SOIL SURVEY OF

Woodbury County, Iowa

United States Department of Agriculture
Soil Conservation Service
In cooperation with
Iowa Agriculture and Home Economics
Experiment Station

Issued September 1972

Major fieldwork for this soil survey was done in the period 1959 to 1964. Soil names and descriptions were approved in 1967. Unless otherwise indicated, statements in this publication refer to conditions in the county in 1967. This survey was made cooperatively by the Soil Conservation Service and the Iowa Agriculture and Home Economics Experiment Station. It is part of the technical assistance furnished to the Woodbury County Soil Conservation District.

Either enlarged or reduced copies of the soil map in this publication can be made by commercial photographers, or they can be purchased on individual order from the Cartographic Division, Soil Conservation Service, United States Department of Agriculture, Washington, D.C. 20250.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms and woodlands; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

Locating Soils

All the soils of Woodbury County are shown on a detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in numerical order by map symbol and gives the capability classification of each. It also shows the page where each soil is described and the page for the capability unit in which the soil has been placed.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the discussions of the capability units.

Game managers, sportsmen, and others can find information about soils and wildlife in the section "Wildlife."

Engineers and builders can find, under "Engineering Uses of the Soils," tables that contain test data, estimates of soil properties, and information about soil features that affect engineering practices.

Scientists and others can read about how the soils formed and how they are classified in the section "Formation, Morphology, and Classification of the Soils."

Students, teachers, and others will find information about soils and their management in various parts of the text.

Newcomers in Woodbury County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the section "General Nature of the County," which gives additional information about the county.

Cover Picture: **Terraces on Napier-Castana silt loams, 10 to 15 percent slopes. Terracing is one of the major soil and water conservation practices used in the county.**

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SOIL SURVEY OF WOODBURY COUNTY, IOWA

BY JOHN R. WORSTER, ELMER H. HARVEY, AND LAURENCE T. HANSON, SOIL CONSERVATION SERVICE [1]

UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE IOWA AGRICULTURE AND HOME ECONOMICS EXPERIMENT STATION

WOODBURY COUNTY is in the northwestern part of Iowa (fig. 1). It has a total area of 557,440 acres, or about 871 square miles. The county is bounded on the west by the State of Nebraska. The Missouri River is the approximate boundary between Woodbury County and Nebraska. Sioux City, a city with a population of 90,000, is the county seat. The soils in the bottom lands make up about 39 percent of the county, and the rest is undulating to steep soils in the uplands. The uplands are covered with a loess mantle that is as much as 100 feet thick in places.

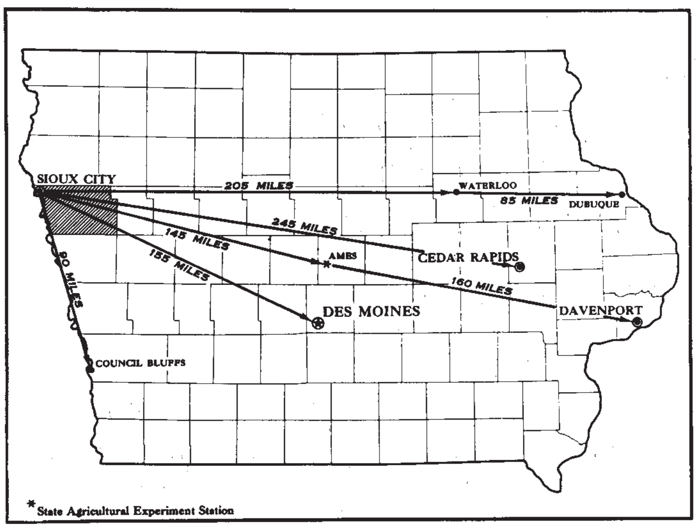

Figure 1.—Location of Woodbury County in Iowa.

Farming and related industries, such as meat processing, are the chief sources of income in Woodbury County. Corn is the main crop, but soybeans, oats, and a mixture of alfalfa and bromegrass are also important. Minor crops are red clover and other legumes, sorghum, wheat, and popcorn. Because livestock is raised extensively in the area, much of the grain is used locally for feed.

The Woodbury County Soil Conservation District was organized in 1942. The Little Sioux River Watershed program, one of eleven pilot watershed projects in the United States, began operation in 1946; it takes in most of the uplands of Woodbury County. By January 1967, construction of 71 subwatersheds had been completed. Twenty-six of these subwatersheds are in Woodbury County.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Woodbury County, where they are located, and how they can be used. The soil scientists went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes, the size and speed of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The soil series and the soil phase are the categories of soil classification most used in a local survey (*20*).[2]

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Monona and Salix, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Ida silt loam, 2 to 6 percent slopes, severely eroded, is one of several phases within the Ida series.

[1] Other members of the Soil Conservation Service who contributed to the soil survey are EARL R. BLAKLEY, EDWARD L. BRUNS, DUANE FREDRICKSON, WILLIAM C. MOFFITT, and JESSE R. THOMAS.

[2] Italic numbers in parentheses refer to Literature Cited, p. 85.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map at the back of this publication was prepared from aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. Two such kinds of mapping units are shown on the soil map of Woodbury County: soil complexes and undifferentiated groups.

A soil complex consists of areas of two or more soils, so intermingled or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Steinauer-Shelby complex, 25 to 40 percent slopes, moderately eroded, is an example.

An undifferentiated group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils, or of two or more. The name of an undifferentiated group consists of the names of the dominant soils, joined by "and." McPaul, Albaton, and Blake soils is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, or so severely eroded that it cannot be classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Riverwash is a land type in Woodbury County.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soil in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soil. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way as to be readily useful to different groups of users, among them farmers, farm managers, and engineers.

On the basis of yield and practice tables and other data, the soil scientists set up trial groups. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others. Then they adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Woodbury County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed or a wildlife area, or in planning engineering works, recreational facilities, and community developments. It is not a suitable map for planning the management of a farm or field, or for selecting the exact location of a road, building, or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The soil associations in Woodbury County are discussed in the following pages.

1. *Albaton-Haynie-Onawa association*

Level or nearly level, stratified, clayey and silty soils that are well drained to poorly drained

This association (fig. 2) occurs as a band 1 to 8 miles wide on bottom lands along the Missouri and Big Sioux Rivers. It is generally level, but in some sandy areas it is hummocky. Crescent-shaped oxbow lakes and swales mark old river channels.

This association makes up about 10 percent of Woodbury County. It consists of about 20 percent Albaton soils, 10 percent Haynie soils, 10 percent Onawa soils, and 60 percent minor soils.

Albaton soils are poorly drained, clayey soils that occupy swales and other low-lying areas. Haynie soils are well drained to moderately well drained silt loams. They are at slightly higher elevations than Albaton soils. Onawa soils, which are at intermediate elevations, are somewhat poorly drained to poorly drained. Onawa soils have a clayey surface layer and are silty or loamy at a depth of 2 or 3 feet.

Minor soils in this association have widely varying properties. The Sarpy soils, for example, are sandy and droughty. Others, such as the Grable, Blake, and Owego soils, have sharply contrasting layers. The Modale soils have a silty surface layer but are clayey at a depth of 2 or 3 feet.

The hazard of flooding was serious until dams were constructed upstream on the Missouri River. Most of these areas are now in cultivated crops, mainly corn and soybeans.

Although the soils of this association have a high content of lime, they benefit from applications of nitrogen and phosphorus. Many of these soils also need artificial drain-

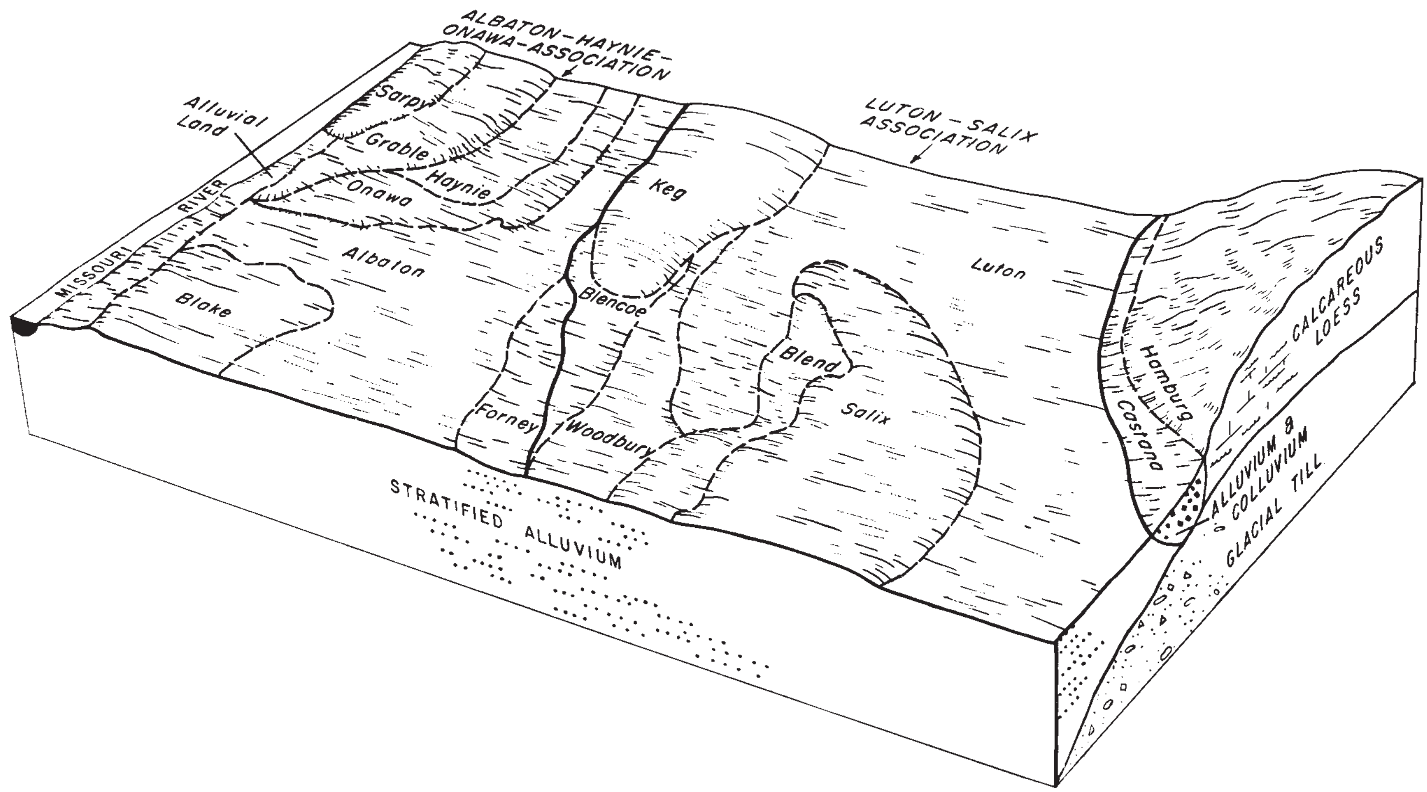

Figure 2.—**Relationship of the soils of the Albaton-Haynie-Onawa association and the Luton-Salix association to topography and underlying material.**

age. Surface drainage systems generally are used. Some of these soils, especially the more sandy ones, are subject to soil blowing.

An average farm is about 200 acres in size, and a few are as large as 500 to 1,000 acres. Some farmers raise cattle or hogs, but the association is mainly a cash-grain area. Small acreages have been planted to sugar beets. There are few, if any, truck farms. Few buildings and roads have been constructed on soils adjacent to the river because the areas were subject to frequent flooding prior to construction of dams on the Missouri River. Gravel roads run along most of the section lines in other parts of the association.

2. Luton-Salix association

Level or nearly level, dark-colored, clayey and silty soils that are moderately well drained to very poorly drained

This association (see fig. 2) occupies bottom lands in the western part of the county. Along the western side of the association is a slightly elevated area several miles wide. Along the eastern side is a level, low-lying area, 4 to 6 miles wide, which in some places varies in elevation by only a few inches.

This association makes up about 10 percent of the county. It is 50 percent Luton soils, 10 percent Salix soils, and 40 percent minor soils.

Luton soils are poorly drained to very poorly drained and are at low elevations. Salix soils are moderately well drained and silty. They are the major soils of the higher elevations.

Minor soils in the association are the Keg, Moville, Blencoe, Woodbury, Solomon, and Napa. Keg soils occupy a sizable acreage, mainly at the highest elevations in the western part of the association. They are well drained to moderately well drained silt loams. Moville soils are silt loams that occupy desilting basins in the eastern part of the association. Most of the other minor soils, such as those of the Blencoe and Woodbury series, are intermediate to Keg and Luton soils in elevation, texture, and natural drainage. Solomon soils are intermingled with Luton soils and are poorly drained to very poorly drained. Napa soils are also very poorly drained; they occupy depressions within areas of Luton and Solomon soils. The Napa soils contain excessive amounts of sodium salts.

Nearly all of this association is used for farming. Corn is the main crop, but soybeans are also important. Many farmers use a cropping system that consists of corn and soybeans. Some wheat is grown in the wetter parts of the association.

The soils in this association range from slightly acid to moderately alkaline, and crops generally respond to applications of nitrogen and phosphorus. Artificial drainage is beneficial to most of these soils, and it is essential to some. A well-established system of ditches (fig. 3) parallels the roads in the association and drains excess water into the Missouri River. The larger ditches also receive water from tributary streams. Surface drains are generally used to get excess water out of the fields and into the drainage network. An increasing acreage has been smoothed and graded to improve drainage and make furrow irrigation possible.

Most farms in this association are 80 to 240 acres in size, but some are larger, especially on the Luton soils. Several

Figure 3.—Pattern of drainage ditches and streams in the Luton-Salix association.

farms along the eastern edge of the association are more than 1,000 acres in size. The towns of Salix and Sloan are in this association, as are U.S. Highway 75 and Interstate 29. Gravel roads run along most section lines.

3. McPaul-Kennebec-Colo association

Level to gently sloping, silty soils that are well drained to poorly drained

This association is in the valleys of the major tributaries of the Missouri River. It includes a narrow strip along the eastern edge of the Missouri River valley, where soils formed in tributary sediments. The tributary valleys are about ½ mile to 2 miles wide. The flood plains, or first bottoms, are about ½ mile wide. Stream benches, or second bottoms, flank the larger streams and in most places are separated from the first bottoms by escarpments 5 to 30 feet high.

This association makes up about 5 percent of the county. It is about 50 percent McPaul soils, about 25 percent Kennebec soils, about 10 percent Colo soils, and about 15 percent minor soils.

The major soils of this association are on first bottoms. McPaul soils are calcareous and well drained to moderately well drained. They make up nearly all of the acreage in some valleys. Kennebec soils are neutral or slightly acid and are moderately well drained. Colo soils are slightly acid and poorly drained.

The minor soils in this association are on stream benches. The Wadena and Salida soils in the Little Sioux River valley are underlain by gravel. A number of gravel pits are in this association. Soils along the West Fork of the Little Sioux River near the northern boundary of the county have gravel fairly near the surface. Most of the stream benches along the West Fork, the Maple River, and other streams are covered with loess. Gravel, where present, is at a depth of 15 to 20 feet. Ida and Monona soils are on these benches. They are deep, well-drained, silty soils formed in loess. Napier and Castana soils are along the edges of the valleys.

Nearly all of this association is cultivated. A few low-lying areas, subject to frequent flooding, have been left in trees, and some of the steep escarpments are in trees or permanent pasture. The main crops are corn, soybeans, oats, and a mixture of alfalfa and bromegrass.

The first bottoms are subject to at least occasional flooding, unless protected by levees, but replanting is seldom necessary. The cropping system generally consists of corn and soybeans. The soils on stream benches are droughty where gravel is near the surface, but in many places the main hazard is erosion. A great deal of water from the uplands flows across these soils. Most areas are nearly level or gently sloping, and they are used mainly for row crops. Runoff needs to be controlled on the sloping areas to control the loss of soil and water.

The size of a typical farm is 300 to 400 acres. Many farms consist of bottom-land soils of this association and steep upland soils of another association. Livestock feeding is the major farm enterprise, but there is also a fair amount of cash-grain farming. State and U.S. highways parallel the rivers and streams in this association. Each valley has one or more towns.

4. Ida-Hamburg association

Steep and very steep, silty soils that are well drained to somewhat excessively drained

This association (fig. 4) is on narrow ridgetops and long, steep hillsides. The steepest hills have small bench-like relief, or catsteps, that form prominent features of the landscape. The catsteps result from slumps. Most of the valleys are narrow and are dissected by deep, wide gullies that have vertical sides.

This association makes up about 5 percent of the county. It is about 70 percent Ida soils, 12 percent Hamburg soils, and 18 percent minor soils.

Ida and Hamburg soils are calcareous silt loams that formed in loess. Ida soils are well drained, and Hamburg soils are somewhat excessively drained. The main limitation to farming is the slope.

Minor soils in the valleys, including those of the Napier, Kennebec, McPaul, and Castana series, are silty and slightly acid to moderately alkaline. The use of Napier and Castana soils is limited somewhat by the slope, which is as much as 20 percent in places. Steinauer soils, which formed in glacial till, are on the lower part of steep hillsides. They are more clayey and less permeable than other soils of this association.

This association is used for growing feed for cattle and also hogs, sheep, and poultry. The steepest hills are left in native vegetation, such as big bluestem, little bluestem, and other native grasses. The soils in valleys and on concave foot slopes contain more moisture, and in places they support bur oak and other trees. The ridges and valleys that are wide enough are used for corn, soybeans, oats, and a mixture of alfalfa and bromegrass. Areas too steep for regular cultivation, but where farm machinery can be used, are left in semipermanent pasture consisting of bromegrass or bromegrass and alfalfa.

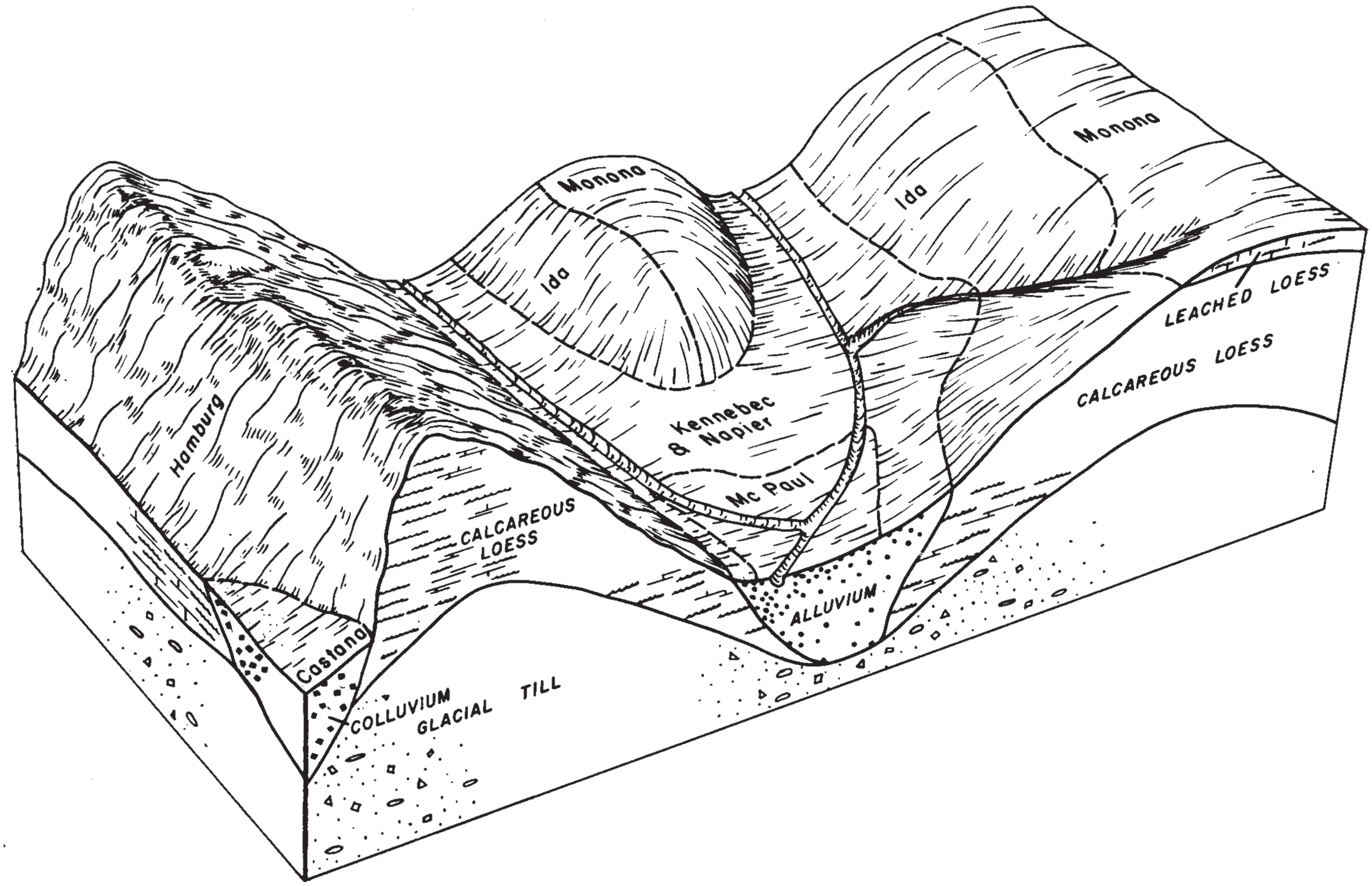

Figure 4.—**Relationship of soils of associations 4 and 5 to topography and underlying material.**

Terraces and contour tillage are used to control runoff and erosion on cultivated fields. Large, level basin terraces built at the base of steep hills at the edge of the valleys check runoff, control rilling, and help slow the formation of large gullies. A number of dams and other gully control structures have been built in the smaller valleys as part of watershed programs.

The size of an average farm in this association is 300 to 400 acres, but some farms are as large as 500 to 1,000 acres. Livestock raising will probably remain the main source of income, but recreational uses of the soils are becoming increasingly important. The ponds produced by watershed projects, the scenery, and abundant deer and other wildlife make the association attractive as a recreational area. More than in other parts of the county, the roads in this association follow the ridges and valleys, rather than the section lines.

5. *Ida-Monona association*

Gently sloping to steep, silty soils that are well drained

This association (see fig. 4) is on narrow, gently sloping ridgetops and long, sloping to steep hillsides. The area is dissected by numerous small valleys, where streams drain southwesterly into the Missouri River. Gullies 20 to 50 feet deep are prominent features of the landscape. Soils on hillsides have slopes of 10 to 40 percent, and most of the steepest soil areas are along the larger stream valleys.

This association makes up about 60 percent of the county. Ida and Monona soils each make up about 30 to 40 percent of the association, and minor soils make up approximately 25 percent.

Ida and Monona soils formed in loess, and they cover the ridgetops and most of the hillsides. They are medium textured, well drained, and moderately permeable. The Ida soils have a high content of lime. Monona soils are neutral or slightly acid.

The minor soils are of the Steinauer, Napier, Kennebec, and McPaul series. Steinauer soils developed in glacial till on the lower part of rolling to steep hillsides. They are loamy and high in content of lime, and they contain many pebbles and stones. Napier and Kennebec soils occupy the valleys. They formed in silty material deposited by water. They are deep, dark colored, silty, and neutral or slightly acid. McPaul soils occur in the larger stream valleys. They are stratified, silty, and calcareous.

Livestock feeding is the major source of income for farmers in this association. Most farmers buy feeder cattle from out-of-state and fatten them for market. They raise grain for feed. Hogs raised for market are also important. Turkeys, sheep, chickens, and cash-grain crops are other sources of income. The major crops are corn, soybeans, oats, and meadows of alfalfa and bromegrass; minor crops are grain sorghum, sweet clover, and other legumes and grasses. Crops grow well except in years when rainfall is below normal.

An average farm in this association is about 240 acres in size, which is also the average size for the county. Contoured fields, terraces, gully control structures, and manmade ponds are common. The fields range from 10 to 40 acres in size. This association has a good network of gravel and blacktop roads. Most of them run along section lines, but a few follow the valleys and ridgetops.

6. *Galva association*

Gently sloping and strongly sloping, dark-colored, silty soils that are well drained

This association is on gently sloping ridgetops and sloping hillsides. In a few areas nearly all the soils are gently sloping, and in others the slope is no more than 9 percent. There are some steep hillsides near the Little Sioux River.

This association makes up about 10 percent of the county. It is about 50 percent Galva soils and 50 percent minor soils, such as those of the Judson, Colo, and Steinauer series.

Galva soils formed in loess. They are well drained and slightly acid in reaction.

Judson and Colo soils occupy most of the valleys in the association. They are silty and slightly acid. Drainage is restricted on the Colo soils. Steinauer soils are on the more strongly sloping hillsides near the Little Sioux River. These are calcareous, loamy soils that formed in glacial till. Pebbles and stones are on the surface in many areas.

Row crops are included in the cropping system on Galva soils and most of the soils in the valleys. Corn and soybeans are the main crops. Alfalfa, red clover, and bromegrass are used for meadows. The more strongly sloping soils are used for permanent pasture. Cash-grain crops and livestock operations are the major sources of income.

Contour tillage and terraces are used to control erosion on the sloping soils of this association. The topography is such that a practical system of terraces with a minimum of short rows can be used in most places. Tile lines have been installed in most of the small valleys. Where there is no tile, field operations may be delayed a day or two by wetness.

An average farm in this area is about 240 acres in size, and the trend is to increasing size. There is a network of paved roads throughout the association, and gravel roads run along most section lines.

Descriptions of the Soils

This section describes the soil series and mapping units of Woodbury County. The approximate acreage and proportionate extent of each mapping unit are given in table 1.

In the pages that follow, a general description of each soil series is given. Each series description has a short narrative description of a representative profile and a much more detailed description of the same profile, from which highly technical interpretations can be made. Following the profile is a brief statement of the range in characteristics of the soils in the series, as mapped in this county. Color names and color symbols given are for a moist soil, unless otherwise indicated. Following the series description, each mapping unit in the series is described individually. For full information on any one mapping unit, it is necessary to read the description of the soil series as well as the description of the mapping unit. Miscellaneous land types, such as Alluvial land and Riverwash, are described in alphabetic order along with other mapping units.

Following the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. At the end of the description of each mapping unit is listed the capability unit in which it has been placed. To find descriptions of these capability units, refer to the "Guide to Mapping Units."

The location and extent of the soils in the county are shown on the soil map. The State boundary shown on the maps in the survey is approximate. The boundary shown between Iowa and Nebraska was plotted from the U.S. Corps of Engineers base map dated January 30, 1940. This boundary was established as the State line by the Iowa-Nebraska Boundary Compact of 1943.

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Soil	Acres	Percent
Albaton silty clay loam	250	[1]
Albaton clay	8, 735	1. 6
Albaton clay, depressional	595	. 1
Alluvial land	1, 525	. 3
Blake silty clay loam	3, 825	. 7
Blencoe silty clay	3, 025	. 5
Blend silty clay	2, 700	. 5
Blend silty clay loam	295	. 1
Blend silty clay loam, overwash	180	[1]
Borrow pits	520	. 1
Calco silty clay loam	510	. 1
Carr fine sandy loam	3, 210	. 6
Castana silt loam, 15 to 20 percent slopes	2, 740	. 5
Castana-Gullied land complex, 6 to 20 percent slopes	1, 230	. 2
Chute loamy fine sand, 5 to 18 percent slopes, severely eroded	250	[1]
Colo silt loam, calcareous overwash	1, 780	. 3
Colo silty clay loam	3, 380	. 6
Colo-Judson silty clay loams, 2 to 6 percent slopes	3, 470	. 6
Corley silt loam	175	[1]
Forney silty clay loam, calcareous overwash	320	. 1
Forney clay	4, 480	. 8
Galva silty clay loam, 2 to 6 percent slopes	11, 835	2. 1
Galva silty clay loam, 6 to 10 percent slopes, moderately eroded	12, 670	2. 3
Galva silty clay loam, 10 to 15 percent slopes, moderately eroded	2, 745	. 5
Grable silt loam	1, 080	. 2
Grable silty clay loam	1, 170	. 2
Hamburg silt loam, 30 to 75 percent slopes	3, 325	. 6
Haynie silt loam	5, 885	1. 1
Holly Springs silty clay loam	1, 025	. 2

TABLE 1.—*Approximate acreage and proportionate extent of the soils*—Continued

Soil	Acres	Percent
Ida silt loam, 2 to 6 percent slopes, severely eroded	1,285	.2
Ida silt loam, 6 to 10 percent slopes, severely eroded	23,930	4.3
Ida silt loam, 10 to 15 percent slopes, severely eroded	62,725	11.3
Ida silt loam, 15 to 20 percent slopes, severely eroded	53,775	9.6
Ida silt loam, 20 to 30 percent slopes, severely eroded	14,170	2.5
Ida silt loam, 30 to 40 percent slopes, severely eroded	2,210	.4
Judson silty clay loam, 2 to 6 percent slopes	1,865	.3
Keg silt loam	3,575	.6
Kennebec silt loam, 0 to 2 percent slopes	7,945	1.4
Kennebec silt loam, 2 to 6 percent slopes	38,610	6.9
Lakeport silty clay loam	1,555	.3
Luton silty clay loam	555	1
Luton clay	27,175	4.9
Made land	190	(1)
Marsh	1,170	.2
McPaul silt loam	27,820	5.0
McPaul silt loam, frequently flooded	2,345	.4
McPaul, Albaton, and Blake soils	1,785	.3
McPaul-Kennebec silt loams, 2 to 6 percent slopes	13,410	2.4
Modale silt loam	2,275	.4
Modale silty clay loam	2,600	.5
Monona silt loam, 0 to 2 percent slopes	730	.1
Monona silt loam, 2 to 6 percent slopes	3,780	.7
Monona silt loam, 2 to 6 percent slopes, moderately eroded	11,675	2.1
Monona silt loam, 6 to 10 percent slopes, moderately eroded	33,280	6.0
Monona silt loam, 10 to 15 percent slopes, moderately eroded	48,800	8.8
Monona silt loam, 10 to 15 percent slopes, severely eroded	2,050	.4
Monona silt loam, 15 to 20 percent slopes, moderately eroded	6,855	1.2
Monona silt loam, 15 to 20 percent slopes, severely eroded	1,610	.3
Monona silt loam, 20 to 30 percent slopes, moderately eroded	3,470	.6
Moville silt loam	1,520	.3
Napa clay	1,770	.3
Napier silt loam, 6 to 10 percent slopes	17,190	3.1
Napier-Castana silt loams, 10 to 15 percent slopes	8,900	1.6
Napier-Gullied land complex, 2 to 10 percent slopes	1,525	.3
Onawa silt loam	400	1
Onawa silty clay	4,770	.9
Owego silt loam, calcareous overwash	235	(1)
Owego silty clay	2,155	.4
Percival silty clay	955	.2
Riverwash	580	.1
Salida sandy loam, 5 to 9 percent slopes, moderately eroded	130	(1)
Salida sandy loam, 9 to 18 percent slopes, severely eroded	395	.1
Salida sandy loam, 18 to 40 percent slopes, severely eroded	240	(1)
Salix silty clay loam	5,565	1.0
Salix silty clay loam, overwash	340	.1
Sarpy loamy fine sand, 1 to 5 percent slopes	705	.1
Sarpy loamy fine sand, 5 to 18 percent slopes	590	.1
Sarpy fine sandy loam, 0 to 2 percent slopes	505	.1
Sarpy soils and Alluvial land	405	.1
Shelby loam, 5 to 14 percent slopes, moderately eroded	205	(1)
Shelby soils, 14 to 24 percent slopes, severely eroded	255	(1)
Solomon clay	2,685	.5
Solomon-Luton silt loams, calcareous overwash	1,130	.2
Spillville loam, frequently flooded	700	.1
Steinauer clay loam, 5 to 14 percent slopes, eroded	600	.1
Steinauer clay loam, 14 to 18 percent slopes, moderately eroded	810	.1
Steinauer clay loam, 18 to 25 percent slopes, moderately eroded	1,180	.2
Steinauer-Shelby complex, 25 to 40 percent slopes, moderately eroded	3,660	.7
Terril loam, 2 to 6 percent slopes	280	.1
Terril loam, 6 to 10 percent slopes	445	.1
Terril and Castana soils, 10 to 20 percent slopes	390	.1
Wadena loam, moderately deep, 2 to 5 percent slopes	275	(1)
Wadena loam, moderately deep, 5 to 9 percent slopes, moderately eroded	270	(1)
Wadena silt loam, moderately deep, 0 to 2 percent slopes	390	.1
Wadena silt loam, moderately deep, 2 to 5 percent slopes	500	.1
Wadena silt loam, deep, 0 to 2 percent slopes	1,520	.3
Wadena silt loam, deep, 2 to 5 percent slopes	425	.1
Waubonsie fine sandy loam	340	.1
Woodbury silty clay	5,760	1.0
Gravel pit	595	.1
Total	557,440	100.0

[1] Less than 0.05 percent.

Albaton Series

The Albaton series consists of moderately dark colored, poorly drained soils that formed in river sediments. These soils are clayey and stratified. They occur as broad areas at low elevations; some areas are in swales. They are level or nearly level.

In a representative profile the plow layer is firm, very dark gray clay about 6 inches thick. It is underlain by stratified, firm and very firm, dark-gray or dark grayish-brown, calcareous clay. The underlying layers extend to a depth of 60 inches.

420-440—72——2

Permeability is slow or very slow, and the available moisture capacity is medium. The organic-matter content is low. The content of available nitrogen is low, of available phosphorus is very low, and of available potassium is high. The surface layer and substratum are generally mildly alkaline or moderately alkaline and calcareous.

Most areas of Albaton soils are cultivated. A few low-lying areas are left in pasture or trees.

Representative profile of Albaton clay, in a soybean field about 3 miles northwest of Sloan, 50 feet west and 75 feet south of the northeast corner of NW¼NW¼ sec. 23, T. 86 N., R. 47 W., on a level flood plain:

Ap—0 to 6 inches, very dark gray (10YR 3/1 tending toward 2.5Y) clay; weak, very fine, subangular blocky structure that has some granular structure in upper 2 inches; firm; mildly alkaline; calcareous; abrupt, smooth boundary.

C1g—6 to 18 inches, dark grayish-brown (2.5Y 4/2) clay; few, fine, prominent, reddish-brown (5YR 4/4) mottles; moderate to weak, very fine and fine, subangular and angular blocky structure; firm; moderately alkaline; calcareous; clear, smooth boundary.

C2g—18 to 60 inches, stratified, dark-gray (5Y 4/1) and dark grayish-brown (2.5Y 4/2) clay; few, fine, prominent, reddish-brown (5YR 4/4) mottles, dark grayish brown (10YR or 2.5Y 4/2) at a depth of 22 to 27 inches and 32 to 60 inches; common, pale-brown (10YR 6/3) mottles at a depth below 32 inches; weak, medium, subangular blocky structure breaking to strong, fine, angular blocky; very firm; moderately alkaline; calcareous.

The Ap horizon is 6 to 10 inches thick. It ranges from very dark gray (10YR 3/1) to very dark grayish-brown (10YR or 2.5Y 3/2) clay, silty clay, or silty clay loam.

The C horizon is silty clay or clay. It ranges from dark grayish brown (2.5Y 4/2) to dark olive gray (5Y 4/2) or olive gray (5Y 5/2); in places part of the matrix color is dark gray (N 4/0) to gray (5Y 5/1). An Ab horizon commonly occurs at a depth of 20 to 40 inches. These dark-colored horizons are 4 to 8 inches thick, very dark gray in color, and range from silty clay loam to clay. The substratum also contains strata, up to 6 inches thick, of coarser textured sediments.

In most places Albaton soils are mildly alkaline or moderately alkaline and calcareous. In places the upper few inches of the profile is neutral.

Albaton soils are similar in texture to Luton soils, but are not so dark colored below the surface layer. They are associated with Forney, Onawa, Owego, and Percival soils. They contain more lime than Forney soils and have a thinner solum. The buried A horizon is not so common in Albaton soils, but where it occurs it is thinner and less distinct than in Forney soils. Albaton soils lack the silty and sandy layers that occur in the C horizon of Onawa, Owego, and Percival soils.

Albaton silty clay loam (0 to 1 percent slopes) (155).—Except that the surface layer is very dark grayish-brown, friable silty clay loam, this soil has a profile like that described as representative for the series.

This soil has a high water table, but it is not so wet as other Albaton soils. The surface layer is easier to till. If it is adequately drained, this soil can be worked earlier in spring and sooner after rains than Albaton clay.

In most areas row crops are frequently included in the cropping system. (Capability unit IIIw–1)

Albaton clay (0 to 1 percent slopes) (156).—This soil has the profile described as representative for the series. It occupies broad areas that are as much as 500 or 600 acres in size. Thus, many farms have large areas of this soil that can be managed separately.

Included with this soil in mapping was about 1,000 acres where the soil is underlain at a depth of about 3 feet by silty or sandy sediments. Internal drainage is better in these included soils, partly because they are at slightly higher elevations than the typical Albaton soil.

This soil is suited to row crops if it is adequately drained. Wetness and a clayey surface layer limit its use for farming. The surface layer becomes cloddy if worked when wet. (Capability unit IIIw–1)

Albaton clay, depressional (0 to 1 percent slopes) (945).—This soil occurs on bottoms of former river channels and in distinct swales.

Most areas are poorly suited to cultivated crops. Soil conditions are unfavorable, because of wetness and lack of adequate drainage. (Capability unit Vw–1)

Alluvial Land

Alluvial land (0 to 2 percent slopes) (315) consists of areas of alluvium recently deposited on first bottoms of major streams in the county. The alluvial material varies widely in color and texture and is distinctly stratified. Generally, Alluvial land consists of light-colored deposits of silt and sand mixed with layers of dark-colored, clayey material. The areas are undulating, frequently flooded, and subject to change by deposition. Sediment of silt or sand is laid down on the areas each year when the streams overflow.

Much of Alluvial land is wooded and cut by shallow, old meanders and oxbows. Some of the old stream channels are filled with water and cannot be crossed with farm machinery. Other areas have a cover of willow and cottonwood saplings and are wet for long periods.

Alluvial land has limited value for farming unless it is cleared, smoothed, and drained. It provides pasture in some areas and is used as habitat for wildlife. (Capability unit Vw–1)

Blake Series

The Blake series consists of moderately dark colored, somewhat poorly drained, silty soils that formed in river sediments. These soils occur at elevations midway between swales and the highest points on the landscape. They are nearly level.

In a representative profile the plow layer is very dark grayish-brown, calcareous silty clay loam about 8 inches thick. The substratum is friable, calcareous, very dark grayish-brown and dark grayish-brown silty clay loam that grades to very friable, stratified, dominantly grayish-brown silt loam at a depth of about 20 inches.

Permeability is moderately slow to moderate in the upper part of the profile and moderate or moderately rapid in the underlying layers. The organic-matter content is low. The available moisture capacity is high. The rooting zone is deep. The content of available phosphorus and nitrogen is low, and the content of available potassium is high. The soils are mildly alkaline or moderately alkaline and calcareous.

Most areas of Blake soils are used for crops.

Representative profile of Blake silty clay loam, in a cornfield about a mile north of the Sioux City Municipal Airport, 300 feet west and 200 feet north of the southeast corner of NE¼ sec. 24, T. 88 N., R. 48 W., on a level flood plain:

Ap1—0 to 3 inches, very dark grayish-brown (10YR to 2.5Y 3/2) light silty clay loam; few, fine, distinct, pale-brown to pale-olive (10YR 6/3 to 5Y 6/3) mottles; moderate, very fine and fine, granular structure; friable; common, dark reddish-brown (5YR 3/3), partly decomposed organic matter; mildly alkaline; calcareous; abrupt, smooth boundary.

Ap2—3 to 8 inches, very dark grayish-brown (10YR to 2.5Y 3/2) light silty clay loam; few, fine, distinct, pale-brown to pale-olive (10YR 6/3 to 5Y 6/3) mottles; weak, coarse, subangular blocky structure breaking to moderate, very fine and fine, granular; common, dark reddish-brown (5YR 3/3), partly decomposed organic matter; mildly alkaline; calcareous; abrupt, smooth boundary.

C1—8 to 20 inches, stratified, very dark grayish-brown (10YR to 2.5Y 3/2) and dark grayish-brown (10YR to 2.5Y 4/6) light silty clay loam; few, fine, distinct, pale-brown to pale-olive (10YR 6/3 to 5Y 6/3) mottles to a depth of 13 inches; weak, fine, subangular blocky structure and moderate, very fine, granular and subangular blocky structure to a depth of 13 inches; moderate, very fine, granular structure below; friable; common worm casts; horizontal, pale-brown to pale-olive (10YR 6/3 to 5Y 6/3) krotovinas, 3½ inches in diameter; moderately alkaline; calcareous; gradual, smooth boundary.

IIC2—20 to 60 inches, stratified, dominantly grayish-brown (2.5Y 5/2 tending toward 2.5Y 5/3) silt loam; common, fine, prominent, strong-brown (7.5YR 5/6) and dark reddish-brown (5YR 3/3) mottles; bedding evident; very friable; moderately alkaline; calcareous.

The Ap horizon is 6 to 10 inches thick. In places it is very dark gray (10YR 3/1).

The C1 horizon has a clay content of 28 to 35 percent overall, but individual strata may exceed 35 percent. Colors range from very dark grayish brown (10YR 3/2) to olive brown (2.5Y 4/4) in this horizon. At a depth of 15 to 30 inches, the C1 horizon grades to a IIC horizon. The IIC horizon is stratified, very friable silt loam or loam that consists of 15 to 40 percent sand and very fine sand. The C1 and IIC horizons contain some dark-gray to strong-brown mottles. Reaction is mildly alkaline to moderately alkaline, except in the Ap horizon, where it is neutral in some places.

Blake soils are associated with Onawa, Haynie, and Grable soils. Blake soils differ from Onawa soils in having silty clay loam rather than silty clay in the uppermost 2 feet. Haynie soils are silt loam throughout. Blake soils are not underlain by sand, as are the Grable soils.

Blake silty clay loam (0 to 2 percent slopes) (144).—Small areas of this soil, about 5 to 20 acres in size, are near the Missouri River channel. Many of these areas are long and narrow. Farther from the river are larger areas, a few as much as 200 or 300 acres in size. Some of this soil can be managed separately. Included with this soil in mapping are small areas that have a sandy or clayey surface layer.

This soil is well suited to row crops, and it is intensively cultivated. There are no serious limitations to use. Fieldwork is sometimes delayed where this soil is associated with patches of clayey soil. (Capability unit I–1)

Blencoe Series

The Blencoe series consists of dark-colored, somewhat poorly drained to poorly drained, clayey soils that formed in river sediments. These soils occur as broad areas on bottom lands. They are at intermediate elevations in the Missouri River valley. They are nearly level.

In a representative profile the surface layer is about 19 inches thick. It is black silty clay that grades to heavy silty clay loam or light silty clay in the lower part. The subsoil, about 17 inches thick, is mainly dark grayish-brown, friable silty clay loam that grades to silt loam. The substratum is grayish-brown, calcareous silt loam.

The available moisture capacity is high. The content of organic matter is high. Permeability is very slow in the clayey surface layer and moderate in the underlying silty clay loam or silt loam. The content of available nitrogen is generally medium or low, the content of phosphorus is very low, and the content of available potassium is high. Reaction is generally neutral in the surface layer.

Nearly all areas of these soils are used for crops.

Representative profile of Blencoe silty clay, in a cornfield 650 feet west and 513 feet south of the northeast corner of NW¼ sec. 8, T. 86 N., R. 46 W., on a level flood plain:

Ap1—0 to 2 inches, black (10YR 2/1) silty clay; cloddy, breaking to moderate, very fine, granular structure; firm; neutral; abrupt, smooth boundary.

Ap2—2 to 7 inches, black (10YR 2/1) silty clay; weak, medium, subangular blocky structure breaking to strong, very fine and fine, angular and subangular blocky; firm; neutral; clear, smooth boundary.

A1—7 to 13 inches, black (10YR 2/1) heavy silty clay loam or light silty clay; few, fine, prominent, brown (7.5YR 4/4) mottles; weak, medium, subangular blocky structure breaking to strong, fine, granular and strong, very fine, subangular blocky; firm; neutral; clear, smooth boundary.

A3—13 to 19 inches, black (10YR 2/1) to very dark gray (10YR 3/1) heavy silty clay loam or light silty clay; few, fine, prominent, brown (7.5YR 4/4) mottles; weak, fine and medium, subangular blocky structure breaking to strong, fine, granular; firm; mildly alkaline; noncalcareous; clear, smooth boundary.

B1—19 to 24 inches, very dark gray (10YR 3/1) silty clay loam; common, fine, prominent, strong-brown (7.5YR 5/6) mottles; weak, fine and medium, subangular blocky structure breaking to moderate, fine, granular and moderate, very fine, subangular blocky; friable; mildly alkaline; calcareous; clear, smooth boundary.

B2—24 to 30 inches, dark grayish-brown (2.5Y 4/2) light silty clay loam; common, fine, prominent, strong-brown (7.5YR 5/6) mottles; weak, fine and medium, subangular blocky structure breaking to moderate, very fine, subangular blocky; friable; calcium carbonate concretions; mildly alkaline; calcareous; clear, smooth boundary.

IIB3—30 to 36 inches, dark grayish-brown (2.5Y 4/2) silt loam; many, fine, distinct, light olive-brown (2.5Y 5/4) mottles; moderate, very fine, subangular blocky structure; friable; calcium carbonate concretions; moderately alkaline; calcareous; gradual, smooth boundary.

IIC—36 to 60 inches, grayish-brown (2.5Y 5/2) silt loam; massive; friable; moderately alkaline; calcareous.

The A horizon is 15 to 20 inches thick. The lower part of the A horizon ranges from silty clay to heavy silty clay loam and in most places is mottled. The mottles range from few to common in abundance and from brown to reddish brown in color. Reaction is neutral or slightly acid.

The B horizon generally extends to a depth of 30 to 40 inches. It is typically neutral or mildly alkaline, but in some places it is moderately alkaline in the lower part. In places the B1 horizon is very dark grayish brown (10YR or 2.5Y 3/2) and the B2 and B3 horizons are grayish brown (2.5Y 5/2). The C horizon commonly has thin strata of silty clay loam and silty clay.

Blencoe soils are similar in texture to Onawa soils, but the depth to calcareous material is greater. In addition, Blencoe soils are not stratified. In these soils the A horizon is thicker and has a higher organic-matter content than that of Onawa soils. Blencoe soils are associated with Blend soils, but they lack the silty clay IIAb and IIIBg horizons that occur in those soils.

Blencoe silty clay (0 to 1 percent slopes) (44).—This soil is in the central and eastern parts of the Missouri River valley. Individual areas are about 10 to 100 acres in size. In the central part of the valley, this soil lies along the edges of slightly higher bottom lands and is associated with silty, moderately well drained soils. In the eastern part of the valley, it is surrounded by wetter soils.

This soil is used intensively for row crops, and it is suited to such use if drainage is adequate. The main limitation to farming is wetness. If the soil is worked while wet, the surface layer puddles easily. It is subject to cloddiness. (Capability unit IIw–2)

Blend Series

The Blend series consists of dark-colored, poorly drained, clayey and silty soils that formed in river sediments in the Missouri River valley. These soils are nearly level.

In a representative profile the surface layer is black to very dark gray silty clay about 14 inches thick. The subsoil is dark grayish-brown, friable light silty clay loam about 9 inches thick. Below this is a black to very dark gray, very firm clayey layer, about 8 inches thick, that is probably the surface layer of an older soil buried by more recent sediments. This layer is underlain by very firm, dark-gray to gray, calcareous silty clay or clay.

Permeability is very slow in the silty clay and clay layers and moderately slow in the silty clay loam layer. The available moisture capacity is medium. The organic-matter content is high. The content of available nitrogen is medium or low, the content of available phosphorus is very low, and the content of available potassium generally is high. The surface layer is neutral or slightly acid. The rooting zone is deep, but root growth is restricted in places where the underlying clay is waterlogged.

Nearly all areas of these soils are used for crops.

Representative profile of Blend silty clay, in a soybean field 2½ miles south of Luton, 100 feet west and 110 feet south of the northeast corner of NW¼ sec. 5, T. 86 N., R. 46 W., on a level flood plain:

Ap—0 to 7 inches, black (N 2/0) to very dark gray (N 3/0) heavy silty clay; moderate, coarse, angular blocky structure; and moderate, fine and medium, subangular blocky structure; firm; neutral; abrupt, smooth boundary.

A1—7 to 14 inches, black (N 2/0) to very dark gray (N 3/0) heavy silty clay; moderate, fine to coarse, subangular blocky structure; firm; slightly acid; clear, smooth boundary.

IIB—14 to 23 inches, dark grayish-brown (2.5Y 4/2) light silty clay loam; common, fine, distinct, yellowish-brown (10YR 5/6) mottles; moderate, fine and medium, granular and subangular blocky structure; friable; abundant black worm casts; mildly alkaline; noncalcareous; abrupt, smooth boundary.

IIIAb—23 to 31 inches, black (N 2/0) to very dark gray (N 3/0) heavy silty clay; moderate, very fine and fine, subangular blocky structure; very firm; shiny ped surfaces; mildly alkaline; noncalcareous; gradual, smooth boundary.

IIIBg—31 to 72 inches, dark-gray (5Y 4/1) to gray (5Y 5/1) silty clay or clay; moderate, very fine and fine, subangular blocky structure; very firm; shiny ped surfaces; mildly alkaline; calcareous at a depth of 40 to 72 inches; gradual, smooth boundary.

The A horizon is silty clay or silty clay loam 10 to 18 inches thick.

The IIB horizon is generally 8 to 12 inches thick, but it ranges from 6 to 20 inches in thickness. It is generally dark grayish brown (10YR or 2.5Y 4/2 or 5/2), but it is mottled in places and has a chroma of 3 or 4. The IIB horizon is generally silty clay loam, but in places it is silt loam and loam. Reaction of the A horizon is neutral or slightly acid. It ranges from neutral to mildly alkaline in the IIB horizon.

The IIIAb horizon (a buried soil) is at a depth of about 15 to 30 inches. This horizon is 8 to 12 inches thick.

The IIIBg horizon ranges from dark gray (10YR to 5Y 4/1) to grayish brown (2.5Y 5/2) and light brownish gray (2.5Y 6/2). In many places there are few to common mottles that range from 4 to 6 in chroma. The IIIAb horizon is neutral or mildly alkaline, and the IIIBg horizon is mildly alkaline or moderately alkaline and calcareous.

Blend soils are associated with Blencoe, Luton, Solomon, Woodbury, and Napa soils. All of these soils have a dark color and clayey texture, but, except for Blencoe soils, none of the associated soils has the silty clay loam B horizon characteristic of the Blend soils. Blend soils have a buried silty clay horizon at a depth of about 2 feet, but Blencoe soils do not. Blend soils are similar in texture to Owego soils, but the A horizon is thicker and the Ab horizon is darker.

Blend silty clay (0 to 1 percent slopes) (244).—This soil has the profile described as representative for the series. In places the silty clay surface layer extends to a depth of about 20 inches. Drainage is slightly better in areas where the subsoil is thicker and less clayey. Individual areas of this soil are as large as 300 to 400 acres.

The soil has a seasonal high water table. The surface layer is easily puddled if worked when wet. This soil is suited to cultivation if drainage is adequate. It can be used intensively for row crops. (Capability unit IIIw-1)

Blend silty clay loam (0 to 1 percent slopes) (245).—This soil has a surface layer of friable, black to very dark gray silty clay loam. The subsoil is slightly less mottled and less clayey than that described as representative for the series. Individual areas of this soil are about 10 to 40 acres in size, and they are mostly at medium to high elevations compared with adjacent soils. A few areas are in narrow swales.

Where this soil is on narrow rises on bottom lands, it is generally surrounded by poorly drained, clayey soils. If the wetter parts of these fields are adequately drained, there is little hazard of wetness. Where this soil is in a swale or adjacent to better drained soils at higher elevations, it needs artificial drainage.

In many places, especially in elongated areas at slightly higher elevations, a siltier, better drained soil is included with this soil in mapping. In such areas, wetness is not so severe a hazard as on other Blend soils.

This soil is well suited to cultivation if drainage is adequate. It is used intensively for row crops. Tillage is easier on this soil than on Blend silty clay. (Capability unit IIw-2)

Blend silty clay loam, overwash (0 to 1 percent slopes) (850).—This soil has about 6 to 15 inches of friable, dark grayish-brown, calcareous, silty overwash over the original surface layer. This layer is less fertile than the older buried surface layer. The subsoil is less mottled and less clayey than that of other Blend soils. Most areas are in narrow swales near the town of Salix.

Wetness is a limitation, and surface drains are used to remove excess water. Although the overwash is low in organic-matter content, this soil generally has good tilth.

This soil is well suited to cultivation if drainage is adequate. It is used intensively for row crops. Generally, this soil is lower in content of available nitrogen and phosphorus than other Blend soils. (Capability unit IIw-2)

Borrow Pits

Borrow pits (BP) are areas where soil material has been dug up and hauled away for use in highway construction. They include soils of all textures except sand and loamy sand. They are low in organic-matter content and fertility. Borrow pits are on bottom lands.

Because they are 2 to 3 feet lower than the surrounding soils, water stands on the surface in many places. If they are dry enough at planting time, some of these areas are used for crops. Use of these areas for crops is risky, however, because long, wet periods are likely to drown out the crops or prevent harvest. (Capability unit Vw-1)

Calco Series

The Calco series consists of dark-colored, poorly drained, silty soils that formed in river sediments. These soils are nearly level.

In a representative profile the uppermost 9 inches is calcareous silty clay loam washed in from the nearby hills. Below this is the original surface layer of black and very dark gray, calcareous silty clay loam about 20 inches thick. The subsoil is very dark gray and dark gray, firm, calcareous silty clay loam about 21 inches thick. It is underlain by very dark gray, firm, calcareous silty clay.

Permeability is moderately slow, and the available moisture capacity is high. The organic-matter content is high. The content of available nitrogen is medium or low, the content of available phosphorus is generally very low, and the content of available potassium is low or very low. Reaction is moderately alkaline, and these soils are calcareous. The rooting zone is deep, except where root growth is restricted by a high water table.

Most areas of Calco soils are used for crops.

Representative profile of Calco silty clay loam, in a plowed field about 3 miles east of Hornick, 250 feet west and 60 feet south of the northeast corner of sec. 26, T. 86 N., R. 45 W., on a level flood plain:

Ap—0 to 7 inches, very dark gray (10YR 3/1) light silty clay loam that has a 5 percent mixing of black (10YR 2/1); few, fine, distinct, light yellowish-brown (10YR 6/4) mottles; weak, coarse, subangular blocky structure breaking to moderate, fine, granular; friable; moderately alkaline; calcareous; clear, smooth boundary.

Cg—7 to 9 inches, very dark gray to dark gray (N 3/0 to 4/0) light silty clay loam; common, fine, prominent, light yellowish-brown (10YR 6/4) mottles; weak, coarse, subangular blocky structure breaking to weak, very fine, subangular blocky and granular; friable; moderately alkaline; calcareous; abrupt, smooth boundary.

A1—9 to 25 inches, black (N 2/0) silty clay loam tending toward very dark gray (N 3/0) in the lower part; few, fine, prominent, light yellowish-brown (10YR 6/4) mottles at a depth of 9 to 14 inches; weak, coarse, subangular blocky structure breaking to moderate, very fine, granular and subangular blocky; friable; moderately alkaline; calcareous; gradual, smooth boundary.

A3—25 to 29 inches, very dark gray (N 3/0) silty clay loam; strong, very fine, subangular blocky and granular structure; friable; moderately alkaline; calcareous; gradual, smooth boundary.

B2g—29 to 40 inches, very dark gray (5Y 3/1) silty clay loam; common, medium to coarse, prominent, light-gray (5Y 7/2) mottles; moderate, fine to medium, prismatic structure and moderate, coarse, subangular blocky; firm; moderately alkaline; calcareous; gradual, smooth boundary.

B3g—40 to 50 inches, dark-gray (5Y 4/1) silty clay loam; common, fine, prominent, yellowish-brown (10YR 5/4) mottles; moderate, very fine and fine, subangular blocky structure; firm; moderately alkaline; calcareous; gradual, smooth boundary.

IICg—50 to 89 inches, very dark gray (N 3/0 to 5Y 3/1) silty clay; massive; firm; calcareous.

The A horizon is light or medium silty clay loam 24 to 40 inches thick. It is typically black (N 2/0 or 10YR 2/1) but ranges to very dark gray (N 3/0 or 10YR 3/1), especially in the lower part. In places there is a 6- to 12-inch layer of overwash that consists of very dark grayish-brown (10YR 3/2) or very dark gray (10YR 3/1) silt loam or light silty clay loam. Snail shells are in the A horizon in some areas.

The Bg horizon is dark gray (N 4/0 or 10YR to 5Y 4/1) or very dark gray (N 3/0 or 10YR to 5Y 3/1). The texture is similar to that of the A horizon. Few or common yellowish-brown to light-gray (5Y 7/2) mottles are in the B horizon and, in places, in the lower part of the A horizon. Snail shells are in the B horizon in many places. The silty clay IICg horizon does not occur in all places.

The Calco, Holly Springs, Napa, and Solomon soils are all dark colored and have a high content of lime. Calco soils have less clay in the B horizon than Solomon, Napa, and Holly Springs soils. They have a less clayey A horizon than Solomon and Napa soils.

Calco silty clay loam (0 to 1 percent slopes) (733).—This soil is on bottom lands. Some of the areas are 40 acres or more in size.

Included in mapping in many places are small areas that have a clayey substratum at a depth of 30 to 40 inches. Those areas have a higher water table and are harder to drain than the Calco soil.

This soil can be drained artificially. In many places it receives excess water from the higher adjacent soils.

This soil is used intensively for row crops. (Capability unit IIw-2)

Carr Series

The Carr series consists of stratified, light-colored, somewhat excessively drained, loamy soils that formed in river sediments. These soils occupy rises in the Missouri River valley. They are nearly level to undulating.

In a representative profile the surface layer is dark grayish-brown, calcareous fine sandy loam about 6 inches thick. The substratum has dominantly grayish-brown strata of calcareous fine sandy loam and loamy fine sand.

Permeability is moderately rapid. The available moisture capacity is generally medium, but it varies greatly according to the number, thickness, texture, and depth of layers in the substratum. These layers are as much as 6 inches thick, and they range from clay to sand. The organic-matter content is low, and the content of available nitrogen and phosphorus is low or very low. The content of available potassium is generally high. These soils are moderately alkaline and calcareous.

These soils are mainly used for crops.

Representative profile of Carr fine sandy loam, in a cornfield 950 feet east and 390 feet south of the northwest corner of NE¼ sec. 5, T. 86 N., R. 47 W., on a nearly level flood plain:

Ap—0 to 6 inches, dark grayish-brown (10YR 4/2) fine sandy loam; weak, fine, subangular blocky structure; loose; moderately alkaline; calcareous; abrupt, smooth boundary.

C1—6 to 23 inches, stratified, dark grayish-brown (10YR 4/2) fine sandy loam and very dark grayish-brown (10YR 3/2) and brown (10YR 4/3) loamy fine sand; few, fine, distinct, dark reddish-brown (5YR 2/2) and reddish-brown (5YR 4/4) mottles at a depth below 14 inches; very weak, medium, subangular blocky structure; very friable; moderately alkaline; calcareous; abrupt, smooth boundary.

C2—23 to 33 inches, stratified, grayish-brown (2.5Y 5/2) and light olive-brown (2.5Y 5/4) fine sandy loam; few, fine, prominent, yellowish-red (5YR 5/6) mottles; single grain; loose; moderately alkaline; calcareous; abrupt, smooth boundary.

C3—33 to 70 inches, stratified, dark grayish-brown (10YR 4/2) and grayish-brown (2.5Y 5/2) loamy very fine sand; few, fine, prominent, yellowish-red (5YR 5/6) mottles; single grain; loose; moderately alkaline; calcareous.

In noncultivated areas the A1 horizon is very dark grayish brown (10YR 3/2) and up to 6 inches thick. The Ap or A1 horizon generally has a high content of very fine sand. The texture ranges from very fine sandy loam to sandy loam but is typically fine sandy loam. Reaction is neutral to moderately alkaline.

The C horizon is dominantly fine sandy loam in texture, but it ranges from sandy loam to very fine sandy loam. The colors range from dark grayish brown (10YR or 2.5Y 4/2) or grayish brown (10YR or 2.5Y 5/2) to brown (10YR 4/3) or light olive brown (2.5Y 5/4). Clayey or silty strata, ¼ inch to 6 inches thick are common. Yellowish-brown (10YR 5/6), yellowish-red (5YR 5/6), and reddish-brown (7.5YR 5/4) mottles occur in some of these layers.

Carr soils are associated with Haynie, Grable, Waubonsie, Modale, and Sarpy soils. The Carr soils are sandier throughout than Haynie soils and sandier in the uppermost 2 feet than Grable soils. They lack the underlying clayey layer present in Waubonsie or Modale soils. Carr soils are not so sandy as Sarpy soils, which have a loamy fine sand or fine sand C horizon.

Carr fine sandy loam (0 to 2 percent slopes) (538).—Most individual areas of this soil are 10 to 40 acres in size. Many are on long and narrow convex rises. This soil is generally slightly higher in elevation than most of the associated soils, but height above the riverbank is variable.

Included with this soil in mapping are some short, sloping remnants of old streambanks that drop to lower elevations. Also included in a few places are soils that are sandier than the Carr soil.

This soil is droughty in years of average or below-average rainfall. It is easily tilled, and response to high-level management is good. This soil is suited to cultivation and can be used intensively for row crops. Where this soil is associated with finer textured soils, it is generally cultivated along with them. (Capability unit IIs–1)

Castana Series

The Castana series consists of well-drained, silty soils that formed in material washed or slumped from surrounding hillsides. These soils are generally moderately dark colored in the surface layer. They occupy foot slopes along the edges of the valleys. The slope ranges from 6 to 20 percent.

In a representative profile the surface layer is silt loam about 18 inches thick. It is very dark brown to very dark grayish brown in the upper part and very dark grayish brown and dark grayish brown in the lower part. The next layer is very dark grayish-brown and dark grayish-brown, very friable, calcareous silt loam about 12 inches thick. This layer has properties of both the surface layer and the substratum. The substratum is dark grayish-brown, very friable, calcareous silt loam.

Permeability is moderate, and the available moisture capacity is high. The organic-matter content is medium. The content of available phosphorus is low or very low, and the content of available nitrogen is low. The content of available potassium is medium or high, and the content of lime is high. The rooting zone is deep. Castana soils are neutral to moderately alkaline and calcareous in the uppermost 12 inches and mildly alkaline or moderately alkaline and calcareous below.

The use of these soils depends a great deal on the width of the valleys. In the narrow upper reaches of the valleys, Castana soils are generally managed with the hillsides for pasture. In the lower parts of the valleys, they are usually cropped along with soils where the slope is 1 to 15 percent.

Representative profile of Castana silt loam, in a field of bromegrass, about 5 miles east of Hornick, about 700 feet north of the southeast corner of SW¼NW¼ sec. 31, T. 86 N., R. 44 W., on an east-facing 17 percent slope:

Ap1—0 to 5 inches, very dark grayish-brown (10YR 3/2) to very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) when dry; moderate, fine, granular structure; very friable; neutral; noncalcareous; clear, smooth boundary.

Ap2—5 to 10 inches, very dark grayish-brown (10YR 3/2) to very dark brown (10YR 2/2) silt loam; weak, medium, subangular blocky structure; very friable; neutral; noncalcareous; clear, smooth boundary.

A12—10 to 18 inches, very dark grayish-brown (10YR 3/2) and dark grayish-brown (10YR 4/2) silt loam, grayish brown (10YR 5/2) when dry; weak, fine and medium, subangular blocky structure breaking to weak, coarse, prismatic; very friable; mildly alkaline; calcareous; gradual, smooth boundary.

AC—18 to 30 inches, very dark grayish-brown (10YR 3/2) and dark grayish-brown (10YR 4/2) silt loam; weak, fine and medium, subangular blocky structure breaking to weak, coarse, prismatic; very friable; moderately alkaline; calcareous; diffuse, smooth boundary.

C—30 to 60 inches, dark grayish-brown (10YR 4/2) silt loam; very weak, fine and medium, subangular blocky structure to massive; very friable; few calcium carbonate concretions; moderately alkaline; calcareous.

The A horizon is 12 to 24 inches thick. It ranges from neutral to moderately alkaline and is calcareous within a depth of about 12 inches. In many areas up to 12 inches of yellowish-brown, calcareous silt loam overwash covers the original surface layer.

The AC horizon is lacking in some places. In many places very dark grayish-brown colors are at a depth of 24 inches or more, which is deeper than is typical for the series.

The C horizon ranges from dark grayish brown (10YR 4/2) to yellowish brown (10YR 5/4). It is mildly or moderately alkaline and calcareous.

Castana soils are associated with Ida, Hamburg, Napier, and Kennebec soils. Castana soils differ from Ida and Hamburg soils in having a thicker A horizon. They have a thinner A horizon than Napier or Kennebec soils, and, unlike those soils, are calcareous.

Castana silt loam, 15 to 20 percent slopes (3E).—This soil has the profile described as representative for the series. It occupies strips, 100 to 400 feet wide, along the edges of the valleys.

Many valleys in the county are split by a deep, actively cutting gully. On each side of the gully is a strip made up of this soil and other, less strongly sloping soils. The soils near the heads of drainageways are too narrow to cultivate. Larger areas generally are cultivated.

This soil is suited to cultivation if erosion is adequately controlled. Basin terraces are built upslope on this Castana soil and at the base of steep uplands (fig. 5). Some areas of this soil are planted to row crops part of the time. Many areas are planted to grass and legumes and are rowcropped only when renovation is necessary. (Capability unit IVe–1)

Castana-Gullied land complex, 6 to 20 percent slopes (983E)—The Castana soil in this complex has the profile described as representative for the series. In each area, this soil is associated with a deep, active gully that makes farming impractical. The gullies are as much as 40 feet deep and are wide. They have vertical sides, and most have active side gullies.

Nearly all the acreage is used for permanent pasture. Reclaiming the areas would necessitate building terraces on adjoining hillsides, installing erosion control structures downstream, bulldozing the gullies, and establishing grassed waterways. In many places even these measures will not result in good cropland, because the valley is too narrow and the reclaimed land must be combined in fields with steep hillsides. (Capability unit VIIe-1)

Chute Series

The Chute series consists of light-colored, excessively drained, sandy soils that formed in wind-deposited sand. These soils occupy 5- to 10-acre areas on ridgetops and hillsides. They are surrounded by silty soils. The slope ranges from 5 to 18 percent.

In a representative profile the surface layer is dark grayish-brown, calcareous loamy fine sand about 7 inches thick. It is underlain by yellowish-brown, loose, calcareous loamy fine sand. This underlying material is at least 5 or 6 feet thick in most places.

Permeability is rapid, and the available moisture capacity is low. The content of organic matter, available phosphorus, and nitrogen is very low. The content of available potassium is medium. The rooting zone is deep, but in many years root growth is restricted by lack of moisture. These soils are moderately alkaline and calcareous throughout.

Chute soils are generally cultivated along with the associated Monona and Ida soils.

Representative profile of Chute loamy fine sand, in an alfalfa field about 4 miles north of Moville, 740 feet west and 280 feet north of the southeast corner of NE¼ sec. 6, T. 89 N., R. 44 W., on a northwest-facing 6 percent slope:

Ap—0 to 7 inches, dark grayish-brown (10YR 4/2) loamy fine sand; weak, medium and coarse, subangular blocky structure breaking to weak, fine, granular; very friable to loose; moderately alkaline; calcareous; clear, wavy boundary.

C1—7 to 17 inches, yellowish-brown (10YR 5/4) loamy fine sand; weak, medium and coarse, subangular blocky structure; loose; moderately alkaline; calcareous; diffuse, smooth boundary.

C2—17 to 60 inches, yellowish-brown (10YR 5/4) loamy fine sand; weak, coarse, subangular blocky structure in upper part; loose; moderately alkaline; calcareous.

The Ap horizon is neutral is some places. Areas not cultivated have a very dark grayish-brown A1 horizon 2 to 4 inches thick. The C horizon is fine sand in places. Thin layers of loam or silt loam are common in the C horizon.

Chute soils are similar to Sarpy and Carr soils in color and texture. They lack the thin strata of fine sandy loam and silt loam that generally occur in Sarpy soils. Chute soils contain more sand and less clay in the uppermost 2 to 3 feet than Carr soils.

Chute loamy fine sand, 5 to 18 percent slopes, severely eroded (25E3).—Almost all of this soil is near and to the south or east of medium or large streams. The less sloping areas are generally on ridgetops that run from northwest to southeast; the more strongly sloping areas are on hillsides below the ridgetops. A few areas of siltier soils are included in mapping.

Figure 5.—**Constructing a basin terrace on Castana soils.**

This soil is subject to soil blowing and water erosion. It is droughty and low in fertility. Many areas are used for meadow. In some places it is managed along with adjacent soils and is used for row crops. (Capability unit VIe-1)

Colo Series

The Colo series consists of dark-colored, poorly drained, silty soils that formed in sediments deposited by streams other than the Missouri River. The soils are nearly level.

In a representative profile black silty clay loam extends to a depth of 65 inches. It is friable in the upper part and firm in the lower part. A few, fine, yellowish-red mottles are at a depth below about 2 feet. The silty clay loam is underlain by a substratum of black and very dark gray, firm silty clay.

Permeability is moderately slow, and the available moisture capacity is high. The organic-matter content is high. The content of available nitrogen is medium or low, the content of available phosphorus is low or very low, and the content of available potassium is medium. The rooting zone is deep. Reaction is neutral or slightly acid to a depth of 3 feet or more, except where calcareous overwash is on the surface.

Most areas of Colo soils are cultivated.

Representative profile of Colo silty clay loam, in a cornfield 400 feet north and 600 feet west of the southeast corner of SW¼ sec. 16, T. 89 N., R. 44 W., on a level flood plain:

Ap—0 to 7 inches, mixed black (10YR 2/1) and very dark grayish-brown (10YR 3/2) silty clay loam, black (10YR 2/1) to very dark gray (10YR 3/1) when crushed, very dark gray (10YR 3/1) and brown (10YR 5/3) when dry; moderate, very fine and fine, granular structure and moderate, very fine, subangular blocky; friable; moderately alkaline; calcareous; abrupt, smooth boundary.

A12—7 to 12 inches, black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) with dark gray (10YR 4/1) coatings when dry; strong, fine, angular blocky structure; friable; slightly acid; abrupt, smooth boundary.

A13—12 to 15 inches, black (10YR 2/1) silty clay loam; moderate, very fine, angular and subangular blocky structure; friable; slightly acid; gradual, smooth boundary.

A14—15 to 23 inches, black (10YR 2/1) silty clay loam; moderate, very fine and fine, granular structure and moderate, very fine, subangular blocky; friable; slightly acid; gradual, smooth boundary.

A15—23 to 34 inches, black (10YR 2/1) silty clay loam; few, fine, prominent, yellowish-red (5YR 4/6) mottles, increasing in number as depth increases; strong, very fine, angular and subangular blocky structure; firm; neutral; gradual, smooth boundary.

AC—34 to 65 inches, black (10YR 2/1) silty clay loam; few, fine, prominent, yellowish-red (5YR 4/6) mottles; weak, fine, prismatic structure and moderate, very fine, subangular blocky; firm; neutral; gradual, smooth boundary.

Cg—65 to 93 inches, black (10YR 2/1) and very dark gray (10YR 3/1) silty clay loam; massive; firm.

The A horizon ranges from 30 to 40 inches in thickness. In many places an overwash of very dark grayish-brown (10YR 3/2) or dark grayish-brown (10YR 4/2) silt loam, 6 to 15 inches thick, covers the surface. Colo soils are neutral to medium acid in the uppermost 12 inches and neutral or slightly acid to a depth of 40 inches or more. Where overwash occurs the surface layer is mildly alkaline or moderately alkaline and calcareous in the uppermost 2 to 12 inches.

In places Colo soils have a weak, structural B horizon that is generally very dark gray (10YR 3/1) or dark gray (10YR to 5Y 4/1).

The C horizon is similar in color to the A horizon, but in places it is dark gray (10YR 4/1) or dark grayish brown (10YR or 2.5Y 4/2) at a depth of more than 36 inches. The C horizon is slightly acid to mildly alkaline.

Colo soils are associated with the dark-colored Calco, Holly Springs, Kennebec, and Lakeport soils on bottom lands. Colo soils are not calcareous, as are the Calco and Holly Springs soils; they are less clayey at a depth below about 2 feet than are the Holly Springs soils. Colo soils are finer textured throughout than Kennebec soils and more poorly drained. They are also more poorly drained than Lakeport soils and lack the brownish B horizon of those soils. Colo soils are generally less clayey to a depth of 40 inches than Lakeport soils.

Colo silt loam, calcareous overwash (0 to 1 percent slopes) (845).—Most areas of this soil have 6 to 15 inches of dark grayish-brown, calcareous silt loam over the original black surface layer. This soil is on first bottoms, and it is more susceptible to flooding and siltation than other Colo soils.

Artificial drainage and levees reduce the wetness and flooding hazard. If wetness is controlled, this soil is well suited to cultivation and it is used intensively for row crops. Most unprotected areas are used for pasture. Tilth is generally not so difficult to maintain as on other Colo soils, but fertilizer requirements are higher for this soil. (Capability unit IIw–2)

Colo silty clay loam (0 to 1 percent slopes) (133).—This soil has the profile described as representative for the series. Most of this soil is in the large valleys of the county.

Included with this soil in many places are small areas of low-lying soils that are so frequently flooded that they are left in pasture or trees. Also included, especially in the Missouri River valley, are small areas of soils that have a high content of lime.

This soil has a seasonal high water table and is subject to occasional flooding. In the northeastern part of the county, many areas of this soil in narrow valleys are managed along with the soils on adjacent hillsides. Field operations in these areas are slightly delayed because this soil stays wet a day or two longer than the upland soils.

This soil is well suited to cultivation if drainage is adequate, and it is used intensively for row crops. (Capability unit IIw–2)

Colo-Judson silty clay loams, 2 to 6 percent slopes (11B).—This complex occupies almost all of the medium-size and small valleys in the northeastern part of the county. Colo soils are in the centers of the valleys on the nearly level flood plains. They generally make up three-fourths or more of the area. Gently sloping Judson soils are on the edges of valleys on the foot slopes.

The Judson soils are well drained, and the Colo soils are poorly drained. These areas are mainly used for row crops. They are managed along with the associated upland soils. (Capability unit IIw–2)

Corley Series

The Corley series consists of dark-colored, poorly drained, silty soils that formed mainly in loess. In many places the upper part formed in local alluvium washed from adjacent soils. These soils occur in depressions. Most of the depressions are less than 5 acres in size.

In a representative profile the surface layer is black and very dark brown silt loam about 15 inches thick. The subsurface layer, about 12 inches thick, is very dark gray silt loam that is light gray when dry. The subsoil is very dark gray silty clay loam that grades to dark grayish brown at a depth of about 4 feet. The ped faces and root channels are coated with black organic matter.

Permeability is moderately slow, and the available moisture capacity is high. The organic-matter content is moderately high. The content of available nitrogen is medium or low, the content of available phosphorus is very low, and the content of available potassium is medium. Reaction is slightly acid or medium acid in the surface layer and subsurface layer. At times during the year, there is a fluctuating high water table and water stands on the surface. Excess water stunts the growth of roots in spring, and the plants are unable to use much of the stored moisture later in the year.

Nearly all areas of Corley soils are cultivated, even though some of the areas are not drained.

Representative profile of Corley silt loam, in a meadow about 3 miles south of Moville, in the middle of a depression near the eastern side of SE¼NW¼ sec. 9, T. 88 N., R. 45 W.:

Ap—0 to 7 inches, very dark brown (10YR 2/2) heavy silt loam; moderate, fine and very fine, granular structure; friable; medium acid; abrupt, smooth boundary.

A12—7 to 15 inches, black (10YR 2/1) heavy silt loam; weak, medium and coarse, subangular blocky structure breaking to moderate, very fine, granular; friable; medium acid to slightly acid; gradual, smooth boundary.

A2—15 to 27 inches, very dark gray (10YR 3/1) heavy silt loam, light gray (10YR 6/1 and 7/1) when dry; weak, thin, platy structure; very friable; slightly acid; clear, smooth boundary.

B21tg—27 to 38 inches, very dark gray (10YR 3/1) silty clay loam, gray (10YR 5/1) to light gray (10YR 6/1) when dry; moderate, fine and medium, subangular blocky structure; friable; clay films and black (10YR 2/1) coatings in root channels and on ped faces; slightly acid; gradual, smooth boundary.

B22tg—38 to 48 inches, very dark gray (10YR 3/1) silty clay loam, gray (10YR 5/1) to light gray (10YR 6/1) when dry; moderate, fine and medium, subangular blocky structure; friable; clay films and black (10YR 2/1) coatings in root channels and on ped faces; neutral; gradual, smooth boundary.

B3tg—48 to 60 inches, dark grayish-brown (10YR 4/2) silty clay loam; weak, fine, subangular blocky structure; friable; patchy clay films and very dark gray (10YR 3/1) coatings in root channels and on ped faces; neutral.

The thickness of the A1 horizon varies, depending on the thickness of sediments that have washed into the depressions. In some places the original A horizon is covered by 6 to 15 inches of very dark brown (10YR 2/2) or very dark grayish-brown (10YR 3/2) silt loam or light silty clay loam.

The A2 horizon is 8 to 15 inches thick. It is very dark gray (10YR 3/1) or dark gray (10YR 4/1) when moist but dries to light gray (10YR 6/1 or 7/1). The A1 and A2 horizons are medium acid or slightly acid.

The B horizon is generally medium silty clay loam, but it has thin layers of heavy silty clay loam in places. The B horizon is black (10YR 2/1 or N 2/0) or very dark gray (10YR 3/1) in the upper part, and it is dark grayish brown (10YR 4/2) to gray (5Y 5/1) in the lower part. In places mottles that have a high chroma occur. The B horizon extends to a depth of 4 to 5 feet in most places. The B2 and B3 horizons are slightly acid or neutral.

The Corley soils do not closely resemble any other soil of the county. No other soils have an A2 horizon that dries to a flourlike consistency and is light gray in color.

Corley silt loam (0 to 1 percent slopes) (233).—This soil is mostly in depressions on the high stream benches along the larger streams, but some areas are in depressions on gently sloping ridgetops. In places the surface layer consists of very dark grayish-brown material washed down from the adjacent slopes. Included in mapping were areas where the material washed down was silty clay loam.

None of the depressions are made up entirely of this Corley soil. Soils that lack the grayish subsurface horizon occur along the edges of the depressions. Sediments accumulated faster in these places than the soil developed. In some depressions, the accumulations cover most of the soil area.

The main limitation to use of this soil is ponded water, and seedings are occasionally lost through siltation. Cuts 6 to 10 feet deep are needed to drain most of the depressions, either with tile or with open ditches. Most areas are left undrained. The undrained soil can generally be used for row crops and managed along with the rest of the field. Crops usually do not drown out, except in unusually wet years. A few areas of this soil are left idle because they are too wet to farm. Applications of lime and potassium are needed for good crop response. (Capability unit IIw-2)

Forney Series

The Forney series consists of moderately dark colored, poorly drained soils that formed in river sediments. These soils are clayey and stratified. They occur as large areas in swales or other low lying areas in the Missouri River valley. They are nearly level.

In a representative profile the plow layer is very dark gray, firm clay. Below this is a layer of mottled, dark-gray and grayish-brown, firm silty clay. At a depth of about 21 inches is a layer of very dark gray to dark gray silty clay about 10 inches thick that is probably the surface layer of an older soil buried by river sediments. The subsoil and substratum of this buried soil are dominantly dark-gray or gray, very firm silty clay.

Permeability is very slow, and the available moisture capacity is medium. The rooting zone is deep, except where a high water table restricts root growth. The organic-matter content is medium. The content of available phosphorus is generally very low, of available nitrogen is low, and of available potassium is high. Reaction is generally neutral or mildly alkaline throughout, except in the plow layer, which is slightly acid in places.

Almost all areas of these soils are cultivated.

Representative profile of Forney clay, in a plowed field about 4 miles east of Sergeant Bluff, 150 feet south of the northwest corner of NE¼NE¼ sec. 35, T. 88 N., R. 47 W., on a level flood plain:

Ap—0 to 7 inches, very dark gray (N 3/0) clay; few, fine, prominent, black (N 2/0) mottles; moderate, fine, granular structure and very fine, subangular blocky structure; firm; slightly acid; clear, smooth boundary.

B2g—7 to 17 inches, dark-gray (5Y 4/1) silty clay; few, distinct, black (N 2/0) mottles and common, fine, distinct, yellowish-brown (10YR 5/4) mottles; moderate, very fine, granular and subangular blocky structure; firm; neutral; clear, smooth boundary.

Cg—17 to 21 inches, grayish-brown (2.5Y 5/2) silty clay; few black (N 2/0) and dark-gray (N 4/0) mottles and common, fine, prominent, strong-brown (7.5YR 5/6) mottles; moderate, very fine and fine, subangular blocky structure; firm; neutral; abrupt, smooth boundary.

Ab—21 to 31 inches, very dark gray (N 3/0) to dark gray (N 4/0) silty clay, gray (10YR 5/1) when dry; few, fine, distinct, light yellowish-brown (10YR 6/4) and grayish-brown (2.5Y 5/2) mottles; weak, medium, subangular blocky structure breaking to strong, very fine, subangular blocky; firm; neutral; clear, smooth boundary.

B2gb—31 to 38 inches, dark-gray (5Y 4/1) silty clay; common, fine, distinct, light yellowish-brown (10YR 6/4) and grayish-brown (2.5Y 5/2) mottles; weak, medium, subangular blocky structure breaking to strong, very fine, subangular blocky; very firm; shiny ped surfaces; neutral; gradual, smooth boundary.

B3gb—38 to 52 inches, gray (5Y 5/1) silty clay; common, fine, prominent, brownish-yellow (10YR 6/6) mottles; common, fine, faint, dark-gray (5Y 4/1) mottles in lower part of horizon; strong, very fine, subangular blocky structure; very firm; neutral; abrupt, smooth boundary.

Ab—52 to 59 inches, very dark gray (5Y 3/1) to dark gray (5Y 4/1) silty clay; strong, very fine, subangular blocky structure; firm; few calcium carbonate concretions; neutral; gradual, smooth boundary.

Cg—59 to 72 inches, dark-gray (5Y 4/1) to gray (5Y 5/1) silty clay; very firm; mottled.

The Ap or A1 horizon is 6 to 10 inches thick. It ranges from black (10YR 2/1) to very dark gray (10YR 3/1 or N 3/0) or very dark grayish brown (10YR 3/2). The texture ranges from silty clay loam to silty clay or clay. Forney silty clay loam has 6 to 15 inches of very dark grayish-brown (10YR 3/2), calcareous silty clay loam overwash overlying the original surface layer.

The B2g horizon ranges from 6 to 18 inches in thickness and is dark gray (10YR to 5Y 4/1) or dark grayish brown (2.5Y 4/2) in color. The Cg horizon is lacking in places. The Ab horizon ranges from black (10YR 2/1 or N 2/0) to dark gray (N 4/0 or 5Y 4/1) and is 6 to about 16 inches thick. The Ab horizon is the surface layer of an older soil buried by recent clayey sediments. In places more than one of these Ab horizons occur. The Bgb horizon ranges from dark gray (5Y 4/1) to grayish brown (2.5Y 5/2). It is clay or silty clay, but in places there are thin strata of silt loam or silty clay loam.

Free carbonates do not occur in the uppermost 20 inches of the profile and generally are at a depth below 36 inches. Reaction throughout is neutral to mildly alkaline, except for the plow layer, which is slightly acid in places.

Of the soils in the county, Forney soils are most like the associated Albaton soils. They have a lower content of lime than Albaton soils, they are more distinctly stratified, and they have buried dark-colored horizons. Forney soils are silty clay to a depth of 40 inches or more, but the associated Owego soils have a layer of silt loam or silty clay loam at a depth of 15 to 30 inches.

Forney silty clay loam, calcareous overwash (0 to 1 percent slopes) (851).—This soil was formed by the deposition of 6 to 15 inches of calcareous silty clay loam sediments over the original surface layer. It occurs on bottom lands that are most susceptible to flooding, some of which are near large drainage ditches.

The use of the soil is limited by flooding and a high water table. In years of above-average rainfall, farming operations are delayed. The surface layer is generally in average tilth, and the soil is easier to work than others of the Forney series.

This soil is suited to cultivation, and it is used intensively for row crops where drainage is adequate. This soil is generally less fertile than Forney clay. (Capability unit IIIw-1)

Forney clay (0 to 1 percent slopes) (553).—This soil has the profile described as representative for the series. Some individual areas are several hundred acres in size and can be managed separately from other soils of the bottom lands.

Included in mapping are a few areas where the soil is silty or sandy at a depth of 30 to 40 inches. Also included are soils that have a less clayey layer, 6 to 10 inches thick, at a depth of about 20 inches. These included soils have slightly better natural drainage than the Forney soil.

This soil has a seasonal high water table. Field operations are delayed in some years because the surface layer puddles easily if worked while wet.

This soil is suited to cultivation. It is used intensively for row crops if drainage is adequate. (Capability unit IIIw-1)

Galva Series

This series consists of well-drained, silty soils that are dark colored in the surface layer except in eroded areas. These soils formed in loess. The slope ranges from 2 to 15 percent.

In a representative profile the surface layer is very dark brown and very dark grayish-brown silty clay loam about 15 inches thick. The subsoil is about 30 inches thick. It is friable, brown silty clay loam in the upper part and yellowish-brown silt loam in the lower part. The substratum is yellowish-brown to light olive-brown, very friable silt loam.

Permeability is moderate, and the available moisture capacity is high. The organic-matter content is moderately high, and the rooting zone is deep. The content of available nitrogen is low to medium, of available phosphorus is low, and of available potassium is high. Reaction in the surface layer is medium acid to neutral.

Almost all of these soils are cultivated. A few of the more sloping areas are used for pasture.

Representative profile of Galva silty clay loam, in a meadow 850 feet east and 225 feet south of the northwest corner of NW¼ sec. 2, T. 88 N., R. 44 W., on a southwest-facing 3 percent slope:

Ap—0 to 7 inches, very dark brown (10YR 2/2) silty clay loam; cloddy, breaking to weak, fine granular structure; friable; medium acid; clear, smooth boundary.

A1—7 to 11 inches, very dark grayish-brown (10YR 3/2) heavy silty clay loam; weak, fine, granular structure and weak, fine, subangular blocky; friable; slightly acid; gradual, smooth boundary.

A3—11 to 15 inches, very dark grayish-brown (10YR 3/2) silty clay loam; many brown (10YR 4/3) mottles; weak, fine, subangular blocky structure and some fine, granular; friable; neutral; clear, smooth boundary.

B1—15 to 21 inches, brown (10YR 4/3) light silty clay loam; weak, fine and medium, subangular blocky structure; friable; neutral; gradual, smooth boundary.

B2—21 to 28 inches, yellowish-brown (10YR 5/4) light silty clay loam; weak, fine and medium, subangular blocky structure; friable; neutral; gradual, smooth boundary.

B3—28 to 44 inches, yellowish-brown (10YR 5/4) silt loam that tends to have a 2.5Y hue when kneaded; few, fine, distinct, grayish-brown (2.5Y 5/2) and olive-gray (5Y 5/2) mottles at a depth below 33 inches; very weak, fine and medium, subangular blocky structure; very friable; neutral; gradual, smooth boundary.

C—44 to 60 inches, yellowish-brown (10YR 5/4) to light olive-brown (2.5Y 5/4) silt loam; common, fine, distinct, grayish-brown (2.5Y 5/2) and olive-gray (5Y 5/2) mottles and common, fine, prominent, brown (7.5YR 4/4) and strong-brown (7.5YR 5/6) mottles; massive; very friable; a few fine concretions of a soft black oxide; neutral.

Where the soil is uneroded or only slightly eroded, the A horizon is about 10 to 16 inches thick. The largest amount of clay is generally in the A1 horizon within 12 inches of the surface, but in some places it is in the A3 and B1 horizons. The A1 horizon is 34 to 36 percent clay. Reaction is neutral to medium acid.

The B horizon is 24 to 30 inches thick in most places. The B2 horizon is brown (10YR 4/3 to 10YR 5/3) or yellowish brown (10YR 5/4). The B3 or C horizon has few to common olive-gray to strong-brown mottles at a depth below 30 inches. The B1 and B2 horizons are neutral or slightly acid.

The C horizon is neutral to moderately alkaline and calcareous. In places these soils are underlain by glacial till at a depth of as little as 40 inches. In other places this contrasting material is lacking to a depth of about 100 inches.

Galva soils are similar to Monona soils in that both formed in loess and are well drained. They differ, however, in that Galva soils are finer textured in the A horizon and the upper part of the B horizon.

Galva silty clay loam, 2 to 6 percent slopes (310B).—This soil has the profile described as representative for the series. It is mostly on ridgetops and hillsides, but a few areas are on high stream benches. Where this soil is on stream benches, the substratum is underlain by stratified sediments. Many individual tracts are as much as 200 to 300 acres in size, and several sections are made up almost entirely of this soil. Many of these areas are so large that this soil can be managed separately.

Included in mapping were some areas that are more gently sloping than is typical and that have a surface layer more than 16 inches thick. Also included were some areas where the surface layer is thin enough that some dark-brown subsoil material is mixed into the plow layer. In the narrow hillside drainageways, soils that are wetter than Galva soils are commonly included.

Erosion is a hazard. If erosion is controlled, this soil is well suited to row crops. (Capability unit IIe-2)

Galva silty clay loam, 6 to 10 percent slopes, moderately eroded (310C2).—This soil has a surface layer of friable, very dark grayish-brown silty clay loam about 6 inches thick. In most places enough of the original dark-colored surface layer has been lost through erosion that dark-brown subsoil material is mixed into the plow layer. In some small patches, the dark-brown subsoil material makes up most of the plow layer. This soil is on side slopes and in places occupies entire hillsides. Areas of this soil extend from the valley to the ridgetop and stretch for half a mile to a mile along the sides of the valley.

Included in mapping were soils in narrow hillside drainageways; these soils are wetter than this Galva soil. Also included were small patches of soils that formed in clay loam glacial till.

Erosion is a hazard. This soil is well suited to row crops if erosion is controlled. (Capability unit IIIe–2)

Galva silty clay loam, 10 to 15 percent slopes, moderately eroded (310D2).—This soil has a surface layer of friable, very dark grayish-brown silty clay loam about 6 inches thick. In most places some dark-brown subsoil material is mixed with the plow layer, and in other places the plow layer is made up mostly of subsoil material. This soil has a subsoil thinner than that representative of the series and is calcareous within a depth of 30 inches in places.

Most areas of this soil are about 10 to 30 acres in size. They are generally in steeper areas, but near the Little Sioux River they lie upslope from steep soils that formed in clay loam glacial till. Included in mapping were some areas that have clay loam glacial till at a depth of less than 3 feet.

Erosion is a hazard. Many areas of this soil are managed along with Galva silty clay loam, 6 to 10 percent slopes, moderately eroded. In places where management is geared to the less sloping soil, erosion is excessive.

Where this soil is associated with steep soils that formed in glacial till, it is generally used for pasture. It is well suited to grasses. Regular farm equipment can be used in most places. (Capability unit IIIe–3)

Grable Series

The Grable series consists of moderately dark colored, well-drained to somewhat excessively drained, silty soils that formed in river sediments in the Missouri River valley. These soils are stratified and are underlain by sand at a depth of about 2 feet. They are nearly level.

In a representative profile the plow layer is dark grayish-brown, calcareous silt loam about 7 inches thick. The substratum is stratified, but is dominantly grayish-brown, very friable, calcareous silt loam to a depth of about 2 feet, grading to loose, calcareous fine sand and loamy fine sand.

Permeability is moderate in the uppermost 2 feet but is rapid below that depth. The available moisture capacity is medium to low. The organic-matter content is low. The content of available nitrogen and phosphorus is very low, and the content of available potassium is high. The rooting zone is deep. The surface layer and upper part of the substratum are mildly alkaline or moderately alkaline and calcareous.

Most areas of these soils are cultivated. A few areas near the river have not been cleared of trees.

Representative profile of Grable silt loam, in a cultivated field about 1 mile west of Browns Lake, 750 feet north and 90 feet west of southeast corner of NW¼ sec. 31, T. 87 N., R. 47 W., on a level flood plain:

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) silt loam; weak clods breaking to moderate, fine, subangular blocky structure and weak, fine, granular; very friable; mildly alkaline; calcareous; clear, smooth boundary.

C1—7 to 20 inches, stratified, dark grayish-brown (10YR 4/2) and grayish-brown (2.5Y to 10YR 5/2) silt loam; few, fine, distinct, strong-brown (7.5YR 5/8) mottles at a depth of 15 to 20 inches; weak, thick, platy structure breaking to weak, fine, angular blocky; very friable; common, fine, tubular pores; moderately alkaline; calcareous; gradual, smooth boundary.

C2—20 to 24 inches, grayish-brown (10YR 5/2) fine sandy loam; massive, with distinct horizontal cleavage; very friable; thin, very dark gray (10YR 3/1) strata, less than 1 millimeter thick, throughout this horizon; moderately alkaline; calcareous; clear, smooth boundary.

IIC3—24 to 60 inches, stratified, grayish-brown (2.5Y 5/2) loamy fine sand and fine sand; bands of light brownish gray (10YR 6/2) and light gray (10YR 7/2); common, fine, distinct, strong-brown (7.5YR 5/8) mottles; massive, with horizontal cleavage and breaking to single grain; loose; few, dark, sand-size grains that look like particles of organic matter; moderately alkaline; calcareous.

The Ap horizon is silt loam or silty clay loam 6 to 10 inches thick. It is generally mildly alkaline and calcareous, but in some places it is neutral and noncalcareous.

The sandy material of the IIC horizon is at a depth of 15 to 30 inches. This material is loose loamy fine sand or fine sand. Very thin strata of loamy or clayey material occur in places. The C1, C2, and IIC3 horizons are dark grayish brown (10YR or 2.5Y 4/2) or grayish brown (10YR or 2.5Y 5/2), mottled with strong brown, yellowish brown, or gray.

Grable soils are associated with Percival soils. The C horizon is silt loam to fine sand in the Grable soils; this horizon is clayey and sandy in the Percival soils.

Grable silt loam (0 to 2 percent slopes) (514).—This soil has the profile described as representative for the series. Almost all areas are about 5 to 20 acres in size. This soil occurs as slightly undulating areas or narrow, convex strips at the higher elevations within the bottom lands. It is closely associated with sandy and clayey soils, and fields that contain this soil also contain a number of other soils.

The soil is used intensively for row crops, although it is somewhat droughty. Farming operations are usually determined by the limitations of the associated soils. Where this soil lies next to wet and clayey soils, field operations are generally delayed; where it lies next to sandier soils, it needs to be protected from soil blowing. (Capability unit IIs–1)

Grable silty clay loam (0 to 2 percent slopes) (513).—This soil has a surface layer of very dark grayish-brown or very dark gray, friable silty clay loam. In places the silty clay loam extends to a depth of 15 inches or more. A typical area of this soil is about 20 acres in size, but some areas near the Missouri River are 200 or 300 acres in size. It occurs as nearly level areas on bottom lands. In almost all areas wetter, clayey soils in narrow swales were included in mapping.

This soil is droughty during part of the growing season, but where it is associated with wet soils, field operations are sometimes delayed by wetness. Wetness is slightly more of a hazard and droughtiness is less so than on Grable silt loam.

This soil is well suited to cultivation, and it is used intensively for row crops. (Capability unit IIs–1)

Hamburg Series

The Hamburg series consists of light-colored, somewhat excessively drained, silty soils that formed in loess. These soils are on bluffs along the Missouri and Little Sioux Rivers. The slope ranges from 30 to 75 percent.

All Hamburg soils have catsteps. These are small shelves a few feet wide formed by the downhill slumping of sections of the soil material (fig. 6).

In a representative profile the surface layer is dark grayish-brown to grayish-brown, very friable, calcareous silt loam about 5 inches thick. It is underlain by yellowish-brown, very friable, calcareous silt loam that has common gray and strong-brown mottles.

Permeability is moderate or moderately rapid. The available moisture capacity is high, but the soils rarely soak up enough moisture to reach capacity. The organic-matter content is low. The content of available phosphorus and nitrogen is very low, and the content of available potassium is high. Reaction is moderately alkaline, and the soils are calcareous.

Hamburg soils are used for pasture. In a number of places, such as in Stone State Park, stands of trees are on foot slopes and in gullied valleys adjacent to these soils. Trees grow on few, if any, areas of Hamburg soils. The native grasses are sparse in most places. They consist mainly of big bluestem, little bluestem, and side-oats grama. Plants that grow in semiarid areas, such as yucca, grow on some areas of this soil.

Representative profile of Hamburg silt loam, in a pasture about 500 miles east of Hornick, about 700 feet north and 170 feet west of the southeast corner of SW¼NW¼ sec. 31, T. 86 N., R. 44 W., on an east-facing 46 percent slope that has catsteps:

AC—0 to 5 inches, dark grayish-brown (10YR 4/2) to grayish-brown (10YR 5/2) silt loam; weak to moderate, fine, granular structure; very friable; moderately alkaline; calcareous; clear, smooth boundary.

C1—5 to 30 inches, yellowish-brown (10YR 5/4) coarse silt loam; few, medium, distinct, light-gray (10YR 6/1) mottles; few, fine, faint, yellowish-brown (10YR 5/6) mottles; and few, fine, distinct, strong-brown (7.5YR 5/6) mottles; very weak, fine, subangular blocky structure; very friable; moderately alkaline; calcareous; diffuse, smooth boundary.

C2—30 to 60 inches, yellowish-brown (10YR 5/4) coarse silt loam; few, medium, distinct, light-gray (10YR 6/1) mottles; few, fine, faint, yellowish-brown (10YR 5/6) mottles; and few fine, distinct, strong-brown (7.5YR 5/6) mottles; massive; very friable; moderately alkaline; calcareous.

The AC or A1 horizon is 4 to 8 inches thick. It ranges from dark grayish brown (10YR 4/2) to yellowish brown (10YR 5/6).

Hamburg soils are associated with Ida soils. They developed in loess that contains more coarse silt and very fine sand and less clay than the parent material of the Ida soils. The catsteps characteristic of Hamburg soils do not occur on Ida soils.

Figure 6.—Catsteps on Hamburg soils.

Hamburg silt loam, 30 to 75 percent slopes (2G).—This soil occurs on bluffs. Some areas, a square mile or more in size, are made up almost entirely of this soil and other very steep soils. Included in mapping were some areas where the yellowish-brown or brown substratum is exposed.

This soil is used almost exclusively for pasture. Because it is too steep to be worked by farm machinery, management is directed towards establishing and maintaining a good stand of native grass. (Capability unit VIIe–1)

Haynie Series

The Haynie series consists of moderately dark colored, well drained to moderately well drained, silty soils that formed in Missouri River sediments. These soils are stratified. They occupy nearly flat rises or slight elevations on the flood plains.

In a representative profile the surface layer is very dark grayish-brown, calcareous silt loam about 10 inches thick. The substratum extends to a depth of 60 inches or more. It is stratified but is mainly dark grayish-brown, very friable, calcareous silt loam.

Permeability is moderate, and the available moisture capacity is high. The organic-matter content is low. The content of available nitrogen and available phosphorus is very low, and the content of available potassium is high. The rooting zone is deep. The soils are mildly alkaline and calcareous.

Most areas of Haynie soils are cultivated. These are among the better farming soils of the Missouri River valley. A few areas near the river are used for trees or pasture.

Representative profile of Haynie silt loam, in a cornfield just south of the Sioux City Municipal Airport, 70 feet south and 130 feet east of the northwest corner of sec. 1, T. 87 N., R. 48 W., on a level flood plain:

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) heavy silt loam; grayish brown (2.5Y 5/2) when dry; moderate, fine, granular structure; very friable; mildly alkaline; carcareous; abrupt, smooth boundary.

A1—7 to 10 inches, very dark grayish-brown (10YR 3/2) silt loam, light brownish gray (2.5Y 6/2) when dry; moderate, coarse and very fine and fine, subangular blocky structure; very friable; stratification visible; 10 percent admixture of C horizon; mildly alkaline; calcareous; abrupt, smooth boundary.

C—10 to 90 inches, stratified, dark grayish-brown (2.5Y 4/2) silt loam that has a number of 3- to 4-inch bands of silty clay loam at a depth below 30 inches; few, fine, distinct mottles of yellowish brown (10YR 5/6), dark reddish brown (5YR 3/4), and reddish brown (5YR 4/4) at a depth below 20 inches; moderate, thick, platy structure breaking to weak, medium and very weak, fine, subangular blocky structure; very friable; mildly alkaline; calcareous; clear, smooth boundary.

The Ap horizon is 6 to 10 inches thick. The A1 horizon is lacking in many places.

The C horizon ranges from dark grayish brown (10YR or 2.5Y 4/2) or grayish brown (10YR or 2.5Y 5/2) to yellowish brown (10YR 5/4) or light olive brown (2.5Y 5/4). It contains thin strata of sand, loam, silty clay loam, or clay. In places the C horizon is very fine sandy loam. Few to common strong-brown, yellowish-brown, reddish-brown, or gray mottles occur in the C horizon.

Haynie soils are mildly alkaline or moderately alkaline, except the Ap or A1 horizon ranges to neutral. They are generally calcareous throughout.

Of the soils that are mainly silt loam to a depth of 40 inches or more, only McPaul soils are as stratified and contain as much lime as Haynie soils. Haynie soils contain more sand than McPaul soils and more thin, sandy or clayey layers. Haynie soils are also lower in content of available phosphorus.

Haynie silt loam (0 to 2 percent slopes) (137).—This soil is on bottom lands of the Missouri River. Near the river, long and narrow areas on slightly convex rises are mostly 5 to 20 acres in size. Areas farther from the river are 300 to 400 acres in size. Included in mapping were a few areas where the surface layer is loam, sandy loam, or silty clay loam and a few areas where the surface layer is dark grayish brown. Also included were swales where the soil is wetter than the Haynie soil.

This soil has no serious limitations. Fingering through most large areas, however, is a veinlike network of wetter soils in narrow swales. Field operations are slightly delayed in fields that include many areas of these wetter soils or in fields that border wet, more clayey soils. Where the Haynie soil is associated with Carr and Sarpy soils, soil blowing is a hazard.

This soil is well suited to cultivation, and it is used intensively for row crops. (Capability unit I–1)

Holly Springs Series

The Holly Springs series consists of dark-colored, poorly drained to very poorly drained, silty soils. These soils formed in sediments deposited by streams, such as the West Fork River, that flow through the Missouri River valley. They are clayey at a depth below about 2 feet. The underlying clay was probably deposited by the Missouri River and then covered by sediments from tributary streams. These soils are nearly level.

In a representative profile the surface layer is black grading to very dark gray, calcareous silty clay loam about 24 inches thick. The subsoil is very dark gray to dark gray, firm silty clay loam to silty clay about 6 inches thick. Next is a layer of very dark gray to very dark grayish-brown, medium to heavy silty clay about 11 inches thick. This layer was once the surface layer of a soil that is now buried. The subsoil of this buried soil is very firm, very dark gray and dark gray silty clay or clay.

Permeability is moderately slow in the uppermost 2 feet and very slow in the clay below. The available moisture capacity is high. The organic-matter content is high. The content of available nitrogen is medium to low, of available phosphorus is very low, and of available potassium is high. The surface layer is moderately alkaline or mildly alkaline and calcareous. The rooting zone is restricted to some extent by the clayey layers and by a seasonal high water table that is within 1 to 4 feet of the surface.

These soils generally are cultivated.

Representative profile of Holly Springs silty clay loam, in a cornfield about 2 miles southeast of Bronson, 600 feet south and 150 feet west of the northeast corner of SE¼NE¼ sec. 9, T. 87 N., R. 46 W., on a level flood plain:

Ap—0 to 5 inches, black (10YR 2/1) silty clay loam; weak, very fine to medium, subangular blocky structure breaking to moderate, very fine, granular; friable; moderately alkaline; calcareous; clear, smooth boundary.

A12—5 to 19 inches, black (10YR 2/1 grading to N 2/0) silty clay loam; weak, very fine, granular structure; friable; mildly alkaline to moderately alkaline; calcareous; clear, smooth boundary.

A3g—19 to 24 inches, black to very dark gray (N 2/0 to N 3/0) silty clay loam; moderate, very fine, subangular blocky structure; friable; mildly alkaline; calcareous; gradual, smooth boundary.

Bg—24 to 30 inches, very dark gray to dark gray (N 3/0 to N 4/0) silty clay loam to silty clay; few, fine, light-gray (5Y 6/1) mottles; strong, very fine, subangular blocky structure; firm; few snail shells; mildly alkaline; calcareous; gradual, smooth boundary.

IIAb—30 to 41 inches, very dark gray (N 3/0) to very dark grayish-brown (2.5Y 3/2) medium to heavy silty clay; common, fine, light olive-gray (5Y 6/2) mottles; strong, very fine, subangular blocky structure; firm; few snail shells; mildly alkaline; calcareous; clear, smooth boundary.

IIBgb—41 to 60 inches, very dark gray (10YR to 5Y 3/1) and dark gray (5Y 4/1) silty clay or clay; moderate to strong, very fine, subangular blocky structure; very firm; common, fine, white concretions of lime; some snail shells; moderately alkaline; calcareous.

The A horizon ranges from silty clay loam to heavy silt loam in texture and from 20 to 30 inches in thickness. Snail shells are mixed in this horizon in many places. Reaction is mildly alkaline or moderately alkaline.

The IIAb horizon is 8 to 18 inches thick. This buried soil, however, is lacking in places. The IIBgb horizon ranges from very dark gray (10YR to 5Y 3/1) to dark gray (10YR to 5Y 4/1). These horizons are mildly alkaline or moderately alkaline, and they are calcareous.

Holly Springs, Calco, Napa, and Solomon soils are the dark-colored, calcareous soils that occur in the Missouri River valley. Holly Springs soils are clayey at a depth below about 2 to 2½ feet. Calco soils are not so clayey; Napa and Solomon soils are clayey throughout.

Holly Springs silty clay loam (0 to 1 percent slopes) (734).—Most of this soil occurs as long, narrow, bottom-land areas that parallel streams. This soil is bordered on one side by friable, better drained soils and on the other side by wetter, more clayey soils. Included in mapping were a few areas where the depth to the buried clay soil is greater or less than in the Holly Springs soil.

This soil has a seasonal high water table, and runoff is slow. Even when artificial drainage is installed, field operations are sometimes delayed. The surface layer puddles easily if worked when wet.

This soil is suited to cultivation. It is used intensively for row crops where drainage is adequate. (Capability unit IIIw–1)

Ida Series

The Ida series consists of light or moderately dark colored, well-drained, silty soils that formed in loess. They occupy narrow ridgetops and hillsides. The slopes are mainly convex and generally west- or south-facing. The more gently sloping soils are on narrow, convex ridgetops. The slope ranges from 2 to 40 percent.

In a representative profile the surface layer is very dark grayish-brown, calcareous silt loam about 6 inches thick. The substratum is brown and yellowish-brown, very friable, calcareous silt loam to a depth of 60 inches. Hard nodules of lime are on the surface in places.

Permeability is moderate, and the available moisture capacity is high. Runoff is rapid. The organic-matter content is generally medium to low, depending on the amount of erosion that has occurred. The content of available nitrogen and of phosphorus is generally very low, and the content of available potassium is medium to high. These soils are generally moderately alkaline and calcareous.

The less strongly sloping soils are suited to cultivation if good management practices are followed. The steep soils are used for pasture. In places stands of trees are growing in pasture areas.

Representative profile of Ida silt loam, in an alfalfa and bromegrass meadow about 3 miles north of Moville, 900 feet south and 100 feet west of the northeast corner of SW¼ sec. 7, T. 89 N., R. 44 W., on a convex, northeast-facing 11 percent slope:

Ap—0 to 6 inches, very dark grayish-brown (10YR 3/2) silt loam that is about 20 percent brown (10YR 5/3); weak, fine, subangular blocky structure and moderate, very fine, granular; very friable; mildly alkaline; calcareous; abrupt, smooth boundary.

C1—6 to 21 inches, brown (10YR 5/3 tending to 2.5Y) silt loam; few, fine, faint, very pale brown (10YR 7/3) mottles and few, fine, distinct, strong-brown (7.5YR 5/6) mottles; weak, fine and medium, prismatic structure breaking to weak, very fine, granular and subangular blocky; very friable; few hard calcium carbonate concretions up to 17 millimeters long; few worm casts; moderately alkaline; calcareous; gradual, smooth boundary.

C2—21 to 60 inches, yellowish-brown (10YR 5/4 to 2.5Y) silt loam; common, fine, distinct, strong-brown (7.5YR 5/8) mottles and common, fine, faint, grayish-brown (10YR 5/2) mottles; weak, very fine, granular and subangular blocky structure; very friable; few small calcium carbonate concretions; moderately alkaline; calcareous.

In some places the Ap horizon is dark brown (10YR 3/3) or brown (10YR 4/3). It is moderately alkaline to neutral. Hard concretions of lime are abundant on the surface in many places.

The C horizon ranges from brown (10YR 4/3) to yellowish brown (10YR 5/6). It contains some strong-brown and yellowish-brown mottles.

Ida soils are associated with Monona and Galva soils. They are calcareous and lack the distinct, brownish B horizon of Galva and Monona soils. They also are lower in organic-matter content and natural fertility than Monona and Galva soils, which are neutral or slightly acid.

Ida silt loam, 2 to 6 percent slopes, severely eroded (1B3).—In about a third of the acreage of this soil, the surface layer is very dark brown or very dark grayish brown and up to 10 inches thick. The rest has a profile similar to that described as representative for the series. This soil is mainly on convex upland ridgetops that are about 100 to 200 feet wide. Individual areas are generally too small to manage separately.

Erosion is a hazard. This soil is well suited to cultivation if erosion is controlled. It is generally managed along with the more strongly sloping associated soils. Some areas that are bordered by very steep soils are used for pasture. (Capability unit IIe–2)

Ida silt loam, 6 to 10 percent slopes, severely eroded (1C3).—This soil has the profile described as representative for the series. It occupies narrow, rounded ridgetops in hilly and steep areas near the larger streams. It is on hillsides where the topography is rolling. The ridgetops are generally 100 to 300 feet wide and several hundred feet to a mile in length. The areas on hillsides are 5 to 30 acres in size.

Included in mapping were areas where the plow layer is dark brown. Also included on some hillsides were grayish-brown soils in strips 25 to 50 feet wide that follow the contour of the hills. These are less productive than Ida soils and are common in the southeastern part of the county (*13*).

Erosion is a hazard. This soil is suited to row crops if erosion is controlled. Most areas are cultivated. (Capability unit IIIe–2)

Ida silt loam, 10 to 15 percent slopes, severely eroded (1D3).—The plow layer of this soil is generally dark-brown silt loam, but in places it is brown. The substratum has more strong-brown and grayish-brown mottles in places than that described in the representative profile. This soil is on narrow, rounded ridgetops in areas near the major streams and on hillsides on rolling to hilly topography. The ridgetops are 100 to 300 feet wide and several hundred feet to a mile in length. The areas on hillsides are 5 to 60 acres in size.

Strips of grayish-brown soils 25 to 50 feet wide occur along the contour on hillsides and were included with this soil in mapping. They are common in the southeastern part of the county. These grayish-brown soils are less productive than the Ida soil.

Sheet and gully erosion are hazards. This soil is suited to cultivation and can be used for row crops if erosion is controlled. Some areas of this soil are used for pasture or meadow. A row crop is generally planted when meadows need renovation. (Capability unit IIIe–3)

Ida silt loam, 15 to 20 percent slopes, severely eroded (1E3).—The surface layer of this soil is generally dark-brown or brown, friable silt loam. It is browner in cultivated areas than in areas of pasture. In some places the substratum is more mottled than that in the profile described as representative for the series. This soil occupies most of the hillsides in the rolling and hilly parts of the county. Individual areas are 5 to 60 acres in size.

One or two grayish-brown bands, 25 to 50 feet wide, are included with this soil in places, especially in the southeastern part of the county. These grayish soils are normally not so productive as the Ida soil.

Sheet and gully erosion are hazards. This soil is suited to cultivation if erosion is controlled. Where it is associated with more gently sloping soils, it is generally used for row crops. Where this soil is associated with steeper soils, it is generally left in pasture or meadow. A row crop is grown when meadows need renovation. (Capability unit IVe–1)

Ida silt loam, 20 to 30 percent slopes, severely eroded (1F3).—This soil has a surface layer that is very dark brown or brown silt loam. It is 8 to 10 inches thick in uncultivated area and darker than the typical Ida soil. It is neutral and noncalcareous in places, especially under trees.

This soil is on hillsides in the steepest parts of the county. Individual areas near the Missouri and Little Sioux Rivers are 10 to 60 acres in size, and a few patches in other parts of the county are 5 to 15 acres in size.

On the bluffs along the Missouri River, this soil is intermingled with Hamburg silt loam, 30 to 75 percent slopes, and many whole sections remain in native grass. Overgrazing creates serious problems because establishment of new stands of grass is most difficult. In the Little Sioux River valley, this soil is commonly upslope from less permeable rocky clay loams. Many stands of trees, dominantly bur oak, are on these hillsides.

Sheet and gully erosion are hazards, and many areas are too steep for farm machinery to be used. This soil is mainly used for legume and bromegrass pasture. A few farmers plant a row crop when pastures need renovation. (Capability unit VIe-1)

Ida silt loam, 30 to 40 percent slopes, severely eroded (1G3).—The surface layer ranges from very dark grayish brown to dark brown and brown. It is generally neutral in wooded areas and noncalcareous. Most of the wooded areas also have a thin litter of leaves and twigs on the surface.

Almost all of this soil is adjacent to the Missouri and Little Sioux River valleys. It generally is on north- and east-facing slopes, and Hamburg soils occupy the others.

The erosion hazard and the slope severely limit the use of this soil. Because it is too steep for farm machinery, this soil is left in trees, dominantly bur oak, or native grass. Both wooded and grassy areas are pastured, with few exceptions. The tree stands are of poor quality. The quality of the native grass pastures is usually poor, but it varies, depending mainly on the level of management. Stands that have deteriorated because of overgrazing are hard to reestablish. (Capability unit VIIe-1)

Judson Series

The Judson series consists of dark-colored, moderately well drained, silty soils on foot slopes and alluvial fans in valleys in the northeastern part of the county. These soils formed in material washed down from the nearby hillsides, and moderately dark overwash is on the surface in places. The slope ranges from 2 to 6 percent.

In a representative profile the plow layer is very dark grayish-brown silty clay loam about 6 inches thick. The plow layer consists of material recently eroded from cultivated fields. The rest of the surface layer represents the original, uncultivated surface layer. It is black and very dark brown, friable silty clay loam about 28 inches thick. The subsoil is very dark grayish-brown and brown, friable silty clay loam.

Permeability is moderate, and the available moisture capacity is high. The organic-matter content is high. The content of available nitrogen is generally medium to low, of available phosphorus is low, and of available potassium is medium. The rooting zone is deep. Reaction is slightly acid or neutral in the surface layer.

These soils generally are cultivated, but most areas are too small to be managed separately. In a few places, mostly near the Little Sioux River where these soils are in narrow valleys flanked by steep hills, they are left in permanent pasture.

Representative profile of Judson silty clay loam, in a cultivated field about 4 miles southwest of Pierson, 1,110 feet east and 800 feet south of the northwest corner of sec. 28, T. 89 N., R. 43 W., on a 3 percent, south-facing alluvial fan:

Ap—0 to 6 inches, very dark grayish-brown (10YR 3/2) light silty clay loam; common, fine, distinct, black (10YR 2/1) mottles; moderate, very fine, granular structure; friable; slightly acid; abrupt, smooth boundary.

A12—6 to 16 inches, black (10YR 2/1) light silty clay loam; weak, medium, subangular blocky structure breaking to moderate, very fine and fine, subangular blocky; friable; neutral; gradual, smooth boundary.

A13—16 to 29 inches, very dark brown (10YR 2/2) light silty clay loam; weak, fine and medium, subangular blocky structure breaking to weak to moderate, very fine, subangular blocky; friable; neutral; gradual, smooth boundary.

A3—29 to 34 inches, very dark brown (10YR 2/2) light silty clay loam, very dark grayish brown (10YR 3/2) when crushed; common, fine, distinct, black (10YR 2/1) mottles; weak to moderate, very fine, subangular blocky structure; friable; slightly acid; gradual, smooth boundary.

B2—34 to 46 inches, very dark grayish-brown (10YR 3/2) light silty clay loam, brown (10YR 4/3) when partly dry; ped interiors are dark brown (10YR 3/3); weak, fine, subangular blocky structure breaking to weak to moderate, very fine, subangular blocky; friable; slightly acid; gradual, smooth boundary.

B3—46 to 60 inches, very dark grayish-brown (10YR 3/2) light silty clay loam, brown (10YR 4/3) when partly dry; ped interiors are dark brown (10YR 3/3); weak, fine, subangular blocky structure breaking to weak to moderate, very fine, subangular blocky; friable; slightly acid.

The A horizon is 24 to 36 inches thick. The Ap and A1 horizons are black (10YR 2/1) or very dark brown (10YR 2/2). In places there is as much as 12 inches of very dark grayish-brown silty clay loam, clay loam, or loam overwash. Reaction is neutral or slightly acid.

The B2 and B3 horizons range from dark brown (10YR 3/3) to brown (10YR 4/3). The darker organic coatings tend to mask the brownish ped interiors. The texture ranges from light to medium silty clay loam. The content of clay remains nearly constant as depth increases, and is generally between 30 and 35 percent.

Judson soils are similar to Kennebec and Napier soils. Judson soils have a brown B horizon that Kennebec soils lack, and they are somewhat finer textured to a depth of about 40 inches. Judson and Napier soils are similar in color, but Judson soils are finer textured to a depth of about 40 inches or more.

Judson silty clay loam, 2 to 6 percent slopes (8B).—This soil is generally on foot slopes at the edges of valleys, between the level bottom-land soils and soils on hillsides. It is mainly in the larger valleys, such as those along Pierson Creek and the Little Sioux River. Included with this soil are sandier strips at the foot of steep hills. Also included, in the more nearly level areas, are soils covered with overwash.

Rill and gully erosion and siltation are hazards. This soil is generally managed along with the associated soils. Where it is associated with large areas of level or nearly level soils, this soil is well suited to cultivation and is used intensively for row crops. Where this soil is near the heads of small valleys, it is managed along with the more sloping, closely associated soils. (Capability unit IIe-1)

Keg Series

The Keg series consists of dark-colored, well drained to moderately well drained, silty soils that formed in stream-deposited sediments. These soils are at the higher elevations in the Missouri River valley. They are nearly level.

In a representative profile the surface layer is very dark brown silt loam about 14 inches thick. The subsoil is mainly dark grayish-brown, friable silt loam about 20 inches thick. The substratum is grayish-brown to light olive-brown, friable, calcareous silt loam.

Permeability is moderate, and the available moisture capacity is high. The organic-matter content is moderate, and the rooting zone is deep. The content of available nitrogen is medium to low, of available phosphorus is medium, and of available potassium is high. The surface layer and upper part of the subsoil are generally neutral.

Except in built-up areas, these soils are nearly all cultivated.

Representative profile of Keg silt loam, in a cornfield 600 feet south and 75 feet west of the northwest corner of sec. 36, T. 86 N., R. 47 W., on a nearly level flood plain:

Ap—0 to 6 inches, very dark brown (10YR 2/2) silt loam; weak, fine and medium, subangular blocky structure and moderate, very fine, granular; very friable; neutral; abrupt, smooth boundary.

A12—6 to 14 inches, very dark brown (10YR 2/2) silt loam; moderate, fine and medium, subangular blocky structure; very friable; neutral; clear, smooth boundary.

B1—14 to 21 inches, very dark grayish-brown (10YR 3/2) silt loam, dark grayish brown (10YR 4/2) when crushed; moderate, fine, subangular blocky structure and moderate, very fine, granular; very friable; neutral; clear, smooth boundary.

B2—21 to 26 inches, dark grayish-brown (10YR 4/2) silt loam that has some very dark grayish-brown (10YR 3/2) exteriors, dark grayish brown (10YR 4/2) when crushed; weak, fine and medium, subangular blocky structure and moderate, very fine, subangular blocky; some vertical cleavage; very friable; slightly acid; clear, smooth boundary.

B3—26 to 34 inches, dark grayish-brown (10YR 4/2) and olive-brown (2.5Y 4/4) heavy silt loam mixed with very dark gray (10YR 3/1); weak, fine to coarse, subangular blocky structure and moderate, very fine, subangular blocky; some vertical cleavage; very friable; mildly alkaline; calcareous; clear, smooth boundary.

C—34 to 60 inches, grayish-brown (2.5Y 5/2) to light olive-brown (2.5Y 5/4) silt loam, light gray (10YR 7/1) when dry; weak, fine, subangular blocky structure and weak, very fine, granular; very friable; mildly alkaline; calcareous.

The A horizon is 10 to 16 inches thick. There is a very dark grayish-brown (10YR 3/2) A3 horizon in places.

The solum is 24 to 36 inches thick. The B horizon ranges from dark grayish brown (10YR or 2.5Y 4/2) to light olive brown (2.5Y 5/4). There are a few yellowish-brown and brown mottles in some places. The B3 horizon is very fine sandy loam in places. The B1 and B2 horizons are neutral or slightly acid, and the B3 horizon ranges from neutral to moderately alkaline.

The C horizon ranges from light silt loam to very fine sandy loam in texture and from dark grayish brown to light olive brown in color. In places there are a few brown to strong-brown mottles. In many places the C horizon is moderately alkaline.

Keg soils are similar in texture to Haynie, McPaul, and Kennebec soils. Keg soils have a darker and thicker A horizon than Haynie and McPaul soils and a thinner A horizon than Kennebec soils. Keg soils have a distinct, dark grayish-brown B horizon that is lacking in the McPaul soils. Keg soils are calcareous in the substratum; McPaul and Haynie soils are calcareous throughout; and Kennebec soils are not calcareous.

Keg silt loam (0 to 2 percent slopes) (46).—The largest areas of this soil are at the higher elevations in the Missouri River valley. Some are more than 100 acres in size. Other areas are long and narrow and on short slope breaks. Somewhat poorly drained soils in narrow swales were included in mapping in almost all areas.

This soil has no serious limitations and is well suited to cultivation. It is used intensively for row crops. Much of the acreage is associated with somewhat poorly drained soils and is managed along with them. In these places field operations are delayed until the more poorly drained soils can be tilled. Keg silt loam is one of the best farming soils in the county. (Capability unit I–2)

Kennebec Series

The Kennebec series consists of dark-colored, moderately well drained, silty soils that formed in sediments carried by streams or washed down from nearby hillsides. These soils are on bottom lands and foot slopes in the valleys. The slope ranges from 0 to 6 percent.

In a representative profile the surface layer is black silt loam about 35 inches thick. Next is a layer of black to very dark brown, friable light silty clay loam, about 15 inches thick, that has characteristics of both the surface layer and the substratum. The substratum is very dark brown silty clay loam to a depth of 60 inches.

Permeability is moderate, and the available moisture capacity is high. The organic-matter content is high. The content of available nitrogen is medium to low, and the content of available phosphorus and potassium is medium. The surface layer is slightly acid. The rooting zone is deep.

Most areas of Kennebec soils are cultivated.

Representative profile of Kennebec silt loam, in a cultivated field about 2 miles northeast of Danbury, 225 feet north of the southeast corner of SW¼NE¼ sec. 13, T. 86 N., R. 42 W., on a level flood plain:

Ap—0 to 6 inches, black (10YR 2/1) heavy silt loam; moderate, coarse, subangular blocky structure breaking to weak, very fine, subangular blocky; moderate, fine, granular structure in the uppermost 2 inches; friable; slightly acid; abrupt, smooth boundary.

A12—6 to 35 inches, black (10YR 2/1) silt loam; moderate, medium, subangular blocky structure breaking to moderate, very fine, subangular blocky; some vertical cleavage at a depth below 13 inches; friable; slightly acid; gradual, smooth boundary.

AC—35 to 50 inches, black (10YR 2/1, but tending toward 10YR 2/2) light silty clay loam; moderate, very fine and fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

C—50 to 60 inches, very dark brown (10YR 2/2) silty clay loam; massive; friable; neutral.

The combined thickness of the Ap and A1 horizons is generally 30 to 40 inches. In places the A1 horizon is very dark brown (10YR 2/2), and the AC horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2). Some areas have about 6 to 15 inches of very dark grayish-brown (10YR 3/2), calcareous silt loam overwash. The Ap and A1 horizons range from silt loam to light silty clay loam. The boundary between the A and the C horizon is somewhat arbitrary in most places and is indistinct.

The C horizon ranges from black (10YR 2/1) and very dark brown (10YR 2/2) to very dark grayish brown (10YR 3/2). In places the substratum appears to be a buried soil. The texture ranges from silt loam to light silty clay loam. The AC and C horizons are neutral or slightly acid.

In many places Kennebec soils are associated with Colo soils on bottom lands. The associated soils on bottoms and foot slopes are those of the Haynie, Keg, Judson, and Napier series.

Kennebec soils do not have so high a clay content in the uppermost 40 inches as Colo soils. They lack the dark-brown or brown B horizon of the Napier and Judson soils. Kennebec soils have a thicker A horizon and a lower content of sand than Haynie and Keg soils, and Kennebec soils are not calcareous at a shallow depth.

Kennebec silt loam, 0 to 2 percent slopes (212A).—This soil has the profile described as representative for the series. In some places there is a brownish, calcareous silt loam overwash, up to 15 inches thick, on this soil, This soil occurs on flood plains, mostly in the larger valleys. Individual areas range from about 5 acres in size to several hundred acres. The largest areas are in the major valleys, such as the Maple River valley.

Generally, this soil does not have any serious limitations. Some areas near drainage ditches or streams are flooded in periods of high rainfall. Some runoff drains onto this soil. A few low-lying areas that were included in mapping are wet during some seasons.

This is one of the best farming soils in the county and is well suited to cultivation. It is used intensively for row crops. (Capability unit I-2)

Kennebec silt loam, 2 to 6 percent slopes (212B).—This soil has a surface layer of very dark brown, friable silt loam. In many places the soil is covered by brownish, calcareous silt loam overwash up to 15 inches thick (fig. 7). The substratum is somewhat browner than that described in the representative profile. This soil occurs throughout the county, except in the northeastern part. It occupies strips, 200 to 400 feet wide, on the gentle foot slopes that form the edges of stream valleys.

In some of the smaller valleys this is the only soil mapped, although included are small areas of more strongly sloping soils next to hills and of nearly level soils next to waterways or gullies.

Rill erosion and siltation are slight hazards. Runoff from upslope soils drains across this soil. This soil is well suited to cultivation if erosion is controlled. It is used intensively for row crops. Some areas are so small that they are managed along with the more strongly sloping soils on hillsides. (Capability unit IIe-1)

Lakeport Series

The Lakeport series consists of dark-colored, somewhat poorly drained, silty soils that formed in river-deposited sediments. These soils are at intermediate elevations in the Missouri River valley. They are nearly level.

In a representative profile the surface layer is black and very dark brown silty clay loam about 22 inches thick. The subsoil extends to a depth of 45 inches. It is very dark gray silty clay loam in the uppermost 5 inches and dark grayish-brown silty clay loam mottled with yellowish brown in the lower part. The substratum is grayish-brown, calcareous light silt loam that is underlain by silty clay at a depth of 60 inches.

Permeability is moderately slow to moderate, and the available moisture capacity is high. The organic-matter content is high. The content of available nitrogen is medium to low, of available phosphorus is medium, and of available potassium is high. The surface layer is slightly acid. The rooting zone is deep.

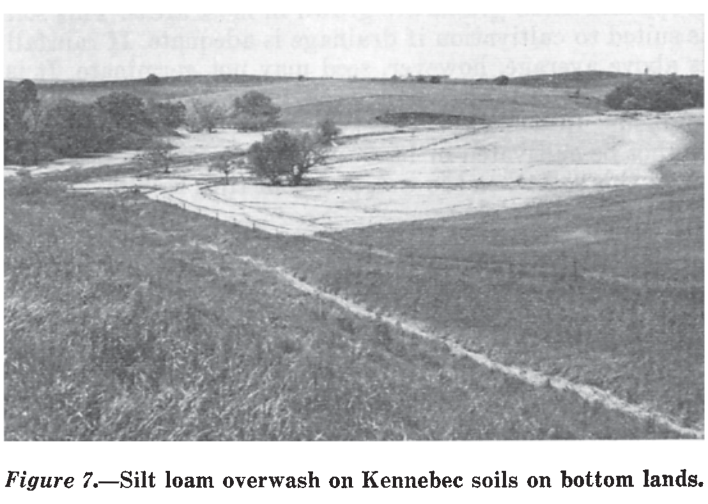

Figure 7.—**Silt loam overwash on Kennebec soils on bottom lands.**

Most areas of Lakeport soils are cultivated.

Representative profile of Lakeport silty clay loam, in a plowed field 800 feet east and 200 feet north of the southwest corner of SE¼ sec. 36, T. 86 N., R. 47 W., on a level flood plain:

Ap—0 to 6 inches, very dark brown (10YR 2/2) silty clay loam; weak, fine, subangular blocky structure and moderate, very fine, granular and subangular blocky; friable; slightly acid; abrupt, smooth boundary.

A1—6 to 10 inches, black (10YR 2/1) to very dark brown (10YR 2/2) silty clay loam; moderate, very fine, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

A3—10 to 22 inches, black (10YR 2/1) silty clay loam; weak, fine, subangular blocky structure and moderate, very fine, subangular blocky and granular; friable; slightly acid; clear, smooth boundary.

B1—22 to 27 inches, very dark gray (10YR 3/1) heavy silty clay loam, very dark grayish brown (2.5Y 3/2) when kneaded; very dark grayish-brown (2.5Y 3/2) ped interiors; moderate, fine, granular structure and very fine, subangular blocky; friable to firm; neutral; clear, smooth boundary.

B21—27 to 34 inches, dark grayish-brown (2.5Y 4/2) medium to heavy silty clay loam that is 10 percent very dark gray (10YR 3/1); few, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; moderate to strong, very fine, subangular blocky structure; firm; shiny ped surfaces; neutral; clear, smooth boundary.

B22—34 to 45 inches, dark grayish-brown (2.5Y 4/2) medium to heavy silty clay loam that has some olive-gray (5Y 5/2) faces; many, fine, distinct, light yellowish-brown (10YR 6/4) mottles and few, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; moderate, very fine, subangular blocky structure; firm; shiny ped surfaces; neutral.

C1—45 to 60 inches, grayish-brown (2.5Y 5/2) light silt loam; very friable; calcareous.

C2—60 to 90 inches, silty clay; very firm; calcareous.

The thickness of the A horizon ranges from 16 to 24 inches. The Ap and A1 horizons are black (10YR 2/1) or very dark brown (10YR 2/2). The A3 horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2). The Ap, A1, and A3 horizons range from light to heavy silty clay loam. Reaction is slightly acid or neutral.

The B horizon is 15 to 30 inches thick. The B21 horizon ranges from dark grayish brown (2.5Y 4/2) to very dark gray (10YR 3/1) and very dark grayish brown (2.5Y 3/2). In many places it is very dark gray or very dark grayish brown to a depth of more than 2 feet, which is deeper than is typical for the series. The B22 horizon ranges from dark grayish brown (2.5Y 4/2) to light olive brown (2.5Y 5/4), gray (5Y 5/1), and olive gray (5Y 5/2). The texture of the B2 horizon ranges from medium silty clay loam to light silty clay.

Reaction is slightly acid or neutral.

The C horizon is calcareous light silt loam or very fine sandy loam. It ranges from dark grayish brown (2.5Y 4/2) to olive gray (5Y 5/2) mottled with yellowish brown and brown. Lime concretions are common. Strata of finer textured materials occur in places.

Lakeport soils are silty clay loam to a depth of about 40 inches, in contrast to the associated Salix soils, which are underlain by silt loam or very fine sandy loam. Lakeport and Colo soils are both silty clay loam, but Lakeport soils are generally more clayey to a depth of 40 inches and are dark grayish brown in the B horizon.

Lakeport silty clay loam (0 to 2 percent slopes) (436).—Individual areas of this soil are generally about 10 to 30 acres in size, but one area is about 200 acres in size. Included in mapping were areas of a similar soil that has a lighter colored, thinner surface layer. In places this included soil has been flooded more recently than the Lakeport soil, and the original dark-colored surface layer has been buried by 15 to 25 inches of lighter colored material. Not enough organic matter has accumulated to make the surface layer of this soil as dark or as thick as that of the Lakeport soil.

The soil has a seasonal high water table. The surface layer tends to clod if worked when wet. The soil is well suited to cultivation, however, and is used intensively for row crops. (Capability unit IIw-2)

Luton Series

The Luton series consists of dark-colored, very poorly drained, clayey soils that formed in river-deposited sediments. These soils are at low elevations on broad bottom lands in the Missouri River valley. They are nearly level.

In a representative profile the surface layer is firm and very firm clay about 28 inches thick. It is black in the upper part and very dark gray in the lower part. The subsoil is very firm clay about 20 inches thick. It is dark gray in the upper part and gray to olive gray in the lower part, and it has common brownish-yellow and yellowish-red mottles. The substratum is calcareous, gray to olive-gray silty clay that has some layers of silt loam.

Permeability is very slow, and the available moisture capacity is medium. The organic-matter content is high. The content of available nitrogen is generally medium to low, of available phosphorus is very low, and of available potassium is high. The surface layer is neutral. The rooting zone is deep, except where root growth is restricted by a high water table.

Luton soils are generally cultivated.

Representative profile of Luton clay, in a plowed field 1 mile north of Sloan, 0.225 mile north of the southeast corner of SW¼ sec. 20, T. 86 N., R. 46 W., on a level flood plain:

Ap1—0 to 3 inches, black (10YR 2/1 to N 2/0) clay; strong, very fine, angular blocky structure; firm; neutral; abrupt, smooth boundary.

Ap2—3 to 8 inches, black (10YR 2/1 to N 2/0) clay; weak to moderate, very fine, subangular blocky structure; firm; neutral; clear, smooth boundary.

A12—8 to 14 inches, black (10YR 2/1 to N 2/0) clay; moderate to strong, very fine, subangular blocky structure; very firm; neutral; gradual, smooth boundary.

A3—14 to 28 inches, very dark gray (N 3/0) to very dark grayish-brown (2.5Y 3/2) clay; few, fine, prominent, brownish-yellow (10YR 6/6) and yellowish-red (5YR 5/6) mottles; moderate to strong, very fine, subangular blocky structure; very firm; thin, discontinuous, very dark gray (N 3/0) ped coatings; neutral; gradual, smooth boundary.

B2g—28 to 36 inches, dark-gray (5Y 4/1) clay; common, fine, prominent, brownish-yellow (10YR 6/6) and yellowish-red (5YR 5/6) mottles; moderate, very fine, subangular blocky structure; very firm; thin, discontinuous, very dark gray (N 3/0) ped coatings; few calcium carbonate concretions; neutral; gradual, smooth boundary.

B3g—36 to 48 inches, gray (5Y 5/1) to olive-gray (5Y 5/2) clay; common to many, fine, prominent, brownish-yellow (10YR 6/6) mottles; weak, very fine, subangular blocky structure; very firm; few, thin, very dark gray (N 3/0) to very dark grayish-brown (2.5Y 3/2) ped coatings; few calcium carbonate concretions; neutral; noncalcareous; abrupt, smooth boundary.

C—48 to 72 inches, stratified, gray (5Y 5/1) to olive-gray (5Y 5/2) silty clay that has a silt loam layer at a depth of 48 to 54 inches; massive; friable; moderately alkaline; calcareous.

The thickness of the A horizon is 20 to 30 inches. The A horizon ranges from silty clay loam to silty clay or clay to a depth of about 15 inches. There is 6 to 12 inches of overwash on these soils in places near the uplands. The overwash is very dark grayish-brown (10YR 3/2) or dark grayish-brown (10YR 4/2) silt loam. Some brownish-yellow, yellowish-brown, and yellowish-red mottles occur in places. The Ap, A1, and A3 horizons are generally neutral, but in places they are slightly acid.

The B2g and B3g horizons range from dark-gray (5Y 5/1) to olive-gray (5Y 5/2) silty clay or clay. Brownish-yellow, yellowish-brown, and yellowish-red mottles are common. The B2g and B3g horizons are generally neutral, but they range to mildly alkaline, and in some places the B3g horizon is calcareous.

The C horizon is distinctly stratified. It is olive-gray (5Y 5/2) to dark-gray (5Y 4/1) silt loam to clay. In places the soils have a thin, buried A horizon, or strata of darkened sediments in the B or C horizon. Lime concretions and snail shells occur in some places in the C horizon and in the B3g horizon if it is calcareous.

Luton soils have a higher content of organic matter and a thicker, darker A horizon than the clayey Albaton and Forney soils. They are not so stratified as those soils. Luton soils are like Napa and Solomon soils in texture, but Napa soils have a high content of sodium and Solomon soils have a high content of lime. Luton soils lack the silty clay loam layer at a depth of 30 to 40 inches that characterizes Woodbury soils.

Luton silty clay loam (0 to 1 percent slopes) (366).—This soil is in the eastern part of the Missouri River valley near tributary streams. It is distinguished from other Luton soils by the surface layer of black, friable silty clay loam, generally 6 to 15 inches thick.

Wetness is a hazard. This soil is generally not so wet as Luton clay, however, and tillage is easier.

This soil is suited to cultivation if drainage is adequate. It is used intensively for row crops. Even where this soil is artificially drained, farming operations are delayed during wet seasons. (Capability unit IIIw-1)

Luton clay (0 to 1 percent slopes) (66).—This soil has the profile described as representative for the series. In some places it has a sequence of dark layers overlying gray layers in the subsoil and substratum. These layers represent older soils buried by more recent deposition. Some individual areas of this soil are 1,000 acres or more in size, and have a few patches of other soils, 5 to 10 acres in size, scattered within them.

Small depressions that contain Napa soils were included in mapping, as were some areas of the calcareous Solomon soils.

Wetness is a severe limitation to use of this soil. Row crops and small grains are grown in most areas. This soil is suited to cultivation if drainage is adequate. If rainfall is above average, however, seed may not germinate. It is not uncommon for farmers to replant whole fields or parts of fields. In some very wet years crops are planted but cannot be cultivated or harvested. It is often necessary to work this soil when too wet, and poor tilth results. (Capability unit IIIw-1)

Made Land

Made land (Ml) consists of those areas built up by hauling in soil material. This land type includes sites that have been built up for the construction of buildings. It also includes sanitary land fills and dumps.

Almost all of the areas are in towns. Some of the areas could be converted to farming use, but this is not likely.

In any case, such a conversion would require a great deal of work. (Capability unit VIIs-1)

Marsh

Marsh (354) consists of wet, periodically flooded areas covered mostly with grasses, cattails, rushes, and similar plants. Most areas are in former river channels. All but a few are in the Missouri River valley.

The best use of this land type is for wildlife habitat. Some of the areas can be drained and used for crops. (Capability unit VIIs-1)

McPaul Series

The McPaul series consists of stratified, well drained to moderately well drained soils that formed in sediments washed from nearby hillsides. The plow layer is moderately dark colored. These soils are nearly level in many places; in other places the slope is 2 to 6 percent.

In a representative profile the plow layer is very dark grayish-brown, calcareous silt loam about 7 inches thick. The substratum is stratified, dominantly very dark grayish-brown and dark grayish-brown, calcareous, very friable silt loam. It extends to a depth of about 30 inches. Next is a layer of black light silty clay loam, about 14 inches thick, which is the surface layer of a soil buried by recent sediments. The subsoil of this buried soil is very dark gray light silty clay loam.

Permeability is moderate, and the available moisture capacity is high. The organic-matter content is low. The content of available nitrogen is very low, of available phosphorus is low, and of available potassium is high. The rooting zone is deep. In most places the surface layer and upper part of the substratum are mildly alkaline and calcareous.

Most areas of McPaul soils are cultivated.

Representative profile of McPaul silt loam, in a cornfield on an alluvial fan in Elliott Creek valley, NW¼NW¼ sec. 3, T. 88 N., R. 46 W., on a 1 percent slope:

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) silt loam; weak, fine and medium, subanglar blocky structure breaking to weak, fine, granular; friable; mildly alkaline; slightly calcareous; clear, smooth boundary.

C—7 to 30 inches, stratified, very dark grayish-brown (10YR 3/2) and dark grayish-brown (10YR 4/2) silt loam; a few very dark brown (10YR 2/2) peds; weak, thick, platy structure and weak to moderate, fine, granular; very friable; mildly alkaline; calcareous; clear, smooth boundary.

Ab—30 to 44 inches, black (10YR 2/1 tending to N 2/0) light silty clay loam; weak, fine, subanglar blocky structure breaking to moderate, fine, granular; friable; mildly alkaline; calcareous; gradual, smooth boundary.

Bb—44 to 60 inches, very dark gray (10YR 3/1 to N 3/0) light silty clay loam, very dark gray (10YR 3/1) when kneaded; weak, fine and medium, subangular blocky structure breaking to moderate, fine, granular; friable; a few streaks of white lime; moderately alkaline; calcareous.

The A horizon of McPaul soils is generally a plow layer that is less than 10 inches thick. In places it is dark grayish brown (10YR 4/2). Reaction is neutral to moderately alkaline.

The C horizon is very dark grayish brown (2.5Y 3/2) to brown (10YR 5/3). In places it is mottled with yellowish brown, brown, strong brown, and gray. The depth to the buried Ab horizon is generally 30 to 40 inches, but this buried soil is lacking in some places. The C, Ab, and Bb horizons range from mildly alkaline to moderately alkaline, and they are calcareous.

McPaul soils developed in similar parent material and are similar in color to Haynie and Grable soils. They contain fewer sandy and clayey strata than Haynie soils and are higher in available phosphorus. McPaul soils lack the sand in the C horizon that is characteristic of Grable soils.

McPaul silt loam (0 to 2 percent slopes) (70).—This soil has the profile described as representative for the series. Individual areas are large. They make up more than 90 percent of the flood plain of some of the medium-size streams, such as Wolf, Elliott, and Big Whiskey Creeks.

Where this soil occupies narrow stream valleys, gullying (fig. 8, top) is a serious hazard. In many places gullying is controlled by dams (fig. 8, bottom) and upstream conservation practices. In some years wetness and siltation are hazards. Water from the hills and tributaries must be diverted in some places to prevent damage to crops.

Flooding from the main stream is also a hazard, although a minor one where the areas are protected by levees. There is a wide variation in the frequency of flooding from place to place. In most places this soil is subject to occasional flooding, but in some places the soil receives no floodwater or sediment at all. Included in mapping were low-lying soils that are frequently flooded.

Most areas of this soil are well suited to cultivation. Row crops are grown intensively where this soil is associated with other nearly level soils. Where this soil is in

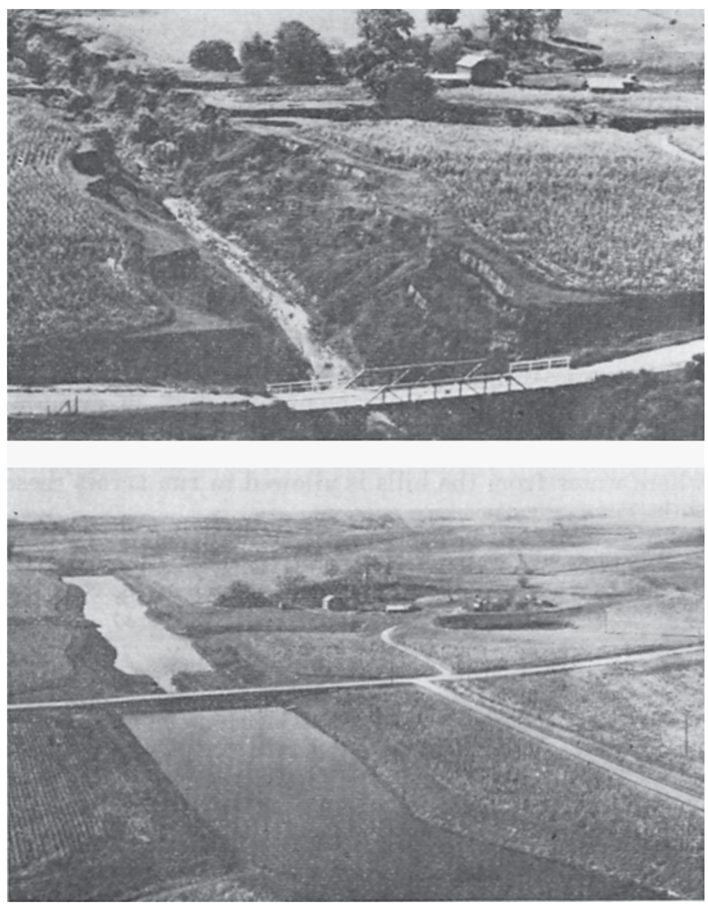

Figure 8.—Top, an active gully widens and destroys areas of McPaul soil; *bottom,* the same area reclaimed by installation of erosion control structures.

narrow stream valleys, some areas are managed along with more sloping soils. (Capability unit I–1)

McPaul silt loam, frequently flooded (0 to 2 percent slopes) (955).—In places this soil has the profile described as representative for the series, but in many recently flooded areas the surface layer is dark grayish brown. This soil is at low elevations, mostly adjacent to streams. It is frequently flooded. Soils at higher elevations have been included in mapping most areas, and these soils are well suited to row crops.

This soil is better suited to pasture or woodland than to cultivated crops. It is well suited to pasture, and especially to water-tolerant grasses. Where it is protected against flooding, this soil is well suited to row crops. If it is used for row crops, replanting is necessary in many years. (Capability unit Vw–1)

McPaul, Albaton, and Blake soils (0 to 1 percent slopes) (896).—These soils are in Sioux City, in areas built up before the soils were surveyed. No attempt has been made to determine the precise percentages of each soil or to delineate them separately on the soil maps.

The McPaul soils are the more extensive in this undifferentiated group. They formed in sediments deposited by such tributary streams as the Floyd River. Where undisturbed, they have the profile described as representative for the series.

Albaton and Blake soils are the main soils of this unit that formed in sediments deposited by the Missouri River. Areas of Onawa, Haynie, and Modale soils were included in mapping.

Because these soils occur on the flood plain of the Missouri River and its tributaries, they are subject to flooding. Major flood control structures have been built to reduce this hazard. (Capability unit Vw–1)

McPaul-Kennebec silt loams, 2 to 6 percent slopes (887B).—This complex is in most valleys, except those in the northeastern part of the county. About a third of this complex is made up of McPaul silt loam, in the center of the valleys. The other two-thirds is made up of McPaul and Kennebec soils, 2 to 6 percent slopes.

The two soils have many similar characteristics. McPaul soils are calcareous and low in organic-matter content; the Kennebec soils are noncalcareous and high in organic-matter content.

Rill and sheet erosion, as well as siltation, are hazards where water from the hills is allowed to run across these soils.

Large areas of this complex are used intensively for row crops. They are well suited to cultivation if runoff is controlled. Areas in small valleys are managed along with the associated upland soils. (Capability unit IIe–1)

Modale Series

The Modale series consists of stratified, moderately well drained to somewhat poorly drained, silty soils that formed in river-deposited sediments. These soils are light colored except in the thin, moderately dark colored surface layer, and they are underlain by clay. They are nearly level and are at high or intermediate elevations in the Missouri River valley.

In a representative profile the surface layer is very dark gray silt loam about 10 inches thick. It is underlain by stratified, dark grayish-brown to grayish-brown, very friable, calcareous loam about 11 inches thick. Below this is firm, calcareous silty clay that is dominantly gray or light gray. The very dark gray to dark gray layer at a depth of 35 to 40 inches was once the surface layer of a buried soil.

Permeability is moderate in the upper part of these soils, but it is very slow to slow in the lower part. The available moisture capacity is high. The organic-matter content is low. The content of available phosphorus and nitrogen is very low, and the content of available potassium is high. Reaction is mildly alkaline in the plow layer and moderately alkaline below. These soils are calcareous. Root growth is somewhat restricted by the clayey substratum, especially in wet years.

Nearly all areas of Modale soils are cultivated.

Representative profile of Modale silt loam, in a cornfield 2 miles east of Sergeant Bluff, 1,100 feet north of the southeast corner of SW¼SW¼ sec. 33, T. 88 N., R. 47 W., on a nearly level flood plain:

Ap—0 to 10 inches, very dark gray (10YR 3/1) to very dark grayish-brown (10YR 3/2) silt loam that is 10 percent pale brown (10YR 6/3); few, fine, prominent, yellowish-red (5YR 4/6) mottles; moderate, coarse, subangular blocky structure breaking to weak, fine, subangular blocky and moderate, very fine, granular; friable; neutral, except mildly alkaline and calcareous in the lower few inches; abrupt, smooth boundary.

C1—10 to 21 inches, stratified, dark grayish-brown to grayish-brown (2.5Y 4/2 to 5/2) loam that has a high percentage of very fine sand; few, prominent, yellowish-red (5YR 4/6), dark reddish-brown (5YR 3/2), and reddish-yellow (7.5YR 6/6) mottles oriented on horizontal plates; weak, thin to thick, platy structure and very fine, granular; very friable; moderately alkaline; calcareous; abrupt, smooth boundary.

IIC2g—21 to 35 inches, gray (5Y 5/1) silty clay; many, fine, prominent, dark reddish-brown (2.5YR 3/4) mottles; few, fine, prominent, red (10R 4/6) mottles; few, fine, distinct, light olive-brown (2.5Y 5/4) mottles; strong, very fine, granular and subangular blocky structure; firm; stratification visible; moderately alkaline; calcareous; abrupt, smooth boundary.

IIAb—35 to 40 inches, very dark gray to dark gray (N 3/0 to 4/0) silty clay; common, fine, prominent, red (2.5YR 4/6) mottles; few, fine, distinct, light yellowish-brown (10YR 6/4) mottles; weak, fine and medium, subangular blocky structure; firm; moderately alkaline; calcareous; clear, smooth boundary.

IIC3g—40 to 90 inches, light-gray (5Y 6/1) silty clay; common, fine, prominent, reddish-brown (2.5YR 4/4) mottles and few, fine, prominent, red (10R 4/6) mottles; weak to moderate, very fine, subangular blocky structure; firm; moderately alkaline; calcareous; reddish mottles are lacking at a depth of 46 to 50 inches.

The Ap or A1 horizon is silty clay loam or silt loam 6 to 10 inches thick. In places, especially near the river, these horizons contain strata of dark grayish-brown (10YR 4/2) material. The A horizon is neutral or mildly alkaline and calcareous.

The C1 horizon centers on stratified silt loam or loam that has a high content of silt and very fine sand. It is dark grayish brown (10YR or 2.5Y 4/2) or grayish brown (10YR or 2.5Y 5/2) mottled with yellowish red, reddish yellow, yellowish brown, or brown. At a depth of 15 to 30 inches, the stratified material ends abruptly. It is underlain by silty clay or clay. The clayey substratum ranges from dark grayish brown (10YR or 2.5Y 4/2) to light gray (5Y 6/1), gray (5Y 5/1), or olive gray (5Y 5/2), except for the buried Ab horizon that occurs in places. The Ab horizon is darker colored and represents the surface layer of an older soil buried by more recent sediments. The clayey part of the substratum contains mottles similar in color to those in the upper part of the substratum.

Modale soils developed in parent material similar to that of Moville, Owego, and Waubonsie soils. They have more sand in the layers above the silty clay than Moville soils. In addition, the uppermost 10 or 15 inches of the underlying clayey layer is generally lighter colored in Modale soils than in Moville soils. Modale soils have less sand in the layers above the silty clay than Waubonsie soils. They are not so fine textured as Owego soils in the Ap horizon and upper part of the C horizon.

Modale silt loam (0 to 2 percent slopes) (149).—This soil has the profile described as representative for the series. It commonly occupies the very gentle, narrow, elongated rises and swales at intermediate elevations. Sandy loams are at the higher elevations; clayey soils are in the distinct swales. Small patches of sandy and clayey soils were included in mapping.

There are generally no serious limitations to farming this soil. In some seasons, however, there is a perched water table above the clayey part of the substratum.

This soil is well suited to cultivation, and it is used intensively for row crops. (Capability unit I-1)

Modale silty clay loam (0 to 2 percent slopes) (147).—The surface layer of this soil is generally very dark gray silty clay loam. There is considerable variation in the depth to the underlying clayey substratum. In some places the underlying clayey layer is within a foot of the surface; in other places it is at a depth of 3 or 3½ feet. Individual areas of this soil are up to 60 acres or more in size. This soil is adjacent to broad swales or former stream channels, where silty sediments have washed over the bank and covered the clayey material. This soil is also in narrow swales flanked by coarser textured soils.

There are no serious limitations to use of this soil, but many areas are associated with wet, clayey soils. During some parts of the year this soil is wetter than other Modale soils. The surface layer becomes cloddy if worked when wet. Farming operations are delayed in some years. If the associated soils are drained, the slight hazard of wetness is usually eliminated.

This soil is well suited to cultivation, and it is used intensively for row crops. (Capability unit I-1)

Monona Series

The Monona series consists of dark colored or moderately dark colored, well-drained silty soils that formed in loess. These soils are on moderately wide ridgetops and convex side slopes. A few areas are on high benches. The slope ranges from 0 to 30 percent.

In a representative profile the surface layer is very dark grayish-brown silt loam about 7 inches thick. The uppermost 5 inches of the subsoil is dark-brown, friable silt loam. Below is brown friable silt loam that has a few yellowish-brown and light-gray mottles at a depth below 27 inches. The substratum, which begins at a depth of 42 inches, is yellowish-brown, very friable, calcareous silt loam.

Permeability is moderate, and the available moisture capacity is high. The organic-matter content is medium or moderately high, but the amount is variable and depends on the degree of erosion. The content of available nitrogen and phosphorus is low, and the content of available potassium is high. The reaction in the surface layer and upper part of the subsoil is generally slightly acid. The rooting zone is deep.

The less sloping Monona soils are used for cultivated crops. The steep soils are used for pasture.

Representative profile of Monona silt loam, in a cultivated field 510 feet west and 225 feet north of the southeast corner of SW¼ sec. 7, T. 89 N., R. 45 W., on a northwest-facing, 4 percent slope:

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) silt loam; weak, fine, subangular blocky structure breaking to moderate, very fine, granular and subangular blocky; friable; slightly acid; abrupt, smooth boundary.

B1—7 to 12 inches, dark-brown (10YR 3/3) silt loam; weak, coarse, subangular blocky structure breaking to moderate, very fine, granular and subangular blocky; friable; slightly acid; clear, smooth boundary.

B2—12 to 27 inches, brown (10YR 4/3) silt loam; few faces of peds very dark brown (10YR 2/2); weak, fine and medium, subangular blocky structure breaking to moderate, very fine, subangular blocky; friable; slightly acid; gradual, smooth boundary.

B3—27 to 42 inches, brown (10YR 4/3) silt loam, light yellowish brown (10YR 6/4) when dry; few, fine, faint, light-gray (10YR 6/1) and yellowish-brown (10YR 5/6) mottles; mottles are relict; weak, fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

C—42 to 60 inches, yellowish-brown (10YR 5/4) silt loam; few, fine, faint, light-gray (10YR 6/1) and yellowish-brown (10YR 5/6) mottles; mottles are relict; massive; very friable; moderately alkaline; calcareous.

In nearly level or uneroded areas, the A horizon ranges from 10 to 18 inches in thickness. The Ap horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2). The A1 horizon, which occurs in many profiles, is black (10YR 2/1) or very dark brown (10YR 2/2). Some profiles have a very dark grayish-brown (10YR 3/2) A3 horizon. In severely eroded areas the A horizon is thinner and lighter colored than that of the profile representative for the series.

The B horizon ranges from 12 to 40 inches in thickness and from slightly acid to mildly alkaline in reaction. The B2 and B3 horizons range from brown (10YR 4/3) to yellowish brown (10YR 5/4). The texture ranges from silt loam to light silty clay loam. Mottles in the B3 or C horizons range from few to common. They range from light gray to grayish brown and yellowish brown or strong brown in color. The C horizon ranges from brown (10YR 4/3) to yellowish brown (10YR 5/4).

These soils are not so fine textured in the A horizon and upper part of the B horizon as Galva soils. Like Monona soils, Galva soils formed in loess and are well drained.

Monona silt loam, 0 to 2 percent slopes (10A).—This soil has a surface layer of very dark brown silt loam about 14 inches thick. It is on high stream benches, such as those along the Maple and West Fork Rivers. Individual areas are generally 60 to 80 acres in size.

Included with this soil are a few small depressions. These areas are wetter than the Monona soil, and in some of them crops drown out during long rainy periods.

This soil has no serious limitations. Some of the areas receive runoff from higher lying soils, but generally, this does not cause a problem.

This soil is well suited to cultivation and can be used intensively for row crops. It is one of the best farming soils in the county. (Capability unit I-3)

Monona silt loam, 2 to 6 percent slopes (10B).—This soil has a surface layer of very dark brown or very dark grayish-brown silt loam about 10 to 14 inches thick. In other respects, its profile is like that described as representative for the series. It occurs on rounded ridgetops and high stream benches. The ridgetops are about 300 to 700 feet wide and about a quarter of a mile to a mile long.

Erosion is a hazard. If erosion is controlled, this soil is well suited to intensive cultivation of row crops. Some of the smaller areas are managed along with the more sloping Monona soils on hillsides. In these places row crops are included less often in the cropping system. (Capability unit IIe-2)

Monona silt loam, 2 to 6 percent slopes, moderately eroded (10B2).—This soil has the profile described as representative for the series. In some places plowing has brought dark-brown subsoil material into the plow layer.

This soil is mainly on rounded ridgetops in undulating to rolling areas. The ridgetops are 300 to 700 feet wide and a quarter of a mile to a mile long. Some areas are on high benches along the Maple and West Fork Rivers and other large streams.

Erosion is a hazard, and the effects of sheet and rill erosion are evident.

If erosion is controlled, row crops can be frequently included in the cropping system. (Capability unit IIe-2)

Monona silt loam, 6 to 10 percent slopes, moderately eroded (10C2).—This soil occurs mostly on moderately wide ridgetops in the rolling and hilly parts of the county. It is also on side slopes at the heads of drainageways in the uplands. In most places the surface layer consists of a mixture of very dark grayish-brown silt loam and dark-brown subsoil material. In some places, especially near hillside drainageways, the surface layer is very dark brown and about 10 inches thick. The subsoil is slightly thinner than that of the profile described as representative for the series.

Included in mapping are many small areas that have a high content of lime in the surface layer. Also included are a few severely eroded areas where the plow layer consists entirely of subsoil material.

Erosion is a hazard. The effects of sheet and rill erosion are evident, and gullies form in a few hillside drainageways.

Most of this soil is cultivated (fig. 9). It is well suited to row crops if erosion is controlled. In many places it is managed along with the more strongly sloping Monona soils. Severely eroded areas need additions of fertilizer. (Capability unit IIIe-2)

Figure 9.—**Contour cultivation on Monona silt loam.**

Monona silt loam, 10 to 15 percent slopes, moderately eroded (10D2).—Most of this soil has a surface layer of very dark grayish-brown, friable silt loam. In places dark-brown subsoil material is mixed into the plow layer, and in many small patches the plow layer consists almost entirely of subsoil material. The subsoil is thinner and more mottled than that of the profile described as representative for the series. In most places this soil is calcareous at a depth of 24 to 36 inches.

This soil is mainly in concave areas at the heads of hillside drainageways or near foot slopes. It occupies entire hillsides on some east- and north-facing slopes; a few areas are on side slopes of high benches.

Included in mapping are many patches of 1 or 2 acres of soil that has a high content of lime. Also included, near the Little Sioux River valley, are small areas of a soil locally called "timber clay." This included soil is more acid and slightly more clayey than typical Monona soils.

The effects of rill and sheet erosion are evident. Some hillside drainageways are gullied.

Most of this soil is cultivated. It is suited to row crops if erosion is controlled and other management is at a high level. Areas closely associated with steep Ida or Monona soils are used for meadow, and row crops are grown when the meadows need renovation. (Capability unit IIIe-3)

Monona silt loam, 10 to 15 percent slopes, severely eroded (10D3).—This soil is most common on north- and east-facing, rounded hillsides. The plow layer is typically dark-brown, friable silt loam. In most places it consists of a mixture of the original very dark grayish-brown surface layer and material from the subsoil. The surface layer is darker and thicker near hillside drainageways. The subsoil is like that of the profile described as representative for the series, except that it is thinner and more mottled. The soil is calcareous at a depth of about 24 to 30 inches in most places.

Included in mapping were patches of soils that have a high content of lime. These areas are 1 or 2 acres in size. Lime nodules are on the surface in many of the included areas.

Rill and sheet erosion are common. In places gullies have formed in hillside drainageways.

This soil needs more fertilizer than the less eroded Monona soils. It is suited to row crops if erosion is controlled and other management is adequate. Most areas are cultivated. (Capability unit IIIe-3)

Monona silt loam, 15 to 20 percent slopes, moderately eroded (10E2).—This soil is mostly on north- and east-facing, rounded hillsides in the hilly and steep parts of the county. Some of this soil is in rolling areas. The surface layer is slightly acid, friable, very dark grayish-brown silt loam. In places the reaction is neutral. The subsoil is thinner than that of the profile described as representative for the series, and in many places it is more mottled. The underlying calcareous layer is within 24 inches of the surface in many places.

Included in mapping are small patches of soil that has a high content of lime in the surface layer and lime nodules on the surface. Also included, near the Little Sioux River valley, are soils locally called "timber clay," which are more acid and slightly more clayey than Monona soils.

The effects of rill and sheet erosion are evident. In places gullies have formed and are enlarging.

In many places the management of this soil depends on the kind of management needed on associated soils. Where adjacent areas are less strongly sloping, this soil usually is cultivated along with those soils. Where the adjacent soils are predominantly steep, this soil is used for meadow. Generally, this soil needs more fertilizer than the less sloping Monona soils. (Capability unit IVe–1)

Monona silt loam, 15 to 20 percent slopes, severely eroded (10E3).—This soil is on rounded hillsides. Individual areas are generally not large. Where it has been plowed, this soil has a surface layer of friable, dark-brown silt loam. In most places the surface layer is made up of subsoil material. The subsoil is thinner and more mottled than that of the profile described as representative for the series. In most places the calcareous layer is at a depth of about 24 inches.

Included with this soil are areas where the surface layer is thicker and darker colored. These areas are near hillside drainageways and at the base of slopes. Also included are a few small areas that are calcareous.

The effects of sheet and gully erosion are evident. Where this soil is associated with less strongly sloping soils, it is usually cultivated along with those soils.

This soil is used mainly for meadow, and a row crop is grown when meadows are renovated. The soil is well suited to this use if erosion is controlled. More fertilizer is needed for this soil than for the less sloping Monana soils. (Capability unit IVe–1)

Monona silt loam, 20 to 30 percent slopes, moderately eroded (10F2).—Where this soil is in native grass or woodland, the surface layer is friable, very dark grayish-brown silt loam 8 to 10 inches thick. Where this soil has been formerly cultivated, the surface layer is browner and thinner. The subsoil is thinner and more mottled than that of the profile described as representative for the series. In most places the soil is calcareous at a depth of about 24 inches, but the depth to calcareous material is greater under the trees.

Most areas of this soil are on convex hillsides that face north and east. Clay loam glacial till is exposed near the foot of the hillsides in places, mostly in the vicinity of Smithland and Anthon. Small areas of this till are included in mapping. A few areas of severely eroded soils are also included.

The erosion hazard is severe, and some places are gullied. The use of farm machinery is severely limited on steep slopes.

Most of this soil is used for grazing. Brome is the major grass grown. Occasionally, a few areas are planted to corn, but the soil is poorly suited to such use. Bur oak is the dominant tree species. Even under a high level of management, however, the timber has limited commercial value. (Capability unit VIe–1)

Moville Series

The Moville series consists of stratified, moderately dark colored, moderately well drained to somewhat poorly drained, silty soils that formed partly in recent sediments and partly in older, slack-water alluvial sediments of the Missouri River. These soils are along the eastern edge of the Missouri River valley. They are nearly level.

In a representative profile the plow layer is very dark grayish-brown silt loam about 6 inches thick. The substratum is stratified, very dark grayish-brown and dark grayish-brown, very friable, calcareous silt loam about 21 inches thick. It has common mottles of dark reddish brown, black, very dark gray, grayish brown, and strong brown. This layer is abruptly underlain by black and very dark gray, firm silty clay, about 18 inches thick, that was originally the surface layer of a now buried soil. The subsoil of this buried soil is very dark gray to dark gray, very firm silty clay about 10 inches thick. Its substratum is light-gray, very firm silty clay.

These soils are moderately permeable in the upper part and very slowly permeable in the lower part. The available moisture capacity is high. The organic-matter content is low. The content of available nitrogen is very low, of available phosphorus is low, and of available potassium is high. The rooting zone is deep, but root growth is restricted in places where the underlying clay is waterlogged. These soils are mildly alkaline in the plow layer, are moderately alkaline below, and are calcareous.

Most areas of these soils are cultivated.

Representative profile of Moville silt loam, in a cornfield about 2 miles northwest of Holly Springs, at the approximate center of SW¼NE¼ sec. 6, T. 86 N., R. 45 W., on a nearly level flood plain:

Ap—0 to 6 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; few, fine, distinct, yellowish-red (5YR 5/6) mottles; weak, coarse, subangular blocky structure breaking to moderate, very fine, granular; very friable; mildly alkaline; calcareous; clear, smooth boundary.

C—6 to 27 inches, stratified, very dark grayish-brown (10YR 3/2) and dark grayish-brown (10YR 4/2) silt loam that has lenses of very dark gray (10YR 3/1) and gray (10YR 5/1); common fine mottles and oxides of dark reddish brown (5YR 3/4), black (10YR 2/1), very dark gray (10YR 3/1), grayish brown (10YR 5/2), and strong brown (7.5YR 5/6); platy structure; very friable; moderately alkaline; calcareous; abrupt, smooth boundary.

IIAb—27 to 45 inches, black (N 2/0) silty clay grading to very dark gray (N 3/0) at a depth below 37 inches; strong, very fine, subangular blocky structure that has some vertical cleavage; firm; neutral; gradual, smooth boundary.

IIBgb—45 to 55 inches, very dark gray (N 3/0) to dark gray (N 4/0) silty clay; common, fine, prominent, yellowish-red (5YR 5/6) mottles; moderate, very fine, subangular blocky structure; very firm; neutral; gradual, smooth boundary.

IICg—55 to 90 inches, light-gray (5Y 6/1) silty clay; common, brownish-yellow (10YR 6/6) to olive-yellow (2.5Y 6/6) mottles; massive; very firm; neutral, grading to moderately alkaline; calcareous in lower part.

The Ap horizon is generally 6 to 10 inches thick. In many places where sedimentation has been recent, the uppermost few inches is dark grayish brown (10YR 4/2). Mixing of this color in the Ap horizon is common in many places. The Ap horizon is neutral to moderately alkaline and calcareous.

The C horizon is generally dark grayish brown (10YR or 2.5Y 4/2) or grayish brown (10YR or 2.5Y 5/2). Layers of very dark grayish-brown (10YR or 2.5Y 3/2) material up to about 6 inches thick are in the uppermost part of the C horizon in places. There are also very thin layers of light-colored material and darker material. Mottles that range from 10YR to 5YR in hue, from 2 to 6 in value, and from 1 to 6 in chroma are common.

The IIAb horizon begins at a depth of 15 to 30 inches. It ranges from black (N 2/0) to a very dark gray (N 3/0 or 10YR 3/1 to 5Y 3/1). The IIBgb and IICg horizons range from very dark gray (N 3/0) to light gray (5Y 6/1). The IIAb, IIBgb and IICg horizons are 50 to 60 percent clay. This buried soil has mottles similar to those of the C horizon. It is generally neutral throughout but ranges from neutral to mildly alkaline and is calcareous in places.

Moville soils are similar to McPaul and Modale soils in the texture and color of the upper part of the profile. They are more poorly drained than McPaul soils because they have an underlying clayey layer, which McPaul soils lack. Moville soils do not have as much sand in the upper part of the profile above the clayey layer as Modale soils, and the clayey underlying layer is generally darker colored.

Moville silt loam (0 to 2 percent slopes) (275).—Many individual areas of this soil are rectangular in shape because they are in desilting basins bordered by dikes. These areas are 40, 80, or 160 acres in size. Included in mapping were areas where more than 3 feet of stratified silty material overlies the clayey substratum. Also included were areas where there is only about a foot of silty material.

In most places this soil is subject to occasional flooding. In active desilting basins, this soil is wet during periods of heavy rainfall, because water drains onto it from the tributary streams. It is also wet where the silty material is only about 15 inches thick over the clay.

This soil is used for crops, except for some areas that are still used as a desilting basin. It is well suited to cultivation and is used intensively for row crops. Farming operations are delayed in some seasons. (Capability unit I-1)

Napa Series

This series consists of dark-colored, very poorly drained soils that formed in river sediments. These soils are in slight depressions in the Missouri River valley.

In a representative profile the surface layer is black and very dark gray to dark gray, strongly alkaline, very firm clay about 22 inches thick. When dry, the surface layer is white. The subsoil is dark-gray, strongly alkaline, very firm clay about 20 inches thick. The substratum is stratified, calcareous clay and silt loam sediments.

Permeability is very slow, and the available moisture capacity is medium. The organic-matter content is high. The content of exchangeable sodium is high. The content of available nitrogen is low, of available phosphorus is very low, and of available potassium is medium. Reaction is strongly alkaline.

A few areas are used for cultivation. Many are left in native pasture.

Representative profile of Napa clay, in a pasture at the south edge of the town of Luton, 650 feet north and 125 feet east of the southwest corner of SE¼ sec. 20, T. 87 N., R. 46 W., in a depressional area on the flood plain:

Ap—0 to 8 inches, black (10YR 2/1) clay; few, fine, faint, grayish-brown (2.5Y 5/2) mottles, drying to white (10YR 8/1); weak, coarse, granular structure breaking to moderate, very fine, granular and subangular blocky; very firm; strongly alkaline; calcareous; gradual, smooth boundary.

A1—8 to 15 inches, black (N 2/0) clay; few, fine, faint, grayish-brown (2.5Y 5/2) mottles; strong, very fine, subangular blocky structure; very firm; strongly alkaline; calcareous; gradual, smooth boundary.

A3—15 to 22 inches, very dark gray (N 3/0) to dark gray (N 4/0) clay; common, fine, faint, grayish-brown (2.5Y 5/2) mottles, drying to white (10YR 8/1); strong, very fine, subangular blocky structure; very firm; strongly alkaline; calcareous; gradual, smooth boundary.

B2g—22 to 35 inches, mixture of dark-gray (5Y 4/1) and 10 percent black (N 2/0) clay, very dark gray (5Y 3/1) in the upper part; many, fine, prominent, yellowish-brown (10YR 5/8) mottles and few, fine, brown (7.5YR 4/4) mottles; strong, very fine, subangular blocky structure; very firm; many gypsum crystals; strongly alkaline; calcareous; gradual, smooth boundary.

B3g—35 to 42 inches, mixture of dark-gray (5Y 4/1) and 5 percent black (N 2/0) clay; many, fine, prominent, yellowish-brown (10YR 5/8) mottles; weak, very fine, subangular blocky structure; very firm; many calcium carbonate concretions and gypsum crystals; strongly alkaline; calcareous; gradual, smooth boundary.

C—42 to 80 inches, stratified, light-gray (5Y 6/1) clay; gray (5Y 5/1) silt loam at a depth of 42 to 53 inches; common, fine, prominent, yellowish-brown (10YR 5/8) and reddish-yellow (7.5YR 6/8) mottles; massive; very firm; abundant calcium carbonate concretions and a few gypsum crystals; strongly alkaline; calcareous.

The combined thickness of the Ap and A1 horizons is generally 12 to 20 inches. The texture ranges from heavy silty clay to clay. Reaction is moderately alkaline to strongly alkaline. The Ap horizon is noncalcareous in some places.

The Bg horizon is generally dark gray (5Y 4/1) but ranges from dark gray to gray (5Y 5/1) or olive gray (5Y 5/2). The texture ranges from clay to heavy silty clay. This horizon is mottled with brown, grayish brown, strong brown, yellowish brown, and reddish yellow. Reaction is moderately alkaline to very strongly alkaline. The Bg horizon is calcareous in places.

In some places the C horizon consists of a sequence of black layers overlying gray layers. These layers range from silty clay to silt loam and represent older soils buried by recent clayey sediments. Color, mottling, and reaction are like those of the subsoil.

These are the only alkali soils in the county. Other soils, such as those of the Solomon series, are called alkali, but they have a high content of lime, rather than of sodium salts. Almost all areas of Napa soils in Iowa are in this county and in Monona County.

Napa clay (0 to 1 percent slopes) (68).—This soil occurs in slight depressions on low bottom lands. Individual areas are 1 to 20 acres in size. This soil is surrounded by other clayey, poorly drained soils.

This soil is wet and high in content of exchangeable sodium. It is difficult to dispose of the excess sodium salts, at least at a reasonable cost. Because of the clayey texture, very slow permeability, and the high water table, it is impractical to leach the sodium out of the rooting zone.

Large areas of this soil are left in native grass. The smaller areas are cropped along with the associated soils. Replanting is common. Crops in some areas can be harvested only after the ground freezes. The surface layer puddles easily if worked when wet. (Capability unit IIIw-1)

Napier Series

The Napier series consists of dark-colored, well-drained, silty soils that formed in materials washed down from nearby hillsides. These soils are on foot slopes that form the edges of valleys. The slope ranges from 2 to 15 percent.

In a representative profile the surface layer is very dark brown and very dark grayish-brown, very friable silt loam about 30 inches thick. The subsoil is dark-brown and brown, very friable silt loam about 22 inches thick. The substratum is brown, very friable silt loam.

Permeability is moderate, and the available moisture capacity is high. The organic-matter content is moderately high. The content of available nitrogen is generally medium to low, of available phosphorus is low, and of available potassium is high. The surface layer is slightly acid or neutral.

Most areas of Napier soils are cultivated. A number of small, inaccessible areas are in pasture or woodland.

Representative profile of Napier silt loam, in a cultivated field approximately 1,000 feet south and 350 feet west of the northeast corner of NW¼ sec. 27, T. 88 N., R. 45 W., on a concave, southwest-facing 6 percent slope:

Ap—0 to 7 inches, very dark brown (10YR 2/2) silt loam; weak, fine, granular structure; friable; slightly acid; abrupt, smooth boundary.

A1—7 to 22 inches, very dark brown (10YR 2/2) silt loam, very dark grayish brown (10YR 3/2) when crushed; weak, fine, subangular blocky structure; very friable; abundant worm casts; neutral; gradual, smooth boundary.

A3—22 to 30 inches, very dark grayish-brown (10YR 3/2) silt loam; weak, fine and medium, subangular blocky structure breaking to moderate, very fine, subangular blocky; very friable; neutral; gradual, smooth boundary.

B2—30 to 40 inches, dark-brown (10YR 3/3) silt loam; common, very dark brown to very dark grayish-brown (10YR 2/2 to 3/2) mottles, brown (10YR 4/3) when crushed; weak, fine, subangular blocky structure; very friable; neutral; gradual, smooth boundary.

B3—40 to 52 inches, dark-brown (10YR 3/3) silt loam, brown (10YR 4/3) when crushed; weak, medium, subangular blocky structure; very friable; neutral; gradual, smooth boundary.

C—52 to 60 inches, brown (10YR 4/3) silt loam, yellowish brown (10YR 5/4) when crushed; massive; mildly alkaline.

The combined thickness of the Ap, A1, and A3 horizons is 24 to 36 inches. Reaction is neutral or slightly acid. In some places there is an overwash of yellowish-brown, calcareous silt loam 6 to 12 inches thick.

The B horizon extends to a depth of 36 to 60 inches. It is neutral or slightly acid.

The substratum ranges from dark brown (10YR 3/3) to brown (10YR 4/3 or 5/3) or yellowish brown (10YR 5/4). It is neutral to moderately alkaline and calcareous in some places.

Napier soils developed in parent material similar to that of the Castana, Judson, and Kennebec soils. Napier soils are noncalcareous in the A and B horizons. Castana soils have a thinner A horizon, have a high content of lime in the lower part of the A horizon, and lack a brown B horizon. Kennebec soils are dark colored to a depth of 3 feet or more and lack a B horizon. Napier soils contain less clay throughout the profile than Judson soils.

Napier silt loam, 6 to 10 percent slopes (12C).—This soil has the profile described as representative for the series. It occurs in valleys, on strips about 200 feet wide that are adjacent to McPaul-Kennebec silt loams, 2 to 6 percent slopes. In very narrow valleys some of these associated soils were included in mapping.

Rill and gully erosion, as well as siltation, are hazards. Where erosion is controlled, this soil is suited to row crops. Cropping patterns are generally determined by those of the associated soils. If the nearby hillsides are steep, this soil and the hillside soils are generally used for meadow. A few areas are managed along with McPaul-Kennebec silt loams, 2 to 6 percent slopes. They are used intensively for row crops. (Capability unit IIIe-1)

Napier-Castana silt loams, 10 to 15 percent slopes (170D).—This complex is made up of about 75 percent Napier soils and 25 percent Castana soils. The Napier soils lie downslope from the Castana soils.

420-440—72——3

Individual areas of these soils are about 5 to 20 acres in size and long and narrow in shape. They are mainly in the valleys (fig. 10).

Rill and gully erosion, as well as siltation, are hazards. In wide valleys, these soils are cropped along with nearly level associated soils. Row crops are frequently included in the cropping system, and the soils are suited to cultivation if erosion is controlled. In narrow valleys these soils are managed along with the adjacent soils on uplands. They are used mainly for hay and pasture. (Capability unit IIIe-1)

Napier-Gullied land complex, 2 to 10 percent slopes (984C).—In more sloping areas, the Napier soil in this complex has a somewhat thinner surface layer and a browner subsoil than that described as representative for the series. In most places this soil is split by a large gully in the center of the valley. The gully is as much as 50 feet deep and 50 feet wide, and it has vertical sides. Active side gullies extend from the main gully. Gullied land occupies 25 to 50 percent of the complex.

Gullies severely limit the use of this complex. Farming equipment cannot be used safely. Nearly all of the soil is used for permanent pasture. Young trees grow in the gullies in places. (Capability unit VIIe-1)

Onawa Series

The Onawa series consists of moderately dark colored, somewhat poorly drained to poorly drained, clayey soils that formed in sediments in the Missouri River valley. These soils are stratified and are underlain by silty and loamy sediments. They are nearly level.

In a representative profile the plow layer is very dark gray, firm silty clay about 7 inches thick. The substratum is mainly dark grayish-brown, very firm, calcareous silty clay to a depth of 2 inches. It is dark-gray and grayish-brown, very friable, calcareous silt loam below.

Permeability is slow in the upper part of the profile and moderate or moderately rapid in the lower part. The available moisture capacity is high. The organic-matter content is low. The content of available nitrogen is low, of available phosphorus is very low, and of available potassium is high. These soils are mildly alkaline in the surface layer and upper part of the substratum, and they are calcareous. The rooting zone is deep, but root

Figure 10.—**Crops on Napier-Castana silt loams, 10 to 15 percent slopes, in a valley bordered by Hamburg soils.**

growth is somewhat restricted by a seasonal high water table.

Most areas of these soils are cultivated. A few sites have not been cleared of trees.

Representative profile of Onawa silty clay, in a cornfield about 3 miles west of Sloan, 20 feet northwest of center of SW¼ sec. 26, T. 86 N., R. 47 W., on a level flood plain:

Ap—0 to 7 inches, very dark gray (10YR 3/1) silty clay; weak, medium, subangular blocky and angular blocky structure breaking to moderate, fine, granular; firm; mildly alkaline; noncalcareous; abrupt, smooth boundary.

C1—7 to 29 inches, stratified, dark-gray (5Y 4/1), dark grayish-brown (2.5Y 4/2), and grayish-brown (2.5Y 5/2) silty clay; few, fine, dark reddish-brown (5YR 3/2) mottles at a depth below 14 inches; strong, very fine, angular blocky structure; very firm; mildly alkaline; calcareous; clear, smooth boundary.

IIC2—29 to 60 inches, stratified, dark-gray (5Y 4/1 tending toward 2.5Y) and grayish-brown (2.5Y 5/2) silt loam; common fine mottles of dark reddish brown (5YR 3/2); dark brown (10YR 3/3), and light gray (10YR 6/1); weak, very fine, subangular blocky structure in upper part, platy structure in lower part; very friable; moderately alkaline; calcareous.

The Ap horizon is very dark gray (10YR 3/1) or very dark grayish-brown (10YR or 2.5YR 3/2) silt loam to silty clay 6 to 10 inches thick. Reaction is neutral, or the soil is mildly alkaline and calcareous.

The strata of the C1 horizon range from dark grayish brown (2.5Y 4/2) to dark gray (5Y to 10YR 4/1) and olive gray (5Y 4/2 or 5/2) in color. The horizon is mottled with dark reddish brown to strong brown or gray. In places a layer of silty clay loam, generally less than 6 inches thick, is between the C1 horizon and the IIC2 horizon.

The IIC2 horizon begins at a depth of 15 to 30 inches. It ranges from dark grayish-brown to dark-gray and olive-gray silt loam to very fine sandy loam.

Onawa soils are associated with Albaton and Forney soils. Onawa soils are silt loam at a depth below about 2 feet, but Albaton and Forney soils are clay or silty clay.

Onawa silt loam (0 to 1 percent slopes) (145).—This soil has a surface layer of very dark grayish-brown, very friable silt loam about 10 inches thick. In some places the silty clay part of the substratum is thicker than that described as representative for the series. This soil occurs at intermediate elevations in long, narrow swales. Individual areas are small.

Wetness is a hazard, but this soil is not so wet as other Onawa soils. This soil is cultivated, and row crops are generally grown intensively. It is well suited to row crops. (Capability unit IIw–1)

Onawa silty clay (0 to 1 percent slopes) (146).—This soil has the profile described as representative for the series. Most areas of this soil are in long, narrow swales near the river; some are on slightly higher lying bottom lands. Individual areas are 40 to 80 acres in size.

Wetness is a hazard. This soil is generally cultivated, and it is used intensively for row crops. It is well suited to cultivation if drainage is adequate. Even where drainage is improved, however, farming operations are delayed in some seasons. The surface layer becomes cloddy if worked when wet. (Capability unit IIw–1)

Owego Series

The Owego series consists of moderately dark colored, poorly drained to somewhat poorly drained, stratified soils that formed in river-deposited sediments in the Missouri River valley. These soils are clayey above and below the distinct, friable, silty layer that occurs at a depth of about 15 inches. They are nearly level.

In a representative profile the surface layer is very dark gray, firm silty clay about 6 inches thick. The subsoil is mottled, dark-gray, firm silty clay about 8 inches thick. The substratum is light olive-gray and pale-olive, friable, calcareous silt loam in the uppermost 8 inches and dark gray, gray, and very dark gray, firm to very firm, stratified silty clay in the lower part.

Permeability is very slow except in the silty layer. The available moisture capacity is medium. The organic-matter content is low. The content of available nitrogen is low, of available phosphorus is very low, and of available potassium is high. Owego silty clay is generally neutral in the plow layer and neutral or mildly alkaline in the upper part of the substratum. Owego silt loam, calcareous overwash, is mildly alkaline or moderately alkaline and calcareous. The rooting zone is restricted by a seasonal high water table.

Most areas of these soils are cultivated.

Representative profile of Owego silty clay, in an alfalfa field 2 miles north of Salix, 150 feet north and 80 feet west of the southeast corner of NE¼NW¼ sec. 23, T. 87 N., R. 47 W., on a level flood plain:

Ap—0 to 6 inches, very dark gray (10YR 3/1) silty clay; moderate, very fine and fine, subangular blocky structure breaking to moderate, fine, granular structure in the uppermost 2 inches; firm; neutral; clear, smooth boundary.

Bg—6 to 14 inches, dark-gray (5Y 4/1) silty clay; common, fine, light olive-brown (2.5Y 5/4) mottles and few, fine, dark-brown (7.5YR 3/2) mottles; weak, medium to coarse, subangular blocky structure breaking to strong, very fine, subangular blocky; firm; mildly alkaline; noncalcareous; abrupt, smooth boundary.

IIC1—14 to 22 inches, stratified, light olive-gray (5Y 6/2) and pale-olive (5Y 6/3) silt loam; many, fine, olive-gray (5Y 5/2) mottles and few, fine, dark reddish-brown (5YR 3/3 and 2/2) and brownish-yellow (10YR 6/6) mottles; massive; friable; moderately alkaline; calcareous; abrupt, smooth boundary.

IIIAb—22 to 32 inches, very dark gray (N 3/0) silty clay; few, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; moderate, very fine, subangular blocky structure; firm; neutral; clear, smooth boundary.

IIICg—32 to 90 inches, stratified, dark gray (5Y 4/1 to N 4/0), gray (N 5/0), and very dark gray (N 3/0) silty clay and silty clay loam; common fine mottles of yellowish brown (10YR 5/4), light yellowish brown (2.5Y 6/4), and dark reddish brown (5YR 3/3); moderate, very fine, subangular blocky structure; firm to very firm; mildly alkaline; dominantly calcareous at a depth below 38 inches.

The Ap or A1 horizon is silt loam or silty clay loam about 6 to 8 inches thick. The color ranges from very dark gray (10YR 3/1) to very dark grayish brown (10YR or 2.5Y 3/2). In places the surface is covered with an overwash of calcareous silt loam 6 to 15 inches thick. This material is very dark grayish brown (10YR 3/2) or dark grayish brown (10YR 4/2). The silty clay soil is calcareous at a depth below 1 to 2 feet.

The Bg horizon is 6 to 12 inches in thickness and dark gray (5Y 4/1) to olive gray (5Y 4/2) in color. Reaction is neutral or mildly alkaline.

The IIC1 horizon is stratified, light olive gray (5Y 6/2), pale olive (5Y 6/3), or olive gray (5Y 5/2) to dark grayish brown (2.5Y 4/2). It is 6 to 15 inches thick and ranges from silt loam to silty clay loam, loam, and clay loam in texture. Reddish to grayish mottles are numerous. The IIIAb and IIICg horizons consist of very dark gray, dark gray, and gray layers that represent older soils buried by recent sediments. Most of these layers are silty clay or clay, but less clayey layers are common at a depth below 40 inches. Reaction in the IIICg horizon ranges from mildly alkaline to moderately alkaline, and some parts of this horizon are calcareous.

Owego soils are associated with Forney and Albaton soils. Owego soils have a distinct silty layer in the substratum, which is lacking in Forney and Albaton soils. They are like Blend soils in texture, but they have a thinner surface layer that is not so dark colored, and they are stratified and calcareous at a depth below about 15 inches.

Owego silt loam, calcareous overwash (0 to 1 percent slopes) (852).—This soil has 6 to 15 inches of calcareous silt loam overlying the original surface layer.

The content of available phosphorus and nitrogen is lower than is normal for Owego soils. Good tilth is a little easier to maintain because the surface layer is silty.

In a typical field this soil is associated with a large proportion of better drained soils. In these places the surface layer is dominantly silty. Excess water on the surface is not so severe a hazard as in many fields in the Missouri River valley. In places, however, the water table is high enough in some years to restrict root growth.

This soil is well suited to cultivation if drainage is adequate. It is used intensively for row crops. (Capability unit IIIw–1)

Owego silty clay (0 to 1 percent slopes) (552).—This soil has the profile described as representative for the series. It is on bottom lands at low elevations. Individual areas are as much as 300 or 400 acres in size.

Included in mapping, especially in the narrow swales, were places where the silty layer in the upper part of the substratum is only a few inches thick or is lacking. Also included are siltier, less poorly drained soils on small, slightly elevated rises.

This soil is wet and has a seasonal high water table. It is suited to intensive cultivation if drainage is adequate. Farming operations are delayed in some seasons. (Capability unit IIIw–1)

Percival Series

The Percival series consists of moderately dark colored, somewhat poorly drained, clayey soils that formed in river-deposited sediments in the Missouri River valley. These soils are stratified and are underlain by sand. They are on gentle rises and in swales. They are nearly level.

In a representative profile the surface layer is thin and corresponds to the plow layer. It is very dark grayish-brown, firm, calcareous silty clay. Below the plow layer is stratified, light olive-gray, firm silty clay to a depth of about 17 inches. This is underlain by light brownish-gray, calcareous, loose loamy sand or sand.

Permeability is slow in the upper part of the profile and rapid in the sandy material. The available moisture capacity is medium to low. The organic-matter content is low. The content of available phosphorus and nitrogen is low, and the content of available potassium is high. The surface layer and substratum are moderately alkaline and calcareous.

Most areas of these soils are used for cultivation. A few areas along the river are wooded.

Representative profile of Percival silty clay, in a cultivated field about 3 miles west of Sloan, approximately 300 feet southeast of the northwest corner of NE¼NW¼ sec. 34, T. 86 N., R. 47 W., on a level flood plain:

Ap—0 to 7 inches, very dark grayish-brown (2.5Y 3/2) light silty clay; few, fine, distinct, light-gray (5Y 6/1) mottles at a depth of 2 to 7 inches; moderate, fine, granular structure and weak, very fine, subangular blocky; firm; partly decomposed organic matter is common; moderately alkaline; calcareous; clear, smooth boundary.

C1g—7 to 17 inches, stratified, light olive-gray (5Y 6/2) silty clay; common, fine, faint, light-gray (5Y 6/1) mottles; moderate, very fine, subangular blocky structure; firm; moderately alkaline; calcareous; abrupt, smooth boundary.

IIC2—17 to 60 inches, light brownish-gray (2.5Y 6/2) sand, in places it is loamy sand in the upper part; common, light yellowish-brown (10YR 6/4) mottles; massive or single grain; loose; moderately alkaline; calcareous.

The Ap horizon is light or heavy silty clay 6 to 8 inches thick. It is very dark grayish brown (10YR or 2.5Y 3/2) or very dark gray (10YR 3/1). Reaction is neutral to moderately alkaline, and the horizon is calcareous.

The C1g horizon is generally light olive gray (5Y 6/2) or olive gray (5Y 4/2 or 5/2) but ranges to dark grayish brown (2.5Y 4/2). This horizon has few to common, dark reddish-brown to light-gray mottles. At a depth of 15 to 25 inches, the clayey material is abruptly underlain by a IIC2 horizon of loamy sand or sand. This horizon is light brownish gray (2.5Y 6/2) or grayish brown (2.5Y 5/2). The IIC2 horizon also has few to common, dark reddish-brown to light-gray mottles.

No other soils in the county have the sharp contrast between the clayey surface layer and the sandy underlying layers that Percival soils have. Percival soils differ from the associated Onawa soils in that the lower part of the C horizon is sandy, rather than loamy. In addition, Percival soils generally have a somewhat thinner clayey layer.

Percival silty clay (0 to 1 percent slopes) (515).—Most of this soil is near the Missouri River, where many areas are in swales. A number of small areas east of Sergeant Bluff are at slightly higher elevations and are surrounded by wetter, clayey soils. Included in mapping were some areas in swales where only 10 or 12 inches of clayey material overlies the sand. These included soils generally have a seasonal high water table.

Slow runoff and a fluctuating water table make this soil wet. The water table subsides during dry periods, however, and droughtiness becomes a hazard, especially on slight rises.

Most areas of this soil are used intensively for row crops, which are suited if drainage is adequate. (Capability unit IIw–1)

Riverwash

Riverwash (53) is a land type made up of areas of coarse sand or fine gravel recently deposited by streams. Little or no vegetation grows in these areas. Most areas are along the Missouri River; a few are along other streams in the county. Riverwash is subject to frequent flooding and has little or no value for farming. (Capability unit VIIs–1)

Salida Series

The Salida series consists of moderately dark colored, excessively drained, gravelly soils that formed in glacial outwash. Most areas are on high stream benches and steep hillsides. The slope ranges from 5 to 40 percent.

In a representative profile the surface layer is very dark brown and very dark grayish-brown, friable sandy loam mixed with some gravel. It is about 13 inches thick. The substratum is dark grayish-brown grading to brown gravelly loamy sand that extends to a depth of 60 inches. It is calcareous.

Permeability is very rapid, and the available moisture capacity is low. The organic-matter content is low to medium. The content of available nitrogen is very low to low, of available phosphorus is very low, and of available potassium is low to medium. The surface layer is neutral to moderately alkaline, and the substratum is moderately alkaline and calcareous.

Most areas of Salida soils are left in native grass or trees because they are droughty. The few areas that are cultivated are small areas that are surrounded by other soils.

Representative profile of Salida sandy loam, in a native grass pasture 400 feet southeast of the northwest corner of sec. 34, T. 89 N., R. 42 W., on a west-facing 24 percent slope:

Ap—0 to 5 inches, very dark brown (10YR 2/2) sandy loam that contains some gravel, dark brown (10YR 3/3) when crushed; dark gray (10YR 4/1) when dry; moderate, very fine and fine, granular structure; very friable; neutral; abrupt, smooth boundary.

A1—5 to 13 inches, very dark grayish-brown (10YR 3/2) sandy loam that contains some gravel, dark grayish brown (10YR 4/2) when crushed, gray (10YR 5/1) when dry; weak, very fine and fine, granular structure; friable; neutral; abrupt, smooth boundary.

C1—13 to 19 inches, dark grayish-brown (10YR 4/2) gravelly loamy sand; structureless; very friable; moderately alkaline; calcareous; gradual, wavy boundary.

C2—19 to 60 inches, brown (10YR 4/3) gravelly loamy sand, very pale brown (10YR 7/3) when dry; structureless; loose; some stones 10 to 12 inches in diameter; some sand and clay loam or loam strata at a depth below 30 inches; moderately alkaline; calcareous.

The combined thickness of the Ap and A1 horizons is 8 to 14 inches, except that where erosion has been more active than typical, it is 6 to 10 inches. These horizons are sandy loam or loam. They contain gravel and, in places, some stones. The Ap and A1 horizons are neutral to moderately alkaline and are calcareous.

The C horizon varies from place to place, mainly in the amount of gravel or coarser material. Gravelly loamy sand is the dominant texture, but there are pockets and strata of gravelly loam to gravelly sand or sand. Cobblestones and stones occur in this horizon in many areas.

Salida and Chute soils are both coarse textured. Salida soils, however, contain pebbles and cobblestones, and Chute soils have no particles larger than sand. Salida soils are associated with Wadena soils in places. Salida soils lack the 2 to 4 feet of silty or loamy material that overlies the gravelly sand layer of Wadena soils.

Salida sandy loam, 5 to 9 percent slopes, moderately eroded (73C2).—This soil has the profile described as representative for the series. If this soil is cultivated, the underlying lighter brown materials are mixed into the plow layer in many places. There is an accumulation of rocks and gravel on the surface in places, where the smaller particles have been removed by erosion.

Individual areas of this soil are about 5 to 15 acres in size. Many of the areas are on short slopes between the nearly level stream benches and the bottom lands along the Little Sioux River. Others are on knolls.

Included in mapping were a few strips of very wet soils that are high in organic-matter content. The wetness is caused by springs.

Droughtiness and erosion are hazards. Some areas of this soil are cultivated. Many areas are left in meadow because they are droughty and the gravel and stones make them difficult to till. (Capability unit IIIe–2)

Salida sandy loam, 9 to 18 percent slopes, severely eroded (73E3).—This soil has a dark-brown to dark grayish-brown plow layer that consists mainly of material from the substratum. Uncultivated areas have a thin, very dark grayish-brown surface layer. Some pebbles and rocks are generally on the surface. Most individual areas of this soil are on stream benches that break from one elevation to another in the Little Sioux River valley. A few are in other valleys.

Included in mapping were a few narrow strips of very wet soils that are high in organic-matter content. The wetness is caused by springs.

This soil is very droughty. Both soil blowing and water erosion are common. Soil blowing is especially damaging in barren areas. Most areas were formerly cultivated but are now used for meadow. (Capability unit VIe–1)

Salida sandy loam, 18 to 40 percent slopes, severely eroded (73G3).—This soil generally has a surface layer of dark-brown, friable sandy loam about 4 to 6 inches thick. In a few places the surface layer is thicker and dark colored. Gravel and stones are common in the steeper and more eroded areas. This soil is on hillsides or on remnants of stream benches that break abruptly from one elevation to another.

Most individual areas are long, narrow fields 5 to 60 acres in size. They adjoin nearly level fields at both the upper and lower edges.

This soil is droughty and erodible. Some areas are wooded, but most are in native grass. Farm equipment cannot be used safely on the steepest slopes. (Capability unit VIIe–1)

Salix Series

The Salix series consists of dark-colored, moderately well drained, silty soils that formed in river-deposited sediments. These soils are in the Missouri River valley at the higher elevations. They are nearly level.

In a representative profile the surface layer is silty clay loam about 23 inches thick. It is black in the upper part and very dark gray and very dark grayish brown in the lower part. The subsoil, about 13 inches thick, is dark grayish brown mottled with yellowish brown and olive brown. It is friable silty clay loam in the uppermost 6 inches, and very friable, calcareous silt loam in the lower 7 inches. The substratum is mottled, dark grayish-brown, very friable, calcareous silt loam.

Permeability is moderate, and the available moisture capacity is high. The rooting zone is deep. The organic-matter content is moderately high. The content of available nitrogen is medium to low, of available phosphorus is generally medium, and of available potassium is high. The surface layer is neutral.

Most areas of these soils are cultivated. They are among the best farming soils in the county.

Representative profile of Salix silty clay loam, in a meadow 30 feet south and 250 feet east of the northwest corner of sec. 31, T. 86 N., R. 46 W., on a level flood plain:

Ap—0 to 8 inches, black (10YR 2/1) light silty clay loam; cloddy breaking to moderate, fine and very fine, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

A1—8 to 16 inches, black (10YR 2/1) light silty clay loam; moderate, very fine and fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

A3—16 to 23 inches, very dark gray (10YR 3/1) and very dark grayish-brown (10YR 3/2) silty clay loam, very dark grayish brown (10YR 3/2) when kneaded; moderate, coarse, prismatic structure breaking to moderate, fine and very fine, subangular blocky; friable; neutral; abrupt, smooth boundary.

B2—23 to 29 inches, dark grayish-brown (2.5Y 4/2) silty clay loam; common, fine, distinct, yellowish-brown (10YR 5/4) mottles; moderate, fine and very fine, subangular blocky structure; friable; some very dark gray (10YR 3/1) coatings; neutral; clear, smooth boundary.

IIB3—29 to 36 inches, dark grayish-brown (2.5Y 4/2) silt loam; many, fine, distinct, olive-brown (2.5Y 4/4) mottles; weak, medium, subangular blocky structure and moderate, very fine, granular and subangular blocky structure; very friable; mildly alkaline; calcareous; gradual, smooth boundary.

IIC—36 to 60 inches, dark grayish-brown (2.5Y 4/2) silt loam, grayish brown (2.5Y 5/2, tends to 3 in chroma) when kneaded; common, fine, faint, yellowish-brown (10YR 5/4) mottles; very weak, medium, subangular blocky structure breaking to moderate, very fine, granular and subangular blocky; very friable; moderately alkaline; calcareous.

The thickness of the A horizon ranges from 16 to 24 inches. The Ap horizon is very dark brown (10YR 2/2) or black (10YR 2/1); the A1 horizon ranges from black (10YR 2/1) to very dark brown (10YR 2/2) or very dark gray (10YR 3/1). In places about 6 to 12 inches of stratified, very dark grayish-brown (10YR 3/2) overwash is on the surface. It is generally light silty clay loam or heavy silt loam in texture. The Ap, A1, and A3 horizons range from neutral to slightly acid.

The combined parts of the B horizon are 10 to 18 inches thick. Reaction ranges from neutral to mildly alkaline or moderately alkaline. The depth to calcareous material is generally 24 to 36 inches. In places the B horizon is grayish brown (2.5Y 5/2). Mottles range from yellowish brown to gray. The B3 horizon is silty clay loam in some places.

The C horizon ranges from silt loam to very fine sandy loam.

Salix soils are similar in texture to Blake soils, except that they have a thicker, darker colored A horizon, a brownish B horizon, and are not so stratified or calcareous throughout. Salix soils are associated with Blencoe and Keg soils. They have more clay in the A and B horizons than Keg soils, and they are not so clayey in the A horizon and upper part of the B horizon as Blencoe soils. Salix soils are also better drained than Blencoe soils.

Salix silty clay loam (0 to 2 percent slopes) (36).—This soil has the profile described as representative for the series. The largest individual areas are 100 to 200 acres in size. Individual areas in the eastern part of the valley are on long, narrow, slightly elevated rises, and they range from 10 to 60 acres in size.

Included in mapping were many areas in narrow drainageways or swales that stay wet longer than this Salix soil.

This soil has no serious limitations to use.

Most areas are cultivated. This soil is used intensively for row crops, and it is well suited to such use. Many farmsteads and other buildings are constructed on this soil. (Capability unit I–2)

Salix silty clay loam, overwash (0 to 2 percent slopes) (865).—The surface layer of this soil is generally very dark grayish-brown, friable light silty clay loam overwash about 6 to 12 inches thick. In a few places it is calcareous. Many areas are at lower elevations than other Salix soils, and some are in swales. Included in mapping were a few areas where the surface layer is silt loam.

Where this soil occurs at lower elevations, water collects and runs off slowly.

Row crops are grown intensively, and the soil is well suited to such use. This soil needs more fertilizer than other Salix soils, and the organic-matter content of the surface layer is lower. (Capability unit I–2)

Sarpy Series

The Sarpy series consists of moderately dark colored, excessively drained, sandy soils that formed in river-deposited sediments. These soils are on the Missouri River flood plains, where the topography is dunelike in places. The slope ranges from 1 to 18 percent.

In a representative profile the plow layer is very dark grayish-brown, loose loamy fine sand about 7 inches thick. It is underlain by pale-brown, calcareous, loose loamy fine sand.

Permeability is very rapid, and the available moisture capacity is low. The organic-matter content is low. The content of available nitrogen and phosphorus is very low, and the content of available potassium is low. The surface layer is neutral to moderately alkaline; the substratum is moderately alkaline and is calcareous. The rooting zone is deep.

Some of the less sloping areas of these soils are cultivated. Other areas are left in pasture or woodland.

Representative profile of Sarpy loamy fine sand, in a cottonwood grove between a paved county road and Interstate Highway 29, SE¼SE¼ sec. 6, T. 87 N., R. 47 W., on an undulating part of the flood plain:

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) loamy fine sand; weak, fine, subangular blocky structure; loose; neutral; clear, smooth boundary.

C1—7 to 24 inches, pale-brown (10YR 6/3) loamy fine sand; weak, coarse, subangular blocky structure and single grain; loose; mildly alkaline; calcareous; gradual, smooth boundary.

C2—24 to 60 inches, pale-brown (10YR 6/3) loamy fine sand and thin strata of fine sandy loam and silt loam; single grain; loose; mildly alkaline; calcareous.

The Ap or A1 horizon is 4 to 8 inches thick, and in most places it is very dark grayish-brown (10YR 3/2) loamy fine sand or fine sandy loam. In severely eroded areas the pale-brown (10YR 6/3) substratum is at the surface. The A horizon is neutral to moderately alkaline and is calcareous.

The C horizon is pale-brown (10YR 6/3) to grayish-brown (2.5Y or 10YR 5/2) loamy fine sand or fine sand. In most places the substratum is distinctly stratified with sand of various sizes. In some places very thin bands of finer textured material are in the substratum. Yellowish-brown, strong-brown, or gray mottles occur in places. The C horizon is moderately alkaline or mildly alkaline and is calcareous.

No other bottom-land soils in the county are as sandy as the Sarpy soils. Sarpy soils are loamy fine sand and fine sand to a depth of 40 inches or more. Nearby excavation indicates that the sand is at least 15 feet thick. The associated Carr soils are sandy loam to a depth of about 3 feet, and the associated Grable soils are silt loam or silty clay loam to a depth of about 2 feet.

Sarpy loamy fine sand, 1 to 5 percent slopes (273B).—This soil has the profile described as representative for the series. In places pale-brown material from the substratum is mixed with plow layer. Most individual areas of this soil are 5 to 20 acres in size.

This soil is very droughty and erodible. Soil blowing, in particular, is a hazard Most of this soil is used for meadow. Areas adjacent to the more strongly sloping Sarpy soil are left in native grasses. There are few trees in some of these places. Where it is associated with soils more suited to crops, this soil is cultivated. (Capability unit IVs–1)

Sarpy loamy fine sand, 5 to 18 percent slopes (237C).—Much of this soil has been eroded by wind, and the substratum is exposed in many places. This soil is on irregular short slopes and knolls or sand dunes. Individual areas range from 5 to 60 acres in size. The largest areas are near the river, where there is little vegetation and much soil blowing and shifting of soil material. Where this soil has been in place long enough, trees and native grasses have formed a cover. In many places, especially in the more gently sloping areas, this native vegetation has been removed.

Included in mapping were some less sandy soils in swales. Some of these included soils are clayey.

This soil is very droughty and erodible. Wind will erode away the surface layer if the soil is bare. Blowouts several feet in diameter occur in places. Areas now cultivated are better suited to meadow. Most areas of this soil are in native grasses, and a few are wooded. (Capability unit VIe–1)

Sarpy fine sandy loam, 0 to 2 percent slopes (238A).—The surface layer of this soil is very dark grayish-brown, friable fine sandy loam about 8 inches thick. In places it is 15 inches thick. Individual areas of this soil generally range from 5 to 20 acres in size.

Included with this soil in mapping were a few areas where the surface layer is finer textured.

Droughtiness and soil blowing are hazards. The surface layer is not so susceptible to soil blowing as that of other Sarpy soils, and it has a slightly higher available moisture capacity.

Some of this soil is cultivated, but more of it is in meadow or native grasses and trees. (Capability unit IVs–1)

Sarpy soils and Alluvial land (0 to 5 percent slopes) (885).—This mapping unit consists of sandy Sarpy soils and of Alluvial land, which is more variable in texture but is sandy in many places. The surface layer of the Sarpy soils is fine sandy loam or loamy fine sand.

This mapping unit is hummocky. Most areas are near the Missouri River, but in many places droughtiness and soil blowing are more serious hazards than flooding. These areas are poorly suited to crops, and they are seldom cultivated. Most areas are in pasture or trees. (Capability unit IVs–1)

Shelby Series

The Shelby series consists of dark colored or moderately dark colored, moderately well drained, loamy soils that formed in glacial till. The slope ranges from 5 to 40 percent.

In a representative profile the surface layer is 11 inches thick. It is black loam in the upper part and very dark grayish-brown light clay loam in the lower part. The subsoil is brown, firm clay loam about 11 inches thick. The substratum is calcareous, yellowish-brown, firm clay loam till.

Permeability is moderately slow, and the available moisture capacity is high. The organic-matter content is medium. The content of available nitrogen is low, of available phosphorus is very low to low, and of available potassium is low to medium. The surface layer is neutral. The rooting zone is deep.

Some Shelby soils that are too steep to cultivate are left in native grasses or trees. Some of the less strongly sloping soils are cultivated.

Representative profile of Shelby loam, from a timbered area of Steinauer-Shelby complex, 25 to 40 percent slopes, moderately eroded, near the northeast corner of SE¼SE¼ sec. 33, T. 89 N., R. 42 W., on an east-facing 35 percent slope:

A1—0 to 6 inches, black (10YR 2/1) loam that has a high content of silt; moderate, very fine and fine, granular structure; friable; common roots; neutral; clear, smooth boundary.

A3—6 to 11 inches, very dark grayish-brown (10YR 3/2) light clay loam that has a high content of silt; some mixing of black (10YR 2/1) peds; weak, fine, subangular blocky structure breaking to weak to moderate, very fine, subangular blocky; friable; common roots; neutral; gradual, smooth boundary.

B2t—11 to 16 inches, very dark grayish-brown (10YR 3/2) clay loam that contains some pebbles, brown (10YR 4/3) when crushed; brown ped interiors; weak, fine, subangular blocky structure breaking to moderate to strong, very fine, subangular blocky and angular blocky; firm; few, thin, discontinuous clay films; few light-gray (10YR 7/1) ped coatings; common roots; slightly acid; gradual, smooth boundary.

B3t—16 to 22 inches, brown (10YR 4/3) clay loam that contains some pebbles; weak, fine and medium, subangular blocky structure; firm; thin, discontinuous clay films; common roots; neutral; clear, smooth boundary.

C—22 to 60 inches, yellowish-brown (10YR 5/4) clay loam that contains some pebbles; massive; firm; thin, discontinuous clay films in the uppermost inch; common roots; moderately alkaline; calcareous.

In uneroded areas the total thickness of the A horizon is about 10 to 18 inches. The color is black (10YR 2/1), very dark brown (10YR 2/2), or very dark grayish brown (10YR 3/2). The severely eroded Shelby soil has a thinner and lighter colored A horizon than that defined as representative of the series. The A horizon is generally loam, but it ranges from clay loam to silt loam in places. It is slightly acid or neutral.

The B horizon is 10 to 20 inches thick, and it is brown (10YR 4/3) or dark yellowish brown (10YR 5/4 or 5/6). In places the upper part of the B2t horizon, or the B1 horizon if present, is dark brown (10YR 3/3). The B2t horizon has very dark grayish-brown ped exteriors. In places few to common strong-brown to gray mottles are in the B3t horizon. The B horizon is generally slightly acid, but it ranges to neutral in the lower part. In some wooded areas the B horizon is slightly more acid and has some grainy ped coatings.

The C horizon is dark yellowish-brown (10YR 4/4) to yellowish-brown (10YR 5/4 or 5/6) clay loam. It contains common sand pockets and lenses, as well as pebbles and glacial boulders. It is mildly alkaline or moderately alkaline and is calcareous. The Shelby soils of Woodbury County are shallower to carbonates than is defined for the series.

Shelby soils are associated with Steinauer soils. They are not calcareous so near the surface as those soils, and they have a brown B horizon, which Steinauer soils lack.

Shelby loam, 5 to 14 percent slopes, moderately eroded (24D2).—The surface layer of this soil is generally very dark grayish-brown loam or gritty silt loam. In some places the original surface layer has been mixed with the browner subsoil by plowing. This soil is generally calcareous at a depth of about 30 or 36 inches.

Most of this soil is on hillsides in the eastern part of the county. In many places it is the most strongly sloping soil in the area. Individual areas are about 5 to 20 acres in size. Where the topography is rolling to hilly, these areas are commonly on ridgetops and shoulders of hillsides. They are surrounded by soils that formed in loess.

Some severely eroded soils were included in mapping. They generally have a surface layer of dark-brown clay loam, and pebbles and glacial stones are on the surface. Small areas of Steinauer soils were also included.

Erosion is a hazard. This soil is suited to row crops if erosion is controlled. The moderately sloping areas are better suited to cultivation than the more strongly sloping areas. Many areas, especially small ones, are left in meadow when the surrounding soils are cultivated. (Capability unit IIIe–3)

Shelby soils, 14 to 24 percent slopes, severely eroded (624F3).—These soils generally have a surface layer of dark-brown, friable loam or clay loam less than 6 inches thick. Stones are on the surface. In a few places the surface layer is very dark grayish-brown loam or silt loam. In places these soils lie just upslope from the steep or very steep Steinauer soils. In other places they are the steepest soils in a hilly topography. Small patches of Steinauer soils were included in mapping.

The hazard of sheet and gully erosion is severe.

Most of these areas are in permanent pasture, but many were formerly cultivated. A few of the less severely eroded areas are in scattered trees and pasture. Some farm operators grow a row crop when pastures need renovation. Although these soils are not suited to cultivation, all but the steepest, most gullied fields can be worked with farm equipment. (Capability unit VIe–1)

Solomon Series

The Solomon series consists of dark-colored, poorly drained to very poorly drained, clayey soils that formed in 3 feet or more of clayey river sediments. These soils are in the Missouri River valley. They are nearly level.

In a representative profile the surface layer is mainly black, calcareous clay and silty clay about 17 inches thick. The subsoil is dark-gray, very firm, calcareous silty clay about 8 inches thick. It is underlain by alternating, thin layers of calcareous, black silty clay and dark-gray to olive-gray silty clay. These are probably the original surface layer of a soil recently buried by clayey sediments.

Permeability is very slow, and the available moisture capacity is medium. The organic-matter content is high. The content of available nitrogen is generally medium to low, of available phosphorus is very low, and of available potassium is medium. The surface layer is mildly alkaline or moderately alkaline and calcareous. The rooting zone is deep, except where root growth is restricted by a high water table.

Solomon soils are generally cultivated. In some years, however, no crop is harvested.

Representative profile of Solomon clay, in a soybean field 2 miles northeast of the town of Luton, 950 feet east and 210 feet south of the northwest corner of SE¼ sec. 9, T. 87 N., R. 46 W., on a level flood plain:

Ap—0 to 6 inches, black (10YR 2/1) clay or silty clay; weak, very fine, subangular blocky structure; firm; mildly alkaline; calcareous; abrupt, smooth boundary.

A12—6 to 10 inches, black (10YR 2/1) silty clay; few, fine, distinct, light-gray (N 6/0) and dark yellowish-brown (10YR 4/4) mottles; weak, very fine, subangular blocky structure; firm; moderately alkaline; calcareous; clear, smooth boundary.

A3—10 to 17 inches, black (10YR 2/1) to very dark gray (10YR 3/1) silty clay; few, fine, distinct, gray (N 5/0) and dark yellowish-brown (10YR 4/4) mottles; moderate, very fine and fine, subangular blocky structure; firm; moderately alkaline; calcareous; gradual, smooth boundary.

Bg—17 to 25 inches, dark-gray (N 4/0) silty clay; common, fine, distinct mottles of dark yellowish brown (10YR 4/4), very dark gray (10YR 3/1), light gray (N 6/0), and light olive brown (2.5Y 5/6); moderate, very fine and fine, subangular blocky structure; very firm; moderately alkaline; calcareous; clear, smooth boundary.

Ab—25 to 34 inches, black (10YR 2/1) silty clay; common, fine, distinct mottles of light gray (N 7/0), dark yellowish brown (10YR 4/4), and light olive brown (2.5Y 5/6); moderate and strong, very fine, subangular blocky structure; firm; moderately alkaline; calcareous; clear, smooth boundary.

Bgb—34 to 45 inches, very dark gray (10YR 3/1) to dark gray (10YR 4/1) silty clay; common, fine, distinct mottles of dark yellowish brown (10YR 4/4), light olive brown (2.5Y 5/6), and light gray (N 7/0); moderate and strong, very fine, subangular blocky structure; very firm; moderately alkaline; calcareous; gradual, smooth boundary.

Cg—45 to 55 inches, olive-gray (5Y 5/2) silty clay; mottled; massive; very firm; moderately alkaline; calcareous; clear, smooth boundary.

Ab2—55 to 65 inches, very dark gray (10YR 3/1) silty clay; very firm; moderately alkaline; calcareous.

The thickness of the A horizon is 10 to 25 inches in most places. In some places the A3 horizon is lacking. The Ap, A1, and A3 horizons are silty clay or clay and are mildly alkaline or moderately alkaline. They are black (10YR 2/1 or N 2/0) to very dark gray (10YR 3/1 or N 3/0) and contain snail shells and lime concretions in many places.

The Bg and Bgb horizons are very dark gray (N 3/0 to 10YR 3/1) to dark gray (N 4/0 or 10YR 4/1) clay or silty clay. The Ab horizon is generally 10 to 15 inches thick. It occurs in most profiles. The C horizon is dark-gray (N 4/0 or 10YR 4/1) to olive-gray (5Y 5/2) silty clay or clay. The B and C horizons have common to many mottles that range from dark yellowish brown to light gray. These horizons are mildly alkaline or moderately alkaline, and they are calcareous.

Solomon soils are associated with Luton, Napa, Calco, and Holly Springs soils. They are like the Luton and Napa soils in texture. Solomon soils are high in content of lime, but low in sodium. Luton soils are low in both, and Napa soils are high in content of sodium (alkali). Solomon soils have more clay throughout than Calco soils and more clay to a depth of 2 or 2½ feet than Holly Springs soils.

Solomon clay (0 to 1 percent slopes) (466).—This soil has the profile described as representative for the series, but the buried, dark-colored layers in the subsoil are lacking in places. This soil is on broad bottom lands at low elevations. A number of smaller areas of this soil are included in the areas mapped as Luton soils.

Wetness is a severe limitation (fig. 11). This soil is used intensively for row crops where artificially drained. Even if the soil is drained, farming operations are delayed in many years. The surface layer clods easily, and weeds are hard to control. In some years harvesting must be delayed until the ground freezes. (Capability unit IIIw-1)

Solomon-Luton silt loams, calcareous overwash (0 to 1 percent slopes) (897).—This complex is along the eastern edge of the Missouri River valley. Most individual areas are a few hundred feet wide and a quarter mile to a mile long, paralleling a stream or large drainage ditch.

The surface layer, which is 6 to 15 inches thick, is very dark grayish-brown, friable, calcareous silt loam. The underlying layers are like those described as representative for the Luton and Solomon series.

Figure 11.—**Weedy corn in a field of wet Solomon and Luton soils. The dragline in the background is being used to clean a drainage ditch.**

Included in mapping were areas where the silt loam overwash is up to 3 feet thick. These small areas have good tilth and are not so wet as most of the Solomon and Luton soils.

Wetness is a major hazard. The soils have a high water table and are subject to some flooding. Where drainage is adequate, row crops are grown intensively, and the soils are suited to such use. In years of above average rainfall, crops cannot be cultivated or harvested. Because of the silt loam overwash, these soils are easier to till than others in the Luton and Solomon series. Seedbeds are less difficult to prepare, even where these soils are worked when wet. (Capability unit IIIw–1)

Spillville Series

The Spillville series consists of dark-colored, moderately well drained to somewhat poorly drained, loamy soils that formed in sediments deposited by streams. These soils are at low elevations near the streams. They are nearly level.

In a representative profile the surface layer is black and very dark brown, very friable loam about 40 inches thick. It is underlain by very dark grayish-brown loam.

Permeability is moderate, and the available moisture capacity is high. The organic-matter content generally is high. The content of available nitrogen is low to medium, and the content of available phosphorus and potassium is medium. The surface layer is neutral. The rooting zone is deep.

Because these soils are subject to flooding, most areas are used for permanent pasture. A small acreage is cultivated.

Representative profile of Spillville loam, frequently flooded, in a bluegrass pasture about 2 miles southeast of Pierson, 125 feet south of bridge in east creek bank near the northeast corner of NW¼NE¼ sec. 20, T. 89 N., R. 42 W., on a level flood plain:

A11—0 to 28 inches, black to very dark brown (10YR 2/1 to 2/2) loam that contains a few pebbles; moderate to strong, very fine and fine, granular structure; very friable; sand and gravel are more abundant at a depth of 17 to 28 inches; neutral; gradual, smooth boundary.

A12—28 to 40 inches, very dark brown (10YR 2/2) loam; moderate, fine, granular structure; very friable; neutral; gradual, smooth boundary.

AC—40 to 54 inches, very dark grayish-brown (10YR 3/2) loam; weak, fine, subangular blocky structure; very friable; neutral; diffuse, smooth boundary.

C—54 to 60 inches, very dark grayish-brown (10YR 3/2) loam that contains coarse sand and pebbles; massive; very friable; neutral.

The A1 horizon is 30 to 40 inches thick. It is generally loam, but in places it is silt loam that has a high content of sand. Reaction is generally neutral or mildly alkaline, but in a few places it is slightly acid. All horizon boundaries are gradual or diffuse. The AC horizon is lacking in some places.

The C horizon generally has a higher content of sand and gravel than the surface layer. In places coarse sand or gravel is at a depth of 8 to 10 feet. In places the C horizon is very dark gray (10YR 3/1) to grayish brown (2.5Y 4/2). It is neutral to a depth of 60 inches or more.

Spillville soils are similar to Terril soils in texture. They generally have a thicker A1 horizon and lack the brownish B horizon of Terril soils.

Spillville loam, frequently flooded (0 to 2 percent slopes) (958).—This soil occurs mainly on the low bottom lands that border both sides of stream channels. The largest individual areas extend for a mile or more. In the Little Sioux River valley, some of the areas are small, elongated patches surrounded by more clayey soils. Remnants of shallow stream channels are present in some areas. In places the surface layer is overlain by a few inches of brownish overwash.

The hazard of flooding is severe on most areas of this soil. Most of the acreage is used for pasture. If protected from flooding, this soil is suited to cultivation and it is used intensively for row crops. A few places are row cropped even though they are frequently flooded. (Capability unit Vw–1)

Steinauer Series

The Steinauer series consists of light-colored, well-drained, loamy soils that formed in glacial till. These soils are on rounded hillsides. The slope ranges from 5 to 40 percent.

In a representative profile the surface layer is mixed, very dark gray and pale-brown, calcareous clay loam about 4 inches thick. The underlying material is mainly yellowish-brown, firm, calcareous clay loam. It contains a few stones and pebbles.

Permeability is moderately slow, and the available moisture capacity is high. The organic-matter content is generally low. The content of available nitrogen and phosphorus is very low, and the content of available potassium is medium. These soils are moderately alkaline and calcareous. The rooting zone is deep.

The less strongly sloping soils are cultivated, but most of these soils are used for permanent pasture. A few areas are wooded.

Representative profile of Steinauer clay loam, in a wooded pasture about 4 miles south of Anthon, about 400 feet north and 600 feet west of the southeast corner of SW¼SW¼ sec. 20, T. 87 N., R. 43 W., on a convex west-facing 35 percent slope:

Ap—0 to 4 inches, a mixture of 60 percent very dark gray (10YR 3/1) and 40 percent pale-brown (10YR 6/3) light clay loam, grayish brown (10YR 5/2) when crushed; weak, fine and medium, subangular blocky structure breaking to moderate, very fine, subangular blocky; friable; accumulation of cobblestones on the surface; moderately alkaline; calcareous; clear, smooth boundary.

C1—4 to 12 inches, light yellowish-brown (10YR 6/4) light clay loam that contains some pebbles; about 15 percent of the peds coated with very dark gray (10YR 3/1); weak, fine and medium, subangular blocky structure breaking to moderate, very fine, subangular blocky; friable; moderately alkaline; calcareous; gradual, smooth boundary.

C2—12 to 60 inches, yellowish-brown (10YR 5/4) light clay loam that contains some pebbles; common, fine, prominent, strong-brown (7.5YR 5/6) mottles; very weak, fine and medium, subangular blocky structure to massive; firm; white calcium carbonate concretions and streaks; moderately alkaline; calcareous.

In the least eroded areas, the Ap or A1 horizon is very dark gray (10YR 3/1), very dark brown (10YR 2/2), or very dark grayish brown (10YR 3/2), and is 4 to 8 inches thick. In severely eroded areas the surface layer is dark brown to brown or yellowish brown with only traces of the darker material remaining. The texture is generally clay loam, but in places it is loam. The A and C horizons contain pebbles and stones. The Ap horizon is neutral in some places.

The C horizon is generally yellowish brown (10YR 5/4 or 5/6), pale brown (10YR 6/3), or light yellowish brown (10YR 6/4). In places it is grayish brown (10YR 5/2) or light grayish brown (10YR or 2.5Y 6/2). Part of the substratum has strong-brown or grayish-brown mottles. Pockets or lenses of sand occur in places.

Steinauer soils and the associated Shelby soils are the only soils in the county that formed in glacial till. Steinauer soils are calcareous throughout, and they lack the distinct, well-developed B horizon of Shelby soils.

Steinauer clay loam, 5 to 14 percent slopes, eroded (33D2).—The surface layer of this soil is very dark grayish-brown, friable light clay loam 4 to 7 inches thick. When this soil is cultivated, some of the yellowish-brown substratum material is mixed with the plow layer. Most of this soil is on rounded ridgetops or on the upper parts of hillsides near the ridgetops. Individual areas are up to 10 acres in size.

Included in mapping were areas where the plow layer is mainly brown or yellowish brown. In a few places the surface layer is neutral.

Many of the road cuts between the towns of Oto, Danbury, Correctionville, and Anthon show glacial till highs covered by differing thicknesses of loess. This is similar to the way small patches of Steinauer soil crop out in fields of loessal soils. Some of the highs in the road cuts are capped by a reddish, clayey soil. Small strips of reddish soil were included in mapping.

This soil is subject to sheet and rill erosion. Some areas are cultivated; some are in pasture. Moderately sloping areas are better suited to row crops than those that are strongly sloping. Stones interfere with tillage in places. Where this soil is associated with steeper Steinauer soils, it is generally left in pasture. (Capability unit IIIe–3)

Steinauer clay loam, 14 to 18 percent slopes, moderately eroded (33E2).—In most places the surface layer of this soil is very dark grayish-brown, friable light clay loam 4 to 7 inches thick. Where it is still in native grass or trees, the surface layer is 6 or 8 inches thick. Where it has been cultivated, some yellowish-brown material has been mixed into the plow layer. The surface layer is neutral to moderately alkaline.

Most of this soil is on hillsides. It is generally downslope from less strongly sloping silt loams that formed in loess. Individual areas are 5 to 30 acres in size. Almost half of the acreage included in mapping is severely eroded, and in these areas the surface layer is brown to yellowish brown.

This soil is subject to sheet, rill, and gully erosion. Most of it is used for pasture, and some areas are partly wooded. When pastures are renovated, a row crop can be grown. Farm equipment can be used safely on this soil. (Capability unit IVe–1)

Steinauer clay loam, 18 to 25 percent slopes, moderately eroded (33F2).—In about half the acreage, this soil has a surface layer about like that of the profile described as representative for the series. Most of the rest of this soil is severely eroded and has a brown to yellowish-brown surface layer. In a few areas where there are stands of native trees, the surface layer is very dark grayish brown and about 6 to 8 inches thick. Almost all of this soil is on hillsides on hilly and steep topography. Individual areas are about 5 to 30 acres in size.

The hazard of erosion is severe. Where plant cover is sparse, this soil is subject to sheet, rill, and gully erosion.

Most of this soil is used for pasture or is wooded. The trees have little commercial value. (Capability unit VIe–1)

Steinauer-Shelby complex, 25 to 40 percent slopes, moderately eroded (35G2).—This complex is made up of about 60 to 80 percent Steinauer soils on rounded hillsides and 20 to 40 percent Shelby soils in cove positions around hillside drainageways and on the higher parts of hillsides. These soils have a loam or clay loam surface layer.

These soils are subject to severe erosion, and about a quarter of the acreage is severely eroded. Sheet, rill, and gully erosion are common where the plant cover is sparse.

Almost all of this complex is in trees or grass. Through the years, overgrazing has resulted in poor stands of grass in many places. Grazing needs to be controlled because stands of grass cannot be reestablished by the usual methods. Fenceposts and firewood are the main products. (Capability unit VIIe–1)

Terril Series

The Terril series consists of dark-colored, moderately well drained, loamy soils that formed in materials washed down from adjacent sloping soils. These soils are on foot slopes that form the edges of valleys. The slope ranges from 2 to 20 percent.

In a representative profile the surface layer is friable, granular loam about 28 inches thick. It is mainly black, but it is very dark grayish brown in the lower part. The subsoil is friable loam about 15 inches thick. It is dark brown in the upper part and brown in the lower part. The substratum is brown, friable clay loam to a depth of 60 inches.

Permeability is moderate, and the available moisture capacity is high. The organic-matter content is high. The content of available nitrogen is generally medium to low, of available phosphorus is low, and of available potassium is medium. The surface layer is slightly acid or medium acid. The rooting zone is deep.

Most areas of these soils are cultivated.

Representative profile of Terril loam, from an area of Terril and Castana soils, 10 to 20 percent slopes, in a cultivated field about 5 miles north of Correctionville, NW¼SE¼ sec. 1, T. 89 N., R. 42 W., on an east-facing 10 percent slope:

Ap—0 to 4 inches, black (10YR 2/1) loam, very dark brown (10YR 2/2) when crushed; weak fine, granular structure; friable; medium acid; abrupt, smooth boundary.

A12—4 to 11 inches, black (10YR 2/1) loam, very dark brown (10YR 2/2) when crushed; weak, coarse, subangular blocky structure breaking to moderate, fine, granular; friable; slightly acid; gradual, smooth boundary.

A13—11 to 18 inches, black (10YR 2/1) loam, very dark grayish brown (10YR 3/2) when crushed; weak to moderate, very fine, subangular blocky structure and moderate, fine, granular; friable; slightly acid; gradual, smooth boundary.

A3—18 to 28 inches, very dark grayish-brown (10YR 3/2) loam, dark brown (10YR 3/3) when crushed; weak to moderate, very fine, subangular blocky structure; friable; almost continuous, very dark gray (10YR 3/1) organic coatings; neutral; gradual, smooth boundary.

B1—28 to 34 inches, dark-brown (10YR 3/3) loam; 50 percent of peds have very dark grayish-brown (10YR 3/2) organic coatings; weak, very fine, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

B2—34 to 43 inches, brown (10YR 4/3) loam; 25 percent of peds have very dark grayish-brown (10YR 3/2) organic coatings; weak, very fine, subangular blocky structure; friable; this horizon has more gravel and coarse sand and is firmer than the overlying horizons; neutral; gradual, smooth boundary.

C—43 to 60 inches, brown (10YR 4/3) clay loam; no large pebbles; friable; neutral.

The Ap and A1 horizons are black (10YR 2/1) or very dark brown (10YR 2/2). In a few places there is a very dark grayish-brown (10YR 3/2) overwash, a few inches thick, and in places the lower part of the A1 horizon crushes to very dark grayish brown. The thickness of the A horizon is 24 to 36 inches. The Ap and A1 horizons are loam to light clay loam, and they range from medium acid to neutral.

The B horizon is generally loam, but ranges to light clay loam. Reaction is slightly acid to neutral. In places the B1 horizon is very dark grayish brown (10YR 3/2). Very dark grayish-brown (10YR 3/2) organic coatings are in the B2 horizon in places. In places there are faint mottles in the lower part of the B2 horizon and in the C horizon.

Terril soils are similar in texture to Spillville soils. They differ in that the Terril soils have a brownish B horizon.

Terril loam, 2 to 6 percent slopes (27B).—This soil has a thicker black and very dark brown surface layer than other Terril soils, and the brownish color typical of the Terril subsoil is at a greater depth and not so apparent as in the more sloping Terril soil. This soil is on foot slopes adjacent to the nearly level soils on first or second bottoms. Individual areas are small in size. In places a less well-drained soil was included in mapping.

Runoff from soils upslope drains across this soil and causes rills and gullies to form. Siltation is a hazard in places.

This soil is suited to intensive use for row crops if erosion and runoff are controlled. (Capability unit IIe-1)

Terril loam, 6 to 10 percent slopes (27C).—This soil has the profile described as representative for the series. Almost all the areas are on foot slopes that form the edge of the Little Sioux River valley or are at the confluence of tributary valleys.

Small areas were included where the slope is 2 to 6 percent or 10 to 15 percent.

Runoff from soils upslope drains across this soil and causes rills and gullies to form. This soil is suited to row crops if erosion is controlled. Small areas are managed along with the associated soils and are used for pasture. (Capability unit IIIe-1)

Terril and Castana soils, 10 to 20 percent slopes (888E).—These soils are in the steepest parts of the county. They formed in material, partly glacial till and partly loess, eroded from steep hillsides. The Terril soil makes up more than 50 percent of most areas. The surface layer is loam in the Terril soils and silt loam in the Castana soils.

Rill and gully erosion and siltation are hazards. These soils are cultivated in areas where runoff and sedimentation from upslope soils are controlled. Most areas are managed along with the associated steep and very steep soils on hillsides. They are used for pasture. (Capability unit IVe-1)

Wadena Series

The Wadena series consists of dark-colored, well-drained soils that formed in about 24 to 40 inches of silty and loamy sediments over gravel and coarse sand. Most of these soils are on high benches. The slope ranges from 0 to 9 percent.

In a representative profile the surface layer is very dark brown silt loam and light silty clay loam about 9 inches thick. The subsoil is brown, friable light clay loam about 17 inches thick. It is underlain by dark yellowish-brown, calcareous sand and gravel.

Permeability is moderate in the upper part and very rapid in the sand and gravel. The available moisture capacity is medium to high, depending on the depth to sand and gravel. The organic-matter content is medium. The content of available nitrogen and phosphorus is low, and the content of available potassium is medium. The surface layer is medium acid. The rooting zone is restricted by the underlying sand or gravel.

Most of these soils are cultivated. The choice of crops is influenced somewhat by the supply of moisture in the soil at planting time. A number of gravel pits have been dug in these soils.

Representative profile of Wadena silt loam, moderately deep, in a cornfield half a mile east of Correctionville, 500 feet west and 420 feet south of the northeast corner of SW¼ sec. 35, T. 89 N., R. 42 W., on a north-facing 5 percent slope:

Ap—0 to 6 inches, very dark brown (10YR 2/2) heavy silt loam; weak, fine and medium, subangular blocky structure breaking to moderate, fine, granular; friable; medium acid; abrupt, smooth boundary.

A1—6 to 9 inches, very dark brown (10YR 2/2) light silty clay loam; moderate vertical cleavage breaking to weak, fine and medium, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

B21—9 to 15 inches, brown (10YR 4/3) tending to dark-brown (10YR 3/3) light silty clay loam or clay loam; weak, fine, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

B22—15 to 26 inches, brown (10YR 4/3) light clay loam; weak, very fine and fine, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

IIC—26 to 60 inches, dark yellowish-brown (10YR 4/4) gravel and sand; pebbles up to 6 inches in diameter in places; neutral to a depth of 22 to 26 inches; moderately alkaline and calcareous below.

In most places the thickness of the A horizon is 8 to 14 inches, but it is as much as 20 inches in some areas. The Ap and A1 horizons are generally very dark brown (10YR 2/2), but they range to very dark grayish brown (10YR 3/2). They are generally slightly acid or neutral, but in places the Ap and A1 horizons are medium acid.

The B horizon is predominantly light clay loam or loam, but the upper part is gritty silty clay loam in places. The colors range from dark brown or brown (10YR 4/3) to dark yellowish brown (10YR 4/4). In most places there are some pebbles in the subsoil. In some places a leached B3 horizon extends a few inches into the gravelly material. In many places there is a layer of sandy loam or sandy clay loam above the gravel. Mottles, where present, are few and faint. Reaction is slightly acid or neutral. The B horizon extends to a depth of 24 to 40 inches.

The IIC horizon is typically sand and gravel, but in places it is sand and in places there are many boulders. It is mildly alkaline or moderately alkaline and calcareous, except in a few places where the uppermost few inches is leached and neutral. In Wadena loam, moderately deep, 5 to 9 percent slopes, moderately eroded, depth to sand and gravel is less than the defined range for the series. In Wadena silt loam, deep, 0 to 2 percent slopes, depth to sand and gravel is greater than the defined range for the series.

Wadena soils are associated with Salida soils. They differ in that the Wadena soils have 24 to 40 inches or more of loamy and silty material over the gravel.

Wadena loam, moderately deep, 2 to 5 percent slopes (108B).—The surface layer is very dark brown, friable loam 9 to 12 inches thick. In most places the brownish subsoil is underlain by sand and gravel at a depth of 24 to 30 inches. This soil occupies elongated ridges or gently sloping breaks of high benches that drop from a higher to a lower elevation within a short distance. Most individual areas are long and narrow and about 5 to 20 acres in size.

Included in mapping were a few places where brownish subsoil material is mixed into the plow layer. There were also a few spots where the gravel is within about a foot of the surface.

This soil is subject to erosion and droughtiness. It is suited to cultivation if erosion is controlled, and it is used intensively for row crops. (Capability unit IIe–2)

Wadena loam, moderately deep, 5 to 9 percent slopes, moderately eroded (108C2).—In most places this soil has some brown subsoil material mixed with the darker colored plow layer. The plow layer is very dark grayish-brown, friable loam. The subsoil is underlain by gravel at a depth of about 20 to 24 inches in most places. Almost all areas of this soil are long and narrow, because they are on short, sloping breaks of high benches that drop from one elevation to another. Individual areas are generally small. Included in mapping were spots of soil that is shallow to gravel and a few sites where boulders are on the surface.

This soil is erodible and droughty. Most areas are cultivated, and this is a suitable use if runoff is controlled. (Capability unit IIIe–2)

Wadena silt loam, moderately deep, 0 to 2 percent slopes (708A).—The surface layer of this soil is very dark brown, friable silt loam about 9 to 14 inches thick. The brownish subsoil is silty in the upper part, but it grades to friable clay loam with increasing depth. Sand and gravel is at a depth of 24 to 30 inches in most places. This soil is on the nearly level part of high benches. Individual areas are up to about 40 acres in size.

Included in mapping were a few spots where gravel is within about a foot of the surface. In these places the surface layer is loam.

This soil is somewhat droughty in years of average and below-average rainfall. It is suited to cultivation when moisture is adequate, and it is used intensively for row crops. (Capability unit IIs–1)

Wadena silt loam, moderately deep, 2 to 5 percent slopes (708B).—This soil has the profile described as representative for the series. It is on gently sloping breaks of high benches that drop from one elevation to another within a short distance. Most areas are 10 to 15 acres in size and are long and narrow.

Included in mapping were a number of spots where plowing has brought subsoil material into the surface layer. Also included were places where the gravel is within about a foot of the surface.

This soil is both erodible and droughty. Row crops are grown intensively, and the soil is suited to cultivation if erosion is controlled. (Capability unit IIe–2)

Wadena silt loam, deep, 0 to 2 percent slopes (709A).—The surface layer of this soil is very dark brown, friable silt loam about 20 inches thick. The brownish subsoil is silty clay loam and silt loam in the upper part and is underlain by sand and gravel at a depth of 42 to 48 inches. Most individual areas are 20 acres or more in size.

Included in mapping were some areas where the underlying gravel is at a depth of as much as 5 feet. Also included were a few spots where gravel is within 1 or 2 feet of the surface.

This soil needs to be protected from excess water and sediments from the hills. There is generally a road at the base of these hills, and runoff water can be drained into the road ditch and carried to the river in a straight ditch dug along the field boundary.

Row crops are grown intensively, and the soil is well suited to such use. (Capability unit I–3)

Wadena silt loam, deep, 2 to 5 percent slopes (709B).—The surface layer of this soil is generally about 10 inches thick. It is very dark brown or very dark grayish-brown, friable silt loam. The brownish subsoil is silty clay loam and silt loam in the upper part and is underlain by gravel and sand, generally at a depth of 36 to 42 inches. In some places the gravel and sand are at a depth of 30 inches. This soil is on gently sloping breaks of high benches. The areas are long and narrow in shape and small in size.

This soil is subject to erosion. Most areas are cultivated and are suited to intensive use for row crops if erosion is controlled. (Capability unit IIe–2)

Waubonsie Series

The Waubonsie series consists of stratified, moderately well drained to somewhat poorly drained, loamy soils. These soils formed in river-deposited sediments that consist of 2 feet of loam overlying clay. These soils are light colored, except for the thin, moderately dark colored surface layer. They are on slightly elevated rises in the Missouri River valley. These soils are nearly level.

In a representative profile the surface layer is calcareous, very dark grayish-brown fine sandy loam about 7 inches thick. It is underlain by stratified sediments about 20 inches thick that are dominantly calcareous, dark grayish-brown, very friable fine sandy loam. Below this, to a depth of 60 inches, is stratified, calcareous, very firm clay. These strata are very dark grayish brown, light gray, black, and dark grayish brown.

Permeability is moderately rapid in the upper part of the profile but very slow in the underlying clay. The available moisture capacity generally is medium. The organic-matter content is low. The content of available nitrogen and phosphorus is very low, and the content of available potassium is high. These soils are moderately alkaline and calcareous throughout. Roots generally penetrate the clay. There is some restriction to root growth, however, and roots tend to bunch above the clay, especially during a wet spring.

Representative profile of Waubonsie fine sandy loam, in a cornfield, 775 feet north and 400 feet west of the southeast corner of sec. 5, T. 87 N., R. 47 W., on a slight rise on a nearly level flood plain:

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) fine sandy loam; common yellowish-brown (10YR 5/4) mottles; moderate, coarse, angular blocky structure breaking to moderate, fine, subangular blocky and moderate, very fine to fine, granular structure; very friable; moderately alkaline; calcareous; clear, smooth boundary.

C1—7 to 27 inches, stratified, dark grayish-brown (10YR 4/2) to brown (10YR 5/3) fine sandy loam grading to gray (10YR 5/1) and grayish-brown (10YR 5/2) silt loam at a depth of 21 to 27 inches; few, fine, distinct, black (10YR 2/1) mottles or concretions at a depth of 7 to 12 inches; common, fine, distinct, dark-red (2.5YR 3/6) mottles at a depth of 12 to 27 inches, and yellowish-brown (10YR 5/6) mottles at a depth of 21 to 27 inches; weak, coarse, subangular blocky structure breaking to weak, fine to medium, subangular blocky and moderate, fine, granular structure; very friable; moderately alkaline; calcareous; clear, smooth boundary.

IIC2—27 to 33 inches, very dark grayish-brown (2.5Y 3/2) clay; many, fine, prominent, red (10YR 4/8) mottles and common, fine, prominent, black (10YR 2/1) mottles; strong, very fine, subangular blocky structure; firm; moderately alkaline; calcareous; clear, smooth boundary.

IIC3—33 to 60 inches, stratified, light-gray (10YR 6/1), black (10YR 2/1), and dark grayish-brown (10YR 4/2) clay that has a silty clay loam stratum at a depth of 33 to 38 inches; many, fine, distinct, brown (7.5YR 4/4) mottles and many, fine, prominent, red (2.5YR 4/8 to 10R 4/8) mottles; massive; friable; bedding planes are visible; mildly alkaline; calcareous.

The Ap horizon is about 6 to 10 inches thick. In places the C1 horizon is mainly grayish brown (10YR or 2.5Y 5/2). It has strata of silt loam, loam, or loamy sand. Mottles range from dark red to brownish yellow in color.

The IIC horizons are clay or silty clay, except where thin layers of coarser material are interbedded with the clay. In places the clayey substratum contains dark layers (Ab horizons) that represent older soils buried by recent sediments. The depth to the IIC horizon is generally 15 to 30 inches. Reaction ranges from mildly alkaline to moderately alkaline. Most of the clayey substratum is calcareous.

Waubonsie soils are associated with Modale, Moville, and Carr soils. They resemble Modale and Moville soils, except that they are coarser textured in the uppermost 15 to 30 inches. Waubonsie soils differ from Carr soils in being underlain by a clayey layer at a depth of about 2 feet.

Waubonsie fine sandy loam (0 to 2 percent slopes) (49).—This soil occurs as elongated areas that are slightly higher in elevation than the surrounding soil. Most individual areas are 10 to 40 acres in size.

A number of narrow, shallow swales finger through this soil in a veinlike network, and almost all contain soils that are less sandy than the Waubonsie soil. Because of the size of the swales, they were included in mapping. Also included were some areas where more than 30 inches of sandy loam overlies the clay.

This Waubonsie soil is slightly droughty and is subject to soil blowing. In wet seasons there is a perched water table above the clay substratum. This restricts growth and makes the crop more susceptible to drought later in the season.

This soil is well suited to cultivation, and it is used intensively for row crops. A few areas adjacent to the river channel are wooded. These areas are suited to crops if they are cleared. (Capability unit IIs–1)

Woodbury Series

The Woodbury series consists of dark-colored, poorly drained, clayey soils that formed in river-deposited sediments in the Missouri River valley. These soils are underlain by slightly less clayey material at a depth of 2 or 3 feet. They are nearly level.

In a representative profile the surface layer is black and very dark gray, firm silty clay about 2 feet thick. The subsoil extends to a depth of about 42 inches. It is mottled, dark grayish-brown, firm light silty clay or heavy silty clay loam in the upper part and dark grayish-brown to olive-brown, friable silty clay loam in the lower part. The underlying material is mottled, olive-brown, very friable silt loam.

Permeability is very slow in the upper part of the profile and moderately slow in the silty clay loam part of the subsoil. The available moisture capacity is high. The organic-matter content is high. The content of available nitrogen is generally medium to low, of available phosphorus is very low, and of available potassium is high. The surface layer is slightly acid or neutral. The rooting zone is deep, except in wet seasons when the water table is within 2 or 3 feet of the surface.

Most of the acreage is cultivated.

Representative profile of Woodbury silty clay, in a soybean field, 700 feet east and 1,270 feet north of the southwest corner of NE¼ sec. 17, T. 86 N., R. 46 W., on a level flood plain:

Ap—0 to 10 inches, black (10YR 2/1) silty clay; moderate, very fine and fine, angular blocky structure; firm; slightly acid; abrupt, smooth boundary.

A12—10 to 16 inches, black (10YR 2/1) silty clay; moderate, fine, subangular blocky structure; firm; neutral; gradual, smooth boundary.

A3—16 to 24 inches, very dark gray (10YR 3/1) silty clay; strong, medium and fine, subangular blocky structure; firm; common oxides; soft concretions of lime; neutral; gradual, smooth boundary.

B2g—24 to 36 inches, dark grayish-brown (2.5Y 4/2) light silty clay or heavy silty clay loam tending to very dark grayish brown (2.5Y 3/2); common, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; strong, fine and medium, subangular blocky structure; some lime concretions and oxides; mildly alkaline; noncalcareous; gradual, smooth boundary.

B3g—36 to 42 inches, dark grayish-brown (2.5Y 4/2) to olive-brown (2.5Y 4/4) silty clay loam; common, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; weak, medium, subangular blocky structure; friable; some lime concretions and oxides; neutral; clear, smooth boundary.

C—42 to 60 inches, mottled, olive-brown (2.5Y 4/4) silt loam; massive; very friable; moderately alkaline; calcareous.

The thickness of the A horizon is 16 to 24 inches. The A horizon is black (10YR 2/1) or very dark gray (10YR 3/1). Reaction is slightly acid to neutral.

The B2g horizon ranges from dark grayish brown (2.5Y 4/2) to grayish brown (2.5Y 5/2) and is mottled with dark yellowish brown, yellowish brown, or olive brown. In places ped exteriors or matrix colors are very dark gray (N 3/0 or 10YR 3/1) or very dark grayish brown (2.5Y 3/2), especially in the upper part. The B2g and B3g horizons are neutral to mildly alkaline, but they are not calcareous. The B3g horizon ranges from dark grayish brown (2.5Y 4/2) to olive gray (5Y 5/2) and light olive brown (2.5Y 5/4).

The C horizon ranges from olive brown (2.5Y 4/4) to olive gray (5Y 5/2) in color and from silt loam to silty clay loam in texture. This horizon begins at a depth of 30 to 48 inches. Mottles, if present, are similar to those in the subsoil Reaction is mildly alkaline to moderately alkaline.

Woodbury soils are associated on bottom lands with Blencoe, Lakeport, and Luton soils. They are more poorly drained than Blencoe soils and have more clay in the subsoil. Woodbury soils differ from Luton soils in that the lower part of the subsoil is silty clay loam. They are more clayey in the uppermost 30 inches than Lakeport soils.

Woodbury silty clay (0 to 1 percent slopes) (67).—Individual areas of this soil are on very slightly elevated rises within the Missouri River valley. The largest areas are about 500 feet wide and a mile long, but most areas are between 5 and 80 acres in size.

This soil is adjacent to areas of more poorly drained Luton soils and to the better drained Blencoe soils on the highest parts of rises. Small areas of both soils were included in mapping.

Wetness is a hazard on this soil, but the hazard is less severe than on other poorly drained soils in the valley.

This soil is suited to row crops if drainage is adequate. In some years crops drown out and replanting is necessary. Field operations are delayed in wet seasons. This soil dries out slowly and puddles easily if worked when wet. (Capability unit IIIw–1)

Use and Management of the Soils

This section describes the system of capability classification used by the Soil Conservation Service and discusses the use and management of groups of soils, or capability units. It also has a table showing the predicted yields per acre of the major crops grown in the county. A section on wildlife is included, as well as a section on engineering uses of the soils.

Use of the Soils for Crops and Pasture

About 57 percent of Woodbury County, or 316,000 acres, is used for crops. About 17 percent, or 96,000 acres, is used for pasture, including much of the county's 25,000 acres of woodland.

The main crops are corn, soybeans, oats, and hay consisting of legumes and a mixture of legumes and grass. Wheat, popcorn, and sorghum occupy smaller acreages. Where the slope is more than 20 percent, the soils generally are used for pasture.

Pastures on Hamburg soils and the steeper Ida soils generally consist of native grasses, such as big bluestem, little bluestem, and side-oats grama. On many slopes where farm machinery can be used, however, the native vegetation has been replaced by bromegrass, alfalfa, and other introduced plants.

Many soils in the county are subject to erosion. Overall, the erosion hazard is most severe on the Ida, Hamburg, and Monona soils of associations 4 and 5. Ida and Hamburg soils, in particular, erode readily because runoff is rapid on their steep, convex slopes. Gently sloping to steep soils of the Chute, Castana, Galva, Judson, Salida, Shelby, Steinauer, and Terril series are also susceptible to erosion. Gullying is a serious hazard. Some gullies in the valleys of associations 4 and 5 are as much as 40 or 50 feet in depth and width. They are generally in areas of McPaul, Kennebec, Napier, or Castana soils. They have vertical sides, and unless control measures are applied, they work upstream rapidly (5). In places large amounts of silty material have washed onto lower lying soils and cause limitations in managing these soils.

In many places a watershed approach has been used to control erosion. Dams and other erosion control structures have been built across streams or gullies. Erosion is also controlled by contour tillage, use of terraces and diversions, and other on-the-land practices, such as minimum tillage. Grassed waterways are used to control gullying in watercourses where the amount of water and the slope are not too great.

Flooding is a hazard on some of the soils of the county, notably those of the Colo, Calco, Kennebec, and Spillville series. In places streams have been straightened or levees built to alleviate the hazard. In the past, flooding of the Missouri River bottoms was a serious hazard, but major flood-control measures have largely alleviated this hazard.

Tile drainage and surface drainage are used to some extent in the county. The largest area of soils that have poor natural drainage is in the Missouri River valley. These soils are those of the Albaton, Luton, Solomon, Blend, and Blencoe series. Surface drainage is used almost exclusively on these soils because the clayey texture and high water table make tile drainage impractical or inefficient.

An elaborate system of ditches has been built in the eastern part of the valley. These ditches parallel the roads and drain excess water to the east and south into large ditches and eventually into the Missouri River. The western part of the valley does not have so complete a network, but the same pattern is followed. Major ditches follow the natural swales south and eventually flow into the Missouri River; the intermediate ditches are parallel to the road. Excess water is drained off the fields by shallow field ditches.

Tile drains are used to reduce wetness in Colo soils, the Colo-Judson complex, and, in some places, Corley and other soils.

Most of the irrigated farms are in the Missouri River valley. Irrigation is a supplement to natural moisture supplies, but it is not a common practice in the county. The fields that have been graded and smoothed for drainage are well suited to furrow irrigation.

Capability Grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The groups are made according to the limitations of the soils when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range, for forest trees, or for engineering uses.

In the capability system, all kinds of soils are grouped at three levels: the capability class, subclass, and unit. These are discussed in the following paragraphs.

Capability Classes, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I soils have few limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife habitat.

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife habitat.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife habitat.

Class VIII soils and landforms have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife habitat, or water supply, or to esthetic purposes. (There are no class VIII soils in Woodbury County)

Capability Subclasses are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in some parts of the United States but not in Iowa, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife habitat, or recreation.

Capability Units are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe–2 or IIIe–3. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass. The soil series represented in each capability unit are named, but not all the soils in each series are included. The "Guide to Mapping Units" lists the capability unit for each individual soil.

In the following pages the capability units in Woodbury County are described and suggestions for the use and management of the soils are given.

CAPABILITY UNIT I–1

This unit consists of level or nearly level, stratified, silty soils that are well drained and moderately well drained to somewhat poorly drained. These soils are of the Blake, Haynie, McPaul, Modale, and Moville series. They are mostly on bottom lands in the Missouri River valley, but some are in the tributary valleys.

The surface layer is friable silt loam or silty clay loam. The available moisture capacity is typically high. Permeability is moderate in most of the soils, but in the Moville and Modale soils it is very slow or slow in the substratum. The organic-matter content is low. Reaction is typically mildly alkaline to moderately alkaline.

Soils of this capability unit are used for cultivated crops. Corn and soybeans are the main crops. Other crops are grain sorghum and oats. Alfalfa is usually grown when these soils are used for meadow or a green-manure catch crop.

These soils are subject to flooding, but usually only a few times over a period of years. They are not subject to sheet and gully erosion. These soils occur where an ample water supply can be developed for irrigation. Where the substratum is clayey, the water table is higher than elsewhere, and in wet years root growth is restricted by the clayey texture and the high water table.

Good management practices are especially suitable on these soils. High plant populations, high rates of fertilization, and chemical control of weeds and insects are likely to result in favorable returns. Corn responds well to applications of nitrogen and phosphorus. A small amount of potassium applied as a starter fertilizer in the corn rows usually gives good response, especially if the soil is wet and cool. Lime is not needed.

CAPABILITY UNIT I–2

This unit consists of level or nearly level, dark-colored, silty soils that are well drained and moderately well drained to somewhat poorly drained. These soils are of the Keg, Kennebec, and Salix series. They are mostly on bottom lands in the Missouri River valley, but some are in the tributary valleys.

The surface layer is friable silt loam and silty clay loam. Permeability is moderate, and the available moisture capacity is high. The organic-matter content is moderately high to high, except in the plow layer of Salix silty clay loam, overwash, where it is low. Reaction is neutral to slightly acid.

Soils of this capability unit are mostly used for cultivated crops. Corn and soybeans are the main crops, and they are commonly grown alternately in the cropping system. Oats, sorghum, and alfalfa are planted occasionally. An occasional year of meadow or a catch crop is grown in places.

Some of these soils are subject to occasional flooding, but the risk is slight. They are not subject to sheet and gully erosion. In places the hazard of flooding has been eliminated by large dams constructed upstream on the Missouri River. These soils occur where an ample water supply can be developed for irrigation.

Good management practices are especially suitable on these soils. High plant populations, high rates of fertilization, and chemical control of weeds and insects are likely to result in favorable returns. Corn responds well to applications of nitrogen and phosphorus. In a cool, wet spring a small amount of potassium applied as a starter fertilizer usually gets good response. Lime is generally not needed, but the soils should be tested to determine the need for lime and fertilizer.

CAPABILITY UNIT I-3

This unit consists of nearly level, silty, well-drained soils on high stream benches. These soils are of the Monona and Wadena series.

The surface layer is friable silt loam or light silty clay loam. Permeability is moderate, available moisture capacity is high, and organic-matter content is medium or moderately high. Reaction is slightly acid in most places.

The Wadena soil in this unit is underlain by gravel at a depth of 3 to 4 feet. This restricts root growth to some extent, and in places it affects the available moisture capacity. This soil has a number of gravel pits.

Soils of this capability unit are mostly cultivated and are used intensively for row crops. Corn and soybeans are the main crops, but oats and a mixture of alfalfa and bromegrass are also important.

These soils are not subject to sheet and gully erosion. In places excess water from the hills runs across these soils. Conservation practices are needed in hilly areas, and, in places, basin or diversion terraces need to be constructed near the foot of the hill to control runoff.

Good management practices are especially suitable on these soils. High plant populations, high rates of fertilization, and chemical control of weeds and insects are likely to result in favorable returns. Corn responds well to applications of nitrogen and phosphorus. A small amount of potassium applied as a starter fertilizer gets good response, especially if the soil is cool and wet. Lime needs to be applied in some areas.

CAPABILITY UNIT IIe-1

This unit consists of gently sloping, dark-colored, silty and loamy soils that are moderately well drained and well drained. These soils are of the Judson, Kennebec, McPaul, and Terril series. They occupy foot slopes and narrow upland valleys.

The surface layer is friable loam, silt loam, and silty clay loam; the subsoil is friable loam to silty clay loam. Permeability is moderate, and the available moisture capacity is high. The organic-matter content is high, except in McPaul soils, where it is low. Reaction is neutral or slightly acid, except in McPaul soils, where it is alkaline, and the soils are calcareous.

Most soils of this unit are cultivated. Corn and soybeans are the main crops, and oats, sorghum, and a mixture of alfalfa and bromegrass are commonly grown. A few inaccessible areas are left in trees and grass.

These soils usually occur as narrow strips and are managed with the adjacent soils. Soils in wide valleys are managed with the level bottom-land soils, and row crops are frequently included in the cropping system. Contour tillage is used, especially where much runoff is received. Soils in narrow valleys are managed with those on adjacent hillsides. Contour tillage and terraces are needed to control deposition. Row crops are grown fairly often if runoff is controlled. Where there is too much runoff, soils need to be kept in grassed waterways. In places where a wetter soil occurs in the center of a valley, tile lines are needed.

Soils of this unit respond well to a high level of management. Corn responds well to applications of nitrogen and phosphorus. Small amounts of potassium used as a starter are beneficial in a cool, wet spring. Some soils need to be limed, but tests should be made to determine this.

CAPABILITY UNIT IIe-2

This unit consists of gently sloping, well-drained, silty and loamy soils on hillsides and stream benches. These soils are of the Galva, Ida, Monona, and Wadena series. The Wadena soils are on stream benches and are underlain by sand and gravel.

The surface layer and subsoil are friable silt loam, loam, and silty clay loam. Permeability is moderate, except in soils underlain by sand or gravel, where it is very rapid in the lower horizons. The available moisture capacity is high, except in soils underlain by sand or gravel, where it is lower. The organic-matter content ranges from low to high. The Ida soils are lower in organic-matter content and fertility than the others. Where soils are underlain by gravel and sand, root growth is restricted in places.

Corn and soybeans are the main crops. These soils are commonly used for oats, red clover, and a mixture of alfalfa and bromegrass. Row crops are grown intensively where these soils are tilled on the contour or are terraced.

All of these soils are subject to erosion, and some of them are slightly droughty. Runoff can be controlled by terracing and contour tillage. Level terraces can be built in the deep, silty soils, but it is not practical to terrace soils that are underlain by sand and gravel.

Corn responds well to applications of nitrogen and phosphorus, especially on soils that have a high content of lime. These soils generally have a medium to high content of potassium, but small amounts of potassium applied as a starter fertilizer give good response. Some of these soils are slightly acid or medium acid, and some have an excess of lime. Liming increases plant growth in some places, but soil tests are needed.

CAPABILITY UNIT IIw-1

This unit consists of level or nearly level, clayey and silty, stratified soils that are somewhat poorly drained to poorly drained. These soils are of the Onawa and Percival series. They occupy bottom lands in the Missouri River valley.

The surface layer is silt loam or silty clay. The upper part of the substratum is firm silty clay, but the lower part is very low in clay content. The available moisture capacity is high in Onawa soils and medium to low in Percival soils. The organic-matter content is low. Permeability is slow in the clayey material and moderate to rapid in the underlying material. A seasonal high water table generally occurs at a depth of 2 to 6 feet. In a few places where the water table is lower, Percival soils are somewhat droughty.

These soils are generally used for row crops. Corn and soybeans are the main crops, but oats and a mixture of alfalfa and bromegrass are planted occasionally. Row crops are generally planted with a lister. A few areas along the river are in woodland.

These soils can be irrigated easily. Wetness is a hazard in most years, but many areas are managed without artificial drainage. Surface drains are used. They commonly consist of a main ditch dug along a swale and secondary ditches that parallel the roads and section lines. In most places the slope and elevation of these soils are such that crop rows can be so arranged that excess water runs off. The soils need to be graded and smoothed, however, where the surface is irregular enough to cause ponding.

High plant populations, high fertilization rates, and other high-level management practices are appropriate on soils of this unit. All the soils have a high content of lime. Corn responds well to applications of nitrogen and phosphorus, and a small amount of potassium used as a starter is generally beneficial.

CAPABILITY UNIT IIw-2

This unit consists of clayey and silty soils that are somewhat poorly drained and poorly drained. These soils are of the Blencoe, Blend, Calco, Colo, Corley, Judson, and Lakeport series. These are mostly level and nearly level soils on bottom lands. The gently sloping soils are on narrow upland drainageways; the Corley soils are in depressions on stream benches and on the uplands.

The surface layer is friable silt loam, silty clay, and silty clay loam. Permeability is moderately slow, except in the clayey part of the Blencoe and Blend soils, where it is very slow. The available moisture capacity is high, except in the Blend soils, where it is medium. The organic-matter content is moderately high to high.

The soils of this capability unit are mostly cultivated. Row crops are grown intensively if wetness is controlled. Corn and soybeans are the main crops. A mixture of alfalfa and bromegrass, seeded with oats, is generally used for meadow.

The soils in the Missouri River valley have an ample water supply that can be developed for irrigation. The soils in low areas adjacent to streams are subject to occasional flooding. Some of these soils have a seasonal high water table within 2 or 3 feet of the surface. Water collects on all of these soils, and runoff is slow. Much of the rainfall percolates through these soils. Surface drains and tile lines are used in places. Soils in the Missouri River valley are drained by surface ditches.

Except for the soils in narrow upland drainageways, these soils are generally managed with the soils of capability units I-1, I-2, and IIIw-1. In many places the soils in narrow areas are managed along with the associated soils on hillsides. Corley soils are also managed with the gently sloping, well-drained associated soils.

Listers are used to plant row crops on soils in the Missouri River valley. Power requirements are high for soils that have a silty clay surface layer, and these soils become cloddy if they are worked when wet. Fields are sometimes plowed in fall because of wetness and to improve the timeliness of field operations. Fall plowing lets a cloddy soil freeze and thaw to improve tilth.

Corn responds well to applications of nitrogen and phosphorus, and small amounts of potassium applied as a starter fertilizer often get good response. Some of these soils respond better if limed. This needs to be determined by soil tests, however, because other soils in this unit have an excess of lime.

CAPABILITY UNIT IIs-1

This unit consists of level or nearly level, loamy and silty soils that are mostly well drained or somewhat excessively drained. These soils are of the Carr, Grable, Wadena, and Waubonsie series. They mostly occupy first bottoms in the Missouri River valley, but the Wadena soil is on high stream benches.

The surface layer is friable or very friable silt loam, fine sandy loam, or silty clay loam. The substratum is mostly sandy. In the Wadena soils, however, the substratum is dominantly gravel in many places, and drainage is restricted in the Waubonsie soils because the substratum is clayey at a depth below about 2 or 3 feet. The available moisture capacity is low to medium, and permeability is variable. These soils are generally moderately permeable in the upper part of the solum and rapidly permeable below. The organic-matter content is low to medium.

Most soils in this unit are cultivated, and row crops are grown intensively. Corn and soybeans are the main crops.

These soils are somewhat droughty. Areas in the Missouri River valley have an ample supply of water that can be developed for irrigation. In many fields low fertility is more of a limitation than droughtiness. These soils should be managed to conserve moisture. The Carr and Waubonsie soils are susceptible to soil blowing.

The soils in this unit warm up quickly in spring and can be worked soon after rains. Corn responds well to applications of nitrogen and phosphorus. Small amounts of potassium used as a starter fertilizer are beneficial, especially in a cool, wet spring. Except for the Wadena soils, these soils contain abundant lime. Many of these soils are managed along with the closely associated soils.

CAPABILITY UNIT IIIe-1

This unit consists of moderately sloping and sloping, silty and loamy soils that are moderately well drained or well drained. These soils are of the Napier, Castana, and Terril series. The moderately sloping soils are on foot slopes, and the sloping soils are in narrow stream valleys.

The surface layer is friable and very friable silt loam and loam. Permeability is moderate, and the available moisture capacity is high. The organic-matter content is medium to high.

These soils are mostly cultivated. The larger areas are used for row crops, and the small areas adjacent to steep hillsides are used for meadow or pasture (fig. 12). Row crops are grown intensively where erosion is controlled. Corn, soybeans, oats, alfalfa, and bromegrass are the main crops.

Most areas of these soils receive large amounts of runoff from the uplands. Sheet erosion, rilling, and siltation are serious hazards if runoff is not controlled. Large gullies cut back from streams entrenched in the centers of the valleys. Basin terraces or diversions built at the foot of the hill just above these soils help control runoff. Regular terraces are effective if the slopes are long enough. In valleys that have an active or potential gully, terracing combined

Figure 12.—**Mowing basin terraces on Napier soil. This soil is in capability unit IIIe-1.**

with other conservation practices, reduces the amount of water running over the edges of the gully. This, in turn, slows the cutting action and makes it possible to shape and seed a grassed waterway or build a structure to control gullying.

Corn responds well to applications of nitrogen and phosphorus. The soils of this capability unit are generally high in content of potassium, and very few areas need to be limed.

CAPABILITY UNIT IIIe-2

This unit consists of moderately sloping, silty and loamy soils that are well drained and excessively drained. These soils are mainly of the Galva, Ida, and Monona series, but minor acreages are of the Salida and Wadena series. All of these soils are on ridgetops, hillsides, and stream benches.

The surface layer ranges from silty clay loam to sandy loam. Salida and Wadena soils are loamy in the upper part and sandy or gravelly in the lower part. They differ in a number of ways from other soils of this capability unit. Permeability is moderate in the silty soils and very rapid in the gravelly or sandy layers of the loamy soils. The available moisture capacity is high in the silty soils, low in the Salida soils, and medium in the Wadena soils. The organic-matter content ranges from low to moderately high.

Most areas of these soils are cultivated. Corn, soybeans, oats, and a mixture of alfalfa and bromegrass are the main crops. If runoff is controlled, these soils can be used intensively for row crops. The loamy soils, however, are so droughty that many areas are left in meadow.

Slopes are strong enough that the erosion hazard is fairly severe. Where runoff is not controlled, the use of the loamy soils is limited by lack of moisture. Terracing and contour tillage (fig. 13) can be used to control runoff. The silty soils are suitable for terracing, but it is not practical to build terraces on the loamy soils.

Corn responds well to applications of nitrogen and phosphorus. Phosphorus is needed for growing meadows,

Figure 13.—**Hillside terraces hold water on Ida and Monona soils. These soils are in capability unit IIIe-2.**

especially on soils high in content of lime. Potassium used as a starter fertilizer gets good response on some of the soils. Tests need to be made to determine whether a particular soil needs liming.

CAPABILITY UNIT IIIe-3

This unit consists of sloping, silty and loamy soils that are well drained and moderately well drained. These soils are of the Galva, Ida, Monona, Shelby, and Steinauer series. They occupy hillsides.

The surface layer is silt loam, loam, or silty clay loam. Permeability is moderate, except in the loamy soils, where it is moderately slow. The available moisture capacity is high. The organic-matter content ranges from low to moderately high.

The soils of this capability unit are mostly cultivated. Corn, oats, and a mixture of alfalfa and bromegrass are the main crops. Row crops can be included in the cropping system fairly often if the soils are terraced and tilled on the contour. Many small areas associated with soils that are more strongly sloping are left in meadow.

Except that they are more strongly sloping, many of these soils are similar to those of capability unit IIIe-2. These soils have a serious erosion hazard and rapid runoff. Regular level terraces and grassed back-slope terraces are used to control runoff. In some places gullies need to be shaped before terraces are built.

Corn responds well to applications of nitrogen and phosphorus. Potassium is used as a starter fertilizer in places. Meadows respond to applications of potassium, especially where the soils have a high content of lime. Some of these soils need lime; others have an abundance of it. A soil test is needed to determine whether or not to apply lime to a specific field.

CAPABILITY UNIT IIIw-1

This unit consists of level or nearly level, clayey soils that are poorly drained. These soils are of the Albaton, Blend, Forney, Holly Springs, Luton, Napa, Oswego, Solomon, and Woodbury series. They are on bottom lands of the Missouri River valley.

The texture is dominantly firm silty clay or clay, but in some soils the surface layer, subsoil, or substratum is silt loam or silty clay loam. Permeability is slow or very slow, and the available moisture capacity is medium or high. The organic-matter content ranges from low to high.

The soils of this capability unit are generally used for corn and soybeans. Minor crops are sorghum, wheat, oats, and hay. Row crops can be grown intensively when these soils are adequately drained. Listers are used to plant row crops in many places, and special equipment is used to pack and break clods in the lister rows. Power requirements are generally high.

These soils have a high water table and slow runoff. The seasonal high water table is within 1 to 3 feet of the surface in most areas, and, unless the soil is dry, rainwater percolates downward very slowly. Moisture causes the clay to swell, and large cracks appear as the soil dries. Unless field operations are timed properly, the wetness and clayey texture of these soils causes clodding.

In many years the use of these soils is limited by wetness in spring and insufficient moisture during the growing season. Because excess water in spring restricts root growth, plants cannot get enough moisture from the soil during the summer. Good root growth is encouraged by draining off excess water in spring and keeping the soil fertile. Fall plowing improves the timeliness of spring operations, and tilth is improved through freezing and thawing. The soils also are drier in fall, and they can be plowed easily. In years of average or above-average rainfall, planting, cultivating, or harvesting operations are usually delayed. Some crops are harvested after the ground freezes.

Surface drains and land grading or smoothing are used to remove excess water. The gradient is slight, however, and road ditches hold water for long periods. Field drains are channeled to large drainage ditches that are spaced at mile and half-mile intervals, but water will not drain from the fields until the level in the main ditches is low.

These soils are in areas where there is an ample supply of water that can be used for irrigation. Care must be taken, however, not to increase the hazard of wetness of the soils. If irrigation water applied in fall is not used by a crop, it is likely to add to the amount of water that must be removed the following spring.

If excess wetness is controlled, crops respond satisfactorily to applications of nitrogen and phosphorus. Application of potassium as a starter fertilizer also gets good response. These soils are mostly neutral or high in content of lime. The Napa soils are high in soluble salts. In a few places some of the darker colored soils need to be limed.

CAPABILITY UNIT IVe-1

This unit consists of sloping and moderately steep, silty and loamy soils that are well drained or moderately well drained. These soils are of the Castana, Ida, Monona, Steinauer, and Terril series. They are on hillsides and upper foot slopes.

The surface layer is friable silt loam or loam. Permeability is moderate, except in the Steinauer soils, where it is moderately slow. The available moisture capacity is high. The organic-matter content is low to high depending on the degree of erosion.

Many areas of these soils are cultivated. Corn is grown occasionally where soils are terraced and tilled on the contour, but these soils are used mainly for meadows of alfalfa and bromegrass. Burrowing animals severely damage long-term meadows.

The main limitation to use of these soils is erosion. Another limitation is the rapid runoff that keeps the soil moisture supply below capacity. To control this runoff, regular level terraces and grassed back-slope terraces are built. In places uncrossable gullies need to be shaped before terraces can be built. A few of the loamy soils contain stones and boulders that hinder tillage operations.

Corn responds satisfactorily to applications of nitrogen and phosphorus, as does bromegrass. Alfalfa and bromegrass meadow respond well to applications of phosphorus. These soils generally have a high content of potassium. Lime is seldom, if ever, needed.

CAPABILITY UNIT IVs-1

This unit consists of nearly level to undulating, stratified, sandy soils that are excessively drained. These are soils of the Sarpy series and some areas of Alluvial land that are closely associated with Sarpy soils. The areas are within a few miles of the Missouri River.

Permeability is very rapid in the Sarpy soils. The available moisture capacity and organic-matter content are low. One of the Sarpy soils has a thin, loamy surface layer. Alluvial land is stratified, and its properties vary widely.

These soils are mostly in native grass or trees, mainly cottonwood or willow. Corn and soybeans are minor crops. Alfalfa is also grown.

These soils are not subject to flooding, except where they occupy low areas next to the channel. They are subject to soil blowing and are too droughty to be depended on for crops. In windy periods blowing sand can damage crops on adjacent soils. Farmers are generally as interested in getting a good plant cover as in growing crops on these soils, and alfalfa is well suited to both purposes. In many places these soils have a seasonal high water table within 3 to 10 feet of the surface. If alfalfa is established, its deep roots can penetrate to the water table.

Trees planted in shelterbelts and groves check surface winds and protect adjoining fields from soil blowing. Cottonwoods and other native trees supply lumber for a number of farm uses. The wooded areas are also used for wildlife habitat and recreational purposes.

These soils are low or very low in content of available nitrogen and phosphorus. They are medium to high in potassium and high in lime. Crop response to fertilization is variable. In many years, use of the soils is limited more by lack of moisture than by lack of fertility.

CAPABILITY UNIT Vw-1

This capability unit consists of Alluvial land, Borrow pits, and soils of the Albaton, Blake, McPaul, and Spillville series. The areas differ greatly in properties. The soils are silty, loamy, or clayey and distinctly stratified. They are depressional, level, and slightly undulating. These areas are on bottom lands in the Missouri River valley, and some are in tributary valleys.

In a few places these soils can be cultivated, but the crop will be lost in many years. They can be better used for pasture. Pastures can be improved by fertilizing and seeding to alfalfa and bromegrass, or, if the area is wet, to other legumes and grasses, such as reed canarygrass. Most areas are suitable for trees. Some areas that have a good stand of trees and are not suitable for crops or pasture are useful for timber production or recreational purposes.

Wetness is a hazard on these soils. Some of the soils have a high water table, some are frequently flooded, and some hold water on the surface. In places these soils are protected by large flood control projects. In the built-up part of Sioux City, which is within these areas, flood control projects have been constructed on the Missouri and Floyd Rivers.

These soils are low or very low in content of available nitrogen and phosphorus. Except for the dark-colored soils, they are generally high in available potassium. Response to fertilization is variable. Lime is generally not needed.

CAPABILITY UNIT VIe-1

This unit consists mainly of steep, silty, well-drained soils of the Ida and Monona series. Also in this unit are sloping to moderately steep, loamy and sandy soils of the Chute, Salida, Sarpy, Shelby, and Steinauer series; these soils are moderately well drained to excessively drained. All the soils are on hillsides except the Sarpy soils, which are on dunelike areas in the Missouri River valley.

Permeability is generally moderate or moderately slow, and the available moisture capacity is generally high. In the Chute, Salida, and Sarpy soils permeability is rapid or very rapid and the available moisture capacity is low. The organic-matter content ranges from low to moderately high, depending mainly on the degree of erosion. These soils are erodible. They are also droughty, especially the sandy soils.

The soils of this unit are nearly all in meadow or permanent pasture. A few areas are wooded. Although farm equipment can be used in most places, the soils are too erodible to be cropped regularly. These soils are generally seeded to bromegrass and alfalfa, although many farmers prefer bromegrass alone. They are well suited to both these crops.

Diversion or basin terraces are used to control runoff on soils downslope or in valleys. Regular terraces are not practical, because the soils are too steep. Gullies need to be shaped and seeded in places. Grazing should be controlled to avoid destroying the plant cover. Pastures generally respond well to fertilization. Phosphorus is needed, and if the stands of legumes are sparse, nitrogen should be applied. Lime and potassium are not needed.

A few areas are used for trees; bur oak is the most common type. These trees are not valuable for commercial lumber, but they furnish some posts and lumber for farm use. They also help reduce soil and water loss and have an increasing value for recreational uses. Soils of this unit that are managed for trees should not be grazed.

CAPABILITY UNIT VIIe-1

This unit consists of Gullied land and steep, silty and loamy soils that are moderately well drained, somewhat excessively drained, and excessively drained. These soils are of the Castana, Hamburg, Ida, Napier, Salida, Shelby, and Steinauer series. They occupy hillsides.

The surface layer is friable silt loam, loam, clay loam, or sandy loam. The available moisture capacity is high, except in Salida soils. The Salida soils are very rapidly permeable and have low available moisture capacity. In many places the amount of water available for plant use is low because runoff is rapid.

These soils are so steep or so badly gullied that their use is restricted to permanent vegetation. They are mostly used for native grasses, such as big and little bluestem. Stands of bur oak grow in some areas, especially where the soils are loamy.

Diversion or basin terraces are built on these soils to control runoff downslope or in the valley. The soils are too steep for regular terraces to be practical. Gullies need to be shaped and seeded in places. Major reclamation generally is needed before Gullied land can be used for farming.

Grazing should be controlled so that the plant cover is not destroyed. A few areas of these soils can be worked with regular farm implements, but most cannot. If the native vegetation is ruined, reclaiming the land requires spreading fertilizer and seed by hand or waiting for natural revegetation to take place. Because any grazing is harmful to wooded areas, livestock should be fenced out of areas that are used for trees.

CAPABILITY UNIT VIIs-1

This unit consists of Riverwash, Marsh, and Made land, which are miscellaneous land types that have varying properties. The areas are impractical for farming without major reclamation.

Areas of Made land are mostly in built-up urban areas, and their use generally will not change. A few areas of sanitary land fill may be converted to other uses in the future. Much of the wetland and many areas near stream channels can be developed for recreational uses and wildlife habitat. Trees and shrubs planted on adjacent soils provide food and shelter for wildlife and beautify the areas.

Predicted Yields

Table 2 lists, for each mapping unit in Woodbury County, the predicted average yields per acre of principal crops under a high level of management. All available sources of yield information were used to make these estimates. They are based on data from the Federal census, the Iowa farm census, experimental farms, cooperative experiments with farmers, and on field experience of soil scientists, extension workers, and others.

The following practices are assumed to be part of a high level of management:

1. Erosion is controlled.
2. Organic-matter content and soil tilth are maintained.
3. Fertilizer is applied in amounts indicated by soil tests and field trials.
4. Wetness is controlled.
5. Plowing and other farm operations are accomplished at the proper time.

The yield predictions in table 2 are approximate figures only and are intended to serve only as guides. Many users will consider the comparative yields between soils to be of more value than the actual yields. These relationships are likely to remain constant over a period of years.

Wildlife

Woodbury County supports many kinds of wildlife that contribute to the economy of the county and that have recreational value. The kinds and numbers of wildlife that can be produced and maintained in the county are largely determined by the kinds and amounts of vegetation the soils can produce and by the way the vegetation is distributed.

TABLE 2.—*Predicted average yields per acre of principal crops under a high level of management*

[Absence of a figure indicates that the crop is not suited to the soil or is not generally grown on it]

Mapping unit	Corn	Soybeans	Oats	Hay [1]	Brome-grass pasture
	Bu.	*Bu.*	*Bu.*	*Tons*	*Animal-unit-days* [2]
Albaton silty clay loam	78	31	51	3.5	120
Albaton clay	75	30	49	3.0	100
Albaton clay, depressional	(3)	(3)	(3)	(3)	(3)
Alluvial land	(3)	(3)	(3)	(3)	(3)
Blake silty clay loam	100	40	65	4.0	125
Blencoe silty clay	88	35	57	3.5	120
Blend silty clay	81	32	53	3.0	100
Blend silty clay loam	86	34	56	3.3	110
Blend silty clay loam, overwash	86	34	56	3.3	110
Borrow pits	(3)	(3)	(3)	(3)	(3)
Calco silty clay loam	95	38	62	4.5	130
Carr fine sandy loam	70	28	46	3.0	100
Castana silt loam, 15 to 20 percent slopes	75		49	3.0	100
Castana-Gullied land complex, 6 to 20 percent slopes					100
Chute loamy fine sand, 5 to 18 percent slopes, severely eroded			33	1.2	55
Colo silt loam, calcareous overwash	106	42	69	5.0	140
Colo silty clay loam	106	42	69	5.0	140
Colo-Judson silty clay loams, 2 to 6 percent slopes	106	42	69	4.5	130
Corley silt loam	85	34	55	3.5	120
Forney silty clay loam, calcareous overwash	74	30	48	3.5	120
Forney clay	71	28	46	3.0	120
Galva silty clay loam, 2 to 6 percent slopes	104	42	68	4.0	160
Galva silty clay loam, 6 to 10 percent slopes, moderately eroded	94	38	61	3.5	130
Galva silty clay loam, 10 to 15 percent slopes, moderately eroded	88	35	57	3.0	110
Grable silt loam	80	32	52	3.0	100
Grable silty clay loam	80	32	52	3.0	100
Hamburg silt loam, 30 to 75 percent slopes					25
Haynie silt loam	105	42	68	5.0	125
Holly Springs silty clay loam	85	34	55	3.0	
Ida silt loam, 2 to 6 percent slopes, severely eroded	90	36	59	3.5	110
Ida silt loam, 6 to 10 percent slopes, severely eroded	85	34	55	3.5	110
Ida silt loam, 10 to 15 percent slopes, severely eroded	69	28	45	3.0	90
Ida silt loam, 15 to 20 percent slopes, severely eroded	63		41	2.5	80
Ida silt loam, 20 to 30 percent slopes, severely eroded					70
Ida silt loam, 30 to 40 percent slopes, severely eroded					[4]40
Judson silty clay loam, 2 to 6 percent slopes	100	44	72	5.0	175
Keg silt loam	113	45	74	4.5	160
Kennebec silt loam, 0 to 2 percent slopes	113	45	74	5.0	175
Kennebec silt loam, 2 to 6 percent slopes	108	43	70	4.5	160
Lakeport silty clay loam	100	40	65	4.5	150
Luton silty clay loam	73	29	47	3.3	110
Luton clay	70	28	46	3.0	100
Made land	(3)	(3)	(3)	(3)	(3)
Marsh	(3)	(3)	(3)	(3)	(3)
McPaul silt loam	106	42	69	4.5	160
McPaul silt loam, frequently flooded	(3)	(3)	(3)	(3)	(3)
McPaul, Albaton, and Blake soils	(3)	(3)	(3)	(3)	(3)
McPaul-Kennebec silt loams, 2 to 6 percent slopes	106	42	69	4.5	160
Modale silt loam	88	35	57	3.5	120
Modale silty clay loam	88	35	57	3.5	120
Monona silt loam, 0 to 2 percent slopes	111	44	72	4.5	160
Monona silt loam, 2 to 6 percent slopes	106	42	69	4.0	140
Monona silt loam, 2 to 6 percent slopes, moderately eroded	101	40	66	3.8	140
Monona silt loam, 6 to 10 percent slopes, moderately eroded	97	39	63	3.6	130
Monona silt loam, 10 to 15 percent slopes, moderately eroded	90	36	59	3.5	120
Monona silt loam, 10 to 15 percent slopes, severely eroded	81		53	3.0	110
Monona silt loam, 15 to 20 percent slopes, moderately eroded	69		45	3.0	90
Monona silt loam, 15 to 20 percent slopes, severely eroded	63		41	2.5	90
Monona silt loam, 20 to 30 percent slopes, moderately eroded				2.0	70
Moville silt loam	85	34	55	4.0	140
Napa clay	40	16	26	1.0	60
Napier silt loam, 6 to 10 percent slopes	95	38	62	4.0	140
Napier-Castana silt loams, 10 to 15 percent slopes	90	36	59	3.5	110
Napier-Gullied land complex, 2 to 10 percent slopes					125
Onawa silt loam	99	40	64	3.5	120
Onawa silty clay	97	39	63	3.5	120
Owego silt loam, calcareous overwash	82	33	53	3.5	120
Owego silty clay	80	32	52	3.5	120
Percival silty clay	85	34	55	3.0	100

Table 2.—*Predicted average yields per acre of principal crops under a high level of management*—Continued

Mapping unit	Corn	Soybeans	Oats	Hay [1]	Brome-grass pasture
	Bu.	*Bu.*	*Bu.*	*Tons*	*Animal-unit-days* [2]
Riverwash					
Salida sandy loam, 5 to 9 percent slopes, moderately eroded	50	20	33	1.5	55
Salida sandy loam, 9 to 18 percent slopes, severely eroded				1.0	40
Salida sandy loam, 18 to 40 percent slopes, severely eroded					25
Salix silty clay loam	110	44	72	4.5	160
Salix silty clay loam, overwash	106	42	69	4.5	160
Sarpy loamy fine sand, 1 to 5 percent slopes	40	16	26	1.0	40
Sarpy loamy fine sand, 5 to 18 percent slopes				.8	30
Sarpy fine sandy loam, 0 to 2 percent slopes	45	18	29	1.0	40
Sarpy soils and Alluvial land	35	14	23	.8	30
Shelby loam, 5 to 14 percent slopes, moderately eroded	69	28	45	3.5	125
Shelby soils, 14 to 24 percent slopes, severely eroded			35	2.5	80
Solomon clay	60	24	39	3.0	100
Solomon-Luton silt loams, calcareous overwash	70	30	46	3.0	100
Spillville loam, frequently flooded					[4] 80
Steinauer clay loam, 5 to 14 percent slopes, eroded	60	24	39	3.5	125
Steinauer clay loam, 14 to 18 percent slopes, moderately eroded	50		33	2.5	80
Steinauer clay loam, 18 to 25 percent slopes, moderately eroded					70
Steinauer-Shelby complex, 25 to 40 percent slopes, moderately eroded					[4] 50
Terril loam, 2 to 6 percent slopes	106	42	69	4.5	115
Terril loam, 6 to 10 percent slopes	95	38	62	4.0	105
Terril and Castana soils, 10 to 20 percent slopes	80		52	3.5	95
Wadena loam, moderately deep, 2 to 5 percent slopes	70	28	46	3.0	95
Wadena loam, moderately deep, 5 to 9 percent slopes, moderately eroded	60	24	39	2.8	85
Wadena silt loam, moderately deep, 0 to 2 percent slopes	75	30	49	3.0	80
Wadena silt loam, moderately deep, 2 to 5 percent slopes	70	28	46	3.0	80
Wadena silt loam, deep, 0 to 2 percent slopes	95	38	62	3.5	100
Wadena silt loam, deep, 2 to 5 percent slopes	90	36	59	3.5	100
Waubonsie fine sandy loam	75	30	49	3.5	100
Woodbury silty clay	83	33	54	3.0	100

[1] Hay is alfalfa and bromegrass.

[2] A term used to express the carrying capacity of pasture. It is the number of animal units carried per acre multiplied by the number of days the pasture is grazed during a single grazing season without injury to the sod. An acre of pasture that provides 30 days of grazing for two cows has a carrying capacity of 60 animal-unit-days

[3] These areas are not used for farming, or yields vary a grea deal because of flooding.

[4] These soils are usually in permanent bluegrass pasture.

Wildlife populations are influenced by topography and such soil characteristics as fertility. Wildlife are more numerous on fertile soils than on less fertile soils. Topography affects the numbers of wildlife through its influence on land use. Extremely rough, irregular areas may be hazardous to livestock and unsuitable for wildlife. If suitable vegetation is lacking in such areas, it can be developed in many places.

In this county large areas of nearly level or gently sloping soils are cropped intensively. Such soils support only limited numbers of wildlife because they lack suitable shelter and nesting areas. Natural wetness and available water capacity of soils are important in selecting sites for the construction of fishponds and habitat for waterfowl. In some places naturally marshy areas can be developed to provide aquatic or semiaquatic habitat for waterfowl and for some furbearers.

The wildlife resources of the county are important primarily for the opportunities they provide for recreation, in the form of hunting and fishing. Many species of wildlife, such as songbirds, hawks, owls, snakes and other predators, are also beneficial in that they help control the numbers of rodents and undesirable insects. The furbearers, especially muskrat and mink, provide income for the farmer.

Most of the soil associations in this county include areas that are suitable for the development of facilities for recreation. In many places areas that are too steep or are otherwise unsuitable for farming can be developed for recreation.

The soils of Woodbury County provide suitable habitat for a number of wildlife species. Soils in the Missouri River valley, and especially those near the River, provide food for large numbers of migrating ducks and geese in fall and spring. These soils include those of the Albaton, Onawa, Blake, and Haynie series. A number of oxbow lakes and marshy areas are filled with water part of the time and provide resting places for migrating waterfowl.

Pheasants are in all parts of the county but are typically most abundant in those areas where the pattern of cropping is such that there is a good food supply and plenty of cover for shelter and nesting areas. Pheasants find good habitat on uplands occupied by gently sloping to moderately steep soils of the Monona, Galva, and Ida series The drainageways and narrow bottom lands that provide food and cover for birds are occupied mostly by soils of the Napier, Judson, Kennebec, and Colo series. Limited numbers of Hungarian partridge find habitat in the uplands.

Fox, raccoon, skunk, woodchuck, and cottontail rabbit find habitat throughout the county. White-tailed deer frequent areas adjacent to the river bottoms of soil associations 2 and 3. Squirrel are most abundant on wooded east- or north-facing slopes adjacent to streams. The soils are mostly of the Steinauer, Shelby, or Monona series. Muskrat, mink, and other furbearers frequent the rivers and creeks throughout the county. They are probably most common along the Missouri River in soil associations 1 and 3 and along watercourses in other associations.

The Missouri and Little Sioux Rivers, tributary streams, and well-managed farm ponds provide fishing. The Missouri River and Browns Lake are used for boating.

Although there are many areas in the county suitable for wildlife, many more could be developed. All the soils will support good wildlife habitat if properly used. Farm ponds provide opportunities for improving habitat for wildlife. Herbaceous and woody plantings provide food and cover. Small, odd-shaped areas that have little farming value can be developed for wildlife by protecting natural cover or by establishing needed cover. Sites suitable for such purposes are many areas of Alluvial land, Borrow pits, Made land, Marsh, Riverwash, and soils of the Salida, Sarpy, Shelby, and Steinauer series.

Engineering Uses of the Soils [3]

Some soil properties are of special interest to engineers because they affect the construction and maintenance of roads, airports, pipelines, facilities for storing water, erosion control structures, irrigation systems, drainage systems, building foundations, and sewage disposal systems. Among the properties that are most important are permeability to water, shear strength, compaction characteristics, drainage, shrink-swell potential, grain size, plasticity, and pH value. The depth to the water table, depth to bedrock, and topography are also important.

Information in this survey can be used to—

1. Make studies that will aid in selecting and developing sites for industrial, business, residential, and recreational uses.
2. Make preliminary evaluations that will aid in selecting locations for highways and airports and in planning detailed surveys of the soils at the site.
3. Develop information for the design of drainage systems, farm ponds, diversion terraces, and other structures for soil and water conservation.
4. Locate possible sources of sand and gravel.
5. Correlate performance of engineering structures with soil mapping units to develop information that can be useful in designing and maintaining such structures.
6. Determine the suitability of soils for cross-country movement of vehicles and construction equipment.
7. Supplement information obtained from published maps, reports, and aerial photographs for the purpose of making maps and reports that can be used readily by engineers.
8. Develop other preliminary estimates for construction purposes pertinent to a particular area.

[3] WAYNE DUCOMMUN, civil engineer, Soil Conservation Service, helped to prepare tables 4 and 5 in this section.

With the use of the soil map for identification, the engineering interpretations reported here can be useful for many purposes. It should be emphasized, however, that they do not eliminate the need for sampling and testing at the site of specific engineering works involving heavy loads or excavations deeper than the depths of the layers here reported. Also, the user should not apply specific values to the estimates of bearing capacity. Some soil mapping units contain areas of a different soil material that are as much as 2 acres in size. Although these areas are too small to be mapped separately, they may be important in engineering planning. Even in these situations, the soil map is useful for planning more detailed field investigations and for suggesting the kinds of problems that may be expected.

Much of the information in this section is given in tables 3, 4, and 5. Table 3 contains laboratory test data on samples taken from selected soils in Woodbury County. In table 4 are given the estimated properties of the soils. Table 5 indicates the suitability of the soils for various engineering uses.

Some of the terms used in this publication have a special meaning to soil scientists and a different meaning to engineers. Many of these terms are defined in the Glossary at the back of this survey.

Engineering classification systems

Most highway engineers classify soil material according to the system used by the American Association of State Highway Officials (AASHO) (*1*). In this system soil materials are classified in seven principal groups based on field performance. The groups range from A–1, consisting of gravelly and coarse, sandy soils of high bearing capacity, to A–7, consisting of clayey soils having low strength when wet. Within each group the relative engineering value of the material is indicated by a group index number. Group indexes range from 0 for the best material to 20 for the poorest.

Some engineers prefer to use the Unified soil classification system (*22*). This system is based on identification of soils according to texture and plasticity and on performance as engineering construction material. In this system soil materials are identified as coarse grained (eight classes), fine grained (six classes), or highly organic (one class). The classification of the soils according to both systems is given in table 4.

Engineering test data

Soil samples were taken, by horizons, of nine soil series and tested according to standard AASHO procedures to help evaluate the soils for engineering purposes. The test data are given in table 3. Because the samples tested were obtained at a depth less than 4 feet, they are not adequate for estimating the characteristics of the soils at a greater depth.

The relationship between the moisture content and the density of compacted soil material is given in table 3. The density, or unit weight, of the compacted dry soil increases as the content of moisture increases until the optimum moisture content is reached. After that, the density decreases with each increase in moisture content. The highest density obtained in the test is at the optimum moisture content and is the maximum dry density. As a rule, optimum stability is obtained if the soil is compacted to about the maximum dry density when the soil is at or near the optimum moisture content.

The liquid limit and the plasticity index indicate the effect of moisture on the consistence of the soil material. As the moisture content of a dry, clayey soil is increased, the material changes from a semisolid to a plastic state. As the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the material passes from a semisolid to a plastic state. The liquid limit is the moisture content at which the material passes from the plastic to the liquid state. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is in a plastic condition.

Estimated properties

Table 4 gives estimates of some of the soil properties that are significant in engineering. These estimates are based on the test data in table 3, on experience with similar soils in other counties, and on information in other parts of the survey.

The depth to bedrock and to seasonal high water table are not given in table 4. Most of the soils of the county are so deep over bedrock that bedrock generally does not affect their use. A few outcrops, however, occur in the Stone State Park area and in areas of Ida and Hamburg soils in the northwestern part of Sioux City and near Sergeant Bluff. Most soils on bottom lands have a seasonal high water table at a depth of 5 feet or less. The seasonal high water table in some poorly or very poorly drained soils is at a depth of 1 to 2 feet. Normally, the water table is deep in soils on stream benches and uplands. Corley soils occur in depressions and have a seasonal high water table within a few feet of the surface.

The percentage of material passing Nos. 4, 10, and 200 sieves is the normal range of soil particles passing the respective screens.

Permeability refers to the rate of movement of water downward through the undisturbed soil. It depends largely on the soil texture and structure.

Available moisture capacity is estimated in table 4 in inches of water per inch of soil. It is the approximate amount of water in the soil when it is wet to field capacity and represents the maximum amount of water that can be removed by plants.

Reaction refers to the acidity or alkalinity of a soil, expressed in terms of pH values. Soil material that has a pH value in a range of 6.6 to 7.3 is considered to be neutral; a lower pH value indicates acidity; and a higher value alkalinity.

The shrink-swell potential indicates the change in volume that occurs with a change in moisture content. It is estimated primarily on the basis of the kind and amount of clay in the soil.

Engineering interpretations of the soils

In table 5 the soils in each series are rated for their suitability for use as topsoil, sand, and road fill. The suitability of the soils as a source of gravel is not given in table 5, because the soils generally do not provide enough gravel for construction purposes. Wadena and Salida soils, however, are fair to good sources. Other potential sources of gravel are areas of Riverwash.

The suitability of soil material for road fill largely depends on the density that can be obtained by compacting the material. Density affects the rigidity, flexibility, and load-bearing properties of the soil as subgrade fill for paved roads and as surfacing material for unpaved roads. Shrink-swell potential is also a factor in evaluating material for road fill.

Soil features affecting the use of soils for highway location, farm ponds, agricultural drainage, irrigation, terraces and diversions, and grassed waterways are given in table 5. Features that have an adverse effect on these practices generally are listed, but beneficial features are listed for some practices.

Also rated in table 5 is the degree of limitation of each soil series for foundations of low buildings and for septic tank disposal fields. For foundations of low buildings, the soils are rated for bearing capacity, compressibility, height of the water table, and other important features. These features vary widely. Engineers and others should not apply specific values to the estimates given for bearing capacity. For septic tank disposal fields, the soils are rated for their ability to absorb sewage effluent over a long period. Before a septic tank and disposal field are installed, however, a percolation test should be made at the site. A sewage system that is near a well or stream may contaminate the water.

Soil features affecting highway construction [4]

Most of the upland soils in Woodbury County formed in loess that overlies glacial till. The thickness of the loess ranges from many feet in the Ida-Hamburg association to about 4 to 8 feet in the Galva association. In places where streams have dissected the landscape, glacial till is exposed; the till is the parent material of Shelby and Steinauer soils. Soils of the Albaton-Haynie-Onawa, Luton-Salix, and McPaul-Kennebec-Colo associations developed in alluvium and occupy about 25 percent of the county. The soils in many small drainageways and stream channels in the uplands also formed in alluvium.

Monona, Ida, Hamburg, and Galva soils are the most extensive of the soils that formed in loess. They are nearly level to very steep. Monona and Galva soils are generally classified A–6 or A–7–6 (ML–CL) in the AASHO system. Group indexes are 8 to 18. Ida soils are generally classified A–6 or A–4 (ML–CL), and Hamburg soils, A–4 (ML or ML–CL). Group indexes for these soils are generally 6 to 10. These soils erode easily where runoff is concentrated. Sodding, paving, or check dams are needed in gutters and ditches to control erosion. Nearly vertical back slopes in the drier Hamburg soils are stable where good ditch drainage has been installed.

In the soils that formed in loess, the seasonal high water table generally is above the depth at which the loess and glacial till come into contact. In these areas the in-place density of the loess is relatively low and the moisture content is high. Subdrains are needed on the back slopes to intercept seepage in places, because the high moisture content may cause instability of embankments unless it is

[4] By DONALD A. ANDERSON, soils engineer, Iowa State Highway Commission.

TABLE 3.—*Engineering*

[Tests performed by the Iowa State Highway Commission according to standard

Soil name and location	Parent material	Iowa report No. AAD3—	Depth from surface	Moisture-density data[1]	
				Maximum dry density	Optimum moisture
			In.	*Lb. per cu. ft.*	*Pct.*
Albaton clay: 50 feet W. and 75 feet S. of NE. corner of NW¼NW¼ sec. 23, T. 86 N., R. 47 W.	Alluvium.	12827	12–18	89	26
Blake silty clay loam: 300 feet W. and 200 feet N. of SE. corner of NE¼ sec. 24, T. 88 N., R. 48 W.	Alluvium.	12821	13–20	97	22
		12822	20–40	97	20
Castana silt loam: 700 feet N. of SE. corner of SW¼NW¼ sec. 31, T. 86 N., R. 44 W.	Alluvial and colluvial material.	12831	18–30	99	19
Chute loamy fine sand: 740 feet W. and 280 feet N. of SE. corner of SE¼NE¼ sec. 6, T. 89 N., R. 44 W.	Eolian sand.	12829	7–17	111	12
Hamburg silt loam: 700 feet N. and 170 feet W. of SE. corner of SW¼NW¼ sec. 31, T. 86 N., R. 44 W.	Wisconsin loess.	12832	5–30	106	16
Haynie silt loam: 70 feet S. and 130 feet E. of NW. corner of sec. 1, T. 87 N., R. 48 W.	Alluvium.	12820	20–30	98	17
Ida silt loam: 980 feet S. and 100 feet W. of NE. corner of SW¼ sec. 7, T. 89 N., R. 44 W.	Wisconsin loess.	12830	6–15	104	19
Modale silt loam: 1,100 feet N. of SE. corner of SW¼SW¼ sec. 33, T. 88 N., R. 47 W.	Alluvium.	12823	11–21	102	19
		12824	40–46	88	29
Onawa silty clay: 20 feet NW. of center of SW¼ sec. 26, T. 86 N., R. 47 W.	Alluvium.	12825	7–14	89	20
		12826	33–45	100	29

[1] Based on AASHO Designation T 99–57, Method A (*1*).

[2] Mechanical analyses according to AASHO Designation T 88–57. Results by this procedure frequently differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method, and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soil.

test data

procedures of the American Association of State Highway Officials (AASHO)]

Mechanical analysis data [2]						Liquid limit	Plasticity index	Classification	
Percentage passing sieve—		Percentage smaller than—						AASHO [3]	Unified [4]
No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.				
						Pct.			
------------	100	98	96	87	70	84	55	A-7-6(20)	CH
100	98	87	69	46	35	52	29	A-7-6(18)	CH
100	97	69	26	7	5	30	5	A-4(8)	ML
100	99	77	38	20	14	40	17	A-6(11)	CL
[5] 49	10	7	4	2	1	([6])	([6])	A-3(0)	SP-SM
100	99	81	33	13	9	31	8	A-4(8)	ML-CL
------------	100	89	52	17	12	36	12	A-6(9)	ML-CL
100	99	83	44	23	15	37	15	A-6(10)	CL
100	77	44	25	16	11	32	12	A-6(9)	CL
100	99	97	93	83	68	85	57	A-7-6(20)	CH
------------	100	97	92	80	64	80	53	A-7-6(20)	CH
------------	100	81	37	18	11	37	15	A-6(10)	CL

[3] Based on AASHO Designation M 145-49.

[4] Based on the Unified Soil Classification System (*22*). SCS and Bureau of Public Roads have agreed to consider that all soils having plasticity indexes within 2 points from A-line are to be given a borderline classification. Examples of borderline classifications are ML-CL and SP-SM.

[5] 90 percent of the material passed the No. 40 sieve, and 100 percent passed the No. 10 sieve.

[6] Nonplastic.

TABLE 4.—*Estimated engineering*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil that may have column of this table. Borrow pits, Made land, Marsh, and Riverwash are not included

Soil name and map symbols	Depth from surface	Classification		
		Dominant USDA texture	Unified	AASHO
	Inches			
Albaton:				
155.	0–10	Silty clay loam	CH	A-7-6(18)
	10–60	Clay	CH	A-7-6(20)
156, 945.	0–60	Clay	CH	A-7-6(20)
Alluvial land: 315.	0–50	(1)	(1)	(1)
Blake: 144.	0–20	Light silty clay loam	CL or CH	A-7-6(14–18)
	20–60	Silt loam	ML–CL, ML, or CL	A-4(8) or A-6(8–12)
Blencoe: 44.	0–19	Silty clay	OH or CH	A-7-5 or A-7-6(20)
	19–30	Silty clay loam	CL or CH	A-7-6(14–18)
	30–60	Silt loam	ML or CL	A-4(8) or A-6(8–12)
Blend:				
244, 245.	0–14	Silty clay or heavy silty clay loam	OH or CH	A-7-6(14–20)
	14–23	Light silty clay loam	CL or ML–CL	A-4(8) or A-6(8–12)
	23–72	Clay or silty clay	CH	A-7-6(20)
850.	0–10	Silt loam	ML or ML–CL	A-6(8–12)
	10–24	Silty clay or heavy silty clay loam	OH or CH	A-7-6(20)
	24–33	Light silty clay loam	CL	A-6(8–12)
	33–82	Clay or silty clay	CH	A-7-6(20)
Calco: 733.	0–50	Silty clay loam	CL, CH, or OH	A-7-5 or A-7-6(14–18)
Carr: 538.	0–33	Fine sandy loam	SM or SC	A-2-4(0) to A-4(4)
	33–70	Loamy very fine sand	SM	A-2-4(0)
Castana: 3E, 983E.	0–10	Silt loam	ML or CL	A-4(6–8) or A-6(8–12)
	10–60	Silt loam	ML or CL	A-4(6–8) or A-6(8–12)
Chute: 25E3.	0–60	Loamy fine sand or fine sand	SM or SP–SM	A-3(0) or A-2-4(0)
*Colo:				
11B, 133. For Judson part of 11B, see Judson series.	0–34	Silty clay loam	OH, CH or CL	A-7-5 or A-7-6(14–20)
	34–93	Silty clay loam	CH or CL	A-7-6(14–20)
845.	0–10	Silt loam	ML–CL	A-6(8–12)
	10–44	Silty clay loam	OH, CH or CL	A-7-6(14–20)
Corley: 233.	0–27	Silt loam	CL	A-7-6(10–14)
	27–60	Silty clay loam	CL or CH	A-7-6(16–18)
Forney:				
553.	0–72	Clay or silty clay	CH	A-7-6(20)
851.	0–10	Silty clay loam	CH	A-7-6(14–19)
	10–60	Silty clay	CH	A-7-6(20)
Galva: 310B, 310C2, 310D2.	0–11	Medium to heavy silty clay loam	ML or ML–CL	A-7-6(14–18)
	11–28	Silty clay loam	ML–CL	A-7-6(12–16)
	28–60	Silt loam	ML–CL	A-6(12) or A-7-6(14)
Grable:				
513.	0–10	Silty clay loam	CL or ML–CL	A-6(8–12)
	10–20	Silt loam	ML	A-6(8–12)
	20–60	Fine sand	SM	A-2-4
514.	0–20	Silt loam	ML	A-6(8–12)
	20–60	Loamy sand and fine sand	SM or SP–SM	A-2-4 or A-3(0)
Hamburg: 2G.	0–60	Silt loam	ML or ML–CL	A-4(6–8)
Haynie: 137.	0–90	Silt loam	ML or ML–CL	A-4(8) to A-6(12)

properties of the soils

different properties and limitations. It is necessary to follow carefully the instructions for referring to other series that appear in the first in this table, because their properties are variable or because evaluations were not made]

Percentage passing sieve— No. 4 (4.7 mm.)	Percentage passing sieve— No. 10 (2.0 mm.)	Percentage passing sieve— No. 200 (0.074 mm.)	Permeability	Available moisture capacity	Reaction	Shrink-swell potential
			Inches per hour	*Inches per inch of soil*	*pH value*	
100	100	97–100	0. 2–0. 63	0. 19	7. 4–7. 8	High.
100	100	97–100	<0. 02	. 14	7. 4–8. 4	High.
100	100	97–100	<0. 02	. 14	7. 4–8. 4	High.
95–100	90–100	(1)	(1)	(1)	6. 6–8. 4	(1).
100	100	94–100	0. 2–2. 0	. 19	7. 4–8. 4	Moderate to high.
100	100	94–100	0. 63–6. 3	. 18	7. 9–8. 4	Moderate.
100	100	98–100	<0. 06	. 15	6. 6–7. 8	High.
100	100	94–100	0. 2–0. 63	. 19	7. 4–7. 8	Moderate to high.
100	100	94–100	0. 63–2. 0	. 20	7. 9–8. 4	Moderate.
100	100	96–100	<0. 06	. 14	6. 1–7. 3	High.
100	100	92–100	0. 2–0. 63	. 17	7. 4–7. 8	Moderate.
100	100	96–100	<0. 06	. 14	7. 4–7. 8	High.
100	100	92–100	0. 63–2. 0	. 17	7. 4–8. 4	Moderate.
100	100	96–100	<0. 06	. 14	6. 1–7. 3	High.
100	100	92–100	0. 2–0. 63	. 17	7. 4–7. 8	Moderate.
100	100	96–100	<0. 06	. 14	7. 4–7. 8	High.
100	100	96–100	0. 2–0. 63	. 21	7. 9–8. 4	High.
100	100	25–50	2. 0–6. 3	. 12	7. 9–8. 4	Low.
100	100	20–30	2. 0–6. 3	. 08	7. 9–8. 4	Low.
100	100	95–100	0. 63–2. 0	. 21	6. 6–7. 3	Low to moderate.
100	100	95–100	0. 63–2. 0	. 18	7. 9–8. 4	Low to moderate.
100	100	5–20	6. 3–20. 0	. 06	7. 9–8. 4	Very low or none.
100	100	92–100	0. 2–0. 63	. 21	6. 1–7. 3	High.
100	100	92–100	0. 2–0. 63	. 19	6. 6–7. 3	High.
100	100	95–100	0. 63–2. 0	. 19	7. 4–8. 4	Moderate.
100	100	92–100	0. 2–0. 63	. 21	6. 1–7. 3	High.
100	100	95–100	0. 63–2. 0	. 20	5. 6–6. 5	Moderate.
100	100	95–100	0. 2–0. 63	. 17	6. 1–7. 3	High.
100	100	97–100	<0. 06	. 14	6. 6–7. 8	High.
100	100	97–100	0. 2–0. 63	. 19	7. 4–7. 8	High.
100	100	97–100	<0. 06	. 14	6. 6–7. 8	High.
100	100	96–100	0. 63–2. 0	. 21	5. 6–6. 5	Moderate to high.
100	100	96–100	0. 63–2. 0	. 19	6. 6–7. 3	Moderate to high.
100	100	90–100	0. 63–2. 0	. 18	6. 6–7. 3	Moderate.
100	100	85–100	0. 63–2. 0	. 20	6. 6–7. 3	Moderate.
100	100	85–95	0. 63–2. 0	. 18	7. 4–8. 4	Moderate.
100	100	10–30	6. 3–20. 0	. 06	7. 4–8. 4	Low.
100	100	80–95	0. 63–2. 0	. 18	7. 4–8. 4	Low to moderate.
100	100	5–30	6. 3–20. 0	. 06	7. 9–8. 4	Low.
100	100	97–100	0. 63–6. 3	. 17	7. 9–8. 4	Low.
100	100	70–100	0. 63–2. 0	. 18	7. 4–7. 8	Low.

TABLE 4.—*Estimated engineering*

Soil name and map symbols	Depth from surface	Classification		
		Dominant USDA texture	Unified	AASHO
	Inches			
Holly Springs: 734.	0–24	Silty clay loam	OH, CH or CL	A–7–5 or A–7–6 (14–19)
	24–45	Silty clay or clay	CH or OH	A–7–6 (20)
Ida: 1B3, 1C3, 1D3, 1E3, 1F3, 1G3.	0–60	Silt loam	ML–CL	A–4(8) to A–6(10)
Judson: 8B.	0–34	Silty clay loam	CL or OL	A–6(9) to A–7–6(13)
	34–60	Silty clay loam	CL	A–6(10) to A–7–6(12)
Keg: 46.	0–21	Silt loam	ML–CL or CL	A–6(8–12) or A–7–6 (10–14)
	21–60	Silt loam	ML–CL	A–6(8–12)
Kennebec: 212A, 212B.	0–35	Silt loam	OL, CL or ML–CL	A–6(8–12) or A–7–6 (10–14)
	35–60	Silty clay loam	CL	A–6(8–12) or A–7–6 (10–14)
Lakeport: 436.	0–27	Silty clay loam	OH, CH or CL	A–7–6(14–19)
	27–45	Silty clay loam	CH or CL	A–7–6(14–19)
Luton:				
66.	0–14	Clay	CH or OH	A–7–6(20)
	14–48	Clay	CH	A–7–6(20)
366.	0–12	Silty clay loam	OH, CH or CL	A–7–6(14–19)
	12–60	Clay	CH	A–7–6(20)
*McPaul: 887B, 896, 955. For Albaton and Blake parts of 896, see Albaton and Blake series; for Kennebec part of 887B, see Kennebec series.	0–30	Silt loam	ML–CL	A–6(8–12)
	30–60	Light silty clay loam	CL	A–7–6(7–14)
Modale: 147,149.	0–10	Silt loam or silty clay loam	CL, CH or ML–CL	A–6(8–10) or A–7–6 (14–18)
	10–21	Loam	ML–CL	A–6(8–10)
	21–90	Silty clay	CH	A–7–6(20)
Monona: 10A, 10B, 10B2, 10C2, 10D2, 10D3, 10E2, 10E3, 10F2.	0–12	Silt loam	ML–CL	A–7–6(10–15)
	12–42	Silt loam	ML–CL	A–7–6(10–15)
	42–60	Silt loam	ML–CL	A–6(8–12) to A–7–6 (10–14)
Moville: 275.	0–27	Silt loam	ML–CL	A–6(8–10)
	27–55	Silty clay	CH or OH	A–7–6(20)
Napa: 68.	0–42	Clay	CH	A–7–6(20)
	42–80	Clay, predominantly stratified	CH	A–7–6(20)
*Napier: 12C, 170D, 984C. For Castana part of 170D, see Castana series.	0–22	Silt loam	ML–CL	A–7–6(10–13)
	22–60	Silt loam	ML–CL	A–7–6(10–13)
Onawa:				
145.	0–10	Silt loam	ML–CL	A–6(8–12)
	10–29	Silty clay	CH	A–7–6(20)
	29–60	Silt loam	CL or ML–CL	A–4(6–8) to A–6(8–12)
146.	0–29	Silty clay	CH	A–7–6(20)
	29–60	Silt loam	CL or ML–CL	A–4(6–8) to A–6(8–12)

properties of the soils—Continued

Percentage passing sieve— No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)	Permeability	Available moisture capacity	Reaction	Shrink-swell potential
			Inches per hour	*Inches per inch of soil*	*pH value*	
100	100	96–100	0. 2–0. 63	. 21	7. 9–8. 4	High.
100	100	96–100	<0. 06	. 14	7. 9–8. 4	High.
100	100	95–100	0. 63–2. 0	. 18	7. 4–8. 4	Low.
100	100	90–100	0. 63–2. 0	. 22	6. 1–7. 3	Moderate.
100	100	90–100	0. 63–2. 0	. 19	6. 1–6. 5	Moderate.
100	100	90–98	0. 63–2. 0	. 21	6. 6–7. 3	Moderate.
100	100	80–98	0. 63–2. 0	. 18	6. 1–7. 8	Moderate.
100	100	90–100	0. 63–2. 0	. 21	6. 1–6. 5	Moderate.
100	100	90–100	0. 63–2. 0	. 19	6. 6–7. 3	Moderate.
100	100	96–100	0. 2–2. 0	. 21	6. 1–7. 3	High.
100	100	90–100	0. 2–0. 63	. 19	6. 6–7. 3	High.
100	100	96–100	<0. 06	. 15	6. 6–7. 3	High.
100	100	96–100	<0. 06	. 14	6. 6–7. 3	High.
100	100	95–100	0. 2–0. 63	. 18	6. 1–7. 3	High.
100	100	96–100	<0. 06	. 14	6. 6–7. 3	High.
100	100	95–100	0. 63–2. 0	. 19	7. 4–7. 8	Moderate.
100	100	95–100	0. 63–2. 0	. 19	7. 4–8. 4	Moderate.
100	100	85–100	0. 63–2. 0	. 21	6. 6–7. 8	Moderate.
100	100	70–85	0. 63–2. 0	. 20	7. 9–8. 4	Moderate.
100	100	96–100	<0. 2	. 16	7. 9–8. 4	High.
100	100	96–100	0. 63–2. 0	. 22	6. 1–6. 5	Moderate.
100	100	96–100	0. 63–2. 0	. 20	6. 1–7. 3	Moderate.
100	100	96–100	0. 63–2. 0	. 20	7. 4–8. 4	Moderate.
100	100	90–100	0. 63–2. 0	. 21	7. 4–8. 4	Moderate.
100	100	96–100	<0. 06	. 16	6. 6–7. 3	High.
100	100	96–100	<0. 06	. 14	8. 4–9. 0	High.
100	100	90–100	<0. 06	. 14	8. 4–9. 0	High.
100	100	96–100	0. 63–2. 0	. 23	6–1. 7. 3	Moderate.
100	100	96–100	0. 63–2. 0	. 21	6. 6–7. 8	Moderate.
100	100	95–100	0. 63–2. 0	. 19	7. 4–8. 4	Moderate.
100	100	96–100	0. 06–0. 2	. 14	7. 4–8. 4	High.
100	100	90–100	0. 63–6. 3	. 19	7. 9–8. 4	Moderate.
100	100	96–100	0. 06–0. 2	. 14	7. 4–8. 4	High.
100	100	90–100	0. 63–6. 3	. 19	7. 9–8. 4	Low to moderate.

TABLE 4.—*Estimated engineering*

Soil name and map symbols	Depth from surface	Classification		
		Dominant USDA texture	Unified	AASHO
	Inches			
Owego:				
552.	0–14	Silty clay	CH	A–7–6(20)
	14–22	Silt loam, stratified	CL or ML–CL	A–4(6–8) or A–6(8–12)
	22–90	Silty clay, stratified	CH	A–7–6(20)
852.	0–10	Silt loam	ML–CL	A–6(8–12)
	10–24	Silty clay	CH	A–7–6(20)
	24–32	Silt loam	CL or ML–CL	A–4(6–8) or A–6(8–12)
	32–90	Silty clay, stratified	CH	A–7–6(20)
Percival: 515.	0–17	Silty clay	CH	A–7–6(20)
	17–60	Fine sand	SM or SP–SM	A–2–4(0) or A–3(0)
Salida: 73C2, 73E3, 73G3.	0–13	Sandy loam with some gravel	SM–SC or SM	A–1 or A–2
	13–60	Gravelly loamy sand	SP–SM	A–1–a, A–1–b, or A–2
Salix: 36, 865.	0–16	Light silty clay loam	OL or ML–CL	A–7–6(12–15)
	16–29	Silty clay loam	ML–CL or CL	A–6(8–12)
	29–60	Silt loam	ML–CL	A–6(8–12)
*Sarpy: 237B, 237C, 238A, 885. For Alluvial land part of 885, see Alluvial land.	0–24	Loamy fine sand	SM or SP–SM	A–2–4(0)
	24–60	Loamy fine sand	SM or SP–SM	A–2–4 or A–3(0)
Shelby: 24D2, 624F3.	0–11	Light clay loam or loam	CL	A–4(8) to A–6(12–14)
	11–22	Clay loam	CL	A–6(10) to A–7–6(14)
	22–60	Clay loam	CL	A–6(6) to A–7–6(10)
*Solomon:				
466.	0–17	Silty clay or clay	CH or OH	A–7–6(20)
	17–60	Silty clay	CH	A–7–6(20)
897. For Luton part, see Luton series.	0–10	Silt loam	ML–CL	A–6(8–12)
Spillville: 958.	0–40	Loam	ML or ML–CL	A–6(8–14) or A–7–6 (10–14)
	40–60	Loam	ML or ML–CL	A–4(6) to A–6(12)
*Steinauer: 33D2, 33E2, 33F2, 35G2. For Shelby part of 35G2, see Shelby series.	0–4	Light clay loam	CL	A–6(8–13)
	4–60	Clay loam	CL	A–6(8–13)
*Terril: 27B, 27C, 888E. For Castana part of 888E, see Castana series.	0–28	Loam	ML or ML–CL	A–4(5) to A–6(9)
	28–60	Loam grading to clay loam at depth of more than 43 inches.	ML or ML–CL	A–6(6–12)
Wadena:				
108B, 108C2, 708A, 708B.	0–6	Silt loam or loam	ML–CL or CL	A–6(6–10) or A–4 to A–6(4–8)
	6–22	Light silty clay loam or clay loam	ML–CL or CL	A–6(8–12)
	22–60	Sand and gravel	SP–SM	A–1–b
709A, 709B.	0–7	Silt loam or light silty clay loam	ML or CL	A–6(6–10)
	7–34	Light silty clay loam to silt loam	CL	A–6(8) to A–7–6(14)
	34–42	Clay loam	CL	A–6(6–10)
	42–60	Gravelly sand	SP–SM or SM	A–1–b or A–2–4(0)
Waubonsie: 49.	0–27	Fine sandy loam	SM	A–2–4(0) to A–4(4)
	27–60	Clay	CH	A–7–6(20)
Woodbury: 67.	0–16	Silty clay	CH or OH	A–7–6(20)
	16–36	Silty clay	CH	A–7–6(20)
	36–42	Silty clay loam	CH or CL	A–7–6(14–19)
	42–60	Silt loam	ML or CL	A–6(8–12)

[1] Variable.

properties of the soils—Continued

Percentage passing sieve—			Permeability	Available moisture capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
			Inches per hour	*Inches per inch of soil*	*pH value*	
100	100	96–100	<0. 06	. 14	6. 6–7. 8	High.
100	100	90–100	0. 63–2. 0	. 17	7. 9–8. 4	Moderate.
100	100	97–100	<0. 06	. 14	7. 4–7. 8	High.
100	100	95–100	0. 63–2. 0	. 19	7. 4–8. 4	Moderate.
100	100	96–100	<0. 06	. 14	7. 4–8. 0	High.
100	100	90–100	0. 63–2. 0	. 17	7. 9–8. 4	Low to moderate.
100	100	97–100	<0. 06	. 14	6. 6–7. 8	High.
100	100	96–100	0. 06–0. 2	. 17	7. 9–8. 4	High.
100	100	5–30	6. 3–20. 0	. 06	7. 9–8. 4	Low.
80–90	70–80	20–30	2. 0–6. 3	. 10	6. 6–7. 3	Low.
75–90	50–70	5–20	>20. 0	. 04	7. 4–8. 4	None.
100	100	94–100	0. 63–2. 0	. 21	6. 6–7. 3	Moderate.
100	100	94–100	0. 63–2. 0	. 20	6. 6–7. 3	Moderate.
100	100	94–100	0. 63–2. 0	. 19	7. 4–8. 4	Moderate.
100	100	10–35	>20. 0	. 08	6. 6–7. 4	Low.
100	100	5–30	>20. 0	. 04	7. 4–7. 9	Low.
90–95	80–90	55–65	0. 63–2. 0	. 18	6. 6–7. 3	Moderate.
85–95	80–90	50–65	0. 2–0. 63	. 16	6. 1–7. 3	Moderate.
85–95	80–90	50–65	0. 2–0. 63	. 15	6. 6–8. 4	Moderate.
100	100	96–100	<0. 06	. 17	7. 4–8. 4	High.
100	100	96–100	<0. 06	. 14	7. 9–8. 4	High.
100	100	95–100	0. 63–2. 0	. 19	7. 4–8. 4	Moderate.
100	95–100	65–80	0. 63–2. 0	. 20	6. 6–7. 8	Moderate.
100	95–100	60–75	0. 63–2. 0	. 15	6. 6–7. 3	Moderate.
95–100	85–97	55–75	0. 63–2. 0	. 18	7. 9–8. 4	Moderate.
95–100	85–97	55–75	0. 2–0. 63	. 16	7. 9–8. 4	Moderate.
100	90–100	60–80	0. 63–2. 0	. 21	5. 6–7. 3	Moderate.
100	90–100	60–80	0. 63–2. 0	. 17	6. 1–7. 3	Moderate.
100	95–100	55–70	0. 63–2. 0	. 21	5. 6–6. 0	Moderate.
100	95–100	55–70	0. 63–2. 0	. 21	6. 1–6. 5	Moderate.
70–90	60–80	5–25	>20. 0	. 04	7. 4–8. 4	None.
100	100	85–95	0. 63–2. 0	. 21	6. 1–6. 6	Moderate to high.
100	100	85–95	0. 63–2. 0	. 21	6. 1–7. 3	Moderate to high.
100	90–100	55–70	0. 63–2. 0	. 18	6. 6–7. 3	Moderate.
70–90	60–80	5–25	>20. 0	. 04	7. 4–8. 4	Very low.
100	80–90	25–50	2. 0–6. 3	. 12	7. 4–8. 4	Low.
100	100	96–100	<0. 06	. 14	7. 4–8. 4	High.
100	100	96–100	<0. 06	. 15	6. 1–7. 3	High.
100	100	96–100	<0. 06	. 14	6. 6–7. 8	High.
100	100	80–100	0. 2–0. 63	. 19	6. 6–7. 3	High.
100	100	85–95	0. 63–2. 0	. 20	7. 9–8. 4	Moderate.

TABLE 5.—*Interpretations of*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil that may that appear in the first

Soil series and map symbols	Suitability as a source of —			Soil features affecting—		
	Topsoil	Sand and gravel	Road fill	Highway location	Farm ponds: Reservoir areas	Farm ponds: Embankments
Albaton: 155, 156, 945.	Poor: high clay content; low organic-matter content.	Not suitable	Very poor: poor shear strength and workability; high compressibility.	Seasonal high water table; very plastic.	Very slow or slow permeability; nearly level.	Fair to poor stability and compaction characteristics; good resistance to piping.
Alluvial land: 315	Poor to good	Generally not suitable: inclusions of poorly graded sand in places.	Poor to good	Flood hazard; seasonal high water table.	Rapid permeability in places; nearly level.	(2)
Blake: 144	Fair: low organic-matter content; moderately high clay content.	Not suitable	Poor to fair: fair to poor workability and shear strength; medium to high compressibility.	Occasional high water table; plastic in surface layer.	Moderately slow permeability to depth of about 2 feet; moderate or moderately rapid below this depth; nearly level.	Fair stability; fair to poor compaction characteristics; fair to good resistance to piping.
Blencoe: 44	Poor: high clay content.	Not suitable	Very poor to depth of about 2 feet: poor shear strength and workability; high compressibility; fair at depth below 2 feet.	Seasonal high water table; very plastic in layers near surface; high organic-matter content in surface layer.	Very slow permeability to depth of about 2 feet, moderate below this depth; nearly level.	Fair to poor stability and compaction characteristics; high organic-matter content in surface layer; poor resistance to piping in silt loam at depth of about 30 inches.
Blend: 244, 245, 850	Poor: high clay content.	Not suitable	Very poor: poor shear strength and workability; high compressibility.	Seasonal high water table; very plastic; high organic-matter content in surface layer.	Very slow permeability; nearly level.	Fair to poor stability and compaction characteristics; good resistance to piping; high organic-matter content in surface layer.
Borrow pits: BP	Poor: low organic-matter content; high clay content in places.	Not suitable	(2)	(2)	Nearly level; features variable.	Nearly level; features variable.

See footnote at end of table.

engineering properties

have different properties and limitations. For this reason it is necessary to follow carefully the instructions for referring to other series column of this table]

Soil features affecting—Continued					Degree and kind of limitation for septic tank disposal fields
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	
Very slow or slow permeability; tile drains do not function well; surface outlets not adequate in places.	Medium available moisture capacity; intake rate varies with amount of vertical cracking; nearly level.	Nearly level	Nearly level	Fair to poor bearing capacity; poor shear strength; high shrink-swell potential; seasonal high water table; poor drainage.	Severe: very slow or slow permeability; seasonal high water table.
Natural drainage normally adequate; subject to flooding.	Properties variable; subject to flooding; nearly level in most places.	Nearly level	Nearly level	Seasonal high water table in most places.	Severe: seasonal high water table in many places; subject to flooding.
Natural drainage adequate.	High available moisture capacity; medium intake rate; nearly level.	Nearly level	Nearly level	Fair to poor bearing capacity; poor to fair shear strength; moderate to high shrink-swell potential.	Slight: moderate to moderately rapid permeability at depth below about 2 feet; occasional high water table.
Very slow permeability to depth of about 2 feet, moderate below this depth; fairly well suited to tile drains, but outlets not adequate in many places.	High available moisture capacity; intake rate varies with amount of vertical cracking in the clayey material; nearly level.	Nearly level	Nearly level	Poor bearing capacity and shear strength; moderate to high shrink-swell potential; seasonal high water table.	Severe: very slow permeability to depth of about 2 feet and moderate below this depth; seasonal high water table.
Very slow permeability; tile drains do not function well; surface outlets not adequate in places.	Medium available moisture capacity; intake rate varies with amount of vertical cracking; nearly level.	Nearly level	Nearly level	Fair to poor bearing capacity; poor shear strength; high shrink-swell potential; seasonal high water table; poor drainage.	Severe: very slow permeability; seasonal high water table.
Drainage needed; low elevation makes disposal of water impractical.	Subject to frequent ponding; low elevation; depressional.	Nearly level	Nearly level	Seasonal high water table; low elevation.	Severe: seasonal high water table.

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TABLE 5.—*Interpretations of*

Soil series and map symbols	Suitability as a source of—			Soil features affecting—		
	Topsoil	Sand and gravel	Road fill	Highway location	Farm ponds: Reservoir areas	Farm ponds: Embankments
Calco: 733	Fair: moderately high clay content.	Not suitable	Very poor: poor shear strength and workability; high compressibility.	Flood hazard; seasonal high water table; plastic; high organic-matter content in surface layer.	Moderately slow permeability; nearly level.	Fair to poor stability and compaction characteristics; good resistance to piping; high content of organic-matter in surface layer.
Carr: 538	Fair: low organic-matter content; medium available moisture capacity.	Fair to good: poorly graded; considerable amount of fines in places.	Good: fair to good shear strength and workability; low compressibility.	Features generally favorable; erodible.	Moderately rapid permeability; nearly level.	Fair stability; fair to good compaction characteristics; fair resistance to piping; pervious if compacted.
Castana: 3E, 983E	Good	Not suitable	Fair to poor: medium compressibility; fair workability and shear strength.	Erodible; moderately steep and rolling to hilly. Severe gullying in Gullied land part of 983E.	Moderate permeability; moderately steep and rolling to hilly. Severe gullying in Gullied land part of 983E.	Fair to poor stability and compaction characteristics; poor resistance to piping.
Chute: 25E3	Poor: very low organic-matter content; low available moisture capacity.	Fair to poor: poorly graded; considerable amount of fines in places.	Fair to good: low compressibility; good shear strength; fair workability.	Erodible; moderately sloping and rolling to hilly.	Rapid permeability; moderately sloping and rolling to hilly.	Poor to fair stability; fair to good compaction characteristics; poor resistance to piping; pervious if compacted.
*Colo: 11B, 133, 845. For Judson part of 11B, see Judson series.	Fair: moderately high in clay content.	Not suitable	Very poor: poor shear strength and workability; high compressibility.	Flood hazard; seasonal high water table; plastic; high organic-matter content in surface layer.	Moderately slow permeability; nearly level; narrow valleys in some places.	Fair to poor stability and compaction characteristics; good resistance to piping; high organic-matter content in surface layer.
Corley: 233	Good	Not suitable	Poor: fair to poor shear strength and workability; medium to high compressibility; subject to ponding.	Subject to ponding; seasonal high water table; plastic; depressional.	Moderately slow permeability; depressional.	Fair stability; fair to poor compaction characteristics; good resistance to piping.

See footnotes at end of table.

engineering properties—Continued

Soil features affecting—Continued					Degree and kind of limitation for septic tank disposal fields
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	
Moderately slow permeability; suited to tile drains; outlets not adequate in some places; subject to flooding.	High available moisture capacity; medium intake rate; subject to flooding.	Nearly level	Nearly level	Fair to poor bearing capacity; poor shear strength; high shrink-swell potential; seasonal high water table; poor drainage.	Severe: seasonal high water table; subject to flooding; moderately slow permeability.
Natural drainage adequate.	Medium available moisture capacity; moderately rapid intake rate; nearly level.	Nearly level	Nearly level	Good to fair bearing capacity; susceptible to liquefaction.	Slight: moderately rapid permeability; danger of contamination of streams and water supply.
Natural drainage adequate.	High available moisture capacity; medium intake rate; moderately steep and rolling to hilly.	Features generally favorable.	Features generally favorable; erodible. Severe gullying in Gullied land part of 983E.	Poor bearing capacity; fair shear strength; susceptible to liquefaction; moderately steep and rolling to hilly.	Severe: slopes and gullying; moderate permeability. Severe gullying in Gullied land part of 983E.
Natural drainage adequate.	Low available moisture capacity; rapid intake rate; moderately sloping and rolling to hilly.	Sandy; difficult to vegetate; erodible.	Erodible; sandy; difficult to vegetate; low available moisture capacity.	Features generally favorable; susceptible to liquefaction.	Slight to moderate: rapid permeability; moderately sloping and rolling to hilly; danger of contamination of streams and water supply.
Moderately slow permeability; suited to tile drains; outlets not adequate in some places; subject to flooding.	High available moisture capacity; moderately slow intake rate; subject to flooding; nearly level.	Nearly level	Nearly level	Fair to poor bearing capacity; poor shear strength; high shrink-swell potential; seasonal high water table; poor drainage.	Severe: seasonal high water table; subject to flooding moderately slow permeabiliy.
Moderately slow permeability; suited to tile drains, but surface outlets improve efficiency; deep cuts needed to provide outlets in most places.	High available moisture capacity; moderately slow intake rate; subject to ponding; depressional.	Nearly level or depressional.	Nearly level or depressional.	Fair to poor bearin capacity and shear strength; moderate to high shrink-swell potential; seasonal high water table; poor drainage; subject to ponding.	Severe: moderately slow permeability seasonal high water table; subject to ponding after heavy rains.

TABLE 5.—*Interpretations of*

Soil series and map symbols	Suitability as a source of—			Soil features affecting—		
	Topsoil	Sand and gravel	Road fill	Highway location	Farm ponds: Reservoir areas	Farm ponds: Embankments
Forney: 553, 851	Poor: high in content of clay.	Not suitable	Very poor: poor shear strength and workability; high compressibility.	Seasonal high water table; very plastic.	Very slow permeability; nearly level.	Fair to poor stability; poor compaction characteristics; good resistance to piping.
Galva: 310B, 310C2, 310D2.	Fair to good: moderately high organic-matter content in surface layer; surface layer is thin in places; moderately high clay content.	Not suitable	Fair: fair to poor shear strength; medium to high compressibility; fair to poor workability.	Gently sloping to sloping and undulating to rolling.	Moderate permeability; gently sloping to sloping and undulating to rolling.	Fair stability; fair to poor compaction characteristics; fair to poor resistance to piping.
Grable: 513, 514.	Fair: low organic-matter content.	Not suitable	Fair: fair shear strength; good to fair workability; medium compressibility.	Occasional high water table.	Rapid permeability at depth below 2 feet; nearly level.	Fair to poor stability; fair compaction characteristics; poor resistance to piping.
Hamburg: 2G	Fair: low organic-matter content.	Not suitable	Fair: fair shear strength; good to fair workability; medium compressibility.	Erodible; steep	Moderate to moderately rapid permeability; steep.	Poor stability; poor compaction characteristics; poor resistance to piping.
Haynie: 137	Fair to good: low organic-matter content.	Not suitable	Fair: fair shear strength; good to fair workability; medium compressibility.	Erodible; occasional high water table.	Moderate permeability; nearly level.	Poor stability; fair compaction characteristics; poor resistance to piping.
Holly Springs: 734	Fair: moderately high in clay content.	Not suitable	Very poor: poor shear strength and workability; high compressibility.	Flood hazard; seasonal high water table; plastic; high organic-matter content in surface layer.	Very slow permeability at depth below 2 feet; nearly level.	Poor stability and compaction characteristics; good resistance to piping; high organic-matter content in surface layer.
Ida: 1B3, 1C3, 1D3, 1E3, 1F3, 1G3.	Fair: low organic-matter content.	Not suitable	Fair: fair to poor shear strength and workability; medium compressibility.	Erodible; gently sloping and undulating to steep.	Moderate permeability; gently sloping and undulating to steep.	Poor to fair stability and compaction characteristics; poor resistance to piping.

See footnotes at end of table.

engineering properties—Continued

Soil features affecting—Continued					Degree and kind of limitation for septic tank disposal fields
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	
Very slow permeability; tile drains do not function well; surface outlets not adequate in places.	Medium available moisture capacity; intake rate varies with amount of vertical cracking; nearly level.	Nearly level	Nearly level	Fair to poor bearing capacity; poor shear strength; high shrink-swell potential; seasonal high water table; poor drainage.	Severe: very slow permeability; seasonal high water table.
Natural drainage adequate.	High available moisture capacity; medium intake rate; gently sloping to sloping and undulating to rolling.	Features generally favorable.	Features generally favorable.	Fair to poor bearing capacity and shear strength; moderate to high shrink-swell potential; gently sloping to sloping, and undulating to rolling.	Slight where slope is not more than 6 percent; moderate where slope is 6 to 10 percent; severe where slope is more than 10 percent; moderate permeability.
Natural drainage normally adequate.	Medium to low available moisture capacity; medium intake rate; nearly level.	Nearly level	Nearly level	Good to poor bearing capacity; fair shear strength.	Slight to moderate: rapid permeability in sandy layer at depth below 2 feet; contamination hazard; occasional high water table.
Natural drainage adequate.	High available moisture capacity; medium intake rate; steep.	Slope is 30 to 75 percent.	Slope is 30 to 75 percent.	Poor bearing capacity; fair shear strength; susceptible to liquefaction; steep.	Severe: moderate to moderately rapid permeability; steep.
Natural drainage normally adequate.	High available moisture capacity; medium to low intake rate; nearly level; soil tends to seal if irrigated by furrow method.	Nearly level	Nearly level	Poor bearing capacity; fair shear strength.	Slight: moderate permeability; high water table occasionally.
Permeability moderately slow in surface layer and very slow at depth below about 2 feet; tile drains do not function well.	High available moisture capacity; moderately slow intake rate; subject to flooding; nearly level.	Nearly level	Nearly level	Poor bearing capacity and shear strength; high shrink-swell potential; poor or very poor drainage.	Severe: seasonal high water table; subject to flooding; permeability is moderately slow in surface layer and very slow at depth below about 2 feet.
Natural drainage adequate.	High available moisture capacity; medium intake rate; gently sloping and undulating to steep.	Features generally favorable; slope is as much as 40 percent in places; difficult to vegetate.	Erodible; slope is as much as 40 percent in places; difficult to vegetate.	Poor bearing capacity; fair to poor shear strength; gently sloping and undulating to steep.	Slight where slope is not more than 6 percent; moderate where slope is 6 to 10 percent; severe where slope is more than 10 percent; moderate permeability.

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TABLE 5.—*Interpretations of*

Soil series and map symbols	Suitability as a source of—			Soil features affecting—		
	Topsoil	Sand and gravel	Road fill	Highway location	Farm ponds	
					Reservoir areas	Embankments
Judson: 8B	Good	Not suitable	Poor: poor shear strength; fair workability; medium compressibility.	Subject to local runoff; high organic-matter content in surface layer.	Moderate permeability; gently sloping; occupies narrow valleys in many places.	Fair stability; fair compaction characteristics; fair resistance to piping; high organic-matter content in surface layer.
Keg: 46	Good	Not suitable	Fair to poor: fair shear strength; good to fair workability; medium compressibility.	Erodible	Moderate permeability; nearly level.	Poor stability and compaction characteristics; poor resistance to piping.
Kennebec: 212A, 212B.	Good	Not suitable	Poor: fair shear strength; good to fair workability; medium compressibility.	Flood hazard; erodible; organic-matter content in surface layer.	Moderate permeability; nearly level or gently sloping; occupies narrow valleys in some places.	Fair to poor stability and compaction characteristics; fair resistance to piping; high organic-matter content in surface layer.
Lakeport: 436	Fair: moderately high clay content.	Not suitable	Very poor: poor shear strength and workability; high compressibility.	Seasonal high water table; plastic; high organic-matter content in surface layer.	Moderately slow to moderate permeability; nearly level.	Poor stability and compaction characteristics; good resistance to piping; high organic-matter content in surface layer.
Luton: 66, 366	Poor: high clay content.	Not suitable	Very poor: poor shear strength and workability; high compressibility.	Seasonal high water table; very plastic; high organic-matter content in surface layer.	Very slow permeability; nearly level.	Fair to poor stability; poor compaction characteristics; good resistance to piping; high organic-matter content in surface layer.
Made land: ML	Poor: mixed materials; includes materials other than soil in many places.	Not suitable	Not suitable: mixed mateials; includes materials other than soil in many places.	(2)	(2)	(2)

See footnotes at end of table.

engineering properties—Continued

Soil features affecting—Continued					Degree and kind of limitation for septic tank disposal fields
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	
Natural drainage normally adequate; suited to tile drainage.	High available moisture capacity; medium intake rate; undulating.	Features generally favorable.	Features generally favorable.	Fair to poor bearing capacity; poor shear strength; moderate shrink-swell potential.	Slight to moderate: moderate permeability; subject to local surface runoff.
Natural drainage adequate.	High available moisture capacity; medium intake rate; nearly level.	Nearly level	Nearly level	Fair to poor bearing capacity; fair shear strength; moderate shrink-swell potential.	Slight: moderate permeability.
Natural drainage normally adequate; subject to flooding; suited to tile drainage.	High available moisture capacity; medium intake rate; subject to flooding; nearly level or undulating.	Features generally favorable; nearly level in many places.	Features generally favorable.	Fair to poor bearing capacity; fair shear strength; moderate shrink-swell potential.	Severe: moderate permeability; subject to flooding and local surface runoff.
Natural drainage adequate at times; moderately slow permeability; suited to tile drainage.	High available moisture capacity; moderately slow intake rate; nearly level.	Nearly level	Nearly level	Poor bearing capacity and shear strength; high shrink-swell potential; seasonal high water table.	Moderate to severe: seasonal high water table; moderately slow permeability to a depth of about 3 feet and moderate below this depth.
Very slow permeability; tile drains do not function well; surface outlets not adequate in places.	Medium available moisture capacity; intake rate varies with amount of vertical cracking; nearly level.	Nearly level	Nearly level	Fair to poor bearing capacity; poor shear strength; high shrink-swell potential; seasonal high water table; poorly drained to very poorly drained.	Severe: very slow permeability; seasonal high water table.
Natural drainage adequate in many places.	(2)	Nearly level in most places.	(2)	(2)	(2).

TABLE 5.—*Interpretations of*

Soil series and map symbols	Suitability as a source of—			Soil features affecting—		
	Topsoil	Sand and gravel	Road fill	Highway location	Farm ponds: Reservoir areas	Farm ponds: Embankments
Marsh: 354	Poor: high clay content in many places; removal impractical.	Not suitable	Not suitable; high organic-matter content; wet.	Flood hazard; subject to ponding; high water table; high organic-matter content in surface layer.	Ponded much of the time; depressional.	Various soil materials; high organic-matter content in surface layer.
*McPaul: 70, 887B, 896, 955. For Albaton and Blake parts of 896, see Albaton and Blake series; for Kennebec part of 887B, see Kennebec series.	Fair: low organic-matter content.	Not suitable	Fair: fair shear strength; good to fair workability; medium compressibility.	Flood hazard; seasonal high water table; erodible.	Moderate permeability; nearly level or gently sloping; occupies narrow valleys in some places.	Fair to poor stability; fair compaction characteristics; fair to poor resistance to piping.
Modale: 147, 149	Fair: low organic-matter content.	Not suitable	Fair to depth of 2 feet; fair shear strength; good to fair workability; medium compressibility; very poor at depth below 2 feet.	Seasonal high water table; very plastic at depth below 2 feet.	Very slow to slow permeability at depth below 2 feet; nearly level.	Fair to poor stability and compaction characteristics at depth below 2 feet; good resistance to piping.
Monona: 10A, 10B, 10B2, 10C2, 10D2, 10D3, 10E2, 10E3, 10F2.	Good: medium or moderately high in organic-matter content in surface layer; surface layer thin in places.	Not suitable	Fair: fair shear strength; good to fair workability; medium compressibility.	Erodible; nearly level to steep.	Moderate permeability; nearly level to steep.	Fair stability; fair compaction characteristics; fair to poor resistance to piping.
Moville: 275	Fair: low organic-matter content.	Not suitable	Fair to depth of 2 feet: fair to poor shear strength; good to fair workability; medium compressibility; very poor at depth below 2 feet.	Seasonal high water table; very plastic at depth below 2 feet.	Very slow permeability at depth below 2 feet; nearly level.	Poor stability and compaction characteristics at depth below about 2 feet; good resistance to piping.
Napa: 68	Poor: high content of clay and harmful salts.	Not suitable	Very poor: poor shear strength and workability; high compressibility.	Subject to ponding; seasonal high water table; very plastic; high organic-matter content in surface layer.	Very slow permeability; nearly level or depressional.	Fair to poor stability; poor compaction characteristics; good resistance to piping; high organic-matter content in surface layer.

See footnotes at end of table.

engineering properties—Continued

Soil features affecting—Continued					
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	Degree and kind of limitation for septic tank disposal fields
Major reclamation needed to secure adequate drainage.	Drainage needed; wide range of soil conditions; nearly level or depressional areas.	Nearly level or depressional.	Nearly level or depressional.	High water table; subject to ponding; low elevation.	Very severe: high water table; ponded most of the time.
Natural drainage normally adequate; subject to flooding; suited to tile drains.	High available moisture capacity; medium intake rate; nearly level.	Nearly level in many places.	Features generally favorable; nearly level in many places.	Fair to poor bearing capacity; fair shear strength; moderate shrink-swell potential.	Moderate to severe: subject to flooding in many places; seasonal high water table; moderate permeability.
Natural drainage normally adequate; tile drains do not function well.	High available moisture capacity; medium intake rate to depth of about 2 feet; slow below this depth; nearly level.	Nearly level	Nearly level	Fair to poor bearing capacity; poor shear strength; moderate to high shrink-swell potential; seasonal high water table.	Severe: very slow to slow permeability at depth below about 2 feet; seasonal high water table.
Natural drainage adequate.	High available moisture capacity; medium intake rate; nearly level to steep.	Features generally favorable; slope is as much as 30 percent.	Features generally favorable; slope is as much as 30 percent.	Fair to poor bearing capacity; fair shear strength; moderate shrink-swell potential; nearly level to steep.	Slight where slope is not more than 6 percent; moderate where slope is 6 to 10 percent; severe where slope is more than 10 percent; moderate permeability; nearly level to steep.
Natural drainage normally adequate; tile drains do not function well.	High available moisture capacity; medium intake rate in surface layer; very slow below this layer; nearly level.	Nearly level	Nearly level	Fair to poor bearing capacity and shear strength; high shrink-swell potential at depth below 2 feet; seasonal high water table.	Severe: very slow permeability at depth below about 2 feet; seasonal high water table.
Very slow permeability; tile drains do not function well; surface outlets not adequate in places.	Medium available moisture capacity; intake rate varies with amount of vertical cracking; nearly level or depressional.	Nearly level or depressional.	Nearly level or depressional.	Fair to poor bearing capacity; poor shear strength; high shrink-swell potential; seasonal high water table; very poorly drained.	Severe: very slow permeability; seasonal high water table; subject to ponding.

TABLE 5.—*Interpretations of*

Soil series and map symbols	Suitability as a source of—			Soil features affecting—		
	Topsoil	Sand and gravel	Road fill	Highway location	Farm ponds: Reservoir areas	Farm ponds: Embankments
*Napier: 12C, 170D, 984C. For Castana part of 170D, see Castana series.	Good	Not suitable	Poor: poor shear strength fair workability; medium compressibility.	Subject to local runoff; erodible; moderately sloping and rolling to steep; high organic-matter content in surface layer. Severe gullying in Gullied land part of 984C.	Moderate permeability; moderately sloping and rolling to steep. Severe gullying in the Gullied land part of 984C.	Fair stability and compaction characteristics; fair resistance to piping; high organic-matter content in surface layer.
Onawa: 145, 146	Poor: high clay content; low organic-matter content.	Not suitable	Very poor to depth of 2 feet; poor shear strength and workability; high compressibility; fair at depth below 2 feet.	Seasonal high water table; very plastic in the surface layer.	Moderate to moderately rapid permeability at depth below 2 feet; nearly level.	Fair to poor stability; poor compaction characteristics; fair resistance to piping.
Owego: 552, 852	Poor: high clay content; low organic-matter content.	Not suitable	Very poor: poor shear strength and workability; high compressibility.	Seasonal high water table; very plastic.	Very slow permeability; nearly level.	Fair stability; poor compaction characteristics; good resistance to piping.
Percival: 515	Poor: high clay content; low organic-matter content.	Not suitable	Very poor to depth of 2 feet: poor shear strength and workability; high compressibility; fair at depth below 2 feet.	Seasonal high water table; very plastic in surface layer.	Rapid permeability at depth below 2 feet; nearly level.	Fair to poor stability; generally poor compaction characteristics; poor resistance to piping.
Riverwash: 53	Poor: sand and gravel.	Fair to good: soil material varies; considerable amount of fines in places.	Good: mostly sand and gravel.	Flood hazard; high water table.	Variable, but very rapid permeability in most places; nearly level; subject to frequent flooding.	Good stability and compaction characteristics; pervious if compacted.
Salida: 73C2, 73E3, 73G3.	Poor: low or medium organic-matter content; low available moisture capacity; gravelly in most places.	Fair to good: fairly well graded mixture of sand and gravel; considerable amount of fines in places.	Good: good shear strength; good to fair workability; low compressibility.	Moderately sloping and rolling to steep; stones hinder excavation in places.	Very rapid permeability; moderately sloping and rolling to steep.	Fair stability; good compaction characteristics; poor resistance to piping; pervious if compacted.

See footnotes at end of table.

engineering properties—Continued

Soil features affecting—Continued					Degree and kind of limitation for septic tank disposal fields
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	
Natural drainage adequate.	High available moisture capacity; medium intake rate; moderately sloping and rolling to steep.	Features generally favorable.	Features generally favorable. Severe gullying in the Gullied land part of 984C.	Poor bearing capacity; poor shear strength; moderate shrink-swell potential.	Moderate: slope is a limitation; moderate permeability; receives runoff from higher lying soils.
Slow permeability in surface layer and moderate to moderately rapid permeability at depth below about 2 feet; suited to tile drains in most places; outlets not adequate in places.	High available moisture capacity; intake rate varies with amount of cracking in surface layer; medium intake rate at depth of about 2 feet; nearly level.	Nearly level	Nearly level	Fair to poor bearing capacity; poor shear strength; seasonal high water table; moderate to high shrink-swell potential.	Severe: moderate to moderately rapid permeability at depth below 2 feet; seasonal high water table.
Very slow permeability; tile drains do not function well; surface outlets not adequate in places.	Medium available moisture capacity; intake rate varies with amount of vertical cracking; nearly level.	Nearly level	Nearly level	Fair to poor bearing capacity; poor shear strength; high shrink-swell potential; seasonal high water table; poor drainage.	Severe: very slow permeability; seasonal high water table.
Natural drainage adequate in many places; tile drains do not function well.	Medium available moisture capacity; intake rate varies with amount of vertical cracking in surface layer; nearly level.	Nearly level	Nearly level	Fair bearing capacity; fair shear strength at depth below 2 feet; seasonal high water table; high shrink-swell potential in surface layer.	Moderate to severe; seasonal high water table; rapid permeability at depth below about 2 feet.
Natural drainage adequate; subject to frequent flooding.	Low available moisture capacity in most places; very rapid intake rate; frequent flooding.	Nearly level	Sand and gravel; nearly level.	High water table; frequent flooding.	Severe: high water table; flooding.
Natural drainage adequate.	Low available moisture capacity; rapid intake rate; moderately sloping and rolling to steep.	Sand and gravel near surface; difficult to vegetate; as much as 40 percent slope; erodible.	Sand and gravel near surface; slope is as much as 40 percent; difficult to vegetate.	Features generally favorable; moderately steep or steep in places; stones hinder excavation in places.	Moderate where slope is 5 to 9 percent; severe where slope is more than 9 percent; very rapid permeability; contamination hazard; moderately sloping and rolling to steep.

TABLE 5.—*Interpretations of*

Soil series and map symbols	Suitability as a source of—			Soil features affecting—		
	Topsoil	Sand and gravel	Road fill	Highway location	Farm ponds: Reservoir areas	Farm ponds: Embankments
Salix: 36, 865	Fair to good: moderately high clay content.	Not suitable	Poor: fair shear strength; fair to poor workability; medium compressibility.	Occasional high water table; surface layer is plastic and has high organic-matter content.	Moderate permeability; nearly level.	Fair stability; fair to poor compaction characteristics; fair resistance to piping.
*Sarpy: 237B, 237C, 238A, 885. For Alluvial land part of 885, see Alluvial land.	Poor: low organic-matter content; low available moisture capacity.	Fair to good: poorly graded; considerable amount of fines in places.	Good: good shear strength; good to fair workability; low compressibility.	Erodible; nearly level to rolling.	Very rapid permeability; nearly level to rolling.	Fair stability; fair to good compaction characteristics; poor resistance to piping; pervious if compacted.
Shelby: 24D2, 624F3	Fair: gravelly in places.	Not suitable	Good: fair shear strength; good to fair workability; low compressibility.	Erodible; moderately sloping and rolling to steep; seep spots in places.	Moderately slow permeability; moderately sloping and rolling to steep.	Fair to good stability and compaction characteristics; good resistance to piping.
*Solomon: 466, 897. For Luton part of 897, see Luton series.	Poor in clayey part of soil; fair in silt loam overwash.	Not suitable	Very poor: poor shear strength and workability; high compressibility.	Seasonal high water table; very plastic; high organic-matter content in surface layer.	Very slow permeability; nearly level.	Fair to poor stability; poor compaction characteristics; good resistance to piping.
Spillville: 958	Good	Poor to not suitable; poorly graded sand or gravel at depth of about 8 feet in places.	Fair: fair shear strength; good to fair workability; medium compressibility.	Flooding hazard; occasional high water table; high organic-matter content in surface layer.	Moderate permeability; nearly level; subject to flooding.	Fair stability; fair compaction characteristics; fair resistance to piping; high organic-matter content in surface layer.
*Steinauer: 33D2, 33E2, 33F2, 35G2. For Shelby part of 35G2, see Shelby series.	Poor: low organic-matter content; gravelly in places.	Not suitable	Good: fair shear strength; good to fair workability; low compressibility.	Erodible; moderately sloping and rolling to steep; hazard of seep spots in places.	Moderately slow permeability; some pockets of sand and gravel; moderately sloping and rolling to steep.	Fair to good stability and compaction characteristics; good resistance to piping.

See footnotes at end of table.

engineering properties—Continued

Soil features affecting—Continued					Degree and kind of limitation for septic tank disposal fields
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	
Natural drainage normally adequate.	High available moisture capacity; medium intake rate; nearly level.	Nearly level	Features generally favorable; nearly level.	Fair to poor bearing capacity; fair shear strength; moderate shrink-swell potential.	Slight: moderate permeability; high water table occasionally.
Natural drainage adequate.	Low available moisture capacity; rapid intake rate; nearly level to rolling.	Sandy; difficult to vegetate; erodible.	Erodible; sandy; difficult to vegetate; low available moisture capacity.	Susceptible to liquefaction and piping; other features generally favorable.	Slight: very rapid permeability; contamination hazard.
Natural drainage adequate.	High available moisture capacity; moderately slow intake rate; moderately sloping and rolling to steep.	Features generally favorable; some stones.	Stones in places	Fair to good bearing capacity and shear strength; moderate shrink-swell potential; moderately sloping and rolling to steep.	Moderate where slope is not more than 9 percent; severe where slope is more than 9 percent; moderately sloping and rolling to steep; moderately slow permeability.
Very slow permeability; tile drains do not function well; surface outlets not adequate in places.	Medium available moisture capacity; intake rate varies with amount of vertical cracking; nearly level.	Nearly level	Nearly level	Fair to poor bearing capacity; poor shear strength; high shrink-swell potential; seasonal high water table; poor to very poor drainage.	Severe: very slow permeability; seasonal high water table.
Natural drainage adequate.	High available moisture capacity; medium intake rate; subject to flooding; nearly level.	Nearly level	Nearly level	Fair bearing capacity and shear strength; moderate shrink-swell potential.	Severe: moderate permeability; subject to frequent flooding; occasional high water table.
Natural drainage adequate.	High available moisture capacity; moderately slow intake rate; moderately sloping and rolling to steep.	Features generally favorable; some stones; slope is as much as 40 percent.	Some stones; as much as 40 percent slope.	Fair to good bearing capacity and shear strength; moderate shrink-swell potential; moderately sloping and rolling to steep.	Moderate where slope is not more than 9 percent; severe where slope is more than 9 percent; moderately slow permeability; moderately sloping and rolling to steep.

TABLE 5.—*Interpretations of*

Soil series and map symbols	Suitability as a source of—			Soil features affecting—		
	Topsoil	Sand and gravel	Road fill	Highway location	Farm ponds	
					Reservoir areas	Embankments
*Terril: 27B, 27C, 888E. For Castana part of 888E, see Castana series.	Good	Not suitable	Fair: fair shear strength; good to fair workability; medium compressibility.	Subject to local runoff; erodible; undulating or rolling; high organic-matter content in surface layer.	Moderate permeability; undulating or rolling.	Fair stability; fair to poor compaction characteristics; fair resistance to piping.
Wadena: 108B, 108C2, 708A, 708B, 709A, 709B.	Good	Suitable at depth below 2 to 4 feet; mixed sand and gravel.	Good at depth below 2 to 4 feet; good shear strength; good to fair workability; low compressibility; fair above this depth.	Features generally favorable; nearly level or undulating; stones hinder excavation in places.	Very rapid permeability at depth below 2 feet; nearly level or undulating in most places.	Good stability and compaction characteristics; good resistance to piping; pervious if compacted.
Waubonsie: 49	Fair: low organic-matter content; medium available moisture capacity.	Not suitable at depth below 2 or 3 feet, fair above; poorly graded; considerable amount of fines in places.	Fair to depth of 2 feet; fair to good shear strength and workability; low compressibility; very poor at depth below about 2 feet.	High water table occasionally; very plastic at depth below 2 feet.	Very slow permeability at depth below 2 feet; nearly level.	Fair to poor stability; fair to poor compaction characteristics, and good resistance to piping at depth below about 2 feet.
Woodbury: 67	Poor: high clay content.	Not suitable	Very poor shear strength and workability; high compressibility.	Seasonal high water table; very plastic; high organic-matter content in surface layer.	Very slow permeability; nearly level.	Fair to poor stability; poor compaction characteristics; good resistance to piping.

[1] Engineers and others should not apply specific values to the estimates given for bearing capacity of soils.
[2] Properties variable.

engineering properties—Continued

Soil features affecting—Continued					Degree and kind of limitation for septic tank disposal fields
Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	
Natural drainage adequate.	High available moisture capacity; medium intake rate; undulating or rolling.	Features generally favorable.	Features generally favorable.	Fair to poor bearing capacity; fair shear strength; moderate shrink-swell potential.	Slight where slope is not more than 6 percent; moderate where slope is 6 to 10 percent; severe where slope is more than 10 percent; moderate permeability.
Natural drainage adequate.	Medium to high available moisture capacity; medium intake rate to depth of 2 to 4 feet; rapid below this depth; nearly level or undulating.	Features generally favorable; difficult to vegetate in places if cuts expose sand and gravel.	Features generally favorable; sand and gravel at depth below 2 to 4 feet.	Features generally favorable; stones hinder excavation in places.	Slight where slope is not more than 5 percent; moderate where slope is 5 to 9 percent; very rapid permeability at a depth below about 2 feet; contamination hazard.
Natural drainage normally adequate; tile drains do not function well.	Medium available moisture capacity in most places; medium intake rate to depth of about 2 feet; very slow below this depth; nearly level.	Nearly level	Nearly level	Fair to poor bearing capacity; poor shear strength and high shrink-swell potential at depth below 2 feet.	Severe: very slow permeability at depth below about 2 feet; periodic high water table.
Very slow permeability; tile drains do not function well; surface outlets not adequate in places.	High available moisture capacity; intake rate varies with amount of vertical cracking; nearly level.	Nearly level	Nearly level	Fair to poor bearing capacity; poor shear strength; high shrink-swell potential; seasonal high water table; poor drainage.	Severe: very slow permeability to depth of about 3 feet, and moderately slow below this depth; seasonal high water table.

controlled enough to permit the soil to compact to a higher density.

The Shelby and Steinauer soils formed in glacial till outcrops that are mainly sloping and are adjacent to stream valleys. They are classified primarily as A–6 and CL, but the subsoil of Shelby soils is A–7–6 in places. Because of their high in-place density, soils formed in glacial till generally do not have an excessively high moisture content and are more readily compacted than are soils that formed in loess.

In many places unstable areas for constructing roads are associated with pockets of sand and gravel that commonly are interspersed throughout the till and in places are water bearing. Frost heaving is likely to occur if the road grade is only a few feet above these pockets and the sand and gravel is overlain by loess or silty till. Frost heaving is less likely to occur if these deposits are drained or the soil above them is replaced with coarse-textured material or clayey glacial till. Where Shelby and Steinauer soils occur in or along a project that is being graded, the material is normally placed in the upper part of the subgrade throughout the unstable areas.

Soils that occur on bottom lands of the Missouri River and other streams and drainageways formed in alluvium. Many of these soils have a high content of organic matter in the surface layer and are very clayey throughout most of the profile. These include soils of the Albaton, Blend, Forney, Solomon, Holly Springs, Luton, Napa, Owego and Woodbury series. Where these soils are used as embankment material, the clayey material should not be placed within 5 feet of the embankment grade. In places these soils occupy old oxbows, and they may be very soft. Therefore, they should be investigated for stability and consolidation if they are required to support an embankment more than 5 feet in height. A number of soils, including those of the Blencoe and Onawa series, are clayey to a depth of about 2 feet and are coarser textured below this depth. Modale and Waubonsie soils are clayey at a depth below about 2 feet and are coarser textured above the clay.

The Colo, Calco, Kennebec, Spillville, Judson, and Napier soils have a thick surface layer that is high in content of organic matter. These soils are on bottom lands and in drainageways of uplands. The surface layer of these soils may consolidate erratically under the load of a heavy embankment. Consequently, sites for proposed embankments should be carefully investigated. Roadways through the bottom lands should be constructed on a continuous embankment that is above the level of floodwaters.

Many soils on bottom lands have a seasonal high water table. A number of them, especially those that formed in recent alluvium near the Missouri River, are dominantly sandy or have layers of fine sandy sediments in the solum or substratum. Among these are soils of the Onawa, Blake, Percival, Sarpy, and Carr series. An embankment constructed on these soils only a few feet above the water table may be damaged by frost heaving unless proper drainage is established or material not susceptible to frost action is used in the subgrade. Some of these soils are among the better sources of borrow material for road construction in the flood plain.

Wadena soils, mainly on benches along the Little Sioux River, formed in shallow deposits of silty or loamy sediments underlain by sand and gravel. These soils are sources of aggregates for the concrete and asphalt mixes used in road construction and for the gravel that is used to surface roads in the county.

In Woodbury County the bedrock is overlain by other deposits and it seldom affects road construction. A few outcrops of limestone, sandstone, and shale occur in Stone State Park.

Ratings are given in table 4 that show the suitability of the soils as a source of topsoil for use in embankments, cut slopes, and ditches, and as a source of borrow material for road construction. At many construction sites, several soils may occur within a short distance, and there may be major differences in the nature of the soil within the depth and scope of the proposed excavation.

Formation, Morphology, and Classification of the Soils

In this section the factors that have affected the formation of the soils of Woodbury County are discussed. Also discussed are the development of soil horizons and the classification of the soils. Table 6 gives the classification of all the soil series mapped in the county.

Factors of Soil Formation

Soil is produced by the action of soil-forming processes on materials deposited or accumulated by geologic forces. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material has accumulated and existed since accumulation; (3) the plant and animal life on and in the soil; (4) the relief, or lay of the land; and (5) the length of time the forces of soil development have been active.

Climate and vegetation are the active factors of soil genesis. They act on the parent material that has accumulated through the weathering of rocks and slowly change it into a natural body that has genetically related horizons. The effects of climate and vegetation are conditioned by relief. The parent material also affects the kind of profile that can be formed, and, in extreme cases, determines it almost entirely. Finally, time is needed for changing the parent material into a soil. It may be much or little, but some time is always required for horizon differentiation. Usually, a long time is required for the development of distinct horizons.

The factors of soil genesis are so closely interrelated that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four. Many of the processes of soil development are unknown.

Parent material

The soils of Woodbury County formed in loess, alluvium, glacial till, and eolian sand. A few outcrops of sandstone, limestone, and shale of Cretaceous age are in the vicinity of Stone State Park, but none of the soils mapped for this survey formed in these materials.

These parent materials are discussed briefly in the following paragraphs. Persons interested in a more detailed discussion may refer to some of the annual reports of the Iowa Geological Survey (*2,3*).

TABLE 6.—*Classification of soil series of Woodbury County*

Series	Family	Subgroup	Order
Albaton	Fine, montmorillonitic, calcareous, mesic	Vertic Haplaquents	Entisols.
Blake	Fine-silty, mixed, calcareous, mesic	Aquic Udifluvents	Entisols.
Blencoe	Clayey over loamy, montmorillonitic, mesic	Aquic Hapludolls	Mollisols.
Blend	Fine, montmorillonitic, noncalcareous, mesic	Fluventic Haplaquolls	Mollisols.
Calco	Fine-silty, mixed, calcareous, mesic	Cumulic Haplaquolls	Mollisols.
Carr	Coarse-loamy, mixed, calcareous, mesic	Typic Udifluvents	Entisols.
Castana	Fine-silty, mixed, mesic	Entic Hapludolls	Mollisols.
Chute	Mixed, mesic	Typic Udipsamments	Entisols.
Colo	Fine-silty, mixed, noncalcareous, mesic	Cumulic Haplaquolls	Mollisols.
Corley	Fine-silty, mixed, mesic	Argiaquic Argialbolls	Mollisols.
Forney	Fine, montmorillonitic, noncalcareous, mesic	Vertic Haplaquolls	Mollisols.
Galva	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Grable	Coarse-silty over sandy or sandy-skeletal, mixed, calcareous, mesic.	Typic Udifluvents	Entisols.
Hamburg	Coarse-silty, mixed, calcareous, mesic	Typic Udorthents	Entisols.
Haynie	Coarse-silty, mixed, calcareous, mesic	Typic Udifluvents	Entisols.
Holly Springs	Fine, montmorillonitic, calcareous, mesic	Cumulic Haplaquolls	Mollisols.
Ida	Fine-silty, mixed, calcareous, mesic	Typic Udorthents	Entisols.
Judson	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Keg	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Kennebec	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Lakeport	Fine, montmorillonitic, mesic	Aquic Hapludolls	Mollisols.
Luton	Fine, montmorillonitic, noncalcareous, mesic	Vertic Haplaquolls	Mollisols.
McPaul	Coarse-silty, mixed, calcareous, mesic	Typic Udifluvents	Entisols.
Modale	Coarse-silty over clayey, mixed, calcareous, mesic	Aquic Udifluvents	Entisols.
Monona	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Moville	Coarse-silty over clayey, mixed, calcareous, mesic	Aquic Udifluvents	Entisols.
Napa	Fine, montmorillonitic, calcareous, mesic	Typic Natraquolls	Mollisols.
Napier	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Onawa	Clayey over loamy, montmorillonitic, calcareous, mesic	Mollic Haplaquents	Entisols.
Owego	Fine, montmorillonitic, calcareous, mesic	Fluventic Haplaquolls	Mollisols.
Percival	Clayey over sandy or sandy-skeletal, montmorillonitic, calcareous, mesic.	Aquic Udifluvents	Entisols.
Salida	Sandy-skeletal, mixed, mesic	Entic Hapludolls	Mollisols.
Salix	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Sarpy	Mixed, mesic	Typic Udipsamments	Entisols.
Shelby	Fine-loamy, mixed, mesic	Typic Argiudolls	Mollisols.
Solomon	Fine, montmorillonitic, calcareous, mesic	Vertic Haplaquolls	Mollisols.
Spillville	Fine-loamy, mixed, mesic	Cumulic Hapludolls	Mollisols.
Steinauer	Fine-loamy, mixed, calcareous, mesic	Typic Udorthents	Entisols.
Terril	Fine-loamy, mixed, mesic	Cumulic Hapludolls	Mollisols.
Wadena	Fine-loamy over sandy or sandy-skeletal, mixed, mesic	Typic Hapludolls	Mollisols.
Waubonsie	Coarse-loamy over clayey, mixed, calcareous, mesic	Aquic Udifluvents	Entisols.
Woodbury	Fine, montmorillonitic, noncalcareous, mesic	Vertic Haplaquolls	Mollisols.

Loess is the most extensive parent material in the county. It is a yellowish-brown, wind-deposited material that consists mainly of silt particles but has clay and sand in smaller amounts. The loess contains no pebbles or stones, but it has numerous lime concretions that have formed since it was deposited.

Most of the soils on uplands formed in loess. The most extensive of these soils are those of the Ida and Monona series. Galva soils are in the northeastern part of the county, and Hamburg soils occupy the bluffs along the Missouri River. The loess is thickest on the bluffs and thinnest in the northeastern part of the county. It ranges from about 4 feet to more than 100 feet in thickness. In places, mainly on steep hillsides adjacent to the Little Sioux River valley, the loess has been removed by geologic erosion, and glacial till is exposed.

Soils that formed in loess are mainly silt loam or light silty clay loam. They provide an unrestricted rooting zone for plants, have high available moisture capacity and are generally well aerated.

Alluvium is the parent material of about one-quarter of the soils in the county. The largest area is in the Missouri River valley. Alluvium consists of sediment deposited along major streams and narrow upland drainageways and on low benches. It varies widely in texture because of differences in the materials from which it came and the manner in which it was deposited.

Some of the alluvial material, the local alluvium, has been transported only short distances and retains many of the characteristics of the soils from which it has washed. Judson and Napier soils, for example, generally are at the base of slopes below soils that formed in loess. Castana soils formed partly in material that moved downslope by the force of gravity. This material, colluvium, is included with local alluvium in this discussion. All these soils are similar in texture to the soils upslope.

About 30 soil series in Woodbury County formed in alluvium. Some of these soils formed in alluvium that has been in place long enough to be affected by other soil-forming processes. Luton, Keg, Salix, Lakeport, and Colo soils are in this group. Other soils formed in parent material of very recent alluvium. Sarpy, McPaul, Haynie, Modale, Onawa, Blake, and Albaton soils are in this group. The most noticeable difference in these soils is that the soils of the first group have accumulated more organic matter and have a darker, thicker surface layer than do those of the second group.

The alluvium and the soils that formed in it vary widely in texture (*10*). For example, Luton and Albaton soils formed entirely in clayey alluvium; Sarpy soils are loamy sand or sand; Keg, Haynie, McPaul, Napier, and Kennebec soils are silt loam; Colo and Lakeport soils are silty clay loam; and Blencoe, Blake, Blend, Holly Springs, Onawa, Modale, and Owego soils formed in alluvium that has layers of differing textures.

Alluvial soils that are mostly sand and gravel are mainly on benches near the Little Sioux River. They consist mostly of glacial outwash that has been carried and sorted by water (*4*). Salida soils, which developed in these coarse materials, are on hillsides or escarpments in the valleys. Wadena soils formed in medium-textured alluvium underlain by sand and gravel.

Glacial till is the parent material for only a few soils that occur throughout the uplands, especially in the eastern part of the county. Most of the thick glacial till deposits are covered by loess. The only large areas that are exposed are on steep hillsides near the Little Sioux River valley where the loess has been removed by erosion.

Most of the glacial till is from the Kansan glaciation. In the northeastern part of the county, where the Galva soils are most extensive, the geological age of the underlying till is uncertain (*19*, *3*). The unweathered till is firm, calcareous clay loam that contains pebbles, boulders, and sand, as well as silt and clay. The till is a heterogeneous mixture that shows little evidence of sorting or stratification. The mineral composition of its components is similar to that of unweathered loess (*9*). Shelby and Steinauer soils formed in glacial till.

Eolian sand is a minor component of parent material in the county. It was deposited by wind during the same period that the loess was deposited. The sand probably was picked up from sources only a few miles away and redeposited.

Eolian sand occurs throughout the uplands in small patches, mostly less than 10 acres in size. The patches are commonly on ridges or hillsides just east of stream valleys.

Eolian sand consists chiefly of quartz, which is very resistant to weathering and, therefore, has not been altered appreciably since it was deposited. Chute soils are the only ones that developed in eolian sand. They have a high content of sand and a low content of clay.

Bedrock outcrops occur only in a small area in and near Stone State Park. Thin soils developed in places in the weathered rock material that overlies the hard rock, but these are of minor extent.

Climate

The general climate has had an important overall influence on the characteristics of the soils but has not caused major differences among the soils. The local climatic differences influence soil characteristics and account for differences in soils within the same climatic region. Woodbury County soils developed under variable climatic conditions (*23*). In the post-Cary glaciation period, about 13,000 to 10,500 years ago, the climate was cool and the vegetation was dominated by conifers. From 10,500 to 8,000 years ago, a warming trend changed the vegetation from conifers to a mixed forest that was dominantly hardwoods. About 8,000 years ago, the climate became warmer and drier. Herbaceous prairie plants became dominant and have continued to dominate to the present time. About 3,000 years ago, a late change in the postglacial climate from relatively dry prairie conditions to more humid conditions began (*11*).

The present climate is midcontinental subhumid. Nearly uniform climate prevails throughout the county, although there is some variation in rainfall from west to east. The influence of the general climate is modified by local conditions in or near the developing soil. For example, on the very steep Hamburg soils on bluffs, most of the water runs off or soaks rapidly into the soil. This results in a warmer and drier microclimate than the average of nearby areas. Because of this, the vegetation is unlike that elsewhere in the county. Plants, such as yucca, common in drier parts of the Great Plains, grow in many places on the bluffs. Soils that tend to pond water, such as those of the Corley series, are colder and wetter than adjacent soils. Slopes that face north and east tend to be cooler and more moist than those that face south, and they are more likely to support natural stands of trees.

Weathering of parent material by water and air is activated by changes in temperature. As a result of weathering, changes caused by both physical and chemical actions take place. Rainfall has influenced the formation of the soils through its effect on the amount of leaching in soils and on the kinds and amount of vegetation that grows. Some variations in plant and animal life are caused by variations in temperature or by the action of other climatic forces on the soil material.

Plant and animal life

A number of kinds of living organisms are important in soil development. The activities of burrowing animals, worms, crayfish, and micro-organisms, for example, have greatly affected the properties of the soils. Differences in the kind of vegetation, however, commonly cause the more marked differences between soils.

Tall grasses were the dominant vegetation in Woodbury County at the time of settlement (*6*). Only about 20,000 acres were in trees. Trees, therefore, have had only a slight influence on soil development, and the soils do not vary a great deal because of this factor. Trees are most common on the steep soils near the Little Sioux River valley. Some of those stands have been in place long enough to have caused slight, but noticeable, changes in the soils. Trees, especially willow and cottonwood, also commonly grow near the larger streams. In this recent alluvium, however, not enough time has elapsed for the trees to have influenced soil development except to drop a thin litter of leaves and twigs on the soil surface.

Man changes soil mainly by causing accelerated erosion. Less obvious are chemical changes in the soil brought about by additions of lime and fertilizer, or changes in microbial activity and organic-matter content brought about by removing the native vegetation and substituting crops.

In this county soils of the McPaul and Moville series have been altered as a result of man's activities. In these bottom-land soils the original dark-colored surface layer has been covered by new parent material that is light colored and calcareous. This is material eroded from the uplands, largely because of man's farming operations.

Relief

Relief, or topography, refers to the lay of the land. It ranges from nearly level to very steep in Woodbury County. Relief is an important factor in soil formation because of its effect on drainage, runoff, height of the water table, and erosion. A difference in topography is the basic reason for the differing soil properties of some of the soils of the county.

Even though soils have formed in the same parent material, the influence of relief is seen in the color, thickness and horizonation of the soils. Soils of the Ida, Monona, and Corley series are examples of soils that formed in similar parent material but differ in characteristics mainly because of relief. Corley soils occur in low places where water accumulates; Monona soils are well drained and occur mostly on slopes where some of the water runs off; and Ida soils are in positions where most of the water runs off and where erosion has occurred at such a rate that little soil formation has taken place. The water that percolates through the soils removes clay from the A horizon, and much of this clay accumulates in the B horizon. Corley soils have accumulated more clay in the B horizon than Monona and Ida soils, because more water percolates through the profile. Monona soils have a thicker, darker colored surface layer than Ida soils and are leached of carbonates. Ida soils, where vegetation is relatively sparse and erosion has taken place, are calcareous at or near the surface.

Relief affects the color of the B horizon through its effect on drainage and soil aeration. The subsoil of a soil that has good drainage generally is brown because iron compounds are well distributed throughout the horizon and are oxidized. The subsoil of soils that have restricted drainage is generally grayish and mottled. For example, the well-drained Keg soils have a brownish subsoil, but the low-lying, poorly drained Luton soils have a gray or olive-gray subsoil. However, the texture of the parent material in the Missouri River bottomlands is generally a co-variant with elevation. The poor drainage of the Luton soils is caused by relief and the clayey texture.

Time

The passage of time enables the factors of relief, climate, and plant and animal life to bring about changes in the parent material. Similar kinds of soils are produced from widely differing kinds of parent material if other factors are active over long periods of time. Soil development is generally interrupted, however, by geologic events that expose new parent material.

New parent material has been added to the uplands at least three times, and in parts of the county four times (*18*, *19*). The bedrock has been covered by glacial drift from two or three glaciations. Then, the present surface material, the loess, was deposited. As a result, soils were buried, and further development of those soils stopped.

The radiocarbon technique for determining the age of carbonaceous material in loess and till has been used to date soils formed partly during the Wisconsin glaciation (*14*). Early Wisconsin is the age of the upper part of the loess on uneroded uplands (*15*), and the age of nearly level loessal soils on stable divides is about 14,000 years. Examples of such soils are those of the Monona and Galva series on ridgetops. In much of Iowa, including Woodbury County, geologic erosion has beveled side slopes and deposited sediments downslope (*12*). The soils on the side slopes that bevel and ascend to the divides are less than 14,000 years old, and some are less than 1,800 years old. Soils of the Napier, Kennebec, Colo, and Judson series formed in the sediments that washed from the side slopes. They are also less than 14,000 years old.

Some of the alluvial soils, such as those of the McPaul, Haynie, Carr, and Onawa series, developed in material deposited since settlement by man. Older soils, such as those of the Salix and Keg series, have not been flooded since before the first settlers plowed them. The difference in the time that the soil-forming factors have been active is reflected in the characteristics of the soils.

The percentage of soils that are about 14,000 years old and less than 14,000 years old can be obtained by extrapolating soil data by landscapes in counties where soil surveys have been completed (*7*). In Woodbury County about 95 percent of the soils are younger than 14,000 years.

Processes of Soil Horizon Differentiation

The differentiation of soil horizons is the result of four basic kinds of change. These are additions, removals, transfers, and transformations in the soil system. These four kinds of change affect the amount of organic matter, soluble salts, carbonates, sesquioxides, or silicate clay minerals in the soils.

The addition of organic matter is important to horizon differentiation in most soils. The soils of the flood plains are divided into two broad groups based mainly on this feature. Dark-colored soils have had organic matter added to the surface layer, and light-colored soils have not had such additions. The dark color distinguishes soils of the Luton series from those of the Albaton series, the Keg soils from Haynie soils, and Blencoe soils from Onawa soils. In some upland soils, such as those of the Ida and Steinauer series, the dark color of the surface layer is the only soil feature that reflects the basic processes of horizonation to any extent.

The removal of substances from parts of the soil profile accounts for some of the most obvious differences among a number of soils of the county. The leaching of calcium carbonates is an example. Such soils as those of the Ida and Steinauer series are calcareous at or near the surface because little calcium carbonate has been removed. Lime concretions are on the surface in many places. No B horizon has developed in these soils. In Monona and Shelby soils, the leaching of calcium carbonates from the upper part of the profile has resulted in the differentiation of a B horizon. Soils of the Monona and Ida series formed in calcareous loess; the Shelby and Steinauer soils formed in glacial till.

The transfer of substances from one horizon to another has occurred in some of the soils of Woodbury County. In Napa soils, for example, harmful salts are moved upward in the profile by a fluctuating water table and by capillary action. Phosphorus is removed from the subsoil by plant roots and transferred to parts of the plant growing above the ground. Then it is returned to the surface layer in the form of plant residue.

The translocation of silicate clay minerals is an important process in horizon differentiation. Percolating water carries the clay minerals in suspension from the A horizon to the B horizon where they accumulate in pores and root channels and as clay films on ped faces. This process has markedly influenced horizonation of the Corley soils. In other soils of the county, the A and B horizons are not markedly different in content of clay, and other evidence of clay movement is minimal. Another kind of transfer that is minimal in most soils, but occurs to some extent in very clayey soils, such as those of the Luton and Albaton series, is that brought about by shrinking and swelling. This causes cracks to form and some materials from the surface layer to transfer into lower parts of the profile.

Transformations are physical and chemical. For example, soil particles are weathered to smaller sizes. The primary apatite mineral in parent material is also weathered to secondary phosphorus compounds where the pH value declines to about 7 (*8*, *16*). This weathering process accounts for the difference in available phosphorus levels between soils formed in similar calcareous parent materials. The Ida and Monona soils, for example, formed in similar calcareous parent materials. Ida soils are very low in available phosphorus; Monona soils, which have been leached and are about neutral in pH value, are low in available phosphorus.

The reduction of iron is another example of a transformation. This process is called gleying and involves the saturation of the soil with water for long periods of time in the presence of organic matter. It is characterized by the presence of iron and by grayish colors. Gleying is evident in poorly drained and very poorly drained soils, such as those of the Luton series.

Classification of the Soils

The soils of Woodbury County have been classified according to the system of classification adopted for general use by the National Cooperative Soil Survey in 1965 and supplemented in March 1967 and in September 1968 (*21*). The system is under continual study, and readers interested in the development of the system should refer to the latest literature available.

Table 6 shows the classification of each of the soil series represented in Woodbury County. It gives the family, subgroup, and order for each series.

The classification system defines classes in terms of observable or measurable properties of soils (*17*). The properties chosen are primarily those that permit the grouping of soils that are similar in genesis. The classification is designed to encompass all soils. It has six categories. Beginning with the most inclusive, they are the order, the suborder, the great group, the subgroup, the family, and the series. These are briefly defined in the following paragraphs.

ORDER: Ten soil orders are recognized in the current system: Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate the soil orders are those that tend to give broad climatic groupings of soils. Two exceptions, Entisols and Histosols, occur in many different climates.

Two of the ten orders, Entisols and Mollisols, are represented in Woodbury County. Entisols are recent soils in which there has been no horizon development. Mollisols have a thick surface layer that has been darkened by organic matter.

SUBORDER: Each order is subdivided into suborders, primarily on the basis of those characteristics that seem to produce classes having the greatest genetic similarity. These are mainly characteristics that reflect either the presence or absence of waterlogging or soil differences resulting from climate or vegetation. The climatic range is narrower than that of the orders.

GREAT GROUP: Soil suborders are divided into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and similarity of the significant features. The horizons used to make separations are those in which clay, iron, or humus have accumulated or those that have pans that interfere with the growth of roots or the movement of water. The features used are the self-mulching properties of clays, soil temperature, chemical composition (mainly calcium, magnesium, sodium, and potassium), and the like.

SUBGROUP: Great groups are subdivided into subgroups, one representing the central (typic) segment of the group, and others, called intergrades, that have properties of one great group and also one or more properties of another great group, suborder, or order. Subgroups may also be made in instances where soil properties intergrade outside the range of any other great group, suborder, or order.

FAMILY: Families are established within a subgroup primarily on the basis of properties that affect the growth of plants or the behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence.

SERIES: The series consists of a group of soils that formed in a particular kind of parent material and have genetic horizons that, except for texture of the surface layer, are similar in differentiating characteristics and in arrangement in the soil profile. Among these characteristics are color, structure, reaction, consistence, and mineralogical and chemical composition.

General Nature of the County

This section discusses the early history and development of the county, farming trends, topography, and the climate.

History and Development

The Lewis and Clark expedition came up the Missouri River and passed what is now Woodbury County in 1804. The first settlers arrived in 1848, and Sioux City was founded a few years later.

The native vegetation at the time of settlement was mainly grass. The principal kinds were big bluestem, little bluestem, switchgrass, and indiangrass. Swamp grasses and rushes were in a sizable area of Marsh in the eastern part of the Missouri River valley.

The early settlers were plagued by serious infestations of grasshoppers, one so severe that money had to be appropriated to buy seed wheat for farmers who had lost their crop. The most serious hazard through the years, however, has been flooding. About 120,000 acres of the county are in the Missouri River valley, and damage is widespread when that stream overflows. Five other rivers and several large creeks flow through the county, and at times they have flooded and caused considerable damage. Sioux City is subject to flooding by the Missouri, Big Sioux, and Floyd Rivers, and by Perry Creek. In former years loss of life and property because of flooding was commonplace, but large upstream dams on the Missouri River and other flood control projects have greatly reduced the hazard.

By 1885, despite the hazards, the population of the county had grown to about 32,000 and that of Sioux City to 19,000. There were 173,604 acres in cultivation, including 74,189 acres in corn, 17,364 in wheat, and 11,488 in oats. Yields, calculated from acreage and total yield figures, were 37 bushels per acre for corn, 14 for wheat, and 30 for oats.

The first settlers engaged mainly in cash-grain farming. Wheat was the most important crop, but corn soon replaced wheat as the leader. Stock raising and feeding also increased rapidly in importance. In 1881 a stockyard company was organized. The stockyards at Sioux City are now among the largest in the world.

By 1960 the population of the county was approximately 110,000, and that of Sioux City was about 90,000. Another 18 towns or villages had populations up to about 1,000 people. In recent years the number of villages has decreased, and the rural population is declining. Sioux City had a 6.2 percent increase in population from 1950 to 1960.

Woodbury County has more than 160 manufacturing and processing firms. Plants in Sioux City are major processors of meat, honey, and popcorn, as well as other foods. A wide variety of other articles are produced in the county. Sioux City is also a retail and wholesale center for a large area that extends into four States.

The county is served by two airlines, five railroad companies, a number of trucking firms, and, recently, by a barge line on the Missouri River. Four U.S. highways cross the county, including Interstate Highway 29. A network of State and county highways puts any point in the county within a few miles of a hard-surface road. In addition, gravel roads run along most section lines.

Two State parks and numerous county and city parks are in Woodbury County.

Trends in Farming

In this section trends in farming are presented. The statistics used are from the 1965 Iowa annual farm census.

In recent years the number of people living on farms and the number of farms has decreased, but the total acreage in farms remained about the same. The size of an average farm has increased, as has the percentage of the acreage owned by the operator. In Woodbury County, there were 8,776 people living on 2,317 farms in 1965. An average farm was 238 acres in size, and 52.7 percent of the farms were owned by the operators. This compares to a State average of 223 acres per farm and 51.3 percent operator-owned.

The acreage of the more important crops has been reasonably consistent, but the acreage of rye, flaxseed, barley, and sorghum has decreased substantially. Drought conditions have caused sorghum to be substituted for corn in some years. The acreage of soybeans has been increased considerably in recent years. The number of acres of crops in Woodbury County in 1965 was as follows: corn, 154,462; oats, 29,134; soybeans, 60,391; wheat, 574; popcorn, 2,071; all hay, 32,325; and all pasture, 100,342. In addition, 101,882 acres were not harvested or pastured, and 44,143 acres were in lots, roads, woods, and wasteland.

The population of sheep and turkeys has increased markedly in recent years, but milk cows and chickens have decreased in number. The number of grain-fed cattle marketed has also increased. The number and the principal kinds of livestock raised and sold in 1965 was as follows: grain-fed cattle marketed, 82,796; grain-fed sheep and lambs marketed, 19,071; calves born, 14,711; lambs born, 4,467; sows farrowed, 32,429; milk cows, 4,075; beef cows, 11,341; hens and pullets of laying age, 101,709; commercial broilers raised, 6,320; and turkeys raised, 397,350.

Topography

Woodbury County is in the western part of the corn belt, near the rangelands of the West. This is an important factor in the development of the large livestock industry of the county.

About 40 percent of the county consists of nearly level and gently sloping soils in stream valleys, but most of the remaining 60 percent is rolling to hilly. Newcomers are often surprised to see row crops planted on the hillsides, because soils with similar slopes are considered suitable only for pasture in many parts of the world. In much of Woodbury County, however, row crops can be grown in regular rotations without excessive soil loss. This is largely because the soils formed in thick deposits of loess.

All of the county is in the watershed of the Missouri River. The major tributary streams that flow through the county are the Big Sioux, Floyd, Maple, Little Sioux, and West Fork of the Little Sioux Rivers and Perry, Big Whiskey, Elliott, and Wolf Creeks. These streams flow to the south and southwest. Only Perry Creek and the Big Sioux and Floyd Rivers enter the Missouri River in this county. The other streams drain into the Little Sioux River, either naturally or through drainage ditches constructed in the Missouri River valley. The Little Sioux River enters the Missouri River about 50 miles south of the county.

Elevations within the county vary by about 400 feet. The town of Hornick, in the Missouri River valley near the southern boundary of the county, is approximately 1,060 feet above sea level. Stone State Park, in the bluffs along the edge of the Missouri and Big Sioux River valleys, is at elevations of about 1,450 feet.

All the towns and villages of the county are at least partly in stream valleys, and about half of them are entirely within a valley. Seven of these towns and villages and parts of Sioux City are in the Missouri River valley.

Climate [5]

Woodbury County, in the central part of the westernmost tier of Iowa counties, slopes to the west and southwest towards the Missouri River. About 20 percent of the county is in the valleys of the Missouri and Big Sioux Rivers, about 20 percent lies in the tributary valleys, and most of the remaining 60 percent is upland. Tables 7 and 8 give temperature and precipitation data recorded at Mapleton, in Monona County. Climatic data from Mapleton, which is in the uplands, are more representative of Woodbury County than data from Sioux City, which is in the valley. The greatest variations in the climate of Woodbury County are in the distribution of minimum temperatures and warm-season showers.

On calm, clear nights minimum temperatures vary throughout the county, sometimes 10° F. or more. The warmest locations are normally in urban and upland areas, and the coldest are in rural lowlands. Maximum temperatures usually do not vary greatly. In an average summer, 30 days have a temperature of 90° or higher, which is generally too warm for optimum crop growth and development. Crops are affected by the evaporation that occurs when temperatures are above 90°.

[5] By PAUL J. WAITE, State climatologist, National Weather Service.

TABLE 7.—*Temperature and precipitation data*

[Data from Mapleton in Monona County, near the southeastern corner of Woodbury County. Period of record 1937 to 1966]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Average monthly maximum	Average monthly minimum	Average total	One year in 10 will have— Less than—	One year in 10 will have— More than—	Average number of days with snow cover of 1 inch or more	Average depth of snow on days with snow cover
	° F.	*° F.*	*° F.*	*° F.*	*Inches*	*Inches*	*Inches*	*Days*	*Inches*
January	29	9	51	−18	0. 56	0. 16	1. 32	16	4
February	34	13	53	−10	1. 04	. 27	2. 35	13	4
March	43	24	70	1	1. 66	. 47	3. 54	9	5
April	61	36	83	21	2. 47	. 88	4. 36	1	2
May	72	48	89	31	3. 94	1. 33	6. 77	(1)	1
June	80	59	94	44	4. 94	2. 65	8. 09	0	0
July	86	63	96	51	3. 47	1. 03	7. 21	0	0
August	85	62	96	48	3. 76	1. 40	8. 32	0	0
September	77	51	91	32	2. 66	. 33	6. 01	0	0
October	67	40	84	21	1. 52	. 18	3. 28	(1)	1
November	47	25	69	3	. 87	. 07	2. 14	4	3
December	35	15	55	−7	. 59	. 05	1. 22	9	3
Year	60	37			27. 48			52	4

[1] Less than half a day.

TABLE 8.—*Probabilities of last freezing temperatures in spring and first in fall*

[Data from Mapleton in Monona County, near the southeastern corner of Woodbury County]

Probability	Dates for given probability and temperature				
	16° F. or lower	20° F. or lower	24° F. or lower	28° F. or lower	32° F. or lower
Spring:					
1 year in 10 later than	April 15	April 23	April 30	May 8	May 17
2 years in 10 later than	April 10	April 18	April 25	May 5	May 12
5 years in 10 later than	March 30	April 7	April 15	April 23	May 2
Fall:					
1 year in 10 earlier than	October 23	October 16	October 11	September 23	September 16
2 years in 10 earlier than	October 28	October 21	October 16	September 28	September 21
5 years in 10 earlier than	November 7	October 31	October 26	October 8	October 1

The annual precipitation increases about 12 percent from the western part of the county to the eastern part. It averages about 24.5 inches in the western townships and about 27.5 inches in the eastern townships. Intense showers are more frequent over the uplands than over the western lowlands. In the years 1951 to 1960, Mapleton averaged 19 days with half an inch or more of rainfall, as compared with 16 days at Sioux City. The amount of rainfall is important in determining the erosion potential, and the sloping uplands are subject to sheet and gully erosion.

The greatest number of showers are reported in May, and almost all occur in the warm half of the year. Most heavy showers occur before the ground cover is well enough established to control erosion. About 75 percent of the annual precipitation falls as showers during the warm season from April through September. The amount of rainfall in scattered showers is variable over the county, but it averages out over a long period of time.

Crops need to be planted when there is ample moisture in the subsoil and the surface layer is relatively dry. Gentle, well-spaced showers are desirable throughout the cropping season. May and June are normally the rainiest months; dry periods are most likely late in July and late in August. The probability of receiving an inch or more of rainfall in a one-week period is about 2 years out of 5 in June and decreases to about 1 out of 4 in July and August. Well-developed corn requires about an inch of moisture per week during the summer; therefore, the amount of soil moisture available to plants in spring is important in anticipating seasonal growth.

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Glossary

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

Bottom land. (see Terrace, geological.)

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Catch crop. A supplementary crop grown at a time when the ground would ordinarily lie fallow, as between the plantings of two principal crops.

Catsteps. Stair-step effect on steep soils caused by natural, downhill slumping of the soil material.

Colluvium. Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Desilting basin. An area in which bottom-land fields are purposely flooded to permit sedimentation and prevent drainageways from becoming clogged with silt.

Drainage class (natural). Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low water-holding capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and have mottling in the lower B and the C horizons.

Somewhat poorly drained soils are wet for significant periods but not all the time, and in Podzolic soils commonly have mottlings below 6 to 16 inches, in the lower A horizon and in the B and C horizons.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Eolian soil material. Earthy parent material accumulated through wind action; commonly refers to sandy material in dunes or to loess in blankets on the surface.

Flood plain. Nearly level land, consisting of stream sediments, that borders a stream and is subject to flooding unless protected artificially.

Glacial drift (geology). Rock material transported by glacial ice and then deposited; also includes the assorted and unassorted materials deposited by streams flowing from glaciers.

Glacial outwash (geology). Cross-bedded gravel, sand, and silt deposited by melt water as it flowed from glacial ice.

Glacial till (geology). Unassorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Gleyed soil. A soil in which waterlogging and lack of oxygen have caused the material in one or more horizons to be neutral gray in color. The term "gleyed" is applied to soil horizons with yellow and gray mottling caused by intermittent waterlogging.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Loess. Fine-grained material, dominantly of silt-sized particles, that has been deposited by wind.

Mottling, soil. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent.* The size measurements are these: *fine,* less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium,* ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Permeability. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline.	9.1 and higher

Silty soils. Soils that have a high percentage of silt and a low percentage of sand.

Slope. The degree of soil incline, classified as follows:

	Percent
Nearly level	0 to 2
Gently sloping	2 to 6
Moderately sloping	5 to 9
Moderately sloping	6 to 10
Strongly sloping	9 to 14
Strongly sloping	10 to 15
Moderately steep	14 to 18
Moderately steep	15 to 20
Steep	18 to 25
Steep	20 to 30
Very steep	25 to 40
Very steep	30+

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular. Structureless* soils are (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that it may soak into the soil or flow slowly to a prepared outlet without harm. Terraces in fields are generally built so they can be farmed. Terraces intended mainly for drainage have a deep channel that is maintained in permanent sod.

Terrace (geological). An old alluvial plain, ordinarily flat or undulating, bordering a river, lake, or the sea. Stream terraces are frequently called second bottoms, as contrasted to flood plains, and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay.* The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

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