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ENVIRONMENTAL SCIENCES DIVISION
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MARTIN MARIETTA ENERGY SYSTEMS, INC.
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ROTHSCHILD, E. R., D. D. HUFF, B. P. SPALDING, S. Y. LEE, R. B. CLAPP, D. A. LIETZKE, R. G. STANSFIELD, N. D. FARROW, C. D. FARMER, and I. L. MUNRO. 1984. Characterization of soils at proposed solid waste storage area (SWSA) 7. ORNL/TM-9326. Oak Ridge National Laboratory, Oak Ridge, Tennessee. 158 pp.

To supplement other waste disposal operations on the DOE Oak Ridge Reservation, the soils at a potential site for shallow land burial of low-level radioactive waste have been characterized. Proposed Solid Waste Storage Area (SWSA) 7 is located in Melton Valley, east of the current burial facilities in the valley. This report documents the physical, chemical, and hydraulic properties of the soils on the site.

The thin veneer (less than 1 m) of soil on proposed SWSA 7 has been mapped in detail and divided into 11 mappable units. In general, the upland soils are well drained, whereas the soils in the lower parts of the site may be poorly drained. Six soil types that are most likely to be affected by waste disposal operations were studied in detail. The soils examined contain little or no carbonate and exhibit low pH. Laboratory studies were carried out to determine the moisture characteristic functions for the six soil types. The laboratory data were combined with field data to produce functions that are directly accessible by numerical models to be used for site evaluation in the future. A total of eighteen soil and sediment samples were collected for determination of their radionuclide adsorption properties. Radioisotopes of I, Cs, Sr, Co, and Am were studied, and all exhibited high Kds (greater than 23 L/kg) with the exception of I, which had a consistently lower. The cation exchange capacities of the soils averaged 169. meq/kg. Three soil profiles were examined in detail and the mineralogy of the horizons determined. Generally, the southern half of the site appears to be dominated by vermiculite-rich micaceous minerals, whereas in the northern half of the site, kaolinite and micaceous minerals dominate. A preliminary evaluation of the potential erosion on this hilly site was made. Once the site is grass covered, the erosion will be on the order of 0.4-4.5 metric tons ha^{-1} $year^{-1}$. Engineering properties of the soils were determined for six borings on the site. The weathered shale and sandy silty clays found on the site are only slightly plastic and very heterogeneous with respect to their relative density.

The soils data collected for the site can be used to assist in the evaluation and design of the site and as input variables for a detailed pathways analysis. This report, together with a subsequent document describing the geohydrology, constitute a physical characterization of the site.

1. INTRODUCTION

As part of the waste management program of the DOE Oak Ridge Reservation (ORR), a potential solid waste storage area (SWSA) is being investigated for future use. The area known as SWSA 7 lies within Melton Valley, west of the High Flux Isotope Reactor (HFIR) facility, on the ORR. Additional low-level radioactive waste disposal facilities will be required at ORNL to replace current areas (SWSA 6) as they become filled and to supplement other waste disposal activities (i.e., Central Waste Disposal Facility). Suitable waste disposal areas on the ORR are limited, and after a broad overview of possible locations (Lomenick, Byerly, and Gonzales 1983), the Melton Valley location was chosen as the prime candidate for future use.

Proposed SWSA 7 is underlain by rocks of the Conasauga Group. Most of the current and past waste disposal operations at Oak Ridge National Laboratory (ORNL) have taken place within these same geologic formations. These operations include ORNL SWSAs 4 through 6, the low-level radioactive waste pits and trenches, and the hydrofracture facilities. Thus, past experience at ORNL can be used to develop and manage waste disposal operations at this proposed location.

Site characterization is a critical first step in the development of a future waste disposal facility. Data collected during the site characterization can be used (1) to determine background conditions, (2) as input into pathways analyses, and (3) to evaluate the potential use and design of the site. The characterization phase is generally a first step in site development, and supplementary data can be collected as required in the future. This report documents the initial characterization of the soils on proposed SWSA 7. The characterization of the geology and hydrology of the site has been included in a separate document (Rothschild et al. 1984).

The Conasauga Group weathers such that a thick residuum is not formed. In the near surface, the carbonate cement present throughout most of the group is leached out but the bedding and structures of the original rock material are still present. This upper, chemically weathered zone is generally referred to as saprolite. Overlying the saprolite is a thin veneer of soil that is generally <1 m (3 ft) thick. The boundaries between horizons (soil, saprolite, and bedrock) are not distinct, but gradational and arbitrary. This report focuses on the upper several meters of earth materials--the soil and, in some instances, the upper saprolite horizons.

The characterization of soils on waste disposal facilities is critical because most of the disposal operations themselves take place in the soil and weathered rock horizons that provide the first and most important natural barrier to contaminant migration. Thus, the chemical and exchange properties of the soils must be known as well as the hydraulic properties. Construction activities on the site will in part be controlled by, but also affect, the soils on a burial facility. To minimize the impact of construction and aid in selecting the proper design, the engineering properties and erosion characteristics of the site must be quantified. Thus, this report focuses on a detailed soil survey, hydraulic properties, radionuclide adsorption properties, chemical properties, mineralogy, potential for erosion, and engineering characteristics. The characterization performed on the site generally follows the format as described in Lutton, Malone et al. (1982) and Lutton, Butler et al. (1982). Further data may be required as the site is being developed. The characterization of any site is an iterative process: site utilization depends on the site characteristics, and proposed designs indicate if and where further data are required.

2. SUMMARY

Proposed SWSA 7 is underlain by rocks of the Conasauga Group in the eastern portion of Melton Valley adjacent to the HFIR facility (Fig. 1). The area is characterized by a gently rolling to steep topography. Soil development on the Conasauga Group is generally thin (<1 m), and residual soils grade into a zone of saprolite. Soils developed in colluvium and alluvium are also present within the area. The soils on proposed SWSA 7 have been divided into 11 mapping units, and a detailed soils map for the site has been produced (Fig. 2). In general, the upland soils are moderately well to well drained, whereas soils in the lower zones may be poorly drained.

Relative to other pathways in a humid environment, the subsurface hydrologic transport of radionuclides poses the most significant pathway for off-site contaminant migration. Assessment of two fundamental hydraulic properties of soils is required to predict contaminant movement: the moisture retention characteristic and hydraulic conductivity functions. To characterize the hydraulic properties of the soils on the site, a sampling program was carried out; sampling sites were selected from the soil types present, based on the proposed site utilization (MCI 1983). It was determined that waste disposal operations would involve six soil types. Short, undisturbed soil cores were taken for the laboratory determination of hydraulic properties. Using the hanging-tube method, the water retention characteristics of the soils were determined. Saturated hydraulic conductivities were determined within the core holes in the field. Considerable variation was apparent, but generally, a trend toward higher moisture content for

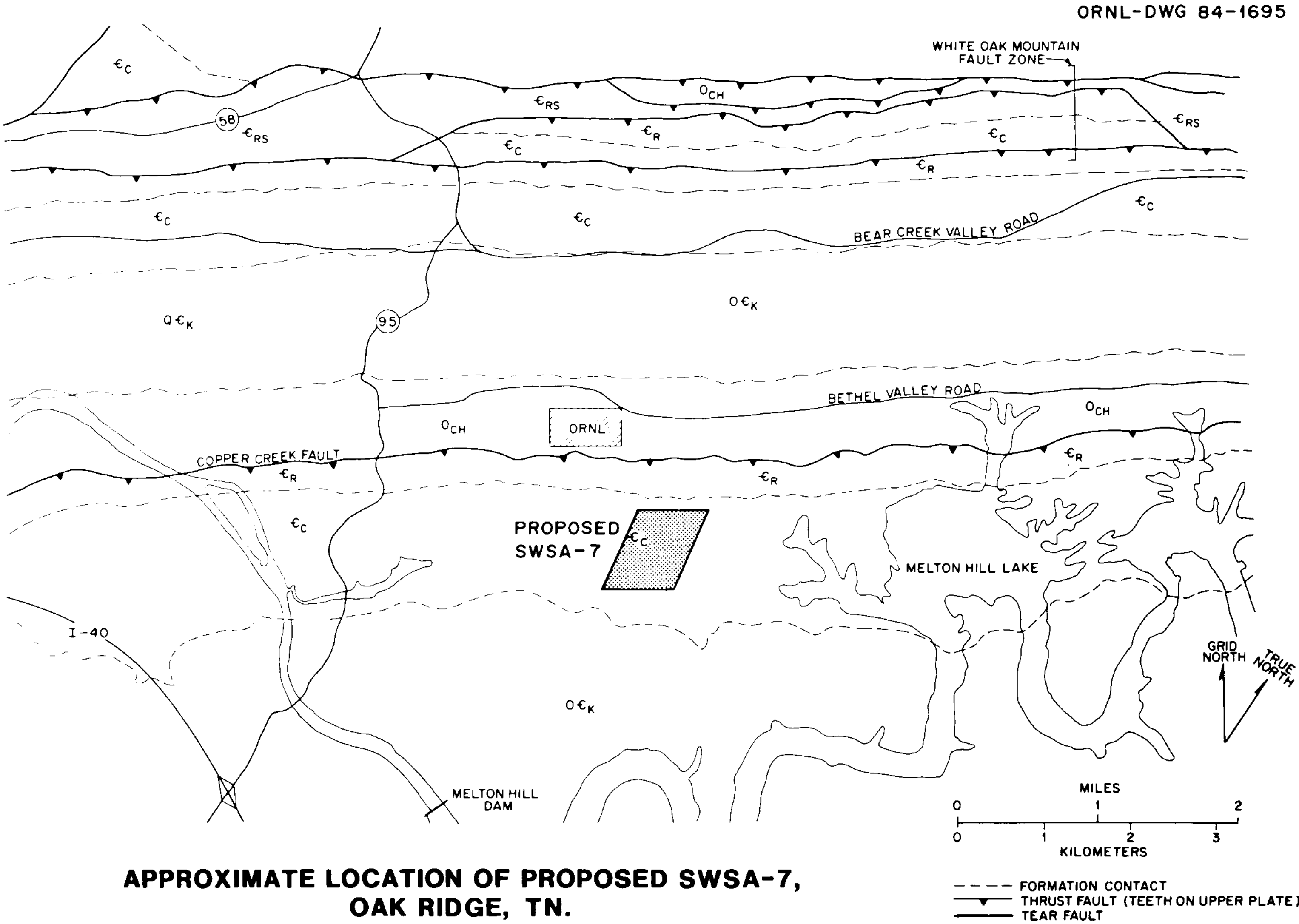

Fig. 1. Location of proposed SWSA 7.

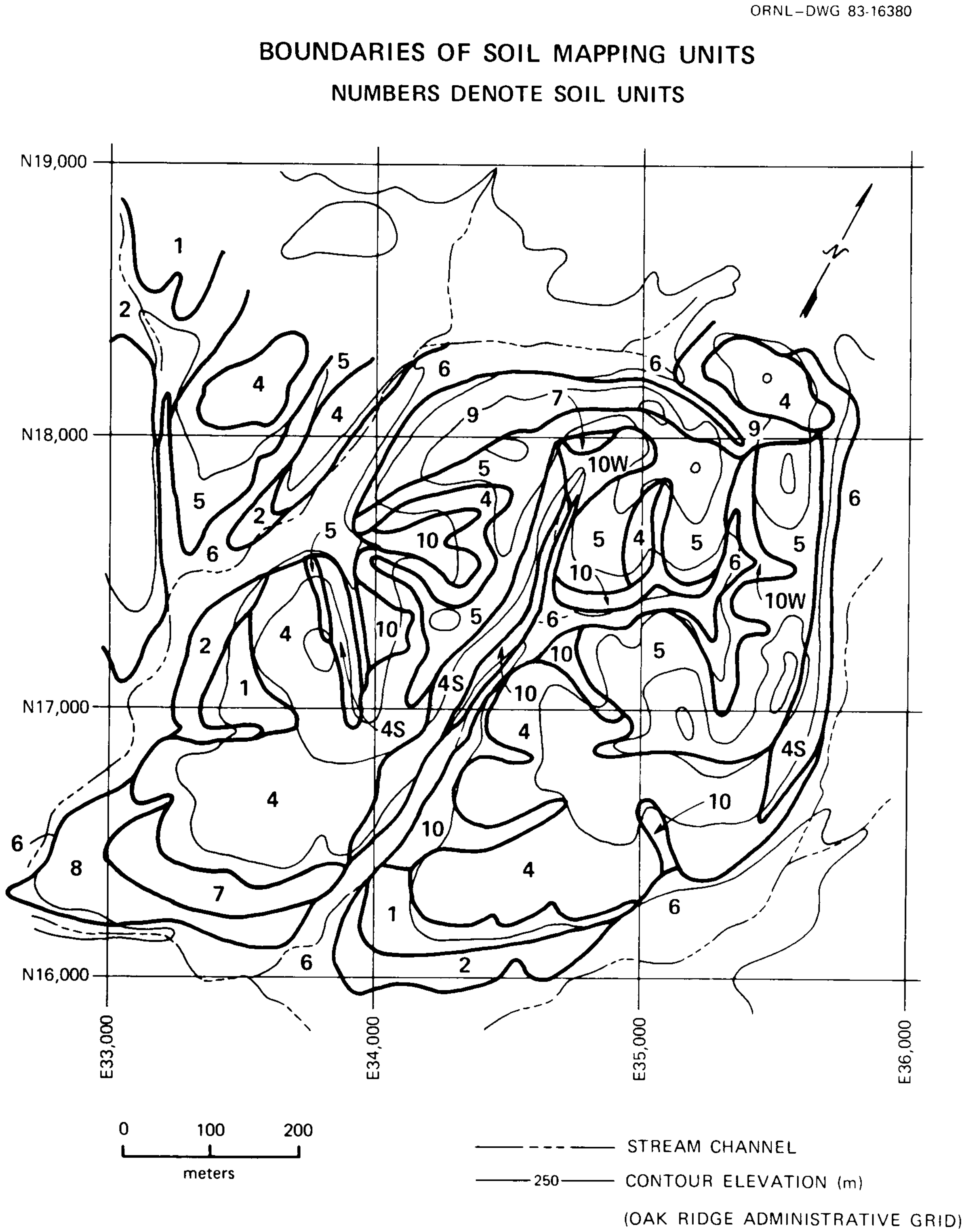

Fig. 2. Map of soil units for SWSA 7.

Descriptive legend for mapping units

Map units	Brief descritpion
1	Upland summits, shoulders, and upper sideslopes. Typic Hapludults formed in residuum weathered from siltstone. Well-drained soils with no root restrictive layer above a depth of 1 m.
2	Lower sideslopes and upper footslopes. Mostly Aquic Hapludults formed in 50 cm or less of colluvium and the underlying residuum that weathered from siltstone. Moderately well and somewhat poorly drained soils with no root-restricting layer above a depth of 1 m.
4, 4S	Upland summits and sideslopes (4S). Mostly Typic Hapludults that formed in residuum from highly fractured siltstone. Soils are mostly well drained and have a root-restricting layer 50 to 100 cm below the surface, which does not perch water.
5	Narrow ridgetops and finger ridges with doubly convex slope shapes. Mostly Typic Dystrochrepts that formed in residuum of siltstone having higher $CaCO_3$ content. Soils are well drained and have a root-restricting layer located at a depth of 50 cm or less and a layer of denser siltstone that perches water at a depth of 50 to 100 cm.
6	Drainageways that have seeps, wet weather springs, or flowing streams. Soils are mostly poorly drained and gray close to or at the surface. Parent materials are alluvium and some colluvium from upland soils that formed in siltstone and shale.
7	Shoulders and sideslopes. Soils are Typic Hapludults that formed in shale residuum. Water perches in the lower part of the clayey soil or at the top of the root-restricting layer. Most soils are moderately well drained.
8	Low toeslopes and terraces. Soils are Aquic Dystrochrepts. Parent materials are modern alluvium 50 to 10 cm thick and overlie older alluvium in which a soil had developed. Drainage is moderate to somewhat poor.
9	Shoulders and sideslopes. Typic Dystrochrepts formed in surficial colluvium and residuum of reddish shales. Soils are well drained and no root-restricting layers occur within a depth of 1 m.
10, 10w	Lower sideslopes and toeslopes, along drainageways, and heads of drainageways (10w). Soils are Typic and Aquic Hapludults. Parent materials are colluvium derived from higher-lying soils. No root-restricting layers within 1 to 1.5 m, but water perches in some areas. Water flows laterally below the surface in most of this unit.

a given water potential with depth was apparent. The laboratory data taken in conjunction with the field-measured, saturated hydraulic conductivities (values range from 3.50 x 10^{-5} to 2.14 x 10^{-3} cm/sec), were used to calculate relationships for moisture content vs hydraulic conductivity. These results can be used directly in hydrologic modeling for the site.

One of the major factors affecting radionuclide movement from the proposed site is the adsorptive properties of the soils. To assess the soils' radionuclide adsorption properties, 18 samples were taken from soils and stream sediments from areas that disposal is most likely to affect. A batch technique was used to determine distribution coefficients (Kds) for isotopes of I, Cs, Sr, Co, and Am. Generally, the upland soils on the site all exhibited high Kds (>23 L/kg) for most of the tested radionuclides, although the Kds for I were consistently lower. The alluvium on the site exhibited lower Kds than that for upland soils. The KDs fro stream sediments were distinctly different from the soils that were tested. The stream sediments have extremely high Kds for Cs, Co, and Am (3040 to 30,000 L/Kg).

In humid regions, generally the most active soil phase in chemical adsorption is the soil cation exchange complex. The nature and quantities of cations on the soil's exchange sites were determined for the important soil types on the site (those that will be affected by site development). The cation exchange capacity (CEC) of the upland soils was moderately high (88.-228. meq/Kg), and the average for all soils was 169. meq/Kg. The pH, carbonate content, total hardness, organic matter content, and available Mn and Fe were determined for the soils. The soils can be described as well leached and acidic in nature. Only one soil sample had any residual carbonate present. The sediments all had traces of carbonate (unlike the soils) and contained very little organic matter.

To interpret the physiochemical properties of the soils on the site, a fundamental knowledge of the mineralogic composition of the soils is needed. Major components of the clay mineralogy are directly inherited from the parent rocks, but mineral transformations have occurred during pedogenic processes. To describe the soil profile and study the mineralogical changes with depth, several soil pits were excavated. The soils on SWSA 7 are composed of quartz and various clay minerals, such as mica (illite), vermiculite, and kaolinite. Quartz is the dominant mineral in the silt size fraction of the soils, particularly in the A and B horizons. The sand fractions are predominantly shaly fragments composed of micaceous minerals as well as coarse sand grains. The distribution of the clay fraction generally shows an increase with depth, as does the accumulation of iron and aluminum oxide. In the southern part of the site, vermiculite-rich micaceous minerals dominate, whereas in the northern half of the site, kaolinite and micaceous minerals are dominant. In general, soils having high kaolinite contents have lower sorption capacities than soils having high vermiculite contents.

A potential hazard to the long-term isolation of wastes in a shallow land burial facility is erosion. As a preliminary assessment of the potential for soil erosion on the site, calculations of long-term erosion rates were made based on data published in the open literature.

The empirically derived Universal Soil Loss Equation was used to take into account the primary variables controlling erosion: soil erodibility, rainfall, slope geometry, vegetative cover, and erosion control practices. Although varying with slope geometry and soil type, soil loss from the proposed SWSA 7 (with a grass cover) is calculated to be on the order of 0.4-4.5 metric tons ha^{-1} $year^{-1}$. Erosion is significantly less for the site with a wooded vegetative cover. The calculation indicates that under normal conditions, the erosion rate will be under the 4.5-metric ton ha^{-1} $year^{-1}$ EPA guideline for hazardous waste facilities.

Before a shallow land burial facility is developed, the engineering characteristics of the burial media must be known. Based on six borings on the site, basic engineering characteristics of the soil and saprolite were determined. Data were gathered on the relative density of the soils in the area by use of standard penetration tests. The depth to auger refusal ranged from 10 to 30 ft on the site, and much variability in resistance within a boring was apparent. Samples were also retrieved to determine moisture content and Atterberg Limits and conduct grain size analyses. The grain size distribution of soils derived from the Conasauga Group is highly dependent on the degree of weathering, but generally, the samples can be described as silty clays containing particles of weathered shale or sandy silty clays. Based on the Atterberg Limits, the soils can be described as being only slightly plastic.

The basic data collected on the soils of the proposed SWSA 7 site can be used to assist in the evaluation and design of the site. The data also serve as input for the pathways analyses that should be completed as part of the overall site evaluation. As the use of the site becomes better defined, further data may be needed to supplement this initial characterization. The characterization of the soils of the site is only one aspect of site characterization and must be used in conjunction with data on the geology, hydrology and biota of the proposed site.

3. SOIL SURVEY

To better understand the variability and nature of soil types on SWSA 7, a detailed soil survey was made and a map produced (Fig. 2). Using the soils map in conjunction with proposed usage maps for the site (MCI 1983) allows the scope of soils characterization to be narrowed. The soils map produced was the basis for further work on detailed soils descriptions, mineralogy, hydraulic properties, and chemical characteristics.

The soils mapping was accomplished by field survey of the entire area in which periodic observations were made on representative parts of each landform. Mapping in the field was done on a 24-m/cm (200-ft/in.) topographic base. A "backsaver" soil probe was used to extract a core to a maximum depth of 105 cm or to a Cr horizon (parent material) if it occurred at a more shallow depth. Road cuts on the site were also used as observation points.

The soil map produced was transferred to a base topographic map having 5-m contour intervals. The soils map is shown in Fig. 2, and brief descriptions of mapping units are contained in the legend. The soils on the higher elevations of the site are all residual (units 1, 4, 4S, 5, and 7), except for units 9 and 10, which are formed in colluvium and residuum. The soils in the lower areas of the site are formed in colluvium, alluvium, and residuum. generally, the upland soils are all well drained to moderately well drained, whereas soils in the lower zones are moderately well drainedto poorly drained.

Soil development on the proposed SWSA 7 site is limited in depth, and in most units, the parent material (Cr horizon) is <1 m deep. Detailed descriptions of the mapping units are included in Appendix A. The descriptions include the general landforms and slope shape on which the soils form, the vegetation type, and detailed soil descriptions with classifications. A summary of soils classification by family and series is presented in Table 1.

Table 1. Classification of major soil types by family and series

Soil	Family classification	Soil series
1	Typic Hapludult; fine loamy[a], mixed[b], thermic. 1 m to paralithic contact	SND[c]
2	Aquic Hapludult; fine loamy, mixed, thermic. 1 m to paralithic contact	SND
4	Typic Hapludult; fine loamy, mixed, thermic. 50 to 100 cm to paralithic contact	Apison
5	Typic Dystrochrept; loamy skeletal, mixed, shallow, thermic. 50 to 100 cm to paralithic contact	Petros
6	Typic Fluvaquents; fine loamy, mixed, thermic	SND
7	Typic Hapludult; clayey, mixed, thermic 50 to 100 cm to paralithic contact	Sequoia
8	Aquic Dystrochrept; fine loamy, mixed, thermic	SND
9	Typic Dystrochrept; loamy skeletal, mixed thermic. 1 m to paralithic contact	Calvin
10	Typic and Aquic Hapludults; fine loamy, mixed thermic. 1 m to paralithic contact	Shelocta

[a]Particle class size estimated from field textures.

[b]Mineralogy class estimated.

[c]Series not designated.

In the soil family classification, Typic Fluvaquent (soil unit 6) belongs to Entisols, which are relatively young mineral soils having no distinct pedogenic horizons within 1 m of the soil surface. The Typic Fluvaquent soils are developed on very young waterlaid deposits that are mostly in wet places on floodplains. Mottling in them extends downward from a point very close to the surface, and the water table is at, or close to, the surface.

Typic Dystrochrept (soil units 5 and 9) is a subgroup of Inceptisols that have pedogenic horizons in which mineral materials have been removed but not accumulated to a significant degree in lower horizons. The subgroup is fixed on soils that are moderately deep, freely drained, and acid and do not have an intermittent argillic horizon. Aquic Dystrochrept (soil unit 8) has gray mottles in a brownish matrix. Groundwater is present in the deep layers of this soil during winter, but these layers are dry in the summer.

Typic Hapludult (soil units 1, 4, 7, and 10) belongs to Ultisols, which have an argillic horizon that is acid and highly leached and have a mean annual soil temperature of 8°C or higher. The Typic Hapludult subgroup is fixed on freely drained, highly leached, acid soils that have a loamy or clayey particle size class in the argillic horizon. Aquic Hapludult soils (soil units 2 and 10) are similar to Typic Hapludults except that the groundwater fluctuates at depth and the horizons that are or were saturated have mottles of low chroma. The ground-water level in these soils is high in winter and early spring.

Four soils profiles, IV (Typic Hapludult), V (Typic Dystrodchrept), VII (Typic Hapludult), and X (Aquic Hapludult), were selected for quantitative mineralogical studies (see Mineralogy, sect. 7). The detailed descriptions of the selected soil profiles are given in Appendix B and the location of the profiles are given in Fig. 3. Area and proportionate extent of the soil mapping units are summarized in Table 2.

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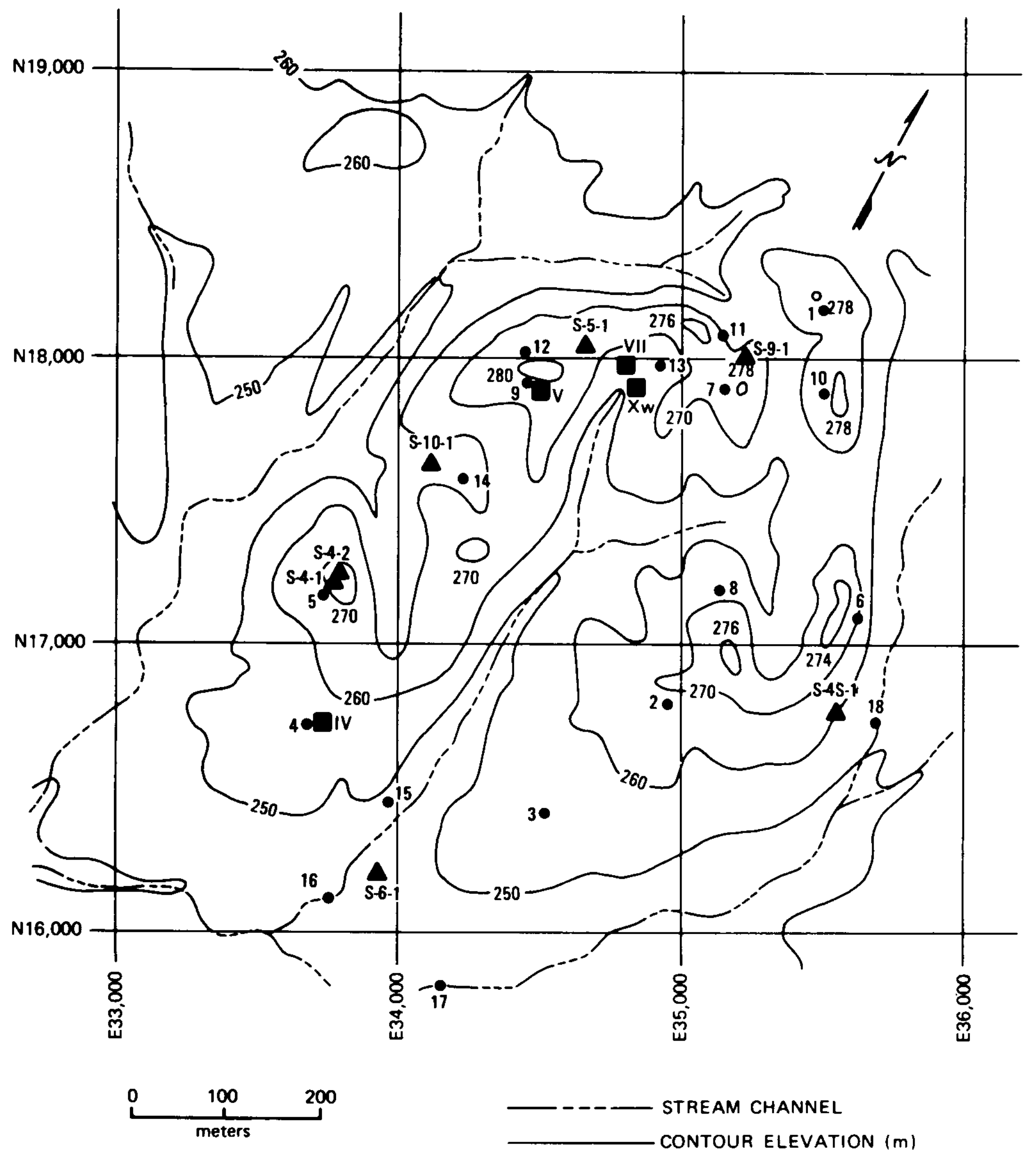

STREAM CHANNEL

CONTOUR ELEVATION (m)

(OAK RIDGE ADMINISTRATIVE GRID)

2● SAMPLING LOCATION FOR SOIL Kd AND CHEMICAL ANALYSES

S-6-1 ▲ LOCATION OF BORINGS FOR SOIL HYDRAULIC PROPERTIES

V ■ SOIL PROFILE PITS

Fig. 3. Location of soil borings, profile pits, and sampling locations.

Table 2. Area and distribution of soil mapping units on SWSA 7

Map Unit	Area ($\times 10^{-3}$ m^2)	Distribution (%)
1	18	3
2	22	4
4	177	29
4S	35	6
5	111	19
6	145	24
7	11	2
8	5	1
9	23	4
10	38	6
10W	14	2
Total area	599	

4. Hydraulic Properties

Relative to other mechanisms, hydrologic transport of radionuclides poses the most important pathway for off-site contamination from low-level waste sites such as proposed SWSA 7. Because the hydrogeologic controls are complex, deterministic mathematical models provide the only practical means for estimating the direction and magnitude of the movement of dissolved radionuclides. Such models become indispensable when the modifying effects of site engineering and management must be evaluated.

The two fundamental hydraulic properties of soils required by most models are the moisture characteristic and hydraulic conductivity function. The moisture characteristic relates moisture content to soil-water pressure, which is inherently negative and is usually expressed as hydraulic head. The relationship is hysteretic (i.e., it is not single valued and depends on recent wetting or drying). Nevertheless, it is conventional to evaluate this relationship for a soil that is dried from initial saturation.

The other fundamental hydraulic property of a soil is the hydraulic conductivity function. In simple terms, it relates the increasing resistance to flow observed in a drying soil. The function is difficult to evaluate experimentally, and so it is usually calculated from the moisture characteristic based on theory derived from flow in capillary tubes.

4.1 FIELD SAMPLING

Determination of the moisture characteristics and hydraulic properties of soils at proposed SWSA 7 is an important step in providing a basis for estimating soil-water movement, ground-water recharge, and potential for contaminant migration at the site. The strategy used to determine the number of soil samples analyzed, as well as sampling locations, was to use the soils map and description of units to identify the important soil types present, examine preliminary site utilization analyses (MCI 1983) to determine which soil types were most likely to be involved in disposal areas or possible transport pathways, and then identify a representative site for each of the soil types of interest. Final site selection was completed in the field, based in part on accessibility for sampling equipment. Following selection, each of the locations was located on the site map by surveying relative to known points; interpolation was then used to determine approximate grid coordinates for future reference. A map of the sampling sites is shown in Fig. 3. Approximate grid locations (Oak Ridge Administrative Grid) for the sites are given in Table 3.

Table 3. Summary of approximate sampling locations for determination of soil hydraulic properties

	Oak Ridge Administrative Grid Coordinates	
Site identifier[a]	Northing	Easting
S-4-1	17205	33760
S-4-2	17220	33790
S-10-1	17624	34106
S-5-1	18051	34677
S-9-1	18025	35290
S-4S-1	16746	35542
S-6-1	16173	33921

[a]The second term in the identifier refers to the soil classification mapping point.

Sampling operations were initially attempted by manual excavation to the desired depth, pressing a brass sampling ring (6.55-cm ID) into the soil, and carefully excavating the ring and sample for transport to the laboratory. The technique consumed a great deal of time and limited sampling depth, so that only one sample (S-4-1) was taken by this method. For subsequent sites, a method in which a solid core barrel that was pushed or driven into the soil was used. The general procedure was to push or drive an 8.89-cm (3-1/2-in.) soil tube containing a thin wall PVC liner to a predetermined depth, retrieve the soil tube and sample in the plastic liner, remove and cap the sample, and place the sample in a plastic bag. The sample was then stored in its original vertical orientation for laboratory processing. The core sampling apparatus is illustrated in Fig. 4.

The liner for the soil tube was thin-wall PVC pipe. It was made by fitting several sections together so that the sample could be retrieved without disturbing its original orientation. By inserting spacer sections between the sample sections, it was possible to retrieve a 5-cm sample from any depth in the core hole. During sampling, the soil core barrel with liner was driven no more than 50 cm before the contents were removed and a new liner was inserted. The maximum drive depth was based on earlier experiments to determine the relationship between core length and sample compaction. The sample sections and spacers were arranged so that two samples were obtained from each core. The midpoint of one 5-cm core was 16 cm from the base of the core-barrel drive shoe, and the other was 36 cm from the bottom. Each 5-cm sample section was sandwiched between 5-cm border sections to form

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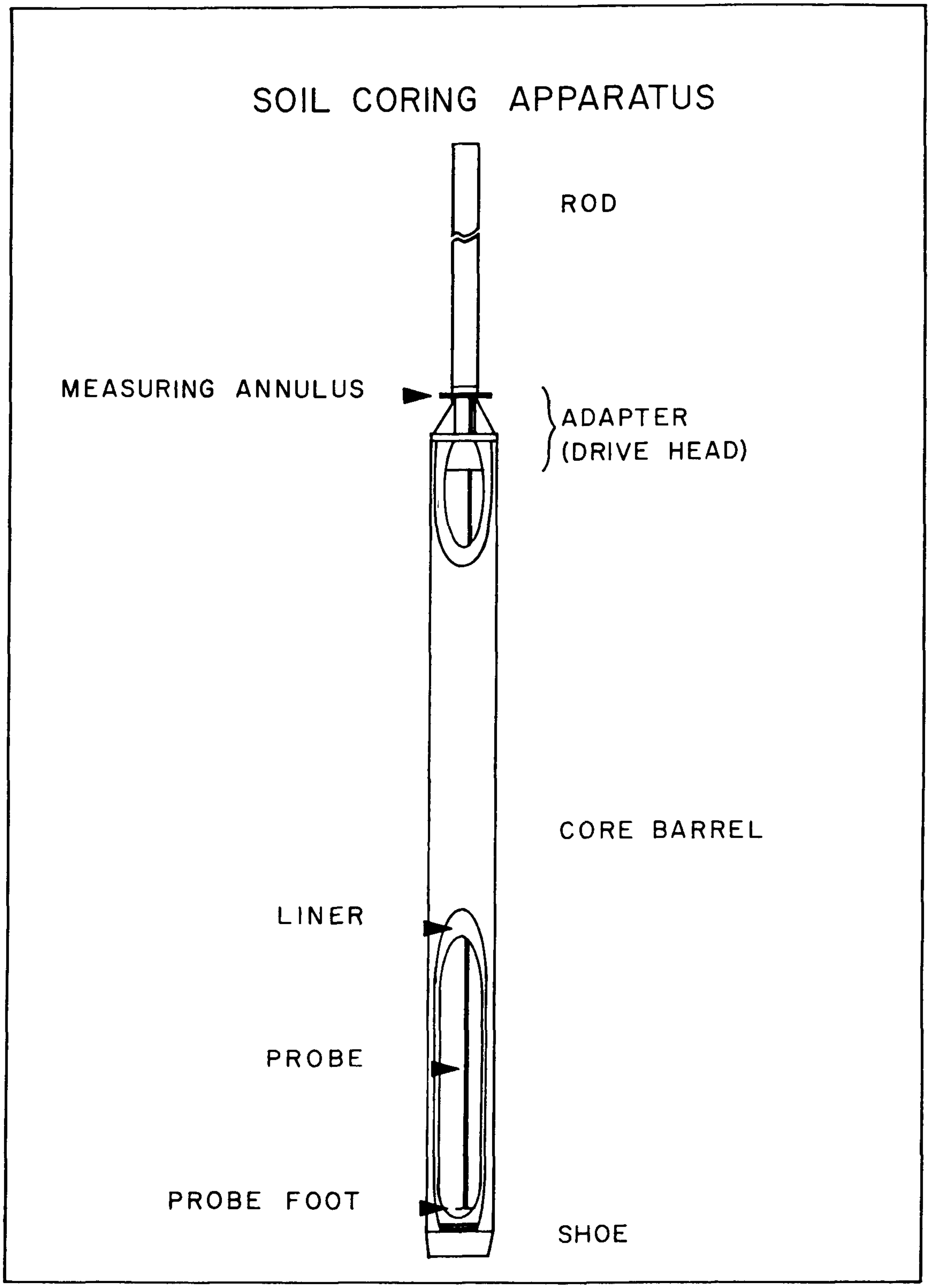

Fig. 4. Diagram of soil coring apparatus.

a 15-cm section that was collected in the field. The 5-cm section that was tested was not separated from the border sections until laboratory processing began.

4.2 MOISTURE CHARACTERISTIC

The primary objective of the laboratory testing program was to determine the moisture release properties of each soil type. The hanging-column method described by Vomocil (1965) was used to determine incremental moisture release associated with change in pressure, over a -5- to -300-cm range of water. A reference column was used to determine evaporative loss rate during testing, and corrections for evaporative loss were used.

The data obtained from laboratory tests represent moisture release characterization for a draining soil having a moisture content that is between saturation and approximate field capacity. To extrapolate the data to drier conditions, the method of McQueen and Miller (1974) was used. The results were tabulated, and a series of figures were developed to display moisture content vs water potential (suction) for each soil type. The data display results for all depths sampled for each sampling location and are presented as Figs. 5 to 10. Although considerable variability exists, a general trend toward higher moisture content with increasing depth for a given water potential is apparent. This trend is probably the result of the downward displacement of fine particles caused by leaching, as well as the general decrease in organic matter (and macropores) with depth.

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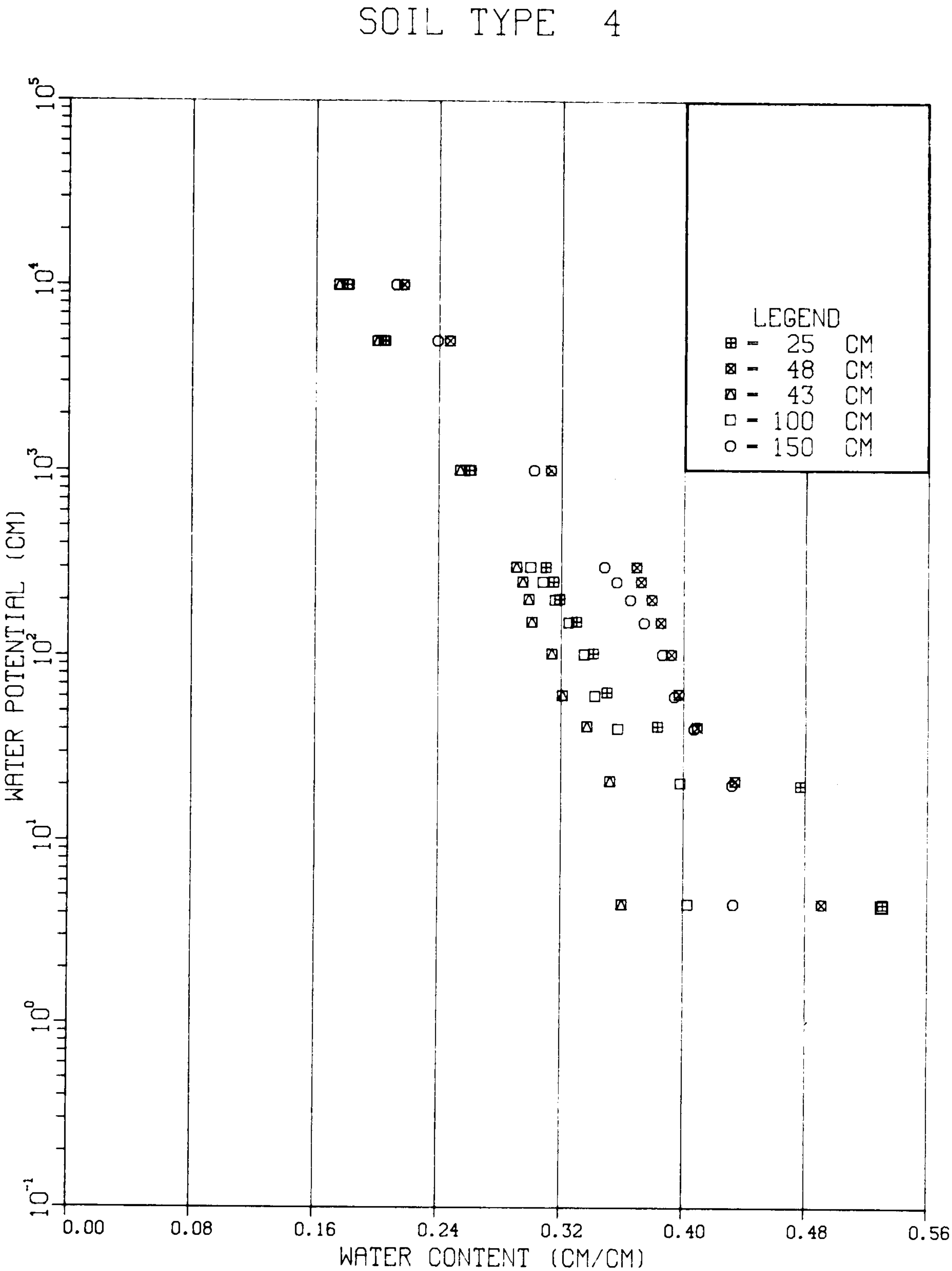

Fig. 5. Moisture-characteristic curves for soil type 4.

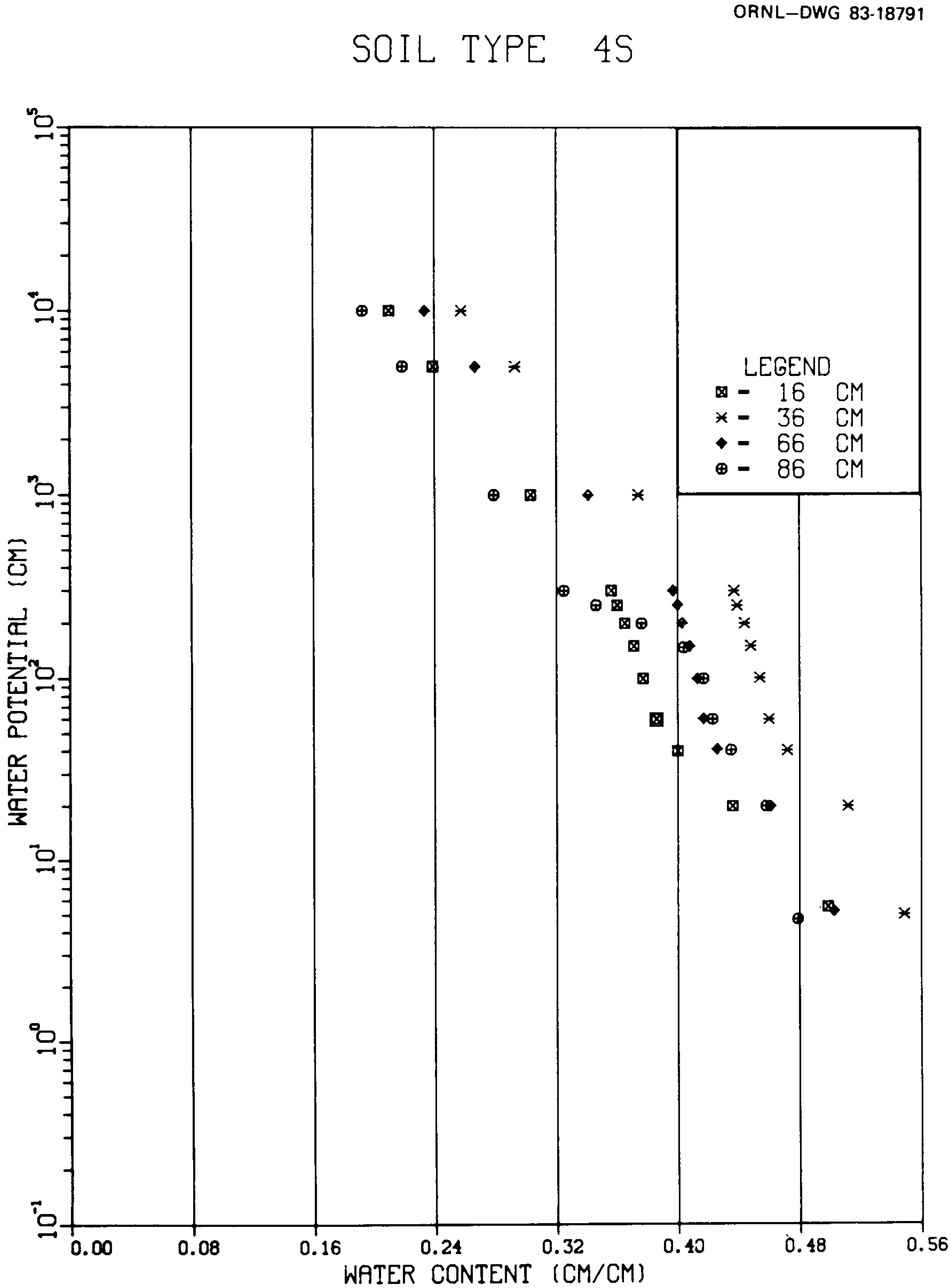

Fig. 6. Moisture-characteristic curves for soil type 4S.

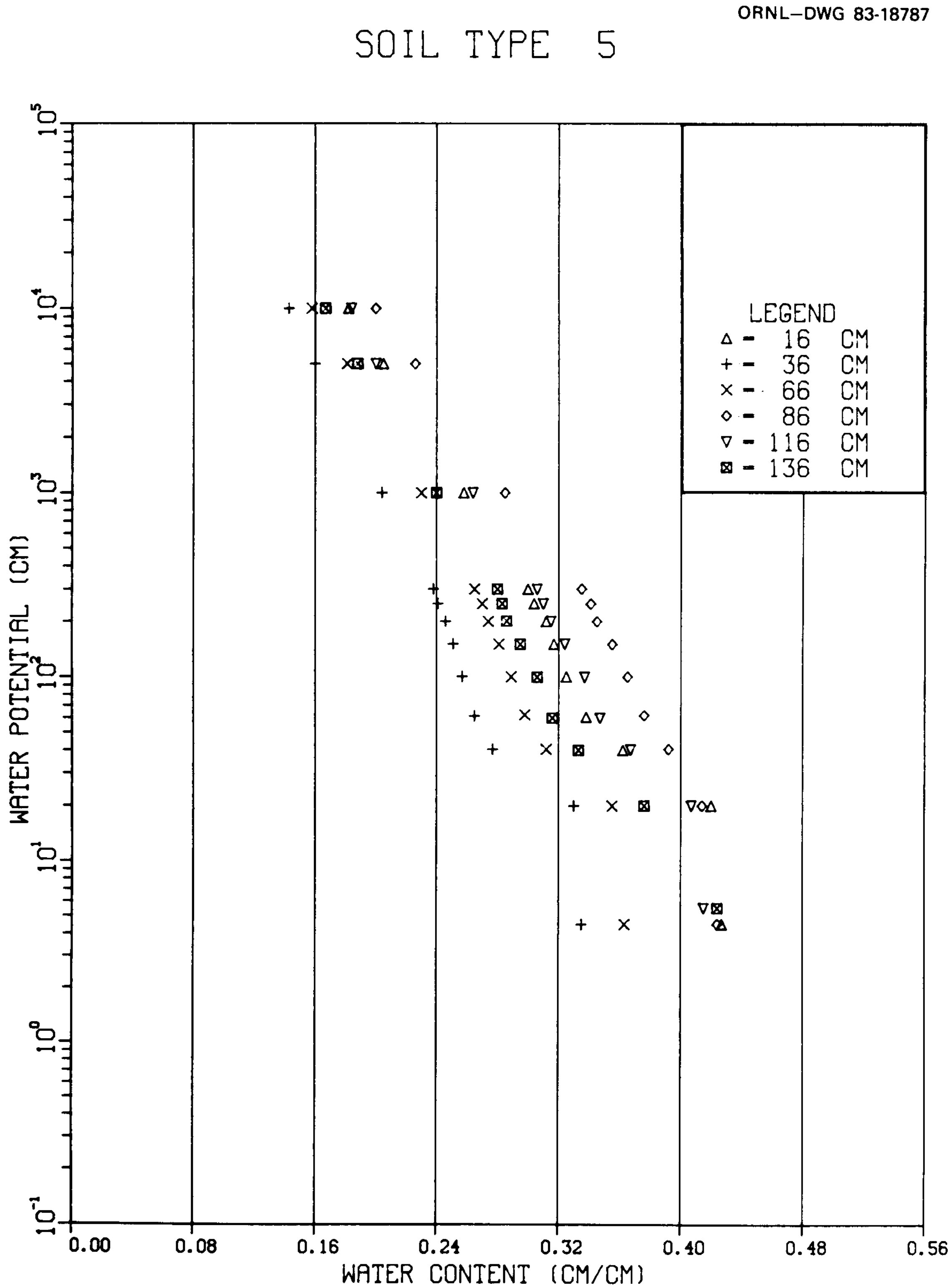

Fig. 7. Moisture-characteristic curves for soil type 5.

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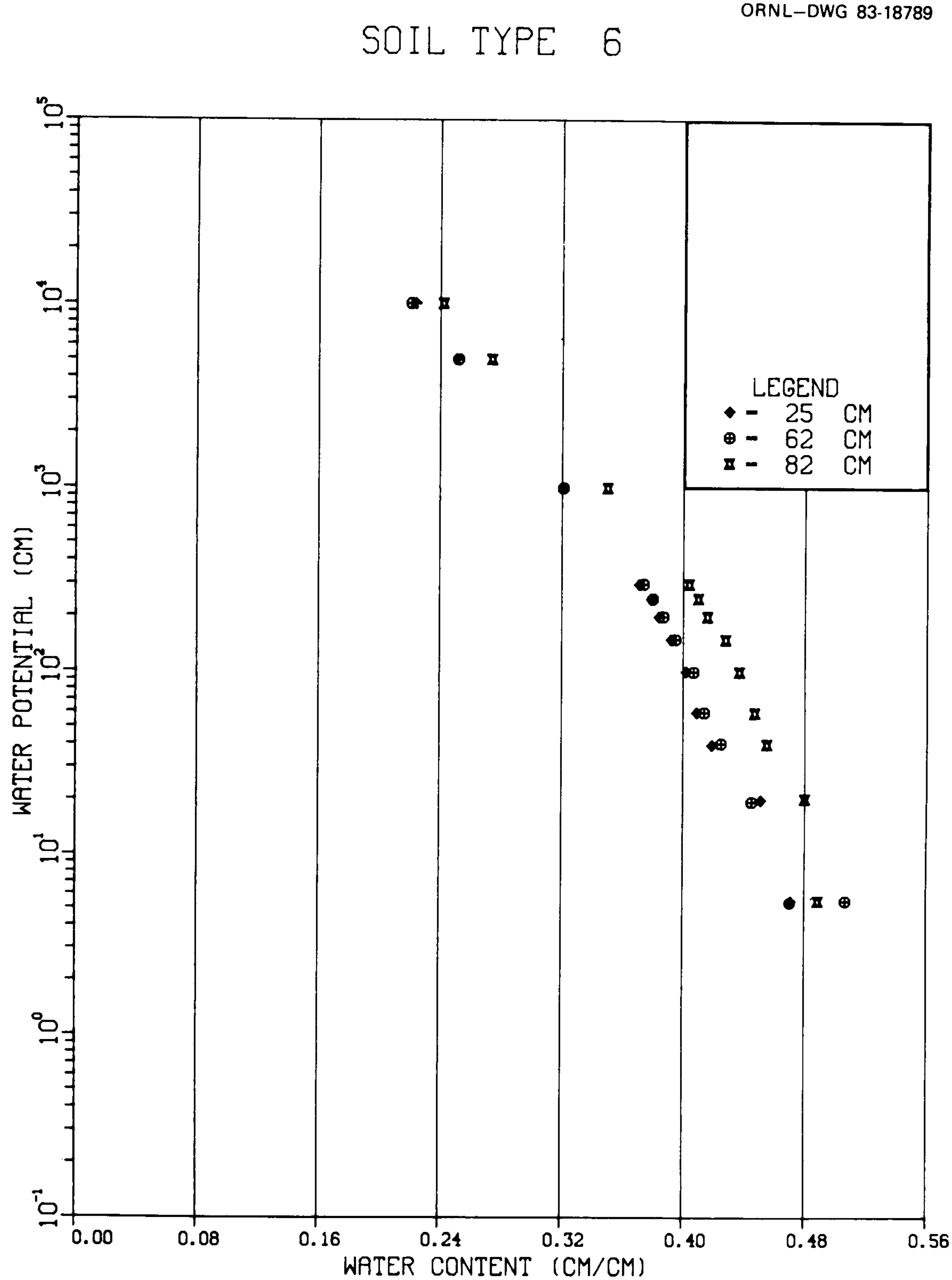

Fig. 8. Moisture-characteristic curves for soil type 6.

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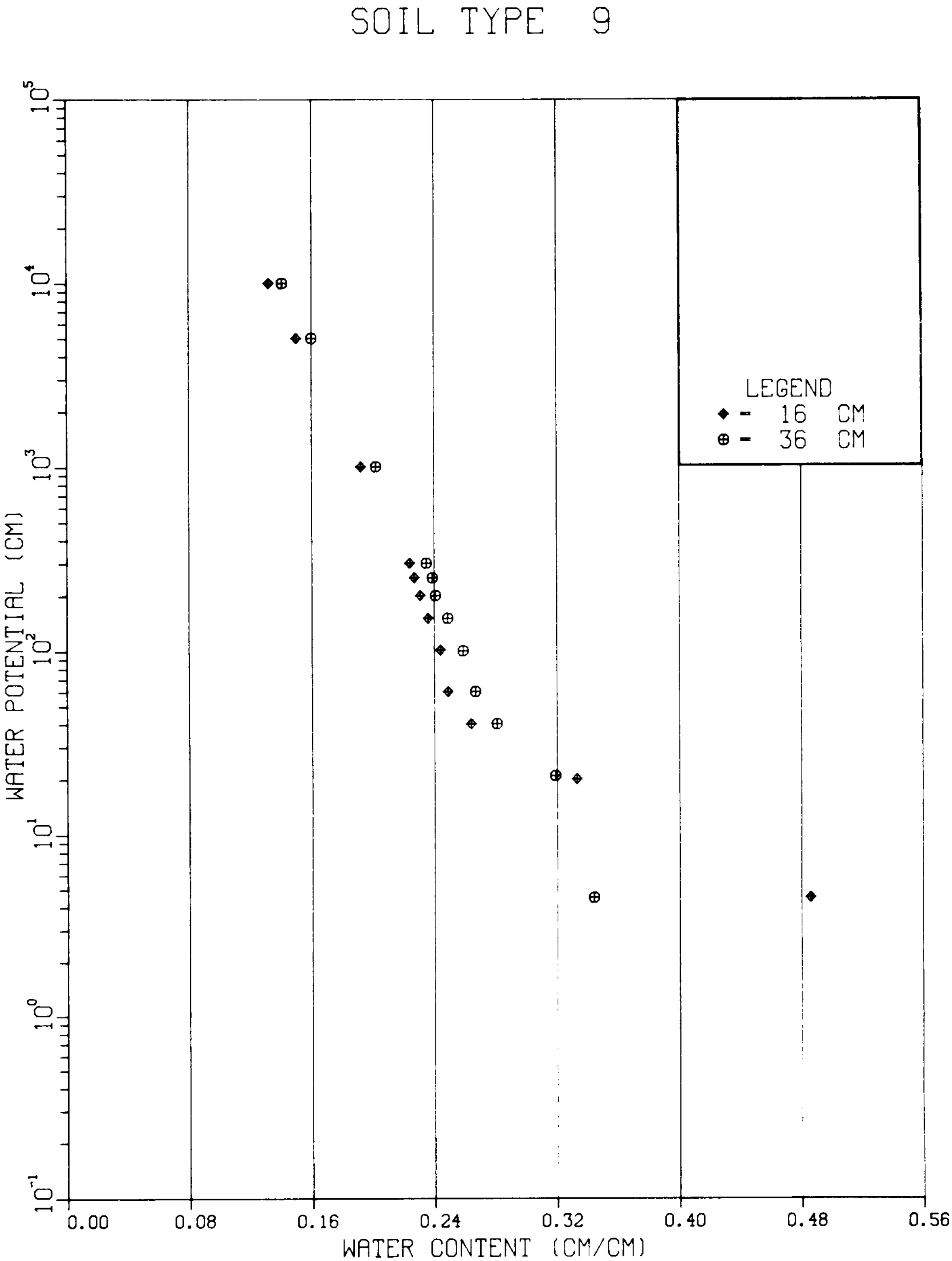

Fig. 9. Moisture-characteristic curves for soil type 9.

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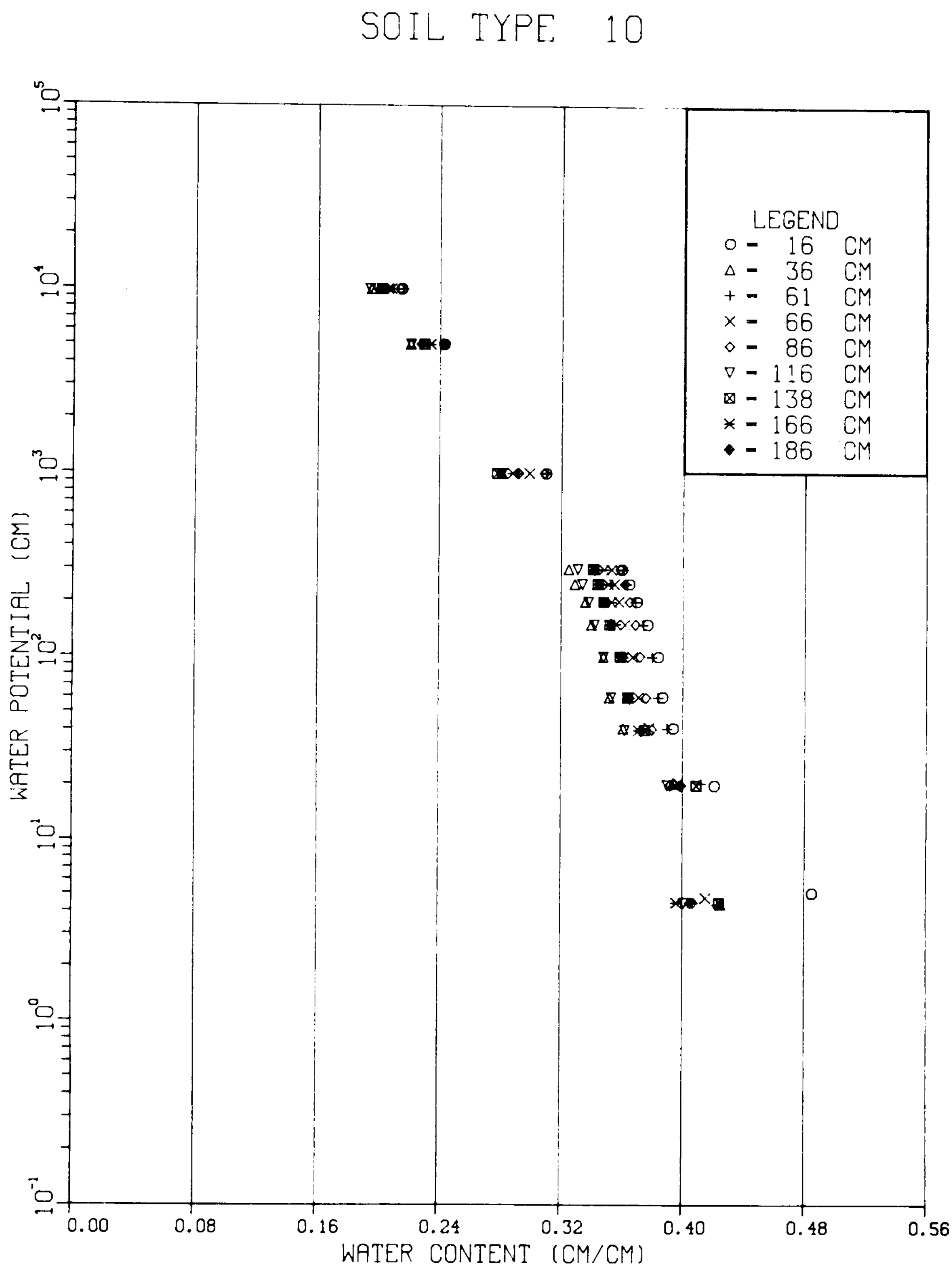

Fig. 10. Moisture-characteristic curves for soil type 10.

4.3 THE HYDRAULIC CONDUCTIVITY FUNCTION

Moisture release data were used with the Green and Corey (1971) model for relating inferred pore-size distribution to hydraulic conductivity for unsaturated conditions. The moisture release values were used together with field-measured values for saturated hydraulic conductivity to produce estimated relationships for moisture content vs hydraulic conductivity for each sample. The use of measured K_s as a matching value to adjust the hydraulic conductivity function ought to yield more reliable estimates of the hydraulic conductivity function than those obtained strictly from theory by the Green and Corey model. The results are tabulated in Appendix C. Hydraulic conductivity functions for each of the soils can be used directly in evapotranspiration and water-budget modeling for each site. The method used to determine K_s is described below.

The K_s values were determined by the shallow-well, pump-in method described by Boersma (1965). Briefly, the auger holes used to retrieve samples for moisture-characteristic determination were filled with water; thereafter, the water level was maintained. When steady state was achieved, the inflow rate was observed and used to calculate the K_s values reported in Table 4. No adjustment for a restrictive soil layer was necessary. The test gives a gross estimate for all soil layers within and immediately below the auger hole. If inhomogeneities are present, and other observations at SWSA 7 indicate that they are, then the composite K_s probably is biased towards the large values. If this is the case, then any computed transport of solutes would tend to be overestimated, resulting in a conservative design with respect to

Table 4. Hydraulic conductivity at saturation of sampled soils at proposed SWSA 7

Auger hole (Soil type)	K_s (cm/sec)
4	1.67×10^{-3}
4S	3.50×10^{-5}
5	3.90×10^{-5}
6	3.55×10^{-4}
9	2.14×10^{-3}
10	3.33×10^{-4}

water and solute movement. It follows that the probable errors associated with the simplicity of this method are in a direction favorable to the conservative management of the site; therefore, the method is appropriate for the purposes of this study (i.e., estimating subsurface transport). For infiltration models, the composite K_s values should be used with caution because they may not fully reflect the highly permeable conditions often observed at the surface. By way of comparison, the values in Table 4 are similar to those for the Sequoia soil series reported by others (Longwell et al. 1963, Luxmoore 1982).

5. RADIONUCLIDE ADSORPTION PROPERTIES

A basic question that must be addressed by any disposal site characterization is the rate at which various radionuclides will move from their initial point of contact through the soil under the prevailing hydrological conditions. One of the major factors in the attenuation of radionuclide migration is the degree of adsorption to the soil or rock of the disposal site formation. To assess the radionuclide adsorption properties on proposed SWSA 7, 18 samples were taken from soils and stream sediments. The sampling locations are shown in Fig. 3. The soil samples all represent areas and soil types where waste burial is most likely to occur.

The prevailing experimental approach to assessing potential migration rates is to determine in the laboratory the degree to which a radionuclide is partitioned between an actual or simulated ground water and the earthen material from the site. Because radionuclide adsorption is often dependent on the time of interaction between the water and earthen material, such determinations are often performed over intervals sufficient to reach equilibrium (this condition is thought to be the most useful or stable condition). But, if equilibrium requires months to attain and ground-water velocities at a particular site are on the order of meters per day, then the measurement of adsorption at equilibrium conditions should, at best, be considered to be of questionable value. Likewise, quite a few other laboratory experimental conditions, if not carefully considered, would lead to unrealistic results (i.e., results that would lead to an inaccurate description of the migration of radionuclides at the site).

The two general laboratory methods for the measurement of soil adsorption, batch and column elution, are each limited in their usefulness for site characterization. Column elution techniques appear to simulate field conditions more than the batch or static "test tube" methods. They have the advantage that the derived Kds are determined from the breakthrough of the radionuclide under dynamic flow conditions. However, they are often determined under arbitrary flow rates selected for the convenience of the experimenter rather than their simulation of field conditions. Almost always, they are performed on reconstituted materials, rather than unperturbed cores, which further compromises their simulation of field conditions. Perhaps, the most serious drawback to column elution studies is that they are time-consuming (i.e., expensive) to perform. If the adsorption characteristics of a number of samples, representing the various earthen materials encountered at a site, need to be determined for a number of radionuclides, then the use of column elution techniques becomes prohibitive. In addition, because of the large elution volumes required and column dispersion, the determination of Kds >100 L/kg by column elution is virtually impossible. Thus, column elution was not selected nor is it recommended for estimating Kds in the laboratory.

Considering the problem of radionuclide migration necessitates focusing on particular radionuclides so that those that might potentially compromise site performance can be singled out from the many that pose significantly less hazard. To achieve this, a typical low-level solid waste must be defined and an estimate must be made of the amount of each radionuclide it contains. The variability of low-level wastes makes such a definition difficult, but, for purposes of illustration, one defined waste stream has been selected. Boiling water reactor filter sludge (BWRFS) is one of the highest activity low-level wastes identified by NRC (1981) and also contains one of the broadest ranges of potentially hazardous radionuclides. These estimates of concentrations in the waste and of their environmental mobility [like the geologic retardation factors (Rd) also estimated by NRC (1981)] facilitate the comparison of these radionuclides for potential migration from a shallow land burial trench. A hazard rating for each radionuclide can be calculated by factoring in its inherent radiological toxicity, as measured by its maximum permissible concentration (MPC) for the unrestricted use of water (NRC 1981),

$$\text{Hazard Rating} = \frac{\text{Concentration in BWRFS}}{\text{Rd} \times \text{MPC}} ,$$

where

$$\text{Rd} = 1 + \frac{\text{PbKd}}{n},$$

Pb = bulk density,

n = porosity.

Such hazard ratings (Table 5) provide a quantitative method to compare radionuclides that occur at differing concentrations in the waste, that are adsorbed to differing degrees by the soil in which they migrate, and that have inherently different radiological toxicities. Such hazard ratings can be used to formulate a ranking system for determining which radionuclides ought to be investigated for site

Table 5. A generic hazard evaluation of radionuclides encountered in the disposal of low-level radioactive waste

Radionuclide	Concentration in BWRFS[a] (Ci/m^3)	Soil Rd[b]	MPC[c] mCi/L	Hazard rating[d]	Rank
^{3}H	1.26×10^{-2}	1	3×10^{-3}	4.2	5
^{14}C	7.78×10^{-4}	10	8×10^{-4}	9.7×10^{-2}	8
^{55}Fe	1.44×10^{0}	2640	8×10^{-4}	6.8×10^{-1}	6
^{59}Ni	1.49×10^{-3}	1750	2×10^{-4}	4.3×10^{-3}	10
^{60}Co	2.41×10^{0}	1750	5×10^{-5}	$2.8 \times 10^{+1}$	4
^{63}Ni	3.25×10^{-2}	1750	3×10^{-5}	6.2×10^{-1}	7
^{94}Nb	4.70×10^{-5}	4640	3×10^{-6}	3.4×10^{-3}	11
^{90}Sr	2.37×10^{-3}	36	3×10^{-7}	$2.2 \times 10^{+2}$	2
^{99}Tc	5.00×10^{-5}	4	3×10^{-4}	4.2×10^{-2}	9
^{129}I	1.33×10^{-4}	4	6×10^{-8}	$5.5 \times 10^{+2}$	1
^{135}Cs	5.00×10^{-5}	350	1×10^{-4}	1.4×10^{-3}	
^{137}Cs	1.33×10^{0}	350	2×10^{-5}	$1.9 \times 10^{+2}$	3
^{235}U	3.32×10^{-7}	3520	3×10^{-5}	3.1×10^{-6}	
^{238}U	2.61×10^{-6}	3520	4×10^{-5}	1.9×10^{-5}	
^{237}Np	6.38×10^{-11}	1200	3×10^{-6}	1.7×10^{-8}	
^{238}Pu	4.66×10^{-4}	3520	5×10^{-6}	2.7×10^{-2}	
^{239}Pu	2.36×10^{-4}	3520	5×10^{-6}	1.3×10^{-2}	
^{241}Pu	1.15×10^{-2}	3520	2×10^{-4}	1.6×10^{-2}	
^{242}Pu	5.18×10^{-7}	3520	5×10^{-6}	2.9×10^{-5}	
^{241}Am	1.56×10^{-4}	1200	4×10^{-6}	3.3×10^{-2}	12
^{243}Am	1.05×10^{-5}	1200	4×10^{-6}	2.2×10^{-3}	
^{243}Cm	2.97×10^{-7}	1200	5×10^{-6}	5.0×10^{-5}	
^{244}Cm	2.24×10^{-4}	1200	7×10^{-6}	2.7×10^{-2}	

[a]BWRFS = boiling water reactor filter sludge per U.S. Nuclear Regulatory Comm (1981).

[b]Case 1, soils with moderate permeability, Table 5.2 from U.S. Nuclear Regulatory Comm. (1981).

[c]MPC = maximum permissible concentration for unrestricted use of water per NRC (1979).

[d]Hazard rating = BWRFS concentration/(Rd x MPC).

characterization. One can also see what makes a radionuclide like ^{129}I exhibit the highest hazard rating; many other radionuclides occur at higher concentrations in BWRFS, but most have much higher soil Rds and much greater MPCs. The rankings follow the order ^{129}I, ^{90}Sr, ^{137}Cs, ^{60}Co, ^{3}H, ^{55}Fe, etc, in which all of the actinide radioisotopes are of lower hazard than the fission and activation products. This hazard rating system merely serves to justify site characterization efforts on the most hazardous radionuclides. In addition, the most hazardous of the actinides, ^{241}Am, was also investigated. In several cases, less hazardous and more analytically facile radioisotope were selected for Kd determination (i.e., ^{85}Sr, ^{125}I, ^{134}Cs, and ^{58}Co.

5.1 METHODS

For the distribution coefficient determination of each radionuclide, a weight of soil equivalent to 5.00 g of oven-dried material was placed in a 30-mL polypropylene "Oak Ridge" centrifuge tube. To this was added 20.0 mL of a bulk sample of stream water collected from the central drainage of proposed SWSA 7. This stream water sample was filtered twice through Whatman No. 1 paper to remove suspended material; it exhibited a pH of 7.2, an electrical conductivity of 160 ds/m, a hardness of 80 mg $CaCO_3$/L, and an alkalinity of 66 mg $CaCO_3$/L. These properties remained unchanged during the several weeks required to complete the distribution coefficient determinations. This sample was also analyzed for elemental composition (USEPA 1979) including Ca, Mg, Na, K, Sr, Co, Cs, and I. These were found to be 24.2, 3.7, 2.7, 1.0, .072, 0.0001, 0.005, and <0.0005 mg/L, respectively.

To the resulting soil-water suspension was added a 1-mL aliquot of a stock carrier-free radioisotopic solution. These stock solutions were prepared by diluting the radioisotope into 100 or 50 mL of tap water. The following total activities of each isotope were employed: ^{125}I (1.9 MBq), ^{134}Cs (2.7 MBq), ^{85}Sr (1.7 MBq), ^{58}Co (2.2 MBq), and ^{241}Am (1.1 MBq). After the soil water suspension was shaken lengthwise for one week at 100 oscillations/min, it was centrifuged at 3600 RCF (relative centrifugal force) for 10 min and an aliquot removed from the supernatant for activity determination. In the case of ^{134}Cs, ^{85}Sr, and ^{58}Co, a 5-mL aliquot was placed in a 25-mL-capacity plastic scintillation vial and counted directly in a well-type NaI gamma detector. In the case of either ^{125}I or ^{241}Am, a 0.5-mL aliquot was placed in a 7-mL capacity plastic scintillation vial with 5 mL of liquid scintillation cocktail (Aquasol, New England Nuclear) and the activity was determined with a Prias liquid scintillation counter. With the five gamma-emitting radioisotopes, only the channels within the photopeak were counted using a multichannel analyzer to divide the gamma spectrum into 200 channels between 0.1 and 2.0 MeV. Blanks were run concurrently to correct for background counting rates in the photopeak of interest. For ^{125}I, the predetermined program of instrument settings was employed, and for ^{241}Am, a counting window between 20 and 100% of full scale was selected. The external standards ratio method was used to correct color and chemical quenching of samples during liquid scintillation counting, but only a few samples manifested such interferences. Triplicate standards for each radioisotope, comprised of 1 mL of stock solution in 20 mL of creek water (without soil), were counted concurrently with each batch of samples. By comparing the ratios of all sample counts to their standards, the fraction adsorbed by each soil (i.e., the relative amount disappearing from solution) was computed from the background-corrected counting rates. Absolute counting efficiencies, therefore, did not have to be determined, and, because of the generally high activities employed, spectrum stripping did not have to be performed to correct for contributions of other isotopes.

From the observed counting rates of sample and standards, the adsorbed fraction of radioisotope can be calculated:

Fraction adsorbed =

$$\frac{[\text{Standard (cpm)} - \text{Background (cpm)}] - [\text{Sample (cpm)} - \text{Background (cpm)}]}{[\text{Standard (cpm)} - \text{Background (cpm)}]}.$$

From this fraction adsorbed, the Kd of the radioisotope can be calculated:

$$\text{Kd} = \frac{(\text{Fraction adsorbed})}{(1 - \text{Fraction adsorbed})} \quad \frac{(\text{Volume of solution})}{(\text{Weight of Soil})}.$$

where the volume of solution is the total of 20.0 mL of creek water plus 1 mL of radioisotopic stock solution plus the moisture added with the soil, and the weight of soil is the equivalent oven-dried weight of soil.

5.2 RESULTS

The measured Kds for soils and stream sediments from SWSA 7 are listed in Table 6. Other chemical and physical properties are also included to compare and contrast soil types. The radioisotopes ^{241}Am and ^{134}Cs exhibited extremely high Kds. There was an upper limit to the Kd that could be measured in these cases that was imposed by a

Table 6. Radionuclide distribution coefficients of soils in L/Kg on the proposed SWSA 7

Sample	Soil type	Kd-Sr	Kd-Cs	Kd-Co (L/Kg)	Kd-I	Kd-Am	Kd Hardness
1	4	41.9	431	23.1	9.4	777	10.8
2	4	75.8	1120	94.4	4.7	817	64.5
3	4	69.4	1760	153	3.6	4620	38.9
4	4	616	53000	228	54.4	5410	112.0
5	4	92.0	345	37.5	12.3	608	56.0
6	4s	99.9	412	77.4	19.9	3220	76.7
7	5	125	457	57.6	14.8	1070	77.9
8	5	117	275	70.5	11.2	613	97.0
9	5	398	1230	152	20.1	3030	331.9
10	5	261	1020	96.9	16.3	1420	189.3
11	9	110	355	164	17.0	1150	119.7
12	9	133	553	52.9	10.9	777	89.6
13	10w	168	207	76.3	37.7	599	149.4
14	10	107	331	66.0	19.5	481	86.5
15	6	31.4	138	16.0	4.4	380	31.8
16	S	88.3	23700	3510	11.1	21700	70.0
17	S	85.7	18900	3040	11.0	15400	61.8
18	S	135	27500	5740	17.0	30000	81.4

combination of background counting rates and the activity of the isotope used; these maximum measurable Kds were calculated to be 30,000 and 53,000 L/kg for ^{241}Am and ^{134}Cs, respectively. Several soil samples approached or reached the maximum levels for ^{241}Am and ^{134}Cs, but the Kds for other radioisotopes were well below maximum levels (30,000 for ^{85}Sr, 12,500 for ^{58}Co, and 54,000 for ^{125}I).

The relative uncertainty in the reported Kds in Table 6 is neither of constant magnitude nor percentage. An excellent discussion of these uncertainties can be found in Baes and Sharp (1983) and will not be repeated here. Nonetheless, the Kds are reported to three significant figures. Generally, extremely high Kds (i.e., $>10^5$ L/kg) will have unsymmetrical confidence limits; a typical 95% confidence interval would range from 10^6 to 10^4 L/kg. Extremely low Kds (i.e., $<10^{-1}$ L/kg) were not encountered for any samples, as might be expected for ^3H (as water) but low values would be subject to the same large range of uncertainty as high values. Actually, such large confidence intervals are not particularly cumbersome to interpret. If a Kd is above 10^4 L/kg, a precise confidence interval would be superfluous because Kds of such magnitude indicate that the radionuclide will not move in the formation. Likewise, extremely low Kds are not worth determining with great precision because the radionuclide will behave like water, and any difference in the rate of migration of the radionuclide to that of water in the formation would be minor. Thus, Kds in the range of 10 to 10^3 L/kg are most useful to determine with precision, because these radionuclides will move in the formation at velocities slower than those of ground water, yet fast enough that, potentially, they might migrate to uncontrolled areas.

In absolute terms, the significance of a potential hazard posed by a radionuclide cannot be assessed from the magnitude of the distribution coefficient. Even if the total inventory of radionuclide in the waste and its inherent radiological hazard are taken into account as discussed in the previous paragraph, the adequacy of a given Kd to retard radionuclide migration depends on the hydraulic conductivities and gradients of the formation. If hydraulic conductivities are low, even low Kds will be adequate to allow radioactive decay before a significant radiological dose is delivered to some predetermined boundary. Such assessments are the major goal of a pathways analysis, and, therefore, the Kds and hydraulic conductivities are critical input parameters.

As can be seen in Table 6, most of the soil samples analyzed are from ridges or slopes (samples 1 through 12, representing soil types 4, 4S, 5, and 9). These are areas where ground water is deep and waste burial is likely to occur and where soils will possibly be used as backfill. Samples 13 through 15 are taken from the walls and bottoms of drainageways. Sample 15 consists primarily of alluvium. These samples (13 through 15) represent soil types 10W, 10, and 6, which are soils in areas where surface runoff is likely to contact them. Samples 16 through 18 are all stream sediments taken from the three major streams draining proposed SWSA 7.

The data indicate that differences in radionuclide adsorption between upland soils is not great. There is a certain amount of variation between soil types (mapping units), but more samples would be required to substantiate differences. Generally, the upland soils have high Kds for all radionuclides, the Kd for ^{125}I being consistently lowest. The pH of water in equilibrium with these soils is acidic (pH is less than 7.0). Organic matter varies between 2 and 5% (with one exception), and only one sample indicated any carbonate present. The CEC of the uplands soils is moderate.

The lowland soils are similar to the upland soils, except for the alluvium surrounding the streams (soil type 6). Data indicate that this soil type has distinctly lower Kd values. Other properties shown are not distinctly different, but differences do appear in other chemical properties (see Sect. 5, Chemical Properties).

The stream sediments are distinctly different from all the soils tested. Sediments exhibit extremely high Kds for ^{134}Cs, ^{58}Co, and ^{241}Am. The sediments all show traces of carbonate present, very little organic matter (<1%) and a basic (>7) equilibrium pH.

For the purpose of modeling and pathways analysis, it appears that the surficial materials present on proposed SWSA 7 can be broken down into three groups (with respect to Kds). The first and major group is the upland soils where burial will take place, and along drainageway walls; the second is drainageway bottoms; and the third is stream sediments.

6. CHEMICAL PROPERTIES

The soil total elemental composition can be misleading because many elements can be present in largely insoluble mineral phases; the other phases, representing only a small fraction of the total elemental composition, can determine the equilibrium solubility of an element in groundwater. In humid regions, generally the most active soil phase is the soil cation exchange complex, which determines ground-water quality. The nature and quantity of cations on soil exchange sites should be the primary considerations in soil chemical characterization. In arid regions, where soil development is much less advanced because of limited profile leaching, residual, more soluble minerals (e.g., halite, gypsum, trona, and soda ash) can be present and exert the dominant influence on ground-water quality. In humid regions, however, the source of most of the exchangeable basic cations in a soil is often the weathering of sparingly soluble calcium carbonate. Thus, the depth of weathering and the residual content of this phase are important determinants for a site characterization, particularly with the calcareous rocks of the Conasauga Group.

In the classification of groundwaters by geochemical type (Stumm and Morgan 1981), the amounts of dissolved cations are often determined to be in equilibrium with calcium carbonate. In the absence of carbonate, much less soluble minerals, such as quartz, feldspars, and phyllosilicates, determine ground-water quality and generally result in ground waters of much lower ionic strength than those influenced by carbonate. The fluxes of carbon dioxide required to dissolve carbonate are generally supplied by plant root respiration and decomposition of soil organic matter, particularly in its zone of concentration near the soil surface. Plants are also responsible for much of the elemental cycling that occurs in a soil profile. Cations from the dissolution of carbonates are brought above ground by the growing vegetation. During plant senescence, these cations are released to the surface soil horizons where weathering and repeated plant uptake continue and the cycle is completed. Such elemental cycling can be extremely important in radionuclide movement for elements, such as ^{90}Sr, which behave in soil like Ca; they can be mined out of buried waste by vegetation and brought to the soil surface. Similarly, ^{137}Cs often behaves like K in soil and can be cycled in the soil profile in a manner similar to ^{90}Sr. The characterization of this elemental cycling requires a determination of the kinds and quantities of exchangeable cations (e.g., Ca, Mg, K, Na, Al, and H) within soil profiles. The summation of all these cations equates with the CEC of the soil. This capacity represents the primary determinant by which any cation, whether a radioactive or stable isotope, added in buried waste will be retarded by soil. It is, therefore, the single most important property for the chemical characterization of soil.

A characteristic related to the nature of the soil's indigenous exchangeable cations is soil pH. This property is generally related to the fraction of exchange sites of a soil that are occupied by acidic cations (i.e., Al^{3+}, H^{+}, and sometimes Mn^{2+}. Soil pH is, therefore, a good index of soil weathering, particularly if the soil parent material contains carbonate, as does the Conasauga Group. Generally, a pH of less than approximately 6.5 indicates that a soil will not contain any carbonate and, as the pH of the soil declines below this, the amounts of exchangeable Ca and Mg will also decline. The amount of $CaCO_3$ present in a soil is also a useful weathering index; none of the soil samples from proposed SWSA 7 contained any $CaCO_3$ as evidenced by the low pH measurements. However, $CaCO_3$ is a major component of the Conasauga Group; significant amounts of $CaCO_3$ can be found at greater depth beneath the soil zone.

The degree of profile interaction with vegetation can be determined by the organic matter content of the soil. Soil profiles exhibit an organic matter content that declines with depth resulting from the distribution of plant roots. However, the depths and absolute amounts of organic matter can vary enormously among soil types. The degree of influence of organic matter on soil properties is considered so important that it forms the basis for classifying many soils at the highest level (i.e., the soil order). Organic matter is also a source of cation exchange in soil and is the source of many specific adsorptions (e.g., organic pesticides or other organic species that might be present in waste). Thus, the organic matter content of a soil profile is extremely valuable for site characterization.

Many standard techniques exist for soil characterization. Those described by the Soil Conservation Service (1972) are oriented towards soil classification; these tend to be the most useful for site characterization because their purpose makes them the most generic. Other generic methods are those of the American Society of Agronomy (1982); these tend to be somewhat biased towards agricultural characterization but are basically generic because of the diversity of agricultural goals that they must address. Other procedures for soil testing (e.g., ASTM 1958) tend to be oriented towards engineering properties and, therefore, have less application for chemical characterization.

6.1 METHODS

Soil exchangeable cations were determined by elemental analyses of Ca, Mg, and Na (USEPA 1979) of 1M KCl extracts (Thomas 1982). Exchangeable acidity was determined by the $BaCl_2$-triethanolamine method (Peech 1965). Cation exchange capacity was calculated as the sum of exchangeable cations and exchangeable acidity. Soil pH was measured with a glass electrode using a 4:1 (v:w) water:soil ratio. Organic matter content was determined by the Walkley-Black method (Allison 1965). Percentage base saturation was computed as the contribution of exchangeable bases (Ca, Mg, and Na) to the CEC.

The carbonate carbon content of the soil was determined in a similar manner to method 6E3 of the U.S. Department of Agriculture, Soil Conservation Service (1972) except that a sealed, rather than a flow-through, system was employed for collecting evolved CO_2. Because this modification represents a significant deviation from the standard procedure, the method is herein described in detail and its accuracy was tested by applying it to standards containing variable amounts of $CaCO_3$. Into a 500-mL large-mouth, screw-cap polystyrene jar was weighed 1.00 g of soil or rock. Within this large jar was also placed a 50-mL large-mouth screw-cap glass jar containing 5.00 or 10.00 mL of 1 M NaOH solution. While tilting the large jar to segregate the contained soil on the elevated portion of the bottom, 20 mL of a

1 M H_2SO_4/5%$FeSO_4$ solution was added; the screw-cap was then secured and the jar returned to an upright position that allowed the H_2SO_4/$FeSO_4$ solution to contact and wet the soil. If the $CaCO_3$ content of the soil was greater than ~1%, a pronounced effervescence was noted. After allowing the jar to remain unperturbed for 72 h, the smaller jar of NaOH was removed and its screw-cap sealed until titration. After adding 10 mL of 1 M $BaCl_2$ to the NaOH, the residual alkalinity was titrated with 1 M HCl to the phenolphthalein endpoint. The difference between the amounts of titrant required for blanks and sample was converted to express evolved CO_2. The carbonate content of the soil or rock was expressed as a weight percent of $CaCO_3$, equivalent to the evolved CO_2. Standards of chemically pure $CaCO_3$ were run to test the accuracy and validity of the method. The regression between mg of $CaCO_3$ found (Y) and $CaCO_3$ added (X) was

$$Y = 0.95 X + 4.2 \quad (r = 0.994, n = 9)$$

over the range of 50 to 450 mg $CaCO_3$ (i.e., 5 to 45% $CaCO_3$ by weight). The minimum detectable amount of $CaCO_3$ was 0.1%.

An additional measurement of the soil solution concentration of Ca and Mg was made by measuring hardness (APHA 1980). A 20-mL aliquot of a batch of creek water collected from the central drainage of the proposed SWSA 7 site was equilibrated with 5.00 g of soil for six days by agitation in a centrifuge tube.

6.2 RESULTS

The chemical properties of the soil samples collected from proposed SWSA 7 are summarized in Table 7. The soils can be described as well leached and acidic in nature. In only one soil sample was any residual carbonate observed; this was also the only soil sample having a pH greater than 6. The soils also have considerable CEC, averaging 169 meq/kg. As discussed in Sect. 5, Radionuclide Adsorption Properties, the properties of soils on proposed SWSA 7 are quite similar. However, the chemical properties of the stream sediments are distinctly different from those of the soils. In comparison to the soils, the stream sediments are of basic pH and have very little organic matter, high total hardnesses, and high Ca content, as well as measurable $CaCO_3$ content.

Soil chemical properties reflect the nature of the mineral phases present. In site characterization, these properties should be compared for consistency with the results of the mineralogical and physical analyses. For example, the presence of carbonate is inconsistent with a strongly acidic soil. In addition, chemical soil properties usually correlate with certain physical properties. For example, a soil having very coarse texture (e.g., 90% sand) would not be expected to have a CEC in excess of 50 meq/kg; nor would a soil, whose clay mineralogy was dominated by kaolinite, be expected to exhibit a CEC much above 100 meq/kg.

Other chemical soil tests (e.g., the many availability tests for essential plant micronutrients) were not carried out because the tests were developed for aiding agricultural production rather than for

Table 7. Properties of soils and sediments on proposed SWSA 7 from B-horizon soil samples of material finer than 2 mm

Sample number	Soil type	Exchangeable				CEC[b]	pH	%$CaCO_3$	Total hardness[b]	Organic matter (%)	Available		Sand (%)	Clay (%)	Silt (%)
		Ca[a]	Mg[a]	Na[a]	Acidity[a]						Mn[c]	Fe[c]			
1	4	08.4	02.8	00.0	76.	87.	5.0	0.0	52	3.06	360.0	118.0	28.4	22.3	49.3
2	4	64.1	21.0	00.0	86.	171.	6.2	0.1	66	4.15	715.0	151.0	39.1	27.5	33.3
3	4	19.8	06.5	00.0	87.	113.	6.0	0.0	34	4.99	1160.0	250.0	22.3	24.9	52.8
4	4	03.9	27.4	01.6	115.	148.	4.7	0.0	14	0.40	170.5	118.0	67.2	19.1	13.6
5	4	16.3	08.2	00.2	118.	142.	4.5	0.0	22	2.06	169.0	120.5	52.4	19.1	28.4
6	4S	50.9	13.5	00.0	90.	154.	5.4	0.0	42	3.48	390.0	119.0	29.3	31.0	39.7
7	5	27.0	13.5	00.0	152.	193.	4.7	0.0	26	3.43	655.0	245.5	40.0	26.4	33.6
8	5	39.4	18.7	00.0	119.	177.	4.9	0.0	30	3.80	645.0	209.0	40.3	26.4	33.3
9	5	95.3	24.1	00.0	108.	228.	4.9	0.0	18	2.01	153.5	78.5	65.8	20.9	13.3
10	5	52.2	31.1	00.0	133.	216.	4.6	0.0	22	3.40	277.5	88.5	34.2	41.2	24.6
11	9	48.0	18.9	00.0	103.	170.	5.0	0.0	28	2.84	367.5	112.5	30.1	38.0	31.9
12	9	37.2	23.7	00.0	147.	208.	4.6	0.0	34	4.61	148.5	96.5	27.5	46.4	26.1
13	10	60.1	23.5	00.0	141.	224.	4.9	0.0	28	3.25	28.5	41.0	29.0	38.6	32.5
14	10	42.0	20.2	00.0	125.	188.	4.9	0.0	36	4.73	825.0	257.0	29.6	31.3	39.1
15	6	15.2	03.8	00.0	97.	116.	4.6	0.0	30	3.48	109.5	83.5	25.5	20.6	53.9
16	[d]	136.0	17.9	00.0	43.	197.	7.2	0.3	110	0.883	1910.0	237.0	43.8	39.7	16.5
17	[d]	152.2	15.8	00.0	44.	212.	7.2	0.6	136	0.847	1575.0	192.0	41.2	46.8	11.9
18	[d]	123.6	19.8	00.0	52.	195.	7.3	0.1	88	0.515	4950.0	317.0	47.2	31.6	21.2

[a] meq/Kg.

[b] mg $CaCO_3$/L.

[c] mg/kg.

[d] Stream sediment.

describing fundamental chemical interactions. The behavior of many radioisotopes (e.g., ^{60}Co and ^{55}Fe, which as elements are essential for plant growth) will be determined by their interaction with the available pools of the more abundant stable isotopes already in the soil. The soil adsorption reactions of many of these elements have been studied for some time and tend to follow reasonably well-established mechanisms (Ellis and Knezek 1972). Each element or radioisotope will follow some empirical adsorption isotherm; the investigations of these isotherms were not judged to be particularly important for this site characterization. Because of the rather large Kds for such radioisotopes, these isotopes will not migrate very far within the formation, so that a more detailed knowledge of their adsorption behavior would only be of academic interest.

7. MINERALOGY

Soil properties are the significant factors influencing the performance of a low-level radioactive waste disposal site because of their obvious role in the transport of contaminants after disposal and long-term stability of the burial site. The mobility of the disposed radionuclides is controlled by physical and chemical processes including sorption properties, permeability, and structural stability of the soils and parent materials. These physiochemical characteristics could be measured or described directly through laboratory and field studies, but the results of the studies could not be properly interpreted without a fundamental knowledge of the mineralogical composition of the soils and bedrocks.

Parent materials of the soils in the study area are highly leached, silty limestone and shale or alluvium and colluvium of the weathered sedimentary rocks. The parent rocks are a part of the Conasauga Group. Major components of the clay mineralogy of the soils are inherited from the parent rocks, but the minerals have been transformed to other minerals in varying degrees, depending on the stability of the minerals and intensity of environmental factors, during pedogenic processes. The mineral transformation accompanies considerable changes of physiochemical properties of the soils and partially weathered materials. Such pedogeochemical changes could be measured through systematic investigations of the mineral distribution within soil profiles.

7.1 METHODS

Soil samples were selected from four soil profiles described in Appendix B, and the locations of the soil profiles were given in the soil map (Fig. 3). Selected properties of the soil samples are presented in Table 8. The air-dried soil samples were crushed and passed though a 2-mm sieve. Before mineralogical analyses, soluble salts and carbonate minerals were removed by 1 N NaOAc (pH 5) and organic matter was removed by H_2O_2 oxidation. The sand, silt, and clay fractions were separated by wet sieving, sedimentation, and centrifugation (Jackson 1975). Free oxide phases in the soils were removed by citrate-bicarbonate-dithionite and estimated as Fe_2O_3 and Al_2O_3.

The clay fractions were saturated with Ca, replaced with Mg (Ca exchange capacity [Ca/EC]), resaturated with K and replaced with NH_4 after heating at 105°C for 24 h (K/EC). Following drying at 105°C and $LiBO_2$ fusion, total elemental analyses of the clay fractions were performed. The amounts of mica were estimated from structural K content from the total analyses. Vermiculite and smectite contents were estimated from the K/EC and Ca/EC values (Jackson 1975).

Kaolinite content was estimated by differential scanning calorimetric analysis. For the qualitative confirmation of the mineral distribution, the clay fractions were examined with an X-ray diffractometer using monochromatic Cu K α radiation after K saturation, heating to 300 and 550°C, Mg saturation, and glycerol salvation. The air-dried clay fractions were examined with a Philips EM-300 transmission electron microscope (TEM) for morphological identification of the minerals (Lee et al. 1983).

Table 8. Soil properties and mineralogical composition of the clay fraction (2 μm) of selected soil samples from SWSA 7

				Particle Size (%)			CBD extractable (%)		Minerals in Clay Fraction (%)				
Profile	Horizon	Depth (cm)	Soil pH	Sand	Silt	Clay	Fe_2O_3	Al_2O_3	Mica	Vermiculite	I.V.[b]	Kaolinite[c]	Others
	A	0-5	4.3	14	73	13	1.4	0.24	28	20	25	7	20
IV	E	5-14	4.2	9	75	16	1.4	0.29	27	18	25	10	20
	Bt_2	35-54	4.0	11	59	30	2.5	0.41	25	22	25	10	18
	Cr1	70-114	3.9	49	38	13	2.7	0.39	36	17	20	15	12
	A	0-8	5.0	23	44	33	2.0	0.32	43	19	10	10	18
V	BW	8-18	3.9	34	46	20	2.0	0.30	47	18	10	10	15
	C	18-95	4.2	61	27	12	1.8	0.23	45	17	10	10	18
	Cr	95-100	4.0	69	25	6	1.2	0.12	48	23	5	6	18
	A	0-15	4.0	10	64	26	1.3	0.30	31	18	15	20	16
VII	Bt_2	31-60	3.9	8	49	43	3.5	0.41	43	21	10	20	6
	Cr	115-122	3.8	55	33	12	2.3	0.28	39	24	10	20	7
	A	0-18	4.2	31	53	16	2.0	0.30	37	22	10	18	13
XW	Bt^2	46-56	4.1	26	49	25	2.3	0.33	39	18	10	15	18
	$2Btg_2$	80-97	3.4	28	45	27	3.0	0.39	45	21	10	15	9

[a]Sodium citrate-bicarbonate-dithionite extraction method.

[b]Interlayered vermiculite estimated from X-ray diffractogram.

[c]Remainder (primary quartz) is calculated by subtracting major components from 100%.

7.2 RESULTS

The selected soils from proposed SWSA 7 are composed of quartz and various clay minerals such as mica (illite), vermiculite, kaolinite, and smectite. Quartz was a dominant mineral of silt fractions, particularly in the diagnostic horizons (A and B) of the soils. The sand fractions had shaly fragments composed of micaceous minerals as well as coarse quartz grains. The distribution of clay fractions within soil profiles showed an accumulation of illuvial clay in the Bt horizons. Iron and aluminum oxide accumulation was also evident in the B horizons and extended to C horizons except in soil profile V.

The mineralogical analyses of the clay fraction in the A and B horizons of soil profile IV showed that vermiculite is the most abundant mineral component, and lesser amounts of mica are present (Table 8). The vermiculite contents decreased with increased mica contents within the soil profile, suggesting that the dioctahedral mica in parent sedimentary rocks was weathered to vermiculite during pedogenic processes. The X-ray diffractograms (XRD) of the Mg-saturated clay fractions showed strong 1.4-nm peaks of vermiculite, and weak 1.0-nm peaks with higher-order peaks of mica (Fig. 11). The presence of 1.4-nm peaks after K saturation and heating at 105 and 300°C suggested that large amounts of vermiculite were interlayered with Al or Fe. The intensity of 0.714- and 0.354-nm peaks after 300°C heating of K-saturated clays indicated that there were noticeable amounts of kaolinite in the clays. The amounts of smectite were too small to depict from the XRD of the clays after Mg saturation and glycerol salvation. Sharp 0.334- and 0.426-nm peaks indicated the presence of quartz as a minor component of the clay fractions.

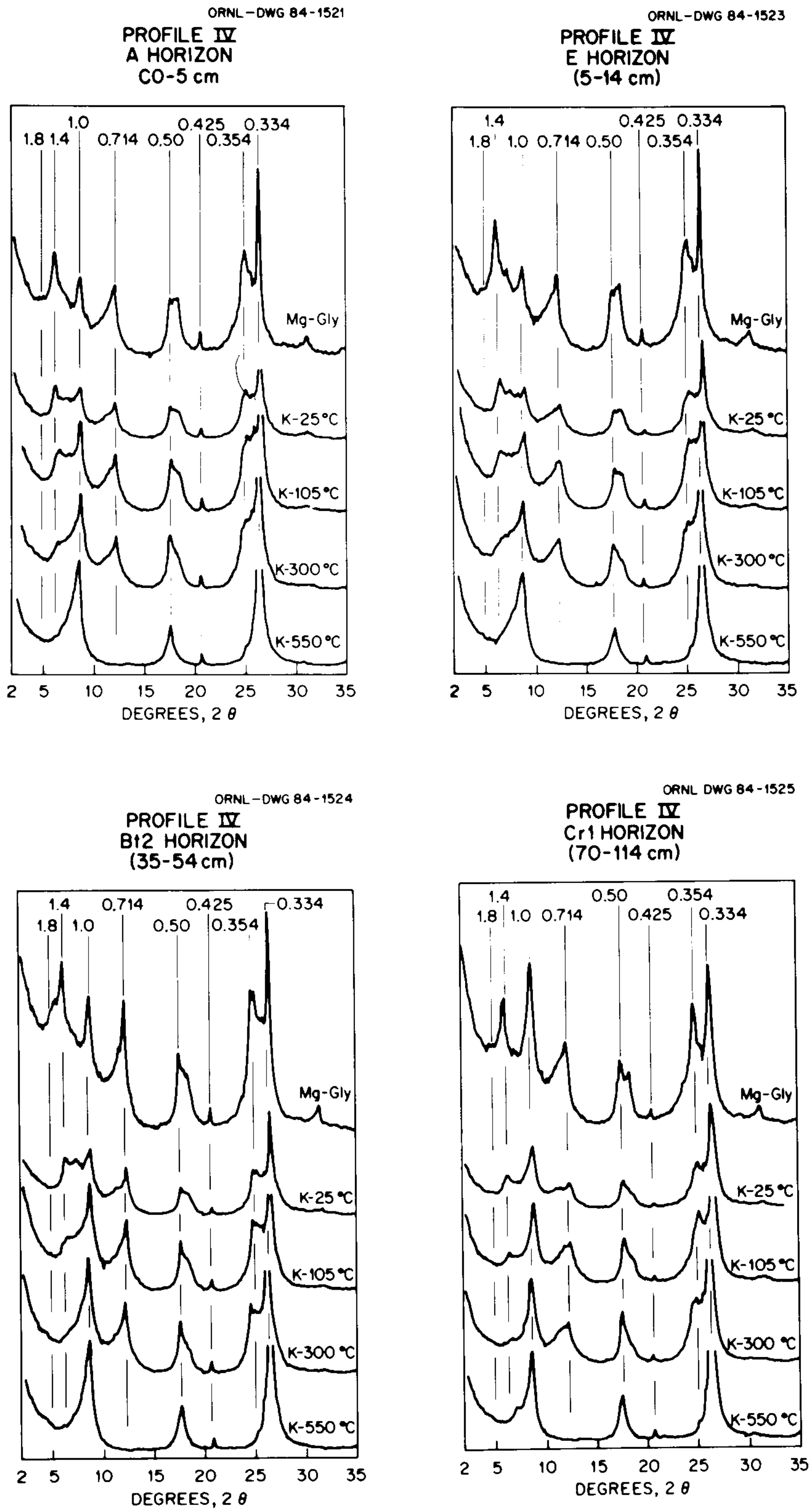

Fig. 11. X-ray diffractograms of clay fractions (2 μm) from selected horizons of soil profile IV (d spacing = nm); (a) A horizon, (b) E horizon, (c) Bt2 horizon, and (d) Cr1 horizon.

Mica was a major component of the clay fraction in soil profile V. The XRD of clay fraction after Mg saturation and glycerol salvation showed an asymmetric broadening (broadening low-angle side) 1.0-nm peak, suggesting that the mica was partially weathered (Fig. 12). A higher intensity of 1.4-nm peak (vermiculite) was observed from the XRD of the Cr horizon in comparison with the upper horizons. Eluviation and illuviation of weathered clays might cause the proportionally high vermiculite content in Cr horizon. The well-defined symmetrical 0.71- and 0.35-nm peaks with a poorly defined weak 1.4-nm peak in the XRD suggested the presence of kaolinite in the upper part of soil profile V.

Mica was the most abundant mineral in the clay fractions of the soil profiles VII (Fig. 13) and Xw, although lesser amounts of kaolinite and vermiculite were also present (Fig. 14). The amounts of kaolinite were estimated by area measurement of 550°C endothermic peaks of differential scanning calorimetric analysis (Table 8). The kaolinite appeared as highly crystalline in the XRD, but TEM could not depict appreciable amounts of the pseudohexagonal plates known to be characteristic of crystalline kaolinite (Fig. 15). The disappearance of 1.4-nm peak in the XRD of the K-saturated clays after heating at 300°C indicated the absence of chlorite mineral in the clays. Chlorite is often found in the unaltered shales from the Maryville Formation of the Conasauga Group which could be a parent rock of the soils developed in the study area. The absence of chlorite in the soils suggested that chlorite, if it were in the parent rock, might be transformed to vermiculite in the early stages of weathering. Smectite was not identified from the samples by XRD.

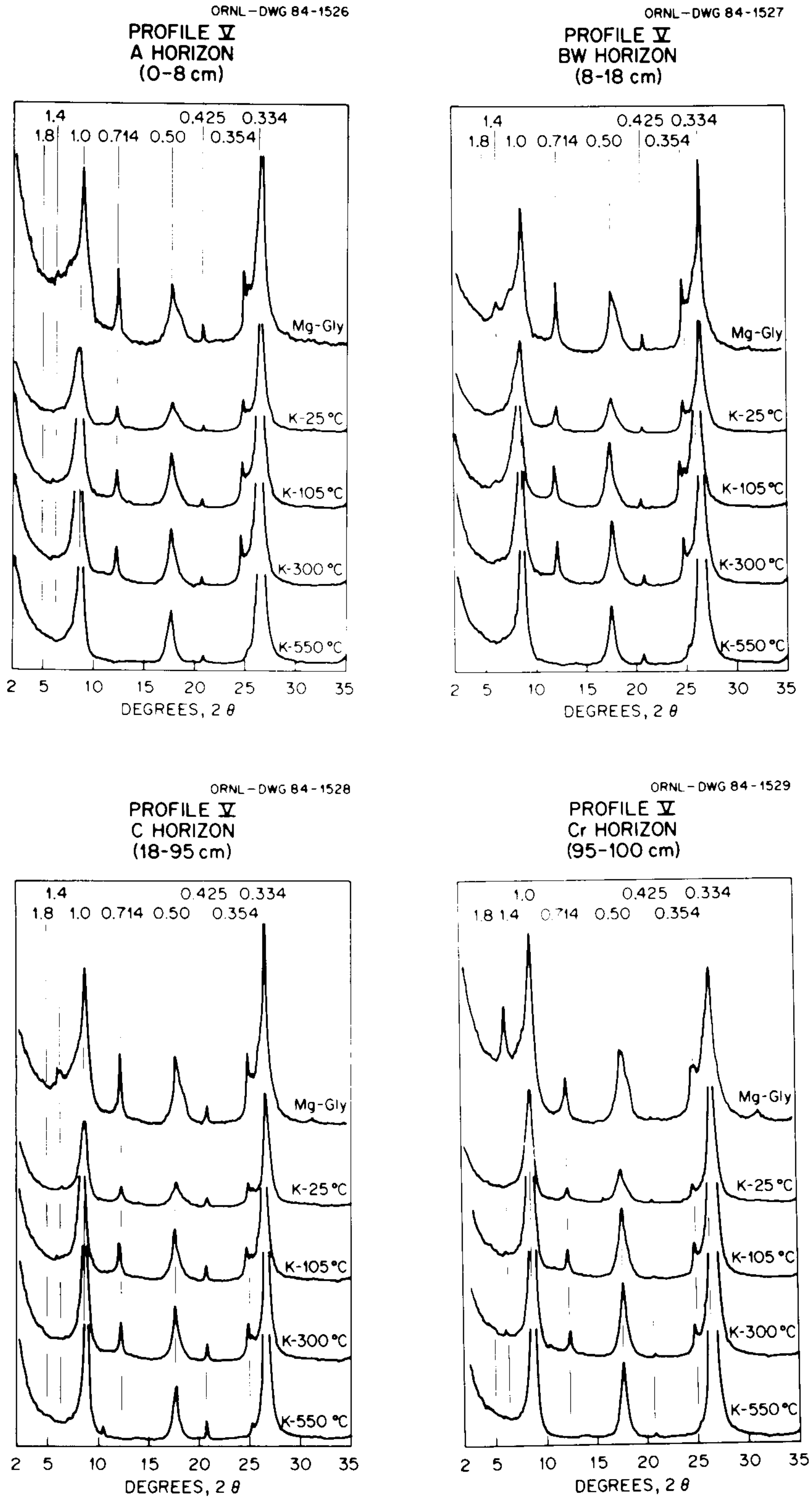

Fig. 12. X-ray diffractograms of clay fractions (2 μm) from selected horizons of soil profile V (d spacing = nm): (a) A horizon, (b) BW horizon, (c) C horizon, and (d) Cr horizon.

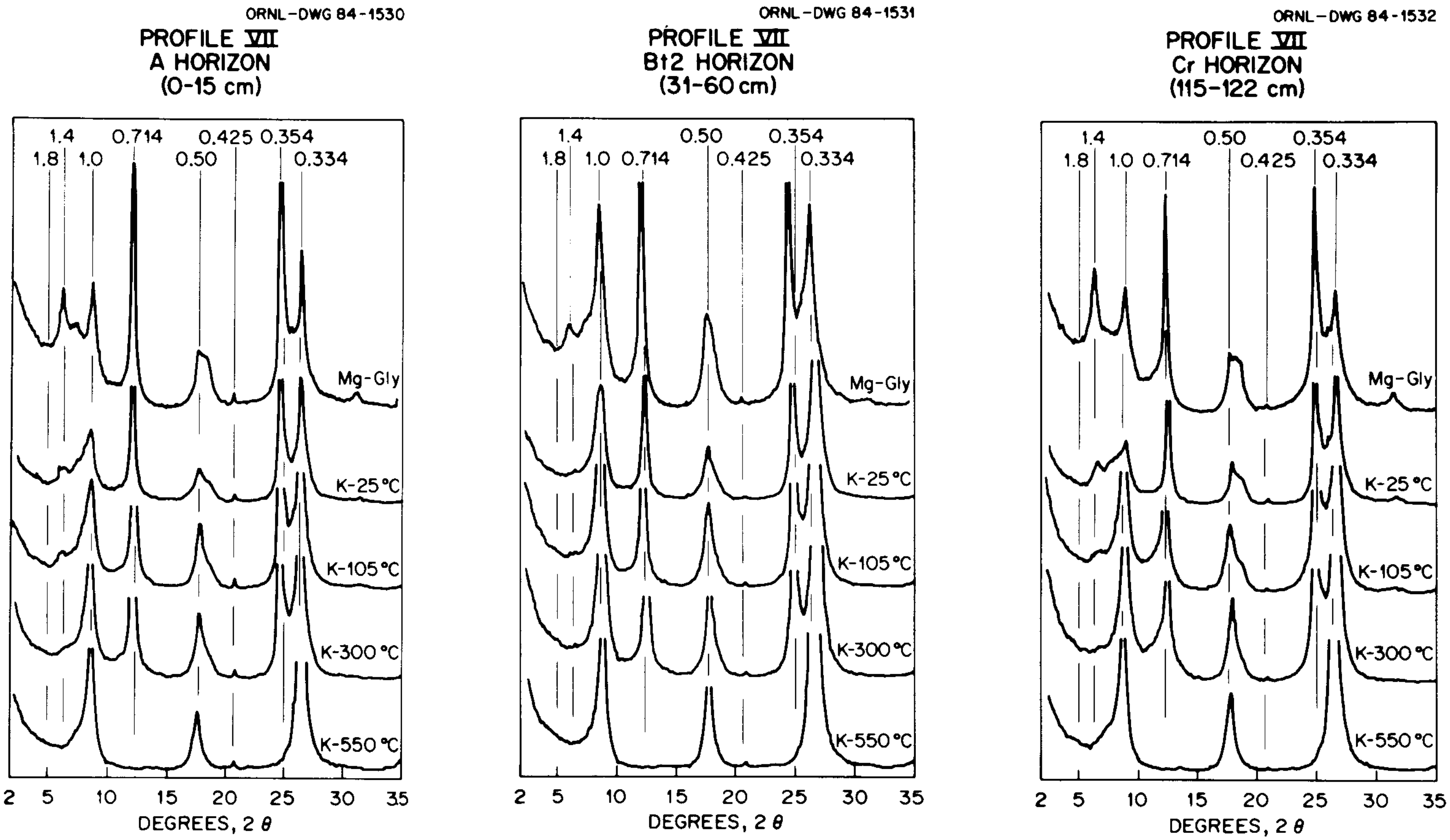

Fig. 13. X-ray diffractograms of clay fractions (2 µm) from selected horizons of soil profile VII (d spacing = nm): (a) A horizon, (b) B12 horizon, and (c) Cr horizon.

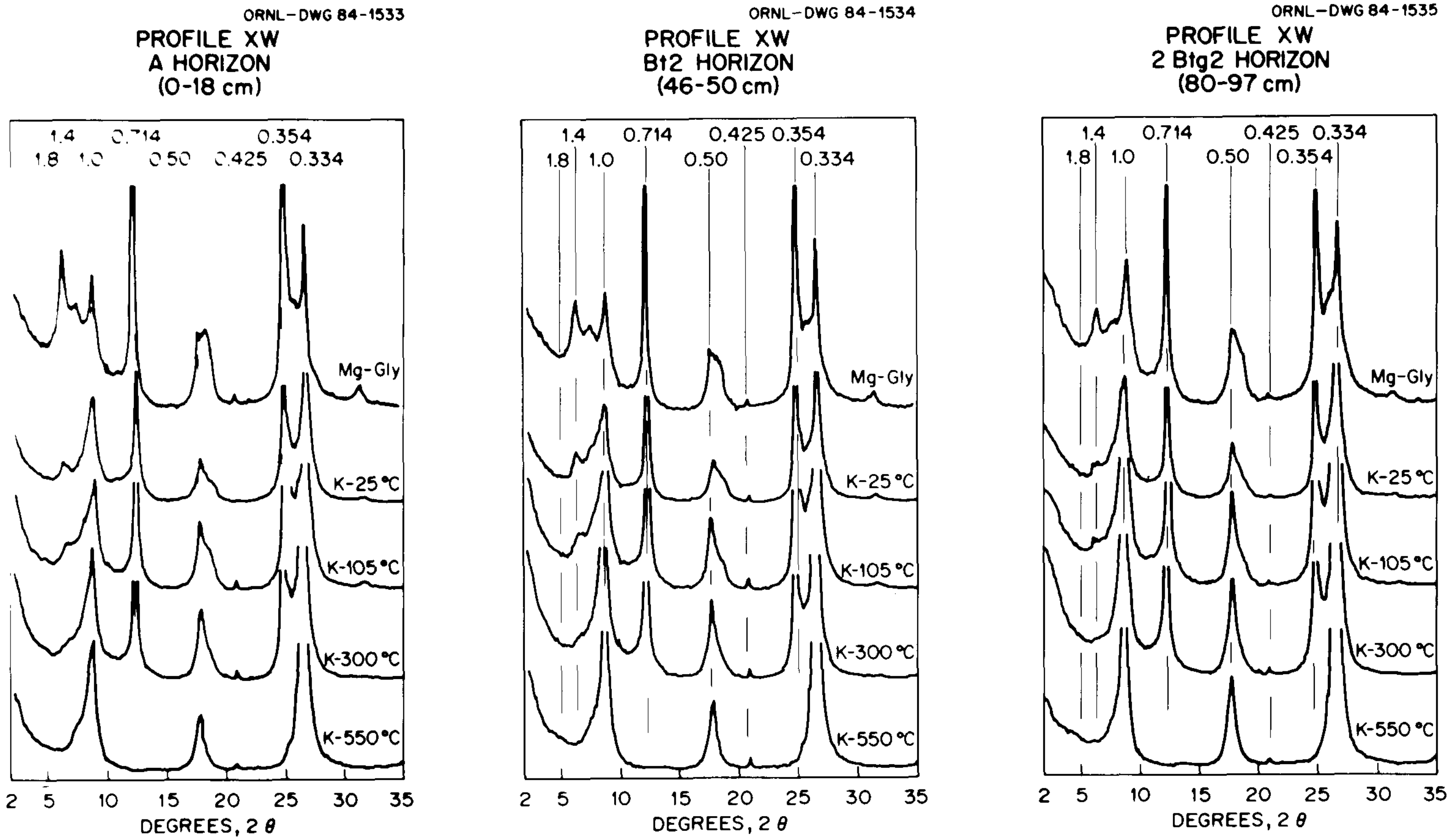

Fig. 14. X-ray diffractograms of clay fractions (2 µm) from selected horizons of soil profile Xw: (a) A horizon, (b) Bt2 horizon, and (c) 2Btg2 horizon.

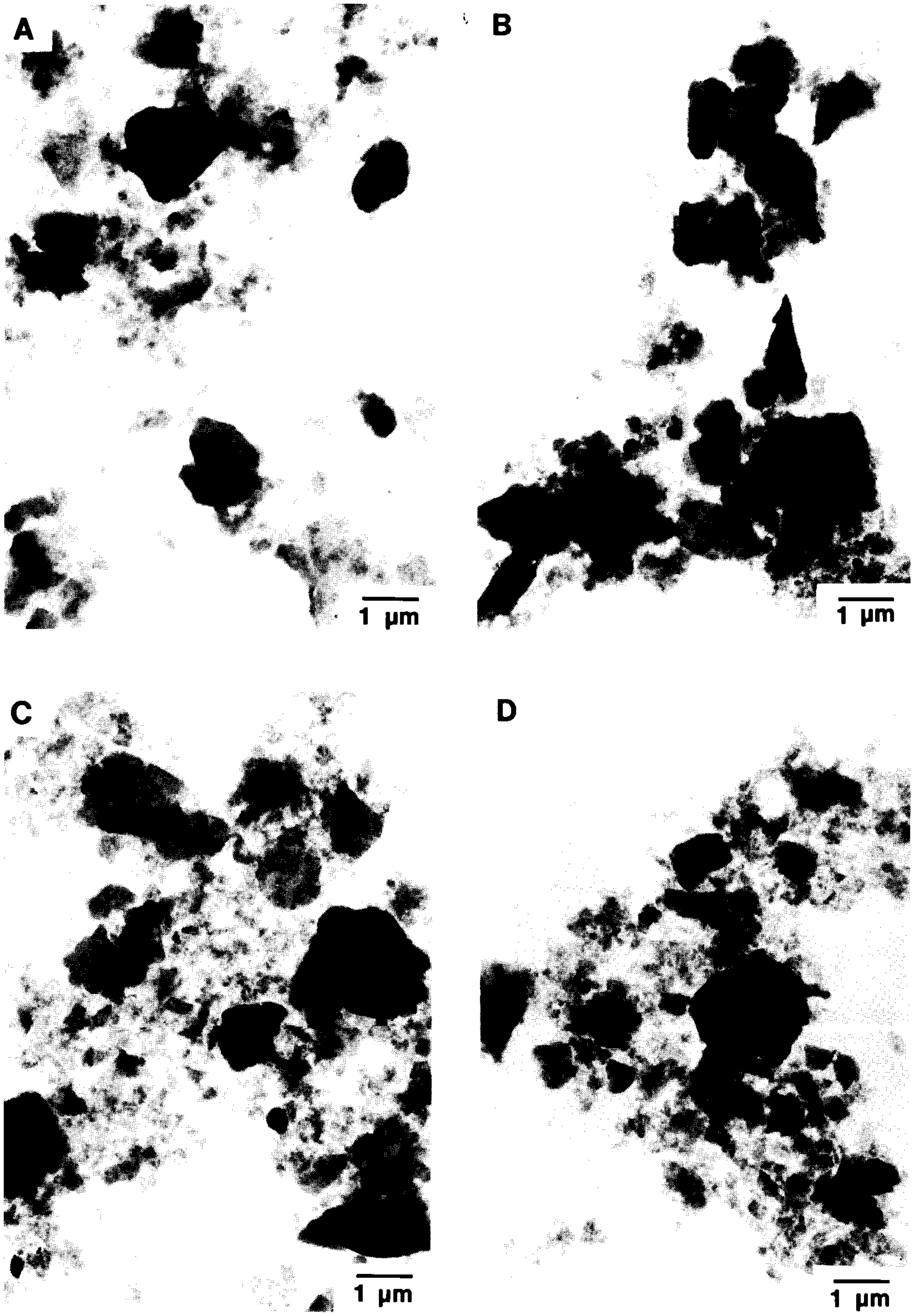

Fig. 15. Transmission electron micrographs of clay fraction (2 µm) from SWSA 7 soils: (a) profile IV (Cr horizon), (b) profile V (A horizon), (c) profile VII (Bt_2 horizon), and (d) profile Xw (Btg_2 horizon).

In summary, the mineralogical investigations show that the major clay minerals in (1) soil profile IV located in the southern part of the study area were vermiculite-rich micaceous minerals and (2) soil profile V located in the northern part of the study area were micaceous minerals with minor amounts of kaolinite. The soil profiles VII and Xw located near the profile V have both kaolinite and micaceous minerals as the major clay minerals. The XRDs indicated that considerable amounts of vermiculite in the clay fractions were interlayered with Al or Fe. Smectite was not identified from XRD patterns, although K/EC and Ca/EC results indicated its presence in minor amounts (less than 10%) in the clays. Quartz and micaceous shale fragments were the major components in the sand and silt fractions of the soils. Considerable amounts of iron and aluminum oxides were distributed in the soil profiles.

Vermiculite is the major contributor for CEC as well as Cs-fixing capacity of the soils. Strontium will also be retained on the exchange sites of the vermiculite but will not be selectively adsorbed. Amorphous and crystalline oxides will retain Sr, Co, Am, and U isotopes. On the other hand, kaolinite has relatively low sorption capacity for those isotopes. Therefore, the soils having higher kaolinite contents would have lower sorption (lower distribution coefficients) for the radionuclides in the wastes to be disposed.

8. POTENTIAL FOR EROSION

Soil erosion is a potential hazard to the long-term isolation of wastes by shallow land burial. In the extreme, the soil cover could be completely removed, exposing the waste to surface runoff. A more realistic danger might occur if the surface layer is reduced to a point at which the root zone extends into the waste area or if the hydraulic properties of the layer are degraded and internal drainage and leaching increase significantly. It follows that site selection and subsequent design and management should ensure acceptably low erosion rates. Accomplishment of this goal requires knowledge of the natural tendency of the soils to erode and the effects of management practices on erosion. As a preliminary assessment of the erosionhazard at proposed SWSA 7, standard methods from the literature were used to calculate long-term rates of erosion. These rates were compared to a recommended criterion published by the Environmental Protection Agency (USEPA 1972) for hazardous waste burial.

8.1 METHODS

At the proposed SWSA 7 site, the primary mechanism of soil erosion is surface runoff, and the main variables that affect the amount of erosion are soil erodibility, intensity and amount of rainfall, length and steepness of ground slope, vegetation cover, and erosion-control practices. Soil erodibility, the vulnerability of a soil to erosion, has been related to commonly reported physical characteristics. The Universal Soil Loss Equation (USLE) is an empirical formula that takes into account these variables to quantitatively predict the average annual rate of soil loss by sheet and rill erosion. Although originally developed to predict soil losses resulting from agricultural practices, the USLE is increasingly used to quantitatively compare erosion potential of other activities, such as surface mining and highway construction. The EPA recommends the use of the USLE as a tool in evaluating how erosion takes into account these variables for quantitatively predicting the average annual rate of soil loss by sheet erosion and potential for final cover systems for hazardous waste burial (USEPA 1980).

As reported by Schwab et al. (1981), the USLE is

$$A = 2.24\ R\ K\ L\ S\ C\ P \quad ,$$

where A = the average annual soil loss in metric tons/ha, R = rainfall, K = soil erodibility, L = slope length, S = steepness of slope, C = vegetative cover, and P = erosion-control practices. Discussion on the derivation and ranges of these factors can be found in standard manuals and texts (e.g., Hudson 1981).

Burial of waste at SWSA 7 will likely be confined to upland areas shown in the soils map (Fig. 2) as units 4, 5, and 9 and described in Appendix A as the Apison, Petros, and Calvin series, respectively. K factors below the upper 18 cm for these soils are reported by the Soil Conservation Service (pers. comm. SCS Soils Staff, Standard Soil Descriptions and Soil Interpretation Records) as 0.37 for the Apison (unit 4) and 0.15 for the Petros and Calvin (units 5 and 9). Experimentally, K factors have been found in a range between 0.02 and 0.69; the greater the index number, the more vulnerable the soil is to erosion.

The Soil Conservation Service (1981) classifies the Petros as consisting of silts, lean clays, silty sands, and clayey gravels under the Unified Soils Classification System and the Calvin as consisting of silts, lean clays, and silty and clayey gravels. The gravels consist of weathered fragments of shales and siltstones, parent materials of the soils. Well-graded soils generally exhibit a relatively low erodibility potential because they have both cohesive and intergranular strength. Conversely, loose, granular soils, especially those which are fine grained, are more highly erodible (USEPA 1972).

The K values for SWSA 7 listed herein were obtained from regional soil information. In the future, when more site-specific data are required for detailed site design, local K factors can be estimated from physical properties: percentages of silt, sand, and organic matter; soil structure; and permeability. From this information, K can be derived using the nomograph originally developed by Wischmeier et al. (1971).

The rainfall factor R is the product of the kinetic energy of rainfall events and the 30-min intensity for a particular geographic location. The USDA (1975) has published a national map of R values based on data compiled by the National Weather Service. From this map the R factor at SWSA 7 can be estimated as 200.

The upland soils at SWSA 7 have existing slopes ranging from nearly level on the summits to >60% on the steep hillsides, and slope lengths vary from <30 to >150 m. These two parameters, steepness and length of slope, have been combined into a single LS factor for the purposes of the USLE (Wischmeier 1974). The LS factors as reported by

King and Holder (1977) represent ratios of the predicted soil loss per unit area on a field slope compared to the measured loss on the basic slope of a specified length (22 m) and steepness (9%). When length of slope and steepness exceed 122 m and 24%, use of the LS factor is speculative because the listed values are extrapolated outside the range of research data. Table 9 which relates the LS factor to slope length and angle, is condensed from King and Holder (1977). Values in Table 9 include those used in the analysis for SWSA 7 described in Sect. 9.

The vegetative cover C is the ratio of the rate of soil loss associated with a particular practice (cover type) compared to the rate at which the soil would erode if the field were continuously barren and tilled. Except for a minimal amount of trail construction, SWSA 7 is currently almost 100% woodland. However, when the site is developed a vegetative cover of grassland will be established. The tabulated values of C for grasslands and woodlands of King and Holder (1977) have

Table 9. Length and steepness of slope (LS) factor

Length of slope (L) (ft)	Slope (S) (%) 5.0	10.0	20.0	60.0
18	0.41	1.0	3.0	18
30	0.54	1.4	4.2	23
61	0.76	2.1	6.3	35
122	1.0	3.2	10	54
244	1.6	4.9	14	81

been condensed in Tables 10 and 11. For the detailed information required to determine C and LS, the reader is referred to the original tables in King and Holder (1977).

The erosion control factor P is based on a percentage of the erosion to be incurred if the land were cultivated and planted up and down the slope. This factor would have its greatest influence during the transition from woodland to grassland. The P factor has been determined mainly for purposes of agriculture and surface-mine reclamation. For slopes in the range of 19 to 24% and for contour planting, P is 0.90. For contour furrows used to reclaim slopes of the same magnitude, erosion is expected to diminish and P is 0.45. There are no detailed values for this parameter directly applicable to the management of waste burial sites.

Table 10. The C factor in the USLE for grass-covered slopes[a]

Type and height of raised canopy	Canopy cover (%)	Type[b]	C factor Percent Ground Cover 60	80	95-100
No appreciable canopy	0	G	0.042	0.013	0.003
		W	0.090	0.043	0.011
Canopy of tall forbs or short brush (0.5 m fall ht.)	25	G	0.038	0.012	0.003
		W	0.082	0.041	0.011
	50	G	0.035	0.012	0.003
		W	0.075	0.039	0.011
	75	G	0.031	0.011	0.003
		W	.067	.038	.011

[a]Condensed from King and Holder (1977).

[b]G = grass, W = broadleaf weeds.

Table 11. The C factor in the USLE for woodlands[a]

Tree Canopy	Forest litter (percentage of area)	Undergrowth	C Factor
100-75	100-90	Managed	0.001
		Unmanaged	0.003-0.011
70-40	85-75	Managed	0.022-0.004
		Unmanaged	0.01 -0.04

[a]Condensed from King and Holder (1977).

8.2 RESULTS

During clearing, grubbing, and grading operations for development of proposed SWSA 7, some of the soil will be disturbed, mixed, and perhaps moved between areas, thereby incurring a change in the K factor of erodibility. The extent of such changes cannot be predicted. If it becomes desirable to know K under such conditions, physical characteristics of the soil could be determined from selected samples using the method of Wischmeier (1974). Nevertheless, because much of the soil will remain in place, and it is appropriate to employ the USLE using the two K factors reported for the three upland soil areas in which burial of waste will be confined. The equation provides a method of quantitative perception and comparison of the erosion potential of the three soil series on grassland and woodland slopes of varying steepness and length as shown in Table 12.

Annual soil-loss predictions shown in Table 12 indicate that under identical conditions of slope and other factors, the soil loss potential for the Petros and Calvin soils (soil map units 5 and 9) is less than one-half the potential of the Apison series (unit 4). Likewise, a

Table 12. Evaluation of annual soil-loss potential (A) at SWSA 7by the USLE (A = 2.24 RKLSCP)

Soil area	K	R	LS	C	P	A (metric tons/ha)
			Grass-covered, 10% slope: 122 m in length			
4	0.37	200	3.2	0.003	0.6	0.95
5 and 9	0.15	200	3.2	0.003	0.6	0.39
			Grass-covered, 20% slope: 122 m in length			
4	0.37	200	10.0	0.003	0.9	4.48
5 and 9	0.15	200	10.0	0.003	0.9	1.81
			Grass-covered, 20% slope: 61 m in length			
4	0.37	200	6.3	0.003	0.9	2.87
5 and 9	0.15	200	6.3	0.003	0.9	1.14
			Wooded, 20% slope: 122 m in length			
4	0.37	200	10.0	0.001	0.9	1.49
5 and 9	0.15	200	10.0	0.001	0.9	0.60
			Wooded, 60% slope: 30 m in length			
4	0.37	200	23.0	0.001	0.9	3.43
5 and 9	0.15	200	23.0	0.001	0.9	1.39

doubling of the steepness of slope in any of the soil series increases the erosion potential more than four times, doubling the length of slope increases the potential by approximately one and one-half times.

To minimize gully development and, therefore, the maintenance costs, EPA recommends that the maximum annual rate of erosion not exceed 4.5 metric tons/ha. As can be seen in Table 12, calculations using the USLE imply that even a 122-m-long, grass-covered slope as steep as 20% in the most erodible of the site's upland soils would meet this EPA criterion. Further, under similar conditions of slope and soil erodibility, wooded slopes at the site have only one-third the erosion potential of grass-covered slopes. Because of this and the fact that exceptionally steep slopes (65%) at the site are less than 24 m in length, even steep wooded slopes at the site meet the EPA soil-loss criterion.

Based on regional data for soil and climate and calculated by standard agricultural engineering methods, the maximum average annual erosion rate for proposed SWSA 7 is similar to the EPA-recommended level for a hazardous waste disposal site. Because this rate pertains to a small fraction of the watershed and because the other calculated rates are below the recommended level, it is concluded that soil erosion at the site can be held to acceptable levels during site development and the operational period by using of standard engineering practices. As site selection and design proceed, more reliable estimates of erosion rates can be determined from measurements of soil characteristics on-site and from local climatic records. The reliability would be further enhanced by direct measurement of soil losses on test plots within the watershed.

9. ENGINEERING CHARACTERISTICS

As part of the soils characterization of proposed SWSA 7, engineering characteristics of the earth materials (soil and saprolite) were determined for samples retrieved from six borings. These borings were made in conjunction with the installation of monitoring wells. The location of boring sites can be seen in Fig. 16. For borings B1-B4 the following data were collected: relative density (blow counts), natural moisture content, Atterberg limits, and grain size distribution. For borings B5 and B6 only relative density data were collected.

The relative density of the soil and saprolite at the site was measured by penetration tests. The standard penetration test (ASTM Spec. #D1568-67) was performed by driving a 3.6-cm (1.4-in.) ID, 5.1-cm (2-in.) OD split-barrel sampler into the undisturbed soil/saprolite by means of a 63.6-kg (140-lb) weight falling 76.2-cm (30-in.). The penetration resistance (N-values) in terms of blows per foot of penetration appears in the recorded logs of borings included in Appendix D. The borings were advanced into the soil/saprolite using augers to refusal (limit of auger penetration).

The relative density data indicate that there is great variability between borings and with depth in a single boring. Auger refusal depth varied between 3 and 10 m (10 and 30 ft), boring B5 being the deepest. The depth of auger refusal is a function of geologic variations over the site and the depth of weathering at a given location. There are too few data points to draw any conclusion on the expected density distribution over the site. Distinct horizons of more resistant

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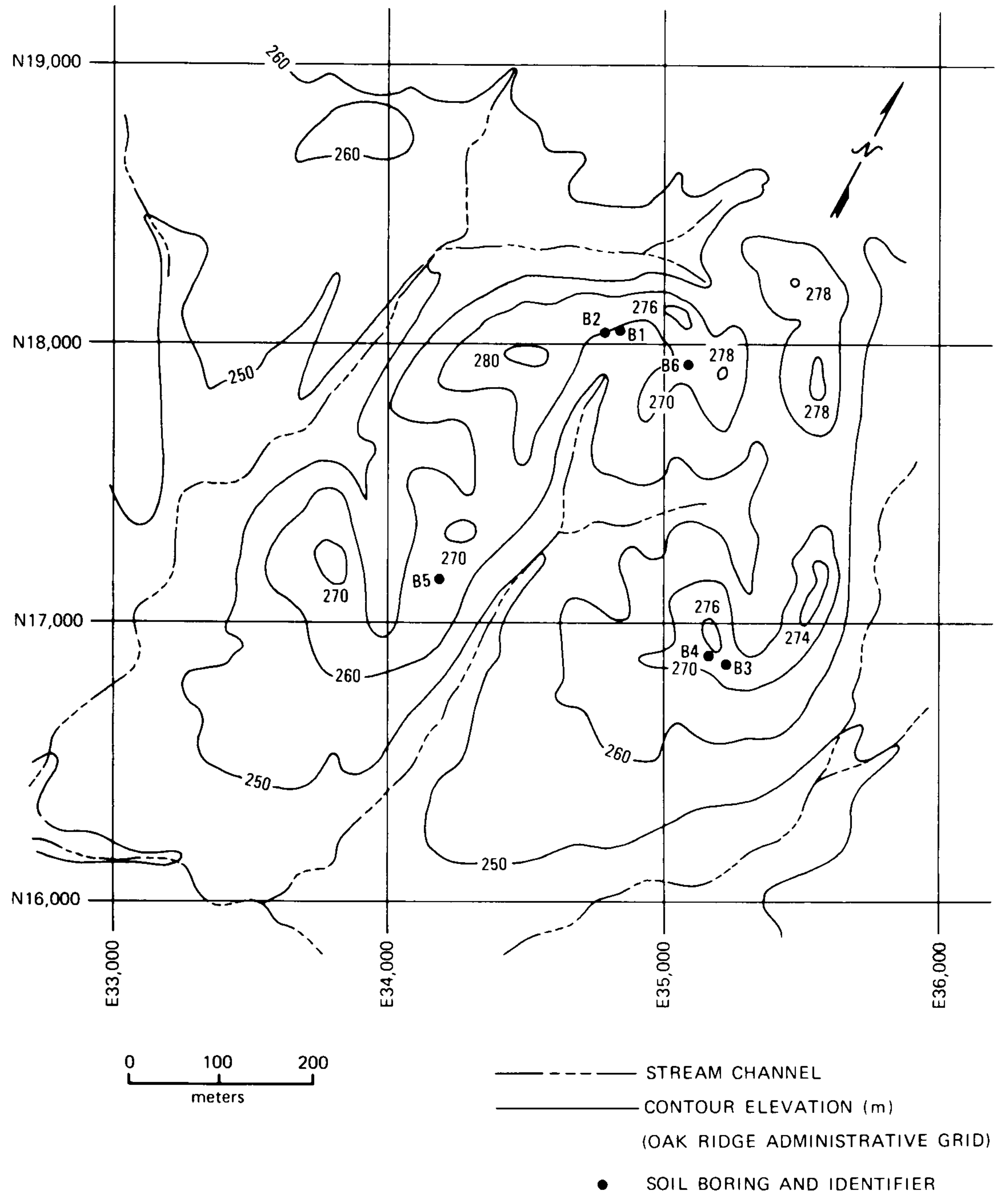

Fig. 16. Map of test sites for soil engineering properties.

material, prior to refusal, can be seen in most of the logs. Based on the N values in the logs, the materials tested can be classified as very stiff to hard (Lambe and Whitman 1969).

To determine the grain size distribution of selected soil/saprolite samples, combined sieve and hydrometer analyses were performed in accordance to ASTM specifications (ASTM D421-58 and D422-63). Results of the tests are plotted as log of particle size vs percent finer by weight. These plots are included in Appendix D. It must be kept in mind that most of the samples are from weathered rock (saprolite) and are not truly unconsolidated materials. This means that the grain size distribution is heavily influenced by the extent of weathering within a zone and how much residual cement is present.

The number of samples limits the conclusions that can be drawn, but, generally, it can be seen that the samples all contain significant percentages of both fines and sand. The silt and clay content of the samples ranges between 34 and 83%. The mean silt and clay content of the 11 samples is about 57%. The remaining coarser portion of the samples was predominantly sand-size particles, but up to 16% were gravel-size particles. Most of the samples can be described as silty clays containing particles of weathered shale or sandy silty clays.

To determine the degree of plasticity of the soil, Atterberg limit tests were performed on selected samples. The material used in these tests was the portion that passed through the U.S. Sieve No. 40. The results are shown in Table 13, along with natural moisture contents.

Table 13. Atterberg limits and moisture contents of soils from selected borings at proposed SWSA 7[a]

Boring No.	Depth of sample (ft)	Natural moisture content (%)	Liquid limit (%)	Plasticity index
1	0.5-2.5	29.5	31.2	9.8
1	2.5-4.5	24.8	34.0	7.0
1	4.5-6.3	29.0	32.3	8.2
1	6.5-6.9	15.8	32.6	10.1
1	8.5-10.5	28.2	30.8	8.2
2	1.0-3.0	28.3	32.2	8.0
2	3.0-5.0	24.8	38.6	11.5
2	5.0-7.0	29.9	31.7	12.0
2	7.0-9.0	42.5	31.8	11.8
3	1.0-3.0	20.9	33.6	14.8
3	3.0-5.0	11.9	34.2	13.1
3	5.0-6.0	9.9	33.6	12.2
3	6.0-7.0	8.5	31.7	11.0
3	7.0-7.5	8.1	30.9	10.2
3	8.0-9.3	9.7	38.6	11.8
3	10.0-12.5	9.2	42.0	21.6
4	1.0-3.0	15.3	41.1	19.0
4	3.0-3.9	12.6	31.0	9.2
4	5.0-5.2	11.3	29.9	8.7
4	7.0-7.3	11.6	28.6	7.7
4	10.0-10.2	7.8	27.9	7.6
4	15.0-15.3	11.0	29.2	7.5

[a]Material used in these tests was the portion that passed through the U.S. Sieve No. 40.

The natural water content of all samples is quite high, up to 42% by weight. The liquid limit (LL) and the plasticity index (PI) are quite low for all samples. Based on the LL and PI, the samples can be classified as CL or ML soils (Unified Soil Classification); that is, clays or silty clays with low liquid limits (Sowers 1979). A PI between 3 and 15 indicates that the soil is only slightly plastic (Sowers 1979).

The engineering data collected are qualitatively useful as an indicator of material variability on the site, both areally and vertically. Engineering characteristics are very useful in the design and construction of a proposed disposal area (e.g., slope stability of trenches or pits). The data collected are for very basic soil properties, and many engineering properties can be derived from these basic data.

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Appendix A

DETAILED MAP UNIT DESCRIPTIONS

Appendix A

DETAILED MAP UNIT DESCRIPTIONS

Map Unit No. 1*

Landform	Undulating upland summits with most slope gradients of 6 to 12% and sideslopes with similar gradients.
Slope shape	Most are convex parallel to the contour and slightly convex to straight-inclined across the contour.
Vegetation	Mostly Oak-Hickory with some Virginia Pine and some white pine, sparse understory with some dogwood.
Soils	Dominant soils classify as Typic Hapludults; fine-loamy, mixed, thermic. The soils drainage interpretation is well drained with no evidence of wetness (gray drainage mottles) above a depth of 1 m. Depth to a Cr horizon of very fine grained sandstone and siltstone is more than 1 m. The Cr horizon perches water but not long enough for much iron reduction and translocation to occur.

On either side of drainageways in this unit are soils that are less well drained or have formed in less than 50 cm of colluvium-alluvium and the underlying residuum.

Following is a limited description of a soil pedon in this map unit.

A1	0 to 5 cm	Loam
E	5 to 30 cm	Loam or silt loam
Bt1	30 to 51 cm	10 YR 5/6 clay loam or silty clay loam
2Bt2	51 to 90 cm	7.5 YR 5/6 gravelly or shaly clay loam
2Bc	90 to 103 cm	gravelly or shaly clay loam or loam with geologic rock structure
2Cr	103 cm	weathered siltstone and very fine grained sandstone

Soils on lower sideslopes show more evidence of having a discontinuity than similar soils on broader upland summit landform segments.

*Map Unit 3 of very limited extent was included in this unit.

Appendix A (continued)

Map Unit No. 2

<u>Landform</u>	Lower sideslope with slope gradients of mostly 2 to 6%.
<u>Slope shape</u>	Combination of slightly convex parallel to contour and mostly slightly concave across contour.
<u>Vegetation</u>	Mixed Oak-Hickory and tulip poplar.
<u>Soils</u>	The dominant soils classify as Aquic Hapludults: fine-loamy, mixed, thermic.

The soils in this unit are moderately well drained with evidence of impeded drainage within 1 m of the surface. Depth to a Cr horizon is usually more than 1 m. The soils in this map unit are wetter as a result of being lower on sideslopes and more subject to lateral subsurface water flow from higher areas.

Soils in this map unit boarder flood plans so there is usually more evidence of an alluvial capping over residuum.

<u>Soil Profile</u>

Ap1	0 to 15 cm	Loam
Bt1	15 to 50 cm	7.5 YR 5/4 clay loam
Bt2	50 to 74 cm	10 YR 5/6 clay loam. Peds are coated with 10 YR 5/4 plasma and there are 10 YR 5/2 reduced zones in root channels and in flow zones
Bt3	74 to 105 cm	Mottled 10 YR 5/4 and 10 YR 5/2 loam or silty clay loam

This soil profile is dominated by iron soil chemistry conditions, while some other soils in this map unit have more manganese and have different appearance. Following is limited description of such a soil.

A	0 to 11 cm	10 YR 4/3 very fine sandy loam
C	11 to 48 cm	10 YR 6/4 stratified very fine sandy loam
2Bt1	48 to 66 cm	10 YR 5/4 clay loam with a few shale fragments
2Bt2	66 to 79 cm	10 YR 6/4 clay loam with many 1 to 2 cm diam Mn concentration zones

Appendix A (continued)

2C	79 to 90 cm	very shaly loam with many black manganese nodules

Usually when Mn controls the soil chemistry, it is unusual to see much Fe reduction and segregation, but one sees instead Mn or Mn-Fe reduction and translocation to areas of concentration.

Soils of this type are usually located adjacent to flowing streams and lower in the landscape.

Appendix A (continued)

Map Unit No. 4

Landform — Upland summits and upper sideslopes. Slope gradients are mostly 6 to 18%

Slope shape — Slopes are complex. Most are slightly convex along the contour and straight inclined or slightly convex across the contour.

Vegetation — White Oak-hickory with some white pine, Virginia pine, and juniper.

Soils — The dominant soils are classified as Typic Hapludults: fine-loamy, mixed, thermic and fall mostly in the Apison Series. The soils are well drained. The Cr horizon occurs at a dept of 50 to 100 cm. The Cr horizon of siltstone is so highly fractured that it perches water only during periods of heavy rain. The cracks in the Cr horizon are close enough that clay particles are filtered out in the upper 5 to 10 cm. Below this, most fragments are coated with red or dark red iron plasma and still lower, a combination of red iron and black manganese coatings, whereas water flow zones have a gray appearance. The upper 10 to 30 cm of the soil usually shows some evidence of colluvial materials, depending on the location in the landform. The remarkable feature of the soils in this map unit is the very fiable, low-bulk density nature of the upper 30 to 50 cm. There is much evidence of ant and termite activity, which is probably the cause of the very porous nature of the upper profile. Along drainways are soils that are eroded and are less than 50 cm to a Cr horizon, whereas other soils formed in more than 50 cm of colluvium and are deeper to a Cr horizon. Some areas of this map unit are highly gullied, but most gullies are stable with the present forest vegetation.

Also included in relatively small amounts are soils derived from highly fractured and ground-up shale. These soils (No. 7) have red or yellow-red clayey subsoils that are less permeable. Also included are small areas of No. 5 soils that occur on very narrow ridgetops and finger ridges with doubly convex slope shapes.

A representative soil profile from this unit is described in detail and is included in this report (Soil Profile IV in Appendix II).

Appendix A (continued)

Map Unit No. 4s

<u>Landform</u> Steep sideslopes. Slope gradients range from 18 to more than 50%. Most delineations of this map unit are on east or northeast aspects.

<u>Slope shape</u> Doubly convex

<u>Vegetation</u> Mostly white oak-tulip poplar with some shagbark hickories, white pine, and juniper.

<u>Soils</u> Most soils in this map unit classify as Typic Hapludults; fine-loamy, mixed mesic, and within the Apison series. (Further study may reveal that these soils have higher base status and may be Ultic Hapludults). Otherwise, they are very similar to the soils of Map Unit No. 4, except for darker and thicker A horizons. Most 4s areas are on east-facing slopes.

Again, a remarkable feature is the very porous, low-bulk density upper soil profile. It appears that these soils generate very little overland runoff (there are essentially no gullied areas), and most rainfall readily percolates downward.

The Cr horizon at depths of 50 to 100 cm is highly fractured and does not perch water above it long enough for iron to be reduced and translocated.

Appendix A (continued)

Map Unit No. 5

Landform — Narrow upland summits, ridges and saddles, and upper sideslopes. Slope gradients range from small nearly level summits to very steep sideslopes, that have mostly south to west aspects.

Slope shape — Double convex

Vegetation — Juniper - especially on the high-lime areas, and Virginia pine, shortleaf pine, plus oak and hickory species on more acid areas.

Soils — Most soils in this map unit classify as Typic Dystrochrepts: loamy-skeletal; mixed mesic. Petros Series.

Most soils have a Cr horizon at 50 to 100 cm, some eroded areas less than 50 cm. The parent materials underlying this map unit are mostly siltstone with lenses and their strata of fine grained sandstone with visible mica flakes and some shale. The rock is extremely fractured.

The depth to the C horizon is usually <25 cm.

Because of the highly folded, fractured, and faulted siltstone, the heterogeneous nature of the formation, there are small areas where soils have a Bt horizon or where a thin limestone strata, 5 to 15 cm thick, has weathered to a red clay.

Most areas of this map unit have been highly eroded from past use from logging, burning, or pasturing of cattle. This map unit generates overland runoff, but considerable rainfall infiltrates it, then moves laterally downslope along the top of the Cr horizon.

A representative soil profile from this unit is described in detail and is included in this report (Soil Profile V in Appendix II).

Appendix A (continued)

Map Unit No. 6

Landform	Wet drainageways. Slope gradients range from 0 to 2%.
Slope shape	Mostly double concave.
Vegetation	Tulip Poplar, hickory, ash, sweet gum.
Soils	There are a variety of soils in this map unit. Most exhibit wetness characteristics close to or at the surface. Most areas have wet weather seeps, springs or a flowing stream of water. Parent materials for these soils are derived from surface soils eroded from the uplands, to subsoil or C horizon materials from headward cutting gullies. Major drainageways in the area are generally parallel to the geologic formations. The smaller deeply incised drainageways in the area are oriented N-S or transverse to the geologic formations. These transverse drainageways have asymmetric cross sections, possibly because of both geologic faulting and folding and modified by geomorphic processes.

Appendix A (continued)

Map Unit No. 7

Landform — Sideslopes. Slope gradients range from 6 to 18%.

Slope shape — Mostly convex.

Vegetation — Oak-Hickory with pine and some juniper.

Soils — Most soils in this map unit classify as Typic Hapludults; clayey, mixed, thermic and within the Sequoia Series. The parent materials are shale with some siltstone and fine grained sandstone. These soils are acid throughout with a pH of 5.0 to 5.5 in the Cr horizon. The Cr horizon occurs at a depth of 75 to 100 cm. However, the lower part of the Bt horizon usually perches water. This is evident from the Mn concentrations in the lower Bt. Other pedons, without MN have gray coatings on ped faces, and gleyed flow zones in the lower Bt horizon through the C horizon and into the upper Cr horizon. Soil drainage interpretation varies from well drained to moderately well drained. Drainageways that cross this unit usually have a strip of associated colluvial soils (No. 10). Also in this map unit are areas of Nos. 4, 2, and 10 soils.

A description of a representative soil is in the accompanying detailed soil profile description section.

A representative soil profile from this unit is described in detail and is included in this report (Soil Profile VII in Appendix II).

Appendix A (continued)

Map Unit No. 8

<u>Landform</u> Toeslope area between footslope and alluvial flood plain, and low terraces. Slope gradients are mostly 2 to 6%.

<u>Slope shape</u> Mostly concave across the contour.

<u>Vegetation</u> Wetness tolerant tree species. Most of this map unit was probably farmed and the vegetation is that typical of old-field succession.

<u>Soils</u> Most soils in this map unit classify as Aquic Dystrochrepts; fine-loamy. Typically there is 50 to 100 cm of yellowish brown modern alluvium over a buried soil.

<u>Note</u>: This unit was not investigated in detail.

Appendix A (continued)

Map Unit No. 9

<u>Landform</u> Steep sideslopes from just below the ridgetop to the drainageway. Slope gradients are steep, 40 to 70%.

<u>Slope shape</u> Doubly convex.

<u>Vegetation</u> Oak-Hickory.

<u>Soils</u> Most soils classify as Typic Dystrochrepts; loamy-skeletal, mixed, mesic, Calvin Series. The parent materials are mostly reddish shale with glauconitic fine-grained sandstone partings. Depth to a root restricting layer is more than 1 m. The Cr horizon is 100 to 150 cm. Within this map unit are small areas of Nos. 4, 5, and 7 soils.

Because of the highly fractured underlying rock there is no evidence within the upper 100 cm of perched water.

Appendix A (continued)

Map Unit No. 10

Landform	Slightly concave areas below steeper convex parts of the landform where sediment collects. This landform can be considered "the head of the hollow." Slope gradients are mostly 12 to 18%.
Slope shape	Concave parallel to the contour and mostly concave across contour.
Vegetation	Oak-Hickory.
Soils	Most soils in this unit classify as Typic Hypludults; fine-loamy, mixed, thermic and within the Shelocta Series. Drainage is interpreted as well drained to moderately well drained. Parent materials are 50 cm to >150 cm of colluvium overlying in-place soil residuum weathered from siltstone. The colluvium is identified by surrounded coarse fragments of more than one lithology. Following is a profile description of a rather typical soil.

A	0 to 8 cm	Dark brown (10 YR 3/3) loam
Bt1	8 to 20 cm	Brown (7.5 YR 4/4) loam
Bt2	20 to 105 cm	Strong brown (7.5 YR 5/6) light clay loam with many fine fragments

Wherever drainageways cross this unit, the soils in and adjacent are less well drained and have wetness characteristics, gray mottles, 50 to 100 cm below the surface.

Most of this map unit is a good potential source of loamy cover material that can be easily compacted. However, pits and trenches will fill with water during wet periods because of lateral subsurface water flow.

Appendix A (continued)

Map Unit #10W

<u>Landform</u> Heads of major drainageways. Several small drainageways from the uplands in this landform coalesce to form a flowing stream at the lower part. Slope gradients are 2 to about 12%.

<u>Slope shape</u> Mostly doubly concave, but with small convexities.

<u>Vegetation</u> Oak-Hickory, some tulip poplar.

<u>Soils</u> The dominant soils in this unit are classified as Aquic Hapludults; fine-loamy over clayey, mixed thermic.

Because of the coalescing drainageways and the clayey lower subsoil, water perches and flows laterally at the contact between the loamy upper subsoil and the clayey lower subsoil. The parent materials appear to be of three kinds: the underlying residuum, an old colluvium weathered to clayey textures, and the surficial younger loamy colluvium with a higher coarse fragment content.

The soils in this unit also have good potential for cover material that can be compacted and made less permeable, or for liners. The only problem in using this material is that interceptor drains will be needed to keep water out of the soil being removed, because pits and holes will fill with water most of the year.

A representative soil profile from this unit is described in detail and is included in this report (Soil Profile Xw in Appendix II).

Appendix B

SOIL PROFILE DESCRIPTIONS

Appendix B

SOIL PROFILE DESCRIPTIONS

Soil Profile IV

Location:	Map Unit No. 4, 15 m east of observation well No. 9
Vegetation:	Oak-Hickory with some white pine and red cedar
Parent materials:	Highly folded and fractured siltstone with fine grained sandstone lenses
Physiology:	Low upland sideslope
Elevation:	250.5 m
Slope:	4 to 6%
Aspect:	Southwest
Erosion:	Slight
Classification:	Typic Hapludult; fine-loamy, mixed, thermic

Soil Profile

Horizon	Depth	Description
A	0 to 5 cm	Dark brown (10 YR 3/3) silt loam; moderate fine granular structure; very friable; many fine and medium roots; very porous; 5% soft siltstone fragments; pH 4.3; abrupt wavy boundary
E	15 to 14 cm	Yellowish brown (10 YR 5/4) silt loam; moderate fine subangular blocky structure; very friable; many medium roots; very porous; 5% soft siltstone fragments; pH 4.2; clear wavy boundary
BE	14 to 23 cm	Strong brown (7.5 YR 5/6) silt loam; moderate fine subangular blocky structure; very friable; common fine roots; very porous; 5 to 10% 2-3 cm soft siltstone fragments; pH 4.2; clear wavy boundary.

Appendix B (continued)

Horizon	Depth	Description
Bt1	23 to 35 cm	Brown (7.5 YR 5/4) silty clay loam; moderate fine subangular blocky structure; very friable; thin discontinuous brown (7.5 YR 5/4) clay films on ped faces; common fine roots; very porous; 10 to 15% 2-4 cm soft siltstone fragments; pH 4.0; clear wavy boundary
Bt2	35 to 54 cm	Strong brown (7.4 YR 5/6) silty clay loam; moderate fine subangular blocky structure; very friable; thin, continuous yellowish red (5 YR 5/6) clay films on ped faces; few fine roots; 10 to 15% 2-3 cm soft siltstone fragments; very porous; pH 4.0; clear wavy boundary.
CBt	54 to 70 cm	Strong brown (7.5 YR 5/6) very shaly silty loam; massive rock structure, but with clay coatings on all fractures and joints; very friable; few fine roots; 80 to 85% soft siltstone fragments; pH 4.0; clear wavy boundary.
Cr1	70 to 114 cm	Light olive brown (2.5 Y 5/4) highly fractured soft siltstone that crushes to a very shaly loam; massive; strong brown (7.5 YR 5/6) coatings on upper sides of fragments and dark red (10 R 3/0) iron coatings on undersides; no roots; pH 3.9; clear wavy boundary.
Cr2	114 to 140 cm	Highly fractured soft light olive brown (2.5 Y 5/4) siltstone; massive; red and black stains on fragment faces.

Notes: Augered to 150 cm without auger refusal. Some clay plugs occur below depth of 70 cm. They are in vertical water flow zones and change color from brownish to grayish with increasing depths.

Appendix B (continued)

Soil Profile V

Location: Map Unit No. 5, south of observation well No. 1

Vegetation: Red cedar, oak, hickory

Parent materials: Calcareous siltstone

Physiology: Dissected upland shoulder position a few feet below a narrow rounded summit

Elevation: 274.5 m

Slope: 20%

Aspect: South

Erosion: Severe before reforestation

Classification: Typic Dystrochrept or Dystric Eutrochrept: loamy skeletal; mixed, thermic, shallow

Soil Profile

Horizon	Depth	Description
A	0 to 8 cm	Very dark grayish brown (10 YR 3/2) shaly clay loam; moderate fine granular structure; very friable; common fine roots; 35 to 50% siltstone fragments; pH 5.0; clear wavy boundary.
Bw	8 to 18 cm	Yellowish brown (10 YR 5/4) very shaly loam; weak fine subangular blocky structure with pockets of rock structure; very friable; common fine roots; 50 to 75% siltstone fragments; pH 3.9; clear wavy boundary.
C	18 to 95 cm	Light olive brown (2.5 Y 5/4) soft highly fractured siltstone; massive; complex micro folded rock structure; all fragments coated with yellowish brown (10 YR 5/4) soil material; loose after being disturbed; 90 to 95% siltstone fragments 1 to 3 cm in mean length; few fine roots; pH 4.2; clear wavy boundary.
Cr	95 to 110 cm	Highly fractured siltstone, dense in place but loose after disturbance; most fragments coated with red and black below a gray clay plugged zone which occurs in the boundary between the C and Cr. No roots; most clay plugged areas were located in micro synclynal folds; pH 4.0.

Notes: Auger refusal @ 110 cm.

Appendix B (continued)

Soil Profile VII

Location:	Map unit No. 7, shoulder of saddle between observation wells Nos. 1 and 2
Vegetation:	Virginia pine, red cedar, hickory, ash, poplar
Parent material:	Shale
Physiology:	Shoulder in a saddle between two narrow ridge crests
Elevation:	262.5 m
Slope:	40%
Aspect:	Southeast
Erosion:	Severe before reforestation
Classification:	Typic Hapludult; clayey; kaolinitic, thermic

Soil Profile

Horizon	Depth	Description
Oi	1 to 0 cm	Leaf litter from the fall.
A	0 to 15 cm	Brown (10 YR 4/3) silt loam; moderate fine granular structure; very friable; common medium and fine roots; 10% shale fragments; pH 4.0; clear wavy boundary.
Bt1	15 to 31 cm	Yellowish red (5 YR 5/6) silty clay loam; moderate medium and coarse subangular blocky structure; firm; thick continuous strong brown (7.5 YR 5/6) clay films on ped faces; few medium roots; 5 to 10% shale fragments; pH 3.9; clear wavy boundary.
Bt2	31 to 60 cm	Yellowish red (5 YR 5/8) silty clay loam; weak medium subangular blocky structure; firm; common fine faint red (2.5 YR 5/6) mottles in ped interiors; thick strong brown (7.5 YR 5/6) clay films on all ped faces; few medium roots; 5 to 10% shale fragments; pH 3.9; clear wavy boundary.

Appendix B (continued)

Horizon	Depth	Description
BCt	60 to 84 cm	Highly mottled red, yellowish brown and strong brown clay loam; weak coarse subangular blocky structure; firm; ped interiors show partial rock controlled structure and color patterns; ped faces coated with thick yellowish red (5 YR 5/6) clay films; few fine roots; 60% of volume is rock structure, but only 10 to 15% fragments; most pores and planar voids are clay plugged; pH 3.9; gradual wavy boundary.
CBt	84 to 110 cm	Very soft multicolored, highly weathered shale that easily crushes to a shaly loam; massive; friable; grayish brown (10 YR 5/2) in water flow zones and old root channels; dark red (10 R 3/6) coatings on some fragments between flow zones; few rootmats; most pores, joints and fractures are clay plugged; pH 3.9; gradual wavy boundary.
Cr	110 to 122 cm	Olive brown (2.54 4/4) weathered shale bedrock; massive; very firm; most fragments coated with gray, black or red

Notes: Auger refusal at 122 cm. Perched water on 12/22/82 in the CBt and top of the Cr horizon and drier in the Cr horizon.

Appendix B (continued)

Soil Profile Xw

Location:	Head of drainageway between observation wells Nos. 1 and 2
Vegetation:	White oak, hickory, tulip poplar, ash
Parent materials:	Colluvium from siltstone plus some shale and sandstone
Physiography:	Head of drain, footslope
Elevation:	261 m
Slope:	6 to 12%
Aspect:	South
Erosion:	None to slightly overwashed
Classification:	Aquic Hapludult; fine-loamy; mixed, thermic

Soil Profile

Horizon	Depth	Description
A	0 to 18 cm	Dark brown (10 YR 3/3) gravelly loam; moderate medium granular structure; very friable; many fine and medium roots; 15 to 20% reddish sandstone siltstone and shale fragments; pH 4.2; clear wavy boundary.
Bt1	18 to 46 cm	Dark brown (7.5 YR 4/4) gravelly loam; moderate fine subangular blocky structure; very friable; common fine and medium roots; 15 to 20% fragments of red sandstone and shale, and yellowish siltstone; pH 4.1; gradual wavy boundary.
Bt2	46 to 56 cm	Strong brown (7.5 YR 5/6) gravelly loam; moderate medium subangular blocky structure; friable; continuous but thin light yellowish brown (10 YR 6/4) clay films on all ped faces; common fine and medium roots; 15 to 20% red sandstone and shale and yellowish brown siltstone fragments; pH 4.1; gradual wavy boundary.

Appendix B (continued)

Horizon	Depth	Description
Bt3	56 to 67 cm	Yellowish red (5 YR 5/6) gravelly loam; moderate medium subangular blocky structure; firm; continuous light yellowish brown (10 YR 6/4) coatings on ped faces and pale brown (10 YR 6/3) in flow zones; few fine roots; 25 to 35% gravel and shale fragments; pH 4.0; clear wavy boundary.
2Btg4	67 to 80 cm	Red (2.5 YR 4/6) silty clay; moderate medium prismatic structure; firm; thick 1 to 5 mm grayish brown (10 YR 5/2) clay films on all ped faces and reduced zones in water flow areas; few fine roots; 10 to 15% shale siltstone fragments; pH 3.8; gradual wavy boundary.
2Btg5	80 to 97 cm	Yellowish red (5 YR 4/6) clay loam; weak coarse prismatic structure; firm; grayish brown (10 YR 5/2) and pale brown (10 YR 6/3) coatings on peds and reduced flow zones; no roots; 10 to 15% shale and siltstone fragments; pH 3.4; gradual boundary.
2Btg6	97 to 124 cm	Yellowish red (5 YR 4/6) clay loam; weak coarse prismatic soil structure; firm; pale brown (10 YR 6/3) ped coatings and grayish brown (10 YR 5/2) in reduced water flow zones; 5 to 10% shale and siltstone fragments; gradual wavy boundary.
2Btg7	124 to 153 cm	Red (2.5 YR 4/6) silty clay; weak coarse prismatic structure; firm; gray (5 Y 5/2) in water flow zones, old root channels and as coatings on prism faces; 5 to 10% shale and siltstone fragments; pH 3.6; gradual wavy boundary.
2Btg8	153 to 179 cm	Yellowish red (5 YR 5/8) gravelly silty clay loam; weak coarse prismatic structure; firm; gray (5 Y 5/1) in flow zones and as prism coatings; 15 to 25% shale, sandstone and siltstone fragments; pH 3.8; clear wavy boundary.
3 Cr	179 to 190 cm	Weathered reddish glauconitic sandstone; massive; very firm but augerable; pH 4.5.

Notes: Auger refusal at 190 cm. Soil permeability estimated as moderate to about 67 cm and slow below.

Appendix C

GUIDE TO COMPUTED HYDRAULIC CONDUCTIVITY DATA SHEETS

Appendix C

GUIDE TO COMPUTED HYDRAULIC CONDUCTIVITY DATA SHEETS

The data format and calculational procedures have been presented in detail by Luxmoore (1973), but a brief description of variables is included here to aid in understanding what is included in the tables. A tabulation of variables and their definition is presented below:

Variable Name	Description of meaning
N	Number of input pairs of water content and pressure used as the basis for calculation
TMAX	Maximum water content (volumetric) for the sample
SCON	Experimentally obtained saturated conductivity (cm/day)
FACTOR	Ratio of experimental to observed saturated conductivity
SURTEN	Surface tension of water (dynes/cm)
DENWAT	Density of water (gm/cm^3)
VISWAT	Viscosity of water at specified temperature (dyne sec/cm^2)
RESWAT	Estimated residual (immobile) water (volumetric)
TEMP	Water temperature (degrees centigrade)
EXPONENT	Factor accounting for interaction of pore classes
GRAVITY	Acceleration due to gravity (cm/sec^2)
ACF	Conversation factor that accounts for temperature and gravity influences
CLASS	Incremental pore class
PRESSURE	Soil-water pressure (suction) (cm)
THETA	Volumetric water content
CALCULATED K	Calculated conductivity using pore interaction model (cm/day)
SAT MATCH	Hydraulic conductivity scaled to match the saturation value (cm/day)

The data presentation on each output record includes a descriptive title that identifies the sample, a set of parameter values for the Green and Corey model (Green and Corey, 1971), a table of corresponding soil-water pressure (suction), moisture content, and hydraulic conductivity values (both calculated and adjusted), and finally a listing of data that were used to generate the results. These latter data come from the moisture release measurements in the laboratory, although the driest values are estimated using the model suggested by McQueen and Miller (1974).

Appendix C (continued)

SOIL TYPE 4 - SAMPLE 1 - 25 CM DEPTH - S

N = 11 TMAX = .5320 SCON = 1.440E+02 FACTOR = 2.158E+00
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	8592.0	.187	7.920E-07	1.709E-06
2	7184.0	.194	3.476E-06	7.502E-06
3	5876.5	.201	8.889E-06	1.919E-05
4	4893.6	.208	1.839E-05	3.970E-05
5	4258.2	.215	3.372E-05	7.278E-05
6	3746.2	.222	5.667E-05	1.223E-04
7	3234.2	.229	8.952E-05	1.932E-04
8	2722.2	.236	1.357E-04	2.929E-04
9	2210.2	.243	2.009E-04	4.335E-04
10	1698.2	.250	2.952E-04	6.371E-04
11	1252.0	.257	4.403E-04	9.504E-04
12	974.9	.264	6.791E-04	1.466E-03
13	838.7	.272	1.065E-03	2.299E-03
14	740.2	.279	1.648E-03	3.558E-03
15	641.6	.286	2.484E-03	5.362E-03
16	543.0	.293	3.659E-03	7.897E-03
17	444.5	.300	5.309E-03	1.146E-02
18	348.8	.307	7.678E-03	1.657E-02
19	264.4	.314	1.123E-02	2.425E-02
20	202.1	.321	1.687E-02	3.642E-02
21	162.0	.328	2.601E-02	5.614E-02
22	130.2	.335	4.052E-02	8.745E-02
23	98.6	.342	6.347E-02	1.370E-01
24	73.2	.349	1.016E-01	2.193E-01
25	60.2	.356	1.666E-01	3.597E-01
26	54.6	.363	2.698E-01	5.823E-01
27	50.0	.370	4.190E-01	9.044E-01
28	45.5	.377	6.234E-01	1.346E+00
29	41.9	.384	8.943E-01	1.930E+00
30	39.6	.391	1.244E+00	2.684E+00
31	38.0	.398	1.680E+00	3.627E+00
32	36.4	.405	2.212E+00	4.775E+00
33	34.7	.412	2.848E+00	6.146E+00
34	33.1	.419	3.597E+00	7.763E+00
35	31.5	.426	4.471E+00	9.650E+00
36	29.9	.433	5.484E+00	1.184E+01
37	28.2	.440	6.650E+00	1.435E+01
38	26.6	.448	7.989E+00	1.724E+01
39	25.0	.455	9.521E+00	2.055E+01
40	23.4	.462	1.127E+01	2.433E+01
41	21.7	.469	1.328E+01	2.866E+01
42	20.0	.476	1.557E+01	3.362E+01
43	18.2	.483	1.821E+01	3.931E+01
44	16.2	.490	2.127E+01	4.591E+01
45	14.2	.497	2.486E+01	5.365E+01
46	12.2	.504	2.913E+01	6.288E+01
47	10.2	.511	3.435E+01	7.413E+01
48	8.2	.518	4.092E+01	8.831E+01
49	5.2	.525	4.961E+01	1.071E+02
50	0.0	.532	6.671E+01	1.440E+02

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.180	10000.0
2	.205	5000.0
3	.260	1000.0
4	.310	300.0
5	.319	201.8
6	.330	152.4
7	.341	102.3
8	.350	63.2
9	.383	41.5
10	.477	19.8
11	.531	4.5

Appendix C (continued)

SOIL TYPE 4 - SAMPLE 2 - 48 CM DEPTH - S

N = 12 TMAX = .5000 SCON = 1.440E+02 FACTOR = 2.512E+00
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	9056.7	.223	4.729E-07	1.188E-06
2	8113.3	.228	2.001E-06	5.026E-06
3	7170.0	.234	4.848E-06	1.218E-05
4	6226.7	.240	9.386E-06	2.357E-05
5	5388.3	.245	1.618E-05	4.063E-05
6	4805.1	.251	2.597E-05	6.522E-05
7	4417.0	.257	3.950E-05	9.921E-05
8	4073.9	.262	5.746E-05	1.443E-04
9	3730.9	.268	8.061E-05	2.025E-04
10	3387.9	.274	1.100E-04	2.762E-04
11	3044.8	.279	1.469E-04	3.689E-04
12	2701.8	.285	1.931E-04	4.851E-04
13	2358.8	.291	2.513E-04	6.311E-04
14	2015.8	.296	3.251E-04	8.166E-04
15	1672.7	.302	4.206E-04	1.056E-03
16	1332.3	.308	5.477E-04	1.376E-03
17	1062.7	.313	7.256E-04	1.822E-03
18	926.6	.319	9.816E-04	2.465E-03
19	855.9	.325	1.338E-03	3.361E-03
20	785.2	.330	1.812E-03	4.552E-03
21	714.5	.336	2.427E-03	6.095E-03
22	643.8	.342	3.211E-03	8.064E-03
23	573.1	.347	4.204E-03	1.056E-02
24	502.4	.353	5.461E-03	1.372E-02
25	431.7	.359	7.064E-03	1.774E-02
26	360.1	.364	9.137E-03	2.295E-02
27	290.1	.370	1.189E-02	2.987E-02
28	230.3	.375	1.571E-02	3.946E-02
29	182.4	.381	2.121E-02	5.328E-02
30	139.1	.387	2.941E-02	7.386E-02
31	98.2	.392	4.237E-02	1.064E-01
32	66.8	.398	6.538E-02	1.642E-01
33	50.2	.404	1.095E-01	2.751E-01
34	41.9	.409	1.888E-01	4.742E-01
35	36.1	.415	3.181E-01	7.989E-01
36	31.6	.421	5.140E-01	1.291E+00
37	27.1	.426	7.972E-01	2.002E+00
38	23.0	.432	1.200E+00	3.015E+00
39	20.2	.438	1.768E+00	4.441E+00
40	18.3	.443	2.549E+00	6.403E+00
41	16.6	.449	3.589E+00	9.014E+00
42	15.0	.455	4.941E+00	1.241E+01
43	13.4	.460	6.678E+00	1.677E+01
44	11.7	.466	8.901E+00	2.236E+01
45	10.1	.472	1.176E+01	2.953E+01
46	8.4	.477	1.548E+01	3.887E+01
47	6.8	.483	2.043E+01	5.132E+01
48	5.4	.489	2.732E+01	6.862E+01
49	3.6	.494	3.723E+01	9.351E+01
50	0.0	.500	5.733E+01	1.440E+02

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.217	10000.0
2	.247	5000.0
3	.313	1000.0
4	.369	300.5
5	.372	250.5
6	.379	200.8
7	.385	150.8
8	.392	101.0
9	.397	61.8
10	.409	41.0
11	.434	21.0
12	.491	4.5

Appendix C (continued)

SOIL TYPE 4 - SAMPLE 3 - 43 CM DEPTH - S

N = 12 TMAX = .3660 SCON = 1.440E+02 FACTOR = 2.137E+01
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	9236.0	.179	1.745E-07	3.730E-06
2	8472.0	.183	7.294E-07	1.559E-05
3	7708.0	.186	1.737E-06	3.712E-05
4	6944.0	.190	3.292E-06	7.035E-05
5	6180.0	.194	5.522E-06	1.180E-04
6	5470.8	.198	8.607E-06	1.840E-04
7	4936.6	.202	1.278E-05	2.732E-04
8	4588.1	.206	1.829E-05	3.909E-04
9	4305.2	.209	2.534E-05	5.415E-04
10	4022.2	.213	3.413E-05	7.295E-04
11	3739.3	.217	4.492E-05	9.602E-04
12	3456.3	.221	5.804E-05	1.241E-03
13	3173.3	.225	7.387E-05	1.579E-03
14	2890.4	.228	9.292E-05	1.986E-03
15	2607.4	.232	1.159E-04	2.477E-03
16	2324.4	.236	1.436E-04	3.070E-03
17	2041.5	.240	1.774E-04	3.792E-03
18	1758.5	.244	2.190E-04	4.682E-03
19	1475.6	.248	2.713E-04	5.799E-03
20	1209.4	.251	3.388E-04	7.242E-03
21	1012.8	.255	4.291E-04	9.173E-03
22	904.7	.259	5.514E-04	1.179E-02
23	832.5	.263	7.133E-04	1.525E-02
24	760.3	.267	9.220E-04	1.971E-02
25	688.1	.270	1.187E-03	2.537E-02
26	615.8	.274	1.521E-03	3.250E-02
27	543.6	.278	1.940E-03	4.148E-02
28	471.4	.282	2.471E-03	5.281E-02
29	399.2	.286	3.149E-03	6.731E-02
30	330.8	.290	4.035E-03	8.625E-02
31	272.6	.293	5.224E-03	1.117E-01
32	217.0	.297	6.860E-03	1.466E-01
33	165.8	.301	9.221E-03	1.971E-01
34	136.9	.305	1.282E-02	2.740E-01
35	122.3	.309	1.815E-02	3.880E-01
36	106.5	.313	2.566E-02	5.486E-01
37	87.5	.316	3.608E-02	7.712E-01
38	69.4	.320	5.089E-02	1.088E+00
39	58.3	.324	7.267E-02	1.553E+00
40	52.7	.328	1.040E-01	2.223E+00
41	48.1	.332	1.471E-01	3.143E+00
42	43.3	.335	2.042E-01	4.364E+00
43	38.4	.339	2.786E-01	5.956E+00
44	33.2	.343	3.754E-01	8.023E+00
45	28.0	.347	5.019E-01	1.073E+01
46	22.3	.351	6.709E-01	1.434E+01
47	15.5	.355	9.084E-01	1.942E+01
48	9.0	.358	1.305E+00	2.789E+01
49	4.2	.362	2.236E+00	4.780E+01
50	0.0	.366	6.737E+00	1.440E+02

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.175	10000.0
2	.200	5000.0
3	.254	1000.0
4	.291	300.5
5	.295	250.4
6	.299	201.7
7	.301	151.8
8	.314	102.0
9	.321	61.0
10	.337	41.5
11	.352	21.0
12	.360	4.5

Appendix C (continued)

SOIL TYPE 4 - SAMPLE 4 - 100 CM DEPTH -

N = 12 TMAX = .4050 SCON = 1.440E+02 FACTOR = 3.047E+01
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	9026.1	.185	2.634E-07	8.024E-06
2	8052.2	.190	1.117E-06	3.403E-05
3	7078.3	.194	2.714E-06	8.269E-05
4	6104.3	.199	5.276E-06	1.607E-04
5	5273.2	.203	9.143E-06	2.785E-04
6	4749.8	.208	1.475E-05	4.492E-04
7	4413.3	.212	2.247E-05	6.846E-04
8	4098.9	.217	3.265E-05	9.948E-04
9	3784.6	.221	4.568E-05	1.392E-03
10	3470.2	.226	6.206E-05	1.891E-03
11	3155.8	.230	8.242E-05	2.511E-03
12	2841.4	.235	1.076E-04	3.278E-03
13	2527.0	.239	1.388E-04	4.227E-03
14	2212.6	.244	1.774E-04	5.406E-03
15	1898.2	.248	2.260E-04	6.886E-03
16	1583.9	.253	2.881E-04	8.778E-03
17	1277.8	.257	3.698E-04	1.127E-02
18	1038.7	.262	4.819E-04	1.468E-02
19	908.1	.266	6.391E-04	1.947E-02
20	827.7	.271	8.546E-04	2.603E-02
21	747.3	.275	1.140E-03	3.473E-02
22	666.9	.280	1.512E-03	4.606E-02
23	586.5	.284	1.992E-03	6.068E-02
24	506.1	.289	2.612E-03	7.959E-02
25	425.6	.293	3.423E-03	1.043E-01
26	351.0	.297	4.503E-03	1.372E-01
27	295.1	.302	5.982E-03	1.823E-01
28	259.7	.306	8.017E-03	2.443E-01
29	231.7	.311	1.077E-02	3.280E-01
30	204.5	.315	1.441E-02	4.390E-01
31	178.8	.320	1.921E-02	5.853E-01
32	154.5	.324	2.552E-02	7.776E-01
33	131.6	.329	3.387E-02	1.032E+00
34	108.7	.333	4.503E-02	1.372E+00
35	84.8	.338	6.036E-02	1.839E+00
36	64.8	.342	8.276E-02	2.521E+00
37	54.1	.347	1.170E-01	3.565E+00
38	48.1	.351	1.677E-01	5.110E+00
39	42.7	.356	2.393E-01	7.291E+00
40	39.0	.360	3.373E-01	1.027E+01
41	36.6	.365	4.666E-01	1.422E+01
42	34.4	.369	6.317E-01	1.924E+01
43	32.3	.374	8.371E-01	2.550E+01
44	30.1	.378	1.088E+00	3.316E+01
45	27.9	.383	1.393E+00	4.243E+01
46	25.8	.387	1.758E+00	5.356E+01
47	23.6	.392	2.195E+00	6.690E+01
48	19.7	.396	2.720E+00	8.285E+01
49	11.6	.401	3.373E+00	1.028E+02
50	0.0	.405	4.727E+00	1.440E+02

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.181	10000.0
2	.204	5000.0
3	.261	1000.0
4	.300	300.0
5	.308	250.0
6	.316	200.0
7	.325	150.5
8	.335	101.0
9	.342	60.5
10	.357	40.3
11	.398	20.5
12	.403	4.5

Appendix C (continued)

SOIL TYPE 4 - SAMPLE 5 - 150 CM DEPTH -

N = 12 TMAX = .4340 SCON = 1.440E+02 FACTOR = 7.670E+01
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	9177.8	.216	2.659E-07	2.040E-05
2	8355.6	.221	1.116E-06	8.559E-05
3	7533.3	.225	2.671E-06	2.049E-04
4	6711.1	.230	5.096E-06	3.909E-04
5	5888.9	.234	8.619E-06	6.611E-04
6	5190.8	.239	1.357E-05	1.041E-03
7	4751.9	.243	2.036E-05	1.562E-03
8	4459.0	.248	2.932E-05	2.249E-03
9	4177.1	.252	4.074E-05	3.125E-03
10	3895.2	.256	5.498E-05	4.217E-03
11	3613.3	.261	7.245E-05	5.557E-03
12	3331.4	.265	9.368E-05	7.186E-03
13	3049.5	.270	1.193E-04	9.154E-03
14	2767.6	.274	1.503E-04	1.153E-02
15	2485.7	.279	1.877E-04	1.440E-02
16	2203.8	.283	2.331E-04	1.788E-02
17	1921.9	.287	2.887E-04	2.214E-02
18	1640.0	.292	3.577E-04	2.743E-02
19	1358.1	.296	4.453E-04	3.416E-02
20	1115.3	.301	5.603E-04	4.298E-02
21	965.2	.305	7.156E-04	5.489E-02
22	883.2	.310	9.238E-04	7.086E-02
23	815.6	.314	1.195E-03	9.166E-02
24	748.1	.319	1.540E-03	1.181E-01
25	680.6	.323	1.973E-03	1.513E-01
26	613.0	.327	2.512E-03	1.927E-01
27	545.5	.332	3.183E-03	2.441E-01
28	478.0	.336	4.020E-03	3.083E-01
29	410.4	.341	5.074E-03	3.892E-01
30	346.5	.345	6.424E-03	4.928E-01
31	296.2	.350	8.191E-03	6.283E-01
32	262.5	.354	1.052E-02	8.072E-01
33	236.4	.359	1.357E-02	1.041E+00
34	211.3	.363	1.750E-02	1.342E+00
35	186.7	.367	2.254E-02	1.729E+00
36	162.8	.372	2.900E-02	2.224E+00
37	141.5	.376	3.733E-02	2.863E+00
38	122.6	.381	4.813E-02	3.692E+00
39	103.5	.385	6.225E-02	4.775E+00
40	82.4	.390	8.107E-02	6.218E+00
41	63.9	.394	1.075E-01	8.245E+00
42	53.2	.398	1.464E-01	1.123E+01
43	46.5	.403	2.027E-01	1.555E+01
44	40.7	.407	2.820E-01	2.163E+01
45	36.4	.412	3.911E-01	3.000E+01
46	32.8	.416	5.374E-01	4.122E+01
47	29.2	.421	7.296E-01	5.596E+01
48	25.6	.425	9.798E-01	7.515E+01
49	17.4	.430	1.306E+00	1.002E+02
50	0.0	.434	1.877E+00	1.440E+02

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.212	10000.0
2	.239	5000.0
3	.302	1000.0
4	.348	300.3
5	.356	250.0
6	.365	200.0
7	.374	150.0
8	.386	101.0
9	.394	60.0
10	.407	40.3
11	.432	20.0
12	.433	4.5

Appendix C (continued)

SOIL TYPE 5 - SAMPLE 6 - 16 CM DEPTH - S

N = 12 TMAX = .4300 SCON = 3.370E+00 FACTOR = 3.209E-01
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	8921.7	.187	3.390E-07	1.088E-07
2	7843.5	.192	1.449E-06	4.649E-07
3	6765.2	.197	3.559E-06	1.142E-06
4	5750.8	.202	7.021E-06	2.253E-06
5	4976.3	.207	1.236E-05	3.965E-06
6	4489.8	.212	2.017E-05	6.471E-06
7	4115.5	.217	3.101E-05	9.949E-06
8	3741.1	.222	4.545E-05	1.458E-05
9	3366.8	.227	6.426E-05	2.062E-05
10	2992.5	.232	8.848E-05	2.839E-05
11	2618.1	.237	1.196E-04	3.836E-05
12	2243.8	.242	1.596E-04	5.122E-05
13	1869.4	.246	2.120E-04	6.802E-05
14	1495.1	.251	2.823E-04	9.057E-05
15	1170.2	.256	3.810E-04	1.222E-04
16	967.5	.261	5.259E-04	1.688E-04
17	861.3	.266	7.366E-04	2.363E-04
18	778.7	.271	1.030E-03	3.304E-04
19	696.0	.276	1.424E-03	4.568E-04
20	613.3	.281	1.944E-03	6.238E-04
21	530.7	.286	2.628E-03	8.433E-04
22	448.0	.291	3.532E-03	1.133E-03
23	366.4	.296	4.746E-03	1.523E-03
24	294.3	.301	6.428E-03	2.063E-03
25	242.3	.306	8.836E-03	2.835E-03
26	203.0	.311	1.230E-02	3.947E-03
27	163.7	.316	1.728E-02	5.544E-03
28	127.8	.321	2.462E-02	7.901E-03
29	101.1	.326	3.586E-02	1.151E-02
30	82.6	.331	5.326E-02	1.709E-02
31	69.0	.336	7.976E-02	2.559E-02
32	59.6	.341	1.193E-01	3.828E-02
33	54.1	.346	1.761E-01	5.651E-02
34	49.8	.351	2.538E-01	8.143E-02
35	45.5	.356	3.561E-01	1.142E-01
36	41.7	.361	4.878E-01	1.565E-01
37	39.0	.366	6.546E-01	2.101E-01
38	37.1	.370	8.615E-01	2.764E-01
39	35.4	.375	1.113E+00	3.570E-01
40	33.7	.380	1.412E+00	4.532E-01
41	31.9	.385	1.766E+00	5.665E-01
42	30.2	.390	2.179E+00	6.991E-01
43	28.5	.395	2.658E+00	8.529E-01
44	26.8	.400	3.212E+00	1.031E+00
45	25.1	.405	3.851E+00	1.236E+00
46	23.4	.410	4.587E+00	1.472E+00
47	21.6	.415	5.434E+00	1.744E+00
48	17.5	.420	6.411E+00	2.057E+00
49	9.4	.425	7.606E+00	2.441E+00
50	0.0	.430	1.050E+01	3.370E+00

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.182	10000.0
2	.205	5000.0
3	.258	1000.0
4	.300	300.0
5	.304	250.3
6	.312	200.0
7	.317	150.4
8	.325	100.3
9	.338	60.7
10	.362	40.0
11	.420	20.0
12	.427	4.5

Appendix C (continued)

SOIL TYPE 5 - SAMPLE 7 - 36 CM DEPTH - S

N = 12 TMAX = .3430 SCON = 3.370E+00 FACTOR = 2.758E-01
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	8823.5	.147	1.898E-07	5.235E-08
2	7647.1	.151	8.175E-07	2.254E-07
3	6470.6	.155	2.031E-06	5.600E-07
4	5446.5	.159	4.067E-06	1.122E-06
5	4778.1	.163	7.260E-06	2.002E-06
6	4363.6	.167	1.194E-05	3.292E-06
7	4000.0	.171	1.839E-05	5.071E-06
8	3636.4	.175	2.695E-05	7.433E-06
9	3272.7	.179	3.808E-05	1.050E-05
10	2909.1	.183	5.238E-05	1.445E-05
11	2545.5	.187	7.070E-05	1.950E-05
12	2181.8	.191	9.430E-05	2.600E-05
13	1818.2	.195	1.251E-04	3.450E-05
14	1454.5	.199	1.664E-04	4.588E-05
15	1143.7	.203	2.243E-04	6.187E-05
16	955.9	.207	3.090E-04	8.522E-05
17	856.0	.211	4.309E-04	1.188E-04
18	773.8	.215	5.990E-04	1.652E-04
19	691.5	.219	8.238E-04	2.272E-04
20	609.3	.223	1.120E-03	3.088E-04
21	527.0	.227	1.507E-03	4.157E-04
22	444.8	.231	2.018E-03	5.566E-04
23	363.4	.235	2.704E-03	7.456E-04
24	290.2	.239	3.654E-03	1.008E-03
25	233.8	.243	5.018E-03	1.384E-03
26	190.5	.247	7.018E-03	1.935E-03
27	152.3	.251	9.974E-03	2.751E-03
28	119.0	.255	1.445E-02	3.983E-03
29	92.5	.259	2.141E-02	5.903E-03
30	72.8	.263	3.249E-02	8.958E-03
31	59.6	.267	5.016E-02	1.383E-02
32	51.0	.271	7.751E-02	2.138E-02
33	44.7	.275	1.180E-01	3.254E-02
34	40.4	.279	1.755E-01	4.840E-02
35	38.2	.283	2.537E-01	6.996E-02
36	36.6	.287	3.550E-01	9.790E-02
37	35.1	.291	4.814E-01	1.328E-01
38	33.5	.295	6.352E-01	1.752E-01
39	32.0	.299	8.189E-01	2.258E-01
40	30.4	.303	1.036E+00	2.856E-01
41	28.9	.307	1.289E+00	3.553E-01
42	27.3	.311	1.582E+00	4.362E-01
43	25.8	.315	1.920E+00	5.296E-01
44	24.3	.319	2.309E+00	6.369E-01
45	22.7	.323	2.756E+00	7.600E-01
46	20.5	.327	3.268E+00	9.011E-01
47	14.9	.331	3.861E+00	1.065E+00
48	7.6	.335	4.648E+00	1.282E+00
49	3.4	.339	6.402E+00	1.765E+00
50	0.0	.343	1.222E+01	3.370E+00

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.143	10000.0
2	.160	5000.0
3	.204	1000.0
4	.238	300.8
5	.241	250.4
6	.246	200.3
7	.251	150.8
8	.257	100.5
9	.265	61.5
10	.277	40.5
11	.330	20.0
12	.335	4.5

Appendix C (continued)

SOIL TYPE 5 - SAMPLE 8 - 66 CM DEPTH - S

N = 12 TMAX = .3650 SCON = 3.370E+00 FACTOR = 5.881E-01
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	9100.0	.162	2.074E-07	1.220E-07
2	8200.0	.166	8.752E-07	5.147E-07
3	7300.0	.170	2.111E-06	1.241E-06
4	6400.0	.175	4.065E-06	2.391E-06
5	5562.4	.179	6.956E-06	4.091E-06
6	4927.9	.183	1.109E-05	6.521E-06
7	4511.8	.187	1.679E-05	9.875E-06
8	4173.9	.191	2.436E-05	1.433E-05
9	3835.9	.195	3.411E-05	2.006E-05
10	3498.0	.199	4.645E-05	2.732E-05
11	3160.0	.204	6.190E-05	3.641E-05
12	2822.0	.208	8.118E-05	4.774E-05
13	2484.1	.212	1.053E-04	6.190E-05
14	2146.1	.216	1.356E-04	7.972E-05
15	1808.2	.220	1.742E-04	1.025E-04
16	1470.2	.224	2.248E-04	1.322E-04
17	1171.1	.228	2.935E-04	1.726E-04
18	974.6	.233	3.909E-04	2.299E-04
19	866.8	.237	5.287E-04	3.110E-04
20	784.1	.241	7.172E-04	4.218E-04
21	701.3	.245	9.678E-04	5.692E-04
22	618.5	.249	1.296E-03	7.623E-04
23	535.7	.253	1.725E-03	1.014E-03
24	453.0	.257	2.287E-03	1.345E-03
25	371.8	.262	3.039E-03	1.788E-03
26	302.5	.266	4.075E-03	2.396E-03
27	249.8	.270	5.535E-03	3.256E-03
28	206.3	.274	7.619E-03	4.481E-03
29	171.4	.278	1.062E-02	6.244E-03
30	143.2	.282	1.493E-02	8.782E-03
31	117.6	.286	2.114E-02	1.243E-02
32	95.4	.290	3.018E-02	1.775E-02
33	77.2	.295	4.351E-02	2.559E-02
34	63.5	.299	6.341E-02	3.729E-02
35	54.8	.303	9.290E-02	5.464E-02
36	48.3	.307	1.351E-01	7.947E-02
37	42.7	.311	1.938E-01	1.140E-01
38	39.1	.315	2.734E-01	1.608E-01
39	36.9	.319	3.778E-01	2.222E-01
40	35.0	.324	5.100E-01	2.999E-01
41	33.0	.328	6.731E-01	3.959E-01
42	31.0	.332	8.712E-01	5.124E-01
43	29.0	.336	1.109E+00	6.520E-01
44	27.1	.340	1.391E+00	8.182E-01
45	25.1	.344	1.725E+00	1.015E+00
46	23.1	.348	2.120E+00	1.247E+00
47	20.5	.353	2.586E+00	1.521E+00
48	15.8	.357	3.143E+00	1.849E+00
49	8.5	.361	3.871E+00	2.277E+00
50	0.0	.365	5.730E+00	3.370E+00

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.158	10000.0
2	.181	5000.0
3	.230	1000.0
4	.265	300.2
5	.270	250.0
6	.274	200.0
7	.281	150.0
8	.289	100.3
9	.298	62.5
10	.312	40.5
11	.355	20.0
12	.363	4.5

Appendix C (continued)

SOIL TYPE 5 - SAMPLE 9 - 86 CM DEPTH -

N = 12 TMAX = .4260 SCON = 3.370E+00 FACTOR = 7.197E-01
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	9130.8	.205	2.739E-07	1.971E-07
2	8261.5	.209	1.153E-06	8.297E-07
3	7392.3	.214	2.772E-06	1.995E-06
4	6523.1	.218	5.318E-06	3.828E-06
5	5688.7	.223	9.057E-06	6.519E-06
6	5029.9	.227	1.437E-05	1.034E-05
7	4617.6	.232	2.168E-05	1.560E-05
8	4311.2	.236	3.134E-05	2.256E-05
9	4004.7	.241	4.371E-05	3.146E-05
10	3698.3	.245	5.922E-05	4.263E-05
11	3391.9	.250	7.842E-05	5.644E-05
12	3085.4	.254	1.020E-04	7.341E-05
13	2779.0	.259	1.309E-04	9.419E-05
14	2472.5	.263	1.663E-04	1.197E-04
15	2166.1	.268	2.100E-04	1.512E-04
16	1859.7	.272	2.646E-04	1.904E-04
17	1553.2	.277	3.339E-04	2.403E-04
18	1258.6	.281	4.247E-04	3.056E-04
19	1036.7	.286	5.482E-04	3.946E-04
20	924.6	.290	7.193E-04	5.177E-04
21	861.4	.295	9.492E-04	6.832E-04
22	798.3	.299	1.247E-03	8.975E-04
23	735.1	.304	1.624E-03	1.169E-03
24	672.0	.308	2.094E-03	1.507E-03
25	608.8	.313	2.675E-03	1.925E-03
26	545.7	.318	3.393E-03	2.442E-03
27	482.6	.322	4.281E-03	3.081E-03
28	419.4	.327	5.387E-03	3.877E-03
29	357.1	.331	6.783E-03	4.882E-03
30	301.6	.336	8.580E-03	6.176E-03
31	254.0	.340	1.094E-02	7.874E-03
32	211.4	.345	1.410E-02	1.015E-02
33	179.9	.349	1.840E-02	1.324E-02
34	156.6	.354	2.428E-02	1.747E-02
35	134.1	.358	3.223E-02	2.319E-02
36	112.5	.363	4.302E-02	3.097E-02
37	93.3	.367	5.788E-02	4.166E-02
38	76.9	.372	7.865E-02	5.661E-02
39	63.9	.376	1.081E-01	7.783E-02
40	55.6	.381	1.502E-01	1.081E-01
41	49.5	.385	2.086E-01	1.501E-01
42	43.6	.390	2.877E-01	2.071E-01
43	38.5	.394	3.934E-01	2.832E-01
44	34.1	.399	5.333E-01	3.839E-01
45	29.9	.403	7.168E-01	5.159E-01
46	25.7	.408	9.573E-01	6.890E-01
47	21.0	.412	1.275E+00	9.180E-01
48	15.2	.417	1.712E+00	1.233E+00
49	8.1	.421	2.400E+00	1.727E+00
50	0.0	.426	4.682E+00	3.370E+00

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.200	10000.0
2	.226	5000.0
3	.285	1000.0
4	.335	301.5
5	.341	250.0
6	.345	200.0
7	.355	150.0
8	.365	100.3
9	.376	62.0
10	.392	40.5
11	.414	20.0
12	.424	4.5

Appendix C (continued)

SOIL TYPE 5 - SAMPLE 10 - 116 CM DEPTH -

N = 12 TMAX = .4170 SCON = 3.370E+00 FACTOR = 5.379E-01
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	8543.8	.189	3.057E-07	1.644E-07
2	7087.5	.193	1.347E-06	7.247E-07
3	5796.3	.198	3.469E-06	1.866E-06
4	4961.3	.203	7.200E-06	3.873E-06
5	4543.8	.207	1.309E-05	7.038E-06
6	4252.5	.212	2.153E-05	1.158E-05
7	3961.3	.217	3.288E-05	1.769E-05
8	3670.0	.221	4.760E-05	2.560E-05
9	3378.8	.226	6.624E-05	3.563E-05
10	3087.5	.231	8.951E-05	4.814E-05
11	2796.3	.235	1.183E-04	6.365E-05
12	2505.0	.240	1.539E-04	8.279E-05
13	2213.8	.245	1.980E-04	1.065E-04
14	1922.5	.249	2.529E-04	1.360E-04
15	1631.3	.254	3.223E-04	1.734E-04
16	1340.0	.259	4.119E-04	2.216E-04
17	1093.2	.263	5.319E-04	2.861E-04
18	944.3	.268	6.970E-04	3.749E-04
19	857.7	.273	9.214E-04	4.956E-04
20	780.0	.277	1.218E-03	6.550E-04
21	702.3	.282	1.601E-03	8.612E-04
22	624.7	.287	2.092E-03	1.125E-03
23	547.0	.291	2.719E-03	1.463E-03
24	469.3	.296	3.525E-03	1.896E-03
25	391.7	.300	4.574E-03	2.460E-03
26	318.0	.305	5.976E-03	3.214E-03
27	256.0	.310	7.917E-03	4.258E-03
28	210.3	.314	1.069E-02	5.748E-03
29	178.1	.319	1.467E-02	7.893E-03
30	153.6	.324	2.035E-02	1.094E-02
31	133.3	.328	2.828E-02	1.521E-02
32	115.1	.333	3.922E-02	2.110E-02
33	96.8	.338	5.420E-02	2.915E-02
34	78.3	.342	7.495E-02	4.031E-02
35	63.3	.347	1.046E-01	5.628E-02
36	55.3	.352	1.477E-01	7.946E-02
37	50.7	.356	2.081E-01	1.119E-01
38	46.1	.361	2.891E-01	1.555E-01
39	41.9	.366	3.949E-01	2.124E-01
40	38.7	.370	5.308E-01	2.855E-01
41	36.2	.375	7.018E-01	3.775E-01
42	33.8	.380	9.131E-01	4.911E-01
43	31.5	.384	1.170E+00	6.295E-01
44	29.1	.389	1.481E+00	7.965E-01
45	26.7	.394	1.854E+00	9.971E-01
46	24.4	.398	2.301E+00	1.237E+00
47	21.8	.403	2.836E+00	1.526E+00
48	17.5	.408	3.484E+00	1.874E+00
49	9.9	.412	4.319E+00	2.323E+00
50	0.0	.417	6.266E+00	3.370E+00

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.184	10000.0
2	.200	5000.0
3	.264	1000.0
4	.306	300.0
5	.310	250.0
6	.315	200.5
7	.324	150.6
8	.337	100.0
9	.347	60.0
10	.367	40.3
11	.407	20.0
12	.415	5.5

Appendix C (continued)

SOIL TYPE 5 - SAMPLE 11 - 136 CM DEPTH -

N = 12 TMAX = .4330 SCON = 3.370E+00 FACTOR = 7.631E-02
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	8733.3	.172	3.996E-07	3.049E-08
2	7466.7	.178	1.733E-06	1.322E-07
3	6211.3	.183	4.351E-06	3.321E-07
4	5181.5	.188	8.843E-06	6.748E-07
5	4569.2	.194	1.599E-05	1.221E-06
6	4160.0	.199	2.652E-05	2.024E-06
7	3750.8	.204	4.113E-05	3.139E-06
8	3341.5	.210	6.077E-05	4.638E-06
9	2932.3	.215	8.676E-05	6.621E-06
10	2523.1	.220	1.210E-04	9.236E-06
11	2113.8	.226	1.665E-04	1.271E-05
12	1704.6	.231	2.282E-04	1.741E-05
13	1317.4	.236	3.150E-04	2.404E-05
14	1031.2	.241	4.446E-04	3.393E-05
15	881.1	.247	6.422E-04	4.901E-05
16	788.1	.252	9.309E-04	7.104E-05
17	695.0	.257	1.334E-03	1.018E-04
18	602.0	.263	1.883E-03	1.437E-04
19	509.0	.268	2.630E-03	2.007E-04
20	415.9	.273	3.655E-03	2.789E-04
21	323.7	.279	5.100E-03	3.892E-04
22	242.8	.284	7.255E-03	5.537E-04
23	187.3	.289	1.068E-02	8.148E-04
24	153.2	.295	1.617E-02	1.234E-03
25	127.4	.300	2.472E-02	1.887E-03
26	103.7	.305	3.772E-02	2.878E-03
27	81.5	.311	5.747E-02	4.386E-03
28	63.9	.316	8.834E-02	6.741E-03
29	53.8	.321	1.370E-01	1.045E-02
30	47.5	.327	2.101E-01	1.603E-02
31	42.0	.332	3.147E-01	2.401E-02
32	38.2	.337	4.593E-01	3.505E-02
33	35.6	.343	6.521E-01	4.977E-02
34	33.1	.348	9.006E-01	6.873E-02
35	30.6	.353	1.213E+00	9.260E-02
36	28.1	.359	1.602E+00	1.222E-01
37	25.7	.364	2.079E+00	1.586E-01
38	23.2	.369	2.663E+00	2.032E-01
39	20.9	.374	3.379E+00	2.579E-01
40	18.9	.380	4.258E+00	3.249E-01
41	17.2	.385	5.333E+00	4.070E-01
42	15.6	.390	6.646E+00	5.072E-01
43	14.0	.396	8.248E+00	6.294E-01
44	12.4	.401	1.021E+01	7.791E-01
45	10.8	.406	1.263E+01	9.639E-01
46	9.2	.412	1.566E+01	1.195E+00
47	7.6	.417	1.954E+01	1.491E+00
48	6.3	.422	2.467E+01	1.883E+00
49	4.3	.428	3.161E+01	2.412E+00
50	0.0	.433	4.416E+01	3.370E+00

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.167	10000.0
2	.188	5000.0
3	.240	1000.0
4	.280	300.5
5	.283	250.4
6	.286	201.0
7	.295	150.0
8	.306	100.0
9	.316	60.0
10	.333	40.0
11	.376	20.0
12	.424	5.5

Appendix C (continued)

SOIL TYPE 6 - SAMPLE 13 - 25 CM DEPTH -

N = 12 TMAX = .4760 SCON = 3.070E+01 FACTOR = 2.112E+00
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	9100.0	.229	3.639E-07	7.686E-07
2	8200.0	.234	1.535E-06	3.243E-06
3	7300.0	.239	3.703E-06	7.821E-06
4	6400.0	.244	7.131E-06	1.506E-05
5	5567.5	.249	1.220E-05	2.577E-05
6	4954.6	.254	1.945E-05	4.107E-05
7	4578.0	.259	2.941E-05	6.212E-05
8	4285.8	.264	4.256E-05	8.988E-05
9	3993.6	.269	5.933E-05	1.253E-04
10	3701.4	.274	8.028E-05	1.695E-04
11	3409.3	.279	1.061E-04	2.241E-04
12	3117.1	.284	1.377E-04	2.907E-04
13	2824.9	.290	1.761E-04	3.719E-04
14	2532.8	.295	2.229E-04	4.708E-04
15	2240.6	.300	2.802E-04	5.918E-04
16	1948.4	.305	3.509E-04	7.410E-04
17	1656.2	.310	4.393E-04	9.278E-04
18	1364.1	.315	5.525E-04	1.167E-03
19	1113.7	.320	7.027E-04	1.484E-03
20	960.4	.325	9.078E-04	1.917E-03
21	876.2	.330	1.185E-03	2.504E-03
22	805.7	.335	1.550E-03	3.273E-03
23	735.1	.340	2.017E-03	4.261E-03
24	664.6	.345	2.608E-03	5.509E-03
25	594.0	.350	3.351E-03	7.077E-03
26	523.4	.355	4.284E-03	9.047E-03
27	452.9	.360	5.462E-03	1.154E-02
28	382.3	.365	6.970E-03	1.472E-02
29	319.9	.370	8.944E-03	1.889E-02
30	274.2	.375	1.158E-02	2.446E-02
31	235.3	.380	1.511E-02	3.192E-02
32	195.6	.385	1.987E-02	4.197E-02
33	161.8	.390	2.642E-02	5.579E-02
34	134.1	.395	3.556E-02	7.510E-02
35	107.7	.400	4.850E-02	1.024E-01
36	81.8	.405	6.743E-02	1.424E-01
37	60.6	.410	9.704E-02	2.049E-01
38	47.7	.416	1.458E-01	3.079E-01
39	40.3	.421	2.246E-01	4.743E-01
40	35.9	.426	3.449E-01	7.285E-01
41	32.7	.431	5.172E-01	1.092E+00
42	29.6	.436	7.518E-01	1.588E+00
43	26.4	.441	1.063E+00	2.245E+00
44	23.3	.446	1.470E+00	3.105E+00
45	20.0	.451	2.002E+00	4.228E+00
46	16.5	.456	2.703E+00	5.709E+00
47	12.8	.461	3.657E+00	7.724E+00
48	9.2	.466	5.040E+00	1.064E+01
49	5.1	.471	7.310E+00	1.544E+01
50	0.0	.476	1.454E+01	3.070E+01

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.224	10000.0
2	.252	5000.0
3	.321	1000.0
4	.371	300.0
5	.379	250.0
6	.384	200.0
7	.392	150.4
8	.402	100.3
9	.409	60.4
10	.419	40.0
11	.451	20.0
12	.471	5.5

Appendix C (continued)

SOIL TYPE 6 - SAMPLE 14 - 62 CM DEPTH -

N = 12 TMAX = .5150 SCON = 3.070E+01 FACTOR = 5.461E-01
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	9051.6	.227	5.181E-07	2.829E-07
2	8103.2	.233	2.193E-06	1.198E-06
3	7154.8	.239	5.316E-06	2.903E-06
4	6206.5	.245	1.030E-05	5.624E-06
5	5368.6	.250	1.777E-05	9.702E-06
6	4793.2	.256	2.854E-05	1.559E-05
7	4411.0	.262	4.343E-05	2.372E-05
8	4070.1	.268	6.318E-05	3.450E-05
9	3729.3	.274	8.863E-05	4.840E-05
10	3388.4	.280	1.209E-04	6.601E-05
11	3047.5	.286	1.614E-04	8.813E-05
12	2706.7	.292	2.121E-04	1.158E-04
13	2365.8	.297	2.758E-04	1.506E-04
14	2024.9	.303	3.566E-04	1.947E-04
15	1684.1	.309	4.608E-04	2.516E-04
16	1343.2	.315	5.992E-04	3.272E-04
17	1067.7	.321	7.923E-04	4.327E-04
18	923.3	.327	1.070E-03	5.845E-04
19	845.3	.333	1.459E-03	7.969E-04
20	767.6	.339	1.981E-03	1.082E-03
21	690.0	.344	2.663E-03	1.454E-03
22	612.4	.350	3.544E-03	1.935E-03
23	534.8	.356	4.680E-03	2.555E-03
24	457.1	.362	6.149E-03	3.358E-03
25	379.5	.368	8.078E-03	4.411E-03
26	308.9	.374	1.068E-02	5.833E-03
27	254.1	.380	1.430E-02	7.809E-03
28	211.0	.386	1.941E-02	1.060E-02
29	173.5	.392	2.670E-02	1.458E-02
30	141.9	.397	3.720E-02	2.031E-02
31	114.6	.403	5.251E-02	2.868E-02
32	87.3	.409	7.527E-02	4.110E-02
33	63.1	.415	1.114E-01	6.083E-02
34	48.4	.421	1.729E-01	9.443E-02
35	39.6	.427	2.759E-01	1.507E-01
36	32.6	.433	4.406E-01	2.406E-01
37	26.4	.439	6.962E-01	3.801E-01
38	21.2	.444	1.093E+00	5.968E-01
39	18.4	.450	1.704E+00	9.307E-01
40	17.0	.456	2.595E+00	1.417E+00
41	15.6	.462	3.813E+00	2.082E+00
42	14.3	.468	5.417E+00	2.958E+00
43	13.0	.474	7.484E+00	4.087E+00
44	11.7	.480	1.011E+01	5.522E+00
45	10.3	.486	1.344E+01	7.338E+00
46	9.0	.491	1.766E+01	9.642E+00
47	7.7	.497	2.305E+01	1.259E+01
48	6.5	.503	3.008E+01	1.643E+01
49	4.3	.509	3.940E+01	2.152E+01
50	0.0	.515	5.622E+01	3.070E+01

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.221	10000.0
2	.252	5000.0
3	.321	1000.0
4	.374	300.3
5	.380	250.3
6	.387	200.2
7	.395	150.2
8	.407	99.8
9	.414	60.3
10	.425	40.8
11	.445	19.5
12	.507	5.5

Appendix C (continued)

SOIL TYPE 6 - SAMPLE 15 - 82 CM DEPTH -

N = 12 TMAX = .4900 SCON = 3.070E+01 FACTOR = 8.359E+00
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	9225.0	.247	3.532E-07	2.952E-06
2	8450.0	.252	1.478E-06	1.235E-05
3	7675.0	.257	3.522E-06	2.944E-05
4	6900.0	.262	6.683E-06	5.586E-05
5	6125.0	.267	1.123E-05	9.385E-05
6	5420.5	.272	1.753E-05	1.466E-04
7	4914.9	.277	2.608E-05	2.180E-04
8	4595.8	.282	3.735E-05	3.122E-04
9	4334.7	.287	5.171E-05	4.322E-04
10	4073.7	.292	6.956E-05	5.814E-04
11	3812.6	.297	9.135E-05	7.636E-04
12	3551.6	.302	1.176E-04	9.834E-04
13	3290.5	.306	1.491E-04	1.247E-03
14	3029.5	.311	1.867E-04	1.560E-03
15	2768.4	.316	2.314E-04	1.934E-03
16	2507.4	.321	2.847E-04	2.379E-03
17	2246.3	.326	3.484E-04	2.912E-03
18	1985.3	.331	4.252E-04	3.554E-03
19	1724.2	.336	5.188E-04	4.337E-03
20	1463.2	.341	6.347E-04	5.306E-03
21	1213.2	.346	7.819E-04	6.536E-03
22	1023.6	.351	9.747E-04	8.147E-03
23	921.2	.356	1.231E-03	1.029E-02
24	856.9	.361	1.564E-03	1.307E-02
25	792.7	.366	1.986E-03	1.660E-02
26	728.4	.371	2.513E-03	2.101E-02
27	664.1	.376	3.164E-03	2.645E-02
28	599.8	.381	3.964E-03	3.313E-02
29	535.5	.386	4.946E-03	4.134E-02
30	471.3	.391	6.159E-03	5.148E-02
31	407.0	.396	7.670E-03	6.411E-02
32	344.7	.401	9.582E-03	8.009E-02
33	290.1	.406	1.206E-02	1.008E-01
34	245.0	.411	1.532E-02	1.281E-01
35	208.2	.416	1.970E-02	1.647E-01
36	181.5	.421	2.561E-02	2.141E-01
37	159.5	.426	3.353E-02	2.802E-01
38	135.4	.430	4.404E-02	3.681E-01
39	109.9	.435	5.822E-02	4.867E-01
40	86.9	.440	7.802E-02	6.522E-01
41	67.8	.445	1.069E-01	8.932E-01
42	52.6	.450	1.506E-01	1.259E+00
43	42.1	.455	2.191E-01	1.831E+00
44	36.2	.460	3.253E-01	2.719E+00
45	32.2	.465	4.819E-01	4.028E+00
46	28.2	.470	7.021E-01	5.869E+00
47	24.2	.475	1.006E+00	8.406E+00
48	19.1	.480	1.423E+00	1.189E+01
49	11.0	.485	2.032E+00	1.699E+01
50	0.0	.490	3.673E+00	3.070E+01

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.242	10000.0
2	.274	5000.0
3	.350	1000.0
4	.404	300.2
5	.410	250.5
6	.416	200.0
7	.428	150.1
8	.437	99.8
9	.447	60.0
10	.455	40.4
11	.480	20.3
12	.489	5.5

Appendix C (continued)

SOIL TYPE 4S - SAMPLE 16 - 16 CM DEPTH -

N = 12 TMAX = .5090 SCON = 3.020E+02 FACTOR = 4.547E+00
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	8969.0	.216	5.375E-07	2.444E-06
2	7937.9	.222	2.289E-06	1.041E-05
3	6906.9	.228	5.595E-06	2.544E-05
4	5900.6	.234	1.096E-05	4.984E-05
5	5083.3	.240	1.917E-05	8.714E-05
6	4570.0	.246	3.116E-05	1.417E-04
7	4196.3	.252	4.780E-05	2.174E-04
8	3822.5	.258	6.997E-05	3.182E-04
9	3448.8	.264	9.881E-05	4.493E-04
10	3075.0	.270	1.359E-04	6.177E-04
11	2701.3	.276	1.832E-04	8.331E-04
12	2327.5	.282	2.441E-04	1.110E-03
13	1953.8	.288	3.231E-04	1.469E-03
14	1580.0	.294	4.281E-04	1.947E-03
15	1239.3	.300	5.736E-04	2.608E-03
16	1005.3	.306	7.850E-04	3.569E-03
17	885.7	.312	1.094E-03	4.974E-03
18	806.8	.318	1.527E-03	6.943E-03
19	727.9	.324	2.110E-03	9.592E-03
20	649.0	.330	2.876E-03	1.308E-02
21	570.1	.336	3.875E-03	1.762E-02
22	491.2	.342	5.176E-03	2.353E-02
23	412.2	.348	6.885E-03	3.131E-02
24	333.8	.354	9.180E-03	4.174E-02
25	260.5	.359	1.238E-02	5.628E-02
26	198.6	.365	1.708E-02	7.765E-02
27	146.6	.371	2.437E-02	1.108E-01
28	103.4	.377	3.657E-02	1.663E-01
29	74.0	.383	5.873E-02	2.670E-01
30	57.1	.389	9.969E-02	4.533E-01
31	46.9	.395	1.714E-01	7.794E-01
32	40.3	.401	2.880E-01	1.310E+00
33	35.9	.407	4.652E-01	2.115E+00
34	32.6	.413	7.177E-01	3.263E+00
35	29.3	.419	1.062E+00	4.829E+00
36	26.0	.425	1.520E+00	6.912E+00
37	22.7	.431	2.124E+00	9.656E+00
38	20.1	.437	2.917E+00	1.326E+01
39	18.3	.443	3.952E+00	1.797E+01
40	17.0	.449	5.275E+00	2.398E+01
41	15.6	.455	6.936E+00	3.154E+01
42	14.2	.461	8.998E+00	4.091E+01
43	12.8	.467	1.154E+01	5.248E+01
44	11.5	.473	1.468E+01	6.674E+01
45	10.1	.479	1.856E+01	8.439E+01
46	8.7	.485	2.341E+01	1.064E+02
47	7.3	.491	2.955E+01	1.344E+02
48	6.2	.497	3.755E+01	1.707E+02
49	4.3	.503	4.811E+01	2.187E+02
50	0.0	.509	6.642E+01	3.020E+02

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.210	10000.0
2	.239	5000.0
3	.303	1000.0
4	.356	300.6
5	.360	250.1
6	.365	200.0
7	.371	150.0
8	.377	100.0
9	.386	60.0
10	.400	40.0
11	.436	20.0
12	.499	5.5

Appendix C (continued)

SOIL TYPE 4S - SAMPLE 17 - 36 CM DEPTH -

N = 12 TMAX = .5530 SCON = 3.020E+02 FACTOR = 1.024E+01
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	9157.1	.264	5.332E-07	5.460E-06
2	8314.3	.270	2.240E-06	2.294E-05
3	7471.4	.276	5.374E-06	5.503E-05
4	6628.6	.282	1.028E-05	1.052E-04
5	5795.1	.287	1.743E-05	1.785E-04
6	5108.8	.293	2.755E-05	2.821E-04
7	4688.9	.299	4.144E-05	4.244E-04
8	4397.5	.305	5.980E-05	6.124E-04
9	4106.2	.311	8.324E-05	8.523E-04
10	3814.8	.317	1.125E-04	1.152E-03
11	3523.5	.323	1.485E-04	1.521E-03
12	3232.1	.329	1.924E-04	1.971E-03
13	2940.7	.335	2.458E-04	2.517E-03
14	2649.4	.341	3.105E-04	3.180E-03
15	2358.0	.346	3.894E-04	3.987E-03
16	2066.7	.352	4.860E-04	4.976E-03
17	1775.3	.358	6.058E-04	6.204E-03
18	1484.0	.364	7.574E-04	7.756E-03
19	1211.7	.370	9.546E-04	9.776E-03
20	1015.1	.376	1.221E-03	1.250E-02
21	912.2	.382	1.583E-03	1.621E-02
22	846.7	.388	2.064E-03	2.113E-02
23	781.1	.394	2.681E-03	2.746E-02
24	715.6	.400	3.460E-03	3.543E-02
25	650.0	.405	4.431E-03	4.537E-02
26	584.4	.411	5.635E-03	5.771E-02
27	518.9	.417	7.129E-03	7.300E-02
28	453.3	.423	8.990E-03	9.206E-02
29	387.8	.429	1.133E-02	1.161E-01
30	315.9	.435	1.434E-02	1.469E-01
31	237.5	.441	1.838E-02	1.882E-01
32	168.5	.447	2.430E-02	2.488E-01
33	114.6	.453	3.401E-02	3.482E-01
34	75.9	.459	5.221E-02	5.347E-01
35	54.5	.464	8.946E-02	9.161E-01
36	44.3	.470	1.611E-01	1.650E+00
37	38.7	.476	2.837E-01	2.905E+00
38	35.3	.482	4.719E-01	4.832E+00
39	32.2	.488	7.391E-01	7.569E+00
40	29.2	.494	1.101E+00	1.128E+01
41	26.2	.500	1.579E+00	1.616E+01
42	23.2	.506	2.200E+00	2.253E+01
43	20.3	.512	3.006E+00	3.078E+01
44	17.7	.518	4.052E+00	4.149E+01
45	15.3	.523	5.414E+00	5.544E+01
46	12.9	.529	7.199E+00	7.372E+01
47	10.6	.535	9.583E+00	9.813E+01
48	8.2	.541	1.288E+01	1.319E+02
49	4.9	.547	1.774E+01	1.817E+02
50	0.0	.553	2.949E+01	3.020E+02

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.258	10000.0
2	.293	5000.0
3	.374	1000.0
4	.437	300.0
5	.439	250.2
6	.444	200.2
7	.448	150.6
8	.454	101.0
9	.460	60.0
10	.472	40.5
11	.512	20.0
12	.549	5.0

Appendix C (continued)

SOIL TYPE 4S - SAMPLE 18 - 66 CM DEPTH -

N = 12 TMAX = .5080 SCON = 3.020E+02 FACTOR = 9.390E+00
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	9169.7	.239	4.416E-07	4.146E-06
2	8339.4	.245	1.854E-06	1.741E-05
3	7509.1	.250	4.442E-06	4.171E-05
4	6678.8	.256	8.482E-06	7.964E-05
5	5848.5	.261	1.436E-05	1.349E-04
6	5148.8	.267	2.265E-05	2.127E-04
7	4713.2	.272	3.403E-05	3.195E-04
8	4414.1	.278	4.907E-05	4.607E-04
9	4117.8	.283	6.828E-05	6.412E-04
10	3821.6	.289	9.231E-05	8.668E-04
11	3525.4	.294	1.219E-04	1.145E-03
12	3229.2	.300	1.581E-04	1.484E-03
13	2933.0	.305	2.021E-04	1.897E-03
14	2636.8	.311	2.556E-04	2.400E-03
15	2340.5	.316	3.208E-04	3.013E-03
16	2044.3	.322	4.011E-04	3.767E-03
17	1748.1	.327	5.011E-04	4.705E-03
18	1451.9	.333	6.282E-04	5.899E-03
19	1182.7	.338	7.950E-04	7.466E-03
20	997.5	.344	1.022E-03	9.594E-03
21	899.1	.349	1.331E-03	1.250E-02
22	830.7	.355	1.741E-03	1.635E-02
23	762.3	.360	2.269E-03	2.131E-02
24	693.9	.366	2.938E-03	2.759E-02
25	625.5	.371	3.776E-03	3.546E-02
26	557.1	.376	4.824E-03	4.530E-02
27	488.7	.382	6.136E-03	5.762E-02
28	420.3	.387	7.792E-03	7.317E-02
29	350.5	.393	9.917E-03	9.313E-02
30	274.8	.398	1.272E-02	1.195E-01
31	199.4	.404	1.668E-02	1.566E-01
32	136.6	.409	2.287E-02	2.148E-01
33	88.3	.415	3.398E-02	3.191E-01
34	57.5	.420	5.738E-02	5.388E-01
35	43.5	.426	1.077E-01	1.012E+00
36	37.9	.431	2.020E-01	1.897E+00
37	34.5	.437	3.531E-01	3.316E+00
38	31.3	.442	5.726E-01	5.377E+00
39	28.0	.448	8.759E-01	8.225E+00
40	24.7	.453	1.284E+00	1.206E+01
41	21.6	.459	1.827E+00	1.716E+01
42	19.0	.464	2.546E+00	2.391E+01
43	17.0	.470	3.492E+00	3.279E+01
44	15.0	.475	4.723E+00	4.435E+01
45	13.1	.481	6.318E+00	5.933E+01
46	11.2	.486	8.394E+00	7.882E+01
47	9.2	.492	1.114E+01	1.046E+02
48	7.3	.497	1.486E+01	1.395E+02
49	4.5	.503	2.019E+01	1.896E+02
50	0.0	.508	3.216E+01	3.020E+02

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.234	10000.0
2	.267	5000.0
3	.341	1000.0
4	.397	301.0
5	.400	251.2
6	.403	200.7
7	.408	150.0
8	.413	100.0
9	.417	60.5
10	.426	41.0
11	.461	20.0
12	.503	5.2

Appendix C (continued)

SOIL TYPE 4S - SAMPLE 19 - 86 CM DEPTH -

N = 12 TMAX = .4830 SCON = 3.020E+02 FACTOR = 2.172E+01
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	8884.6	.199	4.968E-07	1.079E-05
2	7769.2	.205	2.129E-06	4.625E-05
3	6653.8	.210	5.252E-06	1.141E-04
4	5632.7	.216	1.042E-05	2.263E-04
5	4887.9	.222	1.844E-05	4.004E-04
6	4413.3	.228	3.020E-05	6.558E-04
7	4026.7	.234	4.653E-05	1.011E-03
8	3640.0	.239	6.837E-05	1.485E-03
9	3253.3	.245	9.695E-05	2.106E-03
10	2866.7	.251	1.340E-04	2.910E-03
11	2480.0	.257	1.820E-04	3.952E-03
12	2093.3	.263	2.446E-04	5.312E-03
13	1706.7	.268	3.280E-04	7.123E-03
14	1332.9	.274	4.430E-04	9.621E-03
15	1046.5	.280	6.107E-04	1.326E-02
16	896.5	.286	8.618E-04	1.872E-02
17	808.3	.292	1.224E-03	2.658E-02
18	720.0	.297	1.723E-03	3.742E-02
19	631.7	.303	2.395E-03	5.201E-02
20	543.5	.309	3.292E-03	7.149E-02
21	455.2	.315	4.495E-03	9.762E-02
22	371.5	.321	6.137E-03	1.333E-01
23	310.8	.326	8.445E-03	1.834E-01
24	282.9	.332	1.168E-02	2.537E-01
25	269.2	.338	1.603E-02	3.481E-01
26	256.0	.344	2.160E-02	4.691E-01
27	244.5	.350	2.852E-02	6.195E-01
28	234.3	.355	3.693E-02	8.021E-01
29	224.4	.361	4.696E-02	1.020E+00
30	214.6	.367	5.875E-02	1.276E+00
31	204.6	.373	7.246E-02	1.574E+00
32	194.4	.379	8.829E-02	1.918E+00
33	183.8	.384	1.065E-01	2.313E+00
34	173.0	.390	1.273E-01	2.765E+00
35	162.3	.396	1.511E-01	3.281E+00
36	149.9	.402	1.782E-01	3.871E+00
37	133.4	.408	2.094E-01	4.547E+00
38	111.5	.413	2.455E-01	5.333E+00
39	85.1	.419	2.891E-01	6.279E+00
40	61.5	.425	3.460E-01	7.514E+00
41	47.6	.431	4.279E-01	9.294E+00
42	39.8	.437	5.500E-01	1.195E+01
43	33.9	.442	7.291E-01	1.583E+01
44	28.7	.448	9.866E-01	2.143E+01
45	23.6	.454	1.354E+00	2.941E+01
46	18.9	.460	1.886E+00	4.095E+01
47	14.5	.466	2.677E+00	5.815E+01
48	10.2	.471	3.921E+00	8.516E+01
49	5.6	.477	6.126E+00	1.330E+02
50	0.0	.483	1.391E+01	3.020E+02

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.193	10000.0
2	.219	5000.0
3	.279	1000.0
4	.325	300.0
5	.346	250.2
6	.376	199.3
7	.404	147.5
8	.417	100.0
9	.423	60.0
10	.435	40.5
11	.458	20.0
12	.479	4.7

Appendix C (continued)

SOIL TYPE 10 - SAMPLE 20 - 16 CM DEPTH -

N = 12 TMAX = .4990 SCON = 2.880E+01 FACTOR = 3.729E-01
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	8985.7	.221	4.794E-07	1.787E-07
2	7971.4	.226	2.039E-06	7.603E-07
3	6957.1	.232	4.975E-06	1.855E-06
4	5954.7	.238	9.724E-06	3.626E-06
5	5133.0	.243	1.696E-05	6.325E-06
6	4637.0	.249	2.752E-05	1.026E-05
7	4297.9	.255	4.211E-05	1.570E-05
8	3958.8	.260	6.140E-05	2.289E-05
9	3619.7	.266	8.623E-05	3.215E-05
10	3280.6	.272	1.177E-04	4.389E-05
11	2941.5	.277	1.573E-04	5.864E-05
12	2602.4	.283	2.069E-04	7.715E-05
13	2263.3	.289	2.695E-04	1.005E-04
14	1924.2	.295	3.492E-04	1.302E-04
15	1585.1	.300	4.528E-04	1.688E-04
16	1263.8	.306	5.920E-04	2.207E-04
17	1025.3	.312	7.877E-04	2.937E-04
18	898.7	.317	1.067E-03	3.980E-04
19	819.2	.323	1.455E-03	5.424E-04
20	739.8	.329	1.971E-03	7.351E-04
21	660.3	.334	2.648E-03	9.873E-04
22	580.9	.340	3.524E-03	1.314E-03
23	501.4	.346	4.660E-03	1.738E-03
24	421.9	.351	6.146E-03	2.292E-03
25	345.1	.357	8.131E-03	3.032E-03
26	276.5	.363	1.087E-02	4.052E-03
27	219.6	.368	1.478E-02	5.510E-03
28	172.6	.374	2.055E-02	7.664E-03
29	128.7	.380	2.937E-02	1.095E-02
30	85.9	.385	4.390E-02	1.637E-02
31	54.9	.391	7.231E-02	2.696E-02
32	40.5	.397	1.329E-01	4.956E-02
33	34.6	.402	2.475E-01	9.230E-02
34	30.1	.408	4.353E-01	1.623E-01
35	25.7	.414	7.200E-01	2.685E-01
36	21.8	.419	1.139E+00	4.247E-01
37	19.2	.425	1.743E+00	6.501E-01
38	17.7	.431	2.583E+00	9.630E-01
39	16.4	.437	3.698E+00	1.379E+00
40	15.1	.442	5.138E+00	1.916E+00
41	13.7	.448	6.960E+00	2.595E+00
42	12.4	.454	9.242E+00	3.446E+00
43	11.1	.459	1.209E+01	4.508E+00
44	9.8	.465	1.565E+01	5.835E+00
45	8.5	.471	2.012E+01	7.503E+00
46	7.1	.476	2.583E+01	9.630E+00
47	6.0	.482	3.327E+01	1.241E+01
48	5.3	.488	4.320E+01	1.611E+01
49	3.9	.493	5.619E+01	2.095E+01
50	0.0	.499	7.723E+01	2.880E+01

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.215	10000.0
2	.243	5000.0
3	.310	1000.0
4	.360	300.5
5	.365	250.1
6	.370	200.4
7	.377	150.2
8	.384	100.2
9	.387	60.7
10	.394	41.2
11	.421	20.0
12	.485	5.1

Appendix C (continued)

SOIL TYPE 10 - SAMPLE 21 - 36 CM DEPTH -

N = 12 TMAX = .4420 SCON = 2.880E+01 FACTOR = 5.852E-01
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	9050.0	.200	3.372E-07	1.974E-07
2	8100.0	.205	1.428E-06	8.356E-07
3	7150.0	.210	3.461E-06	2.025E-06
4	6200.0	.215	6.707E-06	3.925E-06
5	5364.3	.220	1.157E-05	6.773E-06
6	4798.2	.225	1.859E-05	1.088E-05
7	4428.0	.230	2.829E-05	1.656E-05
8	4098.7	.235	4.112E-05	2.406E-05
9	3769.3	.239	5.761E-05	3.371E-05
10	3440.0	.244	7.843E-05	4.590E-05
11	3110.7	.249	1.045E-04	6.113E-05
12	2781.3	.254	1.369E-04	8.009E-05
13	2452.0	.259	1.773E-04	1.037E-04
14	2122.7	.264	2.280E-04	1.334E-04
15	1793.3	.269	2.925E-04	1.712E-04
16	1464.0	.274	3.766E-04	2.204E-04
17	1171.7	.279	4.903E-04	2.869E-04
18	979.2	.284	6.502E-04	3.805E-04
19	875.0	.289	8.748E-04	5.119E-04
20	796.5	.294	1.180E-03	6.904E-04
21	718.0	.299	1.582E-03	9.257E-04
22	639.4	.304	2.104E-03	1.231E-03
23	560.9	.309	2.777E-03	1.625E-03
24	482.4	.314	3.648E-03	2.135E-03
25	403.8	.318	4.787E-03	2.801E-03
26	328.1	.323	6.312E-03	3.694E-03
27	265.0	.328	8.427E-03	4.931E-03
28	217.0	.333	1.144E-02	6.695E-03
29	173.2	.338	1.579E-02	9.241E-03
30	132.5	.343	2.229E-02	1.304E-02
31	96.3	.348	3.247E-02	1.900E-02
32	65.5	.353	5.000E-02	2.926E-02
33	48.2	.358	8.351E-02	4.887E-02
34	41.0	.363	1.441E-01	8.433E-02
35	36.8	.368	2.416E-01	1.414E-01
36	33.9	.373	3.844E-01	2.250E-01
37	30.9	.378	5.809E-01	3.399E-01
38	27.9	.383	8.420E-01	4.927E-01
39	24.9	.388	1.182E+00	6.919E-01
40	22.0	.393	1.622E+00	9.494E-01
41	19.2	.398	2.190E+00	1.282E+00
42	16.5	.402	2.927E+00	1.713E+00
43	13.8	.407	3.894E+00	2.279E+00
44	11.2	.412	5.189E+00	3.037E+00
45	8.5	.417	6.995E+00	4.094E+00
46	6.2	.422	9.705E+00	5.679E+00
47	4.8	.427	1.416E+01	8.284E+00
48	4.5	.432	2.131E+01	1.247E+01
49	3.4	.437	3.152E+01	1.844E+01
50	0.0	.442	4.921E+01	2.880E+01

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.195	10000.0
2	.221	5000.0
3	.281	1000.0
4	.325	300.5
5	.329	250.0
6	.336	200.0
7	.340	150.0
8	.348	99.9
9	.352	60.4
10	.361	41.0
11	.395	20.5
12	.425	4.4

Appendix C (continued)

SOIL TYPE 10 - SAMPLE 22 - 66 CM DEPTH -

N = 12 TMAX = .4230 SCON = 2.880E+01 FACTOR = 2.060E+00
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	9225.0	.210	2.489E-07	5.126E-07
2	8450.0	.215	1.041E-06	2.144E-06
3	7675.0	.219	2.482E-06	5.111E-06
4	6900.0	.223	4.709E-06	9.699E-06
5	6125.0	.228	7.912E-06	1.630E-05
6	5419.6	.232	1.236E-05	2.545E-05
7	4910.9	.236	1.838E-05	3.786E-05
8	4586.5	.241	2.632E-05	5.421E-05
9	4319.4	.245	3.646E-05	7.509E-05
10	4052.3	.249	4.906E-05	1.011E-04
11	3785.2	.254	6.448E-05	1.328E-04
12	3518.2	.258	8.312E-05	1.712E-04
13	3251.1	.262	1.055E-04	2.173E-04
14	2984.0	.267	1.322E-04	2.724E-04
15	2716.9	.271	1.642E-04	3.381E-04
16	2449.8	.275	2.024E-04	4.169E-04
17	2182.8	.280	2.484E-04	5.115E-04
18	1915.7	.284	3.041E-04	6.262E-04
19	1648.6	.288	3.725E-04	7.672E-04
20	1381.5	.293	4.582E-04	9.437E-04
21	1144.6	.297	5.687E-04	1.171E-03
22	990.4	.301	7.151E-04	1.473E-03
23	911.6	.306	9.089E-04	1.872E-03
24	855.3	.310	1.158E-03	2.385E-03
25	799.1	.315	1.470E-03	3.028E-03
26	742.8	.319	1.855E-03	3.821E-03
27	686.6	.323	2.323E-03	4.785E-03
28	630.3	.328	2.890E-03	5.952E-03
29	574.0	.332	3.573E-03	7.358E-03
30	517.8	.336	4.396E-03	9.054E-03
31	461.5	.341	5.393E-03	1.111E-02
32	405.3	.345	6.608E-03	1.361E-02
33	347.3	.349	8.107E-03	1.670E-02
34	280.8	.354	9.996E-03	2.059E-02
35	209.6	.358	1.250E-02	2.574E-02
36	150.5	.362	1.614E-02	3.324E-02
37	104.5	.367	2.198E-02	4.526E-02
38	69.0	.371	3.261E-02	6.715E-02
39	49.7	.375	5.415E-02	1.115E-01
40	40.8	.380	9.497E-02	1.956E-01
41	34.9	.384	1.641E-01	3.379E-01
42	30.1	.388	2.715E-01	5.592E-01
43	25.4	.393	4.305E-01	8.866E-01
44	20.9	.397	6.627E-01	1.365E+00
45	16.8	.401	1.004E+00	2.067E+00
46	13.0	.406	1.514E+00	3.118E+00
47	9.2	.410	2.313E+00	4.764E+00
48	6.2	.414	3.731E+00	7.683E+00
49	3.8	.419	6.457E+00	1.330E+01
50	0.0	.423	1.398E+01	2.880E+01

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.206	10000.0
2	.234	5000.0
3	.299	1000.0
4	.353	300.0
5	.355	250.4
6	.358	200.5
7	.362	150.2
8	.367	100.2
9	.371	60.6
10	.378	41.4
11	.397	20.6
12	.415	4.8

Appendix C (continued)

SOIL TYPE 10 - SAMPLE 22T - 61 CM DEPTH

N = 12 TMAX = .4260 SCON = 2.880E+01 FACTOR = 5.250E+00
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	9222.2	.220	2.342E-07	1.230E-06
2	8444.4	.224	9.798E-07	5.144E-06
3	7666.7	.229	2.336E-06	1.226E-05
4	6888.9	.233	4.434E-06	2.328E-05
5	6111.1	.237	7.453E-06	3.913E-05
6	5408.6	.241	1.164E-05	6.113E-05
7	4913.2	.245	1.733E-05	9.098E-05
8	4606.0	.250	2.481E-05	1.303E-04
9	4355.2	.254	3.434E-05	1.803E-04
10	4104.5	.258	4.616E-05	2.423E-04
11	3853.7	.262	6.055E-05	3.179E-04
12	3603.0	.266	7.786E-05	4.088E-04
13	3352.2	.271	9.852E-05	5.173E-04
14	3101.5	.275	1.230E-04	6.460E-04
15	2850.7	.279	1.521E-04	7.985E-04
16	2600.0	.283	1.865E-04	9.791E-04
17	2349.3	.287	2.273E-04	1.194E-03
18	2098.5	.292	2.761E-04	1.450E-03
19	1847.8	.296	3.348E-04	1.758E-03
20	1597.0	.300	4.063E-04	2.133E-03
21	1346.3	.304	4.951E-04	2.599E-03
22	1125.4	.308	6.084E-04	3.194E-03
23	982.7	.313	7.567E-04	3.973E-03
24	906.7	.317	9.500E-04	4.988E-03
25	849.0	.321	1.196E-03	6.280E-03
26	791.4	.325	1.502E-03	7.888E-03
27	733.7	.329	1.878E-03	9.861E-03
28	676.1	.334	2.335E-03	1.226E-02
29	618.4	.338	2.886E-03	1.515E-02
30	560.8	.342	3.552E-03	1.865E-02
31	503.1	.346	4.356E-03	2.287E-02
32	445.5	.350	5.333E-03	2.800E-02
33	387.8	.355	6.530E-03	3.429E-02
34	324.6	.359	8.020E-03	4.211E-02
35	261.3	.363	9.935E-03	5.216E-02
36	214.0	.367	1.251E-02	6.567E-02
37	175.9	.371	1.605E-02	8.424E-02
38	137.7	.376	2.104E-02	1.104E-01
39	100.0	.380	2.844E-02	1.493E-01
40	67.3	.384	4.066E-02	2.135E-01
41	48.2	.388	6.371E-02	3.345E-01
42	39.8	.392	1.061E-01	5.570E-01
43	34.8	.397	1.763E-01	9.255E-01
44	30.9	.401	2.824E-01	1.483E+00
45	27.0	.405	4.343E-01	2.280E+00
46	22.9	.409	6.464E-01	3.394E+00
47	18.1	.413	9.430E-01	4.951E+00
48	12.3	.418	1.381E+00	7.251E+00
49	6.2	.422	2.165E+00	1.137E+01
50	0.0	.426	5.486E+00	2.880E+01

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.216	10000.0
2	.243	5000.0
3	.310	1000.0
4	.361	300.0
5	.363	250.0
6	.369	200.0
7	.374	150.0
8	.380	99.9
9	.384	60.4
10	.390	41.0
11	.412	20.5
12	.423	4.4

Appendix C (continued)

SOIL TYPE 10 - SAMPLE 23 - 86 CM DEPTH -

N = 12 TMAX = .4110 SCON = 2.880E+01 FACTOR = 3.663E+00
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	9320.7	.218	1.995E-07	7.307E-07
2	8641.4	.222	8.291E-07	3.038E-06
3	7962.1	.226	1.960E-06	7.179E-06
4	7282.8	.230	3.681E-06	1.348E-05
5	6603.4	.234	6.108E-06	2.238E-05
6	5924.1	.238	9.396E-06	3.442E-05
7	5315.3	.242	1.376E-05	5.039E-05
8	4887.0	.246	1.944E-05	7.123E-05
9	4608.5	.249	2.669E-05	9.779E-05
10	4369.7	.253	3.570E-05	1.308E-04
11	4130.9	.257	4.666E-05	1.709E-04
12	3892.1	.261	5.981E-05	2.191E-04
13	3653.3	.265	7.542E-05	2.763E-04
14	3414.5	.269	9.383E-05	3.438E-04
15	3175.8	.273	1.155E-04	4.230E-04
16	2937.0	.277	1.408E-04	5.157E-04
17	2698.2	.281	1.704E-04	6.244E-04
18	2459.4	.285	2.052E-04	7.519E-04
19	2220.6	.289	2.462E-04	9.021E-04
20	1981.8	.293	2.949E-04	1.080E-03
21	1743.0	.297	3.531E-04	1.293E-03
22	1504.2	.301	4.237E-04	1.552E-03
23	1265.5	.305	5.111E-04	1.872E-03
24	1067.5	.309	6.223E-04	2.280E-03
25	956.2	.313	7.668E-04	2.809E-03
26	896.0	.316	9.522E-04	3.488E-03
27	841.0	.320	1.184E-03	4.338E-03
28	785.9	.324	1.469E-03	5.380E-03
29	730.9	.328	1.814E-03	6.645E-03
30	675.8	.332	2.229E-03	8.166E-03
31	620.7	.336	2.726E-03	9.986E-03
32	565.7	.340	3.320E-03	1.216E-02
33	510.6	.344	4.032E-03	1.477E-02
34	455.6	.348	4.887E-03	1.790E-02
35	400.5	.352	5.924E-03	2.170E-02
36	344.9	.356	7.196E-03	2.636E-02
37	285.8	.360	8.787E-03	3.219E-02
38	224.6	.364	1.085E-02	3.975E-02
39	165.8	.368	1.369E-02	5.017E-02
40	111.6	.372	1.802E-02	6.601E-02
41	70.0	.376	2.585E-02	9.469E-02
42	46.4	.379	4.258E-02	1.560E-01
43	35.1	.383	7.802E-02	2.858E-01
44	28.0	.387	1.447E-01	5.300E-01
45	21.9	.391	2.607E-01	9.550E-01
46	16.9	.395	4.582E-01	1.679E+00
47	12.7	.399	7.924E-01	2.903E+00
48	8.6	.403	1.377E+00	5.045E+00
49	4.4	.407	2.563E+00	9.390E+00
50	0.0	.411	7.861E+00	2.880E+01

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.214	10000.0
2	.243	5000.0
3	.309	1000.0
4	.359	301.3
5	.362	250.3
6	.365	200.2
7	.369	150.5
8	.372	100.6
9	.376	60.2
10	.380	40.5
11	.392	20.2
12	.407	4.5

Appendix C (continued)

SOIL TYPE 10 - SAMPLE 24 - 116 CM DEPTH

N = 12 TMAX = .4040 SCON = 2.880E+01 FACTOR = 4.669E+00
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	9222.2	.198	2.264E-07	1.057E-06
2	8444.4	.202	9.474E-07	4.423E-06
3	7666.7	.207	2.259E-06	1.054E-05
4	6888.9	.211	4.287E-06	2.002E-05
5	6111.1	.215	7.206E-06	3.364E-05
6	5404.4	.219	1.126E-05	5.256E-05
7	4893.3	.223	1.676E-05	7.823E-05
8	4560.0	.228	2.401E-05	1.121E-04
9	4280.0	.232	3.328E-05	1.554E-04
10	4000.0	.236	4.485E-05	2.094E-04
11	3720.0	.240	5.904E-05	2.756E-04
12	3440.0	.244	7.626E-05	3.560E-04
13	3160.0	.249	9.704E-05	4.530E-04
14	2880.0	.253	1.220E-04	5.697E-04
15	2600.0	.257	1.521E-04	7.101E-04
16	2320.0	.261	1.884E-04	8.796E-04
17	2040.0	.265	2.326E-04	1.086E-03
18	1760.0	.270	2.869E-04	1.340E-03
19	1480.0	.274	3.551E-04	1.658E-03
20	1215.8	.278	4.428E-04	2.067E-03
21	1022.8	.282	5.598E-04	2.613E-03
22	924.6	.286	7.173E-04	3.349E-03
23	865.9	.291	9.238E-04	4.313E-03
24	807.2	.295	1.186E-03	5.539E-03
25	748.6	.299	1.513E-03	7.065E-03
26	689.9	.303	1.915E-03	8.942E-03
27	631.2	.307	2.406E-03	1.123E-02
28	572.6	.312	3.002E-03	1.401E-02
29	513.9	.316	3.726E-03	1.740E-02
30	455.2	.320	4.611E-03	2.153E-02
31	396.6	.324	5.700E-03	2.661E-02
32	336.6	.328	7.059E-03	3.296E-02
33	275.3	.333	8.797E-03	4.107E-02
34	216.7	.337	1.111E-02	5.186E-02
35	166.0	.341	1.436E-02	6.702E-02
36	124.7	.345	1.921E-02	8.969E-02
37	90.2	.349	2.694E-02	1.258E-01
38	64.2	.354	4.033E-02	1.883E-01
39	49.7	.358	6.462E-02	3.017E-01
40	41.9	.362	1.063E-01	4.963E-01
41	37.3	.366	1.722E-01	8.041E-01
42	34.2	.370	2.684E-01	1.253E+00
43	31.2	.375	4.005E-01	1.870E+00
44	28.2	.379	5.759E-01	2.688E+00
45	25.1	.383	8.043E-01	3.755E+00
46	21.9	.387	1.100E+00	5.134E+00
47	17.6	.391	1.484E+00	6.929E+00
48	12.2	.396	2.012E+00	9.391E+00
49	6.1	.400	2.879E+00	1.344E+01
50	0.0	.404	6.169E+00	2.880E+01

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.194	10000.0
2	.221	5000.0
3	.281	1000.0
4	.331	301.6
5	.334	250.0
6	.338	200.0
7	.342	150.2
8	.348	100.2
9	.353	60.4
10	.362	40.3
11	.390	20.1
12	.401	4.5

Appendix C (continued)

SOIL TYPE 10 - SAMPLE 25 - 138 CM DEPTH

N = 12 TMAX = .4280 SCON = 2.880E+01 FACTOR = 2.562E+00
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	9192.9	.207	2.729E-07	6.991E-07
2	8385.7	.211	1.144E-06	2.931E-06
3	7578.6	.216	2.734E-06	7.006E-06
4	6771.4	.220	5.207E-06	1.334E-05
5	5964.3	.225	8.788E-06	2.252E-05
6	5243.8	.229	1.380E-05	3.536E-05
7	4717.6	.234	2.066E-05	5.294E-05
8	4320.0	.238	2.979E-05	7.634E-05
9	3943.3	.243	4.163E-05	1.067E-04
10	3566.7	.247	5.673E-05	1.453E-04
11	3190.0	.252	7.581E-05	1.942E-04
12	2813.3	.256	9.988E-05	2.559E-04
13	2436.7	.261	1.304E-04	3.340E-04
14	2060.0	.265	1.695E-04	4.343E-04
15	1683.3	.270	2.208E-04	5.656E-04
16	1321.8	.274	2.904E-04	7.442E-04
17	1057.1	.279	3.904E-04	1.000E-03
18	940.5	.283	5.364E-04	1.374E-03
19	890.4	.288	7.393E-04	1.894E-03
20	840.3	.292	1.006E-03	2.577E-03
21	790.1	.297	1.343E-03	3.442E-03
22	740.0	.301	1.762E-03	4.514E-03
23	689.9	.306	2.273E-03	5.823E-03
24	639.7	.310	2.889E-03	7.403E-03
25	589.6	.315	3.629E-03	9.299E-03
26	539.5	.320	4.515E-03	1.157E-02
27	489.3	.324	5.574E-03	1.428E-02
28	439.2	.329	6.844E-03	1.754E-02
29	389.0	.333	8.378E-03	2.147E-02
30	337.2	.338	1.025E-02	2.626E-02
31	280.0	.342	1.257E-02	3.220E-02
32	219.2	.347	1.555E-02	3.985E-02
33	165.6	.351	1.965E-02	5.033E-02
34	124.8	.356	2.568E-02	6.581E-02
35	91.1	.360	3.515E-02	9.005E-02
36	64.9	.365	5.128E-02	1.314E-01
37	50.8	.369	8.022E-02	2.055E-01
38	43.5	.374	1.290E-01	3.306E-01
39	38.6	.378	2.049E-01	5.249E-01
40	35.6	.383	3.145E-01	8.059E-01
41	32.9	.387	4.641E-01	1.189E+00
42	30.2	.392	6.604E-01	1.692E+00
43	27.5	.396	9.121E-01	2.337E+00
44	24.8	.401	1.231E+00	3.153E+00
45	22.0	.405	1.632E+00	4.180E+00
46	18.7	.410	2.137E+00	5.476E+00
47	14.4	.414	2.792E+00	7.154E+00
48	9.7	.419	3.710E+00	9.506E+00
49	4.9	.423	5.264E+00	1.349E+01
50	0.0	.428	1.124E+01	2.880E+01

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.202	10000.0
2	.230	5000.0
3	.278	1000.0
4	.341	301.2
5	.344	250.0
6	.348	200.0
7	.352	150.2
8	.359	100.2
9	.364	60.4
10	.375	40.2
11	.409	20.0
12	.424	4.5

Appendix C (continued)

SOIL TYPE 10 - SAMPLE 26 - 166 CM DEPTH

N = 12 TMAX = .4000 SCON = 2.880E+01 FACTOR = 5.800E+00
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	9261.5	.212	1.873E-07	1.086E-06
2	8523.1	.216	7.815E-07	4.532E-06
3	7784.6	.220	1.857E-06	1.077E-05
4	7046.2	.223	3.509E-06	2.035E-05
5	6307.7	.227	5.867E-06	3.403E-05
6	5595.2	.231	9.107E-06	5.282E-05
7	5022.3	.235	1.347E-05	7.812E-05
8	4650.4	.239	1.922E-05	1.115E-04
9	4365.9	.243	2.658E-05	1.541E-04
10	4081.5	.246	3.576E-05	2.074E-04
11	3797.0	.250	4.704E-05	2.728E-04
12	3512.6	.254	6.074E-05	3.523E-04
13	3228.1	.258	7.727E-05	4.482E-04
14	2943.7	.262	9.716E-05	5.635E-04
15	2659.3	.266	1.211E-04	7.022E-04
16	2374.8	.269	1.499E-04	8.697E-04
17	2090.4	.273	1.851E-04	1.073E-03
18	1805.9	.277	2.282E-04	1.324E-03
19	1521.5	.281	2.822E-04	1.637E-03
20	1247.0	.285	3.516E-04	2.039E-03
21	1042.5	.289	4.442E-04	2.576E-03
22	947.7	.292	5.691E-04	3.301E-03
23	903.0	.296	7.328E-04	4.250E-03
24	858.2	.300	9.392E-04	5.447E-03
25	813.4	.304	1.193E-03	6.918E-03
26	768.6	.308	1.499E-03	8.695E-03
27	723.8	.312	1.864E-03	1.081E-02
28	679.0	.316	2.296E-03	1.332E-02
29	634.2	.319	2.803E-03	1.626E-02
30	589.5	.323	3.397E-03	1.970E-02
31	544.7	.327	4.092E-03	2.373E-02
32	499.9	.331	4.904E-03	2.844E-02
33	455.1	.335	5.856E-03	3.396E-02
34	410.3	.339	6.977E-03	4.046E-02
35	365.5	.342	8.306E-03	4.817E-02
36	318.1	.346	9.898E-03	5.741E-02
37	259.2	.350	1.184E-02	6.867E-02
38	192.3	.354	1.433E-02	8.309E-02
39	136.0	.358	1.784E-02	1.035E-01
40	93.3	.362	2.341E-02	1.358E-01
41	62.2	.365	3.352E-02	1.944E-01
42	46.1	.369	5.363E-02	3.110E-01
43	39.2	.373	9.057E-02	5.253E-01
44	35.1	.377	1.504E-01	8.724E-01
45	31.9	.381	2.386E-01	1.384E+00
46	28.7	.385	3.612E-01	2.095E+00
47	25.5	.388	5.265E-01	3.054E+00
48	18.6	.392	7.460E-01	4.327E+00
49	7.8	.396	1.093E+00	6.340E+00
50	0.0	.400	4.966E+00	2.880E+01

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.208	10000.0
2	.234	5000.0
3	.288	1000.0
4	.348	300.2
5	.351	250.0
6	.353	200.0
7	.356	151.5
8	.361	100.0
9	.364	60.0
10	.371	40.1
11	.395	20.0
12	.396	4.5

Appendix C (continued)

SOIL TYPE 10 - SAMPLE 27 - 186 CM DEPTH

N = 12 TMAX = .4080 SCON = 2.880E+01 FACTOR = 7.414E+00
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	9233.3	.205	2.212E-07	1.640E-06
2	8466.7	.209	9.247E-07	6.855E-06
3	7700.0	.213	2.202E-06	1.633E-05
4	6933.3	.218	4.175E-06	3.095E-05
5	6166.7	.222	7.007E-06	5.195E-05
6	5460.7	.226	1.093E-05	8.101E-05
7	4942.5	.230	1.623E-05	1.203E-04
8	4617.5	.234	2.322E-05	1.722E-04
9	4358.7	.238	3.213E-05	2.382E-04
10	4100.0	.242	4.321E-05	3.203E-04
11	3841.2	.247	5.672E-05	4.205E-04
12	3582.5	.251	7.301E-05	5.413E-04
13	3323.7	.255	9.251E-05	6.858E-04
14	3065.0	.259	1.157E-04	8.579E-04
15	2806.2	.263	1.433E-04	1.062E-03
16	2547.5	.267	1.761E-04	1.306E-03
17	2288.7	.271	2.153E-04	1.596E-03
18	2030.0	.276	2.624E-04	1.945E-03
19	1771.2	.280	3.195E-04	2.368E-03
20	1512.5	.284	3.898E-04	2.890E-03
21	1254.7	.288	4.785E-04	3.547E-03
22	1048.1	.292	5.939E-04	4.403E-03
23	940.9	.296	7.472E-04	5.540E-03
24	883.0	.300	9.469E-04	7.020E-03
25	825.0	.305	1.199E-03	8.890E-03
26	767.0	.309	1.512E-03	1.121E-02
27	709.1	.313	1.894E-03	1.404E-02
28	651.1	.317	2.359E-03	1.748E-02
29	593.2	.321	2.920E-03	2.165E-02
30	535.2	.325	3.598E-03	2.668E-02
31	477.2	.329	4.421E-03	3.277E-02
32	419.3	.333	5.425E-03	4.022E-02
33	361.3	.338	6.665E-03	4.941E-02
34	300.9	.342	8.225E-03	6.097E-02
35	238.5	.346	1.025E-02	7.600E-02
36	184.2	.350	1.303E-02	9.663E-02
37	144.1	.354	1.708E-02	1.266E-01
38	112.0	.358	2.318E-02	1.719E-01
39	82.5	.362	3.274E-02	2.427E-01
40	59.6	.367	4.885E-02	3.622E-01
41	46.5	.371	7.727E-02	5.728E-01
42	39.5	.375	1.251E-01	9.277E-01
43	35.4	.379	1.995E-01	1.479E+00
44	32.2	.383	3.068E-01	2.274E+00
45	29.0	.387	4.539E-01	3.365E+00
46	25.8	.391	6.500E-01	4.819E+00
47	22.3	.396	9.083E-01	6.733E+00
48	16.6	.400	1.251E+00	9.271E+00
49	8.3	.404	1.767E+00	1.310E+01
50	0.0	.408	3.885E+00	2.880E+01

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.201	10000.0
2	.228	5000.0
3	.292	1000.0
4	.342	300.0
5	.345	250.4
6	.348	200.3
7	.353	150.2
8	.360	100.8
9	.365	60.0
10	.373	40.0
11	.399	20.0
12	.405	4.5

Appendix C (continued)

SOIL TYPE 9 - SAMPLE 28 - 16 CM DEPTH -

N = 12 TMAX = .5030 SCON = 1.850E+02 FACTOR = 5.366E-01
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	7938.9	.139	9.199E-07	4.936E-07
2	6072.2	.147	4.311E-06	2.313E-06
3	4738.5	.154	1.195E-05	6.413E-06
4	3887.6	.162	2.641E-05	1.417E-05
5	3181.0	.169	5.090E-05	2.731E-05
6	2474.3	.177	9.058E-05	4.860E-05
7	1767.6	.184	1.560E-04	8.368E-05
8	1185.3	.191	2.748E-04	1.474E-04
9	863.4	.199	5.116E-04	2.745E-04
10	689.4	.206	9.539E-04	5.118E-04
11	527.1	.214	1.721E-03	9.234E-04
12	372.2	.221	3.060E-03	1.642E-03
13	245.1	.228	5.603E-03	3.006E-03
14	160.0	.236	1.099E-02	5.896E-03
15	104.8	.243	2.289E-02	1.228E-02
16	67.1	.251	5.045E-02	2.707E-02
17	48.2	.258	1.158E-01	6.211E-02
18	41.1	.266	2.465E-01	1.322E-01
19	37.4	.273	4.659E-01	2.500E-01
20	35.2	.280	7.915E-01	4.247E-01
21	33.1	.288	1.237E+00	6.635E-01
22	30.9	.295	1.817E+00	9.750E-01
23	28.8	.303	2.553E+00	1.370E+00
24	26.6	.310	3.468E+00	1.861E+00
25	24.5	.317	4.593E+00	2.464E+00
26	22.3	.325	5.965E+00	3.201E+00
27	20.5	.332	7.637E+00	4.098E+00
28	19.3	.340	9.661E+00	5.184E+00
29	18.6	.347	1.208E+01	6.483E+00
30	17.8	.355	1.493E+01	8.012E+00
31	17.1	.362	1.825E+01	9.792E+00
32	16.3	.369	2.208E+01	1.185E+01
33	15.6	.377	2.646E+01	1.420E+01
34	14.8	.384	3.146E+01	1.688E+01
35	14.1	.392	3.713E+01	1.992E+01
36	13.3	.399	4.356E+01	2.337E+01
37	12.5	.407	5.082E+01	2.727E+01
38	11.8	.414	5.903E+01	3.167E+01
39	11.0	.421	6.830E+01	3.665E+01
40	10.3	.429	7.879E+01	4.228E+01
41	9.5	.436	9.068E+01	4.866E+01
42	8.8	.444	1.042E+02	5.591E+01
43	8.0	.451	1.197E+02	6.420E+01
44	7.3	.458	1.374E+02	7.373E+01
45	6.5	.466	1.580E+02	8.476E+01
46	5.8	.473	1.820E+02	9.768E+01
47	5.1	.481	2.106E+02	1.130E+02
48	4.7	.488	2.449E+02	1.314E+02
49	3.4	.496	2.860E+02	1.535E+02
50	0.0	.503	3.448E+02	1.850E+02

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.132	10000.0
2	.150	5000.0
3	.192	1000.0
4	.224	300.0
5	.227	250.4
6	.231	200.3
7	.236	150.2
8	.244	100.8
9	.249	60.0
10	.264	40.0
11	.333	20.0
12	.486	4.5

Appendix C (continued)

SOIL TYPE 9 - SAMPLE 29 - 36 CM DEPTH -

N = 12 TMAX = .3480 SCON = 1.850E+02 FACTOR = 1.231E+01
SURTEN =73.49 DENWAT = .999 VISWAT =.113800 RESWAT = .100 TEMP = 15.0 C

EXPONENT = 2.00 GRAVITY = 980.0 ACF = 2.094E+06

CLASS (I)	PRESSURE (CM WATER)	THETA (BY VOL)	CALCULATED K (CM/DAY)	SAT MATCH (CM/DAY)
1	8910.5	.145	2.039E-07	2.510E-06
2	7821.1	.149	8.721E-07	1.073E-05
3	6731.6	.153	2.145E-06	2.640E-05
4	5713.5	.158	4.239E-06	5.217E-05
5	4940.5	.162	7.472E-06	9.197E-05
6	4443.8	.166	1.222E-05	1.504E-04
7	4049.5	.170	1.882E-05	2.316E-04
8	3655.2	.174	2.766E-05	3.404E-04
9	3261.0	.178	3.925E-05	4.831E-04
10	2866.7	.182	5.431E-05	6.684E-04
11	2472.4	.187	7.387E-05	9.092E-04
12	2078.1	.191	9.950E-05	1.225E-03
13	1683.8	.195	1.338E-04	1.647E-03
14	1309.9	.199	1.815E-04	2.234E-03
15	1032.9	.203	2.517E-04	3.098E-03
16	888.8	.207	3.570E-04	4.394E-03
17	801.0	.211	5.088E-04	6.262E-03
18	713.2	.216	7.179E-04	8.836E-03
19	625.4	.220	9.995E-04	1.230E-02
20	537.6	.224	1.376E-03	1.693E-02
21	449.8	.228	1.881E-03	2.315E-02
22	364.6	.232	2.571E-03	3.164E-02
23	286.9	.236	3.546E-03	4.365E-02
24	223.7	.240	4.987E-03	6.138E-02
25	181.2	.245	7.188E-03	8.846E-02
26	153.6	.249	1.052E-02	1.295E-01
27	131.3	.253	1.543E-02	1.900E-01
28	110.5	.257	2.250E-02	2.769E-01
29	89.7	.261	3.263E-02	4.016E-01
30	71.1	.265	4.748E-02	5.844E-01
31	58.3	.269	6.984E-02	8.596E-01
32	50.7	.273	1.031E-01	1.269E+00
33	45.0	.278	1.507E-01	1.855E+00
34	40.4	.282	2.166E-01	2.665E+00
35	37.5	.286	3.048E-01	3.752E+00
36	35.4	.290	4.191E-01	5.158E+00
37	33.3	.294	5.625E-01	6.923E+00
38	31.2	.298	7.387E-01	9.092E+00
39	29.2	.302	9.524E-01	1.172E+01
40	27.1	.307	1.209E+00	1.488E+01
41	25.0	.311	1.516E+00	1.866E+01
42	22.9	.315	1.881E+00	2.316E+01
43	20.6	.319	2.317E+00	2.852E+01
44	18.1	.323	2.839E+00	3.494E+01
45	15.4	.327	3.475E+00	4.276E+01
46	12.7	.331	4.267E+00	5.252E+01
47	10.0	.336	5.295E+00	6.517E+01
48	7.3	.340	6.708E+00	8.256E+01
49	4.1	.344	8.882E+00	1.093E+02
50	0.0	.348	1.503E+01	1.850E+02

INPUT DATA FOR THE ABOVE OUTPUT

J	THETA	PRESSURE
1	.141	10000.0
2	.160	5000.0
3	.202	1000.0
4	.235	300.0
5	.239	250.0
6	.241	200.0
7	.249	150.2
8	.259	100.0
9	.267	60.0
10	.281	40.0
11	.319	20.8
12	.344	4.5

Appendix D

ENGINEERING PROPERTIES OF SOILS

Appendix D

ENGINEERING PROPERTIES OF SOILS

2720 NOLENSVILLE ROAD • NASHVILLE, TENNESSEE 37211 • (615) 256-6891
GEOTEK
ENGINEERING COMPANY

ORNL-DWG 84-1351

Log Of Boring

Job No. 81-1020KK

Client: Union Carbide Corporation
Project: Burial Ground 7, X-10 Plant

Location of Boring:	
Water Level	
Time	
Date	

Boring No. 1 Date 3-28-83 Sheet 1 of 1
Type of Boring 4½" Auger Rig Mobile B-53
Casing used ____ Size ____ Drilling mud used ____
Boring begun ____ Boring completed ____
Ground Elevation ____ referred to ____ Datum
Field Party: Tatum & Robinson

Rock Data: Length cored Ft.	Recovery Ft.	% Recovery	Drilling Time, min.	% Drill Water Return	R Q D %	Soil Data: Sample Type*	Sample No.	Blows per 6" Drive	N-Value	Description of soil or rock & notes on drilling operation
										6" topsoil
						N	100.5	6		
								6		Brown silty clay and weathered
								7		shale
								10	17	
						N	102.5	6		
								25		
								39		
								39	78	
						N	104.5	11		
								17		
								31	48	
						N	106.0	50	=4"	Spoon refusal @ 6.3', no recovery
						N	106.5	50	=5"	Spoon refusal @ 6.9'
						N	108.5	10		
								14		
								23		
								49	72	
										Auger refusal @ 12.0'
										From 12.0' to end of boring @ 68.0' Interbedded shale and limestone layers (cuttings from air rotary drilling)

Depth in feet: 0–20

* N = Standard Penetration S = Shelby Tube

Appendix D (continued)

2720 NOLENSVILLE ROAD • NASHVILLE, TENNESSEE 37211 • (615) 256-6891
GEOTEK
ENGINEERING COMPANY

112

ORNL–DWG 84-1350

Log Of Boring

Job No. 81-1020KK

Client Union Carbide Corporation
Project Burial Ground 7, X-10 Plant

Boring No. 2 Date 3-28-83 Sheet 1 of 1
Type of Boring 4½" Auger Rig Mobile B-53
Casing used ____ Size ____ Drilling mud used ____
Boring begun ____ Boring completed ____
Ground Elevation ____ referred to ____ Datum
Field Party: Tatum & Robinson

Location of Boring:	
Water Level	
Time	
Date	

Rock Data: Length cored Ft.	Recovery Ft.	% Recovery	Drilling Time, min	% Drill Water Return	R Q D %	Soil Data: Sample Type*	No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
										0		
												6" topsoil
										1		
						N	201.0	4				Brown silty clay and weathered
								4		2		shale
								12				Red clayey silt seam
								11	23	3		
						N	203.0	17				Reddish brown silty clay and
								26		4		weathered shale
								28				
								50	78	5		
						N	205.0	10				
								9		6		Brown silty clay and weathered shale
								12				
								13	25	7		
						N	207.0	5				
								7		8		Dark reddish brown silty clay and
								7				weathered shale
								10	17	9		
										10		
										11		
										12		
										13		
										14		
												Auger refusal @ 15.0'
										15		
										16		From 15.0' to end of boring @ 68.0' Interbedded limestone and shale layers (cuttings from air rotary drilling)
										17		
										18		
										19		
										20		

* N = Standard Penetration, S = Shelby Tube

Appendix D (continued)

112

2720 NOLENSVILLE ROAD • NASHVILLE, TENNESSEE 37211 • (615) 256-6891
GEOTEK
ENGINEERING COMPANY

ORNL–DWG 84-1349

Log Of Boring

Job No. 81-1020KK

Client Union Carbide Corporation

Project Burial Ground 7, X-10 Plant

Boring No. 3 Date 3-29-83 Sheet 1 of 1

Type of Boring 4½" Auger Rig Mobile B-53

Casing used ___ Size ___ Drilling mud used ___

Boring begun ___ Boring completed ___

Ground Elevation ___ referred to ___ Datum

Field Party: Tatum & Robinson

Location of Boring:	
Water Level	
Time	
Date	

Rock Data						Soil Data						
Length cored Ft.	Recovery Ft.	% Recovery	Drilling Time, min.	% Drill Water Return	R Q D %	Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
										0		6" topsoil
										1		
						N	301.0	6				Dark brown silty clay w/shale and
								11				black flecs
								9		2		
								11	18	3		
						N	303.0	16				
								15		4		Brown silty clay w/weathered shale
								28				
								27	55	5		
						N	305.0	47				
								50	=6"	6		Spoon refusal @ 6.0' on shale
						A	306.0					Auger sample
										7		Spoon refusal @ 7.0'
						N	307.0	50	=6"			Grayish brown hard weathered shale
										8		
						N	308.0	29				
								43		9		
								50	=3"			Spoon refusal @ 9.3'
										10		
						A	310.0					Auger sample
										11		
										12		
										13		
										14		Auger refusal @ 14.5' in weathered shale
										15		From 14.5' to end of boring @ 68.0' Interbedded limestone and shale layers (cuttings from air rotary drilling)
										16		
										17		
										18		
										19		
										20		

* N - Standard Penetration S - Shelby Tube

Appendix D (continued)

112

2720 NOLENSVILLE ROAD • NASHVILLE, TENNESSEE 37211 • (615) 256-6891
GEOTEK
ENGINEERING COMPANY

ORNL-DWG 84-1348

Log Of Boring

Job No. 81-1020KK

Client: Union Carbide Corporation
Project: Burial Ground 7, X-10 Plant

Location of Boring:

Water Level	
Time	
Date	

Boring No. 4 Date 3-29-83 Sheet 1 of 1
Type of Boring 4½" Auger Rig Mobile B-53
Casing used ____ Size ____ Drilling mud used ____
Boring begun ____ Boring completed ____
Ground Elevation ____ referred to ____ Datum
Field Party: Tatum & Robinson

Type*	No	Blows per 6" Drive	N-Value	Depth in feet	Description of soil or rock & notes on drilling operation
				0	6" topsoil
N	401.0	10		1	
		14		2	Brown silty clay w/weathered shale
		16			
		40	56	3	
N	403.0	46			
		50	=5"	4	Spoon refusal @ 3.9'
N	405.0	50	=2"	5	Spoon refusal @ 5.2'
				6	
				7	Gray brown silty clay w/ weathered shale - Spoon refusal @ 7.3'
N	407.0	50	=4"		
				8	
				9	
N	410.0	50	=2"	10	Spoon refusal @ 10.2'
				11	
				12	
				13	
				14	
N	415.0	50	=3"	15	Spoon refusal @ 15.2'
				16	
				17	
				18	Auger refusal @ 18.5'
				19	From 18.5' to end of boring @ 68.0' Interbedded shale and limestone layers (cuttings from air rotary drilling)

Rock Data columns (Length cored Ft., Recovery Ft., % Recovery, Drilling Time min., % Drill Water Return, R Q D %): blank.

* N = Standard Penetration, S = Shelby Tube

Appendix D (continued)

Log Of Boring

ORNL–DWG 84-1358

Project SWSA-7	Boring No B5 Date ______ Sheet 1 of 2
Location of Boring:	Type of Boring Auger Rig ______
	Casing used ______ Size ______ Drilling mud used ______
	Boring begun ______ Boring completed ______
	Ground Elevation ______ referred to ______ Datum
	Field Party ORNL P&E

Water Level	
Time	
Date	

Rock Data: Length cored Ft	Recovery Ft	% Recovery	Drilling Time min	% Drill Water Return	R Q D %	Soil Data: Sample Type*	Sample No	Blows per 6" Drive	N Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
								12 =	18"	0		
									12	1		
								30 =	18"	2		
									20	3		
								315=	18"			
									210	4		
								131=	18"	5		
									87	6		
								170=	18"	7		
									113			
								100=	18"	8		
									67	9		
								95=	18"	10		
									63			
								87	18"	11		
									58	12		
								46=	18"	13		
									31			
								26=	18"	14		
									17	15		
								40=	18"	16		
									27			
								130=	18"	17		
									87	18		
								65=	18"	19		
									43			
								110=	18"	20		

* N = Standard Penetration, S – Shelby Tube

Appendix D (continued)

Log Of Boring

ORNL–DWG 84-1356

Project SWSA-7

Location of Boring	
Water Level	
Time	
Date	

Boring No. B5 Date ______ Sheet 2 of 2
Type of Boring Auger Rig ______
Casing used ______ Size ______ Drilling mud used ______
Boring begun ______ Boring completed ______
Ground Elevation ______ referred to ______ Datum
Field Party ORNL P&E

Rock Data: Length cored Ft	Recovery Ft	% Recovery	Drilling Time min	% Drill Water Return	R Q D %	Soil Data: Sample Type*	Sample No	Blows per 6 Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
										20		
									73	21		
								95=	18"			
										22		
									63			
								70=	18"	23		
									47	24		
								65=	18"			
										25		
									43			
								100=	18"	26		
									67	27		
								55=	18"			
										28		
									37			
								62=	18"	29		
									41	30		
								75=	6"			
								150=	4"	31		
										32		
										3		
										4		
										5		
										6		
										7		
										8		
										9		
										0		

* N = Standard Penetration, S - Shelby Tube

Appendix D (continued)

Log Of Boring

ORNL–DWG 84-1357

Project ORNL SWSA-7

Location of Boring:	
Water Level	
Time	
Date	

Boring No. B6 Date ____ Sheet 1 of 1
Type of Boring Auger Rig ____
Casing used ____ Size ____ Drilling mud used ____
Boring begun ____ Boring completed ____
Ground Elevation ____ referred to ____ Datum
Field Party: ORNL P&E

Length cored Ft	Recovery Ft	% Recovery	Drilling Time min	% Drill Water Return	R Q D %	Type*	No	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
								35=	18"	0		
									23	1		
								170=	18"	2		
									113	3		
								69=	18"			
									45	4		
								150=	18"	5		
									100	6		
								124	18"	7		
									83			
								389=	18"	8		
									259	9		
								432=	18"			
									288	0		
										1		
										2		
										3		
										4		
										5		
										6		
										7		
										8		
										9		
										0		

* N = Standard Penetration S - Shelby Tube

FIG. 1 GRAIN SIZE DISTRIBUTION

Geotek Project No. ______ Date 4-14-83
Project Union Carbide Burial Ground #7

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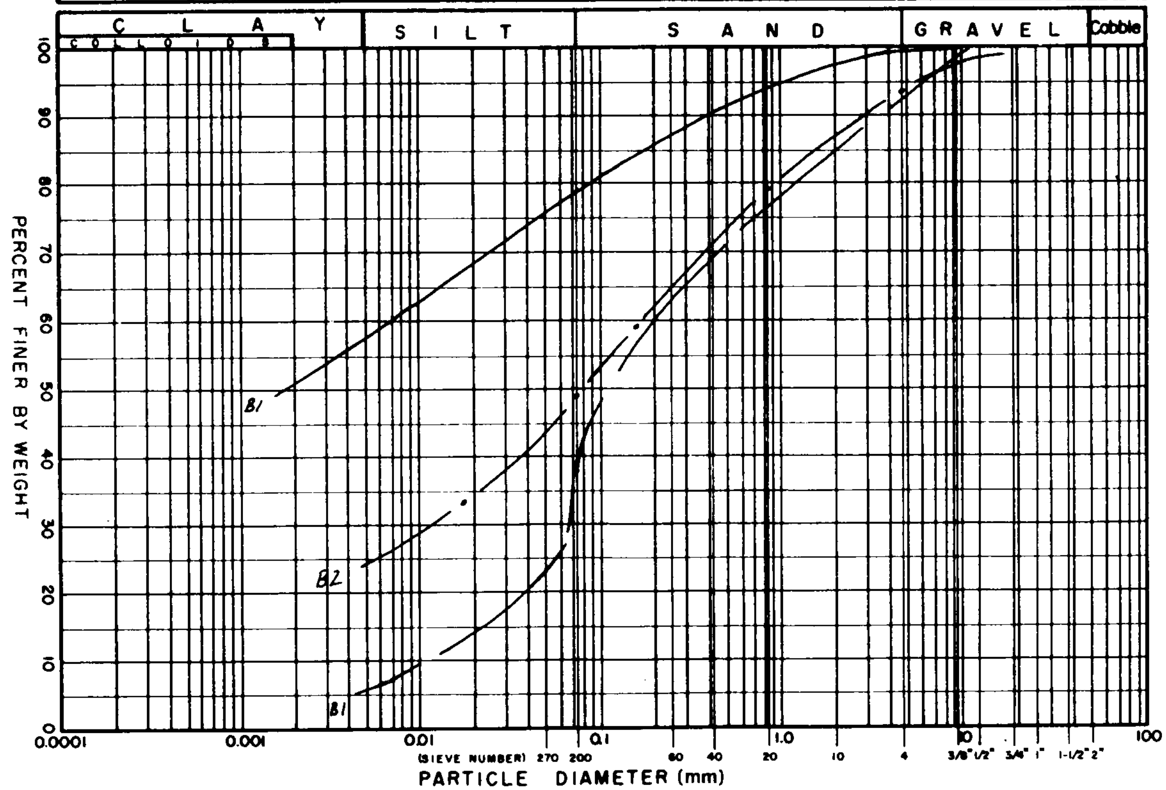
Sample No.	Depth, ft.	Line Symbol	Textural Classification
B1	.5 - 2.5	————	brown silty clay
B1	6.5 - 6.9	— — —	brown silty clay w/ weathered shale
B2	1.0 - 3.0	—·—	brown silty clay w/ weathered shale
		—··—	



ORNL-DWG 84-1353

FIG. 2 **GRAIN SIZE DISTRIBUTION**

Geotek Project No. ______ Date 4-14-83

Project Union Carbide, Burial Ground #7

Sample No.	Depth, ft.	Line Symbol	Textural Classification
B2	5.0 - 7.0	————	brown silty clay w/ weathered shale
B3	1.0 - 3.0	—— ——	brown silty clay w/ weathered shale
B3	3.5 - 5.0	—— · ——	brown silty clay w/ weathered shale
		—— ·· ——	

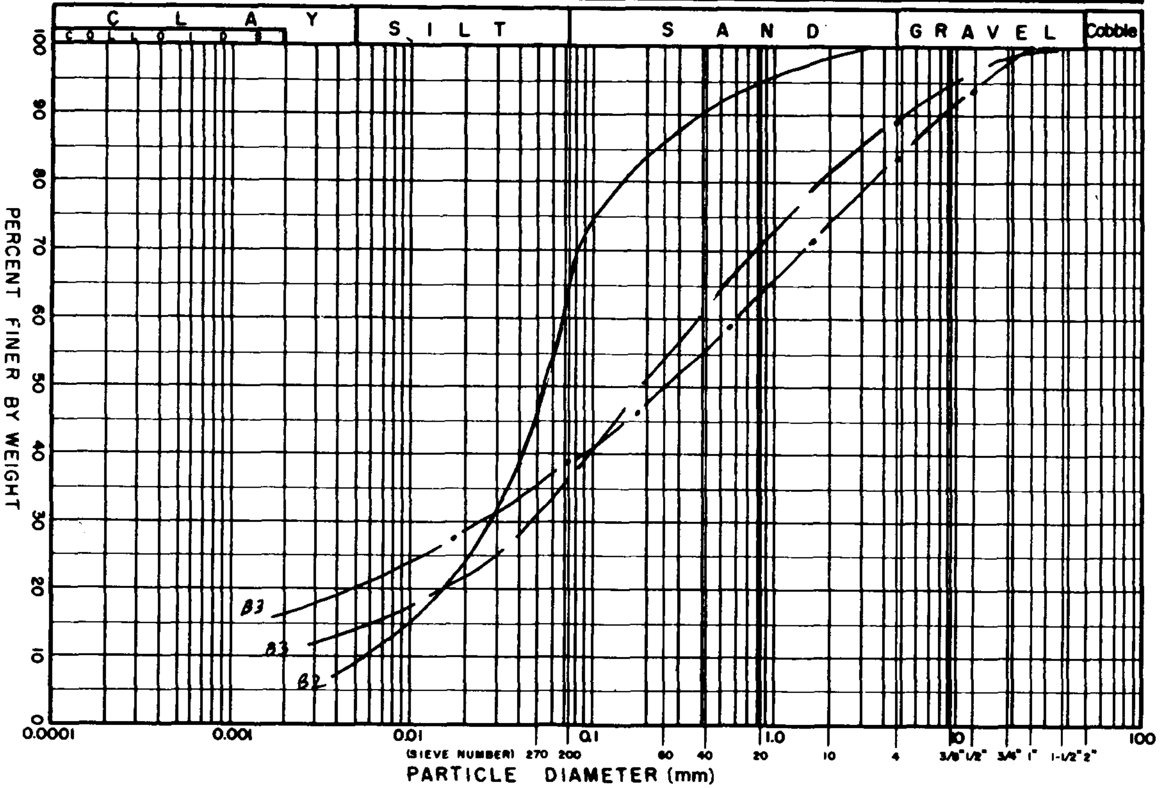


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FIG. 3 GRAIN SIZE DISTRIBUTION

Geotek Project No. ________ Date 4-14-83
Project Union Carbide Burial Ground #7

Sample No.	Depth, ft.	Line Symbol	Textural Classification
B3	8.0 - 9.3	————	brown silty clay w/ weathered shale
B4	1.0 - 3.0	— —	gray brown silty clay w/ weathered shale
B4	3.0 - 3.9	—·—	brown silty clay w/ weathered shale
		—··—	

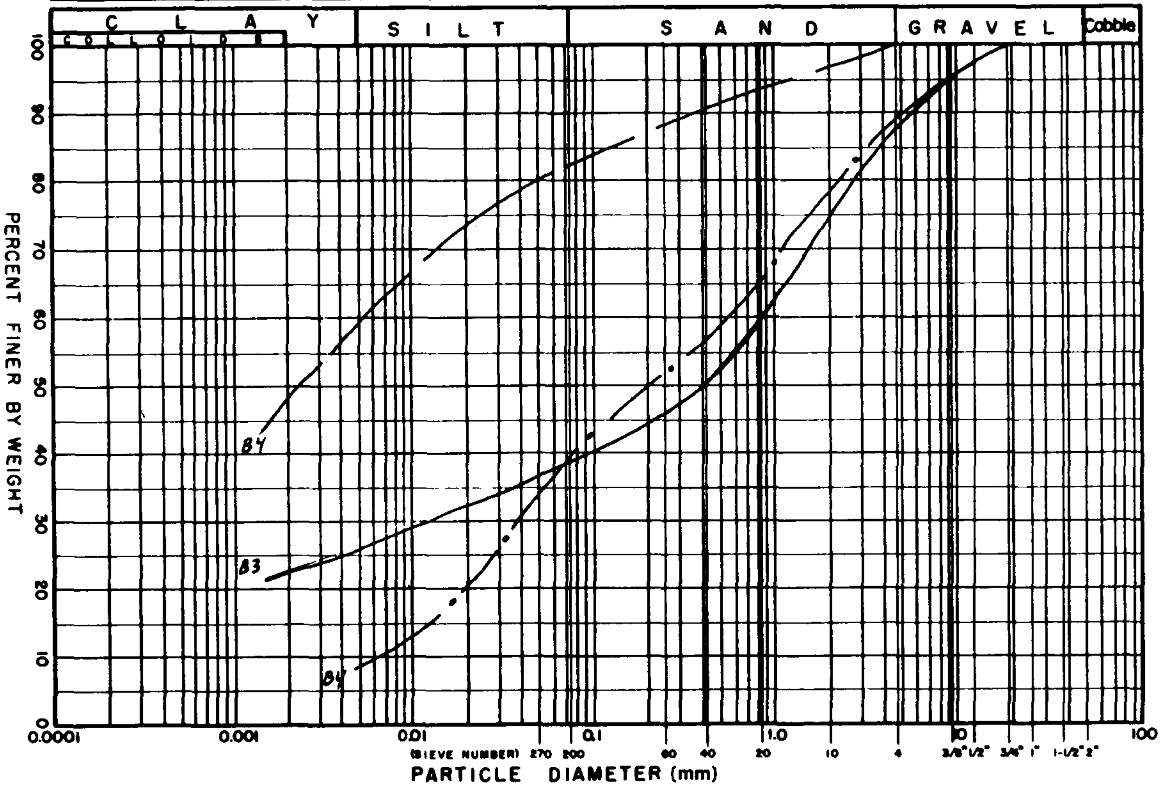

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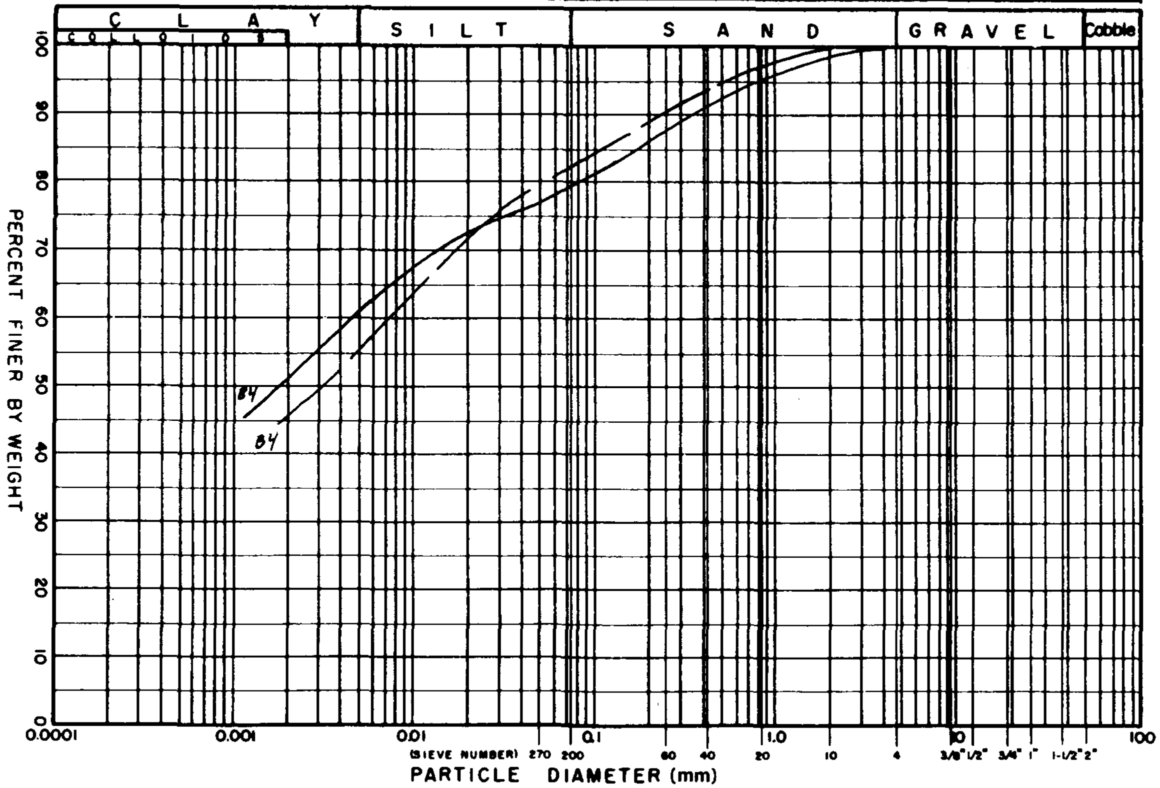
FIG. 4 **GRAIN SIZE DISTRIBUTION**

Geotek Project No. ________ Date 4-14-83

Project Union Carbide, Burial Ground #7

Sample No.	Depth, ft.	Line Symbol	Textural Classification
B4	5.0 - 5.2	———	tan silty clay w/shale
B4	7.0 - 7.3	— — —	gray brown weathered shale
		— · —	
		— ·· —	



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