APPENDIX B

RESULTS FROM WORK PLAN ACTIVITIES

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CONTENTS

FIGURES

TABLES

LIST OF TERMS

bgs	below ground surface
EC	electrical conductivity
H/PP/R	Hanford / Plio-Pleistocene / Ringold unit
Hf/Ppu	Hanford formation / Plio-Pleistocene unit
Kd	distribution coefficient
PNNL	Pacific Northwest National Laboratory
PPlz	upper Plio-Pleistocene unit
RCRA	*Resource Conservation and Recovery Act*
WMA	waste management area

B.1.0 INTRODUCTION

These field characterization studies were completed to increase understanding of the vadose zone contamination as it presently exists in waste management area (WMA) B-BX-BY. The results of these studies are summarized in this appendix. The primary information obtained from these activities resulted from extensive analyses of soil samples taken from three boreholes in the WMA (Figure B.1). These boreholes were as follows:

- *Resource Conservation and Recovery Act* (RCRA) Borehole 299-E33-33: Lies southeast of the B tank farm in an uncontaminated area. This borehole was drilled vertically from the surface to 275.75 ft (83.9 m) below ground surface (bgs). The characterization data from this borehole are considered to be the baseline or background (natural) geochemical conditions for WMA B-BX-BY. Further discussion of borehole 299-E33-338 is provided in Section B.2.0.

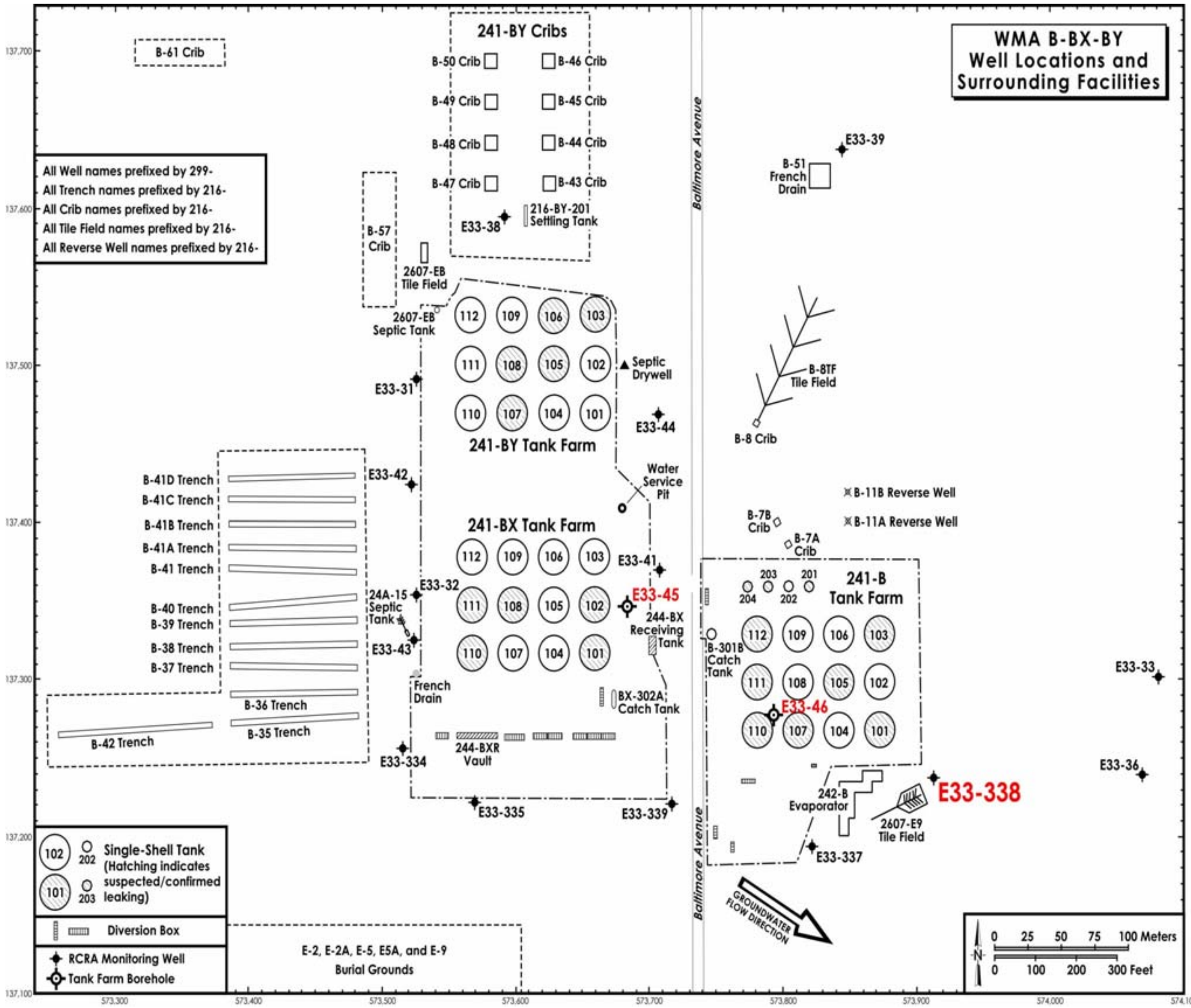
- Borehole 299-E33-45: Lies east of tanks BX-101 and BX-102 and was drilled vertically from the surface to 254 ft (77.42 ft) bgs. This borehole was drilled in the middle of a uranium plume to evaluate the vertical extent of the plume and to measure the concentrations of mobile contaminants, primarily technetium-99 and nitrate, assumed to coexist with uranium. Further discussion of borehole 299-E33-45 is provided in Section B.3.0.

- Borehole 299-E33-46: Lies just northeast of tank B-110. This borehole was drilled from the surface to 256 ft (78.03 m) bgs to further characterize vadose zone contamination caused by a tank B-110 transfer line leak and to determine potential groundwater impacts. Further discussion of borehole 299-E33-45 is provided in Section B.4.0.

Two other boreholes have also been drilled in the vicinity of WMA B-BX-BY and available characterization data from one of these along with some selected samples from the second are also summarized. These boreholes are borehole C3103 in crib 216-B-7A north of B tank farm, and borehole C3104 in BX trench 216-B-38 west of BX tank farm, respectively.

The characterization information summarized in this appendix includes brief descriptions of borehole geology, moisture contents, soil suction data, and soil water chemistry. In the interest of brevity, data reported here are those that have the most direct bearing on contaminant characteristics and migration potential. More detailed discussions of the analytical results are provided in Serne et al. (2002a, b) and Lindenmeier et al. (2002a, b).

Figure B.1. Location of Boreholes 299-E33-45, 299-E33-46, and 299-E33-338 in Waste Management Area B-BX-BY



B.2.0 BOREHOLE 299-E33-338 CHARACTERIZATION SUMMARY

This section summarizes data collected from samples in borehole 299-E33-338 (C3391). Borehole 299-E33-338 was drilled for two purposes. One purpose was for installation of a RCRA ground-water monitoring well (Horton 2002) and the other was to characterize the in situ soils and background porewater chemistry near WMA B-BX-BY that have been largely uncontaminated by tank farm and crib and trench discharge operations. This borehole was drilled just outside the southeast fence line of the B tank farm. The borehole was drilled between July 23 and August 8, 2001 to a total depth of 80.05 m (275.75 ft) bgs using the cable-tool method (Horton 2002). The water table was contacted at 77.5 m (254.2 ft) bgs and the top of basalt at 82.6 m (271 ft) bgs. Samples to the top of basalt were collected via a drive barrel/splitspoon, before switching to a hard tool to drill 5 feet into the basalt.

Nearly continuous core was obtained down to a depth of ~78.6 m (258 ft) bgs. Two hundred and two 2-ft long by 4-in. diameter cores were retrieved, which accounts for ~75% of the total length of the borehole. Each 2-ft splitspoon contained two 1-ft lexan-lined core segments. The lithology of this borehole was summarized onto a field geologist's log by a CH2M HILL Hanford Group, Inc. geologist (L. D. Walker); subsequently visual inspection of the cores was performed in the laboratory by K. A. Lindsey (Kennedy / Jenks Consultants), K. D. Reynolds (Duratek Federal Services), and B. N. Bjornstad (Pacific Northwest National Laboratory), who also collected 24 samples for paleomagnetic analysis.

Subsamples were taken from all 102 cores for moisture content (Table B.1). In addition, 21 core subsamples were collected from a depth of geological interest for mineralogical and geochemical analysis. Data from these samples allow for comparison of uncontaminated versus contaminated soils to better understand the contributions of tank wastes and other wastewaters on the vadose zone in and around WMA B-BX-BY.

B.3.0 GEOLOGY AT BOREHOLE 299-E33-338

B.3.1 HANFORD FORMATION

Wood et al. (2000) and Lindsey et al. (2001), describe cataclysmic flood deposits of the Hanford formation in the vicinity of the 241-B-BX-BY tank farm as consisting of three informal units (H1, H2, and H3).

B.3.1.1 Hanford Formation H1 Unit

Three splitspoon samples were collected from this interval. This unit consists of mostly sandy gravel to silty sandy gravel, with lesser amounts of gravelly sand. A single, thin (0.5 ft) silt layer occurs within this sequence at about 4.6 m (15 ft) bgs. The gravels are multi-lithologic but generally containing a high percentage of basalt (Figure B.2). The gravel clasts were generally subrounded to well rounded up to 50 mm in diameter where not broken. The finer fraction was described as mostly very coarse to coarse sand with perhaps as much as 5 to 7% mud. The samples generally displayed no cementation or obvious sedimentary structure, and only weak to no reaction to hydrochloric acid. The Hanford formation H1 unit is 15.7 m (51.5 ft) thick in borehole 299-E33-338.

B.3.1.2 Hanford Formation H2 Unit

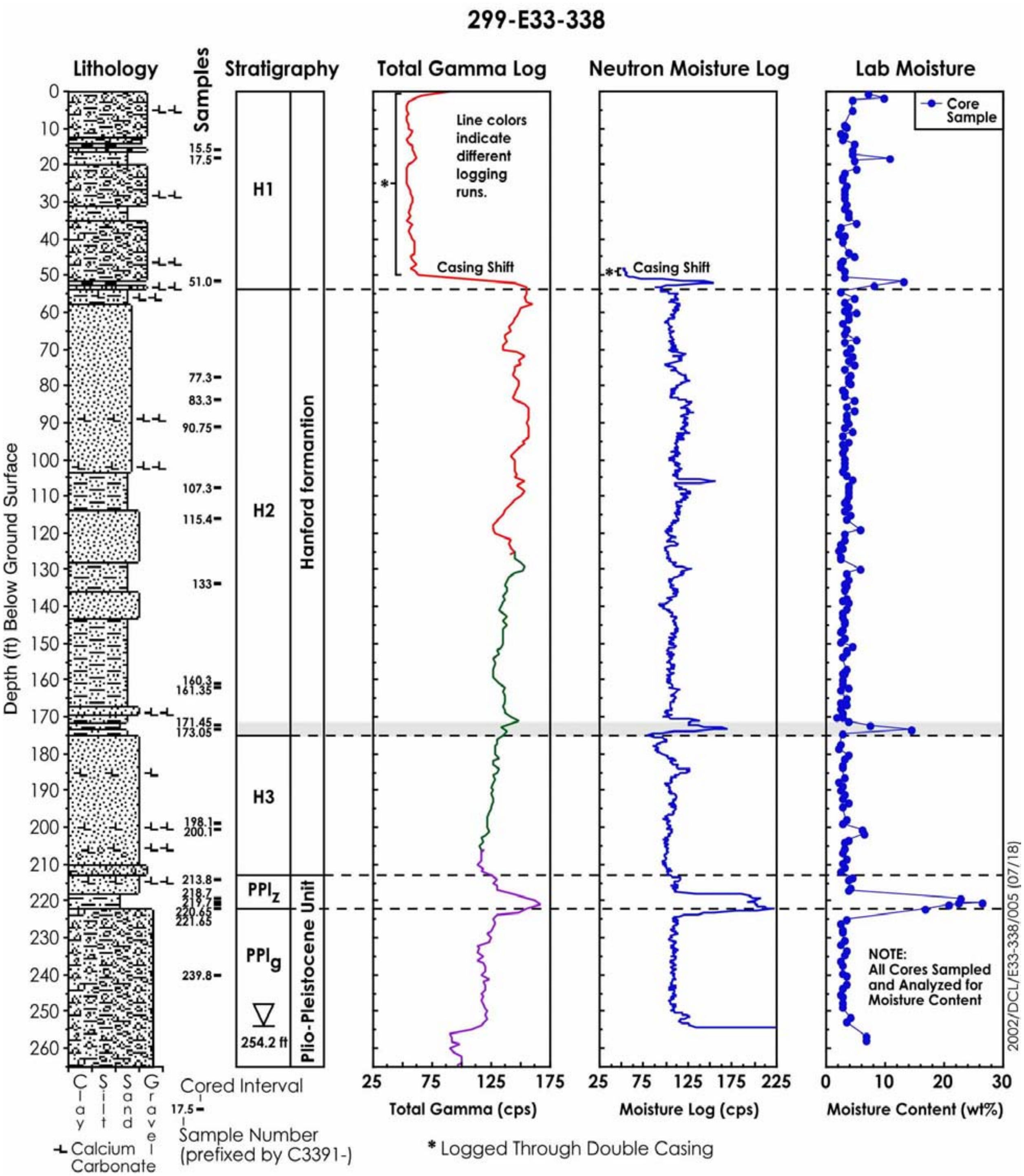
The Hanford formation H2 unit consists of a sand-dominated sequence of cataclysmic flood deposits. The H2 unit is 42.2 m (138.5 ft) thick extending from a depth of 15.7 m (51.5 ft) to 57.9 m (190 ft). A total of ten, one-foot splitspoon liners were sampled for mineralogical and geochemical characterization from the H2 unit. The H2 unit is predominantly a poor to well sorted, medium to coarse-grained sand (Figure B.2). The upper 10 m (30 ft) of the H2 unit is slightly coarser with occasional matrix-supported pebbles floating in a coarse sand matrix. With depth, the medium to coarse sand becomes more frequently interstratified with layers of fine- to medium-grained sand. Distinctive is the "salt and pepper" appearance of the sand imparted by the approximately equal concentrations of dark colored basalt and light colored quartz and feldspar.

Two thin (<0.5 ft) fine-grained silty layers were observed within the Hanford formation H2 unit. One occurs at the top of the H2 unit at ~15.7 m (51.5 ft) and the other lies at ~53 m (174 ft) bgs. The lower of these fine-grained units is shown in Figure B.1. Other fine-grained layers may also be present, but must be limited to the relatively short interval between core runs, which are generally only 0.5 to 1.0 ft thick. One such interval may occur between 105.6 to 106.2 ft bgs, as indicated by a narrow spike in the neutron moisture log at this depth (Figure B.1). Fine-grained units generally retain more moisture, which is often revealed on the neutron moisture log.

B.3.1.3 Hanford Formation H3 Unit

The Hanford formation H3 unit is 10.52 m (34.5 ft) thick, extending from a depth of 57.9 m (190 ft) to 64.8 m (212.5 ft). The top of the H3 unit (190 ft bgs) is chosen based on reappearance of gravelly flood facies. A weak paleosol within this sequence appears to be present at about the 61 m (200 ft) depth, as indicated by a finer-grained, calcareous zone containing organic matter and a tephra horizon.

Figure B.2. Borehole 299-E33-338 Lithology, Stratigraphy, Field Logs, and Moisture Distribution as a Function of Depth



B.3.2 HANFORD FORMATION/PLIO-PLEISTOCENE UNIT

The exact origin of the sedimentary deposits underlying the Hanford formation H3 unit is uncertain and still open to interpretation (Table B.1). Recent reports have designated deposits beneath the Hanford formation H3 unit as the Hanford formation/Plio-Pleistocene unit (Hf/PPu) (Wood et al. 2000) and Hanford/Plio-Pleistocene/Ringold (H/PP/R) unit (Lindsey et al. 2001). Wood et al. (2000) recognized two facies of the Hf/PPu beneath the 241-B, BX, and BY tank farms: a fine-grained eolian/overbank silt (silt facies), up to 10 m thick, and a sandy gravel to gravelly sand facies. The thick silt-rich interval is believed to be a pre-ice age flood deposit, since silty layers associated with ice age flood deposits of the Hanford formation in this area are generally much thinner (i.e., a few centimeters or less) (Wood et al. 2000). The texture, structure, and color of the thick silt layer are all identical to that of the early Palouse soil (Tallman et al. 1979; DOE 1988), more recently referred to as the PPlz or upper Plio-Pleistocene unit, which is widely distributed beneath the 200 West Area (Wood et al. 2000; Serne et al. 2002c).

Where the PPlz unit is absent beneath the B-BX-BY tank farms, the gravel sequence below the silt unit is indistinguishable from similar-appearing facies of the Hanford formation H3 unit, which overlies the PPlz unit (Wood et al. 2000). In fact, prior to the discovery of the thick silt layer, reported in Wood et al. (2000), gravels overlying basalt bedrock were always included in the Hanford formation (Tallman et al. 1979; Last et al. 1989; Connelly et al. 1992; Lindsey et al. 1992). If the thick silt layer predates the Hanford formation, however, then the underlying gravels must also predate the Hanford formation. Thus, the gravel sequence beneath the silt layer must belong to either a mainstream alluvial facies of the Plio-Pleistocene unit or the Ringold Formation.

B.3.2.1 Silt-Dominated Facies (PPlz)

The silt facies encountered by well 299-E33-338 is 3 m (9.9 ft) thick, extending from a depth of 64.8 m (212.5 ft) to 67.8 m (222.4 ft) bgs. The silt facies of the Plio-Pleistocene unit is divided into two distinctive beds in borehole 299-E33-338. The upper bed consists of a light brown to tan colored, massive, well sorted fine sand.

B.3.2.2 Sandy Gravel to Gravelly Sand Dominated Facies (PPlg)

A sequence of sandy gravel to gravelly sand was encountered at a depth of 67.8 m (222.4 ft). This gravel-rich facies continues to the top of basalt at 82.6 m (271 ft bgs). Only one core sample (C3391-239.8) was characterized from this unit (Table B.1). These materials were described as muddy sandy gravel to sandy gravel, consisting of an estimated 30 to 80% gravel, 15 to 65% sand, and up to 15% mud (Figure B.2). The gravel clasts were described as a mixture of mostly quartzite, basalt, and some highly weathered friable granite. Where unbroken, the gravel clasts are subrounded to rounded and range up to at least 60 mm in diameter (intermediate axis). The matrix was described as ranging from mostly very fine sand to poorly sorted coarse to medium sand, with variable mud content. These materials were further described as moderate to uncemented with strong to no reaction to dilute hydrochloric acid. Some caliche fragments were noted, exhibiting a strong reaction to hydrochloric acid.

Table B.1. Moisture Content of Sediments in Borehole 299-E33-338 (3 pages)

Lithologic Unit	Sample No.	Mid Depth (Vertical ft)[(a)]	% Moisture	Lithologic Unit	Sample No.	Mid Depth (Vertical ft)[(a)]	% Moisture
H1	C3391-0	0.5	7.02%	H2	C3391-124.35	124.85	2.00%
H1	C3391-1	1.5	9.75%	H2	C3391-125.6	126.1	2.47%
H1	C3391-2	2.5	4.37%	H2	C3391-126.6	127.1	2.45%
H1	C3391-4.75	5.25	4.27%	H2	C3391-129.3	129.8	5.62%
H1	C3391-8.4	8.9	2.95%	H2	C3391-130.3	130.8	3.20%
H1	C3391-9.4	9.9	3.52%	H2	C3391-132	132.5	3.66%
H1	C3391-10.7	11.2	2.37%	H2	C3391-133	133.5	3.01%
H1	C3391-11.7	12.2	2.89%	H2	C3391-134	134.5	3.21%
H1	C3391-12.5	13	2.65%	H2	C3391-135	135.5	3.02%
H1	C3391-13.5	14	4.57%	H2	C3391-136.95	137.45	3.39%
H1	C3391-15.5	16	4.20%	H2	C3391-137.95	138.45	2.59%
H1	C3391-16.5	17	4.51%	H2	C3391-138.8	138.9	3.54%
H1	C3391-17.5	18	10.57%	H2	C3391-139.8	140.3	3.23%
H1	C3391-18.5	19	4.65%	H2	C3391-141.15	141.65	2.64%
H1	C3391-20.5	21	5.03%	H2	C3391-142.15	142.65	2.58%
H1	C3391-21.5	22	3.04%	H2	C3391-143.1	143.75	3.01%
H1	C3391-22.5	23	2.76%	H2	C3391-144.1	144.6	2.87%
H1	C3391-23.5	24	2.74%	H2	C3391-145.45	145.95	2.81%
H1	C3391-25	25.5	3.21%	H2	C3391-146.45	146.95	2.23%
H1	C3391-26	26.5	3.16%	H2	C3391-147.8	148.3	3.03%
H1	C3391-27.5	28	2.90%	H2	C3391-148.8	149.3	2.28%
H1	C3391-28.5	29	3.03%	H2	C3391-150.05	150.55	4.34%
H1	C3391-30.25	30.75	3.49%	H2	C3391-151.05	151.55	3.28%
H1	C3391-31.25	31.75	3.14%	H2	C3391-152.15	152.65	3.51%
H1	C3391-32.5	33	3.74%	H2	C3391-153.15	153.65	2.55%
H1	C3391-33.5	34	3.74%	H2	C3391-156.3	156.8	3.32%
H1	C3391-35.5	36	5.18%	H2	C3391-156.8	157.3	3.08%
H1	C3391-36.5	37	2.24%	H2	C3391-157.3	157.8	2.88%
H1	C3391-37.78	38.28	1.96%	H2	C3391-157.8	158.3	2.72%
H1	C3391-38.78	39.28	3.01%	H2	C3391-159.3	159.8	2.58%
H1	C3391-39.6	39.65	2.68%	H2	C3391-160.3	160.8	2.59%
H1	C3391-40.6	41.1	2.56%	H2	C3391-161.35	161.85	3.72%
H1	C3391-43.2	43.7	3.63%	H2	C3391-162.35	162.85	2.35%
H1	C3391-44.2	44.7	4.69%	H2	C3391-164.3	164.8	3.36%
H1	C3391-45.2	45.7	2.71%	H2	C3391-165.3	165.8	2.37%
H1	C3391-46.2	46.7	2.46%	H2	C3391-166.15	166.65	3.28%
H1	C3391-47.2	47.7	2.49%	H2	C3391-167.15	167.65	2.28%

Table B.1. Moisture Content of Sediments in Borehole 299-E33-338 (3 pages)

Lithologic Unit	Sample No.	Mid Depth (Vertical ft)[a]	% Moisture	Lithologic Unit	Sample No.	Mid Depth (Vertical ft)[a]	% Moisture
H1	C3391-48.2	48.7	2.88%	H2	C3391-168.35	168.85	2.79%
H1	C3391-50.05	50.55	3.17%	H2	C3391-169.35	169.85	2.81%
H1	C3391-51.05	51.55	12.95%	H2	C3391-169.35 upper	169.85	1.79%
H2	C3391-52.75	52.75	7.91%	H2	C3391-170.45	170.95	3.79%
H2	C3391-53.75	54.25	2.28%	H2	C3391-171.45	171.95	7.33%
H2	C3391-55.7	56.2	4.66%	H2	C3391-173.05	173.55	14.27%
H2	C3391-56.7	57.2	2.89%	H2	C3391-174.05	174.55	2.60%
H2	C3391-57.9	58.4	3.58%	H3z	C3391-176.8	177.3	2.35%
H2	C3391-58.9	59.4	2.87%	H3z	C3391-177.8	178.3	2.13%
H2	C3391-59.3	59.8	5.16%	H3z	C3391-179.9	180.4	3.67%
H2	C3391-60.3	60.8	3.77%	H3z	C3391-180.9	181.4	3.00%
H2	C3391-61.5	62	3.83%	H3z	C3391-182.2	182.7	2.72%
H2	C3391-62.5	63	2.58%	H3z	C3391-183.2	183.7	2.65%
H2	C3391-64.3	64.8	3.21%	H3z	C3391-185.7	186.2	3.13%
H2	C3391-65.3	65.8	2.89%	H3z	C3391-186.7	187.2	2.19%
H2	C3391-66.75	67.25	5.09%	H3z	C3391-188	188.5	2.86%
H2	C3391-67.75	68.25	2.99%	H3z	C3391-189	189.5	2.44%
H2	C3391-69.3	69.8	3.91%	H3z	C3391-190.4	190.9	3.17%
H2	C3391-70.3	70.8	3.27%	H3z	C3391-191.4	191.9	2.84%
H2	C3391-71.7	72.2	4.32%	H3z	C3391-192.6	193.1	3.65%
H2	C3391-72.7	73.2	3.61%	H3z	C3391-193.6	194.1	2.62%
H2	C3391-73.9	74.4	4.76%	H3z	C3391-197.1	197.6	3.53%
H2	C3391-74.9	75.4	3.02%	H3z	C3391-198.1	198.6	2.79%
H2	C3391-76.3	76.8	4.17%	H3z	C3391-200.1	200.6	6.03%
H2	C3391-77.3	77.8	3.69%	H3z	C3391-201.1	201.6	6.20%
H2	C3391-78.1	78.6	3.64%	H3z	C3391-202.6	203.1	3.63%
H2	C3391-79.1	79.6	4.13%	H3z	C3391-203.6	204.1	3.10%
H2	C3391-80.25	80.75	2.72%	H3z	C3391-205.3	205.8	2.88%
H2	C3391-81.25	81.75	3.06%	H3z	C3391-206.3	206.8	2.79%
H2	C3391-82.3	82.8	3.11%	H3z	C3391-208.1	208.6	3.25%
H2	C3391-83.3	83.8	4.58%	H3z	C3391-209.1	209.6	2.65%
H2	C3391-85.05	85.55	3.28%	H3z	C3391-210.3	210.8	3.05%
H2	C3391-86.05	86.55	4.78%	H3z	C3391-211.3	211.8	2.46%
H2	C3391-87.35	87.85	3.42%	PPlz	C3391-212.8	213.3	4.22%
H2	C3391-88.35	88.85	3.22%	PPlz	C3391-213.8	214.3	3.66%
H2	C3391-89.75	90.25	3.83%	PPlz	C3391-215.6	216.1	4.15%

Table B.1. Moisture Content of Sediments in Borehole 299-E33-338 (3 pages)

Lithologic Unit	Sample No.	Mid Depth (Vertical ft)[a]	% Moisture	Lithologic Unit	Sample No.	Mid Depth (Vertical ft)[a]	% Moisture
H2	C3391-90.75	91.25	3.08%	PPlz	C3391-216.6	217.1	3.68%
H2	C3391-92.05	92.55	4.41%	PPlz	C3391-218.7	219.2	22.81%
H2	C3391-93.05	93.55	2.77%	PPlz	C3391-219.7 below sand	220.2	22.30%
H2	C3391-94.5	95	3.66%	PPlz	C3391-219.7 above sand layer	220.2	26.20%
H2	C3391-95.5	96	2.71%	PPlz	C3391-220.65	221.15	20.62%
H2	C3391-96.5	97	3.08%	PPlz	C3391-221.65	222.15	16.64%
H2	C3391-97.5	98	2.60%	PPlg	C3391-224.5	225	3.39%
H2	C3391-99.15	99.65	3.03%	PPlg	C3391-225.5	226	2.23%
H2	C3391-100.15	100.65	2.96%	PPlg	C3391-227	227.5	2.59%
H2	C3391-101.6	102.1	3.14%	PPlg	C3391-228	228.5	2.75%
H2	C3391-102.6	103.1	2.85%	PPlg	C3391-230.2	230.7	3.08%
H2	C3391-103.7	104.2	3.29%	PPlg	C3391-231.2	231.7	2.27%
H2	C3391-104.7	105.2	4.21%	PPlg	C3391-233	233.5	3.50%
H2	C3391-106.3	106.8	3.57%	PPlg	C3391-234	234.5	3.03%
H2	C3391-107.3	107.8	3.82%	PPlg	C3391-235.8	236.3	2.20%
H2	C3391-108.3	108.8	3.57%	PPlg	C3391-236.8	237.3	2.81%
H2	C3391-109.3	109.8	3.56%	PPlg	C3391-238.8	239.3	2.60%
H2	C3391-110.3	110.8	3.51%	PPlg	C3391-239.8	240.3	3.27%
H2	C3391-111.3	111.8	3.05%	PPlg	C3391-241.9	242.4	3.52%
H2	C3391-112.45	112.95	3.72%	PPlg	C3391-242.9	243.4	2.55%
H2	C3391-113.45	113.95	3.03%	PPlg	C3391-244.5	245	2.51%
H2	C3391-114.4	114.9	4.19%	PPlg	C3391-245.5	246	2.64%
H2	C3391-115.4	115.9	3.35%	PPlg	C3391-247.1	247.6	2.80%
H2	C3391-118.5	119	5.74%	PPlg	C3391-248.1	248.6	2.77%
H2	C3391-119.5	120	2.98%	PPlg	C3391-250.9	251.4	3.87%
H2	C3391-121.35	121.85	3.20%	PPlg	C3391-251.9	252.4	3.35%
H2	C3391-122.35	122.85	2.36%	PPlg	C3391-256.1	256.6	6.59%
H2	C3391-123.35	123.85	2.66%	PPlg	C3391-257.1	257.6	6.80%

[a] Multiply by 0.3048 to convert to meters.

B.3.3 GEOPHYSICAL AND MOISTURE CONTENT MEASUREMENTS

All of the cores were sub-sampled for gravimetric moisture content (Table B.1) and the results are shown in Figure B.2 along with field log data. Three relatively moist zones were found, the shallowest and least moist was at ~52 ft bgs at the bottom of the Hanford H1 unit. The second moist zone was at the bottom of the Hanford H2 unit at 171.5 to 174 ft bgs. The zone with highest moisture content was at the bottom of the Plio-Pleistocene mud unit, between 218.7 and 222.6 ft bgs, with water contents reaching values of 21 to 26% by weight. Table B.2 identifies the twenty-two core samples that were selected, some from each of the lithologies, and subjected to water and acid extracts to develop baseline data on porewater pH, electrical conductivity (EC), major cations and anions, and trace metals. The mass of constituents that were water and acid leachable were also determined to allow comparison with similar data for contaminated boreholes. The comparison allows an estimate of the inventory of contaminants in the vadose zone that are attributable to leaked tank fluids.

B.3.4 SOIL WATER CHEMISTRY MEASUREMENTS

An extensive water chemistry analysis has been completed for borehole 299-E33-338 samples collected between 5 and 73 m (16 and 240 ft) bgs. Chemical characteristics show no strong trends as a function of depth and there is little indication of tank waste interaction with vadose zone soils at this location. Primary characteristics include the following:

- The one to one sediment to water extract pH varied from 7.2 to 7.8 and in general increased with depth (Figure B.3 and Table B.2)
- The average pH value is 7.4
- There were small increases in pH at the contact between the Hanford H2 and H3 units and the top and bottom of the Plio-Pleistocene mud unit
- The dilution corrected water extract EC is an estimate of the vadose porewater EC
- Porewater EC varied from 0.88 to 4.3 mS/cm with an average of 2.4 mS/cm
- There were high EC values deep in the Hanford H2 unit at ~160 ft bgs and in the deepest sample characterized (in the Plio-Pleistocene gravelly sand unit (PPLg).

Figure B.3. Borehole 299-E33-338 Lithology, Stratigraphy, and Moisture, Extract pH, and Calculated Porewater Electrical Conductivity Distribution as a Function of Depth

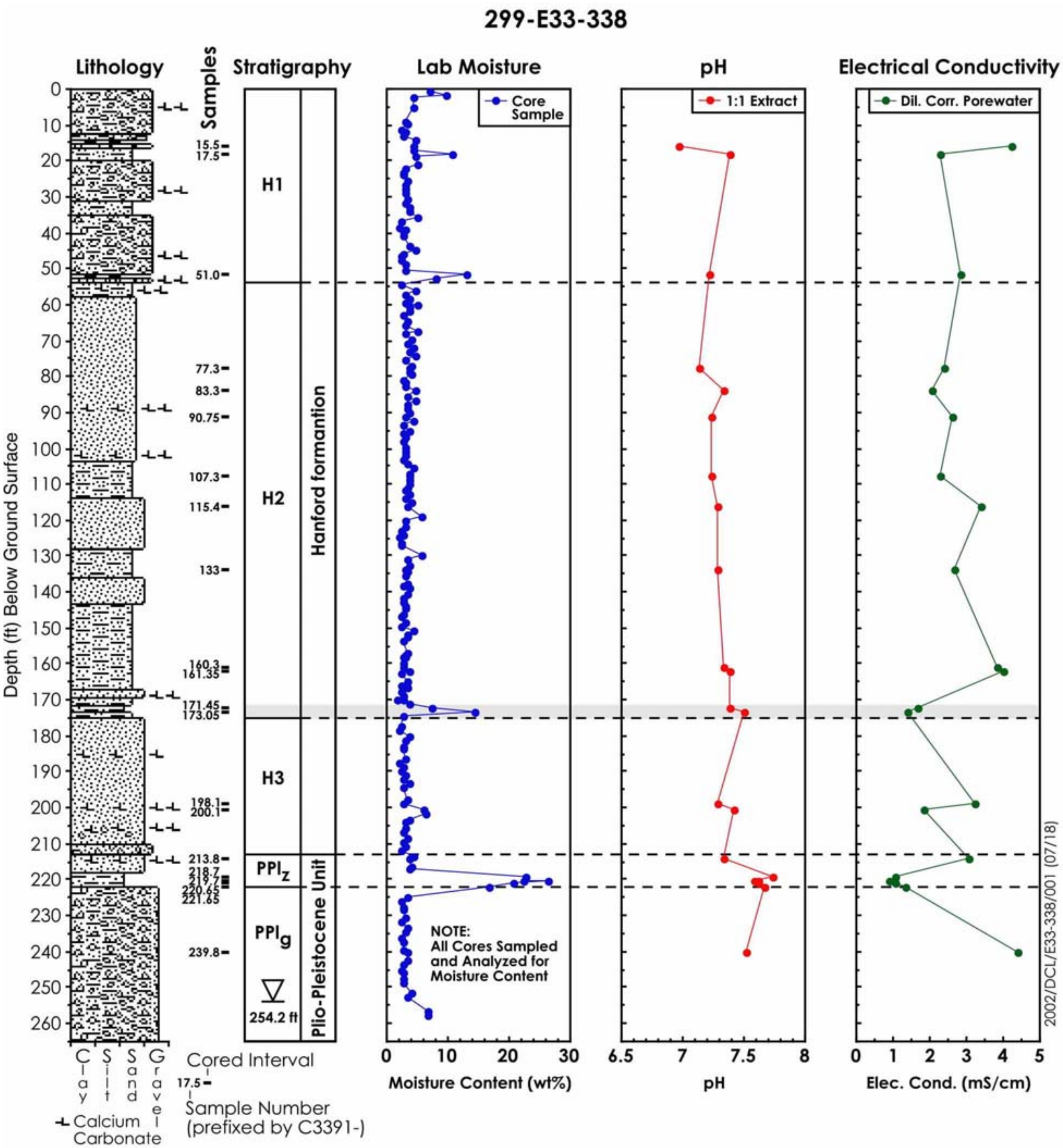


Table B.2. Water Extract pH and Calculated Porewater Electrical Conductivity Values for Borehole 299-E33-338

Sample ID	Mid Depth (ft)[a]	Dilution Factor	1:1 pH	1:1 EC mS/cm	Pore EC mS/cm
H1 Coarse Sand					
C3391-15.5	16	23.82	6.97	0.178	4.24
C3391-17.5	18	9.66	7.39	0.235	2.27
C3391-51.05	51.55	7.78	7.22	0.366	2.85
H2 Hanford Formation H2 Unit — Upper Sequence					
C3391-77.3	77.8	27.10	7.14	0.088	2.38
C3391-83.3	83.8	21.84	7.34	0.095	2.07
C3391-90.75	91.25	32.53	7.23	0.081	2.63
C3391-107.3	107.8	26.18	7.23	0.087	2.28
C3391-115.4	115.9	29.85	7.28	0.113	3.37
C3391-133	133.5	33.26	7.28	0.08	2.66
C3391-160.3	160.8	38.68	7.33	0.099	3.83
C3391-161.35	161.85	26.87	7.38	0.148	3.98
C3391-171.45	171.95	13.65	7.38	0.122	1.66
C3391-173.05	173.55	7.01	7.5	0.203	1.42
Hanford Formation H3 Unit					
C3391-198.1	198.6	35.88	7.29	0.09	3.23
C3391-200.1	200.6	16.59	7.42	0.112	1.86
Plio-Pleistocene Fine-Grained Mud Unit (PPlz)					
C3391-213.8	214.3	27.30	7.34	0.112	3.06
C3391-218.7	219.2	4.39	7.74	0.247	1.08
C3391-219.7 below sand	220.2	4.60	7.59	0.201	0.92
C3391-219.7 above sand layer	220.2	4.19	7.62	0.211	0.88
C3391-220.65	221.15	4.87	7.62	0.213	1.04
C3391-221.65	222.15	6.02	7.67	0.226	1.36
Plio-Pleistocene Gravely Sand Unit (PPlg)					
C3391-239.8	240.3	30.55	7.52	0.143	4.37

[a] Multiply by 0.3048 to convert to meters. Each sample was about 10 inches long, the mid point is used for plotting.

EC = Electrical conductivity

Figure B.4, Table B.3, and Table B.4 show the estimated porewater concentration of major cations and trace metals, respectively. The shapes of the cation profiles versus depth are very similar with slight peaks in the deep portion of the H2 unit at ~160 ft bgs, at the top of the Plio-Pleistocene mud unit, and in the deepest sample characterized in the PPLg unit. All three of these samples had very low water contents and thus the dilution factor was high. The apparent high porewater concentrations likely represent some dissolution of salts from the sediment that are multiplied by a large dilution factor and thus suggest more saline porewater than surrounding sediments with higher water content. In general, the calculated porewater cation concentrations ranged from 63 to 275, 11 to 138, 11 to 56, and 70 to 558 mg/L for calcium, potassium, magnesium, and sodium, respectively. The averages and median values were (142, 149), (60, 58), (34, 38), and (190, 141) mg/L, for calcium, potassium, magnesium, and sodium, respectively. These values are likely somewhat artificially elevated because of the water extraction of soluble salts.

Figure B.5 and Tables B.3 and B.4 show the calculated porewater concentrations for aluminum, barium, iron, silicon, and uranium-238. Of particular interest is the porewater aluminum, iron, and uranium-238 concentrations that ranged from 0.01 to 5.29, 0.0 to 6.4, and 46 to 350 mg/L for aluminum, barium, and iron, respectively and 1.8 to 24 µg/L for uranium. The uncontaminated uranium-238 porewater concentration is especially important for comparison with the two contaminated borehole sediment porewaters. No tank waste derived radionuclides were detected in these soils. Small quantities presumably of naturally occurring uranium (i.e., ~ 2.0 to 24 µg/L) were measured in all water extract samples.

Figure B.6 and Table B.5 show the estimated porewater concentration of major anions. The shapes of the anion profiles versus depth vary from each other instead of being similar as were the cation profiles. There are no consistent depths where all anions peak. The wetter samples consistently show low calculated porewater anion concentrations suggesting that the dilution factor is again controlling the apparent concentrations. That is, all the sediments likely dissolve some salts that are not truly in the porewater so that the dilution correction makes it appear that the porewater anion concentrations are higher in the drier sediments. Primary constituents are carbonate, sulfate, and chloride. Other less concentrated anions include fluoride and nitrate. In general, the calculated porewater anion concentrations range from 0.4 to 23.3, 1.8 to 223, 1.3 to 100, 296 to 1877, and 196, 117 mg/L for fluoride, chloride, nitrate, bicarbonate, and sulfate, respectively. The average and median values are (6.3, 4.8), (35, 19), (19, 10), (993, 1030), and (196, 117) mg/L for fluoride, chloride, nitrate, bicarbonate, and sulfate, respectively. These values are likely somewhat artificially elevated because of the water extraction of soluble salts.

The mass of several constituents per gram of dry sediment that was leached by water and acid extracts are shown in Figures B.7 and B.8 and in Tables B.6 and B.7. In all cases, the mass that was water leachable is a very small fraction of the mass that was acid extractable. These concentrations can be compared with the same constituents for contaminated sediments to get an estimate of the mass of a constituent present in the vadose zone profile from tank leaked liquids.

Figure B.4. Calculated Cation Porewater Content for Borehole 299-E33-338 as a Function of Depth

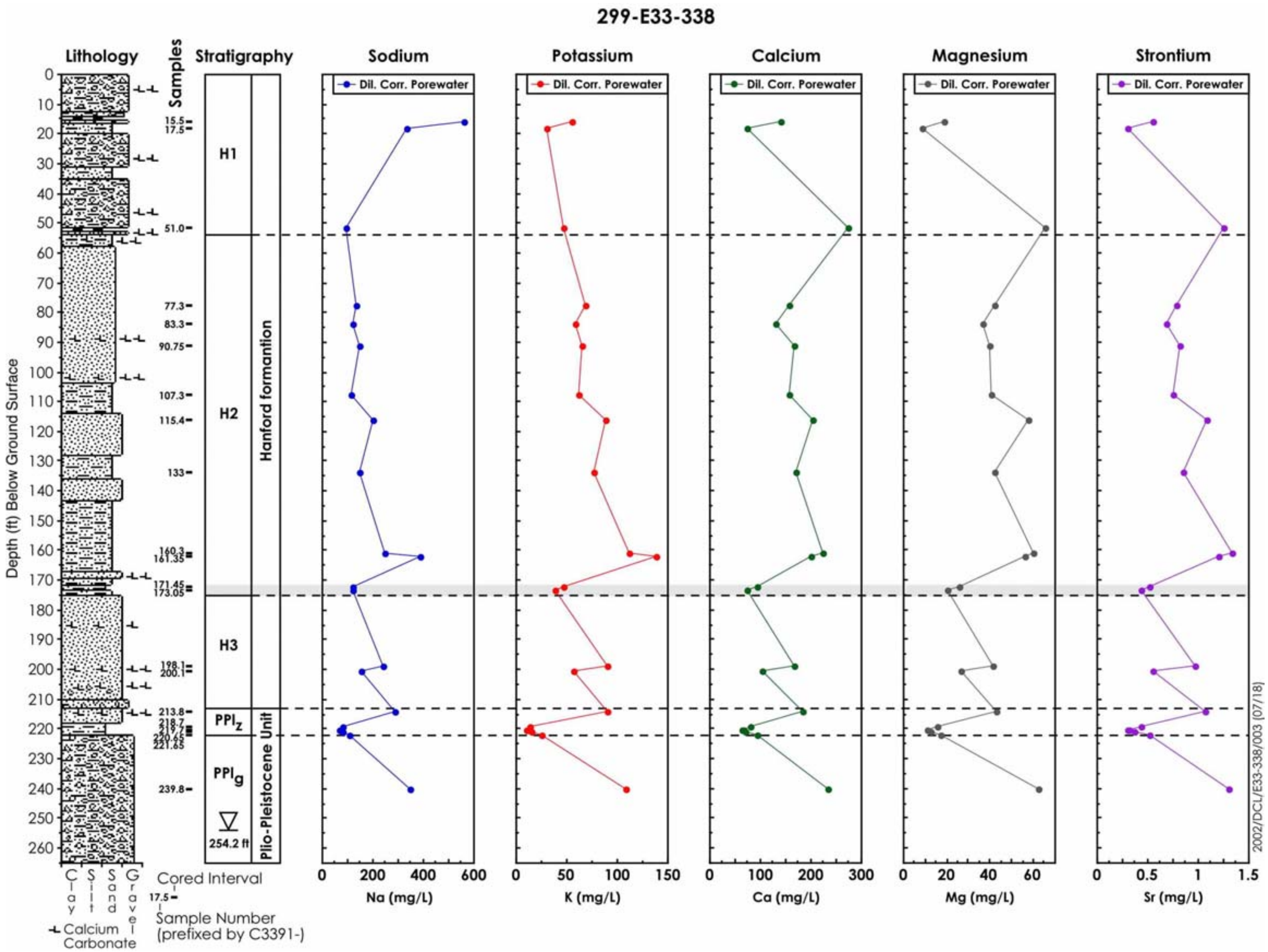


Table B.3. Calculated Cation Porewater Content for Borehole 299-E33-338 (2 pages)

Sample Identification	Depth (ft bgs)[(a)]	Dilution Factor	Dilution Corrected Porewater Concentration of Cations								
			Al mg/L	Ba mg/L	Ca mg/L	Fe mg/L	K mg/L	Mg mg/L	Na mg/L	Si mg/L	Sr mg/L
H1 Coarse Sand											
C3391-15.5	16.00	23.82	(0.64)	0.83	141.47	(0.5)	55.40	18.64	557.59	185.17	0.55
C3391-17.5	18.00	9.66	(0.37)	0.36	73.81	(0.6)	30.90	8.57	336.59	147.04	0.30
C3391-51.05	51.55	7.78	(3.89)	0.28	274.70	(0.0)	47.33	65.55	91.56	74.21	1.25
Hanford Formation H2 Unit — Upper Sequence											
C3391-77.3	77.80	27.10	(1.00)	0.57	156.34	(0.6)	69.13	42.33	134.52	139.23	0.78
C3391-83.3	83.80	21.84	(0.70)	1.03	131.90	(0.5)	58.53	36.31	122.00	144.05	0.69
C3391-90.75	91.25	32.53	(1.76)	0.72	166.33	(1.2)	65.44	40.05	148.22	147.90	0.82
C3391-107.3	107.80	26.18	(1.28)	0.62	157.52	(1.0)	62.42	40.38	117.00	136.04	0.75
C3391-115.4	115.90	29.85	(1.68)	0.92	203.65	(2.9)	89.18	57.88	203.48	258.67	1.09
C3391-133	133.50	33.26	(1.91)	0.42	170.14	(2.6)	76.98	41.96	147.85	168.98	0.85
C3391-160.3	160.80	38.68	(3.12)	1.24	225.28	(2.8)	111.93	59.88	250.21	298.74	1.33
C3391-161.35	161.85	26.87	(5.29)	1.34	200.56	6.4	138.20	55.81	385.86	251.11	1.20
C3391-171.45	171.95	13.65	(0.54)	0.55	92.03	(0.7)	47.11	25.67	123.22	129.21	0.52
C3391-173.05	173.55	7.01	(0.22)	0.28	75.06	(0.2)	38.24	20.65	122.01	73.53	0.44
Hanford Formation H3 Unit											
C3391-198.1	198.60	35.88	(1.76)	0.72	168.53	(1.1)	90.54	41.63	237.88	213.35	0.96
C3391-200.1	200.60	16.59	(0.55)	0.42	103.09	(0.3)	56.60	26.62	152.86	107.71	0.55

Table B.3. Calculated Cation Porewater Content for Borehole 299-E33-338 (2 pages)

Sample Identification	Depth (ft bgs)[a]	Dilution Factor	Dilution Corrected Porewater Concentration of Cations								
			Al mg/L	Ba mg/L	Ca mg/L	Fe mg/L	K mg/L	Mg mg/L	Na mg/L	Si mg/L	Sr mg/L
Plio-Pleistocene Fine-Grained Mud Unit (PPlz)											
C3391-213.8	214.30	27.30	(2.46)	1.05	183.56	3.6	90.50	43.14	285.91	232.64	1.08
C3391-218.7	219.20	4.39	(0.04)	0.22	81.52	(0.0)	14.26	15.59	79.93	51.84	0.44
C3391-219.7 below sand	220.20	4.60	(0.05)	0.22	66.11	(0.1)	11.41	11.31	72.92	46.34	0.32
C3391-219.7 above sand layer	220.20	4.19	(0.01)	0.15	62.73	(0.1)	10.62	10.88	70.28	45.82	0.30
C3391-220.65	221.15	4.87	(0.08)	0.25	70.44	(0.0)	15.58	12.31	83.32	45.93	0.38
C3391-221.65	222.15	6.02	(0.23)	0.33	94.22	(0.3)	24.49	17.06	109.31	63.02	0.51
Plio-Pleistocene Gravely Sand Unit (PPlg)											
C3391-239.8	240.30	30.55	(0.77)	1.24	232.35	(0.7)	108.56	62.56	344.76	349.64	1.30

[a] Multiply by 0.3048 to convert to meters.
Values in parentheses are below level of quantification but spectra look useable.

Table B.4. Calculated Porewater Trace Metal Composition for Water Extracts of Sediment

ID	Depth (ft bgs)[a]	Dilution Factor	Cr ug/L	As ug/L	Se ug/L	U-238 ug/L
H1 Coarse Sand						
C3391-15.5	16.000	23.820	2.39E+01	(1.08E+02)	(6.38E+00)	1.14E+01
C3391-17.5	18.00	9.66	1.82E+01	1.16E+02	(6.09E+00)	1.33E+01
C3391-51.05	51.550	7.777	1.05E+01	4.58E+01	2.06E+01	3.71E+00
Hanford Formation H2 Unit — Upper Sequence						
C3391-77.3	77.800	27.096	(8.35E+00)	1.42E+02	(6.23E+00)	6.33E+00
C3391-83.3	83.800	21.841	1.616E+01	1.47E+02	<5.46E+01	8.66E+00
C3391-90.75	91.250	32.530	(1.01E+01)	2.64E+02	(6.73E+00)	6.15E+00
C3391-107.3	107.800	26.181	(9.74E+00)	2.01E+02	<6.55E+01	7.51E+00
C3391-115.4	115.900	29.850	(1.18E+01)	3.81E+02	<7.46E+01	9.98E+00
C3391-133	133.500	33.263	(2.02E+01)	2.64E+02	<8.32E+01	1.12E+01
C3391-160.3	160.800	38.681	(1.26E+01)	4.38E+02	(3.56E+00)	1.56E+01
C3391-161.35	161.850	26.867	2.42E+01	3.74E+02	(7.79E-01)	2.37E+01
C3391-171.45	171.950	13.646	(6.05E+00)	2.05E+02	<3.41E+01	1.01E+01
C3391-173.05	173.55	7.01	7.20E+00	1.40E+02	<1.75E+01	7.04E+00
Hanford Formation H3 Unit						
C3391-198.1	198.600	35.880	(9.80E+00)	2.49E+02	<8.97E+01	7.64E+00
C3391-200.1	200.600	16.586	(4.35E+00)	1.36E+02	<4.15E+01	1.22E+01
Plio-Pleistocene Fine-Grained Mud Unit (PPlz)						
C3391-213.8	214.300	27.297	1.65E+01	6.20E+02	<6.82E+01	9.61E+00
C3391-218.7	219.20	4.39	2.67E+01	4.70E+01	(1.98E+00)	5.04E+00
C3391-219.7 below sand	220.200	4.602	(1.78E+01)	3.27E+01	(1.09E+00)	1.79E+00
C3391-219.7 above sand layer	220.200	4.186	(2.09E+01)	3.77E+01	(2.22E+00)	2.00E+00
C3391-220.65	221.150	4.875	(1.53E+01)	3.17E+01	(2.49E+00)	2.93E+00
C3391-221.65	222.150	6.023	1.55E+01	5.60E+01	(2.61E+00)	4.61E+00
Plio-Pleistocene Gravely Sand Unit (PPlg						
C3391-239.8	240.300	30.545	(9.47E+00)	2.38E+02	(1.56E+00)	1.52E+01

[a] Multiply by 0.3048 to convert to meters.
Values in parentheses are below level of quantification but spectra look useable.

Figure B.5. Calculated Aluminum, Barium, Iron, Silicon, and Uranium Porewater Content for Borehole 299-E33-338 as a Function of Depth

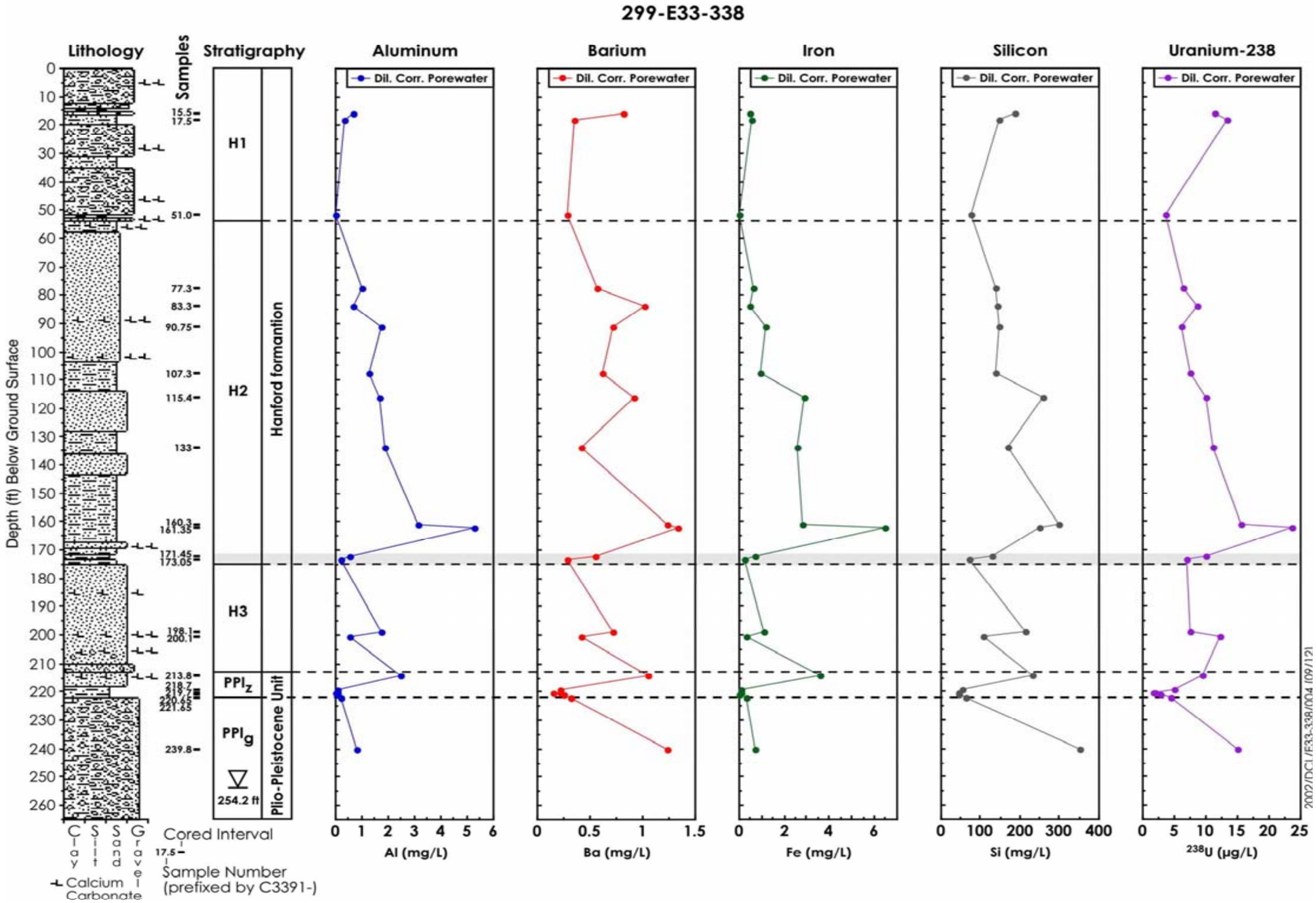


Figure B.6. Calculated Anion Porewater Content for Borehole 299-E33-338 as a Function of Depth

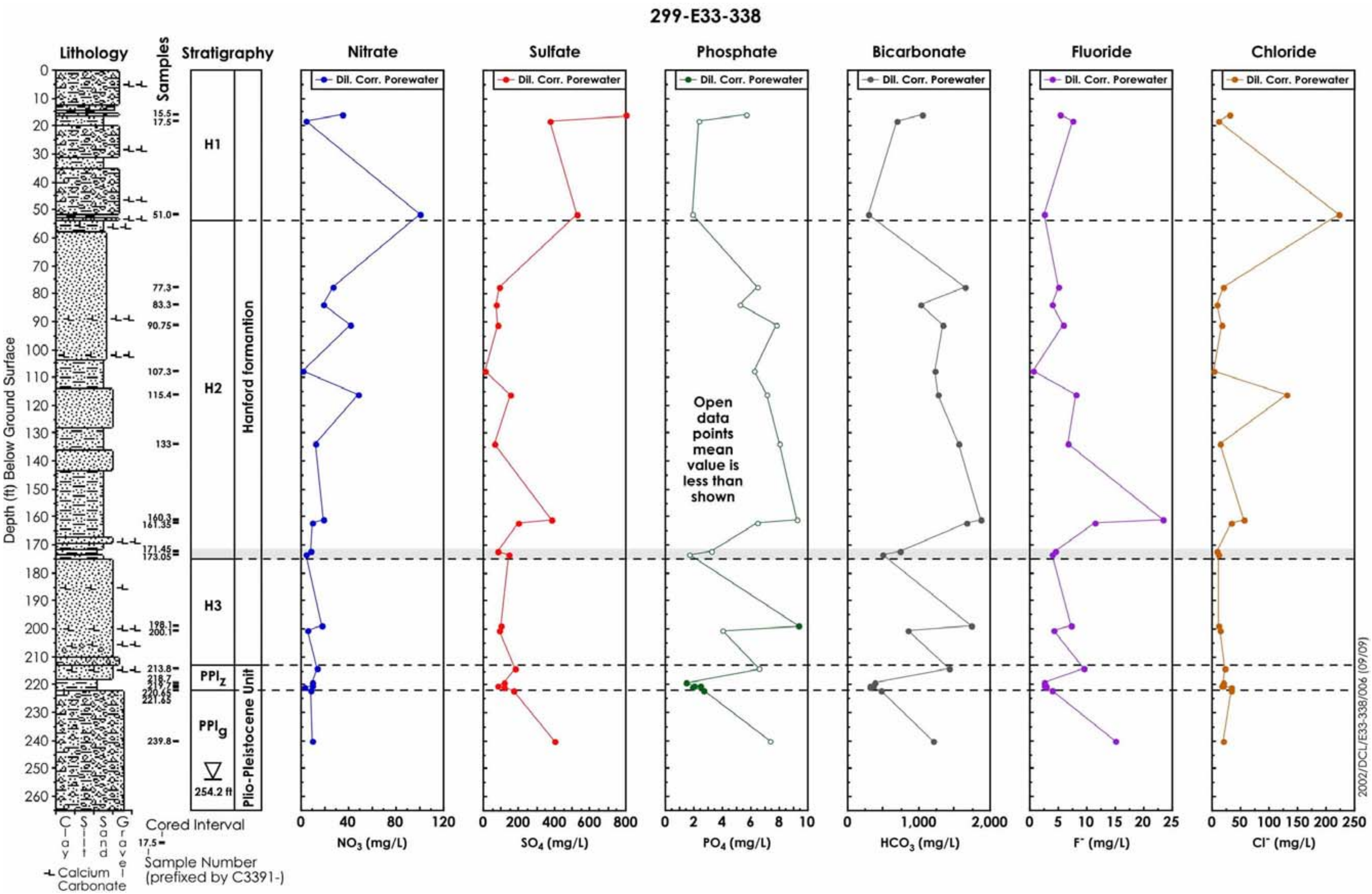


Table B.5. Calculated Anion Porewater Content for Borehole 299-E33-338 (2 pages)

Sample Identification	Depth[(a)]	Dil. Fac.	1:1 Extracts in mg/L							Dilution Corrected Porewater mg/L						
			NO3	F-	NO2	Cl	SO4	PO4	HCO3	NO3	F-	NO2	Cl	SO4	PO4	HCO3
H1 Coarse Sand																
C3391-15.5	16.00	23.82	1.44	0.22	<0.14	1.35	34	<0.24	43.8	34.26	5.18	<3.26	32.09	800	<5.7	1042
C3391-17.5	18.00	9.66	0.42	0.81	<0.14	1.10	40	<0.25	70.4	3.99	7.64	<1.32	10.45	376	<2.3	680
C3391-51.05	51.55	7.78	13.02	0.31	0.19	28.94	68	<0.24	38.1	100.53	2.42	1.46	223.42	521	<1.9	296
H2 Hanford Formation H2 Unit — Upper Sequence																
C3391-77.3	77.80	27.10	1.00	0.19	<0.14	0.78	3.4	<0.24	60.9	27.12	5.08	<3.71	21.07	92	<6.5	1650
C3391-83.3	83.80	21.84	0.85	0.18	<0.14	0.44	3.3	<0.24	46.6	18.64	3.95	<2.99	9.62	73	<5.2	1018
C3391-90.75	91.25	32.53	1.27	0.18	<0.14	0.48	2.4	<0.24	40.9	41.38	5.78	<4.46	15.62	79	<7.8	1331
C3391-107.3	107.80	26.18	0.05	0.02	<0.14	0.07	<0.5	<0.24	46.6	1.31	0.45	<3.59	1.80	<6.3	<6.3	1220
C3391-115.4	115.90	29.85	1.55	0.26	<0.13	4.24	4.8	<0.23	42.8	48.17	8.06	<4.09	131.42	148	<7.2	1278
C3391-133	133.50	33.26	0.38	0.20	<0.14	0.45	1.8	<0.24	46.6	12.56	6.79	<4.56	15.10	61	<8.0	1551
C3391-160.3	160.80	38.68	0.47	0.60	<0.14	1.48	10	<0.24	48.5	18.22	23.28	<5.30	57.12	386	<9.3	1877
C3391-161.35	161.85	26.87	0.37	0.43	<0.14	1.23	7.2	<0.24	61.9	9.86	11.50	<3.68	33.03	193	<6.5	1661
C3391-171.45	171.95	13.65	0.56	0.33	<0.14	0.55	6.1	<0.24	53.3	7.66	4.49	<1.87	7.51	83	<3.3	727
C3391-173.05	173.55	7.01	0.53	0.57	<0.14	1.55	20	<0.24	71.4	3.68	3.96	<0.96	10.83	141	<1.7	500
Hanford Formation H3 Unit																
C3391-198.1	198.60	35.88	0.47	0.20	<0.14	0.35	2.7	0.26	48.5	16.85	7.28	<4.92	12.43	96	9.4	1741
C3391-200.1	200.60	16.59	<0.29	0.25	<0.14	0.92	5.4	<0.24	50.4	<4.84	4.14	<2.27	15.17	90	<4.0	836

Table B.5. Calculated Anion Porewater Content for Borehole 299-E33-338 (2 pages)

Sample Identification	Depth[(a)]	Dil. Fac.	1:1 Extracts in mg/L							Dilution Corrected Porewater mg/L						
			NO3	F-	NO2	Cl	SO4	PO4	HCO3	NO3	F-	NO2	Cl	SO4	PO4	HCO3
Plio-Pleistocene Fine-Grained Mud Unit (PPlz)																
C3391-213.8	214.30	27.30	0.50	0.35	<0.14	0.87	6.7	<0.24	52.3	13.57	9.48	<3.74	23.72	182	<6.6	1428
C3391-218.7	219.20	4.39	2.09	0.60	<0.14	4.20	28	0.33	86.6	9.15	2.61	<0.60	18.40	121	1.4	379
C3391-219.7 bs	220.20	4.60	1.97	0.56	<0.14	4.09	18	0.42	76.1	9.18	2.59	<0.63	19.10	84	2.0	350
C3391-219.7 as	220.20	4.19	2.21	0.66	<0.13	4.14	18	0.55	74.2	9.71	2.89	<0.57	18.22	79	2.4	310
C3391-220.65	221.15	4.87	0.56	0.55	<0.14	6.67	23	0.40	62.8	2.72	2.69	<0.67	32.33	113	2.0	306
C3391-221.65	222.15	6.02	1.38	0.64	<0.14	5.51	28	0.45	77.1	8.27	3.83	<0.83	33.11	169	2.7	464
Plio-Pleistocene Gravely Sand Unit (PPlg)																
C3391-239.8	240.30	30.55	0.31	0.49	<0.14	0.69	13	<0.24	39.0	9.43	15.02	<4.19	21.00	39	<7.3	1191

[(a)]Multiply by 0.3048 to convert to meters.

Figure B.7. Water and Acid Extractable Concentrations (ug/g) of Selected Constituents for Borehole 299-E33-338 as a Function of Depth

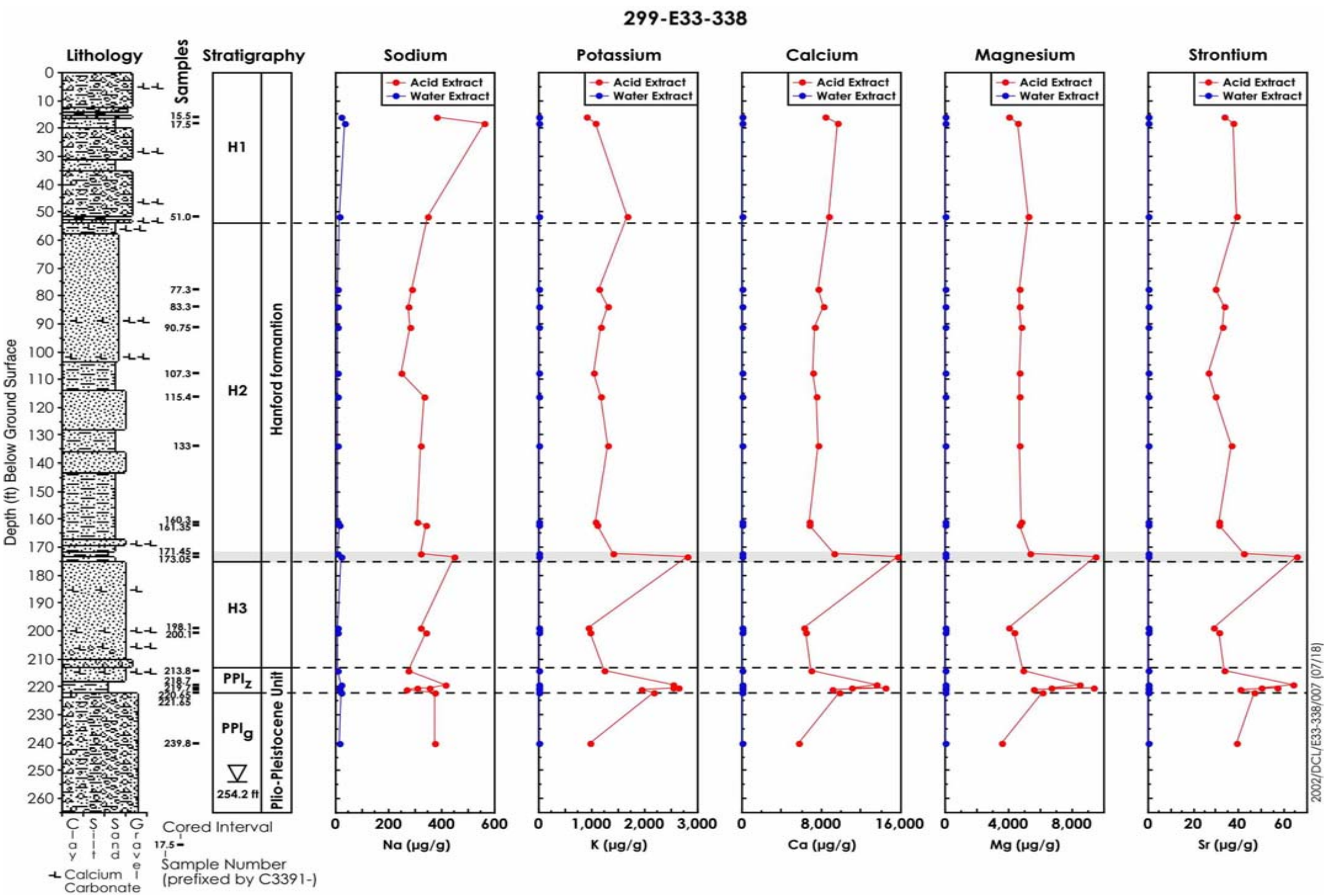


Figure B.8. Water and Acid Extractable Concentrations (ug/g) of Trace Constituents for Borehole 299-E33-338 as a Function of Depth

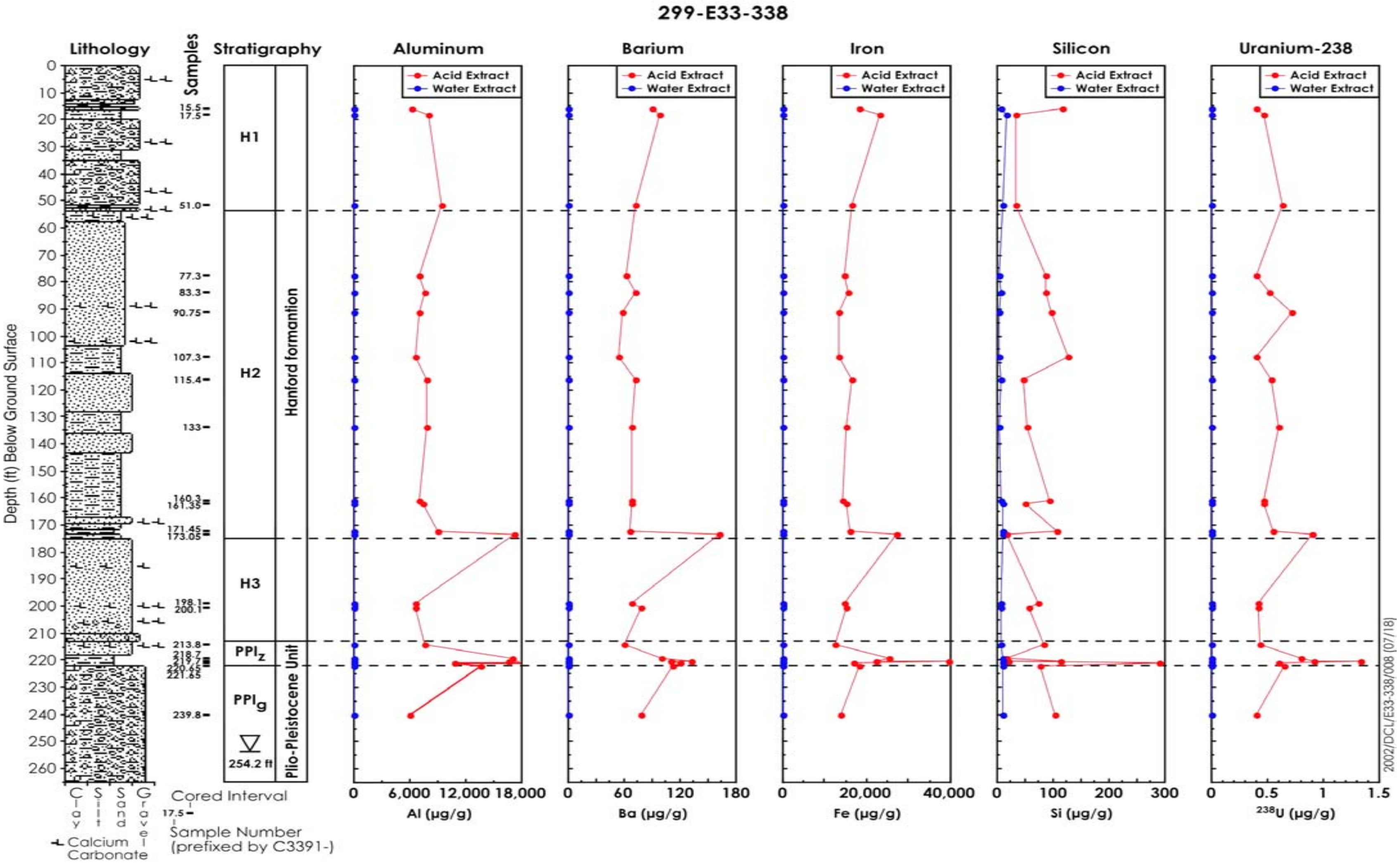


Table B.6. Water Extract of Major Cations in Terms of Dry Sediment (ug/g) (2 pages)

Sample Identification	Depth[(a)] (ft) Mid	Ca ug/g	Mg ug/g	Sr ug/g	Na ug/g	K ug/g
H1 Coarse Sand						
C3391-15.5	16.00	5.95E+00	7.84E-01	2.33E-02	2.34E+01	2.33E+00
17.5	18.00	7.80E+00	9.06E-01	3.13E-02	3.56E+01	3.26E+00
51.05	51.55	3.56E+01	8.49E+00	1.62E-01	1.19E+01	6.13E+00
H2 Hanford Formation H2 Unit — Upper Sequence						
77.3	77.80	5.78E+00	1.56E+00	2.87E-02	4.97E+00	2.55E+00
83.3	83.80	6.04E+00	1.66E+00	3.16E-02	5.59E+00	2.68E+00
90.75	91.25	5.12E+00	1.23E+00	2.54E-02	4.56E+00	2.01E+00
107.3	107.80	6.02E+00	1.54E+00	2.86E-02	4.47E+00	2.38E+00
115.4	115.90	6.57E+00	1.87E+00	3.51E-02	6.56E+00	2.88E+00
133	133.50	5.12E+00	1.26E+00	2.56E-02	4.45E+00	2.31E+00
160.3	160.80	5.83E+00	1.55E+00	3.44E-02	6.47E+00	2.90E+00
161.35	161.85	7.47E+00	2.08E+00	4.48E-02	1.44E+01	5.14E+00
171.45	171.95	6.75E+00	1.88E+00	3.78E-02	9.03E+00	3.45E+00
173.05	173.55	1.07E+01	2.95E+00	6.27E-02	1.74E+01	5.46E+00
Hanford Formation H3 Unit						
198.1	198.60	4.71E+00	1.16E+00	2.69E-02	6.64E+00	2.53E+00
200.1	200.60	6.22E+00	1.61E+00	3.30E-02	9.22E+00	3.41E+00
Plio-Pleistocene Fine-Grained Mud Unit (PPlz)						
213.8	214.30	6.73E+00	1.58E+00	3.94E-02	1.05E+01	3.32E+00
218.7	219.20	1.86E+01	3.55E+00	9.97E-02	1.82E+01	3.25E+00
219.7 Below Sand	220.20	1.42E+01	2.42E+00	6.92E-02	1.56E+01	2.44E+00
219.7 Above Sand	220.20	1.43E+01	2.47E+00	6.81E-02	1.60E+01	2.42E+00
220.65	221.15	1.45E+01	2.54E+00	7.76E-02	1.72E+01	3.21E+00
221.65	222.15	1.57E+01	2.84E+00	8.54E-02	1.82E+01	4.07E+00
Plio-Pleistocene Gravely Sand Unit (PPlg)						
239.8	240.30	7.61E+00	2.05E+00	4.26E-02	1.13E+01	3.55E+00

[(a)]Multiply by 0.3048 to convert to meters.

Table B.6. Water Extract of Major Cations in Terms of Dry Sediment (ug/g) (2 pages)

Sample Identification	Depth (ft) Mid	Al ug/g	Ba ug/g	Fe ug/g	Mg ug/g	Si ug/g	U-238 ug/g
H1 Coarse Sand							
C3391-15.5	16.00	2.71E-02	3.47E-02	2.09E-02	7.84E-01	7.79E+00	4.78E-04
17.5	18.00	3.88E-02	3.76E-02	5.99E-02	9.06E-01	1.55E+01	1.40E-03
H2 Hanford Formation H2 Unit — Upper Sequence							
51.05	51.55	5.04E-01	3.61E-02	3.92E-03	8.49E+00	9.61E+00	4.81E-04
77.3	77.80	3.70E-02	2.10E-02	2.33E-02	1.56E+00	5.14E+00	2.34E-04
83.3	83.80	3.20E-02	4.70E-02	2.13E-02	1.66E+00	6.60E+00	3.97E-04
90.75	91.25	5.40E-02	2.23E-02	3.71E-02	1.23E+00	4.55E+00	1.89E-04
107.3	107.80	4.89E-02	2.37E-02	3.67E-02	1.54E+00	5.20E+00	2.87E-04
115.4	115.90	5.41E-02	2.98E-02	9.33E-02	1.87E+00	8.34E+00	3.22E-04
133	133.50	5.73E-02	1.28E-02	7.67E-02	1.26E+00	5.08E+00	3.36E-04
160.3	160.80	8.07E-02	3.20E-02	7.30E-02	1.55E+00	7.73E+00	4.04E-04
161.35	161.85	1.97E-01	4.98E-02	2.39E-01	2.08E+00	9.35E+00	8.82E-04
171.45	171.95	3.97E-02	4.06E-02	5.20E-02	1.88E+00	9.47E+00	7.44E-04
173.05	173.55	3.18E-02	4.03E-02	3.34E-02	2.95E+00	1.05E+01	1.00E-03
Hanford Formation H3 Unit							
198.1	198.60	4.90E-02	2.01E-02	3.08E-02	1.16E+00	5.96E+00	2.13E-04
200.1	200.60	3.31E-02	2.51E-02	1.83E-02	1.61E+00	6.50E+00	7.35E-04
Plio-Pleistocene Fine-Grained Mud Unit (PPlz)							
213.8	214.30	9.01E-02	3.86E-02	1.31E-01	1.58E+00	8.52E+00	3.52E-04
218.7	219.20	9.40E-03	4.90E-02	1.11E-02	3.55E+00	1.18E+01	1.15E-03
219.7 Below Sand	220.20	1.10E-02	4.61E-02	1.21E-02	2.42E+00	9.93E+00	3.84E-04
219.7 Above Sand	220.20	3.06E-03	3.51E-02	1.30E-02	2.47E+00	1.04E+01	4.55E-04
220.65	221.15	1.66E-02	5.25E-02	9.34E-03	2.54E+00	9.47E+00	6.04E-04
221.65	222.15	3.77E-02	5.43E-02	5.76E-02	2.84E+00	1.05E+01	7.67E-04
Plio-Pleistocene Gravely Sand Unit (PPlg)							
239.8	240.30	2.53E-02	4.06E-02	2.20E-02	2.05E+00	1.14E+01	4.96E-04

[a]Multiply by 0.3048 to convert to meters.

Table B.7. Acid Extract of Major Cations in Terms of Dry Sediment (ug/g) (2 pages)

Sample Identification	Depth[(a)] (ft) Mid	ml/g basis Acid: soil ratio	Ca ug/g	Mg ug/g	Sr ug/g	Na ug/g	K ug/g
H1 Coarse Sand							
C3391-15.5	16.00	4.37	8.32E+03	3.97E+03	3.39E+01	3.81E+02	8.96E+02
17.5	18.00	4.97	9.58E+03	4.55E+03	3.73E+01	5.58E+02	1.08E+03
51.05	51.55	4.84	8.70E+03	5.28E+03	3.89E+01	3.48E+02	1.66E+03
H2 Hanford Formation H2 Unit — Upper Sequence							
77.3	77.80	5.01	7.69E+03	4.64E+03	2.99E+01	2.87E+02	1.14E+03
83.3	83.80	5.47	8.23E+03	4.67E+03	3.38E+01	2.75E+02	1.31E+03
90.75	91.25	5.47	7.32E+03	4.77E+03	3.24E+01	2.78E+02	1.17E+03
107.3	107.80	5.01	7.08E+03	4.66E+03	2.68E+01	2.50E+02	1.04E+03
115.4	115.90	5.00	7.48E+03	4.72E+03	2.98E+01	3.37E+02	1.18E+03
133	133.50	5.02	7.65E+03	4.67E+03	3.64E+01	3.20E+02	1.29E+03
160.3	160.80	4.72	6.85E+03	4.80E+03	3.09E+01	3.05E+02	1.07E+03
161.35	161.85	4.96	6.80E+03	4.63E+03	3.12E+01	3.43E+02	1.09E+03
171.45	171.95	5.01	9.23E+03	5.39E+03	4.24E+01	3.19E+02	1.41E+03
173.05	173.55	4.95	1.56E+04	9.43E+03	6.50E+01	4.45E+02	2.82E+03
Hanford Formation H3 Unit							
198.1	198.60	4.48	6.23E+03	4.02E+03	2.92E+01	3.23E+02	9.31E+02
200.1	200.60	4.88	6.38E+03	4.34E+03	3.12E+01	3.43E+02	9.82E+02
Plio-Pleistocene Fine-Grained Mud Unit (PPlz)							
213.8	214.30	5.05	6.94E+03	4.90E+03	3.39E+01	2.76E+02	1.23E+03
218.7	219.20	5.52	1.36E+04	8.47E+03	6.41E+01	4.13E+02	2.52E+03
219.7 Below Sand	220.20	5.67	1.10E+04	6.71E+03	4.99E+01	3.52E+02	2.53E+03
219.7 Above Sand	220.20	4.93	1.44E+04	9.34E+03	5.67E+01	3.05E+02	2.65E+03
220.65	221.15	5.02	9.13E+03	5.62E+03	4.03E+01	2.70E+02	1.92E+03
221.65	222.15	4.87	9.78E+03	6.13E+03	4.68E+01	3.77E+02	2.17E+03
Plio-Pleistocene Gravely Sand Unit (PPlg)							
239.8	240.30	4.57	5.62E+03	3.56E+03	3.90E+01	3.72E+02	9.83E+02

[(a)] Multiply by 0.3048 to convert to meters.

Table B.7. Acid Extract of Major Cations in Terms of Dry Sediment (2 pages)

Sample Identification	Depth[a] (ft) Mid	ml/g basis Acid: soil ratio	Al ug/g	Ba ug/g	Fe ug/g	Si ug/g	U-238 ug/g
H1 Coarse Sand							
C3391-15.5	16.00	4.37	6.29E+03	9.11E+01	1.83E+04	1.18E+02	0.399
17.5	18.00	4.97	7.99E+03	9.80E+01	2.32E+04	(3.50E+01)	0.461
51.05	51.55	4.84	9.48E+03	7.29E+01	1.65E+04	(3.21E+01)	0.627
H2 Hanford Formation H2 Unit — Upper Sequence							
77.3	77.80	5.01	7.09E+03	6.28E+01	1.46E+04	(8.80E+01)	0.409
83.3	83.80	5.47	7.68E+03	7.12E+01	1.57E+04	(8.83E+01)	0.526
90.75	91.25	5.47	6.99E+03	5.83E+01	1.33E+04	(9.68E+01)	0.718
107.3	107.80	5.01	6.56E+03	5.51E+01	1.33E+04	1.26E+02	0.400
115.4	115.90	5.00	7.75E+03	7.29E+01	1.65E+04	(4.66E+01)	0.528
133	133.50	5.02	7.92E+03	6.87E+01	1.51E+04	(5.20E+01)	0.595
160.3	160.80	4.72	7.10E+03	6.86E+01	1.43E+04	(9.20E+01)	0.465
161.35	161.85	4.96	7.40E+03	6.72E+01	1.50E+04	(5.14E+01)	0.473
171.45	171.95	5.01	8.96E+03	6.66E+01	1.61E+04	(1.08E+02)	0.552
173.05	173.55	4.95	1.72E+04	1.62E+02	2.72E+04	(1.76E+01)	0.910
Hanford Formation H3 Unit							
198.1	198.60	4.48	6.56E+03	6.78E+01	1.46E+04	(7.51E+01)	0.419
200.1	200.60	4.88	6.70E+03	7.83E+01	1.52E+04	(5.79E+01)	0.412
Plio-Pleistocene Fine-Grained Mud Unit (PPlz)							
213.8	214.30	5.05	7.58E+03	5.97E+01	1.26E+04	(8.34E+01)	0.430
218.7	219.20	5.52	1.69E+04	1.00E+02	2.53E+04	(1.75E+01)	0.797
219.7 Below Sand	220.20	5.67	1.66E+04	1.32E+02	2.23E+04	(1.14E+02)	0.918
219.7 Above Sand	220.20	4.93	2.25E+04	1.10E+02	3.94E+04	(2.08E+01)	1.343
220.65	221.15	5.02	1.08E+04	1.20E+02	1.70E+04	2.90E+02	0.597
221.65	222.15	4.87	1.36E+04	1.12E+02	1.82E+04	(7.74E+01)	0.660
Plio-Pleistocene Gravely Sand Unit (PPlg)							
239.8	240.30	4.57	5.96E+03	7.72E+01	1.37E+04	(1.05E+02)	0.408

[a]Multiply by 0.3048 to convert to meters.
Values in parentheses are below level of quantification but spectra look useable.

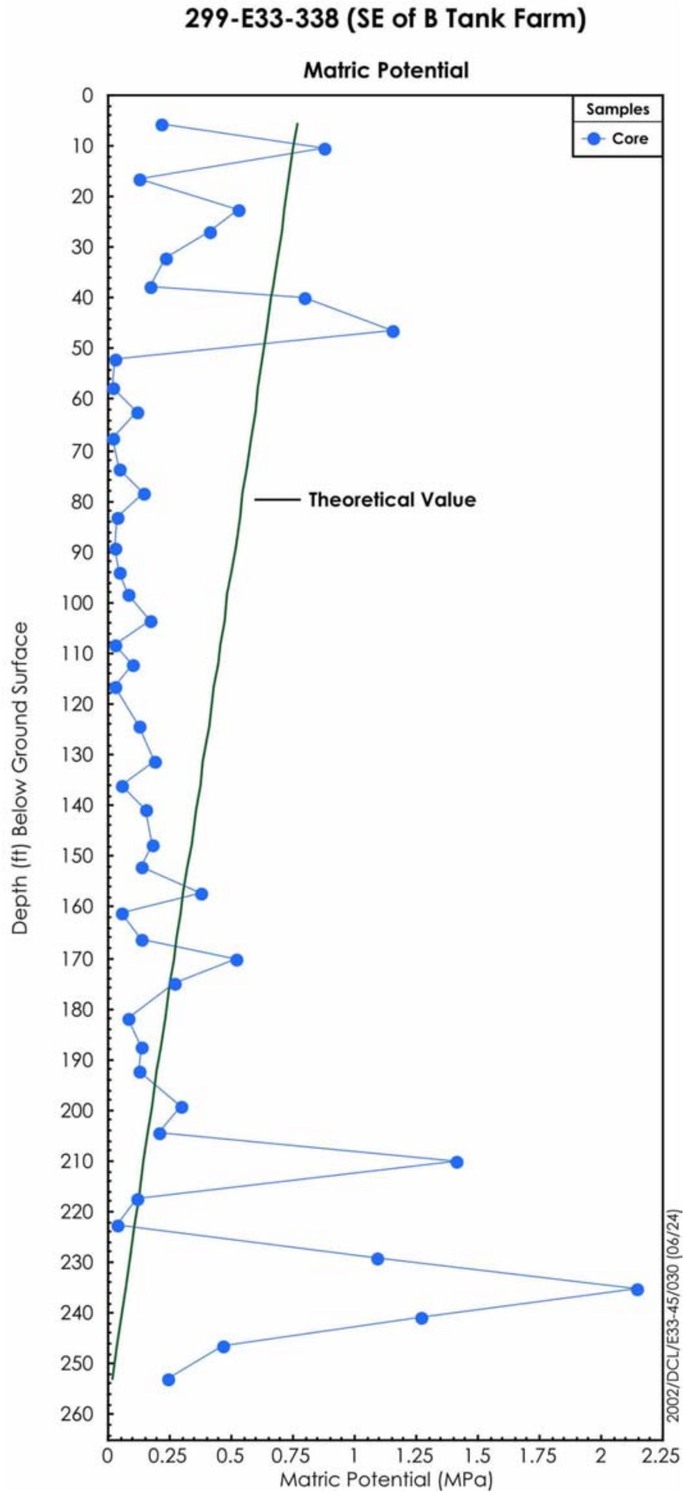
B.3.5 CHEMICAL INTERACTIONS

There were no contaminant adsorption/desorption or leach tests performed with the clean sediments. The chemical and mineralogical data from the uncontaminated sediments from borehole 299-E33-338 are used to compare with the sediments from the contaminated boreholes.

B.3.6 SEDIMENT MATRIC POTENTIAL AT BOREHOLE 299-E33-338

The matric potential of the sediment profile in 299-E33-338 was measured and is plotted in Figure B.9. For borehole 299-E33-338 (C3391), located outside the southeast corner of the B tank farm in relatively undisturbed terrain, the samples were considerably drier than at borehole 299-E33-45 (east of tank BX 102), particularly near the surface. These matric potential data for the two contaminated boreholes (Sections B.3.5 and B.4.5) support the hypothesis that non-vegetated areas, with coarse-textured surfaces, drain more than areas with similar soil, but with vegetation present. It appears that the wetting from meteoric sources has not reached to the water table at the 299-E33-338 site.

Figure B.9. Matric Potential of the Sediment Profile at Borehole 299-E33-338



B.4.0 BOREHOLE 299-E33-45 CHARACTERIZATION SUMMARY

This section summarizes data reported in *Characterization of Vadose Zone Sediment: Borehole 299-E33-45 Near BX-102 in the B-BX-BY Waste Management Area* (Serne et al. 2002a). Borehole 299-E33-45 was completed to further characterize the nature and extent of vadose zone contaminants supplied by the BX-102 tank overfill in 1951 and the BX-101 junction box leak between 1968 and 1972. Elevated concentrations of several constituents were primarily measured between 75 and 170 ft bgs in the H2 subunit of the Hanford formation. The radionuclides present in this zone are technetium-99, uranium, and tritium. The technetium-99 and tritium could have been provided by either leak. The uranium source is the BX-102 leak. Chemical characteristics attributed to tank fluid-soil interaction at different locations within this zone are elevated pH, sodium, nitrate, phosphate, bicarbonate, and perhaps iron. A secondary zone with elevated concentrations of technetium-99, tritium, and nitrate occurs between 67 and 70 m (220 and 230 ft) bgs in the PPlz subunit of the Plio-Pleistocene unit. An isolated perched water zone is present at this depth interval between 69 and 70 m (226 and 228 ft) bgs, which contains relatively lower technetium-99 concentrations. It is plausible that contaminants from more than one source are present at this location. High moisture content is observed in several thin silt-rich layers in the Hanford formation at 75, 120, and 170 ft bgs. A thicker high moisture zone occurs in the Plio-Pleistocene unit between 220 and 240 ft bgs. Within this larger zone, a smaller perched water zone occurs at 227 ft bgs. The perched water suggests recent discharges of liquid from the tank or water line infrastructure or that there is a competent aquitard layer at this depth.

B.4.1 GEOLOGY AT BOREHOLE 299-E33-45

This section summarizes data reported in Serne et al. (2002a) except for groundwater sample data. Borehole 299-E33-45 was completed to further characterize the nature and extent of vadose zone contaminants supplied by tanks BX-101 and BX-102. Borehole 299-E33-45 was drilled using cable-tool percussion techniques. Samples were collected via splitspoon (2 ft long by 4 in. diameter) at 35 previously specified depths. Grab samples (96 total) were collected from drill cuttings throughout the drilled interval. The splitspoon samplers were driven into the formation ahead of the drive casing. After the samples were collected, a drive barrel was lowered into the hole and the bore reamed. When the hole was full size, the casing was advanced by being driven into the ground. After the casing was driven, the borehole was once again cleaned out. If no immediate sample was scheduled, the bore was advanced by alternately removing formation materials and driving the casing ahead. Materials removed via the drive barrel were retained for geologic description and potential chemical and radiological analyses. The casing was downsized twice (i.e., at ~120 and 227 ft bgs) where zones of saturation or near-saturation were encountered.

B.4.1.1 Backfill

Backfill at the drill site extends from the ground surface to a depth of approximately 3 m (10 ft). The material consists of non-cohesive, poorly sorted, sandy gravel with subangular to subrounded pebbles to cobbles.

B.4.1.2 Hanford Formation

Wood et al. (2000) and Lindsey et al. (2001) describe cataclysmic flood deposits of the Hanford formation beneath the 241-BX tank farm as consisting of three informal units (H1, H2, and H3). However, the upper portion of the H1 unit was at least partially removed during excavation of this portion of the tank farm, and then later used as backfill around the tanks.

Based on the lithologies observed during drilling and in core samples from this well, the Hanford formation beneath the backfill can locally be subdivided into an upper gravel dominated unit and three main sand sequences separated by distinctly finer (i.e., muddy/silty) units. Other minor muddy (i.e., silty) facies are found within the major sand sequences.

B.4.1.2.1 Hanford H1 Unit. Three splitspoon samples were collected from this interval. These materials were described as gravel to muddy sandy gravel, ranging from an estimated 90 to 50 percent gravel. The gravels were described as multi-lithologic but generally containing a high percentage of basalt. The gravel clasts were generally subrounded to well rounded up to 50 mm in diameter where not broken**.**

The finer fraction was described as mostly very coarse to coarse sand with perhaps as much as 5 to 7% mud. The samples generally displayed no cementation or obvious sedimentary structure, and only weak to no reaction to hydrochloric acid.

B.4.1.2.2 Hanford H2 Unit. Lindsey et al. (2000) assigned Hanford formation materials above a depth of 51.8 m (169.8 ft)[1] to the Hanford H2 unit. These materials can be further subdivided into an upper sand and gravel sequence and a lower sand sequence with several distinct mud/silt units.

B.4.1.2.2.1 Upper Sand Sequence. The uppermost sand sequence extends from a depth of 10.4 m (34 ft) to a depth of 22.7 m (74.5 ft) where it contacts with a thin muddy very fine to fine sand layer. Five splitspoon samples were collected within this uppermost sand sequence, a sixth splitspoon sample captured the contact with and the entire thickness of the muddy very fine to fine sand layer. The materials within this uppermost sand sequence were described as multi-lithologic, mostly medium to very coarse sand, with some coarse to very coarse sand laminations, and occasional pebbles up to 10 mm in diameter (intermediate axis). Some thin strata with up to 5% gravel are also present, including gravels up to 55 mm in intermediate diameter. These materials are further described as uncemented with weak to no reaction to hydrochloric acid, except for occasional caliche (calcium carbonate cemented) fragments.

B.4.1.2.2.2 Muddy Very Fine to Fine Sand Bed. A muddy very fine to fine sand layer, approximately 30 cm (1 ft) thick, was encountered from a depth of 22.7 m (74.5 ft) to 23.0 m (75.5 ft). These materials were described as muddy very fine to fine sand with an estimated 30% mud (interpreted to be mostly silt). The materials were well stratified to laminated with one prominent coarse sand layer. The materials were described as moist to wet.

[1] Lindsey et al. (2000), page 16 lists the depth of this change at 49.98 m (164 ft). However, their Figure 5 and Table 1 indicate the depth of change is more consistent with the depth reported here.

B.4.1.2.2.3 Middle Sand Sequence. The middle sand sequence is an estimated 27.9 m (91.5ft) thick extending from a depth of 23.0 m (75.5 ft) to 50.9 m (167 ft), where it overlies a thin (1 m thick) fine-grained sequence of very fine sand to muddy very fine sand. Eleven splitspoon samples were collected throughout this middle sand sequence. These materials were described as moderate to well sorted and somewhat stratified ranging mostly from coarse to very coarse sand with some medium to very fine pebble (e.g., near the 23.5 m [77 ft] depth) to mostly coarse to medium sand.

Occasional thin strata up to 0.5 m (1.5 ft) thick of medium to fine sand were observed at the 30.5 m (100 ft), 36.6 m (120 ft), and 45.7 m (150 ft) depths. Four thin zones of moderate cementation and weak to strong reaction to hydrochloric acid were observed at depths of 33.4 m (109.5 ft), 36.6 m (120 ft), 42.5 m (139.5 ft), and 45.7 (150 ft). The thin fine-grained calcic horizon at 36.6 m (120 ft) may represent an old soil (paleosol) surface.

B.4.1.2.2.4 Fine to Very Fine Sand Bed. This fine-grained bed is approximately 0.8 m (2.6 ft) thick and is highly variable in texture. The top of the unit is characterized by a fairly sharp contact with the overlying medium sand at 51.0 m (167.2 ft). The upper 30 cm (12 in.) is weakly stratified to laminated mostly fine to very fine sand, with some slightly coarser (fine sand) stringers. These materials were described as weak to moderately cemented with weak to strong reaction to hydrochloric acid. This material is underlain by a slightly coarser (medium) sand sequence that grades downward to a fine sand. These materials are described as poorly sorted, laminated, and moderately cemented, with weak to strong reaction to hydrochloric acid, and visually contained more moisture compared to the finer sands above. These materials are in turn, underlain by a thin, 6 cm (2.5 in) thick, silty very fine sand layer. This layer is very cohesive, highly compacted, and moderately cemented and forms a very sharp contact with the underlying medium sand at 51.8 m (169.8 ft).

B.4.1.2.2.5 Hanford H3 Unit (Lower Sand Sequence). The lower sand and gravel sequence is approximately 14.6 m (48 ft) thick extending from a depth of 51.8 m (169.8 ft) to 66.4 m (217.8 ft). Lindsey et al. (2001) assigned these materials to the Hanford H3 unit. This sand and gravel sequence consists predominantly of stratified coarse to medium sand with occasional pebbles up to 30 mm. Some reverse graded (coarsening upward) beds on the order of 45 cm (18 in.) thick, with up to 10% gravel, were observed near the middle of this sequence. The materials were further described as poorly sorted, with weak to no cementation near the top of the sequence and moderate to strong cementation near the base. Reactions to hydrochloric acid were primarily weak to none, except at the very top of the sequence where some reactions were described as weak to strong, suggesting the presence of some calcium carbonate.

B.4.1.3 Hanford/Plio-Pleistocene Unit

Materials underlying the Hanford H3 unit correlate to those referred to as the Hanford formation/ Plio-Pleistocene unit (Hf/PPu) by Wood et al. (2000) and the Hanford/Plio-Pleistocene/Ringold (H/PP/R) unit by Lindsey et al. (2001). The origin of these deposits is in question. Wood et al. (2000) recognized two facies of the Hf/PPu beneath the B, BX, and BY tank farms, a fine-grained eolian/overbank silt and a sandy gravel to gravelly sand. The locally thick silt facies is generally believed to be a pre-ice age flood deposit potentially equivalent to the early Palouse soil (Tallman et al. 1979; DOE 1988), which is now believed to be part of the upper

Plio Pleistocene unit (Wood et al. 2000; Lindsey et al. 2001). Lindsey et al. (2001) suggests that the gravelly materials underlying this silt are consistent with the properties of Ringold gravels. However, Wood et al. (2000) indicate that where this silt layer is missing, the sandy gravel to gravelly sand facies cannot be distinguished from the overlying Hanford formation.

B.4.1.3.1 Silt Facies. The silt facies encountered by well 299-E33-335 is an estimated 6.3 m (20.9 ft) thick, extending from a depth of 66.4 m (217.8 ft) to a depth of 72.7 m (238.7 ft). This unit is believed to be equivalent to the Plio-Pleistocene silt (PPlz) unit that overlies an extensive caliche layer (PPlc) beneath the 200 West Area. These materials are characterized by stratified mud (silt) and sand deposits, with relatively thick beds (>45 cm [18 in.]) near the top and bottom of the unit, and relatively thin beds (ranging from 1 to 15 cm) in the middle of the unit. Contacts between the mud (silt) and sand deposits are relatively sharp.

Four splitspoon samples were collected from this unit. The upper beds consist of massive (lacking internal laminations), well sorted, medium to fine sand grading to fine sand in places, with only minor amounts of mud (~5%). These deposits are moderate to uncemented with weak or no reaction to dilute hydrochloric acid. Sand beds in the middle and lower portion of this unit are muddy (silty) fine to very fine sand with weak to strong reaction to hydrochloric acid.

The mud (silt)-dominated beds were described as hard consistency, moderate to strongly cemented with a weak reaction to hydrochloric acid. These materials are mostly silt, with some fine to very fine sand, and very little clay. There are some fine laminations and banding and/or mottling (color changes) present, due in part to the presence of iron oxide staining. However, these beds are often described as massive and homogeneous. The silt facies was generally moist to dry, with the exception of a fully saturated zone between depths of 69.2 m (227.1 ft) and 70.7 m (231.9 ft).

B.4.1.3.2 Sandy Gravel to Gravelly Sand Facies. A sequence of sandy gravel to gravelly sand was encountered at a depth of 72.8 m (238.7 ft). This gravel-rich facies continues to the bottom of the borehole at 79.55 m (261 ft bgs). Four splitspoon samples contained these materials. These materials were described as muddy sandy gravel to sandy gravel, consisting of an estimated 30 to 80% gravel, 15 to 65% sand, and up to 15% mud. The gravel clasts were described as a mixture of mostly quartzite, basalt, and some highly weathered friable granite. Where unbroken, the gravel clasts are subrounded to rounded and range up to at least 60 mm in diameter (intermediate axis). The matrix was described as ranging from mostly very fine sand to poorly sorted coarse to medium sand, with variable mud content. These materials were further described as moderate to uncemented with strong to no reaction to dilute hydrochloric acid. Some caliche fragments were noted, exhibiting a strong reaction to hydrochloric acid.

B.4.2 GEOPHYSICAL AND MOISTURE CONTENT MEASUREMENTS

Down-hole geophysical measurements included a high-purity germanium spectral gamma log and a neutron-neutron log. The total gamma log (derived from spectral gamma logs) and the neutron-neutron log are shown in Figure B.10. The total gamma log includes contributions from natural and man-made gamma emitters. In this borehole, a high count rate from uranium occurs between 125 and 150 ft bgs. Otherwise, potassium-40 and to a lesser extent, uranium, tend to be the primary gamma constituents and are relatively concentrated in the thin silt layers in the

Hanford formation at 75, 120, and 170 ft bgs and the Plio-Pleistocene unit at 220 to 240 ft bgs. The neutron-neutron log shows qualitative moisture content and is consistent with laboratory measured moisture contents shown in the adjacent column. All three measurement methods show good agreement in the location of high moisture zones.

Table B.8 lists the gravimetric moisture content of the cores and grab samples.

Table B.8. Moisture Content of Sediments from Borehole 299-E33-45 (4 pages)

Lithologic Unit	Sample No.	Mid Depth (Vertical ft)[(a)]	% Moisture	Lithologic Unit	Sample No.	Mid Depth (Vertical ft)[(a)]	% Moisture
H1	01C	9.64	4.84	H2-ms	64	135.5	3.58
H1	01B	10.14	6.59	H2-ms	65	137.1	3.36
H1	01A	10.64	4.75	H2-ms	66	138.95	2.19
H1	06D	19.34	6.47	H2-ms	67D	139.75	3.48
H1	06C	19.84	3.83	H2-ms	67C	140.25	3.50
H1	06B	20.34	4.79	H2-ms	67B	140.75	2.91
H1	06A	20.84	5.75	H2-ms	67A	141.25	2.60
H1	11D	30.39	4.77	H2-ms	67	141.6	1.59
H1	11C	30.84	4.34	H2-ms	68	142.55	3.43
H1	11B	31.34	4.03	H2-ms	69	144.45	3.01
H1	11A	31.84	3.30	H2-ms	70	146.6	3.23
H2-us	16D	40.54	3.46	H2-ms	71	148.6	1.85
H2-us	16C	41.04	3.54	H2-ms	72D	150.05	3.59
H2-us	16B	41.54	3.66	H2-ms	72C	150.55	3.70
H2-us	16A	42.04	3.43	H2-ms	72B	151.05	4.10
H2-us	21D	50.14	4.81	H2-ms	72A	151.55	3.02
H2-us	21C	50.64	4.32	H2-ms	72	151.9	2.97
H2-us	21B	51.14	4.04	H2-ms	73	152.7	3.51
H2-us	21A	51.64	3.79	H2-ms	74	154.05	3.08
H2-us	27D	61.49	5.35	H2-ms	75	156.2	3.40
H2-us	27C	61.99	5.62	H2-ms	76	158.4	3.34
H2-us	27B	62.49	5.98	H2-ms	77	159.1	3.42
H2-us	27A	62.99	6.80	H2-ms	78D	159.35	3.45
H2-us	32D	69.74	3.82	H2-ms	78C	159.85	3.82
H2-us	32C	70.24	3.82	H2-ms	78B	160.35	3.60
H2-us	32B	70.74	3.73	H2-ms	78A	160.85	3.80

Table B.8. Moisture Content of Sediments from Borehole 299-E33-45 (4 pages)

Lithologic Unit	Sample No.	Mid Depth (Vertical ft)[(a)]	% Moisture	Lithologic Unit	Sample No.	Mid Depth (Vertical ft)[(a)]	% Moisture
H2-us	32A	71.24	3.88	H2-ms	79	162.1	4.15
H2-us	32	71.74	2.87	H2-ms	80	163.55	3.32
H2-us	33D	71.89	3.71	H2-ms	81	165.55	4.50
H2-us	33C	72.39	5.42	H2-ms	82D	167.15	6.77
H2-us	33B	72.89	3.24	***	82C	167.65	9.91
H2-us	33A	73.39	3.18	***	82B	168.15	14.19
H2-us	33	73.89	14.03	***	82A	168.65	16.22
H2-us	34D	74.15	5.24	***	82	169.1	16.20
*	34C	74.9	15.13	***	83D	169.55	8.47
*	34B	75.15	22.36	H3	83C	170.05	3.66
*	34A	75.65	21.93	H3	83B	170.55	2.48
H2-ms	34	76.15	7.73	H3	83A	171.05	2.84
H2-ms	35D	76.69	1.83	H3	83	171.4	2.12
H2-ms	35C	77.19	1.75	H3	84D	171.85	3.22
H2-ms	35B	77.69	1.82	H3	84C	172.35	2.84
H2-ms	35A	78.19	2.44	H3	84B	172.85	3.53
H2-ms	35	78.69	1.25	H3	84A	173.35	3.19
H2-ms	36D	77.84	3.27	H3	84	173.7	2.08
H2-ms	36C	78.34	2.73	H3	85	174.7	2.67
H2-ms	36B	78.84	2.77	H3	86	176.9	2.54
H2-ms	36A	79.34	3.10	H3	87	179.2	1.81
H2-ms	37	82.49	2.53	H3	88D	180.15	7.33
H2-ms	38	84.78	3.15	H3	88C	180.65	4.64
H2-ms	39	86.245	3.09	H3	88B	181.15	3.60
H2-ms	40D	87.15	3.92	H3	88A	181.65	4.59
H2-ms	40C	87.65	4.25	H3	89	182.7	2.95
H2-ms	40B	88.15	4.53	H3	90	184.4	3.13
H2-ms	40A	88.65	3.62	H3	91	186.2	3.56
H2-ms	40	90	1.22	H3	92	188.4	1.73
H2-ms	41	92.715	4.55	H3	93D	189.15	3.39
H2-ms	42	94.69	4.75	H3	93C	189.65	3.00

Table B.8. Moisture Content of Sediments from Borehole 299-E33-45 (4 pages)

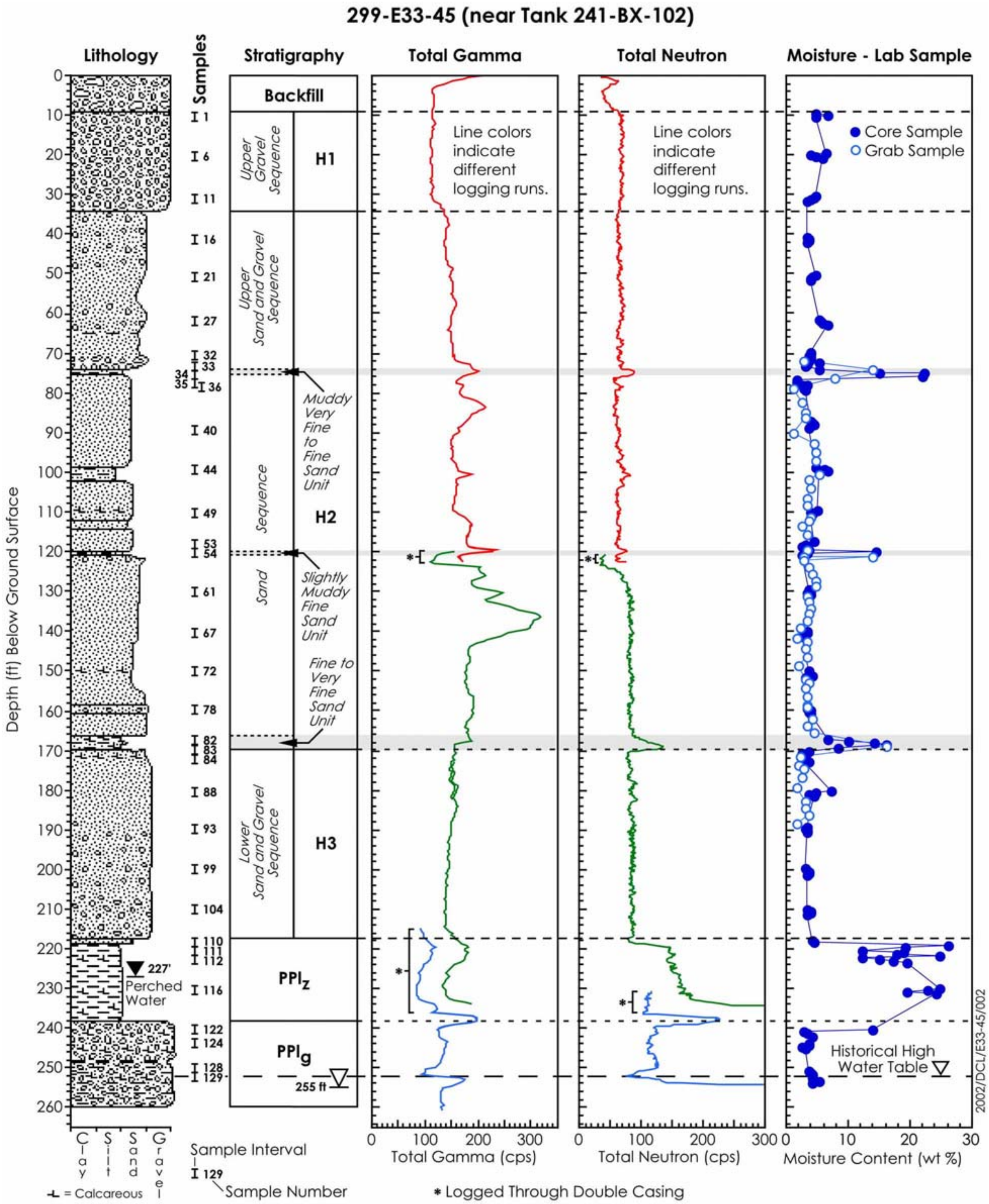
Lithologic Unit	Sample No.	Mid Depth (Vertical ft)[a]	% Moisture	Lithologic Unit	Sample No.	Mid Depth (Vertical ft)[a]	% Moisture
H2-ms	43	97.015	4.70	H3	93B	190.15	3.41
H2-ms	44D	98.59	4.61	H3	93A	190.65	3.37
H2-ms	44C	99.09	6.09	H3	99D	199.85	3.17
H2-ms	44B	99.59	6.79	H3	99C	200.35	3.65
H2-ms	44A	100.09	5.25	H3	99B	200.85	3.77
H2-ms	44	100.44	5.43	H3	99A	201.35	3.25
H2-ms	45	101.765	3.64	H3	104D	209.92	3.49
H2-ms	46	103.845	3.82	H3	104C	210.42	3.99
H2-ms	47	106.515	3.41	H3	104B	210.92	3.86
H2-ms	48	108.415	3.35	H3	104A	211.42	3.39
H2-ms	49D	109.64	5.10	H3	110D	217.95	4.22
H2-ms	49C	110.14	3.87	PPlz	110C	218.45	4.35
H2-ms	49B	110.64	4.09	PPlz	110B	218.95	26.27
H2-ms	49A	111.14	3.87	PPlz	110A	219.45	19.28
H2-ms	49	111.49	3.80	PPlz	111D	220.25	12.27
H2-ms	50	112.39	3.73	PPlz	111C	220.75	18.97
H2-ms	51	113.69	2.53	PPlz	111B	221.25	17.81
H2-ms	52	115.74	3.45	PPlz	111A	221.75	24.79
H2-ms	53D	117.54	4.46	PPlz	112D	222.15	12.20
H2-ms	53C	118.04	3.13	PPlz	112C	222.65	14.99
H2-ms	53B	118.54	2.42	PPlz	112B	223.15	17.35
H2-ms	53A	119.04	3.18	PPlz	112A	223.65	19.37
H2-ms	53	119.39	3.49	PPlz	116D	229.95	24.86
H2-ms	54D	119.39	3.62	PPlz	116C	230.45	22.77
**	54C	120.14	14.59	PPlz	116B	230.95	19.59
H2-ms	54B	120.39	3.50	PPlz	116A	231.45	24.18
H2-ms	54A	120.89	2.56	PPlg	122D	240.39	13.97
H2-ms	54	121.24	2.84	PPlg	122C	240.89	2.75
H2-ms	55	121.34	13.83	PPlg	122B	241.39	3.37
H2-ms	56	122.315	2.85	PPlg	122A	241.89	4.14
H2-ms	57	123.845	3.67	PPlg	124D	243.75	3.61

Table B.8. Moisture Content of Sediments from Borehole 299-E33-45 (4 pages)

Lithologic Unit	Sample No.	Mid Depth (Vertical ft)[(a)]	% Moisture	Lithologic Unit	Sample No.	Mid Depth (Vertical ft)[(a)]	% Moisture
H2-ms	58	125.5	4.13	PPlg	124C	244.25	3.58
H2-ms	59	127.4	4.62	PPlg	124B	244.75	2.65
H2-ms	60	128.65	4.71	PPlg	124A	245.25	3.04
H2-ms	61D	129.45	3.61	PPlg	128C	250.75	3.59
H2-ms	61C	129.95	3.90	PPlg	128B	251.25	3.83
H2-ms	61B	130.45	3.40	PPlg	128A	251.75	4.27
H2-ms	61A	130.95	3.86	PPlg	129D	252.15	4.28
H2-ms	61	131.3	3.48	PPlg	129C	252.65	4.24
H2-ms	62	132.35	3.52	PPlg	129B	253.15	5.19
H2-ms	63	134.1	4.02	PPlg	129A	253.65	4.32

(a) Multiply by 0.3048 to convert to meters.
H1 = Hanford H1 unit-coarse sand
H2-us=Hanford H2 unit-upper sand sequence
H2-ms=Hanford H2 unit-middle sand sequence
H3=Hanford H3 unit-lower sand sequence
PPlz=Plio-Pleistocene mud unit
PPlg=Plio-Pleistocene gravelly unit
*, **, *** = various thin fine-grained lenses in the Hanford sand units.

Figure B.10. Borehole 299-E33-45 Lithology, Stratigraphy, Geophysical Logs, and Moisture Distribution as a Function of Depth



B.4.3 SOIL WATER CHEMISTRY MEASUREMENTS

An extensive water chemistry analysis has been completed for borehole 299-E33-45 samples collected between 10 and 254 ft bgs. The primary means of measuring porewater composition was to add deionized water to soil samples to generate enough water for performing analyses. By back calculating for the dilution introduced by the added water, true concentrations were derived. For fourteen sediment samples, porewater was directly separated from the sediment and analyzed directly. By comparing the dilution-corrected water extract data with the porewater data in these samples, an indication of the closeness of the water extract chemistry to original water chemistry was determined. In general, comparisons were not exact but concentration values were generally within a factor of two or better, and agreement improved with increasing constituent concentration. Generally, the water extraction process appears to dissolve some salts in the soils, yielding a high species concentration. Nevertheless, the water extract method is a useful tool for evaluating tank fluid interactions with vadose zone soil.

Water extract pH and EC measurements with depth are listed in Table B.9 and graphed in Figure B.11. Elevated pH values (greater than 8) are measured at 24 m (79 ft) bgs and between 30 and 46 m (100 and 150 ft) with maximum values (i.e., pH 8.9 to 9.5) occurring between 34 and 43 m (111 and 140 ft) bgs. Because pH values are expected to decrease as increasing interaction with soil and soil water occurs, the location of increased pH values suggests this is the approximate location of initial tank fluid interaction with the soil column. Increases in EC above background also indicate where tank fluid currently resides. In this borehole, the notable increases occur between 24 and 48 m (79 and 156 ft) bgs. Maximum EC values (between 44 and 77 mS/cm) occur between 46 and 49 m (150 and 160 ft) bgs just above the 3-ft thick silt-rich lens around 52 m (170 ft) bgs. The EC maximum zone occurs somewhat lower in the soil column relative to the maximum pH zone.

Table B.9. Water Extract pH and Electrical Conductivity Values for Borehole 299-E33-45 (2 pages)

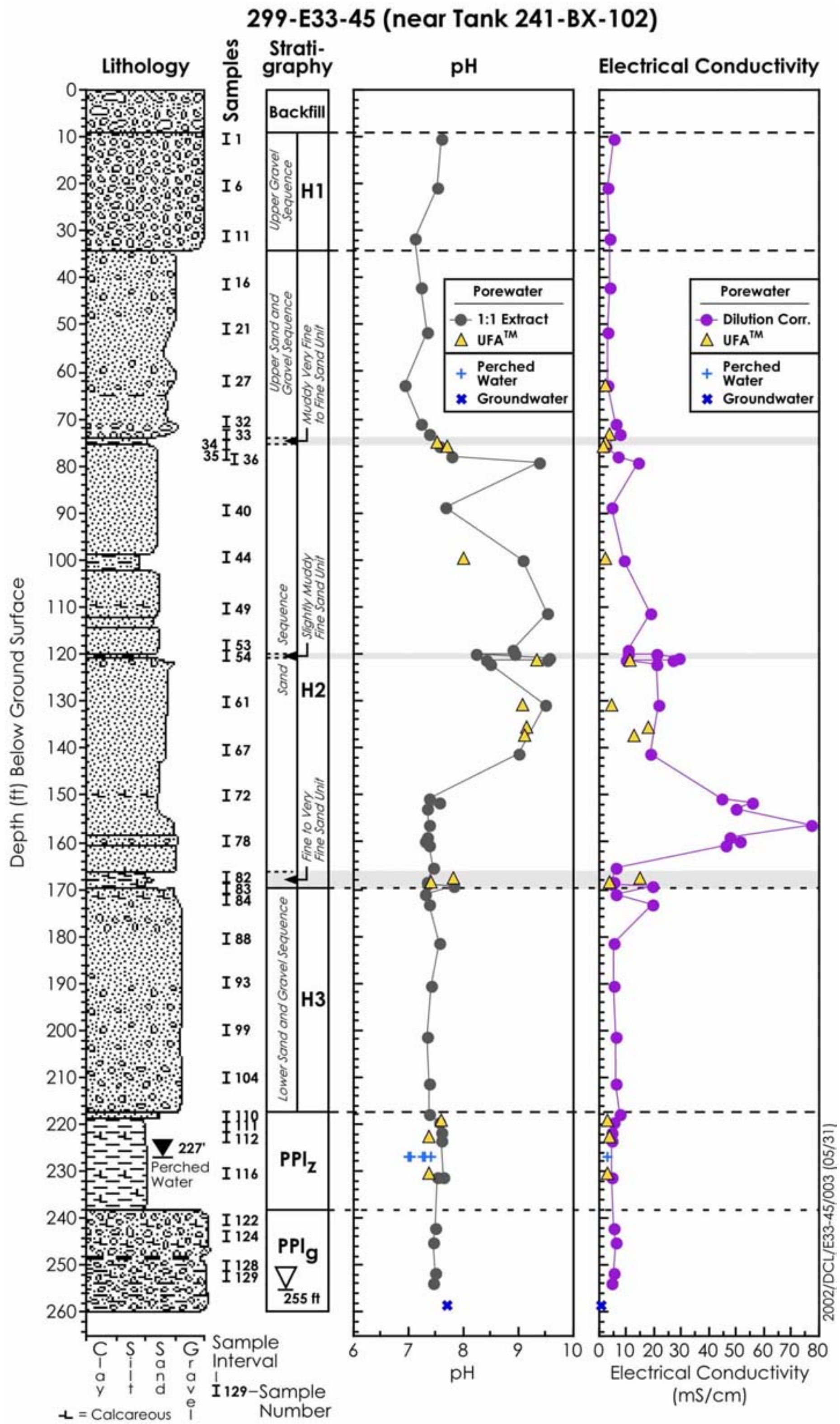
Sample Identification	Mid Depth (ft)[(a)]	Dilution Factor	1:1 pH	1:1 EC	Pore EC
				mS/cm	
Hanford H1 coarse sand					
01A	10.64	21.09	7.61	0.240	5.06
06A	20.84	17.43	7.53	0.171	2.98
11A	31.84	30.27	7.11	0.127	3.84
Hanford H2 upper sand sequence					
16A	42.04	29.2	7.21	0.133	3.88
21A	51.64	26.38	7.34	0.125	3.3
27A	62.99	14.72	6.93	0.215	3.16
32A	71.24	25.83	7.22	0.243	6.28
33A	73.39	31.48	7.37	0.245	7.71
H2 muddy very fine sand lens					
34A	75.65	4.91	7.55	0.458	2.25
34A-Dup	75.65	4.56	7.56	0.480	2.19
H2 middle sand sequence					
35A	78.19	40.97	7.78	0.160	6.56
36A	79.34	32.28	9.38	0.447	14.43
40A	88.65	27.63	7.68	0.158	4.37
44A	100.09	19.04	9.1	0.489	9.31
49A	111.14	25.85	9.51	0.710	18.35
53A	119.04	31.4	8.88	0.344	10.8
H2 muddy very fine sand lens					
54C	120.14	7.02	8.93	1.519	10.66
54C-Dup	120.14	9.27	8.24	1.213	11.24
54A	120.89	39.38	9.55	0.742	29.22
H2 middle sand sequence (continued)					
54	121.24	36.16	9.51	0.738	26.68
55	121.34	6.77	8.4	1.486	10.06
56	122.32	33.95	8.48	0.612	20.78
61A	130.95	25.93	9.5	0.822	21.31
67A	141.25	38.52	9	0.477	18.37
72C	150.55	28.44	7.39	1.567	44.56
72A	151.55	33.05	7.55	1.692	55.91
73	152.7	30.98	7.35	1.593	49.36
75	156.2	33.88	7.36	2.267	76.81

Table B.9. Water Extract pH and Electrical Conductivity Values for Borehole 299-E33-45 (2 pages)

Sample Identification	Mid Depth (ft)[a]	Dilution Factor	1:1 pH	1:1 EC	Pore EC
				mS/cm	
77	159.1	28.82	7.35	1.638	47.2
78C	159.85	27.04	7.3	1.906	51.55
78A	160.85	26.29	7.39	1.737	45.67
81	165.55	21.84	7.45	0.261	5.7
H2 -- fine-very fine sand lens					
82A	168.65	6.17	7.34	0.737	4.55
82A-Dup	168.65	6.17	7.32	0.806	4.97
82	169.1	5.78	7.33	0.775	4.48
83D	169.55	12.01	7.81	1.626	19.53
Hanford H3 Lower sand unit					
83A	171.05	35.27	7.3	0.168	5.93
84A	173.35	31.43	7.38	0.613	19.27
88A	181.65	21.76	7.58	0.240	5.22
93A	190.65	29.65	7.41	0.182	5.4
99A	201.35	30.75	7.35	0.201	6.18
104A	211.42	29.56	7.38	0.195	5.76
110D	217.95	34.26	7.37	0.210	7.19
PPlz Mud unit					
110A	219.45	5.32	7.56	0.932	4.96
111A	221.75	4.03	7.59	1.201	4.84
112A	223.65	5.31	7.58	0.800	4.25
116A	231.45	4.13	7.62	1.029	4.25
116A-Dup	231.45	4.14	7.52	1.034	4.28
PPlg Gravelly unit					
122A	241.89	24.16	7.49	0.204	4.93
124A	245.25	33.06	7.46	0.174	5.75
128A	251.75	23.88	7.49	0.206	4.92
129A	253.65	23.18	7.45	0.179	4.15

[a] Multiply by 0.3048 to convert to meters.
Each sample was about 10 in. long; the mid point is used for plotting.
EC = Electrical conductivity.
Values in red type indicate elevated values from caustic tank liquor.

Figure B.11. pH and Electrical Conductivity for Calculated and Actual Porewaters for Borehole 299-E33-45



Water extract anion concentrations as a function of depth are listed in Table B.10 and graphed in Figures B.12 and B.13. Numerous anions show peaks at various depths, particularly in or near high moisture soils that occur periodically in the soil column. These include silt-rich layers in the Hanford formation at 23, 37, and 52 m (75, 120, and 170 ft) bgs and the Plio-Pleistocene unit from 67 m (220 ft) to the water table at 78 m (255 ft) bgs. Generally, enriched anion concentrations are found in the H2 subunit between 23 and 52 m (75 and 170 ft) bgs.

The primary indicator of tank fluid occurrence is elevated nitrate concentrations that are measured in borehole 299-E33-45 from 21 down to 78 m (68 to 255 ft) bgs, which is the bottom of the borehole. Maximum nitrate values (between 1,100 and 6,200 mg/L) occur between 43 and 52 m (140 and 170 ft) bgs just above the primary silt-rich layer between the H2 and H3 subunits of the Hanford formation. A secondary enriched nitrate zone (between 1,100 and 1,400 mg/L) occurs in the Plio-Pleistocene unit at 67 to 70 m (220 to 230 ft) bgs near the bottom of the borehole. The sulfate maximum concentration zone is similar to nitrate including some enrichment beginning at 22 m (72 ft) bgs and going to the bottom of the borehole with a maximum concentration occurring between 16,500 and 40,200 mg/L at 46 to 49 m (150 to 160 ft) bgs.

Other anions show multiple high concentration zones, including peaks in the 43 and 52 m (140 and 170 ft) depths bgs. These are chloride with concentrations of 138 and 214 mg/L at 46 and 48 m (151 and 156 ft) bgs and nitrite with aconcentration of 33 mg/L at 46 m (151 ft) bgs. A slightly enriched chloride zone (35 to 159 mg/L) also occurs between 23 and 30 m (75 and 100 ft) bgs and between 61 and 71 m (200 and 232 ft) bgs where concentrations fall between 100 and 165 mg/L. A sharp nitrite peak (32 and 41 mg/L) occurs at about 24 m (78 and 79 ft) bgs.

Bicarbonate shows enhanced concentrations between (78 and 141) ft bgs and a highly enriched zone (1,100 to 12,900 mg/L) around the silt-rich layer at 37 m (120 ft) bgs. A phosphate peak (between 390 and 2,100 mg/L) also occurs over the same depth interval. Fluoride shows enhanced concentrations at several depth intervals. The largest interval containing the greatest amount of fluoride occurs between 24 to 51 m (78 and 166 ft) bgs with the largest peak (55 mg/L) occurring at 43 m (140 ft) bgs. This peak does not correlate with any other peak. Enriched fluoride zones (between 6 and 35 mg/L) occur near the top of the borehole between 3 and 8 m (10 and 26 ft) bgs and in the Plio-Pleistocene between 73 and 77 m (240 and 254 ft) bgs. These enriched zones are not observed with other anionic species.

Water extract cation concentrations as a function of depth are graphed in Figures B.14 and B.15 and listed in Table B.11. Among the cations, elevated sodium concentrations are the primary indicators of tank fluid occurrence in the soil column. Sodium concentrations are elevated over the largest depth interval from 23.8 to 48.8 m (78 to 160 ft) bgs relative to other cations and display changes in concentration quite similar to nitrate. Maximum concentrations (7,500 and 10,500 mg/L) occur between 46 and 49 m (150 and 160 ft) bgs. Other cations showing maximum concentrations in this range include magnesium (between 40 and 160 mg/L), calcium (between 250 and 2,300 mg/L), potassium (between 290 and 500 mg/L), and natural strontium (between 1.3 and 9.7 mg/L).

Three other cations, aluminum, silicon, and iron show some enrichment between 23 and 52 m (75 and 170 ft) bgs and similar changes in relative concentration over this depth range (Figure B.15). Maximum concentrations of aluminum, silicon, and iron (62, 634, and 64 mg/L, respectively) occur in the silt-rich layer around 46 m (150 ft) bgs. It is not clear whether these enrichments are due to a contribution to the soil column from tank waste, a natural variation, or are a product of tank fluid-soil interaction.

The last group of analyzed constituents included radionuclides and trace metals. Dilution corrected porewater concentrations obtained from the water extracts are shown in Figure B.16 and listed in Table B.12. Additional uranium analyses data to measure total uranium in the soil samples is provided in Figure B.17. The only radionuclides found in these soils were technetium-99 and uranium. Technetium-99 concentration distributions are nearly identical to nitrate with the most elevated concentrations occurring between 78 and 170 ft bgs. Maximum concentrations (between 13,200 and 53,600 pCi/L) occur between 43 and 50 m (140 and 165 ft) bgs. A secondary elevated concentration interval (between 29,600 and 79,100 pCi/L) occurs in the Plio-Pleistocene between 66 and 71 m (218 and 232 ft) bgs.

Elevated uranium concentrations on a per gram of sediment basis are found primarily between 21 and 52 m (70 and 170 ft) bgs. Within this interval, smaller zones showing peak values are present. These tend to occur around the silt-rich layers at 23, 37, and 52 m (75, 120, and 170 ft) bgs. The thickest and highest concentration zone occurs between 34 and 43 m (112 and 142 ft). The largest uranium concentration, 1,649 µg/g, occurs at 37 m (120 ft) bgs. The highest phosphate and very high bicarbonate concentrations are also in this sample. Secondary zones of smaller concentrations occur between 22 and 23 m (73 and 76 ft) bgs and between 48 and 52 m (156 and 170 ft) bgs that include maximum uranium concentrations of 369 and 307 µg/g, respectively, derived from gamma energy analyses.

Figure B.12. Anions (Nitrate, Bicarbonate, Sulfate, Chloride) Calculated and Actual Porewaters for Borehole 299-E33-45

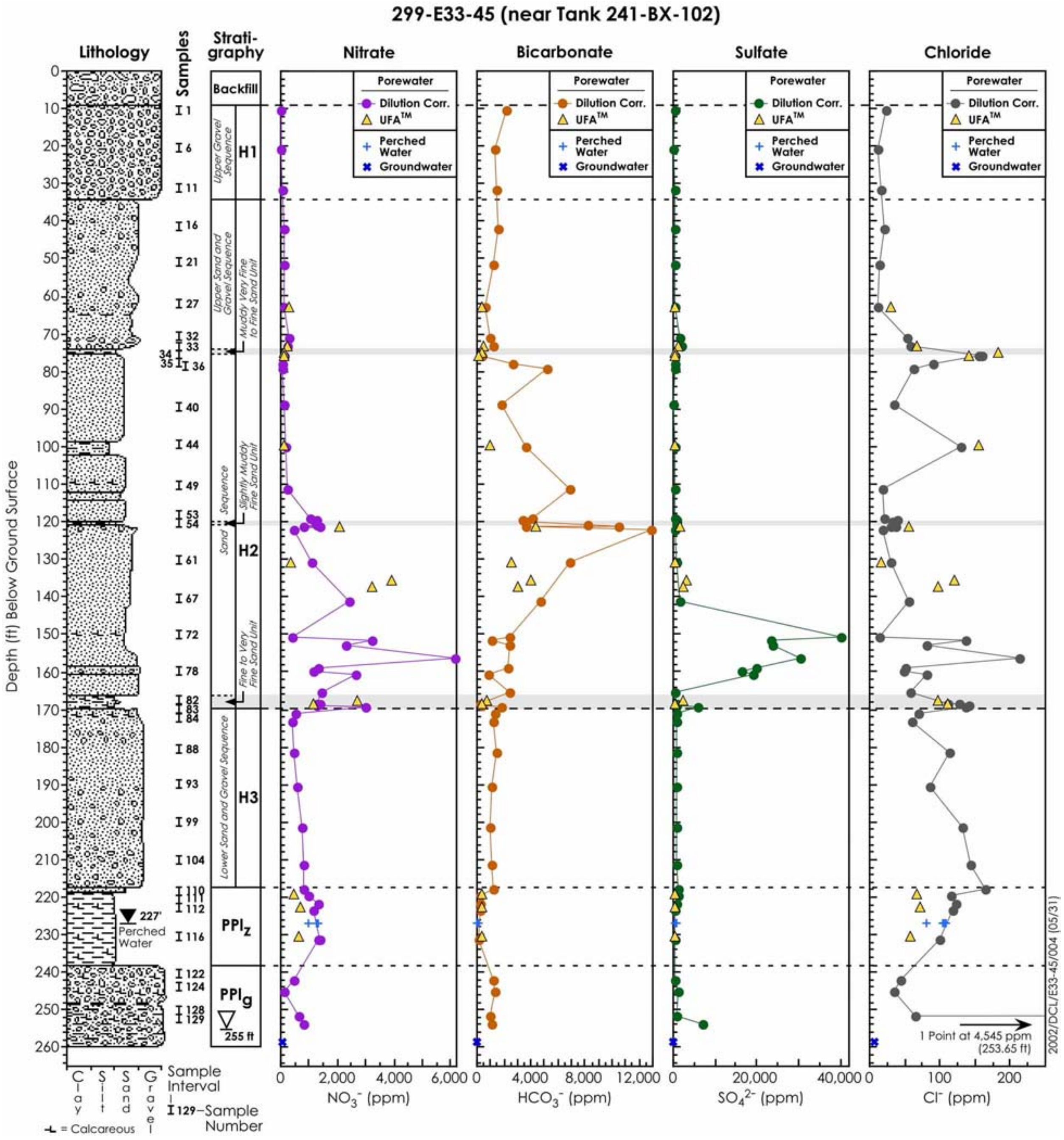


Figure B.13. Anions (Fluoride, Phosphate, Nitrite) Calculated and Actual Porewaters for Borehole 299-E33-45

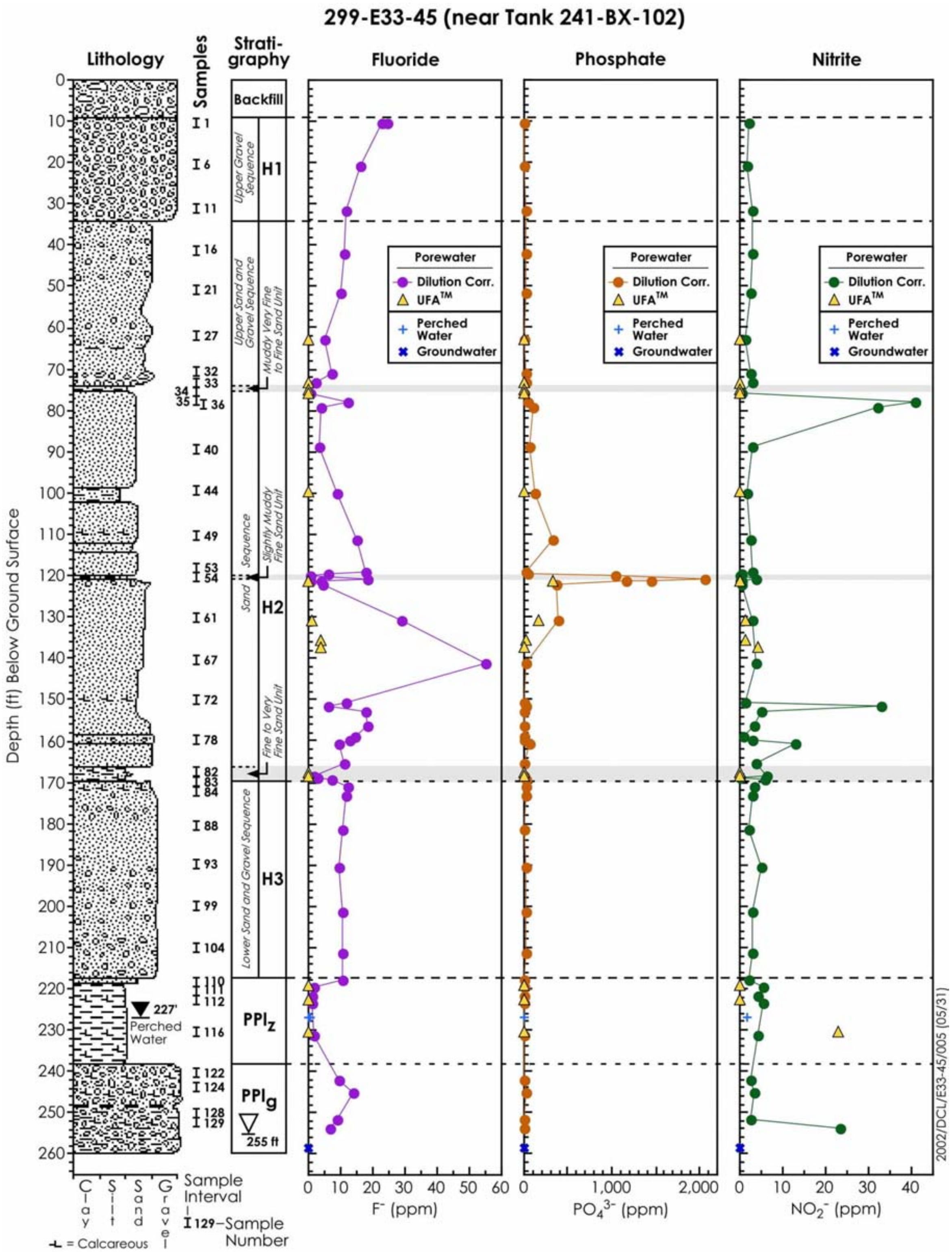


Table B.10. Anion Content of Water Extracts for Borehole 299-E33-45 (4 pages)

Identification	Depth[(a)]	Dil. Fac.	1:1 Extracts in mg/L							Dilution Corrected Porewater mg/L						
			NO3	F-	NO2	Cl	SO4	PO4	HCO3	NO3	F-	NO2	Cl	SO4	PO4	HCO3
Hanford H1 coarse sand																
01A	10.64	21.09	1.1	1.2	<0.1	1.2	20.8	0.35	105.7	22	24.3	2.1	24	439	7	2229
01A-Dup	10.64	21.09	1	1.1	<0.1	1.1	20.8	0.38	N/A	22	23	2.1	24	438	8	N/A
06A	20.84	17.43	1.4	0.9	<0.1	0.7	10	<0.5	76.2	24	16	1.7	12	174	<9	1328
11A	31.84	30.27	1.9	0.4	<0.1	0.6	10.2	<0.5	47.6	58	11.5	3	18	308	<15	1441
Hanford H2 upper sand sequence																
16A	42.04	29.2	4.8	0.4	<0.1	0.7	11.7	<0.5	52.4	139	11.4	2.9	21	340	<15	1529
21A	51.64	26.38	5	0.4	<0.1	0.6	11.4	<0.5	46.0	133	10	2.6	15	301	<13	1213
27A	62.99	14.72	9.9	0.4	<0.1	0.9	24	<0.5	45.5	146	5.2	1.5	13	352	<7	670
32A	71.24	25.83	11.3	0.3	<0.1	2.1	55.3	<0.5	39.2	291	7.5	2.6	53	1429	<13	1012
33A	73.39	31.48	7.8	0.1	<0.1	1.9	62.3	<0.5	40.2	245	2.5	3.2	59	1962	<16	1267
H2 muddy very fine sand lens																
34A	75.65	4.91	25.8	0.1	<0.1	32.4	85.5	1.07	68.2	127	0.4	0.5	159	420	5	335
34A-Dup	75.65	4.56	27.6	0.1	<0.1	34	91.4	0.07	68.4	126	0.3	0.5	155	417	0	312
H2 middle sand sequence																
35A	78.19	40.97	1.5	0.3	<1	2.2	12.5	1.01	64.8	59	12.3	41	91	513	41	2654
36A	79.34	32.28	1.9	0.1	<1	1.9	11.9	2.95	161.1	62	3.9	32.3	62	383	95	5200
40A	88.65	27.63	3.6	0.1	<0.1	1.3	7.4	1.97	66.6	98	3.6	2.8	35	205	54	1840
44A	100.09	19.04	9.6	0.5	<0.1	6.9	16.8	6.05	189.0	182	9.1	1.9	130	319	115	3598
49A	111.14	25.85	10.1	0.6	<0.1	0.7	11.9	12.34	263.8	260	15	2.6	19	309	319	6818
53A	119.04	31.4	33.8	0.6	<0.1	0.7	15	<0.5	131.1	1062	17.9	3.1	22	470	<16	4115

Table B.10. Anion Content of Water Extracts for Borehole 299-E33-45 (4 pages)

Identification	Depth[a]	Dil. Fac.	1:1 Extracts in mg/L							Dilution Corrected Porewater mg/L						
			NO3	F-	NO2	Cl	SO4	PO4	HCO3	NO3	F-	NO2	Cl	SO4	PO4	HCO3
H2 muddy very fine sand lens																
54C Fine	120.14	7.02	173.7	0	0.02	4.7	121.3	148.561	513.5	1219	0.3	0.1	33	852	1043	3605
54C DUP Fine	120.14	9.27	96	0	0.36	2.8	64.7	126.351	408.0	890	0.3	3.3	26	600	1172	3782
54C Upper	120.14	14.98	85.8	0.4	0.04	2.6	52.8	3.498	226.0	1286	6.2	0.6	39	791	52	3385
54A	120.89	39.38	32	0.5	<0.1	0.9	21.8	52.18	209.4	1259	18.5	3.9	35	858	2055	8247
H2 middle sand sequence (continued)																
54	121.24	36.16	22	0.1	<0.01	0.8	18.8	40.297	290.8	796	3.9	<0.26	30	679	1457	10516
55	121.34	6.77	201.5	0.1	0.01	5.6	127.1	172.616	530.6	1364	0.4	0.1	38	860	1169	3592
56	122.32	33.95	12.9	0.1	0.01	0.5	9.6	10.997	381.0	438	4.7	0.4	18	327	373	12936
61A	130.95	25.93	43	1.1	0.12	1.1	32.9	15.09	263.3	1115	29	3.1	29	852	391	6827
67A	141.25	38.52	62	1.4	<0.1	1.4	46.2	<0.5	122.3	2390	55.1	3.9	55	1779	<19	4712
72C	150.55	28.44	15	0.4	0.05	0.5	1413	0.063	86.1	426	11.9	1.3	14	40183	2	2449
72A	151.55	33.05	97.4	0.2	<1	4.2	701.9	<0.5	34.3	3217	6	33.1	138	23196	<17	1132
73	152.7	30.98	74	0.6	0.17	2.6	767.3	<0.014	77.9	2292	17.7	5.2	81	23775	<0.43	2412
75	156.2	33.88	181.6	0.5	0.1	6.3	896.6	<0.014	N/A	6155	18.2	3.5	214	30379	<0.47	N/A
77	159.1	28.82	45.6	0.5	0.03	1.8	692.1	<0.014	81.6	1314	14.5	0.8	51	19946	<0.40	2352
78C	159.85	27.04	41.9	0.5	0.12	1.8	612.2	<0.014	N/A	1134	12.7	3.1	48	16556	<0.38	N/A
78A	160.85	26.29	100.1	0.4	<0.5	3.1	732.3	<2.5	33.5	2632	9.5	13.2	82	19253	<66	881
81	165.55	21.84	66.2	0.5	0.18	2.7	19.5	<0.014	111.5	1447	11.1	3.8	59	425	<0.31	2436

Table B.10. Anion Content of Water Extracts for Borehole 299-E33-45 (4 pages)

Identification	Depth[a]	Dil. Fac.	1:1 Extracts in mg/L							Dilution Corrected Porewater mg/L						
			NO3	F-	NO2	Cl	SO4	PO4	HCO3	NO3	F-	NO2	Cl	SO4	PO4	HCO3
H2 – fine-very fine sand lens																
82A	168.65	6.17	204.6	0.3	<1	17.9	111.1	<0.5	35.8	1262	1.9	6.2	110	685	<3	221
82A-Dup	168.65	6.17	228.6	0.3	<1	20.7	124.1	<0.5	33.1	1410	1.9	6.2	128	765	<3	204
82	169.1	5.78	209.9	0.5	0.04	23	112.5	<0.014	74.6	1295	2.8	0.2	142	694	<0.09	431
83D	169.55	12.01	249.4	0.6	0.5	11.4	492.3	1.91	150.2	2995	7.3	6	136	5911	23	1804
Hanford H3 Lower sand unit																
83A	171.05	35.27	15.5	0.4	<0.1	2	19.7	<0.5	39.2	546	12.3	3.5	70	693	<18	1384
84A	173.35	31.43	13.2	0.4	<0.1	1.9	20	<0.5	38.4	416	11.6	3.1	60	630	<16	1208
88A	181.65	21.76	21.9	0.5	<0.1	5.3	29	<0.5	68.2	477	10.5	2.2	114	631	<11	1483
93A	190.65	29.65	20.1	0.3	0.17	2.9	22.8	<0.5	37.9	595	9.5	5	87	677	<15	1123
99A	201.35	30.75	25.2	0.3	<0.1	4.3	29.1	<0.5	32.7	774	10.5	3.1	133	893	<15	1005
104A	211.42	29.56	27.2	0.4	<0.1	4.8	24.1	<0.5	35.3	803	10.3	3	143	712	<15	1042
110D	217.95	34.26	23.6	0.3	0.06	4.8	31	0.038	36.3	810	10.5	2	164	1062	1	1245
PPlz Mud unit																
110A	219.45	5.32	186	0.3	<1	21.7	206.9	<0.5	58.5	989	1.7	5.3	116	1100	<3	311
111A	221.75	4.03	323.6	0.3	<1	30.4	227.5	<0.5	55.8	1305	1.3	4	123	918	<2	225
112A	223.65	5.31	213.4	0.3	<1	22.2	108.9	<0.5	51.0	1134	1.4	5.3	118	579	<3	271
116A	231.45	4.13	331.4	0.5	<1	24.3	145.8	<0.5	42.9	1370	2	4.1	100	603	<2	177
116A-Dup	231.45	4.14	322.8	0.5	<1	24	147.4	<0.5	45.2	1335	2	4.1	99	610	<2	187

Table B.10. Anion Content of Water Extracts for Borehole 299-E33-45 (4 pages)

Identification	Depth[(a)]	Dil. Fac.	1:1 Extracts in mg/L							Dilution Corrected Porewater mg/L						
			NO3	F-	NO2	Cl	SO4	PO4	HCO3	NO3	F-	NO2	Cl	SO4	PO4	HCO3
PPlg Gravelly unit																
122A	241.89	24.16	20.2	0.4	<0.1	1.8	25.4	<0.5	51.7	487	9.4	2.4	44	614	<12	1248
124A	245.25	33.06	3.2	0.4	<0.1	1	32.5	<0.5	41.0	106	13.9	3.3	34	1075	<16	1355
128A	251.75	23.88	27.3	0.4	<0.1	2.7	27.4	<0.5	41.2	652	8.8	2.4	65	654	<11	983
129A	253.65	23.18	34.3	0.3	<1	196	299	<0.5	49.5	794	6.7	23.2	4545	6932	<11	1148

[(a)] Multiply by 0.3048 to convert to meters.
NA = not analyzed
Red type = Sample 129A sulfate value is likely erroneous
Purple shading indicates values that are elevated because of presence of tank or other waste fluids

Figure B.14. Cations for Calculated and Actual Porewaters for Borehole 299-E33-45 Sediment

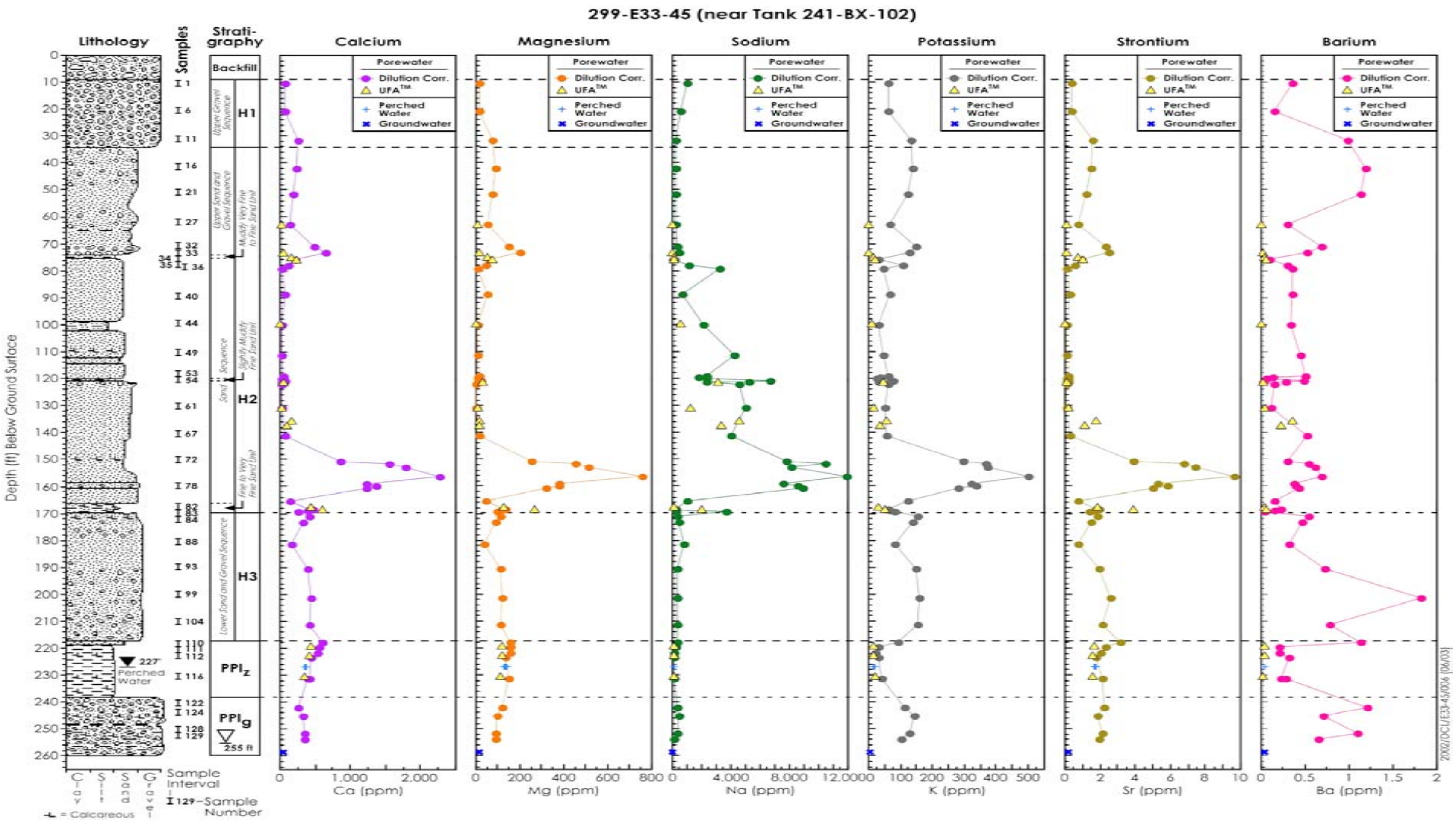


Figure B.15. Aluminum, Iron, and Silicon Concentrations for Calculated Actual Porewaters for Borehole 299-E33-45 Sediment

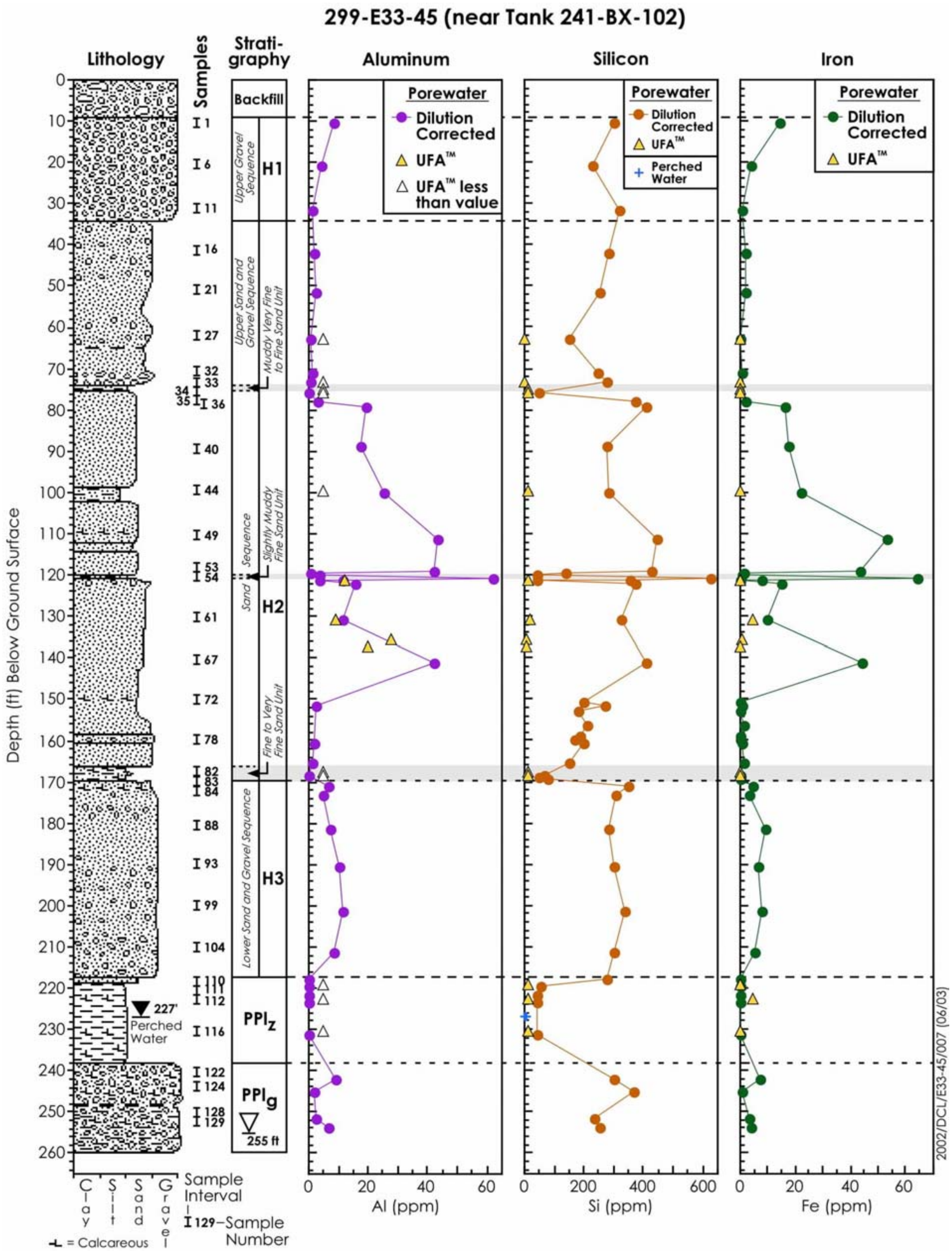


Table B.11. Calculated Porewater Cation Composition from Water Extracts of Vadose Zone Sediment from 299-E33-45 (4 pages)

Identification	Depth[(a)] (ft bgs)	Dil. Fac.	Dilution Corrected Porewater Concentration of Cations								
			Al mg/L	Ba mg/L	Ca mg/L	Fe mg/L	K mg/L	Mg mg/L	Na mg/L	Si mg/L	Sr mg/L
Hanford H1 coarse sand											
01A	10.64	21.09	8.55E+00	3.50E-01	7.44E+01	1.45E+01	6.09E+01	1.56E+01	9.77E+02	3.00E+02	3.76E-01
06A	20.84	17.43	4.00E+00	1.51E-01	6.47E+01	4.26E+00	6.07E+01	1.48E+01	5.42E+02	2.30E+02	3.37E-01
11A	31.84	30.27	1.20E+00	9.77E-01	2.64E+02	(8.67E-01)	1.35E+02	7.51E+01	**2.52E+02**	3.18E+02	1.62E+00
Hanford H2 upper sand sequence											
16A	42.04	29.2	1.90E+00	1.19E+00	2.31E+02	(1.73E+00)	1.38E+02	8.82E+01	2.78E+02	2.84E+02	1.53E+00
21A	51.64	26.38	2.50E+00	1.14E+00	1.88E+02	(2.33E+00)	1.21E+02	7.42E+01	2.80E+02	2.56E+02	1.24E+00
27A	62.99	14.72	(4.95E-01)	3.00E-01	1.53E+02	(3.05E-01)	6.69E+01	5.06E+01	1.93E+02	1.50E+02	7.84E-01
32A	71.24	25.83	1.40E+00	6.82E-01	4.86E+02	(5.26E-01)	1.46E+02	1.47E+02	3.33E+02	2.47E+02	2.35E+00
33A	73.39	31.48	(4.88E-01)	5.23E-01	6.39E+02	<3.15E+00	1.26E+02	1.99E+02	4.08E+02	2.79E+02	2.55E+00
H2 muddy very fine sand lens											
34A	75.65	4.91	2.45E-01	8.42E-02	2.07E+02	<4.91E-01	3.24E+01	5.84E+01	1.19E+02	5.11E+01	9.13E-01
34A-Dup	75.65	4.56	2.28E-01	1.00E-01	2.00E+02	<4.56E-01	3.20E+01	5.66E+01	1.19E+02	4.95E+01	8.95E-01
H2 middle sand sequence											
35A	78.19	40.97	2.94E+00	3.02E-01	1.14E+02	(1.94E+00)	1.09E+02	4.31E+01	1.12E+03	3.73E+02	5.47E-01
36A	79.34	32.28	1.91E+01	3.51E-01	(1.66E+01)	1.64E+01	4.51E+01	4.84E+00	3.18E+03	4.10E+02	(8.57E-02)
40A	88.65	27.63	1.73E+01	3.46E-01	8.08E+01	1.78E+01	6.44E+01	5.49E+01	6.71E+02	2.78E+02	3.00E-01
44A	100.09	19.04	2.55E+01	3.36E-01	2.58E+01	2.19E+01	3.22E+01	6.22E+00	2.12E+03	2.81E+02	(1.09E-01)
49A	111.14	25.85	4.35E+01	4.50E-01	3.05E+01	5.31E+01	4.72E+01	1.16E+01	4.26E+03	4.43E+02	(1.37E-01)
53A	119.04	31.4	4.21E+01	5.10E-01	5.92E+01	4.32E+01	6.42E+01	1.55E+01	2.38E+03	4.28E+02	(2.38E-01)

Table B.11. Calculated Porewater Cation Composition from Water Extracts of Vadose Zone Sediment from 299-E33-45 (4 pages)

Identification	Depth[(a)] (ft bgs)	Dil. Fac.	Dilution Corrected Porewater Concentration of Cations								
			Al mg/L	Ba mg/L	Ca mg/L	Fe mg/L	K mg/L	Mg mg/L	Na mg/L	Si mg/L	Sr mg/L
H2 muddy very fine sand lens											
54C Fine	120.14	7.02	<3.51E+00	6.08E-02	3.68E+01	9.35E-01	2.60E+01	9.04E+00	2.31E+03	4.50E+01	1.21E-01
54C Dup Fine	120.14	9.27	<4.64E+00	1.34E-01	4.23E+01	(1.42E-01)	2.98E+01	1.07E+01	2.21E+03	5.38E+01	1.33E-01
54C Upper	120.14	14.98	(7.35E-01)	1.24E-01	4.53E+01	(1.35E+00)	3.86E+01	5.71E+00	1.74E+03	1.37E+02	1.87E-01
54A	120.89	39.38	6.18E+01	4.82E-01	6.37E+01	6.42E+01	7.89E+01	2.33E+01	6.68E+03	6.24E+02	(2.20E-01)
H2 middle sand sequence (continued)											
54	121.24	36.16	(1.15E+01)	2.87E-01	3.15E+01	7.54E+00	6.82E+01	5.71E+00	5.26E+03	3.59E+02	(1.60E-01)
55	121.34	6.77	<3.39E+00	(1.63E-02)	3.91E+01	(1.12E-01)	3.31E+01	1.32E+01	2.36E+03	4.21E+01	1.11E-01
56	122.32	33.95	(1.59E+01)	1.48E-01	2.29E+01	1.53E+01	5.94E+01	3.16E+00	4.61E+03	3.72E+02	(1.10E-01)
61A	130.95	25.93	1.17E+01	1.19E-01	2.67E+01	9.97E+00	5.09E+01	2.62E+00	5.01E+03	3.23E+02	(1.30E-01)
67A	141.25	38.52	4.21E+01	5.19E-01	6.38E+01	4.41E+01	5.89E+01	1.36E+01	4.03E+03	4.12E+02	(2.78E-01)
72C	150.55	28.44	<1.42E+01	2.98E-01	8.51E+02	(2.17E-01)	2.96E+02	2.53E+02	7.74E+03	1.98E+02	3.89E+00
72A	151.55	33.05	2.18E+00	5.32E-01	1.56E+03	(1.00E+00)	3.67E+02	4.55E+02	1.05E+04	2.70E+02	6.76E+00
73	152.7	30.98	<1.55E+01	6.09E-01	1.78E+03	(2.02E-01)	3.75E+02	5.10E+02	8.15E+03	1.81E+02	7.45E+00
75	156.2	33.88	<1.69E+01	6.83E-01	2.28E+03	(1.12E+00)	5.02E+02	7.59E+02	1.19E+04	2.10E+02	9.63E+00
77	159.1	28.82	<1.44E+01	3.77E-01	1.23E+03	(1.32E-01)	3.22E+02	3.78E+02	7.54E+03	1.84E+02	5.27E+00
78C	159.85	27.04	<1.35E+01	3.84E-01	1.38E+03	(1.54E-01)	3.39E+02	3.78E+02	8.59E+03	1.67E+02	5.88E+00
78A	160.85	26.29	1.60E+00	4.20E-01	1.22E+03	(6.20E-01)	2.78E+02	3.23E+02	8.88E+03	1.99E+02	5.05E+00
81	165.55	21.84	(1.03E+00)	1.51E-01	1.47E+02	(1.44E+00)	**1.24E+02**	4.25E+01	9.89E+02	1.52E+02	7.76E-01

Table B.11. Calculated Porewater Cation Composition from Water Extracts of Vadose Zone Sediment from 299-E33-45 (4 pages)

Identification	Depth[(a)] (ft bgs)	Dil. Fac.	Dilution Corrected Porewater Concentration of Cations								
			Al mg/L	Ba mg/L	Ca mg/L	Fe mg/L	K mg/L	Mg mg/L	Na mg/L	Si mg/L	Sr mg/L
H2 – fine-very fine sand lens											
82A	168.65	6.17	9.83E-02	2.25E-01	4.27E+02	(9.25E-02)	6.38E+01	1.26E+02	2.07E+02	6.52E+01	1.79E+00
82A-Dup	168.65	6.17	7.41E-02	2.27E-01	4.70E+02	(1.17E-01)	6.13E+01	1.37E+02	2.17E+02	6.78E+01	1.97E+00
82	169.1	5.78	<2.89E+00	1.42E-01	3.85E+02	(1.85E-02)	6.56E+01	1.14E+02	1.85E+02	4.87E+01	1.67E+00
83D	169.55	12.01	<6.00E+00	4.42E-02	2.53E+02	(3.30E-02)	8.22E+01	9.42E+01	3.70E+03	8.10E+01	1.36E+00
Hanford H3 Lower sand unit											
83A	171.05	35.27	6.57E+00	5.45E-01	4.26E+02	4.76E+00	1.54E+02	1.12E+02	3.81E+02	3.50E+02	1.88E+00
84A	173.35	31.43	4.81E+00	4.65E-01	3.24E+02	3.56E+00	1.36E+02	8.74E+01	4.00E+02	3.09E+02	1.53E+00
88A	181.65	21.76	7.55E+00	3.26E-01	1.70E+02	8.84E+00	8.35E+01	4.11E+01	8.01E+02	2.85E+02	7.78E-01
93A	190.65	29.65	1.03E+01	7.25E-01	3.99E+02	6.76E+00	1.49E+02	1.10E+02	3.08E+02	2.99E+02	1.94E+00
99A	201.35	30.75	1.17E+01	1.81E+00	4.51E+02	7.78E+00	1.56E+02	1.23E+02	3.70E+02	3.36E+02	2.65E+00
104A	211.42	29.56	8.64E+00	7.71E-01	4.30E+02	5.06E+00	1.51E+02	1.12E+02	3.49E+02	3.02E+02	2.17E+00
110D	217.95	34.26	(2.53E-01)	1.14E+00	6.03E+02	(9.14E-02)	9.40E+01	1.55E+02	3.98E+02	2.76E+02	3.12E+00
PPlz Mud unit											
110A	219.45	5.32	1.60E-02	2.08E-01	5.58E+02	(2.78E-02)	3.01E+01	1.59E+02	1.89E+02	5.43E+01	2.31E+00
111A	221.75	4.03	1.14E-02	1.99E-01	5.30E+02	(2.53E-02)	2.08E+01	1.59E+02	1.66E+02	4.10E+01	2.06E+00
112A	223.65	5.31	(7.63E-02)	3.16E-01	4.36E+02	1.36E-01	3.00E+01	1.33E+02	1.35E+02	4.52E+01	1.79E+00
116A	231.45	4.13	(3.31E-02)	2.28E-01	4.12E+02	(6.90E-02)	4.29E+01	1.49E+02	1.47E+02	4.13E+01	2.11E+00
116A-Dup	231.45	4.14	(1.48E-02)	2.75E-01	4.07E+02	(4.48E-02)	4.33E+01	1.51E+02	1.50E+02	4.21E+01	2.13E+00

Table B.11. Calculated Porewater Cation Composition from Water Extracts of Vadose Zone Sediment from 299-E33-45 (4 pages)

Identification	Depth[a] (ft bgs)	Dil. Fac.	Dilution Corrected Porewater Concentration of Cations								
			Al mg/L	Ba mg/L	Ca mg/L	Fe mg/L	K mg/L	Mg mg/L	Na mg/L	Si mg/L	Sr mg/L
PPlg Gravelly unit											
122A	241.89	24.16	8.91E+00	1.20E+00	2.55E+02	7.31E+00	1.13E+02	1.21E+02	3.92E+02	3.01E+02	2.19E+00
124A	245.25	33.06	1.71E+00	7.03E-01	3.24E+02	(8.69E-01)	1.45E+02	9.46E+01	4.88E+02	3.66E+02	1.86E+00
128A	251.75	23.88	2.42E+00	1.09E+00	3.46E+02	3.54E+00	1.29E+02	9.18E+01	3.32E+02	2.37E+02	2.12E+00
129A	253.65	23.18	6.53E+00	6.45E-01	3.49E+02	3.71E+00	1.02E+02	9.28E+01	1.64E+02	2.55E+02	1.96E+00

[a] Multiply by 0.3048 to convert to meters.
Values in parentheses are below level of quantification but spectra look useable.
< Values are reported as the detection limit for lowest standard that gave good value.
Blue type signifies significantly lower values than most of profile (perhaps ion exchanged or leached away).
Red type signifies that concentration is much higher than expected natural background values.

Table B.12. Calculated Porewater Trace Metal Composition for Water Extracts of Sediment from 299-E33-45 (2 pages)

Sample Identification	Depth (ft bgs)[(a)]	Dil. Fac.	Cr ug/L	As ug/L	Se ug/L	Tc-99 pCi/L	U-238 ug/L
Hanford H1 coarse sand							
01A	10.64	21.09	3.31E+01	6.79E+02	6.31E+01	<4.47E+04	4.41E+01
06A	20.84	17.43	8.28E-01	2.20E+02	1.93E+01	<3.70E+04	1.46E+01
11A	31.84	30.27	<3.78E+02	2.21E+02	(9.84E+00)	<6.42E+04	1.23E+01
Hanford H2 upper sand sequence							
16A	42.04	29.2	<3.65E+02	2.69E+02	(2.34E+01)	<6.19E+04	1.31E+01
21A	51.64	26.38	<3.30E+02	2.86E+02	(7.25E+00)	<5.59E+04	1.12E+01
27A	62.99	14.72	(7.21E+00)	1.74E+02	(4.41E+00)	<3.12E+04	4.34E+00
32A	71.24	25.83	<3.23E+02	2.04E+02	<6.46E+01	<5.48E+04	1.12E+01
33A	73.39	31.48	<3.93E+02	(6.83E+01)	(2.07E+01)	<6.67E+04	2.97E+04
H2 muddy very fine sand lens							
34A	75.65	4.91	(4.91E+00)	4.20E+01	1.64E+01	<1.04E+04	2.75E+03
34A-Dup	75.65	4.56	(5.27E+00)	4.06E+01	1.46E+01	<9.67E+03	2.68E+03
H2 middle sand sequence							
35A	78.19	40.97	(1.19E+01)	1.05E+03	(2.09E+01)	5.21E+03	2.24E+04
36A	79.34	32.28	<4.03E+02	4.95E+02	(1.05E+00)	(6.84E+04)	8.11E+04
40A	88.65	27.63	(2.44E+01)	2.22E+02	(4.32E+00)	(5.86E+04)	9.02E+03
44A	100.09	19.04	(1.67E+01)	4.31E+02	(2.07E+01)	<4.04E+04	1.15E+04
49A	111.14	25.85	(2.80E+01)	9.61E+02	(2.45E+01)	<2.19E+03	9.34E+04
53A	119.04	31.4	(1.24E+01)	8.78E+02	<7.85E+01	<2.26E+04	1.83E+05
H2 muddy very fine sand lens							
54C Fine	120.14	7.02	NA	NA	NA	1.31E+05	6.58E+05
54C Dup Fine	120.14	9.27	NA	NA	NA	9.21E+04	6.51E+05
54C Upper	120.14	14.98	NA	NA	NA	(9.50E+04)	2.68E+05
54A	120.89	39.38	(4.41E+01)	3.41E+03	(5.02E+01)	1.09E+05	6.61E+05
H2 middle sand sequence (continued)							
54	121.24	36.16	NA	NA	NA	9.93E+04	6.34E+05
55	121.34	6.77	NA	NA	NA	1.56E+05	6.28E+05
56	122.32	33.95	NA	NA	NA	(4.55E+04)	2.21E+05
61A	130.95	25.93	(2.42E+01)	3.85E+03	(9.27E+00)	1.32E+05	5.91E+05
67A	141.25	38.52	(4.55E+01)	7.32E+02	(2.31E+00)	2.82E+05	3.89E+05
72C	150.55	28.44	NA	NA	NA	(3.95E+04)	2.03E+05
72A	151.55	33.05	<4.13E+02	2.51E+02	(4.30E+01)	3.35E+05	9.29E+04
73	152.7	30.98	NA	NA	NA	1.32E+05	1.42E+05

Table B.12. Calculated Porewater Trace Metal Composition for Water Extracts of Sediment from 299-E33-45 (2 pages)

Sample Identification	Depth (ft bgs)[(a)]	Dil. Fac.	Cr ug/L	As ug/L	Se ug/L	Tc-99 pCi/L	U-238 ug/L
75	156.2	33.88	NA	NA	NA	5.36E+05	2.51E+05
77	159.1	28.82	NA	NA	NA	1.60E+05	1.46E+05
78C	159.85	27.04	NA	NA	NA	1.28E+05	1.42E+05
78A	160.85	26.29	<3.29E+02	(1.13E+02)	(2.74E+01)	3.49E+05	7.04E+04
81	165.55	21.84	NA	NA	NA	1.36E+05	9.08E+04
H2 – fine-very fine sand lens							
82A	168.65	6.17	(7.59E+00)	(2.99E+01)	(9.31E+00)	6.20E+04	5.32E+03
82A-Dup	168.65	6.17	(2.02E+00)	(2.70E+01)	(1.34E+01)	7.47E+04	4.69E+03
82	169.1	5.78	NA	NA	NA	2.13E+04	4.36E+03
83D	169.55	12.01	NA	NA	NA	(3.98E+05)	4.54E+05
Hanford H3 Lower sand unit							
83A	171.05	35.27	(6.53E+01)	3.27E+02	(1.86E+01)	<7.48E+04	4.80E+03
84A	173.35	31.43	<3.93E+02	3.07E+02	(2.38E+01)	<6.66E+04	7.77E+03
88A	181.65	21.76	(1.87E+01)	3.15E+02	(1.02E+01)	<4.61E+04	7.03E+04
93A	190.65	29.65	<3.71E+02	2.03E+02	(4.16E+01)	<6.29E+04	4.79E+04
99A	201.35	30.75	<3.84E+02	2.02E+02	(3.84E-01)	(5.21E+03)	1.91E+01
104A	211.42	29.56	(1.74E+01)	(1.63E+02)	(3.16E+01)	(3.01E+04)	6.28E+00
110D	217.95	34.26	NA	NA	NA	7.84E+04	(1.71E+01)
PPlz Mud unit							
110A	219.45	5.32	(5.08E+00)	(1.72E+01)	2.27E+01	7.91E+04	2.76E+02
111A	221.75	4.03	(6.61E+00)	(8.11E+00)	2.20E+01	5.12E+04	7.13E+00
112A	223.65	5.31	(2.42E+00)	(1.78E+01)	2.89E+01	6.83E+04	1.69E+00
116A	231.45	4.13	(1.73E+00)	(1.17E+01)	1.48E+01	2.96E+04	1.25E+01
116A-Dup	231.45	4.14	(2.19E+00)	(1.11E+01)	1.63E+01	2.98E+04	1.69E+01
PPlg Gravelly unit							
122A	241.89	24.16	<3.02E+02	2.05E+02	(2.79E+01)	(8.20E+03)	8.70E+00
124A	245.25	33.06	<4.13E+02	2.69E+02	(1.72E+02)	<7.01E+04	4.79E+00
128A	251.75	23.88	(1.05E+01)	1.06E+02	(4.78E+01)	(1.11E+04)	5.07E+00
129A	253.65	23.18	<2.90E+02	1.05E+02	6.86E+01	(1.97E+04)	4.11E+01

[(a)] Multiply by 0.3048 to convert to meters.
Depth represents the vertical depth in feet.
Identification notes: Dup represents a duplicate water extract on a separate aliquot of sediment.
NA = not analyzed
Values in parentheses are below level of quantitation but dilutions and spectra looked adequate.
Red type signifies that concentration is much higher than expected natural background values.

Figure B.16. Trace Metals Pore Fluid for Calculated and Actual Porewaters for BX-102 Borehole Sediment

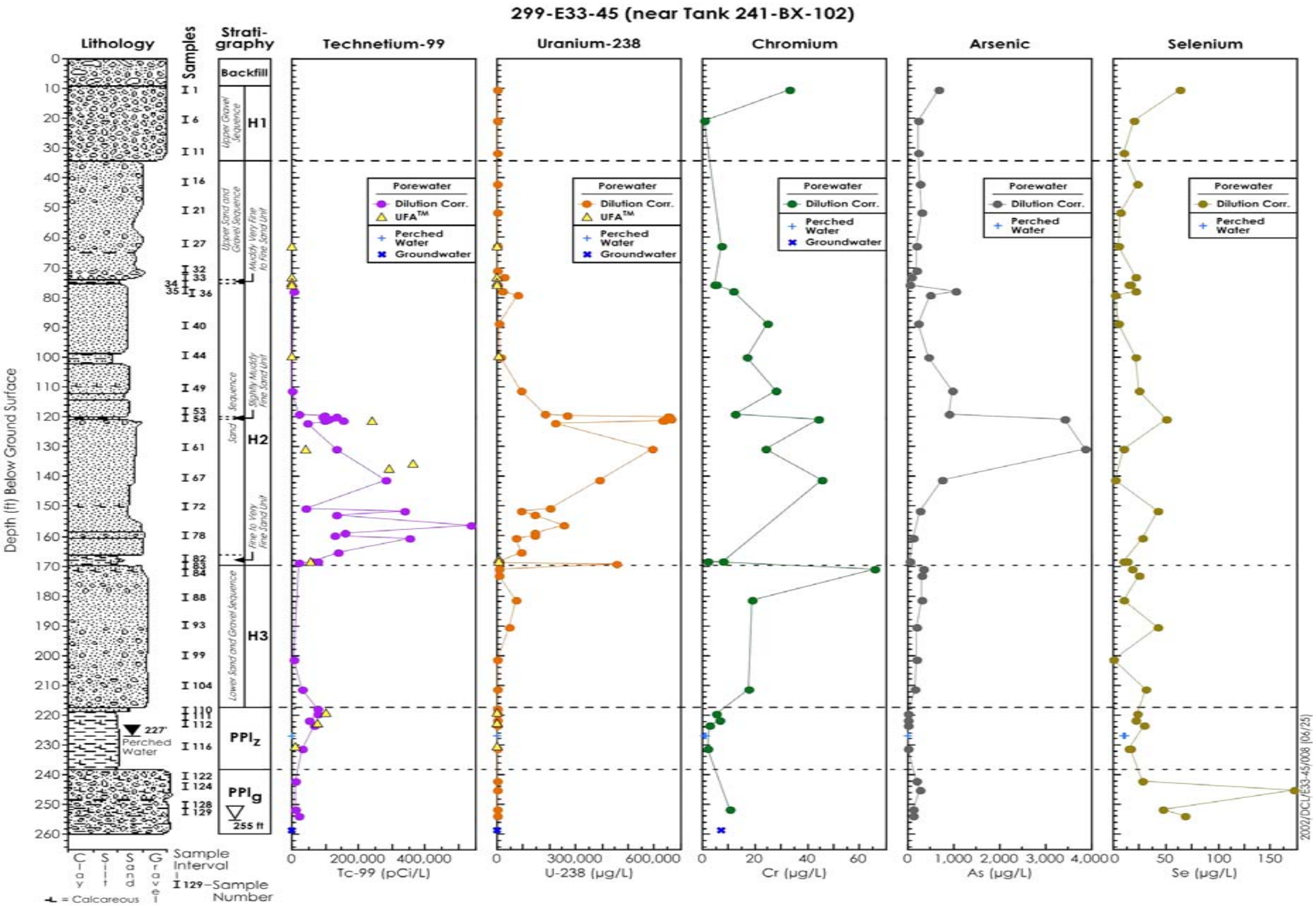
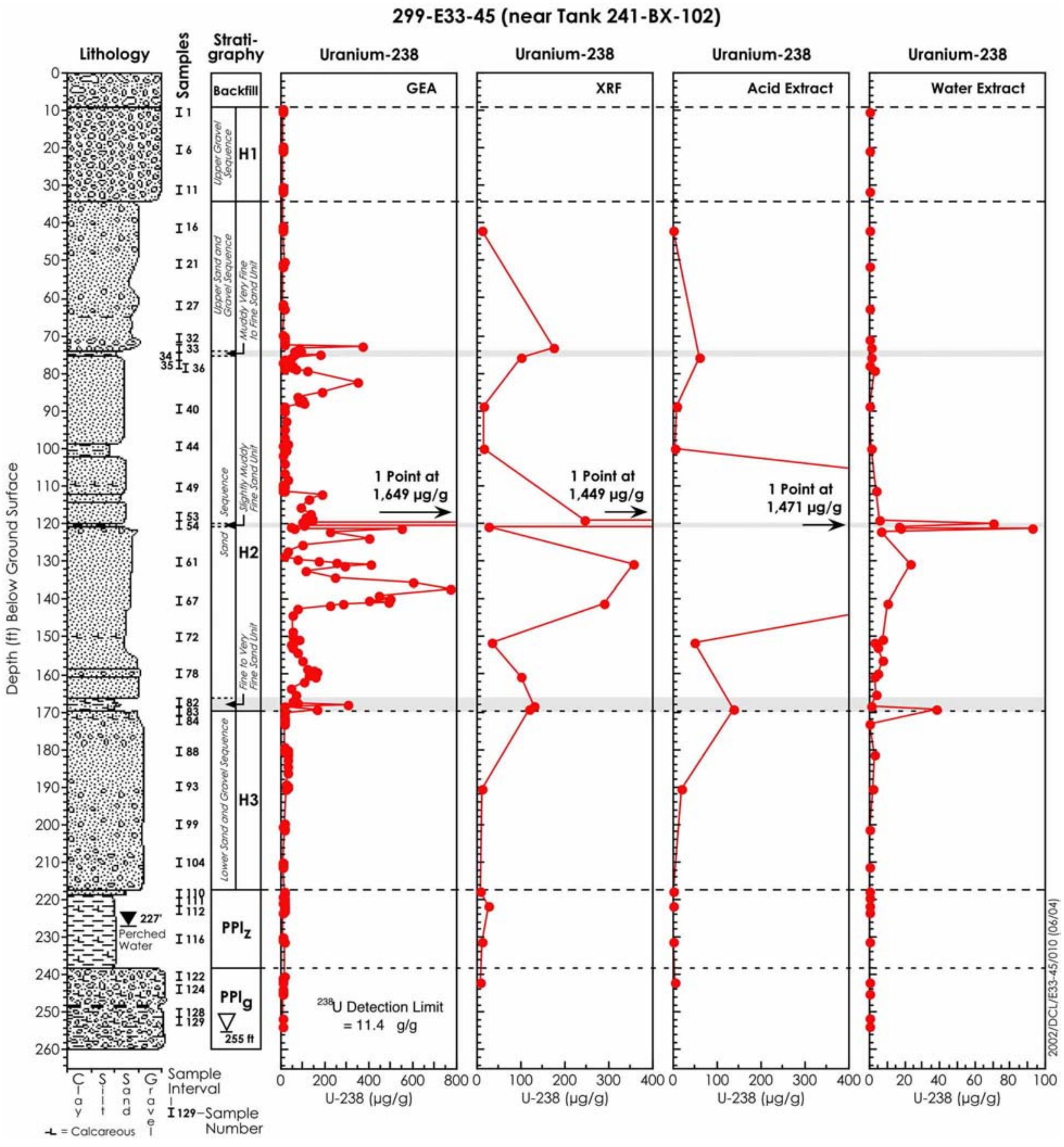


Figure B.17. Three Independent Methods of Estimating Uranium-238 in Borehole 299-E33-45 Vadose Sediments (pCi/g)



Tritium concentration in the 299-E33-45 vadose sediment, reported both in pCi per gram of sediment and as pCi/L (assuming all the tritium resided in the porewater) are listed in Table B.13. The tritium levels are relatively low and it is difficult to determine if there are two sources: 1) the BX-102/BX-101 overfills/junction box leaks for the tritium in the Hanford formation sediments, and 2) crib and trench disposal for the tritium in the perched water, deeper Plio-Pleistocene sediments, and groundwater.

The effects of acid extraction versus water extraction of technetium-99 and uranium are shown in Figures B.18 and B.19. A comparison of acid versus water extract concentrations indicates very high technetium mobility as very similar concentrations occur in the water and acid soil-extract fluid. Uranium is less mobile than technetium. Empirical distribution coefficients determined by comparing water and acid extracts are essentially 0 mL/g for technetium-99 and > 1 mL/g for uranium.

A perched water zone was observed between 69 and 70 m (226 and 228 ft) bgs in the Plio-Pleistocene unit. Perched water is moderately alkaline pH (~7.3) with the dominant anions being nitrate (~ 1300 mg/L) and sulfate (~650 mg/L), and the dominant cations being calcium (~360 mg/L), magnesium (~125 mg/L), and sodium (~120 mg/L). The radionuclides technetium-99 (~560 to 2300 pCi/L) and tritium (~78,000 pCi/L) are also present.

Table B.13. Tritium Content in Water Extracts, Perched Water, and Groundwater (pCi/L) (3 pages)

Sample Identification	Depth[(a)] (ft bgs)	Dilution Factor	1:1 Extract Tritium pCi/mL	± Uncertainty pCi/mL	Calculated Porewater pCi/mL
Hanford H1 coarse sand					
01A	10.64	21.09	<2.04E+00		
06A	20.84	17.43	<1.72E+00		
11A	31.84	30.27	<2.92E+00		
Hanford H2 upper sand sequence					
16A	42.04	29.2	6.63E+00	2.92E+01	
21A	51.64	26.38	<2.52E+00		
27A	62.99	14.72	<1.39E+00		
32A	71.24	25.83	2.35E+00	2.57E+01	
33A	73.39	31.48	1.43E+00	3.15E+01	
H2 muddy very fine sand lens					
34A	75.65	4.91	<4.80E-01		
34A-Dup	75.65	4.56	<4.46E-01		

Table B.13. Tritium Content in Water Extracts, Perched Water, and Groundwater (pCi/L) (3 pages)

Sample Identification	Depth[(a)] (ft bgs)	Dilution Factor	1:1 Extract Tritium pCi/mL	± Uncertainty pCi/mL	Calculated Porewater pCi/mL
H2 middle sand sequence					
35A	78.19	40.97	1.58E+01	4.15E+01	
36A	79.34	32.28	1.76E+01	3.31E+01	
40A	88.65	27.63	<2.60E+00		
44A	100.09	19.04	2.45E+01	2.05E+01	2.45E+04
49A	111.14	25.85	5.30E+01	2.88E+01	5.30E+04
53A	119.04	31.4	4.64E+01	3.41E+01	4.64E+04
H2 muddy very fine sand lens					
54C Fine	120.14	7.02			
54C DUP Fine	120.14	9.27			
54C Upper	120.14	14.98			
54A	120.89	39.38	1.71E+02	4.96E+01	1.71E+05
H2 middle sand sequence					
54	121.24	36.16			
55	121.34	6.77			
56	122.32	33.95			
61A	130.95	25.93	1.77E+02	3.56E+01	1.77E+05
67A	141.25	38.52	2.50E+02	5.25E+01	2.50E+05
72C	150.55	28.44			
72A	151.55	33.05	2.58E+02	4.75E+01	2.58E+05
73	152.7	30.98			
75	156.2	33.88			
77	159.1	28.82			
78C	159.85	27.04			
78A	160.85	26.29	2.33E+02	3.94E+01	2.33E+05
81	165.55	21.84			

Table B.13. Tritium Content in Water Extracts, Perched Water, and Groundwater (pCi/L) (3 pages)

Sample Identification	Depth[a] (ft bgs)	Dilution Factor	1:1 Extract Tritium pCi/mL	± Uncertainty pCi/mL	Calculated Porewater pCi/mL
H2 --fine-very fine sand lens					
82A	168.65	6.17	3.89E+01	8.34E+00	3.89E+04
82A-Dup	168.65	6.17	5.11E+01	8.97E+00	5.11E+04
82	169.1	5.78			
83D	169.55	12.01			
Hanford H3 Lower sand unit					
83A	171.05	35.27	1.12E+01	3.57E+01	
84A	173.35	31.43	1.58E+01	3.22E+01	
88A	181.65	21.76	7.94E+00	2.21E+01	
93A	190.65	29.65	<1.46E+01		
99A	201.35	30.75	2.30E+01	3.24E+01	
104A	211.42	29.56	4.03E+01	3.20E+01	4.03E+04
110D	217.95	34.26			
PPlz Mud unit					
110A	219.45	5.32	5.30E+01	8.18E+00	5.30E+04
111A	221.75	4.03	3.39E+01	5.89E+00	3.39E+04
112A	223.65	5.31	4.49E+01	7.76E+00	4.49E+04
Perched	227	1			7.55E+04
116A	231.45	4.13	2.24E+01	5.44E+00	2.24E+04
116A-Dup	231.45	4.14	4.69E+00	4.62E+00	4.69E+03
PPlg Gravelly unit					
122A	241.89	24.16	7.16E+00	2.43E+01	
124A	245.25	33.06	<3.17E+00		
128A	251.75	23.88	9.24E+00	2.43E+01	
129A	253.65	23.18	1.32E+01	2.38E+01	
GW(1)	258.7	1			2.52E+03
GW(2)	258.7	1			2.41E+03

[a] Multiply by 0.3048 to convert to meters.
< Values were below the detection limit; empty cells indicate no measurements made or tritium value is uncertain.
Values in purple shading are considered best quality data.
Perched = excess standing water in borehole extracted with bailer during hiatus in drilling.
GW = one sample of groundwater was taken but submitted to two independent laboratories.

Figure B.18. Concentration of Water and Acid Extractable Technetium-99 in Borehole 299-E33-45

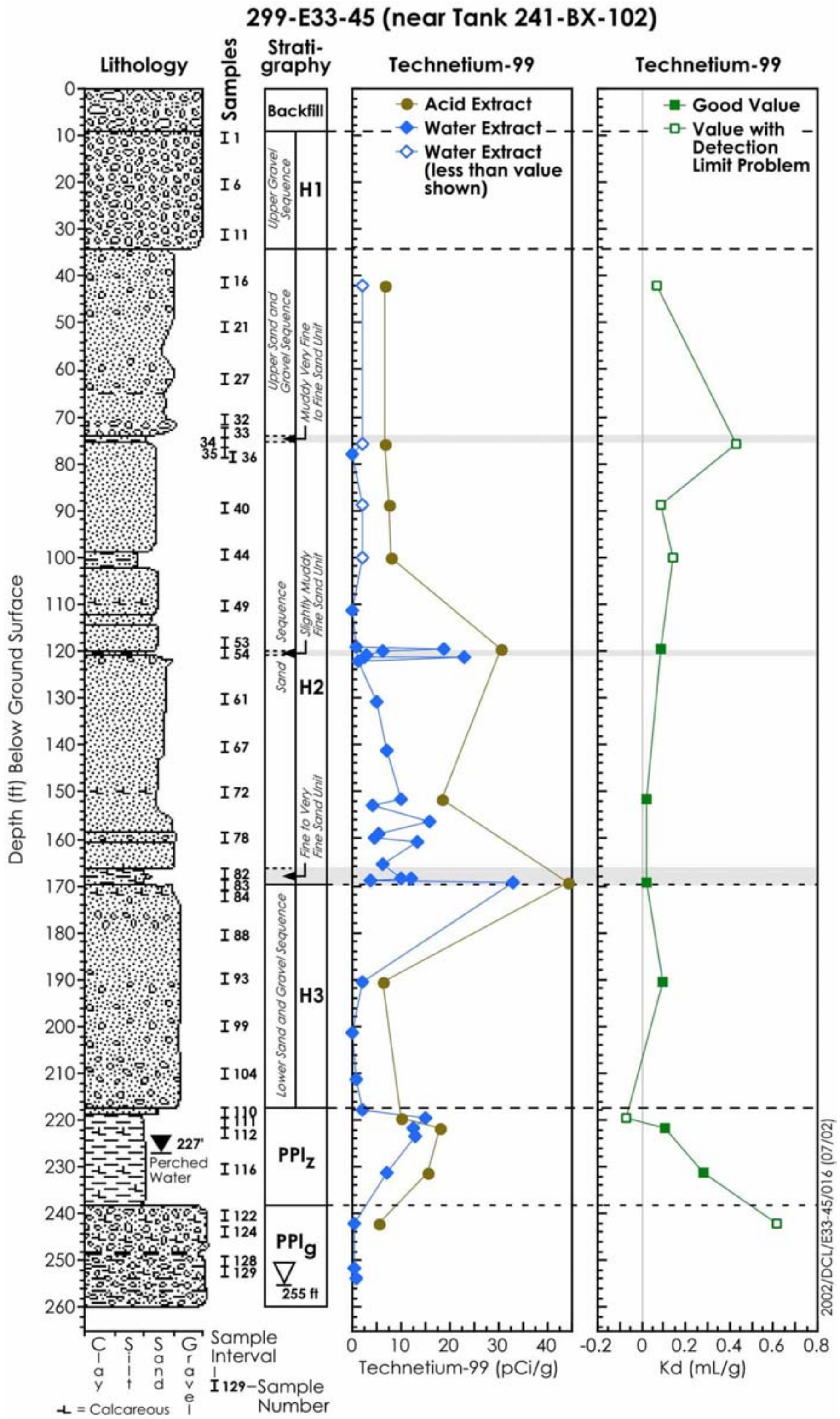
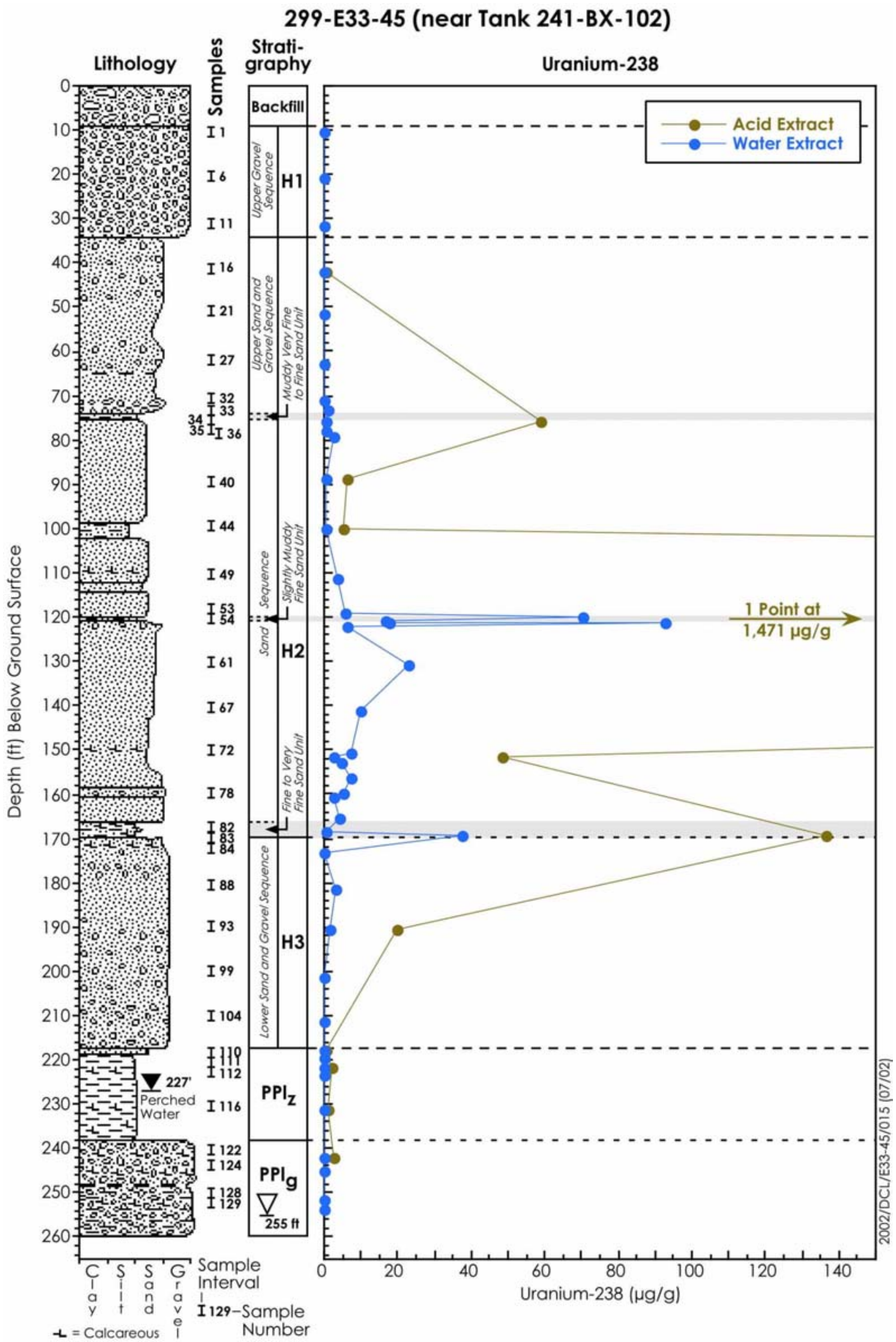


Figure B.19. Water and Acid Extractable Uranium-238 in Borehole 299-E33-45 Sediment



B.4.4 CHEMICAL INTERACTIONS

Laboratory batch leach/desorption tests using three of the uranium contaminated sediments from the H2 unit were performed using a simulated pore fluid that contained mainly sodium bicarbonate with minor amounts of magnesium, sulfate, calcium, and nitrate. The simulated pore fluid represents the porewater in the borehole sediments above where the uranium plume was first encountered. If the long-term fate is that rainfall will recharge the vadose zone, the porewater would be pushed into the contaminated sediments and leaching might occur. The batch leach tests were performed for several months with the hope that equilibrium (steady state) uranium solution concentrations would be attained. After 28 days for two of the samples tested, the uranium concentration in solution was still slowly increasing. The contacting solution was replaced with a simple 0.02 M sodium bicarbonate solution to see if equilibrium would be reached. All the time-dependent data collected in the batch leach tests were used to calculate uranium desorption distribution coefficient (Kd) values as a function of time and type of leachant. A summary of the results follows.

The desorption uranium Kd values after 7 days of leaching ranged from 1.6 to 2.0, 12 to 18, and 5 to 11 mL/g for the three samples when in contact with the simulated porewater. The subsequent desorption Kd values on the residual contaminated sediment after changing to the simpler 0.02 M sodium bicarbonate solution ranged from 3 to 12 mL/g. These laboratory test derived uranium desorption Kd values differed from values measured from the comparison of short term water and acid extractions of the sediment. The water versus acid extract approach gave lower values than the more traditional batch leach test. Some of the differences were caused by the different chemical composition of the fluids used. The one to one water extracts led to solutions with higher pH, dissolved carbonate, and total ionic strength than the simulated porewater and 0.02 M sodium bicarbonate solutions. The other parameter that appears to affect the desorption Kd is time of leaching. There is a slow component to leaching of uranium from these sediments suggesting that the uranium is not solely adsorbed to sediment surface adsorption sites. Further discussions on uranium leachability from borehole 299-E33-45 sediments is found in the Science and Technology Project contribution to this document (Appendix D).

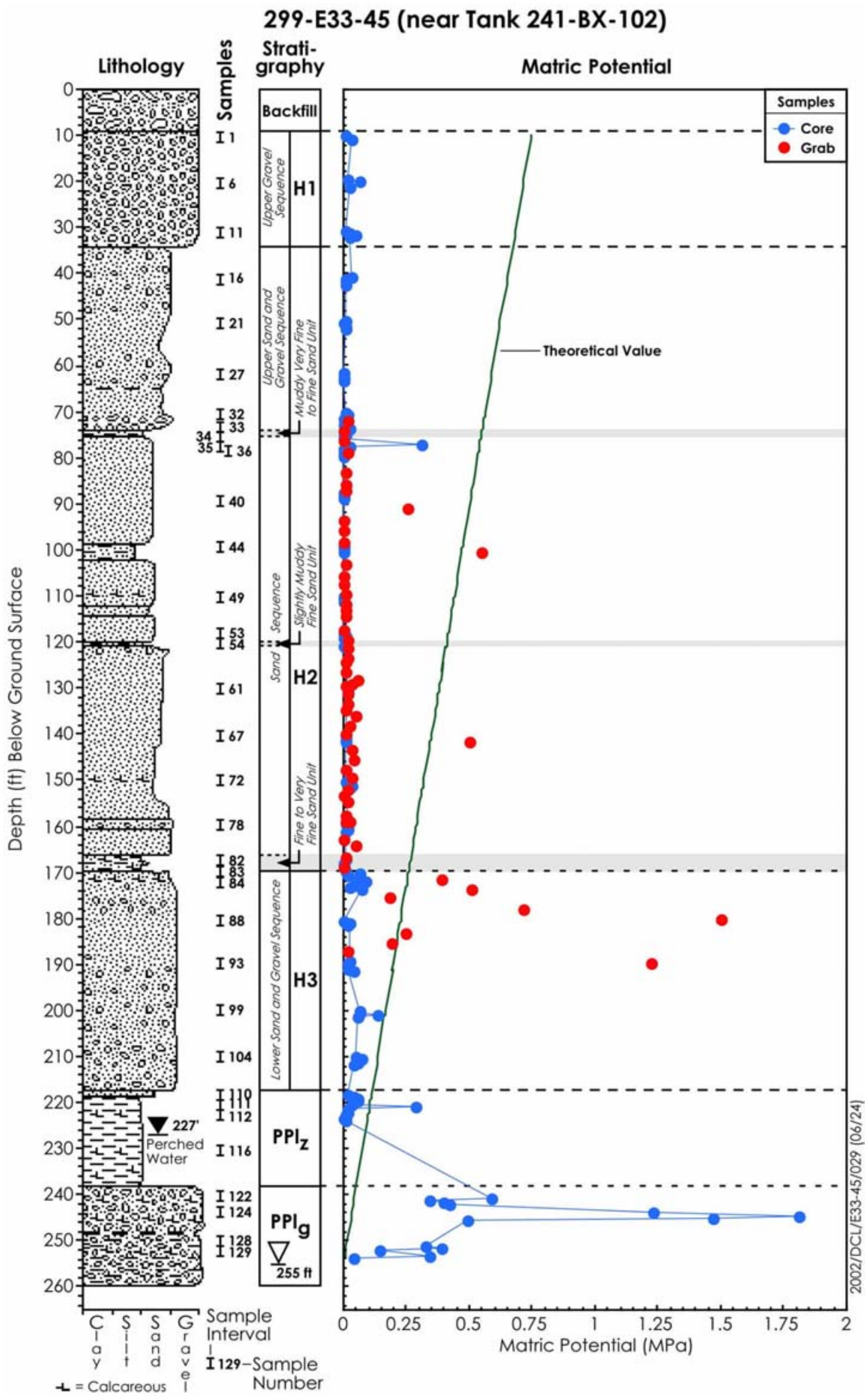
Precipitation of uranium-bearing phases (Appendix D, Sections D.3.2, D.3.3, and D.3.4) has occurred and cycles of dissolution and reprecipitation are plausible. Uranium sorption and desorption may also have occurred. The high sodium concentrations in tank fluids have probably displaced divalent cations on sorption sites, causing migration of these species in the soil column. Of the other constituents, there is no indication that nitrate or technetium-99 has reacted chemically in the soil column. Phosphate and iron have been reactive but the specific reactions are not known.

A distinct fluid migration event appears to have occurred in the Plio-Pleistocene unit where a perched water zone currently exists. Comparison of perched water chemistry with that of nearby water extract data suggests the perched water is a laterally migrating fluid slightly enriched in nitrate, tritium-bearing, and deficient in uranium. It is not clear whether the technetium-99 came with the laterally migrating fluid or was present at lower moisture contents from the tank waste sources before the migration event. Mixing of the laterally migrating fluid with the pre-existing tank fluid has had the effect of locally increasing the moisture content, reducing technetium-99 concentrations, adding tritium, and slightly increasing nitrate concentrations.

B.4.5 SEDIMENT MATRIC POTENTIAL AT BOREHOLE 299-E33-45

The general trend is that the water potentials at 299-E33-45 are consistent with a draining profile (water potentials wetter than -0.01 MPa as shown in Figure B.20). Below 70 m (230 ft) and to the water table at ~76 m (~250 ft), there appears to be a drier condition than above that depth. Note that the lower depths contain coarse materials, so sample handling (e.g., very slight drying) may be responsible for the apparent drier matric potentials. This is the third borehole within the operations area at tank farms where gravel covers and vegetation removal occur that suggest draining soil water profiles. However, as found outside the SX tank farm, a borehole outside B tank farm (299-E33-338) does not show a draining profile down to the water table.

Figure B.20. Matric Potential Distribution in Sediment in Borehole 299-E33-45



B.5.0 BOREHOLE 299-E33-46 CHARACTERIZATION SUMMARY

This section summarizes data reported in *Characterization of Vadose Zone Sediment: Borehole 299-E33-46 Near B-110 in the B-BX-BY Waste Management Area* (Serne et al. 2002b). Borehole 299-E33-46 was completed to further characterize the nature and extent of vadose zone contaminants supplied by the B-110 transfer line leak in the early 1970s. Elevated concentrations of several constituents were measured primarily between 15 and 26 m (50 and 85 ft) bgs in the H2 subunit of the Hanford formation. The primary radionuclide present in this zone is strontium-90. Chemical characteristics attributed to tank fluid-soil interaction at different locations within this zone are elevated pH, sodium, fluoride, bicarbonate, and nitrate. A secondary zone with elevated concentrations of technetium-99 and nitrate occurs between 68 and 69 m (222 and 225 ft) bgs in the PPlz subunit of the Plio-Pleistocene unit.

B.5.1 GEOLOGY AT BOREHOLE 299-E33-46

This section summarizes data reported in Serne et al. (2002b) except for groundwater data that comes from the site-wide monitoring program (Hartman et al. 2002). Borehole 299-E33-46 was completed to further characterize the nature and extent of vadose zone contaminants supplied by waste transfers into and out of tank B-110. Four zones of elevated moisture content were encountered in the sediment profile from this borehole as shown in Figure B.21. Two thin zones with higher moisture in the H2 unit correspond to fine-grained beds; there is one thin wet zone in the H3 unit, and a thicker wet zone in the Plio-Pleistocene mud unit. A perched water zone was anticipated during the planning of this bore but was not encountered. The borehole was completed as a multi-level vadose zone soil water, matric potential monitoring, and porewater sampling structure with remote monitoring capability.

Borehole 299-E33-46 was drilled using the cable-tool technique between May 8 and June 26, 2001. The borehole is located approximately 5 m (15 ft) from the northeast edge of single-shell tank 241-B-110 (Figure B.22), which was first recognized as a suspected leaker in 1973 and later becoming an assumed leaker in 1984 (DOE-GJPO 1999). Total depth of the borehole was 264.4 ft bgs and the groundwater table was encountered at 255.9 ft bgs. The borehole was later instrumented with down-hole hydrologic sensors (Reynolds 2001). The surveyed well elevation is 657.3 ft above mean sea level and geographic coordinates are N13728.365 and E573792.553.

During drilling, a total of 33 two-ft long, 4-inch diameter splitspoon core samples were collected starting at a depth of about 3 m (10 ft) bgs. A total of 120 composite or grab samples were collected from drill cuttings throughout the drilled interval. The splitspoon samplers were driven into the formation ahead of the drive casing. After the samples were collected, a drive barrel was lowered into the hole and the bore reamed. When the hole was full size, the casing was advanced by driving it into the ground. After the casing was driven, the borehole was once again cleaned out. If no immediate sample was scheduled, the bore was advanced by alternately removing formation materials and driving the casing ahead. Materials removed via the drive barrel were retained for geologic description and potential chemical and radiological analysis. The casing was down-sized only once as no zones of saturation were encountered.

Figure B.21. Borehole 299-E33-46 Lithology, Stratigraphy, Geophysical Logs, and Moisture Distribution as a Function of Depth

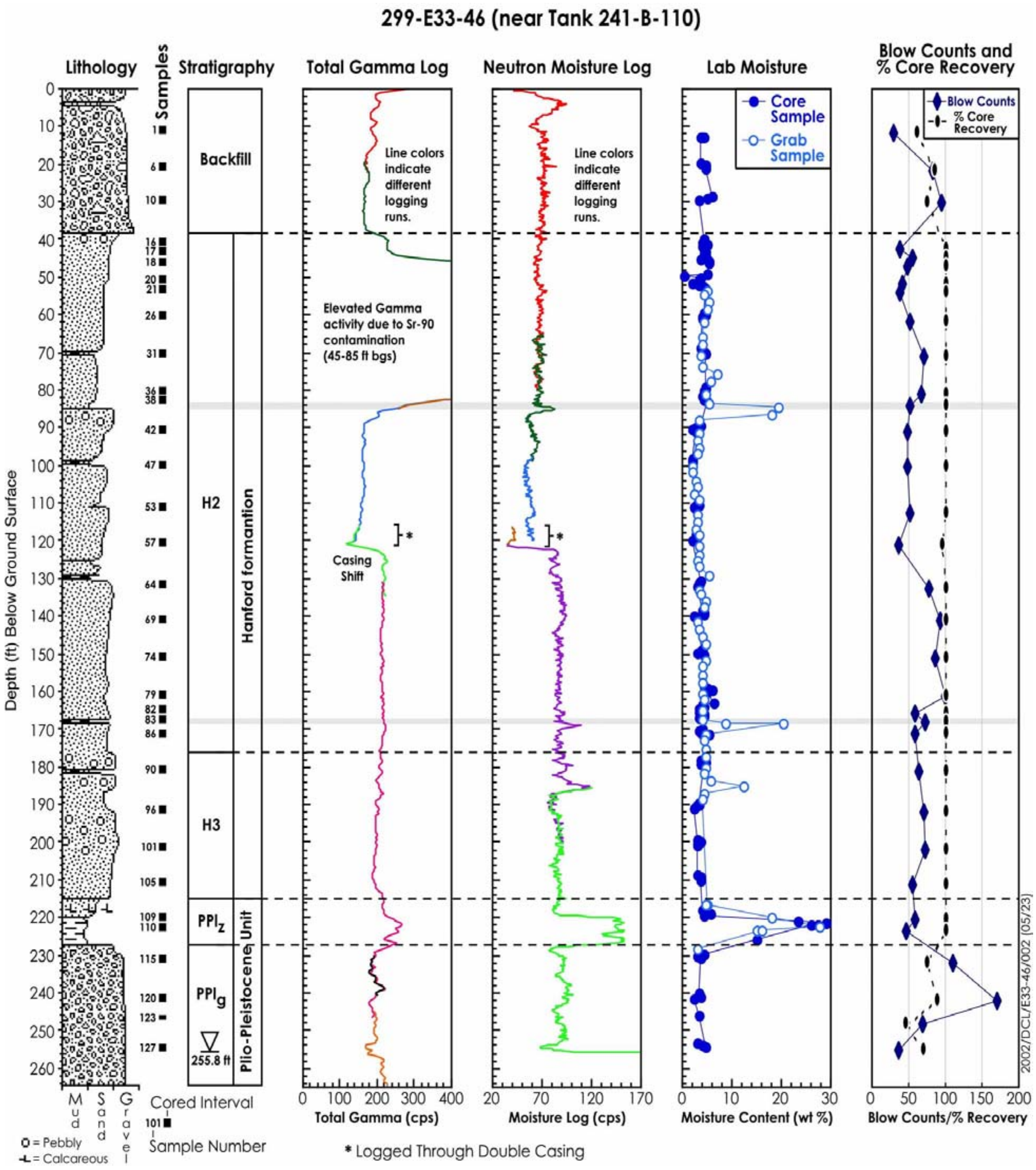
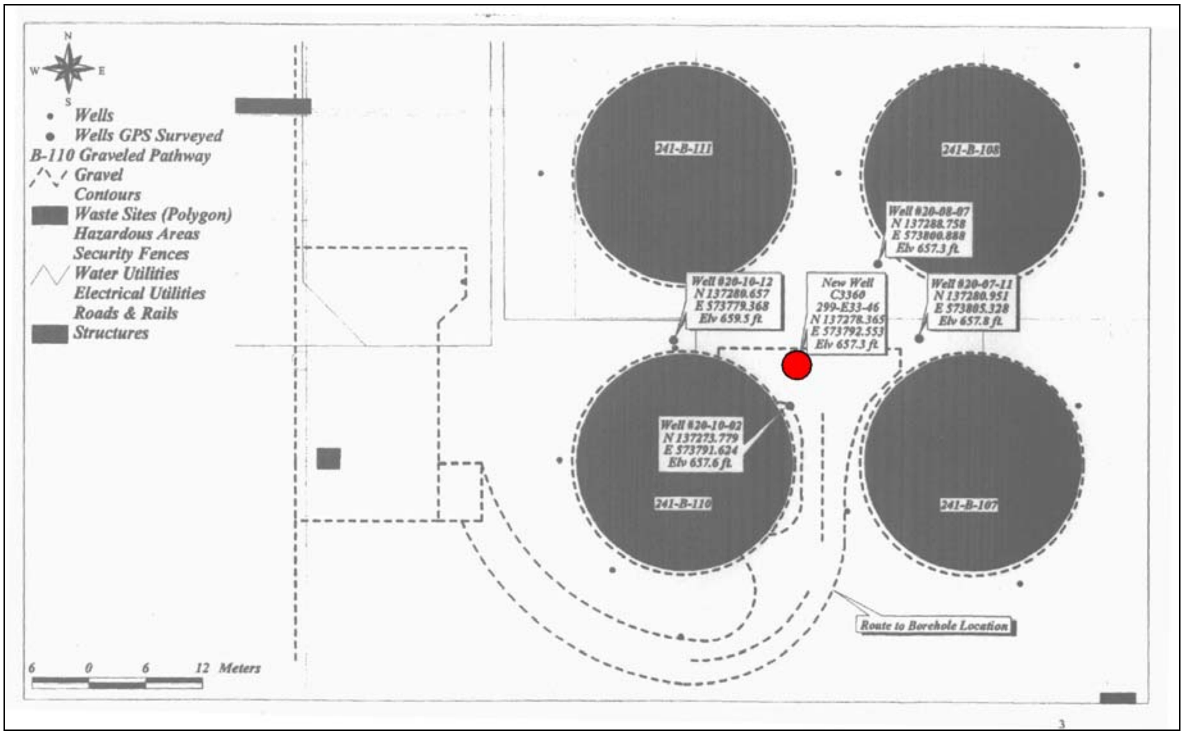


Figure B.22. Location of Borehole 299-E33-46 within B Tank Farm



B.5.1.1 Backfill

The backfill extends from the ground surface to a depth of 11.7 m (38.5 ft) where it contacts the Hanford formation. Three splitspoon and eleven grab samples were collected from this interval. The backfill material consists of predominantly dark to olive gray, moderately sorted, silty sandy gravel to gravelly sand, which is unconsolidated and weakly to strongly calcareous. An unusual pink coating was noted on cobbles recovered from about 6.4 m (21 ft) bgs. The neutron-moisture log shows higher moisture just below the surface, which is probably associated with near-surface natural recharge. A greater penetration resistance (i.e., blow counts) and poorer core recovery in the backfill are consistent with the relatively high percentage of gravel compared to the underlying sands of the Hanford formation.

B.5.1.2 Hanford Formation

Recent geologic reports (Wood et al. 2000; Lindsey et al. 2001), divide cataclysmic flood deposits of the Hanford formation beneath the 241-B tank farm into three informal units (H1, H2, and H3). However, it appears that the H1 unit was completely removed during excavation in the vicinity of borehole 299-E33-46, and then later used as backfill around the tanks. Based on the lithologies observed during drilling and in core samples, the Hanford formation beneath the backfill consists of mostly sand separated by several distinctly finer (fine sand to silt) strata. Three zones of increased moisture occur within the Hanford formation. These zones are associated with these thin silt-rich intervals and/or interfaces between strata with contrasting grain sizes.

The sands are associated with moderate to high energy deposition during flooding, while relatively thin silt layers represent remnants of slack-water sedimentation deposited towards the end of ice age flood episodes (Baker et al. 1991). According to Lindsey et al. (2001), the H2 unit, which consists of predominantly sand, occurs to a depth of 56.7 m (186 ft) bgs. Below this depth lies the H3 unit, a coarser-grained gravelly sand sequence that extends to base of the Hanford formation at 65.5 m (215 ft) bgs. A moisture spike appears to be associated with the contrast in grain size at the contact between the H2 and H3 units.

A zone, approximately 12 m (40 ft) thick, of radionuclide contamination (strontium-90) occurs at the top of the Hanford formation starting at the interface with the overlying coarse-grained backfill. The base of the contamination is well defined and occurs just above a 0.5 m (1.5 ft) thick very fine sand layer.

B.5.1.2.1 Hanford Formation H2 Unit. Lindsey et al. (2001) assigned Hanford formation materials above a depth of 56.7 m (186 ft) bgs to the Hanford formation H2 unit but geologists from Pacific Northwest National Laboratory (PNNL) have chosen the contact at 176 ft bgs (Serne et al. 2002b). The following discussion and all figures ascribe to this shallower contact. A total of 20 two-foot splitspoon cores were collected from this unit, which consists of mostly olive grey moderately to well sorted, fine- to coarse-grained sand beds. These beds show occasional weak horizontal laminations and are generally noncalcareous to weakly calcareous. Other less abundant facies interspersed within the H2 unit include two intervals of loose, gravelly sand. Also present are four separate thin, olive brown to grayish brown, compact, well-sorted fine sand to silt beds dispersed within the H2 unit. A well developed neutron-moisture spike is associated with one of these fine-grained layers at 51.2 to 51.3 m (168.1 to 168.4) ft bgs. A total of 20 splitspoon samples (consisting of four 6-inch long liners) and 73 grab samples were obtained from the H2 unit in borehole 299-E33-46.

The most common sediment type within the H2 unit is a medium-to coarse-grained sand (see Serne et al. 2002b for photographs). The term “salt and pepper” is often used to describe sands of the H2 unit on geologic logs due to the roughly equal amounts of dark- (basaltic) and light-colored (quartz and feldspar) grains. While this unit appears to be unconsolidated, the penetration resistance (i.e., blow counts) increases slightly for the middle portion between 40 to 47 m (130 to 155 ft) bgs, which might reflect a greater degree of compaction within this interval. Core recovery was consistently 100% within the H2 unit.

B.5.1.2.2 Hanford Formation H3 Unit. The top of the Hanford formation H3 unit was defined by Lindsey et al. (2001) by a transition from mostly sand to slightly gravelly sand at 56.7 m (186 ft) bgs. The Hanford formation H3 unit is about 8.8 m (29 ft) thick, the base of which is defined by the top of the Plio-Pleistocene unit silty facies (PPlz) at 65.5 m (215 ft) bgs. As mentioned, PNNL selected the H2/H3 contact shallower at 54 m (176 ft) bgs. A total of four, two-foot splitspoon cores were collected from the Hanford formation H3 unit. Like the H2 unit, core recovery within the H3 unit was consistently 100%. This gravelly sand sequence consists predominantly of grey to olive grey, “salt and pepper”, unconsolidated, moderately to well sorted, medium- to coarse-grained sand with pebbles up to 3 cm in diameter. The unit is unconsolidated and non-calcareous to weakly calcareous. The H3 unit in 299-E33-46 grades downward into medium to coarse sand with depth, identical to that described for the overlying H2 unit.

B.5.1.3 Plio-Pleistocene Unit

The exact origin of the sedimentary deposits underlying the Hanford formation H3 unit is uncertain and open to interpretation. Recent reports have designated deposits beneath the Hanford formation H3 unit as the Hanford formation/Plio-Pleistocene unit (Hf/PPu) (Wood et al. 2000) and Hanford/Plio-Pleistocene/Ringold (H/PP/R) unit (Lindsey et al. 2001). Wood et al. (2000) recognized two facies of the Hf/PPu beneath the 241-B, BX, and BY tank farms; a fine-grained eolian/overbank silt (silt facies) up to 10 m thick and a sandy gravel to gravelly sand facies. The thick silt-rich interval is believed to be a pre-ice age flood deposit, since silty layers associated with ice age flood deposits of the Hanford formation in this area are always much thinner (a few centimeters or less) (Wood et al. 2000). The texture, structure, and color of the thick silt layer are all identical to that of the early Palouse soil (Tallman et. al. 1979; DOE 1988), more recently referred to as the PPlz or upper Plio-Pleistocene unit, which is widely distributed beneath the 200 West Area (Wood et al. 2000; Serne et al. 2002c).

B.5.1.3.1 Silty Facies (PPlz). A fine-grained PPlz unit, 3.9 m (12.7 ft) thick, underlies the basalt-rich sands of the Hanford formation in borehole 299-E33-46 between 65.5 m (215 ft) and 69.4 m (227.7 ft) bgs. This unit can be subdivided into two facies types in borehole 299-E33-46. The upper part of the PPlz unit consists of a pale olive, loose, laminated, very well sorted, calcareous, fine- to medium-grained, quartzo-feldspathic sand. The lower part of the PPlz unit consists of a grayish brown, laminated to massive, compacted and very well sorted, moderately calcareous, silt to silty fine sand. One splitspoon core was collected from each of these facies types. The upper facies type, which begins at 65.5 m (215 ft) bgs, was not recognized by the geologist in the field or by Lindsey et al. (2001), who picked the base of the Hanford formation 5 ft deeper at 67 m (220 ft) at a sharp increase in the total gamma log. The upper facies type was identified later upon opening the 217.7 to 220 ft bgs splitspoon core. The characteristics of the sediment from this unit, including its relatively high calcium carbonate content and predominantly quartzo-feldspathic mineralogy, suggest it is not part of the Hanford formation and therefore is likely part of the Plio-Pleistocene unit.

Relatively high neutron moisture and gamma activity on geophysical logs corroborate that the lower part of the PPlz unit in this borehole is fine-grained (mostly silt). This unit, particularly the lower portion, has characteristics similar to the Plio-Pleistocene silt (PPlz unit) that overlies an extensive calcic paleosol sequence (PPlc unit) beneath 200 West Area (Lindsey et al. 2000; Serne et al. 2002c).

B.5.1.3.2 Sandy Gravel to Gravelly Sand Facies (PPlg). A sequence of gravelly sand to sandy gravel was encountered starting at a depth of 69.4 m (227.7 ft) bgs. Four splitspoon cores and 12 grab samples were collected within this unit. It consists of mostly an olive gray, loose, clast-supported, moderately to poorly sorted, sandy gravel to silty sandy gravel. This unit contains a moderate amount (~30-50%) of basalt and is non-calcareous. Poor core recovery and considerable pulverization of the sample resulted from trying to drive a narrow-diameter (4-inch inside diameter) splitspoon through the clast-supported pebbles and cobbles. Surfaces of individual gravel clasts are relatively unaltered and lack surface staining.

B.5.2 GEOPHYSICAL AND MOISTURE CONTENT MEASUREMENTS

Down-hole geophysical measurements included a high purity germanium spectral gamma log and a neutron-neutron log. The total gamma log (derived from spectral gamma logs) and the neutron-neutron log are shown in Figure B.21. The total gamma log includes contributions from natural and man-made gamma emitters. In this borehole, high count rates are primarily from strontium-90, particularly between 12 and 26 m (40 and 85 ft) bgs. The neutron-neutron log shows qualitatively that moisture content is relatively high in the thin silt layers in the Hanford formation at 26, 51, and 57 m (85, 168, and 186 ft) bgs and in the Plio-Pleistocene unit at 68 to 69 m (220 to 225 ft) bgs. The neutron-neutron log shows qualitative relative moisture content and is consistent with laboratory measured moisture content also shown in the adjacent column of Figure B.21. The gravimetric moisture content is shown in Table B.14 and Figure B.23.

Table B.14. Moisture Content of Sediments in Borehole 299-E33-46 (3 pages)

Lithologic Unit	Sample No.	Mid Depth (Vertical ft)[(a)]	% Moisture	Lithologic Unit	Sample No.	Mid Depth (Vertical ft)[(a)]	% Moisture
Backfill	02C	12.94	3.89%	H2	64B	131.35	3.27%
Backfill	02B	12.94	4.48%	H2	64A	131.85	3.11%
Backfill	02A	12.94	3.60%	H2	65	132.85	3.36%
Backfill	06D	19.62	3.71%	H2	66	134.2	3.66%
Backfill	06C	20.12	4.66%	H2	67	136	4.56%
Backfill	06B	20.62	4.78%	H2	68	137.6	4.29%
Backfill	06A	21.12	4.84%	H2	69D	138.55	3.87%
Backfill	10C	28.42	5.94%	H2	69C	139.05	4.32%
Backfill	10B	28.92	4.94%	H2	69B	139.55	4.35%
Backfill	10A	29.42	3.30%	H2	69A	140.05	2.52%
H2	16D	39.97	4.31%	H2	70	141.4	3.20%
H2	16C	40.72	4.15%	H2	71	143.35	3.44%
H2	16B	41.22	5.10%	H2	72	145.5	3.91%
H2	16A	41.72	3.97%	H2	73	147.45	4.66%
H2	17D	42.52	4.31%	H2	74D	148.65	4.16%
H2	17C	43.02	4.55%	H2	74C	149.15	3.83%
H2	17B	43.52	4.42%	H2	74B	149.65	3.03%
H2	17A	44.02	4.70%	H2	74A	150.15	4.27%
H2	18D	44.92	4.46%	H2	75	151.45	4.72%
H2	18C	45.42	3.72%	H2	76	153.3	3.87%
H2	18B	45.92	5.32%	H2	77	155.5	4.04%
H2	18A	46.42	5.33%	H2	78	157.6	4.05%
H2	20D	49.12	4.87%	H2	79D	158.65	4.43%
H2	20C	49.62	0.29%	H2	79C	159.15	5.03%
H2	20B	50.12	3.67%	H2	79B	159.65	6.14%
H2	20A	50.62	3.40%	H2	79A	160.15	5.12%
H2	21D	51.52	1.91%	H2	79	160.55	4.00%
H2	21C	52.02	3.29%	H2	80	161.75	4.36%
H2	21B	52.52	4.30%	H2	81	161.75	4.21%

Table B.14. Moisture Content of Sediments in Borehole 299-E33-46 (3 pages)

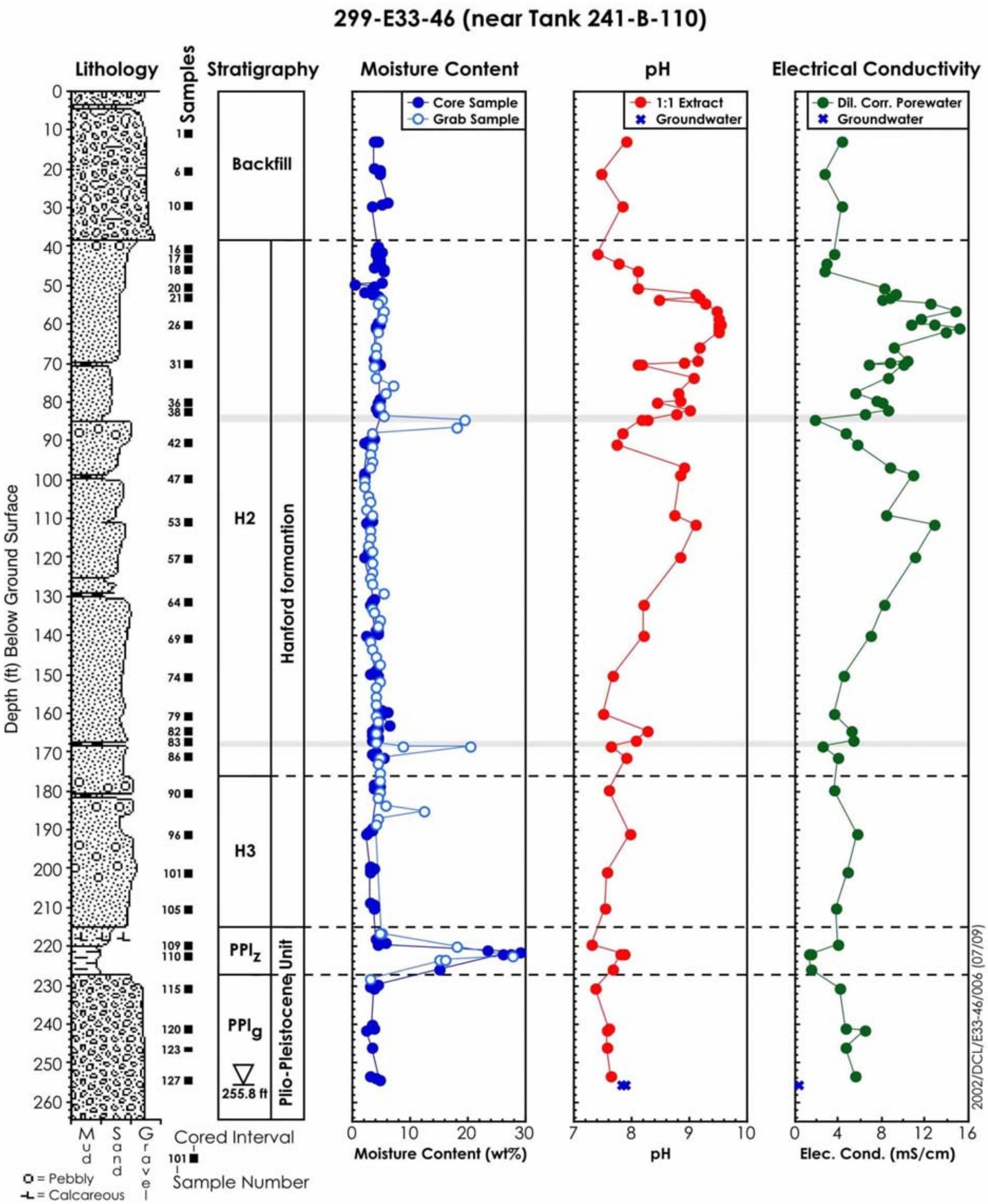
Lithologic Unit	Sample No.	Mid Depth (Vertical ft)[a]	% Moisture	Lithologic Unit	Sample No.	Mid Depth (Vertical ft)[a]	% Moisture
H2	21A	53.02	4.82%	H2	82D	163.05	6.22%
H2	21(shoe)	53.44	5.15%	H2	82C	163.55	3.98%
H2	22	54.6	4.40%	H2	82B	164.05	4.32%
H2	24	56.7	5.25%	H2	82A	164.55	3.42%
H2	25	58.4	5.03%	H2	82	164.95	3.93%
H2	26D	59.22	4.24%	H2	82 Dup	164.95	4.14%
H2	26C	59.72	4.58%	H2	83D	165.35	3.29%
H2	26C-Dup	59.72	4.40%	H2	83C	165.85	4.33%
H2	26B	60.22	4.16%	H2	83B	166.35	4.23%
H2	26-A	60.72	4.08%	H2	83A	166.85	3.34%
H2	27	62.1	4.21%	H2	83	167.25	4.07%
H2	29	66.05	4.04%	**	84	168.45	8.77%
H2	30	67.95	4.18%	**	85	168.25	20.21%
H2	31D	68.95	3.69%	H2	86D	169.65	3.87%
H2	31C	69.45	3.89%	H2	86C	170.15	3.43%
H2	31B	69.95	4.36%	H2	86B	170.65	3.82%
H2	31A	70.45	4.81%	H2	86A	171.15	5.31%
H2	31(shoe)	70.85	3.70%	H2	86	171.55	4.64%
H2	33	73.5	4.15%	H2	87	172.9	4.36%
H2	34	75.4	7.15%	H2	88	175.1	4.61%
H2	35	77.35	5.63%	H3	89	177.1	4.70%
H2	36D	78.95	4.78%	H3	90D	178.35	3.63%
H2	36C	79.45	4.79%	H3	90C	178.85	4.70%
H2	36B	79.95	4.36%	H3	90B	179.35	3.78%
H2	36A	80.35	4.38%	H3	90A	179.85	4.37%
H2	37	80.9	4.62%	H3	90	180.25	4.66%
H2	38D	81.55	3.98%	H3	91	181.75	4.37%
H2	38C	82.05	4.49%	H3	92	183.7	5.66%
H2	38B	82.55	4.35%	***	93	185.1	12.33%
H2	38A	83.05	5.09%	H3	94	186.85	4.38%
H2	38(shoe)	83.45	5.23%	H3	95	188.45	4.07%
*	39	84.55	19.39%	H3	96D	189.35	3.37%
*	40	86.3	18.16%	H3	96C	189.85	3.41%
H2	41	87.85	3.49%	H3	96B	190.35	2.77%
H2	42D	89.12	3.74%	H3	96A	190.8	2.42%
H2	42C	89.62	2.67%	H3	101D	199.45	3.00%
H2	42B	90.12	2.12%	H3	101C	199.85	3.65%
H2	42A	90.62	2.83%	H3	101B	200.45	2.91%
H2	43	91.45	3.26%	H3	101A	200.95	2.94%
H2	44	93.15	3.00%	H3	105D	208.55	2.91%
H2	45	95.15	3.37%	H3	105-C	208.95	3.83%
H2	46	96.8	3.16%	H3	105-B	209.45	3.71%

Table B.14. Moisture Content of Sediments in Borehole 299-E33-46 (3 pages)

Lithologic Unit	Sample No.	Mid Depth (Vertical ft)[a]	% Moisture	Lithologic Unit	Sample No.	Mid Depth (Vertical ft)[a]	% Moisture
H2	47D	98.12	2.03%	H3	105-A	209.95	3.73%
H2	47C	98.62	2.10%	PPlz	108	216.7	5.06%
H2	47B	99.12	2.02%	PPlz	108 Dup	216.7	4.72%
H2	47A	98.62	2.18%	PPlz	109D	217.95	4.17%
H2	47(shoe)	100.04	2.09%	PPlz	109C	218.45	4.58%
H2	48	101.55	2.13%	PPlz	109B	218.95	5.75%
H2	49	103.85	2.75%	PPlz	109A	219.45	4.35%
H2	50	105.7	2.96%	PPlz	109	219.95	17.88%
H2	51	107.45	2.53%	PPlz	110D	220.65	23.33%
H2	52	109	3.52%	PPlz	110C	221.15	29.04%
H2	53D	109.92	2.98%	PPlz	110B	221.65	27.24%
H2	53C	110.42	3.21%	PPlz	110B Dup	221.65	27.55%
H2	53B	110.92	2.51%	PPlz	110A	222.05	25.94%
H2	53A	111.42	2.58%	PPlz	111	223.5	14.98%
H2	54	113	2.90%	PPlz	112	223.5	15.91%
H2	55	114.9	2.97%	PPlz	113	225.9	14.99%
H2	56	117	2.82%	PPlg	114	228.45	3.10%
H2	57D	118.42	2.80%	PPlg	115C	229.75	4.21%
H2	57C	118.92	2.98%	PPlg	115B	230.25	3.04%
H2	57B	119.42	2.72%	PPlg	115A	230.75	3.71%
H2	57A	119.92	2.09%	PPlg	120D	239.95	3.32%
H2	58	121.5	3.31%	PPlg	120C	240.45	3.46%
H2	59	123.5	3.21%	PPlg	120B	240.95	3.71%
H2	60	118.5	3.48%	PPlg	120A	241.45	2.50%
H2	61	125.05	3.17%	PPlg	123A	245.75	3.33%
H2	62	126.75	3.38%	PPlg	127C	254.15	4.57%
H2	63	128.9	5.49%	PPlg	127B	253.65	4.06%
H2	64D	130.35	3.63%	PPlg	127A	253.15	3.17%
H2	64C	130.85	3.21%				

[a] Multiply by 0.3048 to convert to meters.
H2 = Hanford H2 sand sequence
H3 = Hanford H3 unit-lower sand sequence
PPlz = Plio-Pleistocene mud unit
PPlg = Plio-Pleistocene gravelly unit
*, **, *** = various thin fine-grained lenses in the Hanford sand units.
Red type indicates wettest sediment zones possibly indicating fine grain material.

Figure B.23. Moisture Content, Water Extract pH, and Calculated Porewater Electrical Conductivity for Borehole 299-E33-46



B.5.3 SOIL WATER CHEMISTRY MEASUREMENTS

An extensive water chemistry analysis has been completed for borehole 299-E33-46 samples collected between 4 and 77 m (13 and 254 ft) bgs. The primary means of measuring porewater composition was to add deionized water to soil samples to generate enough water for performing analyses. By back calculating for the dilution introduced by the added water, true concentrations were derived. Generally, the water extraction process appears to dissolve some salts in the soils, yielding a high species concentration. Nevertheless, the water extract method is a useful tool for evaluating tank fluid interactions with vadose zone soil.

Water extract pH and EC measurements with depth are listed in Table B.15 and graphed in Figure B.23. Elevated pH values (greater than 8.5) are measured between 16 and 37 m (52 and 120 ft) with maximum pH values (9.0 to 9.5) occurring between 16 and 21 m (52 and 70 ft) bgs. Because pH values are expected to decrease as increasing interaction with soil and soil water occurs, the location of increased pH values suggests the approximate location of the maximum tank fluid interaction with the soil column. Increases in EC above background, which, based on Section B.2.3, is 1 to 4 mS/cm, also indicate tank fluid interactions with soils. In this borehole, the notable increases occur between 15 and 40 m (50 and 132 ft) bgs. Maximum EC values (between 10 and 14 mS/cm) occur between 16 and 19 m (54 and 62 ft) bgs. The EC maximum zone occurs at about the same location in the soil column relative to the maximum pH zone.

Table B.15. Water Extract pH and Electrical Conductivity Values for Borehole 299-E33-46 (3 pages)

Sample Identification	Mid Depth (ft)[(a)]	Dilution Factor	1:1 pH	1:1 EC mS/cm	Pore EC mS/cm
Backfill					
02A	13.70	27.80	7.89	0.154	4.28
06A	21.12	20.66	7.48	0.133	2.75
10A	29.42	30.33	7.83	0.139	4.22
Hanford H2 Sand (upper sequence) Unit					
16A	41.72	25.18	7.39	0.139	3.50
17A	44.02	21.29	7.78	0.137	2.92
18A	46.42	18.75	8.10	0.142	2.66
20A	50.62	29.43	8.11	0.276	8.12
21C	52.02	29.45	9.09	0.317	9.34
21A	53.02	20.75	9.18	0.42	8.71
21A-dup	53.44	19.42	8.48	0.413	8.02
22	54.60	22.75	9.27	0.544	**12.38**
24	56.70	19.05	**9.47**	0.778	**14.82**
25	58.40	19.92	**9.51**	0.583	**11.61**
26C	59.72	19.45	**9.49**	0.549	**10.68**
26C-dup	59.72	22.74	**9.54**	0.567	**12.89**

Table B.15. Water Extract pH and Electrical Conductivity Values for Borehole 299-E33-46 (3 pages)

Sample Identification	Mid Depth (ft)[(a)]	Dilution Factor	1:1 pH	1:1 EC mS/cm	Pore EC mS/cm
26-A	60.72	24.50	**9.49**	0.615	**15.07**
27	62.10	23.78	**9.52**	0.586	**13.94**
29	66.05	24.84	9.18	0.367	9.12
31C	69.45	28.74	9.13	0.362	10.40
31B	69.95	23.92	8.89	0.367	8.78
31A	70.45	20.80	8.18	0.328	6.82
31A-dup	70.45	27.03	8.10	0.366	9.89
33	73.50	25.04	9.08	0.345	8.64
35	77.35	15.03	8.80	0.367	5.51
36C	79.45	21.67	8.84	0.346	7.50
36A	79.95	22.85	8.44	0.354	8.09
38C	82.05	24.70	9.00	0.345	8.52
38A	83.05	19.64	8.76	0.331	6.50
Thin Fine Grained Lens					
39	84.55	5.17	8.26	0.345	1.78
39-dup	84.55	5.41	8.18	0.342	1.85
Hanford H2 Sand (middle sequence) Unit					
41	87.85	27.98	7.84	0.165	4.62
42A	90.62	35.28	7.74	0.163	5.75
46	96.80	31.85	8.90	0.276	8.79
47A	98.62	45.97	8.84	0.237	10.89
52	109.00	28.40	8.75	0.292	8.29
53A	111.42	38.76	9.09	0.329	12.75
57A	119.92	47.96	8.84	0.232	11.13
64A	131.85	32.15	8.19	0.257	8.26
69A	140.05	39.70	8.20	0.177	7.03
74A	150.15	23.41	7.67	0.189	4.42
79A	160.15	19.54	7.52	0.181	3.54
82A	164.55	29.22	8.28	0.178	5.20
83A	166.85	29.95	8.07	0.181	5.42
Fine Grained Lens					
84	168.45	11.44	7.64	0.217	2.48
Hanford H2 Sand Unit					
86A	171.15	18.85	7.90	0.204	3.84

Table B.15. Water Extract pH and Electrical Conductivity Values for Borehole 299-E33-46 (3 pages)

Sample Identification	Mid Depth (ft)[(a)]	Dilution Factor	1:1 pH	1:1 EC mS/cm	Pore EC mS/cm
Hanford H3 Sand Unit					
90A	179.85	22.89	7.60	0.154	3.52
96A	190.80	41.31	7.97	0.136	5.62
101A	200.95	34.06	7.57	0.139	4.73
105A	209.95	26.84	7.55	0.142	3.81
Plio-Pleistocene Mud Unit					
109A	219.45	23.01	7.30	0.169	3.89
110A	222.05	3.85	7.88	0.351	1.35
110A-dup	222.05	3.85	7.81	0.319	1.23
113	225.90	6.67	7.68	0.217	1.45
Plio-Pleistocene Gravel Unit					
115A	230.75	27.17	7.38	0.153	4.16
120B	240.95	28.68	7.61	0.159	4.56
120A	241.45	39.95	7.56	0.161	6.43
123A	245.75	30.01	7.57	0.156	4.68
127A	253.15	31.57	7.62	0.174	5.49

[(a)]Multiply by 0.3048 to convert to meters.
EC = Electrical conductivity.
Red type indicates elevated values from caustic tank liquor.
Bold type indicates **maximum values** in profile.

Water extract anion concentrations as a function of depth are listed in Table B.16 and graphed in Figures B.24. Unlike the tank BX-102 borehole (299-E33-45), silt-rich layers are not prominent features and do not correlate with anion elevated concentration zones. In fact, the wet fine-grained sediments show low porewater anion concentrations likely because the dilution factor is lower than for the dry sediments and any salts that are dissolved out of the sediments are not multiplied by as large dilution factors as for the dry sediments. The primary indicators of tank fluid occurrence are carbonate, fluoride, and nitrate. Normally, nitrate is the dominant high concentration anion in soils contacted by tank waste fluids. Although not the most abundant anion in the porewater, nitrate does appear to be elevated (compared to the calculated porewater in the uncontaminated borehole 299-E33-338) from about 84 to 226 ft bgs. The bulk of the high nitrate resides between 110 and 170 ft bgs in the Hanford H2 unit.

For this borehole, bicarbonate and fluoride are the dominant anionic species to the point that the EC profile appears to be most elevated.

Table B.16. Calculated Porewater Anion Concentrations from Water Extracts for Borehole 299-E33-46 (3 pages)

ID	Depth[a]	Dil. Fac.	1:1 Extracts in mg/L							Dilution Corrected Porewater mg/L						
			NO3	F	NO2	Cl	SO4	PO4	HCO3	NO3	F	NO2	Cl	SO4	PO4	HCO3
Backfill																
02A	13.70	27.80	0.37	<0.5	<0.1	0.48	5.21	0.74	65.47	10.3	<13.9	<2.8	13.3	145	20.6	1820
06A	21.12	20.66	<0.3	<0.5	<0.1	0.33	5	<0.5	55.18	6.20	<10.3	<2.1	6.8	103	10.33	1140
10A	29.42	30.33	0.4	0.69	<0.1	0.89	49.11	0.51	44.16	12.1	20.9	<3.0	27.0	1490	15.47	1339
Hanford H2 Sand (upper sequence) Unit																
16A	41.72	25.18	<0.3	<0.5	<0.1	0.29	7.21	<0.5	51.34	7.55	<12.6	<2.5	7.3	182	12.59	1293
17A	44.02	21.29	0.38	<0.5	<0.1	0.3	6.55	<0.5	50.65	8.1	<10.6	<2.1	6.4	139	10.64	1078
18A	46.42	18.75	0.46	1.31	<0.1	0.2	5.06	<0.5	55.27	8.6	24.6	<1.9	3.8	95	9.38	1037
20A	50.62	29.43	0.36	2.77	<0.1	0.15	5.21	<0.5	142.45	10.6	81.5	<2.9	4.4	153	14.71	4192
21C	52.02	29.45	0.55	2.389	<0.7	0.26	3.407	0.446	199.041	16.2	70.4	<20.6	7.7	100	13.1	5862
21A	53.02	20.75	0.34	3.63	<0.1	0.15	7.82	0.99	214.3	7.1	75.3	<2.1	3.1	162	20.5	4446
21A-dup	53.44	19.42	0.38	3.68	<0.1	0.19	6.9	0.9	199.72	7.4	71.5	<1.9	3.7	134	17.5	3879
22	54.60	22.75	5.03	7.008	<0.7	0.45	5.033	1.937	317.638	114.3	159.4	<15.9	10.2	115	44.1	7227
24	56.70	19.05	8.13	10.79	<0.7	0.8	13.409	1.902	387.411	154.8	205.5	<13.3	15.2	255	36.2	7380
25	58.40	19.92	5.80	6.807	<0.7	0.53	5.804	1.111	348.533	115.6	135.6	<13.9	10.6	116	22.1	6941
26C	59.72	19.45	1.72	5.943	<0.7	0.41	5.552	1.29	319.593	33.5	115.6	<13.6	8	108	25.1	6215
26C-dup	59.72	22.74	1.87	5.927	<0.7	0.41	5.165	1.48	348.568	42.5	134.8	<15.9	9.3	118	33.7	7926
26-A	60.72	24.50	0.69	6.82	<0.1	0.4	6.68	4.39	307.13	16.9	167.1	<2.4	9.8	164	107.6	7525
27	62.10	23.78	3.71	6.909	<0.7	0.34	5.597	1.676	351.331	88.2	164.3	<16.6	8.1	133	39.9	8355
29	66.05	24.84	4.00	5.84	<0.7	0.38	9.117	0.351	211.701	99.4	145.1	<17.4	9.4	226	8.7	5258
31C	69.45	28.74	8.63	5.727	<0.7	0.47	7.946	0.561	207.478	248	164.6	<20.1	13.5	228	16.1	5962
31B	69.95	23.92	2.95	7.917	<0.7	0.38	9.048	0.811	202.361	70.6	189.4	<16.7	9.1	217	19.4	4841
31A	70.45	20.80	3.02	7.72	<0.1	0.37	8.77	0.9	162.7	62.8	160.6	<2.1	7.7	182	18.7	3385

Table B.16. Calculated Porewater Anion Concentrations from Water Extracts for Borehole 299-E33-46 (3 pages)

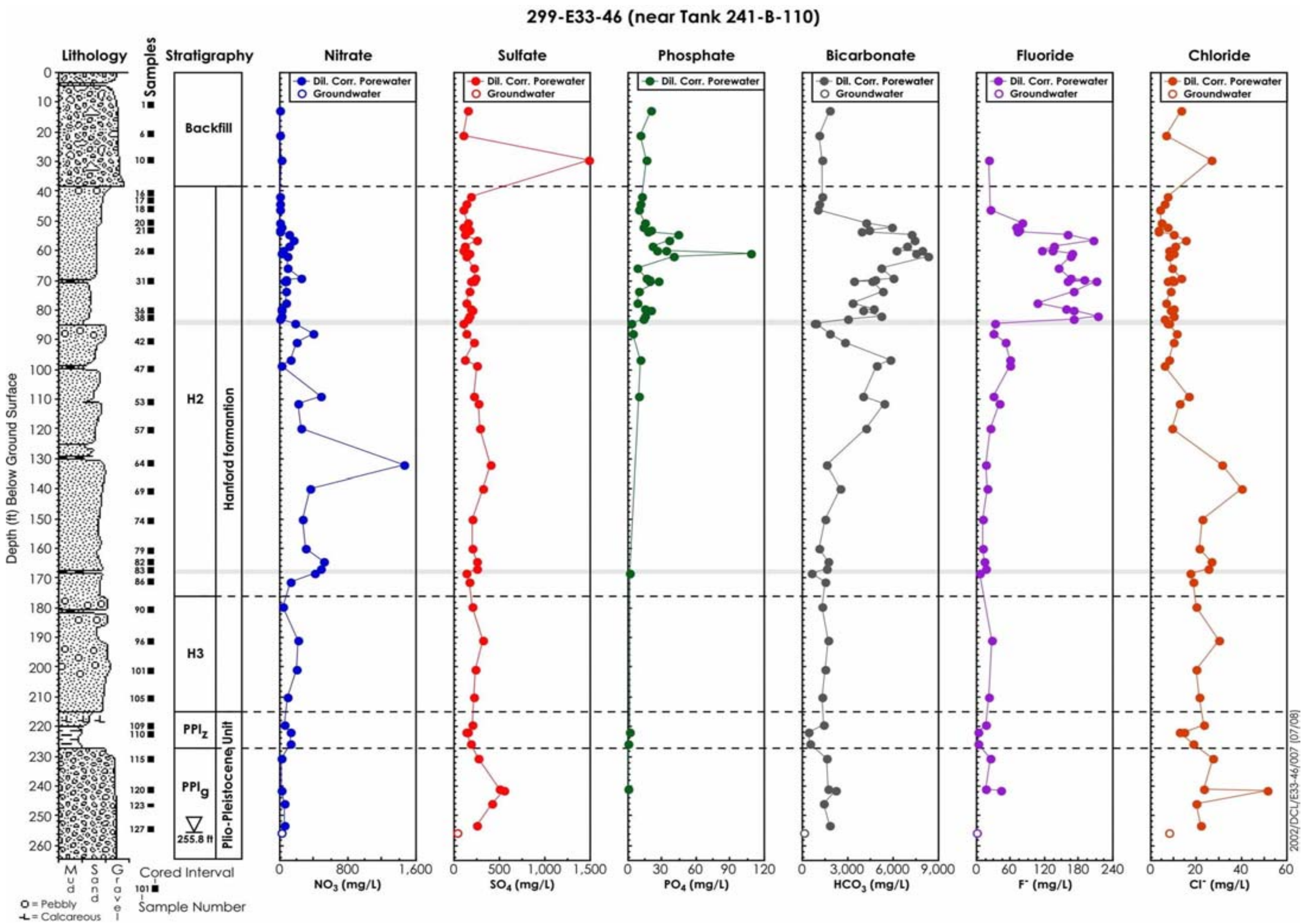
ID	Depth[(a)]	Dil. Fac.	1:1 Extracts in mg/L							Dilution Corrected Porewater mg/L						
			NO3	F	NO2	Cl	SO4	PO4	HCO3	NO3	F	NO2	Cl	SO4	PO4	HCO3
31A-dup	70.45	27.03	2.45	7.79	<0.1	0.37	8.24	0.98	171.26	66.2	210.6	<2.7	10	223	26.5	4629
33	73.50	25.04	3.26	6.839	<0.7	0.35	6.803	0.389	213.114	81.5	171.2	<17.5	8.8	170	9.7	5336
35	77.35	15.03	4.91	7.115	<0.7	0.43	9.183	0.516	218.09	73.8	106.9	<10.5	6.5	138	7.8	3277
36C	79.45	21.67	0.89	7.288	<0.7	0.45	8.696	0.704	217.218	19.2	157.9	<15.2	9.8	188	15.3	4707
36A	79.95	22.85	0.55	7.45	<0.1	0.37	9.12	0.87	175.64	12.6	170.3	<2.3	8.5	208	19.9	4014
38C	82.05	24.70	0.50	8.609	<0.7	0.41	6.943	0.586	209.791	12.4	212.7	<17.3	10.1	172	14.5	5182
38A	83.05	19.64	0.46	8.75	<0.1	0.3	7.84	0.69	155.19	9	171.8	<2.0	5.9	154	13.5	3047
Thin Fine Grained Lens																
39	84.55	5.17	33.866	6.29	<0.7	1.45	18.469	0.585	160.454	174.9	32.5	<3.6	7.5	95.4	3.0	828.8
39-dup	84.55	5.41	34.405	6.196	<0.7	1.44	18.68	0.567	162.164	186.0	33.5	<3.8	7.8	101	3.1	876.5
Hanford H2 Sand (middle sequence) Unit																
41	87.85	27.98	14.004	1.056	<0.7	0.41	5.029	0.141	66.075	391.9	29.6	<19.6	11.5	141	3.9	1849
42A	90.62	35.28	5.68	1.41	<0.1	0.29	6.27	<0.5	79.66	200.4	49.7	<3.5	10.2	221	<17.6	2810
46	96.80	31.85	4.113	1.814	<0.7	0.25	3.636	0.326	182.588	131.0	57.8	<22.3	8.0	116	10.4	5815
47A	98.62	45.97	0.32	1.31	<0.1	0.13	5.45	<0.5	106.87	14.7	60.2	<4.6	6.0	251	<23.0	4913
52	109.00	28.40	16.711	1.031	<0.7	0.59	7.912	0.321	142.045	474.6	29.3	<19.9	16.8	225	9.1	4034
53A	111.42	38.76	5.51	1.02	<0.1	0.33	6.9	<0.5	139.76	213.6	39.5	<3.9	12.8	267	<19.4	5417
57A	119.92	47.96	5.05	0.51	<0.1	0.2	6.1	<0.5	87.42	242.2	24.5	<4.8	9.6	293	<24.0	4192
64A	131.85	32.15	45.32	<0.5	<0.1	0.98	12.62	<0.5	51.59	1457.2	16.08	<3.2	31.5	406	<16.1	1659
69A	140.05	39.70	8.85	<0.5	<0.1	1.01	8.2	<0.5	62.89	351.3	19.85	<4.0	40.1	326	<19.8	2496
74A	150.15	23.41	11.65	<0.5	<0.1	0.98	8.56	<0.5	63.29	272.7	11.71	<2.3	22.9	200	<11.7	1482
79A	160.15	19.54	15.19	<0.5	<0.1	1.1	10.12	<0.5	59.06	296.8	9.77	<2.0	21.5	198	<9.8	1154
82A	164.55	29.22	17.42	<0.5	<0.1	0.92	8.56	<0.5	58.40	509.1	14.61	<2.9	26.9	250	<14.6	1707

Table B.16. Calculated Porewater Anion Concentrations from Water Extracts for Borehole 299-E33-46 (3 pages)

ID	Depth[(a)]	Dil. Fac.	1:1 Extracts in mg/L							Dilution Corrected Porewater mg/L						
			NO3	F	NO2	Cl	SO4	PO4	HCO3	NO3	F	NO2	Cl	SO4	PO4	HCO3
83A	166.85	29.95	16.03	0.5	<0.1	0.85	8.2	<0.5	53.26	480.1	15.0	<3.0	25.5	246	<15.0	1595
Fine Grained Lens																
84	168.45	11.44	35.383	0.401	<0.7	1.5	12.246	0.076	52.048	404.9	4.6	<8.0	17.2	140	0.9	595.5
Hanford H2 Sand Unit																
86A	171.15	18.85	6.99	<0.5	<0.1	1	9.17	<0.5	81.24	131.7	<9.4	<1.9	18.8	173	<9.4	1531
Hanford H3 Sand Unit																
90A	179.85	22.89	1.29	<0.5	<0.1	0.89	8.51	<0.5	58.00	29.5	<11.4	<2.3	20.4	195	<11.4	1327
96A	190.80	41.31	5.03	0.62	<0.1	0.73	7.52	<0.5	42.50	207.8	25.6	<4.1	30.2	311	<20.7	1756
101A	200.95	34.06	5.73	<0.5	<0.1	0.58	6.66	<0.5	44.59	195.2	<17.0	<3.4	19.8	227	<17.0	1519
105A	209.95	26.84	3.14	0.82	<0.1	0.8	8.04	<0.5	48.80	84.3	22.0	<2.7	21.5	216	<13.4	1310
Plio-Pleistocene Mud Unit																
109A	219.45	23.01	2.27	0.71	<0.1	1.02	8.95	<0.5	62.99	52.2	16.3	<2.3	23.5	206	<11.5	1449
110A	222.05	3.85	33.29	0.66	<0.1	3.77	38.22	0.50	101.30	128.3	2.5	<0.4	14.5	147	1.93	390.5
110A-dup	222.05	3.85	33.51	0.69	<0.1	3.32	34.84	<0.5	95.86	129.2	2.7	<0.4	12.8	134	1.93	369.5
113	225.90	6.67	19.431	0.57	<0.7	2.85	27.718	0.105	74.466	129.6	3.8	<4.7	19.0	185	0.70	496.8
Plio-Pleistocene Gravel Unit																
115A	230.75	27.17	0.48	0.94	<0.1	1.02	9.87	<0.5	60.12	13.0	25.5	<2.7	27.7	268	<13.6	1633
120B	240.95	28.68	<0.012	0.548	<0.7	0.82	17.333	<0.014	60.752		15.7	<20.1	23.5	497	0.40	1743
120A	241.45	39.95	0.44	1.05	<0.1	1.29	13.83	<0.5	54.52	17.6	42.0	<4.0	51.5	553	<20.0	2178
123A	245.75	30.01	1.57	<0.5	<0.1	0.67	13.93	<0.5	47.00	47.1	<15.0	<3.0	20.1	418	<15.0	1410
127A	253.15	31.57	1.52	<0.5	<0.1	0.7	7.87	<0.5	57.29	48.0	<15.8	<3.2	22.1	248	<15.8	1809

[(a)] Multiply by 0.3048 to convert to meters.
Red type signifies high values possibly indicating presence of tank leak fluids.

Figure B.24. Porewater Anion Concentrations Calculated from Sediment to Water Extracts for Borehole 299-E33-46



Elevated bicarbonate concentrations (between 3,000 and 8,400 mg/L) are measured in borehole 299-E33-46 from 15 to 37 m (50 to 120 ft) bgs. Maximum bicarbonate values (between 6,200 and 8,400 mg/L) occur between 16 and 19 m (54 and 62 ft) bgs. Elevated fluoride concentrations (> 15 mg/L) occur sporadically throughout the entire length of the borehole. Maximum fluoride values (between 100 and 215 mg/L) are measured from 16 to 25 m (54 to 83 ft) bgs coincident with the largest bicarbonate concentrations. Given their location in the soil column, both bicarbonate and fluoride have been chemically reactive with vadose zone soils.

As mentioned, nitrate concentrations are elevated throughout much of the soil column (> 100 mg/L). Maximum concentrations are more prevalent at greater depth in the soil column relative to bicarbonate and fluoride indicating that it is largely non-reactive with the soil column and may represent the leading edge of the downward migration of the tank waste fluid. The primary zone of high nitrate concentration (between 130 and 1460 mg/L) occurs between 26 and 61 m (84 and 200 ft) bgs. Water extract data suggest there may be some elevated phosphate concentrations in the vadose zone sediments between 55 and 62 ft bgs just below the bottom of the tank.

Water extract cation concentrations as a function of depth are graphed in Figure B.25 and listed in Table B.17. Among the cations, elevated sodium concentrations are the primary indicator of tank fluid occurrence in the soil column. Sodium concentrations are elevated throughout much of the soil column (> 400 mg/L). Highest concentrations exist between 15 and 40 m (50 and 132 ft) bgs. Maximum concentrations (1,000 and 3,500 mg/L) occur between 15 and 26 m (50 and 85 ft) bgs. The potassium concentration pattern is similar to sodium although present at lower concentrations and more evenly distributed in the soil column. A high concentration zone (100 and 185 mg/L) occurs between 15 and 24 m (50 and 80 ft) bgs and corresponds to the location of the maximum sodium concentration zone. Elevated potassium concentrations in the same range are also found in the Plio-Pleistocene unit between 70 m (230 ft) bgs and the bottom of the borehole at 77 m (254 ft) bgs with concentrations between 200 and 315 mg/L.

Additional magnesium and calcium have probably not been added to the vadose zone from a tank leak event but do show a distinct concentration pattern with depth. Between 50.6 and 120 ft bgs, all the alkaline earth cations (e.g., calcium, magnesium, and strontium) are depleted in the water extracts. This is caused by the high sodium concentration from the tank leak displacing the alkaline earth cations off the sediment exchange sites and flushing them deeper in the profile. Below 120 ft bgs all the way to the bottom of the borehole at 77 m (254 ft) bgs, noticeably higher concentrations of the alkaline earth cations occur (between 50 and 100 mg/L for magnesium and between 75 and 300 mg/L for calcium). These concentrations are within to slightly larger than the range found at the uncontaminated borehole.

The combined pattern of sodium, potassium, calcium, and magnesium distribution in the soil column is a classic example of ion exchange of sodium for the other natural cations creating a chromatographic effect in the column. This occurs as sodium in the infiltrating fluid preferentially displaces the divalent cations originally sorbed on soil phases causing them to be depleted in the interaction zone and to migrate ahead of the sodium front in the direction of flow.

Figure B.25. Porewater Cation Concentrations Calculated from Sediment-to-Water Extracts for Borehole 299-E33-46

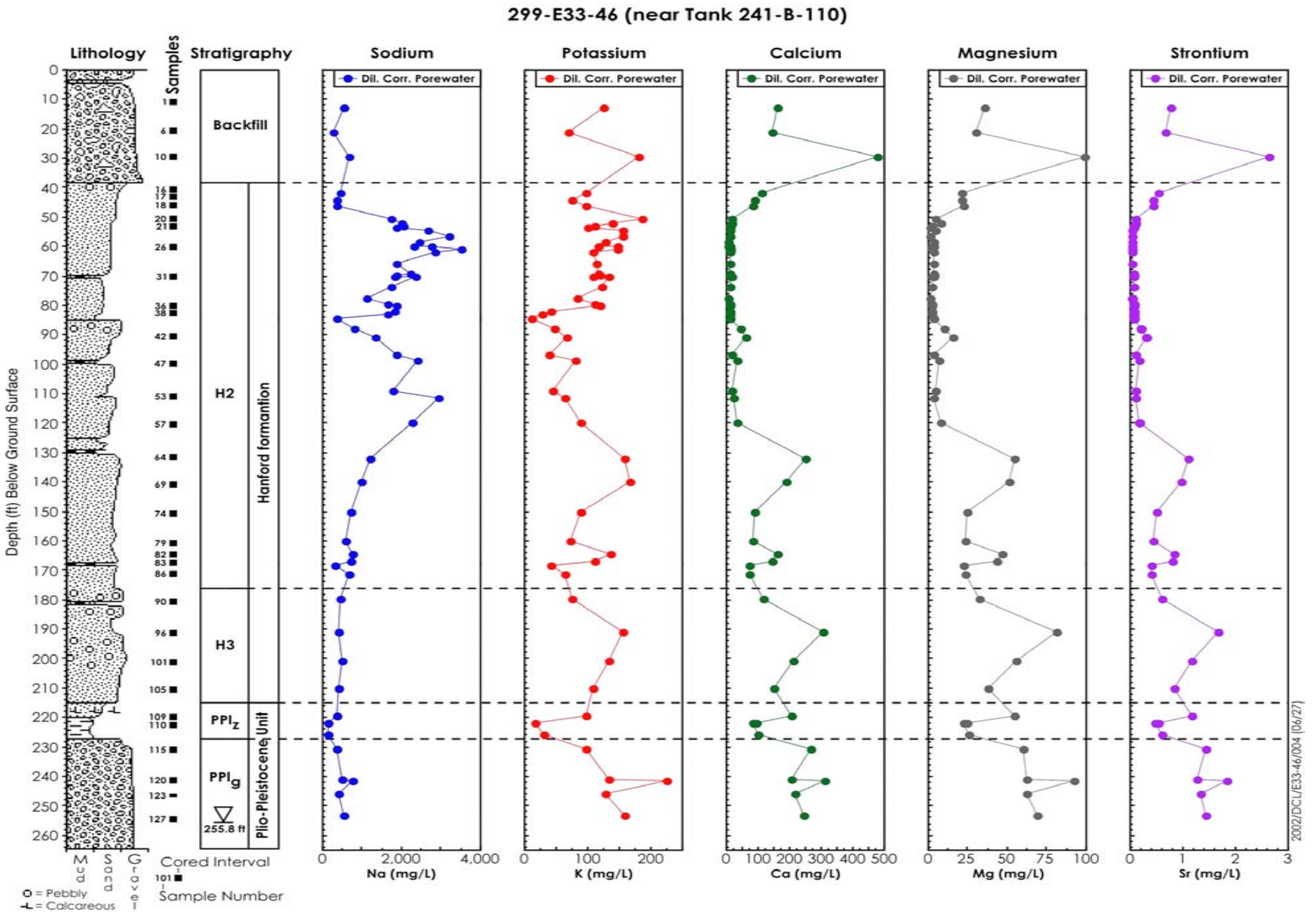


Table B.17. Porewater Cation Concentrations Calculated from Water Extracts for Borehole 299-E33-46 (4 pages)

Sample Identification	Depth (ft bgs)[(a)]	Dilution Factor	Dilution Corrected Porewater Concentration of Cations								
			Al mg/L	Ba mg/L	Ca mg/L	Fe mg/L	K mg/L	Mg mg/L	Na mg/L	Si mg/L	Sr mg/L
Backfill											
02A	13.70	27.80	0.78	0.37	161.0	2.4	124.2	36.02	545	305	0.78
06A	21.12	20.66	0.58	0.19	147.5	0.4	69.4	29.73	250	237	0.66
10A	29.42	30.33	1.45	0.83	480.4	0.4	179.9	99.29	674	309	2.63
Hanford H2 Sand (upper sequence) Unit											
16A	41.72	25.18	1.39	0.22	111.0	1.3	96.9	21.62	444	263	0.54
17A	44.02	21.29	0.94	0.44	86.7	2.2	74.7	21.42	358	227	0.43
18A	46.42	18.75	0.72	0.20	84.6	1.2	96.8	22.84	344	197	0.43
20A	50.62	29.43	7.76	0.21	16.7	11.9	185.3	4.55	1737	350	0.10
21C	52.02	29.45	17.51	0.53	16.4	33.1	138.0	7.50	1986	355	0.10
21A	53.02	20.75	3.39	0.19	11.4	3.8	111.5	2.01	2047	279	0.06
21A-dup	53.44	19.42	3.25	0.13	9.1	4.3	100.8	1.77	1853	284	0.05
22	54.60	22.75	15.20	0.75	9.4	23.9	154.7	4.29	2677	252	0.05
24	56.70	19.05	3.57	0.22	9.1	5.9	156.0	1.22	3193	249	0.04
25	58.40	19.92	9.67	0.18	7.2	16.4	127.7	2.94	2454	211	0.03
26C	59.72	19.45	10.94	0.16	7.3	17.9	118.1	3.10	2318	203	0.03
26C-dup	59.72	22.74	9.65	0.30	9.3	12.8	147.2	2.35	2767	248	0.04
26-A	60.72	24.50	9.28	0.20	10.2	10.3	146.3	1.97	3504	294	0.05
27	62.10	23.78	10.78	0.55	9.3	15.4	109.2	3.07	2865	242	0.05
29	66.05	24.84	7.14	0.30	10.9	10.0	113.6	2.96	1874	252	0.05
31C	69.45	28.74	7.35	0.38	12.9	9.7	117.6	3.18	2220	301	0.06
31B	69.95	23.92	8.03	0.28	14.2	9.2	118.7	3.68	1851	236	0.07

Table B.17. Porewater Cation Concentrations Calculated from Water Extracts for Borehole 299-E33-46 (4 pages)

Sample Identification	Depth (ft bgs)[(a)]	Dilution Factor	Dilution Corrected Porewater Concentration of Cations								
			Al mg/L	Ba mg/L	Ca mg/L	Fe mg/L	K mg/L	Mg mg/L	Na mg/L	Si mg/L	Sr mg/L
31A	70.45	20.80	3.61	0.11	12.2	3.4	107.9	2.66	1839	198	0.06
31A-dup	70.45	27.03	4.57	0.12	15.3	2.7	134.5	3.26	2362	265	0.08
33	73.50	25.04	6.00	0.33	11.5	5.8	121.7	2.39	1754	205	0.07
35	77.35	15.03	2.69	0.17	7.2	2.5	83.5	1.35	1111	126	0.04
36C	79.45	21.67	4.18	0.22	10.2	5.7	110.6	2.06	1629	213	0.07
36A	79.95	22.85	3.89	0.09	12.9	2.0	120.3	2.42	1866	211	0.07
38C	82.05	24.70	4.04	0.15	12.3	4.1	42.4	2.53	1841	218	0.08
38A	83.05	19.64	2.57	0.13	10.5	1.4	26.9	2.18	1645	180	0.06
Thin Fine Grained Lens											
39	84.55	5.17	0.16	0.04	10.8	1.6	10.9	3.32	360	51	0.07
39-dup	84.55	5.41	0.14	0.05	10.7	1.7	11.6	3.27	376	52	0.07
Hanford H2 Sand (middle sequence) Unit											
41	87.85	27.98	2.27	0.42	46.1	15.1	48.5	9.88	815	221	0.21
42A	90.62	35.28	3.20	0.19	64.0	2.0	67.9	15.18	1346	330	0.30
46	96.80	31.85	8.84	0.21	16.2	10.4	40.3	3.88	1864	310	0.09
47A	98.62	45.97	8.19	0.16	32.7	3.3	80.9	6.98	2392	455	0.18
52	109.00	28.40	6.62	0.40	15.5	9.0	45.3	4.05	1764	290	0.10
53A	111.42	38.76	5.49	0.18	20.2	2.2	63.8	3.80	2916	481	0.11
57A	119.92	47.96	7.76	0.45	31.3	4.2	90.0	8.15	2263	483	0.18
64A	131.85	32.15	1.77	0.31	250.5	2.3	159.2	54.18	1211	272	1.09
69A	140.05	39.70	2.39	0.41	190.2	2.6	166.7	51.50	981	344	0.96
74A	150.15	23.41	1.91	1.42	86.9	1.3	90.4	24.14	698	207	0.49

Table B.17. Porewater Cation Concentrations Calculated from Water Extracts for Borehole 299-E33-46 (4 pages)

Sample Identification	Depth (ft bgs)[(a)]	Dilution Factor	Dilution Corrected Porewater Concentration of Cations								
			Al mg/L	Ba mg/L	Ca mg/L	Fe mg/L	K mg/L	Mg mg/L	Na mg/L	Si mg/L	Sr mg/L
79A	160.15	19.54	1.25	0.51	81.1	0.9	71.7	23.81	567	175	0.43
82A	164.55	29.22	1.40	0.29	160.8	0.8	135.2	47.31	777	250	0.84
83A	166.85	29.95	2.06	0.74	146.3	1.0	111.1	43.80	716	261	0.79
Fine Grained Lens											
84	168.45	11.44	2.84	0.23	74.7	2.9	41.4	22.76	325	102	0.41
Hanford H2 Sand Unit											
86A	171.15	18.85	0.69	0.19	74.2	0.5	64.0	23.99	658	207	0.42
Hanford H3 Sand Unit											
90A	179.85	22.89	0.77	0.30	117.0	0.6	75.9	32.53	435	244	0.62
96A	190.80	41.31	1.48	0.91	307.4	6.1	156.4	81.73	401	411	1.68
101A	200.95	34.06	1.35	0.48	214.4	0.7	134.6	55.48	483	343	1.16
105A	209.95	26.84	1.53	0.66	153.1	1.1	107.8	38.09	422	262	0.83
Plio-Pleistocene Mud Unit											
109A	219.45	23.01	1.24	0.79	205.3	1.0	97.0	54.31	369	191	1.18
110A	222.05	3.85	0.19	0.29	93.9	1.1	16.5	24.40	136	50	0.54
110A-dup	222.05	3.85	0.10	0.16	85.7	0.0	16.1	22.28	127	48	0.48
113	225.90	6.67	1.42	0.30	101.5	1.0	32.1	25.16	137	59	0.61

Table B.17. Porewater Cation Concentrations Calculated from Water Extracts for Borehole 299-E33-46 (4 pages)

Sample Identification	Depth (ft bgs)[(a)]	Dilution Factor	Dilution Corrected Porewater Concentration of Cations								
			Al mg/L	Ba mg/L	Ca mg/L	Fe mg/L	K mg/L	Mg mg/L	Na mg/L	Si mg/L	Sr mg/L
Plio-Pleistocene Gravel Unit											
115A	230.75	27.17	0.80	0.59	265.8	0.5	98.2	59.68	341	257	1.44
120B	240.95	28.68	4.66	0.73	206.8	8.0	132.6	62.46	512	270	1.26
120A	241.45	39.95	2.07	0.82	310.8	2.0	226.5	92.57	778	376	1.84
123A	245.75	30.01	1.48	0.84	217.3	1.5	128.1	62.56	401	294	1.35
127A	253.15	31.57	2.03	0.62	242.9	1.7	158.7	69.19	530	268	1.44

[(a)] Multiply by 0.3048 to convert to meters.
Blue type indicates lower concentration values than found in uncontaminated sediments possibly indicating depletion due to sodium ion exchange.
Red type indicates high concentration values.

The porewater aluminum and iron concentrations are above the range found in the uncontaminated borehole 299-E33-338 over a narrow zone from 52 to 62 and 50 to 70 ft bgs, respectively. The higher porewater concentrations for these two species suggests that tank fluids may have contained reactive dissolved iron or aluminum or that tank fluids interacted with the sediments creating some more soluble forms of iron and aluminum. Caustic reactions may have dissolved some of the native sediment and upon pH neutralization, amorphous hydrous oxides of aluminum and iron may have formed that preferentially dissolved during the water extract process.

The last group of analyzed constituents included radionuclides and trace metals. Calculated porewater concentrations that were derived from dilution correction of the water extract values are shown in Figure B.26 and listed in Table B.18. No strontium-90 above a detection limit of 9000 pCi/L was found in water extracts. The radionuclides found in the sediments from 299-E33-46 were uranium, strontium-90, and technetium-99. The strontium-90 profile is shown in Figure B.27 and Table B.19. The total concentration of uranium and technetium-99 in the sediments from borehole 299-E33-46 are shown in Figures B.28 and B.29, respectively and Table B.19.

Uranium concentrations in the sediment are not distinguishable from natural background but the zone immediately below the bottom of the tank was not adequately measured because gamma energy analysis was affected by the bremsstrahlung signal from the strontium-90. Throughout the sediment, acid extraction did not remove more than 3 μg/g of uranium. Such values are similar to the total concentrations of uranium in uncontaminated sediments. However, the water extractable uranium values shown in Table B.18 and Figure B.26 suggest that there is processed uranium from Hanford activities at low concentrations between the depths of 50.6 to 120 ft bgs. The deepest penetration of uranium is down to the thin fine-grained bed in the Hanford H2 unit.

Strontium-90 is considered to be the primary radionuclide released from tank B-110 transfer lines and is concentrated in the sediment between 19 and 28 m (62 and 83 ft) bgs at concentrations between 1000 and 11,250 pCi/g. There is some strontium-90 as shallow as 46.5 ft bgs with 600 pCi/g concentration and the bottom of the plume lies between 89 and 111 ft bgs where the concentrations range between 20 and 70 pCi/g. As mentioned, the strontium-90 in the sediments is not readily water leachable with distilled water and several hours contact. More detailed studies on the leachability of the strontium-90 in these sediments are found in Appendix D.

Technetium-99 was measured unequivocally at low concentrations only in the Plio-Pleistocene unit between 68 and 69 m (222 and 226 ft) bgs at concentrations between 40 and 50 pCi/g in the sediment (Table B.19). Above, in the Hanford sediments, there may be very trace concentrations of technetium between 20 to 25, 15 to 20, and 7 to 10 pCi/g at 70, 79 to 83, and 190 to 220 ft bgs, respectively. Depending on acid matrix, the detection limit for total technietium-99 in the sediments was between 3 to 6 pCi/g, therefore most of the observed values are close to the detection limit. The water leachable technetium-99 data are shown in Table B.18 and Figure B.26 after conversion to porewater concentrations. The water versus acid extractable technetium data are shown in Figure B.28 in units of pCi per gram of sediment.

Figure B.26. Porewater Trace Metals Concentrations Calculated from Water Extracts for Borehole 299-E33-46

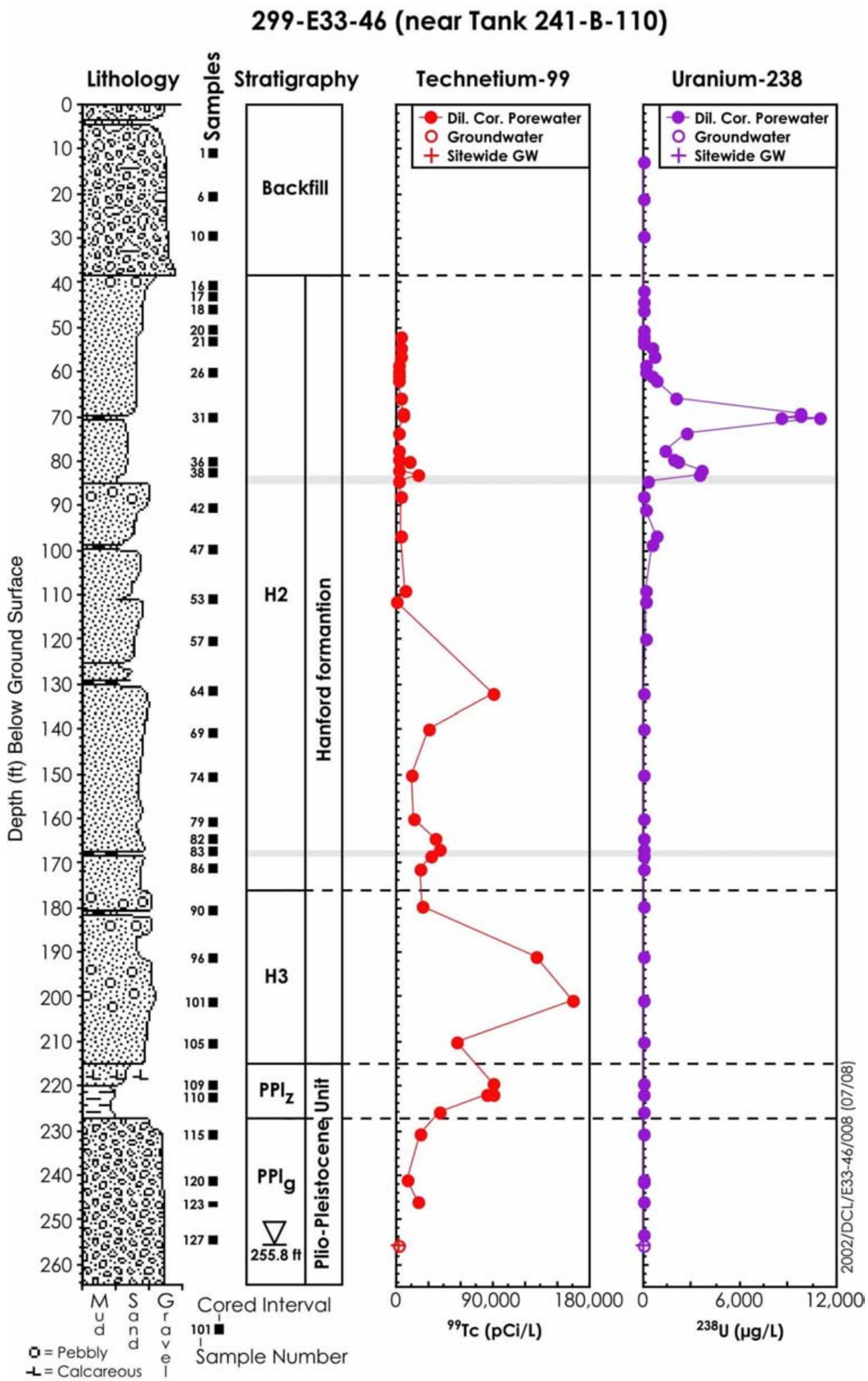


Table B.18. Porewater Radionuclide Concentrations Calculated from Water Extracts of Sediment from Borehole 299-E33-46 (3 pages)

Sample Identification	Depth (ft bgs)[(a)]	Dilution Factor	Tc-99 pCi/L	U-238 ug/L	Sr-90 pCi/L
Backfill					
02A	13.70	27.80	<10000	27	<9000
06A	21.12	20.66	<10000	24	<9000
10A	29.42	30.33	<10000	15	<9000
Hanford H2 Sand (upper sequence) Unit					
16A	41.72	25.18	<10000	22	<9000
17A	44.02	21.29	<10000	21	<9000
18A	46.42	18.75	<10000	35	<9000
20A	50.62	29.43	<10000	70	<9000
21C	52.02	29.45	(3496)	63	<9000
21A	53.02	20.75	<10000	69	<9000
21A-dup	53.44	19.42	<10000	66	<9000
22	54.60	22.75	(3859)	597	<9000
24	56.70	19.05	(3231)	632	<9000
25	58.40	19.92	(3040)	175	<9000
26C	59.72	19.45	(2968)	148	<9000
26C-dup	59.72	22.74	(3085)	180	<9000
26-A	60.72	24.50	(2493)	560	<9000
27	62.10	23.78	(2823)	842	<9000
29	66.05	24.84	(3370)	2056	<9000
31C	69.45	28.74	(5849)	9714	<9000
31B	69.95	23.92	(5275)	9731	<9000
31A	70.45	20.80	<10000	8510	<9000
31A-dup	70.45	27.03	<10000	10946	<9000
33	73.50	25.04	(2972)	2703	<9000
35	77.35	15.03	(2039)	1351	<9000
36C	79.45	21.67	(2940)	1847	<9000
36A	79.95	22.85	(11627)	2161	<9000
38C	82.05	24.70	(2933)	3547	<9000
38A	83.05	19.64	(19315)	3425	<9000
Thin Fine Grained Lens					
39	84.55	5.17	(1314)	312	<9000
39-dup	84.55	5.41	(1467)	270	<9000

Table B.18. Porewater Radionuclide Concentrations Calculated from Water Extracts of Sediment from Borehole 299-E33-46 (3 pages)

Sample Identification	Depth (ft bgs)[(a)]	Dilution Factor	Tc-99 pCi/L	U-238 ug/L	Sr-90 pCi/L
Hanford H2 Sand (middle sequence) Unit					
41	87.85	27.98	(4271)	40	<9000
42A	90.62	35.28	<10000	160	<9000
46	96.80	31.85	(3781)	836	<9000
47A	98.62	45.97	<10000	580	<9000
52	109.00	28.40	(8669)	98	<9000
53A	111.42	38.76	(657)	150	<9000
57A	119.92	47.96	<10000	141	<9000
64A	131.85	32.15	(91071)	31	<9000
69A	140.05	39.70	(30970)	33	<9000
74A	150.15	23.41	(15088)	32	<9000
79A	160.15	19.54	(15576)	26	<9000
82A	164.55	29.22	(36181)	43	<9000
83A	166.85	29.95	(40382)	34	<9000
Fine Grained Lens					
84	168.45	11.44	31438	18	<9000
Hanford H2 Sand Unit					
86A	171.15	18.85	(23013)	33	<9000
Hanford H3 Sand Unit					
90A	179.85	22.89	(24454)	27	<9000
96A	190.80	41.31	(129618)	24	<9000
101A	200.95	34.06	(164075)	19	<9000
105A	209.95	26.84	(55542)	17	<9000
Plio-Pleistocene Mud Unit					
109A	219.45	23.01	(89756)	17	<9000
110A	222.05	3.85	89755	5	<9000
110A-dup	222.05	3.85	84523	4	<9000
113	225.90	6.67	39832	5	<9000

Table B.18. Porewater Radionuclide Concentrations Calculated from Water Extracts of Sediment from Borehole 299-E33-46 (3 pages)

Sample Identification	Depth (ft bgs)[(a)]	Dilution Factor	Tc-99 pCi/L	U-238 ug/L	Sr-90 pCi/L
Plio-Pleistocene Gravel Unit					
115A	230.75	27.17	(21656)	12	<9000
120B	240.95	28.68	(11189)	13	<9000
120A	241.45	39.95	<10000	20	<9000
123A	245.75	30.01	(20867)	10	<9000
127A	253.15	31.57	<10000	12	<9000

[(a)] Multiply by 0.3048 to convert to meters.
Values in parentheses are below level of quantification but spectra look usable.
Red type indicates higher concentration than found in uncontaminated sediment.

Table B.19. Concentration of Radionuclides in Sediment from Borehole 299-E33-46 (3 pages)

Sample Identification	Depth (ft bgs)[(a)]	Tc-99 pCi/g	U-238 ug/g	Sr-90 pCi/g
Backfill				
02A	13.70	(1.45E+00)	<10.8	1.07E+01
06A	21.12	NA	<11.4	NA
10A	29.42	(1.46E+00)	<14.1	6.57E+00
Hanford H2 Sand (upper sequence) Unit				
16A	41.72	(3.73E+00)	24	2.72E+00
17A	44.02	NA	<16.2	2.13E+01
18A	46.42	(8.67E-01)	35	5.90E+02
20A	50.62	(1.57E+00)	INT	6.34E+03
21C	52.02	(3.76E+00)	INT	7.857E+03
21A	53.02	(8.09E+00)	INT	5.93E+03
21A-dup	53.44	(2.57E+00)	INT	7.80E+03
22	54.60	(3.77E+00)	INT	6.533E+03
24	56.70	(5.18E+00)	INT	1.096E+04
25	58.40	(4.62E+00)	INT	8.559E+03
26C	59.72	(4.99E+00)	INT	9.517E+03
26C-dup	59.72	(4.56E+00)	INT	8.341E+03
26-A	60.72	(3.58E+00)	12.9	1.05E+04
27	62.10	(4.97E+00)	NA	1.125E+04
29	66.05	(4.58E+00)	NA	7.760E+03

Table B.19. Concentration of Radionuclides in Sediment from Borehole 299-E33-46 (3 pages)

Sample Identification	Depth (ft bgs)[(a)]	Tc-99 pCi/g	U-238 ug/g	Sr-90 pCi/g
31C	69.45	(4.74E+00)	NA	1.603E+03
31B	69.95	(5.43E+00)	13.5	NA
31A	70.45	(2.64E+01)	INT	1.57E+03
31A-dup	70.45	(2.58E+01)	INT	NA
33	73.50	(5.75E+00)	INT	5.467E+03
35	77.35	(4.52E+00)	INT	5.053E+03
36C	79.45	(4.70E+00)	INT	3.399E+03
36A	79.95	(1.42E+01)	INT	2.21E+03
38C	82.05	(4.61E+00)	INT	1.811E+03
38A	83.05	(2.19E+01)	INT	6.89E+02
Thin Fine Grained Lens				
39	84.55	(4.98E+00)	INT	9.563E+02
39-dup	84.55	NA	INT	NA
Hanford H2 Sand (middle sequence) Unit				
41	87.85	(3.63E+00)	INT	5.281E+01
42A	90.62	(4.41E+00)	17.1	4.44E+00
46	96.80	(4.60E+00)	INT	7.122E+01
47A	98.62	(4.74E+00)	<14.8	1.54E+01
52	109.00	(3.75E+00)	INT	NA
53A	111.42	(1.40E+00)	<11.8	2.58E+01
57A	119.92	(2.12E+00)	<15.6	3.84E-01
64A	131.85	(3.04E+00)	<12.5	5.96E+00
69A	140.05	(7.65E-01)	<11.6	2.94E+00
74A	150.15	(3.12E+00)	<15.1	5.39E+00
79A	160.15	(3.11E+00)	<8.5	8.53E+00
82A	164.55	(1.52E+00)	<12.9	1.99E+00
83A	166.85	(1.53E+00)	<13.7	3.17E-01
Fine Grained Lens				
84	168.45	(7.18E+00)	INT	NA
Hanford H2 Sand Unit				
86A	171.15	(3.02E+00)	<8.8	3.35E+00

Table B.19. Concentration of Radionuclides in Sediment from Borehole 299-E33-46 (3 pages)

Sample Identification	Depth (ft bgs)[(a)]	Tc-99 pCi/g	U-238 ug/g	Sr-90 pCi/g
Hanford H3 Sand Unit				
90A	179.85	(1.45E+00)	<14.8	2.57E+00
96A	190.80	(7.72E+00)	<12.8	3.99E+00
101A	200.95	(7.72E+00)	<8.4	1.66E+00
105A	209.95	(8.43E+00)	<15.2	1.70E+00
Plio-Pleistocene Mud Unit				
109A	219.45	(9.93E+00)	<13.3	1.35E+00
110A	222.05	5.22E+01	<7.8	2.50E+00
110A-dup	222.05	4.52E+01	INT	6.11E+00
113	225.90	(2.36E+01)	27.3	NA
Plio-Pleistocene Gravel Unit				
115A	230.75	(3.48E+00)	<9	2.58E+00
120B	240.95	(4.69E+00)	INT	NA
120A	241.45	(7.26E-01)	<10.9	8.37E+00
123A	245.75	(7.43E-01)	<7.7	1.29E+01
127A	253.15	(2.40E+01)	<14.9	3.96E-02

(a) Multiply by 0.3048 to convert to meters.
NA = not analyzed. For uranium, XRF was used when available and GEA when XRF not performed.
INT indicates unable to report due to analytical interference.
Red type indicates high concentration values.

Figure B.27. Strontium-90 Concentration (pCi/g) in Sediment from Borehole 299-E33-46

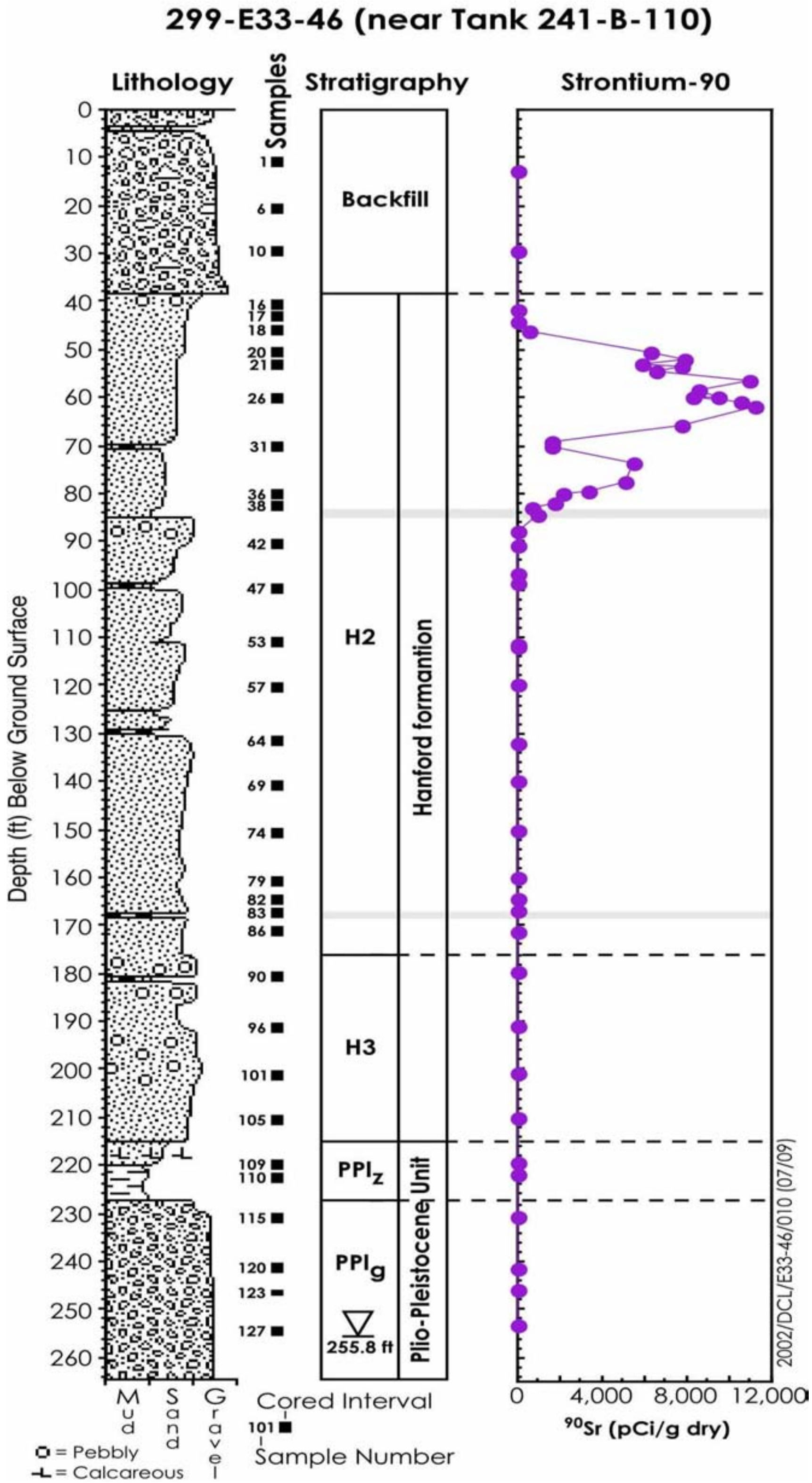


Figure B.28. Total Technetium-99 in Sediment Based on Acid Extracts

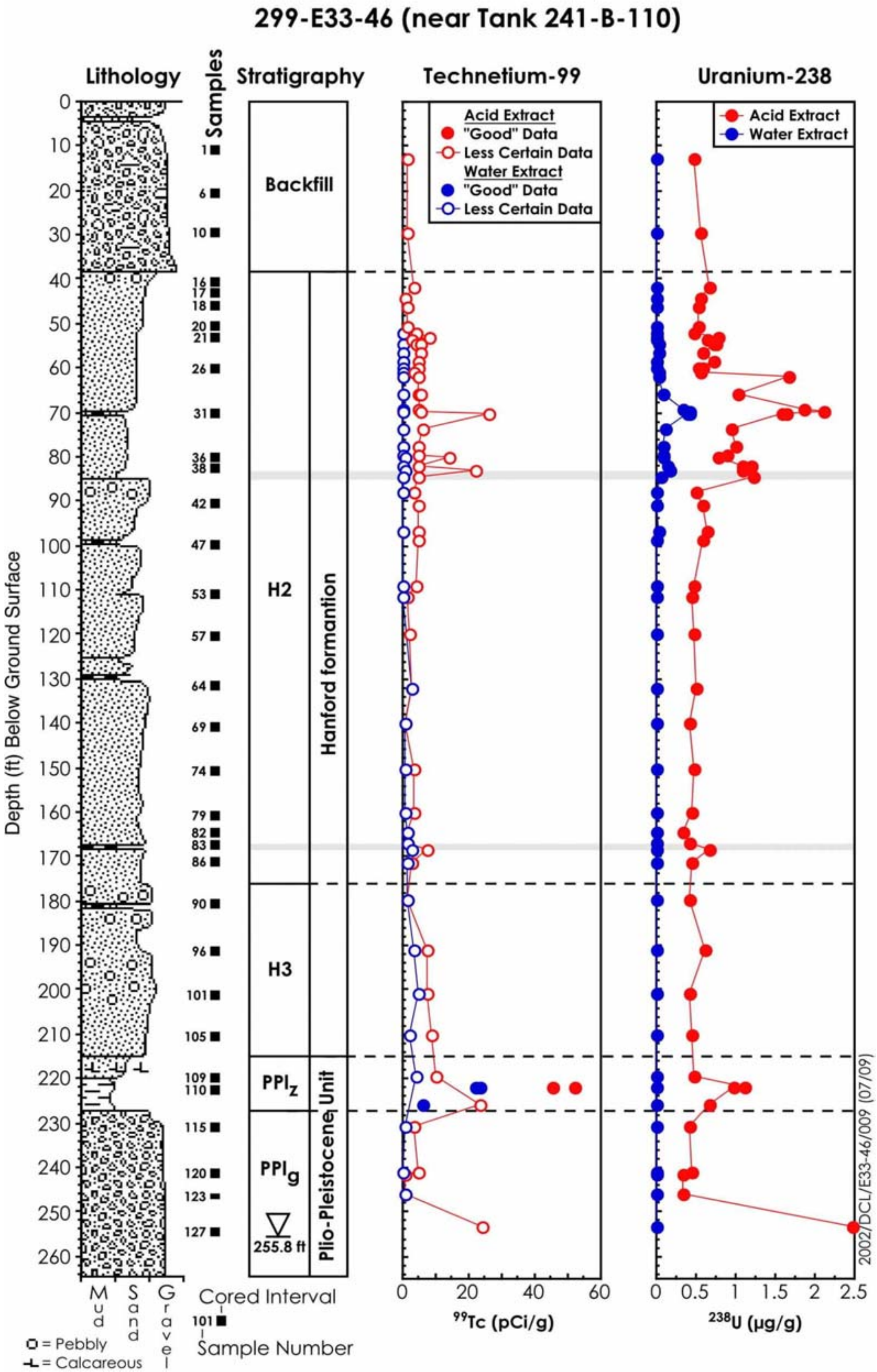
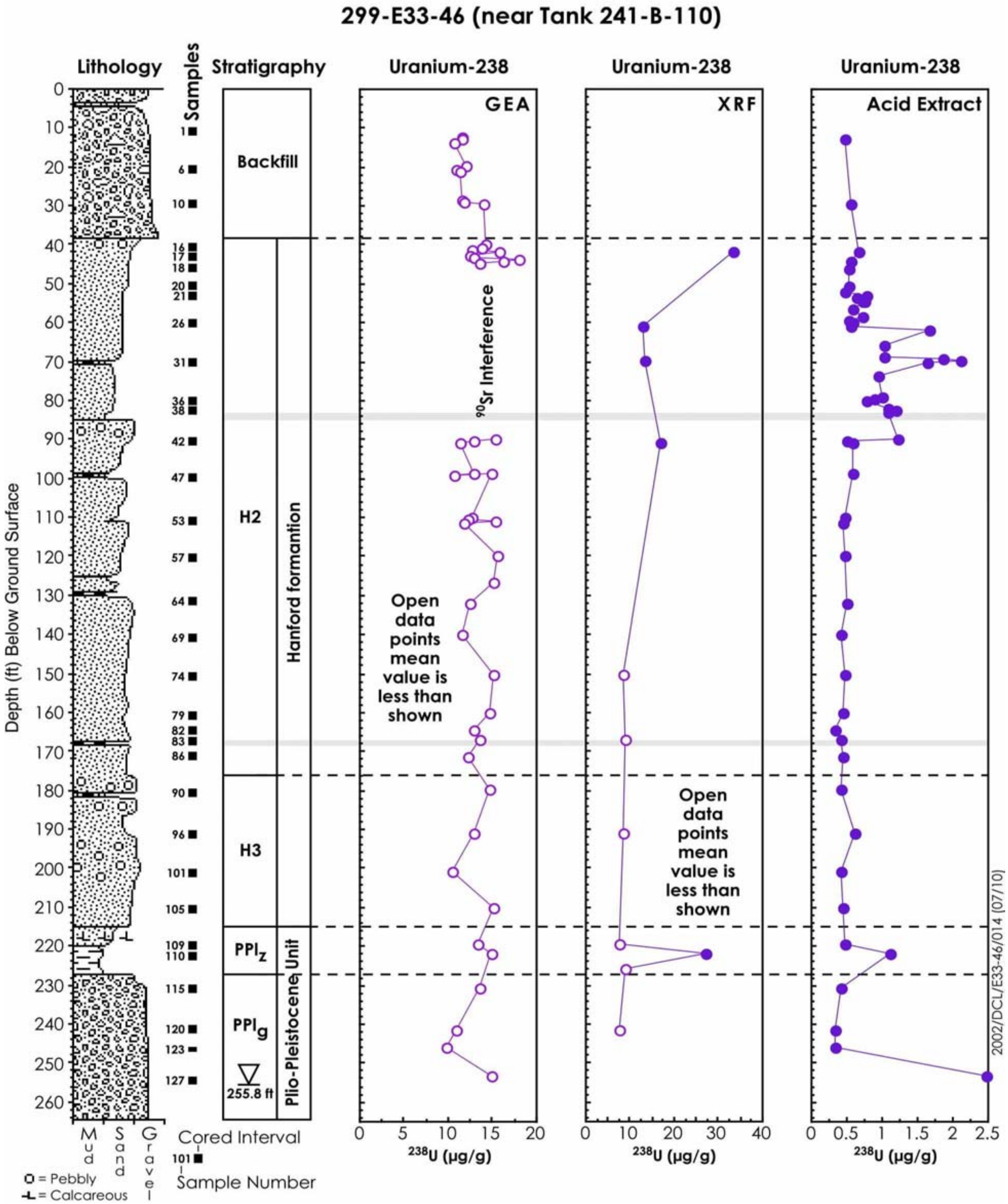


Figure B.29. Total Uranium in Sediment Based on Three Techniques



Because the sediments are so dry in the Hanford formation (i.e., dilution factors are large), the porewater technetium-99 concentrations appear to be between 39,800 and 89,800 pCi/L in places within the Hanford formation and as large as 160, 000 pCi/L in the Plio-Pleistocene mud unit. The analytical data are difficult to interpret because of the low acid extractable and water extractable amount of technetium per gram of sediment (generally <20 and <10 pCi/g, respectively). It is difficult to determine if the technetium profile at borehole 299-E33-46 indicates that the tank B-110 transfer line leak contained enough technetium to pose a risk and whether B-110 is the source of technetium-99 in the deep sediments and groundwater. Other sources could be nearby crib discharges.

B.5.4 CHEMICAL INTERACTIONS

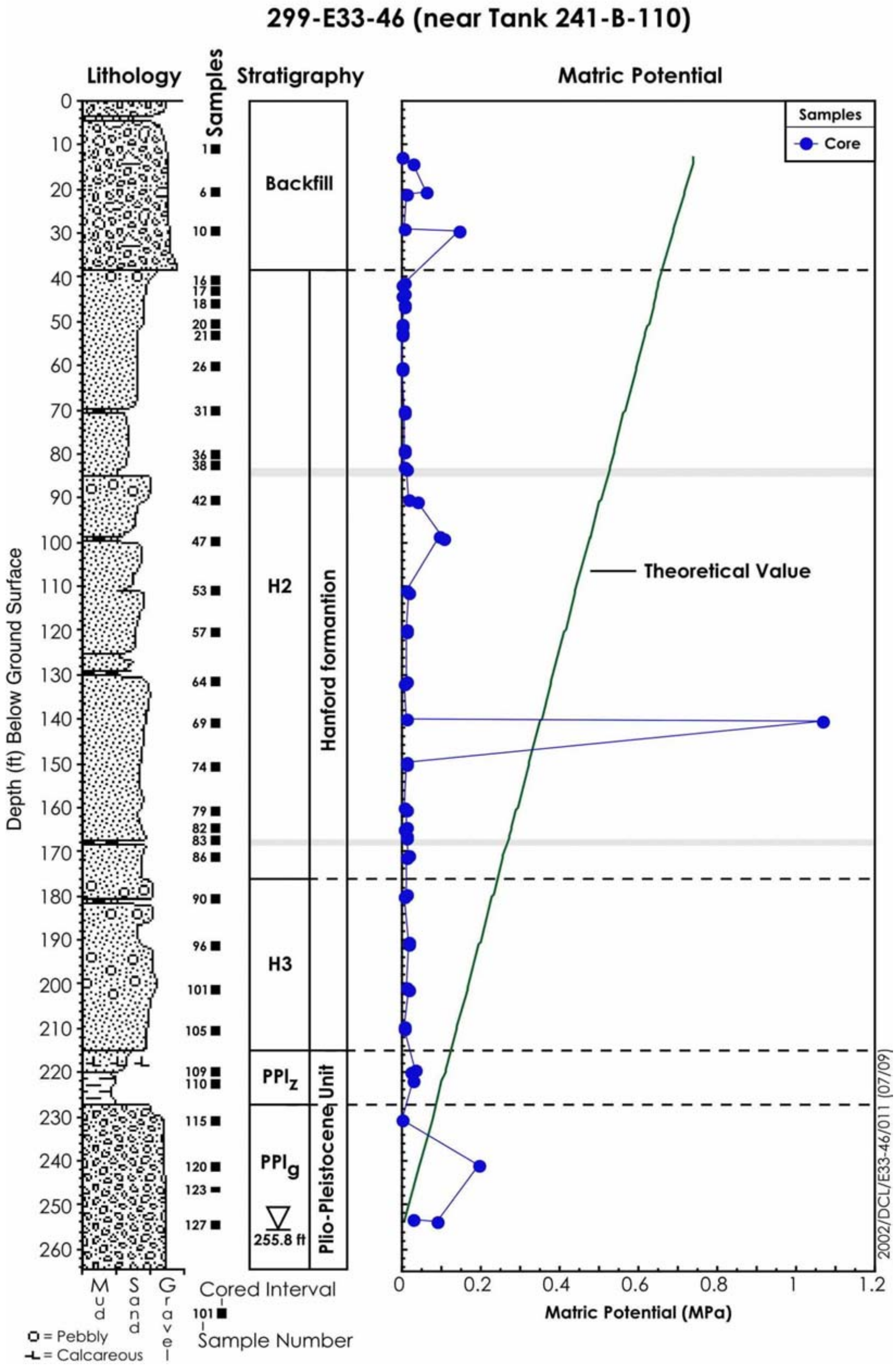
No specific experiments were completed on soils from this borehole to quantify geochemical reactions influencing contaminant migration. Typically, chemical reactions affecting radionuclides and tank fluid chemicals are inferred from the relative location of these constituents in the soil column, comparison of acid-leachable versus water-leachable concentrations for specific contaminants, and general knowledge of tank fluid chemistry. The primary reactions involving tank waste and the soil column appear to be a reduction of tank fluid pH as the tank fluid reacts with lower pH soil water, in situ displacement of ambient divalent cations with high sodium present in the tank fluids, and variable reactivity of strontium-90 with the soil column. Best estimates of the starting tank waste fluid suggest that a pH between 10 and 11 was likely. The observation of an elevated zone between pH 8.5 and 9 indicates partial buffering of the infiltrating tank fluid by reaction with soil phases and soil water whose ambient pH values are about 8.

The high sodium concentrations in tank fluid have probably displaced divalent cations on sorption sites, causing migration of these species in the soil column. The depth of strontium-90 in the soil column suggests that strontium-90 was initially less reactive with soils than observed under undisturbed conditions. Given what is known about the strontium recovery processing history, it is likely that an organic component in the waste stream is responsible for forming anionic species that migrated with the fluid for some time. Currently, no trace of these species or other unusual organic components have been found and water versus acid extraction experiments indicate that strontium-90 is now relatively immobile, with distribution coefficient (Kd) values falling in the range measured in undisturbed soils. This suggests that the chelating species became unstable after some time in the soil column and the period of high strontium-90 mobility ceased.

B.5.5 SEDIMENT MATRIC POTENTIAL AT BOREHOLE 299-E33-46

The general trend is that the water potentials at 299-E33-46 are consistent with a draining profile (i.e., water potentials wetter than -0.01 MPa as shown in Figure B.30). Below 70 m (230 ft) and to the water table at ~76 m (~250 ft), there appears to be a drier condition than above that depth. Note that the lower depths contain coarse materials, so sample handling (e.g., very slight drying) may be responsible for the apparent drier matric potentials. This is the third borehole within the tank farms operations area, where gravel covers and vegetation removal occur, that suggest draining soil water profiles. However, as found outside the SX tank farm and at borehole 299-E33-33 outside B tank farm, boreholes in undisturbed areas do not show a draining profile all the way to the water table.

Figure B.30. Sediment Matric Potential Distribution for Borehole 299-E33-46



B.6.0 BOREHOLE C3103 (216-B-7A-CRIB) CHARACTERIZATION SUMMARY

This section summarizes data collected from samples in borehole C3103. Borehole C3103 was drilled and sampled to further characterize the nature and extent of vadose zone contaminants supplied by intentional liquid discharges into cribs 216-B7A/7B between 1954 and 1967. These cribs received dilute waste streams from the bismuth phosphate fuel reprocessing program in the 1950s and decontamination waste in the 1960s. Elevated concentrations of several constituents were measured at different depth intervals. The primary radionuclides present in this borehole are cesium-137 and uranium near the top of the borehole. Chemical characteristics attributed to wastewater-soil interaction at different locations within this zone are elevated pH, sodium, fluoride, carbonate, nitrate, and sulfate.

B.6.1 GEOLOGY AT BOREHOLE C3103

B.6.1.1 Drilling and Sampling

Borehole C3103 was drilled directly through the 216-B-7A crib. This borehole was initially drilled to a depth of 56.5 ft, backfilled with silica sand, and then redrilled to final depth of 222.5 ft (DOE-RL 2002). The borehole was drilled using cable tool-drive barrel methods. Splitspoon samples were collected from 14 discrete depths throughout the borehole, with 10 of these locations occurring in the top 40 feet. DOE-RL (2002) reported the results of laboratory analyses of these samples and subsamples. Grab samples, primarily collected from the contents of the drive barrel (DOE-RL 2002), were collected at roughly 10-ft intervals throughout the lower 200 ft of the borehole. Borehole geophysical logging was also conducted, using both spectral gamma and neutron-neutron moisture tools (DOE-RL 2002).

B.6.1.1.1 Borehole Geology. The geologic materials penetrated by this borehole have been interpreted primarily from the geologists' logs of the borehole cuttings, the borehole geophysical logs, and correlations with other recently installed boreholes. DOE-RL (2002) identified four principal geologic materials: 1) backfill, 2) gravel-dominated Hanford formation, 3) sand-dominated Hanford formation, and 4) Hanford formation/Plio-Pleistocene unit silt.

B.6.1.1.2 Backfill. DOE-RL (2002) identified the backfill as extending from the surface to a depth of 23 ft, with the wooden crib structure encountered at a depth of 21 ft, and the base of the crib estimated to be at 23 ft; this is consistent with the depth reported by Maxfield (1976). The geologists' logs indicate that the backfill consists primarily of brown (10YR5/3), very poorly sorted, silty, sandy gravel to moderately sorted, slightly silty, gravelly sand with 10% to 50% gravel. The gravel fraction was described as mainly medium to very coarse pebble with a maximum particle size of 55 mm, with the exception of a boulder encountered in the top 2.5 ft. These materials were further described as moist with a strong reaction to dilute hydrochloric acid. The geologists logs report finding wood (presumably from the crib structure) at a depth of 21 to 23 ft. The logs also reported that the materials from this depth (21 to 25 ft) were very moist (but not saturated) and that the wood was wet.

B.6.1.1.3 Hanford formation. DOE-RL (2002) describes the Hanford formation beneath the backfill as consisting of a gravel-dominated sequence (equivalent to the Hanford H1 unit) and a sand dominated sequence (equivalent to the Hanford H2 unit). A lower coarse (gravelly sand) unit equivalent to the Hanford H3 unit found in nearby wells (Serne et al. 2002a, b; Lindenmeier et al. 2002a) has not been identified. However, a thin fine-grained sequence of silty sand and slightly silty sand found between depths of 168.5 and 180 ft may be equivalent to fined-grained materials found above the Hanford H3 unit (where identified).

B.6.1.1.3.1 Gravel Dominated Sequence (Hanford H1 Unit). The gravel-dominated sequence is believed to be equivalent to the Hanford H1 unit. DOE-RL (2002) defines the gravel-dominated sequence as occurring between the depths of 23 ft and 35 ft bgs. The geologists' logs describe these materials as a very dark grayish brown (10YR3/2) very poorly sorted silty sandy gravel. The materials are 25 to 35% gravel, generally consisting of fine to medium pebble ranging up to 50 mm, and composed mainly of basalt. The materials were described as wet at 25 to 26 ft bgs and moist below that, with no to weak reaction to dilute hydrochloric acid.

B.6.1.1.3.2 Sand-Dominated Sequence (Hanford H2 unit). DOE-RL (2002) reported the sand-dominated sequence as extending from a depth of 35 ft to 218 ft. This sequence is believed to be equivalent to the Hanford H2 unit. The top five feet of this unit (35 to 40 ft) is described as gravelly, silty sand containing approximately 13% gravel up to 32 mm and 12% silt. The sand fraction is described as predominantly fine to medium sand.

The next 105 ft (40 to 145 ft bgs) is generally described as moderately sorted sand, ranging from mostly coarse to medium sand, to very coarse to medium sand, with occasional pebbles up to 10 mm. The materials are described as very loose to weakly cemented, with little to no reaction to dilute hydrochloric acid (with the exception of one zone from 50 to 56.5 ft bgs described as having a weak to strong reaction to hydrochloric acid). The materials are generally dark grayish brown (10YR4/2) with the sand composed mostly (60 to 90%) of basalt.

Numerous cemented zones are identified starting at the 145-ft depth. Here the sand is described as less sorted (poorly sorted) coarse to fine sand, with a strong reaction to dilute hydrochloric acid. From 150 to 168.5 ft bgs, this coarse to fine sand (with 5 to 10% silt) is further described as interstratified with very coarse to medium sand. These materials are still weakly cemented with weak to strong reactions to dilute hydrochloric acid.

A thin fine-grained sequence of silty sand and slightly silty sand was encountered between the depths of 168.5 ft and 180 ft bgs. A 0.5-foot thick silty sand was encountered from 168.5 to 169 ft bgs, and was described as brown (10YR5/3), moist, and poorly sorted, with 25 to 35% silt and mostly medium to very coarse sand. The materials were further described as non-plastic and weakly cemented, with strong reaction to hydrochloric acid. Below this depth, the materials are described as brown (10YR/4/3) slightly silty sand, with 10 to 15% silt, and mostly very fine to coarse sand. The materials were described as very weakly cemented, with only a weak reaction to hydrochloric acid. A second silty sand stringer was encountered at 172.5 ft bgs.

From 180 to 218 ft bgs, the materials are described as poorly sorted sand with 5 to <10% silt, and very little gravel. The sand ranged from mostly very coarse to fine, to very coarse to medium. The maximum gravel size ranged from 4 to 15 mm. The material was described as brown (10YR4/3) to light brown (10YR6/3), moist to nearly dry, weakly cemented, and with weak to no reaction to hydrochloric acid. Basalt content ranged from 40 to 60%. Material deeper in the profile (200 to 218 ft bgs) contained some zones described as very compact with some intact clumps recovered that exhibited strong reaction to hydrochloric acid.

B.6.1.1.3.3 Hanford Formation/Plio-Pleistocene Unit (PPlz). DOE-RL (2002) correlates the material below 218 ft bgs to the bottom of the borehole (222.5 ft) with the Hanford formation/Plio-Pleistocene unit described by Serne et al. (2002a, b, c) and Wood et al. (2000). The field geologist described these materials as light grayish brown (10YR6/2) silt, well sorted, with strong reaction to hydrochloric acid. The material was described as moist with a zone of saturation occurring between the depths of 219 and 219.5 ft bgs.

B.6.2 GEOPHYSICAL AND MOISTURE CONTENT MEASUREMENTS

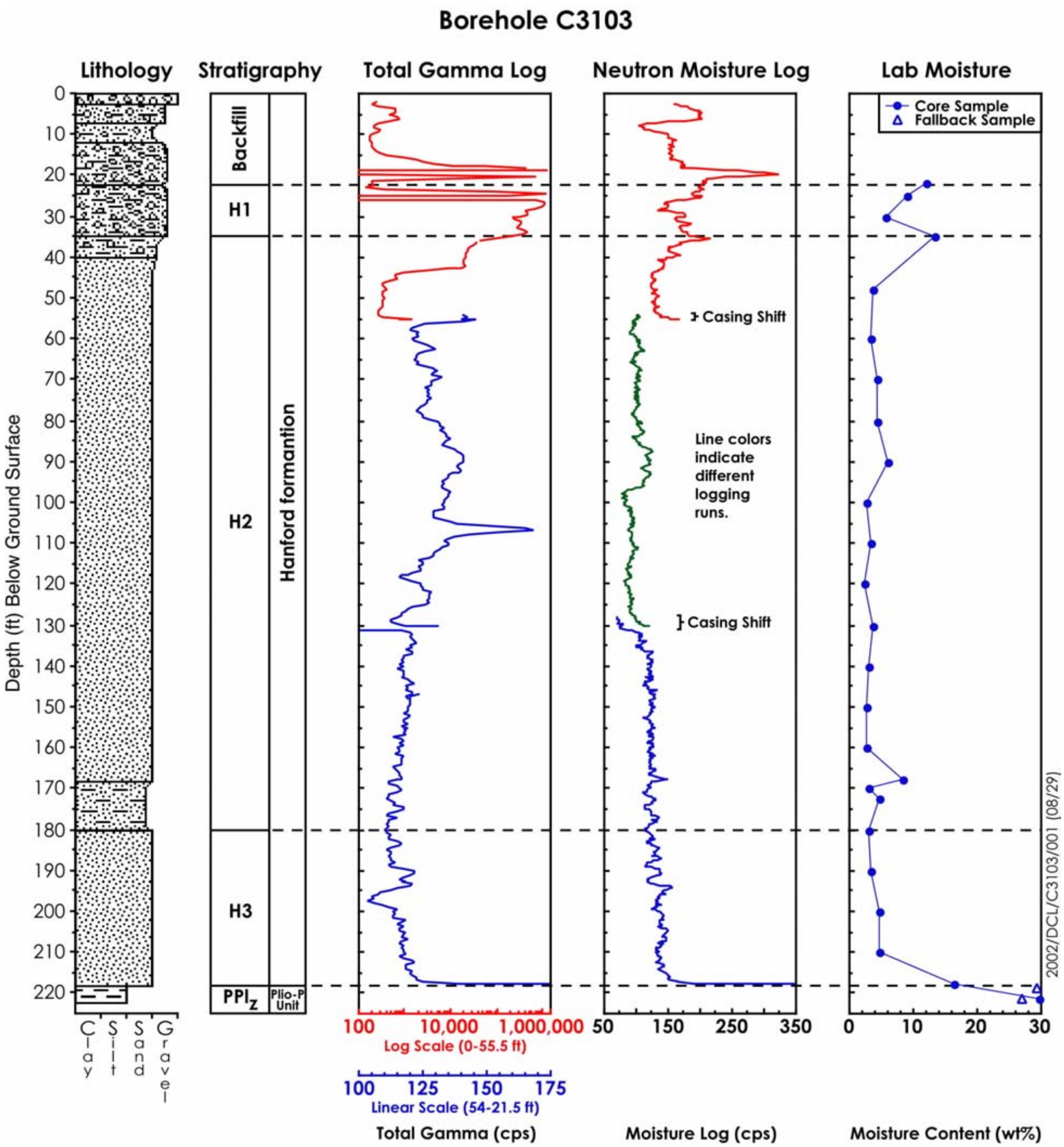
Laboratory moisture content measurements of each of the samples as a function of depth are shown in Table B.20. Down-hole geophysical measurements including a high purity germanium spectral gamma log and a neutron-neutron log compared with laboratory moisture content measurements are shown in Figure B.31.

Table B.20. Moisture Content of Sediments in Borehole C3103

Lithologic Unit	Sample Number	Mid Depth (vertical ft)[a]	% Moisture
Back Fill			
Backfill	7A-22.0	22	12.10%
H1 Coarse Sand			
H1	7A-25.0	25	9.13%
H1	7A-30.0	30	5.67%
H2 Hanford Formation H2 Unit– upper sequence			
H2	7A-35.0	35	13.48%
H2	7A-35Dup	35	13.48%
H2	7A-48	48	3.63%
H2	B10024	60	3.52%
H2	B10025	70	4.30%
H2	B10026	80	4.29%
H2	B10027	90	5.90%
H2	B10027-Dup	90	5.90%
H2	B10028	100	2.79%
H2	B10031	110	3.38%
H2	B10032	120	2.33%
H2	B10033	130	3.81%
H2	B10034	140	2.96%
H2	B10035	150	2.63%
H2	B10036	160	2.82%
H2	B10037	168	8.39%
H2	B10038	170	2.98%
H2	B10039	172.5	4.67%
H2	B10040	180	3.06%
H2	B10041	190	3.29%
H2	B10042	200	4.84%
H2	B10043	210	4.77%
H2	B10043-Dup	210	4.77%
Plio-Pleistocene Mud Unit (PPLz)			
PPLz	B10044	218	16.39%
PPLz	B10045	221.5	29.66%
PPLz	B10046	219	29.44%
PPLz	B10047	221.5	26.94%

[a]Multiply by 0.3048 to convert to meters.

Figure B.31. Borehole C3103 Lithology, Stratigraphy, Geophysical Logs, and Moisture Distribution as a Function of Depth



B.6.3 SOIL WATER CHEMISTRY MEASUREMENTS

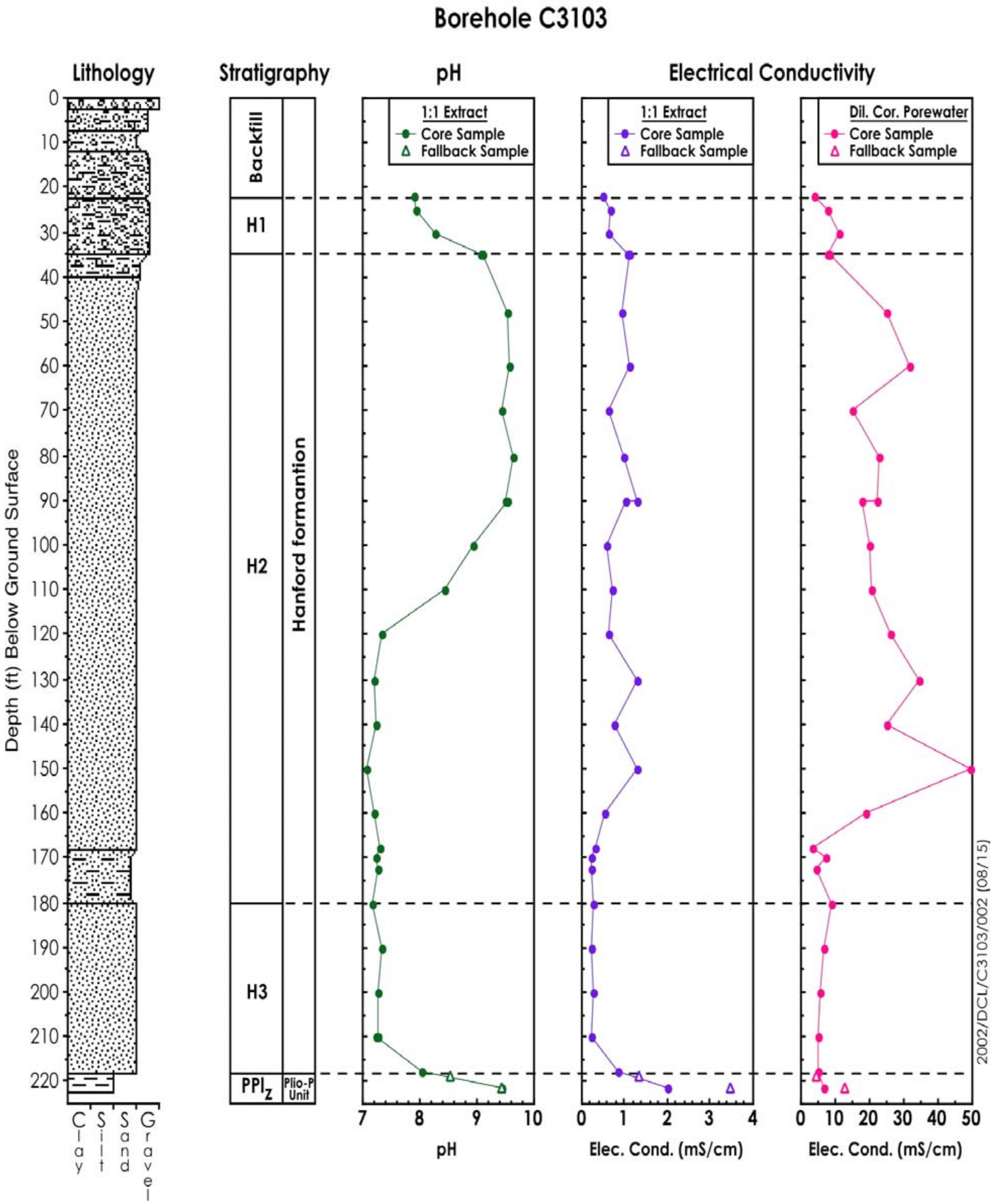
An extensive water chemistry analysis has been completed for borehole C3103 samples collected between 4 and 68 m (12 and 222 ft) bgs. Water extract pH and EC measurements with depth are listed in Table B.21 and graphed in Figure B.32. Elevated pH values (greater than 8.5) are measured between 11 and 30 m (35 and 100 ft) with maximum pH values (9.0 to 9.5) occurring between 11 and 27 m (35 and 90 ft) bgs. Because pH values are expected to decrease as increasing interaction with soil and soil water occurs, the location of increased pH values suggest that the approximate location of initial wastewater interaction with the soil column is at this location. Increases in EC above background also indicate wastewater interactions with soils. In this borehole, the notable increases between 15 and 50 mS/cm occur between 14 and 46 m (45 and 150 ft) bgs. The elevated EC zone occurs at about the same location in the soil column relative to the elevated pH zone but extends about 15 m (50 ft) bgs deeper.

Table B.21. Water Extract pH and Electrical Conductivity Values for Borehole C3103

Sample Identification	Mid Depth (ft)[a]	Dilution Factor	1:1 pH	1:1 EC mS/cm	Pore EC mS/cm
Back Fill					
7A-22.0	22	8.30	7.9	0.49	4.04
H1 Coarse Sand					
7A-25.0	25	10.97	7.92	0.69	7.56
7A-30.0	30	17.62	8.26	0.63	11.05
7A-35.0	35	7.42	9.08	1.09	8.07
H2 Hanford Formation H2 Unit – upper sequence					
7A-35 Dup	35	7.43	9.11	1.12	8.32
7A-48	48	27.59	9.53	0.92	25.33
B10024	60	28.47	9.58	1.12	31.77
B10025	70	23.64	9.45	0.65	15.27
B10026	80	23.31	9.64	0.98	22.77
B10027	90	16.96	9.52	1.30	22.09
B10027-Dup	90	16.94	9.53	1.04	17.60
B10028	100	35.85	8.93	0.57	20.29
B10031	110	29.62	8.45	0.69	20.56
B10032	120	42.95	7.32	0.61	26.07
B10033	130	26.28	7.2	1.31	34.35
B10034	140	33.74	7.23	0.75	25.13
B10035	150	37.99	7.08	1.31	49.76
B10036	160	35.51	7.22	0.53	18.75
B10037	168	11.92	7.31	0.30	3.54
B10038	170	33.60	7.24	0.22	7.42
B10039	172.5	21.45	7.26	0.22	4.70
B10040	180	32.86	7.18	0.28	9.14
B10041	190	30.36	7.34	0.23	6.89
B10042	200	20.68	7.28	0.27	5.56
B10043	210	20.97	7.28	0.23	4.84
B10043-Dup	210	21.21	7.23	0.25	5.22
Plio-Pleistocene Fine-Grained Mud Unit (PPlz)					
B10044	218	6.10	8.04	0.84	5.14
B10045	221.5	3.38	9.45	2.00	6.74
B10046	219	3.40	8.54	1.33	4.52
B10047	221.5	3.71	9.43	3.49	12.97

[a] Multiply by 0.3048 to convert to meters.
EC = electrical conductivity

Figure B.32. Moisture Content, Water Extract pH, and Calculated Porewater Electrical Conductivity for Borehole C3103



Water extract anion concentrations as a function of depth are listed in Table B.22 and graphed in Figure B.33. The primary indicators of wastewater occurrence are nitrate, carbonate, and fluoride. Normally, nitrate is the dominant contaminant in soils contacted by tank waste fluids. However, in this case, all three anions contribute to the electrical elevated conductivity profile. Nitrate is the only contributor to elevated EC at the bottom of the zone measuring elevated EC values.

Elevated bicarbonate concentrations (between 3,000 and 10,500 mg/L) are measured in borehole C3103 from 9 to 34 m (30 to 110 ft) bgs. Maximum bicarbonate values (~10,00 mg/L) occur at 15 m (48 ft) bgs. Elevated fluoride concentrations (between 225 and 1000 mg/L) occur between 8 and 27 m (25 and 90 ft) bgs. Nitrate shows elevated concentrations throughout most of the soil column (> 200 mg/L) and maximum concentrations at greater depth in the soil column relative to carbonate and fluoride indicating that it is largely nonreactive with the soil column. Maximum nitrate values (between 7,000 and 24,000 mg/L) are measured between 34 and 49 m (110 and 160 ft) bgs coincident with the largest carbonate concentrations. Given their location in the soil column, both carbonate and fluoride have been chemically reactive with vadose zone soils.

The other anion with elevated concentrations is sulfate. Like nitrate, sulfate occurs at elevated concentrations (> 100 mg/L) throughout most of the soil column. The highest concentrations (between 600 and 1200 mg/L) occur between 30 and 61 m (180 and 220 ft) bgs. By comparison, calculated sulfate concentrations vary from 70 to 400 mg/L at the clean 299-E33-338 borehole.

Table B.22. Anion Content of Water Extracts for Borehole C3103 (2 pages)

Sample Identification	Depth[(a)]	Dilution Factor	1:1 Extracts in mg/L							Dilution Corrected Porewater mg/L						
			NO3	F	NO2	Cl	SO4	PO4	HCO3	NO3	F	NO2	Cl	SO4	PO4	HCO3
Back fill																
7A-22.0	22	8.30	20.77	5.63	1.23	6.68	24.71	0.45	224.47	172.3	46.7	10.24	55.4	205.0	3.73	1862.38
H1 Coarse Sand																
7A-25.0	25	10.97	110.82	23.96	<0.08	6.29	29.05	0.66	170.79	1215.3	262.7	<0.88	69.0	318.6	7.23	1873.02
7A-30.0	30	17.62	30.66	23.61	<0.08	1.88	22.86	0.51	225.09	540.3	416.1	<1.41	33.1	402.8	8.98	3966.65
H2 Hanford Formation H2 Unit – upper sequence																
7A-35.0	35	7.42	100.48	32.05	<0.08	4.96	40.92	0.69	351.67	745.3	237.7	<0.59	36.8	303.5	5.14	2608.44
7A-35 Dup	35	7.43	115.44	33.26	<0.08	5.57	48.60	0.58	343.10	858.2	247.3	<0.59	41.4	361.3	4.29	2550.56
7A-48	48	27.59	15.59	21.80	<0.08	2.08	12.57	2.15	374.19	430.2	601.5	<2.21	57.5	346.7	59.44	10324.60
B10024	60	28.47	188.66	21.54	0.57	6.53	10.36	1.02	289.19	5370.9	613.2	<16.09	185.8	295.1	28.93	8232.84
B10025	70	23.64	9.33	12.58	<0.08	0.74	3.50	0.50	297.58	220.5	297.3	<1.89	17.5	82.8	11.85	7033.89
B10026	80	23.31	23.85	42.85	<0.08	1.19	6.57	<0.24	338.41	555.9	998.6	<1.86	27.8	153.1	<5.59	7886.98
B10027	90	16.96	188.46	16.60	<0.08	9.17	26.96	1.44	383.32	3196.9	281.7	<1.36	155.6	457.3	24.49	6502.31
B10027-Dup	90	16.94	97.41	11.83	<0.08	4.91	13.22	1.29	353.74	1650.4	200.4	<1.36	83.1	224.0	21.79	5993.35
B10028	100	35.85	125.77	2.76	<0.08	4.96	14.79	0.30	168.15	4509.1	99.0	<2.87	177.9	530.3	10.81	6028.26
B10031	110	29.62	247.49	0.38	0.10	5.18	17.20	<0.24	105.41	7331.6	11.3	3.10	153.4	509.6	<7.11	3122.82
B10032	120	42.95	248.47	0.25	0.14	4.56	10.76	<0.24	<50.00	10671.1	10.7	5.99	195.8	462.1	<10.31	<2147.35
B10033	130	26.28	625.53	0.23	0.22	9.18	14.97	<0.24	<50.00	16438.9	6.1	5.76	241.2	393.4	<6.31	<1313.99
B10034	140	33.74	319.51	0.23	<0.08	4.69	10.18	<0.24	<50.00	10779.1	7.9	2.70	158.2	343.4	<8.10	<1686.81
B10035	150	37.99	629.88	0.20	<0.08	9.53	20.02	<0.24	<50.00	23927.4	7.6	3.04	362.0	760.5	<9.12	<1899.37
B10036	160	35.51	207.48	0.21	<0.08	4.26	16.98	<0.24	<50.00	7367.5	7.6	2.84	151.3	602.9	<8.52	<1775.45
B10037	168	11.92	53.77	0.48	<0.08	4.16	30.64	<0.24	70.37	641.1	5.7	0.95	49.6	365.4	<2.86	839.11
B10038	170	33.60	24.30	0.37	<0.08	2.94	25.37	<0.24	65.53	816.2	12.5	2.69	98.7	852.4	<8.06	2201.43
B10039	172.5	21.45	22.80	0.44	<0.08	1.89	25.86	<0.24	69.44	489.1	9.3	1.72	40.5	554.8	<5.15	1489.76
B10040	180	32.86	45.39	0.34	<0.08	4.94	35.67	<0.24	<50.00	1491.7	11.2	2.63	162.2	1172.4	<7.89	<1643.17

Table B.22. Anion Content of Water Extracts for Borehole C3103 (2 pages)

Sample Identification	Depth[a]	Dilution Factor	1:1 Extracts in mg/L							Dilution Corrected Porewater mg/L						
			NO3	F	NO2	Cl	SO4	PO4	HCO3	NO3	F	NO2	Cl	SO4	PO4	HCO3
B10041	190	30.36	16.45	0.49	<0.08	3.88	31.02	0.27	<50.00	499.5	14.9	2.43	117.8	941.8	8.22	<1517.97
B10042	200	20.68	19.75	0.57	<0.08	7.77	40.02	<0.24	<50.00	408.4	11.7	1.65	160.7	827.5	<4.96	<1033.82
B10043	210	20.97	19.62	0.33	<0.08	8.86	29.20	<0.24	<50.00	411.4	6.9	1.68	185.7	612.3	<5.03	<1048.36
B10043-Dup	210	21.21	19.53	0.32	<0.08	8.81	37.08	<0.24	<50.00	414.2	6.7	1.70	186.9	786.3	<5.09	<1060.29
Plio-Pleistocene Fine-Grained Mud Unit (PPlz)																
B10044	218	6.10	71.84	22.32	<0.08	17.22	142.28	<0.24	118.20	438.3	136.2	0.49	105.0	868.1	<1.46	721.20
B10045	221.5	3.38	217.50	64.80	<0.08	15.29	88.07	6.00	571.43	734.5	218.8	0.27	51.7	297.4	20.26	1929.72
B10046	219	3.40	57.30	44.81	<0.08	31.14	158.47	0.96	333.21	194.7	152.2	0.27	105.8	538.4	3.26	1132.08
B10047	221.5	3.71	591.85	132.13	3.61	26.97	182.49	3.91	688.70	2197.6	490.6	13.42	100.1	677.6	14.51	2557.26

[a] Multiply by 0.3048 to convert to meters.

Figure B.33. Porewater Anions Calculated from Water Extracts for Borehole C3103 (2 pages)

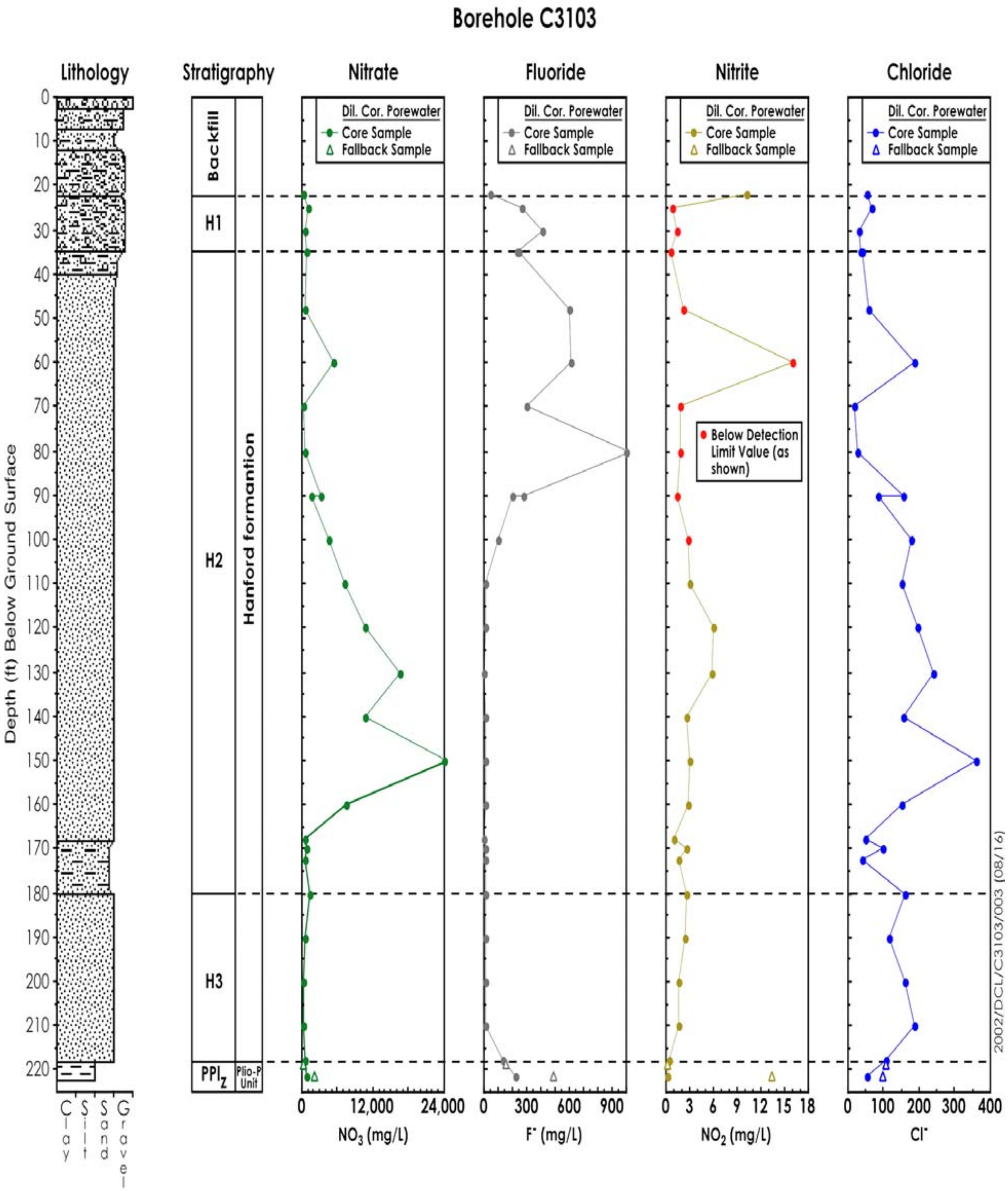
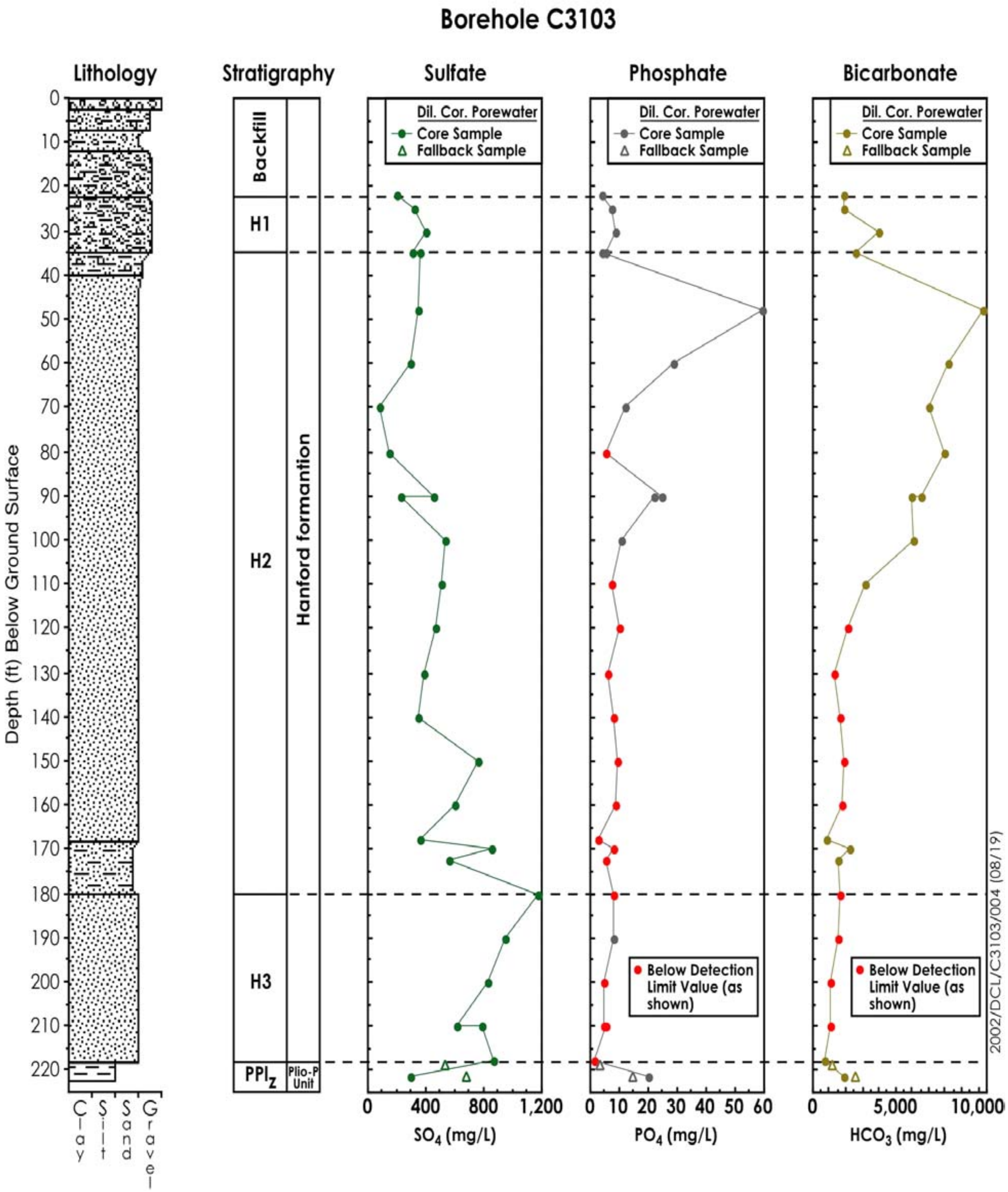


Figure B.33. Porewater Anions Calculated from Water Extracts for Borehole C3103 (2 pages)



Water extract cation concentrations as a function of depth are graphed in Figure B.34 and listed in Table B.23. Among the cations, elevated sodium concentrations are the primary indicators of wastewater occurrence in the soil column. Sodium concentrations in most samples are elevated throughout the soil column (> 300 mg/L). Highest concentrations (1,900 and 6,200 mg/L) exist between 9 and 40 m (30 and 130 ft) bgs. The other monovalent cation, potassium, is present at lower but still elevated concentrations (200 to 600 mg/L) and is more evenly distributed in the soil column.

Other cations showing elevated concentrations include magnesium (between 75 and 1400 mg/L) and calcium (between 250 and 1,400 mg/L) between 37 and 64 m (120 and 210 ft) bgs. These cations are also depleted between 8 and 34 m (25 and 110 ft) bgs. The combined pattern of sodium, potassium, calcium, and magnesium distribution in the soil column is a classic example of ion exchange creating a chromatographic effect in the column. This occurs as sodium in the infiltrating fluid preferentially displaces the divalent cations originally sorbed on soil phases causing them to be depleted in the interaction zone and to migrate ahead of the sodium front in the direction of flow.

The last group of analyzed constituents included radionuclides and trace metals as shown in Table B.24 and Figure B.35. The only radionuclides found in these soils were uranium and cesium-137. Uranium concentrations (between 22 and 330 µg/g) were elevated between 7 and 11 m (22 and 35 ft) bgs. In the remainder of the soil column, uranium concentrations were < 3 µg/g and are assumed to be naturally occurring soil concentrations. Cesium-137 is also concentrated between at the top of the soil column between 7 and 12 m (22 and 48 ft) bgs. Concentrations range between 7 to 90,800 pCi/g. In the remainder of the soil column, cesium-137 was only detected at 58 m (190 ft) bgs at a low concentration of 0.2 pCi/g.

Table B.23. Cation Content of Water Extracts for Borehole C3103 (2 pages)

Sample Identification	Depth (ft bgs)[(a)]	Dilution Factor	Dilution Corrected Porewater Concentration of Cations								
			Al mg/L	Ba mg/L	Ca mg/L	Fe mg/L	K mg/L	Mg mg/L	Na mg/L	Si mg/L	Sr mg/L
Back Fill											
7A-22.0	22	8.30	(6.67E-02)	1.92E-01	2.42E+02	1.31E-01	1.36E+02	6.96E+01	3.97E+02	7.32E+01	1.60E+00
H1 Coarse Sand											
7A-25.0	25	10.97	5.66E-01	1.14E-01	3.77E+01	2.75E-01	1.89E+02	6.81E+00	1.36E+03	7.96E+01	4.78E-01
7A-30.0	30	17.62	2.15E+00	3.19E-01	3.28E+01	1.77E+00	6.20E+02	1.60E+01	1.93E+03	1.62E+02	(7.24E-02)
H2 Hanford Formation H2 Unit – upper sequence											
7A-35.0	35	7.42	5.82E-01	6.22E-02	3.42E+00	2.29E+00	2.61E+02	1.13E+00	1.60E+03	8.16E+01	(1.88E-02)
7A-35Dup	35	7.43	6.95E-01	5.67E-02	3.46E+00	2.60E+00	2.65E+02	1.14E+00	1.61E+03	8.62E+01	(2.11E-02)
7A-48	48	27.59	1.50E+01	2.03E-01	1.30E+01	1.90E+01	2.92E+02	3.85E+00	5.32E+03	3.34E+02	(1.37E-01)
B10024	60	28.47	7.86E+00	2.30E-01	1.68E+01	2.40E+00	1.99E+02	1.96E+00	6.21E+03	3.05E+02	(1.59E-01)
B10025	70	23.64	9.49E+00	5.37E-01	1.10E+01	1.60E+01	5.05E+01	3.64E+00	3.04E+03	3.00E+02	(1.22E-01)
B10026	80	23.31	8.37E+00	4.54E-01	1.25E+01	6.97E+00	5.22E+01	1.59E+00	4.72E+03	2.80E+02	(1.45E-01)
B10027	90	16.96	4.45E+00	3.93E-01	7.72E+00	4.03E+00	4.75E+01	9.56E-01	4.54E+03	1.83E+02	(1.22E-01)
B10027-Dup	90	16.94	5.26E+00	3.08E-01	6.98E+00	9.90E+00	3.87E+01	9.32E-01	3.55E+03	1.93E+02	(1.00E-01)
B10028	100	35.85	5.80E+00	3.25E-01	2.18E+01	3.38E+00	7.85E+01	5.45E+00	3.94E+03	3.29E+02	(2.18E-01)
B10031	110	29.62	2.11E+00	4.33E-01	4.75E+01	1.66E+00	1.05E+02	1.21E+01	3.76E+03	2.56E+02	3.81E-01
B10032	120	42.95	8.51E-01	1.84E+00	8.01E+02	6.17E-01	3.23E+02	2.81E+02	3.20E+03	2.99E+02	5.42E+00
B10033	130	26.28	<2.63E-01	4.89E+00	ND	2.24E-01	3.58E+02	6.16E+02	2.68E+03	2.49E+02	1.54E+01
B10034	140	33.74	(6.62E-02)	4.31E+00	ND	2.28E-01	3.89E+02	6.35E+02	6.86E+02	2.60E+02	1.46E+01
B10035	150	37.99	<3.80E-01	5.22E+00	ND	5.06E-01	5.05E+02	1.38E+03	9.76E+02	2.78E+02	3.03E+01
B10036	160	35.51	(1.96E-01)	2.63E+00	1.41E+03	5.09E-01	3.25E+02	4.71E+02	7.06E+02	2.92E+02	9.47E+00
B10037	168	11.92	2.75E-01	2.90E-01	2.35E+02	1.65E-01	7.45E+01	6.97E+01	2.28E+02	1.27E+02	1.34E+00

Table B.23. Cation Content of Water Extracts for Borehole C3103 (2 pages)

Sample Identification	Depth (ft bgs)[(a)]	Dilution Factor	Dilution Corrected Porewater Concentration of Cations								
			Al mg/L	Ba mg/L	Ca mg/L	Fe mg/L	K mg/L	Mg mg/L	Na mg/L	Si mg/L	Sr mg/L
B10038	170	33.60	1.27E+00	8.56E-01	3.41E+02	1.22E+00	1.85E+02	1.05E+02	6.72E+02	2.90E+02	2.22E+00
B10039	172.5	21.45	5.87E-01	1.01E+00	2.50E+02	3.08E-01	1.07E+02	6.97E+01	3.90E+02	2.16E+02	1.49E+00
B10040	180	32.86	1.24E+00	9.61E-01	5.90E+02	7.37E-01	2.10E+02	1.86E+02	5.30E+02	2.94E+02	3.55E+00
B10041	190	30.36	1.27E+00	9.43E-01	4.16E+02	5.54E-01	1.71E+02	1.30E+02	4.84E+02	3.23E+02	2.84E+00
B10042	200	20.68	9.51E-01	6.54E-01	2.86E+02	4.49E-01	1.37E+02	8.64E+01	4.73E+02	1.85E+02	2.24E+00
B10043	210	20.97	9.34E-01	6.03E-01	3.32E+02	9.26E-01	9.10E+01	7.97E+01	3.14E+02	1.86E+02	2.13E+00
B10043-Dup	210	21.21	9.64E-01	1.06E+00	3.66E+02	4.09E-01	9.58E+01	8.68E+01	3.27E+02	1.96E+02	2.41E+00
Plio-Pleistocene Fine-Grained Mud Unit (PPlz)											
B10044	218	6.10	6.57E-02	9.40E-02	8.66E+01	3.19E-01	3.54E+02	3.68E+01	6.55E+02	1.27E+02	8.14E-01
B10045	221.5	3.38	1.41E+00	6.37E-02	1.93E+00	1.54E+00	5.39E+01	1.20E-01	1.40E+03	2.10E+01	4.24E-02
B10046	219	3.40	1.46E-01	7.54E-02	4.91E+00	2.83E-01	1.64E+02	8.43E-01	8.66E+02	3.58E+01	7.77E-02
B10047	221.5	3.71	1.07E+00	6.04E-02	2.42E+00	2.27E-01	1.70E+01	2.87E-01	2.60E+03	1.85E+01	8.15E-02

[(a)] Multiply by 0.3048 to convert to meters.
Values in parentheses are below level of quantification but spectra look useable.
ND = no data available; results exceeded calibration limit

Figure B.34. Porewater Cations Calculated from Water Extracts for Borehole C3103 (2 pages)

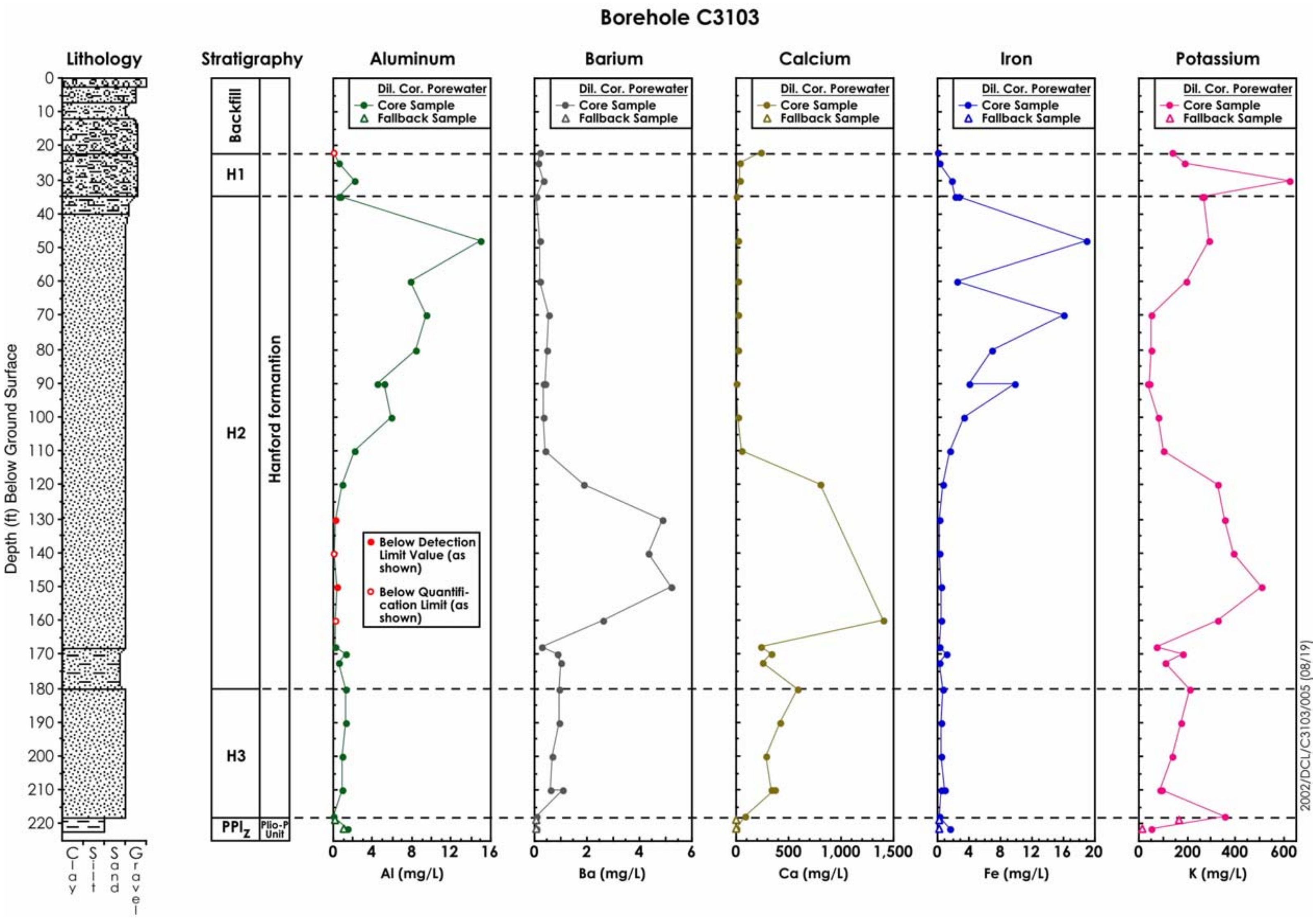


Figure B.34. Porewater Cations Calculated from Water Extracts for Borehole C3103 (2 pages)

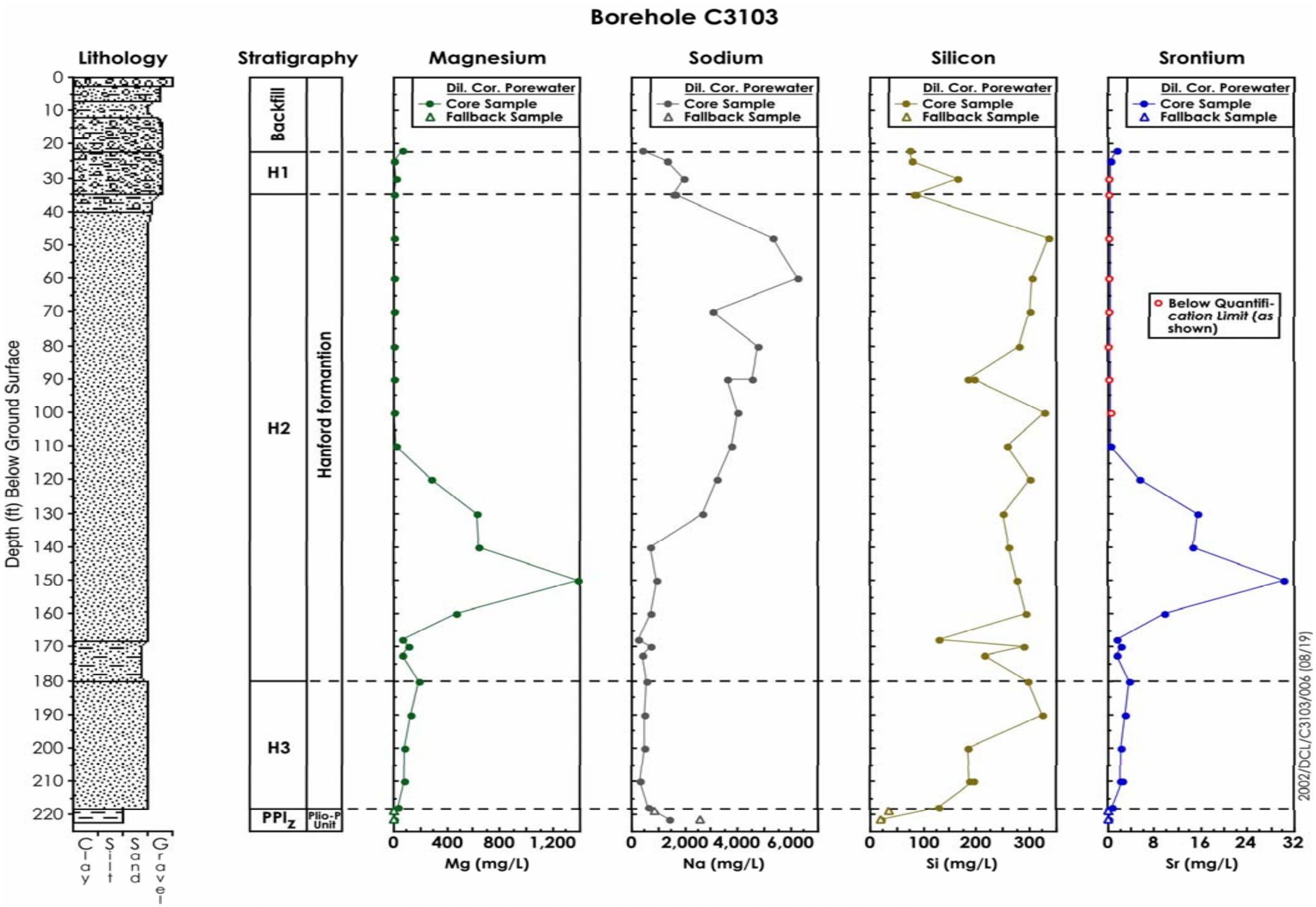
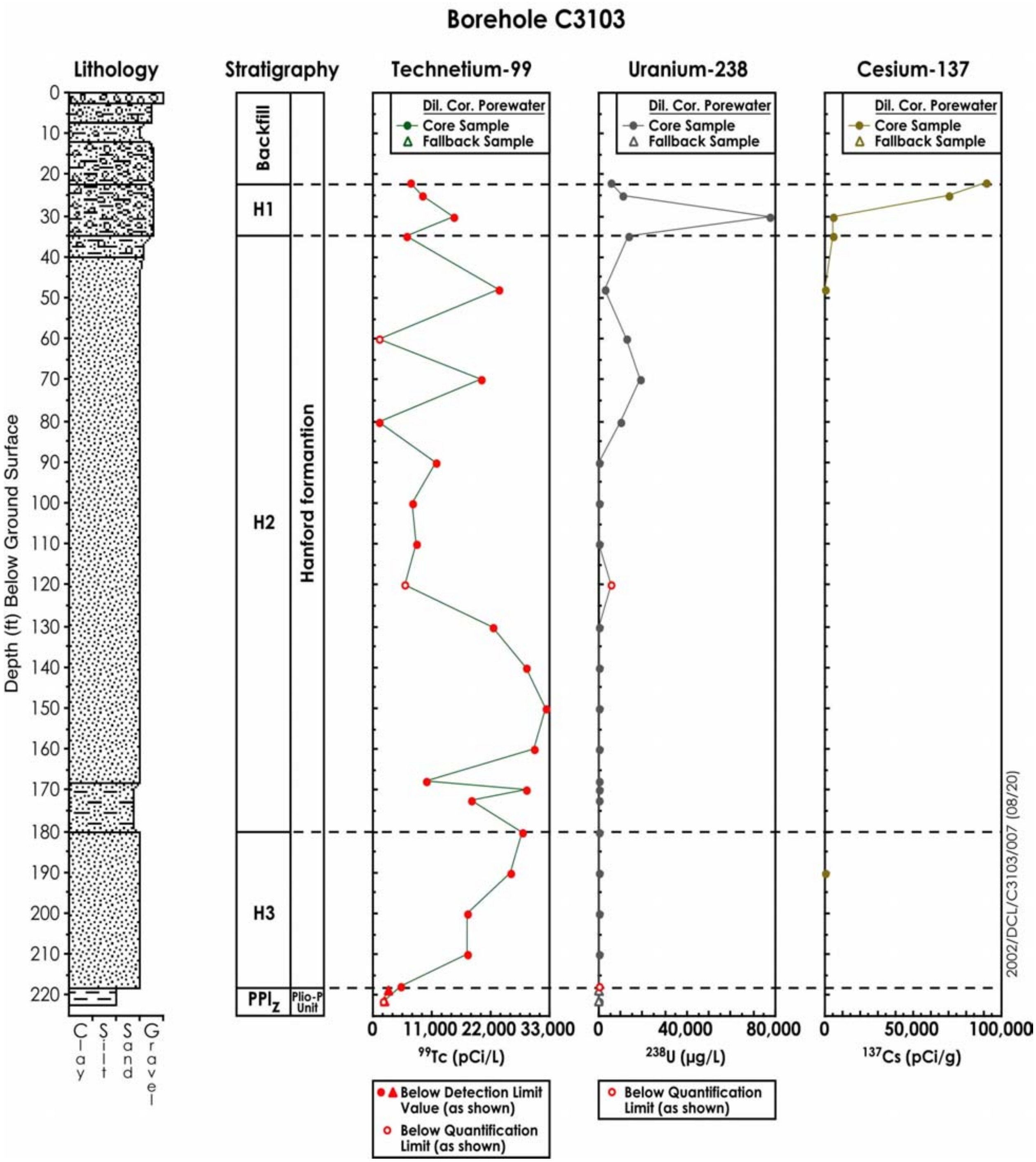


Table B.24. Porewater Radionuclides Concentrations Calculated from Water Extracts and Total Cesium-137 in Sediment for Borehole C3103

Identification	Depth (ft bgs)[a]	Dilution Factor	Tc-99 pCi/L	U-238 ug/L	Cs-137 pCi/g
Back fill					
7A-22.0	22	8.30	<7.04E+03	5.11E+03	9.08E+04
H1 Coarse Sand					
7A-25.0	25	10.97	<9.30E+03	1.07E+04	6.97E+04
7A-30.0	30	17.62	<1.49E+04	7.78E+04	4.95E+03
H2 Hanford Formation H2 Unit– upper sequence					
7A-35.0	35	7.42	<6.29E+03	1.31E+04	4.81E+03
7A-35 Dup	35	7.43	<6.30E+03	1.42E+04	5.10E+03
7A-48	48	27.59	<2.34E+04	2.32E+03	7.55E+00
B10024	60	28.47	(9.66E+02)	1.26E+04	<MDA
B10025	70	23.64	<2.00E+04	1.87E+04	<MDA
B10026	80	23.31	<1.19E+03	1.01E+04	<MDA
B10027	90	16.96	<1.18E+04	4.70E+02	<MDA
B10027-Dup	90	16.94	<5.17E+03	3.61E+02	<MDA
B10028	100	35.85	<7.30E+03	6.50E+01	<MDA
B10031	110	29.62	<8.04E+03	2.78E+01	<MDA
B10032	120	42.95	(5.83E+03)	(5827.04)	<MDA
B10033	130	26.28	<2.23E+04	8.83E+00	<MDA
B10034	140	33.74	<2.86E+04	1.19E+01	<MDA
B10035	150	37.99	<3.22E+04	2.34E+01	<MDA
B10036	160	35.51	<3.01E+04	2.34E+01	<MDA
B10037	168	11.92	<1.01E+04	7.47E+00	<MDA
B10038	170	33.60	<2.85E+04	1.24E+01	<MDA
B10039	172.5	21.45	<1.82E+04	8.77E+00	<MDA
B10040	180	32.86	<2.79E+04	1.45E+01	<MDA
B10041	190	30.36	<2.57E+04	1.93E+01	1.18E-01
B10042	200	20.68	<1.75E+04	7.38E+00	<MDA
B10043	210	20.97	<1.78E+04	1.38E+01	<MDA
B10043-Dup	210	21.21	<1.80E+04	1.70E+01	<MDA
Plio-Pleistocene Fine-Grained Mud Unit (PPlz)					
B10044	218	6.10	<5.17E+03	(3.66E-02)	<MDA
B10045	221.5	3.38	(1.72E+03)	1.08E+01	<MDA
B10046	219	3.40	<2.88E+03	4.18E+00	<MDA
B10047	221.5	3.71	<2.33E+03	3.70E+01	<MDA

[a] Multiply by 0.3048 to convert to meters.
<MDA = Below minimum detectable activity

Figure B.35. Trace Metals and Radionuclides Calculated from Sediment-to-Water Extracts and Measured in Actual Porewaters for Borehole C3103



B.6.4 CHEMICAL INTERACTIONS

No specific experiments were completed on soils from borehole C3103 to quantify geochemical reactions influencing contaminant migration. Typically, chemical reactions affecting radionuclides and wastewater chemicals are inferred from the relative locations of these constituents in the soil column, comparison of acid-leachable versus water-leachable concentrations for specific contaminants, and general knowledge of tank fluid chemistry. The primary reactions involving wastewater and the soil column appear to be a reduction of tank fluid pH as it has reacted with lower pH soil water, in situ displacement of ambient divalent cations with high sodium present in the wastewater, and precipitation of uranium and essentially complete sorption of cesium-137 just below the crib bottom.

Best estimates of typical wastewater fluid suggest that a pH between 10 and 11 was likely. The observation of an elevated zone between pH 8.5 and 9 just below the crib bottom indicates partial buffering of the infiltrating wastewater by reaction with soil phases and soil water whose ambient pH values are between 7.0 and 7.5 in this area. The location of a high concentration of cesium-137 at 9.08×10^4 pCi/g from a grab sample analysis is shown in Table B.24 and is estimated to be between 7 and 11 m (22 and 35 ft) bgs. This value is consistent with the 6.73×10^4 to 1.53×10^5 pCi/g cesium-137 concentration range for this depth as reported in the *Remedial Investigation Report for the 200-TW-1 and 200-TW-2 Operable Units* (DOE-RL 2002). Further down the soil column (18.3 m), the concentration of cesium-137 becomes nonexistent above background indicating a rapid and essentially complete reaction of this contaminant with the soil-water system. Uranium appears to have migrated down as far as 90 ft bgs. Conversely, other more mobile constituents appear to have migrated down to groundwater as indicated by the elevated concentrations of nitrate and sulfate in almost all samples.

B.6.5 SEDIMENT MATRIC POTENTIAL AT BOREHOLE C3103

No samples were preserved by the environmental restoration contractor that could be used to measure matric potential for the borehole at this disposal facility.

B.6.6 SELECTED SAMPLES FROM BOREHOLE C3104 (TRENCH 216-B-38)

To investigate potential locations and depths of technetium-99 contamination located in WMA B-BX-BY, three samples from drums containing drill cuttings from the C3104 borehole at trench 216-B-38 were collected and transported to PNNL for technetium-99 analyses. The samples were collected on January 11, 2002 from 3 separate drums identified as 200E-0100063 with “soils from 106-ft to 118-ft”, 200E-01-0068 with “soils from 198-ft to 217-ft”, and 200E-01-0071 with “soils from 240-ft to 263.5-ft.” A best effort was made to collect samples from target depths of 110 ft, 210 ft, and 250 ft respectively, however, due to the potential mixing of sediment within these drums during filling, the samples collected should be considered approximations of the target depths.

B.6.7 SOIL MOISTURE AND WATER CHEMISTRY MEASUREMENTS

Results from ICP-MS analysis (Table B.28) did not show any technetium-99 above the quantification limit for either the water or acid extract methods. Of note was an extremely high porewater corrected nitrate value of 64,142 mg/L found at a depth of ~110 ft-bgs. Such elevated nitrate levels are usually associated with technetium-99 contamination if both contaminants are waste discharge constituents. A summary of additional water and acid extract analyses are shown in Tables B.25 through B.28.

Table B.25. Soil Moisture Content of Drum Samples from Borehole C3104

Sample Identification	Mid Depth (vertical ft)[a]	% Moisture
S02021-01-110	110	2.12%
S02021-02-210	210	3.45%
S02021-03-350	250	2.35%

[a] Multiply by 0.3048 to convert to meters.

Table B.26. Water Extract pH and Electrical Conductivity Values for Borehole C3104

Sample Identification	Mid Depth (ft)[a]	Dilution Factor	1:1 pH	1:1 EC mS/cm	Pore EC mS/cm
S02021-01-110	110	48.90	7.04	2.4	117.354
S02021-02-210	210	29.56	7.37	0.256	7.567
S02021-03-350	250	42.35	7.52	0.251	10.629

[a] Multiply by 0.3048 to convert to meters.

Table B.27. Anion Content of Water Extracts for Borehole C3104

Sample Identification	Depth (ft)[a]	Dilution Factor	1:1 Extracts in mg/L						
			NO3	F	NO2	Cl	SO4	PO4	HCO3
S02021-01-110	110	NA	1312.6	0.187	8.662	17.19	30.0	<0.014	58.5
S02021-02-210	210	NA	22.4	0.507	<0.007	1.95	46.5	<0.014	54.0
S02021-03-350	250	NA	6.0	0.651	<0.007	1.90	54.4	<0.014	53.7
Dilution Corrected Porewater mg/L									
S02021-01-110	110	48.90	64182	9.15	423.55	840.6	1469.4	<0.685	2860.9
S02021-02-210	210	29.56	662.2	15.0	<0.216	57.6	1374.5	<0.414	1595.8
S02021-03-350	250	42.35	252.7	27.6	<0.309	80.4	2302.9	<0.593	2272.6

[a] Multiply by 0.3048 to convert to meters.

B.6.8 TRACE METAL AND RADIONUCLIDE ANALYSIS

Both one-to-one water extracts and acid leachates from each of the three samples were analysed by ICP-MS for uranium and technetium-99 and the results are shown in Table B.28.

Table B.28. Porewater and Dry Sediment Concentration of Technetium-99 and Uranium-238 Calculated from Water and Acid Extracts for Borehole C3104

Sample Identification	Depth (ft bgs)[(a)]	Dilution Factor	Tc-99 pCi/L	U-238 ug/L
Concentration as Porewater				
S02021-01-110	110	48.90	<4107	29.84
S02021-02-210	210	29.56	<2483	14.22
S02021-03-350	250	42.35	<3557	19.95
Concentration as Dry Sediment				
S02021-01-110	110	5.54	<848	628.20
S02021-02-210	210	5.69	<848	455.99
S02021-03-350	250	5.52	<848	498.31

B.6.9 ADDITIONAL DATA FROM BECHTEL HANFORD, INC. BOREHOLE C3104 INVESTIGATION

The C3104 was drilled through the 216-B-38 trench using the cable tool method to a final depth of 263.5 ft (80.3 m). A total of 18 depths were sampled during the drilling as shown in Table B.29. Laboratory analyses for soil pH and anions (Table B.29), major cations (Table B.30), and radionuclides (Table B.31) are reported from *Remedial Investigation Report for the 200-TW-1 and 200-TW-2 Operable Units* (DOE-RL 2002).

Table B.29. Soil pH and Anion Concentrations Reported in Terms of Dry Sediment

Sample	Sample Interval (ft-bgs)	Date	pH Measurement pH	Chloride ug/kg	Fluoride ug/kg	Nitrate ug/kg	Nitrite ug/kg	Nitrogen in Nitrite and Nitrate ug/kg	Phosphate ug/kg	Sulfate ug/kg	Total organic carbon ug/kg
B12684	0-0.5	7/18/2001	—	—	—	—	—	—	—	—	—
B12C67	3.5-5.0	8/1/2001	8.7	5000	5,200 U	94400	2,620 U	23100	8200	51100	1,510,000
B12C68	9.5-12.0	8/2/2001	8.8	6900	2,700 U	208000	1,340 U	59100	1600	248000	988,000
B12C63	14.5-15.5	8/2/2001	8.9	110 U	7,400 B	193000	69 U	39,500	370 U	114,000 B	274000
B12C64	18-20.5	8/2/2001	9.6	100 U	14,200 B	54400	69 U	6,100	27,100 B	35,000 B	1060000
B12DB8	22.5-25	8/3/2001	9.4	100 U	20,000 B	67700	69 U	8400	34,100 B	49,100 B	889000
B12DB9	29-31.5	8/3/2001	9.6	11,700 B	33,400 B	141000	69 U	25300	67,400 B	151,000 B	151000
B12C88	37.5-40	8/5/2001	9.5	24,600 B	32,900 B	615000	69 U	110000	137,000 B	69,800 B	166000
B12DC0	Split	8/5/2001	8.8	20,500 B	28,900 B	522000	69 U	146000	106,000 B	60,600 B	133000
B12C69	52-54.5	8/6/2001	9.65	25600	12,900 U	2090000	34300	464000	149000	106000	191000
B12C70	Duplicate	8/6/2001	9.5	26400	12,900 U	2140000	34700	486000	121000	110000	127000
B12C71	97.5-100	8/7/2001	9.3	31000	6,400 U	1880000	35200	449000	6,400 U	131000	1610000
B12C72	147.5-150	8/8/2001	8.3	41100	6,400 U	3180000	41200	753000	6,400 U	48200	1380000
B12C73	197.5-200	8/9/2001	8.8	6600	2,600 U	57600	2,560 U	17800	2,600 U	38100	2760000
B12C74	264-265.5	8/10/2001	8.9	2800	1,300 U	1480	1,310 U	200 U	1,300 U	13500	1550000

[a] Multiply by 0.3048 to convert to meters.
B = The associated QC sample has a result greater than two times the MDA
J = Concentration estimated
U=Analyzed for but not detected above the minimum activity in the sample

Table B.30. Cation Concentrations Reported in Terms of Dry Sediment (2 pages)

Sample	Sample Interval (ft-bgs)	Date	Aluminum mg/kg	Bismuth mg/kg	Cadmium mg/kg	Calcium mg/kg	Chromium mg/kg	Copper mg/kg	Hexavalent Chromium mg/kg	Iron mg/kg	Lead mg/kg
B12684	0-0.5	7/18/2001	—	—	—	—	—	—	—	—	—
B12C67	3.5-5.0	8/1/2001	—	—	0.06	—	11.6	12.9	0.42 U	—	6.8
B12C68	9.5-12.0	8/2/2001	—	—	0.1	—	11.5	15.1	0.43 U	—	8
B12C63	14.5-15.5	8/2/2001	7600	2.2 U	0.021 U	9,610.00	7.1	12.20	0.08 U	18,100	44.5 B
B12C64	18-20.5	8/2/2001	7830	2.2 U	0.021 U	8,030.00	10	13.00	0.08 U	19,800	5.9 B
B12DB8	22.5-25	8/3/2001	—	—	0.18 U	—	11.1	11.7	0.08 U	—	4.2 B
B12DB9	29-31.5	8/3/2001	—	—	0.18 U	—	9.2	9.9	0.08 U	—	3.9 B
B12C88	37.5-40	8/5/2001	—	—	0.18 U	—	8	11.4	0.08 U	—	3.4 U
B12DC0	Split	8/5/2001	—	—	0.18 U	—	8	11.8	0.08 U	—	3.3 U
B12C69	52-54.5	8/6/2001	—	—	0.07	—	8.4	8.8	0.49	—	3.4
B12C70	Duplicate	8/6/2001	—	—	0.09	—	12.7	13.4	0.62	—	3.1
B12C71	97.5-100	8/7/2001	—	—	0.03 U	—	18	12.1	0.41 U	—	3.6
B12C72	147.5-150	8/8/2001	—	—	0.03 U	—	14.5	9.4	0.41 U	—	2.9
B12C73	197.5-200	8/9/2001	—	—	0.03 U	—	14.4	10.4	0.41 U	—	2.7
B12C74	264-265.5	8/10/2001	—	—	0.03 U	—	14	18.8	0.42 U	—	3.1

[a] Multiply by 0.3048 to convert to meters.
B = The associated QC sample has a result greater than two times the MDA
J = Concentration estimated
U=Analyzed for but not detected above the minimum activity in the sample.

Table B.30. Cation Concentrations Reported in Terms of Dry Sediment (2 pages)

Sample	Sample Interval (ft-bgs)	Date	Magnesium mg/kg	Manganese mg/kg	Mercury mg/kg	Molybdenum mg/kg	Nickel mg/kg	Potassium mg/kg	Silver mg/kg	Vanadium mg/kg	Zinc mg/kg
B12684	0-0.5	7/18/2001	—	—	—	—	—	—	—	—	—
B12C67	3.5-5.0	8/1/2001	—	—	0.02 U	—	12.1	—	0.05 U	—	—
B12C68	9.5-12.0	8/2/2001	—	—	0.02 U	—	10.7	—	0.05 U	—	—
B12C63	14.5-15.5	8/2/2001	3,820	287	0.089 B	0.92 U	6.3	1,140	0.11 U	55.1	43.9
B12C64	18-20.5	8/2/2001	4,580	317	0.035 B	0.91 U	6.6	1,120	0.1 U	63.9	54.9
B12DB8	22.5-25	8/3/2001	—	—	0.025 B	—	8.1	—	0.95 U	—	—
B12DB9	29-31.5	8/3/2001	—	—	0.025 U	—	9.9	—	0.96 U	—	—
B12C88	37.5-40	8/5/2001	—	—	0.025 U	—	5.8	—	0.95 U	—	—
B12DC0	Split	8/5/2001	—	—	0.025 U	—	5.6	—	0.95 U	—	—
B12C69	52-54.5	8/6/2001	—	—	0.02 U	—	8	—	0.05 U	—	—
B12C70	Duplicate	8/6/2001	—	—	0.01 U	—	15.4	—	0.05 U	—	—
B12C71	97.5-100	8/7/2001	—	—	0.02 U	—	22	—	0.05 U	—	—
B12C72	147.5-150	8/8/2001	—	—	0.02 U	—	13.3	—	0.05 U	—	—
B12C73	197.5-200	8/9/2001	—	—	0.02 U	—	14.5	—	0.05 U	—	—
B12C74	264-265.5	8/10/2001	—	—	0.02 U	—	12.1	—	0.05 U	—	—

[a] Multiply by 0.3048 to convert to meters
B= The associated QC sample has a result greater than two times the MDA
J = Concentration estimated
U=Analyzed for but not detected above the minimum activity in the sample.

Table B.31. Radionuclide Activity Reported in Terms of Dry Sediment (2 pages)

Sample	Sample Interval (ft-bgs)	Date	Total beta radiostrontium pCi/g	Cesium-137 pCi/g	Potassium-40 pCi/g	Radium-226 pCi/g	Radium-228 pCi/g	Technetium-99 pCi/g
B12684	0-0.5	7/18/2001	—	—	—	—	—	—
B12C67	3.5-5.0	8/1/2001	0.175 U	1.82	14	0.594	0.685	-0.1 U
B12C68	9.5-12.0	8/2/2001	-0.06 U	0.036 U	14.5	0.12 U	0.974	-0.04 U
B12C63	14.5-15.5	8/2/2001	1390	226000	87 U	62 U	45 U	0.20 U
B12C64	18-20.5	8/2/2001	2050	226000	273	86 U	54 U	0.007 U
B12DB8	22.5-25	8/3/2001	288	17900	19.3	4.4 U	1.7 U	-0.209 U
B12DB9	29-31.5	8/3/2001	50.9	95700	93 U	85 U	40 U	-0.07 U
B12C88	37.5-40	8/5/2001	0.129 U	31600	34.2	12 U	4.6 U	0.128 U
B12DC0	Split	8/5/2001	0.164 U	25800	32.9	6.7 U	2.59	0.037 U
B12C69	52-54.5	8/6/2001	0.033 U	0.102	15.4	0.438	0.741	1.9 J
B12C70	Duplicate	8/6/2001	-0.032 U	0.11	16.8	0.479	0.827	1.93 J
B12C71	97.5-100	8/7/2001	-0.182 U	0.047 U	14.3	0.575	0.751	0.184 U
B12C72	147.5-150	8/8/2001	-0.051 U	0.028 U	16.1	0.089 U	0.61	0.888 J
B12C73	197.5-200	8/9/2001	-0.007 U	0.165	16	0.489	0.687	-0.043 U
B12C74	264-265.5	8/10/2001	-0.018 U	.062 J	11.2	0.447	0.626	0.094 U

[a] Multiply by 0.3048 to convert to meters.
B = The associated QC sample has a result greater than two times the MDA
J = Concentration estimated
U=Analyzed for but not detected above the minimum activity in the sample

Table B.31. Radionuclide Activity Reported in Terms of Dry Sediment (2 pages)

Sample	Sample Interval (ft-bgs)	Date	Plutonium-238 pCi/g	Plutonium-239/240 pCi/g	Thorium-228 pCi/g	Thorium-230 pCi/g	Thorium-232 pCi/g	Total Uranium ug/kg	Uranium-233/234 pCi/g	Uranium-238 pCi/g
B12684	0-0.5	7/18/2001	—	—	—	—	—	—	—	—
B12C67	3.5-5.0	8/1/2001	0 U	0.029 U	0.431	0.621 J	0.621 J	1600	0.667 J	0.667 J
B12C68	9.5-12.0	8/2/2001	0 U	0 U	0.839	0.587 J	0.587 J	1690	0.448 J	0.544 J
B12C63	14.5-15.5	8/2/2001	7.85	106	6.44 U	-6.44 U	9.65 U	11300 B	8.15 U	5.82 U
B12C64	18-20.5	8/2/2001	3.36	159	1.41 U	-3.26 U	0.93 U	32500	9	5.63 U
B12DB8	22.5-25	8/3/2001	3.66 U	64.6	-1.74 U	0 U	2.06 U	19100	8.52 U	7.31 U
B12DB9	29-31.5	8/3/2001	3.48	4.64	-0.171 U	-0.854 U	0.525 U	14800	5.16	6.35
B12C88	37.5-40	8/5/2001	0.657 J	0.776 J	-0.989 U	0.329 U	0 U	7740	2.72	2.83
B12DC0	Split	8/5/2001	0.324 U	0.883 J	-0.258 U	-0.321 U	0.193 U	8090	2.73	2.48
B12C69	52-54.5	8/6/2001	0.051 U	0.051 U	1.26	0.496 J	0.382 J	2900	0.754 J	0.782 J
B12C70	Duplicate	8/6/2001	-0.038 U	0 U	1.84	0.894 J	0.988 J	3500	1.08	1.23
B12C71	97.5-100	8/7/2001	0 U	-0.045 U	0.933	0.632 J	0.366 J	934	0.512 J	0.456 J
B12C72	147.5-150	8/8/2001	-0.052 U	0 U	0.777	0 U	0.443 J	901	0.272 J	0.431 J
B12C73	197.5-200	8/9/2001	0 U	0 U	0.778	0.068 U	0.405 J	862	0.480 J	0.38 J
B12C74	264-265.5	8/10/2001	0 U	0.028 U	0.774	0.665 J	0.558 J	790	0.262 J	0.314 J

(a) Multiply by 0.3048 to convert to meters
B = The associated QC sample has a result greater than two times the MDA
J = Concentration estimated
U=Analyzed for but not detected above the minimum activity in the sample.

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