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Recharge Estimate for the Hanford Site 200 Areas Plateau

Prepared for the U.S. Department of Energy
Assistant Secretary for Defense Programs

Westinghouse
Hanford Company Richland, Washington

Hanford Operations and Engineering Contractor for the
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EXECUTIVE SUMMARY

An evaluation was made to assess the magnitude of recharge from natural precipitation on the Hanford Site 200 Areas plateau. Two sources of data were used in the evaluation. These sources were (1) moisture accumulation in a 200 East Area closed-bottom lysimeter for 13 yr and (2) distribution of ^{137}Cs in a solid-waste trench in which contaminated soil had been buried for 10 yr.

A well was core drilled in 1985 to the bottom of the 200 East Area closed-bottom lysimeter, and the moisture content was determined gravimetrically. The 1985 moisture content of the lysimeter was compared with its initial moisture content to estimate the recharge. There was an apparent net loss of moisture over the 13-yr experiment. However, the average moisture content for sediment below 3.0 m was essentially the same for both measurements because the moisture was redistributed from the top half to the bottom half of the lysimeter. This redistribution was essentially complete in 1972, except for the top 3.0 m. There has been no detectable moisture accumulation in the bottom of the lysimeter since 1972. Thus, the recharge rate was 0 ±0.2 cm/yr over the 13 yr of measurement.

Cesium-137 contaminated soil was placed in a solid-waste burial ground. After 10 yr, the distribution of ^{137}Cs was determined from core-drilled samples. There was no ^{137}Cs detected beneath the trench bottom above the background radiation level. Thus, there was no measurable downward recharge. However, ^{137}Cs was detected above the trench suggesting negative recharge.

In summary, the recharge rate was found to be zero or negative, within the estimated error of measurement, for two locations on the Hanford Site 200 Areas plateau.

1.0 INTRODUCTION

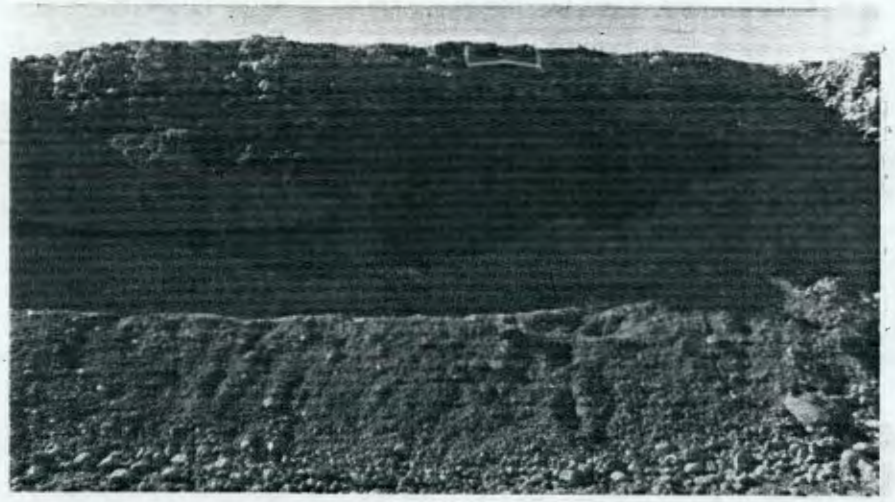
A significant portion of the Hanford Site's nuclear and hazardous wastes are stored in the vadose zone on the 200 Areas plateau. Infiltrating precipitation is the medium that may potentially transport a portion of these wastes to the Hanford Site ground water and, ultimately, to the surrounding population. The proportion of natural precipitation that percolates through the 200 Areas plateau sediments (recharge) must be known to assess the hazard to the public from nuclear and hazardous waste storage in the vadose zone (Routson 1973). The purpose of this report is to estimate the 200 Areas plateau recharge rate by reviewing the available literature and lysimeter monitoring data.

The literature and data reviewed in this report will be limited to studies and data concerning the Hanford Site 200 Areas plateau. There is a broader group of literature, largely published by Pacific Northwest Laboratory (PNL), which is used to evaluate Hanford Site recharge in general (Gee and Heller 1985). These general data and evaluations are less applicable to recharge on the 200 Areas plateau because of the locations from which much of the data were taken and the type of sediments studied. The PNL data were collected in different microenvironments and from sediments that tend to be more homogeneous than the layered sediments of the 200 Areas plateau. The surface sediments of the sites studied by PNL have generally been reworked by wind, resulting in a more homogenized sediment than the varve-like strongly layered sediments prevalent on the 200 Areas plateau (Fecht et al. 1977; Routson and Fecht 1980). These alternating fine-course sediments can have a profound effect on the movement of moisture through the partially saturated sediments (fig. 1). The tendency is for the layering to limit the percolation of water, allowing time for evapotranspiration to further limit recharge.

Recharge to ground water results from the infiltration and redistribution of natural precipitation in areas without artificial- and surface-water sources. Percolation through sediments surrounding buried waste is the primary source for recharge after any waste-burial operations are completed. The movement of precipitation is a continuous cyclic process. The cycle is initiated with the entrance of precipitation into the soil by infiltration. This is followed by temporary storage and redistribution of water in the sediments. The final part of the cycle is the removal of water from the sediments by evaporation, transpiration (plant uptake), and deep drainage (recharge) to a water table.

On the average, this cycle can be viewed as a quasi-steady state in the deep sediments. The moisture content in the deeper sediments below buried waste tends to remain constant (Jones 1978; Last et al. 1976). The travel time of deep-draining moisture to some depth, such as the ground water, can be determined if the recharge rate and volumetric water content of the sediment are known (Heller et al. 1985). The recharge rate is the average depth (amount) of water entering the ground water per year. The volumetric water content is the volume of water divided by the volume of soil

(a) After 6 hours



(b) After 24 hours

Figure 1. Typical Horizontal and Vertical Movement of Liquids in Hanford Site Formation Sediments Under Partially Saturated Conditions. Taped area outlines location of water addition.

(expressed as a percentage) at which that soil drains under the quasi-steady state natural sediment conditions. The content on the 200 Areas plateau, although variable, tends to average approximately six percent by volume (Jones 1978; Isaacson and Brown 1978). Dividing the recharge (centimeters per year) by the volumetric water content will give the depth distance that moisture will travel per year (the velocity). Dividing depth to ground water by the velocity gives the time required for the moisture to travel from a buried waste to ground water. In mathematical form the governing equations are as follows:

$$V = r/\Theta \tag{1}$$

and

$$T = D/V \tag{2}$$

where

V = velocity (cm/yr)
r = recharge rate (cm/yr)
Θ = volumetric water content (mL/cm^3)
T = travel time to ground water (yr)
D = depth to ground water (cm).

By rearranging equations 1 and 2, the velocity can be determined. Discussion and derivation of these equations are available in Heller et al. (1985).

Two principal data sources will be relied upon for estimating recharge. The first is a deep lysimeter study that has been continued for more than 13 yr (Jones 1978). The second data source is an evaluation of the radionuclide movement within a 200 West Area solid-waste burial ground, taken from sampling data. Both of these data sources provide relatively long-term data (10 to 13 yr) from far-field or near-field situations.

2.0 RESULTS AND DISCUSSION

2.1 THE 200 EAST AREA LYSIMETER STUDY

In 1971, two large lysimeters were installed 1.6 km south of the 200 East Area (fig. 2). These lysimeters are approximately 3 m in diameter and 18-m deep. Both were equipped with instruments to evaluate possible vertical movement of sediment moisture. One lysimeter was left open at the bottom while the other was sealed at approximately 18 m (fig. 3) (Hsieh et al. 1973). Any large amount of downward moisture movement was projected

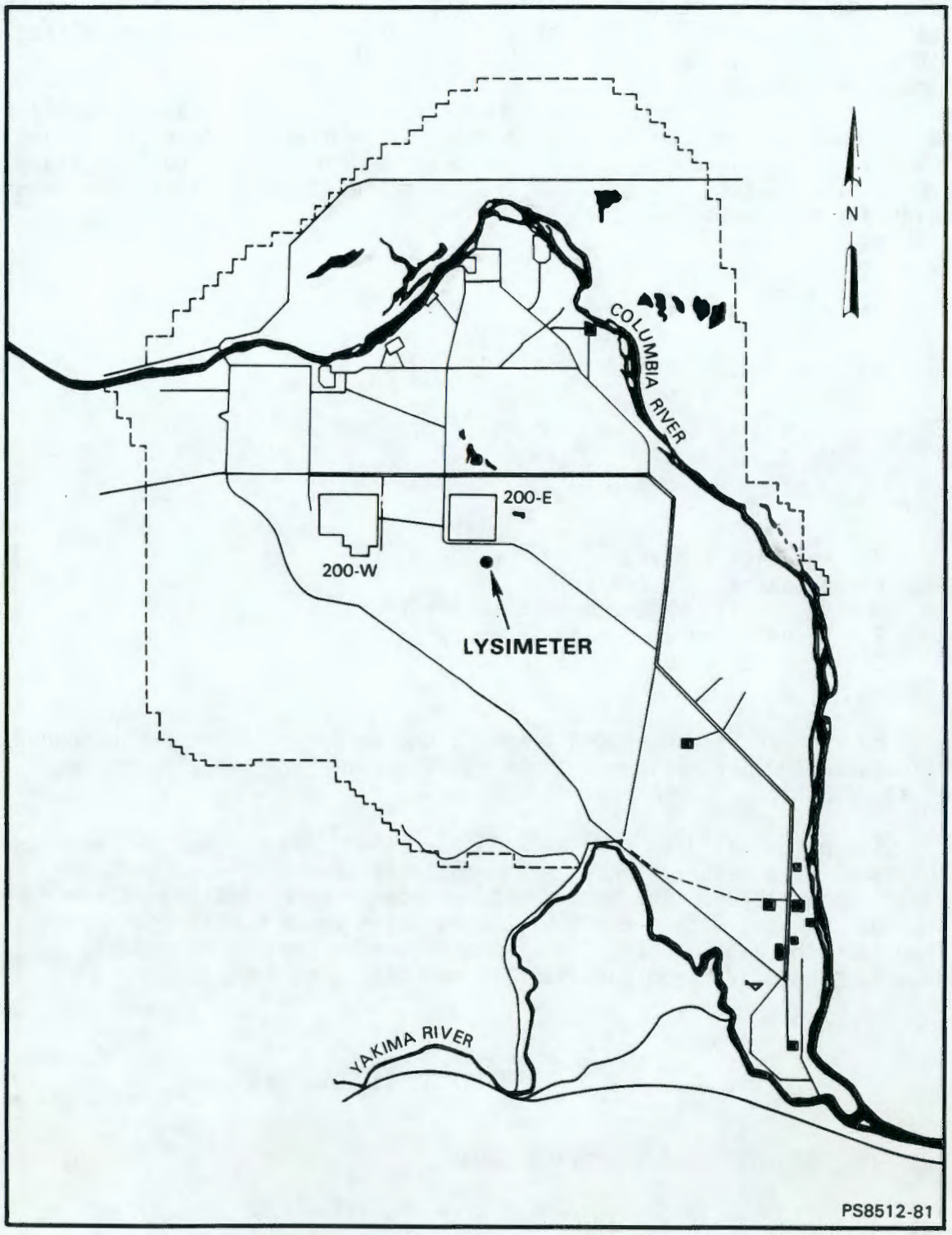


Figure 2. Hanford Site Map Showing the Location of the 200 East Area Lysimeter.

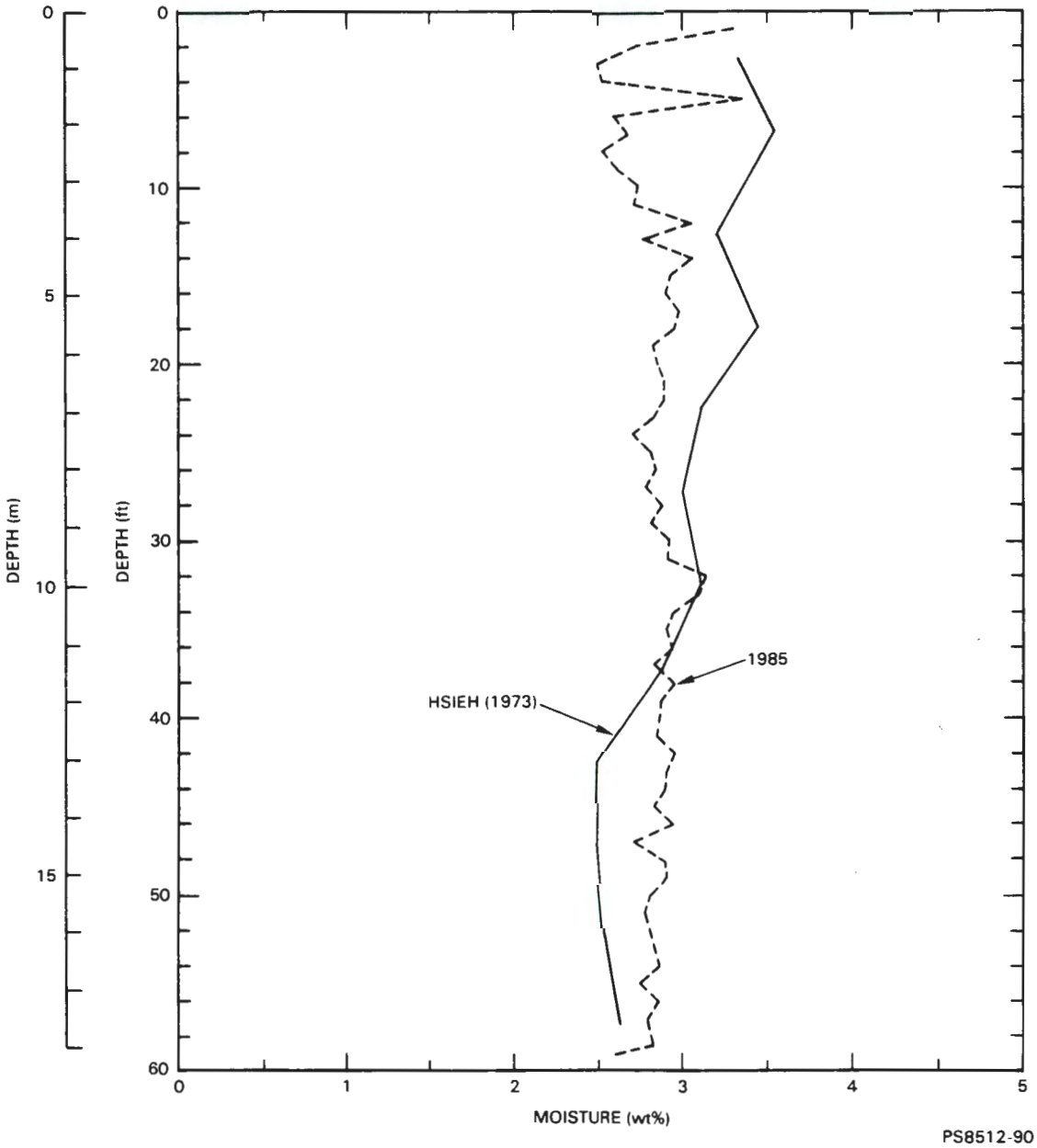


Figure 3. Depth Moisture Profile in Closed-Bottom Lysimeter, 200 East Area.

to result in an accumulation of recharge moisture in the lower portion of the closed-bottom lysimeter. Three 4.09-cm access tubes for neutron moisture probes were installed in each lysimeter to permit measurement of the moisture content at various depths. These lysimeters are described in detail in Hsieh et al. (1973). The open-bottom lysimeter was subsequently dismantled and, therefore, will not be considered further in this report.

Three earlier studies, using data from the 200 East Area plateau lysimeter, found recharge to be approximately zero within the estimated error of measurement (Brownell et al. 1975; Last et al. 1976; Jones 1978). The former two studies did not estimate error, while the latter study estimated that up to 0.5 cm/yr of recharge could be occurring without being detected. Gee and Heller (1985) made a sensitivity evaluation of the lysimeter data. Based on 6 yr of data, they estimated that the recharge rate should be 0 ±2.6 cm/yr. Assuming that there is currently no measurable water accumulation, this value would be reduced to 0 ±1.2 cm/yr (13 yr of data). The primary error identified in the Gee and Heller (1985) evaluation occurs in neutron probe monitoring (estimated at ±1 volumetric moisture percent) due to innate neutron probe variability, calibration, and the use of several neutron probes in the various studies.

To overcome the neutron probe shortcomings delineated by Gee and Heller (1985), a 10.2-cm well was core drilled to the bottom of the lysimeter in 1985, and the moisture content distribution determined gravimetrically as a function of depth. Figure 4 is a plot of the moisture distribution (weight percent) in the closed-bottom lysimeter as a function of depth. Weight percent moisture can be converted to volumetric percent moisture by multiplying by the bulk density ($\sim$1.7 g/cm^3) (Routson and Fecht 1980). There is no measurable accumulation of moisture at the bottom of the lysimeter after 13 yr of operation. Also plotted in figure 4 is the initial moisture distribution in the closed-bottom lysimeter, which was measured when the lysimeter was constructed (Hsieh et al. 1973). There has been a net loss of moisture during the lysimeter's operation. However, below the 3.0-m depth, the average initial and 1985 moisture contents differ little when the estimated error in the 1985 moisture content values are considered (±0.08%). There has been a redistribution of moisture from the upper half of the lysimeter to the lower half of the lysimeter. The 1985 relative moisture distribution was essentially established as early as 1972. The upper several feet showed a seasonal variability (Hsieh et al. 1973). This redistribution probably represents an approach to a steady-state system and not recharge. Since there is no measurable accumulation of moisture in the bottom of the lysimeter, recharge is 0 ±0.08 cm/yr.

Sparce vegetation can remove water by transpiration from the surface soil of the lysimeter site. A portion of the moisture was likely removed by the vegetation's transpiration process. However, it is likely due to paucity of the vegetation that a significantly greater amount of moisture would be removed by transpiration on an undisturbed, lightly disturbed, or revege-tated site. Conversely, on a totally unvegetated site, such as a tank farm, it is possible that there would be some recharge.

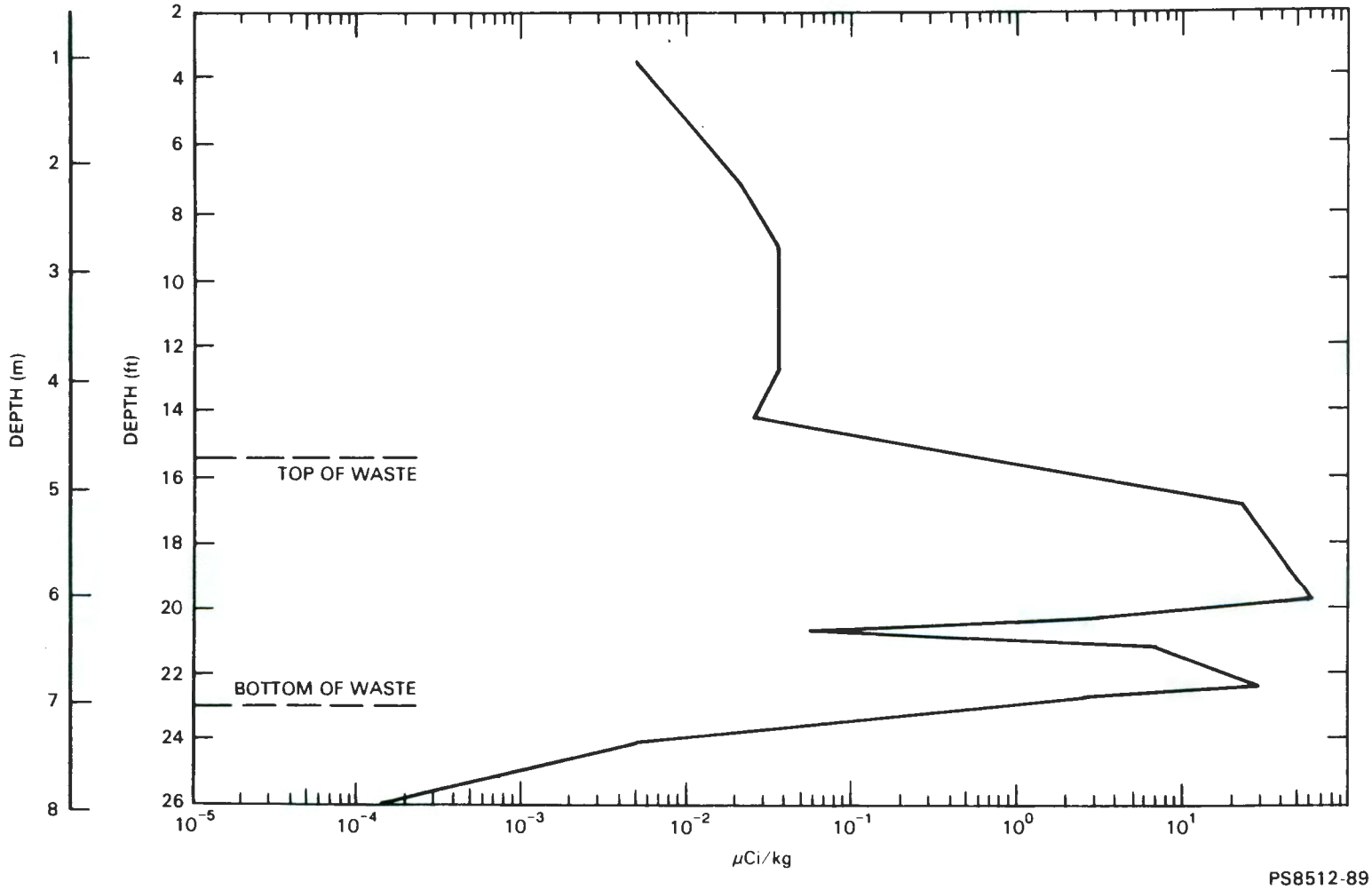


Figure 4. Gravimetric Moisutre Content Distribution for 1985 (dashed curve) and 1972 in the 200 East Area Closed-Bottom Lysimeter.

2.2 THE 200 WEST AREA SOLID-WASTE BURIAL-GROUND RECHARGE STUDY

In 1970, a radioactive spill into the surface soil occurred on the Hanford Site. The contaminated soil was buried beneath approximately 4.72 m of cover in the 200 West Area solid-waste burial ground. In 1980, as part of a solid-waste burial-ground study, the surrounding soil was core drilled and sampled to determine how deep the waste might have leached (Routson et al. 1981). Figure 5 is a representation of the measured ^{137}Cs activity as a function of depth. This figure shows that there was no measurable activity below the bottom of the burial trench. There was, however, increased ^{137}Cs activity above the top of the waste. This suggests that the net movement of moisture was upward during the storage period, and that net recharge is zero, and probably negative, over the 10-yr burial period.

3.0 SUMMARY

A review and evaluation was made to estimate the recharge rate for two areas on the Hanford Site 200 Areas plateau. Several previous studies found that the recharge rate approached zero within the error of measurement. In this evaluation, recharge was found to be 0 ±0.08 cm/yr based on 13 yr of moisture accumulation in the Hanford Site 200 East Area closed-bottom lysimeter. Field recharge was further evaluated utilizing waste distribution data from a decade-old burial trench. Waste transport in a solid-waste burial trench was found to apparently be upward, suggesting no or negative recharge. Thus, the field study was in good agreement with the lysimeter study, strongly suggesting that recharge is small and probably zero on these two areas of the Hanford Site 200 Areas plateau under the litholgic, climatic, and vegitative cover conditions at the study sites.

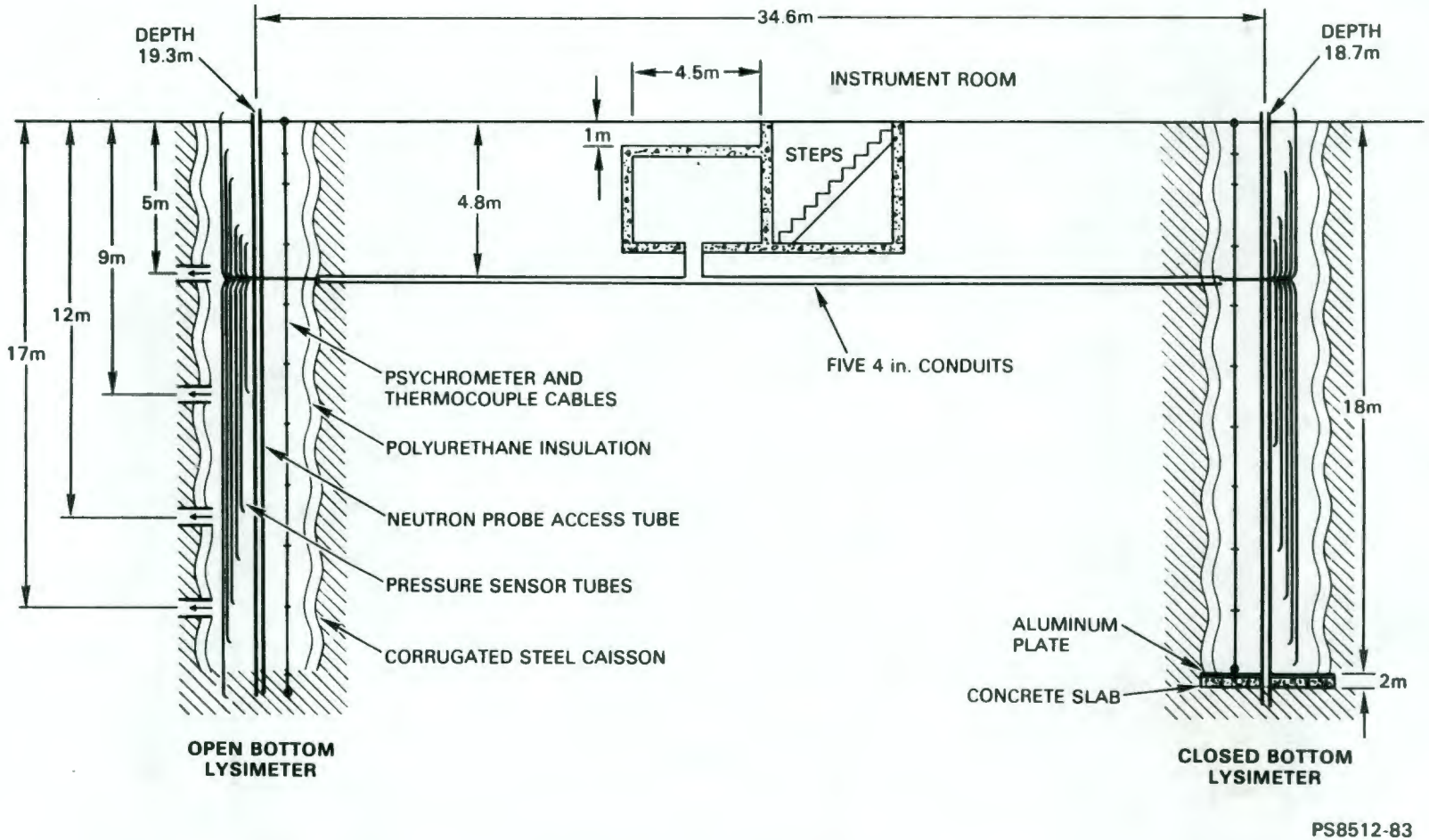


Figure 5. Cesium-137 Distribution Around a Shallow-Land Burial Trench at the Hanford Site. (Background for Cesium-137 is approximately 10^{-3} to 10^{-2} Ci/Kg.)

4.0 REFERENCES

Brownell, L. E., J. G. Backer, R. E. Isaacson, and D. J. Brown, 1975, Soil Moisture Transport in Arid Site Vadose Zone, ARH-ST-123, Atlantic Richfield Hanford Company, Richland, Washington.

Fecht, K. R., G. V. Last, and K. R. Price, 1977, Evaluation of Scintillation Probe Profiles from 200 Area Crib Monitoring Wells, 3 Volumes, ARH-ST-156, Atlantic Richfield Hanford Company, Richland, Washington.

Gee, G. W. and P. R. Heller, 1985, Unsaturated Flow at the Hanford Site: A Review of Literature and Annotated Bibliography, PNL-5428, Pacific Northwest Laboratory, Richland, Washington.

Heller, P. R., G. W. Gee, and D. A. Meyers, 1985, Moisture and Textural Variations in Unsaturated Soils/Sediments Near the Hanford Wye Barricade, PNL-5377, Pacific Northwest Laboratory, Richland, Washington.

Hsieh, J. C., L. E. Brownell, and A. E. Reisenauer, 1973, Lysimeter Experiment Description and Progress Report on Neutron Measurements, BNWL-1711, Battelle Northwest Laboratory, Richland, Washington.

Isaacson, R. E. and D. J. Brown, 1978, Environmental Assessment Related to Hanford Radioactive Waste Burial, RHO-SA-36, Rockwell Hanford Operations, Richland, Washington.

Jones, T. L., 1978, Sediment Moisture Relations: Lysimeter Project 1976-1977 Water Year, RHO-ST-15, Rockwell Hanford Operations, Richland, Washington.

Last, G. V., P. G. Easley, and D. J. Brown, 1976, Soil Moisture Transport During the 1974-1976 Water Years, ARH-ST-146, Atlantic Richfield Hanford Company, Richland, Washington.

Routson, R. C., 1973, A Review of Studies on Soil-Waste Relationships on the Hanford Reservation from 1944-1967, BNWL-1464, Battelle Northwest Laboratory, Richland, Washington.

Routson, R. C. and K. R. Fecht, 1980, Soil (Sediment) Properties of Twelve Hanford Wells with Geologic Interpretation, RHO-LD-82, Rockwell Hanford Operations, Richland, Washington.

Routson, R. C., J. B. Sisson, D. Paine, and J. Caggiano, 1981, Proposed Siting Criteria for the Shallow-Land Burial of Solid Low-Level Radioactive Wastes, RHO-LD-81, Rockwell Hanford Operations, Richland, Washington.

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