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Analysis of Soil Morphology and Long-Term Water Table Records from a Miamian-Kokomo Drainage Sequence in Central Ohio

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TED M. ZOBECK[1] **and ALEXANDER RITCHIE, JR.**[2]

INTRODUCTION

Soils are often placed in a natural drainage class based on the frequency and duration of periods when the soil is free of saturation or partial saturation (16). The natural drainage classes found in Ohio include excessively well-drained, well-drained, moderately well-drained, somewhat poorly drained, poorly drained, and very poorly drained soils. Excessively well-drained soils are usually coarse-textured and occur in topographic positions which promote rapid surface and internal drainage. In well-drained soils, water is removed readily from the soil but not rapidly; in moderately well-drained soils, on the other hand, water is removed from the soil somewhat slowly so that the profile is wet for a small but insignificant part of the time. Water is removed slowly enough from somewhat poorly drained soils to keep them wet for significant periods, but not all of the time. Water is at or near the surface during a considerable part of the year in poorly drained soils, and remains at or on the surface most of the time in very poorly drained soils.

In Ohio, soils are placed into one of the natural drainage classes based upon assumed relationships between the depth of an apparent ground water table and certain soil morphological features, such as depth to mottling or gray soil colors. Many predictions of soil behavior or response to certain management techniques are based, in part, upon the natural drainage class. Therefore, an accurate estimation of the natural drainage class is essential to correctly predict soil behavior.

Water table depth is a dynamic soil feature which fluctuates greatly from year to year and throughout the year when measured in the same soil or in different soils. Most studies relating soil properties to observed water table depths have been based on short-term data, usually two or three seasons, while few studies span 4 or more years. The results of water table observations from an extensive system of observation wells located throughout The Netherlands in the period 1952-1956 were used to predict mean highest and mean lowest water table levels for the entire country (23). Soils were placed into one of seven water table classes, based on combinations of mean high and low water table levels. Fritton and Olson (7) described the range in water table depths for 17 New York soils over a 7-year period, but statistical analyses of the data were not included. Water table depths also have been measured over a 4-year period in a drainage sequence of medium textured soils in Indiana (22). The authors related duration of saturation and drying to soil genesis and listed the length of time water stood above specified levels in each soil.

The general relationship between the depth of an apparent water table and the depth to mottling or gray soil colors has long been known (20). Many different techniques and theories to further define this relationship and predict water table depth through time have subsequently been described. Some studies have related soil properties to observed water table depths (3, 6, 7, 8, 14, 22). Other studies have employed regression analyses based on measured or inferred water table depths and soil characteristics to predict future water table fluctuations (2, 4, 5, 10, 11, 12). Simonson and Boersma (15) also used this technique to relate soil color value, chroma, and mottling to the amount of time the water table was above a specific horizon. Other studies have suggested that total saturation of the soil is not necessary for the formation of gray soil colors or manganese coatings in some soils (24, 25, 26).

These studies have contributed greatly to the understanding of the relationship of soil properties to water table depths. However, because there is no generally accepted systematic method of describing water table depth, comparisons between different soils have been difficult. Recently, scientists of the National Cooperative Soil Survey have proposed a method of characterizing soil wetness classes in terms of saturation depth and duration (18). This method provides more information than is currently available for most soil series.

The purpose of this study was to analyze long-term water table depth data for a drainage sequence of soils in central Ohio and correlate the results with soil morphological features. A graphical method of conveying water table information is suggested. In addition, the long-term nature of the water table depth observations reported in this study make it possible to examine dif-

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ferences in water table depth estimates due to differences in study duration.

MATERIALS AND METHODS

The study area is located in the Eyman Estate Woods in Fayette County, Ohio (Fig. 1). The woods consist of a mature mixed oak forest occupying a nearly level portion of the undissected Wisconsin Till Plain (21). Overstory vegetation includes white oak (*Quercus alba* L.), hickory (*Carya* spp.), white ash (*Fraxinus americana* L.), swamp white oak (*Q. bicolor* Willd.), black oak (*Q. velutina* Lam.), and black walnut (*Juglans nigra* L.). Understory vegetation includes elm (*Ulmus* spp.), black cherry (*Prunus serotina* Ehrh.), redbud (*Cercis canadensis* L.), sugar maple (*Acer saccharum* Marsh.), ash (*Fraxinus* spp.), hawthorne (*Crataegus* spp.), and viburnum (*Viburnum* spp.).

A wooded site was chosen because it best corresponds to the vegetation under which most Ohio soils have formed. Changes in soil water content caused by agricultural practices are recent alterations relative to the total age of the soil and are not considered to have caused a significant change in genetic soil properties.

Four study plots were located on soils with different natural drainage classes, and ground water wells were installed in 1960 by the Ohio Department of Natural Resources, Division of Soil and Water Conservation.[3] Two types of wells were installed (Fig. 2). Both wells were made of 2-cm ID PVC pipe. Well Type A pipes, perforated below a depth of 20 cm and encased in a gravel envelope to allow infiltration throughout the entire length, were installed to a depth of 105 cm in Soils 1, 2, and 3. Well Type A pipes in Soil 4 were installed to a depth of 165 cm in an effort to intercept water occurring throughout the deeper solum. Well Type B pipes, perforated only in the lower 30 cm, were installed to a depth of 165 cm in all soils. The lower 30 cm of well Type B pipes were isolated from the remainder of the pipe by layers of cement, bentonite and sand mixes, and packed earth. Well Type A was

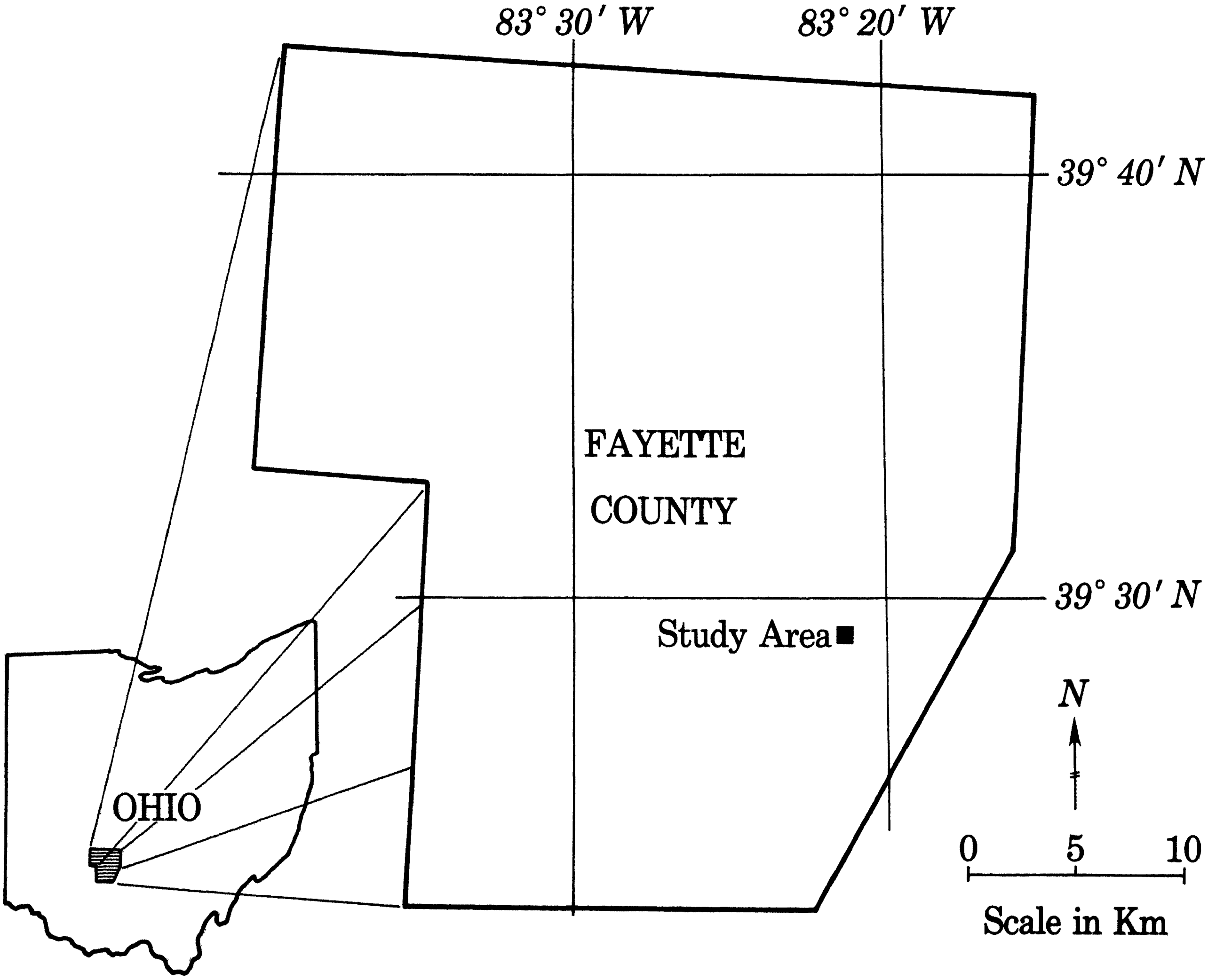

FIG. 1.—Location of the study area in Fayette County, Ohio.

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[3] Formerly the Division of Lands and Soils

designed to intercept and indicate the depth to water tables as measured in unlined boreholes. Well Type B was designed to measure water tables which occur deeper in the substratum, isolated from continuous pores occurring in the subsoil.

The depth to water was measured throughout the entire year from 1962 to 1971. Water levels were observed from 3 to more than 10 times a month, with larger numbers of observations taken during the wet portions of the year. Water levels reported in this bulletin represent average readings of all wells of the indicated well type for each 2-week time period. Water table values for Soils 1 and 2 represent averages from three Type A and one Type B well. Water table values for Soil 3 were averages of six Type A and two Type B wells, and for Soil 4 were averages of three Type A and two Type B wells. Each pipe was inspected and repaired when damaged. Precipitation was measured in an adjacent clearing with a standard U. S. Weather Bureau rain gauge at the same time water levels were measured. Statistical analyses of the data consisted of an analysis of variance procedure followed by Duncan's multiple range test provided on the Statistical Analysis System (13).

Subsequent to water table readings, the soil in each

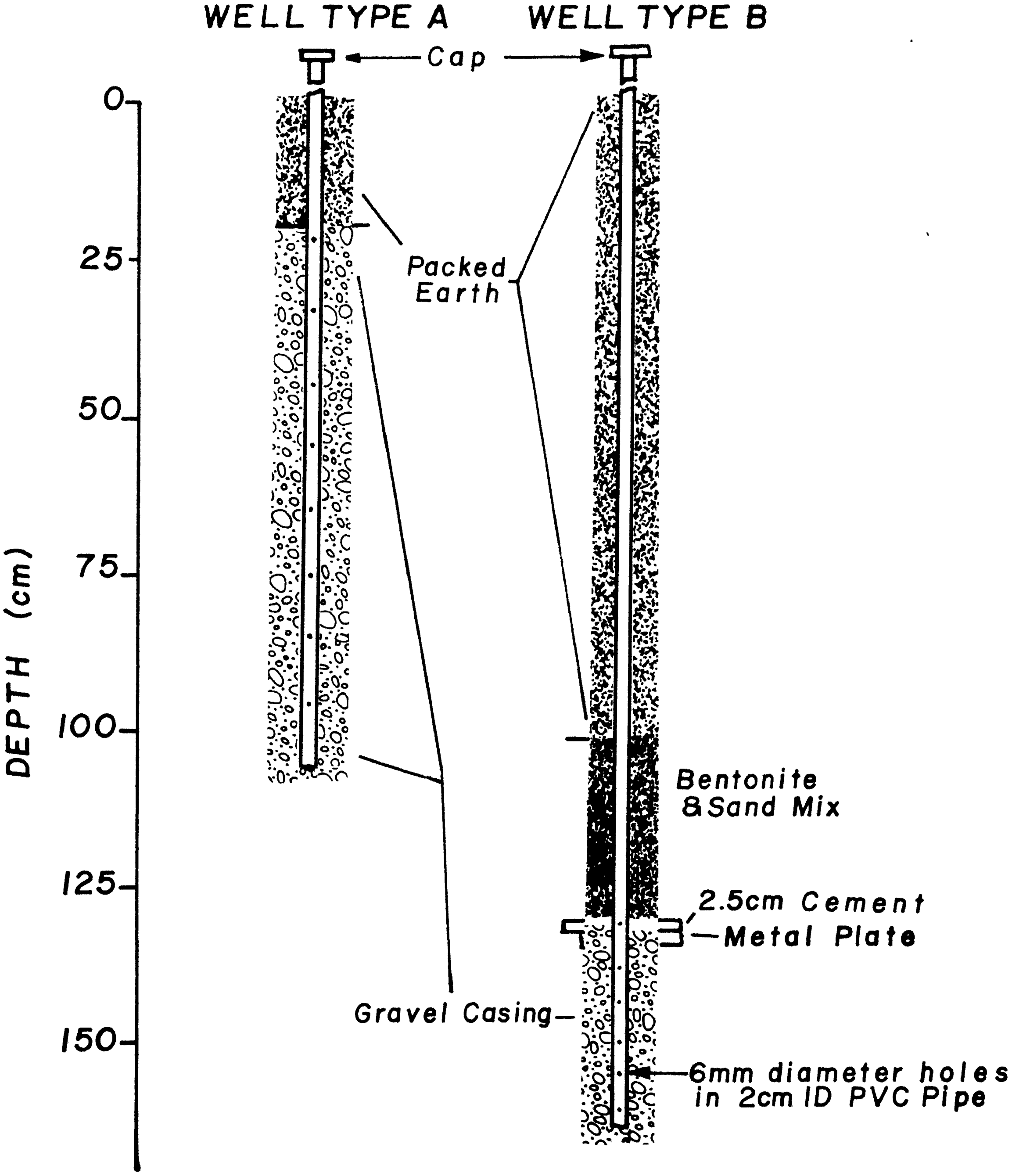

FIG. 2.—Schematic diagram of well types used to observe water table depths.

plot was excavated, sampled, and described according to standard procedures (16, 18). The saran-coated clod method was used to determine bulk density, and the pipette method was used to determine the particle size distribution of all soil materials (<2 mm). Thin sections were prepared from soil clods impregnated with Scotchcast electrical resin No. 3 as described by Innes and Pluth (9).

RESULTS AND DISCUSSION

Soils Studied

The soils observed in this study were in close proximity to each other (110-m maximum separation) and formed a drainage sequence related to landscape position (Fig. 3). Soil 1 was located on the highest landscape position and was well drained. Soil 2 was 53 cm lower in elevation than Soil 1 and was moderately well drained. Soil 3 was 79 cm lower in elevation than Soil 2 and was poorly drained. Soil 4 was 60 cm lower in elevation than Soil 3 and was very poorly drained. The drainage differences were reflected in the classification of each soil studied.

The soils were classified according to Soil Taxonomy (17) as follows: Soil 1 — Miamian silt loam; fine, mixed, mesic Typic Hapludalf; Soil 2 — Celina silt loam; fine, mixed, mesic Aquic Hapludalf; Soil 3 — fine-loamy, mixed, nonacid, mesic Aeric Haplaquept; Soil 4 — Kokomo Variant silt loam; fine, mixed, mesic Typic Haplaquoll. Soil 3 was not similar to any currently recognized soil series. Soil 4 was similar to the Kokomo series, but was more acid in the subsoil, lacked an argillic horizon, and had slightly different colors in the lower part of the subsoil.

All soils were developed in Wisconsin age glacial till under a forest vegetation so that any differences between the soils were related to variations in relief and concomitant variations in drainage. A schematic cross-section of the landscape (Fig. 3) reveals several important morphological differences which affect or have been affected

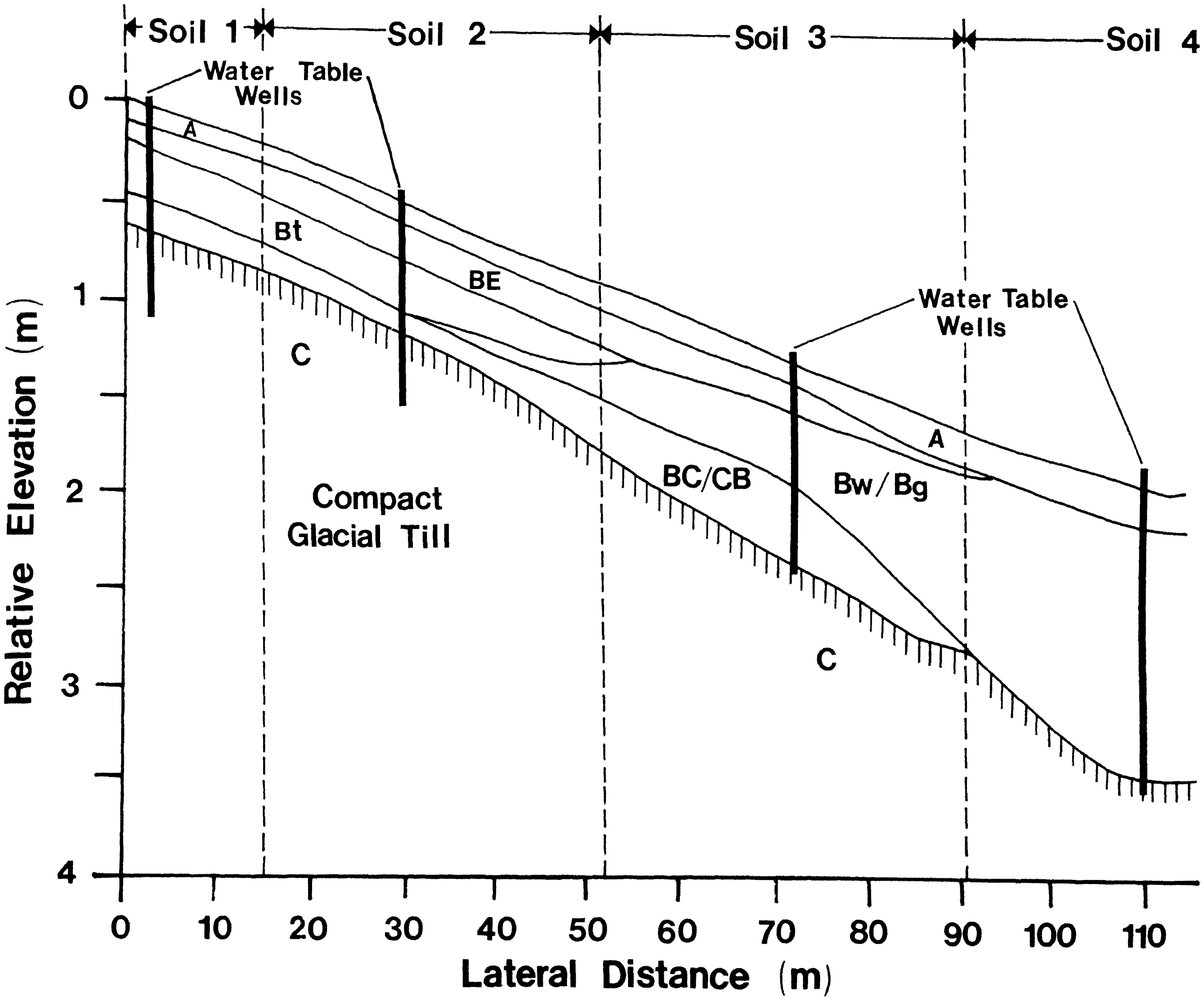

FIG. 3.—Cross-section of the four study soils. Vertical exaggeration, 20 times.

by water table differences.

The thickness of the solum increased with increasing soil wetness. The A horizons were thickest in Soil 4 and thinnest in Soil 2 (see Table 1 and Appendix A for detailed descriptions). This difference was accompanied by the absence of an eluvial BE horizon in Soil 4 and the thickest BE horizon being observed in Soil 2. The difference in the thickness of the A horizons was probably due to the effects of erosion occurring on Soils 1 and 2, causing sediment deposition on Soils 3 and 4. In addition, the rate of organic matter decomposition may have been slower in Soils 3 and 4 compared to Soils 1 and 2 due to longer periods of saturation (see page 9). The differences in the thickness of the E and BE horizons may be related to differences in weathering caused by fluctuating water levels. However, the proof of this hypothesis is beyond the scope of this study.

The differences in solum thickness had a profound effect on water movement due to differences in soil structure and density between the B and C horizons. The structure of the B horizons was prismatic and subangular blocky, and the structure of the C horizons was massive in all soils (Table 1). The structure differences coincide with generally lower bulk densities in the B horizons than in the C horizons. Bouma and Anderson (1) found good agreement between estimates of water movement (hydraulic conductivity), calculated from the width and length of voids between structural units and field-measured hydraulic conductivity. The prismatic and subangular blocky structure of the B horizons contained many conductive pores and did not severely restrict water movement compared to the compact glacial till substratum. Since the B horizons extended to greater depths in the sequence Soil 1 <Soil 2 <Soil 3 <Soil 4, it is reasonable to assume water percolating through these soils was restricted by the C

TABLE 1.—Selected Physical and Morphological Features of the Four Soils Under Study.

Horizon	Depth (cm)	Texture	Particle Size Distribution (% < 2 mm)			Structure	⅓-Bar Bulk Density (g/cm^3)	Organic Matter (%)
			Sand	Silt	Clay			
				Soil 1—Typic Hapludalf				
A	0-10	sil	20.8	64.0	15.2	2fgr		5.1
BE	10-20	sil	20.8	58.3	20.9	1msbk		1.0
Bt1	20-35	sicl	17.5	46.3	36.2	2msbk	1.7	1.0
Bt2	35-48	sic	16.0	41.8	42.2	1mpr/2msbk	1.4	1.7
BC	48-61	sicl	17.8	49.7	32.5	1msbk		0.0
C1	61-84	sil	25.6	53.5	20.9	m		0.0
C2	84-122	sil	30.6	50.6	18.8	m	1.8	0.0
				Soil 2—Aquic Hapludalf*				
A	0-8	sli				2fgr		
E	8-20	sil				1msbk		
BE	20-30	sicl				2msbk		
Bt1	30-46	cl				1msbk/2msbk		
Bt2	46-56	l				1msbk		
BC	56-66	l				1msbk		
C1	66-89	l				m		
C2	89-114	l				m		
				Soil 3—Aeric Haplaquept				
A1	0-5	sil	16.7	61.3	22.0	2fgr		7.1
A2	5-13	sil	19.6	60.8	19.6	1fsbk		2.6
BEg	13-23	sicl	17.8	54.3	27.9	1msbk	1.5	1.7
Bg	23-38	sicl	15.0	46.4	38.6	1mpr/2fsbk		1.8
Bw	38-64	sicl	18.4	43.6	38.0	2mpr/2msbk	1.4	1.4
BC	64-81	cl	28.2	44.5	27.3	1msbk		0.0
CB	81-99	l	30.6	49.2	20.2	1fsbk		0.0
C1	99-127	l	33.9	47.6	18.5	m	1.7	0.0
				Soil 4—Typic Haplaquoll				
A1	0-8	sicl	15.0	54.4	30.6	2mgr		7.3
A2	8-20	sicl	15.4	51.9	32.7	2fsbk		4.0
Bw1	20-43	sicl	13.6	46.2	40.2	1mpr/2msbk	1.4	2.6
Bw2	43-64	sic	10.8	43.9	45.3	1mpr/1msbk		1.7
Bg3	64-89	sic	9.9	47.7	42.4	1mpr/1msbk	1.5	1.0
B'w1	89-104	sicl	14.6	46.8	38.6	1mpr/1msbk		0.6
B'w2	104-119	cl	21.2	44.2	34.6	1mpr/1msbk	1.5	0.7
Bw3	119-152	sicl	16.7	48.8	34.5	1mpr/1msbk		1.0
C	152-168	l	29.3	45.3	25.4	m		0.0

*Soil 2 was not sampled.

TABLE 2.—Soil Matrix, Mottles, and Coatings Color and Type of the Four Soils Under Study.*

Horizon	Depth (cm)	Moist Color	Mottle 1 Color	Mottle 1 Type	Mottle 2 Color	Mottle 2 Type	Surface 1 Coating Color	Surface 1 Coating Type†	Surface 2 Coating Color	Surface 2 Coating Type†
				Soil 1—Typic Hapludalf (Well-drained)						
A	0-10	10YR 3/2								
BE	10-20	10YR 5/3					10YR 4/2	om		
Bt1	20-35	10YR 4/4					10YR 5/3	cl	10YR 5/4	cl
Bt2	35-48	7.5YR 4/4					10YR 4/3	cl	10YR 5/3	cl
BC	48-61	10YR 4/3	10YR 5/4	f1f	10YR 6/3	f1f	10YR 4/2	cl	10YR 4/3	cl
C1	61-64	10YR 5/3	10YR 5/2	m3f	10YR 5/6	c2d	10YR 4/2	un		
C2	64-84	10YR 4/4	10YR 6/2	m2d	10YR 5/6	f1d	10YR 5/2	un	10YR 6/2	calc
				Soil 2—Aquic Hapludalf (Moderately Well-drained)						
A	0-8	10YR 3/2								
E	8-20	10YR 5/3					10YR 3/2	om	10YR 5/4	si
BE	20-30	10YR 4/4					10YR 5/3	un	10YR 6/3	si
Bt1	30-46	10YR 4/4					10YR 4/3	cl	10YR 5/3	cl
Bt2	46-56	10YR 4/4	10YR 5/6	f1d	10YR 4/2	f1d	10YR 4/3	cl	10YR 5/3	cl
BC	56-66	10YR 4/3	10YR 5/2	c2f	10YR 5/6	c2d	10YR 5/3	un	10YR 6/2	calc
C1	66-89	10YR 5/4	10YR 5/2	m2d	10YR 5/6	c2d	10YR 6/2	calc		
C2	89-114	10YR 4/4	2.5Y 6/0	c2d	10YR 5/6	c2d	10YR 6/2	calc		
				Soil 3—Aeric Haplaquept (Poorly Drained)						
A1	0-5	10YR 3/2								
A2	5-13	10YR 3/2	10YR 5/2	f1f	10YR 5/6	f1d				
BEg	13-23	10YR 5/2	10YR 6/2	f1f	5YR 4/3	f1p				
Bg	23-38	10YR 4/2	10YR 5/4	f1f	10YR 5/2	c2f	10YR 4/1	cl	10YR 5/1	cl
Bw	38-64	10YR 5/4	7.5YR 5/6	m2d	10YR 5/2	c2f	10YR 4/1	cl		
BC	64-81	10YR 5/4	7.5YR 5/6	m3d	10YR 5/2	c2f	10YR 5/1	un		
CB	81-99	10YR 5/6	10YR 5/2	c2d			10YR 4/3	un		
C1	99-127	10YR 5/6	10YR 5/2	c2d						
				Soil 4—Typic Haplaquoll (Very Poorly Drained)						
A1	0-8	10YR 3/1								
A2	8-20	10YR 3/1	10YR 4/3	c1f						
Bw1	20-43	10YR 3/1	10YR 4/3	c1f			10YR 3/2	un		
Bw2	43-64	10YR 3/1	10YR 4/3	c1f	2.5Y 4/2	f1d	10YR 3/2	un		
Bg	64-89	2.5Y 4/2	10YR 4/4	f1d	10YR 5/2	f1d	2.5Y 4/2	un	10YR 3/2	om
B'w1	89-104	10YR 5/6	2.5Y 5/2	c2d	2.5Y 4/2	f1d	2.5Y 5/2	un	10YR 3/1	kr
B'w2	104-119	10YR 5/6	2.5Y 5/2	m2d	10YR 6/1	f1d	2.5Y 5/2	un	10YR 3/1	kr
Bw3	119-152	10YR 5/6	2.5Y 5/2	c1d	10YR 6/1	f1d	2.5Y 5/2	Mn	10YR 3/1	kr
C	152-168	10YR 5/6	2.5Y 5/2	m2d			10YR 3/1	Mn		

*Abbreviations according to Soil Survey Manual (16).

†Surface features attributed to the following: om = organic matter, cl = clay film, un = unidentifiable, calc = calcium carbonate, Mn = manganese

horizon and flowed laterally through the B horizons towards Soil 4. A similar analysis has been reported for comparable soils in Indiana (8).

Considerable differences in the colors of soil matrices, mottles, and coatings occurred between soils (Table 2). Although the colors of Soils 1 and 2 were similar, 4 2 colors occurred as ped coatings in Soil 1 but as mottles in Soil 2 at a similar depth. The difference in classification between Soils 1 and 2 was due to the depth of the argillic horizon. The top of the argillic in Soil 2 was deep enough that 4/2 mottles occurred within the upper 25 cm, placing the soil in the Aquic Hapludalfs subgroup. In addition, low chroma mottles were observed closer to the soil surface in soils with wetter soil moisture regimes. Soil 4 was excluded from this analysis because dark organic coatings masked low chroma mottles near the soil surface. The reasons for these differences will be discussed in another section.

Finally, differences between soils were also noted in the occurrence of argillic horizons. Only Soils 1 and 2 had argillic horizons. Although each soil had the necessary 20% increase in clay between the eluvial and the illuvial horizons (Table 1), only Soils 1 and 2 had observable argillans in thin sections. Smeck *et al.* (19) have previously reported and discussed a lack of argillic horizon formation in very poorly drained soils similar to Soils 3 and 4. Part of the clay accumulation in Soils 3 and 4 may have been caused by additions of loamy sediment in runoff from adjacent slopes over finer-textured material, resulting in a relative increase in clay content with depth.

Apparent and Perched Water Tables

Water tables are often called perched water tables when zones of saturated soil form above zones of unsaturated soil. Apparent water tables occur when soils are continuously saturated throughout the entire profile. In this study the water table wells were used to estimate both apparent and perched water table depths. Water table observation Type A wells were designed to intercept water present in the soil regardless of its location. The water table levels measured therefore indicate the highest level of free water. Type B wells, perforated only in the lower 30 cm, were designed to measure deeper zones of saturation. The precise location of the zone of saturation was not measured by the experimental design. More Type B wells at various depths would be needed to make this measurement. Comparisons of the depths to the water table observed in Type A and Type B wells on a given date were made to determine the relative location of saturated zones in the soil.

The depths to a water table were averaged on a semimonthly (2-week period) basis over the 10-year study period. The results of this analysis (Fig. 4) indicate that perched water tables occurred in Soils 1, 2, and 3 during mid-December through mid-April, but only from mid-December through February in Soil 4. The entire profile was considered saturated, suggesting an apparent water table, when the curves coincide. When the curves do not coincide, and the wells were not dry, a perched water table was suggested by unsaturated soil horizons between zones of saturated soil. The wells were usually dry from July through November. When the wells were dry in Soils 1, 2, and 3, the curves do not coincide due to differences in the depths of the observation wells. In Soil 4 this difference was not observed when both types of observation wells were installed to a depth of 165 cm.

The differences in water table height may also be the result of differences in soil permeability. Well Type A had the perforated portion in the shallower, more permeable part of the soil than well Type B. Higher water table levels in Type A wells, for a given date, may have reflected more rapid responses to rainfall or snowmelt due to the higher permeability. Since the wells were not pumped out after each measurement, and tensiometers were not used to measure soil moisture tension, this possibility was not evaluated.

Annual Fluctuations in Water Table Depth

Comparisons of all soils simultaneously, using Duncan's multiple range test provided on Statistical Analysis System computer programs (13), for each well type suggest significant differences in water table depths occurred during April and May (Table 3). Comparisons of well Type A data indicate Soil 4 was significantly different ($P < 0.05$) from Soils 1, 2, and 3 for most of the year. In the summer months these differences were due to the depth of the observation wells; that is, Type A observation wells were installed to a depth of 165 cm in Soil 4. This difference was not observed when all wells were similar (see Table 3, well Type B). Statistical analysis of the data (Table 3) also revealed that only during the month of April did significant differences ($P < 0.05$) occur between the water table depths of all four soils. During the first 2 weeks of May, Soils 1 and 2 did not have significantly different water table depths; however, they were significantly different from Soils 3 and 4.

Reliability of Water Table Information as Affected by Study Duration

Although this study spanned 10 years, in many other studies time and economic considerations do not usually allow long-term data collection. In an effort to estimate the reliability of shorter term measurements, the 10-year average water table depths and precipitation data were compared to all consecutive 5-, 4-, 3-, 2- and 1-year intervals. Comparisons were made by calculating the average water table depths for each possible combination of consecutive shorter term time intervals. For example, the 5-year intervals were made using averages of years 1-5, 2-6, 3-7, 4-8, 5-9, and 6-10 for each 2-week period of the year. To visualize the gross differences in long-term and shorter term studies, comparisons were made of the percent deviation of shorter term water table depths from the long-term averages. This was done by calculating the difference between each shorter term average and the 10-year average, multiplying by 100, and dividing by the 10-year average to obtain the percent deviation of the shorter term water table measurement from the long-term average. The largest deviations of all possible shorter term combinations

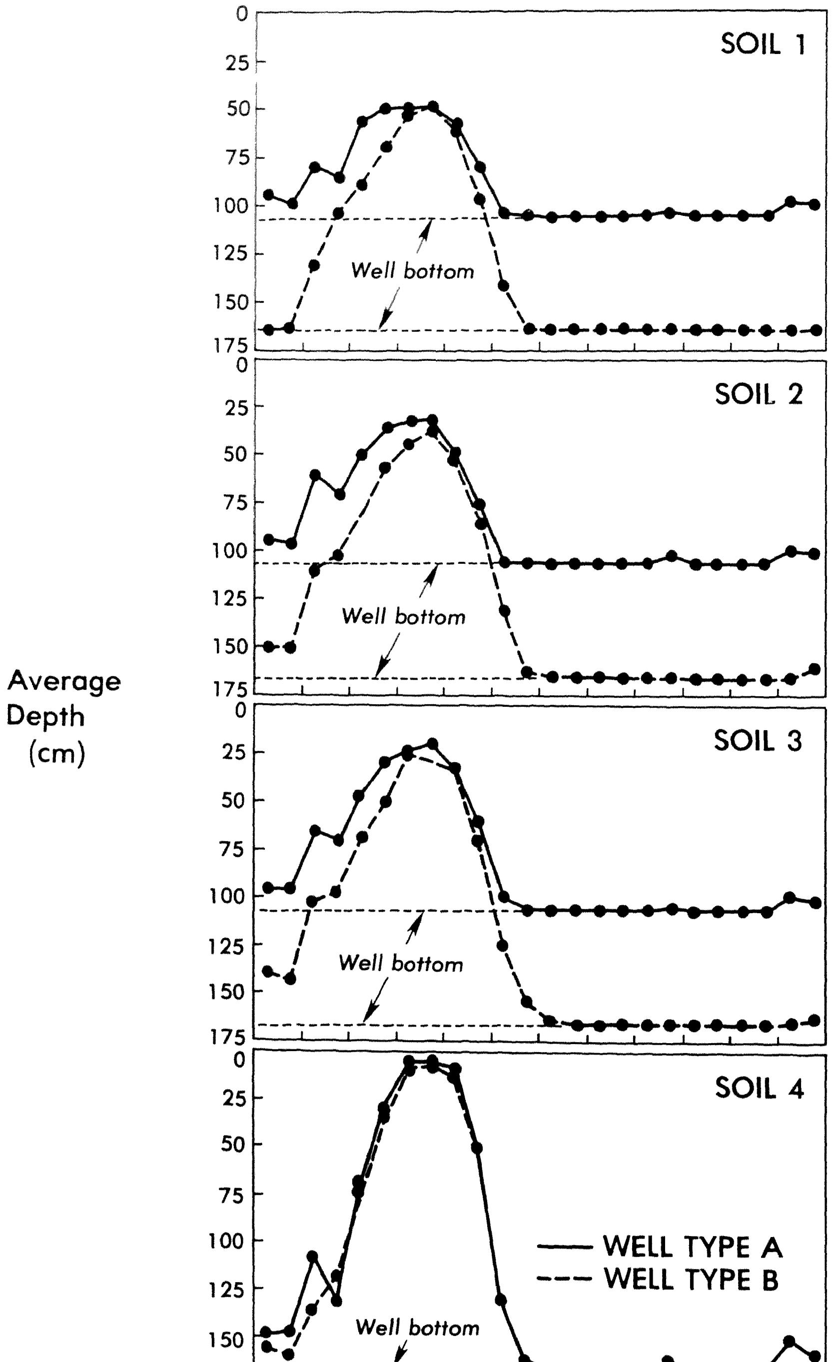

FIG. 4.—Ten-year average water table depths and precipitation by 2-week intervals.

TABLE 3.—Ten-Year Average Water Table Depths and Relative Level of Significance by 2-Week Periods.

Month	2-Week Period No.	Well Type A Soil 1	Well Type A Soil 2	Well Type A Soil 3	Well Type A Soil 4	Well Type B Soil 1	Well Type B Soil 2	Well Type B Soil 3	Well Type B Soil 4
		cm							
J	1	94b*	89b	91b	147a	165a	150ab	140b	157ab
	2	99b	94b	91b	145a	165a	150bc	145c	160ab
F	3	79b	61c	66c	107a	132a	112ab	102b	135a
	4	86b	71b	71b	130a	109a	104a	97a	117a
M	5	58a	48a	46a	69a	89a	81a	69a	74a
	6	51a	36b	28b	28b	69a	56a	51a	36a
A	7	48a	33b	23c	5d	53a	43b	25c	8d
	8	48a	33b	20c	5d	48a	38b	20c	5d
M	9	58a	48a	33b	13c	61a	51b	33c	13d
	10	81a	76a	64b	51c	94a	84b	69c	48d
J	11	104b	104b	99b	127a	142a	132b	124c	130bc
	12	—†	—	—	163	165a	163a	155b	160a
J	13	—	—	—	—	—	—	163	—
	14	—	—	—	—	—	—	—	—
A	15	—	—	—	—	—	—	—	—
	16	—	—	—	—	—	—	—	—
S	17	—	—	—	—	—	—	—	—
	18	104b	102b	104b	160a	—	—	—	—
O	19	—	—	—	—	—	—	—	—
	20	—	—	—	—	—	—	—	—
N	21	—	—	—	—	—	—	—	—
	22	—	—	—	165	—	—	—	—
D	23	97b	97b	97b	150a	168a	165ab	163b	165ab
	24	99b	99b	99b	157a	—	160ab	147a	163b

*Means with the same letter are not significantly different ($P < 0.05$). Comparisons are only valid within well type.
†Dash indicates the well was dry.

TABLE 4.—Deviations of Average Water Table Depth Measurements for Short-Term Studies Compared to 10-Year Average Values.

Month	2-Week Period No.	Soil 1						Soil 2						Soil 3						Soil 4					
		10	5	4	3	2	1	10	5	4	3	2	1	10	5	4	3	2	1	10	5	4	3	2	1
		cm						cm						cm						cm					
J	1	165	△†	△	△	△	▲	150	△	▲	▲	□	○	140	△	▲	▲	□	○	157	△	△	△	▲	○
	2	165	△	△	△	△	▲	150	△	△	▲	□	○	145	△	△	▲	▲	○	160	△	△	▲	▲	○
F	3	135	▲	▲	□	□	■	112	▲	□	■	○	○	102	▲	□	■	○	○	135	▲	▲	□	■	○
	4	109	▲	▲	■	○	○	104	▲	▲	□	○	○	97	▲	▲	■	○	○	117	▲	□	○	○	○
M	5	89	▲	□	○	○	○	81	△	▲	■	■	○	69	▲	□	○	○	○	74	□	○	○	○	○
	6	69	△	▲	□	■	○	56	△	▲	▲	□	○	51	▲	□	○	○	○	36	▲	□	■	○	○
A	7	53	△	△	△	△	▲	46	△	△	△	△	△	25	△	△	△	△	△	8	△	△	△	△	△
	8	51	△	△	△	△	▲	38	△	△	△	△	▲	20	△	△	△	△	▲	5	△	△	△	△	△
M	9	61	△	▲	▲	□	□	51	△	▲	▲	▲	□	33	△	▲	▲	▲	▲	13	△	△	△	△	▲
	10	94	▲	□	■	■	■	84	▲	□	■	■	○	69	▲	□	■	○	○	48	▲	□	□	○	○
J	11	142	△	▲	□	■	■	132	△	▲	□	■	■	124	▲	▲	□	■	■	130	△	▲	▲	□	○
	12	165	△	△	△	△	▲	163	△	△	△	△	▲	155	△	△	▲	▲	▲	163	△	△	△	△	▲

†△ = 0–12cm; ▲=13–25cm; □=26–39cm; ■ = 40–50cm; ○ = > 50cm

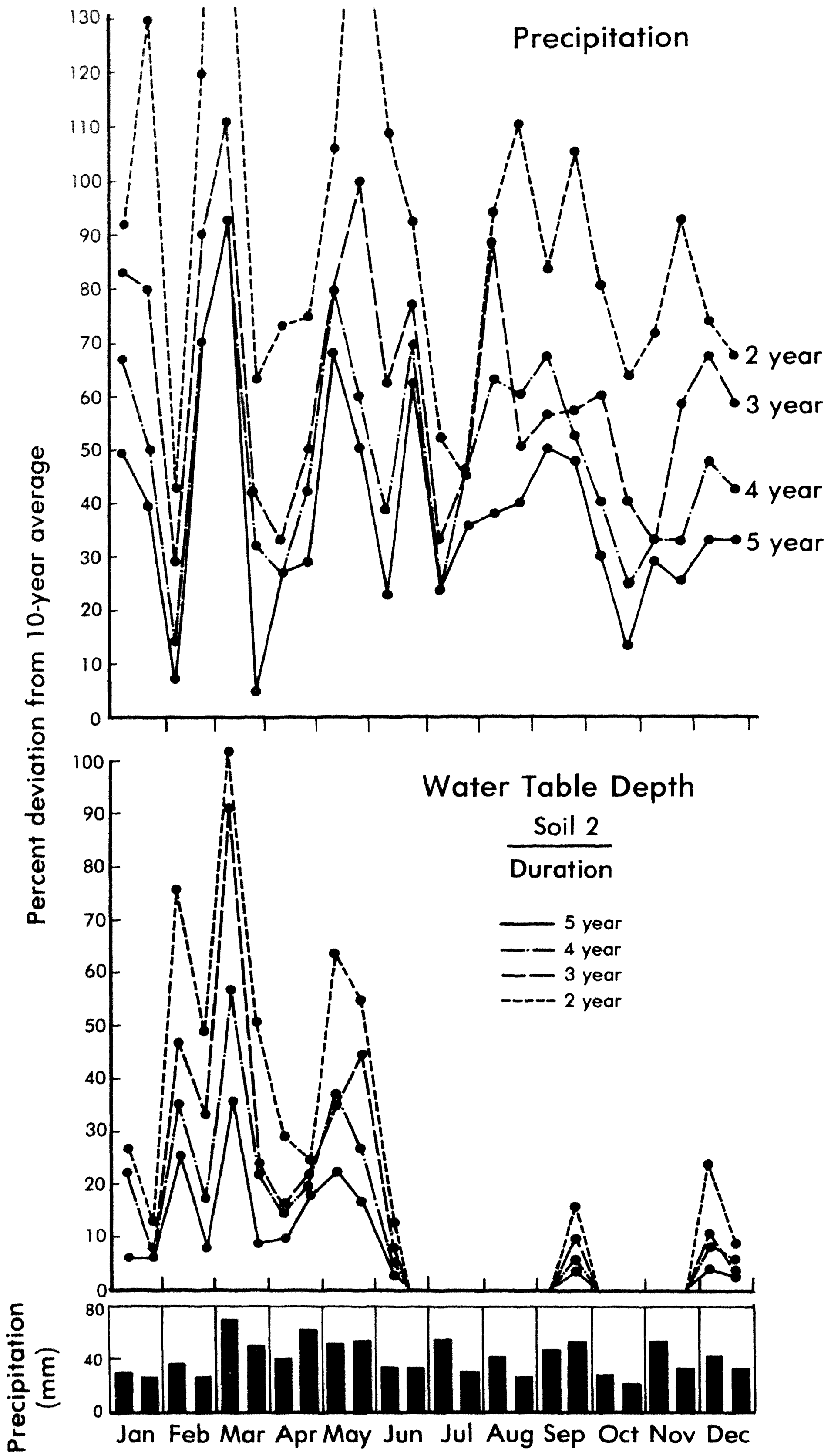

FIG. 5.—Percent deviation of average well Type A, Soil 2, and precipitation values for shorter term studies, compared to 10-year average values.

were compared for each soil and the precipitation data by 2-week intervals (Appendix B, Tables 1 and 2).

Comparison of shorter term data collection periods to 10-year average values for all water tables and the precipitation data indicated that as the length of study decreased, the variability increased. Figure 5 illustrates the deviations observed in the precipitation and water table depth data from a representative soil. The greatest difference in variability most often occurred between the 3- and 2-year intervals because unusually dry or wet years cause greater perturbations when averaged with only one or two other numbers.

A more detailed analysis of the variability due to study duration was also made by comparing long-term average water table depths for each soil to the greatest average deviation in centimeters from the long-term averages for all consecutive 5-, 4-, 3-, 2- and 1-year intervals. Table 4 lists the 10-year average water table depths by 2-week time periods, and the deviations of average water table depths for shorter term intervals from the 10-year average. The number of years of data averaged (interval) for each soil is listed above every column in Table 4. The deviation of the average water table depth from the 10-year average for a given interval is represented by a symbol as described in the table. The latter half of the year generally had low deviations, less than 25 cm, or the observation wells were dry and therefore were not listed.

This analysis further illustrates and supports the prior analysis; as the length of study decreased, the variability increased. The greatest deviations occurred in the poorly and very poorly drained soils in February and March for 1-, 2- and 3-year periods. The wettest period of study, April and the first 2 weeks of May, was consistently wet and only a 1-year interval varied appreciably from the 10-year average water table depths.

The minimum number of years needed to adequately describe water table depths in similar soils can also be estimated using Table 4, and will depend on the amount of deviation from long-term averages considered acceptable, soil drainage class, and season of the year. For example, in some situations it may be necessary to know the average depth to the water table within 1 m of the soil surface, plus or minus 25 cm. Table 4 indicates that in the forested situation described in this study, the number of years of observation needed will depend on soil drainage and season of the year. More than 1 year of study may be necessary in extremely wet or dry years. Well-drained soils (Soil 1) will require 4 years of observation in February, March, May, and the first 2 weeks of June, and only 1 year of study for the remainder of the year. Poorly and very poorly drained soils (Soil 3), however, require 5 years of study in February, March, the last half of May, and the first half of June; 3 or 4 years are required for January and the rest of May and June. This amount of precision may be impractical in poorly and very poorly drained soils. When deviations of up to 50 cm from the long-term average are acceptable, 3-year studies will be adequate in all similar soils for most months, with the exception of February and March.

Estimating Water Table Depth Class Frequencies

Currently the staff of the USDA-Soil Conservation Service estimates the depth, duration, and kind of water table for each established soil series on Soils Interpretations Records, also known as SCS-SOI-5 (Form 5). The depth and duration estimates are listed as a range and the kind of water table is listed as either perched or apparent. The information is generalized and refers to only one depth range. Recently, in an effort to define soil wetness zones more precisely, the SCS has proposed a new system for "soil wetness characterization" (18). In this system five classes are defined to describe depth to the wet state (depth to free water), and four classes to define duration of the wet state as follows:

Classes of Depth to the Wet State:

Class 1: Not wet above a depth of 150 cm.

Class 2: Wet in some part above a depth of 150 cm, but not above a depth of 100 cm.

Class 3: Wet in some part above a depth of 100 cm, but not above a depth of 50 cm.

Class 4: Wet in some part above a depth of 50 cm, but not above a depth of 25 cm.

Class 5: Wet above a depth of 25 cm.

Classes of Duration of the Wet State:

Class a: Wet less than one-twelfth of the time.

Class b: Wet one-twelfth to one-fourth of the time.

Class c: Wet one-fourth to one-half of the time.

Class d: Wet more than one-half of the time.

The Soil Survey Staff also suggests that soil wetness characterization be written in narrative form or shown graphically (18). This approach provides considerably more information than currently provided in Form 5, but does not describe the months of saturation or the probability that such conditions might occur in a given time period.

Table 5 lists the soil wetness classes, as defined above, for each soil. In this system each depth class of one soil may have a different duration class, or soils which are currently classified in different natural drainage classes may have identical depth and duration classes, such as Soils 1 and 2. The system does not appear to be very sensitive to currently recognized drainage classes, sep-

TABLE 5.—Soil Wetness Classes as Defined in the Soil Survey Manual (16).

Soil Number	Depth Class*			
	2	3	4	5
	Duration Class*			
1	d	c	b	a
2	d	c	b	a
3	d	c	b	b
4	d	c	b	b

*See text for class limits.

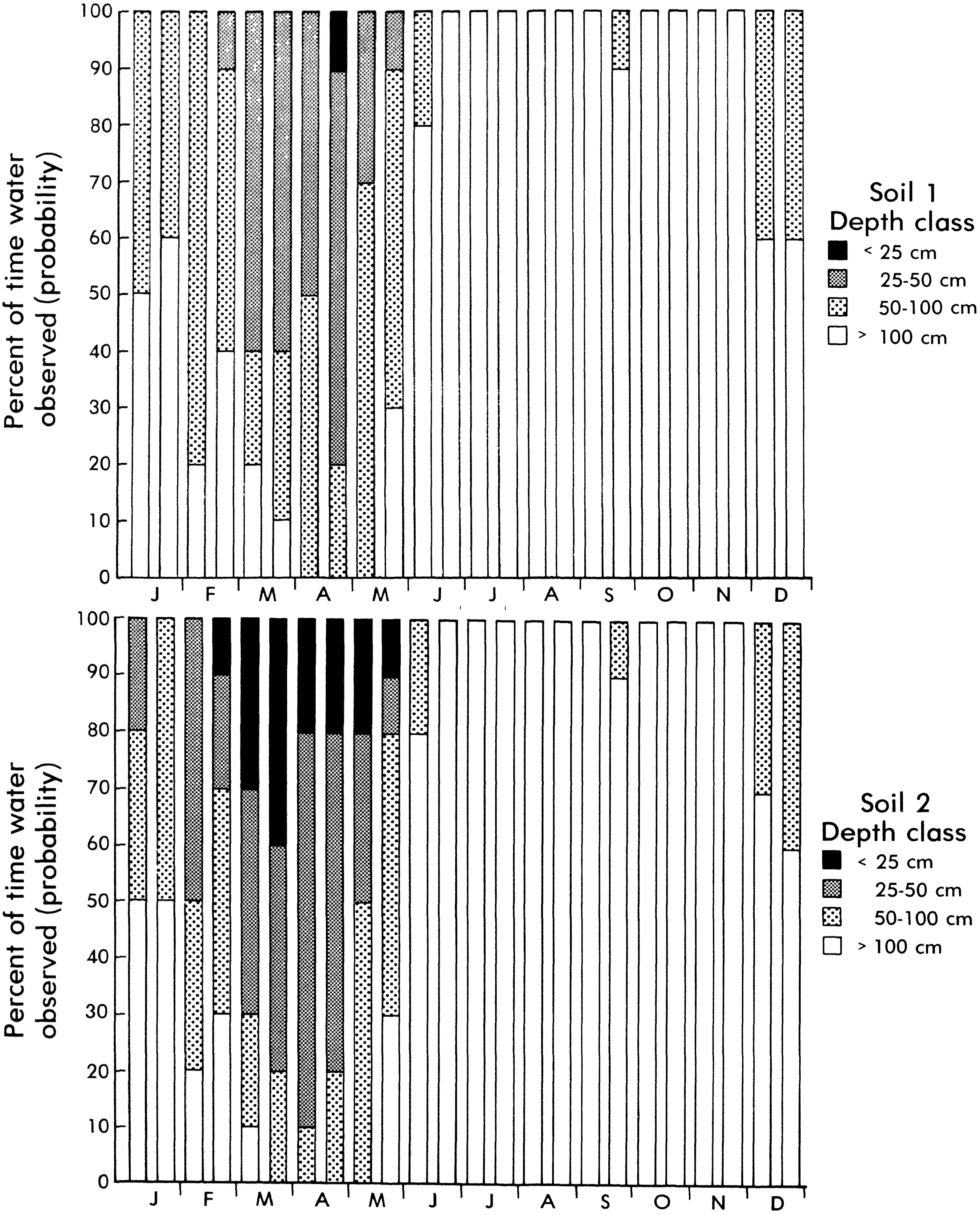

FIG. 6.—Water table probability diagrams describing the probability of observing water tables, by depth class, for each soil.

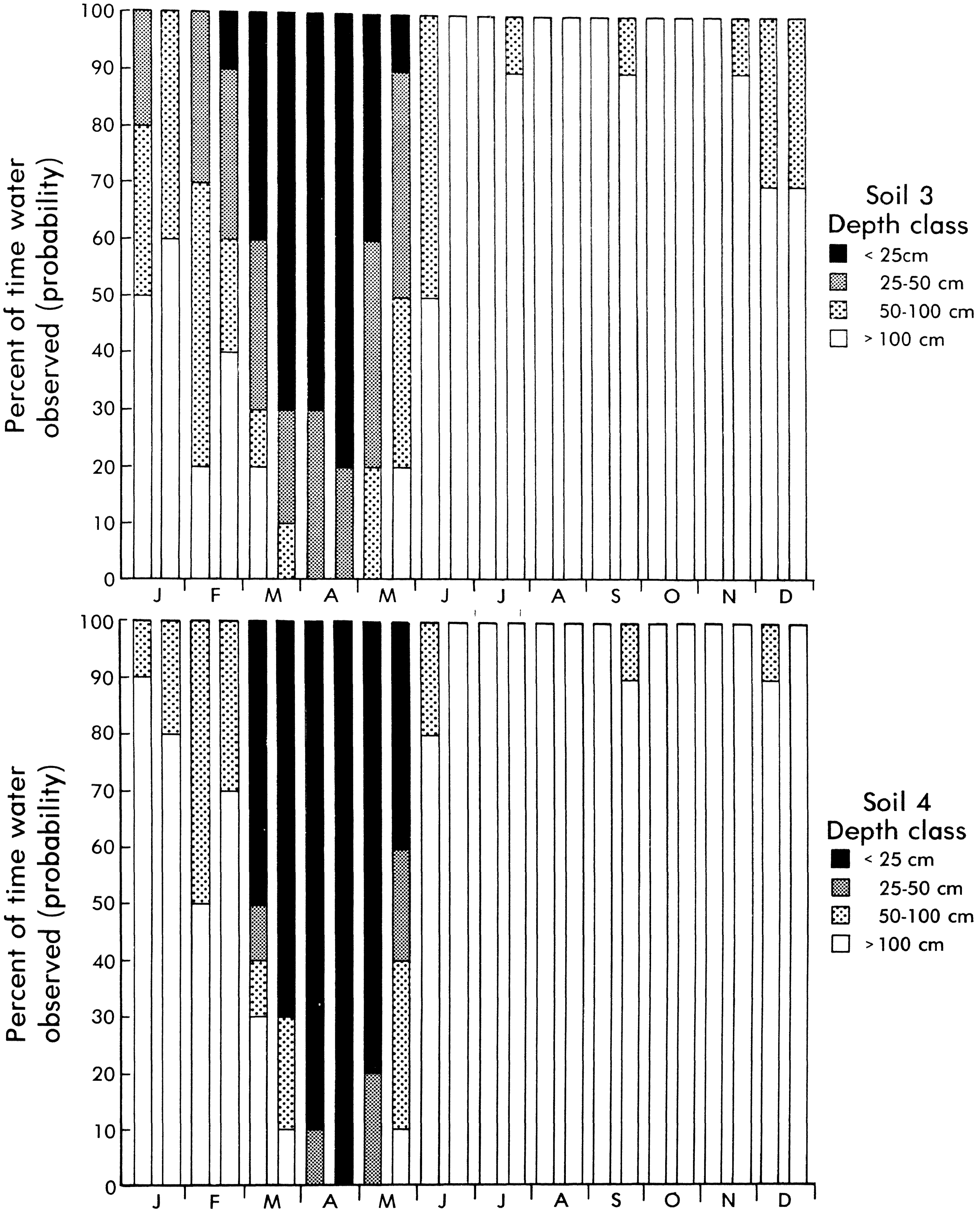

FIG. 6.—Water table probability diagrams describing the probability of observing water tables, by depth class, for each soil.

arating only the well-drained and moderately well-drained soils from the poorly and very poorly drained soils in only one depth class, Class 5.

In cases where long-term data are available, even more information can be conveyed by noting the probability that soils will be wet at a defined depth class and time period by constructing a soil wetness probability graph. Figure 6 illustrates the soil wetness probability diagrams for each of the soils studied.

Tabulated probability values for each soil and well type are listed in Appendix B, Tables 3 and 4. The soil depth classes are indicated by different types of shading patterns. The duration of wetness can be estimated using the horizontal axis. The probability of finding water in each depth class for a given 2-week interval is indicated on the vertical axis. If a soil depth class is not shown, the probability of observing a water table at that particular time and at that depth is zero.

Estimates of the probability of finding wet soils above a given depth can be found by adding the probability of the depth class under consideration and all shallower classes. For example, the probability of observing water at a depth of less than 100 cm for the first time period in Soil 2 is 50% (Fig. 6); 20% of the time the water table is between 50 and 25 cm in depth. Well Type A data were used to construct the water table probability graphs. The presence of a water table at a shallow depth does not necessarily imply that deeper zones were also saturated. This condition may occur in the spring months when perched water tables are present.

Analyses of these graphs reveal several interesting results. Well-drained Soil 1 (Miamian) had a water table above a depth of 100 cm more than 50% of the time from February through May, one-third of the year. In addition, the probability of observing a water table at a depth of less than 50 cm is 50% or more during March and April. This result conflicts with the SCS Form 5, which estimates the water table to be more than 150 cm throughout the year in Miamian.

A similar problem arises in the SCS water table estimate for the moderately well-drained Celina series, Soil 2. The Celina Form 5 estimates a perched water table occurs between the depths of 60 and 105 cm from January through April. In this study, the water table in Celina was within 100 cm of the soil surface 50% or more of the time from January through May. More significantly, water tables were observed within a depth of 50 cm 50% or more of the time during March, April, and the first half of May.

Although no water estimates were available for a soil similar to Soil 3, the Kokomo series is similar to Soil 4 and is described in a Form 5. An apparent water table is estimated to occur between depths of 0 to 30 cm from December to May. In both Soils 3 and 4 the water tables were observed within 50 cm of the surface 50% or more of the time only during March, April, and May, and within 25 cm of the surface for shorter lengths of time (Fig. 6). In this instance the SCS estimate correctly listed the kind of water table, but indicated a longer high water table period than was measured in this study.

There are several reasons why the SCS water table estimates do not coincide with the long-term average water table depth observations illustrated in Figure 6. First, the soils in this study had a forest cover and SCS estimates do not consider vegetation type. Second, the SCS estimates represent average water table values and this study only represents one site for each soil. Finally, the SCS estimates are generalizations and were not intended to convey precise information but only general relationships.

Further examination of Figure 6 yields other interesting relationships. Water tables were not observed in any soil above a depth of 100 cm with more than a 50% probability from June through December, and the probability of a water table between 50 and 100 cm during this period is 40% or less for all soils. This result has practical significance, suggesting little need to measure water tables during these months in similar soils under similar conditions unless zones deeper than 100 cm are of interest.

All soils had a probability of having a water table within 25 cm of the surface. Soil 1, Miamian, had the lowest probability (10%) for the shortest period of time (2 weeks). All other soils had probabilities of 10% or more for 12 or 14 weeks. However, the probability of observing water tables within 25 cm of the soil surface increases in most time intervals in the order: Soil 1 < Soil 2 <Soil 3 <Soil 4.

Soil Morphology vs. Water Table Depth

Soil color features are considered visual evidence of the effects water table regimes have had on the oxidation, reduction, and translocation of free oxides, primarily of iron (15). Soil Taxonomy (17) suggests that horizons with mottles which have chroma of 2 or less (low chroma mottles) and value moist of 4 or more are saturated with water at some period of the year when the temperature of the horizon is above 5° C (if the soil is not artificially drained). The amount of time the soil is saturated is not specified.

Since this study is based on long-term data from relatively few sites, statistical analyses of the relationship of measured water table depth and soil color could not be made. However, several trends or possible relationships can be noted. Colors of soil matrices, mottles, and coatings differed considerably between soils (Table 2). Although the colors of Soils 1 and 2 were similar, 4/2 colors occurred as ped coatings in Soil 1, but as mottles in Soil 2 at a similar depth.

The reason for the color differences may be related to the percent of time the 25- to 50-cm zone was saturated. In Soil 2 this zone was saturated for 50% or more of the time for 12 weeks during February to May, compared to 8 weeks for the same period in Soil 1 (Fig. 6). In addition, this zone was saturated 70% or more of the time for 8 weeks during March and April in Soil 2, but only for 2 weeks in Soil 1. This suggests that 4/2 color mottles form in soil horizons which have a greater probability of being saturated for longer periods than soil horizons with 4/2 color coatings, and the two features should be treated differently when evaluating drainage.

In addition, low chroma mottles were observed close to the soil surface in soils with wetter soil moisture regimes (Table 2). Soil 4 was excluded from this analysis because dark organic coatings masked low chroma mottling near the soil surface. In well-drained Soil 1, low chroma mottling was found in the 50- to 100-cm zone. Low chroma mottles were found in the 25- to 50-cm zone in moderately well-drained Soil 2, and in the 0- to 25-cm zone in poorly drained Soil 3. As can be seen in Figure 4 and Table 3, these depths generally correspond to the highest average water table level. In Soils 1 and 2, the highest average water table levels were 13 cm higher than the top of the horizon in which mottles were first observed. In Soil 3, mottles were observed higher in the profile than the level of the highest average water table.

CONCLUSIONS

- Perched water tables occurred in the well-drained Miamian, moderately well-drained Celina, and the poorly drained Typic Haplaquept. An apparent water table was observed in a very poorly drained Kokomo Variant. The SCS Form 5 did not predict a perched water table in a similar well-drained soil, but did correctly identify the kind of water table in similar moderately well-drained and very poorly drained soils.
- Most soils were found to have significantly different ($P < 0.05$) average water table depths for a 6-week period in April and early May.
- The probability of observing high water tables in similar poor and very poorly drained forested soils during summer months is low. The water table begins to decline shortly after the onset of leaf formation and remains at more than 150 cm in depth throughout the summer and early fall.
- Variability of water table depth measurements changed with soil drainage class, duration of data collection, and season of the year. Sampling in more poorly drained soils during late winter and early spring and for shorter periods of time all increased the variability of water table measurements.
- The probability of observing perched water tables at a depth of less than 50 cm in well-drained and moderately well-drained soils may exceed 50% in March and April.
- Results from this study indicate that low chroma mottles form in horizons which have a greater probability of being saturated for longer periods of time compared to horizons with low chroma coatings.

LITERATURE CITED

1 Bouma, J and J L Anderson 1973 Relationships between soil structure characteristics and hydraulic conductivity pp 77-105 *In* R R Bruce (ed.), Field Soil Water Regime Amer Soc. of Agron. Spec. Pub. No 5, Madison, Wis

2 Boersma, L , G H Simonson, and D. C. Watts. 1972. Soil morphology and water table relations: I. Annual water table fluctuations Soil Sci. Soc. Amer. Proc., 36:644-648.

3. Bullock, P., M. H Milford, and M. G. Cline. 1974. Degradation of argillic horizons in Udalf soils of New York State. Soil Sci. Soc. Amer. Proc., 38:621-628.

4. Coleman, T. L. and T. E. Fenton. 1982. Stratigraphy and water table relationships of upland loess-derived soils in south-central Iowa. Soil Sci. Soc. Amer. J., 46:82-87

5. Daniels, R. B., E. E. Gamble, and L. A. Nelson. 1971. Relations between soil morphology and water-table levels on a dissected North Carolina Coastal Plain surface. Soil Sci. Soc. Amer. Proc., 35:781-784.

6. Duncan, N. A. 1979. The moisture regimes of six soil series of the central lowlands of Scotland. J. Soil Sci., 30:215-223.

7. Fritton, D. D. and G. W. Olson. 1972. Depth to the apparent water table in 17 New York soils from 1963 to 1970. New York s Food and Life Sci., Bull. 13.

8. Harlan, P. W. and D. P. Franzmeier. 1974. Soil-water regimes in Brookston and Crosby soils. Soil Sci. Soc. Amer. Proc., 38:638-643.

9. Innes, R. P. and D. J. Pluth. 1970. Thin section preparation using an epoxy impregnation for petrographic and electron microprobe analysis. Soil Sci. Soc. Amer. Proc., 34:483-485.

10. Nelson, L. A., R. B. Daniels, and E. E. Gamble. 1973. Generalizing water table data. Soil Sci. Soc. Amer. Proc., 37:74-78.

11. Pomerening, J. A. and E. G. Knox. 1962. A test for natural soil groups within the Willamette catena population. Soil Sci. Soc. Proc., 26:282-287.

12. Rennolls, K., R. Carnell, and V. Tee. 1980. A descriptive model of the relationship between rainfall and soil water table. J. Hydro., 47:103-114.

13. SAS Institute. 1979. SAS User's Guide. SAS Institute Inc., Raleigh, N. C.

14. Schelling, J. 1960. New aspects of soil classification with particular reference to reclaimed hydromorphic soils. 7th Int. Congr. Soil Sci. Trans., Madison, Wis., 4:218-224.

15 Simonson, G. H. and L. Boersma. 1972. Soil morphology and water table relations: II. Correlation between annual water table fluctuations and profile features. Soil Sci. Soc. Amer. Proc., 36:649-653.

16. Soil Survey Staff. 1951. Soil survey manual. U. S. Dept. of Agriculture, Handbook No. 18. U.S. Govt. Printing Office, Washington, D.C.

17. Soil Survey Staff. 1975. Soil taxonomy. A basic system of soil classification for making and interpreting soil surveys. U. S. Dept. of Agriculture, Soil Conservation Service. U.S. Govt. Printing Office, Washington, D.C.

18. Soil Survey Staff. 1981. Soil survey manual. Chapter 4. Examination and description of soils in the field. Issue 1, Directive 430-V-SSM, May 1981. U. S. Dept. of Agriculture, Soil Conservation Service, Washington, D.C.

19. Smeck, N. E., A. Ritchie, L. P. Wilding, and L. R. Drees. 1981. Clay accumulation in sola of poorly drained soils of western Ohio. Soil Sci. Soc. Amer. J., 45:95-102.

20. Spaeth, J. N. and C. H. Diebold. 1938. Some interrelationships between soil characteristics, water tables, soil temperature, and snow cover in the forest and adjacent open areas in south-central New York. N.Y. State Agri. Exp. Sta., Ithaca, Memoir 213.

21. Stein, C. B. 1974. Evaluation of the Eyman Estate Woods, Ohio, as a national landmark. Ohio State Univ., Museum of Zool., Columbus, Mimeo.

22. Thorp, J. and E. E. Gamble. 1972. Annual fluctuations of water levels in soils of the Miami catena Wayne County, Indiana. Earlham College, Richmond, Ind., Sci. Bull. 5.

23. Van Heesen, H. C. 1970. Presentation of the seasonal fluctuation of the water table on soil maps. Geoderma, 4:257-278.

24. Veneman, P. L. M., M. J. Vepraskas, and J. Bouma. 1976. The physical significance of soil mottling in a Wisconsin toposequence. Geoderma, 15:103-118.

25. Vepraskas, M. J., F. G. Baker, and J. Bouma. 1974. Soil mottling and drainage in a Mollic Hapludalf as related to suitability for septic tank construction. Soil Sci. Soc. Amer. Proc., 38:497-501.

26. Vepraskas, M. J. and J. Bouma. 1976. Model experiments on mottle formation simulating field conditions. Geoderma, 15:217-230.

APPENDIX A
DETAILED SOILS DESCRIPTIONS

SOIL 1 **County:** Fayette

Series: Miamian **Site:** FY-12

Pedon Classification: Fine, mixed, mesic Typic Hapludalf

Location: 4,371,650 m N. and 299,000 m E. Universal Transverse Mercator Grid System

Physiography: Ground moraine **Elevation:** 283 m

Topography: Nearly level **Slope:** 2%

Drainage: Well

Parent Materials: Wisconsin glacial till

(Colors are for moist soil unless stated otherwise.)

A—0-10 centimeters; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; moderate fine granular structure; friable; many medium roots; abrupt smooth boundary.

BE—10-20 centimeters; brown (10YR 5/3) silt loam; weak medium subangular blocky structure; friable; common medium roots; thin patchy dark grayish brown (10YR 4/2) organic coatings on peds and in pores; clear smooth boundary.

Bt1—20-35 centimeters; dark yellowish brown (10YR 4/4) silty clay loam; moderate medium subangular blocky structure; friable; common medium roots; thin patchy brown (10YR 5/3) clay coatings on ped faces; clear smooth boundary.

Bt2—35-48 centimeters; dark brown (7.5YR 4/4) silty clay loam; weak medium prismatic parting to moderate medium subangular blocky structure; firm; few medium roots; thin continuous dark brown (10YR 4/3) clay coatings on peds and in pores; gradual wavy boundary.

BC—48-61 centimeters; dark brown (10YR 4/3) silty clay loam; few fine faint yellowish brown (10YR 5/4) and pale brown (10YR 6/3) mottles; weak medium subangular blocky structure; friable; few medium roots; thin patchy dark grayish brown (10YR 4/2 and 10YR 4/3) clay coatings on ped faces; slight effervescence; gradual wavy boundary.

C1—61-84 centimeters; brown (10YR 5/3) loam; many coarse faint grayish brown (10YR 5/2) and common medium distinct yellowish brown (10YR 5/6) mottles; massive; firm; few medium roots; black (N 2/0) organic and dark grayish brown (10YR 4/2) coatings in cleavages; violent effervescence; clear wavy boundary.

C2—84-122 centimeters; dark yellowish brown (10YR 4/4) loam; many medium distinct light grayish brown (10YR 6/2) and few fine distinct yellowish brown (10YR 5/6) mottles; massive; firm; few fine roots; black (N 2/0) organic coatings in vertical cleavages; thin patchy grayish brown (10YR 5/2) and light brownish gray (10YR 6/2) coatings in horizontal cleavages; violent effervescence.

Note: C is horizontally bedded.

Soil Series: Miamian
Site: FY-12
County: Fayette
OSU Lab. Numbers: 24441-24447

Depth	Horizon	Coarse Fragments >2 mm	Particle Size Distribution (% <2 mm) Sand VC	C	M	F	VF	Total
cm			%					
0-10	A	1.9	0.9	2.4	2.4	8.1	7.0	20.8
10-20	BE	5.4	1.8	2.5	2.4	7.8	6.3	20.8
20-36	Bt1	2.4	1.7	2.1	1.9	6.4	5.4	17.5
36-48	Bt2	2.4	1.8	2.0	1.7	5.5	5.0	16.0
48-61	BC	6.0	2.1	2.5	1.8	5.7	5.7	17.8
61-84	C1	8.1	5.3	4.8	2.8	6.9	5.8	25.6
84-122	C2	11.2	6.3	5.9	3.3	8.3	6.8	30.6

Depth	Horizon	Coarse Fragments >2 mm	Particle Size Distribution (% <2 mm) Silt (μm) 50-20	20-5	5-2	Total	Clay (μm) 2-0.2	<0.2	Total	Texture Class
cm			%							
0-10	A	1.9	22.9	31.3	9.8	64.0	11.0	4.2	15.2	Sil
10-20	BE	5.4	18.9	29.1	10.3	58.3	15.7	5.2	20.9	Sil
20-36	Bt1	2.4	14.4	21.9	10.0	46.3	20.4	15.8	36.2	Sicl
36-48	Bt2	2.4	13.9	17.9	10.0	41.8	25.4	16.8	42.2	Sic
48-61	BC	6.0	17.3	22.6	9.8	49.7	22.1	10.4	32.5	Sicl
61-84	C1	8.1	18.3	25.4	9.8	53.5	16.6	4.3	20.9	Sil
84-122	C2	11.2	17.9	22.9	9.8	50.6	14.8	4.0	18.8	Sil

Depth	1:1 Water	0.01M $CaCl_2$	Organic C	Calcite	Dolomite	Carbonate	Extractable Cations H	Ca	Mg	K	Sum	Base Saturation
cm	pH		%	Eq, %			meq/100g					%
0-10	6.6	6.0	3.01				4.9	9.4	3.1	0.37	17.8	72
10-20	6.6	5.7	0.58				3.4	5.2	2.9	0.18	11.7	71
20-36	5.7	5.1	0.56				6.8	7.6	5.6	0.32	20.3	67
36-48	6.8	6.2	0.54	0.1	3.3	3.6	4.9	11.7	8.3	0.35	25.3	81
48-61	8.1	7.5		1.0	18.8	21.4						
61-84	8.3	7.8		11.6	27.2	41.1						
84-122	8.4	7.8		12.2	29.3	43.9						

SOIL 2 **County:** Fayette

Series: Celina **Site:** FY-00

Pedon Classification: Fine, mixed, mesic Aquic Hapludalf

Location: 4,371,650 m N. and 299,000 m E. Universal Transverse Mercator Grid System

Physiography: Ground moraine **Elevation:** 282 m

Topography: Nearly level **Slope:** 2%

Drainage: Moderately well

Parent Materials: Wisconsin glacial till

(Colors are for moist soil unless stated otherwise.)

A—0-8 centimeters; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; moderate fine granular structure; friable; many medium roots; 1% coarse fragments; abrupt wavy boundary.

E—8-20 centimeters; brown (10YR 5/3) silt loam; weak medium subangular blocky structure; friable; common medium roots; thin patchy very dark grayish brown (10YR 3/2) organic coatings in pores; thin patchy yellowish brown (10YR 5/4) silt coatings on ped faces; 1% coarse fragments; clear wavy boundary.

BE—20-30 centimeters; dark yellowish brown (10YR 4/4) silty clay loam; moderate medium subangular blocky structure; firm; few coarse roots; thin patchy brown (10YR 5/3) coatings on peds and in pores; thin patchy pale brown (10YR 6/3) silt coatings on peds and in pores; 1% coarse fragments; clear wavy boundary.

Bt1—30-46 centimeters; dark yellowish brown (10YR 4/4) clay loam; weak medium prismatic parting to medium subangular blocky structure; firm; few coarse roots; thin continuous brown (10YR 4/3 and 10YR 5/3) clay coatings on ped faces and in pores; 4% coarse fragments; clear wavy boundary.

Bt2—46-56 centimeters; dark yellowish brown (10YR 4/4) loam; few fine distinct yellowish brown (10YR 5/6) and few fine distinct dark grayish brown (10YR 4/2) mottles; weak medium subangular blocky structure; friable; few medium roots; thin patchy brown (10YR 4/3 and 10YR 5/3) clay coatings on ped faces; 4% coarse fragments; slight effervescence; clear wavy boundary.

BC—56-66 centimeters; brown (10YR 4/3) loam; common medium faint grayish brown (10YR 5/2) and common medium distinct yellowish brown (10YR 5/6) mottles; weak medium subangular blocky structure; friable; few fine roots; thin patchy brown (10YR 5/3) coatings on ped faces; thin patchy light brownish gray (10YR 6/2) carbonate coatings on ped faces; 8% coarse fragments; strong effervescence; clear wavy boundary.

C1—66-89 centimeters; yellowish brown (10YR 5/4) loam; many medium distinct grayish brown (10YR 5/2) and common medium distinct yellowish brown (10YR 5/6) mottles; massive; friable; few fine roots; thin patchy brownish gray (10YR 6/2) carbonate coatings on cleavages; 5% coarse fragments; strong effervescence; gradual wavy boundary.

C2—89-114 centimeters; dark yellowish brown (10YR 4/4) loam; common medium distinct gray (2.5Y 6/0) and common medium distinct yellowish brown (10YR 5/6) mottles; massive; firm; thin patchy brownish gray (10YR 6/2) carbonate coatings on cleavages; 5% coarse fragments; strong effervescence.

Note: C is horizontally bedded and C1 has pockets of firm material.

SOIL 3 **County:** Fayette

Series: None recognized **Site:** FY-13

Pedon Classification: Fine-loamy, mixed, nonacid, mesic Aeric Haplaquept

Location: 4,371,650 m N. and 299,000 m E. Universal Transverse Mercator Grid System

Physiography: Ground moraine **Elevation:** 282 m

Topography: Nearly level **Slope:** Less than 1%

Drainage: Poor

Parent Materials: Wisconsin glacial till

(Colors are for moist soil unless stated otherwise.)

A1—0-5 centimeters; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; moderate fine granular structure; very friable; abrupt wavy boundary.

A2—5-13 centimeters; very dark grayish brown (10YR 3/2) silt loam; few fine faint grayish brown (10YR 5/2) and few medium distinct yellowish brown (10YR 5/6) mottles; weak fine subangular blocky structure; friable; 1% coarse fragments; clear wavy boundary.

BEg—13-23 centimeters; grayish brown (10YR 5/2) silt loam; few fine distinct light grayish brown (10YR 6/2) and few fine prominent reddish brown (5YR 4/3) mottles; weak medium subangular blocky structure; friable; 1% coarse fragments; clear wavy boundary.

Bg—23-38 centimeters; dark grayish brown (10YR 4/2) silty clay loam; few fine faint yellowish brown (10YR 5/4) and common medium faint grayish brown (10YR 5/2) mottles; weak medium prismatic parting to moderate fine subangular blocky structure; firm; thin patchy dark gray (10YR 4/1) coatings on ped faces and in pores; 5% coarse fragments; clear wavy boundary.

Bw—38-64 centimeters; yellowish brown (10YR 5/4) silty clay loam; many distinct strong brown (7.5YR 5/6) and common medium faint grayish brown (10YR 5/2) mottles; moderate medium prismatic parting to moderate medium subangular blocky structure; firm; thin patchy dark gray (10YR 4/1) and gray (10YR 5/1) coatings on ped faces; thin continuous very dark grayish brown (10YR 3/2) organic coatings on ped faces; 8% coarse fragments; clear wavy boundary.

BC—64-81 centimeters; yellowish brown (10YR 5/4) clay loam; many medium distinct strong brown (7.5YR 5/6) and common medium faint grayish brown (10YR 5/2) mottles; weak medium subangular blocky structure; firm; thin patchy dark gray (10YR 5/1) coatings on ped faces; 10% coarse fragments; slight effervescence; gradual wavy boundary.

CB—81-99 centimeters; yellowish brown (10YR 5/6) loam; common medium distinct grayish brown (10YR 5/2) mottles; weak fine subangular blocky structure; firm; thin patchy brown (10YR 4/3) coatings on ped faces; 5% coarse fragments; strong effervescence; gradual wavy boundary.

C1—99-127+ centimeters; yellowish brown (10YR 5/6) loam; common medium distinct grayish brown (10YR 5/2) mottles; massive; firm; 3% coarse fragments; strong effervescence.

Soil Series: Soil 3
Site: FY-13
County: Fayette
OSU Lab. Numbers: 24448-24456

Depth	Horizon	Coarse Fragments >2 mm	Particle Size Distribution (% <2 mm) Sand VC	C	M	F	VF	Total
cm		%						
0-5	A1	0.2	0.3	2.2	2.2	6.7	5.3	16.7
5-13	A2	0.1	1.0	3.5	2.8	7.2	5.1	19.6
13-23	BEg	0.0	1.7	2.9	2.3	6.2	4.7	17.8
23-38	Bg	2.3	1.3	2.2	1.9	5.4	4.2	15.0
38-51	Bw	1.5	1.1	1.9	2.0	6.4	5.3	16.7
51-64	Bw	7.2	1.2	2.4	2.2	7.3	7.0	20.1
64-81	BC	10.0	3.6	4.1	3.1	9.4	8.0	28.2
81-99	CB	13.7	5.2	5.2	3.2	9.0	8.0	30.6
99-127	C1	13.8	5.8	6.1	3.6	9.8	8.6	33.9

Depth	Horizon	Coarse Fragments >2 mm	Particle Size Distribution (% <2 mm) Silt (μm) 50-20	20-5	5-2	Total	Clay (μm) 2-0.2	<0.2	Total	Texture Class
Cm		%								
0-5	A1	0.2	21.3	28.9	11.1	61.3	15.0	7.0	22.0	Sil
5-13	A2	0.1	17.2	30.8	12.8	60.8	15.0	4.6	19.6	Sil
13-23	BEg	0.0	15.0	28.6	10.7	54.3	18.3	9.6	27.9	Sicl
23-38	Bg	2.3	14.0	21.2	11.2	46.4	20.9	17.7	38.6	Sicl
38-51	Bw	1.5	13.5	18.7	9.9	42.1	21.4	19.8	41.2	Sic
51-64	Bw	7.2	16.6	18.3	10.1	45.0	19.1	15.8	34.9	Cl
64-81	BC	10.0	15.6	19.4	9.5	44.5	16.4	10.9	27.3	Cl
81-99	CB	13.7	19.1	21.0	9.1	49.2	13.1	7.1	20.2	L
99-127	C1	13.8	19.6	18.9	9.1	47.6	12.4	6.1	18.5	L

Depth	1:1 Water	0.01M $CaCl_2$	Organic C	Calcite	Dolomite	Carbonate	Extractable Cations H	Ca	Mg	K	Sum	Base Saturation
cm	pH		%	Eq, %			meq/100g					%
0-15	6.1	5.6	4.21				8.9	10.4	4.6	0.44	24.3	63
5-13	5.8	5.2	1.53				7.1	5.8	3.5	0.19	16.6	57
13-23	5.1	4.5	0.97				9.4	4.5	4.1	0.22	18.2	48
23-38	5.2	4.7	1.04				10.7	7.9	8.2	0.39	27.2	61
38-51	6.3	5.8	0.83				5.5	12.7	10.8	0.35	29.3	81
51-64	7.8	7.2		0.2	8.4	9.3	2.7	14.1	9.9	0.27	27.0	90
64-81	8.0	7.6		3.7	16.9	22.0						
81-99	8.2	7.8		6.8	25.3	34.2						
99-127	8.2	7.9		8.0	29.9	40.3						

SOIL 4 **County:** Fayette

Series: Kokomo Variant[4] **Site:** FY-14

Pedon Classification: Fine, mixed, mesic Typic Haplaquoll

Location: 4,371,650 m N. and 299,000 m E. Universal Mercator Grid System

Physiography: Ground moraine **Elevation:** 281 m

Topography: Nearly level **Slope:** Less than 1%

Drainage: Very poor

Parent Materials: Wisconsin glacial till

(Colors are for moist soils unless stated otherwise.)

A1—0-8 centimeters; very dark gray (10YR 3/1) silt loam, grayish brown (10YR 5/2) dry; moderate medium granular structure; very friable; many very fine roots; 0% coarse fragments; clear smooth boundary.

A2—8-20 centimeters; very dark gray (10YR 3/1) silt loam, grayish brown (10YR 5/2) dry; common fine faint brown (10YR 4/3) mottles; moderate fine subangular blocky structure; firm; common very fine roots; 1% coarse fragments; clear wavy boundary.

Bw1—20-43 centimeters; very dark gray (10YR 3/1) silty clay loam; common fine faint brown (10YR 4/3) mottles; weak medium prismatic parting to moderate medium subangular blocky structure; firm; common coarse roots; thin continuous very dark grayish brown (10YR 3/2) coatings on peds and in pores; 1% coarse fragments; gradual wavy boundary.

Bw2—43-64 centimeters; very dark gray (10YR 3/1) silty clay loam; common fine faint brown (10YR 4/3) and few fine faint dark grayish brown (2.5Y 4/2) mottles; weak medium prismatic parting to weak medium subangular blocky structure; firm; common medium roots; thin continuous very dark grayish brown (10YR 3/2) coatings on peds and in pores; 2% coarse fragments; gradual wavy boundary.

Bg—64-89 centimeters; dark grayish brown (2.5Y 4/2) silty clay loam; few fine distinct dark yellowish brown (10YR 4/4) and few fine distinct grayish brown (10YR 5/2) mottles; weak medium prismatic parting to weak medium subangular blocky structure; firm; few fine roots; thin patchy dark grayish brown (2.5Y 4/2) and very dark grayish brown (10YR 3/2) coatings on ped faces; 2% coarse fragments; gradual wavy boundary.

B'w1—89-104 centimeters; yellowish brown (10YR 5/6) silty clay loam; common medium distinct grayish brown (2.5Y 5/2) and few fine distinct dark grayish brown (2.5Y 4/2) mottles; weak medium prismatic parting to weak medium subangular blocky structure; firm; few fine roots; thin patchy grayish brown (2.5Y 5/2) coatings on ped faces; few very dark gray (10YR 3/1) krotovinas in the matrix; 4% coarse fragments; gradual wavy boundary.

B'w2—104-119 centimeters; yellowish brown (10YR 5/6) loam; many medium distinct grayish brown (2.5Y 5/2) and few fine distinct gray (10YR 6/1) mottles; weak medium prismatic parting to weak medium subangular blocky structure; firm; few very fine roots; thin patchy grayish brown (2.5Y 5/2) coatings on ped faces; few very dark gray (10YR 3/1) krotovinas in the matrix; 4% coarse fragments; slight effervescence; gradual wavy boundary.

Bw3—119-152 centimeters; yellowish brown (10YR 5/6) loam; common fine distinct grayish brown (2.5Y 5/2) and few fine distinct gray (10YR 6/1) mottles; weak medium prismatic parting to weak medium subangular blocky structure; firm; few very fine roots; thin patchy grayish brown (2.5Y 5/2) coatings on ped faces; few very dark gray (10YR 3/1) krotovinas in the matrix; 3% coarse fragments; slight effervescence; gradual wavy boundary.

C—152-168 centimeters; yellowish brown (10YR 5/6) loam; many medium distinct grayish brown (2.5Y 5/2) mottles; massive; firm; few very dark gray (10YR 3/1) iron-manganese coatings on ped faces; 5% coarse fragments; strong effervescence.

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[4] This soil was very similar to Kokomo but had more acid in the subsoil, lacked an argillic horizon, and had slightly different colors in the lower part of the profile.

Soil Series: Kokomo Variant
Site: FY-14
County: Fayette
OSU Lab. Numbers: 24457-24467

			Particle Size Distribution (% <2 mm)					
		Coarse Fragments	Sand					
Depth	Horizon	>2 mm	VC	C	M	F	VF	Total
cm					%			
0-8	A1	0.6	0.9	1.9	1.7	5.4	5.1	15.0
8-20	A2	1.0	1.9	2.3	1.7	5.1	4.4	15.4
20-33	Bw1	5.4	1.7	2.1	1.6	4.8	3.9	14.1
33-43	Bw1	1.1	2.0	2.0	1.5	4.1	3.4	13.0
43-64	Bw2	0.8	1.1	1.8	1.4	3.6	2.9	10.8
64-76	Bg	0.7	0.6	1.4	1.2	3.2	2.7	9.1
76-89	Bg	0.9	0.4	1.3	1.4	4.1	3.5	10.7
89-104	B'w1	1.3	1.7	2.2	1.9	5.1	3.7	14.6
104-119	B'w2	0.3	2.9	3.9	3.0	6.9	4.5	21.2
119-152	Bw3	1.4	1.6	2.3	1.9	5.9	5.0	16.7
152-168	C	8.7	3.5	4.1	3.2	9.4	9.1	29.3

			Particle Size Distribution (% <2 mm)							
		Coarse Fragments	Silt (μm)				Clay (μm)			Texture
Depth	Horizon	>2 mm	50-20	20-5	5-2	Total	2-0.2	<0.2	Total	Class
cm						%				
0-8	A1	0.6	19.7	23.1	11.6	54.4	17.8	12.8	30.6	Sicl
8-20	A2	1.0	17.1	24.0	10.8	51.9	18.9	13.8	32.7	Sicl
20-33	Bw1	5.4	14.4	22.1	11.5	48.0	22.6	15.3	37.9	Sicl
33-43	Bw1	1.1	12.8	19.8	11.8	44.4	22.0	20.6	42.6	Sic
43-64	Bw2	0.8	12.2	20.6	11.1	43.9	21.7	23.6	45.3	Sic
64-76	Bg	0.7	13.0	21.7	12.3	47.0	20.8	23.1	43.9	Sic
76-89	Bg	0.9	14.5	24.1	9.8	48.4	20.4	20.5	40.9	Sic
89-104	B'w1	1.3	15.5	21.3	10.0	46.8	21.2	17.4	38.6	Sicl
104-119	B'w2	0.3	15.0	19.3	9.9	44.2	20.2	14.4	34.6	Cl
119-152	Bw3	1.4	16.5	21.6	10.7	48.8	21.2	13.3	34.5	Sicl
152-168	C	8.7	17.5	19.6	8.2	45.3	16.7	8.7	25.4	L

							Extractable Cations					
Depth	1:1 Water	0.01M $CaCl_2$	Organic C	Calcite	Dolomite	Carbonate	H	Ca	Mg	K	Sum	Base Saturation
cm	pH		%		Eq, %				meq/100g			%
0-8	6.2	5.7	4.30				10.5	13.0	5.7	0.60	29.8	65
8-20	5.6	5.0	2.33				11.3	8.5	5.4	0.41	25.6	56
20-33	5.5	5.0	1.57				9.9	9.5	7.4	0.38	27.2	64
33-43	5.7	5.1	1.41				9.4	11.5	9.4	0.43	30.7	69
43-64	5.7	5.3	0.99				6.7	13.4	11.3	0.47	31.9	79
64-76	6.1	5.7	0.67				4.7	14.3	11.2	0.43	30.6	85
76-89	6.5	6.1	0.47				5.0	13.4	11.3	0.34	30.0	83
89-104	6.9	6.4	0.38	0.2	1.0	1.3	3.0	11.4	9.4	0.34	24.1	88
104-119	7.1	6.8	0.42	0.3	1.1	1.4	2.3	9.7	8.1	0.26	20.4	89
119-152	7.3	7.0	0.56	0.3	2.0	2.4	1.7	9.4	7.8	0.25	19.2	91
152-168	7.6	7.3		1.1	16.3	18.8						

APPENDIX B

APPENDIX TABLE B-1.—Percent Deviation of Average Well Type A and Precipitation Values for Short-Term Studies Compared to 10-Year Average Values.

Month	2-Week Period No.	Interval Averages Compared											
		Soil 1				Soil 2				Soil 3			
		5-Yr	4-Yr	3-Yr	2-Yr	5-Yr	4-Yr	3-Yr	2-Yr	5-Yr	4-Yr	3-Yr	2-Yr
		%											
J	1	4	14	14	20	6	22	22	27	5	18	18	23
	2	5	5	4	7	6	8	8	13	10	10	9	16
F	3	13	15	23	35	26	35	47	76	24	32	46	63
	4	7	17	20	24	8	17	33	49	10	20	38	46
M	5	31	43	72	82	36	57	92	103	49	72	118	123
	6	11	20	28	56	9	22	24	51	25	38	57	106
A	7	6	11	12	22	10	15	16	29	14	12	19	28
	8	9	18	22	26	18	20	22	25	26	25	27	31
M	9	17	27	29	47	23	37	35	64	29	47	46	61
	10	13	24	36	42	17	27	45	55	24	37	52	64
J	11	3	4	7	12	3	5	8	13	7	9	14	20
	12	0	0	0	0	0	0	0	0	0	0	1	1
J	13	0	0	0	0	0	0	0	0	0	0	0	0
	14	0	0	0	0	0	0	0	0	1	1	1	2
A	15	0	0	0	0	0	0	0	0	0	0	0	0
	16	0	0	0	0	0	0	0	0	0	0	0	0
S	17	0	0	0	0	0	0	0	0	0	0	0	0
	18	4	6	9	15	4	6	10	16	4	5	8	15
O	19	0	0	0	0	0	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0	0	0	0	0	0
N	21	0	0	0	0	0	0	0	0	0	0	0	0
	22	0	0	0	0	0	0	0	0	1	1	2	3
D	23	6	10	11	11	5	9	11	24	4	11	14	26
	24	5	6	6	13	3	5	4	9	6	9	6	13

Month	2-Week Period No.	Soil 4				Precipitation			
		5-Yr	4-Yr	3-Yr	2-Yr	5-Yr	4-Yr	3-Yr	2-Yr
		%							
J	1	5	13	13	18	50	67	83	92
	2	12	12	10	16	40	50	80	130
F	3	19	28	45	55	7	14	29	43
	4	8	17	26	33	70	70	90	120
M	5	60	84	145	147	93	93	111	193
	6	53	86	148	232	5	32	42	63
A	7	72	76	76	140	27	27	33	73
	8	80	80	80	87	29	42	50	75
M	9	44	79	88	102	68	79	79	105
	10	46	73	74	119	50	60	100	190
J	11	15	19	25	35	23	39	62	108
	12	2	3	4	6	62	69	77	92
J	13	1	1	1	2	24	24	33	52
	14	1	1	1	2	36	46	46	45
A	15	0	0	0	0	38	63	88	94
	16	0	0	0	0	40	60	50	110
S	17	0	0	0	0	50	67	56	83
	18	5	7	11	18	48	52	57	105
O	19	0	0	0	0	30	40	60	80
	20	0	0	0	0	13	25	40	63
N	21	0	0	0	0	29	33	33	71
	22	1	2	3	5	25	33	58	92
D	23	6	11	16	30	33	47	67	73
	24	5	5	7	7	33	42	58	67

APPENDIX TABLE B-2.—Percent Deviation of Average Well Type B Values for Short-Term Studies Compared to 10-Year Average Values.

Month	2-Week Period No.	Interval Averages Compared							
		Soil 1				Soil 2			
		5-Yr	4-Yr	3-Yr	2-Yr	5-Yr	4-Yr	3-Yr	2-Yr
		%							
J	1	2	3	4	6	4	12	13	26
	2	1	1	2	4	4	9	11	19
F	3	12	15	21	27	20	25	38	51
	4	15	25	40	52	15	23	33	60
M	5	26	40	73	78	10	26	54	56
	6	14	37	46	87	5	32	34	59
A	7	4	11	13	17	7	11	10	21
	8	14	16	16	18	4	19	16	19
M	9	17	27	30	49	21	33	34	53
	10	22	32	45	49	24	36	50	57
J	11	9	14	22	28	10	15	24	30
	12	2	3	4	4	2	3	6	7
J	13	0	0	0	0	0	0	0	0
	14	0	0	0	0	0	0	0	0
A	15	0	0	0	0	0	0	0	0
	16	0	0	0	0	0	0	0	0
S	17	0	0	0	0	0	0	0	0
	18	0	0	0	0	0	0	0	0
O	19	0	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0	0
N	21	0	0	0	0	0	0	0	0
	22	0	0	0	0	0	0	0	0
D	23	1	1	1	2	1	2	3	5
	24	0	0	0	0	5	5	7	13

Month	2-Week Period No.	Interval Averages Compared							
		Soil 3				Soil 4			
		5-Yr	4-Yr	3-Yr	2-Yr	5-Yr	4-Yr	3-Yr	2-Yr
		%							
J	1	2	17	18	24	1	7	7	13
	2	5	10	13	17	3	5	9	16
F	3	23	33	44	65	10	18	23	36
	4	17	23	42	73	13	22	43	58
M	5	28	49	90	91	41	70	125	122
	6	37	58	100	142	49	82	140	220
A	7	12	16	14	24	36	43	50	79
	8	27	27	30	31	65	70	75	85
M	9	31	52	54	65	45	75	80	90
	10	29	47	59	79	42	67	74	107
J	11	13	20	28	33	10	14	18	26
	12	6	8	10	11	3	4	4	6
J	13	2	2	2	2	1	1	1	2
	14	0	0	0	0	0	0	0	0
A	15	0	0	0	0	0	0	0	0
	16	0	0	0	0	0	0	0	0
S	17	0	0	0	0	0	0	0	0
	18	0	0	0	0	1	1	1	2
O	19	0	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0	0
N	21	0	0	0	0	0	0	0	0
	22	0	0	0	0	0	0	0	0
D	23	1	3	4	7	0	1	1	2
	24	8	13	15	30	3	4	6	10

APPENDIX TABLE B-3.—Percent of Time Water Tables Were Observed in Type A Wells for Each 2-Week Time Period at Four Depths Over a 10-Year Period.

Month	2-Week Period No.	Depths Observed (cm)							
		0-25	25-50	50-100	>100	0-25	25-50	50-100	>100
		Soil 1				Soil 2			
		%							
J	1			50	50		20	30	50
	2			40	60			50	50
F	3			80	20		50	30	20
	4		10	50	40	10	20	40	30
M	5		60	20	20	30	40	20	10
	6		60	30	10	40	40	20	
A	7		50	50		20	70	10	
	8	10	70	20		20	60	20	
M	9		30	70		20	30	50	
	10		10	60	30	10	10	50	30
J	11			20	80			20	80
	12				100				100
J	13				100				100
	14				100				100
A	15				100				100
	16				100				100
S	17				100				100
	18			10	90			10	90
O	19				100				100
	20				100				100
N	21				100				100
	22				100				100
D	23			40	60			30	70
	24			40	60			40	60

Month	2-Week Period No.	Depths Observed (cm)							
		0-25	25-50	50-100	>100	0-25	25-50	50-100	>100
		Soil 3				Soil 4			
		%							
J	1		20	30	50			10	90
	2			40	60			20	80
F	3		30	50	20			50	50
	4	10	30	20	40			20	70
M	5	40	30	10	20	50	10	10	30
	6	70	20	10		70		20	10
A	7	70	30			90	10		
	8	80	20			100			
M	9	40	40	20		80	20		
	10	10	40	30	20	40	20	30	10
J	11			50	50			20	80
	12				100			10	90
J	13				100				100
	14			10	90				100
A	15				100				100
	16				100				100
S	17				100				100
	18			10	90			10	90
O	19				100				100
	20				100				100
N	21				100				100
	22			10	90				100
D	23			30	70			10	90
	24			30	70				100

APPENDIX TABLE B-4—Percent of Time Water Tables Were Observed in Type B Wells for Each 2-Week Time Period at Four Depths Over a 10-Year Period.

Month	2-Week Period No.	Soil 1 0-25	Soil 1 25-50	Soil 1 50-100	Soil 1 >100	Soil 2 0-25	Soil 2 25-50	Soil 2 50-100	Soil 2 >100
		%							
J	1				100			10	90
	2				100			10	90
F	3			10	90			40	60
	4		10	50	40		10	40	50
M	5		40	20	40	10	40	10	40
	6		60	20	20		70	10	20
A	7		40	60			80	20	
	8		70	30		10	70	20	
M	9		30	70		20	20	60	
	10		10	40	50		20	50	30
J	11			10	90			20	80
	12				100				100
J	13				100				100
	14				100				100
A	15				100				100
	16				100				100
S	17				100				100
	18				100				100
O	19				100				100
	20				100				100
N	21				100				100
	22				100				100
D	23				100				100
	24				100				100

Month	2-Week Period No.	Soil 3 0-25	Soil 3 25-50	Soil 3 50-100	Soil 3 >100	Soil 4 0-25	Soil 4 25-50	Soil 4 50-100	Soil 4 >100
		%							
J	1		10	10	80				100
				10	90			10	90
F	3		20	40	40			20	80
	4	10	10	40	40	10	10	10	70
M	5	30	20	10	40	50		10	40
	6	40	20	30	10	50	20	20	10
A	7	70	30			100			
	8	80	20			100			
M	9	40	40	20		80	20		
	10	10	40	30	20	40	20	30	10
J	11			20	80			10	90
	12				100				100
J	13				100				100
	14				100				100
A	15				100				100
	16				100				100
S	17				100				100
	18				100				100
O	19				100				100
	20				100				100
N	21				100				100
	22				100				100
D	23				100				100
	24			10	90				100

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