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EVALUATION OF ISOTOPE MIGRATION - LAND BURIAL
WATER CHEMISTRY AT COMMERCIALLY OPERATED LOW-LEVEL RADIOACTIVE WASTE DISPOSAL SITES

QUARTERLY PROGRESS REPORT

APRIL - JUNE 1980

K. S. CZYSCINSKI AND A. J. WEISS

NUCLEAR WASTE MANAGEMENT DIVISION
DEPARTMENT OF NUCLEAR ENERGY, BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK 11973

Prepared for the U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
Contract No. DE-AC02-76CH00016

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ABSTRACT

This report presents the analytical results for tritium content of soil cores taken at the Barnwell, South Carolina, disposal site, field measurements at Barnwell, concentrations of free chelating agents in selected trench waters, and the analyses of water samples collected at the Maxey Flats, Kentucky, disposal site. Tritium contents in soil cores taken below the trenches show a decrease in tritium with depth to a minimum value at approximately ten meters, followed by an increase below this depth. This deeper maximum probably represents the downward movement of the previous years seasonal maxima for water infiltration into the trenches. This amount of downward migration from the trench bottom is approximately what would be expected based on the hydraulic conductivity of these sediments. Field measurements of trench waters at the Barnwell, South Carolina, disposal site indicate that the waters are chemically oxidizing regimes relative to those at Maxey Flats and West Valley.

Analyses were performed to determine the amounts of free chelating agents DTPA, EDTA, and NTA in selected trenches at the Maxey Flats, West Valley, Barnwell, and Sheffield, disposal sites. Amounts of free chelating agents were generally below 1 μg/g, with one sample as high as 28 μg/g.

No drastic changes in trench water compositions were observed relative to previous sampling at Maxey Flats. The experimental interceptor trenches contain detectable amounts of strontium and plutonium. Tritium contents vary from typical disposal trench levels (E7-E8 pCi/L) in trench IT-2E, downward four oders of magnitude in trench IT-5 in a decreasing trend along the line of experimental trenches.

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1. TRITIUM CONTENT OF SOIL CORES TAKEN FROM BENEATH DISPOSAL TRENCHES AT THE BARNWELL, SOUTH CAROLINA, DISPOSAL SITE (R. Pietrzak and K. Czyscinski)

1.1 Introduction

An integral part of the present program is the analysis of cores recovered from some of the commercial disposal facilities. Analyses of these cores in terms of their radionuclide content serves several purposes: (1) to supply data for site-specific modeling studies, (2) to determine mineral-radionuclide associations and, (3) compare results of laboratory K_d studies against the field situation.

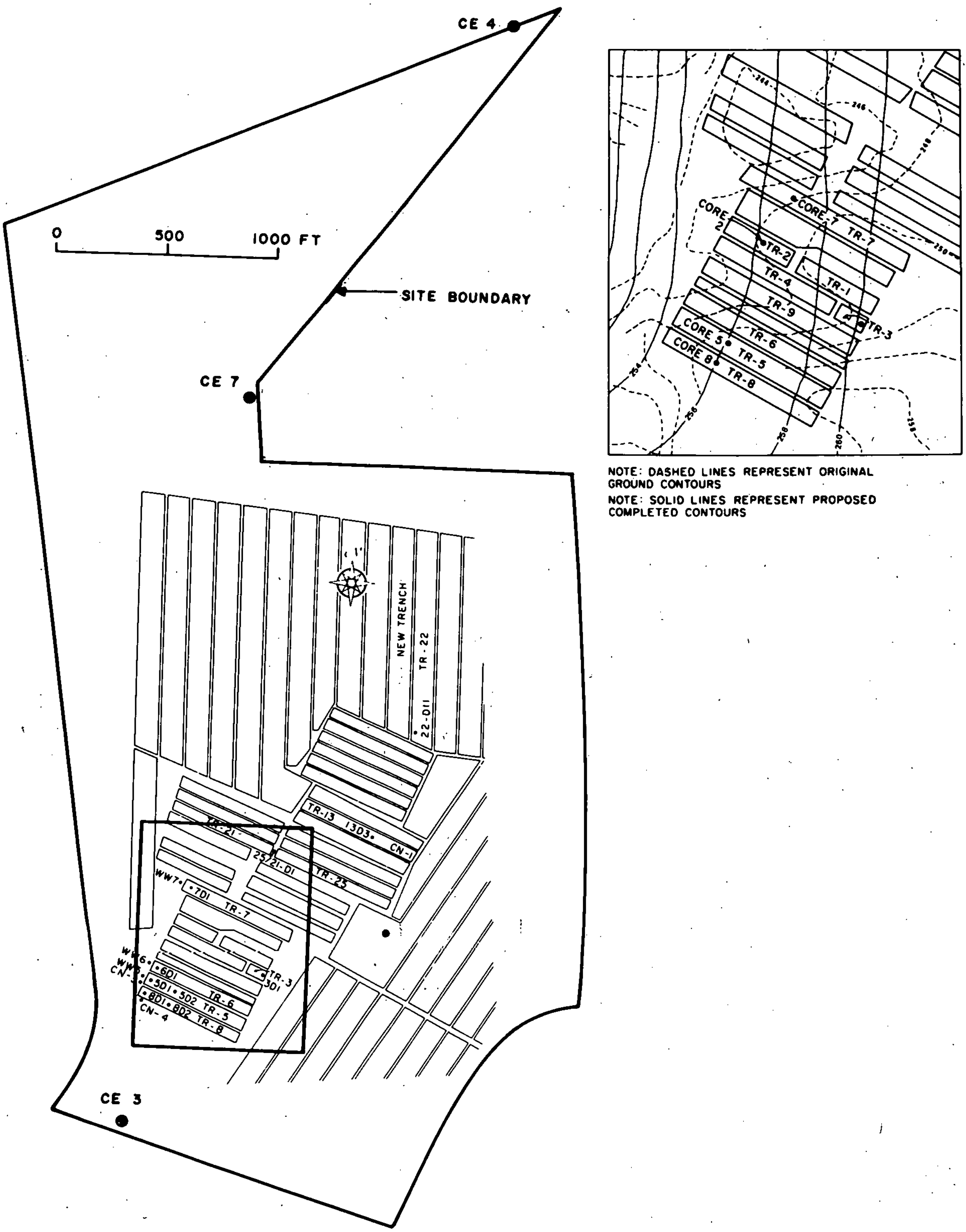
The first step in this effort is the determination of tritium content in the cores as a function of depth. Procedures for sample handling, and the apparatus designed for the tritium distillations have been described previously, along with some of the results.(1) Figure 1.1 shows the location of the trenches where the cores were collected by the U.S. Geologic Survey.

1.2 Tritium Content vs Depth

Results of the tritium distillations are listed in Tables 1.1-1.4 and are graphically presented in Figures 1.2-1.5.

In the core from trench 7, the tritium content decreases to a minimum at approximately ten meters depth and increases again at deeper levels. A similar pattern is shown for the trench 5 data, where the lowest tritium levels are also near the ten meter level. For the last core (trench 8), tritium levels drop steeply with depth to a minimum level, with no evidence of a deeper maxima. In this case also, the tritium content has reached the lowest levels at approximately ten meters depth. Results for the trench 2 core (Figure 1.5) reported previously(1) also show the lowest tritium levels at ten meters and a clearly delineated rise at lower depths.

In Figure 1.6, the data for all four cores are presented. The data points are grouped for each segment of packaged core material. The general tritium distribution below the trenches shows an immediate drop beneath the trench bottom, to the lowest levels at approximately ten meters, followed by an increase in tritium levels at lower depths. This profile may represent either, (1) the intersection of two water flow paths beneath the trenches or, (2) two slugs of water moving downward through the unsaturated sediments. The first explanation appears unlikely in that a change in sediment character would be expected at approximately ten meters for this explanation to be correct. However, the cores are uniform in texture throughout their lengths (coarse sands), and no significant changes in bulk density occur at ten meters depth. The



NOTE: DASHED LINES REPRESENT ORIGINAL GROUND CONTOURS

NOTE: SOLID LINES REPRESENT PROPOSED COMPLETED CONTOURS

Figure 1.1. Locator map of the Barnwell, South Carolina, disposal facility.

Table 1.1

Barnwell, South Carolina, Trench 7D1 Core-
Physical Parameters and Tritium Activity

Core Sample Number	Core Depth (m)	Wet Weight (grams)	Wet Clyinder Dimensions		Dry Weight (grams)	Dry Cylinder Dimensions		H-3[a] pCi/L
			Diameter (cm)	Height (cm)		Diameter (cm)	Height (cm)	
BN-C-7-1	8.89-8.94	54.52	3.0	3.2	50.41	3.0	3.2	1.6 E9
BN-C-7-2	8.94-8.99	70.59	3.2	3.7	63.62	3.2	3.6	1.7 E9
BN-C-7-3	8.99-9.04	74.22	3.2	4.0	64.71	3.2	3.8	1.8 E9
BN-C-7-4	9.04-9.09	98.60	3.3	6.0	90.51	3.3	6.0	1.7 E9
BN-C-7-5	9.09-9.14	103.94	3.3	5.1	92.51	3.3	5.0	1.8 E9
BN-C-7-6	9.14-9.19	107.35	3.8	5.5	98.80	3.8	5.5	1.8 E9[b]
BN-C-7-7	9.19-9.25	95.25	3.6	6.3	90.68	3.6	6.2	1.7 E9
BN-C-7-8	9.25-9.31	90.44	3.3	4.9	82.33	3.3	4.8	1.7 E9
BN-C-7-9	9.31-9.38	103.96	3.3	5.0	94.72	3.3	4.9	1.7 E9
BN-C-7-10	9.38-9.45	78.27	3.5	4.0	69.77	3.5	4.0	1.7 E9
BN-C-7-11	9.45-9.50	85.61	3.5	4.1	76.72	3.4	4.1	1.7 E9
BN-C-7-12	9.50-9.56	112.05	3.4	6.0	100.14	3.4	6.0	1.6 E9[b]
BN-C-7-13	9.56-9.62	114.21	3.5	6.0	100.15	3.5	6.0	1.6 E9[b]
BN-C-7-14	9.62-9.68	71.37	3.5	5.0	61.46	3.5	5.0	1.5 E9[b]
BN-C-7-15	9.68-9.74	78.05	3.5	5.3	68.70	3.5	5.5	1.5 E9[b]
BN-C-7-16	9.74-9.80	84.67	3.5	4.0	73.35	3.5	4.0	1.5 E9
BN-C-7-17	9.80-9.90	90.48	3.5	6.5	78.65	3.5	6.5	1.4 E9[b]
BN-C-7-18	9.90-10.01	63.97	3.5	4.3	55.53	3.5	3.8	1.4 E9
BN-C-7-19	10.01-10.11	71.65	3.5	4.4	62.93	3.5	4.6	1.4 E9
BN-C-7-20	10.11-10.20	79.17	3.4	4.4	68.03	3.4	4.4	1.4 E9
BN-C-7-21	10.20-10.28	80.73	3.3	4.5	69.38	3.3	4.4	1.4 E9
BN-C-7-22	10.28-10.36	89.41	3.5	5.8	75.86	3.5	5.4	1.4 E9
BN-C-7-23	10.41-10.47	91.05	3.5	4.6	78.98	3.5	4.5	1.4 E9
BN-C-7-24	10.47-10.53	98.45	3.5	4.8	85.70	3.6	4.8	1.5 E9
BN-C-7-25	10.53-10.60	98.59	3.6	4.4	85.38	3.5	4.4	1.3 E9
BN-C-7-26	10.60-10.66	87.07	3.5	4.0	74.85	3.5	4.0	1.4 E9
BN-C-7-27	10.66-10.72	86.66	3.5	4.2	73.90	3.4	4.0	1.4 E9
BN-C-7-28	10.72-10.76	101.63	3.5	5.2	84.34	3.4	5.2	1.4 E9
BN-C-7-29	10.76-10.80	109.95	3.6	5.4	90.18	3.6	5.3	1.4 E9
BN-C-7-30	10.80-10.84	114.02	3.5	5.5	92.92	3.4	5.5	1.5 E9
BN-C-7-31	10.84-10.89	101.14	3.4	5.1	85.40	3.4	5.1	1.5 E9
BN-C-7-32	10.89-10.93	94.12	3.4	4.9	79.87	3.4	5.0	1.5 E9
BN-C-7-33	10.93-10.97	99.22	3.4	5.0	85.43	3.4	4.9	1.5 E9
BN-C-7-34	11.02-11.05	56.18	3.2	3.4	47.06	3.2	3.3	1.6 E9
BN-C-7-35	11.05-11.08	79.85	3.4	5.0	65.47	3.4	4.9	1.6 E9[b]
BN-C-7-36	11.08-11.12	81.82	3.5	4.5	66.77	3.4	4.5	1.5 E9[b]
BN-C-7-37	11.12-11.15	71.14	3.5	5.0	60.16	3.5	5.0	1.6 E9
BN-C-7-38	11.15-11.18	70.20	3.6	4.2	61.63	3.5	4.2	1.4 E9
BN-C-7-39	11.18-11.23	70.37	3.5	4.0	60.18	3.4	4.0	1.6 E9
BN-C-7-40	11.23-11.28	62.45	3.3	4.0	53.03	3.3	4.0	1.6 E9
BN-C-7-41	11.28-11.33	79.73	3.2	4.5	68.11	3.2	4.5	1.5 E9
BN-C-7-42	11.33-11.38	73.84	3.3	4.4	72.59	3.3	4.2	1.7 E9
BN-C-7-43	11.38-11.43	73.52	3.5	4.0	61.85	3.5	4.0	1.6 E9[b]
BN-C-7-44	11.43-11.48	62.94	3.3	4.5	56.17	3.2	4.5	1.6 E9[b]
BN-C-7-45	11.48-11.53	87.55	3.4	5.5	61.92	3.4	5.5	1.5 E9
BN-C-7-46	11.53-11.58	66.13	3.5	4.0	59.79	3.5	3.9	1.5 E9
BN-C-7-47	11.58-11.63	72.63	3.5	4.7	64.57	3.4	4.6	1.5 E9
BN-C-7-48	11.63-11.68	81.44	3.6	6.0	72.62	3.6	5.8	1.5 E9
BN-C-7-49	11.68-11.73	74.59	3.5	4.7	60.08	3.4	4.5	1.5 E9

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[a] The one sigma error is 1 % of the tritium result.
[b] Samples crumbled during distillation.

Table 1.2

Barnwell, South Carolina, Trench 5-
Physical Parameters and Tritium Activity

Core Sample Number	Core Depth (m)	Wet Weight (grams)	Wet Clyinder Dimensions		Dry Weight (grams)	Dry Cylinder Dimensions		H-3[a] pCi/L
			Diameter (cm)	Height (cm)		Diameter (cm)	Height (cm)	
BN-C-5-1	11.53-11.48	29.53	2.5	3.0	21.66	2.2	3.0	4.7 E6
BN-C-5-2	11.48-11.43	22.46	2.5	1.5	17.15	2.2	1.5	4.7 E6
BN-C-5-3	11.43-11.35	55.46	2.5	5.0	42.53	2.2	4.8	4.7 E6
BN-C-5-4	11.28-11.23	97.35	3.9	5.0	86.60	3.2	4.7	4.1 E6
BN-C-5-5	11.23-11.18	90.64	3.3	5.7	79.00	3.3	5.5	4.9 E6
BN-C-5-6	11.18-11.12	78.44	3.3	4.1	62.15	3.0	4.0	5.0 E6
BN-C-5-7	11.08-11.04	61.39	3.3	3.8	47.49	3.2	3.6	4.2 E6
BN-C-5-8	11.04-10.99	57.86	3.3	3.9	44.02	3.3	3.9	4.2 E6
BN-C-5-9	10.99-10.95	64.60	3.4	3.5	50.87	3.2	3.5	4.3 E6
BN-C-5-10	10.90-10.86	73.89	3.4	4.4	55.68	3.2	4.4	4.3 E6
BN-C-5-11	10.86-10.81	63.37	3.4	3.6	50.07	3.4	3.6	4.3 E6
BN-C-5-12	10.81-10.76	71.73	3.4	4.4	56.74	3.3	4.2	4.3 E6
BN-C-5-13	10.76-10.72	78.87	3.3	4.4	61.73	3.3	4.4	4.3 E6
BN-C-5-14	10.54-10.52	88.29	3.5	4.9	71.07	3.4	4.8	3.9 E6
BN-C-5-15	10.52-10.50	87.23	3.5	4.5	71.69	3.3	4.5	3.9 E6[b]
BN-C-5-16	10.50-10.48	68.74	3.4	4.8	57.55	3.3	4.8	3.8 E6[b]
BN-C-5-17	10.48-10.46	81.86	3.4	4.5	65.28	3.4	4.5	3.8 E6
BN-C-5-18	10.34-10.30	55.44	3.4	3.0	47.23	3.2	2.8	3.5 E6
BN-C-5-19	10.30-10.25	54.06	3.4	3.0	46.93	3.4	2.8	3.6 E6
BN-C-5-20	10.25-10.20	78.86	3.3	4.5	67.42	3.2	4.4	3.6 E6
BN-C-5-21	10.20-10.16	84.92	3.2	4.5	73.41	3.2	4.5	3.6 E6
BN-C-5-22	9.47-9.44	86.67	3.3	4.6	77.13	3.3	4.4	3.2 E6
BN-C-5-23	9.44-9.40	69.89	3.3	4.0	61.34	3.3	4.0	3.2 E6
BN-C-5-24	9.40-9.37	99.84	3.1	5.0	84.20	3.1	5.0	3.1 E6
BN-C-5-25	9.75-9.71	70.61	3.3	4.0	62.26	3.3	3.9	3.3 E6
BN-C-5-26	9.71-9.67	102.26	3.5	5.5	89.28	3.4	5.5	3.3 E6
BN-C-5-27	9.67-9.63	74.39	3.5	3.4	68.45	3.4	3.2	3.3 E6
BN-C-5-28	9.63-9.60	62.69	3.4	3.2	54.52	3.2	3.2	3.4 E6
BN-C-5-29	9.14-9.10	82.61	3.3	3.9	72.19	3.3	3.9	3.2 E6
BN-C-5-30	9.10-9.06	91.65	3.4	4.1	81.10	3.4	4.0	3.2 E6
BN-C-5-31	9.06-9.02	85.93	3.4	4.0	75.70	3.4	3.9	3.3 E6
BN-C-5-32	9.02-8.98	79.37	3.4	3.5	67.23	3.4	3.5	3.4 E6
BN-C-5-33	8.98-8.94	80.83	3.7	3.9	68.16	3.4	3.9	3.4 E6
BN-C-5-34	8.94-8.90	78.02	3.5	3.8	64.09	3.5	3.8	3.4 E6
BN-C-5-35	8.90-8.86	82.60	3.5	4.0	70.04	3.4	3.9	3.5 E6
BN-C-5-36	8.71-8.66	113.16	3.5	5.3	98.78	3.4	5.2	3.7 E6
BN-C-5-37	8.66-8.62	111.98	3.5	5.4	96.76	3.5	5.2	3.7 E6
BN-C-5-38	8.62-8.56	100.23	3.4	5.4	86.39	3.4	5.2	3.8 E6
BN-C-5-39	8.53-8.50	70.55	3.3	3.5	61.84	3.3	3.5	3.8 E6
BN-C-5-40	8.50-8.46	56.60	3.5	3.5	49.79	3.5	3.5	3.6 E6[b]
BN-C-5-41	8.46-8.43	59.14	3.5	3.5	51.30	3.5	3.3	3.6 E6

[a] The one sigma error is 1 % of the result.
[b] Samples crumbled during distillation.

Table 1.3

Barnwell, South Carolina, Trench 8D1 Core-Physical Parameters and Tritium Activity

Core Sample Number	Core Depth (m)	Wet Weight (grams)	Wet Clyinder Dimensions		Dry Weight (grams)	Dry Cylinder Dimensions		H-3[a] pCi/L
			Diameter (cm)	Height (cm)		Diameter (cm)	Height (cm)	
BN-C-8-1	8.80-8.87	84.00	3.4	5.0	70.17	3.4	4.8	9.7 E7
BN-C-8-2	8.87-8.93	84.10	3.5	4.5	70.46	3.4	4.4	9.1 E7
BN-C-8-3	8.93-8.99	88.40	3.3	4.8	75.36	3.3	4.8	9.0 E7
BN-C-8-4	8.99-9.07	81.09	3.5	4.2	65.24	3.4	4.2	7.0 E7
BN-C-8-5	9.07-9.14	86.21	3.1	5.0	72.02	3.1	5.0	7.1 E7
BN-C-8-6	9.14-9.22	85.90	3.0	5.0	71.16	3.0	5.0	7.1 E7
BN-C-8-7	9.22-9.30	91.36	3.2	5.2	75.88	3.2	5.2	7.2 E7
BN-C-8-8	9.30-9.35	69.32	3.7	3.6	58.35	3.6	3.6	4.6 E7
BN-C-8-9	9.35-9.40	80.84	3.6	4.5	67.68	3.6	4.5	4.5 E7
BN-C-8-10	9.40-9.45	84.07	3.5	6.0	71.46	3.5	6.0	4.4 E7[b]
BN-C-8-11	9.45-9.50	64.91	3.4	3.9	54.72	3.4	3.8	4.6 E7
BN-C-8-12	9.50-9.55	70.16	3.6	3.5	58.89	3.4	3.5	4.5 E7
BN-C-8-13	9.55-9.60	80.02	3.3	4.3	68.55	3.3	4.3	4.5 E7
BN-C-8-14	9.60-9.66	54.18	3.3	3.0	42.19	3.3	3.0	8.1 E6
BN-C-8-15	9.66-9.72	83.58	3.3	4.7	66.80	3.3	4.7	8.1 E6
BN-C-8-16	9.72-9.79	58.36	3.5	3.2	46.80	3.5	3.1	9.7 E6
BN-C-8-17	9.79-9.85	73.31	3.4	3.7	63.29	3.3	3.7	9.9 E6
BN-C-8-18	9.85-9.91	71.44	3.4	5.0	59.67	3.4	4.9	9.8 E6
BN-C-8-19	9.91-9.98	110.63	3.7	6.2	91.15	3.5	6.1	3.8 E6
BN-C-8-20	9.98-10.06	79.07	3.6	4.6	57.76	3.5	4.5	3.8 E6
BN-C-8-21	10.06-10.14	68.71	3.6	4.0	49.07	3.5	3.8	3.8 E6
BN-C-8-22	10.14-10.21	76.33	3.6	5.7	58.57	3.5	5.7	3.8 E6[b]
BN-C-8-23	10.21-10.27	89.58	3.8	5.1	71.96	3.6	5.0	3.7 E6
BN-C-8-24	10.27-10.33	92.56	3.7	5.9	77.12	3.6	5.7	3.1 E6
BN-C-8-25	10.33-10.40	88.18	3.5	5.2	70.58	3.5	5.1	2.0 E6
BN-C-8-26	10.40-10.46	92.21	3.6	5.0	70.49	3.6	5.0	1.9 E6
BN-C-8-27	10.46-10.52	93.95	3.6	6.0	76.52	3.6	5.9	2.0 E6[b]
BN-C-8-28	10.52-10.57	59.56	3.5	3.8	44.53	3.4	3.6	1.2 E6
BN-C-8-29	10.57-10.62	85.68	3.5	4.9	67.14	3.5	4.9	1.2 E6
BN-C-8-30	10.62-10.67	63.10	3.6	5.0	47.36	3.5	5.0	1.1 E6[b]
BN-C-8-31	10.67-10.72	69.08	3.6	4.2	52.11	3.5	4.2	1.2 E6
BN-C-8-32	10.72-10.77	57.25	3.5	3.7	43.09	3.6	3.7	1.2 E6
BN-C-8-33	10.77-10.82	45.88	3.5	3.2	34.55	3.5	3.2	1.1 E6

---

[a] The one sigma error is 1 % of the tritium result.

[b] Sample crumbled during distillation.

Table 1.4

Barnwell, South Carolina, Trench 2 Core-
Physical Parameters and Tritium Activity

Core Sample Number	Core Depth (m)	Wet Weight (grams)	Approximate[a] Wet Clyinder Dimensions		Dry Weight (grams)	Dry Cylinder Dimensions		H-3[b] pCi/L
			Diameter (cm)	Height (cm)		Diameter (cm)	Height (cm)	
BN-C-2-1	11.84-11.79	82.10	3.8	5.1	66.18	3.5	4.4	3.3 E5
BN-C-2-2	11.79-11.74	89.86	3.8	5.1	73.34	3.2	3.8	2.8 E5
BN-C-2-3	11.74-11.67	100.94	3.8	6.4	77.88	3.8	4.4	2.4 E5
BN-C-2-4	11.67-11.59	104.68	3.8	6.4	79.65	3.2	5.1	2.3 E5
BN-C-2-6	11.40-11.34	89.42	3.8	6.4	73.81	3.2	4.4	1.2 E6
BN-C-2-7	11.34-11.28	91.89	3.8	6.4	74.17	3.5	5.7	1.2 E6[c]
BN-C-2-5	11.28-11.23	75.39	3.8	5.1	62.00	3.2	3.8	1.5 E6
BN-C-2-8	11.23-11.18	78.25	3.8	5.1	63.59	3.2	4.4	1.4 E6
BN-C-2-9	11.18-11.12	72.12	3.8	5.1	59.08	3.2	3.8	1.4 E6[c]
BN-C-2-10	11.12-11.02	77.56	3.8	5.1	66.05	3.2	3.8	1.4 E6
BN-C-2-11	11.02-10.97	88.69	3.8	5.1	73.84	3.2	5.1	1.4 E6
BN-C-2-12	10.87-10.92	81.67	3.8	5.1	69.08	3.8	4.4	1.4 E6
BN-C-2-13	10.82-10.77	124.85	3.8	5.1	107.17	3.5	5.7	1.0 E6
BN-C-2-14	10.77-10.72	113.37	3.8	5.1	96.47	3.5	5.1	1.0 E6
BN-C-2-15	10.72-10.67	94.21	3.8	5.1	78.46	3.2	4.4	1.0 E6
BN-C-2-16	10.67-10.52	71.12	3.8	5.1	61.02	3.5	3.8	8.5 E5[c]
BN-C-2-17	10.52-10.46	79.67	3.8	5.1	66.62	3.5	3.8	9.1 E5
BN-C-2-18	10.46-10.41	93.24	3.8	5.1	77.40	3.2	4.1	9.5 E5
BN-C-2-19	10.41-10.36	77.04	3.8	5.1	68.85	3.5	3.8	9.6 E5
BN-C-2-20	10.29-10.22	106.76	3.8	6.4	93.35	3.2	5.1	7.9 E5[c]
BN-C-2-21	10.22-10.16	115.62	3.8	6.4	103.99	3.2	5.1	8.1 E5[c]
BN-C-2-22	10.16-10.11	75.99	3.8	5.1	68.96	3.2	3.8	8.4 E5
BN-C-2-23	10.03-10.01	40.31	3.8	3.8	37.18	---	---	2.2 E5
BN-C-2-24	10.01-9.94	92.85	3.8	6.4	83.54	3.2	3.8	2.3 E5
BN-C-2-25	9.94-9.91	98.35	3.8	6.4	84.69	3.2	4.4	2.1 E5
BN-C-2-26	9.91-9.83	87.52	3.8	3.8	80.68	3.5	4.4	1.8 E5
BN-C-2-27	9.83-9.78	89.41	3.8	3.8	78.44	3.2	3.8	1.4 E5
BN-C-2-28	9.78-9.74	82.64	3.8	3.8	75.59	3.2	3.8	1.6 E5
BN-C-2-29	9.74-9.70	67.27	3.8	3.8	61.18	3.5	3.8	1.5 E5
BN-C-2-30	9.60-9.56	87.42	3.8	3.8	78.53	3.2	3.8	1.4 E5
BN-C-2-31	9.56-9.52	67.08	3.8	3.8	61.33	3.5	3.5	1.5 E5
BN-C-2-32	9.52-9.49	80.64	3.8	3.8	73.11	3.5	3.8	1.2 E5
BN-C-2-33	9.49-9.45	76.77	3.8	3.8	70.23	3.2	3.8	1.8 E5
BN-C-2-34	9.35-9.30	76.62	3.8	3.8	68.54	3.2	3.8	1.4 E5
BN-C-2-35	9.30-9.25	77.20	3.8	3.8	68.32	3.2	3.8	1.3 E5
BN-C-2-36	9.25-9.20	82.42	3.8	3.8	76.01	3.2	3.8	1.6 E5
BN-C-2-37	9.14-9.09	105.68	3.8	6.4	95.84	3.2	5.1	1.1 E5
BN-C-2-38	9.09-9.04	122.10	3.8	6.4	107.47	3.2	5.7	9.0 E4
BN-C-2-39	9.04-9.02	128.84	3.8	6.4	111.10	3.2	5.7	1.2 E5
BN-C-2-40	8.92-8.86	106.91	3.8	6.4	92.27	3.2	5.1	9.5 E4
BN-C-2-41	8.86-8.81	94.47	3.8	6.4	81.31	3.2	4.4	1.0 E5
BN-C-2-42	8.81-8.76	106.39	3.8	6.4	95.69	3.2	5.1	1.2 E5

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[a] Wet dimensions were obtained by a visual estimate.
[b] The one sigma error is 1 % of the tritium result.
[c] Samples crumbled during distillation.

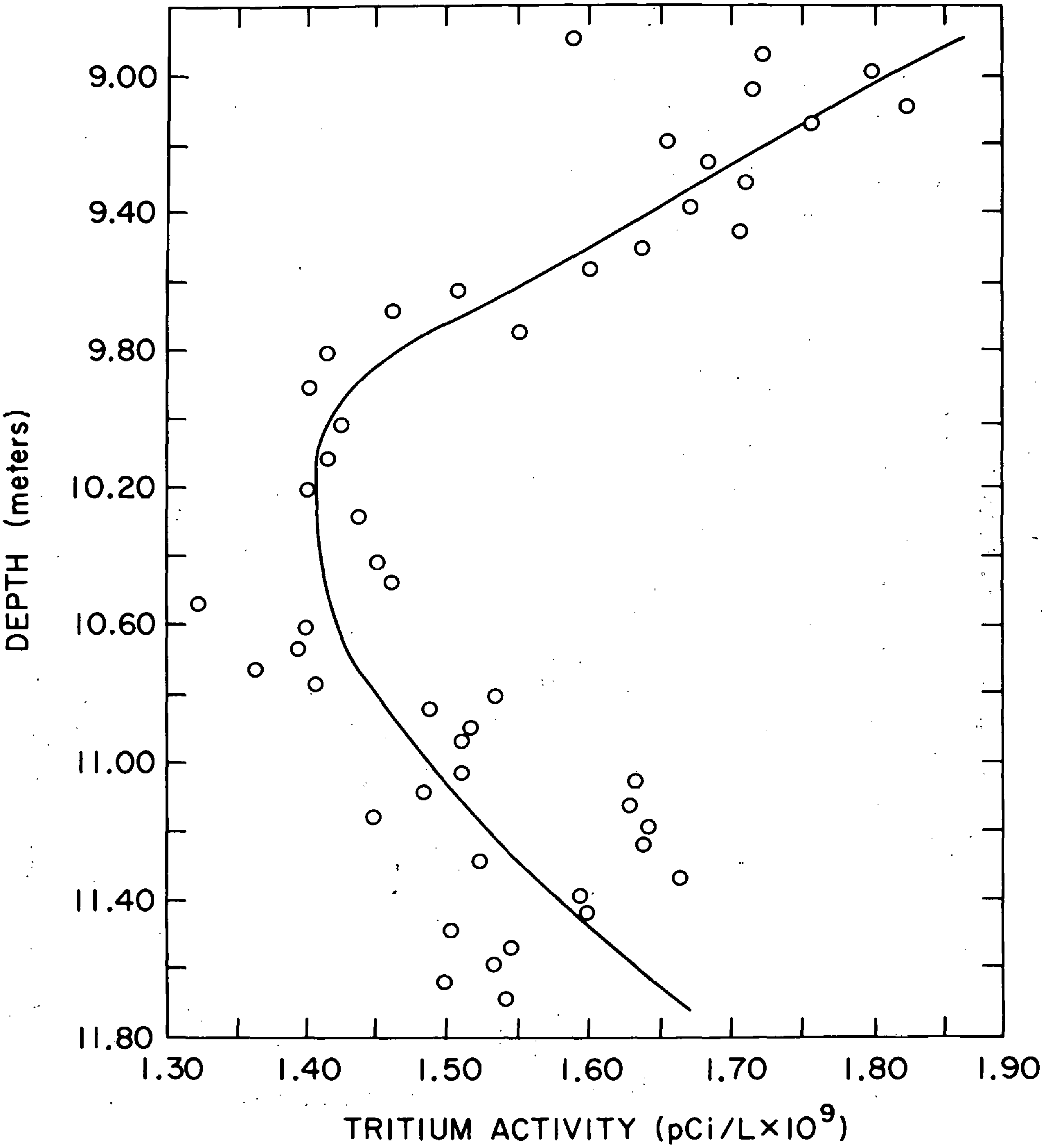

Figure 1.2. Tritium activity vs depth - Barnwell, South Carolina, trench 7 core.

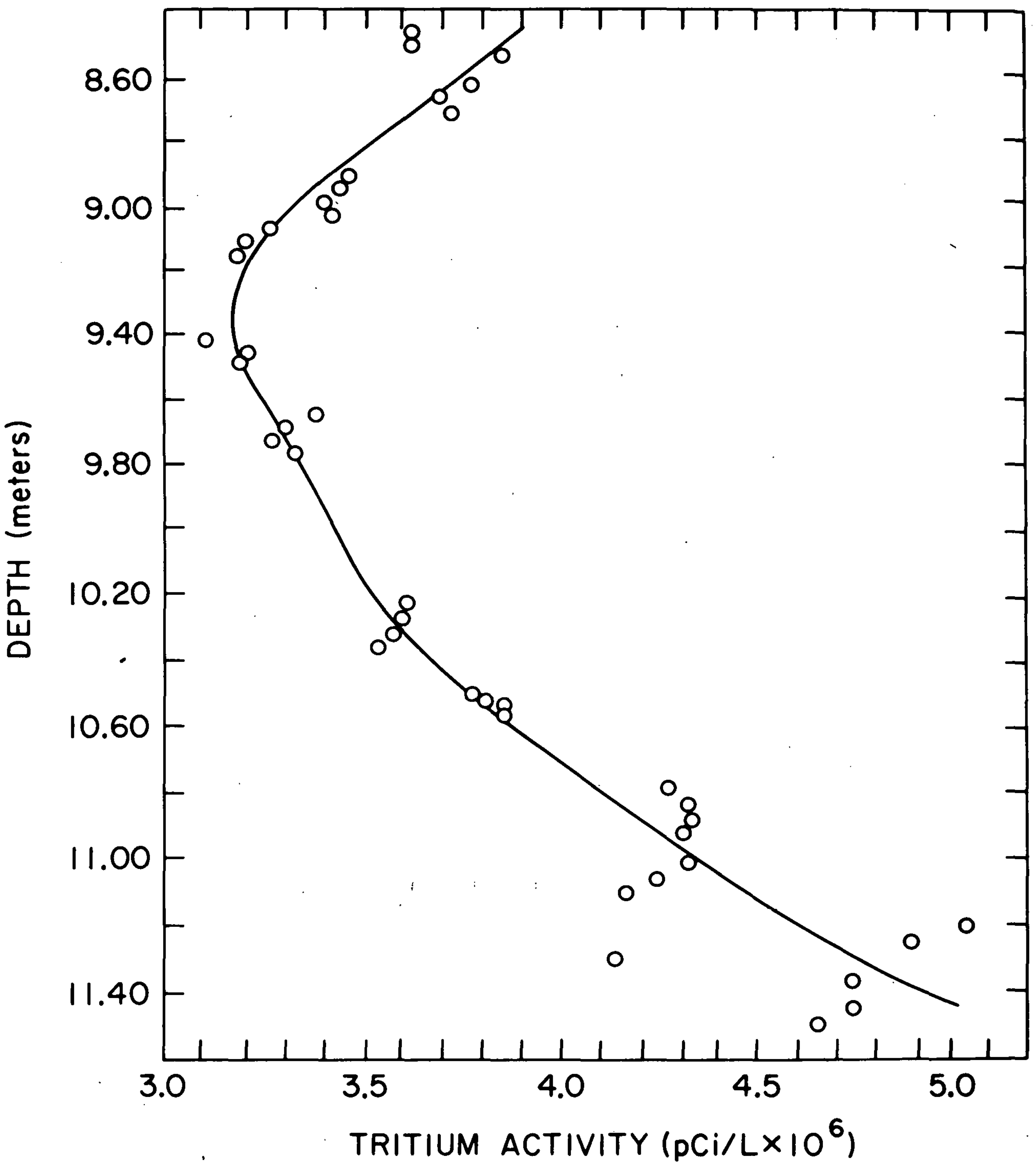

Figure 1.3. Tritium activity vs depth - Barnwell, South Carolina, trench 5 core.

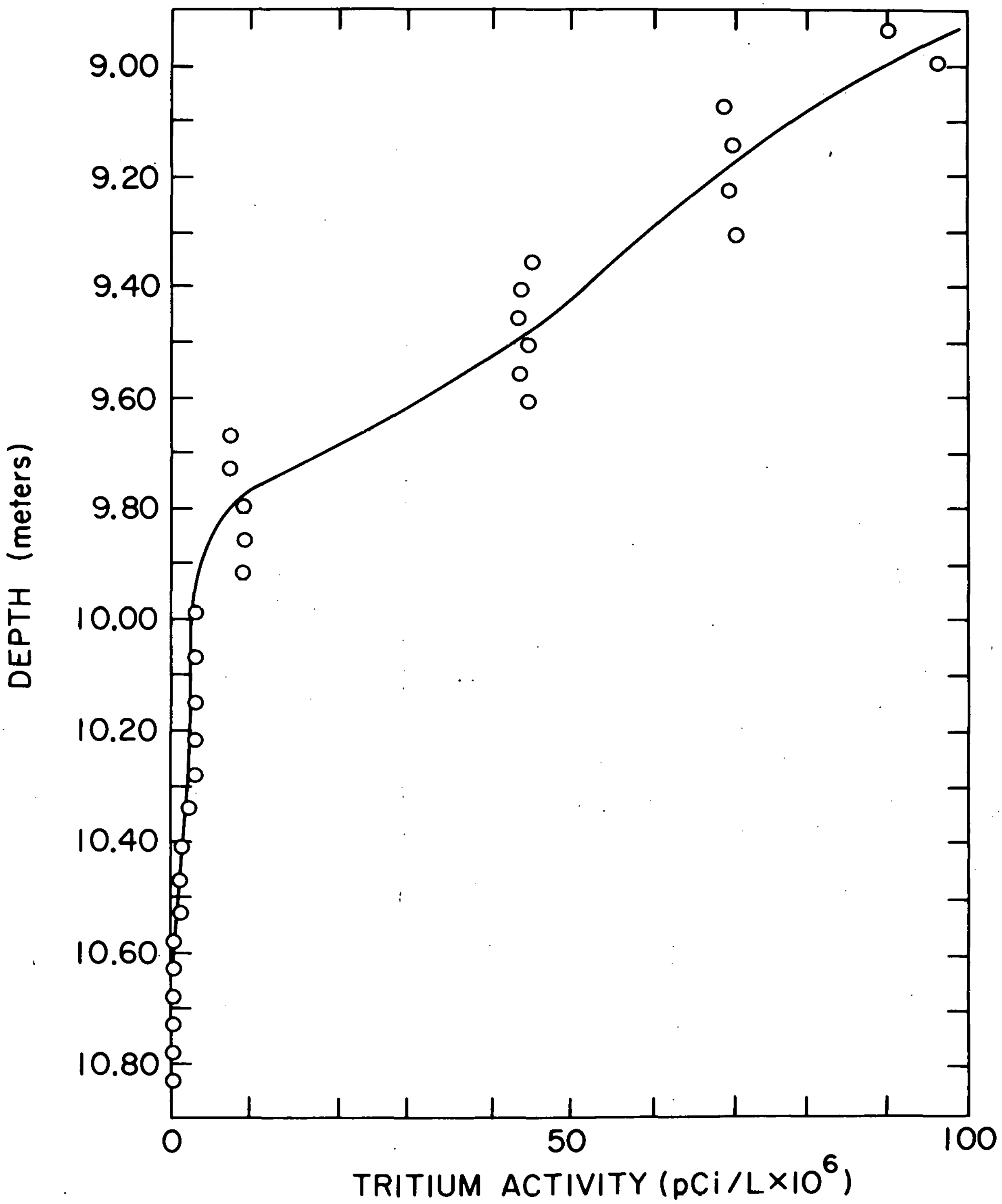

Figure 1.4. Tritium activity vs depth - Barnwell, South Carolina, trench 8 core.

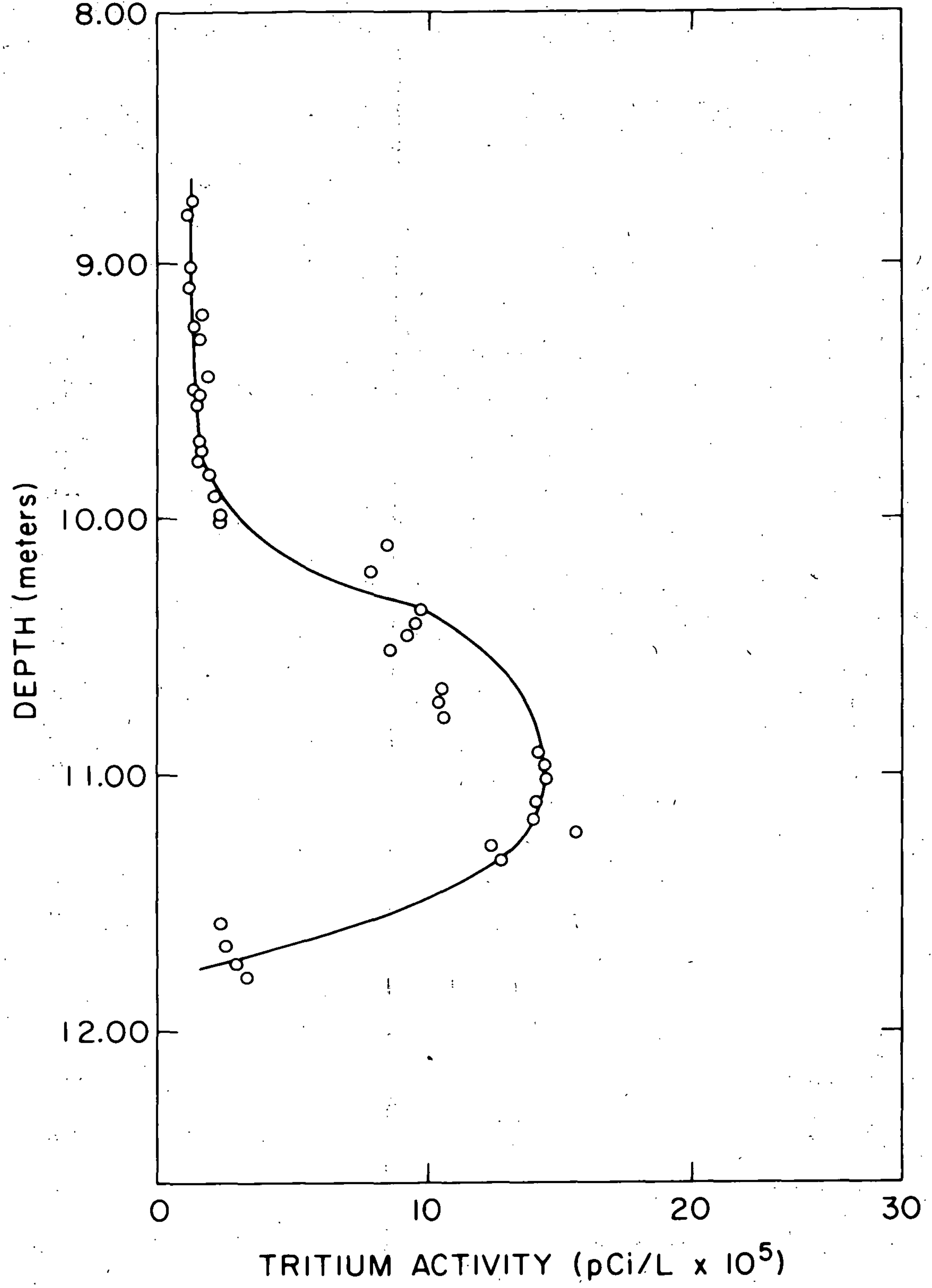

Figure 1.5. Tritium activity vs depth - Barnwell, South Carolina, trench 2 core.

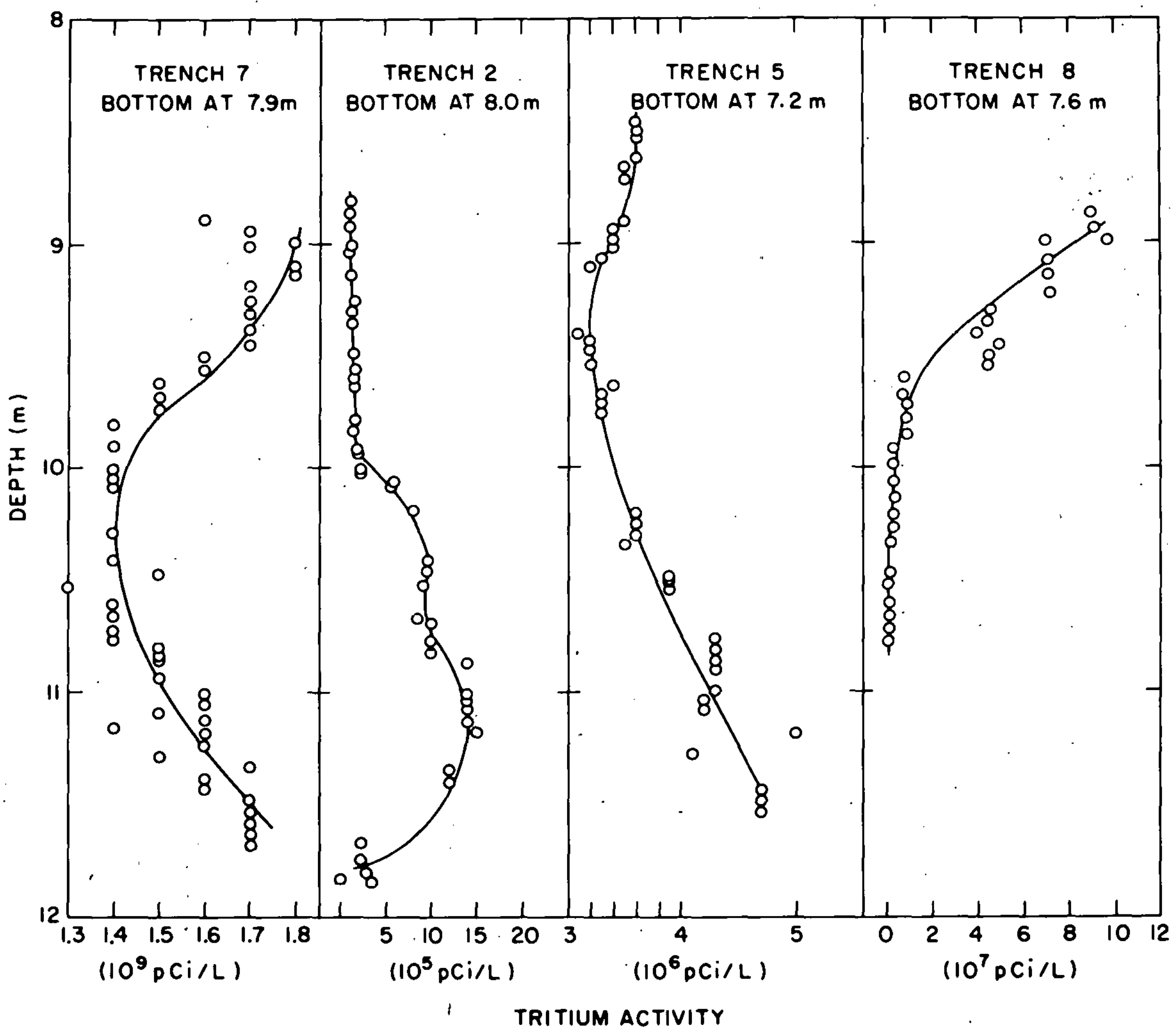

Figure 1.6. Tritium activity vs depth - Barnwell, South Carolina disposal trench cores.

second explanation appears more likely. Rainfall in the southeastern United States varies during the year, with the heaviest rainfalls in the earlier months. Consequently, water accumulates in the trenches via groundwater infiltration only when the rainfall is relatively heavy. Because the hydraulic conductivity of these sediments is low (in the order of 10^{-5} cm/s), accumulated water stays in the trenches long enough to develop high tritium contents before percolating through the surrounding sediments. Presumably, the deeper tritium maxima represent trench waters that developed high tritium contents during an earlier period of water accumulation in the trench, and subsequently migrated to this lower depth. Based on a hydraulic conductivity of 10^{-5} cm/s, over a one year period, water will migrate approximately three meters under saturated flow conditions. Under unsaturated flow conditions, the migration will be less. The distance between the tritium maximum in core eight and the lower maximum in core two is approximately three meters, a distance approximatley equal to one years migration distance if the two maxima represent yearly high water accumulations. For cores five and seven, the distance between high tritium levels are approximately three and two meters respectively. Both distances are within the expected range based on hydraulic conductivity measurements.

It appears likely that the lower tritium maxima represent the depth of penetration of previous water accumulated in the trenches during periods of heavy rainfall.

1.3 Bulk Density and Mositure Content

The dimensions of both the wet and dry samples listed in the tables are approximate. For the dried samples, these dimensions are particularly difficult to measure because the cylindrical plugs distort after distillation and frequently crumble. Dimensions of the wet samples are more reliable in this respect. The wet dimensions listed for the core from trench two are very approximate, however, because they were not measured as accurately as the other cores. These numbers are intended for use in calculating approximate bulk densities for use in modeling attempts. Figure 1.7 shows the trends in moisture content and bulk density for the trench cores as a function of depth. No apparent correlation with tritium content is apparent.

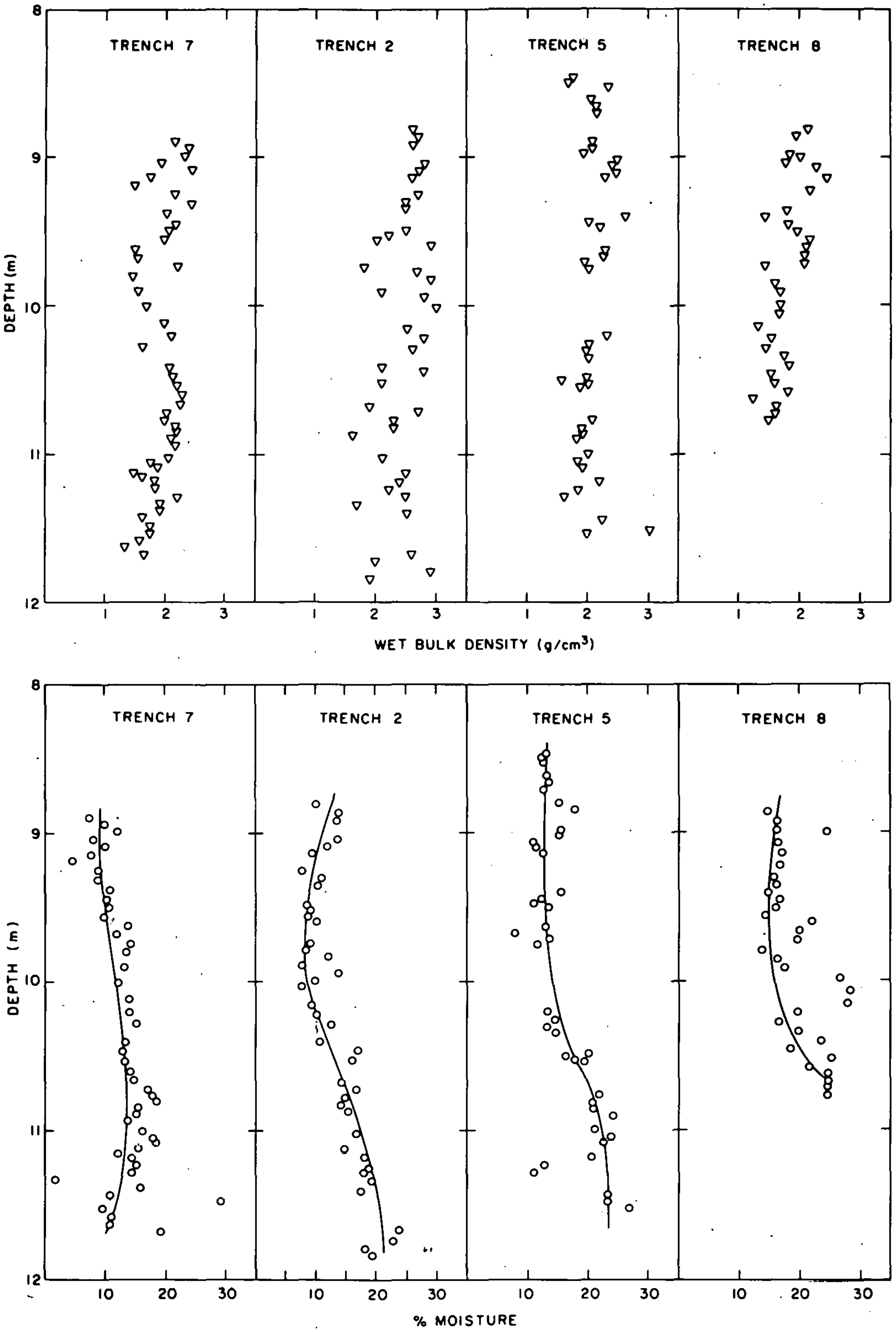

Figure 1.7. Wet bulk density and moisture content - Barnwell trench cores.

2. SAMPLE COLLECTION AT THE BARNWELL, SOUTH CAROLINA, DISPOSAL SITE, MAY 1980.

(J. Clinton, C. Anderson, and J. Smith)

2.1 Introduction

In May of this year, a sampling trip was made to the Chem Nuclear low-level radioactive waste disposal site near Barnwell, South Carolina. The objectives of the trip were as follows:

1. to obtain samples of trench waters from disposal trenches for additional source term characterization of the site;
2. to obtain local groundwaters to be used in laboratory experiments and;
3. to obtain undisturbed core material for use in laboratory flow-through column experiments.

This was the seond trip to the South Carolina facility. Results of organic, inorganic, and radiochemical analyses from the earlier sampling have been reported previously.(2) This report will present the results of field measurements made on the samples collected during this second trip.

2.2 Trench Waters

Waters were collected by means of anaerobic sampling procedures developed for this purpose. A complete description of these procedures has been reported previously.(2) The trenches sampled were limited to those in which a sufficient quantity of water had accumulated to allow sampling. Efforts were made to collect water from the same trenches sampled on the first trip, but not all of these trenches could be resampled due to the absence of water accumulations in them. In line measurements of temperature, specific conductance, dissolved oxygen, Eh and pH were performed. The results of these measurements are listed in Table 2.1, and the location of the trenches are shown in Figure 2.1.

2.3 Ground Water

Five gallons of water were collected from an observation well on the site. The depth of the well is approximately 200 feet below the surface. This uncontaminated water is presumably typical of the groundwater in this areas and is to be used in laboratory experiments described previously.(1,2)

2.4 Core Samples

"Undisturbed" cores of sediment were obtained from the floor of a disposal trench under construction. These cores are to be used in laboratory flow-through column experiments. The cores were obtained by driving a 3-inch diameter steel tube into the sandy sediment at the bottom of the trench. The edge of the coring tube was chamfered to aid in penetrating the sediment. Characterization of these sediments in terms of particle size distribution, surface area, cation exchange capacity, and mineralogy is in progress. Approximately three feet of cored sediment was recovered in the total of three cores taken.

Table 2.1

Field Measurements of Water Samples Collected at the Barnwell, South Carolina, Disposal Site, May 1980

Sampling Location	Date	Volume Collected (L)	Apparent Color	Temperature (°C)	Specific Conductance (μmho/cm)[a]	Dissolved Oxygen (mg/L)	Eh (mV,NHE)[b]	pH
Burial Trenches:								
6D1	5-8-80	8	colorless	15.3	260	4.2	350	6.1[c]
8D3[e]	5-7-80	8	amber	16.0	2600	0.25	130	7.4
13D4	5-9-80	6	colorless	17.0	30	4.3	390	7.6[c]
18D5	5-9-80	4	brownish-gray	12.8	42	3.05	330	7.0[c]
25/21d1[e]	5-9-80	8	colorless	13.3	190	0.15	160	6.2[c]
Monitoring Well:								
6	5-6-80	20	colorless	d	d	d	d	d

[a] Specific conductance expressed as μmho/cm at 25°C.

[b] Field measurements of Eh are reported relative to the Normal Hydrogen Electrode (NHE).

[c] Due to instrumentation problems pH measurements were not obtained in the field. The listed values were obtained after filtration of samples at BNL.

[d] Not measured in field.

[e] Trenches sampled on the first trip to the South Carolina disposal site, March 1979.

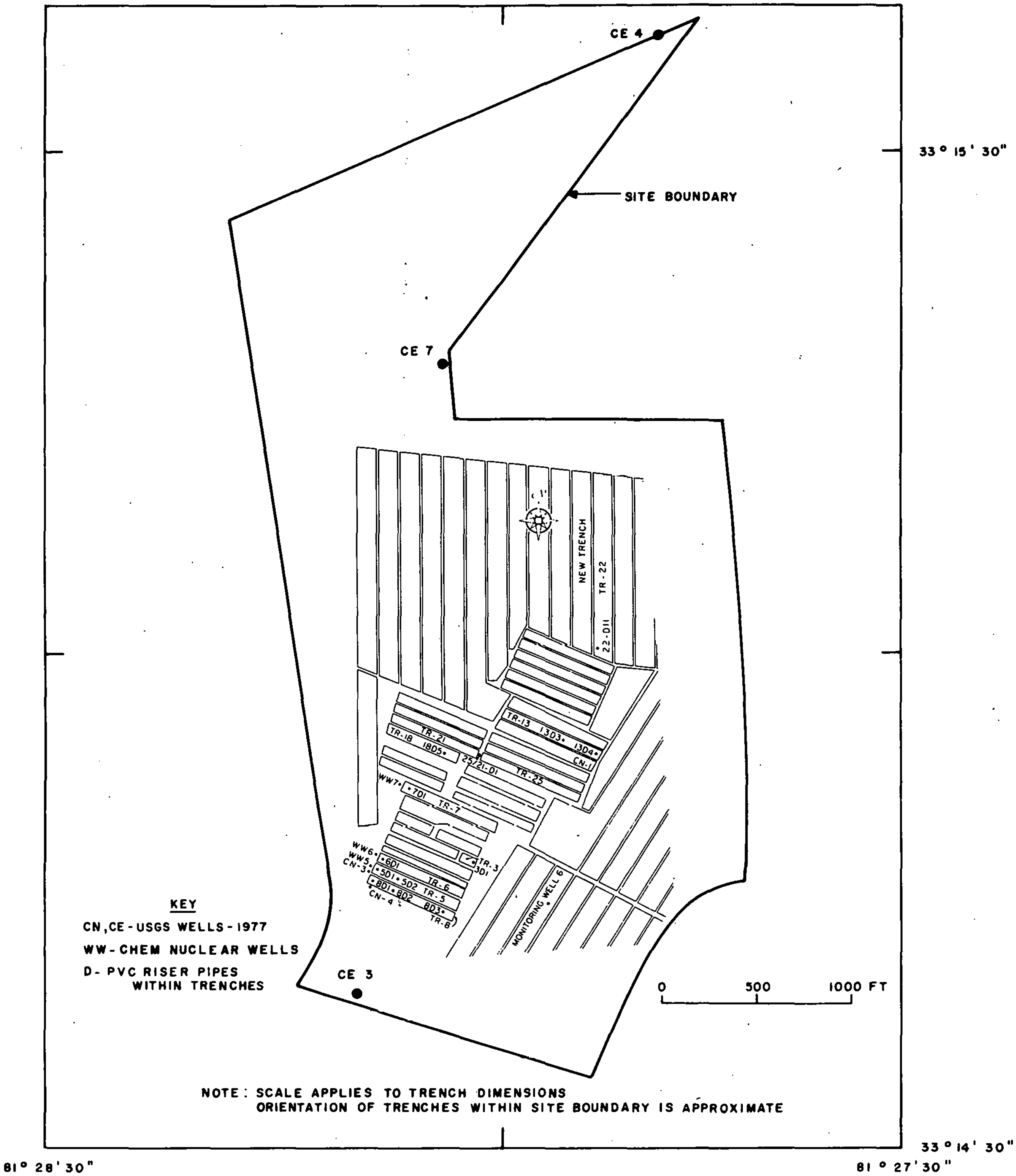

Figure 2.1. Locator map of the Barnwell, South Carolina, disposal facility.

3. ORGANIC CHELATING AGENTS IN SELECTED TRENCHES AT COMMERCIAL DISPOSAL SITES

(A. J. Weiss)

There has been considerable concern in the past about the presence of organic chelating agents in low-level waste disposal trenches. Radionuclides complexed with organic chelating agents are not likely to be removed by the geomedia around the disposal trenches, thereby resulting in considerably enhanced migration potential. Strong organic chelating agents are used in decontaminating solutions used extensively in academic, medical, and industrial situations. These waste products are disposed of via shallow land burial, and it is probable that some radionuclides enter the trench environment already in complexed form. In one documented case, complexing with an organic chelating agent has been linked to enhanced radionuclide migration.(3)

Samples of water from selected disposal trenches at Maxey Flats, as well as the experimental interceptor trenches, were analyzed for their content of selected organic complexing agents. Analyses for the amounts of uncomplexed EDTA (ethylenediaminetetracetic acid), DTPA (diethylene triamine pentacetic acid) and NTA (nitriloacetic acid) were performed. The results are listed in Table 3.1. These particular compounds were selected because they are among the most frequently encountered complexing agents used in decontaminating solutions and laboratory procedures.

In addition, trench water samples from the West Valley disposal facility were analyzed, the trenches selected on the basis of high DOC contents. The samples from the Barnwell and Sheffield sites were selected on the basis of the presence of activity in these waters.

Results show the contents of free chelating agents to be quite low, except for two trenches (Maxey Flats 27 and West Valley 3). These numbers represent the amounts of free chelating agents, rather than the total amount of chelating agent present. The extent of complexed chelating substance is not possible to assess based on these numbers alone. The feasibility of analyzing these waters for the total amounts of chelating agents present is being investigated. Such information is necessary before the extent of radionuclide complexing in the trench waters can be assessed.

Table 3.1

Concentration of Free Chelating Agents in Selected Disposal Trenches[a]

Disposal Site	Date Sampled	Trench	Concentration-(μg/g)-Free Chelating Agent DTPA	EDTA	NTA
Maxey Flats, KY	10-79	19S	12	1	<0.01
Maxey Flats, KY	10-79	27	0.20	<0.01	<0.01
Maxey Flats, KY	5-78	27	2.0	0.06	<0.01
Maxey Flats, KY	10-79	32	0.10	0.25	0.03
Maxey Flats, KY	10-79	30	<0.02	<0.01	<0.01
Maxey Flats, KY	10-79	Interceptor IT-5	<0.02	<0.01	<0.01
Maxey Flats, KY	10-79	Interceptor IT-4E	0.20	<0.01	<0.01
Maxey Flats, KY	10-79	Interceptor IT-3W	0.10	<0.01	<0.01
Maxey Flats, KY	10-79	Interceptor IT-2E	0.12	<0.01	<0.01
Maxey Flats, KY	10-79	Interceptor IT-2E (anoxic)[b]	0.12	<0.01	<0.01
West Valley, NY	10-78	3	28	1.6	0.08
West Valley, NY	10-78	5	1.2	0.10	<0.01
West Valley, NY	10-78	8	0.40	0.10	0.06
Barnwell, SC	3-79	25/21D1	<0.02	<0.01	0.03
Sheffield, IL	4-79	18A	<0.02	<0.01	<0.01
Blank			<0.01	0.10	<0.01

[a] Analyses performed by LFE Laboratories, Richmond, CA.

[b] All inteceptor trench waters were collected under oxic conditions except where noted.

4. ANALYSES OF WATERS COLLECTED FROM THE MAXEY FLATS, KENTUCKY, DISPOSAL SITE-OCTOBER-NOVEMBER 1979

4.1 Introduction

Waters collected from the disposal and experimental interceptor trenches and well UB1-A, were analyzed in the laboratory for their radionuclide content, inorganic species and organic compounds extractable with methylene chloride. The location of the waste trenches, the interceptor trenches, and wells samples are shown in Figure 4.1. Details of the collection and analytical procedrues are described elsewhere.(2) The interceptor trenches did not contain sufficient water to allow sampling using the anaerobic collection procedure except for one instance (interceptor trench 2E). This samples is designated IT2E (anoxic) in the text. The remainder of the interceptor trench waters were obtained under aerobic conditions.

4.2 Dissolved Radionuclides (J. Clinton)

Waters from disposal trenches, interceptor trenches, and well UB1-A, were analyzed for their dissolved radionuclide content. The water samples were analyzed after filtration through a 0.45 m Millipore filter. Results of radiochemical analyses are presented in Tables 4.1 and 4.2.

In comparison against water samples obtained from these trenches previously,(2) the changes in concentration are all within one order of magnitude of the previous sampling (May 1978). Trench 27 showed the largest increases in plutonium, while trench 19S showed an approximately equal decline. All the relative changes in specific isotopes are reflected in comparable changes in gross alpha and beta activities for each trench. Results for well UB1-A show a slight increase in plutonium activity and decreases in strontium and cobalt activities compared to the earlier sampling (May 1978). The interceptor trenches showed detectable amounts of strontium and plutonium.

4.3 Tritium Content in Rainfall Samples Collected at Maxey Flats (J. Clinton and A. J. Weiss)

Between the period of March 1977 and September 1979, rainfall samples were collected by USGS personnel at the disposal site for the purpose of determining tritium levels in these samples. Results of these analyses are listed in Table 4.3. The samples were taken using rainfall collectors located adjacent to wells 11E, 13E, UA and UB, which are shown in Figure 4.1.

In general, a relative increase or decrease in the tritium content from one sampling period to the next is reflected at all the sampling locations. This would indicate that the relative changes are controlled by climatic variations at the site. A more quantitative evaluation of this data would require information concerning the amounts of rainfall during these time intervals, amounts of trench water processed through the evaporator and its tritium contents.

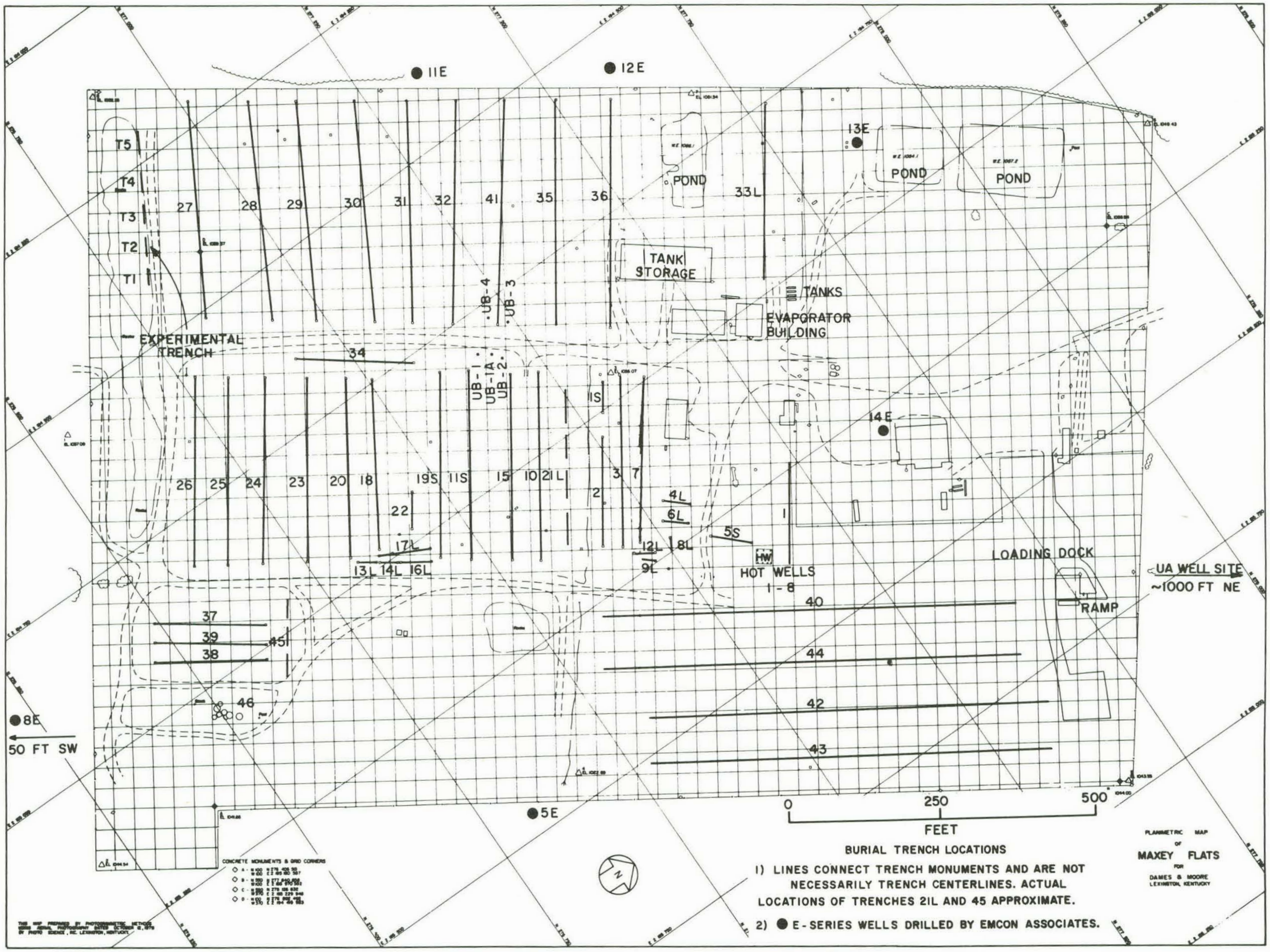

Figure 4.1 Locator map of the Maxey Flats, Kentucky, disposal site.

Table 4.1

Concentration of Dissolved Radionuclides in Water Samples Taken From Maxey Flats, Kentucky, Disposal Site, October-November 1979

[pCi/L (±2 σ%)]

Radionuclide	Trench 19S	Trench 27	Trench 30	Trench 32	Well UB1-A
Gross alpha	6.3 E4 (1.6)	6.9 E4 (1.0)	1.7 E3 (5.7)	9.7 E4 (<1)	< 11
Gross beta	3.2 E4 (<1)	1.9 E5 (<1)	6.4 E4 (<1)	5.8 E5 (<1)	1.0 E 2 (34.)
Tritium	8.7 E7 (<1)	5.1 E9 (<1)	1.8 E10 (<1)	2.1 E9 (<1)	4.9 E 6 (<1)
^{90}Sr	2.1 E5 (10)	1.5 E5 (10)	2.0 E4 (10)	3.2 E5 (10)	3.9 E 1 (20)
^{238}Pu	7.3 E4 (6.0)	2.6 E4 (10)	2.0 E2 (10)	3.7 E4 (10)	2.6 E 1 (10)
$^{239,240}Pu$	2.6 E2 (6.0)	2.5 E3 (10)	3.3 E2 (10)	8.1 E2 (10)	3.5 E-1 (134)
^{241}Am	1.3 E3 (7.6)	4.7 E3 (3.0)	1.2 E2 (22)	6.0 E3 (3.0)	a
^{60}Co	3.3 E3 (1.5)	4.0 E3 (2.6)	3.6 E4 (<1)	2.3 E3 (3.6)	1.1 E 2 (17)
^{134}Cs	a	a	4.3 E2 (9.6)	1.1 E2 (23)	a
^{137}Cs	2.7 E3 (1.4)	2.2 E3 (3.2)	2.9 E4 (<1)	3.2 E3 (2.4)	a

[a] Not detected.

Table 4.2

Concentration of Dissolved Radionuclides in Water Samples Taken From Maxey Flats, Kentucky, Interceptor Trenches, October-November 1979

[pCi/L (±2 σ%)]

Radionuclide	Interceptor Trench 5	Interceptor Trench 4E	Interceptor Trench 3W	Interceptor Trench 2E (Anoxic)[a]	Interceptor Trench 2E
Gross alpha	3.6 E 1 (67)	1.7 E 1 (64)	3.9 E1 (56)	7.5 E 1 (24)	6.8 E1 (26)
Gross beta	<34	<34	5.8 E2 (7.0)	3.5 E 4 (<1)	3.3 E4 (<1)
Tritium	1.7 E 4 (3.1)	1.5 E 5 (1.1)	3.7 E7 (<1)	6.7 E 8 (<1)	6.7 E8 (<1)
$^{90}Sr^{b}$	3.5 E 1 (22)	1.8 E 1 (38)	2.3 E2 (10)	1.9 E 4 (10)	1.8 E4 (10)
$^{238}Pu^{b}$	5.0 E 0 (18)	2.3 E 1 (10)	1.7 E2 (10)	7.0 E 1 (10)	6.5 E1 (10)
$^{239,240}Pu^{b}$	2.5 E-1 (126)	9.1 E-1 (50)	1.7 E0 (34)	9.3 E-1 (20)	1.4 E0 (18)

[a] Water collected using anaerobic collection procedures.
[b] Analyses performed by LFE Laboratories, Richmond, CA.

Table 4.3

Tritium Content in Rainfall Samples Collected at Maxey Flats, Kentucky
(pCi/L$\pm 2\sigma$%)

Date	11E	13E	UA	UB
3/9/77-4/20/77	3.87 E3 (4.2%)	1.53 E5 (1.3%)	<7 E2	-----
4/13/77-5/17/77	6.36 E3 (12%)	2.62 E4 (19%)	2.01 E3 (35%)	-----
5/77-6/21/77	2.75 E4 (2.3%)	2.85 E4 (2.1%)	4.27 E4 (1.8%)	-----
6/21/77-7/20/77	1.08 E4 (4.1%)	1.65 E4 (3.2%)	1.08 E4 (4.2%)	-----
7/20/77-8/25/77	2.99 E3 (13%)	4.96 E4 (1.8%)	1.47 E3 (20%)	-----
8/25/77-9/21/77	6.29 E3 (5.8%)	7.75 E3 (4.9%)	3.46 E3 (10%)	-----
9/21/77-10/14/77	7.28 E3 (5.3%)	4.36 E3 (9.0%)	<7 E2	-----
10/14/77-11/22/77	1.30 E4 (3.9%)	7.90 E3 (5.1%)	1.53 E4 (3.3%)	-----
11/22/77-12/20/77	1.04 E5 (<1)	4.68 E4 (1.7%)	4.91 E3 (8.1%)	-----
12/20/78-3/20/78	1.72 E4 (3.5%)	1.05 E5 (<1)	-----	4.6 E4 (2.0%)
3/22/78-4/19/78	4.28 E4 (1.9%)	5.55 E4 (1.6%)	1.65 E4 (3.0%)	6.96 E4 (1.4%)
4/19/78-5/15/78	8.66 E4 (1.2%)	4.93 E4 (1.8%)	1.70 E3 (40%)	2.74 E5 (<1%)
5/15/78-6/16/78	2.90 E4 (2.1%)	1.83 E5 (1.1%)	8.81 E4 (2.8%)	3.63 E4 (1.2%)
6/16/78-7/12/78	4.11 E3 (7.5%)	2.20 E4 (2.7%)	3.71 E3	7.41 E3 (6.0%)
7/12/78-8/9/78	4.25 E3 (3.8%)	3.38 E3 (10.1%)	5.91 E2 (38.0%)	------
8/9/78-9/5/78	5.71 E3 (6.0%)	6.50 E3 (5.5%)	2.63 E2 (86%)	3.12 E3 (9.9%)
9/5/78-10/5/78	3.82 E3 (10.2%)	5.28 E3 (6.3%)	<2.4 E2	2.92 E3 (10.6%)
10/5/78-11/9/78	8.70 E3 (4.5%)	7.50 E3 (5.2%)	6.54 E3 (6.1%)	2.72 E4 (2.6%)
11/8/78-12/5/78	1.03 E5 (<1%)	1.73 E4 (2.9%)	2.69 E4 (2.2%)	4.73 E4 (1.7%)
12/5/78-2/28/79	2.2 E4	6.3 E4	1.5 E4	1.6 E4
2/28/79-3/28/79	6.25 E3 (5.6%)	1.57 E5 (1.1%)	9.07 E3 (4.7%)	2.58 E3 (7.7%)
3/28/79-4/23/79	4.27 E4 (2.2%)	4.84 E4 (2.0%)	1.79 E4 (3.4%)	7.16 E3 (5.3%)
4/23/79-5/22/79	1.02 E4 (8.5%)	7.14 E3 (11.6%)	2.92 E3 (27%)	5.00 E3 (14%)
5/22/79-6/19/79	3.82 E4 (2.7%)	2.86 E4 (3.2%)	3.46 E3 (14%)	1.14 E4 (5.8%)
6/19/79--8/2/79	<6.2 E2	3.13 E3 (19%)	4.50 E3 (16%)	<6.2 E2
8/2/79-8/28/79	3.40 E3 (19%)	8.16 E2 (73%)	<6 E2	7.93 E2 (75%)
8/29/79-9/28/79	5.57 E3 (12%)	8.85 E4 (1.6%)	1.81 E5 (1.1%)	2.87 E4 (3.3%)

4.4 Inorganic Analyses of Waters Collected at the Maxey Flats, Disposal Site

(M. Kinsley and T. McGee)

4.4.1 Procedures

Waters collected during the October-November 1979 sampling trip were analyzed as part of the source term investigation at the commercial low-level disposal site. In addition, water samples from the experimental interceptor trenches were also included. Detailed sample handling, preparation and analysis procedures have been described in detail in a previous report.(2) Results of threse analyses are presented in Tables 4.4 and 4.5.

4.4.2 Additional Analyses

In addition to those analyses performed previously, several additional analyses were performed to more thoroughly characterize these waters, as a check on the reliability of previous results. These additional analyses are:

1) Analyses for ferrous iron by means of a colorimetric procedure.(4)

2) Additional pH and Eh measurements in the laboratory.

3) Sulfate analyses using an ion-chromatographic (I.C.) technique.(5)

4) Analyses for dissolved sulfide by means of an ion-selective electrode.(6)

5) Analyses for bromide and chloride using an ion-chromatographic technique.(5)

The ferrous iron determination is useful in evaluating redox equilibria in the trench waters and the stability of the trench waters after collection and handling. Laboratory pH and Eh measurements are also required for these evaluations. Sulfide was detected in field measurements during collection of these waters(1) as would be expected in anoxic waters. Quantification of this procedure is being investigated. The ion chromatographic analyses were performed to check the reliability of the sulfate analyses. Bromide, present in the interceptor trenches, interferes with chloride determinations analyzed by the indirect colorimetric technique. To circumvent this difficulty, an ion chromatographic technique is being employed for both halogen ion determinations. Bromide was used as a tracer in the interceptor experiment (trenches 1,2,3,5).

Table 4.4

Concentrations of Dissolved Metals in Water Samples
Taken From the Maxey Flats, Kentucky, Disposal Site,
October-November 1979
(Concentrations in mg/L)

Metal	Interceptor Trenches				Well	Disposal Trenches			
	2E	3W	4E	5	UB1A	19S	27	30	32
Barium	<2	<2	<2	<2	<2	<2	17	<2	19
Calcium	380	450	610	610	180	42	740	32	42
Cesium	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Iron[a]	1.3	1.3	0.5	0.2	<0.1	60	1400	10	0.4
Iron[b]	2.0	1.2	<0.5	<0.5	<0.5	58	1400	10	<0.5
Fe^{+2}/Fe^{+3} [b]	4/1[d]	0.07/1[e]	---	---	---	30/1	39/1	25/1	---
Lithium	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	2.3	<0.5	<0.5
Magnesium	160	95	95	130	300	130	720	1300	300
Manganese	3.5	2.7	1.1	0.20	<0.1	0.19	190	0.32	0.34
Potassium	35	26	17	32	12	27	100	43	160
Sodium	530	910	280	1200	530	480	770	1000	720
Strontium	7.7	6.6	5.6	8.4	2.6	0.65	6.7	0.1	0.52
Total Cations[c] (Meq/L)	57	71	51	92	57	39	200	160	69

[a] Atomic absorption method.

[b] Colorimetric method

[c] Total meq for metals plus nitrogen from NH_4^+ analyses.

[d] Sample was not filtered anaerobically.

[e] Trench was not sampled anaerobically.

Table 4.5

Concentrations of Dissolved Non-Metals in Water Samples Taken From the Maxey Flats, Kentucky, Disposal Site, October-November 1979 (Concentrations in mg/L)

	Interceptor Trenches				Well	Disposal Trenches			
Component	2E	3W	4E	5	UB1-A	19S	27	30	32
Total alkalinity (as $CaCO_3$)	300	450	300	320	30	900	300	6400	1700
Hardness (Mg+Ca) (as $CaCO_3$)	1600	1500	1900	2000	1700	650	4800	5400	1400
Inorganic Carbon	68	120	50	86	15	170	74	1500	350
D.O.C.	120	15	29	14	5.1	300	500	260	670
Nitrogen (N) (NH_3-Probe)	20	a	5	<1	<1	30	60	50	90
Nitrogen (N) (NH_4 -Color)	13	1.0	<1	<1	<1	34	75	110	88
Chloride-I.C.[b]	1200	160	140	84	350	190	6100	200	330
Bromide-I.C.	180	2200	2.4	4100	8.2	1.3	180	3.8	3.3
Nitrogen (N) (NO_2-Color)	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Nitrogen (N) (NO_2+NO_3)	0.51	0.39	<0.05	1.4	0.50	0.12	0.75	0.11	0.8
Phosphate	<1	<1	<1	<1	<1	<1	<1	2.0	1.1
Silica	7.7	8.7	7.5	0.74	19	15	19	42	29
Sulfate-Color (Anoxic)	550	1000	1500	1300	1700	23[c]	1100[d]	≥60[e]	≥60[e]
Sulfate-I.C.	530	980	1500	1300	1700	<0.5	2.2	f	9.6
Sulfate-I.C. (Acidified)	560	1100	1500	1400	1900	g	62	85	64
pH[h]	7.0	6.8	7.2	7.5	6.4	7.1	5.6	7.9	7.5
Total Anions[i] (Meq/L)	54	64	42	88	50	24	180	140	46

[a] Unstable system.
[b] Ion chromatography
[c] Standard deviation ±20%
[d] Standard deviation ±10%
[e] Interfering components
[f] Insufficient sample.
[g] Nitrate interference
[h] pH after anoxic filtration.
[i] Calculations used data for acidified I.C. sulfate analysis.

4.4.3 Results

Results for the disposal trench waters are similar to those reported for waters collected during earlier sampling trips.(2) These waters show low contents of sulfate and nitrate, high titration alkalinity, the presence of ammonia and sulfide, and low Eh values. These are characteristics of chemically reducing, anoxic water regimes frequently found in stagnant waters in natural environments, and typical of organic laden waste waters.

As reported previously,(2) the titration alkalinity shows an irregular behavior reflecting the complex nature and high buffering capacity typical of these anoxic trench waters.

Comparison of the disposal trench waters against the more typical ground waters (well UB1-A) shows the contrast between ground waters and the anoxic trench waters. The interceptor trench waters show a chemistry intermediate between the well and disposal trench waters. This may reflect an increased influence of disposal trench waters on the interceptor trenches relative to their influence on the well waters.

4.4.4 Redox Equilibria (K. Czyscinski and R. Pietrzak)

Preserving the in situ water chemistry of trench water samples was a prime consideration in developing sampling and analytical procedures. During the sample collection, transportation and filtering processes prior to analysis, some shifts in the numerous chemical equilibria present in these complex waters are to be anticipated. These changes result because the waters have been removed from contact with the soil media and have experienced temperature and gas phase changes. It is hoped that these alterations of the sample environment do not produce changes so drastic that the inorganic analyses are completely unrepresentative of in situ field conditions. One method of evaluating the extent of these changes is to examine Eh-pH relationships measured in the field, and later in the laboratory during subsequent sample manipulations.

Figure 4.2 presents an Eh-pH stability diagram for iron species frequently found in both oxidized and reduced natural environments. Field trench water Eh-pH measurements correlate well with those expected for equilibria between aqueous ferrous iron and limonitic iron oxide (a common soil component) and iron sulfides (commonly formed in anoxic sediment-water systems). After sampling, transporation and laboratory filtration, the Eh-pH values for the various trenches have shifted but are still in good agreement with the equilibria lines for these systems. This indicates that the water systems have not been drastically altered during sample handling. Waters from well UB1-A are drastically different than the trench waters in that the redox environment is oxidizing and not controlled by iron equilibria.

A more detailed picture of the chemical systems for individual trenches can be seen on this diagram. Field data for trench 32 indicates an equilibrium with iron sulfide. Field measurements for sulfide ion activity(1) showed the highest readings for trench 32 and the color of the water drawn from the trench was black. Precipitated iron sulfide is black in color and is frequently

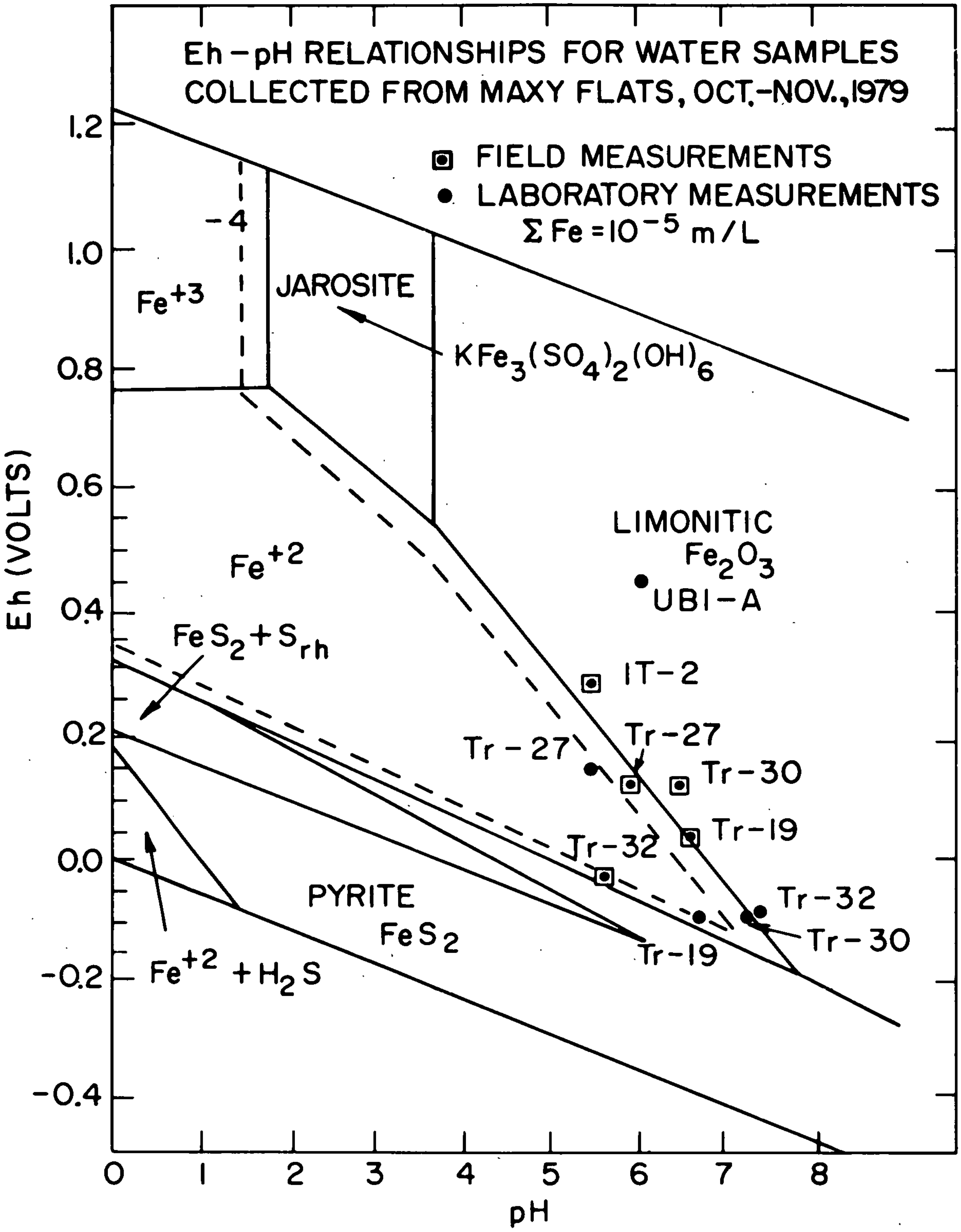

Figure 4.2. Eh-pH relationships for water samples collected from Maxey Flats, October-November 1979.

observed forming in natural anoxic waters. The remaining waters appear to be controlled by ferrous iron and iron oxides commonly present in soils. In the trench 27 waters, total dissolved iron is in the range of 10^{-3} mol/L, however, chloride content in this water is also high so that the actual concentration of free ferrous iron is in the proper range for this diagram due to extensive iron-chloride ion pairing at these relatively high iron and chloride concentrations. The interceptor trench 2E also shows an equilibrium of ferrous iron and iron oxide, although the redox state of this water is more oxidizing than the disposal trenches.

4.5 Carbon Analyses (B. Nine)

Aliquots of the trench waters were analyzed by means of a Beckman Total Carbon Analyser. The instrument measures total and inorganic carbon, the organic carbon is equal to the difference between these numbers. Results are presented in Table 4.6. For the disposal trenches, the results are similar to those obtained previously. The carbon content of the interceptor trench waters are higher than the well sample, but considerably lower than the disposal trenches, reflecting the influence of the disposal trenches vs the local groundwater on the interceptor trench water composition.

Table 4.6

Carbon Analyses of Maxey Flats, Kentucky, Disposal and Interceptor Trenches and Well UB1-A-Sampled October-November 1979

Sample Location	Total Carbon (ppm)	Inorganic Carbon (ppm)	Organic Carbon (ppm)
Trench 19S	470	170	300
Trench 27	580	70	510
Trench 30	1800	1500	300
Trench 32	1000	350	650
Well UB1A	20	15	5
Interceptor 2E (anoxic)	180	70	110
Interceptor 2E	190	70	120
Interceptor 3W	140	120	20
Interceptor 4E	80	50	30
Interceptor 5	100	90	10

4.6 Organic Compounds (B. Nine)

Water samples collected from the disposal and interceptor trenches were analyzed for organic constituents soluble in methylene chloride. Aliquots of the waters were extracted into methylene chloride, concentrated, and analyzed by GC-mass spectroscopy techniques for qualitative identification of the compounds present. Quantifications were performed by gas chromatographic techniques. Complete details of the procedures have been described previously.(2) Results for the interceptor trenches are presented in Table 4.7. Concentrations of the organic compounds are those in the methylene chloride extract, rather than the original trench water samples. Small amounts of a few methylene chloride soluble organic compounds were found. The largest amount was found in interceptor trench 3W.

Table 4.7

Compounds Identified in Interceptor Trenches at Maxey Flats, Kentucky

Trench	Concentration (mg/L)	Trench	Concentration (mg/L)
Interceptor 5		Interceptor 2E (anoxic)	
acid fraction:		acid fraction:	
none		phenol	0.06
basic fraction:		C$_8$ acid TMS	N.Q.
none		2-ethylhexanoic acid	0.44
neutral fraction:			
tetrahydrofuran	N.Q.[a]	basic fraction:	
		p-dioxane	N.Q.
DOC	10	neutral fraction:	
		tetrahydrofuran	N.Q.
Interceptor 4E		p-dioxane	N.Q.
		cyclohexanone	N.Q.
acid fraction:			
none		DOC	110
basic fraction:			
tetrahydrofuran	N.Q.	Interceptor 2E	
Neutral fraction:			
2-butanone	N.Q.	acid fraction:	
tetrahydrofuran	N.Q.	phenol	0.06
cyclohexanone	N.Q.	C$_8$ acid TMS	N.Q.
		2-ethylhexanoic	0.48
DOC	30		
		basic fraction:	
Interceptor 3W		p-dioxane	N.Q.
acid fraction:		neutral fraction:	
ethylene glycol-diTMS	N.Q.	2-butanone	N.Q.
(ethylene glycol) n-diTMS	N.Q.	tetrahydrofuran	N.Q.
dioctyl adipate	3.4	p-dioxane	N.Q.
di-isooctyl pthalate	N.Q.	cyclohexanone	N.Q.
basic fraction:			
p-dioxane	N.Q.	DOC	120
neutral fraction:			
p-dioxane	N.Q.		
DOC	20		

[a] N.Q.-not quantified.

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