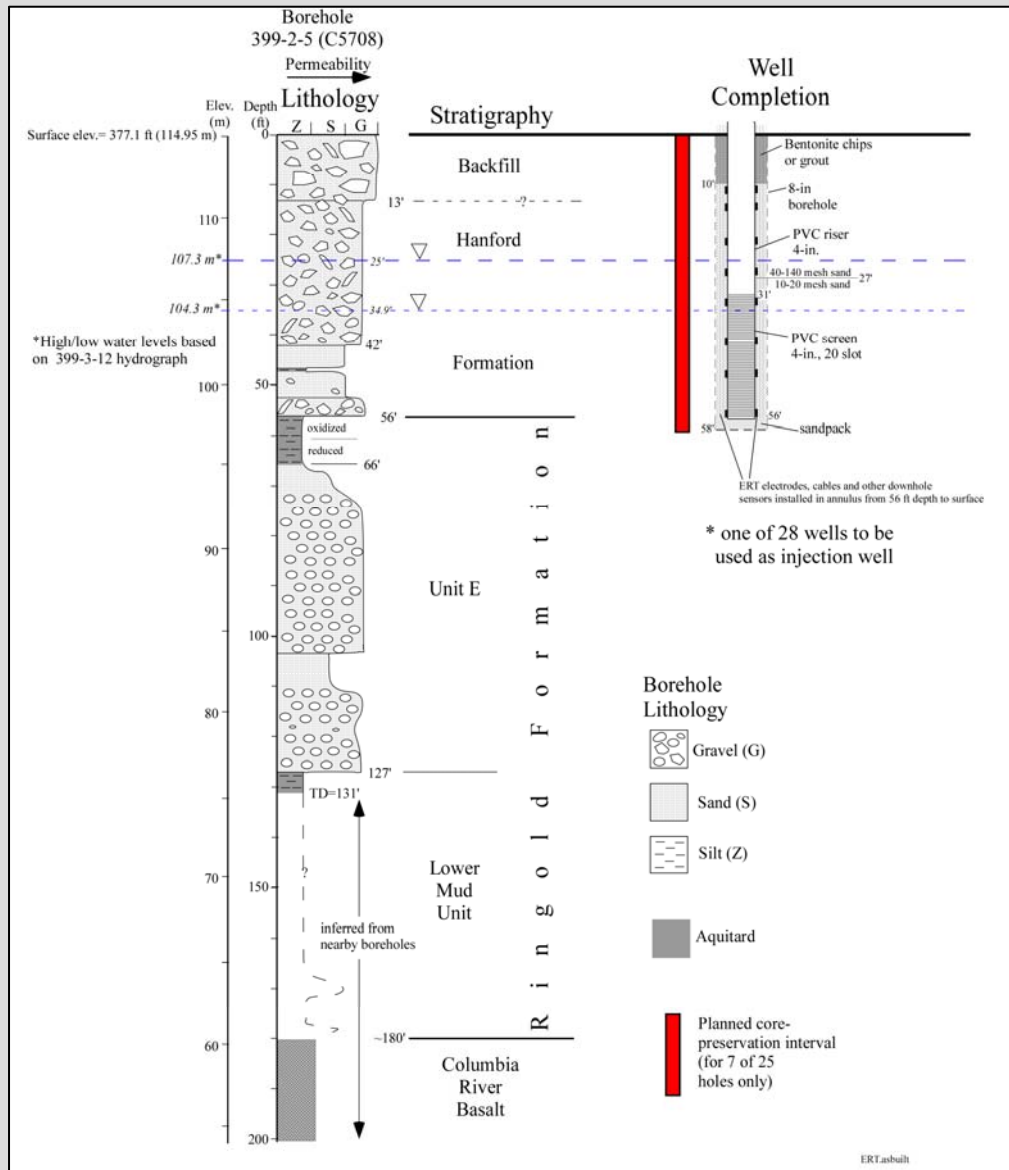
Vadose Zone



Saturated Zone



Well Construction: ERT-Instrumented/GW Monitoring Wells



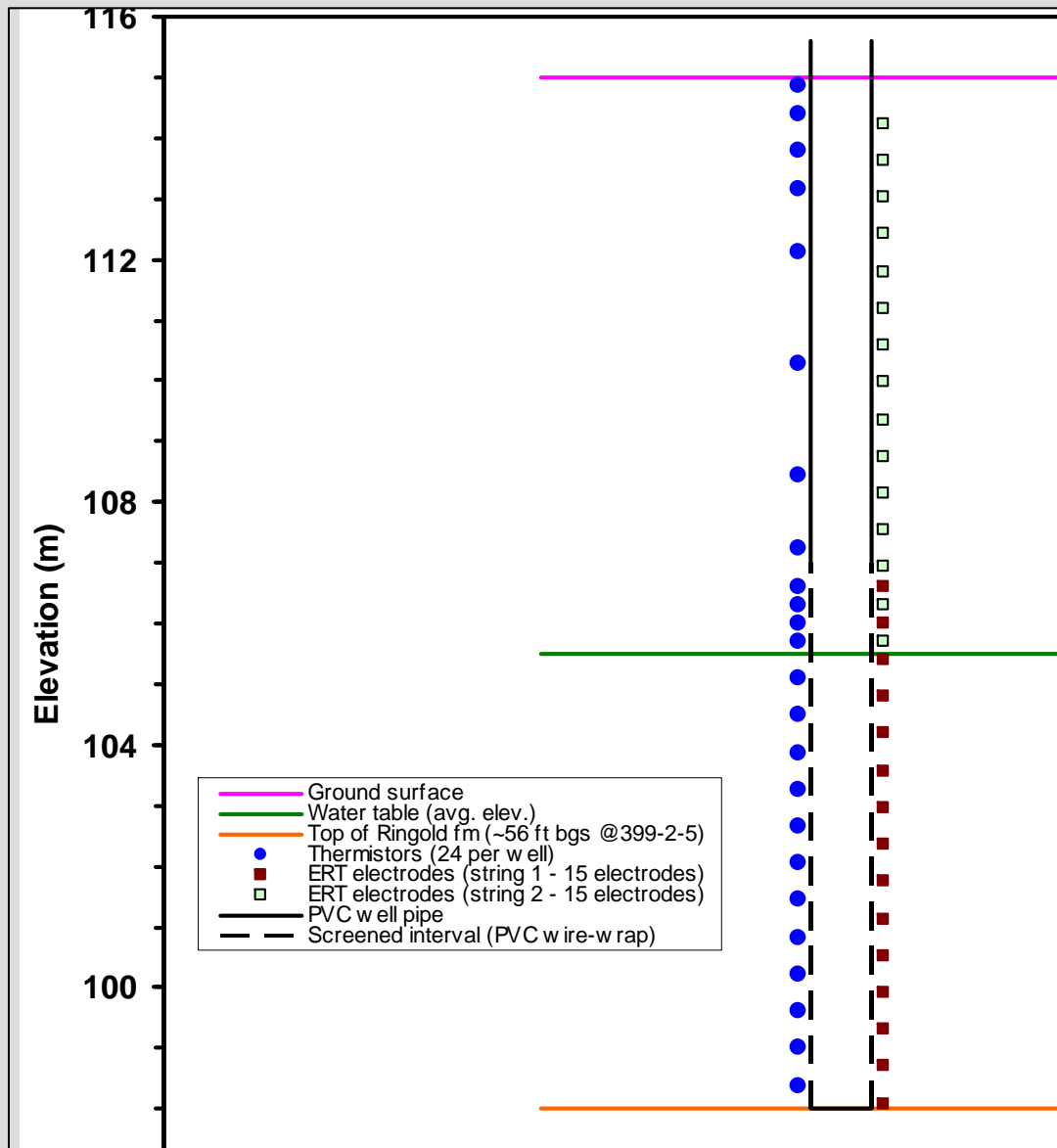
- Designed to accommodate downhole sensors and monitor unconfined aquifer

- Provide intact core and bulk grab samples for physical and chemical characterization

- Act as potential sites for injection experiments

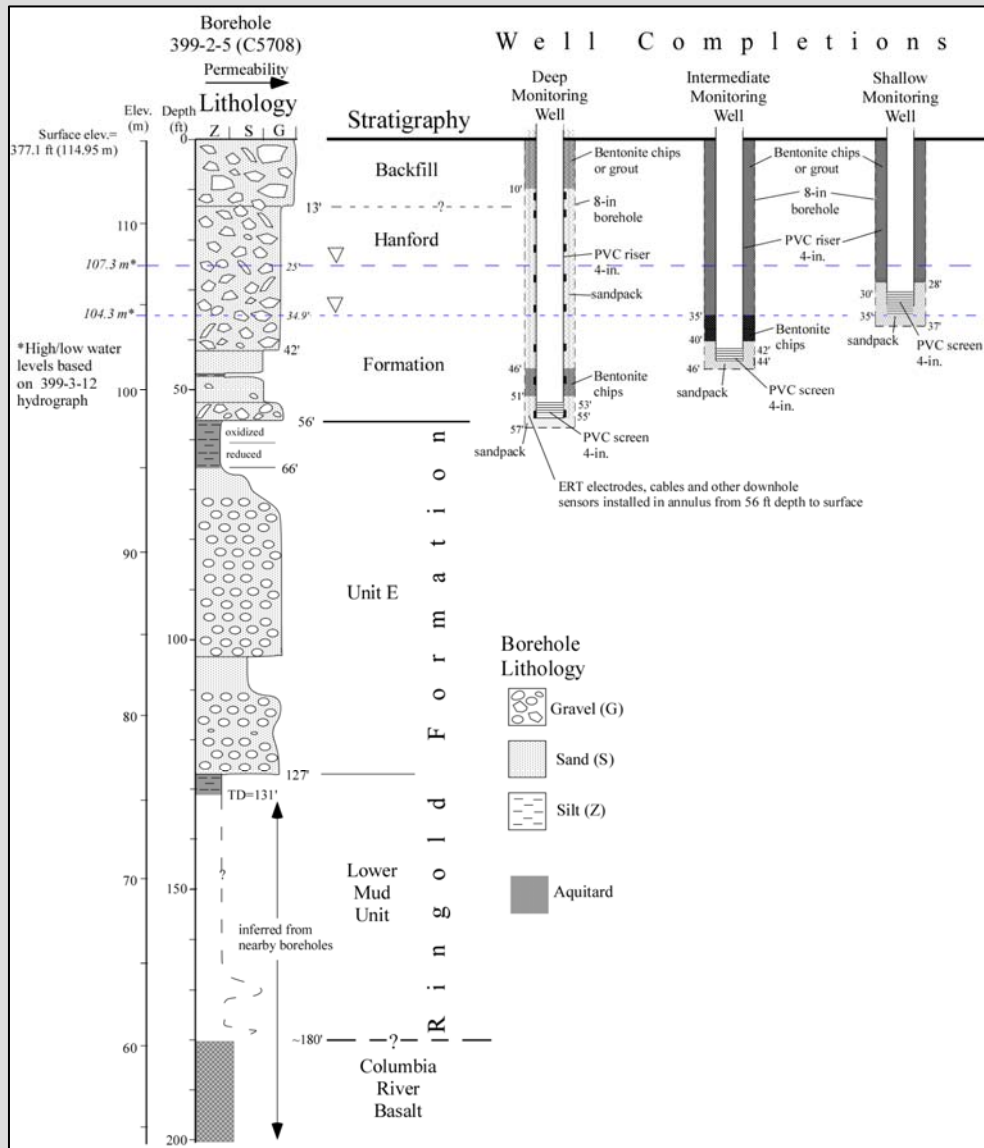
- # Wells = 25

Configuration of Downhole Sensors for ERT-Instrumented Wells



- Sensors installed in annulus outside 4-in PVC casing and screen

Well Construction: Multi-Level GW Monitoring Well Clusters



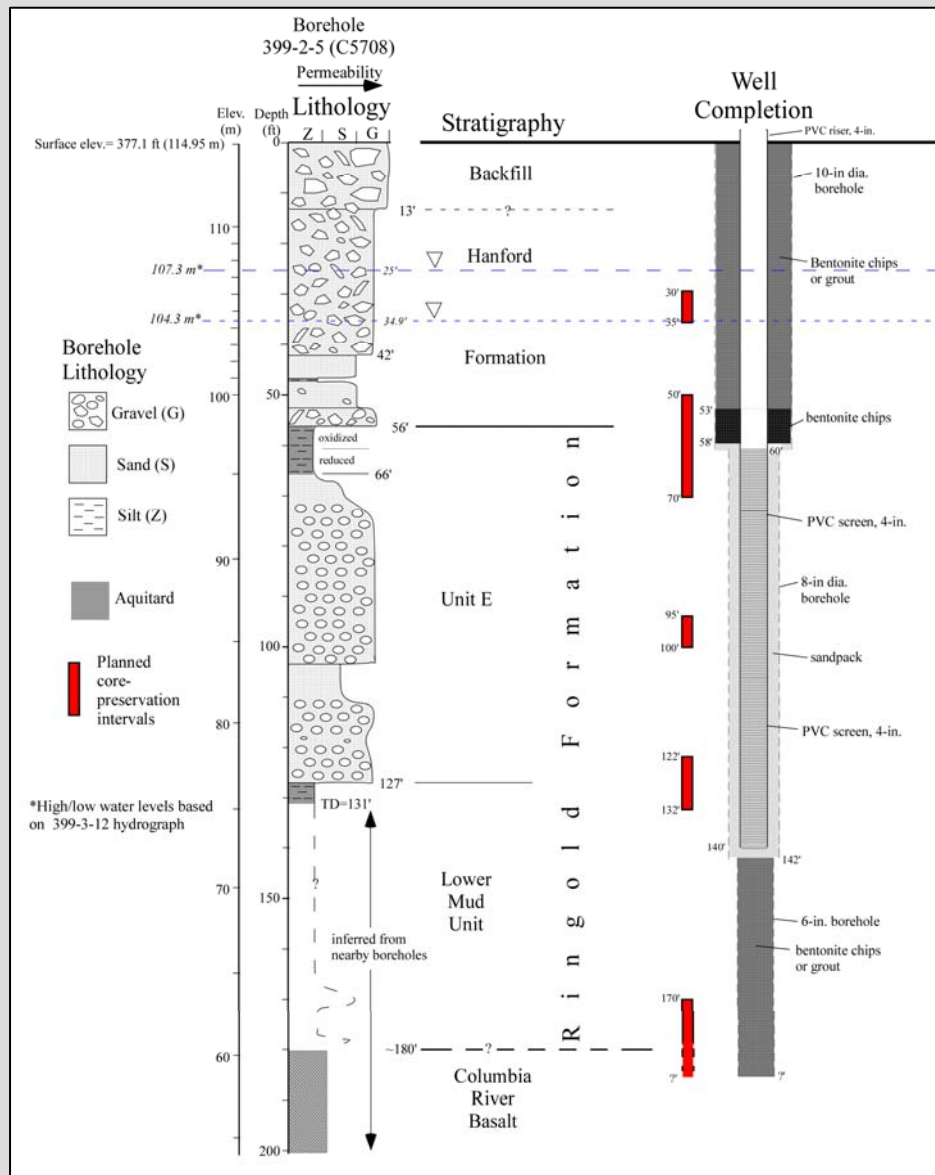
- Designed to monitor hydrochemistry of unconfined aquifer

- Accommodate downhole sensors (deepest well only)

- Provide bulk grab samples for physical and chemical characterization

- # Wells =
3 X three-well clusters
= 9

Well Construction: Deep Microbiology Characterization Well



- Designed to monitor hydrochemistry of the confined (Ringold Unit E) aquifer
- Provide intact core material from variety of saturated Ringold strata exhibiting variable redox conditions for microbiological characterization
- # Wells = 1

Downhole Geophysical Logging

- ▶ Performed on all 35 wells in temporary casing prior to well completion

- ▶ SGLS (200 seconds every ½ ft)
 - Man-made radionuclides (e.g., Cs-137, U-235, U-238)
 - Natural gamma (K-40, U-238, Th-232)
 - Total gamma

- ▶ Neutron Moisture (vadose zone only = 0 to 35 ft)

Sampling and Well-Completion Summary (page 1 of 2)

Well ID	Well Name	Function	Total depth (ft)	Temp. Casing Diameter (in.)	Sampling			Well Completion								Comments
					Type	Sample Depth Interval (ft bgs)	Approx. # samples ⁵	Completed Depth (ft)	PVC diameter (in)	Screen Interval (ft bgs)	Screen Slot size	Bentonite seal (ft bgs)	Minimum # Centralizers ⁴	Sump	Surface completion	
C6184	399-2-7	ERT electrodes	58	8	Grab ¹	0-58	30	58	4	31-56	20	0-10	3	none	Flush mount	10-20 sand to 2 ft above screen, then 40-140 sand to surface seal
C6185	399-2-8	ERT electrodes	58	8	Grab ¹	0-58	30	58	4	31-56	20	0-10	3	none	Flush mount	10-20 sand to 2 ft above screen, then 40-140 sand to surface seal
C6186	399-2-9	ERT electrodes + characterization + gw injection	58	8	Intact core ²	0-58	55	58	4	31-56	20	0-10	3	none	Flush mount	10-20 sand to 2 ft above screen, then 40-140 sand to surface seal
C6187	399-2-10	ERT electrodes	58	8	Grab ¹	0-58	30	58	4	31-56	20	0-10	3	none	Flush mount	10-20 sand to 2 ft above screen, then 40-140 sand to surface seal
C6188	399-2-11	ERT electrodes	58	8	Grab ¹	0-58	30	58	4	31-56	20	0-10	3	none	Flush mount	10-20 sand to 2 ft above screen, then 40-140 sand to surface seal
C6189	399-2-12	ERT electrodes + characterization	58	8	Intact core ²	0-58	55	58	4	31-56	20	0-10	3	none	Flush mount	10-20 sand to 2 ft above screen, then 40-140 sand to surface seal
C6190	399-2-13	ERT electrodes + characterization	58	8	Intact core ²	0-58	55	58	4	31-56	20	0-10	3	none	Flush mount	10-20 sand to 2 ft above screen, then 40-140 sand to surface seal
C6191	399-2-14	ERT electrodes	58	8	Grab ¹	0-58	30	58	4	31-56	20	0-10	3	none	Flush mount	10-20 sand to 2 ft above screen, then 40-140 sand to surface seal
C6192	399-2-15	ERT electrodes	58	8	Grab ¹	0-58	30	58	4	31-56	20	0-10	3	none	Flush mount	10-20 sand to 2 ft above screen, then 40-140 sand to surface seal
C6193	399-2-16	ERT electrodes	58	8	Grab ¹	0-58	30	58	4	31-56	20	0-10	3	none	Flush mount	10-20 sand to 2 ft above screen, then 40-140 sand to surface seal
C6194	399-2-23	ERT electrodes	58	8	Grab ¹	0-58	30	58	4	31-56	20	0-10	3	none	Flush mount	10-20 sand to 2 ft above screen, then 40-140 sand to surface seal
C6195	399-2-17	ERT electrodes	58	8	Grab ¹	0-58	30	58	4	31-56	20	0-10	3	none	Flush mount	10-20 sand to 2 ft above screen, then 40-140 sand to surface seal
C6196	399-2-18	ERT electrodes	58	8	Grab ¹	0-58	30	58	4	31-56	20	0-10	3	none	Flush mount	10-20 sand to 2 ft above screen, then 40-140 sand to surface seal
C6197	399-2-19	ERT electrodes + characterization	58	8	Intact core ²	0-58	55	58	4	31-56	20	0-10	3	none	Flush mount	10-20 sand to 2 ft above screen, then 40-140 sand to surface seal
C6198	399-2-20	ERT electrodes	58	8	Grab ¹	0-58	30	58	4	31-56	20	0-10	3	none	Flush mount	10-20 sand to 2 ft above screen, then 40-140 sand to surface seal
C6199	399-2-24	ERT electrodes	58	8	Grab ¹	0-58	30	58	4	31-56	20	0-10	3	none	Flush mount	10-20 sand to 2 ft above screen, then 40-140 sand to surface seal
C6200	399-3-25	ERT electrodes + characterization	58	8	Intact core ²	0-58	55	58	4	31-56	20	0-10	3	none	Flush mount	10-20 sand to 2 ft above screen, then 40-140 sand to surface seal
C6201	399-2-21	ERT electrodes	58	8	Grab ¹	0-58	30	58	4	31-56	20	0-10	3	none	Flush mount	10-20 sand to 2 ft above screen, then 40-140 sand to surface seal
C6202	399-2-22	ERT electrodes	58	8	Grab ¹	0-58	30	58	4	31-56	20	0-10	3	none	Flush mount	10-20 sand to 2 ft above screen, then 40-140 sand to surface seal

Sampling and Well-Completion Summary (page 2 of 2)

C6203	399-3-26	ERT electrodes + characterization	58	8	Intact core ²	0-58	55	58	4	31-56	20	0-10	3	none	Flush mount	10-20 sand to 2 ft above screen, then 40-140 sand to surface seal
C6204	399-3-27	ERT electrodes	58	8	Grab ¹	0-58	30	58	4	31-56	20	0-10	3	none	Flush mount	10-20 sand to 2 ft above screen, then 40-140 sand to surface seal
C6205	399-3-28	ERT electrodes	58	8	Grab ¹	0-58	30	58	4	31-56	20	0-10	3	none	Flush mount	10-20 sand to 2 ft above screen, then 40-140 sand to surface seal
C6206	399-3-29	ERT electrodes	58	8	Grab ¹	0-58	30	58	4	31-56	20	0-10	3	none	Flush mount	10-20 sand to 2 ft above screen, then 40-140 sand to surface seal
C6207	399-2-23	ERT electrodes	58	8	Grab ¹	0-58	30	58	4	31-56	20	0-10	3	none	Flush mount	10-20 sand to 2 ft above screen, then 40-140 sand to surface seal
C6208	399-2-24	ERT electrodes + characterization	58	8	Intact core ²	0-58	55	58	4	31-56	20	0-10	3	none	Flush mount	10-20 sand to 2 ft above screen, then 40-140 sand to surface seal
C6210	399-2-26	Shallow gw monitoring	37	8	Grab ¹	0-37	18	37	4	30-35	20	0-28	2	2 ft	Flush mount	
C6211	399-2-27	Intermediate gw monitoring	46	8	Grab ¹	0-46	23	46	4	42-44	20	0-40	2	none	Flush mount	
C6212	399-2-28	Deep gw monitoring + ERT electrodes	57	8	Grab ¹	0-57	29	57	4	53-55	20	0-10, 46-51	3	none	Flush mount	
C6213	399-3-30	Shallow gw monitoring	37	8	Grab ¹	0-37	18	37	4	30-35	20	0-28	2	2 ft	Flush mount	
C6214	399-3-31	Intermediate gw monitoring	46	8	Grab ¹	0-46	23	46	4	42-44	20	0-40	2	none	Flush mount	
C6215	399-3-32	Deep gw monitoring + ERT electrodes	57	8	Grab ¹	0-57	29	57	4	53-55	20	0-10, 46-51	3	none	Flush mount	
C6216	399-2-29	Shallow gw monitoring	37	8	Grab ¹	0-37	18	37	4	30-35	20	0-28	2	2 ft	Flush mount	
C6217	399-2-30	Intermediate gw monitoring	46	8	Grab ¹	0-46	23	46	4	42-44	20	0-40	2	none	Flush mount	
C6218	399-2-31	Deep gw monitoring + ERT electrodes	57	8	Grab ¹	0-57	29	57	4	53-55	20	0-10, 46-51	3	none	Flush mount	
C6209	399-2-25	Deep Microbiological Characterization + gw monitoring	0-60	10	Grab ¹	0-30, 35-50, 70-95, 100-122, 132-170	45	142	4	60-140	10	0-58, 142-TD	5	none	Standard	20-40 mesh sandpack, telescope temp casing across aquitards
			0-142	8	Intact core ²	30-35, 50-70, 95-100, 122-132, 170-180?	50									
			0~180	6												
													101			
		² Geologic samples														
		Grab (plastic bucket)	750													
		1' intact lexan core	435													
		Total	1185													
													¹ Core sample from thin, flexible plastic sleeve transferred to 2-gal. plastic bucket after photographing and logging			
													⁴ Non-metallic			
													³ Intact core sample collected downhole in 1-ft long, ~4-in dia. lexan liners			

Geologic Field Characterization

- ▶ Continuous digital photographic log
- ▶ Sample log
- ▶ Geologic field log to include detailed descriptions of:
 - Sediment class
 - Range in particle size
 - Maximum particle size
 - Sorting
 - Roundness
 - Mineralogy (esp. mafic % in sand vs. gravel fraction)
 - Color
 - Consolidation
 - Cementation
 - Reaction to 10% HCl (i.e., relative concentration CaCO_3)
 - Sedimentary structure
 - Fabric
 - Moisture

Sample ID, Inventory, and Storage

- ▶ Sample ID combination of well name (minus 399 prefix) + sample type (“G” or “C”) + depth interval

Example: Sample ID for lexan-lined core sample from 36 to 37 ft depth in well 399-2-16 =
2-16-C36-37

- ▶ Two labels with sample ID affixed to each sample (top and side)
- ▶ Samples stored onsite in dedicated seatainer
- ▶ Sample inventory maintained of all samples collected with record of distribution to onsite/offsite investigators