

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

QUARTERLY PROGRESS REPORT

JANUARY - MARCH 1980

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NUCLEAR WASTE MANAGEMENT DIVISION

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UPTON, NEW YORK 11973



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ABSTRACT

This report presents results for tritium analyses for soil cores taken at West Valley, NY, and Barnwell, SC. Tritium movement at West Valley appears to be diffusion controlled. The Barnwell core data suggests that coring has intersected a water flow path below the trench. An apparatus has been designed for flow through column K_d determinations and is described. Gel filtration experiments using spiked trench water from West Valley have been continued using a longer column than used in previous work. Increased resolution of DOC components has been observed.

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1. ORGANO-RADIONUCLIDE COMPLEXES IN TRENCH WATER
(M. Kinsley, B. J. Nine, and A. J. Weiss)

1.1 Introduction

Experiments were continued to examine trench waters to determine the existence of organo-radionuclide complexes that could influence the mobility of radionuclides from the trenches into neighboring ground waters and environs.

1.2 Methodology and Equipment

Gel filtration chromatography was used to fractionate the trench waters. A description of the method and equipment and the results of preliminary screening experiments can be found in a previous report.⁽¹⁾

The gamma photon counting procedure⁽¹⁾ was modified to selectively count cesium-137 photons and cobalt-60 photons, in addition to the total gamma count. The three channels of the automatic counting system¹ were set to record photons with three different energy ranges. Channel A recorded gamma photons with energies between 15 and 3000 keV (total gamma count). Channel B recorded photons with energies between 560 and 760 keV (to determine the 662 keV photopeak of ¹³⁷Cs). Channel C was set for gamma photons with energies between 1000 and 3000 keV to recorded the 1173 and 1333 keV photopeaks of ⁶⁰Co. Since contributions from ⁶⁰Co were recorded in channel B, corrections were subtracted from all channel B counts. The corrections were determined by multiplying the sample counts in channel C by the ratio of the counts in channels B and C for a pure cobalt-60 source.

1.3 Experimental

Large chromatographic columns [1.6-cm-i.d., 100-cm-long, and 180 mL total column volume (V_t)] were packed with Sephadex¹ G-10 gel and used in the experiments described in this report. Five-mL aliquots were used for all the fractions. The fractions were eluted with 0.02 M NaCl at flow rates of about 0.7 mL per minute. Fractions containing 2.4 mL were collected and analyzed. Four sets of fractionation experiments were conducted.

A solution containing 0.5% Blue Dextran 2000 in 0.02 M NaCl was fractionated to determine the void volumes (V_0) of the columns. The fractions were analyzed colorimetrically at 600 nm.

¹Pharmacia Fine Chemicals, Piscataway, NJ 08854.

Solutions containing either tracer ^{137}Cs or ^{60}Co in 0.02 M NaCl were fractionated to determine the elution peaks for their inorganic species. The fractions were analyzed for total gamma activity.

A solution containing tracer ^{137}Cs , tracer ^{60}Co , and 0.3 w/v% EDTA in 0.02 M NaCl was fractionated to determine the elution profile of EDTA complexes. The fractions were analyzed for ^{137}Cs , ^{60}Co , and dissolved organic carbon (DOC).

Trench water (anoxically sampled in October 1978 from Trench 8 (point 8-1B) in the West Valley, NY, waste disposal site) was air-oxidized and filtered through a 0.45 μm filter. The water contained small amounts of cesium-137, and very small amounts of cesium-134, and was spiked with cesium-137 and cobalt-60 tracers prior to the fractionation. The cobalt-60 spike was added to determine if it would form an organo-radionuclide complex in this trench water. The cesium-137 was enriched 3000% to provide sufficient gamma activity in the fractions to get reliable counting statistics. It was reported previously⁽¹⁾ that the added cesium-137 exchanged with the cesium-137 radionuclide originally present in the trench water. The fractions were analyzed for ^{137}Cs , ^{60}Co , and DOC.

1.4 Results and Discussion

The concentrations in the Blue Dextran fractions and the gamma counts in the $^{137}\text{CsCl}$ fractions (expressed as percent yields of the amounts in their solutions prior to the fractionations) were plotted in Figures 1.1 and 1.2. These peaks show the locations of the V_0 and inorganic peaks. The total yields for the Blue Dextran and cesium-137 fractions were 95% and 100%, respectively.

No gamma counts were recorded for the fractions eluted during the $^{60}\text{CoCl}_2$ experiments. In one experiment, about thirty V_t were eluted but no cobalt-60 was recovered. The cobalt-60 was recovered in less than two V_t when a 0.3% EDTA in 0.02 M NaCl solution was passed through the column. The manufacturer reported⁽²⁾ that the gels contain small amounts of negatively charged groups and recommended using an eluant with an ionic strength equal to or greater than 0.02 M. These experiments indicated that the G-10 gel had a much greater affinity for tracer cobalt ions than for 0.02 M sodium ions in chloride solutions.

The yields for cobalt-60 and cesium-137 in the fractions from the ^{60}Co - ^{137}Cs -EDTA solution were plotted in Figure 1.2; the total yields were 100% and 103% respectively. The DOC analyses have not been completed, but the results obtained using the small column showed that all the DOC was recovered in the fractions containing the cobalt-60. All the cobalt-60 was recovered in a well-defined peak that coincided with V_0 peak indicating the presence of a ^{60}Co -EDTA complex. The maximum yield and shape of the cesium-137 elution peak was the same as that obtained for the inorganic peak in the $^{137}\text{CsCl}$ experiment. The results indicated that the cesium-137 was recovered as an

¹Automatic Gamma Counting System, 1185 Series, Searle Analytic, Inc., Des Plaines, IL 60018.

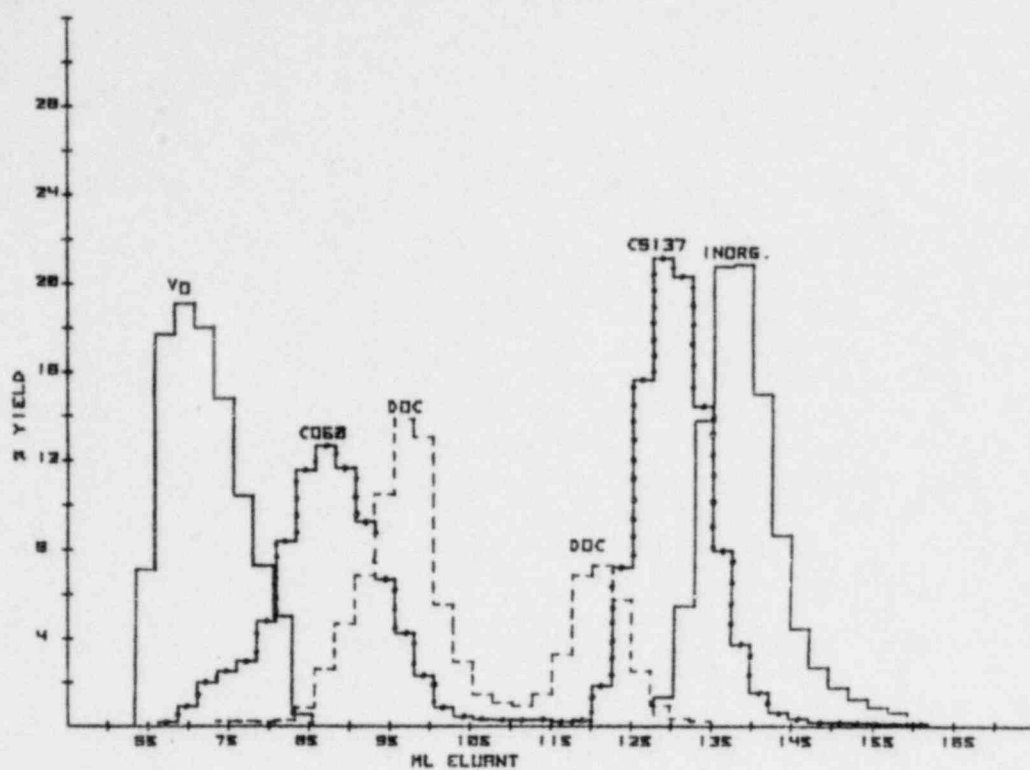


Figure 1.1. Fractionations of blue dextran, $^{137}\text{CsCl}$, and West Valley trench sample, using Sephadex G-10 gel-column B.

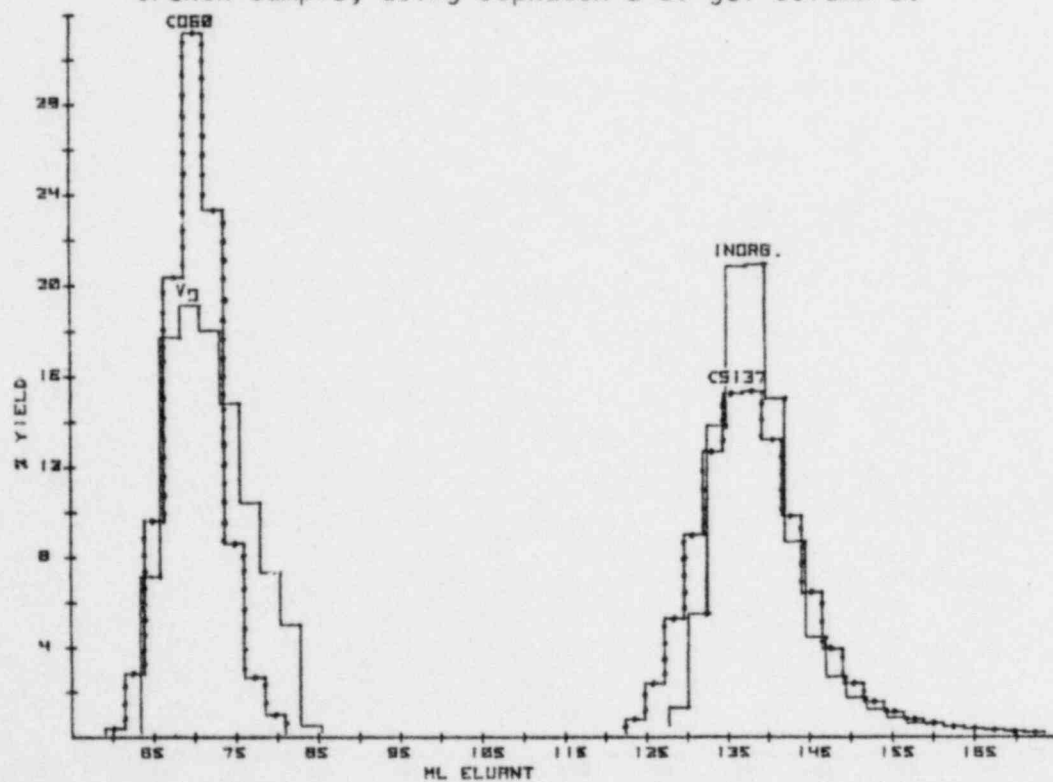


Figure 1.2. Fractionations of blue dextran, $^{137}\text{CsCl}$, and EDTA spiked with ^{60}Co and ^{137}Cs , using Sephadex G-10 gel-column B.

inorganic species and confirmed the results reported previously using the small column.

The yields for the cesium-137, cobalt-60, and DOC in the fractions from the spiked trench water, were plotted in Figure 1.1. Aliquots were fractionated on duplicate columns and the elution plots were the same. The total yields, averaged for the duplicate fractionations, were 98.2%, 81.4%, and 99.3% for the cesium-137, cobalt-60, and DOC respectively. These results showed better resolution of elution peaks than the resolution observed in experiments using the small column.⁽¹⁾ The DOC was resolved into two peaks. The second DOC peak reached its maximum prior to the maximum of the cesium-137 peak and tailed into the beginning of the cesium-137 peak. The maximum for the cesium-137 peak occurred prior to that of the inorganic species. The plot showed that the cesium-137 species had a molecular weight between 175 and 700 (closer to 200) and probably contained a low molecular weight organic ligand that was present in low concentrations in this trench water.

The maximum yield for the cobalt-60 species occurred between the V_0 and the first DOC maximums. The cobalt-60 peak had a shoulder at low elution volumes coinciding with the V_0 peak. The leading edge of the DOC peak coincided with the fractions containing cobalt-60. This profile probably indicates that the cobalt-60 formed more than one complex in the trench water. Since the more abundant complex did not coincide with V_0 , it was concluded that a $^{60}\text{Co-EDTA}$ complex could not be the major contributor. About 20% of the cobalt-60 was not recovered in the fractions and probably adhered to the negatively charged groups in the gel. Since 80% was recovered, the formation of cobalt ligands in the trench water was favored over the ionic species.

1.5 References

1. M. T. Kinsley, A. J. Francis, B. J. Nine, and A. J. Weiss, Brookhaven National Laboratory, "Organo-Radionuclide Complexes in Trench Water," in Evaluation of Isotope Migration-Land Burial- Water Chemistry at Commercially Operated Low-Level Radioactive Waste Disposal Sites -Quarterly Progress Report, October-December 1979, NUREG/CR-1325, BNL-NUREG-51143, February 1980. Available from the National Technical Information Service, Springfield, VA 22161.
2. Sephadex - Gel Filtration in Theory and Practice, p. 35 (1977). Available from Pharmacia Fine Chemicals, Division of Pharmacia, Inc., Piscataway, NJ 08854.

2. TRITIUM CONTENT OF WATER IN SOIL CORES COLLECTED AT THE WEST VALLEY, NEW YORK, AND BARNWELL, SOUTH CAROLINA, DISPOSAL SITES
(R. Pietrzak, B. Nine, S. Garber, and K. Czyscinski)

2.1 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) determine mineral-radionuclide associations and, (3) compare results of laboratory K_d studies against the field situation. The general analytical plan has been described previously.⁽¹⁾ A flow chart of the planned core analysis scheme is shown in Figure 2.1.

Tritium analysis is the first step in the scheme after the core material is sectioned. This report presents results of tritium distillations for cores taken from a pump-out lagoon at the West Valley, New York, disposal facility, and one of the cores taken from beneath the disposal trenches at the Barnwell, South Carolina, disposal site.

2.2 West Valley, New York - Lagoon Cores

In 1975, a lagoon was excavated at the West Valley, New York, disposal site to hold water pumped out of the burial trenches. It is located 40 feet west of trench 14, is approximately 40 feet wide, 100 feet long, and 10 feet deep (Figure 2.2). The lagoon has sloping walls, especially at the north and south ends which were used as access ramps by the bulldozers.

"Below a depth of 8 feet on the north end and including the trench floor was unoxidized clay-rich till with no fracture traces. At the south end of the lagoon and below a depth of 8 feet including the trench floor were numerous distorted and folded layers of silts and clays (mass bedded lacustrine deposits).

The lagoon has been used to hold trench water from at least three previous pumpouts--fall of 1975, summer and fall of 1976, and fall of 1977. Water from a trench was pumped to the lagoon where hypochlorite was added to the trench water to kill the bacteria. The trench water in the lagoon was periodically stirred using an electric motor attached to the walk bridge.

The lagoon has not been used since. At present, the water level in the lagoon is about 5.8 feet above the trench floor. This water is mainly the result of direct precipitation accumulated since the last time the lagoon was pumped out (November-December 1977)". (D. Prudic, U.S. Geologic Survey, personal communication, December 1978).

Two core samples were collected from the lagoon by D. Prudic, on December 13, 1978. The samples were obtained from the center of the lagoon, approximately one foot apart. The sampling procedure was as follows: an aluminum tube covered with a plastic bag was driven into the lagoon floor thus keeping water from entering the inside of the tube. A two inch thin-walled steel tube was driven about 18 inches into the lagoon floor bottom. After

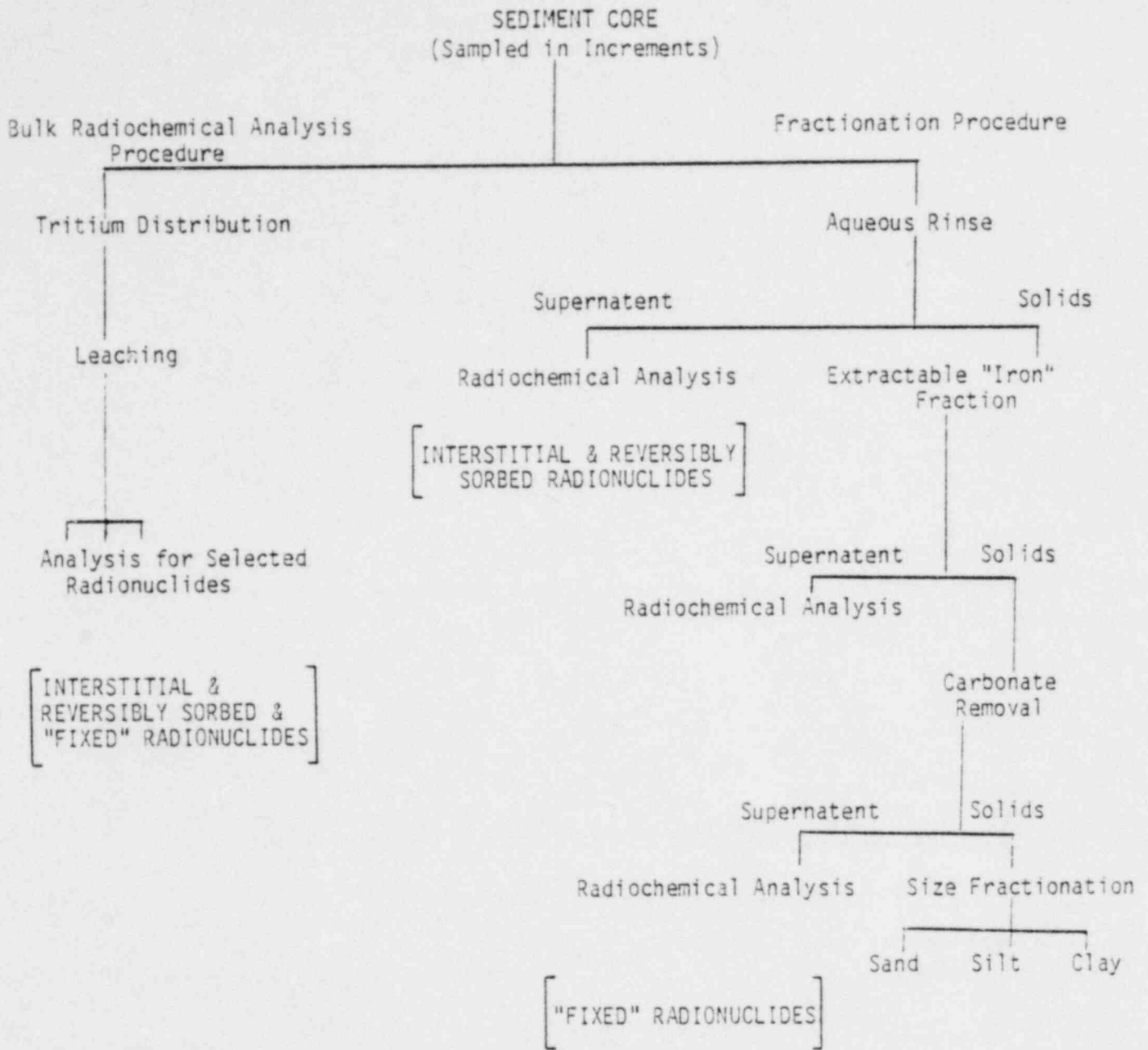


Figure 2.1. Flow chart outline for core analysis.

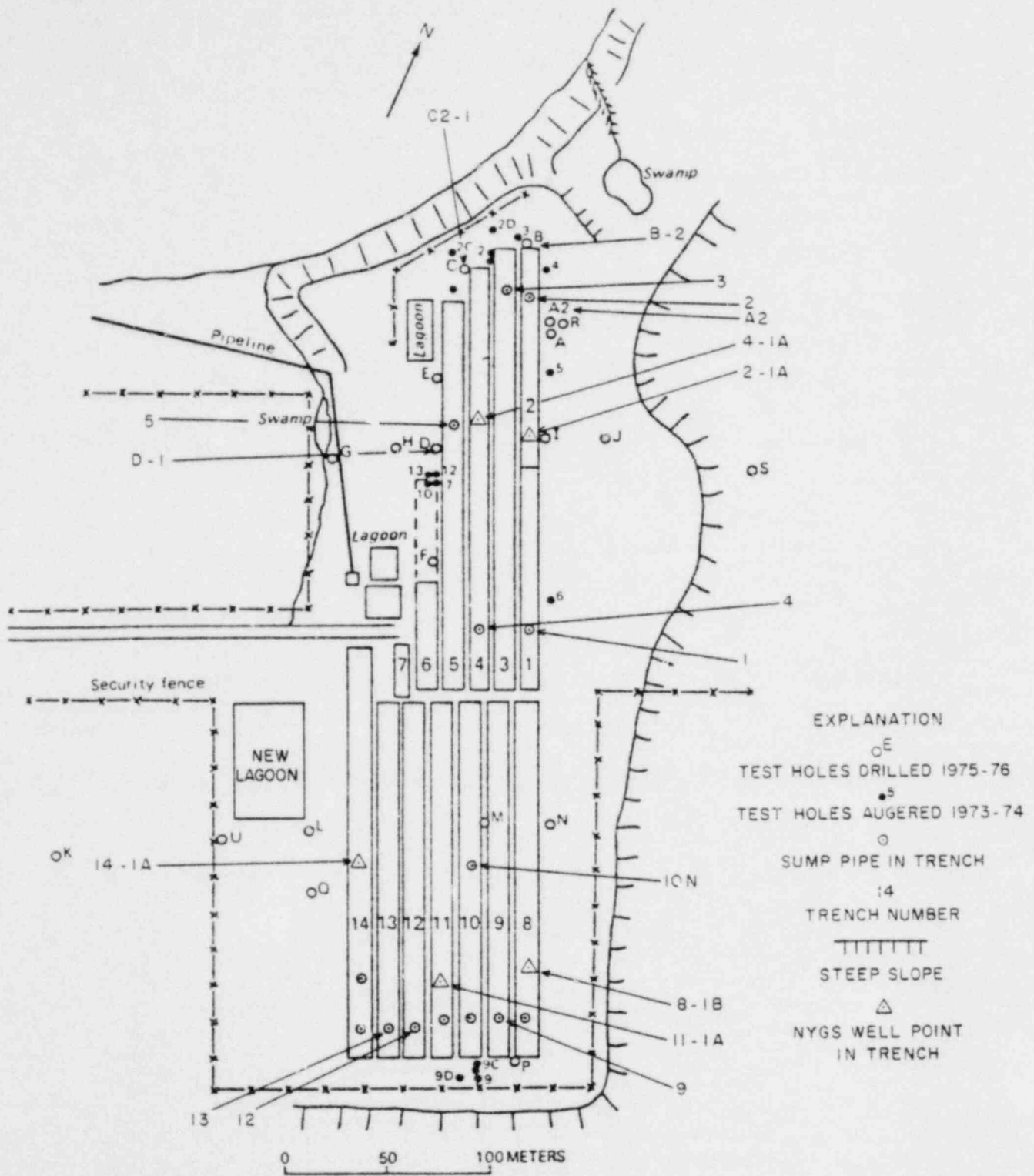


Figure 2.2. Locator map of the West Valley, NY, disposal facility showing the location of the pump-out lagoon sampled.

retrieving the sample tube, the outside was cleaned and the ends were capped for shipping. The core was subdivided in the laboratory by cutting through the tubing with a hacksaw. Using a sharpened brass tube, a "clean" cylinder of material was bored out of the core section. The remaining sediment (the annular portion) was kept in the lengths of metal tubing which were in turn stored in sealed glass jars.

2.3 Barnwell, South Carolina - Trench Cores:

Four cores were collected by J. Cahill of the U.S. Geological Survey in 1979. The cores were taken from beneath disposal trenches by drilling through the top of the selected trenches, and using a split spoon sampler. The locations where cores were taken are shown in Figure 2.3.

The material was sectioned and alternate lengths of the cored sediment sent to BNL for analysis. These lengths were packed in PVC tubing, with paper packing at each end to prevent moisture loss. The ends were also sealed with duct tape. Prior to further sectioning for analysis, the core sections were stored in a refrigerator as a further precaution against moisture loss.

2.4 Equipment and Materials

Vacuum distillation apparatus - glassware was prepared from glass pipe and is shown in Figure 2.4. The distillation setup is shown in Figure 2.5.

Liquid scintillation cocktail - Packard Insta-Gel

Scintillation vials - low potassium glass vials with polyseal cap

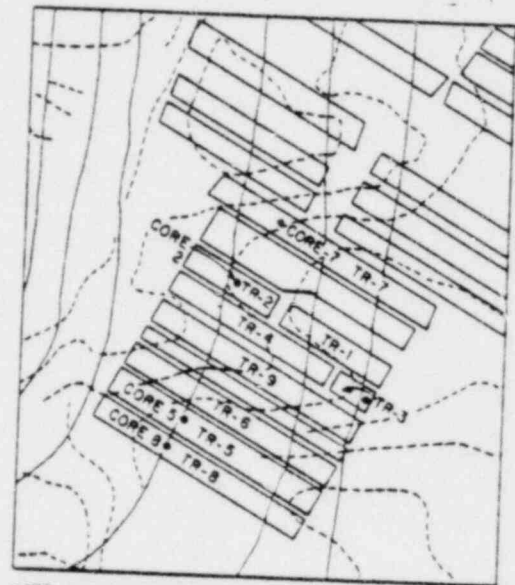
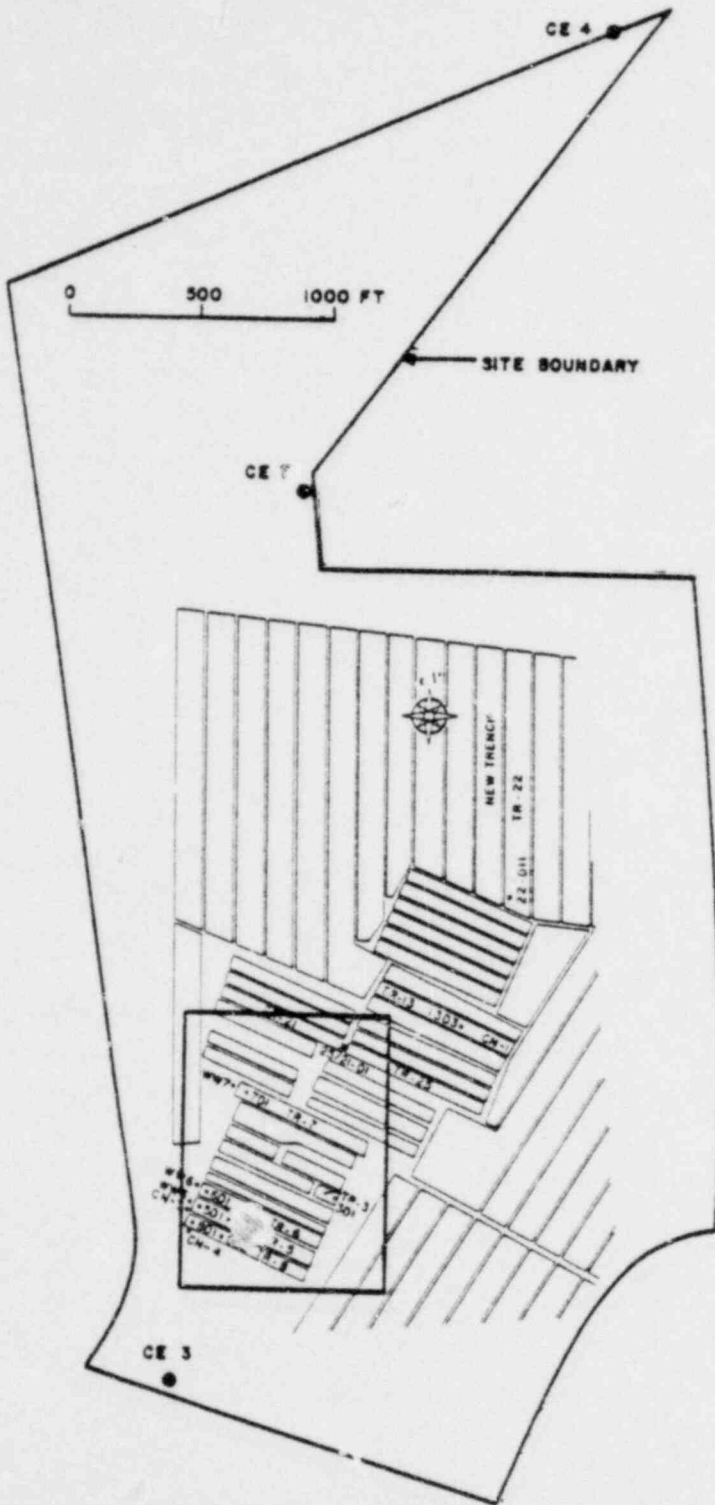
Tritiated water - National Bureau of Standards SRM-4926-C tritiated water

Liquid scintillation counter - Searle Analytic-92

2.5 Procedure

The soil core samples were subdivided into small cylinders approximately one inch in diameter by two inches in length. The exterior of the core was removed to minimize any possible cross contamination that may have occurred during the sampling operation. The cylinders were kept in preweighed glass weighing bottles that were covered with a ground glass joint lid. Before distillation, the lid was removed and the remainder of the bottle containing the core section was placed directly in the glassware assembly.

Water was distilled from the core samples by vacuum distillation and collected in a trap cooled with liquid nitrogen. The cores were further dried (two hours) in an oven at 180°C to completely dry the soil core sections. An aliquot of the distillate was pipetted into a glass liquid scintillation vial containing 10 mL of scintillation cocktail. The vial was sealed and shaken to form a solution.



NOTE: DASHED LINES REPRESENT ORIGINAL GROUND CONTOURS
 NOTE: SOLID LINES REPRESENT PROPOSED COMPLETED CONTOURS

Figure 2.3. Locator map of the Barnwell, SC, disposal facility showing the location of the trenches from which cores were taken.

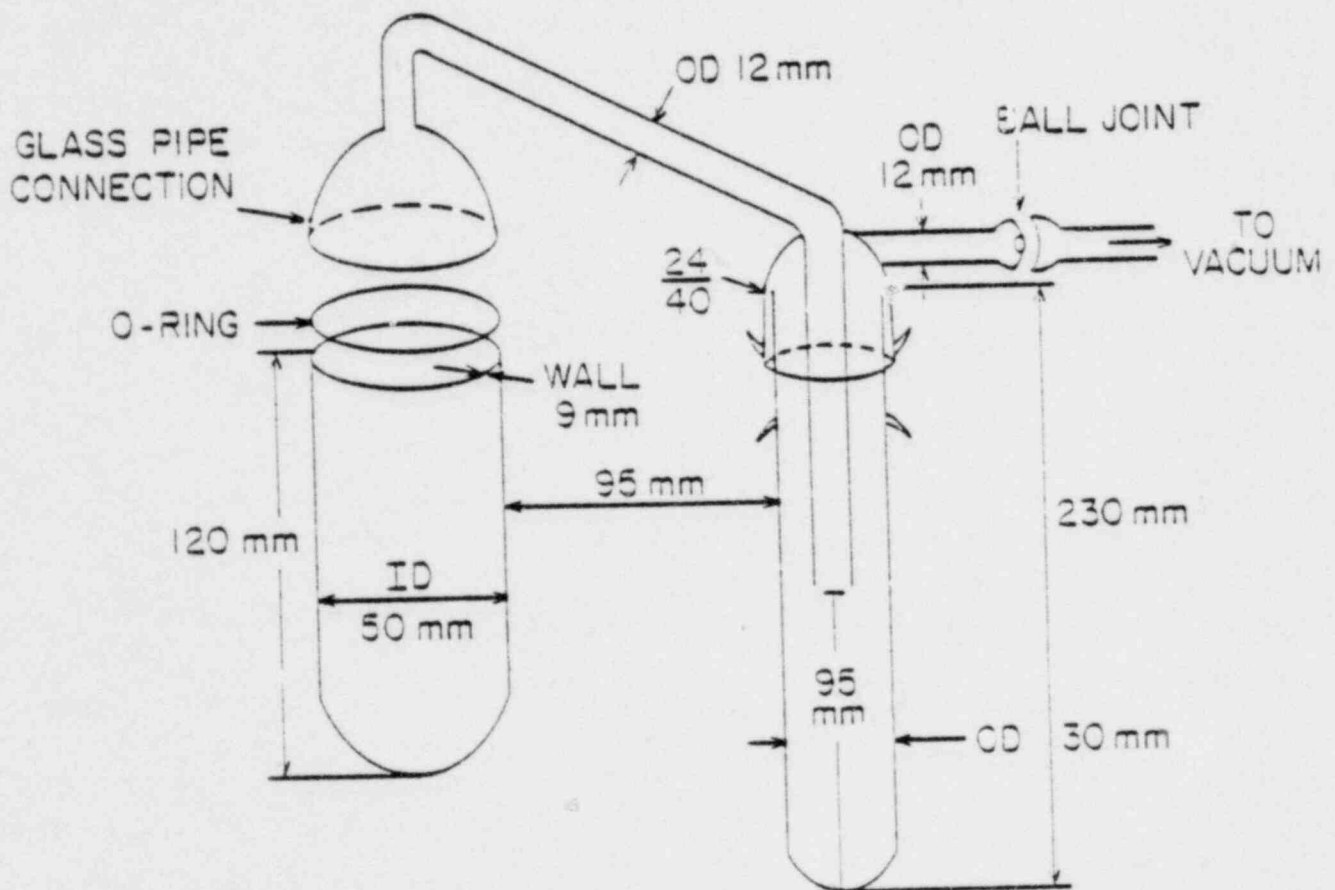


Figure 2.4. Glassware assembly for tritium distillation.

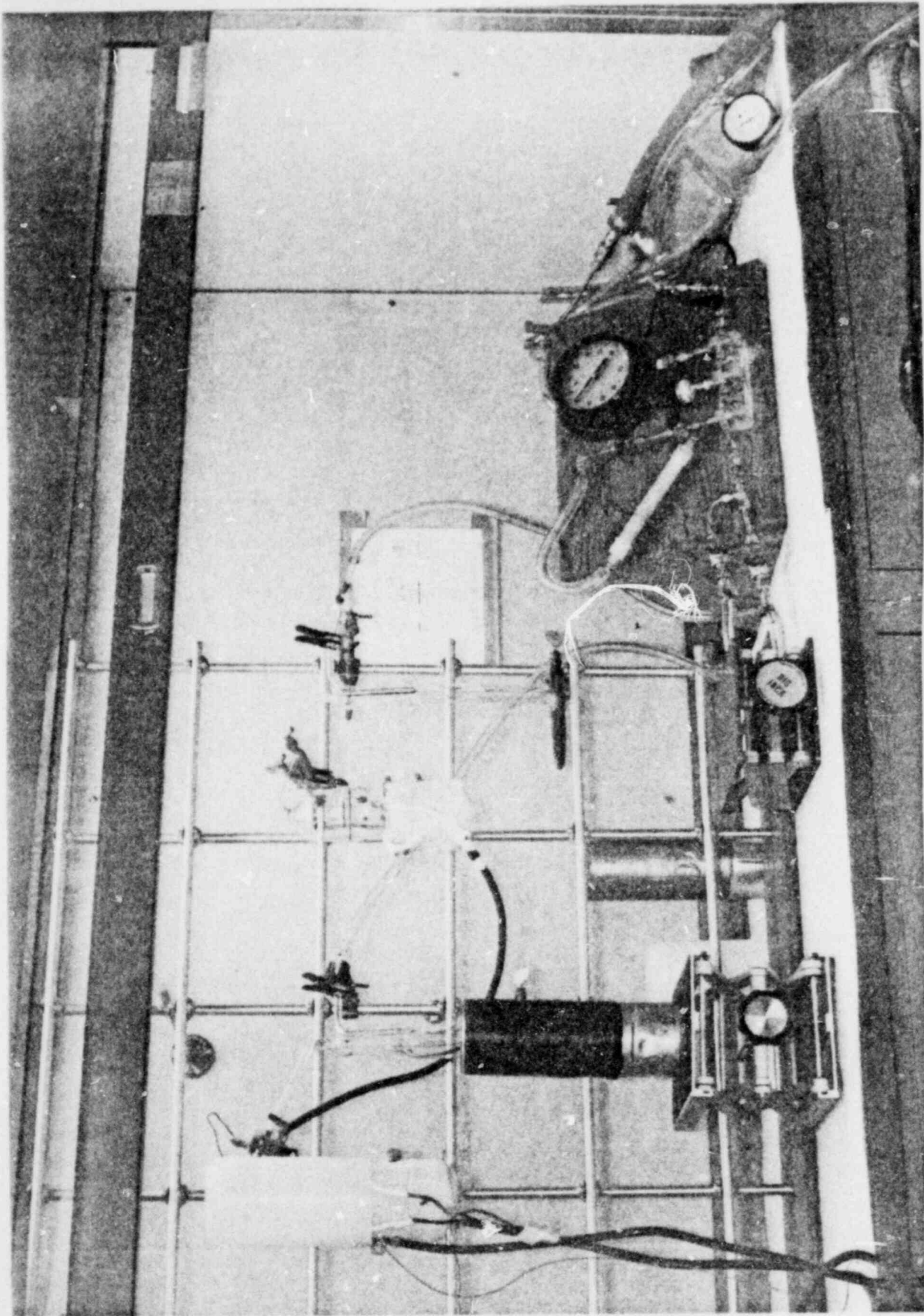


Figure 2.5. Photograph of the complete tritium distillation assembly.

Deionized water was distilled to prepare blanks. Tritium calibration standards were prepared by addition of small volumes (0.02 mL) of tritiated water to a blank.

The water plus scintillation cocktail samples were cooled and dark-adapted for at least one hour prior to counting (50 minutes) in a liquid scintillation counter. To calculate the tritium activity, the counts in a tritium window (which excludes higher energy beta particles) were corrected for background counts, counting time, counting efficiency, and sample volume.

2.6 Results and Discussion

West Valley Cores

The dimensions, pre and post distillation weights of the core samples, and the tritium activity of the core water, are reported in Tables 2.1 and 2.2. The pH of a soil/water paste⁽²⁾ prepared from the annulus material is included. The tritium activity vs depth for the the two cores is shown in Figure 2.6. A slight decrease in the tritium activity was observed with core depth. Tritium activity in the cores decreased from the lagoon floor downward into the clay bed. The scatter in the data may reflect some experimental problems that occurred during the distillation process. Linear regression of the data shows poor correlation ($r = 0.3$) with a degree of certainty of greater than 80%. A curved (dashed) line shows a better correspondence with the data, however. This distribution suggests that the tritiated water moves downward from the lagoon floor into the clay bed by a diffusion mechanism. Considering the very low hydraulic conductivities of sediments at West Valley (10^{-7} to 10^{-9} cm/s)⁽³⁾ the diffusion mechanism appears reasonable.

The Barnwell Core - Trench 2

Figure 2.7 gives the tritium activity for core 2 from Barnwell, South Carolina. The descriptive data is tabulated in Table 2.3. Tritium activity increases with depth to a maximum and drops to a low value at the greatest depth sampled. The data appears to represent an intersection of a horizontal band of tritiated water, perhaps along a flow path in the semi-consolidated sands below the trench. The data points were grouped in clusters probably due to the fact that core sections (6-8 inches in length) were separately sealed during the sampling operation. The sediments in these cores are composed of semiconsolidated sands and clays with hydraulic conductivities in the range of 10^{-5} cm/s.⁽⁴⁾ This relatively high permeability would allow the tritiated water to equilibrate by diffusion between the time of sampling at Barnwell, South Carolina, and division of the sample in the laboratory at BNL.

Table 2.1
West Valley Lagoon Core #1
Physical Parameters, Tritium Activity and pH

Core Sample Number	Core Depth (cm)	Wet Weight (grams)	Wet Cylinder Dimensions		Dry Weight (grams)	Dry Cylinder Dimensions		pH	H-3 pCi/L
			Diameter (cm)	Height (cm)		Diameter (cm)	Height (cm)		
WV-C-1-1	30-36 Btm	34.20	2.5	---	28.54	---	---	7.4	8.7 E7
WV-C-1-2	25-30	43.88	2.5	5.1	36.39	2.3	4.6	7.4	1.1 E8
WV-C-1-3	20-25	74.09	3.2	5.1	62.35	2.7	4.8	7.3	1.0 E8
WV-C-1-4	15-20	77.07	3.2	5.1	64.40	2.8	4.9	7.2	8.6 E7
WV-C-1-5	10-15	60.87	3.2	5.1	50.48	2.8	4.0	7.8	6.3 E7
WV-C-1-6	5-10	75.40	3.2	5.1	62.01	2.8	4.8	7.5	1.4 E8
WV-C-1-7	0.6-5	18.59	3.2	---	15.56	2.6	3.4	8.4	2.0 E7
WV-C-1-8	0.0-0.6 Top	50.31	3.2	---	41.64	2.8	0.6	---	8.5 E7

Table 2.2
West Valley Lagoon Core #2
Physical Parameters, Tritium Activity and pH

Core Sample Number	Core Depth (cm)	Wet Weight (grams)	Wet Cylinder Dimensions		Dry Weight (grams)	Dry Cylinder Dimensions		pH	H-3 pCi/L
			Diameter (cm)	Height (cm)		Diameter (cm)	Height (cm)		
WV-C-2-1	36-38	66.52	2.5	2.5	56.42	3.6	2.8	7.7	7.0 E7
WV-C-2-2	30-36	71.58	3.2	5	61.02	2.9	4.9	7.7	5.1 E7
WV-C-2-3	28-30	34.31	3.2	5	30.64	---	---	7.7	1.0 E8
WV-C-2-4	23-29	76.00	3.2	5	66.18	4.7	4.7	7.8	9.5 E7
WV-C-2-5	18-23	79.41	3.2	5	67.74	5.3	5.3	7.8	3.7 E7
WV-C-2-6	13-18	78.18	3.2	5	64.48	4.8	4.9	7.7	9.6 E7
WV-C-2-7	10-13	40.70	3.2	5	33.38	2.9	2.7	7.6	2.0 E8
WV-C-2-8	5-10	66.92	3.2	5	55.01	2.9	4.6	7.8	1.1 E8
WV-C-2-9	2.5-5	18.04	3.2	2.5	14.68	2.2	1.9	8.0	1.4 E8
WV-C-2-10	0.6-5	16.81	3.2	1.9	13.68	2.3	1.5	8.6	1.8 E8
WV-C-2-11	0-0.6	16.63	---	---	12.07	---	---	---	1.0 E8

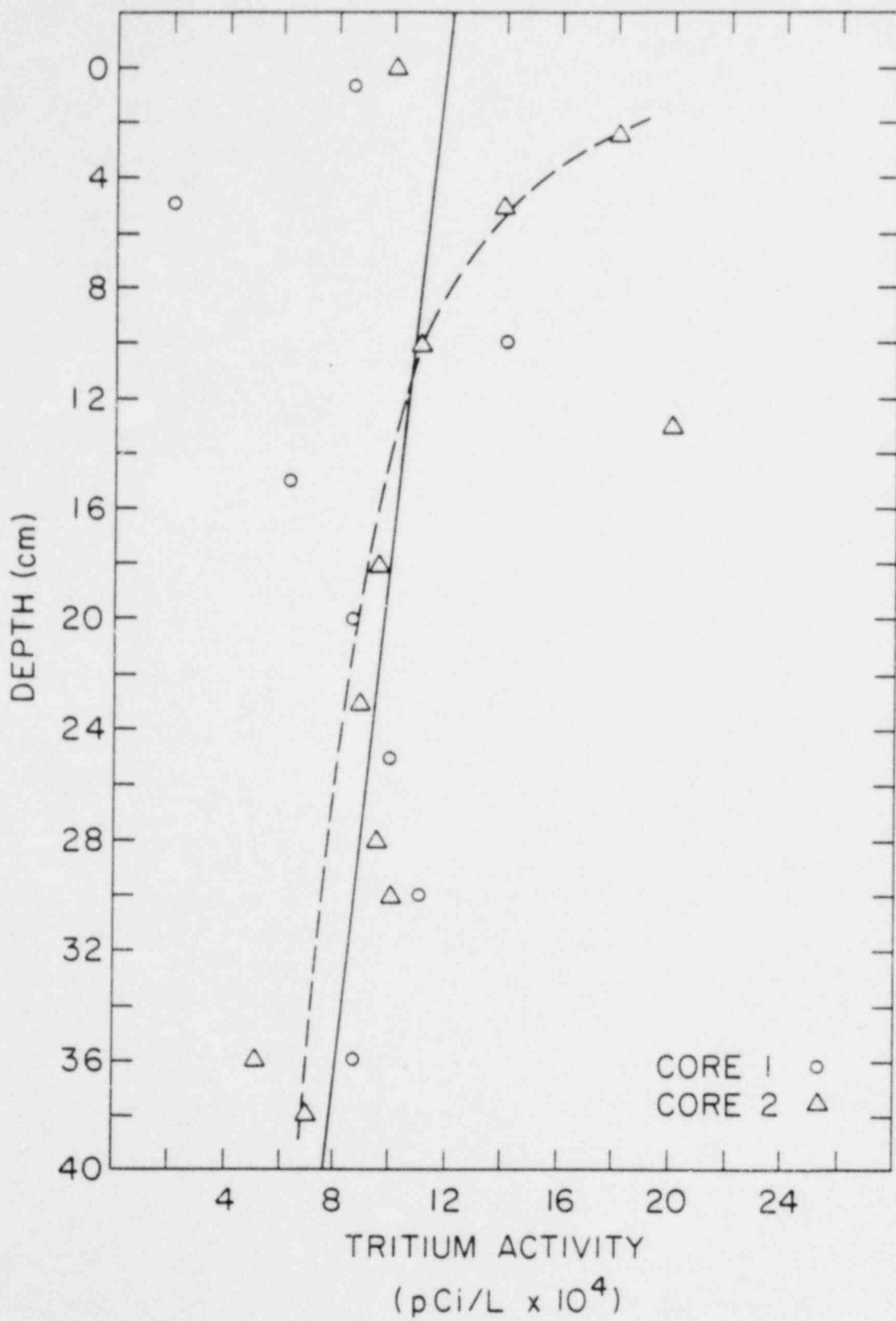


Figure 2.6. Tritium activity vs depth-West Valley lagoon cores.

Table 2.3
 Barnwell, South Carolina, Trench 2 Core
 Physical Parameters and Tritium Activity

Core Sample Number	Core Depth (m)	Wet Weight (grams)	Approximate Wet Cylinder Dimensions		Dry Weight (grams)	Dry Cylinder Dimensions		H-3 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	3.2 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
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
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
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
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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
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BN-C-2-32	9.52-9.49	80.54	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	3.8	95.84	3.2	5.1	1.1 E5
BN-C-2-38	9.09-9.04	122.10	3.8	3.8	107.47	3.2	5.7	9.0 E4
BN-C-2-39	9.04-9.02	128.84	3.8	3.8	111.10	3.2	5.7	1.2 E5
BN-C-2-40	8.92-8.86	106.91	3.8	3.8	92.27	3.2	5.1	9.5 E4
BN-C-2-41	8.86-8.81	94.47	3.8	3.8	81.31	3.2	4.4	1.0 E5
BN-C-2-42	8.81-8.76	106.39	3.8	3.8	95.69	3.2	5.1	1.2 E5

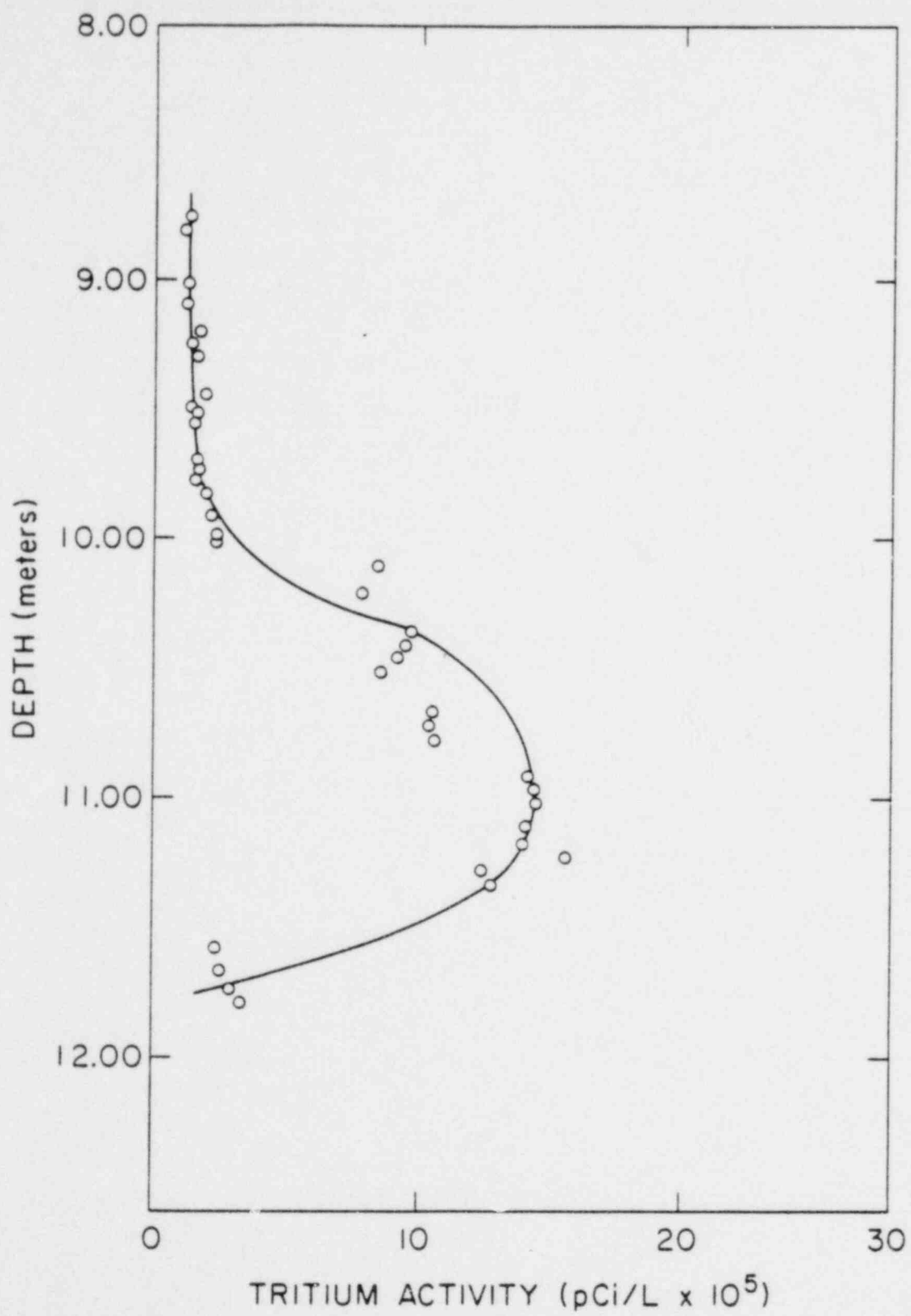


Figure 2.7. Tritium activity vs depth-Barnwell, SC, trench 2 core.

2.7 References

1. K. Czyscinski and R. Pietrzak, Brookhaven National Laboratory, "Geochemical Considerations," in Evaluation of Isotope Migration-Land Burial- Water Chemistry at Commercially Operated Low-Level Radioactive Waste Disposal Sites-Status Report Through September 30, 1979, NUREG/CR-1289, BNL-NUREG-51143, pp. 178-184, March 1980. Available from the National Technical Information Center, Springfield, VA 22161.
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3.0 FLOW THROUGH COLUMN K_d DETERMINATION (K. Czyscinski and C. Anderson)

3.1 Introduction

Laboratory determinations of sorption coefficients use either a dynamic or a static experimental design. The "batch" test is the most commonly used static test, involving solid and liquid phase interactions in a closed system. The K_d determinations reported in this project to date have been of this type. Flow-through columns are the most commonly used dynamic test. Flow through column tests are being undertaken to compare results from batch tests with those obtained from column tests using comparable materials and experimental conditions. These results will in turn be compared with results from analyses of trench core material recovered from the disposal sites. Future batch and column tests will be performed so that the results can be closely compared for the purpose of formulating a detailed testing procedure for testing the sorption capacity of potential disposal site geomeia.

Characterization data for the material selected for the column tests are given in this report, as well as a description of the apparatus designed for use in these experiments.

3.2 Materials and Characterizations

Sediments from the Barnwell, South Carolina, disposal facility were selected for the column experiments for several reasons: (1) the relatively high permeability of the silty-sands allows manageable experimental flow rates and breakthrough times, (2) trench cores are available for comparison with laboratory experiments and, (3) trench waters are available for use in batch and column experiments. "Undisturbed" core material for use in the experiments was obtained from J. Cahill of the U.S. Geological Survey. The sediments were characterized in terms of sedimentary parameters thought to influence sorptive behavior. These characterization techniques were described previously⁽¹⁾ and the appropriate data listed in Table 3.1. The sediments are silty-sand and sand (Figure 3.1) composed primarily of quartz with minor amounts of mica and feldspars. The fine fraction is composed of kaolinite with minor amounts of hematite and goethitic materials. Sandy sediments were selected for the experiments because the trench cores are composed of these materials, and also so that experiments can be performed without a great deal of difficulty.

3.3 Flow Through Column Apparatus

The "undistrurbed" core material was trimmed to uniform cylindrically shaped columns (approximately 1-3/4 x 3 inches) for the experiments. A duplicate column was made from repacked powdered material for comparison with the intact core. The apparatus for the column is shown schematically in Figure 3.2. A photograph of the apparatus is shown in Figure 3.3.

The components of the design shown in Figure 3.2 function as follows: The sediment column (G) is saturated with water from the main reservoir (A) by use of the bypass line (I). Once the column is saturated, the water is redirected

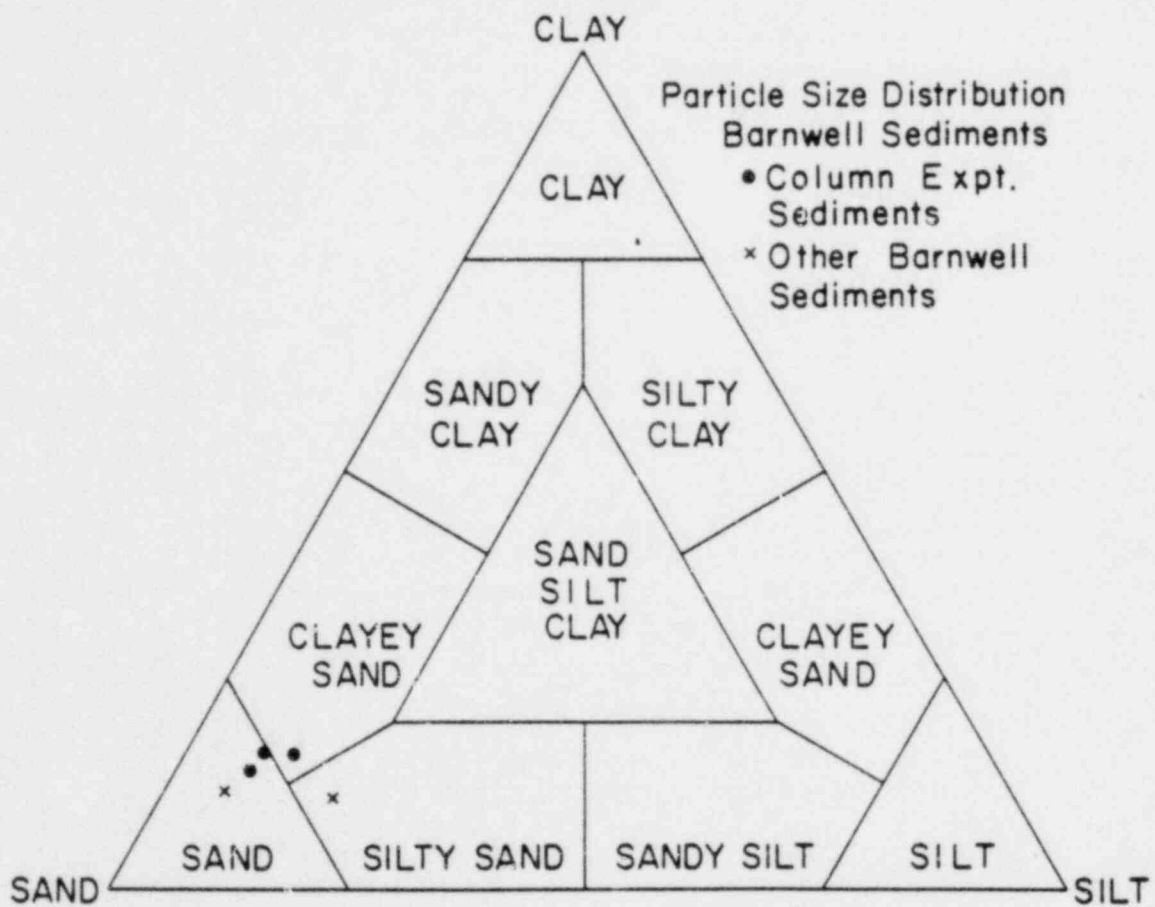
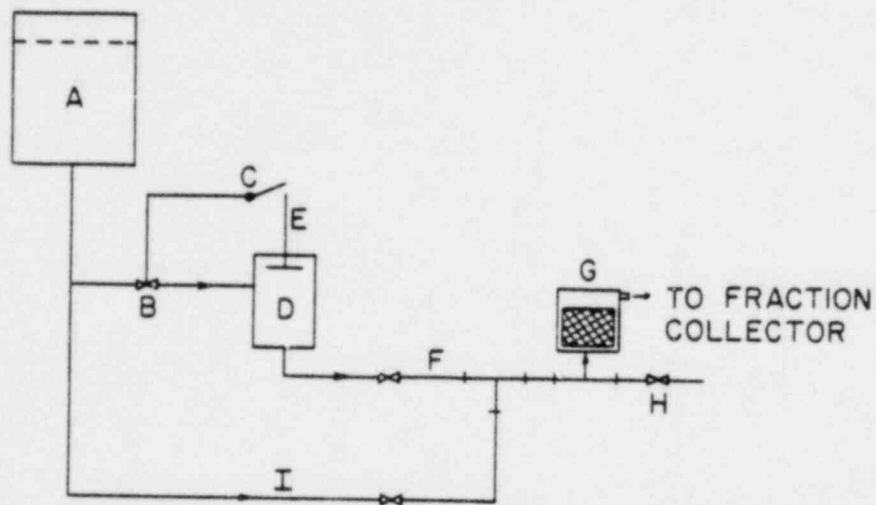


Figure 3.1. Particle size distribution of Barnwell, SC, sandy sediments to be used for column experiments.



FLOW-THROUGH COLUMN APPARATUS

- | | | | |
|---|-------------------------|---|-----------------------------|
| A | MAIN RESERVOIR | H | COLUMN CHAMBER |
| B | SOLENOID VALVE | | DRAIN LINE |
| C | MICRO SWITCH | I | BY-PASS LINE |
| D | HYDRAULIC HEAD RESEVOIR | ↑ | DIRECTION OF WATER MOVEMENT |
| E | FLOAT | ⊗ | VALVE - ONE WAY |
| F | FEED LINE | ⊥ | T-CONNECTOR |
| G | COLUMN CHAMBER | | |

Figure 3.2. Schematic diagram of flow-through column apparatus.

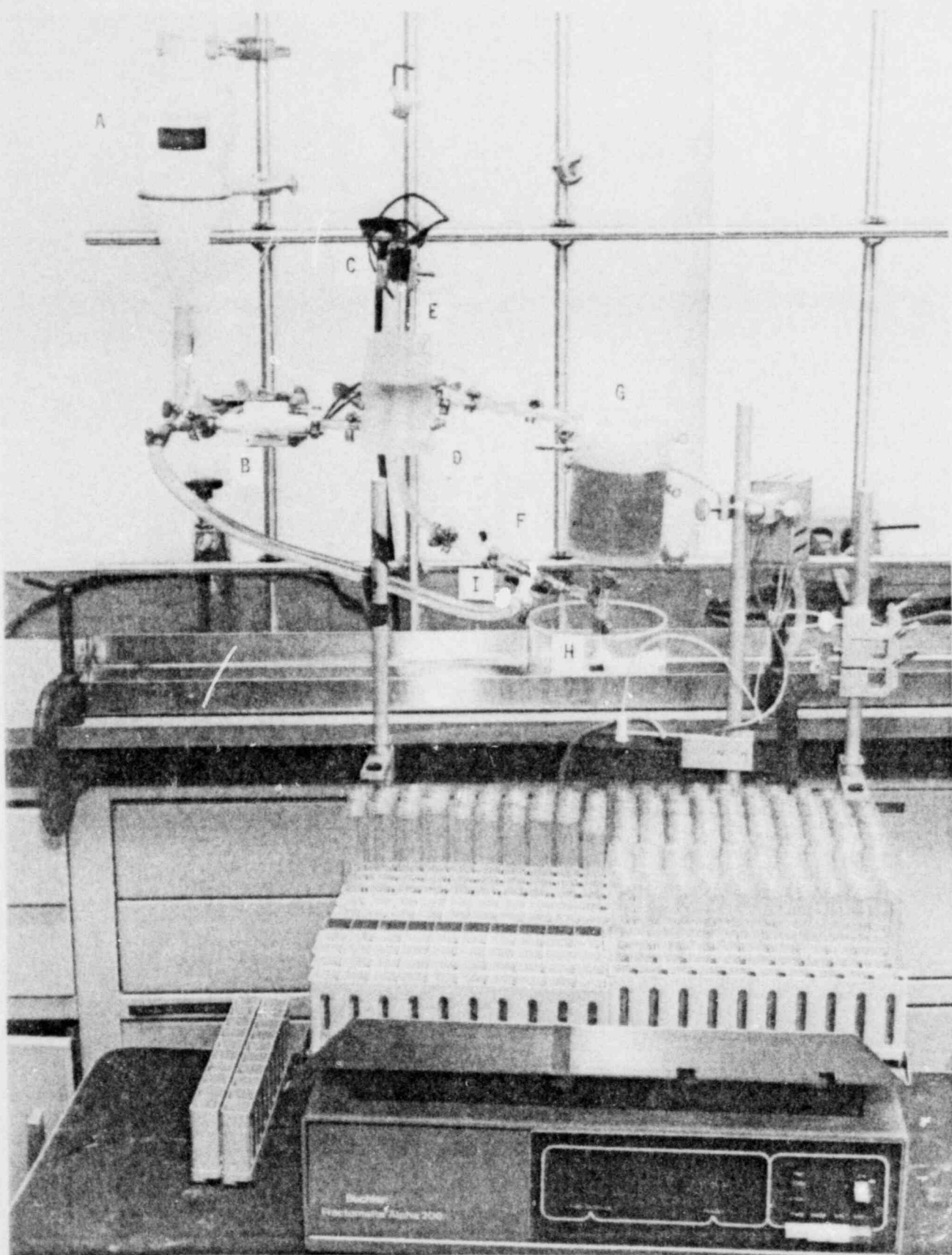


Figure 3.3 Photograph of flow-through column apparatus.

through the hydraulic head reservoir (D). This device maintains a constant pressure head by means of a float (E)-microswitch (C) combination which opens a solenoid valve (B) allowing water to flow from the main reservoir into the head reservoir. In this way as water drains through the column (G), a constant water level is maintained in the head reservoir so that a constant flow rate through the column can be maintained during the course of an experiment.

Table 3.1

Sediment Characterization Data-Barnwell, South Carolina
Sediments to be Used for Column Experiments

Parameter	Characterization Data
Surface Area	
BET	5.9 m ² /gm
EG	1-15 m ² /gm
EGME	0.3-13 m ² /gm
Organic Material	0.03%
Carbonate	Not Detectable
Extractable Fe	0.2-0.3 wt.% Fe ₂ O ₃
Cation Exchange Capacity	
CEC _{Total}	6.0 meq/100 gm
CEC _{pH}	3.9 meq/100 gm
CEC _{Sr}	1.9 meq/100 gm

The column chamber design is shown in Figure 3.4. The core material was placed on a porous stone (silicon carbide disk) and both pieces were imbedded in silicone rubber to seal the edges of the core section so that the percolating water does not flow along the sides of the core. This assembly was then encased in a polyester material for rigidity so that it could be mounted in the lucite sample holder. The silicone rubber material is flexible so that the core is not cracked during the column preparation. The materials used to construct the chamber were as follows:

Porous stone (silicon carbide disk) - Soil Test-2204, Morris Avenue, Union, NJ 07083.

Silicone rubber - General Electric, Silicone RTV700 (base) and beta 2 red (Cataly Stree) - base/catalyst ratio = 1011.

Polyester resin - Crystal Clear Casting Resin - Fibre Glass - Evercoat Co., Inc., Cornell Road, Cincinnati, OH 45242.

The operation of the apparatus has been tested. In the coming quarter, flow rates as a function of hydraulic head will be determined using deionized simulated groundwater (simulated to approximate the composition of a trench

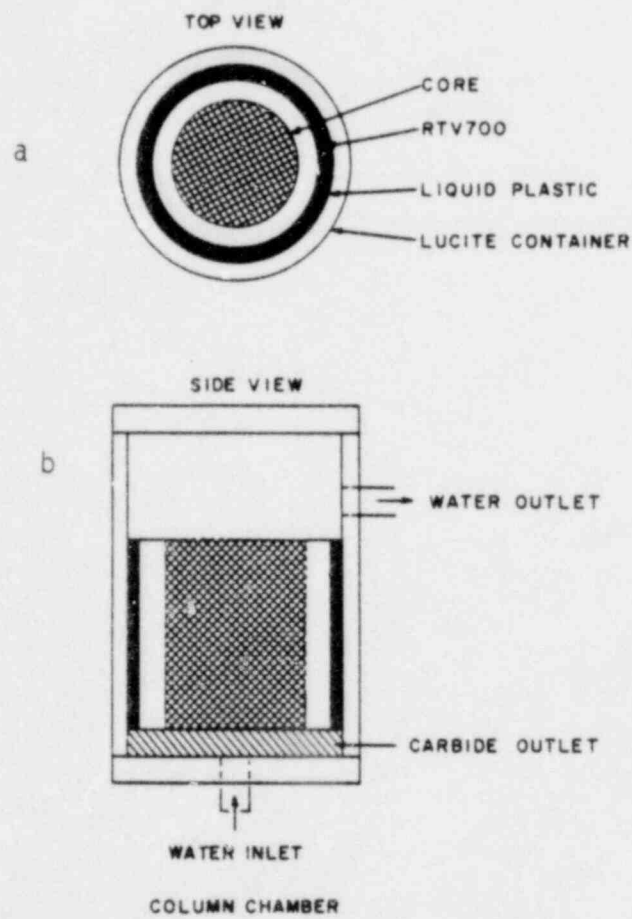


Figure 3.4. Diagram of column chamber construction (a) top view (b) side view.

water, collected from the Barnwell disposal facility) and actual trench water for both the repacked and "undisturbed" columns. These measurements are necessary so that the proper flow rates can be selected for the actual breakthrough experiments.

3.4 References

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