USE OF SOIL SURVEYS IN PRECISION SOIL AND CROP MANAGEMENT

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Introduction

Soil survey involves the mapping, classification, correlation, and interpretation of soils. The first soil survey in Iowa was in the Dubuque County area but did not include the entire county. The field work was done in 1902 and the report was published in 1903. Since that time, most Iowa counties have had at least two soil surveys completed and some have had three. The basic factors of soil formation have not changed but the use of the soils for intensive agriculture has resulted in changes in some soil properties, especially of the surface horizons. However, generally factors other than soil differences have been responsible for multiple soil surveys over one area. Over time, our concept of soil has changed. Early soil scientists with a background in geology considered the soil to be primarily that part of the earth's surface that had been darkened by the addition of organic matter., Our concept of soil has evolved so that soil now is considered a natural body made up of several horizons or layers that are genetically related to the soil forming factors under which the soil has developed. Total analyses of soils for phosphorus and potassium was a common practice during the early 1900's. Later, it was learned that it was not the total amount of a nutrient that was important for plant growth but the amount that was available to the plant. Other major factors in resurveys were the scale and the base map used.

The early soil maps were generally made at a scale of 1 inch per mile on a plane-table base map. In the late 1930's the use of aerial photographs as base maps for soil survey was implemented. Most of the surveys were made at a scale of 4 inches per mile and most of the modern surveys we have in Iowa were made at that scale. Beginning in the 1990's, orthophotographs were used as base maps and the field mapping is presently being done at a scale of 1:12,000 or 5.28 inches per mile.

Availability of Soil Information

Soil surveys are available for all Iowa counties in published reports and presently 95 of the 99 counties also have the same information available in digital format. Many digital soil maps of Iowa are available on the internet @ http://www.ia.nrcs.usda.gov/

To access the soil information select-Soils, Soils Information, and Digital Soil Survey Data From Iowa Cooperative Soil Survey on successive screens. Data bases giving soil properties and interpretations are available at the same site. The Iowa State University Extension home page also contains soil information as well as a link to the digital soil maps and databases. The home page address is:
http://extension.agron.iastate.edu/soils/soilsurv.html

Descriptions for all soil series in the U.S. are located at: http://www.statlab.iastate.edu/cgi-bin/osd/osdname.cgi
For those who do not have access to the internet, the digital soil information and associated data bases are available on CD-ROM or diskettes. The digital soil information is available in several different formats and is suitable for use in most Geographic Information Systems (GIS). For those users not interested in using a GIS the digital information may be used with the ISOIL program which is our software package for handling soil maps and data.

Soil Map Information

In Iowa we have twenty-one principal soil association areas (Figure 1). Within each soil association areas generalizations can be made about soil-landscape-vegetation relationships. Figure 2 shows the relationships we expect to find in the Clarion-Nicollet-Webster Soil Association Area which is in North-Central Iowa. Figure 3a shows a soil map of an area in Boone County made at a scale of 1:15840 (4 inches=1 mile). Figures 3b and 3c give the soil legend and symbol legend used in Boone County. Two 80-acre tracts of land in Boone County, Iowa, were a part of a detailed research project. This information will be used to help understand the relationships between soil maps and soil properties. A paper entitled "An evaluation of soil survey crop yield interpretations for two central Iowa farms" by Steinwand et al. (J.Soil and Water Consv., 51 (1)66-71, 1996) contains information about the soils and yields from these two farms with two different management systems, conventional and alternative. It is attached as an appendix to this document.

Relationship of Yields to Soil Maps

A question that is often asked of those of us in the Soil Survey Program is "What should be the relationship of the yield monitor data to my soil map? We would like to say that there is a direct relationship of the soil map to the yield data. However, it is important to recognize that the yield monitor data is collected on a second by second basis. The soil maps generally available are made at a scale of 1:15840 and were not necessarily designed to correlate to the second by second yield data. In fact, the soil surveys at that scale were designed to be used primarily for field level decisions. For example, which conservation practices will help reduce soil loss within this field etc. ?

Most yield data collected within a field will show a range in yields within a soil map unit. This trend does not mean that the soil map is not correct. However, it is important to understand the factors that contribute to variability in yields as related to soils.

Yield Variability and Contributions of Soils to Variability

There are many causes of yield variability but many of them are related to soil variability. Soil scientists group soil variability into two broad categories, systematic and random. Systematic variability is scale dependent as is some of the random variability. More closely spaced sampling points within areas thought to be randomly variable may indeed have a systematic pattern. Factors contributing to soil variability are discussed in the attached paper entitled "Soil Variability". The soil properties listed in this paper (Table 3) all contribute to soil productivity (Figure 4). Soil productivity is defined as "The capacity of a soil to produce a certain yield of crops or other plants with a specified system of management". Thus it follows that variations in soil properties are related to variations in productivity. Some of the important soil factors I would like to discuss are shown in Figures 5, 6, 7, 8, 9, and 10 and in Table 1.

Newer Technologies

Technologies Available That Provide Useful Information For Precision Soil and Crop Management
-soil maps and supporting data bases
-digital soil maps and supporting data bases
-ortho imagery
-digital elevation models (DEM)
-topographic maps
-geographic information systems (GIS)
-global positioning systems (GPS)

-yield monitors
-variable rate applicators
-remote sensing
---imagery (black and white, color, infrared etc. airplane & satellite)
---electromagnetic induction meters (EM)

Thompson-Baker Study Area

The soils of this study are in the Clarion-Nicollet-Webster soil association area (Figure 1) which makes up about 20% of the state. Figure 2 shows the landscape relationship of the major soils in this area. The 4-inch per mile soil map sheet of the southeast one quarter of Section 16 (Figure 3a) shows the study area. The legend and symbols used for the soil maps of Boone County are shown in Figures 3b and 3c. Figure 4 shows some of the major factors that affect soil productivity, which is the ability of a soil to produce a crop under a specified management system.

Table 1 gives the percentages of soil separates in each textural class. A brief discussion of soil variability is given together with the degree of variability of selected soil properties and parent materials (Tables 2 and 3).

Figure 11 shows a relief map in meters of the Boone County site in the southeast one quarter of Section 16. One meter is equivalent to 3.28 feet. Table 4 shows the statistics for selected soil properties measured in the 160-acre field.

Figure 12 shows the soils identified at each of the grid points plotted on elevation contours. Figures 13 through 18 show drainage class, depth to carbonates, mollic epipedon thickness, organic matter content, clay percentage, and sand percentage, respectively, all plotted on elevation contours. Figure 19 shows estimated five-year corn yields on elevation contours. Figures 20 shows soil map units on pH contours. Figure 21 shows pH on pH contours. Note however, that we had only 70 pH measurements. Figures 22 to 26 show various parameters plotted on estimated corn yield contours. Study of these figures should help understand the relationship among soil properties, how these properties vary across the landscape, and the effect of soil properties on productivity.

Soil Properties Study

1. Go to Figure 14 entitled "Depth To Carbonates". The "0" indicates that there is free calcium carbonate at the surface in these soils. These areas do not need lime. In fact, the problem is excess lime. Outline "no lime" management areas. Are these same management areas identifiable on the 1:15840 soil map?

2. Go to Figure 16. Is there a relationship between organic matter content and the elevation contours? Explain.

3. Examine Figures 22 through 26. Explain the relationships you observe.

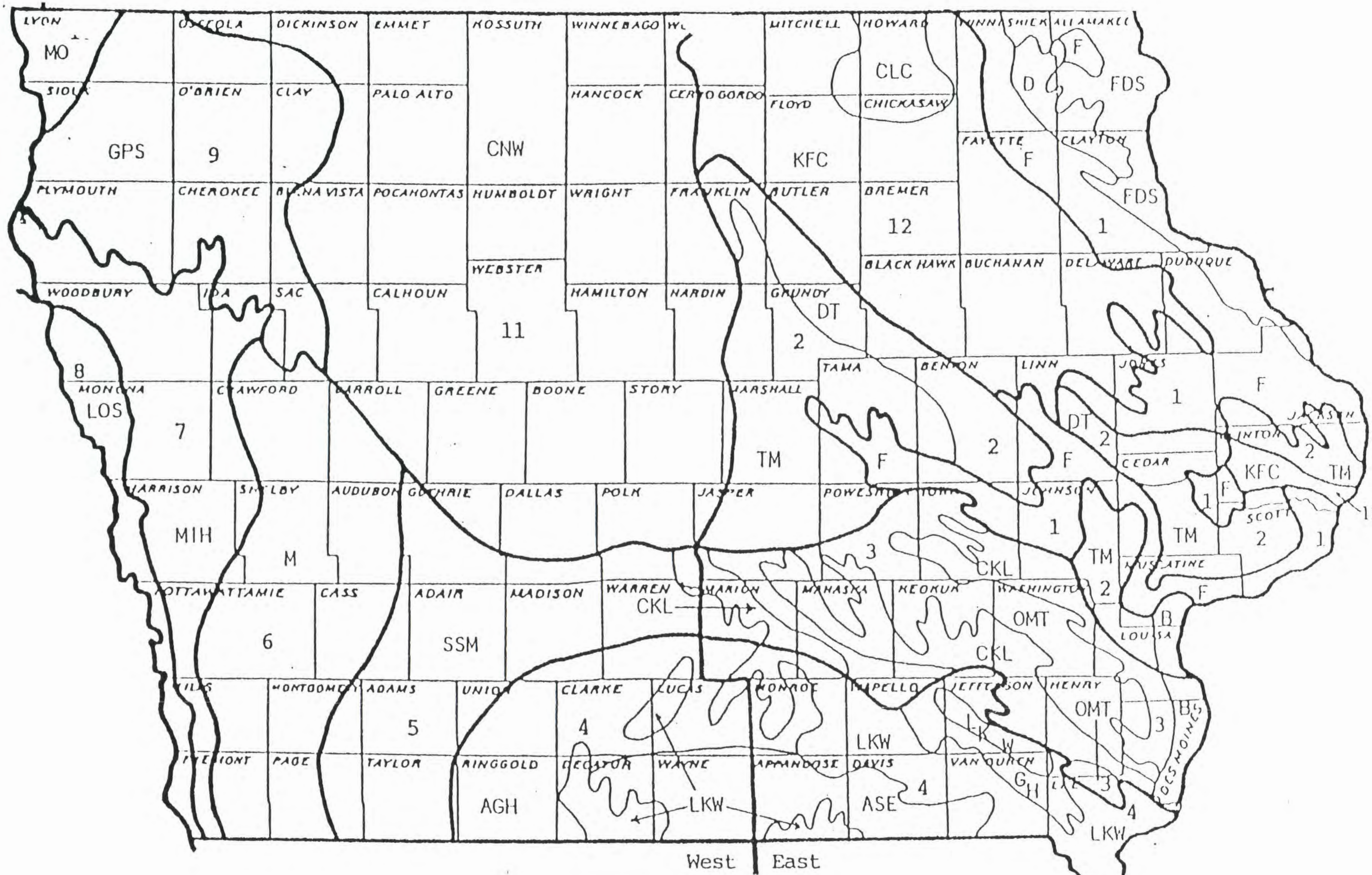
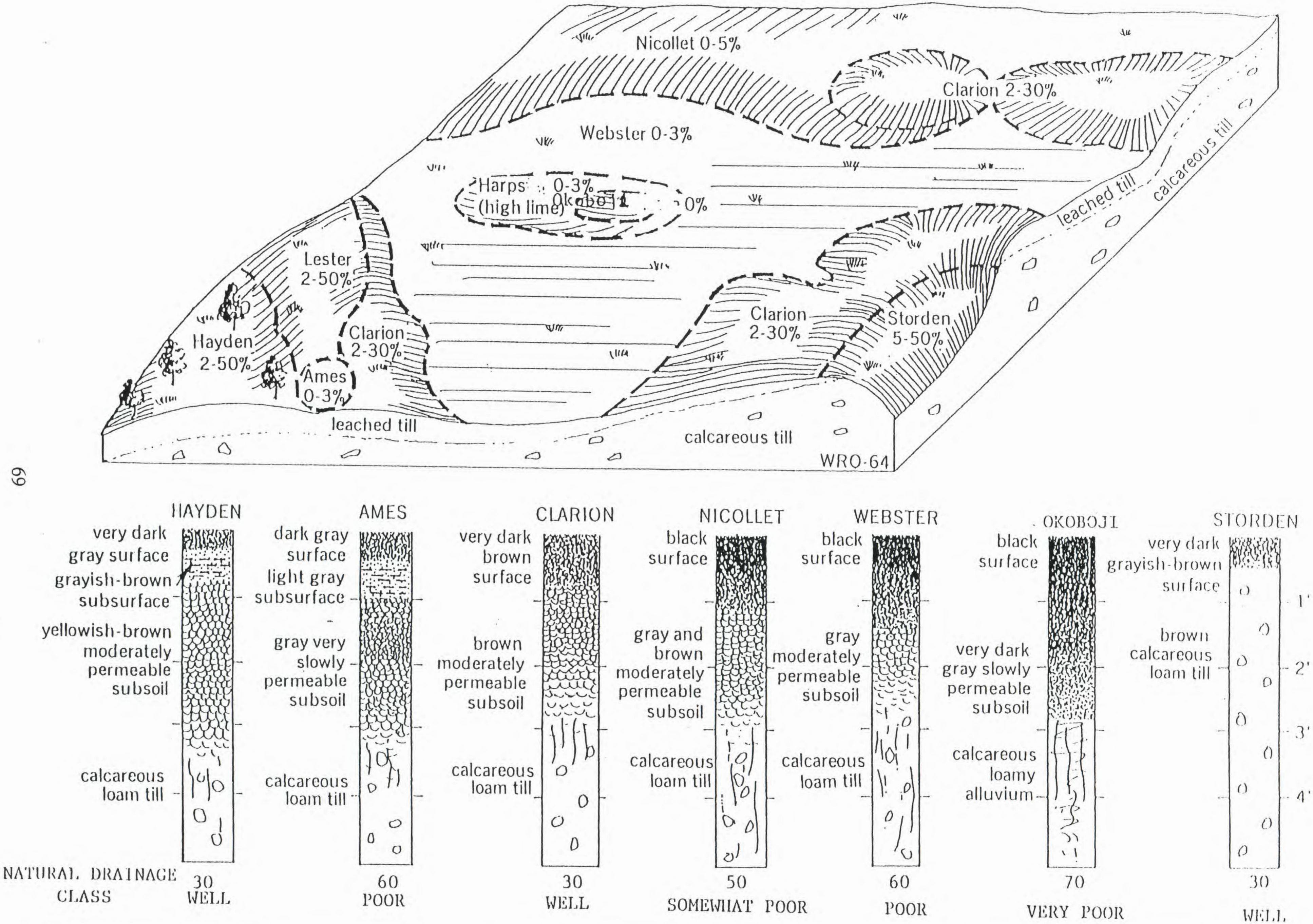


Figure 1. Map of Iowa delineating the 21 principal soil association areas (letters) and the 12 major soil areas (numbers) (from Fenton et al., 1971) (B=Miss. Bottomland)

AGH: ADAIR-GRUNDY-HAIG	D: DOWNS	GH: GRUNDY-HAIG	MIH: MONONA-IDA-HAMBURG
ASE: ADAIR-SEYMOUR-EDINA	DT: DINSDALE-TAMA	KFC: KENYON-FLOYD-CLYDE	MO: MOODY
CKL: CLINTON-KESWICK-LINDLEY	F: FAYETTE	LKW: LINDLEY-KESWICK-WELLER	OMT: OTLEY-MAHASKA-TAINTOR
CLC: CRESCO-LOURDES-CLYDE	FDS: FAYETTE-DUBUQUE-STONYLAND	LOS: LUTON-ONAWA-SALLY	SSM: SHELBY-SHARPSBURG-MACKSBURG
CNW: CLARION-NICOLLET-WEBSTER	GPS: GALVA-PRIMGHAR-SAC	M: MARSHALL	TM: TAMA-MUSCATINE

Figure 2.



Nicollet 0-5%
Clarion 2-30%
Webster 0-3%
Harps 0-3% (high lime)
Okoboji 0%
leached till
calcareous till
Lester 2-50%
Hayden 2-50%
Clarion 2-30%
Ames 0-3%
Clarion 2-30%
Storden 5-50%
leached till
calcareous till
WRO-64
HAYDEN
very dark gray surface
grayish-brown subsurface
yellowish-brown moderately permeable subsoil
calcareous loam till
AMES
dark gray surface
light gray subsurface
gray very slowly permeable subsoil
calcareous loam till
CLARION
very dark brown surface
brown moderately permeable subsoil
calcareous loam till
NICOLLET
black surface
gray and brown moderately permeable subsoil
calcareous loam till
WEBSTER
black surface
gray moderately permeable subsoil
calcareous loam till
OKOBOJI
black surface
very dark gray slowly permeable subsoil
calcareous loamy alluvium
STORDEN
very dark grayish-brown surface
brown calcareous loam till
1'
2'
3'
4'
NATURAL DRAINAGE CLASS
30 WELL
60 POOR
30 WELL
50 SOMEWHAT POOR
60 POOR
70 VERY POOR
30 WELL

69

Figure 3a. Soil map, sheet 34, Boone County.

T84N R25W
BOONE COUNTY, IOWA

SCALE 1:15840
4"=1 MILE

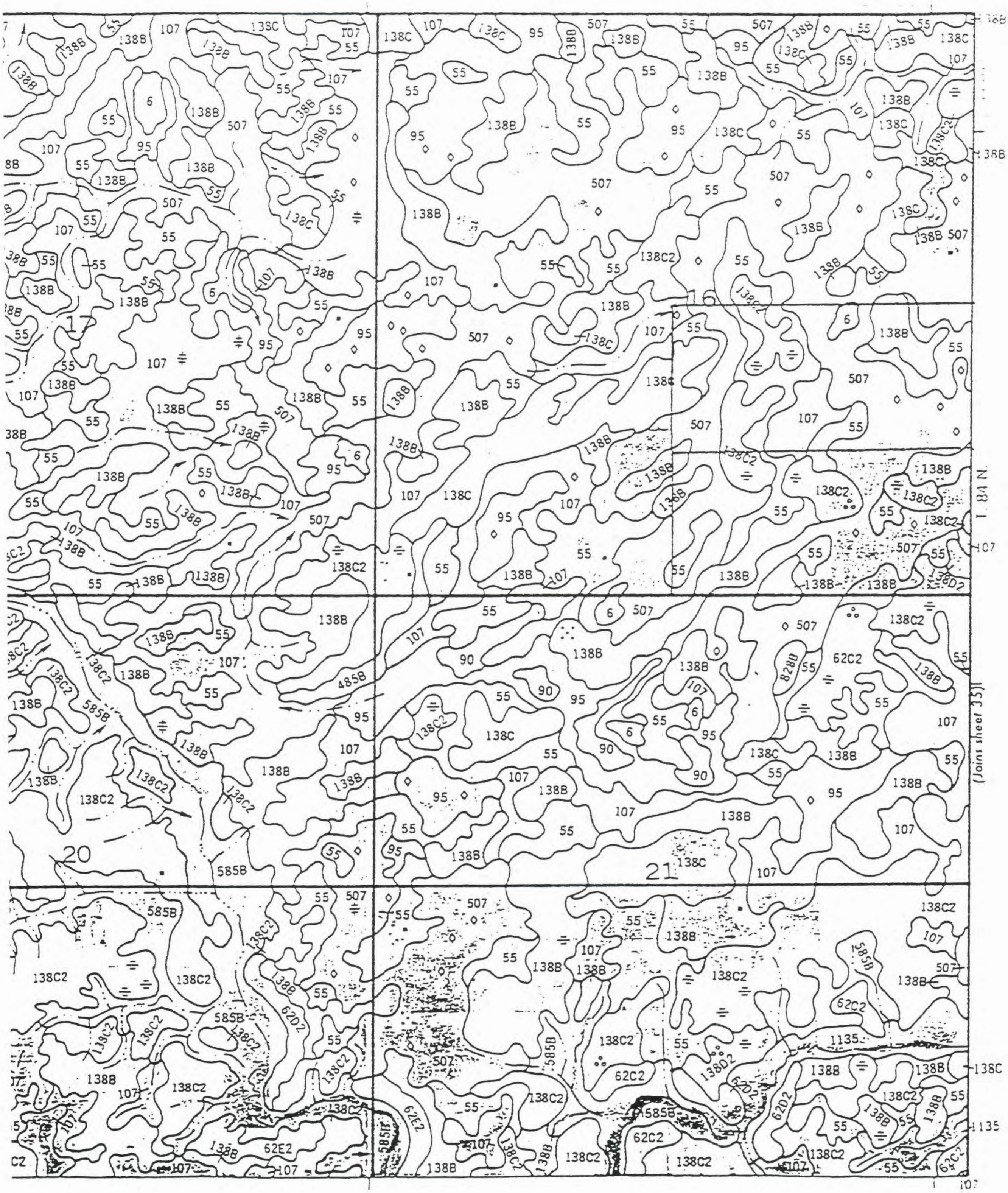


Figure 3b. SOIL LEGEND

Map symbols consist of numbers or a combination of numbers and letters. The initial numbers represent the kind of soil. A capital letter following these numbers indicates the class of slope. Symbols without a slope letter are for nearly level soils or miscellaneous areas. A final number of 2 following the slope letter indicates that the soil is moderately eroded.

SYMBOL	NAME
6	Okoboji silty clay loam, 0 to 1 percent slopes
27C	Terril loam, 5 to 9 percent slopes
28B	Dickman fine sandy loam, 1 to 5 percent slopes
28C	Dickman fine sandy loam, 5 to 9 percent slopes
55	Nicollet loam, 1 to 3 percent slopes
62C2	Storden loam, 5 to 9 percent slopes, moderately eroded
62D2	Storden loam, 9 to 14 percent slopes, moderately eroded
62E2	Storden loam, 14 to 18 percent slopes, moderately eroded
62F	Storden loam, 18 to 25 percent slopes
73D	Salida gravelly sandy loam, 5 to 14 percent slopes
73F	Salida gravelly sandy loam, 14 to 25 percent slopes
90	Okoboji mucky silt loam, 0 to 1 percent slopes
95	Harps loam, 0 to 2 percent slopes
107	Webster silty clay loam, 0 to 2 percent slopes
135	Coland clay loam, 0 to 2 percent slopes
138B	Clarion loam, 2 to 5 percent slopes
138C	Clarion loam, 5 to 9 percent slopes
138C2	Clarion loam, 5 to 9 percent slopes, moderately eroded
138D2	Clarion loam, 9 to 14 percent slopes, moderately eroded
167	Ames silt loam, 0 to 1 percent slopes
168B	Hayden loam, 2 to 5 percent slopes
168C	Hayden loam, 5 to 9 percent slopes
168C2	Hayden loam, 5 to 9 percent slopes, moderately eroded
168D2	Hayden loam, 9 to 14 percent slopes, moderately eroded
168E	Hayden loam, 14 to 18 percent slopes
203	Cylinder loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes
221	Palms muck, 0 to 1 percent slopes
224	Linder sandy loam, 0 to 2 percent slopes
236B	Lester loam, 2 to 5 percent slopes
236C2	Lester loam, 5 to 9 percent slopes, moderately eroded
259	Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes
307	Dundas silt loam, 0 to 2 percent slopes
308	Wadena loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes
308B	Wadena loam, 32 to 40 inches to sand and gravel, 2 to 5 percent slopes
325	Le Sueur loam, 0 to 2 percent slopes
335	Harcot loam, 0 to 2 percent slopes
354	Palms muck, ponded, 0 to 1 percent slopes
355	Luther loam, 0 to 2 percent slopes
356G	Hayden—Storden loams, 25 to 50 percent slopes
383	Marna silty clay loam, 0 to 2 percent slopes
385B	Guckeen clay loam, 1 to 4 percent slopes
444C	Jacwin loam, 3 to 9 percent slopes
485	Spillville loam, 0 to 2 percent slopes
485B	Spillville loam, 2 to 5 percent slopes
507	Canisteo silty clay loam, 0 to 2 percent slopes
511	Blue Earth mucky silt loam, 0 to 1 percent slopes
536	Hanlon fine sandy loam, 0 to 2 percent slopes
559	Talcot clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slo[pes]
566B	Moingona loam, 1 to 5 percent slopes
566C	Moingona loam, 5 to 9 percent slopes
566D	Moingona loam, 9 to 14 percent slopes
585B	Coland—Spillville complex, 2 to 5 percent slopes
636	Buckney fine sandy loam, 1 to 3 percent slopes
639D	Storden—Salida complex, 9 to 14 percent slopes
639E	Storden—Salida complex, 14 to 25 percent slopes
655	Crippin loam, 1 to 3 percent slopes
733	Calco silty clay loam, 0 to 2 percent slopes
778	Sattre loam, 0 to 2 percent slopes
778B	Sattre loam, 2 to 5 percent slopes
778C	Sattre loam, 5 to 9 percent slopes
823	Ridgeport sandy loam, 0 to 2 percent slopes
823B	Ridgeport sandy loam, 2 to 5 percent slopes
823C2	Ridgeport sandy loam, 5 to 9 percent slopes, moderately eroded
828B	Zenor sandy loam, 2 to 5 percent slopes
828C	Zenor sandy loam, 5 to 9 percent slopes
828C2	Zenor sandy loam, 5 to 9 percent slopes, moderately eroded
829D2	Zenor—Storden complex, 9 to 14 percent slopes, moderately eroded
829E2	Zenor—Storden complex, 14 to 25 percent slopes, moderately eroded
1135	Coland clay loam, channeled, 0 to 2 percent slopes
1636	Buckney fine sandy loam, channeled, 0 to 2 percent slopes
2485B	Spillville—Buckney complex, 2 to 5 percent slopes
4055	Nicollet—Urban land complex, 1 to 3 percent slopes
4138B	Clarion—Urban land complex, 2 to 5 percent slopes
4138C	Clarion—Urban land complex, 5 to 9 percent slopes
4507	Canisteo—Urban land complex, 0 to 2 percent slopes
5010	Pits, gravel
5020	Dumps, mine
5040	Orthents, loamy

Figure 3c. CONVENTIONAL AND SPECIAL SYMBOLS LEGEND

CULTURAL FEATURES

BOUNDARIES

- National, state or province
- County or parish
- Minor civil division
- Reservation (national forest or park, state forest or park, and large airport)
- Land grant
- Limit of soil survey (label)
- Field sheet matchline & neatline

D HOC BOUNDARY (label)

- Small airport, airfield, park, oilfield, cemetery, or flood pool — Davis Airstrip; FLOOD POOL LINE

TATE COORDINATE TICK

AND DIVISION CORNERS (sections and land grants)

DADS

- Divided (median shown if scale permits)
- oads
- Trail

DAD EMBLEMS & DESIGNATIONS

- Interstate — 79
- Federal — 410
- State — 52
- County, farm or ranch — 378

ILROAD

WER TRANSMISSION LINE (normally not shown)

E LINE (normally not shown)

NCE (normally not shown)

EES

- Without road
- With road
- With railroad

MS

- arge (to scale)
- or small

ravel pit

ine or quarry

MISCELLANEOUS CULTURAL FEATURES

- Farmstead, house (omit in urban areas)
- Church
- School
- Indian mound (label) — Indian Mound
- Located object (label) — Tower
- Tank (label) — GAS
- Wells, oil or gas
- Windmill
- Kitchen midden

WATER FEATURES

DRAINAGE

- Perennial, double line
- Perennial, single line
- Intermittent
  - Crossable with tillage implements
  - Not crossable with tillage implements
- Drainage end
- Canals or ditches
  - Double-line (label) — CANAL
  - Drainage and/or irrigation

LAKES, PONDS AND RESERVOIRS

- Perennial — water
- Intermittent — int

MISCELLANEOUS WATER FEATURES

- Marsh or swamp
- Spring
- Well, artesian
- Well, irrigation
- Wet spot

SPECIAL SYMBOLS FOR SOIL SURVEY

SOIL DELINEATIONS AND SYMBOLS — 138B 507

ESCARPMENTS

- Bedrock (points down slope)
- Other than bedrock (points down slope)

SHORT STEEP SLOPE

GULLY

DEPRESSION OR SINK

SOIL SAMPLE SITE (normally not shown) — S

MISCELLANEOUS

- Blowout
- Clay spot
- Gravelly spot
- Gumbo, slick or scabby spot (sodic)
- Dumps and other similar non soil areas
- Prominent hill or peak
- Rock outcrop (includes sandstone and shale)
- Saline spot
- Sandy spot
- Severely eroded spot
- Slide or slip (tips point upslope)
- Stony spot, very stony spot
- Calcareous spot
- Better drained soil spot
- Sewage lagoon — S.L.

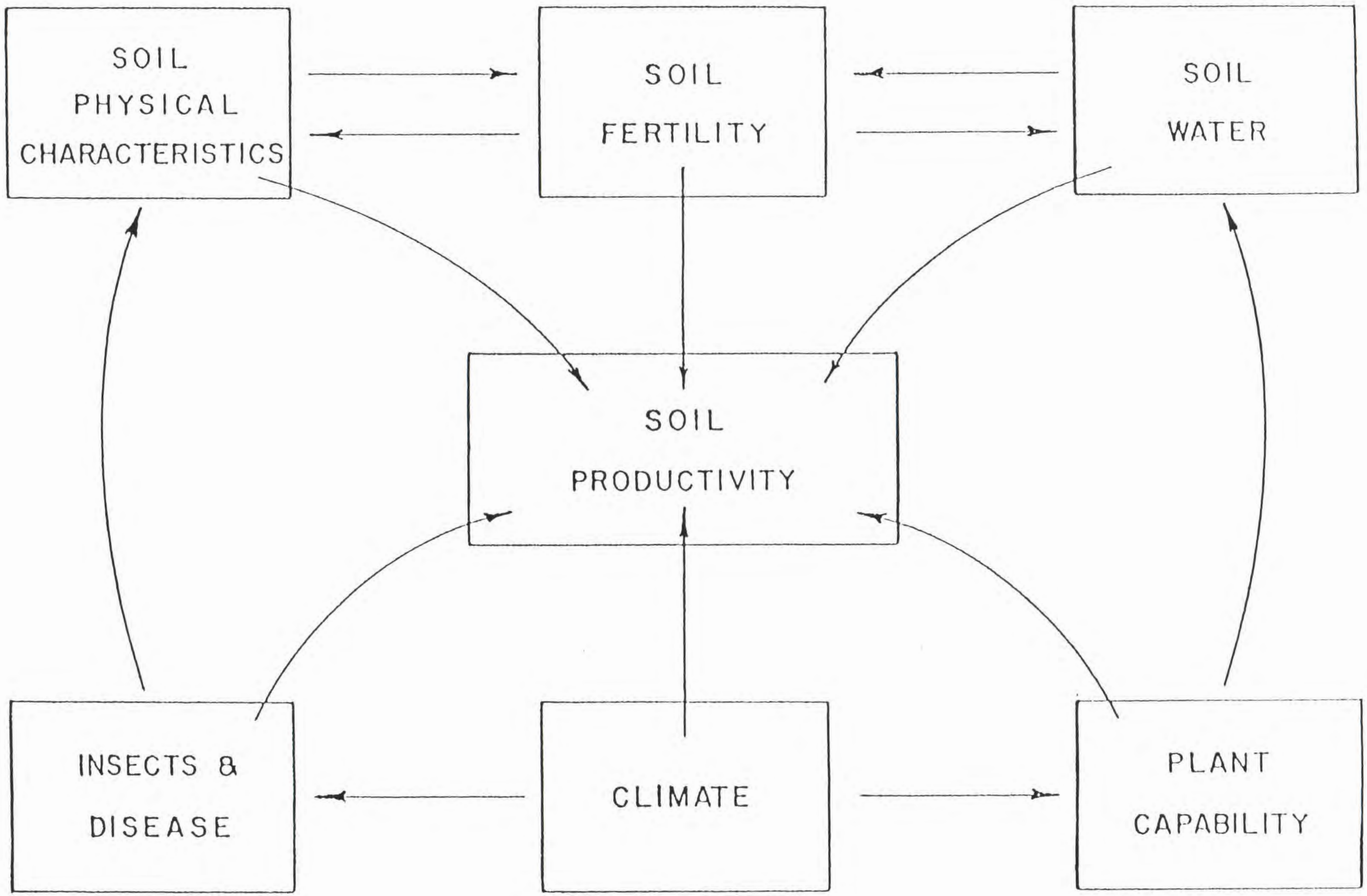


Figure 4. --Physical and Biological factors involved in soil productivity.

VOLUME COMPOSITION OF AN AVERAGE MINERAL SOIL

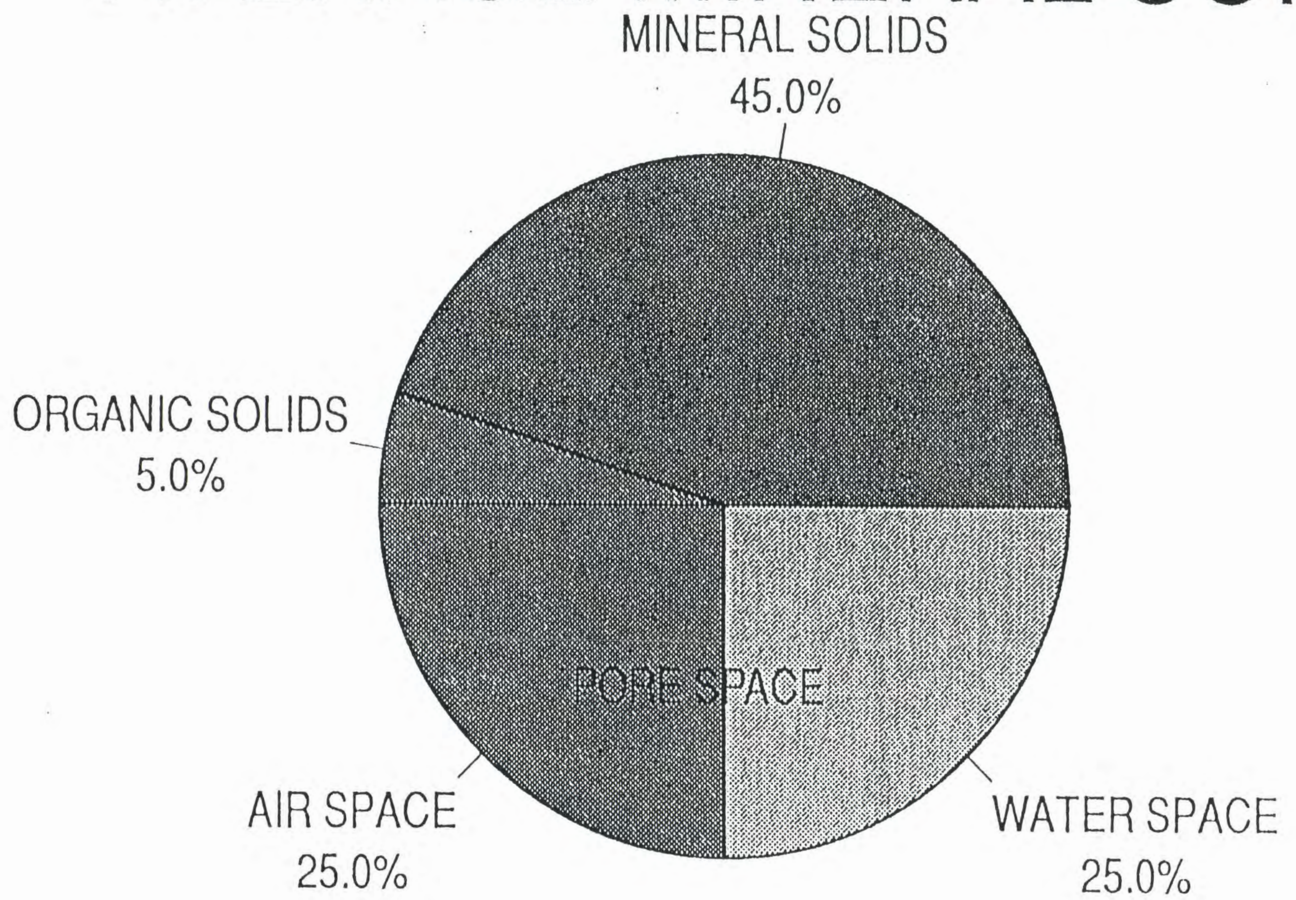


Figure 5.

SOIL TEXTURE	WEIGHT			MOISTURE PROPERTIES			
	PARTICLE DENSITY (SOLIDS)	BULK DENSITY (SOLIDS ● PORES ○)	POUNDS PER CUBIC FOOT (AVE.)	DRAINAGE (INCHES)	AVAILABLE TO PLANTS	UN-AVAILABLE	PROBABLE PERMEA-BILITY
COARSE TEXTURED	2.6	1.38	98	2.7	0.8	1.2	VERY GOOD
MEDIUM TEXTURED	2.6	1.28	80	2.8	2.3	1.4	GOOD
FINE TEXTURED	2.6	1.37	75	1.5	2.8	3.0	FAIR TO POOR
MUCKS	2.0	0.8	50	?	3^{+}	3^{+}	POOR (BOG)
PEATS	1.7	0.4	25	?	3^{++}	3^{++}	POOR (BOG)

Figure 6. --Diagrammatic presentation of some of the average weights and moisture properties of soils.

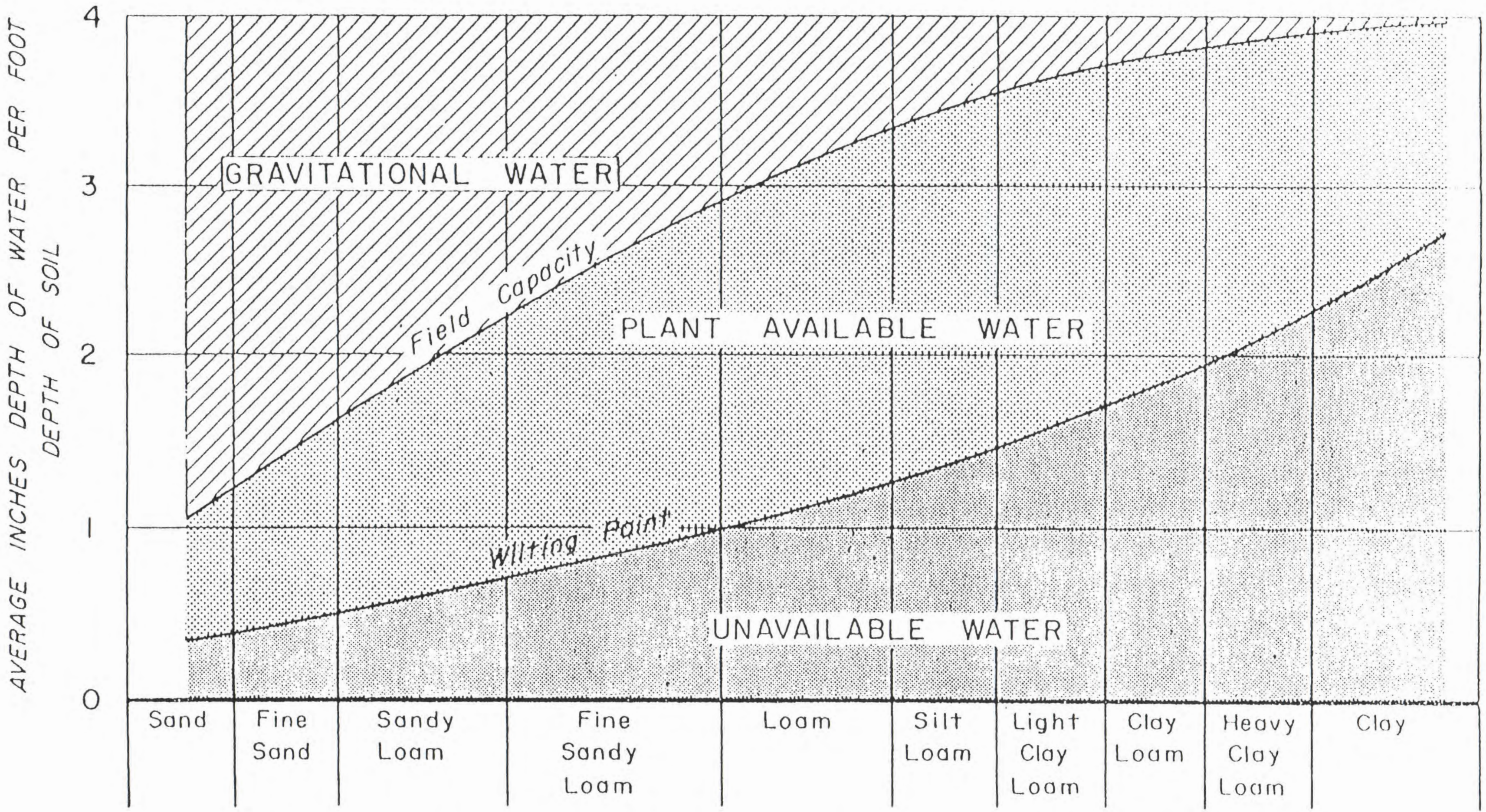


Figure 7. --Typical water characteristics of different-textured soils.

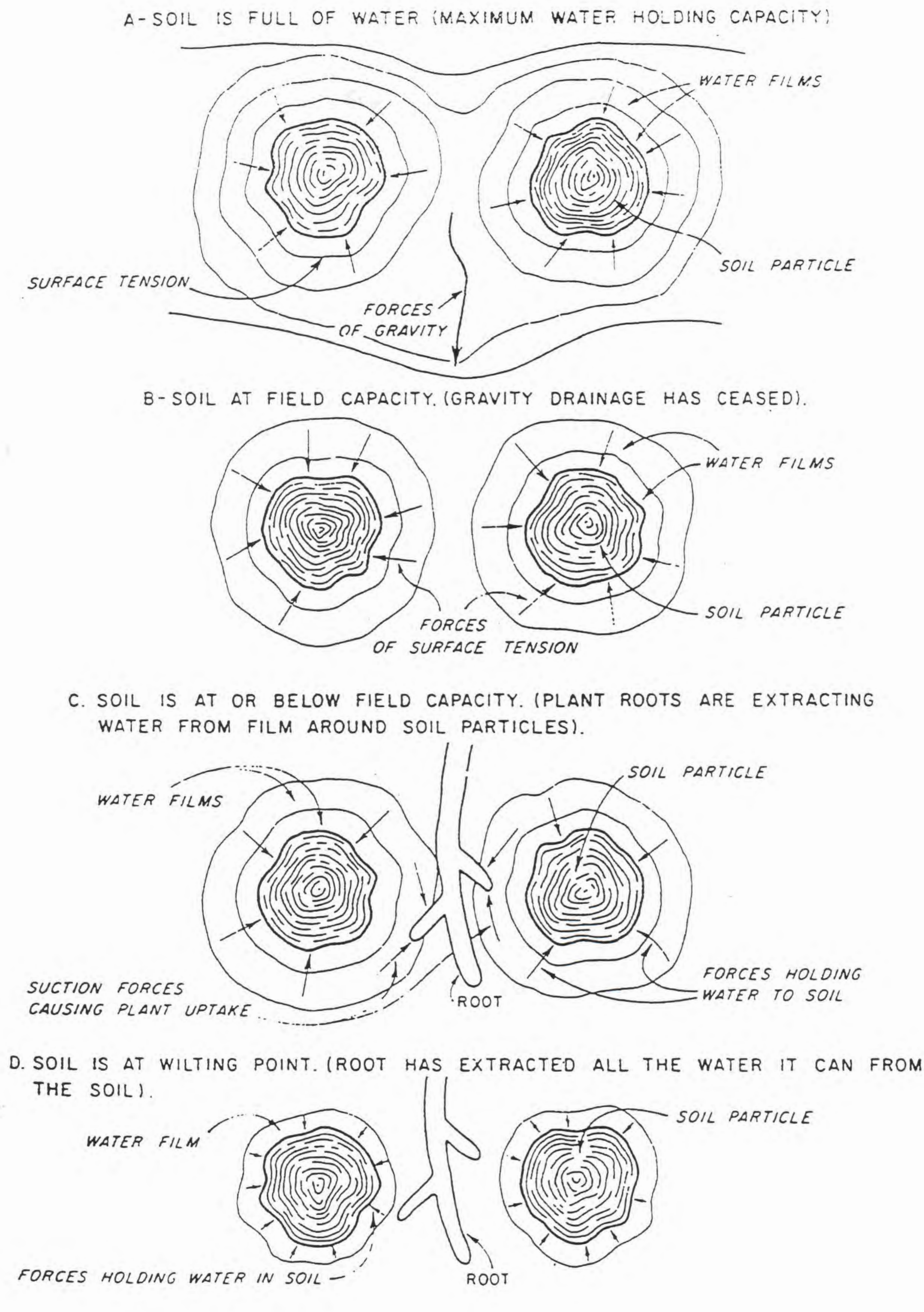
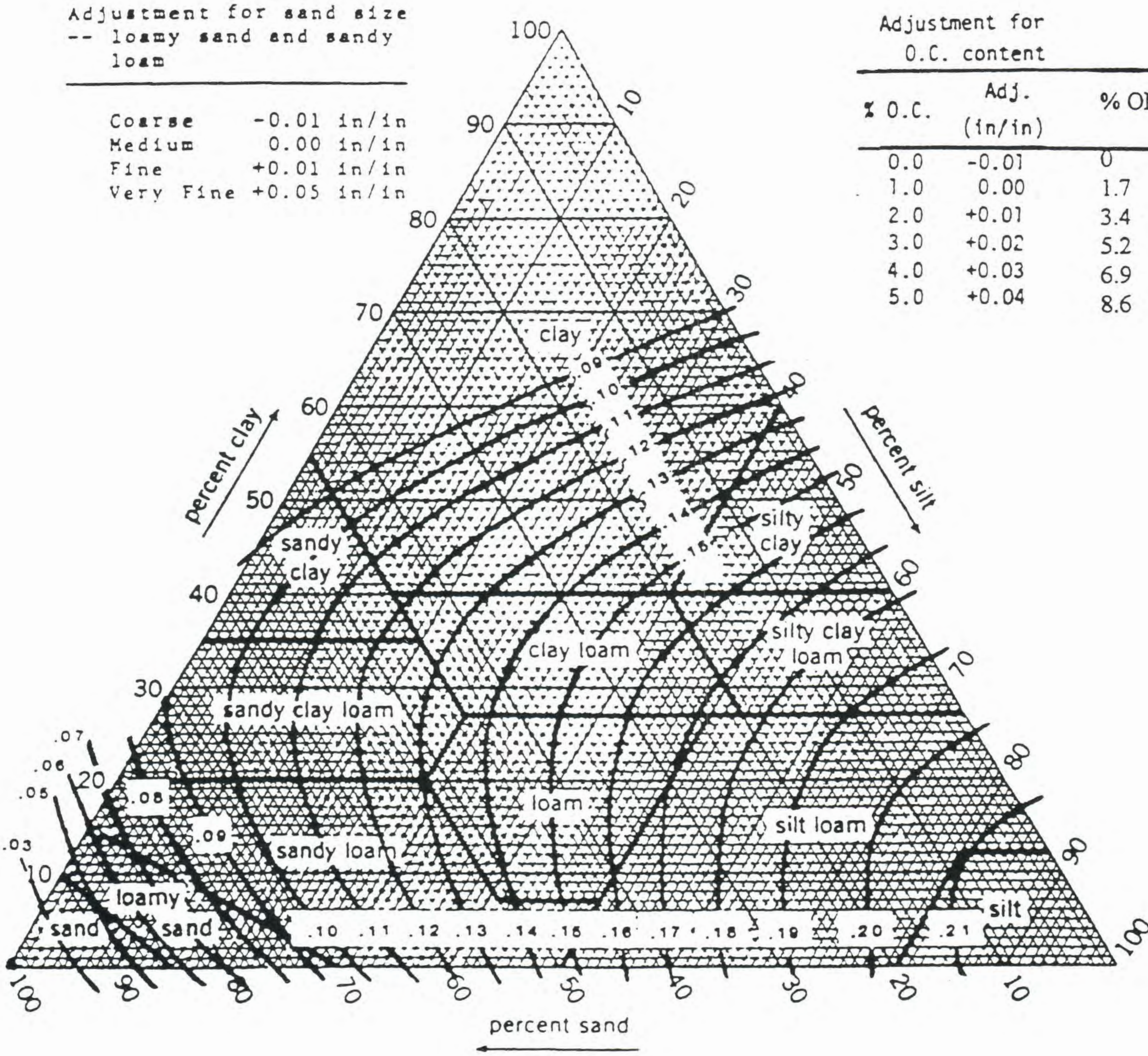


Figure 8. --Schematic diagrams of soil-moisture relationships.

Figure 9. - Estimated relationship between plant available water capacity (PAWC) and soil texture components*

Adjustment for sand size -- loamy sand and sandy loam

Coarse	-0.01 in/in
Medium	0.00 in/in
Fine	+0.01 in/in
Very Fine	+0.05 in/in



Adjustment for O.C. content

% O.C.	Adj. (in/in)	% OM
0.0	-0.01	0
1.0	0.00	1.7
2.0	+0.01	3.4
3.0	+0.02	5.2
4.0	+0.03	6.9
5.0	+0.04	8.6

L.C. Dumenil and T.E. Fenton. I.S.U. 1977.

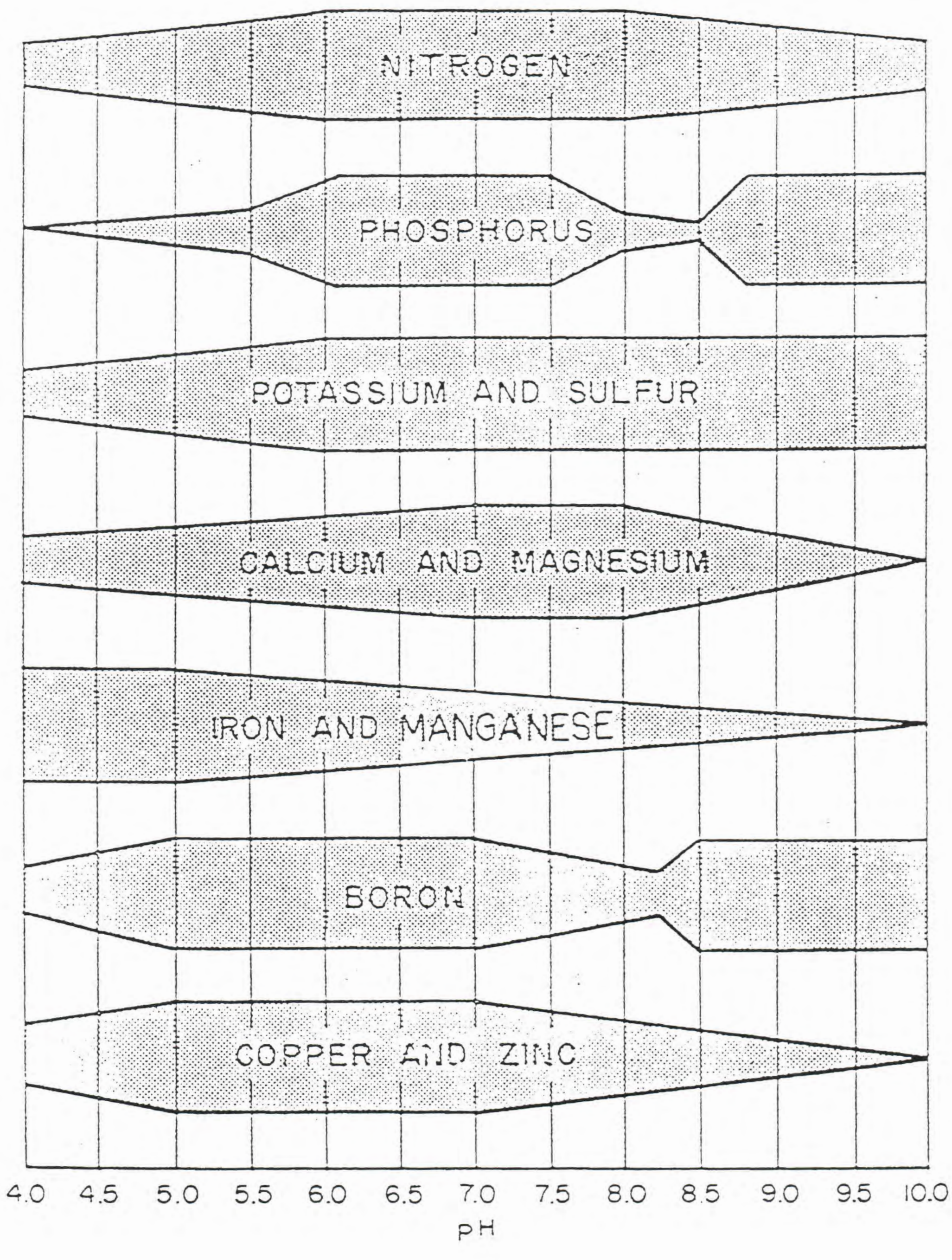


Figure 10. --The relative availability of plant nutrients in the soil as influenced by pH. The width of the bar indicates the level of availability. (Adopted from E. Truog and L. E. Engelbert. 1954. Soils: Nature and Management. College Typing Co., Madison, Wisconsin.)

Table 1. --Percentages of sand, silt, and clay in the several textural classes

Textural name (Soil class)	Range in percent		
	Sand	Silt	Clay
Sand[1/]	85-100	0-15	0-10
Loamy sand[1/]	70-90	0-30	0-15
Sandy loam[1/]	43-80	0-50	0-20
Loam	23-52	28-50	7-27
Silt loam	0-50	50-88	0-27
Silt	0-20	8-10	0-12
Sandy clay loam	45-80	0-28	20-35
Clay loam	20-45	15-53	27-40
Silty clay loam	0-20	40-73	27-40
Sandy clay	45-65	0-20	35-55
Silty clay	0-20	40-60	40-60
Clay	0-45	0-40	40-100

1/ Coarse : Greater than 25 percent coarse sand.

Fine : 50 percent or more fine sand; less than 25 percent coarse sand.

Very fine: 50 percent or more very fine sand.

Soil Variability

Variability in soils can be grouped into two broad categories, systematic and random. Systematic variability is a gradual or marked change in soil properties as a function of landform, geomorphic element, and soil-forming factors. Soil scientists have long emphasized systematic change. However, it may often become highly complex, impossible to express, and changes in soil properties cannot be related to a known cause. These kinds of changes are termed random.

One of the objectives of soil mapping is to delineate soil bodies that contain less-variable soil conditions than the population of soil as a whole. Also, the use of soil maps depends in part upon the precision of statements that can be made about the map units. Thus, for both of these parameters, the causes and magnitude of soil variability is useful information. The data in Table 2 indicates accuracy of mapping soil series, soil slope, and soil erosion for selected Iowa soils. Other data reported by Wilding et al. (1965) indicates that in a study area in Ohio the series was mapped accurately 42% of the time and erosion class 94% of the time.

Mausbach et al. (1980) reported the following generalized order of spatial variability:

Physical properties	loess < glacial drift < alluvium ≅ residuum A ≅ B < C horizons no consistent trend among soil orders
Chemical properties	loess < glacial drift, alluvium and residuum A ≅ B < C horizons (except for pH and sum of cations) Vertisols < Mollisols ≅ Alfisols < Entisols ≅ Inceptisols ≅ Ultisols < Spodosols

Drees and Wilding (1973) suggest the following generalized sequence of spatial variability for physical, chemical, and elemental properties:

Loess < glacial till < glacial outwash ≅ glacial lacustrine ≅ alluvium
Elemental K ≅ Ti ≤ Zr < Fe ≤ Ca
No consistent trend among A, B, and C horizons

The magnitude of spatial variability in a soil body does not change, but our perception of the variability depends on the choice of sampling sites and the analysis of these sites.

Wilding and Drees (1983) summarize the above observation with the following statement:

> Soil variability is thus a consequence of real space changes within the landscape body, choice of a sampling site or pedon to portray those changes, and systematic or random field sampling and laboratory errors of determination. The magnitude of these sources of variability from greatest to least is proposed as follows:
>
> Landscape body >>> Choice of pedon >> Pedon sampling > Laboratory analyses

Table 2 Accuracy of mapping soil series, soil slope, and soil erosion classes in Iowa (Dideriksen, 1966).†

Soil	Slope group	Average percent correct		
		Series	Slope	Erosion class
Ida	5-9%	91	100	91
(Typic	9-14%	80	70	60
Udorthent)	14-20%	71	100	86
	weighted mean	83	90	79
Monona	0-2%	66	100	100
(Typic	2-5%	60	100	90
Hapludoll)	5-9%	69	100	69
	9-14%	100	100	94
	14-20%	57	86	71
	weighted mean	76	98	84
Marshall	0-2%	60	80	100
(Typic	2-5%	83	66	83
Hapludoll)	5-9%	79	100	71
	9-14%	70	80	80
	weighted mean	75	83	81
Sharpsburg	0-2%	100	100	100
(Typic	2-5%	63	100	78
Argiudoll)	5-9%	55	90	73
	weighted mean	63	100	81
Tama	0-2%	100	100	100
(Typic	2-5%	100	100	100
Argiudoll)	5-9%	100	100	75
	weighted mean	100	100	92
Shelby	5-9%	100	100	100
(Typic	9-14%	77	89	100
Argiudoll)	14-18%	50	100	100
	weighted mean	75	92	100

† Based on 161 profile descriptions: Ida, 29; Monona, 49; Marshall, 41; Sharpsburg, 22; Tama, 8; and Shelby, 12.

The effect of accelerated erosion on Mollisols is a major problem in soil classification. The criteria for classificaiton at the highest category, the order level, is linked directly to surface-soil thickness (mollic epipedon). Smith (1978, p. 13) stated:

> In general, we tried throughout taxonomy to use the characteristics of the subsurface horizon rather than the surface horizon because we wanted to keep the eroded and uneroded soils in the same series, as has been our practice in mapping. The use of the mollic epipedon as a diagnostic horizon violated the general principles that we started with, but we could find no escape from it.

In soils with sola thicker than 75 cm, the minimum thickness of the mollic epipedon for the soil to be classified as a Mollisol is 25 cm. Failure to meet the thickness criterion for a mollic epipedon results in a classification of Mollic Hapludalf, if the soils are well drained and have an argillic horizon. Without an argillic horizon but with a cambic horizon, the soils would be classified as Inceptisols. Because of the emphasis given to the mollic

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Table 3. Relative variability of selected soil properties sampled within mapping units of a given soil series.

Soil property	CV(%)† Mean	CV(%)† Range	Relative order of soil variability
Bulk density	7	5–13	
Soil color hue	9	2–20	
Soil color value	10	4–12	Least variable
Soil pH	10	5–15	
Plasticity limit	15	5–28	
Liquid limit	17	8–31	
A Horizon thickness	18	8–31	
Water retention (33 kPa)		10–31	
Base saturation	25	17–33	
Total sand content	25	8–46	Moderately
Total clay content	25	10–61	variable
Calcium carbonate equivalence	28	20–30	
Soil color chroma	28	15–50	
Depth to carbonates	30	20–49	
Cation exchange capacity	32	20–40	
Depth to mottling	35	20–50	
Organic matter content	39	20–61	
Plasticity index	41	20–63	
Soil thickness	43	25–58	Most
Exchangeable Ca	48	30–73	variable
Exchangeable K	57	7–160	
Exchangeable Mg	58	31–121	
Water-soluble salt extract	48	–	
Hydraulic conductivity	75	13–150	

†The coefficient of variability (CV) values represent variations for equivalent horizons or depths.

Table 4. Selected statistics for soil properties.

SAND (%) STATISTICS

192	Number of numeric cells
6336.4	Sum
33.00208	Average
12.91825	Standard Deviation
8.3	Minimum
77	Maximum

ORGANIC MATTER STATISTICS

192	Number of numeric cells
881.6	Sum
4.591667	Average
1.598046	Standard Deviation
1.3	Minimum
10.1	Maximum

CLAY (%) STATISTICS

192	Number of numeric cells
4699.8	Sum
24.47812	Average
5.635819	Standard Deviation
14	Minimum
41	Maximum

DEPTH TO CARBONATES (IN.) STATISTICS

192	Number of numeric cells
6107.087	Sum
31.80774	Average
21.32158	Standard Deviation
0	Minimum
85.03937	Maximum

DRAINAGE CLASS STATISTICS

192	Number of numeric cells
10030	Sum
52.23958	Average
12.52996	Standard Deviation
25	Minimum
70	Maximum

CORN YIELD (BU/AC) STATISTICS

192	Number of numeric cells
27193	Sum
141.6302	Average
13.9949	Standard Deviation
74	Minimum
159	Maximum

MOLLIC EPIPEDON THICKNESS (IN.)

192	Number of numeric cells
4984.457	Sum
25.96071	Average
9.13907	Standard Deviation
6	Minimum
49	Maximum

pH STATISTICS

70	Number of numeric cells
487.3	Sum
6.961429	Average
0.8617967	Standard Deviation
5	Minimum
7.8	Maximum

Figure 11. ELEVATION, METERS, THOMPSON-BAKER AREA

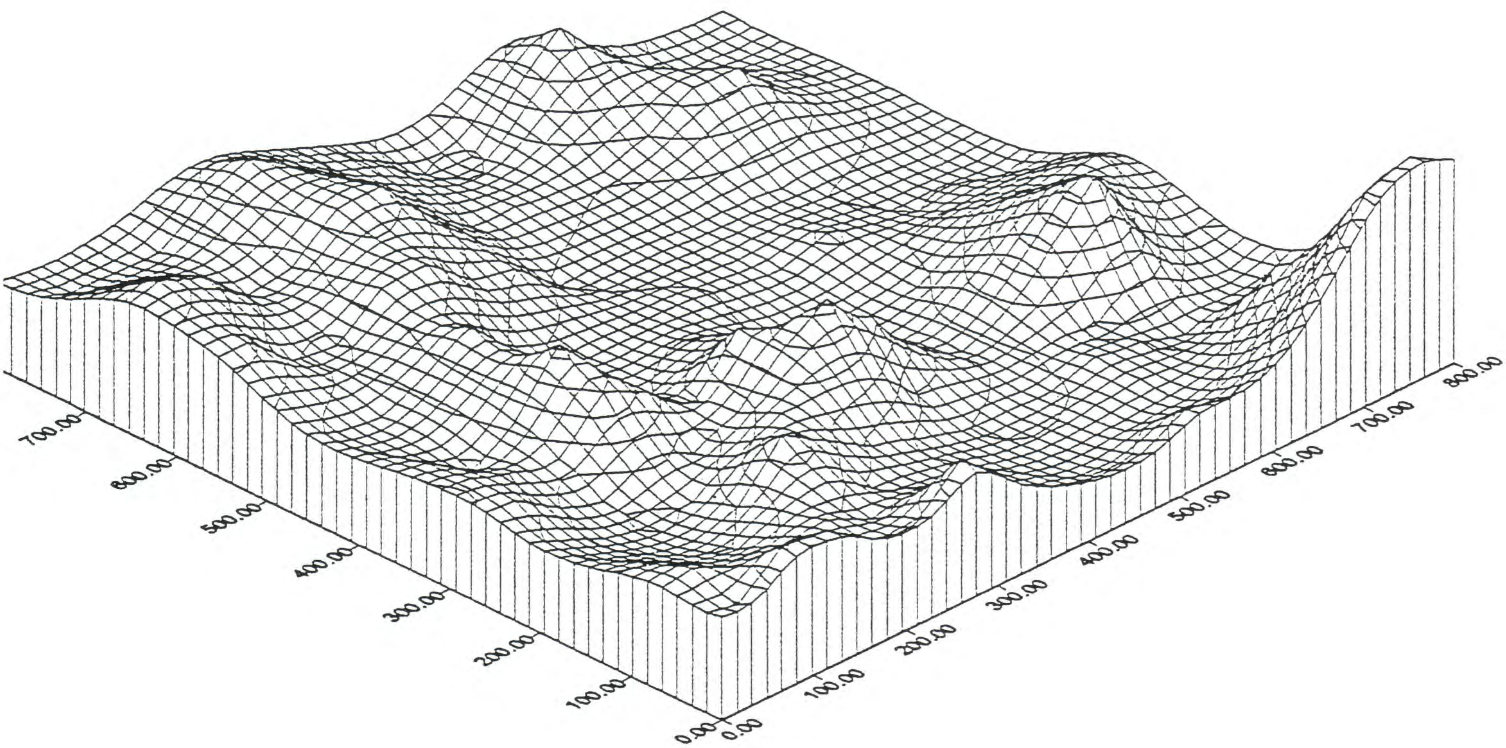


Figure 12. SOIL MAP UNITS ON ELEVATION CONTOURS, THOMPSON-BAKER AREA

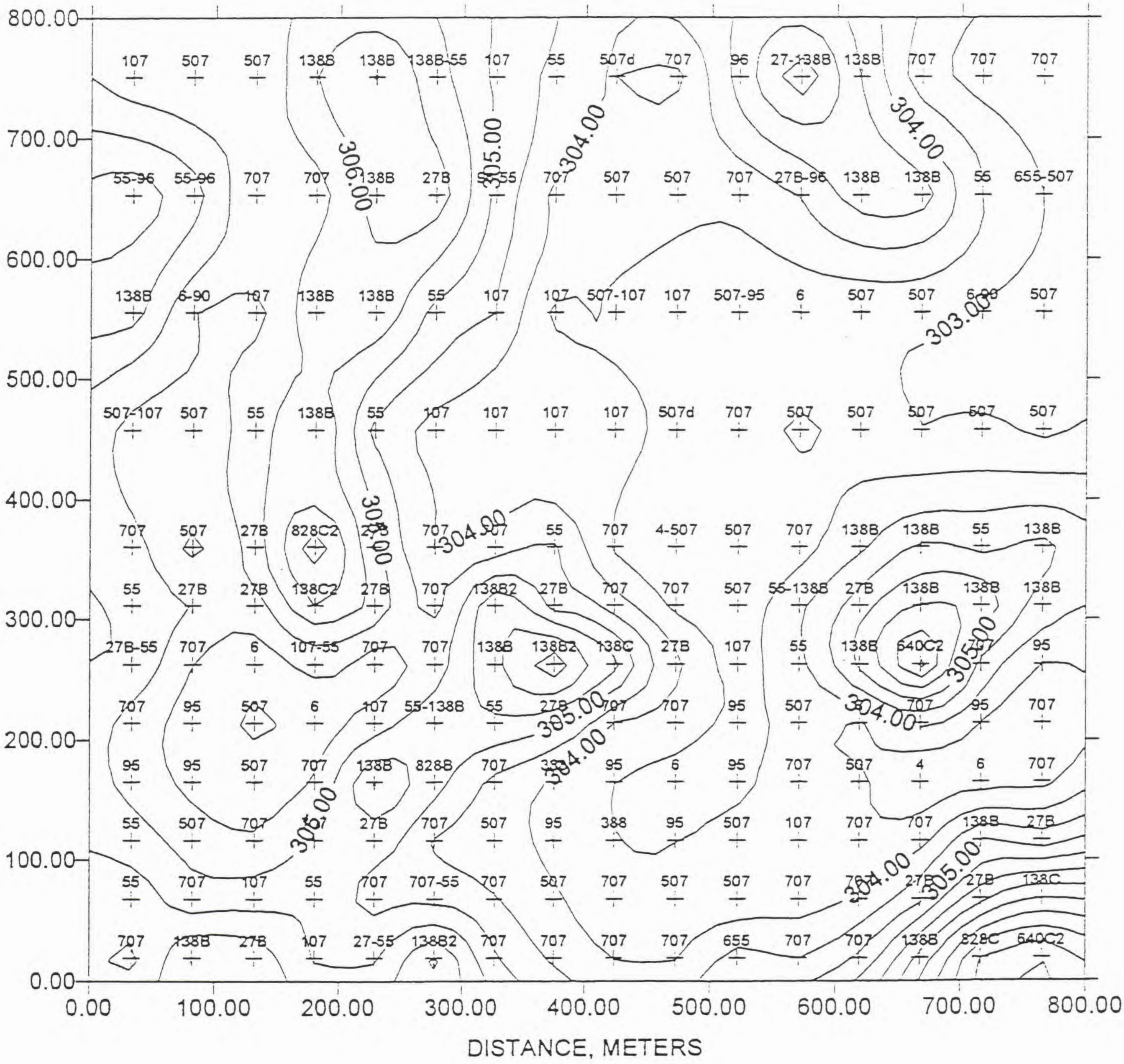
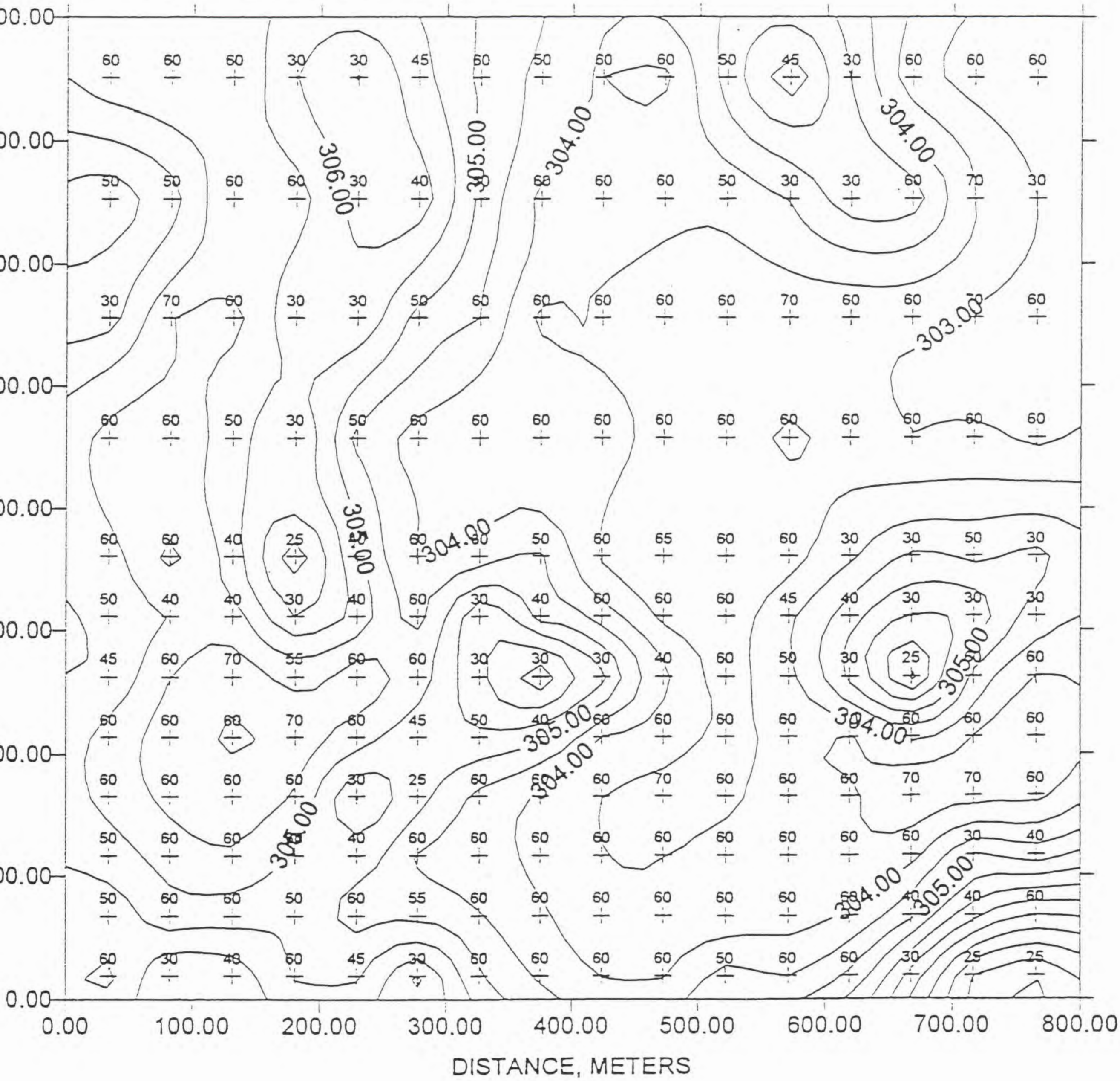
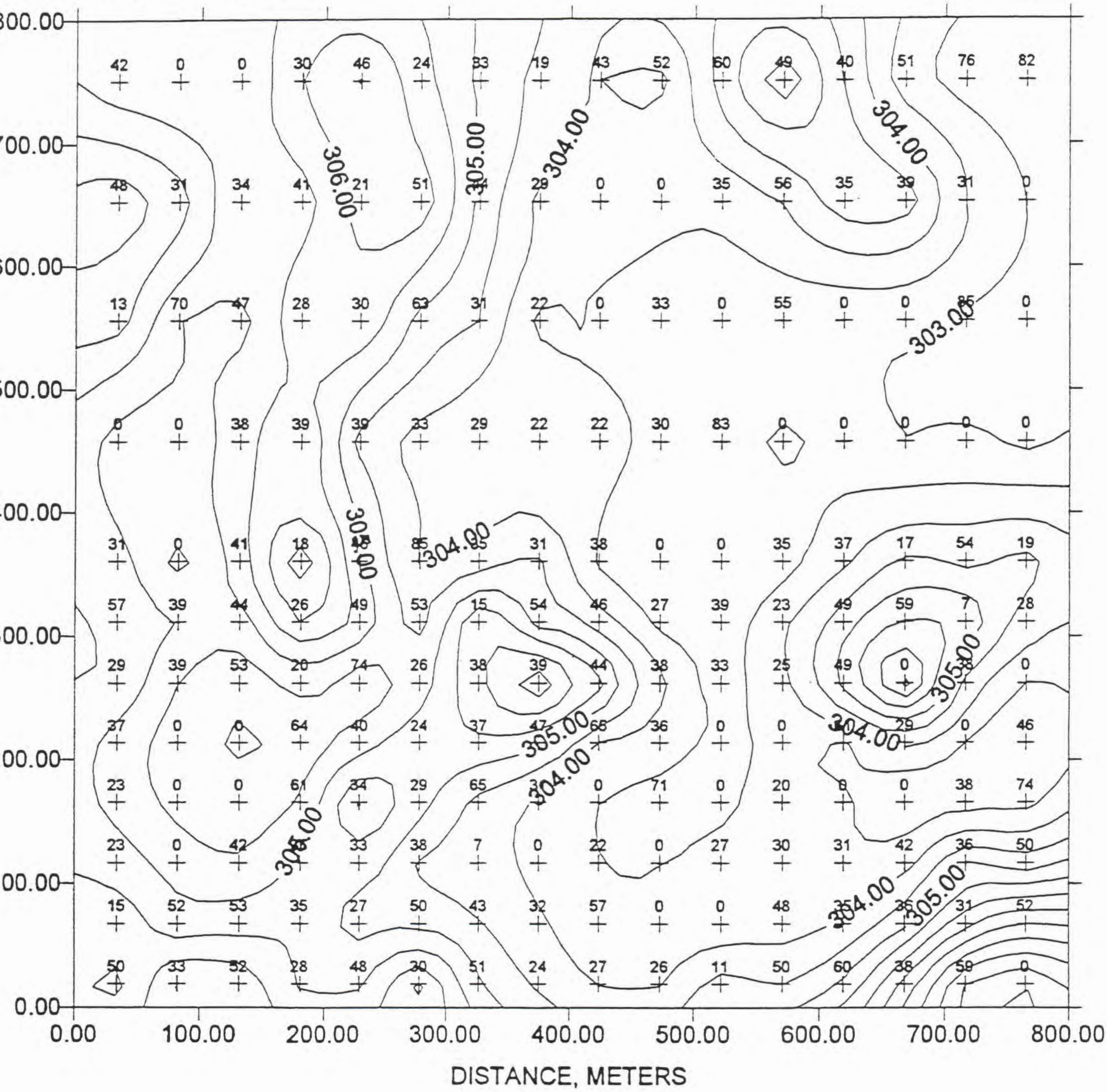


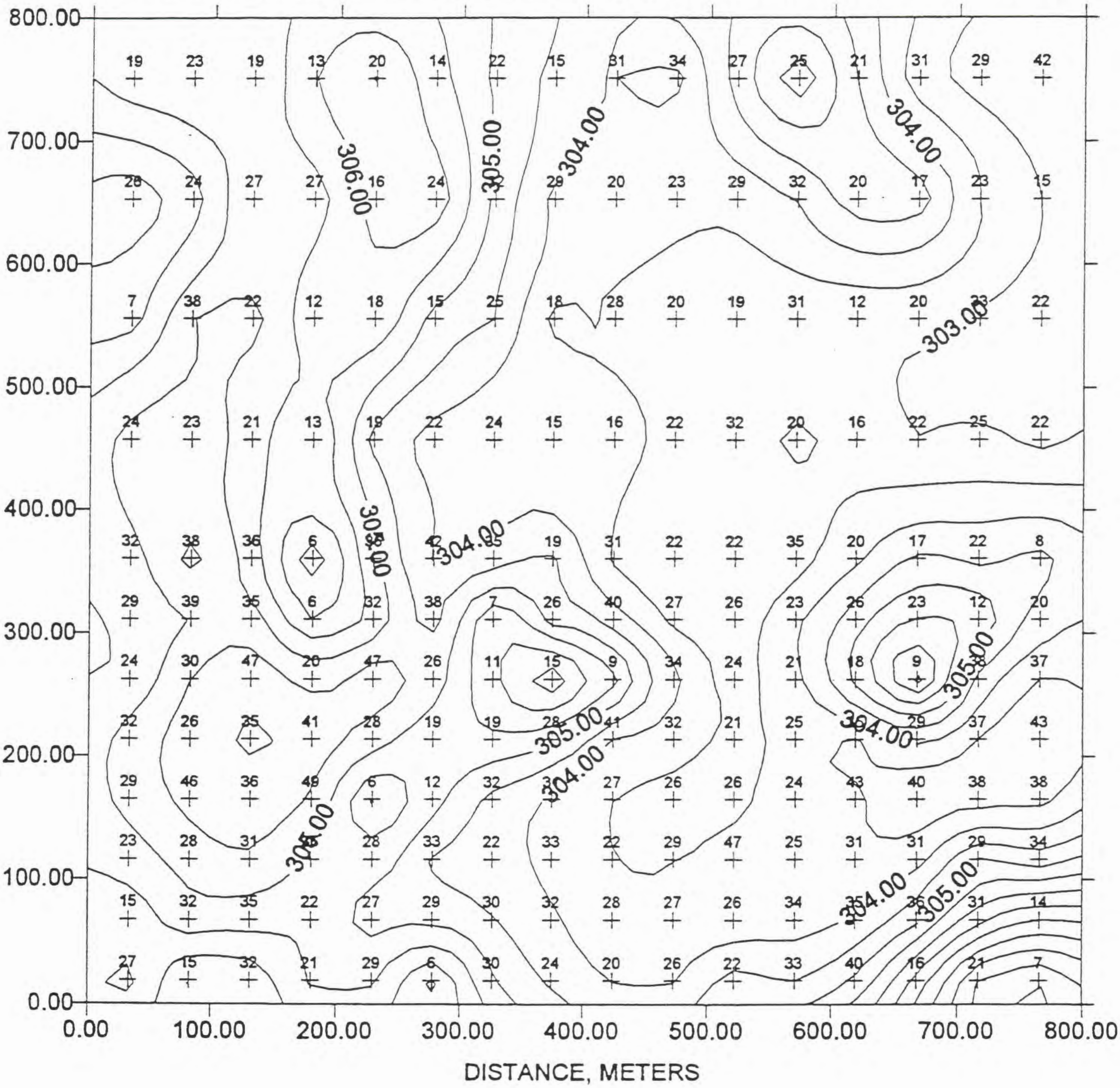
Figure 13. DRAINAGE CLASS ON ELEVATION CONTOURS, THOMPSON-BAKER AREA



igure 14. DEPTH TO CARBONATES (IN.) ON ELEVATION CONTOURS, THOMPSON-BAKER AREA



gure 15. MOLLIC EPIPEDON THICKNESS (IN.) ON ELEVATION CONTOURS, THOMPSON-BAKER AREA



igure 16. ORGANIC MATTER CONTENT (%) ON ELEVATION CONTOURS, THOMPSON-BAKER AREA

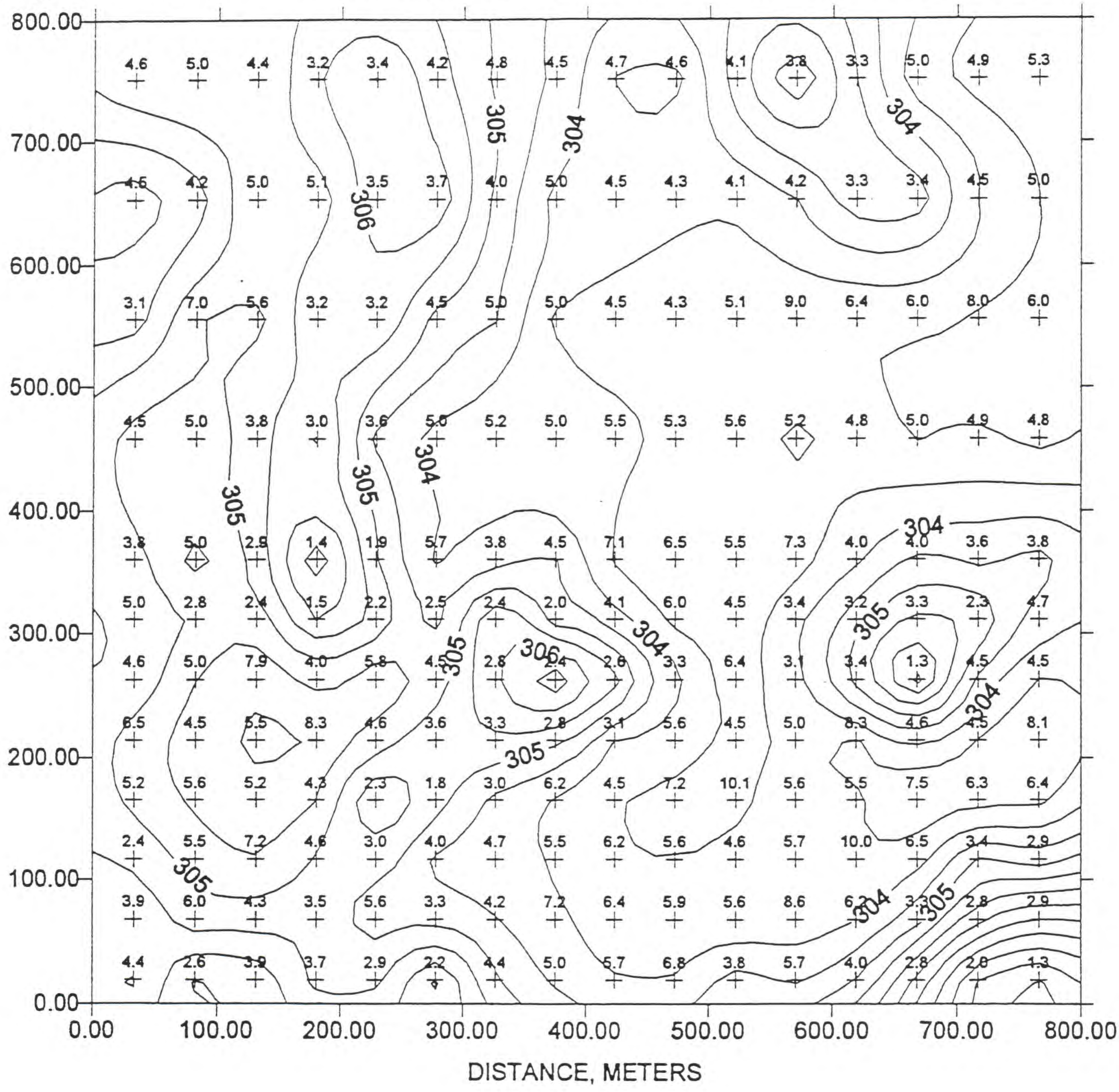


Figure 17. CLAY (%) ON ELEVATION CONTOURS, THOMPSON-BAKER AREA

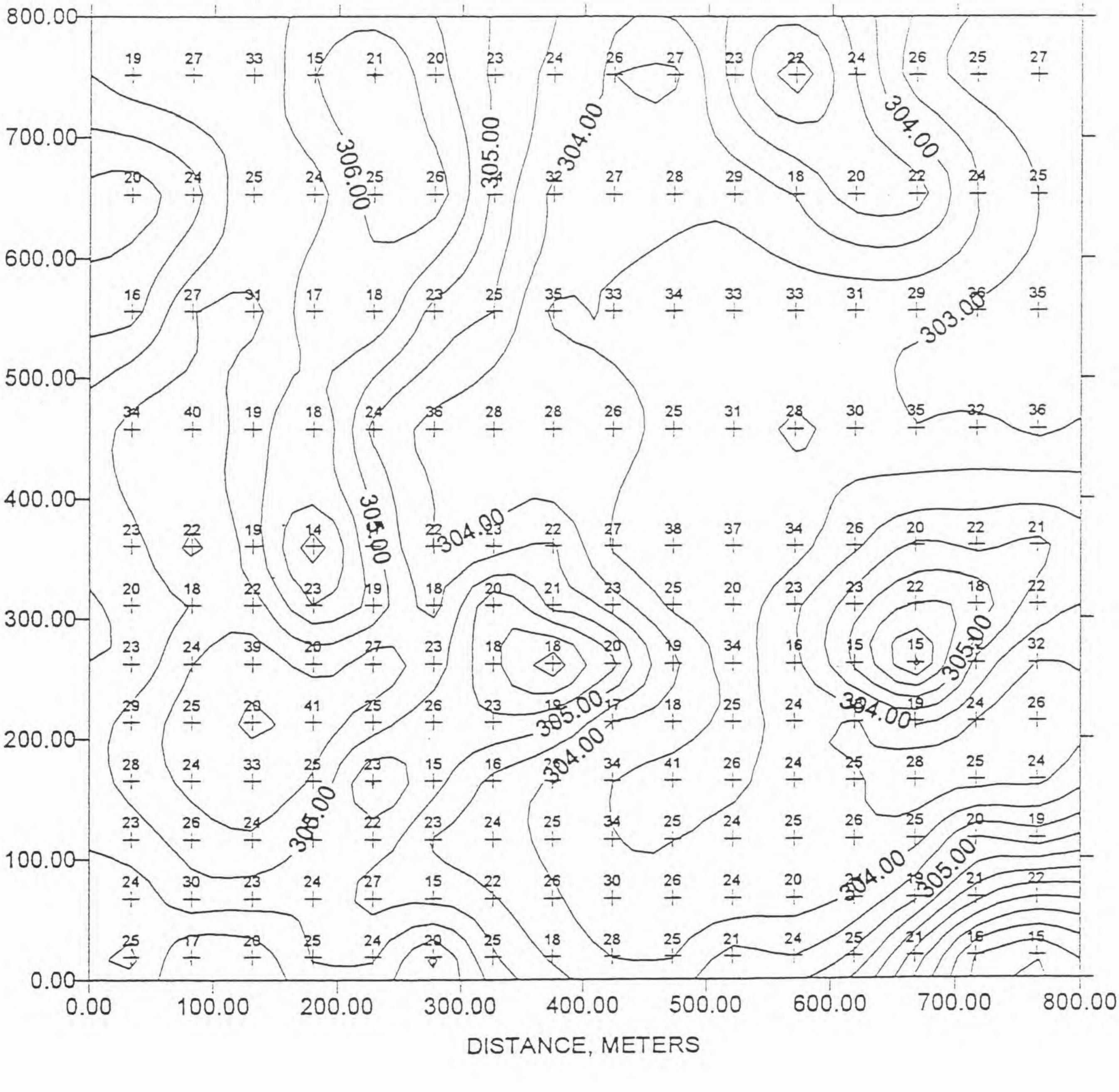
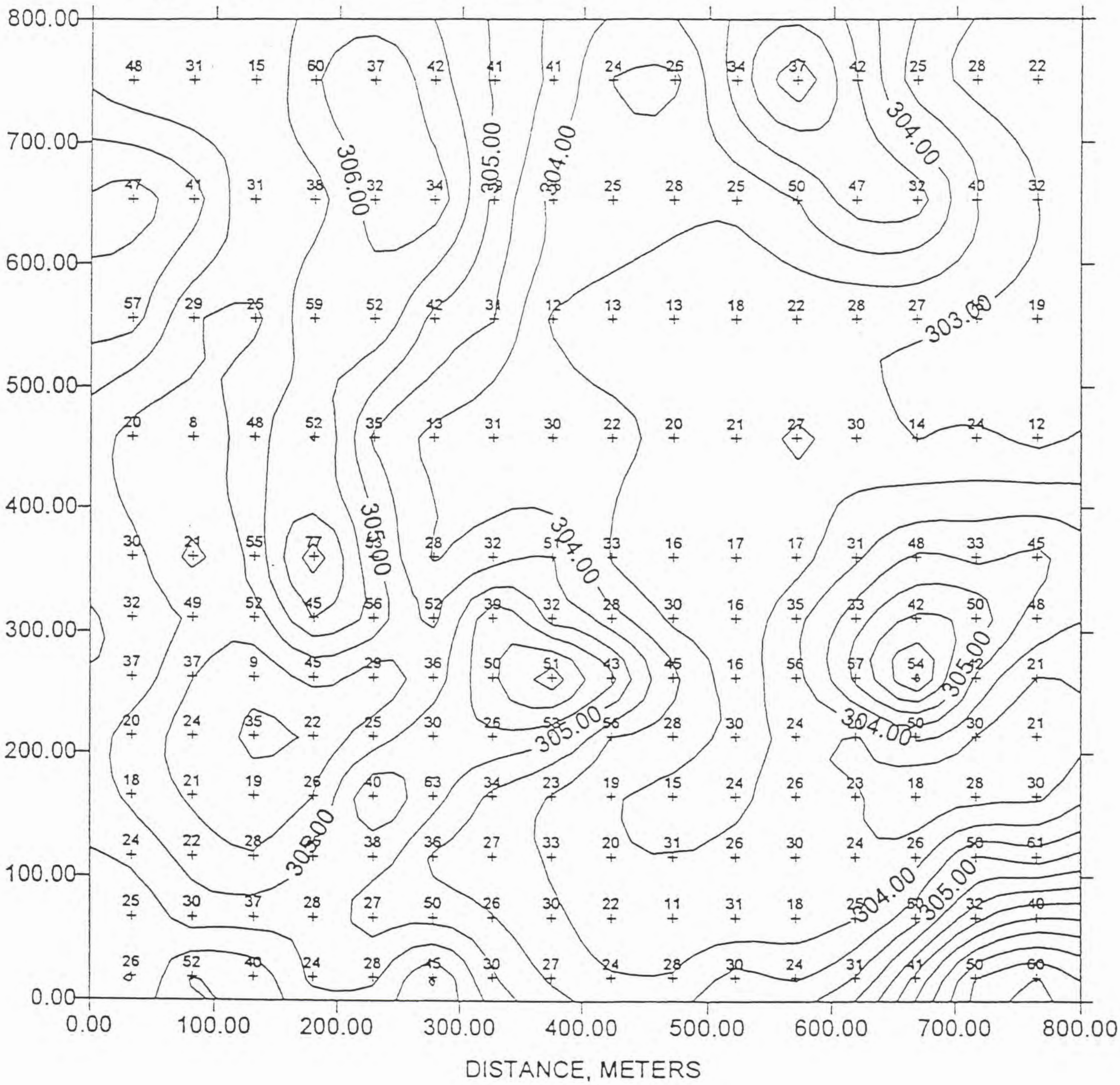


Figure 18. SAND(%) ON ELEVATION CONTOURS, THOMPSON-BAKER AREA



.gure 19.

'IMATED FIVE-YEAR AVERAGE CORN YIELDS (BU/AC) ON ELEVATION CONTOURS, THOMPSON-BAKER ARE/

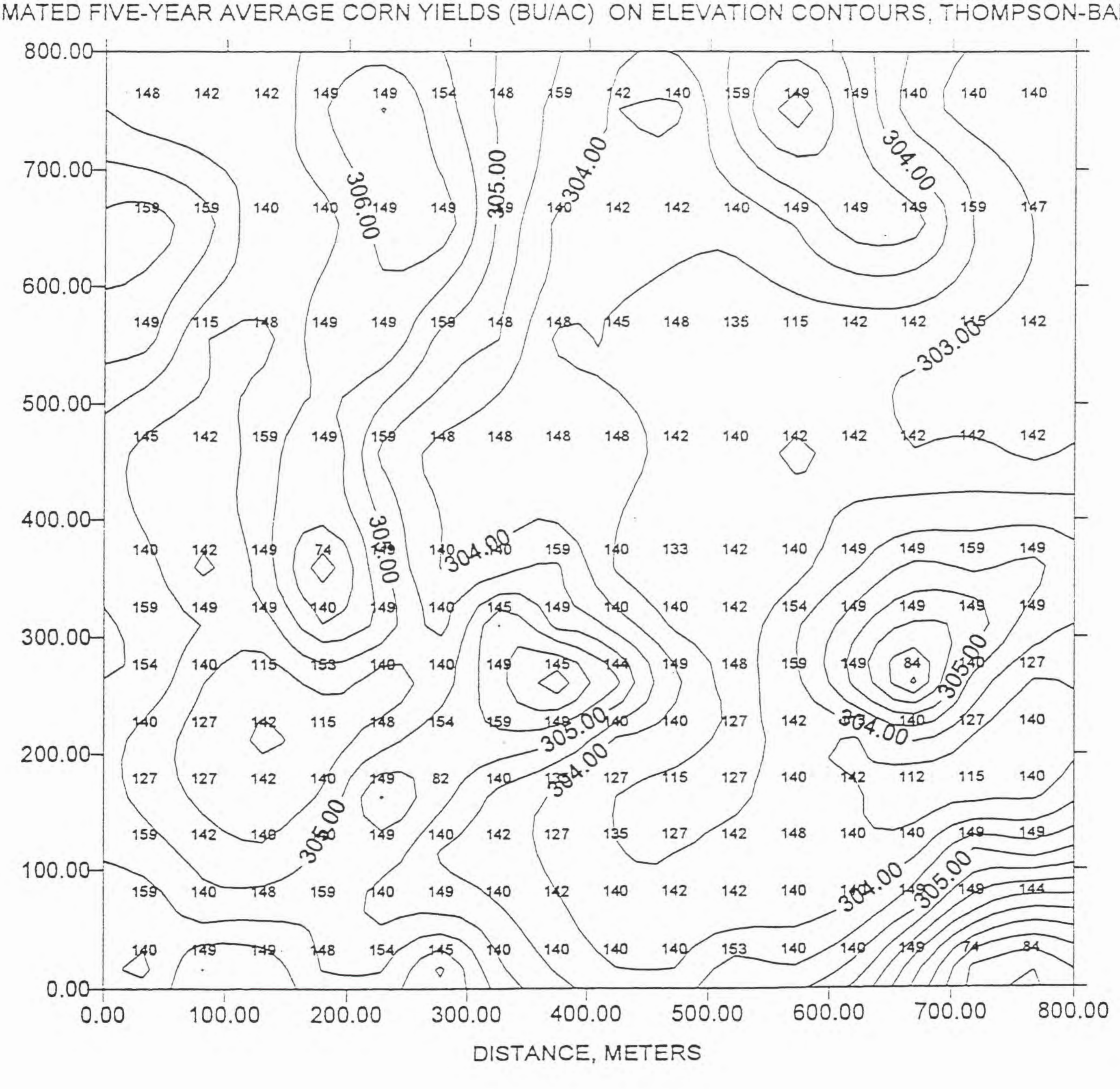


Figure 20. SOIL MAP UNITS ON pH CONTOURS

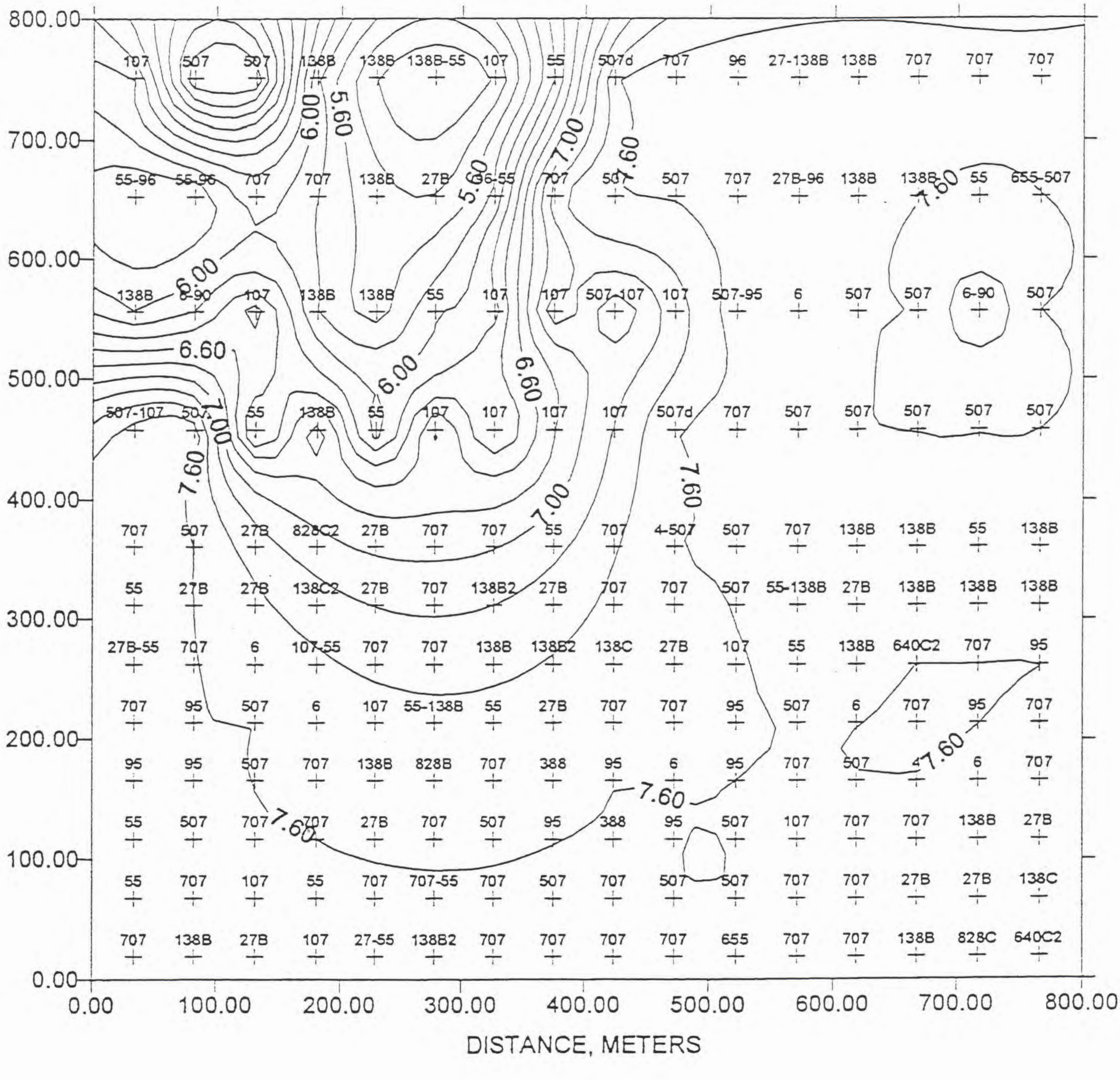


Figure 21. pH ON pH CONTOURS

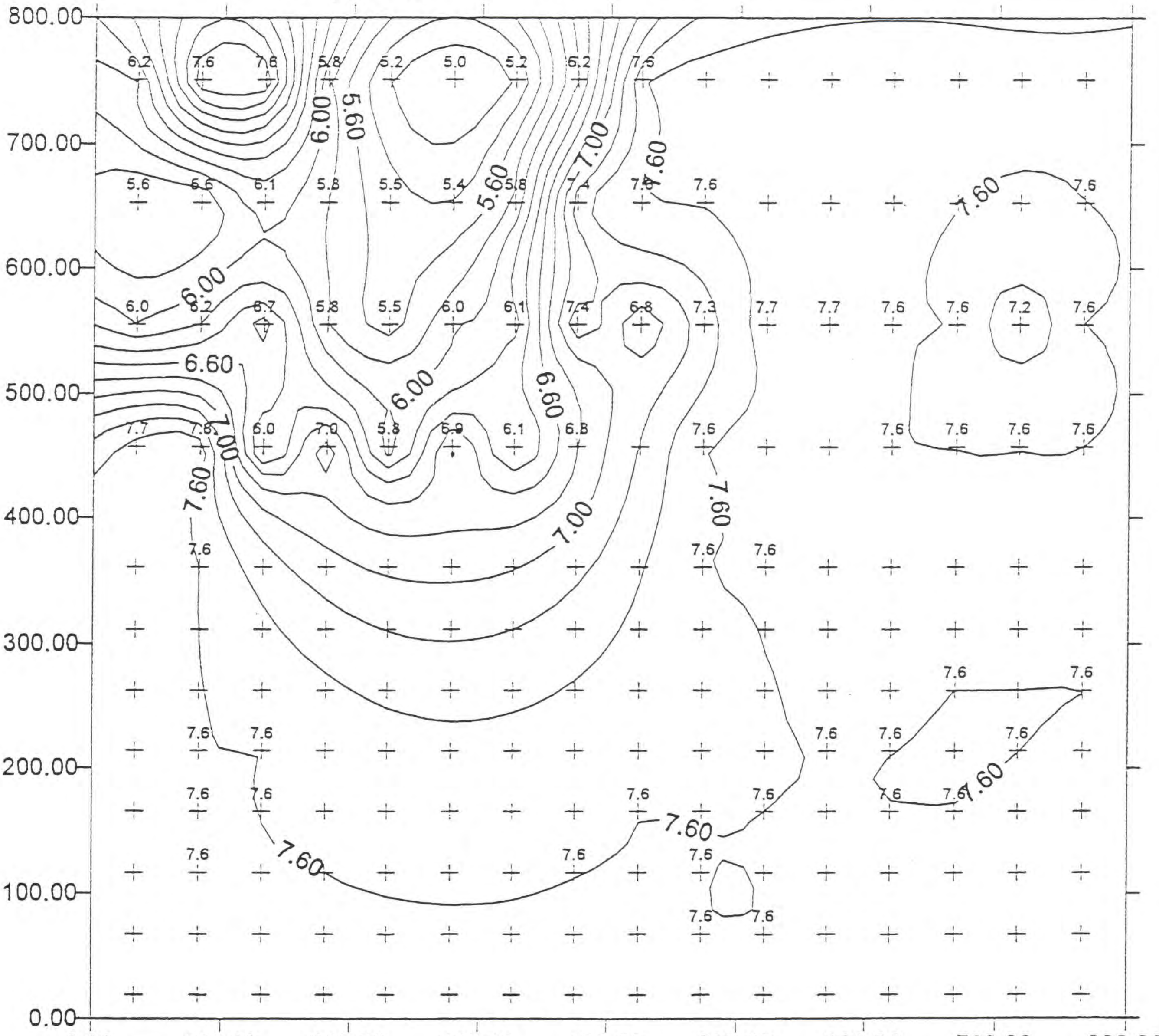


Figure 22. CORN YIELDS (BU/AC) ON CORN YIELD CONTOURS, THOMPSON-BAKER AREA

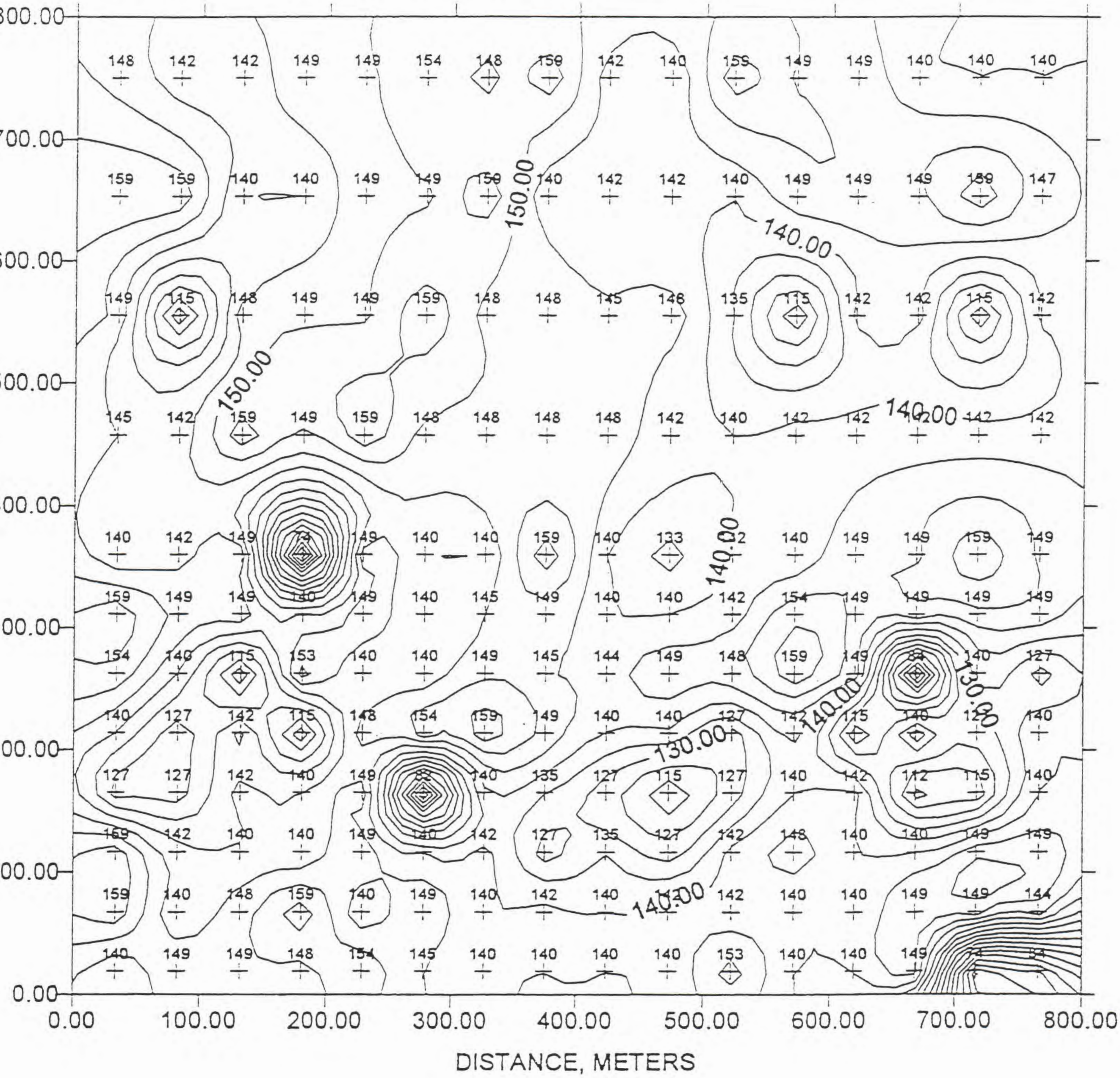


Figure 23. SOIL MAP UNITS ON CORN YIELD CONTOURS, THOMPSON-BAKER AREA

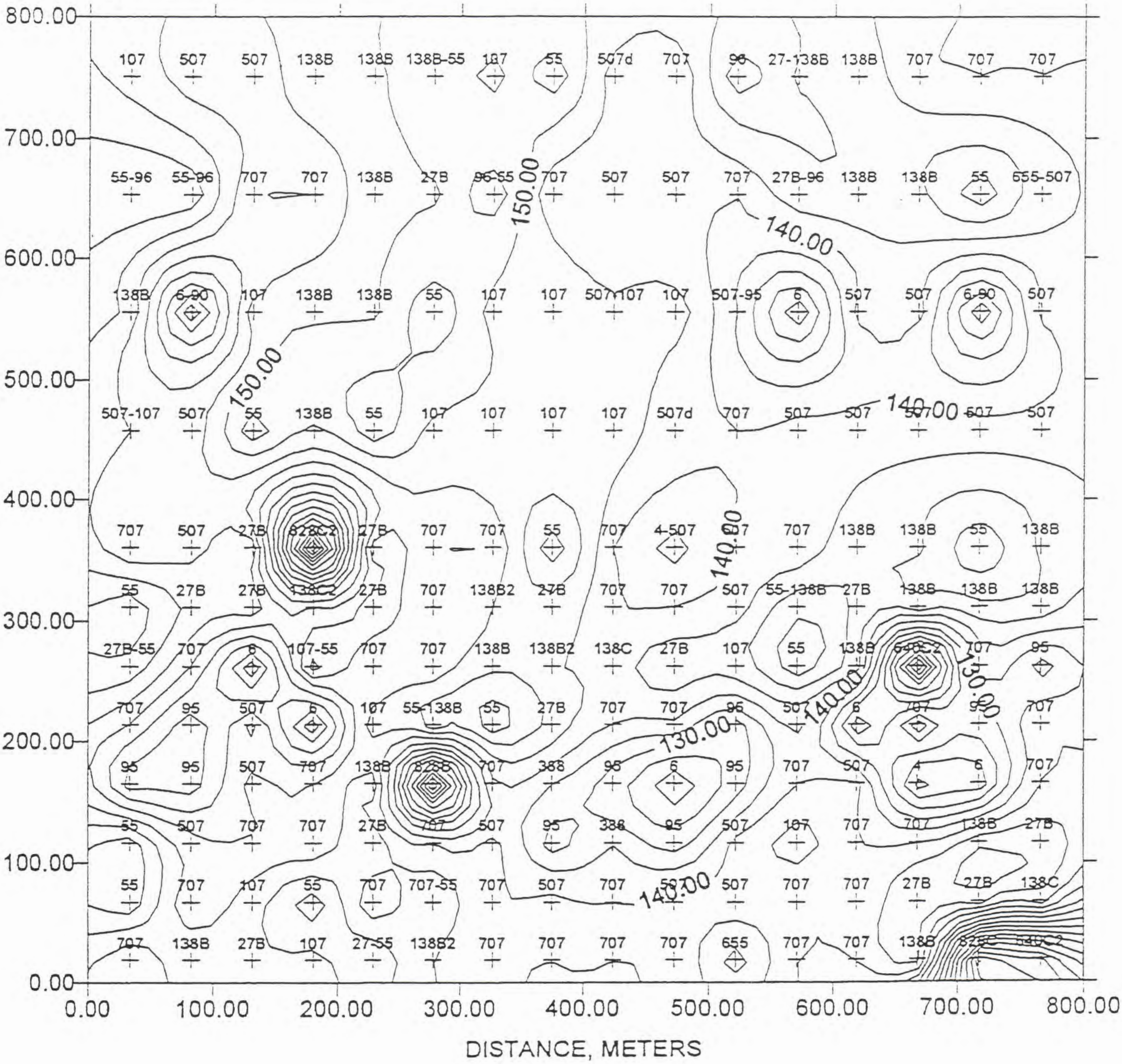


Figure 24. CLAY CONTENT (%) ON CORN YIELD CONTOURS, THOMPSON-BAKER AREA

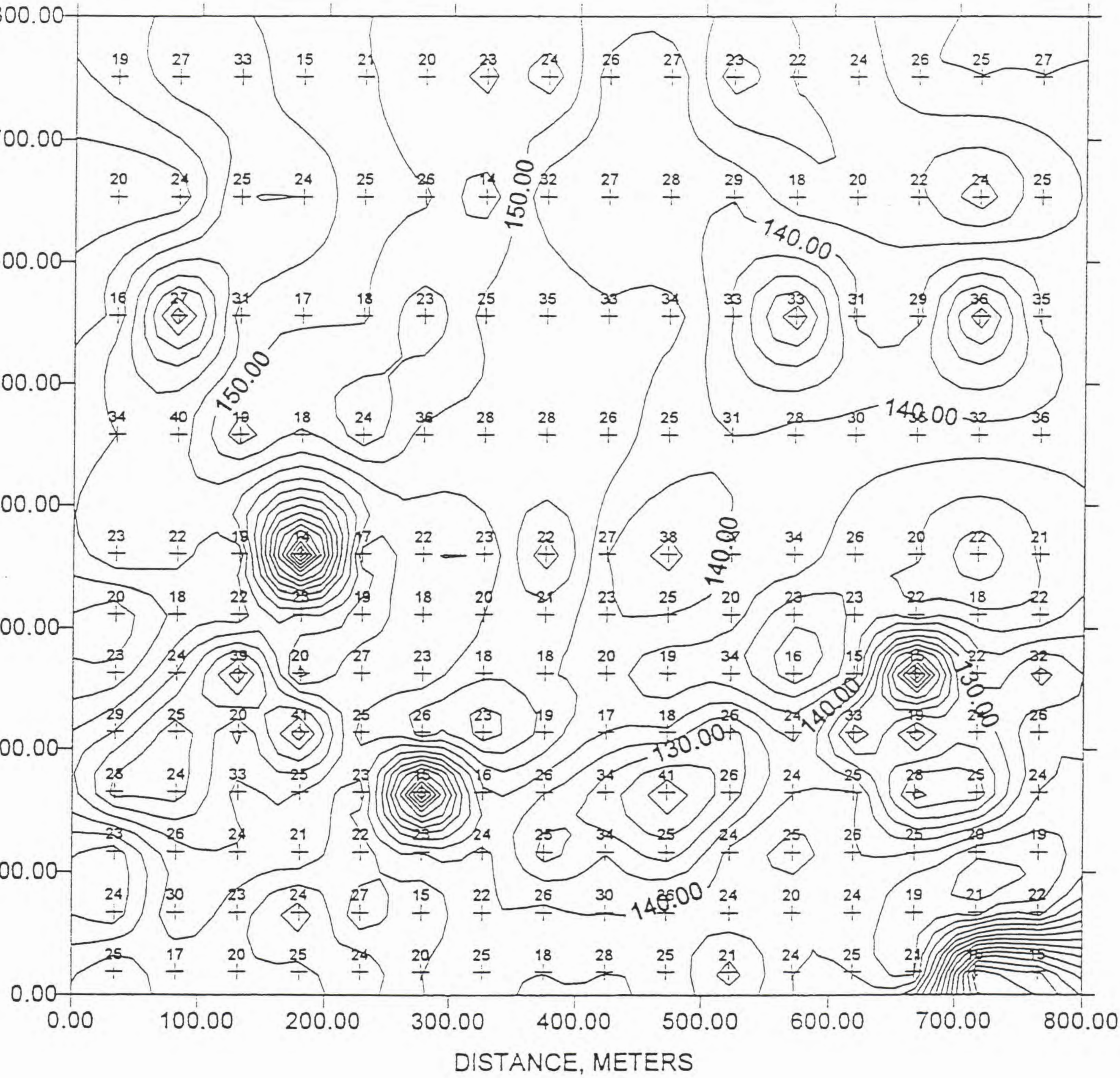


Figure 25. SAND CONTENT (%) ON CORN YIELD CONTOURS, THOMPSON-BAKER AREA

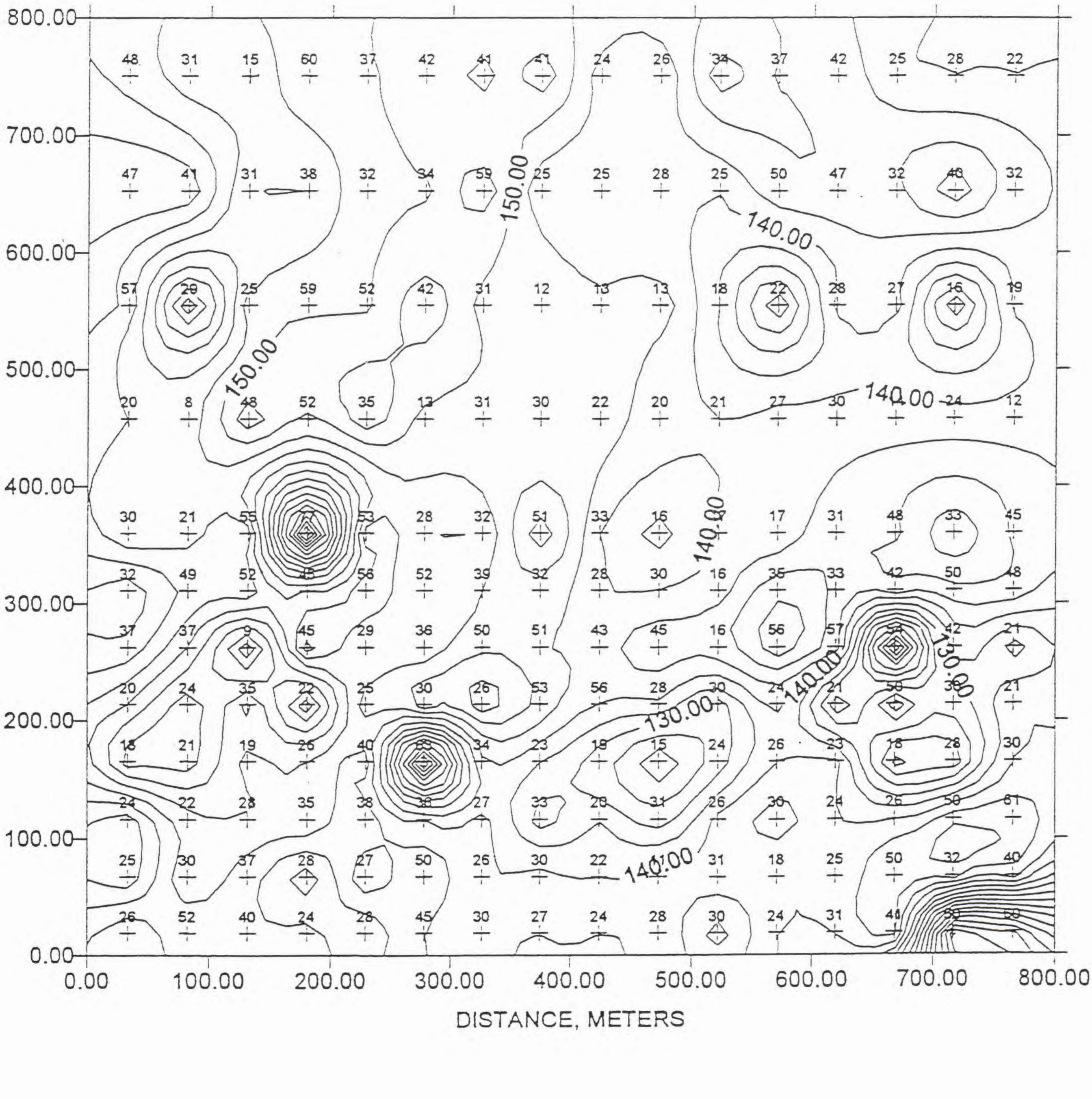


Figure 26. DRAINAGE CLASS ON CORN YIELD CONTOURS, THOMPSON-BAKER AREA