S-SX Sediment Characterization Results and Issues

R. Jeff Serne

PNNL

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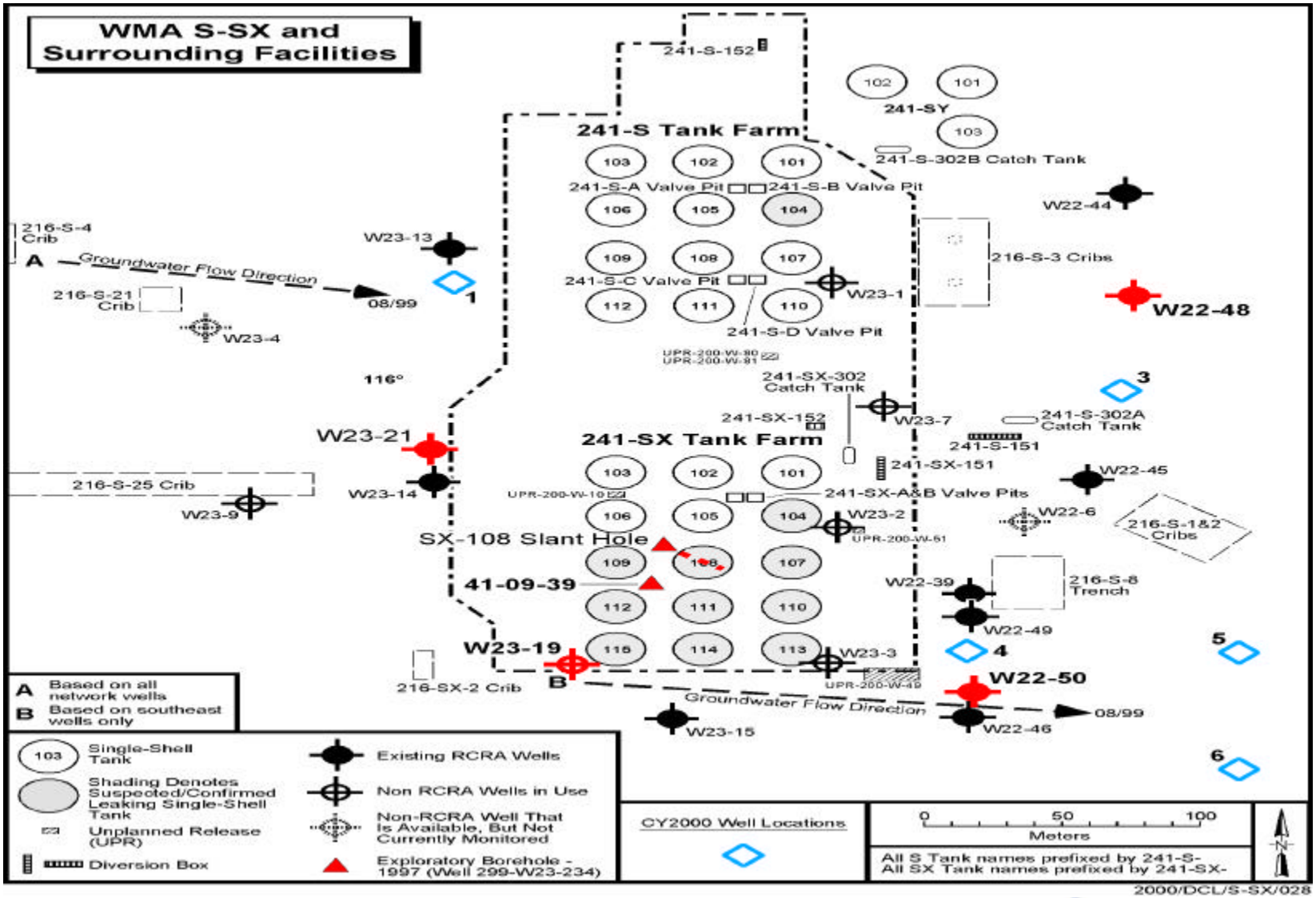
Core Samples

- Contaminated
  - SX41-09-39 extension
  - SX41-09-39 side-wall
  - SX-115 (W23-19)
  - SX-108 (slant)
- Uncontaminated
  - W22-50 (Myers)
  - W22-48 (Zachara)
  - W23-21
- Archived RCRA
  - Grab samples every 5 ft.



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Drilling Techniques

- Drive Barrel with near continuous split spoons
  - SX41-09-39 (131 to 215 ft)
  - SX-115 (W23-19) thru Hanford/Plio-Pleistocene
  - Cold Boreholes (W22-48, W22-50, W23-21)
- Pile Drive (Closed Pipe) with Periodic Split Spoon or Side-wall Coring
  - SX41-09-39 (0 – 130 ft) side-wall
  - SX-108 slant borehole (0 – 144 ft vertical)

Drilling Techniques

- Techniques varied because of worker safety and waste concerns
- (don't bring up too much hot dirt that needs to be disposed and that would dose workers)
- SX41-09-39 closed end casing to 131 ft already in place
- Can't drive barrel coarse/consolidated Ringold efficiently

Characterization Strategy

- Staged Approach
  - Moisture content, Gamma Energy, Water Extract (pH, EC, anions, cations), geologic description on all sleeves
  - Acid Extract, Pore Water Extraction, Carbonate, Organic Content, Particle Size, Mineralogy, Sr-90, Actinides on selected sleeves
  - Desorption tests, “sciencey” tests on a few

Characterization Objectives

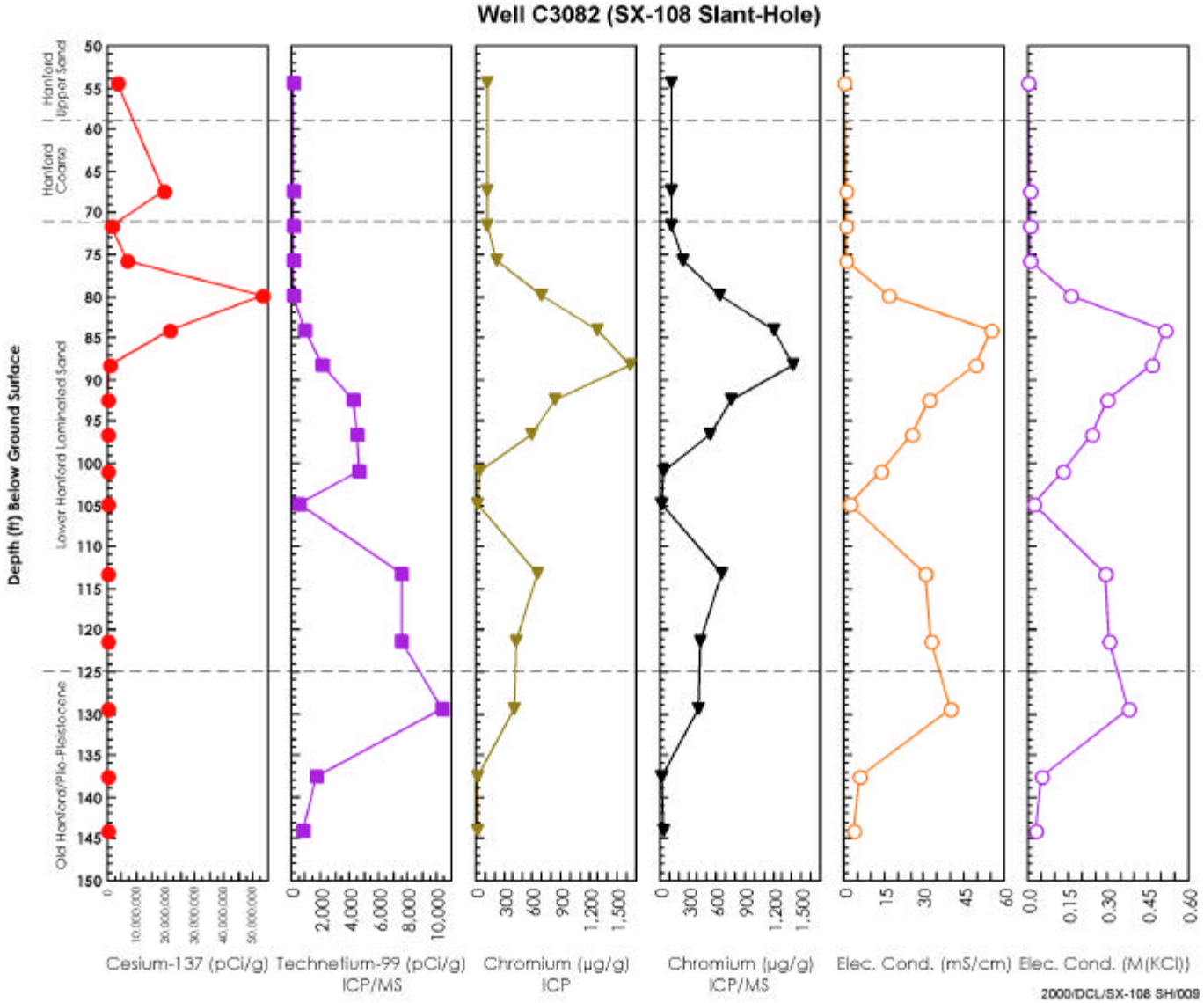
- Define vertical distribution of “risk driver” contaminants
- Address mobility potential of contaminants
- Gather data to aid in elucidating geochemical mechanisms/processes that control contaminants fate
- Compare nearby Clean with Hot Sediment to differentiate natural variation from tank

1 to 1 Water Extract

- Low moisture content precludes direct extraction of porewater in most samples
- Long list of constituents to measure –need significant volume
- Cores are small (1 kg to 4 kg—50 to 200 ml max porewater)
- Have shown for most constituents that dilution corrected 1:1 extracts == porewater

Acid Extracts vs. Fusion vs. XRF

- Acid extract is a proxy for the total amount in sediment; fusions dilute too much to get data for many
- Doesn't work for Si, partial recovery for most sediment major elements (Al, Fe, Mn, Ti, Alkaline Earths)
- Standard Procedure for doing Nukes
- Does good job on "anthropormorhics"
- Getting a hot XRF; don't have laser ablation ICP



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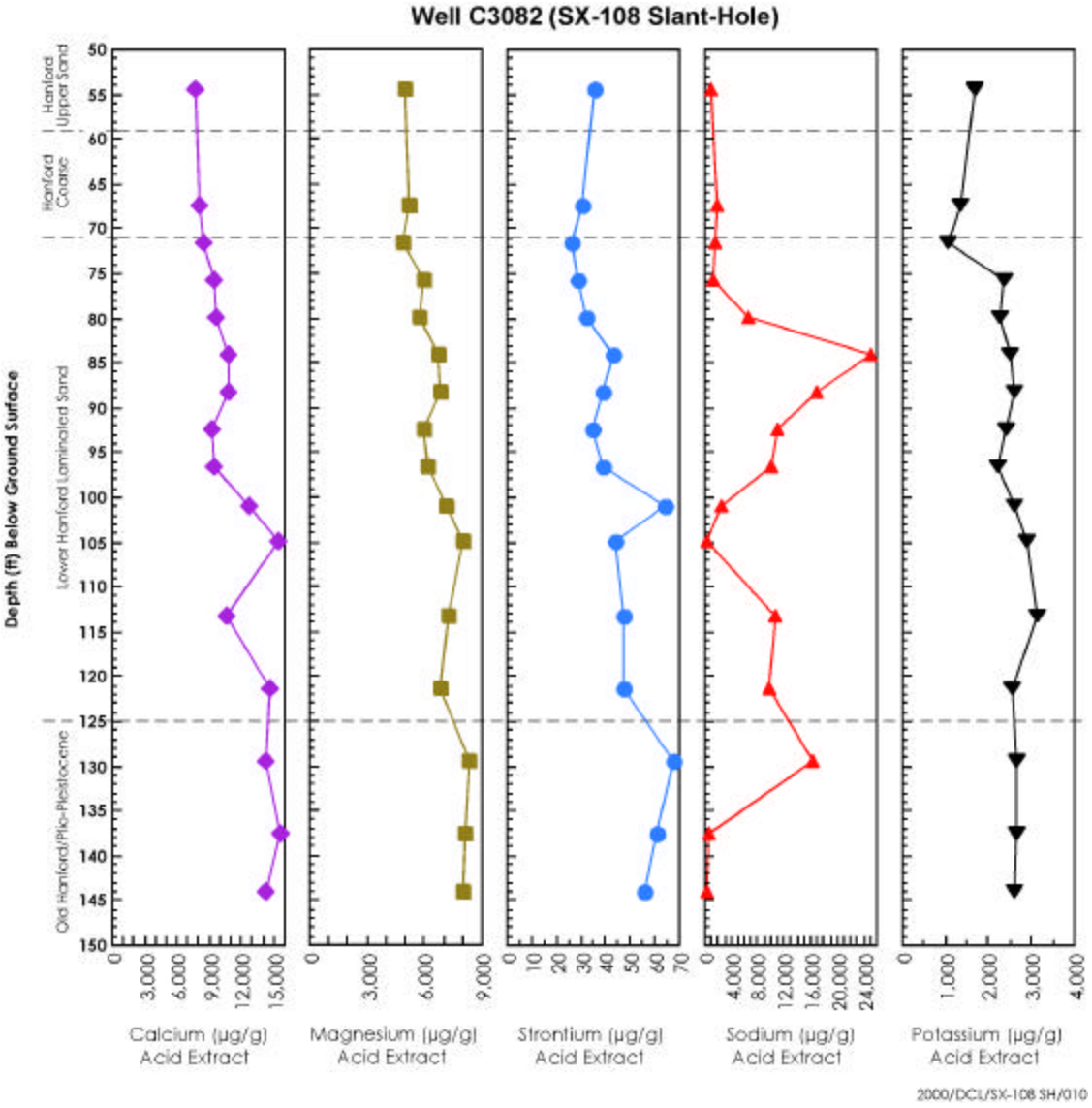

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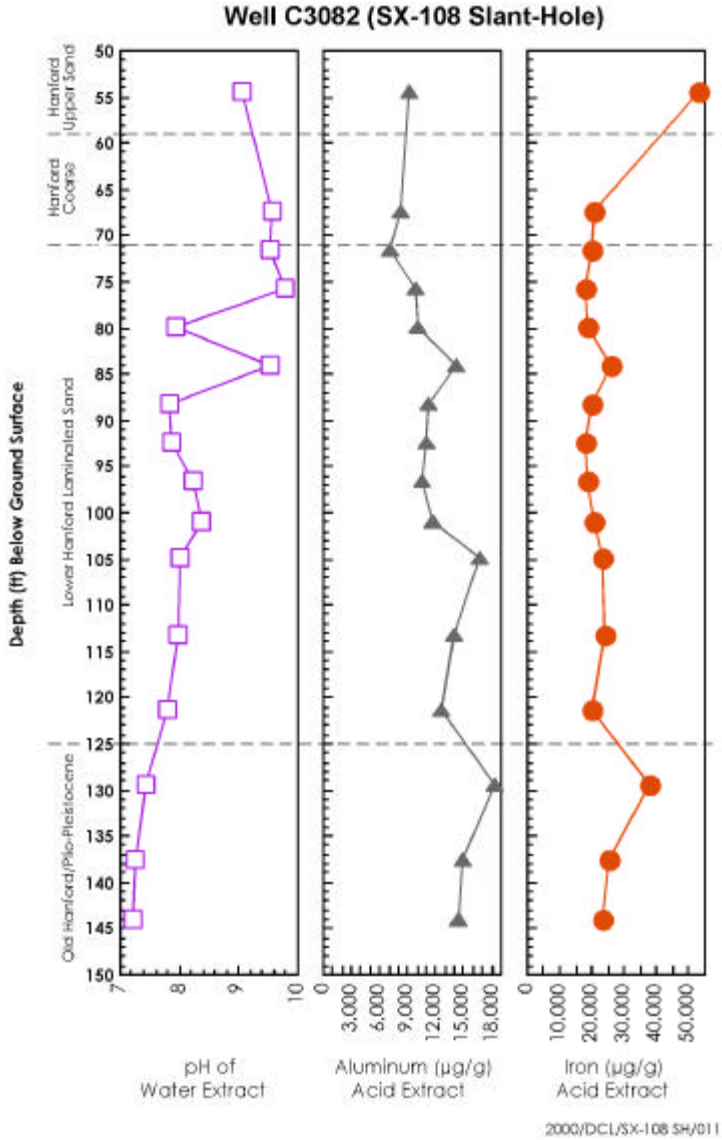

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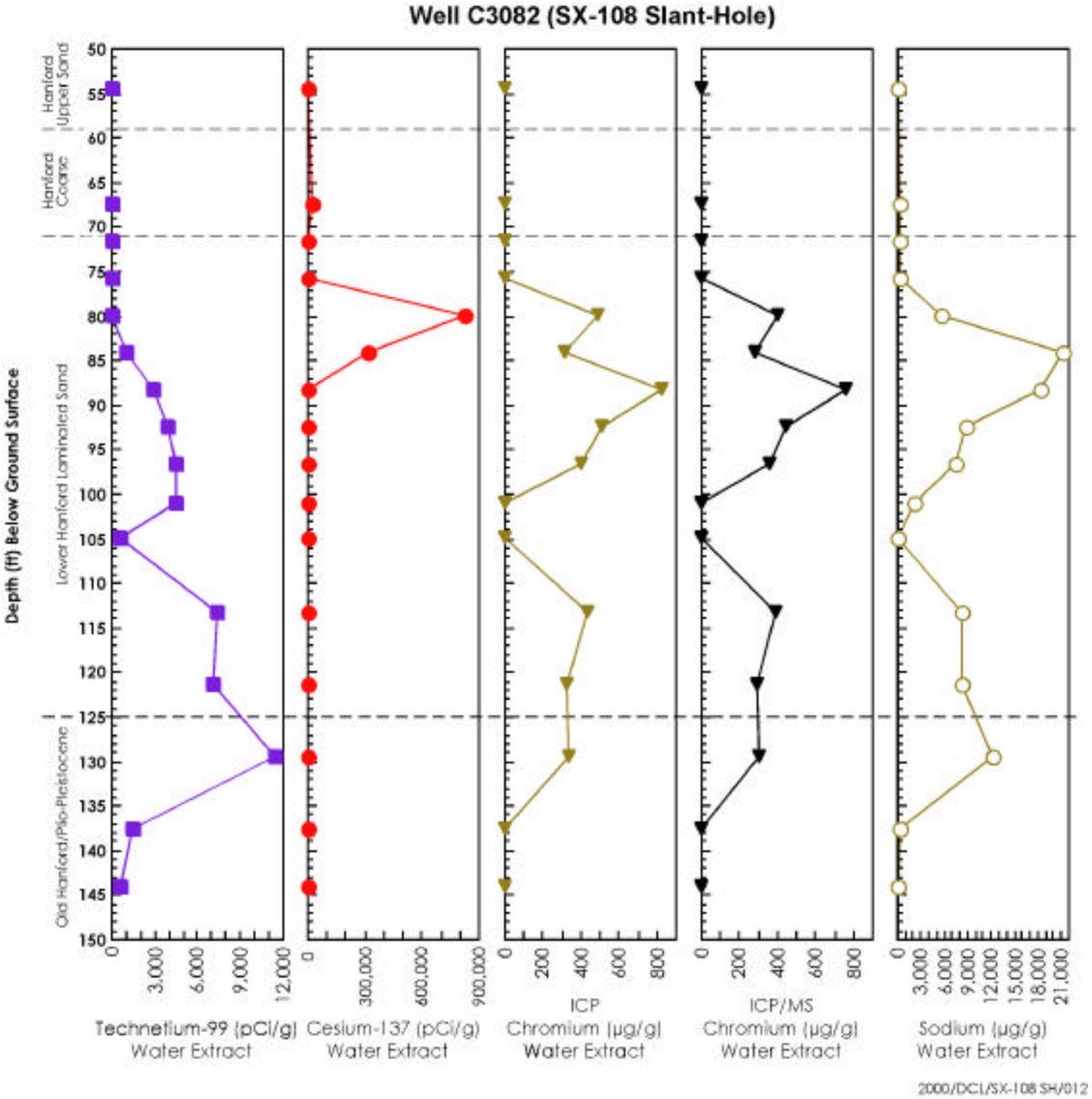

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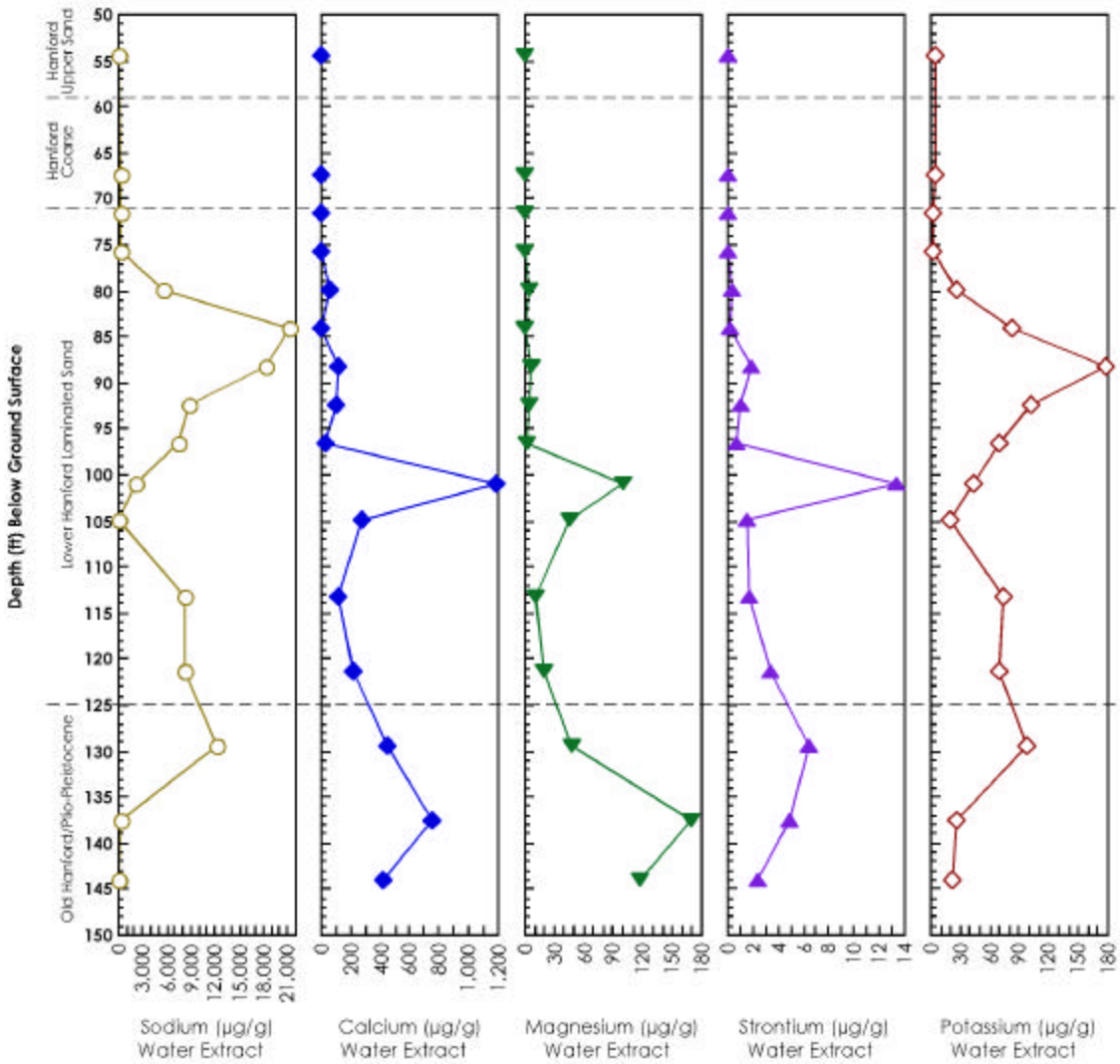
Well C3082 (SX-108 Slant-Hole)



2000/DCL/SX-108 SH/013

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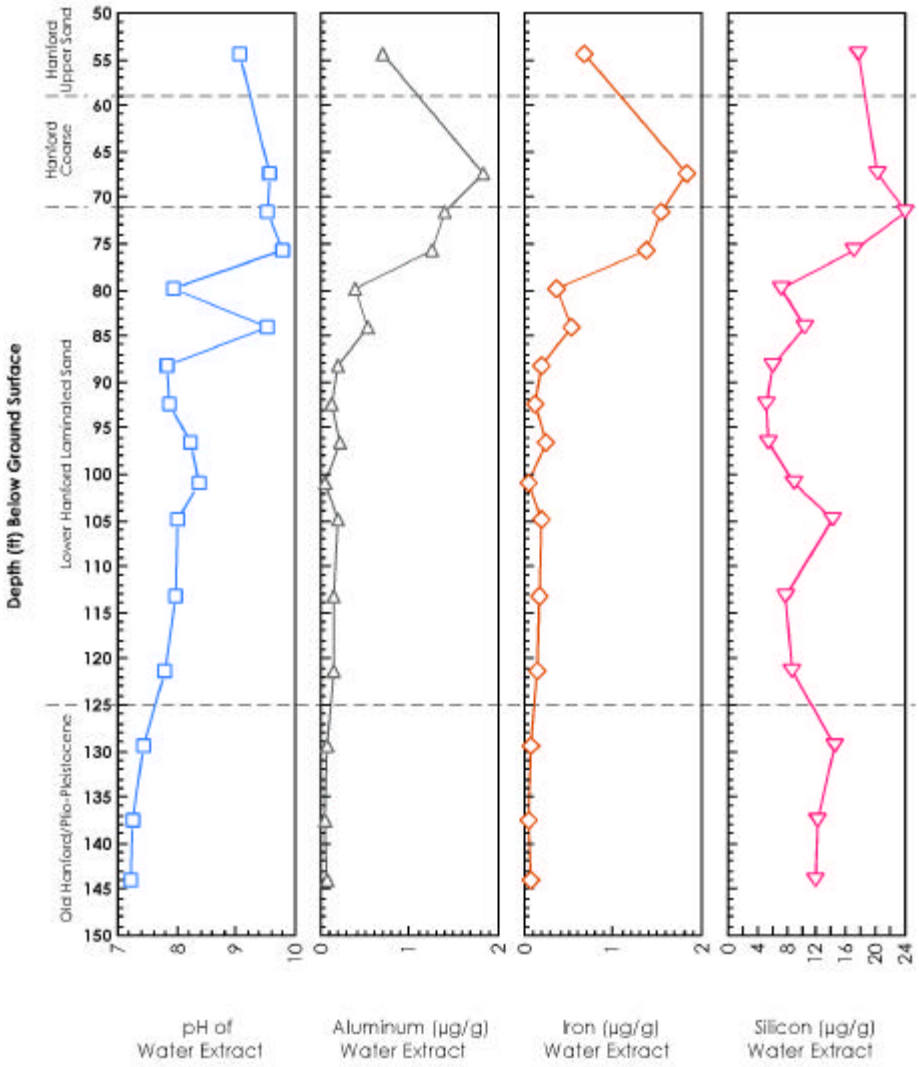

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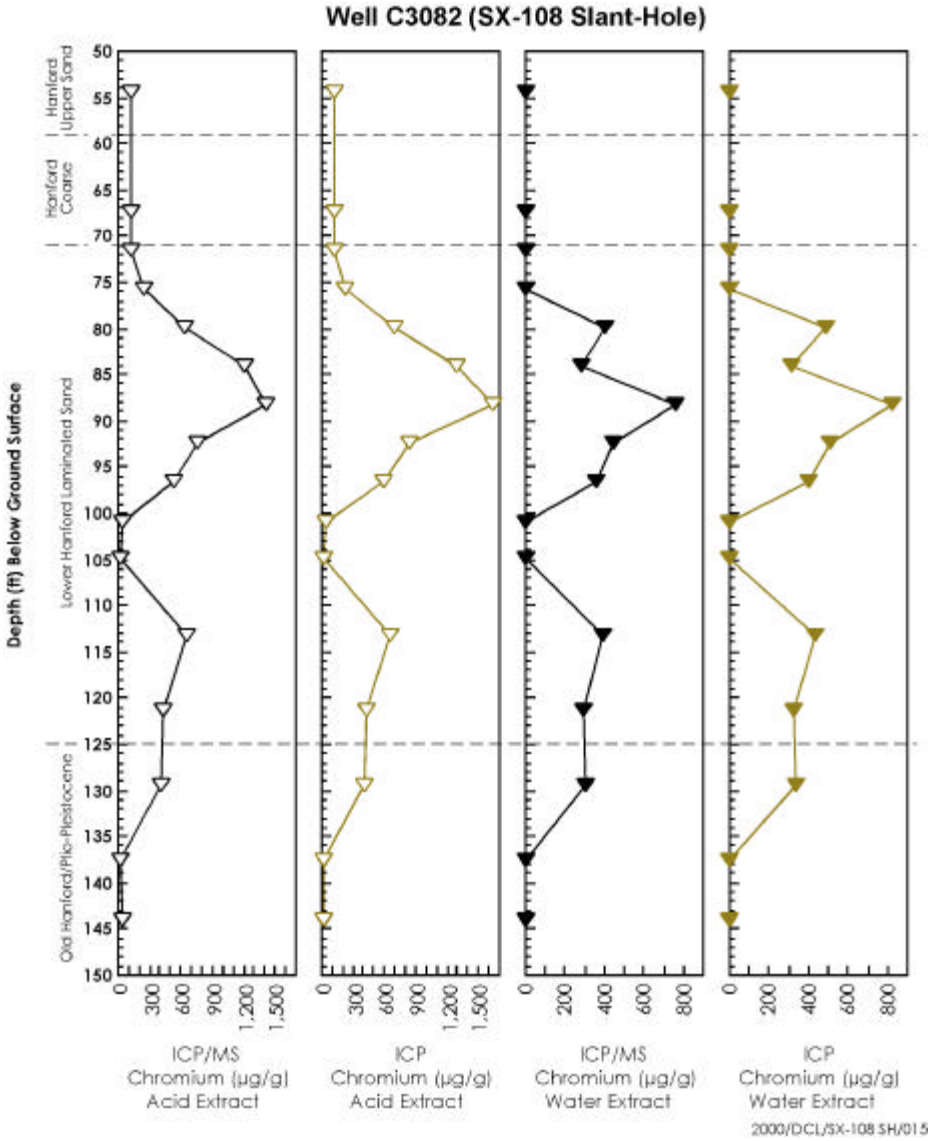

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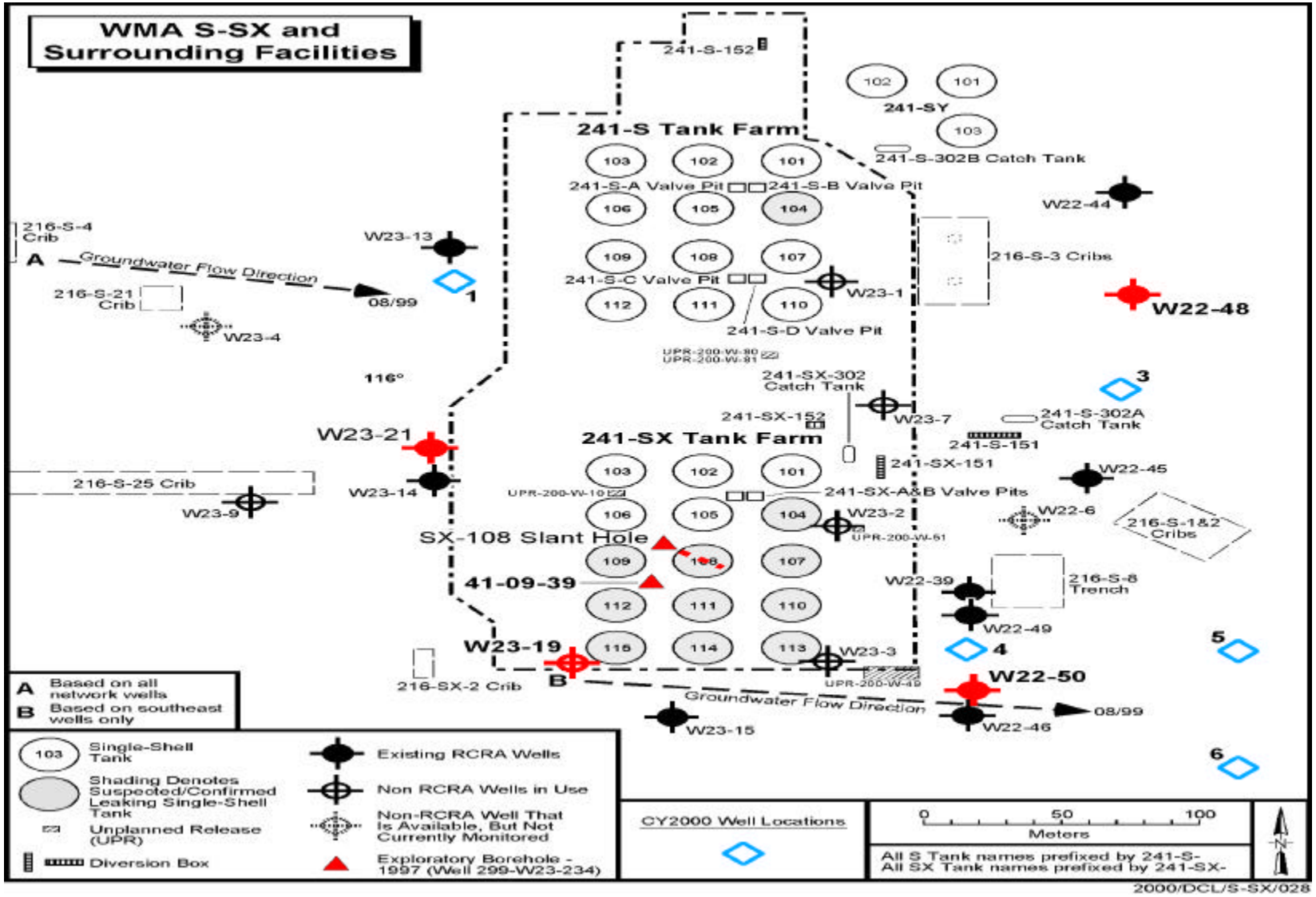

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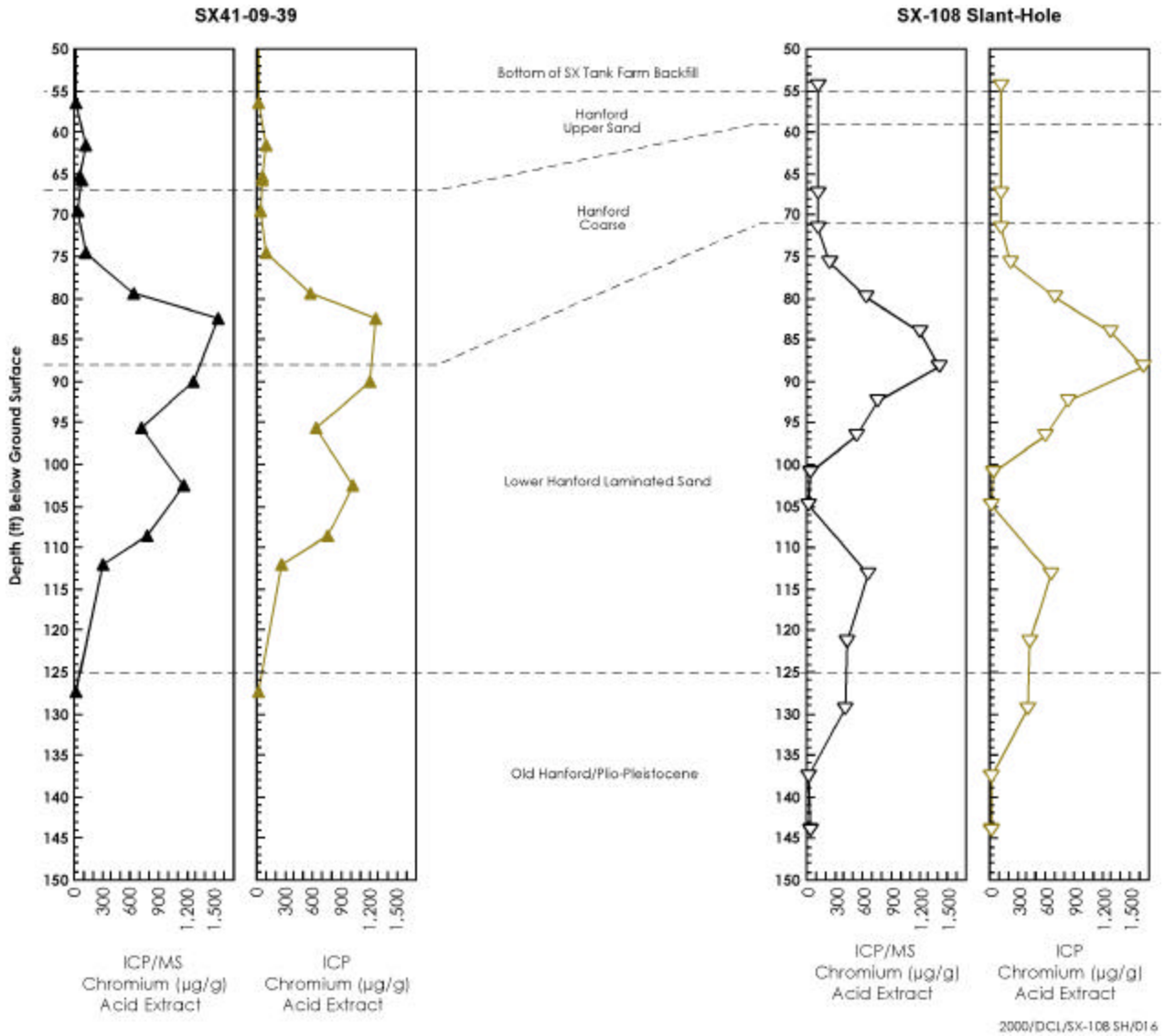

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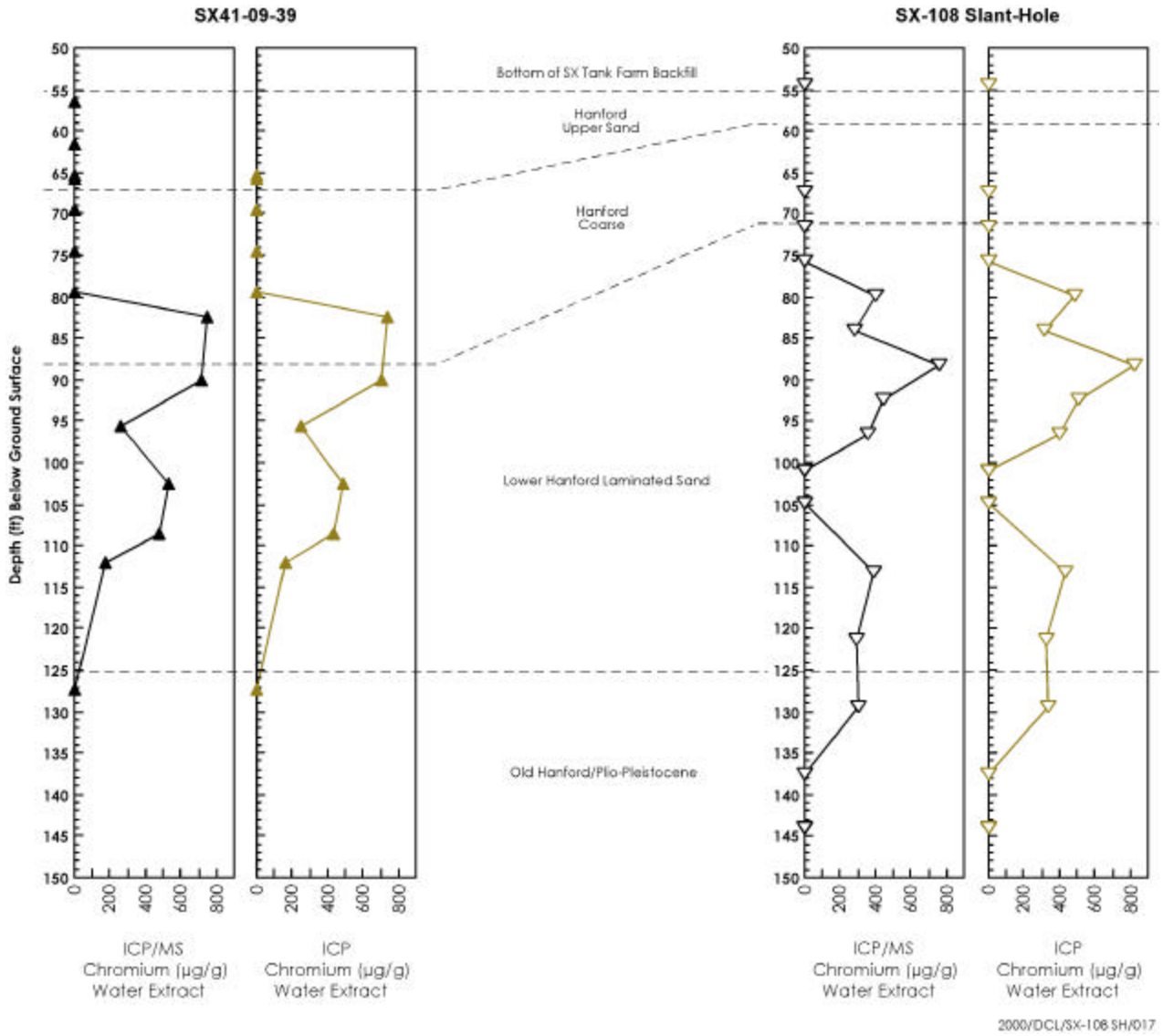

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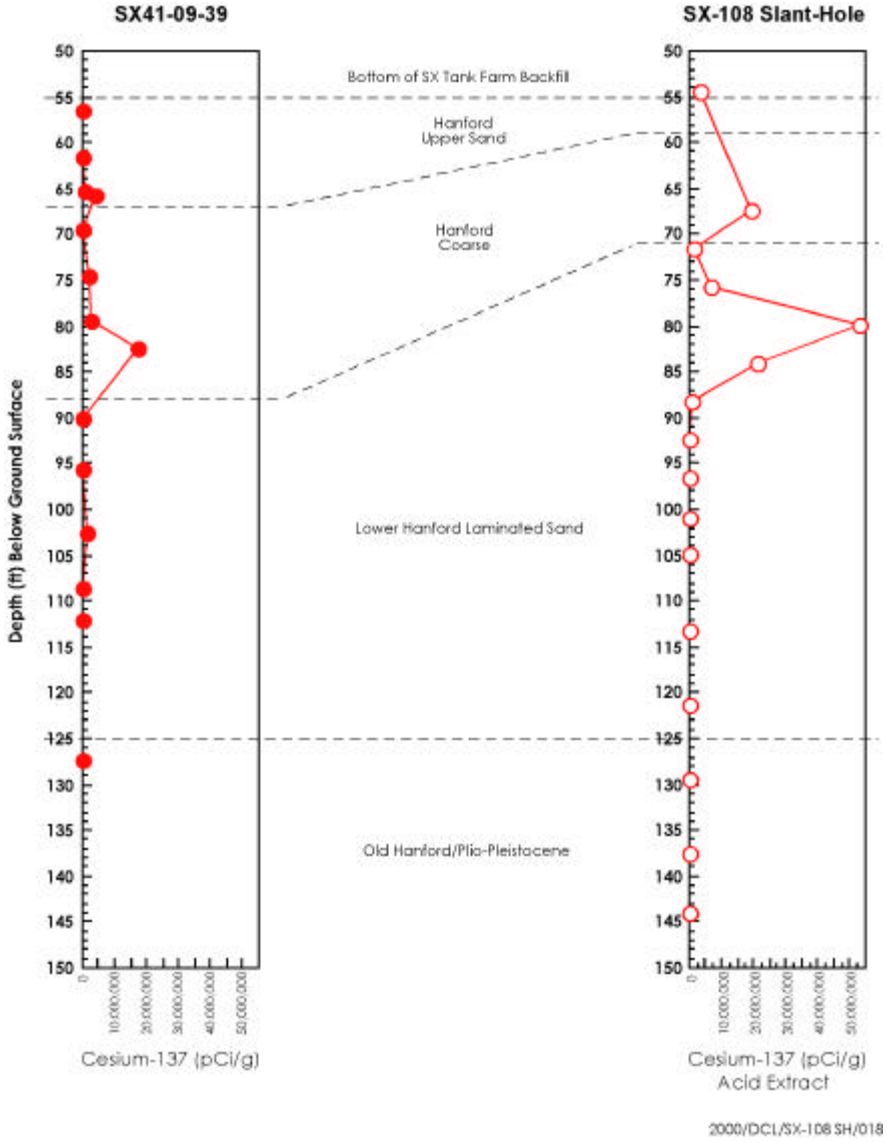

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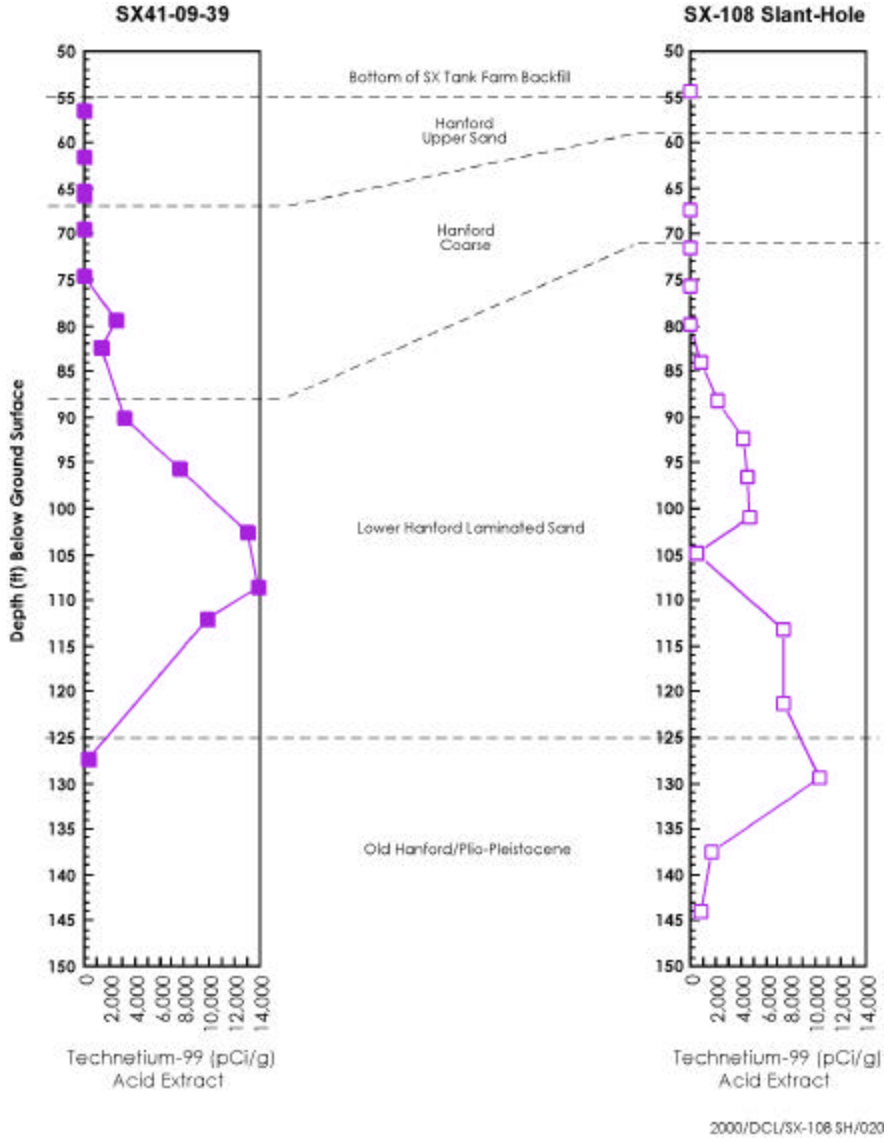

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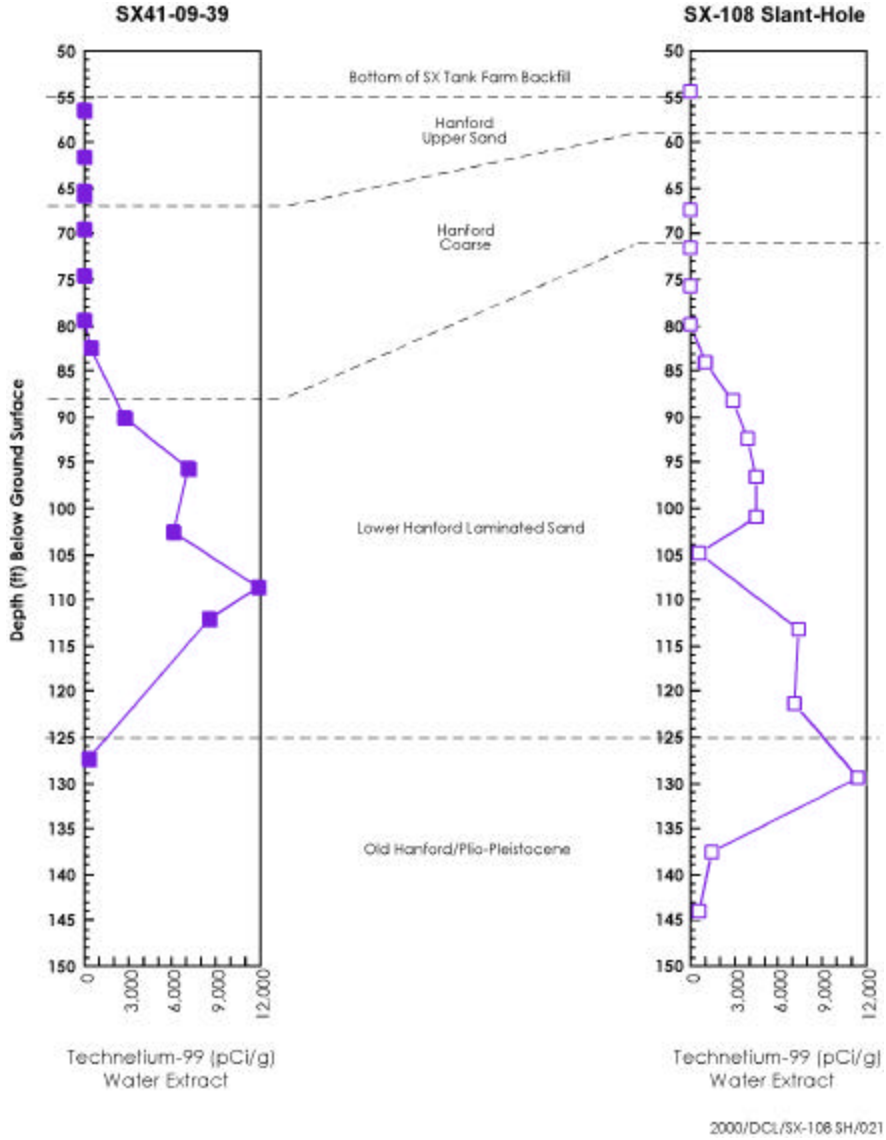

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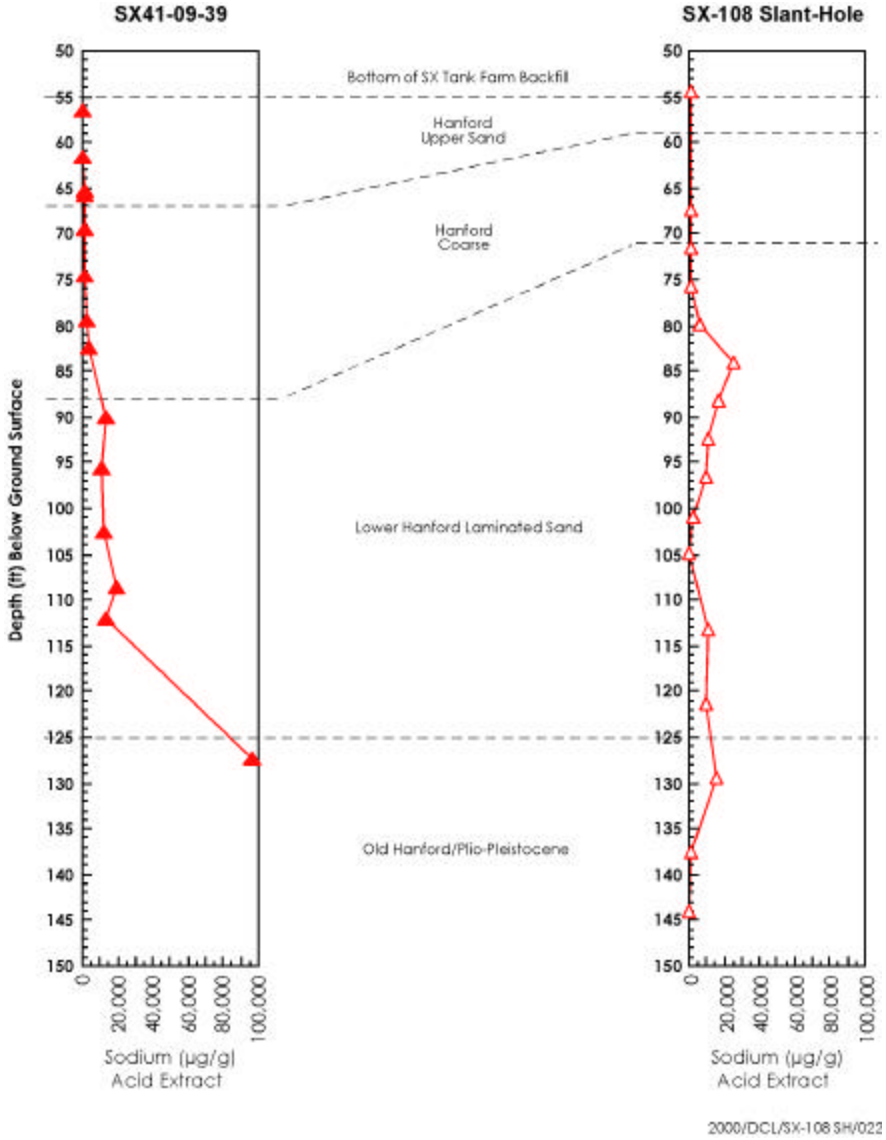

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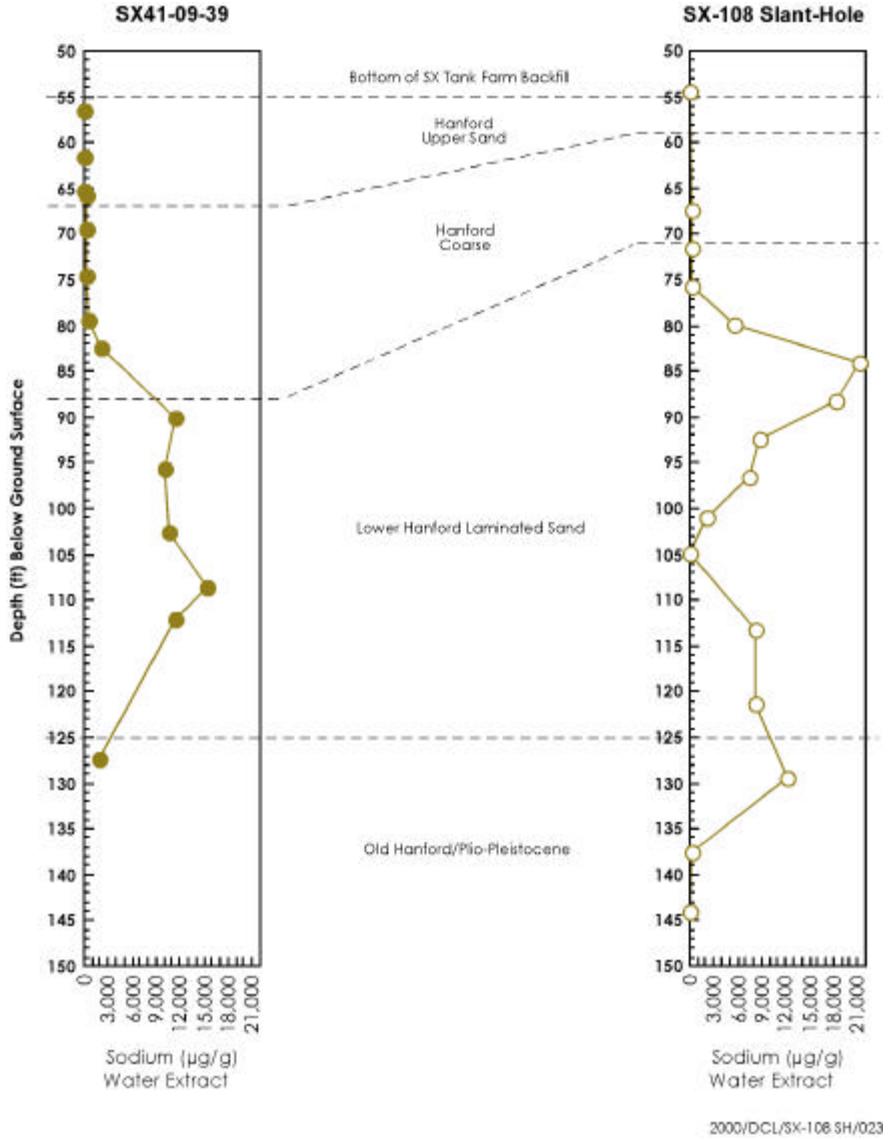

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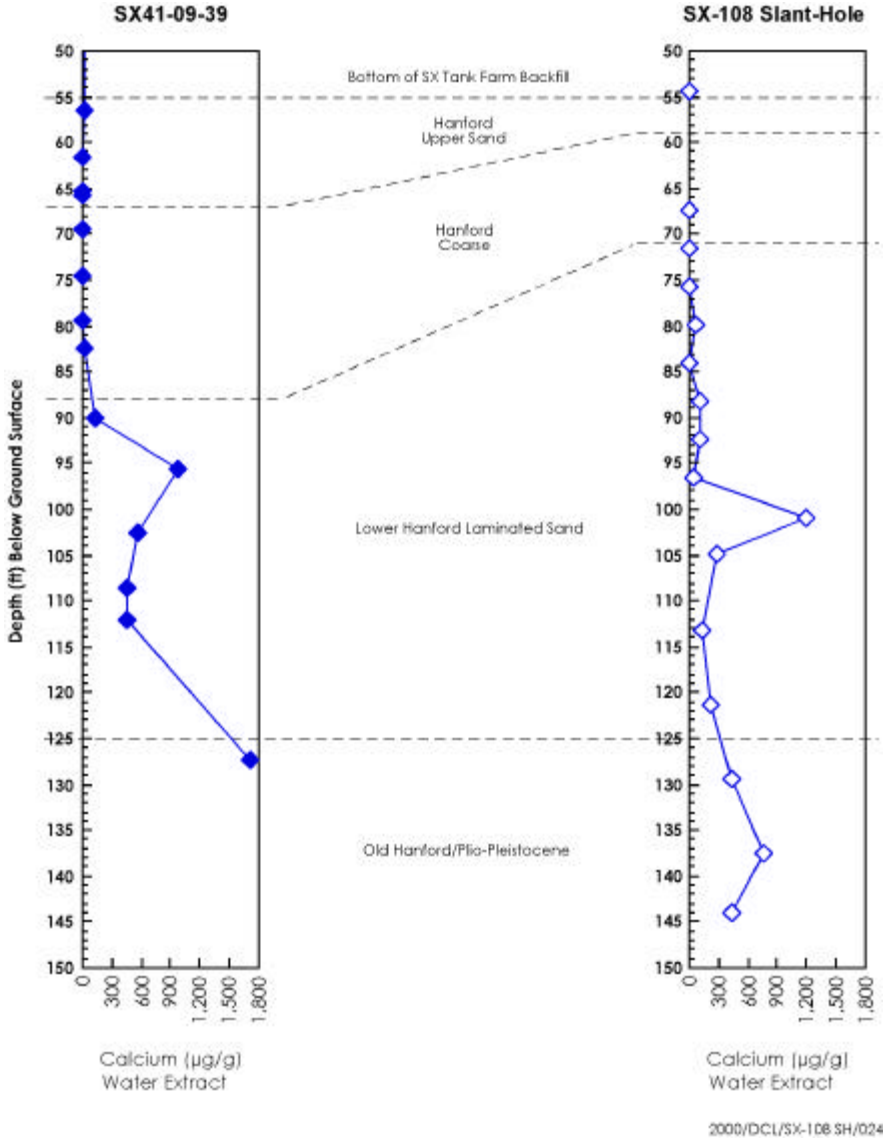

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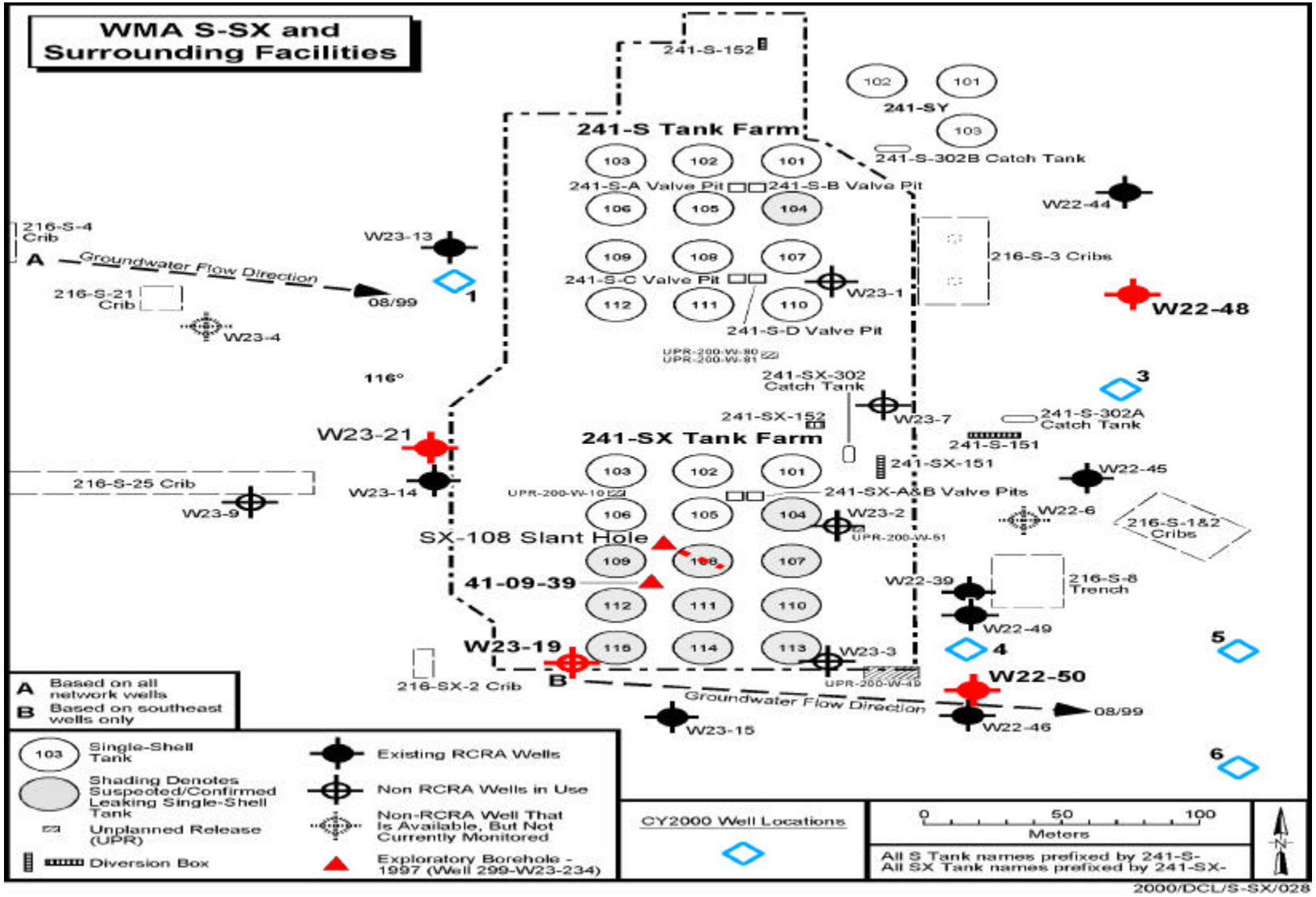

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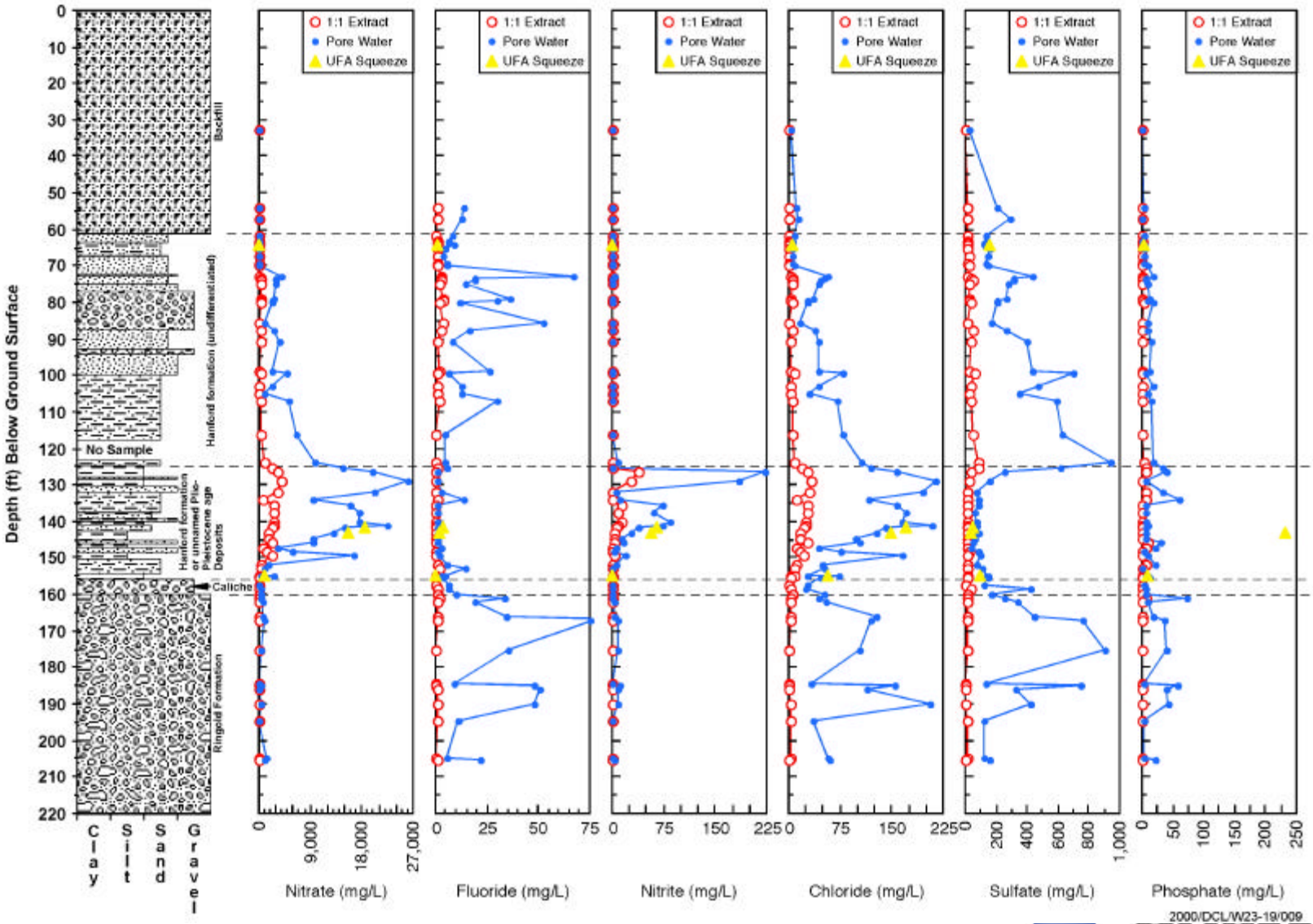
Well 299-W23-19



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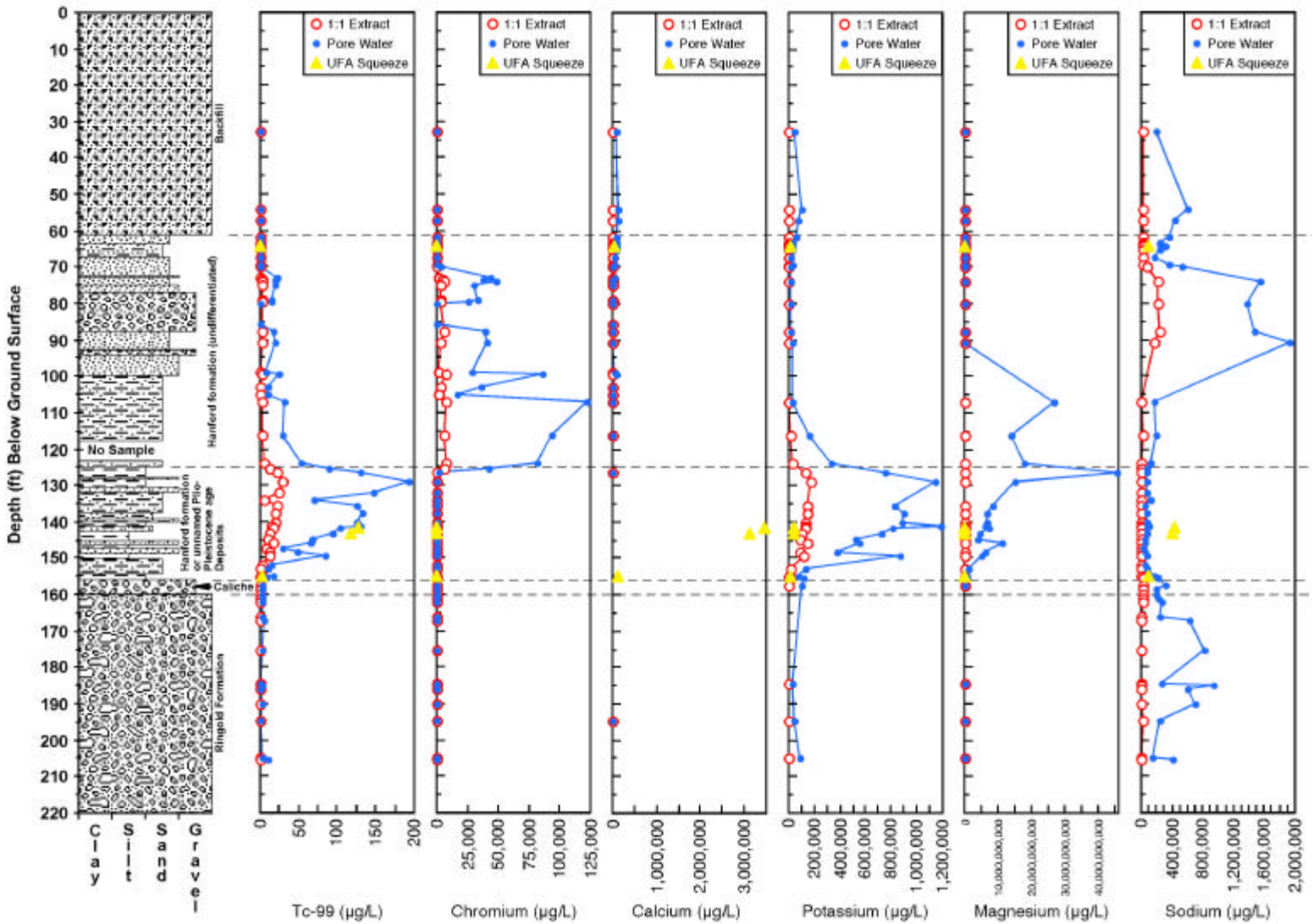

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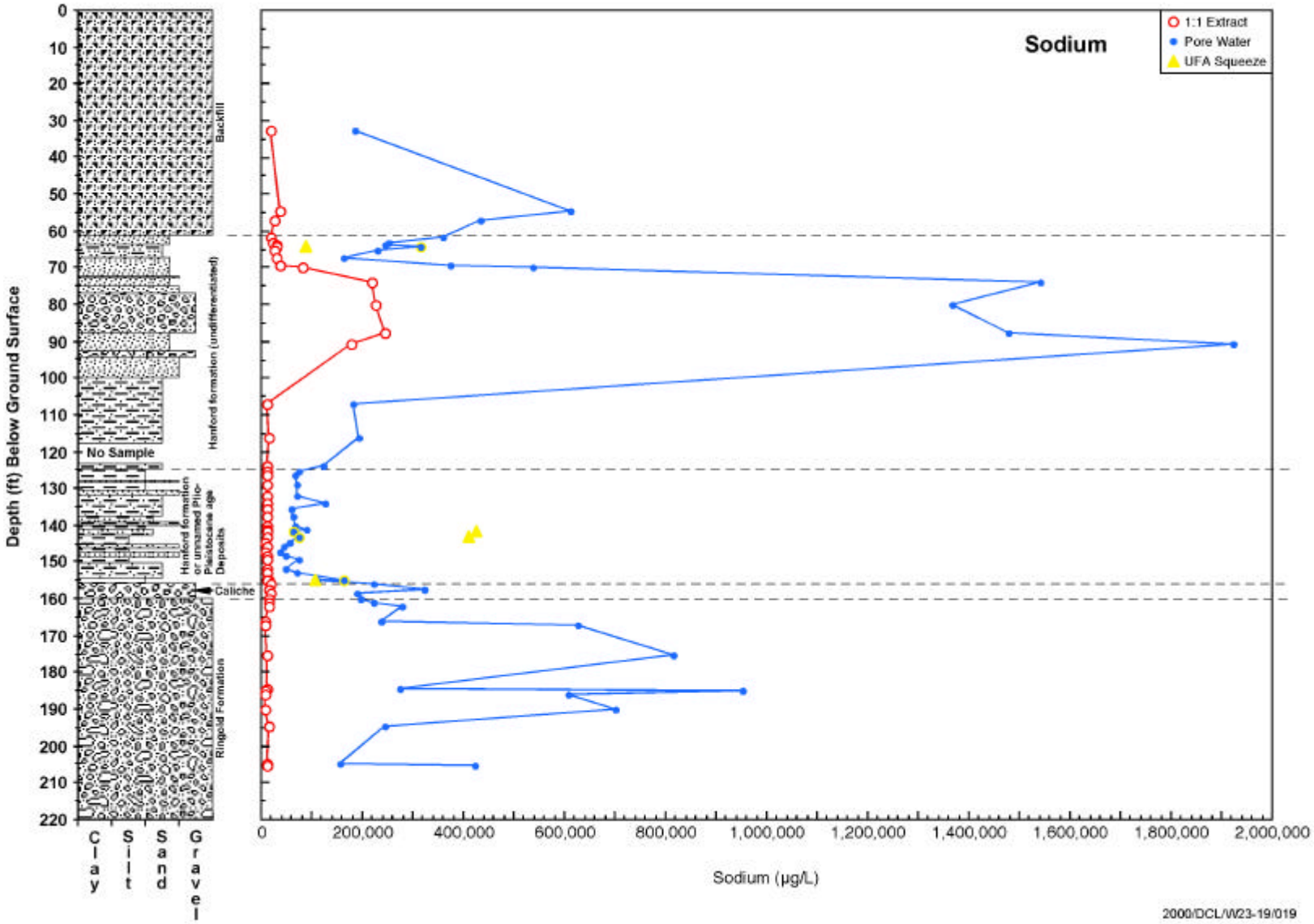

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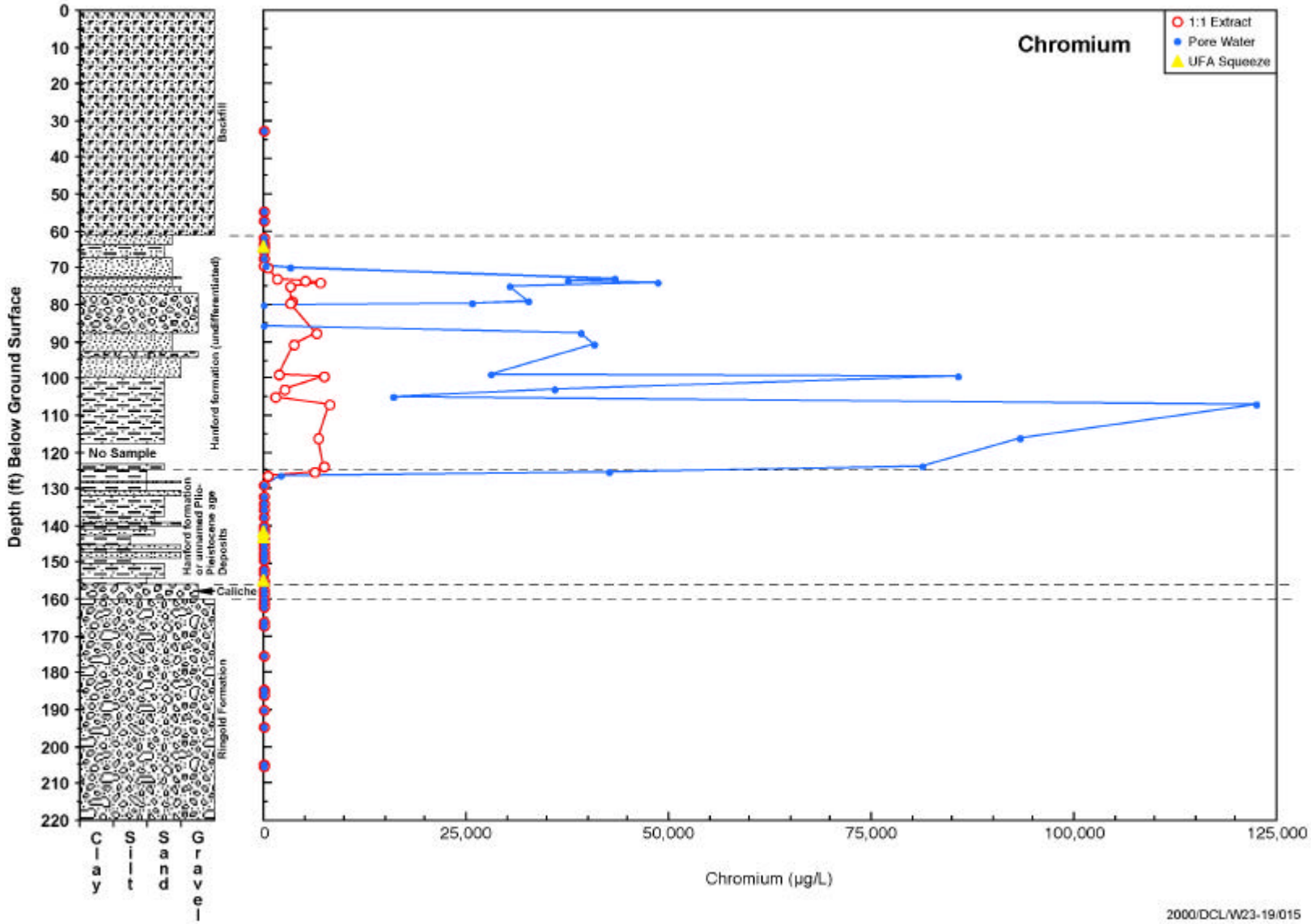

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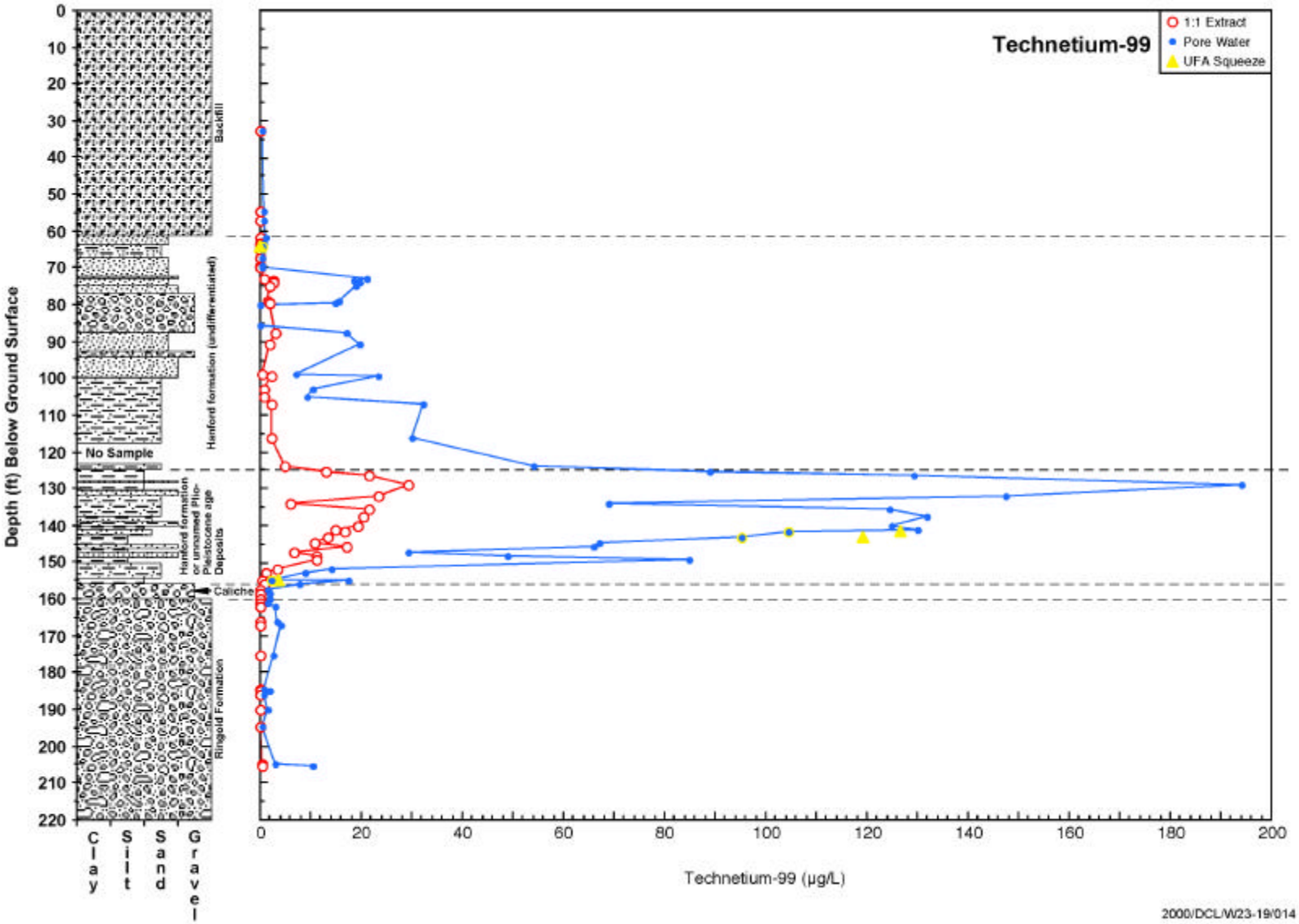

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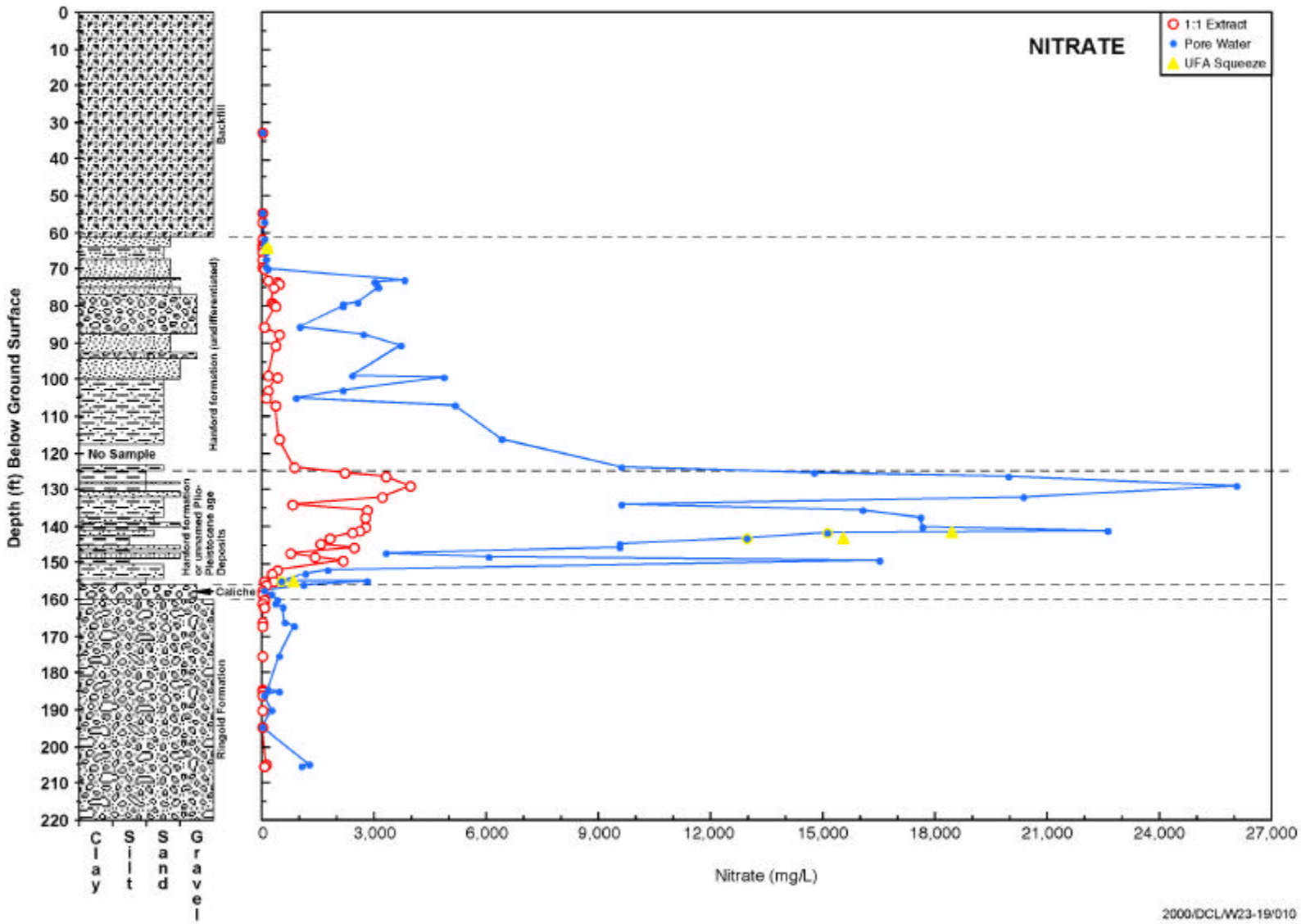

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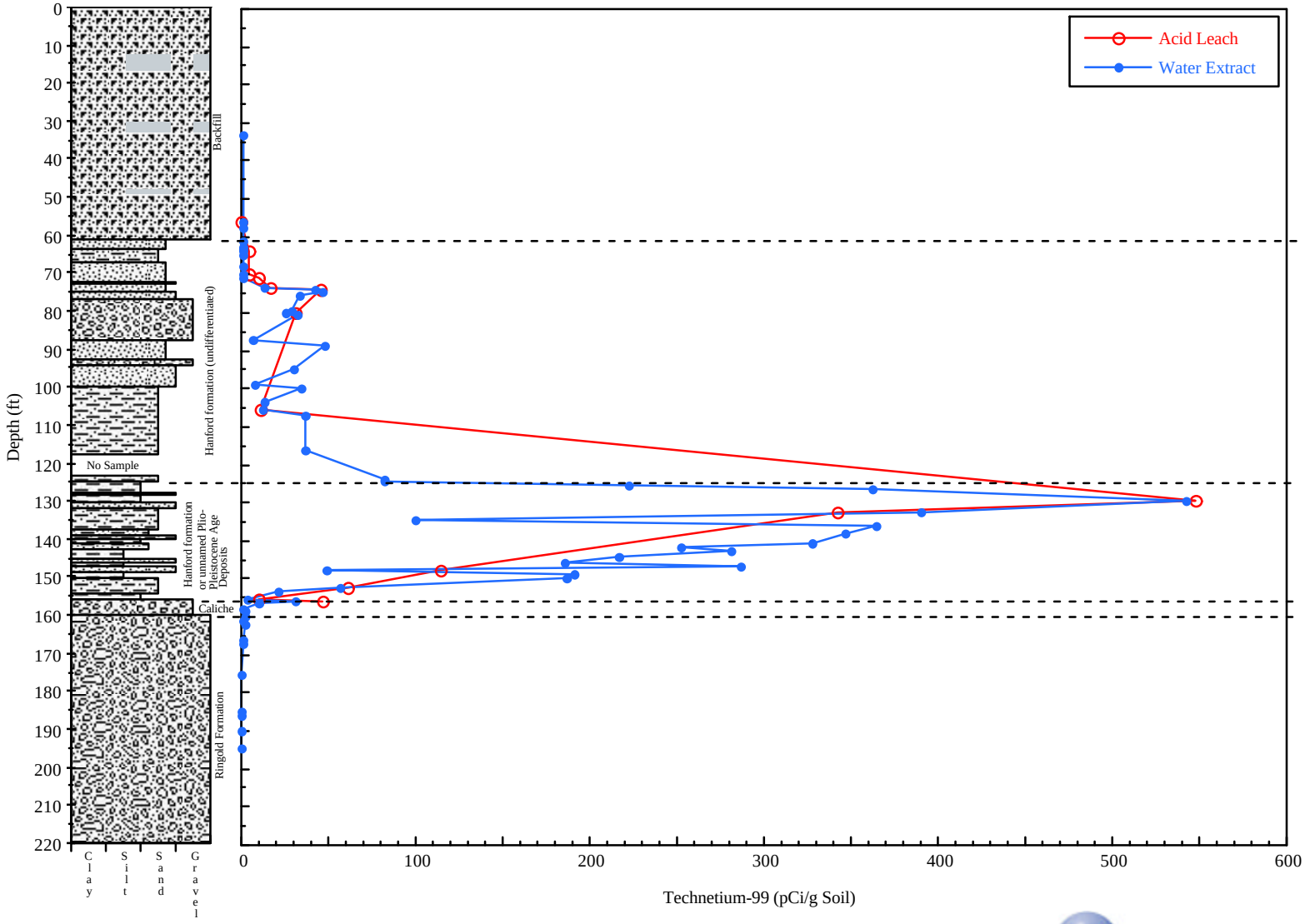

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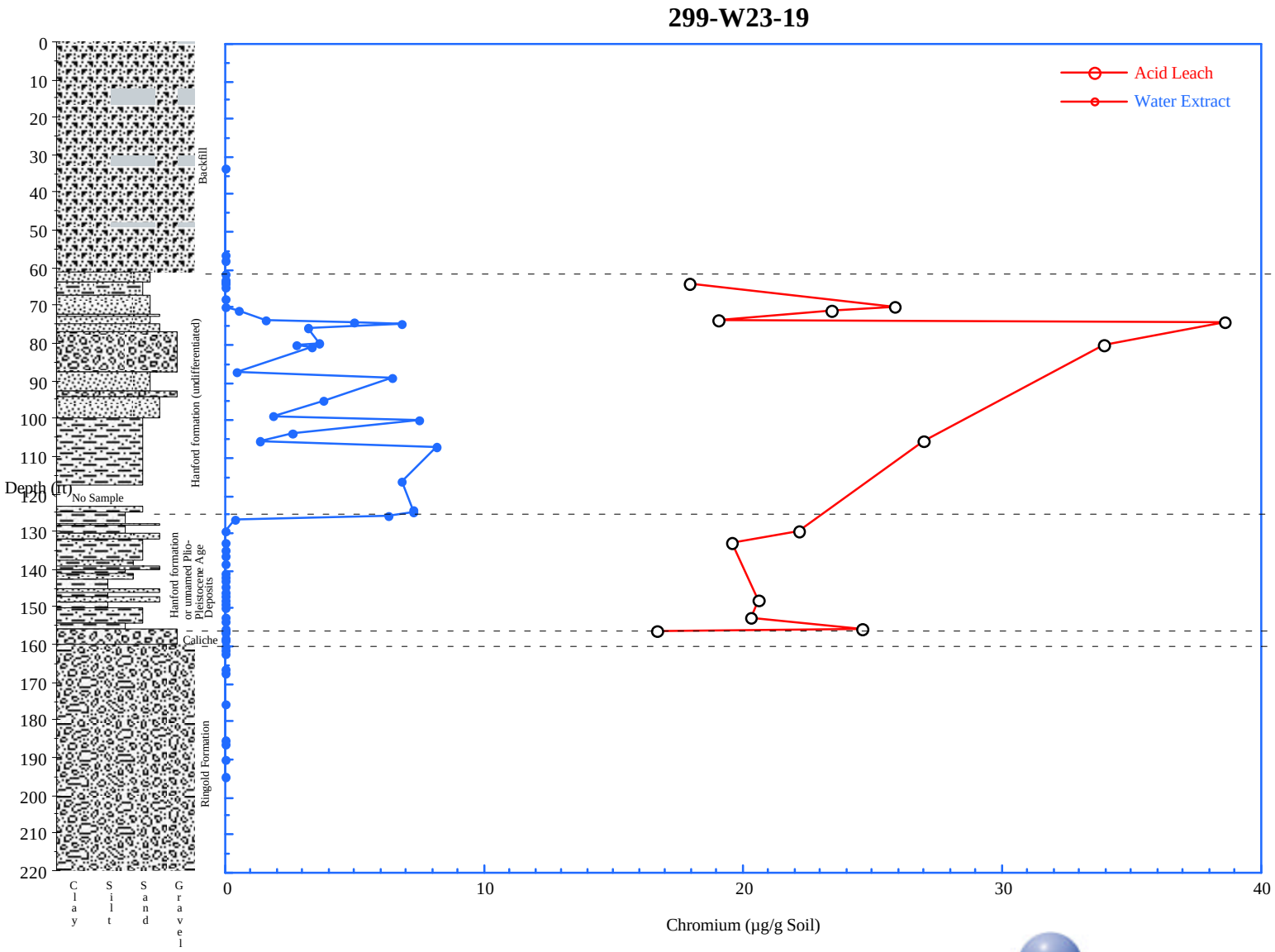

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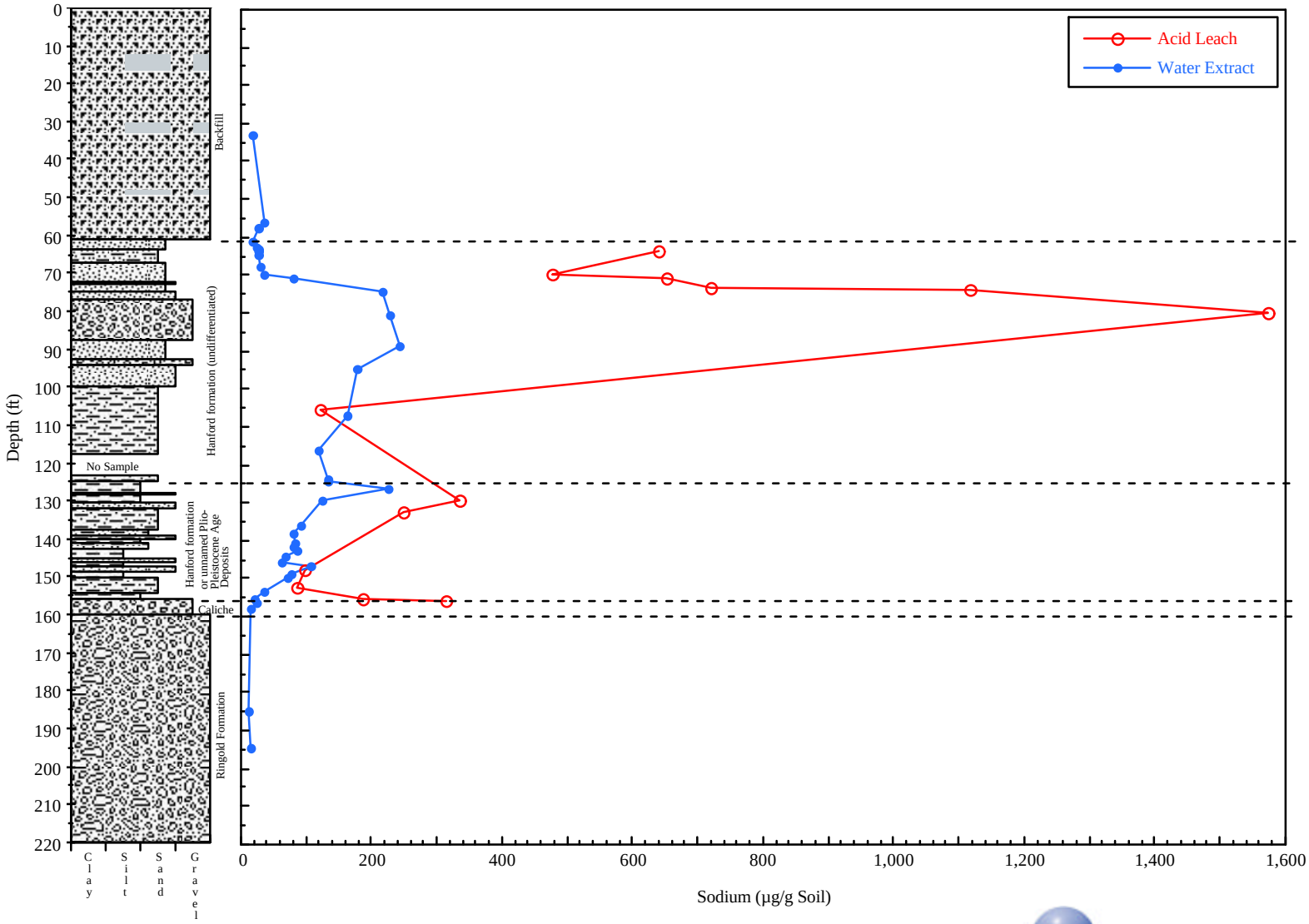
299-W23-19



2000/DCL/W23-19/037

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Summary of Findings

- Tc-99 and nitrate show little tendency to interact with sediments
- Cr(VI) and Na show slight tendency to interact with sediments
- The concentrations of contaminants in SX41-09-39 and SX-108 are very similar.
- At SX-108 peak distributions reach deeper.

Summary Findings--2

- Cs-137 does interact with sediments
- Sr-90 only found in one borehole distribution not fully defined yet
- Actinides work on slant just started –only one Pu hit at depth of tank bottom

SX-41-09-39 "In-Situ" K_d

Sample epth (Ft bg	Sample ID	Cs Kd in-situ mL/g	% Cs Leached by water vs total in sediment
25-26	15A/B/C	nd	NA
44-45	14A/B/C	nd	NA
56-57	13A/B/C	3.77E+03	0.03%
61-62	12A/B/C	1.30E+04	0.01%
65-66	11A/B	2.55E+03	0.04%
65-66	11C	1.03E+03	0.10%
69-70	10A/B/C	1.27E+02	0.79%
74-75	9A/B/C	8.99E+03	0.01%
79-80	8A/B/C	9.59E+03	0.01%
82-83	7A/B/C	4.61E+02	0.22%
90	6A/B	1.99E+02	0.50%
95-96	3A/B/C	5.12E+01	1.95%
102-103	5A/B/C	1.68E+02	0.60%
108-109	4A/B/C	2.06E+02	0.48%
112	2B/C	2.37E+02	0.42%
127.4	1A/B/C	5.33E+04	0.15%

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SX 41-09-39 In-situ K_d

Sample epth (Ft bg	Sample ID	Cr ug/g Cr	Cr Water	Cr Kd's	% Cr Water Leached
25-26	15A/B/C	6.53	5.00E-04	1.31E+04	0.01%
44-45	14A/B/C	6.04	2.89E-03	2.09E+03	0.05%
56-57	13A/B/C	24.13	3.42E-03	7.05E+03	0.01%
61-62	12A/B/C	130.30	8.15E-03	1.60E+04	0.01%
65-66	11A/B	80.25	3.42E-01	2.34E+02	0.43%
65-66	11C	69.50	3.44E-01	2.01E+02	0.50%
69-70	10A/B/C	42.32	5.07E+00	7.35E+00	11.97%
74-75	9A/B/C	122.00	4.09E+00	2.88E+01	3.35%
79-80	8A/B/C	597.35	7.17E-01	8.32E+02	0.12%
82-83	7A/B/C	1458.59	7.45E+02	9.57E-01	51.09%
90	6A/B	1277.77	7.12E+02	7.95E-01	55.71%
95-96	3A/B/C	710.70	2.60E+02	1.73E+00	36.63%
102-103	5A/B/C	1169.64	5.28E+02	1.22E+00	45.14%
108-109	4A/B/C	783.93	4.81E+02	6.30E-01	61.34%
112	2B/C	298.53	1.75E+02	7.03E-01	58.73%
127.4	1A/B/C	15.80	1.15E-02	1.38E+03	0.07%

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SX 41-09-39 In-Situ K_d

Sample epth (Ft bg	Sample ID	Tc Kd in-situ mL/g	% Tc leached by water vs acid extractable
		Tc	Tc
25-26	15A/B/C	<130	>81%
44-45	14A/B/C	5.17	>16%
56-57	13A/B/C	54.97	1.8%
61-62	12A/B/C	14.44	6.5%
65-66	11A/B	5.33	15.8%
65-66	11C	0.66	60.1%
69-70	10A/B/C	3.58	>22%
74-75	9A/B/C	3.58	>22%
79-80	8A/B/C	131.22	0.8%
82-83	7A/B/C	1.77	36.1%
90	6A/B	0.18	84.8%
95-96	3A/B/C	0.08	92.9%
102-103	5A/B/C	1.11	47.3%
108-109	4A/B/C	0.16	86.4%
112	2B/C	0.15	87.0%
127.4	1A/B/C	0.21	82.4%

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Pu Data

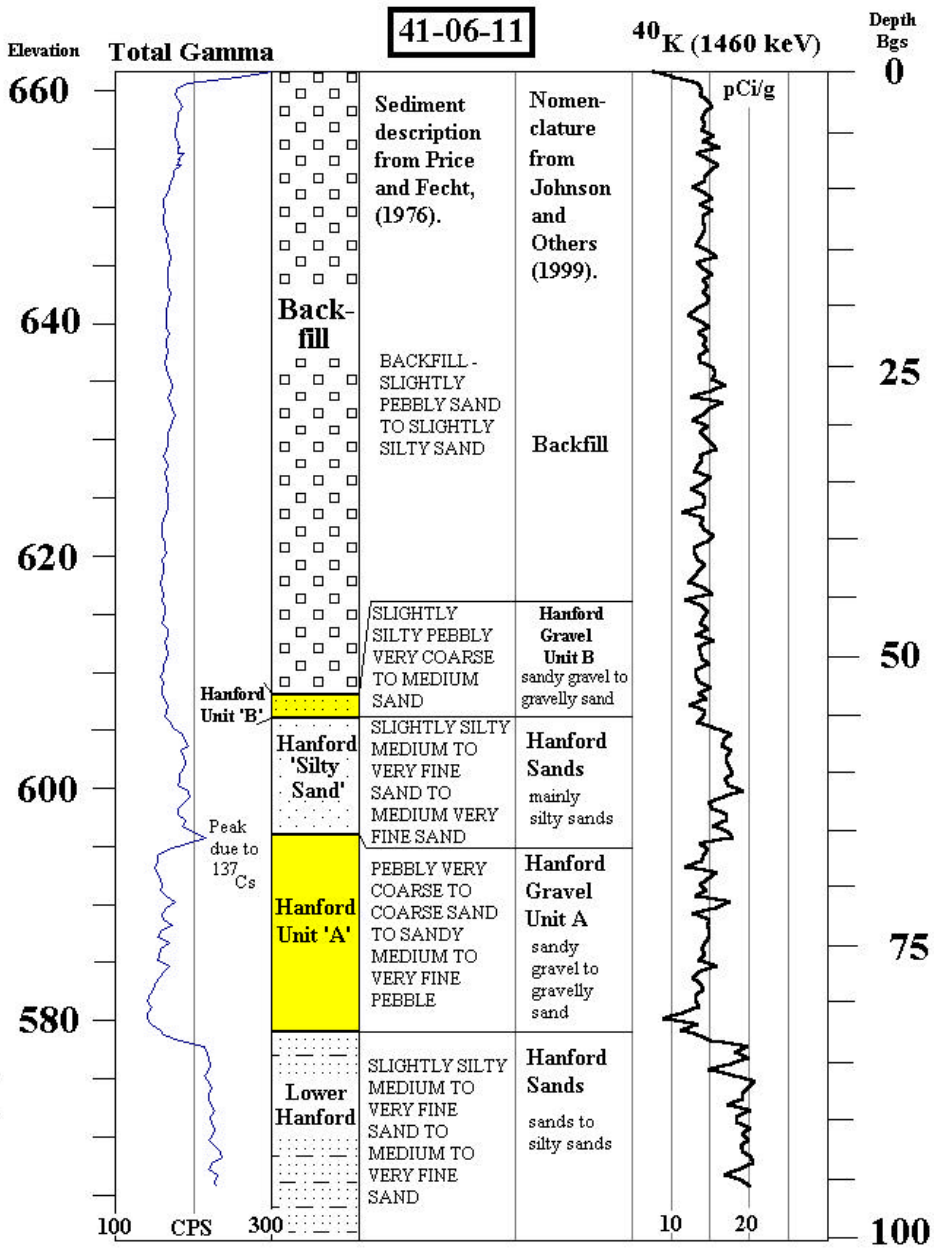
Plutonium	SX41-09-39			
Depth	Sample	Pu 239	Pu239	Pu239
		Activity(pCi/g)	error (pCi/g)	MDA (pCi)
25-26	**15A/B/C**	-0.113	0.019	0.005
44-45	**14A/B/C**	-0.119	0.019	0.012
56-57	**13A/B/C**	3.960	0.171	0.004
61-62	**12A/B/C**	-0.109	0.019	0.006
65-66	**11A/B**	-0.076	0.022	0.016
65-66	**11C**	-0.112	0.018	0.012
69-70	**10A/B/C**	-0.115	0.019	0.005
74-75	**9A/B/C**	-0.111	0.019	0.012
79-80	**8A/B/C**	-0.118	0.019	0.006
82-83	**7A/B/C**	-0.090	0.020	0.005
90	**6A/B**	-0.111	0.018	0.013
95-96	**3A/B/C**	0.012	0.024	0.010
102-103	**5A/B/C**	-0.085	0.020	0.011
108-109	**4A/B/C**	-0.053	0.021	0.004
112	**2B/C**	-0.081	0.020	0.005
127.4	**1A/B/C**	-0.019	0.023	0.005

Summary Findings --3

- There is no indication that contaminants have traveled beyond ~135 ft at SX41-09-39.
- At the slant borehole we did not find the maximum vertical extent of contamination but concentrations were dropping at 138 ft.
- At SX-115 (W23-19) contaminants appear to penetrate to 155 ft., yet groundwater at 220 ft has high Tc-99, some Cr(VI). Caliche at 155-160 seems to be barrier.

Geologic Cross-Sections

- PNNL
  - Continuous beds with Hanford coarse=gravel
- Sobczyk
  - Continuous beds slight differences from PNNL in upper Hanford
- Lindsey
  - Coarse Hanford unit is not continuous and not "gravel"



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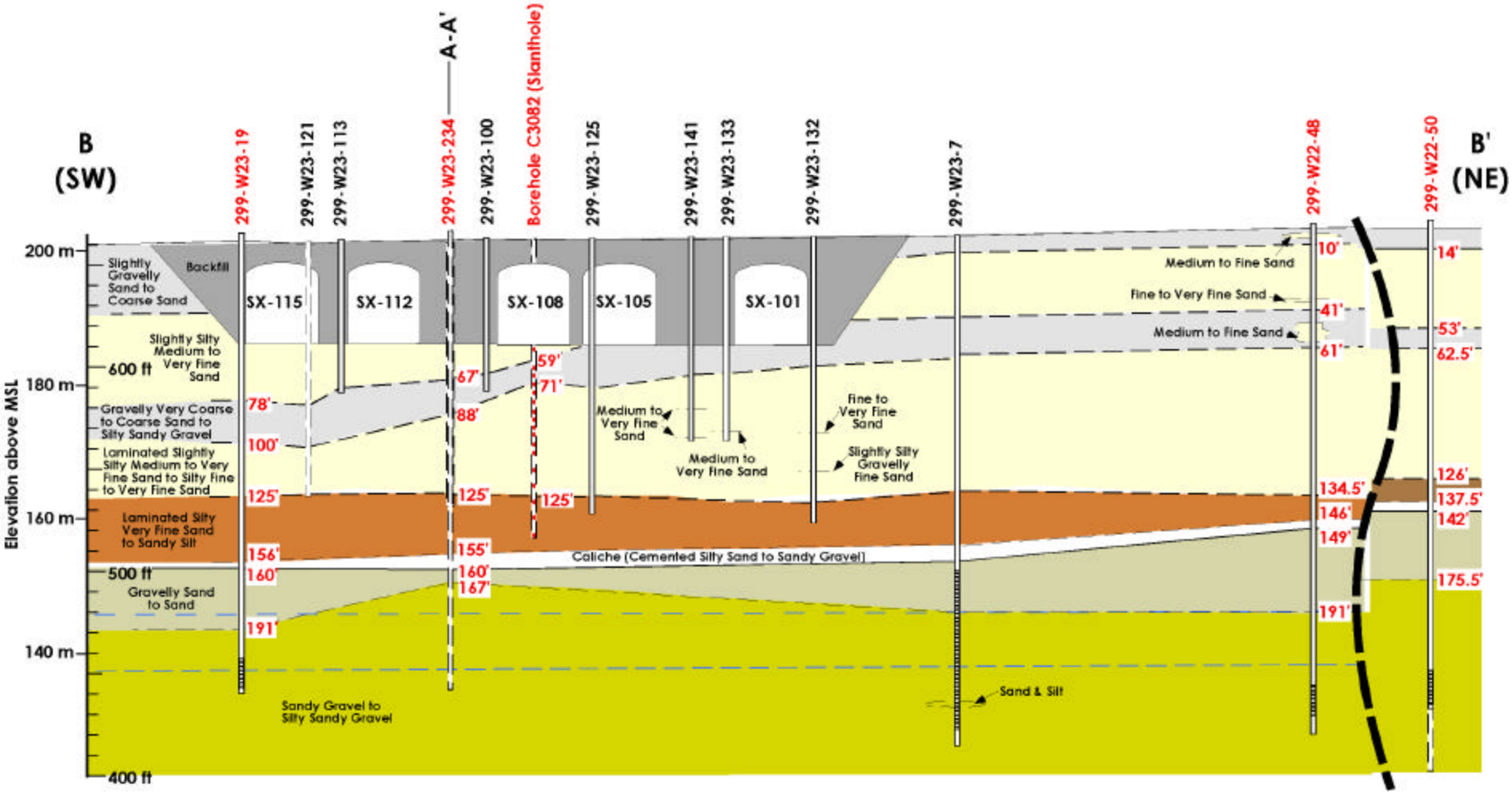
Cross-Section Through SX Tank Farm

(2X Vertical Exaggeration)



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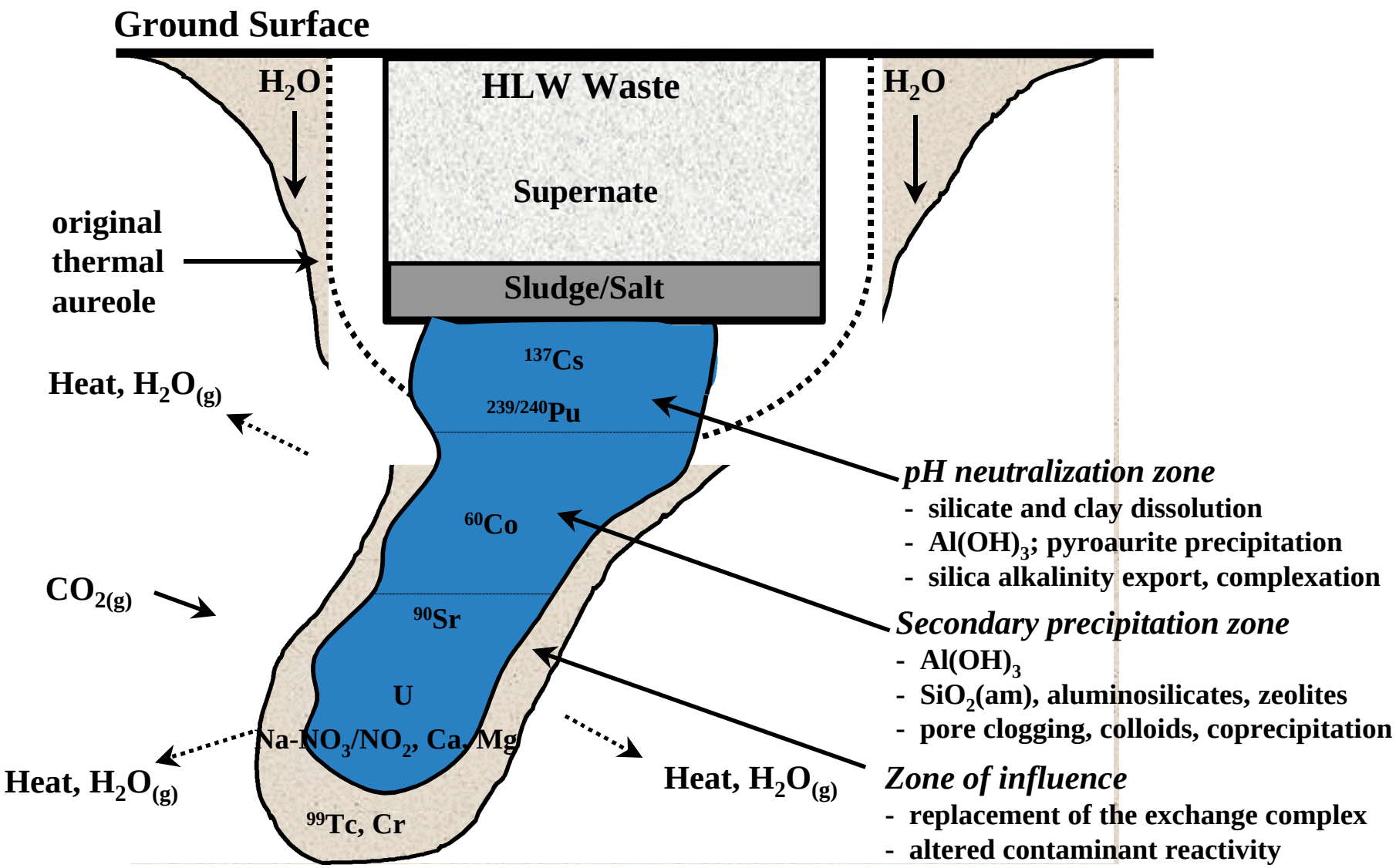
Scientific Questions--1

- What is process that slows Cr(VI) migration ?
  - Alkaline earth chromate or mixed sulfate precipitate?
  - Reduction of some Cr(VI) to Cr(III) by Fe^{+2} solids? Recall Scott Chambers talk
  - Anion adsorption onto hydrous oxides/zeolites?
  - Sample heterogeneity and lousy analytical work?
- Is there any Tc(VII) removal in the shallow depths?
- Where is all the caustic and soluble Al that was present in the tank fluids?

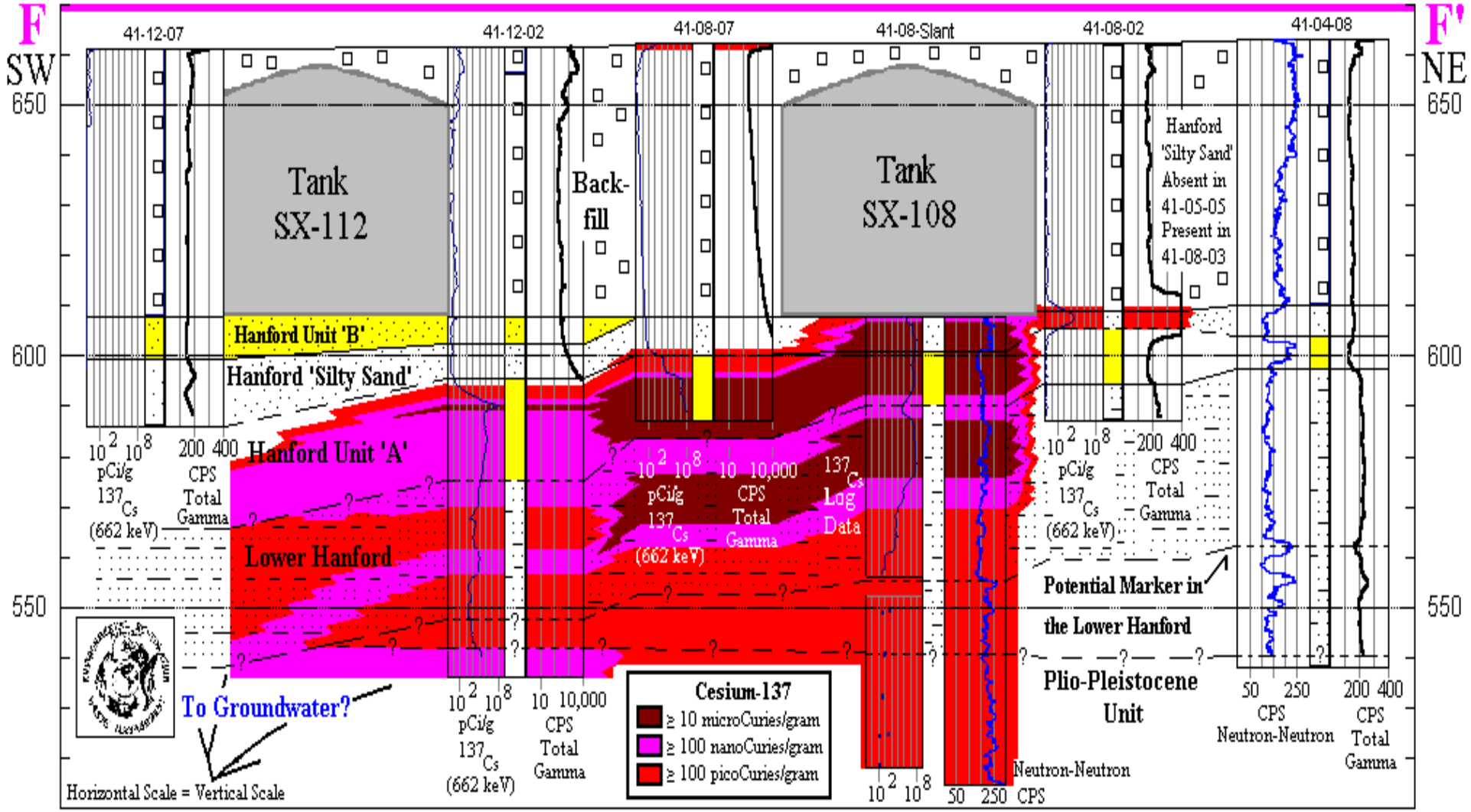
Hypothetical Geochemical Model of a Leaker



Migration path determined by artificial recharge, geologic heterogeneities, and density gradient

Scientific Questions --2

- Does the geologic bed dipping control the contaminant distributions?
- Does the geochemistry control the distribution?
- **Why is Cs-137 concentrations so high in the coarse Hanford sediment; Why are there two peaks vs. depth at SX-41-09-39 and SX-108?**



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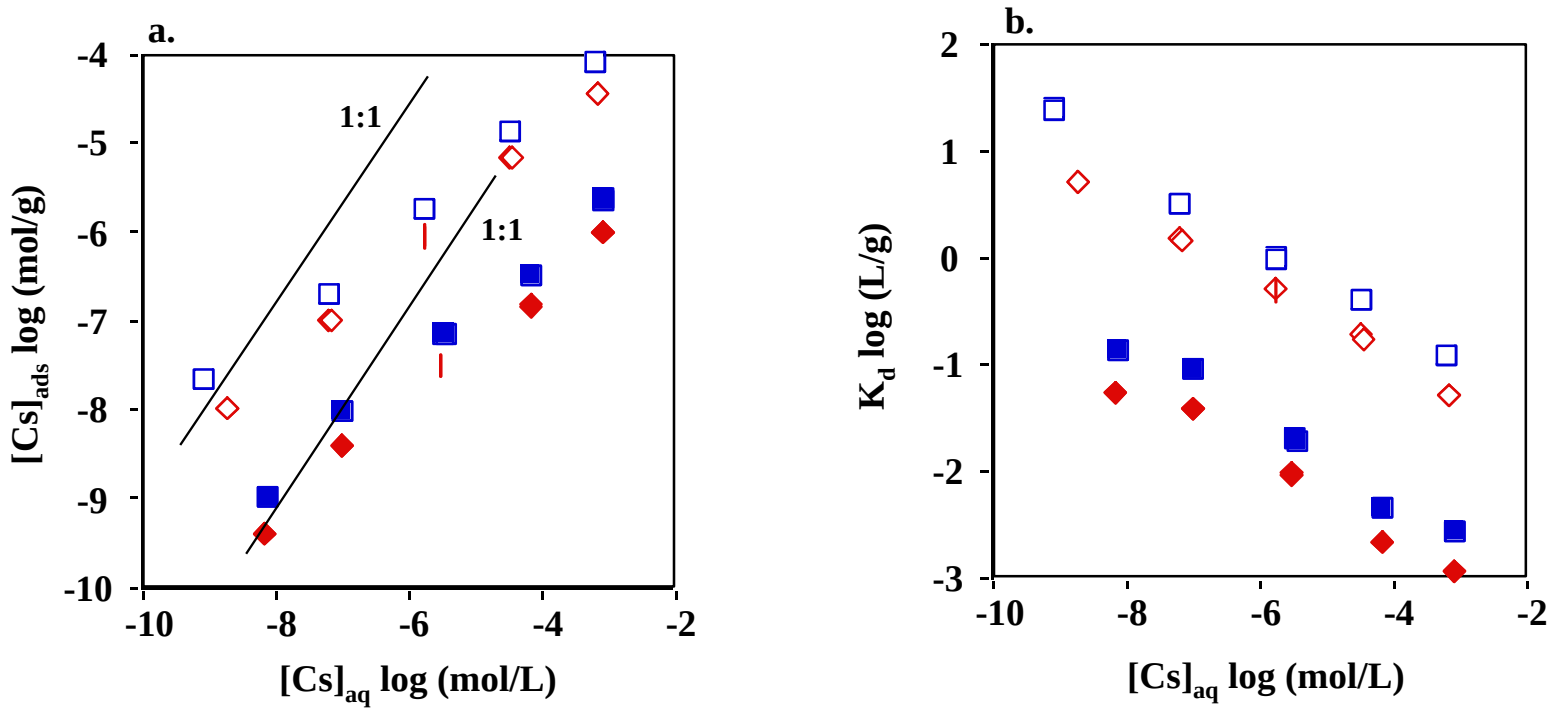
Scientific Questions --3

- Is there "enhanced" migration of Cs-137 vs. past predictions?
  - Past work "maxed out" at 4 M $NaNO_3$
    - Current work >7 M
  - Past work was done at trace Cs loading
    - Current work shows high non-linearity and tank conditions reach ~10^{-3} M Cs in solution recall John Zachara's talk
  - Past modeling predictions were too simple/optimistic but past modeling was for "systems PA" [engineers/hydrologists]not science-driven [geochemists]

Cesium Sorption on Selected Hanford Laminated Sand Size Fractions



- □ < 63 um Size Fraction; 5 g/L Solids; 0.005 M $NaNO_3$
- ◇ 125 - 250 um Size Fraction; 10 g/L Solids; 0.005 M $NaNO_3$
- ■ < 63 um Size Fraction; 100 g/L Solids; 5 M $NaNO_3$
- ◆ 125 - 250- um Size Fraction; 250 g/L Solids; 5 M $NaNO_3$

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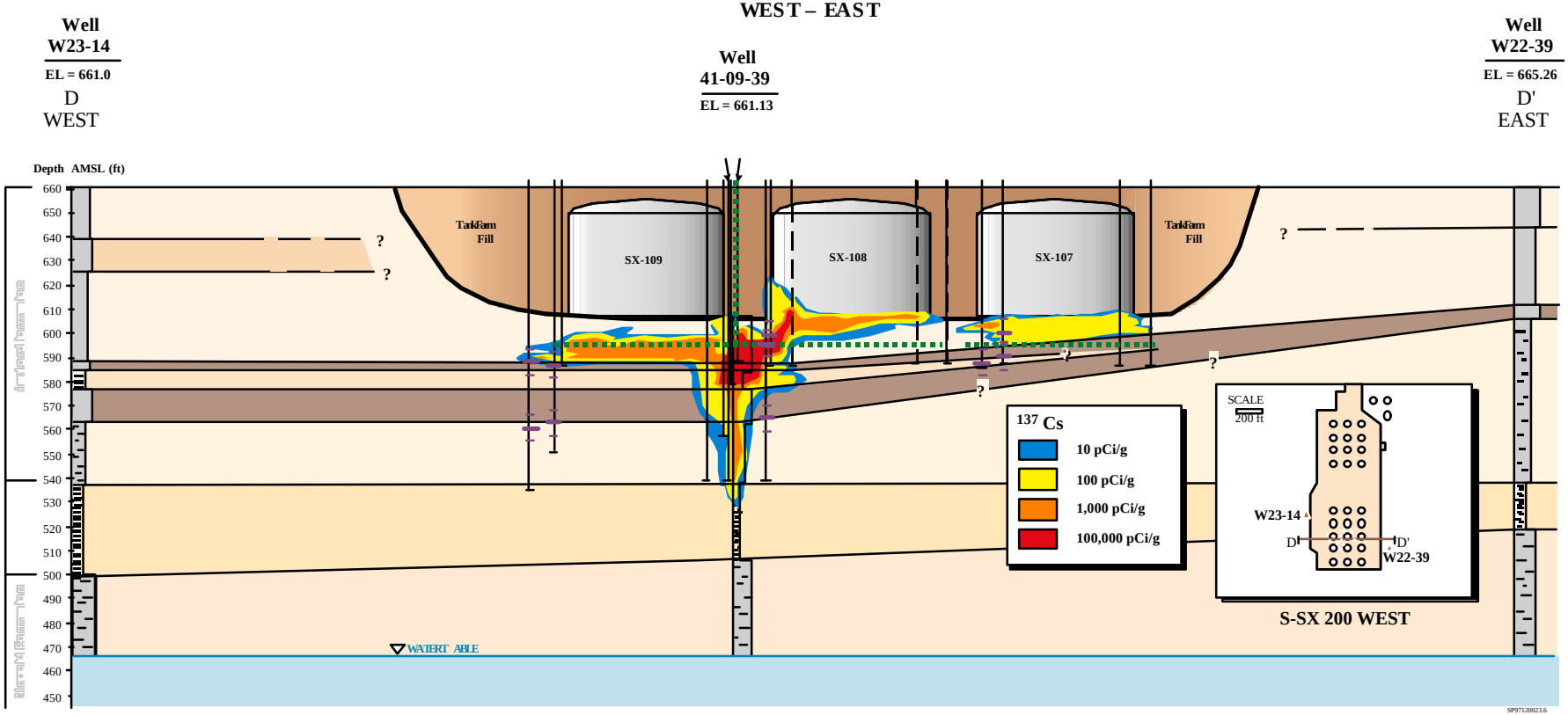
Scientific Questions --4

- Why is the deep vadoseczone penetration localized to the “Bermuda Quandrangle” and GW contamination to south and east of SX-115?
- Is this “Geology” controlling the fate?
  - Clastic dike (?)
  - High Volume of Leaks occurred here only and overwhelmed Geology (?)
  - Localized Discontinuous bedding (?)
- Why was post-leak Cs-137 movement found only in monitoring dryholes west of SX-109?

SX Tank Farm
WEST – EAST



RP980600029.1

LEGEND:

Vadose borehole used to establish ^{137}Cs contaminant distribution

Geologic contacts ±5' uncertainty (after Fecht et. al., 1976)

Silt

Silty Sand

Sand

Coarse Sand to Sandy Gravel

Gravel and Sandy Gravel

75 Feet
25 Meters

Lateral logging boreholes

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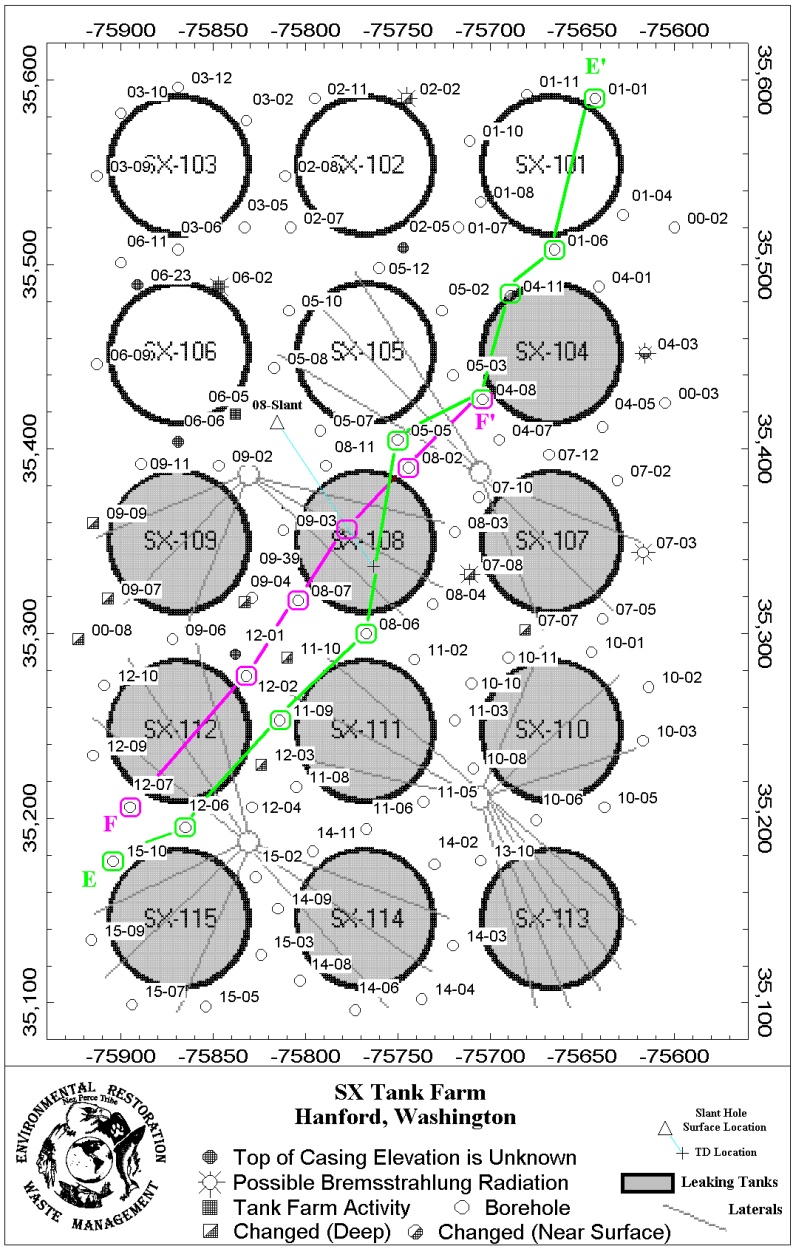

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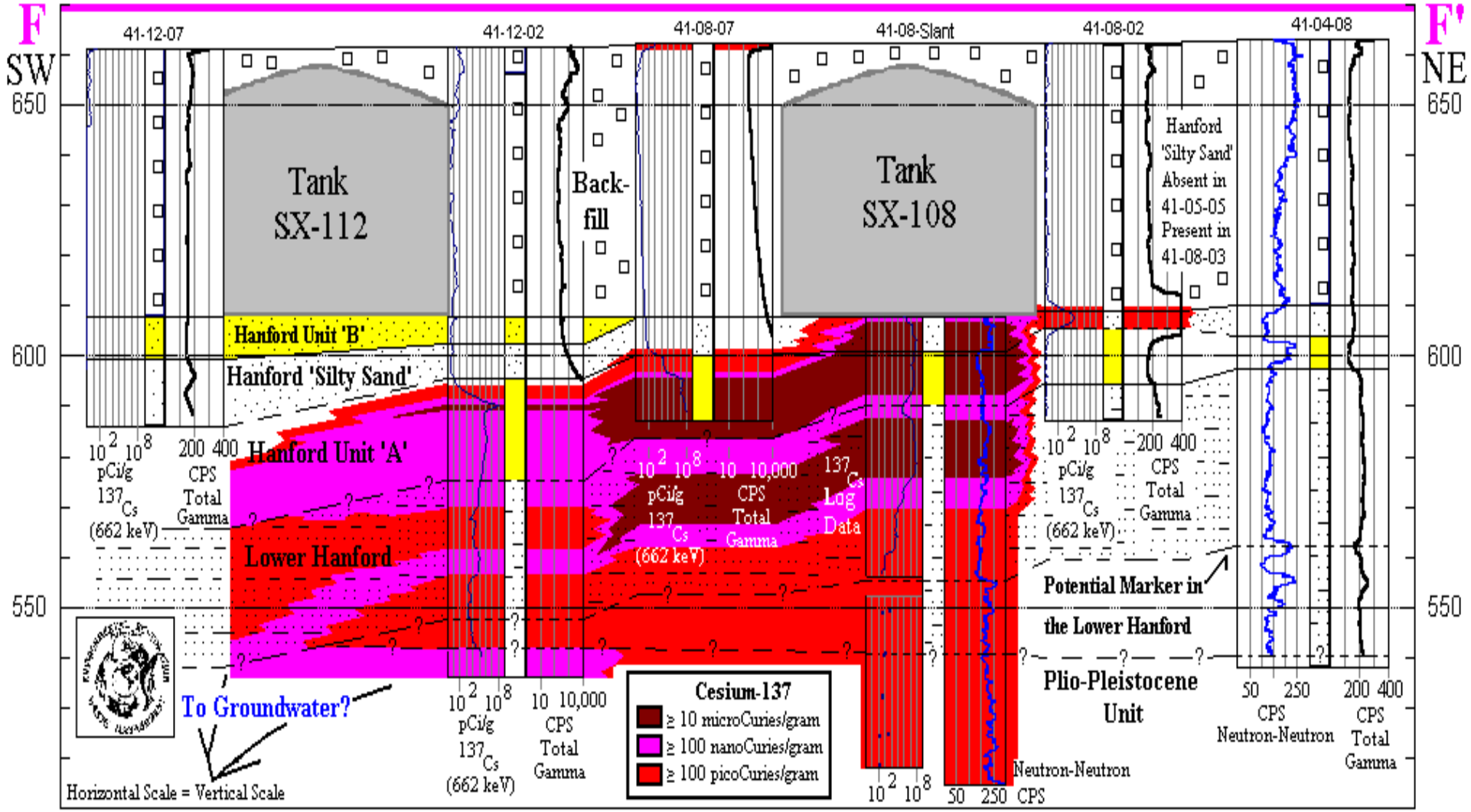

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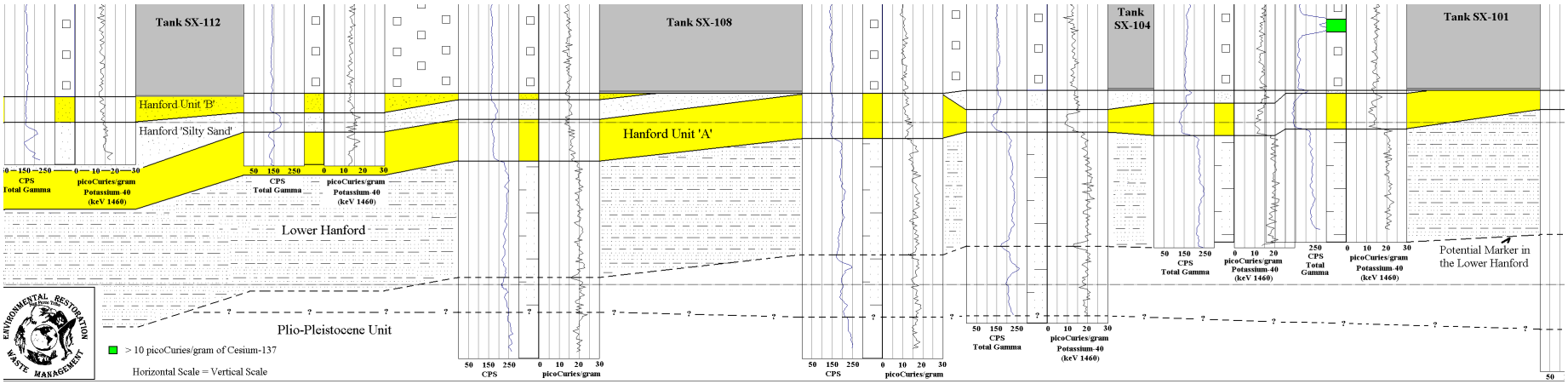
Cross Section E to E’



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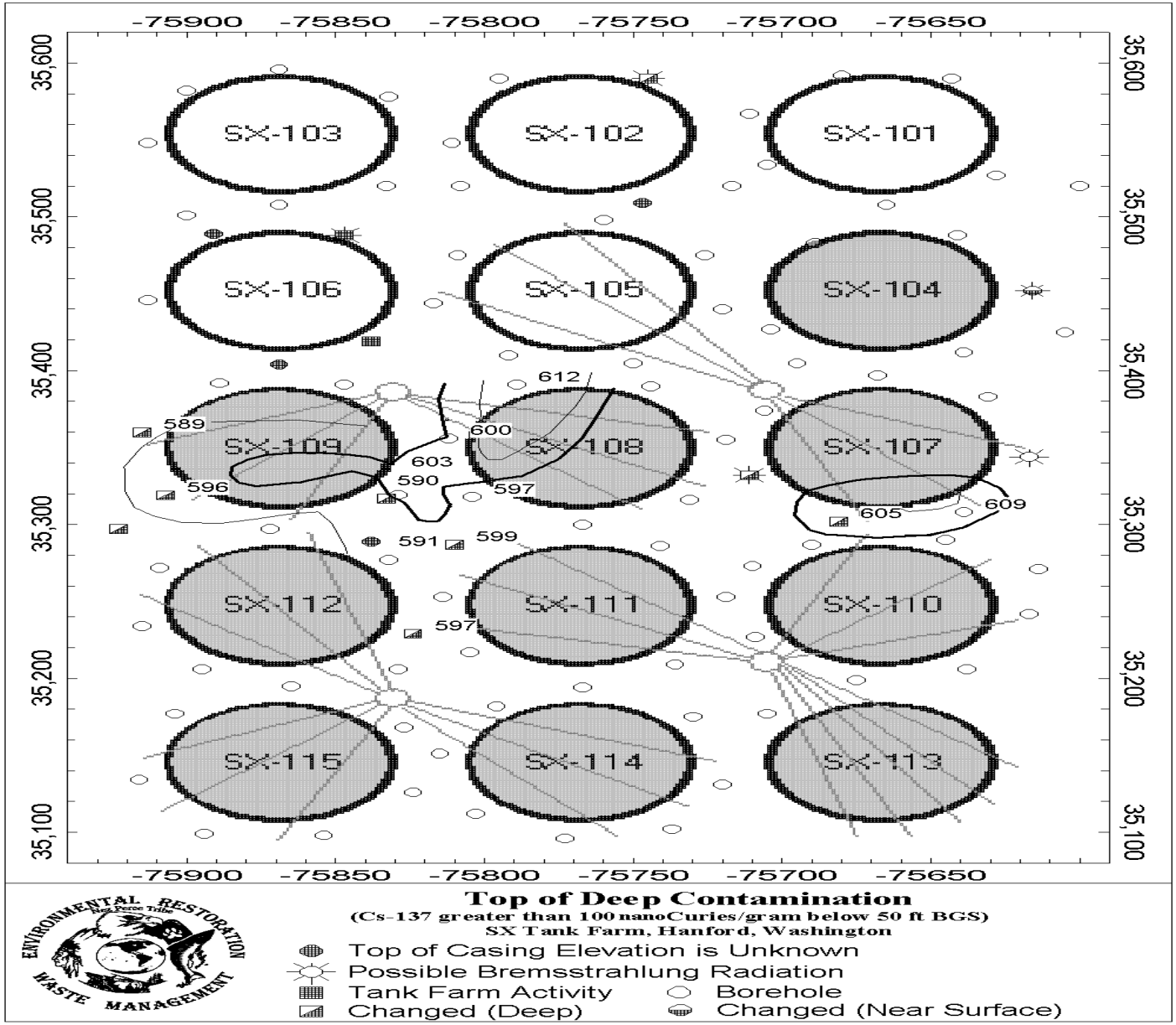

Top of Deep Contamination
(Cs-137 greater than 100 nanoCuries/gram below 50 ft BGS)
SX Tank Farm, Hanford, Washington

- Top of Casing Elevation is Unknown
- Possible Bremsstrahlung Radiation
- Tank Farm Activity
- Borehole
- Changed (Deep)
- Changed (Near Surface)

ENVIRONMENTAL RESTORATION WASTE MANAGEMENT

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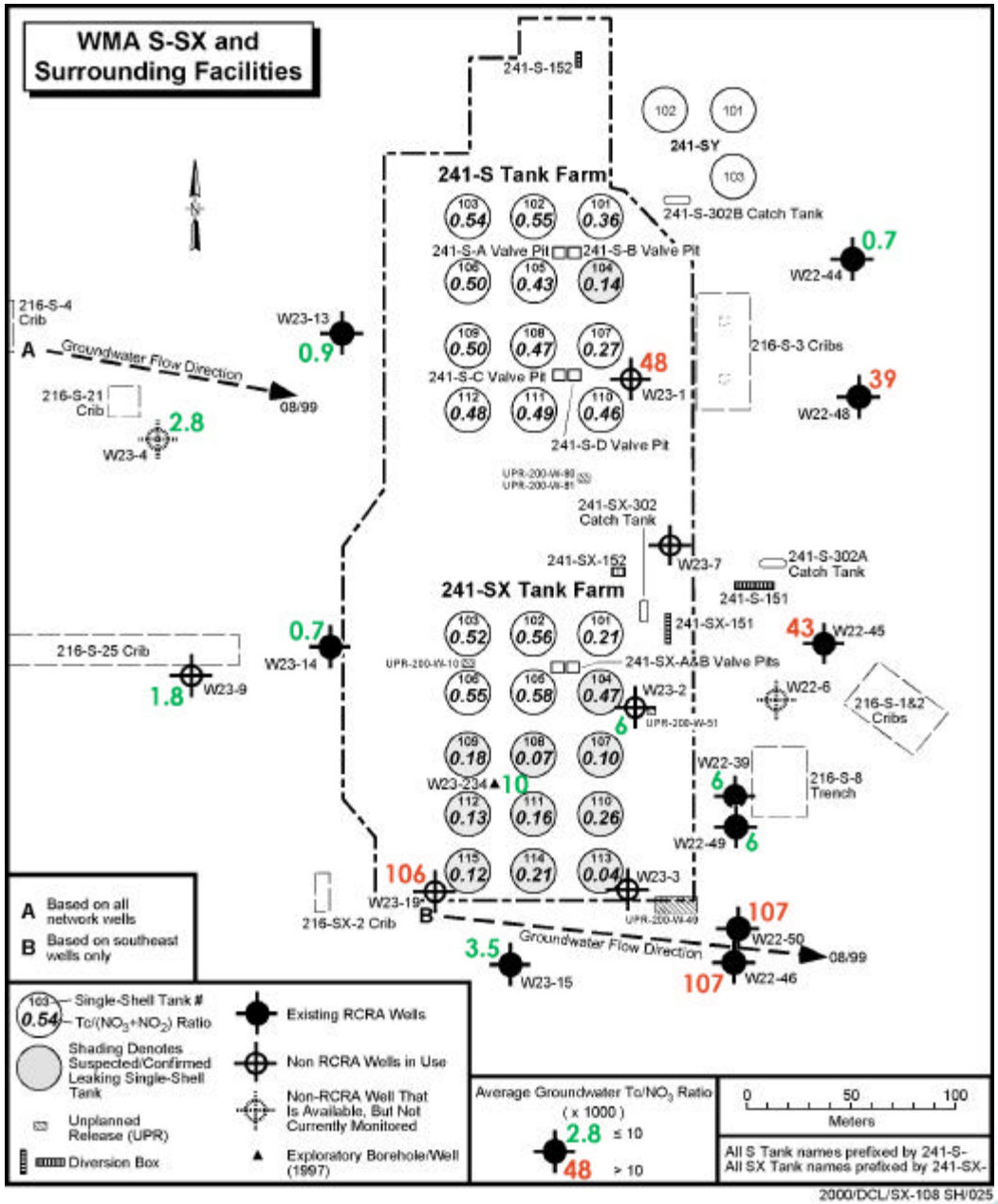
Scientific Questions--5

- Why is the groundwater "hits" for Tc-99, Cr(VI), nitrate, and calcium (from Na exchange) episodic?
  - These constituents appeared for a few years and then disappear for several years. New data from Vern.
  - All 3 contaminated boreholes do not show a continuous trial of contaminants below the caliche to the groundwater



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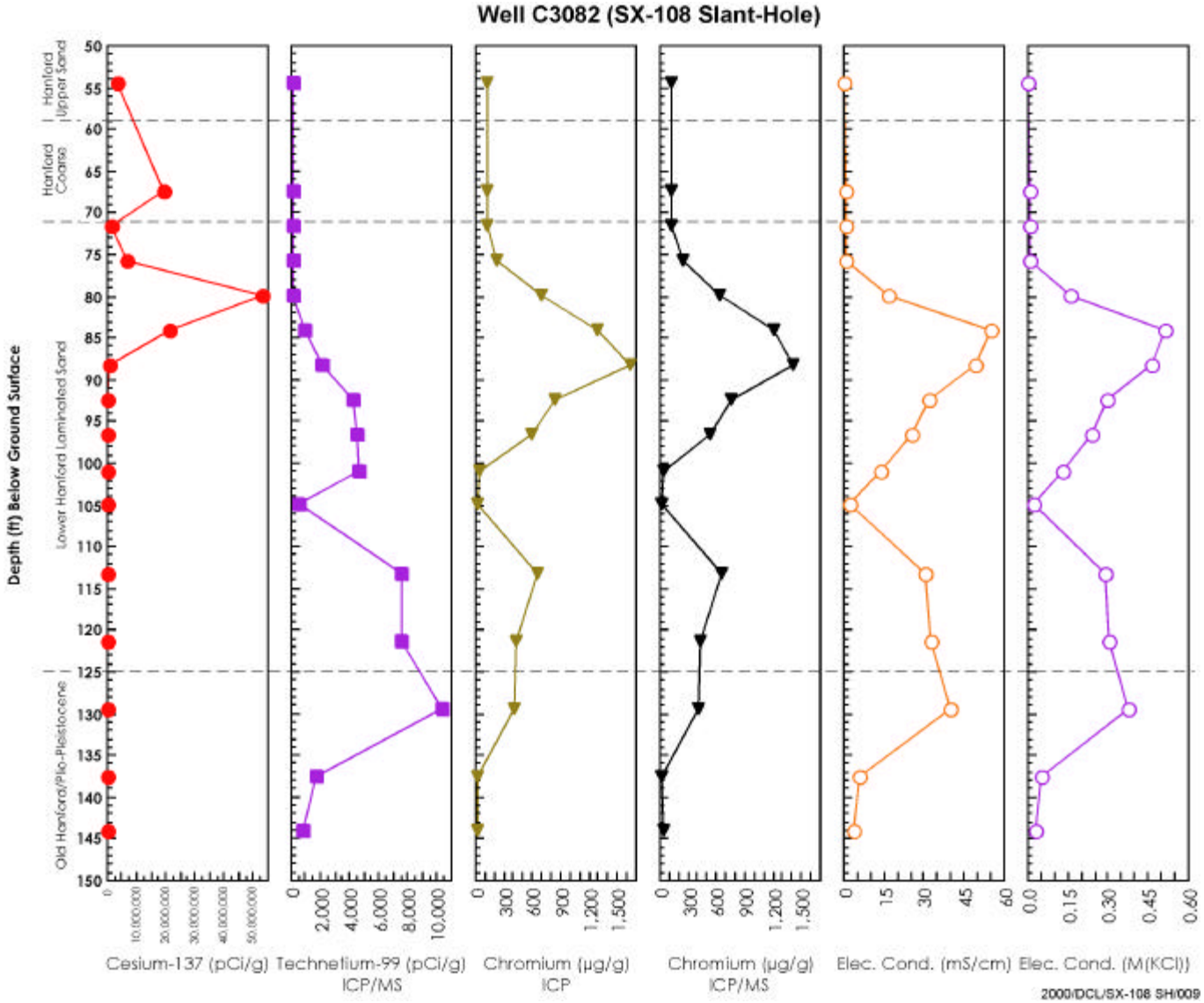
Scientific Questions--6

- Simple Kd Transport Modeling of the SX Site (Chemical, geologic), and generic vadose zone hydrologic data suggests that “mobiles” reach groundwater in ~30-40 years.

- If so why do we see no contaminants below the caliche in the 3 boreholes available?



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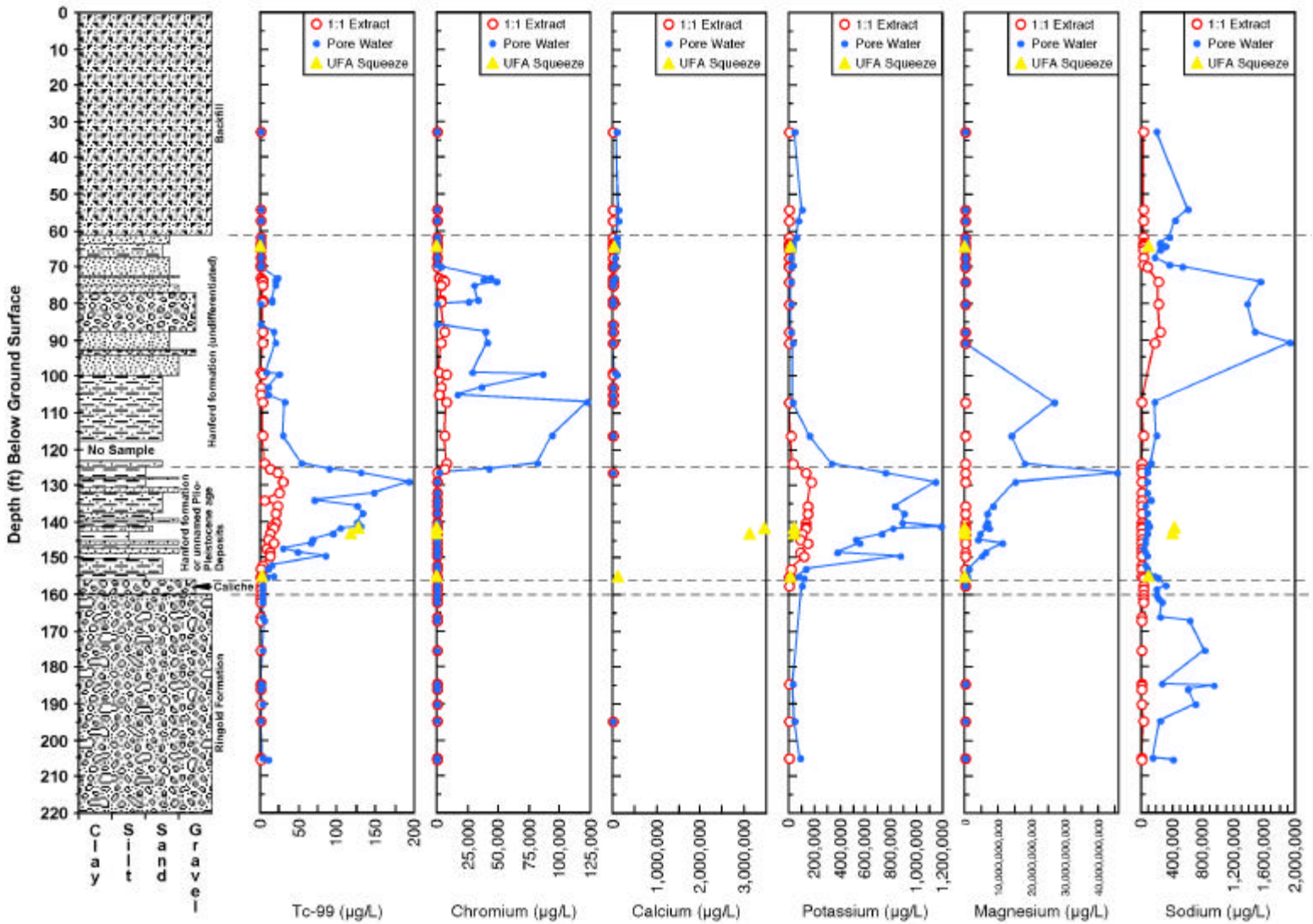
Well 299-W23-19



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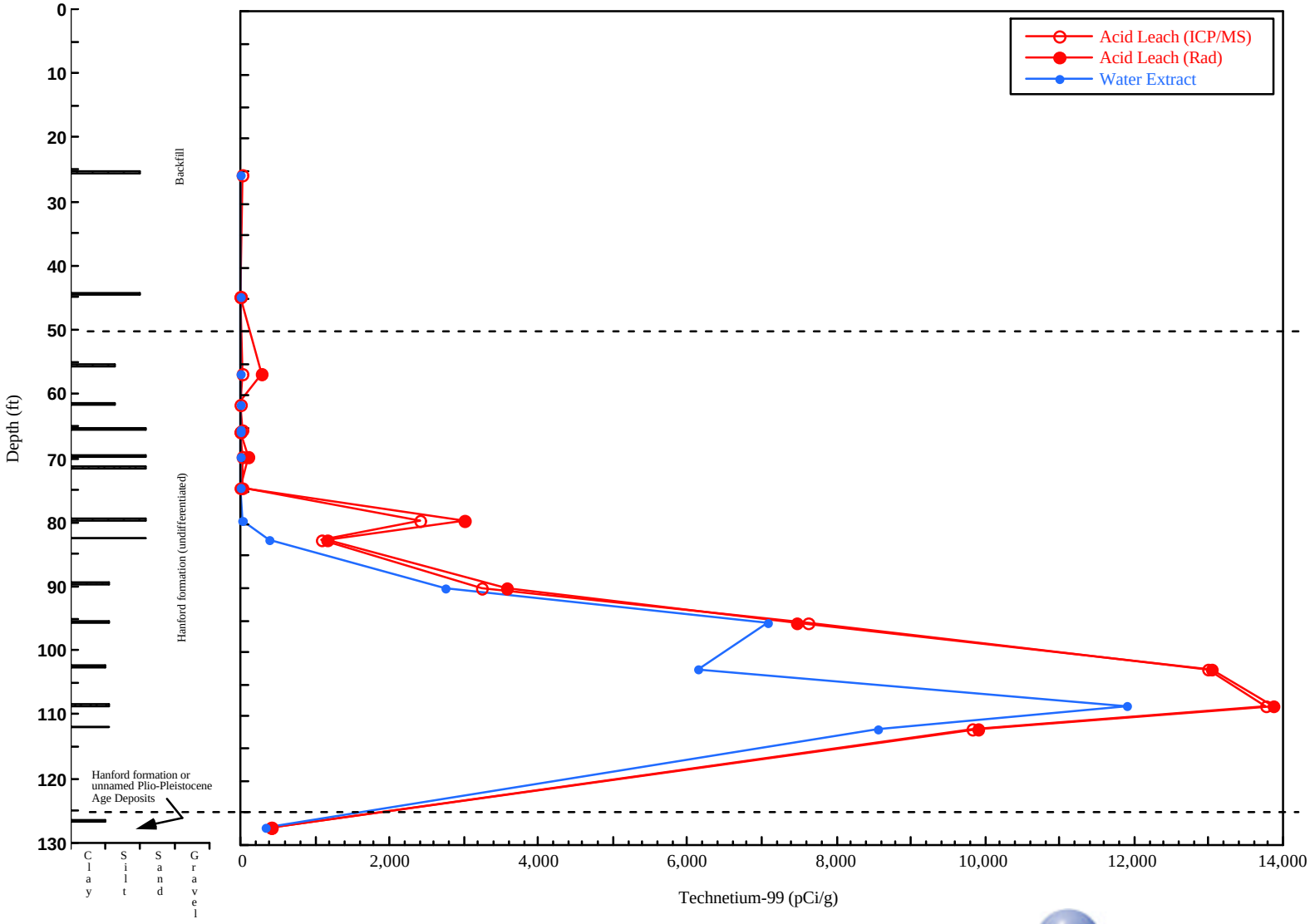
Borehole SX41-09-39



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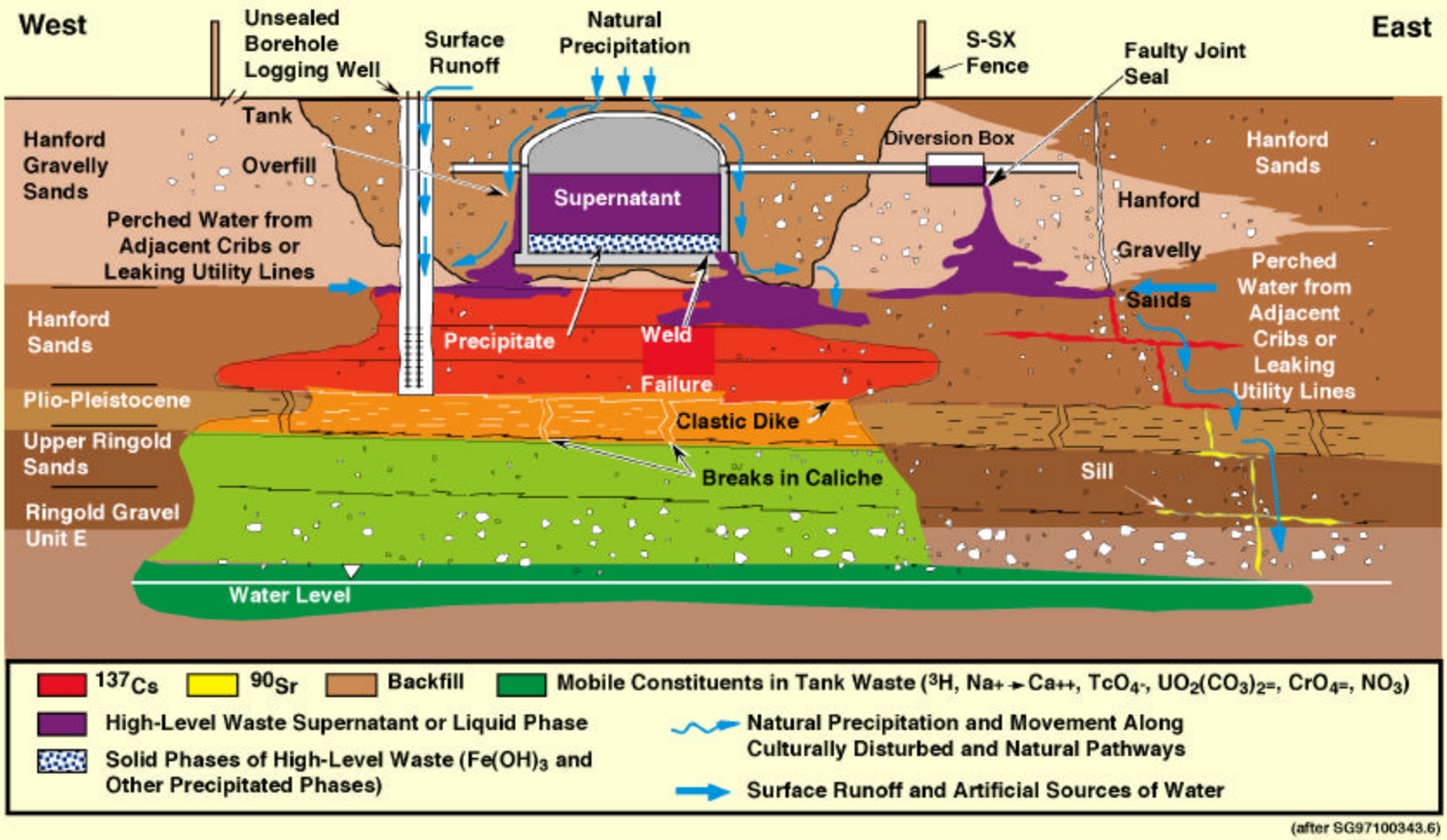
WMA S-SX SOIL PATHWAY CONCEPTUAL MODEL



(after SG97100343.6)

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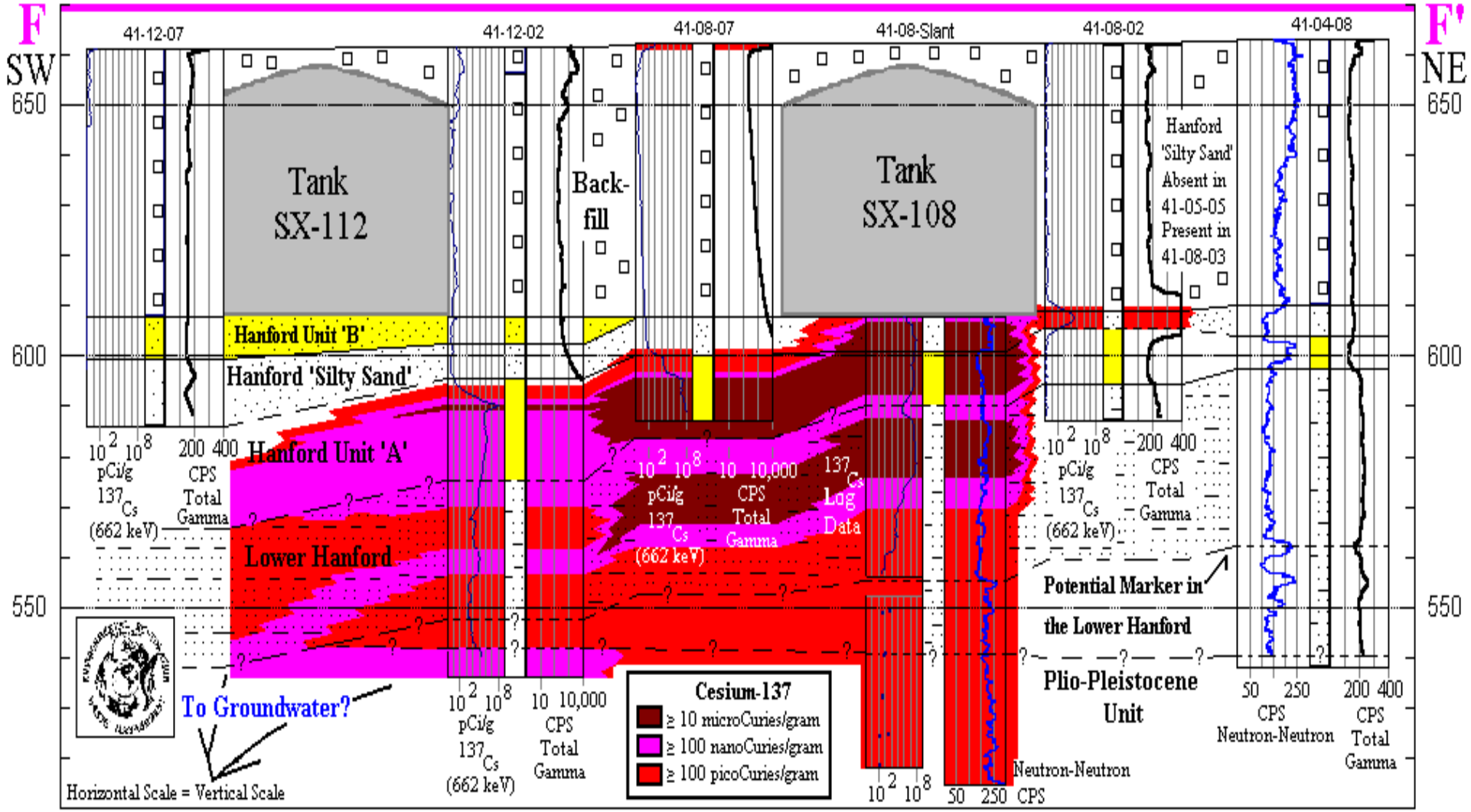

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