United States Department of Agriculture

Soil Conservation Service

In cooperation with Missouri Agricultural Experiment Station

Soil Survey of Atchison County, Missouri

How To Use This Soil Survey

General Soil Map

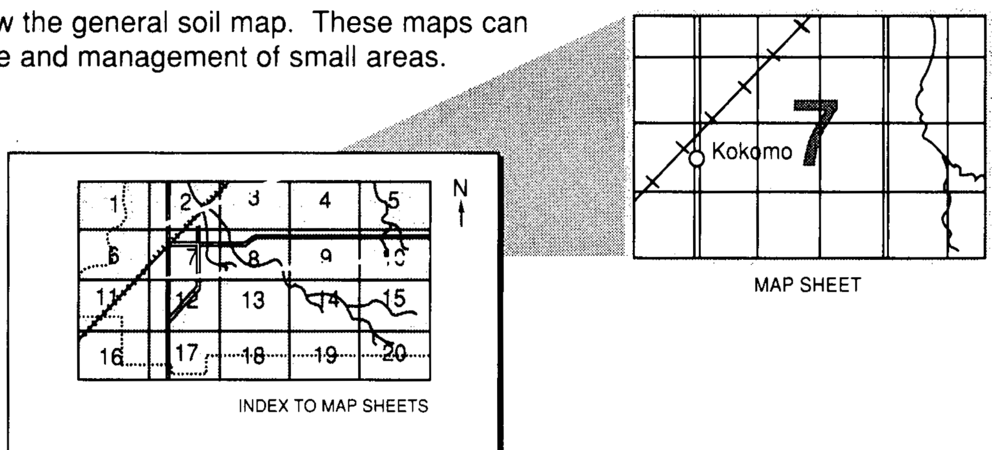
The general soil map, which is the color map preceding the detailed soil maps, shows the survey area divided into groups of associated soils called general soil map units. This map is useful in planning the use and management of large areas.

To find information about your area of interest, locate that area on the map, identify the name of the map unit in the area on the color-coded map legend, then refer to the section **General Soil Map Units** for a general description of the soils in your area.

Detailed Soil Maps

The detailed soil maps follow the general soil map. These maps can be useful in planning the use and management of small areas.

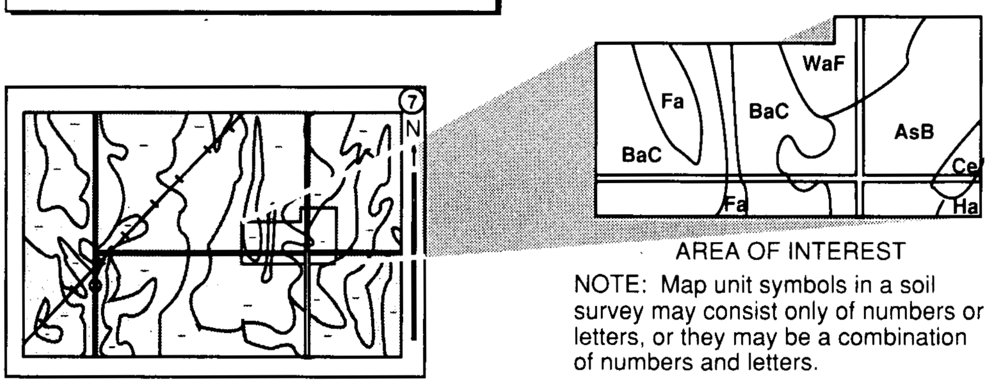
To find information about your area of interest, locate that area on the **Index to Map Sheets**, which precedes the soil maps. Note the number of the map sheet, and turn to that sheet.



INDEX TO MAP SHEETS

MAP SHEET

Locate your area of interest on the map sheet. Note the map unit symbols that are in that area. Turn to the **Index to Map Units** (see Contents), which lists the map units by symbol and name and shows the page where each map unit is described.



MAP SHEET

AREA OF INTEREST

NOTE: Map unit symbols in a soil survey may consist only of numbers or letters, or they may be a combination of numbers and letters.

The **Summary of Tables** shows which table has data on a specific land use for each detailed soil map unit. See **Contents** for sections of this publication that may address your specific needs.

This soil survey is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Soil Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey.

Major fieldwork for this soil survey was completed in 1987. Soil names and descriptions were approved in 1988. Unless otherwise indicated, statements in this publication refer to conditions in the survey area in 1987. This survey was made cooperatively by the Soil Conservation Service and the Missouri Agricultural Experiment Station. The Missouri Department of Natural Resources provided a soil scientist to assist with the fieldwork. This survey is part of the technical assistance furnished to the Atchison County Soil and Water Conservation District.

Soil maps in this survey may be copied without permission. Enlargement of these maps, however, could cause misunderstanding of the detail of mapping. If enlarged, maps do not show the small areas of contrasting soils that could have been shown at a larger scale.

Cover: Typical landscape in an area of the Monona-Ida association. The hazard of erosion has been reduced by farming on the contour and by installing terraces that have a steep, grass-covered back slope.

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Issued May 1994

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Summary of Tables

Foreword

This soil survey contains information that can be used in land-planning programs in Atchison County. It contains predictions of soil behavior for selected land uses. The survey also highlights limitations and hazards inherent in the soil, improvements needed to overcome the limitations, and the impact of selected land uses on the environment.

This soil survey is designed for many different users. Farmers, foresters, and agronomists can use it to evaluate the potential of the soil and the management needed for maximum food and fiber production. Planners, community officials, engineers, developers, builders, and home buyers can use the survey to plan land use, select sites for construction, and identify special practices needed to ensure proper performance. Conservationists, teachers, students, and specialists in recreation, wildlife management, waste disposal, and pollution control can use the survey to help them understand, protect, and enhance the environment.

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are shallow over bedrock. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

These and many other soil properties that affect land use are described in this soil survey. Broad areas of soils are shown on the general soil map. The location of each soil is shown on the detailed soil maps. Each soil in the survey area is described. Information on specific uses is given for each soil. Help in using this publication and additional information are available at the local office of the Soil Conservation Service or the Cooperative Extension Service.

Russell C. Mills
State Conservationist
Soil Conservation Service

Soil Survey of Atchison County, Missouri

By Fred J. Young, Soil Conservation Service, and Patricia Kowalewycz, Missouri Department of Natural Resources

Fieldwork by Patricia Kowalewycz, Missouri Department of Natural Resources, and Clayton Lee, John Preston, Fred J. Young, and Jerome Zimmerman, Soil Conservation Service

United States Department of Agriculture, Soil Conservation Service, in cooperation with the Missouri Agricultural Experiment Station

ATCHISON COUNTY is in the northwest corner of Missouri (fig. 1). It has an area of 349,280 acres, or 545.75 square miles. Iowa is to the north, Nodaway County to the east, Holt County to the south, and Nebraska to the west, across the Missouri River. In 1984, the population of Atchison County was about 8,600 *(5)*. Rock Port is the county seat. Tarkio is the largest town. Other towns in the county are Fairfax and Westboro.

Farming is the main enterprise in Atchison County. Most of the agricultural land is used for cultivated crops, mainly corn and soybeans. Grasses and legumes are grown for hay and pasture. Raising beef cattle is the largest livestock enterprise.

This survey updates the soil survey of Atchison County published in 1910 *(4)*. It provides additional information and larger maps, which show the soils in greater detail.

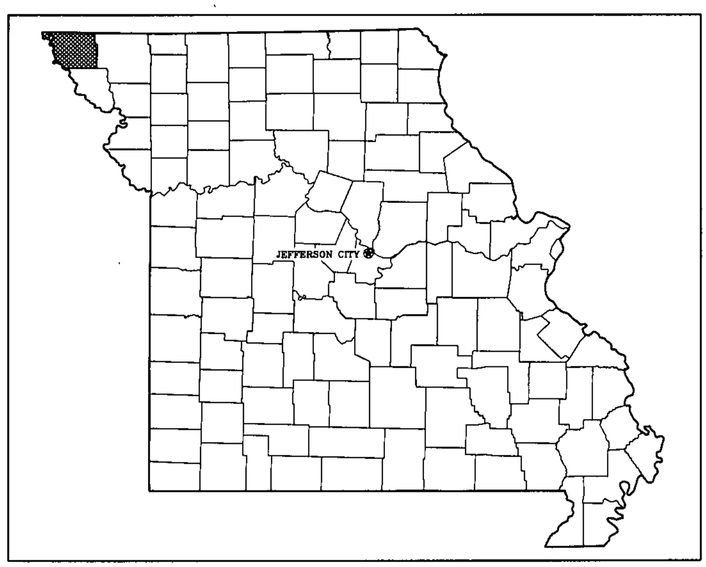

Figure 1.—Location of Atchison County in Missouri.

General Nature of the County

This section gives general information about the county. It describes climate; physiography, relief, and drainage; and history and development.

Climate

Atchison County has cold winters and long, hot summers. Heavy rains occur mainly in spring and early in summer when moist air from the Gulf of Mexico interacts with the drier continental air. The annual rainfall is normally adequate for corn, soybeans, and all grain crops.

Table 1 gives data on temperature and precipitation for the survey area as recorded at Tarkio, Missouri, in the period 1951 to 1986. Table 2 shows probable dates of the first freeze in fall and the last freeze in spring. Table 3 provides data on length of the growing season.

In winter, the average temperature is 27 degrees F and the average daily minimum temperature is 17 degrees. The lowest temperature on record, which occurred at Tarkio on January 12, 1974, is -26 degrees. In summer, the average temperature is 75 degrees and the average daily maximum temperature is 87 degrees. The highest recorded temperature, which occurred at Tarkio on July 21, 1974, is 106 degrees.

Growing degree days are shown in table 1. They are equivalent to "heat units." During the month, growing degree days accumulate by the amount that the average temperature each day exceeds a base temperature (50 degrees F). The normal monthly accumulation is used to schedule single or successive plantings of a crop between the last freeze in spring and the first freeze in fall.

The total annual precipitation is 34.56 inches. Of this, about 25 inches, or 72 percent, usually falls in April through September. The growing season for most crops falls within this period. In 2 years out of 10, the rainfall in April through September is less than 20 inches. The heaviest 1-day rainfall during the period of record was 4.36 inches at Tarkio on July 19, 1965. Thunderstorms occur on about 53 days each year.

The average seasonal snowfall is about 27 inches. The greatest snow depth at any one time during the period of record was 24 inches. On the average, 20 days of the year have at least 1 inch of snow on the ground. The number of such days varies greatly from year to year.

The average relative humidity in midafternoon is about 60 percent. Humidity is higher at night, and the average at dawn is about 80 percent. The sun shines 70 percent of the time possible in summer and 55 percent in winter. The prevailing wind is from the south. Average windspeed is highest, 13 miles per hour, in spring.

Tornadoes and severe thunderstorms occur occasionally but are local and of short duration. Damage from these storms varies and is spotty. Hailstorms occur in small, scattered areas during the warmer part of the year.

Physiography, Relief, and Drainage

The landscape in Atchison County is about two-thirds uplands and one-third flood plains. The slopes in the uplands range from gently sloping to very steep. Generally, the uplands in the western part of the county are the most highly dissected. They have steep or very steep side slopes and narrow ridgetops. The uplands in the central part generally have strongly sloping side slopes and moderately wide, sloping ridgetops. The uplands in the eastern part have sloping side slopes and broad, gently sloping ridgetops. Most of the ridges in the county are at an elevation of 1,100 to 1,150 feet. In a few places in the northern part, the loess bluffs exceed 1,200 feet.

The flood plain along the Missouri River includes more than half of the acreage of flood plains in the county. It is about 4 to 8 miles wide and runs along the entire western edge of the county. In most places it is about 5 to 30 feet higher than the river. Other flood plains are along the Nishnabotna River, Tarkio River, Little Tarkio Creek, Rock Creek, Mill Creek, High Creek, and McElroy Creek. All of these drainageways are tributaries of the Missouri River and flow in a south to southwesterly direction. The Missouri River enters Atchison County from the north at an elevation of about 900 feet and leaves to the south at about 865 feet.

History and Development

The earliest inhabitants of what is now Atchison County were members of various Indian tribes, including the Sac, Fox, Ioway, and Missouri tribes. Settlers were not allowed in the area until after the Platte Purchase of 1836, at which time the population of the county increased rapidly. These settlers came from Germany and Ireland and from the Southern and Eastern States. Atchison County was established in 1845. It was named in honor of Senator David R. Atchison. In 1900, the population of the county was 16,501. It has been slowly declining ever since *(5)*.

A railroad was built on the flood plain along the Missouri River in the 1860's, and the first train went through the county in 1870. Interstate 29 was completed and opened in the county in 1974. Other north-south highways include U.S. Highways 59 and 275 and Missouri Highway 111. The major east-west routes are U.S. Highway 136 and Missouri Highway 46, which extends east from Fairfax.

Agricultural development increased rapidly in the county after settlement began. By 1900, the county had 2,149 farms, which averaged 157 acres in size. In the 1920's and 1930's, the average size of farms increased to about 200 acres and the county had about 1,500 to 1,650 farms. Since 1940, the average size of farms has continued to increase and the number of farms has decreased steadily *(5)*. In 1950, the Federal levee system was completed along the Missouri River. It protects the valley from most flooding, except for extremely high levels of floodwater, and greatly increases the productivity of the soils on the flood plain.

How This Survey Was Made

This survey was made to provide information about the soils in the survey area. The information includes a description of the soils and their location and a discussion of the suitability, limitations, and management of the soils for specified uses. Soil scientists observed the steepness, length, and shape of slopes; the general pattern of drainage; the kinds of crops and native plants growing on the soils; and the kinds of bedrock. They dug many holes to study the soil profile, which is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

The soils in the survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil is associated with a particular kind of landscape or with a segment of the landscape. By observing the soils in the survey area and relating their position to specific segments of the landscape, a soil scientist develops a concept, or model, of how the soils were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. The system of taxonomic classification used in the United States is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot assure that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Map Unit Composition

A map unit delineation on a soil map represents an area dominated by one major kind of soil or an area dominated by two or three kinds of soil. A map unit is identified and named according to the taxonomic classification of the dominant soil or soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural objects. In common with other natural objects, they have a characteristic variability in their properties. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of soils of other taxonomic classes. Consequently, every map unit is made up of the soil or soils for which it is named and some soils that belong to other taxonomic classes. These latter soils are called inclusions or included soils.

Most inclusions have properties and behavioral patterns similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting (similar) inclusions. They may or may not be mentioned in the map unit descriptions. Other inclusions, however, have properties and behavior divergent enough to affect use or require different management. These are contrasting (dissimilar) inclusions. They generally occupy small areas and cannot be shown separately on the soil maps because of the scale used in mapping. The inclusions of contrasting soils are mentioned in the map unit descriptions. A few inclusions may not have been observed and consequently are not mentioned in the descriptions, especially where the soil pattern was so complex that it was impractical to make enough observations to identify all of the kinds of soil on the landscape.

The presence of inclusions in a map unit in no way diminishes the usefulness or accuracy of the soil data. The objective of soil mapping is not to delineate pure taxonomic classes of soils but rather to separate the landscape into segments that have similar use and management requirements. The delineation of such landscape segments on the map provides sufficient information for the development of resource plans, but onsite investigation is needed to plan for intensive uses in small areas.

General Soil Map Units

The general soil map at the back of this publication shows the soil associations in this survey area. Each association has a distinctive pattern of soils, relief, and drainage. Each is a unique natural landscape. Typically, an association consists of one or more major soils and some minor soils. It is named for the major soils. The soils making up one association can occur in another but in a different pattern.

The general soil map can be used to compare the suitability of large areas for general land uses. Areas of suitable soils can be identified on the map. Likewise, areas where the soils are not suitable can be identified.

Because of its small scale, the map is not suitable for planning the management of a farm or field or for selecting a site for a road or building or other structure. The soils in any one association differ from place to place in slope, depth, drainage, and other characteristics that affect management.

The descriptions, names, and delineations of the soils identified on the general soil map of this county do not fully agree with those of the soils identified on the maps of adjacent counties published at a different date. Differences are the result of additional soil data, variations in the intensity of mapping, and correlation decisions that reflect local conditions. In some areas combining small acreages of similar soils that respond to use and management in much the same way is more practical than mapping these soils separately.

Soil Descriptions

Dominantly Very Deep, Nearly Level to Gently Sloping Soils That Are Well Drained to Very Poorly Drained; Subject to Flooding

These soils are on flood plains and the adjacent foot slopes. Water erosion is not a major management concern. Most areas are used for cultivated crops. Wetness in many of the soils and the hazard of flooding affect building site development.

1. Onawa-Paxico-Haynie Association

Nearly level, somewhat poorly drained and moderately well drained, clayey and silty soils that formed in alluvium; on low flood plains along the Missouri River

This association is on low flood plains adjacent to the channel of the Missouri River. It generally is nearly level, but some areas are gently undulating. Slopes are dominantly less than 2 percent. Relief generally does not exceed 4 feet. In a few areas short, steep scarps are parallel to the river. Excess surface water is removed from many fields by grade ditches that lead to canals. A Federal flood-control levee is in an area along the Missouri River in the association. Areas on the same side of the levee as the river are frequently flooded. Areas that are protected by the levee are subject to rare flooding, which occurs when the levee is broken or overtopped.

This association makes up about 7 percent of the survey area. It is about 41 percent Onawa and similar soils, 26 percent Paxico soils, 18 percent Haynie soils, and 15 percent minor soils (fig. 2).

The Onawa soils are in concave areas. They are somewhat poorly drained. Typically, they are calcareous, very dark grayish brown and dark grayish brown silty clay to a depth of 21 inches. The substratum to a depth of 60 inches or more is stratified grayish brown and olive silt loam and very fine sandy loam.

The Paxico soils are in broad intermediate areas. They are somewhat poorly drained. Typically, the surface layer is calcareous, very dark grayish brown silt loam. The upper part of the substratum to a depth of 40 inches is dark grayish brown very fine sandy loam. The lower part to a depth of 60 inches or more is dark grayish brown loamy fine sand.

The Haynie soils are in broad convex areas. They are moderately well drained. Typically, the surface layer is calcareous, very dark grayish brown silt loam. The upper part of the substratum to a depth of 52 inches is dark grayish brown and grayish brown silt loam. The lower part to a depth of 60 inches or more is

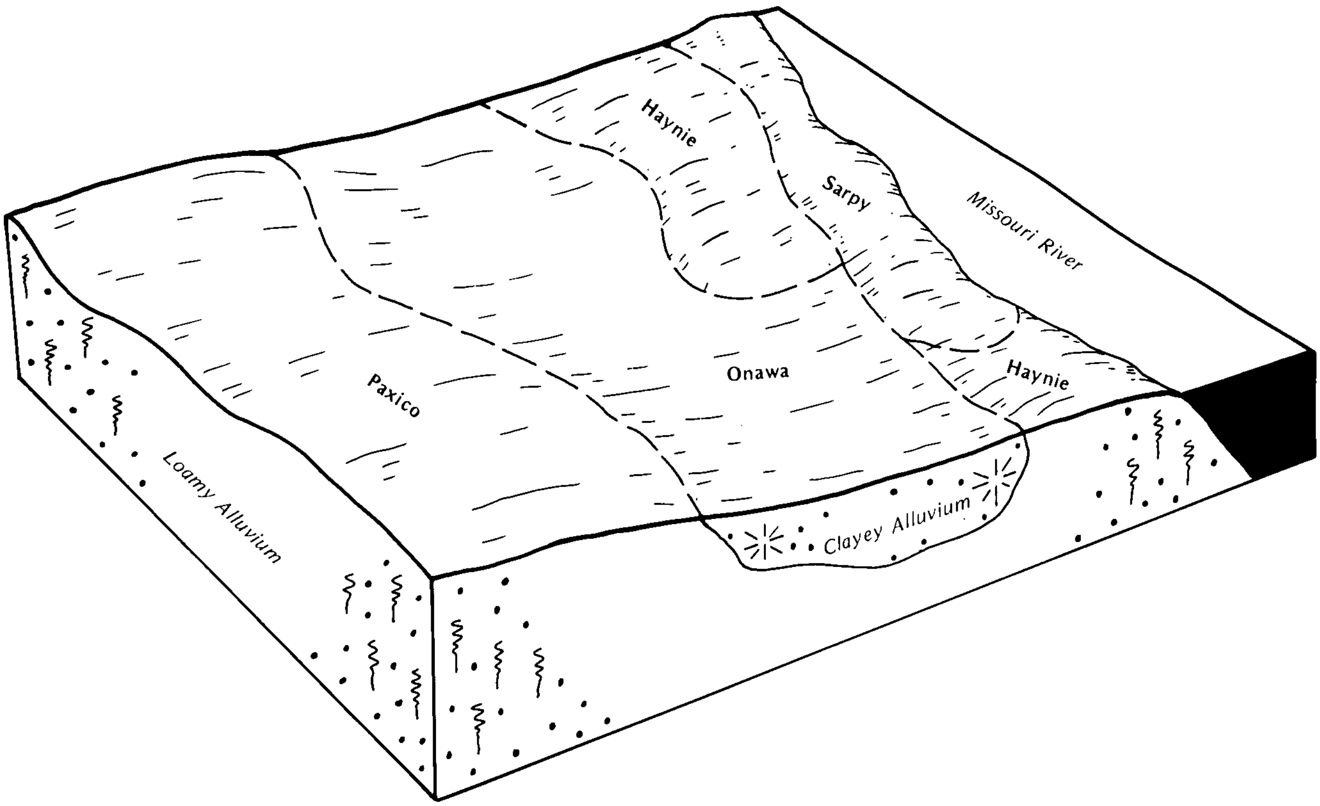

Figure 2.—Typical pattern of soils and parent material in the Onawa-Paxico-Haynie association.

dark grayish brown loamy fine sand.

Of minor extent in this association are Moville and Sarpy soils. Moville soils are loamy in the upper part and clayey in the lower part. They are in landscape positions similar to those of the Onawa soils. Sarpy soils are sandy throughout and are excessively drained. They are in the higher positions on the landscape, generally adjacent to stream channels.

The major soils in this association are used extensively for cultivated crops. Corn and soybeans are the main crops. Grain sorghum and winter wheat also are grown. A few small areas are used for alfalfa. In some areas corn stubble and bean stubble are used as forage. The acreage seeded to pasture plants is very small. Wooded areas between the river and the main levee are frequently flooded. They are dominated by eastern cottonwood and other water-tolerant species. A few small areas of woodland are protected from flooding by the levee. They generally are in low spots that are wet during much of the year and are unsuitable for crops and pasture. No towns are in areas of the association. The only buildings are those on a few widely scattered farmsteads and storage bins for grain. In fall, hunting migratory waterfowl is an important recreational activity.

This association is suited to cultivated crops, small grain, and grasses and legumes. Wetness in the Onawa and Paxico soils is the main management concern.

Areas on the same side of the levee as the river are unsuited to building site development because of the hazard of flooding. Areas that are protected by the levee are limited by rare flooding. The wetness in the Onawa and Paxico soils is a limitation.

This association provides important feeding areas for waterfowl, such as geese, during the fall migration. A large number of geese feed on spilled grain in harvested fields. Many landowners lease hunting rights during the fall goose season. Wooded areas along the Missouri River provide habitat for deer and other wildlife.

2. Blencoe-Haynie-Luton Association

Nearly level, poorly drained, moderately well drained, and very poorly drained, loamy, silty, and clayey soils that formed in alluvium; on high flood plains along the Missouri River

This association is on high flood plains along the Missouri River. It generally is nearly level, but some areas are gently undulating. Slopes are dominantly less than 2 percent. Relief generally does not exceed 2 feet. Excess surface water is removed from many fields by grade ditches that lead to canals. Levees in areas along the Missouri River and secondary streams provide protection against flooding. The soils are subject to rare flooding, which occurs if the levees break.

This association makes up about 12 percent of the survey area. It is about 35 percent Blencoe soils, 29 percent Haynie and similar soils, 28 percent Luton soils, and 8 percent minor soils.

The Blencoe soils are in broad concave areas. They are poorly drained. Typically, the surface layer is very dark grayish brown silty clay loam. Below this to a depth of 35 inches is very dark grayish brown, dark grayish brown, and grayish brown silty clay. The substratum to a depth of 60 inches or more is stratified grayish brown and light brownish gray silt loam and grayish brown silty clay.

The Haynie soils are in broad convex areas. They are moderately well drained. Typically, the surface layer is very dark grayish brown silt loam. The upper part of the substratum is dark brown and yellowish brown silt loam. The lower part to a depth of 60 inches or more is dark brown silt and very fine sandy loam.

The Luton soils are in broad concave areas. They are very poorly drained. Typically, the Luton soil has a surface soil of very dark gray and black silty clay and a multicolored subsoil of silty clay and clay. The substratum is multicolored clay to a depth of 60 inches or more.

Of minor extent in this association are Dockery, Moville, Paxico, and Sarpy soils. Dockery and Paxico soils are loamy and somewhat poorly drained. They are in areas where the smaller tributaries enter the large flood plain. Moville soils are loamy in the upper part and have a clayey substratum at a moderate depth. They are in low areas. Sarpy soils are sandy and excessively drained. They are in high areas, generally adjacent to stream channels.

The major soils in this association are used extensively for cultivated crops. Corn and soybeans are the main crops. Grain sorghum and winter wheat also are grown. A few small areas are used for alfalfa. In some areas corn stubble and bean stubble are used as forage. The acreage seeded to pasture plants is very small. A few small towns, scattered farmsteads, and storage bins for grain are located in areas of the association. In fall, hunting migratory waterfowl is an important recreational activity.

This association is suited to cultivated crops, small grain, and grasses and legumes. Wetness is the main management concern in areas of the Blencoe and Luton soils. Haynie soils have few limitations that affect farming.

This association has severe limitations affecting building site development. The flooding is the main limitation. The wetness in the Blencoe and Luton soils also is a limitation.

This association provides important feeding areas for waterfowl, such as geese and ducks, during the fall migration. A large number of geese feed on spilled grain in harvested fields. Many landowners lease hunting rights during the fall goose season.

3. Dockery-Napier Association

Nearly level to gently sloping, somewhat poorly drained and well drained, silty soils that formed in stream and slope alluvium; on flood plains along secondary streams and on the adjacent foot slopes

This association is on long, narrow flood plains along secondary streams, such as the Nishnabotna and Big Tarkio Rivers and Rock Creek, and on the foot slopes of the loess bluffs adjacent to the Missouri River valley. The flood plains are nearly level, and the foot slopes are gently sloping. Slopes range from 0 to 5 percent and generally are long and smooth. Some streams have cut deep channels into the flood plain. Levees protect most streams against flooding, but they are occasionally overtopped by floodwater.

This association makes up about 6 percent of the survey area. It is about 55 percent Dockery and similar soils, 33 percent Napier soils, and 12 percent minor soils (fig. 3).

The Dockery soils are in concave areas on flood plains adjacent to the stream channels. They are nearly level, somewhat poorly drained soils that formed in stream alluvium. Typically, the surface layer is very dark grayish brown silt loam. The substratum to a depth of 60 inches or more is very dark grayish brown and dark grayish brown silt loam and silty clay loam.

The Napier soils are on concave foot slopes. They are gently sloping, well drained soils that formed in slope alluvium. Typically, the surface layer is very dark brown silt loam. The subsurface layer and substratum to a depth of 60 inches or more are very dark grayish brown, dark brown, and brown silt loam.

Of minor extent in this association are McPaul and Zook soils. McPaul soils are calcareous and are adjacent to stream channels and drainage ditches. Zook soils have more clay than the major soils, are poorly drained, and are in the lowest areas.

The major soils in this association are used extensively for cultivated crops. Corn and soybeans are the main crops. Grain sorghum and winter wheat also

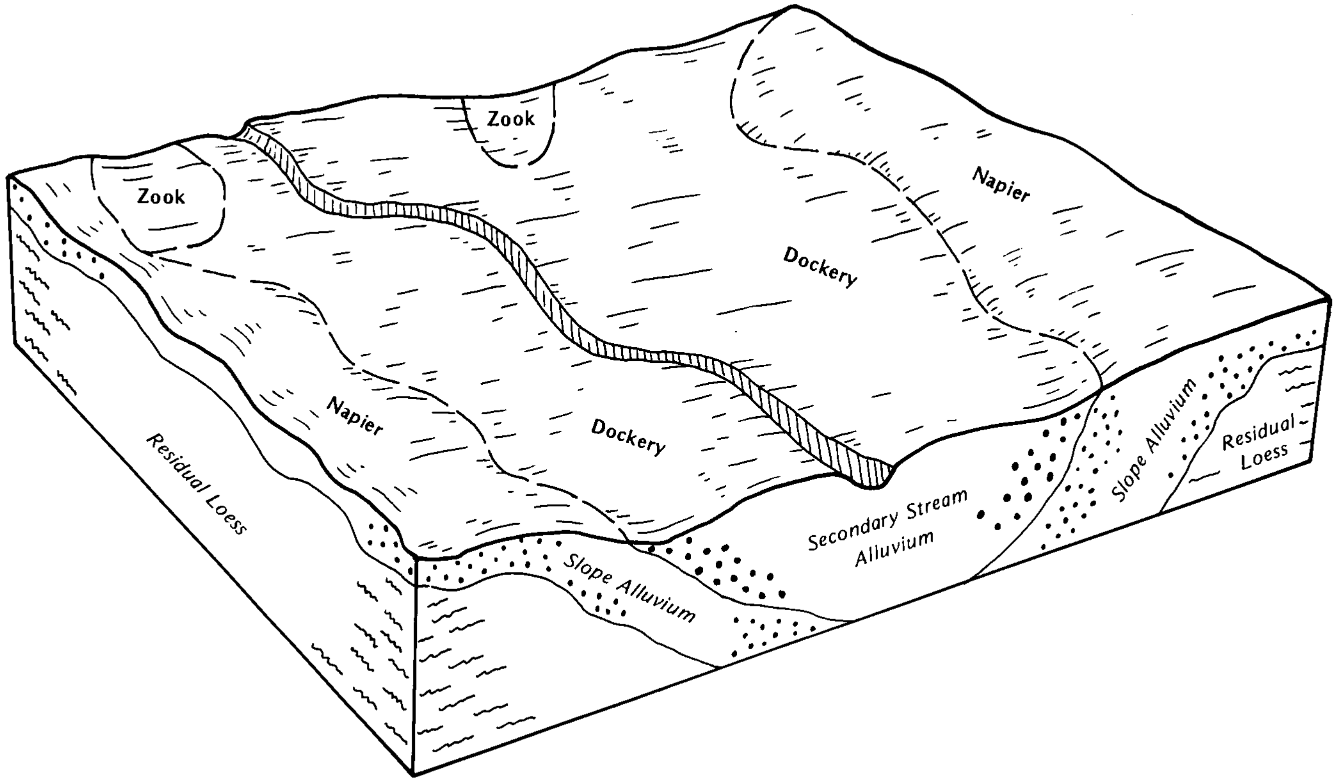

Figure 3.—Typical pattern of soils and parent material in the Dockery-Napier association.

are grown. A few small areas are used for alfalfa. In some areas corn stubble and bean stubble are used as forage. The acreage seeded to pasture plants is very small. Scattered farmsteads and storage bins for grain are in areas of the Napier soils. In fall, hunting game birds and deer is a recreational activity.

This association is suited to cultivated crops, small grain, and grasses and legumes. The flooding and wetness are the main management concerns in areas of the Dockery soils. Drainage ditches help to remove excess surface water. Erosion is a slight hazard in areas of the Napier soils.

The Dockery soils in this association generally are unsuited to building site development because of the hazard of flooding. The Napier soils have few limitations affecting building site development, but low strength and frost action limit road construction.

Small tracts of timber and brush areas along the stream channels and drainageways provide important habitat for wildlife. Wildlife feed on spilled grain in harvested fields. Maintaining or expanding the narrow, permanently vegetated buffer strips along watercourses can enhance the limited habitat for wildlife.

4. Colo-Zook-Nodaway Association

Nearly level, poorly drained and moderately well drained, silty and loamy soils that formed in alluvium; on flood plains along secondary streams

This association is on flood plains along secondary rivers and major streams. Areas are narrow and elongated and contain perennial waterways. Slopes range from 0 to 2 percent and in some areas are gently undulating. Some streams have cut deep channels into the flood plain. Levees protect most streams against flooding, but they are occasionally overtopped by floodwater.

This association makes up about 5 percent of the survey area. It is about 64 percent Colo soils, 18 percent Zook soils, 17 percent Nodaway soils, and 1 percent areas of water.

The Colo soils are in concave areas. They are poorly drained. Typically, the surface layer is black silt loam and silty clay loam. Below this to a depth of 60 inches or more is black, very dark brown, and very dark grayish brown silty clay loam.

The Zook soils are in concave areas. They are poorly drained. Typically, the surface layer is black silty clay loam. Below this to a depth of 60 inches or more is black and very dark gray silty clay loam and silty clay.

The Nodaway soils are on convex natural levees adjacent to stream channels. They are moderately well drained. Typically, the surface layer is very dark gray silt loam. Below this to a depth of 60 inches or more is stratified, multicolored silt loam.

The soils in this association are used mostly for cultivated crops. Corn and soybeans are the main crops. Grain sorghum and winter wheat also are grown. In some areas bean stubble and corn stubble are used as forage. The acreage seeded to pasture plants is very small. Small patches of timber are along the main channels and in branching drainageways. The timber along the main channels helps to stabilize streambanks. No towns or farmsteads are in areas of the association. In fall, hunting game birds and deer is a recreational activity.

This association is suited to cultivated crops, small grain, and grasses and legumes. The flooding and wetness are the main management concerns.

This association is generally unsuited to building site development because of the hazard of flooding. The wetness also is a limitation in the Colo and Zook soils.

The small tracts of timber and brush areas along the stream channels and drainageways provide important habitat for wildlife. Wildlife feed on spilled grain in harvested fields. Maintaining or expanding the narrow, permanently vegetated buffer strips along watercourses can enhance the limited habitat for wildlife.

Dominantly Very Deep, Gently Sloping to Steep Soils on Uplands That Are Well Drained to Somewhat Poorly Drained; Subject to Erosion

These soils are on uplands. Water erosion is a management concern affecting most of the soils. Some soils are too steep for cultivated crops. The gently sloping soils on ridgetops are suited to building site development.

5. Timula-Ida Association

Strongly sloping to steep, well drained, silty soils that formed in loess

This association is on a narrow strip of bluffs and hills adjacent to the flood plain along the Missouri River. It is highly dissected, having narrow, branching ridgetops and steep, gullied side slopes. Drainageways are deeply incised and have few or no flood plains. Slopes dominantly range from 9 to 60 percent. A few of the bluffs are nearly vertical.

This association makes up about 4 percent of the survey area. It is about 58 percent Timula soils, 20 percent Ida soils, and 22 percent minor soils.

The Timula soils are in relatively stable areas on steep side slopes. Slopes range from 25 to 60 percent. Typically, the surface layer is very dark gray and very dark grayish brown silt loam. Below this to a depth of 60 inches or more is brown and yellowish brown, calcareous silt loam.

The Ida soils are on side slopes, generally in the eastern part of the association. They are strongly sloping and moderately steep. Slopes range from 9 to 25 percent. Typically, the surface layer is dark brown silt loam. Below this to a depth of 60 inches or more is yellowish brown, grayish brown, and light olive brown, calcareous silt loam.

Of minor extent in this association are Hamburg, Monona, and Napier soils. Hamburg soils are on the faces of bluffs in the western part of the association. They have less clay than the major soils. Monona soils have a thick, dark surface layer. They are moderately sloping to moderately steep and are on ridges. Napier soils are gently sloping and are on foot slopes.

Most of this association is wooded, dominantly by hardwoods, such as red oak, black oak, shagbark hickory, and basswood. A limited amount of commercial timber is harvested, but wildlife habitat is the primary use. Some of the narrow ridges and narrow valleys are cultivated. Corn and soybeans are the main crops. Alfalfa, grain sorghum, and winter wheat also are grown. Some areas are used as permanent pasture, generally in the easternmost parts of the association. No towns and only a few scattered homes are in areas of the association. Deer hunting in the fall is a major recreational activity. Game birds also are hunted.

Except for the soils on a few narrow ridges and in a few narrow valleys, this association is unsuited to cultivated crops. The slope and a very severe hazard of erosion are the main management concerns. Most areas also are too steep for the establishment of pasture.

Only the narrow ridgetops and valley foot slopes are suited to building site development in this association. Most areas are too steep.

The extensive woodland in this association provides important habitat for various wildlife. Hunting is an important recreational activity.

6. Monona-Ida Association

Gently sloping to moderately steep, well drained, silty soils that formed in loess

This association is mainly on narrow, elongated ridgetops and long, undulating side slopes dissected by narrow, deep gullies. Slopes range from 2 to 25 percent.

This association makes up about 12 percent of the

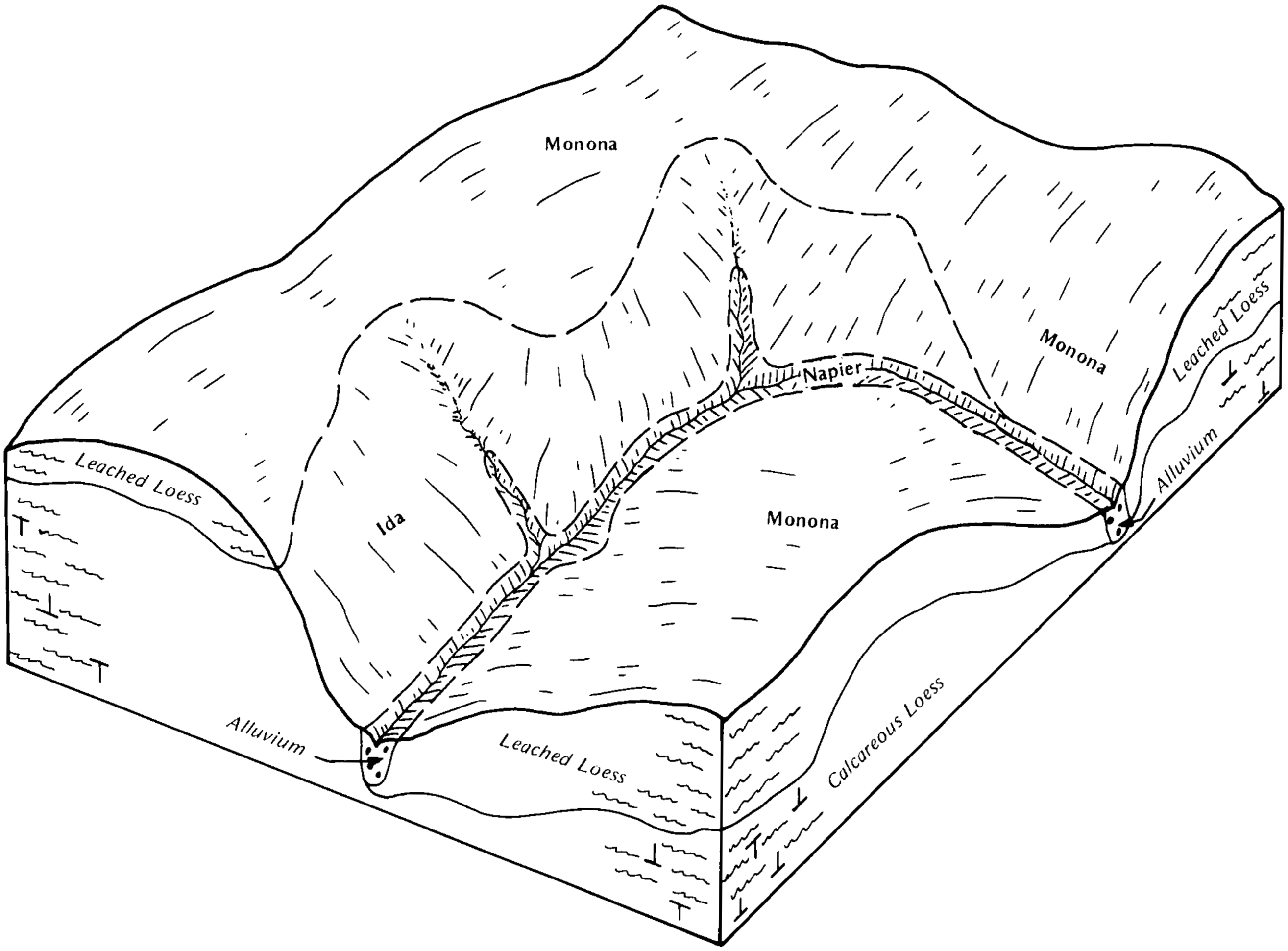

Figure 4.—Typical pattern of soils and parent material in the Monona-Ida association.

survey area. It is about 57 percent Monona and similar soils, 37 percent Ida soils, and 6 percent minor soils (fig. 4).

Monona soils are on ridgetops and the upper side slopes. They are gently sloping to strongly sloping. Slopes range from 2 to 16 percent. Typically, the surface soil is very dark grayish brown silt loam. Below this to a depth of 60 inches or more is dark brown and dark yellowish brown silt loam.

Ida soils are on side slopes. They are strongly sloping and moderately steep. Slopes range from 9 to 25 percent. Typically, the surface layer is dark brown silt loam. Below this to a depth of 60 inches or more is yellowish brown, grayish brown, and light olive brown, calcareous silt loam.

Of minor extent in this association are Malvern, Napier, Shelby, and Timula soils. Malvern soils have more clay than the major soils and are on the lower slopes. Napier soils are gently sloping and are on foot slopes. Shelby soils have glacial sand and gravel and are on the lower slopes. Timula soils have a light colored surface layer and are in the western part of the association.

Most of this association is used for cultivated crops. Corn and soybeans are the main crops. Grain sorghum and winter wheat also are grown. A few small areas are used for alfalfa. Some areas are used as permanent pasture, mainly in the westernmost part of the association. In some areas corn stubble and bean stubble are used as forage. A few small areas of woodland are in the association. They are mainly along small creeks, but some 5- to 30-acre tracts are in the uplands. Several towns are located in the association. Farmsteads are in scattered areas. In fall, hunting game birds and deer is a recreational activity.

This association is suited to cultivated crops, small grain, and grasses and legumes. The hazard of erosion is the main management concern.

The gently sloping areas of Monona soils are the best suited areas in this association for building site development and sanitary facilities. The slope is the main limitation, and frost action is a management concern affecting road construction.

The small areas of woodland in this association provide important habitat for wildlife. Additional habitat for birds is provided along fence rows, on terraces that have steep back slopes, and in vegetated turnouts. Wildlife feed on spilled grain in harvested fields. Expanding and improving the permanent plant cover in uncultivated areas can enhance the habitat for wildlife.

7. Marshall-Contrary Association

Gently sloping to strongly sloping, well drained, silty soils that formed in loess

This association is mainly on narrow to relatively wide, elongated ridgetops and long, plane side slopes dissected by narrow, branching drainageways. Slopes range from 2 to 14 percent.

This association makes up about 23 percent of the survey area. It is about 58 percent Marshall and similar soils, 21 percent Contrary and similar soils, and 21 percent minor soils (fig. 5).

The Marshall soils are on ridgetops and side slopes. They are gently sloping to strongly sloping. Slopes range from 2 to 14 percent. Typically, the surface layer is very dark grayish brown silt loam. The subsurface layer is silty clay loam. Below this to a depth of 60 inches or more is dark yellowish brown, dark brown, and light olive brown silty clay loam.

The Contrary soils are on side slopes. They are moderately sloping to strongly sloping. Slopes range from 5 to 14 percent. Typically, the surface layer is dark brown silt loam. Below this to a depth of 60 inches or more is dark brown, brown, and yellowish brown silt loam.

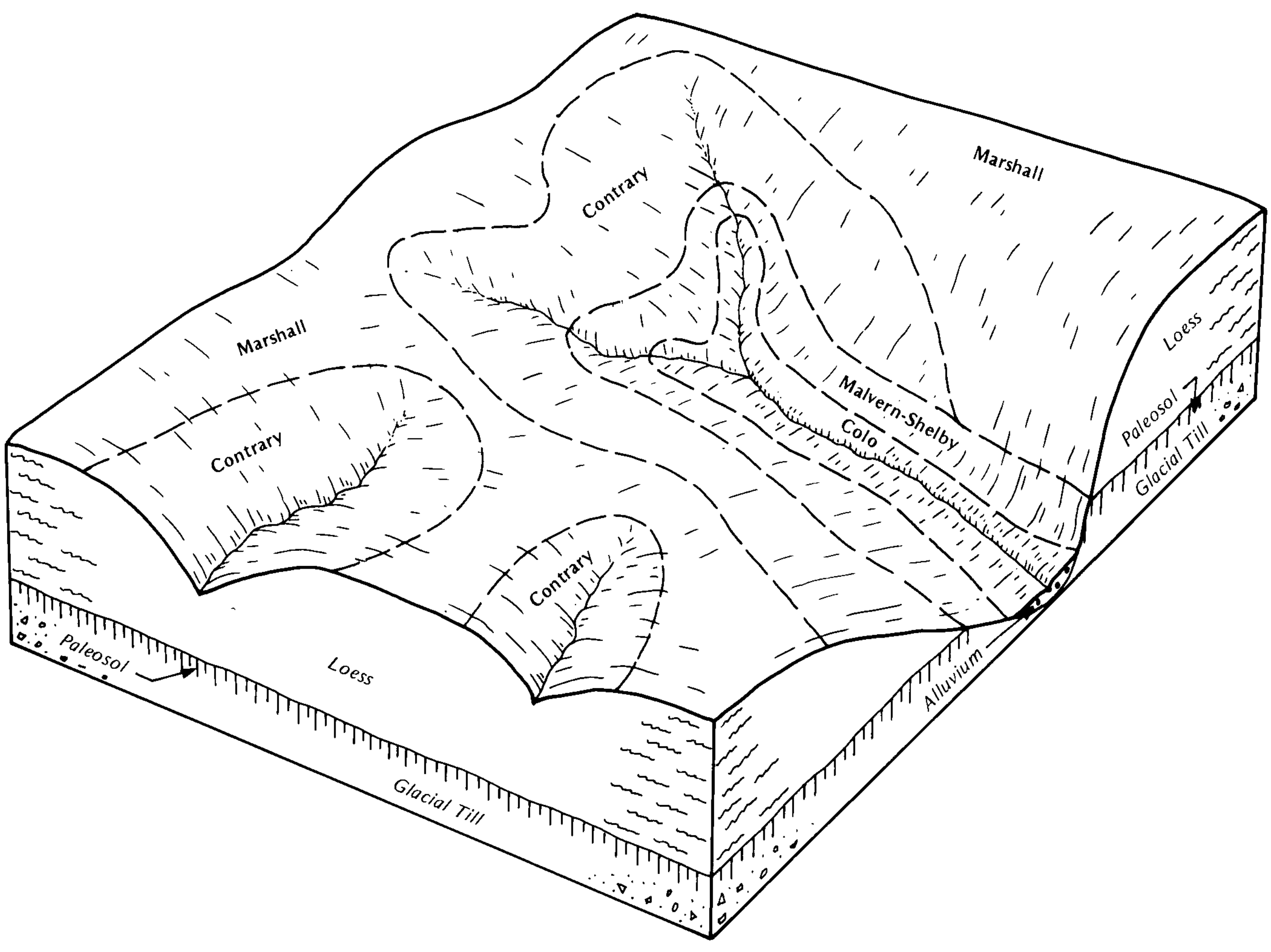

Figure 5.—Typical pattern of soils and parent material in the Marshall-Contrary association.

Of minor extent in this association are Colo, Higginsville, Lamoni, Malvern, Napier, and Shelby soils. Colo soils are nearly level and are on narrow flood plains. Higginsville soils are somewhat poorly drained and are in areas similar to those of the Contrary soils. Lamoni and Malvern soils are somewhat poorly drained, have more clay than the major soils, and are on the lower side slopes. Napier soils have a thick, dark surface layer and are on foot slopes. Shelby soils have glacial sand and gravel and are on the lower side slopes.

Most of this association is used for cultivated crops. Corn and soybeans are the main crops. Grain sorghum and winter wheat also are grown. A few small areas are used for alfalfa. In some areas corn stubble and bean stubble are used as forage. The acreage seeded to pasture plants is small. A few small areas of woodland are in the association. They are mainly along small creeks, but some 5- to 30-acre tracts are in the uplands. Several towns are in the association. Farmsteads are in scattered areas, primarily in areas of the Marshall soils on gently sloping ridgetops. In fall, hunting game birds and deer is a recreational activity.

This association is suited to cultivated crops, small grain, and grasses and legumes. The hazard of erosion is the main management concern.

The gently sloping areas of Marshall soils are the best suited areas in this association for building site development and sanitary facilities. The slope is the main limitation on the side slopes, and frost action is a management concern affecting road construction.

The small areas of woodland in this association provide important habitat for wildlife. Additional habitat for birds is provided along fence rows, on terraces that have steep back slopes, and in vegetated turnouts. Wildlife feed on spilled grain in harvested fields. Expanding and improving the permanent plant cover in uncultivated areas can enhance the habitat for wildlife.

8. Marshall-Shelby Association

Gently sloping to moderately steep, well drained, silty and loamy soils that formed in loess and glacial till

This association is mainly on narrow and moderately wide, elongated ridgetops and long, plane to undulating side slopes dissected by narrow, branching drainageways. Slopes range from 2 to 20 percent.

This association makes up about 25 percent of the survey area. It is about 44 percent Marshall and similar soils, 31 percent Shelby soils, and 25 percent minor soils (fig. 6).

The Marshall soils are on ridgetops and convex side slopes. They are gently sloping to strongly sloping soils that formed in loess. Slopes range from 2 to 14 percent. Typically, the surface layer is very dark grayish brown silt loam and the subsurface layer is silty clay loam. Below this to a depth of 60 inches or more is dark yellowish brown, dark brown, and yellowish brown silty clay loam.

The Shelby soils are on side slopes. They are moderately sloping to moderately steep soils that formed in glacial till. Slopes range from 5 to 20 percent. Typically, the surface layer is very dark gray clay loam. The subsoil to a depth of 60 inches or more is dark yellowish brown and yellowish brown clay loam.

Of minor extent in this association are Colo, Higginsville, Lamoni, and Nodaway soils. The poorly drained Colo and moderately well drained Nodaway soils are nearly level and are on flood plains. Higginsville soils are somewhat poorly drained. Lamoni soils are somewhat poorly drained and are more clayey than the major soils. Higginsville and Lamoni soils are on side slopes between areas of the Marshall and Shelby soils.

This association is used mainly for cultivated crops. Corn and soybeans are the main crops. Grain sorghum and winter wheat also are grown. A few small areas are used for alfalfa. In some areas corn stubble and bean stubble are used as forage. Several tracts of pasture are in areas of the association, but the overall acreage is small. A few small tracts of timber are in areas of the association. They are mainly along small creeks, but some 5- to 30-acre tracts are in the uplands. A town is located in the association. Farmsteads are in scattered areas, primarily in areas of the Marshall soils on gently sloping ridgetops. In fall, hunting game birds and deer is a recreational activity.

This association is suited to cultivated crops, small grain, and grasses and legumes. The slope, wetness, and the hazard of erosion are the main management concerns.

This association is suited to building site development and sanitary facilities. The slope is a limitation in areas of the Marshall and Shelby soils. Frost action is a management concern affecting road construction.

The small areas of timber in this association provide important habitat for wildlife. Additional habitat for birds is provided along fence rows, on terraces that have steep back slopes, and in vegetated turnouts. Wildlife feed on spilled grain in harvested fields. Expanding and improving the permanent plant cover in uncultivated areas can enhance the habitat for wildlife.

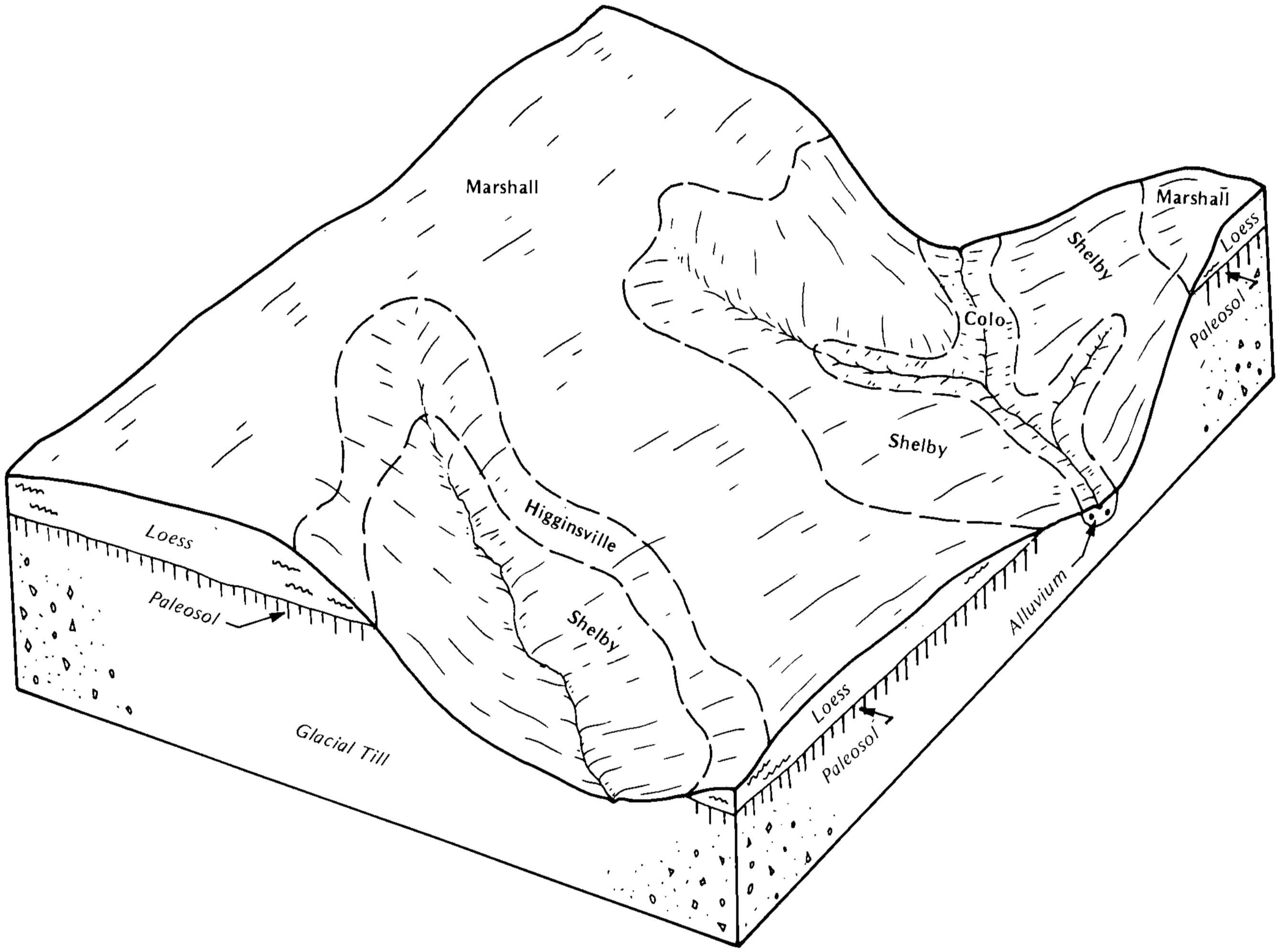

Figure 6.—Typical pattern of soils and parent material in the Marshall-Shelby association.

9. Higginsville-Sharpsburg-Shelby Association

Gently sloping to moderately steep, somewhat poorly drained to well drained, silty and loamy soils that formed in loess and glacial till

This association is mainly on narrow to wide, elongated ridgetops and long, undulating side slopes dissected by narrow, branching drainageways. Slopes range from 2 to 20 percent.

This association makes up about 6 percent of the survey area. It is about 33 percent Higginsville and similar soils, 31 percent Sharpsburg soils, 27 percent Shelby and similar soils, and 9 percent minor soils (fig. 7).

The Higginsville soils are on side slopes. They are moderately sloping and strongly sloping, somewhat poorly drained soils that formed in loess. Slopes range from 5 to 14 percent. Typically, the surface layer is very dark grayish brown silty clay loam. The subsoil and the substratum to a depth of 60 inches or more are olive brown, brown, and yellowish brown silty clay loam and light olive brown silt loam.

The Sharpsburg soils are on ridgetops and side slopes. They are gently sloping and moderately sloping, moderately well drained soils that formed in loess. Slopes range from 2 to 9 percent. Typically, the surface soil is very dark grayish brown and dark brown silty clay loam. The subsoil and the substratum to a depth of 60 inches or more are dark yellowish brown and yellowish brown silty clay loam.

The Shelby soils are on side slopes. They are moderately sloping to moderately steep, well drained soils that formed in glacial till. Slopes range from 5 to 20 percent. Typically, the surface layer is very dark gray

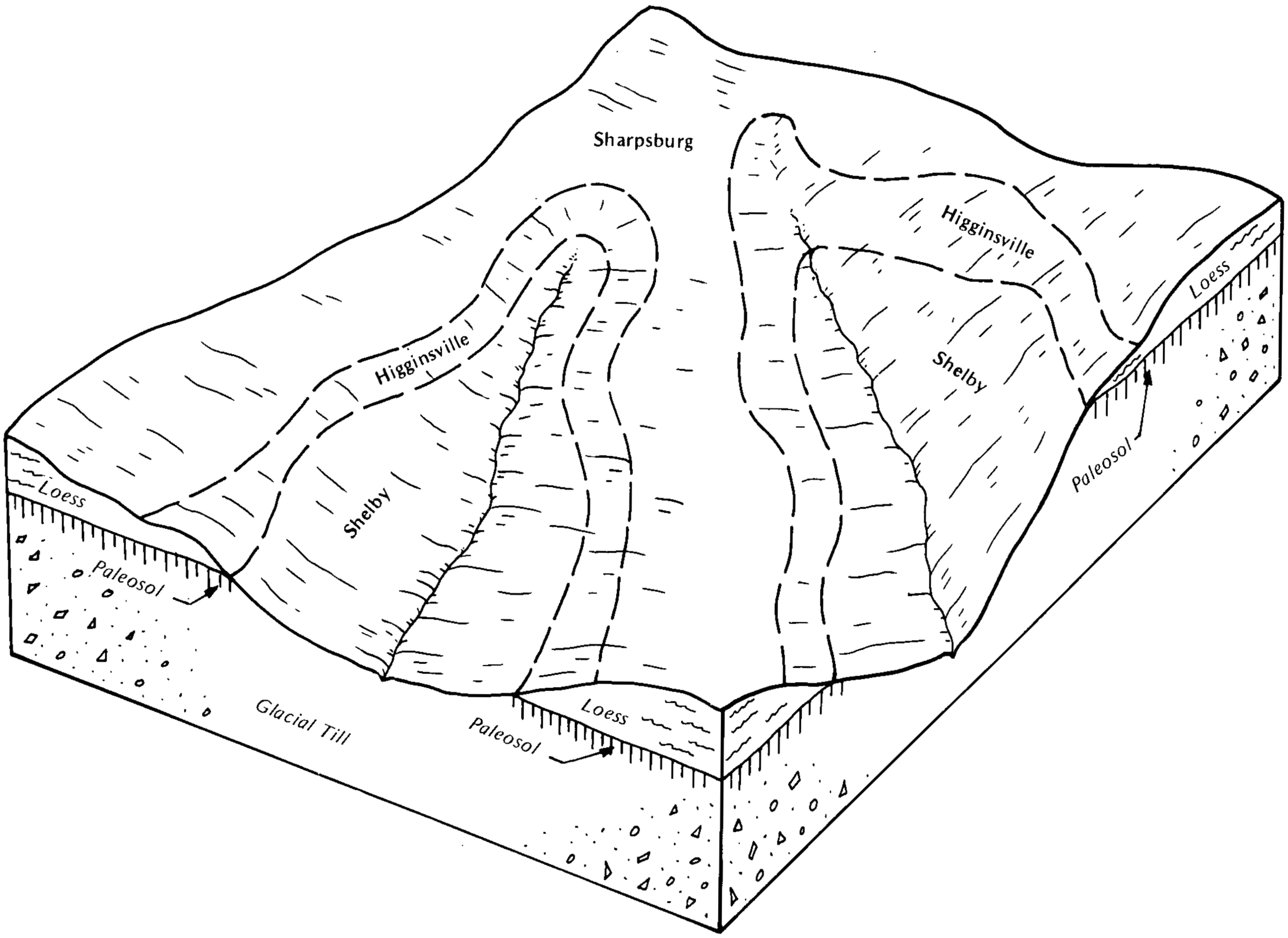

Figure 7.—Typical pattern of soils and parent material in the Higginsville-Sharpsburg-Shelby association.

clay loam. The subsoil to a depth of 60 inches or more is dark yellowish brown and yellowish brown clay loam.

Of minor extent in this association are the nearly level Colo soils on flood plains.

This association is used mainly for cultivated crops. Corn and soybeans are the main crops. Grain sorghum and winter wheat also are grown. A few small areas are used for alfalfa. In some areas corn stubble and bean stubble are used as forage. A few of the steeper areas are forested. No towns are in areas of the association. Farmsteads are in widely scattered areas. In fall, hunting game birds and deer is a recreational activity.

This association is suited to cultivated crops, small grain, and grasses and legumes. The slope, wetness, and the hazard of erosion are the main management concerns.

The less sloping areas of Shelby and Sharpsburg soils are the best suited areas in this association for building site development and sanitary facilities. The wetness, the slope, a high shrink-swell potential, and slow permeability are limitations affecting these uses. Low strength and frost action are limitations on sites for local roads and streets.

The small areas of timber in this association provide important habitat for wildlife. Additional habitat for birds is provided along fence rows, on terraces that have steep back slopes, and in vegetated turnouts. Wildlife feed on spilled grain in harvested fields. Expanding and improving the permanent plant cover in uncultivated areas can enhance the habitat for wildlife.

Detailed Soil Map Units

The map units on the detailed soil maps at the back of this survey represent the soils in the survey area. The map unit descriptions in this section, along with the soil maps, can be used to determine the suitability and potential of a soil for specific uses. They also can be used to plan the management needed for those uses. More information on each map unit, or soil, is given under the heading "Use and Management of the Soils."

Each map unit on the detailed soil maps represents an area on the landscape and consists of one or more soils for which the unit is named.

A symbol identifying the soil precedes the map unit name in the soil descriptions. Each description includes general facts about the soil and gives the principal hazards and limitations to be considered in planning for specific uses.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer or of the substratum, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer or of the substratum. They also can differ in slope, stoniness, salinity, wetness, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Marshall silt loam, 2 to 5 percent slopes, is a phase of the Marshall series.

Some map units are made up of two or more major soils. These map units are called soil complexes. A *soil complex* consists of two or more soils, or one or more soils and a miscellaneous area, in such an intricate pattern or in such small areas that they cannot be shown separately on the soil maps. The pattern and proportion of the soils are somewhat similar in all areas. Malvern-Shelby complex, 9 to 14 percent slopes, severely eroded, is an example.

Most map units include small scattered areas of soils other than those for which the map unit is named. Some of these included soils have properties that differ substantially from those of the major soil or soils. Such differences could significantly affect use and management of the soils in the map unit. The included soils are identified in each map unit description. Some small areas of strongly contrasting soils are identified by a special symbol on the soil maps.

The descriptions, names, and delineations of the soils identified on the detailed soil maps of this survey do not fully agree with those of the soils identified on the maps of adjacent counties published at a different date. Differences are the result of additional soil data, variations in the intensity of mapping, and correlation decisions that reflect local conditions. In some areas combining small acreages of similar soils that respond to use and management in much the same way is more practical than mapping these soils separately.

Table 4 gives the acreage and proportionate extent of each map unit. Other tables (see "Summary of Tables") give properties of the soils and the limitations, capabilities, and potentials for many uses. The "Glossary" defines many of the terms used in describing the soils.

Soil Descriptions

10—Blencoe silty clay loam, clayey substratum. This very deep, nearly level, poorly drained soil is on high flood plains along the Missouri River. It is subject to rare flooding, which can occur if levees along the Missouri or Nishnabotna Rivers break. Individual areas are irregular in shape and range from 15 to 2,400 acres in size.

Typically, the surface layer is very dark grayish brown, friable silty clay loam about 8 inches thick. The subsurface layer is very dark grayish brown silty clay about 4 inches thick. The subsoil is grayish brown and dark grayish brown, mottled silty clay about 23 inches thick. The upper 17 inches of the substratum is calcareous, stratified grayish brown and light brownish gray, mottled silt loam. The lower part to a depth of 60 inches is grayish brown, mottled silty clay. In some places the thickness of the dark surface layer has been affected by land shaping and is less than 10 inches. In other places the surface layer is silty clay. In some areas the soil does not have a clayey substratum. In other areas a buried surface soil is common. In places the layer of silt loam in the substratum is at a depth of more than 40 inches or less than 25 inches. In a few areas the soil does not have a layer of silt loam in the substratum.

Included with this soil in mapping are areas of Salix soils. These soils are in the higher positions on the landscape, are silty clay loam in the upper part, and are moderately well drained. Also included are soils that are ponded in spring and after heavy rains. Included soils make up about 5 percent of this unit.

Permeability is slow in the upper part of the Blencoe soil, moderate in the next part, and very slow in the lower part. Surface runoff is slow. Available water capacity is high. The organic matter content is moderate or high. The shrink-swell potential is high in the substratum. The seasonal high water table commonly is at a depth of 1 to 3 feet from November through June.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. The wetness is the main limitation. It may delay fieldwork in the spring. Most areas, however, are effectively drained by lateral surface drains and by field ditches or by a tile drainage system. Because of the slow permeability, the surface soil is wet for several days following heavy rains. Restricting fieldwork when the soil is wet minimizes compaction and the formation of clods.

This soil is suited to grasses and legumes that can withstand the wetness. Examples are ladino clover and reed canarygrass. The soil is poorly suited to warm-season grasses and hay crops. The main limitation in areas used for pasture is the seasonal high water table. Lateral surface drains and field ditches help to remove excess surface water. Fieldwork should be avoided when the soil is saturated. A properly designed rotation grazing system can help to prevent the damage caused by grazing when the soil is wet.

The main limitations on sites for dwellings are the flooding, the wetness, and the high shrink-swell potential. Adequately reinforcing the concrete in foundations and backfilling with coarse textured material help to prevent the damage caused by shrinking and swelling. Constructing dwellings without basements on raised, well compacted fill material helps to prevent the damage caused by wetness. The fill material should be of sufficient thickness to raise the dwelling above expected flood levels.

This soil is severely limited as a site for septic tank absorption fields, mainly because of the wetness and the restricted permeability. The absorption fields can be constructed on moderately rapidly permeable fill material. Holding tanks or sewage lagoons are effective alternatives to septic tank absorption fields.

Low strength, the high shrink-swell potential, the wetness, and frost action are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, helps to prevent the damage caused by low strength and by shrinking and swelling. Grading the roads so that they shed water, constructing adequate roadside ditches, and installing culverts help to overcome the wetness. A moisture barrier of gravel in the subgrade helps to prevent the damage caused by frost action.

The land capability classification is IIw.

11—Colo silt loam. This very deep, nearly level, poorly drained soil is on flood plains along secondary streams. It is occasionally flooded from November through June. Individual areas are irregular in shape and range from 10 to 100 acres in size.

Typically, the surface layer is black, friable silt loam about 8 inches thick. The subsurface layer is black silty clay loam to a depth of 25 inches. The subsoil to a depth of 56 inches is mottled silty clay loam that grades from black to very dark brown with increasing depth. The substratum is very dark grayish brown, mottled silty clay loam to a depth of 66 inches or more. In a few places the surface layer is silty clay loam. Depth to the seasonal high water table varies over short distances, depending on the distance to the stream channel and the microrelief of the unit. In places flooding is rare.

Included with this soil in mapping are areas of Judson and Nodaway soils and areas of Colo soils that are frequently flooded. Judson soils are well drained and are on foot slopes on the adjacent uplands. Nodaway soils are moderately well drained, are silt loam throughout, and are in the slightly higher areas adjacent to the stream channel. Included soils make up about 5 percent of this unit.

Permeability is moderate in the Colo soil. Surface runoff is slow. Available water capacity is high. The organic matter content is moderate or high. The shrink-swell potential is high in the subsoil. The seasonal high water table commonly is at a depth of 1 to 3 feet from November through June.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture.

This soil is suited to corn, soybeans, grain sorghum, and winter wheat. It is limited by the flooding and the wetness. The wetness may delay fieldwork in the spring. Most areas, however, are effectively drained by lateral surface drains and by field ditches or by a tile drainage system. Planting and harvesting are delayed in some years because of the flooding. Because of the moderate permeability, excess surface water quickly drains into the soil. Access to fields is possible soon after heavy rains.

This soil is suited to grasses and legumes that can withstand the wetness. Examples are alsike clover and reed canarygrass. The soil is poorly suited to warm-season grasses and hay crops. The main limitation in areas used for pasture is the seasonal high water table. Fieldwork should be avoided when the soil is saturated. A properly designed rotation grazing system can help to prevent the damage caused by grazing when the soil is wet. Grazing should be restricted to periods when flooding is not likely. The flooding can damage fences and structures and can cause sedimentation, which reduces forage yields and kills plants in some areas.

This soil is unsuited to building site development. It is limited by the flooding. Extreme measures are needed to overcome this limitation. Dwellings should be built in areas of better suited soils.

The land capability classification is IIw.

12—Colo-Judson silty clay loams, 1 to 5 percent slopes. These very deep, very gently sloping and gently sloping soils are in small drainageways in the uplands. The Colo soil is occasionally flooded from November through June. Individual areas are very long, narrow, and branching. They range from 8 to 40 acres in size.

The percentage of each soil in the unit varies, although the Colo soil generally is dominant. In the eastern part of the county, the percentage of Colo soil is higher than that of the Judson soil. In the western part, however, the Judson soil is dominant. A small stream channel is in the center of each mapped area. It is incised 5 to 30 feet into the surrounding landscape. The stream channel, steep streambanks, and branching gullies make up about 10 to 15 percent of the unit. Mapping the two soils separately at the scale used was not possible.

The Colo soil is very gently sloping and poorly drained. It is on flood plains along the streams. Slopes are 1 or 2 percent. Typically, the surface layer is black, friable silty clay loam about 10 inches thick. The subsurface layer is black silty clay loam about 39 inches thick. Below this is very dark gray silty clay loam to a depth of 64 inches. In some areas the soil is only rarely flooded. In other areas the surface layer is silt loam. In places the lower part of the soil is silty clay.

Permeability is moderate in the Colo soil. Surface runoff is slow. Available water capacity is high. The organic matter content is moderate or high. The shrink-swell potential is moderate in the subsoil. The seasonal high water table commonly is at a depth of 1 to 3 feet from November through June.

The Judson soil is gently sloping and well drained. It is on foot slopes on the adjacent uplands. Slopes range from 2 to 5 percent. Typically, the surface layer and subsurface layer are very dark gray, friable silty clay loam. They have a combined thickness of about 25 inches. The subsoil to a depth of 55 inches is silty clay loam. It is dark brown grading to dark yellowish brown with increasing depth. The substratum to a depth of 60 inches or more is mottled, dark yellowish brown silty clay loam. In some areas the slope is more than 5 percent.

Permeability is moderate in the Judson soil. Surface runoff is medium. Available water capacity is very high. The organic matter content is high. The shrink-swell potential is moderate in the subsoil.

Included in this unit in mapping are small areas of Shelby soils. These included soils have more sand and gravel than the Colo and Judson soils and are on the upslope margins of the areas of Judson soil. Included soils make up about 3 percent of this unit.

This unit is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. Most mapped areas are deeply incised by a stream channel, which affects field design. Only about two-thirds of the unit can be cultivated. Erosion is a slight hazard on the Judson soil. It can be minimized by farming on the contour and by applying a conservation tillage system that leaves a protective cover of crop residue on the surface. The wetness is a limitation in the Colo soil. It may delay fieldwork in the spring. Planting and harvesting are delayed in some years because of the flooding on the Colo soil. Because of the moderate permeability of both soils, excess surface water quickly infiltrates the surface. Access to fields is possible soon after heavy rains.

The Colo soil is suited to grasses and legumes that can withstand the wetness. Examples are alsike clover and reed canarygrass. The soil is poorly suited to warm-season grasses and hay crops. The main limitations in areas used for pasture are the high water table and the flooding. Fieldwork should be avoided when the soil is saturated. A properly designed rotation grazing system can help to prevent the damage caused by grazing when the soil is wet. Grazing should be restricted to periods when flooding is not likely. The flooding can damage fences and structures and can cause sedimentation, which reduces forage yields and kills plants in some areas.

The Judson soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, smooth bromegrass, and switchgrass. No serious limitations affect the areas used as pasture or hayland. Erosion is a hazard in newly seeded areas. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established.

The Judson soil is suited to building site development, but the Colo soil is unsuited because of the flooding. The main limitation on sites for dwellings on the Judson soil is the moderate shrink-swell potential. Adequately reinforcing the concrete in foundations and backfilling with coarse textured material help to prevent the damage caused by shrinking and swelling. The Judson soil is suited to septic tank absorption fields.

Low strength, the shrink-swell potential, and frost action are limitations on sites for local roads and streets on the Judson soil. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, helps to prevent the damage caused by low strength and by shrinking and swelling. A moisture barrier of gravel in the subgrade helps to prevent the damage caused by frost action.

The land capability classification is IIe.

13C2—Contrary silt loam, 5 to 9 percent slopes, eroded. This very deep, moderately sloping, well drained soil is on concave head slopes in the uplands. Erosion has removed much of the original dark surface soil. Individual areas are irregular in shape and range from 7 to 120 acres in size.

Typically, the surface layer is very dark grayish brown, very friable silt loam about 8 inches thick. The subsoil is about 39 inches thick. It is dark yellowish brown, mottled silt loam in the upper part and dark grayish brown, mottled silt loam in the lower part. The substratum to a depth of 60 inches or more is mottled grayish brown, strong brown, and dark brown silt loam. In places the dark surface layer is more than 10 inches thick.

Included with this soil in mapping are areas of Colo, Higginsville, and Judson soils. Colo soils are in downslope areas on flood plains, are poorly drained, and have a very thick, dark surface soil. Higginsville soils generally are on the lower head slopes and are somewhat poorly drained. Judson soils are in downslope areas on gently sloping foot slopes and have a very thick, dark surface soil. Included soils make up about 5 percent of this unit.

Permeability is moderate in the Contrary soil. Surface runoff is medium. Available water capacity is very high. The organic matter content is moderate. The shrink-swell potential is low in the subsoil.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. Erosion is a moderate hazard. It can be minimized by farming on the contour, terracing or stripcropping, and applying a conservation tillage system that leaves a protective cover of crop residue on the surface. The construction of terraces exposes the subsoil in some areas. Fertilization rates can be adjusted if necessary in these areas. Terrace drains generally are not needed. Grassed waterways help to prevent excessive erosion in small drainageways. Because of the moderate permeability, excess surface water quickly drains into the soil. Access to fields is possible soon after heavy rains.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, smooth bromegrass, and switchgrass. No serious limitations affect the areas used as pasture or hayland. Erosion is a hazard in newly seeded areas. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established.

This soil is suited to building site development and sanitary facilities. Few limitations affect these uses.

Low strength and frost action are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, helps to prevent the damage caused by low strength. Grading the roads so that they shed water and installing a moisture barrier of gravel in the subgrade help to prevent the damage caused by frost action.

The land capability classification is IIIe.

13D2—Contrary silt loam, 9 to 14 percent slopes, eroded. This very deep, strongly sloping, well drained soil is on side slopes. Erosion has removed much of the original dark surface soil. Individual areas are irregular in shape and range from 10 to 320 acres in size.

Typically, the surface layer is dark brown, very friable silt loam about 7 inches thick. The subsoil is about 28 inches thick. It is dark brown, mottled silt loam in the upper part and brown and yellowish brown, mottled silt loam in the lower part. The substratum to a depth of 60 inches or more is yellowish brown, mottled silt loam. In some places the dark surface layer is more than 10 inches thick. In other places the soil is somewhat poorly drained.

Included with this soil in mapping are areas of Colo and Judson soils. Colo soils are in downslope areas on flood plains, are poorly drained, and have a very thick surface layer. Judson soils are in downslope areas on gently sloping foot slopes and have a thick surface layer. Included soils make up about 5 percent of this unit.

Permeability is moderate in the Contrary soil. Surface

Figure 8.—Alfalfa in an area of Contrary silt loam, 9 to 14 percent slopes, eroded. Maintaining a permanent vegetative cover is a good management practice on this highly erodible soil.

runoff is rapid. Available water capacity is very high. The organic matter content is moderate. The shrink-swell potential is low in the subsoil.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. Erosion is a severe hazard. It can be minimized by farming on the contour, installing terraces, and applying a conservation tillage system that leaves a protective cover of crop residue on the surface. The construction of terraces exposes the subsoil in some areas. Fertilization rates can be adjusted if necessary in these areas. Terrace drains generally are not needed. Grassed waterways help to prevent excessive erosion in small drainageways. Because of the moderate permeability, excess surface water quickly drains into the soil. Access to fields is possible soon after heavy rains.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, smooth bromegrass, and switchgrass (fig. 8). Erosion is the main hazard in areas used as pasture or hayland when new seedlings are becoming established. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a ground cover is quickly established. Erosion is also a hazard on livestock trails and in overgrazed areas. It can be minimized by applying a rotation grazing system and carefully locating water and supplements for livestock.

The main limitation on sites for dwellings is the slope. Dwellings can be designed so that they conform to the natural slope of the land, or the site can be graded to a suitable gradient.

This soil is moderately limited as a site for septic tank absorption fields, mainly because of the slope. Land shaping and installing the distribution lines across the slope are necessary for the proper functioning of the absorption field.

Low strength, frost action, and the slope are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, helps to prevent the damage caused by low strength. Grading the roads so that they shed water and installing a moisture barrier of gravel in the subgrade help to prevent the damage caused by frost action. Some cutting and filling may be necessary because of the slope. Also, the roads can be designed so that they conform to the natural slope of the land.

The land capability classification is IIIe.

14—Dockery silt loam. This very deep, nearly level, somewhat poorly drained soil is on flood plains along the Nishnabotna and Tarkio Rivers. It is subject to occasional flooding, which can occur from November through June if levees along the Nishnabotna or Tarkio Rivers break. Individual areas are irregular in shape and range from 30 to 400 acres in size.

Typically, the surface layer is very dark grayish brown, friable silt loam about 8 inches thick. The substratum to a depth of 60 inches or more is stratified very dark gray to grayish brown, mottled silt loam. In some areas the surface layer is silty clay loam. A buried surface soil of silty clay loam is common in areas on the flood plain along the Tarkio River. In some places the dark surface layer is more than 10 inches thick. In other places the soil is poorly drained.

Included with this soil in mapping are areas of McPaul and Moville soils on the flood plain along the Nishnabotna River and areas of Nodaway soils on the flood plain along the Tarkio River. McPaul soils are well drained and are in the higher positions on the landscape. Moville soils have substrata of silty clay and are commonly near clayey soils, such as the Blencoe soils. Nodaway soils are moderately well drained and are on natural levees. Included soils make up about 5 percent of this unit.

Permeability is moderate in the Dockery soil. Surface runoff is slow. Available water capacity is very high. The organic matter content is moderate. The shrink-swell potential is moderate in the substratum. The seasonal high water table commonly is at a depth of 2 to 3 feet from November through June.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. It is limited by the flooding and the wetness. Planting and harvesting are delayed in some years because of the flooding. Also, the flooding may damage crops. The wetness may delay fieldwork in the spring. Most areas, however, are effectively drained by lateral surface drains and by field ditches or by a tile drainage system. Because of the moderate permeability, excess surface water quickly drains into the soil. Access to fields is possible soon after heavy rains.

This soil is suited to grasses and legumes that can withstand the wetness. Examples are ladino clover, reed canarygrass, and switchgrass. The main limitation in areas used as pasture or hayland is the wetness. However, because the soil is seldom saturated to the surface, fieldwork and grazing are seldom restricted.

This soil is unsuited to building site development. It is limited by the flooding. Extreme measures are needed to overcome this limitation. Dwellings should be built in areas of better suited soils.

The land capability classification is IIw.

15—Gilliam silt loam. This very deep, nearly level, somewhat poorly drained soil is on high flood plains along the Missouri River. It is subject to rare flooding, which can occur if levees along the Missouri River break. Individual areas are irregular in shape and range from 20 to 400 acres in size.

Typically, the surface layer is very dark brown, friable silt loam about 10 inches thick. The subsoil is dark grayish brown, mottled silt loam 10 inches thick. The substratum to a depth of 60 inches or more is calcareous, grayish brown, mottled silt loam grading to stratified silt loam, silty clay loam, and very fine sandy loam with increasing depth. In places the soil is moderately well drained.

Included with this soil in mapping are areas of Blencoe soils. These soils are in slight depressional areas, are poorly drained, and have a subsoil of silty clay. They make up about 5 percent of this unit.

Permeability is moderate in the Gilliam soil. Surface runoff is slow. Available water capacity is high. The organic matter content is moderate in the surface layer. The shrink-swell potential is moderate in the substratum. The seasonal high water table commonly is at a depth of 1.5 to 3.0 feet from November through June.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. It is limited by the wetness, which may delay fieldwork in the spring. Most areas, however, are effectively drained by lateral surface drains and by field ditches or by a tile drainage system. Because of the moderate permeability, excess surface water quickly drains into the soil. Access to fields is possible soon after heavy rains.

This soil is suited to grasses and legumes that can withstand the wetness. Examples are ladino clover, reed canarygrass, and switchgrass. The main limitation in areas used as pasture or hayland is the wetness. However, because the soil is seldom saturated to the surface, fieldwork and grazing are seldom restricted.

The main limitations on sites for dwellings are the flooding and the wetness. Constructing dwellings without basements on raised, well compacted fill material helps to prevent the damage caused by wetness. The fill material should be of sufficient thickness to raise the dwelling above expected flood levels.

This soil is severely limited as a site for septic tank absorption fields, mainly because of the wetness. The absorption fields can be constructed on moderately rapidly permeable fill material. Holding tanks are an effective alternative to septic tank absorption fields.

Low strength, the shrink-swell potential, and frost action are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, helps to prevent the damage caused by low strength and by shrinking and swelling. Grading the roads so that they shed water and installing a moisture barrier of gravel in the subgrade help to prevent the damage caused by frost action.

The land capability classification is IIw.

16—Haynie silt loam. This very deep, nearly level, moderately well drained soil is in convex areas on high flood plains along the Missouri River. It is subject to rare flooding, which can occur if levees along the Missouri River break. Individual areas are irregular in shape and range from 30 to more than 1,000 acres in size.

Typically, the surface layer is very dark grayish brown, very friable silt loam about 12 inches thick. The subsoil is about 13 inches of dark brown and yellowish brown silt loam. The substratum to a depth of 60 inches or more is dark brown, mottled, calcareous silt loam and very fine sandy loam. In some places the dark surface layer is less than 10 inches thick. In other places the surface layer and subsoil are silty clay loam. In many areas the substratum has thick, sandy strata. In a few areas the soil has strata of silty clay loam.

Included with this soil in mapping are areas of Gilliam soils. These soils are in the slightly lower positions on the landscape, are somewhat poorly drained, and have a higher content of clay than the Haynie soil. They make up about 5 percent of this unit.

Permeability is moderate in the Haynie soil. Surface runoff is slow. Available water capacity is high. The organic matter content is moderately low or moderate. The seasonal high water table commonly is at a depth of 3 to 6 feet from November through June.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. It has few limitations. Because of the moderate permeability, excess surface water quickly drains into the soil. Access to fields is possible soon after heavy rains.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, smooth bromegrass, and switchgrass. No serious limitations affect the areas used as pasture or hayland.

The main limitations on sites for dwellings are the flooding and the wetness. Constructing dwellings without basements on raised, well compacted fill material helps to prevent the damage caused by wetness. The fill material should be of sufficient thickness to raise the dwelling above expected flood levels.

This soil is severely limited as a site for septic tank absorption fields, mainly because of the wetness. The absorption fields can be constructed on moderately rapidly permeable fill material. Holding tanks are an effective alternative to septic tank absorption fields.

Low strength and frost action are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, helps to prevent the damage caused by low strength. Grading the roads so that they shed water and installing a moisture barrier of gravel in the subgrade help to prevent the damage caused by frost action.

The land capability classification is I.

17—Haynie silt loam, sandy substratum, rarely flooded. This very deep, nearly level, moderately well drained soil is in the highest areas on the low flood plains along the Missouri River. It is subject to rare flooding, which can occur if levees along the Missouri River break. Individual areas are irregular in shape and range from 20 to 180 acres in size.

Typically, the surface layer is very dark grayish brown, very friable silt loam about 6 inches thick. The upper part of the substratum to a depth of 52 inches is calcareous, stratified, dark grayish brown and grayish brown, mottled silt loam. The lower part to a depth of 60 inches or more is calcareous, dark grayish brown loamy fine sand. In some places depth to the sandy part of the substratum is less than 40 inches. In other places strata of sand and fine sandy loam are in the upper part of the substratum. Short, moderately sloping areas are along some drainageways. Many areas are gently undulating.

Included with this soil in mapping are areas of Sarpy and Paxico soils. Sarpy soils are on convex rises and are sandy throughout. Paxico soils are in the slightly lower positions on the landscape and are somewhat poorly drained. Included soils make up about 10 percent of this unit.

Permeability is moderate in the upper part of the

Haynie soil and rapid in the sandy part of the substratum. Surface runoff is slow. Available water capacity is high. The organic matter content is moderately low or moderate. The seasonal high water table commonly is at a depth of 3 to 6 feet from November through June.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. It has few limitations. Because of the moderate to rapid permeability, excess surface water quickly drains into the soil. Access to fields is possible soon after heavy rains.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, smooth bromegrass, and switchgrass. No serious limitations affect the areas used as pasture or hayland.

The main limitations on sites for dwellings are the flooding and the wetness. Constructing dwellings without basements on raised, well compacted fill material helps to prevent the damage caused by the wetness. The fill material should be of sufficient thickness to raise the dwelling above expected flood levels.

This soil is severely limited as a site for septic tank absorption fields, mainly because of the wetness. The absorption fields can be constructed on moderately rapidly permeable fill material. Holding tanks are an effective alternative to septic tank absorption fields.

Low strength and frost action are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, helps to prevent the damage caused by low strength. Grading the roads so that they shed water and installing a moisture barrier of gravel in the subgrade help to prevent the damage caused by frost action.

The land capability classification is I.

18—Haynie silt loam, sandy substratum, frequently flooded. This very deep, nearly level, moderately well drained soil is in high, convex positions on the flood plain along the Missouri River. It is on the same side of the levee as the river. It is frequently flooded from November through June. Individual areas are irregular in shape and range from 5 to 100 acres in size.

Typically, the surface layer is calcareous, very dark grayish brown, very friable silt loam about 7 inches thick. The upper part of the substratum to a depth of 55 inches is calcareous, stratified dark grayish brown and grayish brown, mottled silt loam having strata of silty clay loam and very fine sandy loam. The lower part to a depth of 60 inches or more is calcareous, dark grayish brown loamy fine sand. In some places depth to the sandy part of the substratum is less than 40 inches. In other places strata of sand and fine sandy loam are in the upper part of the substratum. Short, moderately sloping areas are along some drainageways. Many areas are gently undulating. In some areas the soil has a thin overwash layer of fine sand. In other areas it is somewhat poorly drained.

Included with this soil in mapping are areas of Onawa and Sarpy soils. Onawa soils are in channels and depressional areas, are poorly drained, and are silty clay in the upper part. Sarpy soils are on convex rises or bars and are sandy throughout. Included soils make up about 10 percent of this unit.

Permeability is moderate in the upper part of the Haynie soil and rapid in the sandy part of the substratum. Surface runoff is slow. Available water capacity is high. The organic matter content is moderately low or moderate. The seasonal high water table commonly is at a depth of 3 to 6 feet from November through June.

This soil is used primarily for corn, soybeans, or winter wheat. Some areas support cottonwood forest and are used for hunting and wildlife habitat.

This soil is suited to corn, soybeans, grain sorghum, and winter wheat. Planting and harvesting are delayed in some years because of the flooding (fig. 9). The flooding causes sedimentation, which can reduce yields and result in an uneven surface. Land smoothing can minimize the effects of sedimentation. Because of the moderate to rapid permeability, excess surface water quickly drains into the soil. Access to fields is possible soon after heavy rains.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, smooth bromegrass, and switchgrass. The main hazard in areas used as pasture or hayland is the flooding. Grazing should be restricted to periods when flooding is not likely. The flooding can damage fences and structures and can cause sedimentation, which reduces forage yields and kills plants in some areas.

This soil is unsuited to building site development. It is limited by the flooding. Extreme measures are needed to overcome this limitation. Dwellings should be built in areas of better suited soils.

The land capability classification is IIIw.

19C2—Higginsville silty clay loam, 5 to 9 percent slopes, eroded. This very deep, moderately sloping, somewhat poorly drained soil is on concave head slopes. Erosion has removed much of the original dark surface soil. Individual areas are irregular in shape and range from 8 to 100 acres in size.

Typically, the surface layer is black, very friable silty clay loam about 7 inches thick. The subsoil is about 29

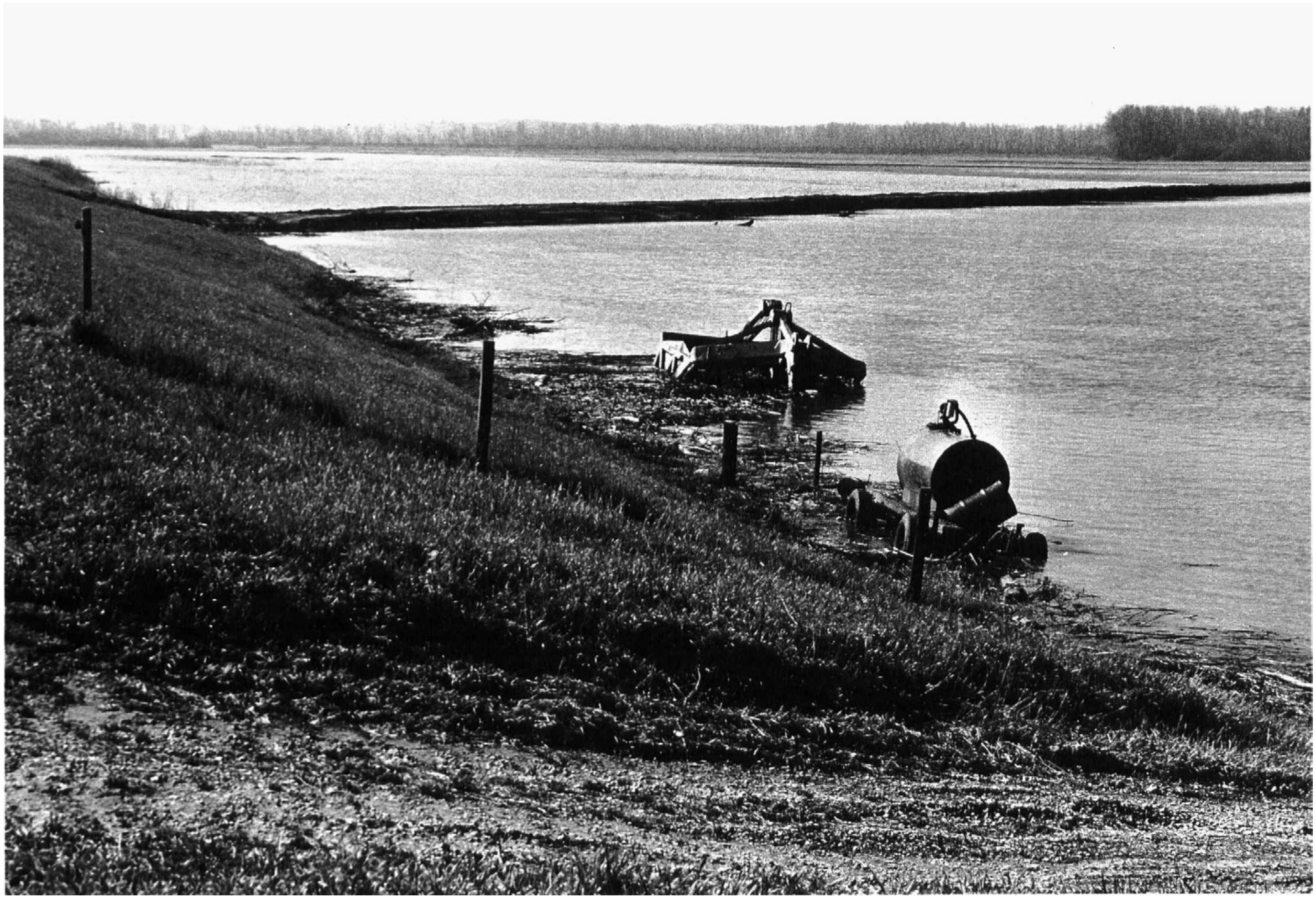

Figure 9.—An area of Haynie silt loam, sandy substratum, frequently flooded, during a flood in the spring.

inches thick. It is dark brown, mottled silty clay loam in the upper part and dark grayish brown, mottled silty clay loam in the lower part. The substratum to a depth of 60 inches or more is olive brown and grayish brown, mottled silty clay loam. In places the dark surface layer is more than 10 inches thick. In some small areas the soil is severely eroded. In a few small areas the slope is more than 9 percent.

Included with this soil in mapping are areas of Contrary, Marshall, Lamoni, and Shelby soils. Contrary and Marshall soils are on the upper slopes and in convex areas and are well drained. Contrary soils have a subsoil of silt loam. Marshall soils are not mottled in the upper part of the subsoil. Lamoni and Shelby soils are downslope from the Higginsville soil and have glacial sand and gravel. Shelby soils are well drained. Included soils make up about 5 to 10 percent of this unit.

Permeability is moderate in the Higginsville soil. Surface runoff is medium. Available water capacity is high. The organic matter content is moderate. The shrink-swell potential is moderate in the subsoil. A perched water table commonly is at a depth of 1.5 to 3.0 feet from November through May.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. The wetness is a limitation in a few areas in the easternmost part of the county. Erosion is a moderate hazard. It can be minimized by farming on the contour, terracing or stripcropping, and applying a conservation tillage system that leaves a protective cover of crop residue on the surface. The construction of terraces exposes the subsoil in some areas. Fertilization rates can be adjusted if necessary in these areas. Terrace drains generally are needed. Grassed waterways help to prevent excessive erosion in small drainageways and in areas where they are used as an outlet for terrace drains. Because of the restricted permeability, the surface soil is wet for several days following heavy rains. Restricting fieldwork when the soil is wet minimizes compaction and the formation of clods.

This soil is suited to grasses and legumes that can withstand the wetness. Examples are ladino clover, reed canarygrass, and switchgrass. The main limitation in areas used as pasture or hayland is the perched water table during winter and spring months. Fieldwork should be avoided when the soil is saturated. A properly designed rotation grazing system can help to prevent the damage caused by grazing when the soil is wet. Erosion is a hazard in newly seeded areas. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established.

The main limitations on sites for dwellings are the wetness and the shrink-swell potential. Constructing dwellings without basements on raised, well compacted fill material helps to prevent the damage caused by wetness. Adequately reinforcing the concrete in foundations and backfilling with coarse textured material minimize the damage caused by shrinking and swelling.

This soil is severely limited as a site for septic tank absorption fields, mainly because of the wetness. Installing perimeter drains around the septic tank absorption field lowers the water table.

Low strength, the shrink-swell potential, the wetness, and frost action are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by low strength and by shrinking and swelling. Grading the roads so that they shed water, constructing adequate roadside ditches, and installing culverts help to overcome the wetness. A moisture barrier of gravel in the subgrade helps to prevent the damage caused by frost action.

The land capability classification is IIIe.

19D2—Higginsville silty clay loam, 9 to 14 percent slopes, eroded. This very deep, strongly sloping, somewhat poorly drained soil is on concave head slopes. Erosion has removed much of the original dark surface soil. Individual areas are irregular in shape and range from 9 to 50 acres in size.

Typically, the surface layer is very dark grayish brown, very friable silty clay loam about 9 inches thick. The subsoil is mottled silty clay loam about 35 inches thick. It is olive brown to yellowish brown in the upper part and light olive brown in the lower part. The substratum to a depth of 60 inches or more is light olive brown, mottled silt loam. In places the dark surface layer is more than 10 inches thick. In some small areas the soil is severely eroded. In a few small areas the slope is less than 9 percent.

Included with this soil in mapping are areas of Contrary, Marshall, Lamoni, and Shelby soils. Contrary and Marshall soils are on the upper side slopes and in convex areas and are well drained. Contrary soils have a subsoil of silt loam. Marshall soils are not mottled in the upper part of the subsoil. Lamoni and Shelby soils are downslope from the Higginsville soil and have glacial sand and gravel. Shelby soils are well drained. Included soils make up about 5 to 10 percent of this unit.

Permeability is moderate in the Higginsville soil. Surface runoff is rapid. Available water capacity is high. The organic matter content is moderate. The shrink-swell potential is moderate in the subsoil. A perched water table commonly is at a depth of 1.5 to 3.0 feet from November through May.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. The wetness is a limitation in a few areas in the easternmost part of the county. Erosion is a severe hazard. It can be minimized by farming on the contour, installing terraces, and applying a conservation tillage system that leaves a protective cover of crop residue on the surface. The construction of terraces exposes the subsoil in some areas. Fertilization rates can be adjusted if necessary in these areas. Terrace drains generally are needed. Grassed waterways help to prevent excessive erosion in small drainageways and in areas where they are used as an outlet for terrace drains. Because of the moderately slow permeability, the surface soil is wet for several days following heavy rains. Restricting fieldwork when the soil is wet minimizes compaction and the formation of clods.

This soil is suited to grasses and legumes that can withstand the wetness. Examples are ladino clover, reed canarygrass, and switchgrass. The main limitations in areas used as pasture or hayland are the hazard of erosion when establishing new seedings and the wetness. Erosion can be minimized by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established. Erosion is also a hazard on livestock trails and in overgrazed areas. It can be minimized by applying a rotation grazing system and carefully locating water and supplements for livestock. Fieldwork should be avoided when the soil is saturated. A properly designed rotation grazing system can help to prevent the damage caused by grazing when the soil is wet.

The main limitations on sites for dwellings are the wetness, the shrink-swell potential, and the slope. Constructing dwellings without basements on raised, well compacted fill material helps to prevent the damage caused by wetness. Adequately reinforcing the concrete in foundations and backfilling with coarse textured material minimize the damage caused by shrinking and swelling. Dwellings can be designed so that they conform to the natural slope of the land, or the site can be graded to a suitable gradient.

This soil is severely limited as a site for septic tank absorption fields, mainly because of the wetness and the slope. Installing perimeter drains around the septic tank absorption field lowers the water table. Land shaping and installing the distribution lines across the slope are necessary for the proper functioning of the absorption field.

Low strength, the shrink-swell potential, the wetness, frost action, and the slope are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by low strength and by shrinking and swelling. Grading the roads so that they shed water, constructing adequate roadside ditches, and installing culverts help to overcome the wetness. A moisture barrier of gravel in the subgrade minimizes the damage caused by frost action. Some cutting and filling may be necessary because of the slope. Also, the roads can be designed so that they conform to the natural slope of the land.

The land capability classification is IIIe.

20D2—Ida silt loam, 9 to 14 percent slopes, eroded. This very deep, strongly sloping, well drained soil is on side slopes. Erosion has removed much of the original dark surface soil. Individual areas are irregular in shape and range from 7 to 40 acres in size.

Typically, the surface layer is brown, very friable silt loam about 5 inches thick. The substratum to a depth of 60 inches or more is calcareous, light olive brown and light brownish gray, mottled silt loam. In some areas the upper part of the substratum is not calcareous. In other areas the slope is more than 14 percent. In some small areas the soil is severely eroded.

Included with this soil in mapping are areas of Malvern, Monona, and Napier soils. Malvern soils are on a few of the lower nose slopes in the easternmost mapped areas. They have redder colors than the Ida soil and more clay. Monona soils generally are on narrow, secondary ridgetops. In a few places they are on the lower, gentler side slopes. They have a dark surface layer that is thicker than that of the Ida soil and have a noncalcareous subsoil. Napier soils are on gently sloping foot slopes and have a very thick, dark surface layer. Included soils make up about 10 percent of this unit.

Permeability is moderate in the Ida soil. Surface runoff is rapid. Available water capacity is very high. The organic matter content is low.

This soil is used for cultivated crops or for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. Erosion is a severe hazard. It can be minimized by farming on the contour, installing terraces, and applying a conservation tillage system that leaves a protective cover of crop residue on the surface. The construction of terraces exposes the substratum in some areas. Fertilization rates can be adjusted if necessary in these areas. Terrace drains generally are not needed. Grassed waterways help to prevent excessive erosion in small drainageways. Because of the moderate permeability, excess surface water quickly drains into the soil. Access to fields is possible soon after heavy rains.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, smooth bromegrass, and switchgrass. Erosion is the main hazard in areas used as pasture or hayland when new seedlings are becoming established. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a ground cover is quickly established. Erosion is also a hazard on livestock trails and in overgrazed areas. It can be minimized by applying a rotation grazing system and carefully locating water and supplements for livestock.

The main limitation on sites for dwellings is the slope. Dwellings can be designed so that they conform to the natural slope of the land, or the site can be graded to a suitable gradient.

This soil is moderately limited as a site for septic tank absorption fields, mainly because of the slope. Land shaping and installing the distribution lines across the slope are necessary for the proper functioning of the absorption field.

Low strength, frost action, and the slope are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by low strength. Grading the roads so that they shed water and installing a moisture barrier of gravel in the subgrade minimizes the damage caused by frost action. Some cutting and filling may be necessary because of the slope. Also, the roads can be designed so that they conform to the natural slope of the land.

The land capability classification is IIIe.

20E2—Ida silt loam, 14 to 25 percent slopes, eroded. This very deep, moderately steep, well drained soil is on side slopes. Erosion has removed much of the original dark surface soil. Individual areas are irregular

Figure 10.—A terrace that has a steep back slope in an area of Ida silt loam, 14 to 25 percent slopes, eroded. Such terraces reduce the hazard of erosion.

in shape and range from 15 to 420 acres in size.

Typically, the surface layer is dark brown, very friable silt loam about 4 inches thick. The substratum to a depth of 60 inches or more is calcareous, yellowish brown, grayish brown, and light olive brown, mottled silt loam. In places the upper part of the substratum is not calcareous. In some small areas the soil is severely eroded.

Included with this soil in mapping are areas of Monona and Napier soils. Monona soils generally are on narrow ridgetops. In a few places they are on the lower, gentler side slopes. They have a thick, dark surface layer and a noncalcareous subsoil. Napier soils are on gently sloping foot slopes and have a very thick, dark surface layer. Included soils make up about 10 percent of this unit.

Permeability is moderate in the Ida soil. Surface runoff is very rapid. Available water capacity is very high. The organic matter content is low.

This soil is used for cultivated crops or for pasture. In a few areas it has a permanent cover of grass. It is suited to corn, soybeans, grain sorghum, and winter wheat on a limited basis. Erosion is a very severe hazard. It can be minimized by farming on the contour, installing terraces, and applying a conservation tillage system that leaves a protective cover of crop residue on the surface. The soil generally is too steep for the construction of broad-base terraces. Terraces that have a steep back slope or a narrow base can be constructed (fig. 10). Even where terraces are installed and a conservation tillage system is applied, the rate of erosion is high in the steepest areas. Conversion of cropland to a permanent vegetative cover, such as pasture, helps to control erosion in these areas. A crop rotation that includes pasture and hay crops generally is needed. The construction of terraces exposes the substratum in some areas. Fertilization rates can be adjusted if necessary in these areas. Terrace drains generally are not needed. Grassed waterways help to prevent excessive erosion in small drainageways. Because of the moderate permeability, excess surface water quickly drains into the soil. Access to fields is possible soon after heavy rains.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, smooth bromegrass, and switchgrass. Erosion is the main hazard in areas used as pasture or hayland when new seedlings are becoming established. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a ground cover is quickly established. Erosion is also a hazard on livestock trails and in overgrazed areas. It can be minimized by applying a rotation grazing system and carefully locating water and supplements for livestock.

The main limitation on sites for dwellings is the slope. Dwellings can be designed so that they conform to the natural slope of the land, or the site can be graded to a suitable gradient.

This soil is severely limited as a site for septic tank absorption fields, mainly because of the slope. Land shaping and installing the distribution lines across the slope are necessary for the proper functioning of the absorption field.

Low strength, frost action, and the slope are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by low strength. Grading the roads so that they shed water and installing a moisture barrier of gravel in the subgrade minimizes the damage caused by frost action. Cutting and filling generally are necessary because of the slope.

The land capability classification is IVe.

21B—Judson silt loam, 2 to 5 percent slopes. This very deep, gently sloping, well drained soil is on foot slopes adjacent to flood plains along major secondary streams. Individual areas are elongated and parallel to the stream channels. They range from 7 to 50 acres in size.

Typically, the surface layer is very dark grayish brown, friable silt loam about 7 inches thick. The subsurface layer is mixed black and very dark grayish brown silt loam and mixed very dark grayish brown and dark brown silty clay loam to a depth of 33 inches. The subsoil to a depth of 60 inches or more is dark brown silty clay loam. In some areas the soil is moderately well drained. In other areas, the dark surface soil is less than 20 inches thick and the soil is moderately sloping.

Included with this soil in mapping are areas of Colo, Marshall, and Shelby soils. Colo soils are in nearly level areas along the downslope edges of the unit and are poorly drained. Marshall and Shelby soils are in strongly sloping areas along the upslope margins. They have a dark surface layer that is thinner than that of the Judson soil. Also, Shelby soils have glacial sand and gravel. Included soils make up about 5 percent of this unit.

Permeability is moderate in the Judson soil. Surface runoff is medium. Available water capacity is very high. The organic matter content is high. The shrink-swell potential is moderate in the subsoil.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. Erosion is a slight hazard. It can be minimized by farming on the contour, applying a conservation tillage system that leaves a protective cover of crop residue on the surface, terracing, and stripcropping. Terrace drains generally are not needed. Grassed waterways help to prevent excessive erosion in small drainageways. Because of the moderate permeability, excess surface water quickly drains into the soil. Access to fields is possible soon after heavy rains.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, smooth bromegrass, and switchgrass. No serious limitations affect the areas used as pasture or hayland. Erosion is a hazard in newly seeded areas. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established.

The main limitation on sites for dwellings is the moderate shrink-swell potential. Adequately reinforcing the concrete in foundations and backfilling with coarse textured material minimize the damage caused by shrinking and swelling.

This soil is suited to septic tank absorption fields. Few limitations affect this use.

Low strength, the shrink-swell potential, and frost action are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by low strength and by shrinking and swelling. Grading the roads so that they shed water and installing a moisture barrier of gravel in the subgrade minimize the damage caused by frost action.

The land capability classification is IIe.

22C2—Lamoni clay loam, 5 to 9 percent slopes, eroded. This very deep, moderately sloping, somewhat poorly drained soil is on the lower side slopes and concave head slopes. Erosion has removed much of the original dark surface soil. Individual areas are irregular in shape and range from 15 to 120 acres in size.

Typically, the surface layer is very dark grayish brown, friable clay loam about 8 inches thick. The subsoil is mottled clay loam about 46 inches thick. The upper part is very dark grayish brown and dark brown, and the lower part is dark yellowish brown and olive gray. The substratum to a depth of 60 inches or more is mottled, light gray, olive gray, and strong brown clay loam. In places the dark surface layer is more than 10 inches thick. In some small areas the soil is severely eroded. In other small areas the slope is more than 9 percent. In places the soil is silty clay loam throughout.

Included with this soil in mapping are areas of Higginsville and Shelby soils. Higginsville soils are near the upslope edges of the mapped areas. They do not have glacial sand and gravel. Shelby soils are on the lower slopes and in convex areas and are well drained. Included soils make up about 5 percent of this unit.

Permeability is slow in the Lamoni soil. Surface runoff is medium. Available water capacity is high. The organic matter content is moderate. The shrink-swell potential is high in the subsoil. A perched water table commonly is at a depth of 1 to 3 feet from November through May.

This soil is used primarily for corn or soybeans. In some areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. It is limited by the wetness and a moderate hazard of erosion. The wetness often delays fieldwork in the spring and fall and can reduce yields in some areas. A tile drainage system can help to overcome the wetness. Erosion can be minimized by farming on the contour, terracing or stripcropping, and applying a conservation tillage system that leaves a protective cover of crop residue on the surface. The construction of terraces exposes the subsoil in some areas. Fertilization rates can be adjusted if necessary in these areas. The surface layer can be stockpiled during terrace construction and then spread across the finished terraces. Terrace drains generally are needed. Grassed waterways help to prevent excessive erosion in small drainageways and in areas where they are used as an outlet for terrace drains. Because of the slow permeability, the surface layer is wet for several days following heavy rains. Restricting fieldwork when the soil is wet minimizes compaction and the formation of clods.

This soil is suited to grasses and legumes that can withstand the wetness. Examples are ladino clover, reed canarygrass, and switchgrass. The main limitations in areas used as pasture or hayland are erosion when establishing new seedings and the wetness. Erosion can be minimized by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established. Fieldwork should be avoided when the soil is saturated. A properly designed rotation grazing system can help to prevent the damage caused by grazing when the soil is wet.

The main limitations on sites for dwellings are the wetness and the high shrink-swell potential. Constructing dwellings without basements on raised, well compacted fill material minimizes the damage caused by wetness. Adequately reinforcing the concrete in foundations and backfilling with coarse textured material minimize the damage caused by shrinking and swelling.

This soil is severely limited as a site for septic tank absorption fields, mainly because of the wetness and the slow permeability. The absorption fields can be constructed on moderately rapidly permeable fill material. Holding tanks are an effective alternative to septic tank absorption fields.

Low strength, the high shrink-swell potential, the wetness, and frost action are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by low strength and by shrinking and swelling. Grading the roads so that they shed water, constructing adequate roadside ditches, and installing culverts help to overcome the wetness. A moisture barrier of gravel in the subgrade minimizes the damage caused by frost action.

The land capability classification is IIIe.

22D2—Lamoni clay loam, 9 to 14 percent slopes, eroded. This very deep, strongly sloping, somewhat poorly drained soil is on the lower side slopes and concave head slopes. Erosion has removed much of the original dark surface soil. Individual areas are irregular in shape and range from 10 to 80 acres in size.

Typically, the surface layer is very dark gray, friable silty clay loam about 7 inches thick. The subsoil is about 35 inches thick. The upper part is dark grayish brown, mottled silty clay loam. The lower part is yellowish brown and light olive brown, mottled clay loam. The substratum to a depth of 60 inches or more is mottled grayish brown to light olive gray clay loam. In places the surface soil is more than 10 inches thick. In a few small areas the slope is less than 9 percent. In other areas the soil is silty clay loam throughout.

Included with this soil in mapping are areas of Shelby soils and some small, scattered, severely eroded areas of Lamoni soils. Shelby soils are on the lower slopes and in convex areas and are well drained. Included soils make up about 5 percent of this unit.

Permeability is slow in the Lamoni soil. Surface runoff is rapid. Available water capacity is high. The organic matter content is moderate. The shrink-swell potential is high in the subsoil. A perched water table commonly is at a depth of 1 to 3 feet from November through May.

This soil is used primarily for corn or soybeans. In some areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. It is limited by a severe hazard of erosion and the wetness. Erosion can be minimized by farming on the contour, installing terraces, and applying a conservation tillage system that leaves a protective cover of crop residue on the surface. The construction of terraces exposes the subsoil in some areas. Fertilization rates can be adjusted if necessary in these areas. The surface layer can be stockpiled during terrace construction and then spread across the finished terraces. Terrace drains generally are needed. Grassed waterways help to prevent excessive erosion in small drainageways and in areas where they are used as an outlet for terrace drains. The wetness often delays fieldwork in the spring and fall and can reduce yields in some areas. Because of the slow permeability, the surface layer is wet for several days following heavy rains. A tile drainage system can help to overcome the wetness. Restricting fieldwork when the soil is wet minimizes compaction and the formation of clods.

This soil is suited to grasses and legumes that can withstand the wetness. Examples are ladino clover, reed canarygrass, and switchgrass. The main limitations in areas used as pasture or hayland are the hazard of erosion when establishing new seedings and the wetness. Erosion can be minimized by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established. Erosion is also a hazard on livestock trails and in overgrazed areas. It can be minimized by applying a rotation grazing system and carefully locating water and supplements for livestock. Fieldwork should be avoided when the soil is saturated. A properly designed rotation grazing system can help to prevent the damage caused by grazing when the soil is wet.

The main limitations on sites for dwellings are the wetness, the high shrink-swell potential, and the slope. Constructing dwellings without basements on raised, well compacted fill material minimizes the damage caused by wetness. Adequately reinforcing the concrete in foundations and backfilling with coarse textured material minimize the damage caused by shrinking and swelling. Dwellings can be designed so that they conform to the natural slope of the land, or the site can be graded to a suitable gradient.

This soil is severely limited as a site for septic tank absorption fields, mainly because of the wetness and the slow permeability. The slope is a moderate limitation. The absorption fields can be constructed on moderately rapidly permeable fill material. Holding tanks are an effective alternative to septic tank absorption fields. Land shaping and installing the distribution lines across the slope are necessary for the proper functioning of the absorption field.

Low strength, the high shrink-swell potential, the wetness, frost action, and the slope are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by low strength and by shrinking and swelling. Grading the roads so that they shed water, constructing adequate roadside ditches, and installing culverts help to overcome the wetness. A moisture barrier of gravel in the subgrade minimizes the damage caused by frost action. Some cutting and filling may be necessary because of the slope. Also, the roads can be designed so that they conform to the natural slope of the land.

The land capability classification is IVe.

23—Luton silty clay. This very deep, nearly level, very poorly drained soil is on high flood plains along the Missouri River. It is subject to rare flooding, which can occur if levees along the Missouri River break. Individual areas are irregular in shape and range from 50 to 2,300 acres in size.

Typically, the surface layer is very dark gray and very dark grayish brown, firm silty clay about 10 inches thick. The subsurface layer is black silty clay about 5 inches thick. The subsoil is about 15 inches of dark grayish brown, mottled silty clay and clay. The substratum to a depth of 60 inches or more is calcareous, dark grayish brown to dark gray, mottled clay. In some areas the surface layer is silty clay loam. In other areas the substratum has thin to thick strata of silt loam.

Included with this soil in mapping are some areas of Luton soils that are ponded in the spring and after heavy rains. These soils make up less than 5 percent of the unit.

Permeability is very slow in this Luton soil. Surface runoff is slow. Available water capacity is moderate. The organic matter content is moderate or high. The shrink-swell potential is high in the subsoil. The seasonal high water table commonly is at a depth of 1 to 3 feet from November through June.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. It is limited by the wetness, which may delay fieldwork in the spring. Most areas, however, are effectively drained by lateral surface drains and by field ditches or by a tile drainage system. Because of the very slow permeability, the surface soil is wet for several days following heavy rains. Restricting fieldwork when the soil is wet minimizes compaction and the formation of clods.

This soil is suited to grasses and legumes that can withstand the wetness. Examples are ladino clover and reed canarygrass. The soil is poorly suited to warm-season grasses and hay crops. The main limitation in areas used for pasture is the wetness. Lateral surface drains and field ditches help to remove excess surface water. Fieldwork should be avoided when the soil is saturated. A properly designed rotation grazing system can help to prevent the damage caused by grazing when the soil is wet.

The main limitations on sites for dwellings are the flooding, the wetness, and the high shrink-swell potential. Adequately reinforcing the concrete in foundations and backfilling with coarse textured material minimize the damage caused by shrinking and swelling. Constructing dwellings without basements on raised, well compacted fill material minimizes the damage caused by wetness. The fill material should be of sufficient thickness to raise the dwelling above expected flood levels.

This soil is severely limited as a site for septic tank absorption fields, mainly because of the wetness and the very slow permeability. The absorption fields can be constructed on moderately rapidly permeable fill material. Holding tanks or sewage lagoons are effective alternatives to septic tank absorption fields.

Low strength, the high shrink-swell potential, the wetness, and frost action are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by low strength and by shrinking and swelling. Grading the roads so that they shed water, constructing adequate roadside ditches, and installing culverts help to overcome the wetness. A moisture barrier of gravel in the subgrade minimizes the damage caused by frost action.

The land capability classification is IIIw.

24D3—Malvern-Shelby complex, 9 to 14 percent slopes, severely eroded. These very deep, strongly sloping soils are on the lower nose slopes and the adjacent side slopes. The somewhat poorly drained Malvern soil is upslope from the well drained Shelby soil. Erosion has removed much of the original dark surface layer. Individual areas are narrow and range from 15 to 120 acres in size.

Generally, the Malvern soil makes up about 50 percent of the unit, the Shelby soil 30 percent, and included soils 20 percent. In many areas the percentage of the Shelby soil is much smaller, and in a few areas the Shelby soil does not occur.

Typically, the Malvern soil has a surface layer of dark brown, very friable silty clay loam about 4 inches thick. The subsoil extends to a depth of 60 inches or more. The upper part is reddish brown silty clay loam and reddish brown, mottled silty clay. The lower part is grayish brown silty clay loam that has reddish brown, brown, and yellowish brown mottles. In some areas the subsoil has clay loam glacial till. In a few areas it is silty clay loam throughout.

Permeability is slow in the Malvern soil. Surface runoff is rapid. Available water capacity is high. The organic matter content is moderately low. The shrink-swell potential is high in the subsoil. A perched water table commonly is at a depth of 1 to 3 feet from November through May.

Typically, the Shelby soil has a surface layer of very dark grayish brown, friable clay loam about 6 inches thick. The subsoil is about 38 inches thick. The upper part is dark yellowish brown clay loam, and the lower part is yellowish brown, mottled clay loam. The substratum to a depth of 60 inches or more is yellowish brown, mottled clay loam. Gravel and cobbles are common on the surface. In places strata of fine sandy loam are in the subsoil.

Permeability is moderately slow in the Shelby soil. Surface runoff is rapid. Available water capacity is high. The organic matter content is moderately low. The shrink-swell potential is moderate in the subsoil.

Included in this unit in mapping are areas of Colo, Judson, Marshall, and Monona soils. Colo soils are in drainageways. They have a thick, dark surface soil and are poorly drained. Judson soils are along the downslope edges of the mapped areas and on the lower head slopes. They have a thick, dark surface soil. Marshall soils are in the more eastern areas, and Monona soils are in the more western areas. Both soils are along the upslope edges of the mapped areas on side slopes and head slopes. They are well drained. Marshall soils are silty clay loam. Monona soils are silt loam. Also included in the unit are soils that are shallow over bedrock in the lower part of the Tarkio River valley south of Fairfax. The band of bedrock generally is less than 100 feet wide, but it severely restricts most land uses. Included soils make up about 20 percent of the unit.

This unit is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. The seasonal wetness in the Malvern soil generally does not limit farming or reduce yields. Erosion is a severe hazard on both soils. It can be minimized by farming on the contour, installing terraces, and applying a conservation tillage system that leaves a protective cover of crop residue on the surface. The construction of terraces exposes the subsoil in some areas. Fertilization rates can be adjusted if necessary in these areas. The surface layer can be stockpiled during terrace construction and then spread across the finished terraces. Terrace drains generally are needed. Grassed waterways help to prevent excessive erosion in small drainageways and in areas where they are used as an outlet for terrace drains. Because of the restricted permeability, the surface soil is wet for several days following heavy rains. Restricting fieldwork when the soil is wet minimizes compaction and the formation of clods.

This unit is suited to grasses and legumes that can withstand the wetness. Examples are ladino clover, reed canarygrass, and switchgrass. The main limitations in areas used as pasture or hayland are the hazard of erosion when establishing new seedings and the wetness in the Malvern soil. Erosion can be minimized by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established. Erosion is also a hazard on livestock trails and in overgrazed areas. It can be minimized by applying a rotation grazing system and carefully locating water and supplements for livestock. Fieldwork should be avoided when the Malvern soil is saturated. A properly designed rotation grazing system can help to prevent the damage caused by grazing when the soil is wet.

The main limitations on sites for dwellings in areas of the Shelby soil are the slope and the moderate shrink-swell potential. The main limitations in areas of the Malvern soil are the slope, the wetness, and the high shrink-swell potential. If possible, dwellings should be built in areas of the Shelby soil. They should be designed so that they conform to the natural slope of the land, or the site should be graded to a suitable gradient. Adequately reinforcing the concrete in foundations and backfilling with coarse textured material minimize the damage caused by shrinking and swelling. Constructing dwellings without basements on raised, well compacted fill material minimizes the damage caused by wetness.

This unit is severely limited as a site for septic tank absorption fields. The Shelby soil is limited by the moderately slow permeability, and the Malvern soil is limited by the slow permeability and the wetness. The slope is a moderate limitation on both soils. If possible, absorption fields should be installed in areas of the Shelby soil. The moderately slow permeability in the Shelby soil can be overcome by increasing the size of the absorption area. Absorption fields in areas of the Malvern soil can be constructed on moderately rapidly permeable fill material. Holding tanks are an effective alternative to septic tank absorption fields in areas of the Malvern soil. Land shaping and installing the distribution lines across the slope are necessary for the proper functioning of the absorption field.

Low strength, the shrink-swell potential, the slope, and frost action are limitations on sites for local roads and streets. The wetness also is a limitation in areas of the Malvern soil. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by low strength and by shrinking and swelling. Some cutting and filling may be necessary because of the slope. Also, the roads can be designed so that they conform to the natural slope of the land. Grading the roads so that they shed water, constructing adequate roadside ditches, and installing culverts help to overcome the wetness in areas of the Malvern soil. A moisture barrier of gravel in the subgrade helps to prevent the damage caused by frost action.

The land capability classification is IVe.

25B—Marshall silt loam, 2 to 5 percent slopes. This very deep, gently sloping, well drained soil is on broad ridgetops. Individual areas are long and branching. They range from 20 to 120 acres in size.

Typically, the surface layer is very dark grayish brown, friable silt loam about 8 inches thick. The subsurface layer is very dark grayish brown and dark brown silty clay loam about 13 inches thick. The subsoil extends to a depth of 60 inches or more. It is dark yellowish brown silty clay loam in the upper part and dark brown and yellowish brown, mottled silt loam in the lower part. In places the dark surface soil is less than 10 inches thick.

Included with this soil in mapping are areas of Higginsville soils. These soils are in swales and on the upper head slopes. They are somewhat poorly drained and have mottles in the upper part of the subsoil. Included soils make up about 4 percent of this unit.

Permeability is moderate in the Marshall soil. Surface runoff is medium. Available water capacity is high. The organic matter content is moderate. The shrink-swell potential is moderate in the subsoil.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. Erosion is a slight hazard. It can be minimized by farming on the contour, applying a conservation tillage system that leaves a protective cover of crop residue on the surface, terracing, and stripcropping. Terrace drains generally are not needed. Grassed waterways help to prevent excessive erosion in small drainageways. Because of the moderate permeability, excess surface water quickly drains into the soil. Access to fields is possible soon after heavy rains.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, smooth bromegrass, and switchgrass. No serious limitations affect the areas used as pasture or hayland. Erosion is a hazard in newly seeded areas. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established.

The main limitation on sites for dwellings is the moderate shrink-swell potential. Adequately reinforcing the concrete in foundations and backfilling with coarse textured material minimize the damage caused by shrinking and swelling.

This soil is suited to septic tank absorption fields. Few limitations affect this use.

Low strength, the shrink-swell potential, and frost action are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by low strength and by shrinking and swelling. Grading the roads so that they shed water and installing a moisture barrier of gravel in the subgrade help to prevent the damage caused by frost action.

The land capability classification is IIe.

25C2—Marshall silty clay loam, 5 to 9 percent slopes, eroded. This very deep, moderately sloping, well drained soil is dominantly on convex, undulating ridgetops. In a few areas it is on side slopes. Erosion has removed much of the original dark surface soil. Individual areas are long and branching. They range from 10 to 460 acres in size.

Typically, the surface layer is very dark grayish brown, friable silty clay loam about 8 inches thick. The subsoil is 42 inches thick. The upper part is dark yellowish brown silty clay loam. The lower part is yellowish brown, mottled silt loam. The substratum to a depth of 60 inches or more is yellowish brown silt loam. In some areas the soil is gently sloping. In a few small areas the slope is more than 9 percent. In places the dark surface soil is more than 10 inches thick. In some small areas the soil is severely eroded. In other areas the upper part of the subsoil has grayish mottles.

Included with this soil in mapping are areas of Higginsville, Shelby, and Lamoni soils in the eastern part of the county. Higginsville soils are on the upper, concave head slopes and in swales, are somewhat poorly drained, and have mottles in the upper part of the subsoil. Shelby and Lamoni soils are downslope along the boundaries of the mapped areas and have clay loam glacial till. Lamoni soils are somewhat poorly drained. Included soils make up about 5 percent of this unit.

Permeability is moderate in the Marshall soil. Surface runoff is medium. Available water capacity is high. The organic matter content is moderate. The shrink-swell potential is moderate in the subsoil.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. Erosion is a moderate hazard. It can be minimized by farming on the contour, terracing or stripcropping, and applying a conservation tillage system that leaves a protective cover of crop residue on the surface. The construction of terraces exposes the subsoil in some areas. Fertilization rates can be adjusted if necessary in these areas. Terrace drains generally are not needed. Grassed waterways help to prevent excessive erosion in small drainageways. Because of the moderate permeability, excess surface water quickly drains into the soil. Access to fields is possible soon after heavy rains.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, smooth bromegrass, and switchgrass. No serious limitations affect the areas used as pasture or hayland. Erosion is a hazard in newly seeded areas. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established.

The main limitation on sites for dwellings is the moderate shrink-swell potential. Adequately reinforcing the concrete in foundations and backfilling with coarse textured material minimize the damage caused by shrinking and swelling.

This soil is suited to septic tank absorption fields. Few limitations affect this use.

Low strength, the shrink-swell potential, and frost action are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by low strength and by shrinking and swelling. Grading the roads so that they shed water and installing a moisture barrier of gravel in the subgrade minimize the damage caused by frost action.

The land capability classification is IIIe.

25D2—Marshall silty clay loam, 9 to 14 percent slopes, eroded. This very deep, strongly sloping, well drained soil is on side slopes. Erosion has removed much of the original dark surface soil. Individual areas are irregular in shape and range from 15 to 80 acres in size.

Typically, the surface layer is very dark grayish brown, friable silty clay loam about 6 inches thick. The subsoil is about 42 inches thick. It is brown silty clay loam in the upper part and yellowish brown, mottled silt loam in the lower part. The substratum to a depth of 60 inches or more is yellowish brown, mottled silt loam. In a few areas the slope is less than 9 percent. In some places the dark surface soil is more than 10 inches thick. In other places the upper part of the subsoil has grayish mottles. In some small areas the soil is severely eroded.

Included with this soil in mapping are areas of Higginsville, Judson, Lamoni, and Shelby soils. Higginsville soils are on concave head slopes, primarily in the easternmost mapped areas. They are somewhat poorly drained and have mottles in the upper part of the subsoil. Judson soils are on the gently sloping lower head slopes and foot slopes near the downslope edges of the mapped areas. They have a very thick, dark surface soil. Lamoni and Shelby soils are on the lower nose slopes and side slopes and have clay loam glacial till. Also, Lamoni soils are somewhat poorly drained. Included soils make up about 10 percent of this unit.

Permeability is moderate in the Marshall soil. Surface runoff is rapid. Available water capacity is high. The organic matter content is moderate. The shrink-swell potential is moderate in the subsoil.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. Erosion is a severe hazard. It can be minimized by farming on the contour, installing terraces, and applying a conservation tillage system that leaves a protective cover of crop residue on the surface. The construction of terraces exposes the subsoil in some areas. Fertilization rates can be adjusted if necessary in these areas. Terrace drains generally are not needed. Grassed waterways help to prevent excessive erosion in small drainageways. Because of the moderate permeability, excess surface water quickly drains into the soil. Access to fields is possible soon after heavy rains.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, smooth bromegrass, and switchgrass. Erosion is the main hazard in areas used as pasture or hayland when new seedlings are becoming established. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a ground cover is quickly established. Erosion is also a hazard on livestock trails and in overgrazed areas. It can be minimized by applying a rotation grazing system and carefully locating water and supplements for livestock.

The main limitations on sites for dwellings are the slope and the moderate shrink-swell potential. Dwellings can be designed so that they conform to the natural slope of the land, or the site can be graded to a suitable gradient. Adequately reinforcing the concrete in foundations and backfilling with coarse textured material minimize the damage caused by shrinking and swelling.

This soil is moderately limited as a site for septic tank absorption fields, mainly because of the slope. Land shaping and installing the distribution lines across the slope are necessary for the proper functioning of the absorption field.

Low strength, the shrink-swell potential, frost action, and the slope are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by low strength and by shrinking and swelling. Grading the roads so that they shed water and installing a moisture barrier of gravel in the subgrade minimize the damage caused by frost action. Some cutting and filling may be necessary because of the slope. Also, the roads can be designed so that they conform to the natural slope of the land.

The land capability classification is IIIe.

26—McPaul silt loam. This very deep, nearly level, well drained soil is along secondary streams in the Missouri River valley. It is subject to occasional flooding, which can occur from November through June if levees along major secondary streams break. Individual areas are irregular in shape and range from 30 to 530 acres in size.

Typically, the surface layer is very dark grayish brown, friable silt loam about 7 inches thick. The substratum to a depth of 60 inches or more is calcareous, stratified dark grayish brown and brown silt loam. In some areas part or all of the substratum is not calcareous. In a few areas the seasonal high water table is at a depth of less than 60 inches.

Included with this soil in mapping are small areas of Dockery and Napier soils. Dockery soils are in the slightly lower positions on the landscape or are closer to drainageways. They are somewhat poorly drained. Napier soils are on gently sloping foot slopes near the upslope edges of the mapped areas. They have a very thick, dark surface soil. Included soils make up about 10 percent of this unit.

Permeability is moderate in the McPaul soil. Surface runoff is slow. Available water capacity is very high. The organic matter content is moderately low.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. It has few limitations. The flooding may cause minor crop damage in some years. Because of the moderate permeability, excess surface water quickly drains into the soil. Access to fields is possible soon after heavy rains.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, smooth bromegrass, and switchgrass. No serious limitations affect the areas used for pasture or hayland.

This soil is unsuited to building site development. It is limited by the flooding. Extreme measures are needed to overcome this limitation. Dwellings should be built in areas of better suited soils.

The land capability classification is I.

27B—Monona silt loam, 2 to 5 percent slopes. This very deep, gently sloping, well drained soil is on broad ridgetops. Individual areas are irregular in shape and range from 15 to 390 acres in size.

Typically, the surface layer and subsurface layer are very dark grayish brown, very friable silt loam. They have a combined thickness of about 12 inches. The subsoil is about 36 inches thick. It is dark brown silt loam in the upper part and dark yellowish brown, mottled silt loam in the lower part. The substratum to a depth of 60 inches or more is brown and yellowish brown, mottled silt loam. In places the dark surface soil is less than 10 inches thick.

Included with this soil in mapping are small areas of Ida soils. These soils are on shoulder slopes near the edges of the mapped areas. They commonly have a slope of 5 percent or more. They have a thin surface layer and have a calcareous substratum at a shallow depth. They make up about 5 percent of this unit.

Permeability is moderate in the Monona soil. Surface runoff is medium. Available water capacity is very high. The organic matter content is moderate. The shrink-swell potential is moderate in the subsoil.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. Erosion is a slight hazard. It can be minimized by farming on the contour, applying a conservation tillage system that leaves a protective cover of crop residue on the surface, terracing, and stripcropping. Terrace drains generally are not needed. Grassed waterways help to prevent excessive erosion in small drainageways. Because of the moderate permeability, excess surface water quickly drains into the soil. Access to fields is possible soon after heavy rains.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, smooth bromegrass, and switchgrass. No serious limitations affect the areas used as pasture or hayland. Erosion is a hazard in newly seeded areas. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established.

The main limitation on sites for dwellings is the moderate shrink-swell potential. Adequately reinforcing the concrete in foundations and backfilling with coarse textured material minimize the damage caused by shrinking and swelling.

This soil is suited to septic tank absorption fields. Few limitations affect this use.

Low strength, the shrink-swell potential, and frost action are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, helps to reduce the damage caused by low strength and by shrinking and swelling. Grading the roads so that they shed water and installing a moisture barrier of gravel in the subgrade minimize the damage caused by frost action.

The land capability classification is IIe.

27C2—Monona silt loam, 5 to 9 percent slopes, eroded. This very deep, moderately sloping, well drained soil is dominantly on convex, undulating ridgetops (fig. 11). In a few areas it is on side slopes. It formed in loess. Erosion has removed much of the original dark surface soil. Individual areas are long and branching. They range from 30 to 340 acres in size.

Typically, the surface layer is dark brown, friable silt loam about 8 inches thick. The subsoil is about 21 inches thick. It is dark yellowish brown silt loam in the upper part and yellowish brown, mottled silt loam in the lower part. The substratum to a depth of 60 inches or more is grayish brown and light olive brown, mottled silt loam. In some areas the soil is gently sloping. In a few small areas the slope is more than 9 percent. In some places the surface soil is more than 10 inches thick. In other places the upper part of the subsoil has gray colors and mottles. In some small areas the soil is severely eroded.

Included with this soil in mapping are small areas of Ida soils. These soils are on shoulder slopes near the edges of the mapped areas. They commonly have a slope of 9 percent or more. These soils have a thin surface layer and have a calcareous substratum at a shallow depth. They generally are in the westernmost mapped areas. They make up about 5 percent of this unit.

Permeability is moderate in the Monona soil. Surface runoff is medium. Available water capacity is very high.

Figure 11.—An area of Monona silt loam, 5 to 9 percent slopes, eroded, on a convex, undulating ridgetop in the western part of the county. Timula silt loam, 25 to 60 percent slopes, is in the wooded areas in the background.

The organic matter content is moderate in the surface layer. The shrink-swell potential is moderate in the subsoil.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. Erosion is a moderate hazard. It can be minimized by farming on the contour, terracing or stripcropping, and applying a conservation tillage system that leaves a protective cover of crop residue on the surface. The construction of terraces exposes the subsoil in some areas. Fertilization rates can be adjusted if necessary in these areas. Terrace drains generally are not needed. Grassed waterways help to prevent excessive erosion in small drainageways. Because of the moderate permeability, excess surface water quickly drains into the soil. Access to fields is possible soon after heavy rains.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, smooth bromegrass, and switchgrass. No serious limitations affect the areas used as pasture or hayland. Erosion is a hazard in newly seeded areas. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established.

The main limitation on sites for dwellings is the moderate shrink-swell potential. Adequately reinforcing the concrete in foundations and backfilling with coarse textured material minimize the damage caused by shrinking and swelling.

This soil is suited to septic tank absorption fields. Few limitations affect this use.

Low strength, the shrink-swell potential, and frost action are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by low strength and by shrinking and swelling. Grading the roads so that they shed water and installing a moisture barrier of gravel in the subgrade minimize the damage caused by frost action.

The land capability classification is IIIe.

27D2—Monona silt loam, 9 to 16 percent slopes, eroded. This very deep, strongly sloping, well drained soil is on side slopes. It formed in loess. Erosion has removed much of the original dark surface soil. Individual areas are irregular in shape and range from 15 to 180 acres in size.

Typically, the surface layer is dark brown, friable silt loam about 9 inches thick. The subsoil is about 25 inches thick. It is dark yellowish brown silt loam in the upper part and yellowish brown silt loam in the lower part. The substratum to a depth of 60 inches or more is brown silt loam. In a few areas the slope is less than 9 percent. In some places the surface soil is more than 10 inches thick. In other places the upper part of the subsoil has gray colors and mottles. In some small areas the soil is severely eroded.

Included with this soil in mapping are small areas of Ida, Malvern, and Napier soils. Ida soils are on shoulder slopes and the upper side slopes in the western mapped areas. They have a thin surface layer and have a calcareous substratum at a shallow depth. Malvern soils are on the lower nose slopes and have a subsoil of reddish silty clay. Napier soils are on the lower, gently sloping head slopes and foot slopes near the downslope edges of the mapped areas. They have a very thick, dark surface layer. Included soils make up about 5 percent of this unit.

Permeability is moderate in the Monona soil. Surface runoff is rapid. Available water capacity is very high. The organic matter content is moderate in the surface layer. The shrink-swell potential is moderate in the subsoil.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. Erosion is a severe hazard. It can be minimized by farming on the contour, installing terraces, and applying a conservation tillage system that leaves a protective cover of crop residue on the surface. The construction of terraces exposes the subsoil in some areas. Fertilization rates can be adjusted if necessary in these areas. Terrace drains generally are not needed. Grassed waterways help to prevent excessive erosion in small drainageways. Because of the moderate permeability, excess surface water quickly drains into the soil. Access to fields is possible soon after heavy rains.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, smooth bromegrass, and switchgrass. Erosion is the main hazard in areas used as pasture or hayland when new seedlings are becoming established. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a ground cover is quickly established. Erosion is also a hazard on livestock trails and in overgrazed areas. It can be minimized by applying a rotation grazing system and carefully locating water and supplements for livestock.

The main limitations on sites for dwellings are the slope and the moderate shrink-swell potential. Dwellings can be designed so that they conform to the natural slope of the land, or the site can be graded to a suitable gradient. Adequately reinforcing the concrete in foundations and backfilling with coarse textured material minimize the damage caused by shrinking and swelling.

This soil is moderately limited as a site for septic tank absorption fields, mainly because of the slope. Land shaping and installing the distribution lines across the slope are necessary for the proper functioning of the absorption field.

Low strength, the shrink-swell potential, frost action, and the slope are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by low strength and by shrinking and swelling. Grading the roads so that they shed water and installing a moisture barrier of gravel in the subgrade minimize the damage caused by frost action. Some cutting and filling may be necessary because of the slope. Also, the roads can be designed so that they conform to the natural slope of the land.

The land capability classification is IIIe.

28—Moville silt loam. This very deep, nearly level, somewhat poorly drained soil is on high flood plains along the Missouri River. It is subject to rare flooding, which can occur if levees along the Missouri River break. Individual areas are irregular in shape and range from 35 to 320 acres in size.

Typically, the surface layer is very dark grayish brown, mottled, very friable silt loam about 8 inches thick. The upper substratum, to a depth of 25 inches, is stratified, dark grayish brown, mottled silt loam. Next is a buried surface layer of very dark grayish brown, mottled silty clay about 9 inches thick. The lower substratum to a depth of 60 inches or more is dark gray and gray, mottled silty clay. In some places the overwash layer of silt loam is less than 18 inches thick. In other places the soil is calcareous only in the lower part. In some areas the surface layer is very fine sandy loam or silty clay loam. In other areas the soil has a substratum of silt loam below a depth of 50 inches.

Included with this soil in mapping are small areas of Blencoe and Luton soils. Both soils are clayey in the upper part. These soils are along the outer edges of the mapped areas where the silty layer of overwash thins. Ponding occurs in some areas in the spring and after heavy rains. Included soils make up about 10 percent of this unit.

Permeability is moderate in the upper part of the Moville soil and very slow in the lower part. Surface runoff is slow. Available water capacity is high. The organic matter content is moderately low or moderate. The shrink-swell potential is high in the substratum. The seasonal high water table commonly is at a depth of 1 to 3 feet from November through June.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. It is limited by the wetness, which may delay fieldwork in the spring. Most areas, however, are effectively drained by lateral surface drains and by field ditches or by a tile drainage system. Because of the moderate permeability, excess surface water quickly drains into the soil. Access to fields is possible soon after heavy rains.

This soil is suited to grasses and legumes that can withstand the wetness. Examples are ladino clover, reed canarygrass, and switchgrass. The main limitation in areas used as pasture or hayland is the wetness, which occasionally restricts fieldwork and grazing.

The main limitations on sites for dwellings are the flooding, the wetness, and the high shrink-swell potential. Adequately reinforcing the concrete in foundations and backfilling with coarse textured material minimize the damage caused by shrinking and swelling. Constructing dwellings without basements on raised, well compacted fill material minimizes the damage caused by wetness. The fill material should be of sufficient thickness to raise the dwelling above expected flood levels.

This soil is severely limited as a site for septic tank absorption fields, mainly because of the wetness and the slow permeability. The absorption fields can be constructed on moderately rapidly permeable fill material. Holding tanks or sewage lagoons are effective alternatives to septic tank absorption fields.

Low strength, the shrink-swell potential, the wetness, and frost action are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by low strength and by shrinking and swelling. Grading the roads so that they shed water, constructing adequate roadside ditches, and installing culverts help to overcome the wetness. A moisture barrier of gravel in the subgrade minimizes the damage caused by frost action.

The land capability classification is IIw.

29B—Napier silt loam, 2 to 5 percent slopes. This very deep, gently sloping, well drained soil is on foot slopes adjacent to the Missouri River valley and to the flood plains along major secondary streams. Individual areas are elongated and parallel to the stream channels. They range from 15 to 230 acres in size.

Typically, the surface layer is very dark brown, friable silt loam about 8 inches thick. The subsurface layer is very dark grayish brown silt loam about 16 inches thick. The subsoil is about 19 inches of dark brown silt loam. The substratum to a depth of 60 inches or more is dark brown silt loam. In some areas the soil is nearly level. In a few areas, it is moderately sloping and the dark surface soil is less than 24 inches thick.

Included with this soil in mapping are small areas of Colo, Dockery, McPaul, and Monona soils. Colo, Dockery, and McPaul soils are nearly level and are on flood plains. Colo soils are poorly drained. Dockery soils are somewhat poorly drained. Dockery and McPaul soils have a thin, dark surface layer. Monona soils are near the upslope edges of the mapped areas. They commonly have a slope of 5 percent or more. The dark upper layers of the Monona soils are thinner than those of the Napier soil. Included soils make up about 5 percent of this unit.

Permeability is moderate in the Napier soil. Surface runoff is medium. Available water capacity is very high. The organic matter content is moderate.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. Erosion is a slight hazard. It can be minimized by farming on the contour, applying a conservation tillage system that leaves a protective cover of crop residue on the surface, terracing, and stripcropping. Terrace drains generally are not needed. Grassed waterways help to prevent excessive erosion in small drainageways. Because of the moderate permeability, excess surface water quickly drains into the soil. Access to fields is possible soon after heavy rains.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, smooth bromegrass, and switchgrass. No serious limitations affect the areas used as pasture or hayland. Erosion is a hazard in newly seeded areas. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established.

This soil is suited to building site development and septic tank absorption fields. Few limitations affect these uses.

Low strength and frost action are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by low strength. Grading the roads so that they shed water and installing a moisture barrier of gravel in the subgrade minimize the damage caused by frost action.

The land capability classification is IIe.

30—Gullied land-Napier complex, 1 to 5 percent slopes. This very gently sloping and gently sloping unit is in small drainageways in the uplands. Individual areas are very long, narrow, and branching. They range from 15 to 300 acres in size.

The percentage of each component in the unit varies, although the Gullied land generally is dominant. Mapping the two components separately at the scale used was not possible.

The Gullied land occurs as steep to vertical streambanks and branching gully walls. A small stream channel is in the center of each mapped area. The gullies are about 5 feet to more than 30 feet deep and commonly are overgrown with trees and brush.

The Napier soil is deep, gently sloping, and well drained. It is on foot slopes. Typically, the surface soil is friable, very dark grayish brown silt loam about 26 inches thick. The subsoil to a depth of 60 inches or more is dark brown, mottled silt loam.

Permeability is moderate in the Napier soil. Surface runoff is medium. Available water capacity is very high. The organic matter content is moderate.

Included in this unit in mapping are small areas of Colo, Timula, and Monona soils. Colo soils are in nearly level areas adjacent to the stream channels. They are poorly drained. Timula and Monona soils are along the moderately sloping upslope edges of the mapped areas. They have a thinner dark surface layer than that of the Napier soils. Included soils make up about 15 percent of the unit.

This unit is used primarily for wildlife habitat. The edges of some areas are cultivated or used for pasture if the adjacent soils are cultivated or grazed.

This unit is unsuited to cultivated crops and generally unsuited to pasture because of the gullies. Some areas of the Napier soil along the edges of the mapped areas can be cultivated or used for pasture, but these areas generally are very small. Maintaining a filter strip of permanent vegetation along the edges of the gullies helps to prevent the sedimentation of streams and further gullying.

Most areas of the Napier soil are suited to building site development and septic tank absorption fields. Stream contamination from septic tank absorption fields is a hazard. Dwellings and sanitary facilities should be located as far from the Gullied land as possible, and gullies in the vicinity of the building sites should be stabilized.

The Napier soil is suited to local roads and streets. It is limited by low strength and frost action. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by low strength. Grading the roads so that they shed water and installing a moisture barrier of gravel in the subgrade minimize the damage caused by frost action. Roads should be located as far from the Gullied land as possible, and gullies in the vicinity of the roads should be stabilized.

The land capability classification is VIIe.

31—Nodaway silt loam. This deep, nearly level, moderately well drained soil is on natural levees along major secondary streams. It is subject to occasional flooding, which can occur from November through June if levees along the stream break. Individual areas are long and narrow, closely follow the stream channel, and range from 20 to 140 acres in size.

Typically, the surface layer is very dark gray, friable silt loam about 9 inches thick. The substratum to a depth of 44 inches is stratified very dark gray, brown, and yellowish brown, mottled silt loam. Below this to a depth of 60 inches or more is a buried surface layer of very dark gray silt loam. In some areas the buried surface layer is silty clay. In places the dark surface layer is more than 10 inches thick.

Included with this soil in mapping are small areas of Colo and Zook soils. Both soils are poorly drained and are in the slightly lower landscape positions. They are near the outside edges of the mapped areas. Constructed levees along the streams and the stream channel also are commonly included in the unit. Included soils make up about 5 percent of this unit.

Permeability is moderate in the Nodaway soil. Surface runoff is slow. Available water capacity is very high. The organic matter content is moderate. The shrink-swell potential is moderate in the substratum. The seasonal high water table commonly is at a depth of 3 to 5 feet from November through June.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. The flooding is a hazard. Planting and harvesting are delayed in some years because of the flooding. Because of the moderate permeability, excess surface water quickly drains into the soil. Access to fields is possible soon after heavy rains.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, smooth bromegrass, and switchgrass. The main hazard in areas used as pasture or hayland is the flooding. Grazing should be restricted to periods when flooding is not likely. The flooding can damage fences and structures and can cause sedimentation, which reduces forage yields and kills plants in some areas.

This soil is unsuited to building site development. It is limited by the flooding. Extreme measures are needed to overcome this limitation. Dwellings should be built in areas of better suited soils.

The land capability classification is IIw.

32B—Olmitz loam, 2 to 5 percent slopes. This very deep, gently sloping, moderately well drained soil is on foot slopes. Individual areas are commonly long and narrow and range from 15 to 100 acres in size.

Typically, the surface layer is very dark brown, friable loam about 8 inches thick. The subsurface layer is about 24 inches thick. It is very dark brown loam in the upper part, very dark gray loam in the next part, and very dark grayish brown clay loam in the lower part. The subsoil to a depth of 60 inches or more is very dark grayish brown, dark grayish brown, and brown clay loam.

Included with this soil in mapping are small areas of Colo, Lamoni, and Shelby soils. Colo soils are in nearly level areas on flood plains and are poorly drained. Lamoni and Shelby soils are in moderately sloping areas near the upslope edges of the mapped areas and have a thinner dark surface layer than that of the Olmitz soil. Lamoni soils are somewhat poorly drained. Included soils make up about 5 percent of this unit.

Permeability is moderate in the Olmitz soil. Surface runoff is medium. Available water capacity is high. The organic matter content is moderate. The shrink-swell potential is moderate in the subsoil.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. Erosion is a slight hazard. It can be minimized by farming on the contour, applying a conservation tillage system that leaves a protective cover of crop residue on the surface, terracing, and stripcropping. Terrace drains generally are not needed. Grassed waterways help to prevent excessive erosion in small drainageways. Because of the moderate permeability, excess surface water quickly drains into the soil. Access to fields is possible soon after heavy rains.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, smooth bromegrass, and switchgrass. No serious limitations affect the areas used as pasture or hayland. Erosion is a hazard in newly seeded areas. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established.

The main limitation on sites for dwellings is the moderate shrink-swell potential. Adequately reinforcing the concrete in foundations and backfilling with coarse textured material minimize the damage caused by shrinking and swelling.

This soil is moderately limited as a site for septic tank absorption fields, mainly because of the moderate permeability. This limitation can be overcome by increasing the size of the absorption field.

Low strength and the shrink-swell potential are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by low strength and by shrinking and swelling.

The land capability classification is IIe.

33—Onawa silty clay, rarely flooded. This very deep, nearly level, somewhat poorly drained soil is in low areas on low flood plains along the Missouri River. It is subject to rare flooding, which can occur if levees along the Missouri River break. Individual areas are irregular in shape and range from 20 to 1,000 acres in size.

Typically, the surface layer is very dark grayish brown, firm silty clay about 9 inches thick. The substratum extends to a depth of 60 inches or more. The upper part to a depth of 21 inches is stratified dark grayish brown and very dark grayish brown, mottled silty clay. The lower part is stratified, grayish brown and olive, mottled silt loam and very fine sandy loam. In some places the lower part of the substratum is sand. In other places the soil is clayey to a depth of more than 40 inches.

Included with this soil in mapping are small areas of Paxico and Sarpy soils. Paxico soils are in the slightly higher positions on the landscape and are silt loam and very fine sandy loam in the upper part. Sarpy soils are on very narrow, convex natural levees and are sandy throughout. Also included are small, low areas of Onawa soils that are subject to ponding. Included soils make up about 5 percent of this unit.

Permeability is slow in the upper part of this Onawa soil and moderate in the lower part. Surface runoff is slow. Available water capacity is high. The organic matter content is moderate. The shrink-swell potential is high in the upper part. The seasonal high water table commonly is at a depth of 2 to 4 feet from November through June.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. It is limited by the wetness, which often delays fieldwork in the spring and fall and can reduce yields in some areas. Lateral surface drains and field ditches help to remove excess water in most areas. Because of the slow permeability, the surface soil is wet for several days following heavy rains. Restricting fieldwork when the soil is wet minimizes compaction and the formation of clods.

This soil is suited to grasses and legumes that can withstand the wetness. Examples are ladino clover and reed canarygrass. The soil is poorly suited to warm-season grasses and hay crops. The main limitation in areas used for pasture is the wetness. Ponding occurs in some areas. It can damage plantings. Lateral surface drains and field ditches help to remove excess surface water. Fieldwork should be avoided when the soil is saturated. A properly designed rotation grazing system can help to prevent the damage caused by grazing when the soil is wet.

The main limitations on sites for dwellings are the flooding and the wetness. Constructing dwellings without basements on raised, well compacted fill material minimizes the damage caused by wetness. The fill material should be of sufficient thickness to raise the dwelling above expected flood levels.

This soil is severely limited as a site for septic tank absorption fields, mainly because of the wetness. The absorption fields can be constructed on moderately rapidly permeable fill material. Holding tanks are an effective alternative to septic tank absorption fields.

Low strength, the shrink-swell potential, the wetness, and frost action are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, helps to prevent the damage caused by low strength and by shrinking and swelling. Grading the roads so that they shed water, constructing adequate roadside ditches, and installing culverts help to overcome the wetness. A moisture barrier of gravel in the subgrade helps to prevent the damage caused by frost action.

The land capability classification is IIw.

34—Onawa silty clay, frequently flooded. This very deep, nearly level, somewhat poorly drained soil is on the flood plain along the Missouri River. It is in low areas adjacent to the levee on the same side of the levee as the river. It is frequently flooded from November through June. Individual areas are irregular in shape and range from 20 to 300 acres in size.

Typically, the surface layer is very dark gray, firm silty clay about 4 inches thick. The upper part of the substratum to a depth of 20 inches is stratified very dark gray and dark grayish brown, mottled silty clay. The lower part to a depth of 60 inches or more is mottled, stratified dark gray to grayish brown silt loam and very fine sandy loam. A few areas are gently undulating. In some places the lower part of the substratum is sand. In other places the soil is clayey to a depth of more than 40 inches.

Included with this soil in mapping are small areas of Haynie, Paxico, and Sarpy soils. Haynie and Paxico soils are in the higher positions on the landscape and are silt loam in the upper part. Also, Haynie soils are moderately well drained. Sarpy soils are on narrow, convex natural levees and are sandy throughout. Also included are areas of soils that were used as a source of borrow material when the adjacent levee was built. These areas are lower than the surrounding areas and are commonly ponded for much of the year. Included soils make up about 10 to 15 percent of this unit.

Permeability is slow in the upper part of the Onawa soil and moderate in the lower part. Surface runoff is slow. Available water capacity is high. The organic matter content is moderate. The shrink-swell potential is high in the upper part. The seasonal high water table commonly is at a depth of 2 to 4 feet from November through June.

Some areas of this soil are used primarily for winter wheat, corn, or soybeans. Other areas support cottonwood forest or brush and are used for hunting and wildlife habitat.

This soil is suited to corn, soybeans, grain sorghum, and winter wheat. It is limited by the flooding and the wetness. Planting and harvesting are delayed in some years because of the flooding. The wetness often delays fieldwork in the spring and fall and can reduce yields in some areas. Lateral surface drains and field ditches help to remove excess water in most areas. Because of the slow permeability, the surface soil is wet for several days following heavy rains. Restricting fieldwork when the soil is wet minimizes compaction and the formation of clods.

This soil is suited to grasses and legumes that can withstand the wetness. Examples are ladino clover and reed canarygrass. The soil is poorly suited to warm-season grasses and hay crops. The main limitations in areas used for pasture are the wetness and the hazard of flooding. Ponding occurs in some areas. It can damage plantings. Lateral surface drains and field ditches help to remove excess surface water. Fieldwork should be avoided when the soil is saturated. A properly designed rotation grazing system can help to prevent the damage caused by grazing when the soil is wet. Grazing should be restricted to periods when flooding is not likely. The flooding can damage fences and structures and can cause sedimentation, which reduces forage yields and kills plants in some areas.

This soil is unsuited to building site development. It is limited by the flooding. Extreme measures are needed to overcome this limitation. Dwellings should be built in areas of better suited soils.

The land capability classification is IIIw.

35—Paxico silt loam. This very deep, nearly level, somewhat poorly drained soil is on low flood plains along the Missouri River. It is subject to rare flooding, which can occur if levees along the Missouri River break. Individual areas are irregular in shape and range from 20 to 430 acres in size.

Typically, the surface layer is calcareous, very dark grayish brown, mottled, very friable silt loam about 8 inches thick. The upper part of the substratum is calcareous, dark grayish brown, mottled very fine sandy loam. The lower part to a depth of 60 inches or more is calcareous, dark grayish brown, mottled loamy fine sand. In places depth to the sandy part of the substratum is less than 40 inches. Many areas are gently undulating.

Included with this soil in mapping are areas of Sarpy, Onawa, and Percival soils. Sarpy soils are on the higher, convex natural levees, are somewhat excessively drained, and are sandy throughout. Onawa and Percival soils are in low swales and channels and are silty clay in the upper part. Also included are low, depressional areas of soils that are ponded. Included soils make up about 15 percent of the unit.

Permeability is moderate in the upper part of the Paxico soil and moderately rapid in the sandy part of the substratum. Surface runoff is slow. Available water capacity is high. The organic matter content is moderately low or moderate. The seasonal high water table commonly is at a depth of 1.5 to 3.0 feet from November through June.

This soil is used primarily for corn or soybeans. It is suited to corn, soybeans, grain sorghum, and winter wheat. It is limited by the wetness, which often delays fieldwork in the spring and fall and can reduce yields in some areas. Lateral surface drains and field ditches help to remove excess water in most areas. Because of the moderate permeability, excess surface water quickly drains into the soil. Access to fields is possible soon after heavy rains.

This soil is suited to grasses and legumes that can withstand the wetness. Examples are ladino clover and reed canarygrass. The soil is poorly suited to warm-season grasses and hay crops. The main limitation in areas used for pasture is the wetness. Lateral surface drains and field ditches help to remove excess surface water. Fieldwork should be avoided when the soil is saturated. A properly designed rotation grazing system can help to prevent the damage caused by grazing when the soil is wet.

The main limitations on sites for dwellings are the flooding and the wetness. Constructing dwellings without basements on raised, well compacted fill material minimizes the damage caused by wetness. The fill material should be of sufficient thickness to raise the dwelling above expected flood levels.

This soil is severely limited as a site for septic tank absorption fields, mainly because of the wetness. The absorption fields can be constructed on moderately rapidly permeable fill material. Holding tanks are an effective alternative to septic tank absorption fields.

Low strength, the wetness, and frost action are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by low strength. Grading the roads so that they shed water, constructing adequate roadside ditches, and installing culverts help to overcome the wetness. A moisture barrier of gravel in the subgrade minimizes the damage caused by frost action.

The land capability classification is IIw.

36—Percival silty clay. This very deep, nearly level, somewhat poorly drained soil is in low areas on low flood plains along the Missouri River. It is subject to rare flooding, which can occur if levees along the Missouri River break. Individual areas are irregular in shape and range from 30 to 800 acres in size.

Typically, the surface layer is very dark grayish brown, firm silty clay about 9 inches thick. The upper part of the substratum to a depth of 23 inches is stratified, dark grayish brown, mottled silty clay. The lower part to a depth of 60 inches or more is dark grayish brown, mottled fine sand that has strata of very fine sandy loam and silt loam. In some places depth to the sandy part of the substratum is less than 15 inches. In other places the lower part of the soil is silt loam. In some areas the surface layer is lighter colored.

Included with this soil in mapping are areas of Paxico and Sarpy soils. Paxico soils are in the slightly higher positions on the landscape and are silt loam in the upper part. Sarpy soils are on very narrow, convex natural levees and are sandy throughout. Also included are areas of soils in swales that are ponded for long periods in the spring. Included soils make up about 10 percent of the unit.

Permeability is slow in the upper part of the Percival soil and rapid in the lower part. Surface runoff is slow. Available water capacity is low. The organic matter content is moderately low or moderate. The shrink-swell potential is high in the upper part. The seasonal high water table commonly is at a depth of 2 to 4 feet from November through June.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. It is limited by the wetness, which often delays fieldwork in the spring and fall and can reduce yields in some areas. Lateral surface drains and field ditches help to remove excess water in most areas. Because of the slow permeability, the surface soil is wet for several days following heavy rains. Restricting fieldwork when the soil is wet minimizes compaction and the formation of clods.

This soil is suited to grasses and legumes that can withstand the wetness. Examples are ladino clover and reed canarygrass. The soil is poorly suited to warm-season grasses and hay crops. The main limitation in areas used for pasture is the wetness. Lateral surface drains and field ditches help to remove excess surface water. Fieldwork should be avoided when the soil is saturated. A properly designed rotation grazing system can help to prevent the damage caused by grazing when the soil is wet.

The main limitations on sites for dwellings are the flooding and the wetness. Constructing dwellings without basements on raised, well compacted fill material minimizes the damage caused by wetness. The fill material should be of sufficient thickness to raise the dwelling above expected flood levels.

This soil is severely limited as a site for septic tank absorption fields, mainly because of the wetness and a poor filtering capacity. The absorption fields can be constructed on moderately rapidly permeable fill material. Holding tanks are an effective alternative to septic tank absorption fields.

The wetness and frost action are limitations on sites for local roads and streets. Grading the roads so that they shed water, constructing adequate roadside ditches, and installing culverts help to overcome the wetness. A moisture barrier of gravel in the subgrade minimizes the damage caused by frost action.

The land capability classification is IIw.

37—Salix silty clay loam. This very deep, nearly level, moderately well drained soil is on high flood plains along the Missouri River. It is subject to rare flooding, which can occur if levees along the Missouri River break. Individual areas are irregular in shape and range from 15 to 275 acres in size.

Typically, the surface layer is very dark grayish brown, friable silty clay loam about 9 inches thick. The subsurface layer is dark brown silty clay loam about 3 inches thick. The subsoil is about 12 inches thick. It is dark grayish brown, mottled silty clay loam in the upper part and dark brown, mottled silt loam in the lower part. The substratum extends to a depth of 60 inches or more. It is calcareous, dark brown, mottled silt loam in the upper part and stratified, calcareous, dark brown and light brownish gray, mottled very fine sandy loam in the lower part. In some places the substratum has thick strata of silty clay loam or silty clay. In other places the upper part of the soil is silt loam. In a few areas the soil is somewhat poorly drained.

Included with this soil in mapping are areas of Blencoe soils. These soils are in the lower positions on the landscape, are poorly drained, and have a subsoil of silty clay. They make up less than 5 percent of this unit.

Permeability is moderate in the Salix soil. Surface runoff is slow. Available water capacity is very high. The organic matter content is moderate. The shrink-swell potential is moderate in the upper part. The seasonal high water table commonly is at a depth of 4 to 6 feet from November through June.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. It has few limitations. Because of the moderate permeability, excess surface water quickly drains into the soil. Access to fields is possible soon after heavy rains.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, smooth bromegrass, and switchgrass. No serious limitations affect the areas used for pasture or hayland.

The main limitations on sites for dwellings are the flooding and the wetness. Constructing dwellings without basements on raised, well compacted fill material minimizes the damage caused by the flooding and the wetness. The fill material should be of sufficient thickness to raise the dwelling above expected flood levels.

This soil is moderately limited as a site for septic tank absorption fields, mainly because of the wetness and the moderate permeability. The absorption fields can be constructed on moderately rapidly permeable fill material. Holding tanks are an effective alternative to septic tank absorption fields.

Low strength and frost action are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by low strength. Grading the roads so that they shed water and installing a moisture barrier of gravel in the subgrade minimize the damage caused by frost action.

The land capability classification is I.

38—Sarpy loamy fine sand, loamy substratum, rarely flooded. This very deep, gently undulating, excessively drained soil is in high convex areas on natural levees and low flood plains along the Missouri River. It is subject to rare flooding, which can occur if levees along the Missouri River break. Individual areas are irregular in shape and range from 20 to 200 acres in size.

Typically, the surface layer is dark brown, very friable loamy fine sand about 4 inches thick. The upper 51 inches of the substratum is dark grayish brown and grayish brown fine sand and loamy fine sand. The lower part to a depth of 60 inches or more is dark gray, mottled silt loam. In some areas the soil does not have a loamy substratum. In other areas it has a thin overwash layer of silt loam.

Included with this soil in mapping are areas of Haynie and Percival soils. Haynie soils are in the slightly lower concave areas. They are silt loam and very fine sandy loam throughout. Percival soils are in swales and channels, are somewhat poorly drained, and are silty clay in the upper part. Also included are areas of Sarpy soils that have a clayey substratum. Included soils make up about 5 to 10 percent of this unit.

Permeability is rapid in the upper part of the Sarpy soil and moderate in the lower part. Surface runoff is slow. Available water capacity is low. The organic matter content is very low.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. If the soil is used for cultivated crops, it is best suited to winter wheat. It is limited by the low available water capacity. Sprinkler irrigation can improve crop growth during dry periods. Because of the rapid permeability, excess surface water quickly drains into the soil. Access to fields is possible soon after heavy rains.

This soil is suited to grasses and legumes that can withstand droughtiness. Examples are crownvetch, lespedeza, reed canarygrass, and switchgrass. The main limitation in areas used as pasture or hayland is the low available water capacity. Sprinkler irrigation can improve yields during dry periods and allows additional species to be grown.

The main hazard on sites for dwellings is the flooding. Constructing dwellings on raised, well compacted fill material minimizes the damage caused by flooding. The fill material should be of sufficient thickness to raise the dwelling above expected flood levels.

This soil is severely limited as a site for septic tank absorption fields, mainly because of a poor filtering capacity. The absorption fields can be constructed on moderately rapidly permeable fill material. Holding tanks are an effective alternative to septic tank absorption fields.

The flooding is a hazard on sites for local roads and streets, which should be constructed on raised, well compacted fill material.

The land capability classification is IVs.

39—Sarpy loamy fine sand, frequently flooded. This very deep, gently undulating, excessively drained soil is on high, narrow, convex natural levees on the flood plain along the Missouri River. It is between the river channel and the flood-control levee and is commonly adjacent to the river channel. It is frequently flooded from November through June. Individual areas are commonly elongated and parallel to the river. They range from 15 to 140 acres in size.

Typically, the surface layer is dark brown, very friable loamy fine sand about 8 inches thick. The substratum is stratified dark grayish brown and grayish brown fine sand and loamy fine sand to a depth of 60 inches or more. In uncultivated areas the soil has thin overwash layers of silt loam or loam.

Included with this soil in mapping are areas of Haynie and Percival soils. Haynie soils are in the slightly lower concave areas. They are silt loam and very fine sandy loam throughout. Percival soils are in swales and channels, are somewhat poorly drained, and are silty clay in the upper part. Also included are areas of Sarpy soils that have clayey substrata. Included soils make up about 10 percent of this unit.

Permeability is rapid in the Sarpy soil. Surface runoff is slow. Available water capacity is low. The organic matter content is very low.

Most areas of this soil support cottonwood forest and are used for hunting and wildlife habitat. Some areas are cultivated.

This soil generally is not used for cultivated crops because it is limited by the flooding and the low available water capacity. In areas that are cleared and used for crops, winter wheat is best suited. Crop damage is probable in most years because of the flooding or droughtiness in the summer.

Areas of this soil that are cleared are suited to grasses and legumes that are tolerant of the droughty soil conditions. Examples are crownvetch, lespedeza, reed canarygrass, and switchgrass. The main limitations in areas used as pasture or hayland are the low available water capacity and the hazard of flooding. Grazing should be restricted to periods when flooding is not likely. The flooding can damage fences and structures and can cause sedimentation, which reduces forage yields and kills plants in some areas.

This soil is unsuited to building site development. It is limited by the flooding.

The land capability classification is IVw.

40B—Sharpsburg silty clay loam, 2 to 5 percent slopes. This very deep, gently sloping, moderately well drained soil is on broad ridgetops. Individual areas are long and branching. They range from 15 to 40 acres in size.

Typically, the surface layer is very dark grayish brown, friable silty clay loam about 7 inches thick. The subsurface layer is dark brown silty clay loam about 5 inches thick. The subsoil is about 39 inches thick. The upper part is dark yellowish brown silty clay loam, and the lower part is yellowish brown, mottled silty clay loam. The substratum to a depth of 60 inches or more is yellowish brown, mottled silty clay loam. In places the dark surface soil is less than 10 inches thick. In some areas the soil is moderately sloping.

Included with this soil in mapping are areas of the somewhat poorly drained Higginsville soils on concave head slopes. These soils make up about 5 percent of this unit.

Permeability is moderately slow in the Sharpsburg soil. Surface runoff is medium. Available water capacity is high. The organic matter content is moderate. The shrink-swell potential is moderate in the subsoil.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. Erosion is a slight hazard. It can be minimized by farming on the contour, applying a conservation tillage system that leaves a protective cover of crop residue on the surface, terracing, and stripcropping. Terrace drains generally are needed. Grassed waterways help to prevent excessive erosion in small drainageways and in areas where they are used as an outlet for terrace drains. Because of the moderately slow permeability, the surface soil is wet for several days following heavy rains. Restricting fieldwork when the soil is wet minimizes compaction and the formation of clods.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, smooth bromegrass, and switchgrass. No serious limitations affect the areas used as pasture or hayland. Erosion is a hazard in newly seeded areas. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established.

The main limitation on sites for dwellings is the moderate shrink-swell potential. Adequately reinforcing the concrete in foundations and backfilling with coarse textured material help to prevent the damage caused by shrinking and swelling.

This soil is moderately limited as a site for septic tank absorption fields, mainly because of the moderate permeability in the substratum. This limitation can be overcome by increasing the size of the absorption field.

Low strength, the shrink-swell potential, and frost action are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by low strength and by shrinking and swelling. Grading the roads so that they shed water and installing a moisture barrier of gravel in the subgrade minimize the damage caused by frost action.

The land capability classification is IIe.

40C2—Sharpsburg silty clay loam, 5 to 9 percent slopes, eroded. This very deep, moderately sloping, moderately well drained soil is on side slopes. A few areas are on convex, undulating ridgetops. Erosion has removed much of the original dark surface soil. Individual areas are irregular in shape and range from 20 to 230 acres in size.

Typically, the surface layer is very dark grayish brown, friable silty clay loam about 7 inches thick. The upper part of the subsoil is dark yellowish brown to olive brown silty clay loam. The lower part to a depth of 60 inches or more is light olive brown to light brownish gray, mottled silty clay loam. In places the dark surface soil is more than 10 inches thick.

Included with this soil in mapping are areas of Higginsville, Judson, Lamoni, and Shelby soils and a few scattered areas of severely eroded Sharpsburg soils. Higginsville soils are on concave head slopes and the lower side slopes and are somewhat poorly drained. Judson soils are on foot slopes near the downslope edges of mapped areas and have a thicker surface layer than that of the Sharpsburg soil. Lamoni and Shelby soils are on the lower slopes and have glacial till sand and gravel. Lamoni soils are somewhat poorly drained. Included soils make up about 5 to 10 percent of this unit.

Permeability is moderately slow in the Sharpsburg soil. Surface runoff is medium. Available water capacity is high. The organic matter content is moderate. The shrink-swell potential is moderate in the subsoil.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. Erosion is a moderate hazard. It can be minimized by farming on the contour, terracing or stripcropping, and applying a conservation tillage system that leaves a protective cover of crop residue on the surface. The construction of terraces exposes the subsoil in some areas. Fertilization rates can be adjusted if necessary in these areas. Terrace drains generally are needed. Grassed waterways help to prevent excessive erosion in small drainageways and in areas where they are used as an outlet for terrace drains. Because of the moderately slow permeability, the surface soil is wet for several days following heavy rains. Restricting fieldwork when the soil is wet minimizes compaction and the formation of clods.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, smooth bromegrass, and switchgrass. No serious limitations affect the areas used as pasture or hayland. Erosion is a hazard in newly seeded areas. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established.

The main limitation on sites for dwellings is the moderate shrink-swell potential. Adequately reinforcing the concrete in foundations and backfilling with coarse textured material help to prevent the damage caused by shrinking and swelling.

This soil is moderately limited as a site for septic tank absorption fields, mainly because of the moderately slow permeability. This limitation can be overcome by increasing the size of the absorption field.

Low strength, the shrink-swell potential, and frost action are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by low strength and by shrinking and swelling. Grading the roads so that they shed water and installing a moisture barrier of gravel in the subgrade help to prevent the damage caused by frost action.

The land capability classification is IIIe.

41C2—Shelby clay loam, 5 to 9 percent slopes, eroded. This very deep, moderately sloping, well drained soil is on shoulder slopes, upper side slopes, and secondary ridgetops. Erosion has removed much of the original dark surface soil. Individual areas are irregular in shape and range from 10 to 40 acres in size.

Typically, the surface layer is very dark grayish brown, friable clay loam about 7 inches thick. The subsoil is about 30 inches thick. It is brown and dark yellowish brown clay loam in the upper part and yellowish brown and dark yellowish brown, mottled clay loam in the lower part. The substratum to a depth of 60 inches or more is yellowish brown and light brownish gray, mottled clay loam. Gravel and cobbles are common on the surface and throughout the soil. In some areas the surface layer is silty clay loam. In places the dark surface soil is more than 10 inches thick.

Included with this soil in mapping are areas of Higginsville, Lamoni, Marshall, and Sharpsburg soils and a few scattered areas of Shelby soils that are severely eroded. Higginsville and Lamoni soils are on concave head slopes and are somewhat poorly drained. Also, Higginsville soils do not have glacial sand and gravel. Marshall and Sharpsburg soils are on the upper slopes near the upslope edges of the mapped areas. They do not have glacial sand and gravel. Included soils make up about 5 to 10 percent of this unit.

Permeability is moderately slow in the Shelby soil. Surface runoff is medium. Available water capacity is high. The organic matter content is moderate. The shrink-swell potential is moderate in the subsoil.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. Erosion is a moderate hazard. It can be minimized by farming on the contour, terracing or stripcropping, and applying a conservation tillage system that leaves a protective cover of crop residue on the surface. The construction of terraces exposes the subsoil in some areas. Fertilization rates can be adjusted if necessary in these areas. The surface layer can be stockpiled during terrace construction and then spread across the finished terraces. Terrace drains generally are needed. Grassed waterways help to prevent excessive erosion in small drainageways and in areas where they are used as an outlet for terrace drains. Because of the moderately slow permeability, the surface soil is wet for several days following heavy rains. Restricting fieldwork when the soil is wet minimizes compaction and the formation of clods.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, smooth bromegrass, and switchgrass. No serious limitations affect the areas used as pasture or hayland. Erosion is a hazard in newly seeded areas. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a good ground cover is quickly established.

The main limitation on sites for dwellings is the moderate shrink-swell potential. Adequately reinforcing the concrete in foundations and backfilling with coarse textured material help to prevent the damage caused by shrinking and swelling.

This soil is severely limited as a site for septic tank absorption fields, mainly because of the moderately slow permeability. This limitation can be overcome by constructing absorption fields on moderately rapidly permeable fill material. Sewage lagoons are an effective alternative if the site can be leveled.

Low strength, the shrink-swell potential, and frost action are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by low strength and by shrinking and swelling. Grading the roads so that they shed water and installing a moisture barrier of gravel in the subgrade help to prevent the damage caused by frost action.

The land capability classification is IIIe.

41D2—Shelby clay loam, 9 to 14 percent slopes, eroded. This very deep, strongly sloping, well drained soil is on the lower side slopes. Erosion has removed much of the original dark surface soil. Individual areas are irregular in shape and range from 20 to 400 acres in size.

Typically, the surface layer is very dark gray, friable clay loam about 7 inches thick. The subsoil is 38 inches thick. It is dark yellowish brown clay loam in the upper part and yellowish brown, mottled clay loam in the lower part. The substratum to a depth of 60 inches or more is yellowish brown, mottled clay loam. Gravel and cobbles are common on the surface and throughout the soil. In places the dark surface soil is more than 10 inches thick. In some areas the surface layer is silty clay loam.

Included with this soil in mapping are areas of Higginsville, Lamoni, Malvern, Marshall, and Olmitz soils and a few scattered areas of Shelby soils that are severely eroded. Higginsville and Lamoni soils are on concave head slopes and are somewhat poorly drained. Also, Higginsville soils have glacial sand and gravel. Malvern soils are on the upper slopes. They have more clay in the subsoil than the Shelby soil and are redder. Marshall soils are on the upper slopes near the upslope edges of the mapped areas and do not have glacial sand and gravel. Olmitz soils are on foot slopes near the downslope edges of the mapped areas. They have a dark surface layer that is thicker than that of the Shelby soil. Included soils make up about 10 percent of this unit.

Permeability is moderately slow in the Shelby soil. Surface runoff is rapid. Available water capacity is high. The organic matter content is moderate. The shrink-swell potential is moderate in the subsoil.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. Erosion is a severe hazard. It can be minimized by farming on the contour, installing terraces, and applying a conservation tillage system that leaves a protective cover of crop residue on the surface. The construction of terraces exposes the subsoil in some areas. Fertilization rates can be adjusted if necessary in these areas. The surface layer can be stockpiled during terrace construction and then spread across the finished terraces. Terrace drains generally are needed. Grassed waterways help to prevent excessive erosion in small drainageways and in areas where they are used as an outlet for terrace drains. Because of the moderately slow permeability, the surface soil is wet for several days following heavy rains. Restricting fieldwork when the soil is wet minimizes compaction and the formation of clods.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, smooth bromegrass, and switchgrass. Erosion is the main hazard in areas used as pasture or hayland when new seedlings are becoming established. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a ground cover is quickly established. Erosion is also a hazard on livestock trails and in overgrazed areas. It can be minimized by applying a rotation grazing system and carefully locating water and supplements for livestock.

The main limitations on sites for dwellings are the slope and the moderate shrink-swell potential. Dwellings can be designed so that they conform to the natural slope of the land, or the site can be graded to a suitable gradient. Adequately reinforcing the concrete in foundations and backfilling with coarse textured material help to prevent the damage caused by shrinking and swelling.

This soil is severely limited as a site for septic tank absorption fields, mainly because of the moderately slow permeability. The slope is a moderate limitation. The moderately slow permeability can be overcome by constructing the absorption field in a sufficient amount of moderately rapidly permeable fill material. Land shaping and installing the distribution lines across the slope are necessary for the proper functioning of the absorption field. Sewage lagoons are an effective alternative if the site can be leveled.

Low strength, the shrink-swell potential, the slope, and frost action are limitations on sites for local roads and streets. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by low strength and by shrinking and swelling. Some cutting and filling may be necessary because of the slope. Also, the roads can be designed so that they conform to the natural slope of the land. Grading the roads so that they shed water and installing a moisture barrier of gravel in the subgrade minimize the damage caused by frost action.

The land capability classification is IVe.

41E2—Shelby clay loam, 14 to 20 percent slopes, eroded. This very deep, moderately steep, well drained soil is on the lower side slopes. Erosion has removed much of the original dark surface soil. Individual areas are irregular in shape and range from 15 to 130 acres in size.

Typically, the surface layer is very dark grayish brown, friable clay loam about 7 inches thick. The subsoil is about 39 inches thick. The upper part is dark yellowish brown clay loam, and the lower part is yellowish brown, mottled clay. The substratum to a depth of 60 inches or more is yellowish brown, mottled clay loam. Gravel and cobbles are common on the surface and throughout the soil. In some areas the surface layer is silty clay loam. In places the dark surface soil is more than 10 inches thick.

Included with this soil in mapping are areas of Higginsville, Lamoni, Malvern, Marshall, and Olmitz soils and a few scattered areas of severely eroded Shelby soils. Higginsville and Lamoni soils are on concave head slopes and the upper side slopes and are somewhat poorly drained. Also, Higginsville soils do not have glacial sand and gravel. Malvern soils are on the upper slopes, have more clay in the subsoil than the Shelby soil, and are redder. Marshall soils are on the upper side slopes near the upper edges of the mapped areas. They do not have glacial sand and gravel. Olmitz soils are on foot slopes near the downslope edges of the mapped areas. They have a dark surface layer that is thicker than that of the Shelby soil. Included soils make up about 10 percent of this unit.

Permeability is moderately slow in the Shelby soil. Surface runoff is rapid. Available water capacity is high. The organic matter content is moderate. The shrink-swell potential is moderate in the subsoil.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. The soil is unsuited to cultivated crops because of a severe hazard of erosion. If cultivated crops are grown, severe erosion can be expected and extreme measures are needed to help control erosion. A conservation tillage system, such as no-till farming, that leaves a protective cover of crop residue on the surface should be applied. The soil generally is too steep for the installation of terraces. The construction of terraces exposes the subsoil. Grassed waterways help to prevent excessive erosion in small drainageways. Because of the moderately slow permeability, the surface soil is wet for several days following heavy rains. Restricting fieldwork when the soil is wet minimizes compaction and the formation of clods.

This soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, smooth bromegrass, and switchgrass. Erosion is the main hazard in areas used as pasture or hayland when new seedlings are becoming established. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a ground cover is quickly established. Erosion is also a hazard on livestock trails and in overgrazed areas. It can be minimized by applying a rotation grazing system and carefully locating water and supplements for livestock.

The main limitations on sites for dwellings are the slope and the moderate shrink-swell potential. Dwellings can be designed so that they conform to the natural slope of the land, or the site can be graded to a suitable gradient. Adequately reinforcing the concrete in foundations and backfilling with coarse textured material help to prevent the damage caused by shrinking and swelling.

This soil is severely limited as a site for septic tank absorption fields, mainly because of the slope and the moderately slow permeability. Land shaping and installing the distribution lines across the slope in moderately rapidly permeable fill material are necessary for the proper functioning of the absorption field. Sewage lagoons are an effective alternative if the site can be leveled.

Slope, low strength, the shrink-swell potential, and frost action are limitations on sites for local roads and streets. Cutting and filling generally are necessary because of the slope. Strengthening the subgrade with crushed rock or other suitable material or mixing the base material with additives, such as hydrated lime, minimizes the damage caused by low strength and by shrinking and swelling. Grading the roads so that they shed water and installing a moisture barrier of gravel in the subgrade help to prevent the damage caused by frost action.

The land capability classification is VIe.

42F—Timula silt loam, 25 to 60 percent slopes. This very deep, steep, well drained soil is on highly dissected uplands adjacent to the flood plain along the Missouri River. Individual areas are irregular in shape and range from 30 to 1,000 acres in size.

Typically, the surface layer is very friable silt loam about 8 inches thick. It is very dark gray in the upper part and very dark grayish brown in the lower part. The subsoil to a depth of 35 inches is dark brown silt loam. The substratum is calcareous, yellowish brown silt loam to a depth of 60 inches or more. In places the calcareous substratum is at a depth of less than 18 inches or more than 36 inches. In some areas the slope is less than 25 percent or more than 60 percent.

Included with this soil in mapping are areas of Hamburg, Ida, and Monona soils. Hamburg soils have a lower content of clay than the Timula soil and are less than 10 inches deep to a calcareous substratum. They are mainly on steep shoulder slopes, particularly in areas that have a southern or western exposure, in the more western areas. Ida soils are less than 10 inches deep to a calcareous substratum and have a higher content of clay than the Timula soil. They are on the upper side slopes in the more eastern areas. Monona soils have a dark surface layer that is thicker than that of the Timula soil, are more than 40 inches deep to a calcareous substratum, and generally are on ridgetops and foot slopes. Included soils make up about 15 percent of this unit.

Permeability is moderate in the Timula soil. Surface runoff is very rapid. Available water capacity is high. The organic matter content is moderately low. The shrink-swell potential is low in the subsoil.

Most areas of this soil support hardwood forest and are used as a source of firewood and commercial timber. These areas also are used for hunting and wildlife habitat. Some areas are used for pasture, particularly in the easternmost mapped areas.

The main limitations affecting the commercial harvesting of timber are the slope and the hazard of gully erosion on logging roads and skid trails. Logging roads can be located along the long, branching ridgetops and in some areas along flood plains. The steep, concave, intermittent drainageways in the side slopes are susceptible to gully erosion and thus should be avoided as sites for roads and trails.

This soil is unsuited to cultivated crops. It is limited by the slope and a very severe hazard of erosion.

This soil is suited to pasture only in those areas that have a slope of less than about 30 percent. These areas generally are in the more eastern mapped areas. The soil is suited to most of the commonly grown grasses and legumes, such as alfalfa, red clover, smooth bromegrass, and switchgrass. Erosion is the main hazard in areas used as pasture or hayland when new seedlings are becoming established. It can be minimized by preparing the seedbed on the contour and by timing tillage so that a ground cover is quickly established. Erosion is also a hazard on livestock trails and in overgrazed areas. It can be minimized by applying a rotation grazing system and carefully locating water and supplements for livestock.

This soil is unsuited to building site development. It is limited by the slope. Extreme measures are needed to overcome this limitation. Dwellings should be built in areas of better suited soils.

The land capability classification is VIIe.

43G—Timula-Hamburg silt loams, 30 to 90 percent slopes. These very deep, steep soils are on highly dissected uplands, including the bluffs adjacent to the flood plain along the Missouri River (fig. 12). Individual areas are very long and narrow and range from 35 to 800 acres in size.

Typically, this unit is about 60 percent Timula soil and 30 percent Hamburg soil. The percentage of the Hamburg soil generally is higher than that of the Timula soil in the northern part of the county and lower in the southern part. These soils could not be separated at the scale selected for mapping.

The Timula soil is well drained. It is dominantly on the middle and lower side slopes and foot slopes and on secondary ridgetops and benches. In some areas that have a northern or eastern exposure, it is on the upper side slopes and shoulders. Slopes range from 30 to 60 percent. Nearly all areas are forested.

Typically, the surface layer of the Timula soil is very dark grayish brown, very friable silt loam about 4 inches thick. The subsoil to a depth of 14 inches is dark brown silt loam. The substratum to a depth of 60 inches or more is calcareous, brown silt loam. In places depth to the calcareous substratum is less than 18 inches or more than 36 inches.

Permeability is moderate in the Timula soil. Surface runoff is very rapid. Available water capacity is high. The organic matter content is moderately low.

The Hamburg soil is somewhat excessively drained. It is on shoulder slopes and the upper side slopes, particularly in areas that have a western or southern exposure. Slopes dominantly range from 45 to 90 percent. Some areas, however, are nearly vertical. The steepest west-facing bluffs support shrubs and native grasses. Other areas are forested.

Typically, the surface layer of the Hamburg soil is very dark grayish brown and brown, very friable silt loam about 6 inches thick. The substratum to a depth of 60 inches or more is calcareous, yellowish brown silt loam. The thickness of the surface layer and depth to the calcareous substratum generally are greater in areas where the soil formed under forest vegetation than where it formed under prairie vegetation.

Permeability is moderate in the Hamburg soil. Surface runoff is very rapid. Available water capacity is high. The organic matter content is low or moderately low.

Included in this unit in mapping are areas of soils that are shallow over bedrock. These included soils are on the westernmost edge of the mapped areas at the base of the slopes. They are more common in the southern part of the county. Also included are areas of Napier soils and areas of gullies, which do not have

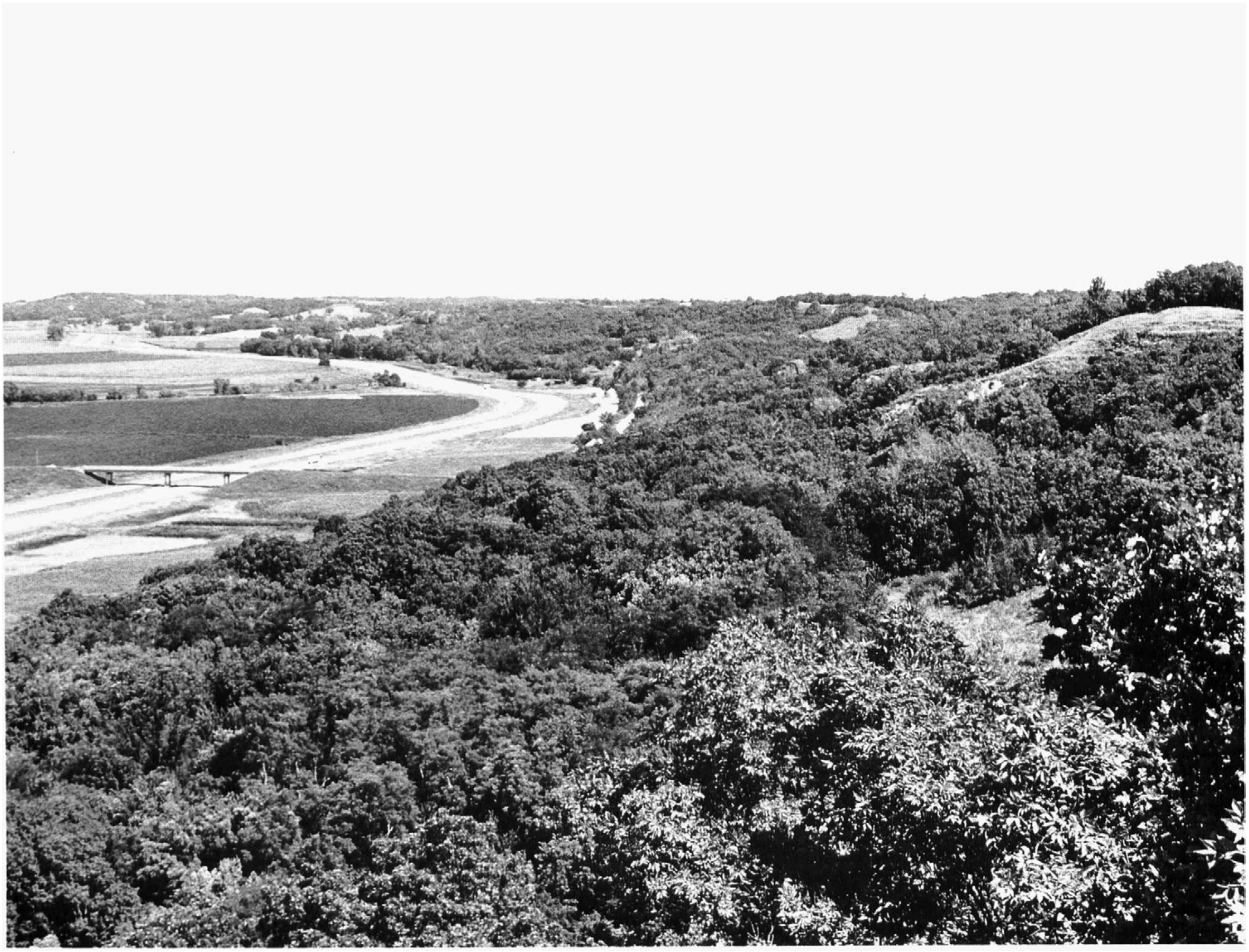

Figure 12.—An area of Timula-Hamburg silt loams, 30 to 90 percent slopes, on the loess bluffs adjacent to the Missouri River valley. The Timula soil is forested. The steepest areas of Hamburg soil support grasses and shrubs.

vegetative cover. Napier soils have a thick, dark surface soil and are on foot slopes. Inclusions make up about 10 percent of this unit.

Nearly all areas of this unit support either hardwood forest or native prairie grasses and are used primarily for hunting and wildlife habitat. Forested areas are a source of firewood and commercial timber.

Most trees of merchantable size are in areas of the Timula soil. The main limitations for commercial timber harvesting are the slope and the hazard of gully erosion on logging roads and skid trails. Logging roads can be located along the long, branching ridgetops and in some areas along flood plains. The steep, concave, intermittent drainageways in the side slopes are susceptible to gully erosion and thus should be avoided as sites for roads and trails.

This unit is unsuited to cultivated crops. It is limited by the slope and a very severe hazard of erosion. Extreme management measures are needed to overcome these limitations.

This unit generally is unsuited to pasture and hayland. The main limitations are the slope and the very severe hazard of erosion. Only a few narrow, isolated areas on foot slopes are suited to pasture establishment.

This unit is unsuited to building site development. It

Figure 13.—A flooded area of Zook silty clay loam along the Tarkio River.

is limited by the slope. Extreme measures are needed to overcome this limitation. Dwellings should be built in areas of better suited soils.

The land capability classification is VIIe.

44—Zook silty clay loam. This very deep, nearly level, poorly drained soil is in depressions on flood plains along major secondary streams. It is occasionally flooded from November through June (fig. 13). Individual areas are irregular in shape and range from 15 to 240 acres in size.

Typically, the surface layer is black, friable silty clay loam about 9 inches thick. The subsurface layer is about 25 inches of black, friable silty clay loam and very dark gray silty clay. The subsoil and substratum to a depth of 60 inches or more are very dark gray, mottled silty clay. In some areas the surface layer is silt loam or silty clay. In other areas the substratum has thick strata of silt loam.

Included with this soil in mapping are areas of Zook soils that are subject to ponding in the spring and after heavy rains. These soils make up about 10 percent of the unit.

Permeability is slow in this Zook soil. Surface runoff also is slow. Available water capacity and the organic matter content are high. The shrink-swell potential also is high in the subsoil. The seasonal high water table commonly is within a depth of 3 feet from November through June.

This soil is used primarily for corn or soybeans. In a few areas it is used for pasture. It is suited to corn, soybeans, grain sorghum, and winter wheat. It is limited by the flooding and the wetness. The wetness may delay fieldwork in the spring. Most areas, however, are effectively drained by lateral surface drains and by field ditches or by a tile drainage system. Planting and harvesting are delayed in some years because of the flooding. Because of the slow permeability, the surface soil is wet for several days following heavy rains. Restricting fieldwork when the soil is wet minimizes compaction and the formation of clods.

This soil is suited to grasses and legumes that can withstand the wetness. Examples are ladino clover and reed canarygrass. The soil is poorly suited to warm-season grasses and hay crops. The main limitations in areas used for pasture are the wetness and the hazard of flooding. Lateral surface drains and field ditches help to remove excess surface water. Fieldwork should be avoided when the soil is saturated. A properly designed rotation grazing system can help to prevent the damage caused by grazing when the soil is wet. Grazing should be restricted to periods when flooding is not likely. The flooding can damage fences and structures and can cause sedimentation, which reduces forage yields and kills plants in some areas.

This soil is unsuited to building site development. It is limited by the flooding. Extreme measures are needed to overcome this limitation. Dwellings should be built in areas of better suited soils.

The land capability classification is IIw.

Prime Farmland

Prime farmland is one of several kinds of important farmland defined by the U.S. Department of Agriculture. It is of major importance in meeting the Nation's short- and long-range needs for food and fiber. Because the supply of high-quality farmland is limited, the U.S. Department of Agriculture recognizes that responsible levels of government, as well as individuals, should encourage and facilitate the wise use of our Nation's prime farmland.

Prime farmland, as defined by the U.S. Department of Agriculture, is the land that is best suited to food, feed, forage, fiber, and oilseed crops. It may be cultivated land, pasture, woodland, or other land, but it is not urban or built-up land or water areas. It either is used for food or fiber crops or is available for those crops. The soil qualities, growing season, and moisture supply are those needed for a well managed soil to produce a sustained high yield of crops in an economic manner. Prime farmland produces the highest yields with minimal expenditure of energy and economic resources, and farming it results in the least damage to the environment.

Prime farmland has an adequate and dependable supply of moisture from precipitation or irrigation. The temperature and growing season are favorable. The level of acidity or alkalinity is acceptable. Prime farmland has few or no rocks and is permeable to water and air. It is not excessively erodible or saturated with water for long periods and is not frequently flooded during the growing season. The slope ranges mainly from 0 to 6 percent. More detailed information about the criteria for prime farmland is available at the local office of the Soil Conservation Service.

About 50,800 acres in the survey area, or 15 percent of the total acreage, meets the soil requirements for prime farmland. Scattered areas of this land are throughout the county, but most are in associations 1, 2, 3, and 8, which are described under the heading "General Soil Map Units." Nearly all of this prime farmland is used for crops, mainly corn and soybeans.

The map units in the survey area that are considered prime farmland are listed in table 5. This list does not constitute a recommendation for a particular land use. The extent of each listed map unit is shown in table 4. The location is shown on the detailed soil maps at the back of this publication. The soil qualities that affect use and management are described under the heading "Detailed Soil Map Units."

Some soils that have a seasonal high water table qualify as prime farmland only in areas where this limitation has been overcome by drainage measures. The need for these measures is indicated after the map unit name in table 5. Onsite evaluation is needed to determine whether or not this limitation has been overcome by corrective measures.

Use and Management of the Soils

This soil survey is an inventory and evaluation of the soils in the survey area. It can be used to adjust land uses to the limitations and potentials of natural resources and the environment. Also, it can help to prevent soil-related failures in land uses.

In preparing a soil survey, soil scientists, conservationists, engineers, and others collect extensive field data about the nature and behavioral characteristics of the soils. They collect data on erosion, droughtiness, flooding, and other factors that affect various soil uses and management. Field experience and collected data on soil properties and performance are used as a basis in predicting soil behavior.

Information in this section can be used to plan the use and management of soils for crops and pasture; as woodland; as sites for buildings, sanitary facilities, highways and other transportation systems, and parks and other recreational facilities; and for wildlife habitat. It can be used to identify the potentials and limitations of each soil for specific land uses and to help to prevent construction failures caused by unfavorable soil properties.

Planners and others using soil survey information can evaluate the effect of specific land uses on productivity and on the environment in the survey area. The survey can help planners to maintain or create a land use pattern in harmony with the natural soil.

Contractors can use this survey to locate sources of sand and gravel, roadfill, and topsoil. They can use it to identify areas where bedrock, wetness, or very firm soil layers can cause difficulty in excavation.

Health officials, highway officials, engineers, and others may also find this survey useful. The survey can help them plan the safe disposal of wastes and locate sites for pavements, sidewalks, campgrounds, playgrounds, lawns, and trees and shrubs.

Crops and Pasture

Ron Owens, district conservationist, Soil Conservation Service, helped prepare this section.

General management needed for crops and pasture is suggested in this section. The crops or pasture plants best suited to the soils, including some not commonly grown in the survey area, are identified; the system of land capability classification used by the Soil Conservation Service is explained; and the estimated yields of the main crops and hay and pasture plants are listed for each soil.

Planners of management systems for individual fields or farms should consider the detailed information given in the description of each soil under the heading "Detailed Soil Map Units." Specific information can be obtained from the local office of the Soil Conservation Service or the Cooperative Extension Service.

In 1985, approximately 284,000 acres, or about 80 percent of Atchison County, was used for cultivated crops *(18)*. Of this total, about 114,000 acres was planted to corn, 112,000 acres to soybeans, 2,700 acres to grain sorghum, and 1,300 acres to winter wheat. About 10,000 acres was used for hay *(5)*. The remaining acreage of cropland was used for specialty crops, such as potatoes, broccoli, and asparagus; for conservation purposes; or was idle land. The average size of a farm was 459 acres *(5)*.

Because of the favorable climate and fertile soils, more corn is produced in Atchison County than in any other county in Missouri. High commodity crop prices in the 1970's resulted in farmers commonly using a cropping sequence of corn and soybeans. In 1986, low commodity crop prices and a general oversupply of corn and soybeans fostered interest in other crops. As a result, potatoes, broccoli, and asparagus have been grown commercially in the county. Many soils in the county are suited to a variety of vegetable crops; seed crops, such as warm-season grasses; and other specialty crops. The economic feasibility of growing specialty crops is being tested.

The potential for sustained production of food is good. About 50,800 acres, or 15 percent of the county, is prime farmland. Sustained agricultural production is possible on more than 90 percent of the soils in the county, although careful management is necessary on much of this land. Only about 10,700 acres, or 3 percent of the county, is so steep that tillage is not feasible. This acreage is on the loess bluffs adjacent to

Figure 14.—An area in the Blencoe-Haynie-Luton association. Soils on the flood plains along the Missouri River are used intensively for agriculture.

the Missouri River valley. It includes Hamburg and Timula soils that have slopes of more than 25 percent. About 5,300 acres, or 1.5 percent of the county, is on the same side of the Federal levee as the Missouri River and is frequently flooded. Growing crops in these frequently flooded areas of Haynie, Onawa, and Sarpy soils is hazardous.

Of the potentially tillable acreage, about 11,500 acres, or 3 percent of the county, has a slope of 14 to 25 percent. Erosion is a very severe hazard in these areas. The need for erosion-control measures should be carefully considered. Farming may not be economical or desirable in some of these areas.

The flood plain along the Missouri River makes up approximately 67,300 acres, or 19 percent of the county (fig. 14). The soils on the flood plain generally are intensively cultivated. Only a small acreage is used for permanent pasture or hay. About half of the soils on the flood plain have a clayey surface, which is commonly referred to as "gumbo." Blencoe, Luton, and Onawa soils are the main "gumbo" soils. Wetness is the main limitation on these soils. Because of the clayey surface, tillage and trafficability are management concerns. Most of the other soils on the flood plain are loamy in the upper part. These loamy soils include some of the most productive soils in the county. Examples are Haynie, Gilliam, and Salix soils. Other loamy soils, such as Paxico soils, are limited by wetness, which may affect yields. Flooding is effectively controlled on most of the flood plain by the Federal levee. If the levee breaks or is overtopped by floodwater, crop and property damage can be severe.

About 50,600 acres, or 15 percent of the county, occurs as alluvial soils along large drainageways in the uplands and along secondary streams on the flood plains. Colo and Dockery are the main soils in these areas. They are highly productive, although wetness and flooding are limitations.

Soils in the uplands make up about 229,000 acres, or 66 percent of the county. The majority of these soils formed in loess, which is silty, windblown material. Those used for agriculture include Ida soils in the western part of the county; Monona, Contrary, Marshall, and Higginsville soils in the central part; and Sharpsburg soils in the eastern part. All of these soils are highly productive; however, in most areas they also are highly erodible. Erosion control is the main management concern.

Soils that formed in glacial till in the uplands make up about 46,000 acres. These soils are on side slopes in the eastern half of the county. They are Lamoni and Shelby soils. As with the soils that formed in loess, erosion is the main hazard. Unlike the soils that formed in loess, the subsoil of the soils that formed in glacial till is not favorable for seedling establishment and development; therefore, erosion may be a more severe hazard in areas of Shelby and Lamoni soils than in areas of the soils that formed in loess. Lamoni soils also are limited by wetness.

About 196,800 acres, or 57 percent of the county, has a slope of more than 5 percent or less than 25 percent. Erosion is the main hazard affecting most of the soils in the uplands.

Erosion, or the loss of the fertile surface layer, is damaging and costly. Productivity may be reduced as the surface layer is lost and part of the subsoil is incorporated into the tillage zone. Expensive commercial fertilizers that are incorporated into the surface layer are lost along with the soil. Erosion is especially damaging on soils that have a clayey subsoil. Examples are Lamoni and Malvern soils. Seedbed preparation and tillage are difficult on clayey spots where erosion has removed the original surface layer.

Erosion in areas of farmland also results in sedimentation of streams, lakes, and ponds. Controlling erosion minimizes sedimentation and thus improves the quality of water for municipal use, for recreation, and for fish and wildlife and prolongs the useful life of ponds and lakes. Costly road and ditch maintenance by both county government and private individuals could be greatly reduced by controlling erosion.

Erosion-control practices protect the surface with a vegetative cover or alter the slope. They increase the amount of water that infiltrates into the soil and reduce the runoff rate. Combinations of these practices are commonly used, especially on highly erodible soils.

The soil can be partially protected against erosion by leaving a cover of crop residue on the surface. The more crop residue that remains, the greater the erosion-control benefits. Tilling in the spring instead of in the fall leaves more residue on the surface during the winter. Applying a conservation tillage system, such as no-till farming, further protects the soil during the growing season.

Certain crops and cropping systems protect the soil more than others. Growing grasses and legumes for hay and pasture is a very effective erosion-control practice. A crop rotation that includes corn, soybeans, and pasture in combination with careful management of crop residue and conservation tillage also is effective in controlling erosion. Contour planting, contour tillage, and contour stripcropping also help to control erosion. In areas where contour stripcropping is used, permanent strips of grasses or grasses and legumes are established and the areas between the strips are cropped on the contour. The grasses and legumes are generally used for hay.

Terracing is an important erosion-control practice in the county. It reduces the length of the slope and in some cases the gradient. The three types of terraces used in Atchison County are those that have a broad base, a steep back slope, or a narrow base (fig. 15).

Broad-base terraces are the most common kind of terrace in the county. They are most practical on soils that have a slope of less than 8 percent. The gently sloping or moderately sloping Contrary, Higginsville, Judson, Lamoni, Marshall, Monona, Napier, Olmitz, Sharpsburg, and Shelby soils are suited to broad-base terraces. The entire terrace can be cropped. Because the back slope of the terrace is actually steeper than the original slope, sediments may accumulate in the terrace channel. Runoff also may accumulate in the terrace channel, and compaction caused by equipment may result in ponding and crop loss. Maintenance is essential on broad-base terraces.

Strongly sloping areas of Contrary, Higginsville, Ida, Lamoni, Malvern, Marshall, Monona, and Shelby soils have a severe hazard of erosion. Although broad-base terraces can be used, they increase the gradient. As a result, other erosion-control measures, such as conservation tillage, must also be used. Also, the back slope of the terrace is so steep that it can be difficult or hazardous to farm. For these reasons, terraces that have a steep back slope or a narrow base may be more appropriate. They reduce the hazard of erosion by establishing narrow strips of very steep land that has a permanent cover of vegetation. Piping may be a problem on terraces that have a steep back slope or a narrow base in areas of Ida or Contrary soils. It occurs when water forms a channel, or pipe, underneath the terrace. It can occur along an animal burrow or in areas where improper compaction techniques were applied during terrace construction. Erosion enlarges the pipe until a section of the terrace collapses.

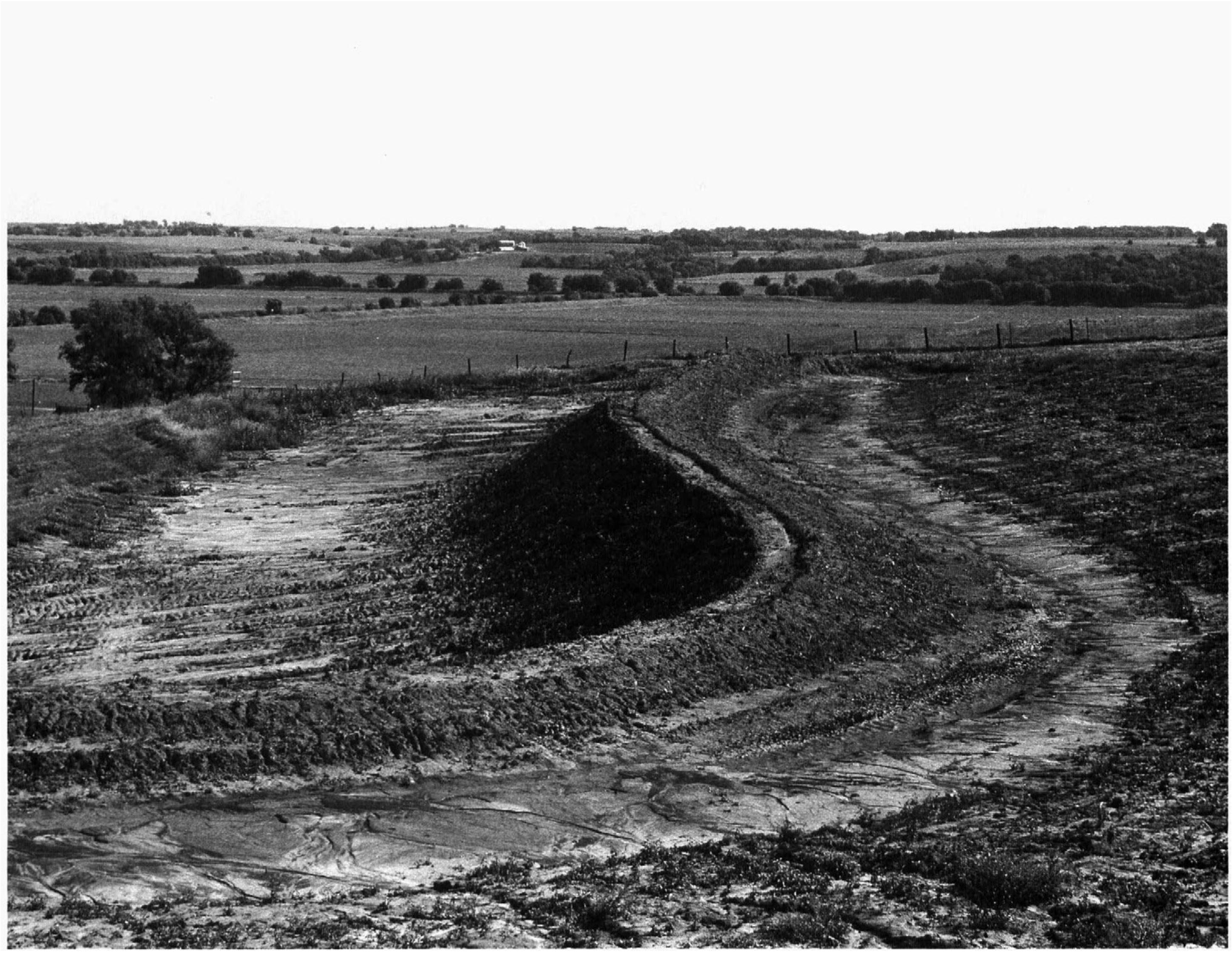

Figure 15.—A newly constructed narrow-base terrace in an area of Monona silt loam, 9 to 16 percent slopes, eroded. This type of terrace is particularly effective in areas of soils that have a slope of more than 9 percent.

Terraces constructed on Higginsville, Lamoni, Malvern, Sharpsburg, or Shelby soils require a drainage system. These soils are moderately slowly permeable or slowly permeable or have a seasonal high water table. If a drainage system is not installed, water may pond in the terrace channels. In areas of these soils, terrace channels are graded to an outlet, such as a tile drain or a grassed waterway.

Contrary, Ida, Judson, Marshall, Monona, and Napier soils are well drained and are moderately permeable. A drainage system generally is not needed on these soils.

During terrace construction, the layer of surface soil becomes thinner or is removed in some areas. Yields may be lower the following year in both of these areas. Additional fertilizer or a cover crop may be necessary. Most of the soils in the uplands formed in loess, and thus if fertilizer is applied properly, the exposed subsoil or substratum can be readily used as a seedbed. Lamoni, Malvern, and Shelby soils, however, have a clayey or firm subsoil that has poor physical characteristics, which result in a seedbed that is less desirable. On these soils the topsoil can be stockpiled during terrace construction and then spread across the finished terraces.

In Atchison County wetness is a management concern on about 100,000 acres, including areas of Blencoe, Colo, Dockery, Gilliam, Higginsville, Lamoni, Luton, Malvern, Moville, Onawa, Paxico, Percival, and

Zook soils. All of these soils have a seasonal high water table that generally is highest from late fall through the winter and that recedes in the spring. Fieldwork may be delayed in the spring and fall because of saturated soil conditions. The wetness limits some perennial crops, such as alfalfa, and most warm-season grasses. Crop damage can result if the clayey soils on flood plains become saturated following excessively heavy rains during the growing season.

If possible, fieldwork should be timed to avoid periods of excessive soil saturation. Tilling the soils on flood plains in the fall is particularly effective on the clayey Blencoe, Luton, Onawa, and Percival soils because frost action in the winter breaks up the large clods formed during tillage and creates a favorable seedbed. Unfortunately, tilling in the fall buries spilled grain, which would otherwise provide food for wildlife. A no-till method, such as ridge tillage, is an alternative to tilling in the fall.

Crops that are not so susceptible to wetness or that do not need to be planted so early in the spring should be selected for planting. For example ladino clover, which is tolerant of wetness, can be planted instead of alfalfa, and soybeans, which commonly are planted later than corn, can be planted in years when the soils are excessively wet in the spring.

A drainage system is needed in some areas. Drainage practices that are commonly used in Atchison County range from land shaping and bedding, which remove excess surface water, to tile drainage systems. Most of the soils on the flood plain along the Missouri River are directly or indirectly drained by an intricate system of canals and surface ditches. In some areas excess water is pumped out of the canals into the river. For a drainage system to be effective, a suitable outlet must be established. In areas of soils on the low flood plain along the Missouri River, the water table is generally controlled by the level of the river. Onawa, Percival, and Paxico soils are in these areas. Lowering the water table below the level of the river is not feasible.

Clearing and draining wetlands for agricultural production was once a common and accepted practice throughout the United States. In recent years, however, loss of wetland wildlife habitat and the overproduction of agricultural products have resulted in Federal regulations designed to prevent the drainage of wetlands for agricultural purposes. Landowners who are considering the installation of a drainage system should contact the Soil Conservation Service and other Federal and State agencies to ensure compliance with these regulations.

Flooding is a management concern in areas of soils on the flood plain along the Missouri River, in large drainageways in the uplands, and on flood plains along the smaller tributaries. Soils that are along rivers in the uplands are occasionally flooded from November through June. Examples are Colo, Dockery, McPaul, Nodaway, and Zook soils. These soils are protected by levees in some areas; however, occasional flooding may occur because of breaks in the levees. The occurrence of flooding generally is quite variable, depending on the characteristics of the stream and the watershed. In some areas the hazard of flooding can be reduced by building levees or by improving the condition of existing levees. However, eliminating the hazard of flooding in areas of the Colo, Dockery, McPaul, Nodaway, and Zook soils is not feasible.

If protected by Federal levees, the soils on the flood plain along the Missouri River are only rarely flooded. A break in these levees is rare. The soils that are on the same side of the levee as the river are frequently flooded, generally during the spring. Examples are Haynie, Onawa, and Sarpy soils. Because the level of the Missouri River is controlled by the U.S. Army Corps of Engineers, most of this flooding is the result of a deliberate and necessary part of the management of the Missouri River watershed. Eliminating all of the flooding on the flood plain along the Missouri River is not feasible.

Adequate soil fertility is important in maintaining high yields over an extended period. Continuous cropping without applying fertilizer inevitably leads to declining crop yields. The natural fertility of the soils in the county is high, but the addition of nutrients, notably nitrogen, phosphorus, and potassium, is necessary to maintain maximum crop production. The kind and amount of fertilizer required varies, depending on the soil, the crop, and the past management history. Soils that have a high content of clay generally require less potassium than soils that have a lower content. Some soils in areas on flood plains reportedly are high in phosphorus; however, a correlation between the taxonomic classification of soil and content of phosphorus has not been established. A deficiency of zinc has been reported in a few small areas of the eroded Marshall soils, but applications of micronutrient fertilizer generally are not necessary for the crops commonly grown in the county.

Corn and soybeans grow best if the soil is slightly acid or neutral. Many commercial, nitrogen-based fertilizers tend to acidify the soil. Lime commonly is added as a soil amendment to counteract this effect. None of the soils in the county are naturally acidic. Many of the soils, such as Ida, Haynie, and Onawa soils, have soluble lime in the surface layer or the upper part of the substratum. On all of the soils, applications of lime and fertilizer should be based on the results of soil tests, the needs of the crop, and the desired level of production. The Cooperative Extension Service can help to determine the kinds and amounts of fertilizer and lime to apply.

Soil tilth is an important factor affecting seedbed establishment and the rate of water infiltration. Soils have good tilth when they are under natural conditions. Tilth is degraded in cultivated areas when the bare surface is exposed to intense rainfall, which results in crusting, and when the soil is crossed by heavy machinery, which results in compaction.

The crust that forms on the surface of exposed soils during periods of heavy rainfall is hard when dry and is impervious. As a result, the rate of infiltration is reduced and the runoff rate is increased. Silty soils, such as most of the soils in the uplands in the county, are particularly susceptible to crusting. Tilling these soils in the fall results in surface crusting, increased runoff, and excessive erosion. Crusting can be prevented by minimizing tillage and thus maintaining crop residue on the surface.

Operating heavy machinery on the soils results in soil compaction either at the surface or at the base of the tillage zone. Except for the sandy Sarpy soils, all of the soils in the county are subject to compaction. Practices that limit the amount of traffic in the fields minimize compaction. Periodic chiseling or ripping may be necessary, particularly in level terrace channels. Soils are most susceptible to compaction when they are moist or wet. Fieldwork should be avoided at these times if possible; however, tillage may be difficult and ineffective if the soils are tilled when they are dry.

Field crops commonly grown in the county are generally suited to the climate of the county. Drought or excessive rain, however, is not uncommon. Excessive rain can limit field access at crucial times and can result in localized flooding. Although inadequate moisture in the soil often reduces yields, irrigation in Atchison County is cost effective only on a few soils on the flood plains. Examples are Sarpy and Haynie soils. All irrigation systems in the county are center-pivot, overhead sprinklers. These systems increase yields by supplying water during critical periods.

In 1982, about 39,400 acres in Atchison County was used for hay and pasture *(5)*. The acreage that is suited to grasses and legumes is much larger, but because of the high commodity crop prices in the 1970's, the acreage used for corn and soybeans has increased and the acreage used for forage crops has correspondingly decreased. Lower commodity prices and a reemphasis on erosion control may result in an increase of the acreage used for hay and pasture.

Grasses and legumes are effective in controlling erosion on sloping soils (fig. 16). Proper management, however, is essential. Newly seeded areas are susceptible to erosion. Seedbeds should be prepared on the contour. Livestock trails and bare spots develop if feeding and watering areas are not properly managed. They are susceptible to erosion. Overgrazing reduces the extent of the ground cover, increases the hazard of erosion, and reduces yields.

In Atchison County the grass species used for hay is primarily smooth bromegrass or bluegrass. The legume species used for hay is mainly alfalfa or red clover. The most common mixture of grasses and legumes for hay is either of these grasses with either of these legumes. All of these species are best suited to deep, moderately well drained or well drained soils, many of which are in the county. On soils that are limited by wetness, ladino clover or alsike clover is a better suited legume and reed canarygrass or switchgrass is a better suited grass.

Before Atchison County was settled, tallgrass prairie covered much of the uplands. The dominant species were warm-season grasses, such as big bluestem, little bluestem, indiangrass, and switchgrass. Warm-season grasses can be used effectively in a modern grazing system. They grow primarily during the hot summer months, when cool-season grasses are dormant and have low nutritional value. They also offer better wildlife habitat than cool-season grasses. They are slow to become established and require careful grazing management but are highly productive if properly managed. Warm-season grasses should be kept separate from cool-season grasses and legumes. A system of rotation grazing that includes several pastures helps to keep the plants in better condition. The warm-season grasses can be grazed in the hot summer months, and the cool-season grasses and legumes can be grazed in the spring and fall.

Yields per Acre

The average yields per acre that can be expected of the principal crops under a high level of management are shown in table 6. In any given year, yields may be higher or lower than those indicated in the table because of variations in rainfall and other climatic factors. The land capability classification of each map unit also is shown in the table.

The yields are based mainly on the experience and records of farmers, conservationists, and extension agents. Available yield data from nearby counties and results of field trials and demonstrations also are considered.

The management needed to obtain the indicated yields of the various crops depends on the kind of soil and the crop. Management can include drainage, erosion control, and protection from flooding; the proper

Figure 16.—Permanent pasture in an area of Timula silt loam, 25 to 60 percent slopes. The steeper areas of the soil are forested.

planting and seeding rates; suitable high-yielding crop varieties; appropriate and timely tillage; control of weeds, plant diseases, and harmful insects; favorable soil reaction and optimum levels of nitrogen, phosphorus, potassium, and trace elements for each crop; effective use of crop residue, barnyard manure, and green manure crops; and harvesting that ensures the smallest possible loss.

The estimated yields reflect the productive capacity of each soil for each of the principal crops. Yields are likely to increase as new production technology is developed. The productivity of a given soil compared with that of other soils, however, is not likely to change.

Crops other than those shown in table 6 are grown in the survey area, but estimated yields are not listed because the acreage of such crops is small. The local office of the Soil Conservation Service or of the Cooperative Extension Service can provide information about the management and productivity of the soils for those crops.

Land Capability Classification

Land capability classification shows, in a general way, the suitability of soils for most kinds of field crops. Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. The criteria used in grouping the soils do not include major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor do they include possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for woodland and for engineering purposes.

In the capability system, soils are generally grouped at three levels—capability class, subclass, and unit *(16)*. Only class and subclass are used in this survey.

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. The classes are 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 or that require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants or that require very careful management, or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use.

Class VI soils have severe limitations that make them generally unsuitable for cultivation.

Class VII soils have very severe limitations that make them unsuitable for cultivation.

Class VIII soils and miscellaneous areas have limitations that nearly preclude their use for commercial crop production.

There are no class V or VIII soils in Atchison County.

Capability subclasses are soil groups within one class. They are designated by adding a small letter, *e, w,* or *s* to the class numeral, for example, IIe. The letter *e* shows that the main hazard is the 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); and *s* shows that the soil is limited mainly because it is shallow, droughty, or stony.

In class I there are no subclasses because the soils of this class have few limitations. The capability classification of each map unit is given in the section "Detailed Soil Map Units" and in the yields table.

Woodland Management and Productivity

Frank Hershey, district forester, Missouri Department of Conservation, helped prepare this section.

Before Atchison County was settled, native woodlands were extensive on the flood plain along the Missouri River and in areas of the steep bluffs that parallel the river valley. They were also along or near rivers and streams throughout the county. In 1972, about 4 percent of Atchison County was forested. Most of the flood plain along the Missouri River has been cleared of timber, and the soils are used for row crops. Although extensive acreages of timber are now uncommon in the county, several of the soil associations could produce high-quality timber.

In Atchison County the native timber is primarily in areas of the Timula-Ida association on Timula and Hamburg soils. Timula and Hamburg soils are well suited to a mixture of high-quality hardwoods, especially on north- and east-facing slopes. The most common species are northern red oak, black oak, bur oak, chinkapin oak, shagbark hickory, American linden, black walnut, ironwood, hackberry, and American elm. Napier soils, which are minor soils in the association, are best suited to timber production. They are excellent for growing black walnut, which is a valuable species.

Grazing is common in areas of Timula soils that are used as woodland. It causes some reduction in the quality of the timber. The slope is a limitation affecting the use of equipment on these soils. The hazard of gully erosion is high after harvesting. Hamburg and Monona soils on ridges are commonly too dry during parts of the growing season to produce high yields of timber; however, these areas provide important wildlife habitat.

Scattered tracts of timber are in areas of the Onawa-Paxico-Haynie association on the flood plain along the Missouri River and in areas of the Dockery-Napier and Colo-Zook-Nodaway associations on the flood plains along secondary streams. Common timber species in these associations include cottonwood, silver maple, green ash, sycamore, black willow, and hackberry. Most of the timber in the Onawa-Paxico-Haynie association is in areas that are unprotected by the Federal levees and that are frequently flooded. Timber on the flood plains along secondary streams is generally along streambanks and adjacent to gullies.

The management of naturally occurring woodland in Atchison County is economically feasible. High-quality, valuable timber can be produced. Markets for timber that is to be processed into lumber or veneer are readily available within a 60-mile radius.

The soils in the county can be used for a variety of trees. Plantations of pecan trees, black walnut trees, or trees that are harvested as Christmas trees can be established. Trees also can be planted to stabilize streambanks and for fuel wood and fenceposts.

Except for Timula and Hamburg soils, the soils on ridges and side slopes in the county generally formed under prairie vegetation. These soils include most areas of Contrary, Higginsville, Ida, Lamoni, Malvern, Marshall, Monona, Sharpsburg, and Shelby soils. The successful establishment of trees on these soils, particularly on the ridges and the upper side slopes, requires extra care and maintenance. The planting of native trees is not successful in areas of these soils unless a high level of management is maintained. Adapted species that are planted for special uses can be very successful.

Trees to be harvested as Christmas trees can be established on any of the soils that are not poorly drained or very poorly drained. The species that are best suited to the soils in the county are Scotch pine, Austrian pine, red pine, and white pine.

Pecan trees are native to the flood plain along the Missouri River 40 miles south of Atchison County. Pecan trees from this area have been successfully established in Nebraska. They should be equally well suited to Atchison County. Except for small areas that are ponded in the spring and following heavy rains, most of the soils on the flood plains and foot slopes in the county are well suited to the production of pecans.

Black walnut trees are best suited to deep, medium textured soils that are moderately well drained or well drained. The best suited soils are Haynie, Ida, Judson, McPaul, Napier, Nodaway, Olmitz, Salix, and Timula soils; Monona soils on side slopes; and Colo soils that are drained. Other soils also are suited but may be less productive.

The plantations of fast growing trees that are used for fuel wood and fenceposts have excellent potential in the county. Osage-orange, black locust, and catalpa are fast growing hardwoods suited to the production of fenceposts. Eastern redcedar can be planted as a source for fenceposts and other wood products and for wildlife habitat. Several fast growing hardwoods also are excellent fuel woods and can be planted for intensive fuel production. Species most suited for this purpose are green ash, black locust, black alder, sycamore, and silver maple.

Planting trees to stabilize streambanks and channels can benefit many miles of streams and the adjacent cropland in the county. The soils along streams are highly productive for some valuable tree species, especially black walnut and pecan. Examples are Napier, Nodaway, and Colo soils. Streambanks and channels could be stabilized and a crop produced by growing trees.

Table 7 can be used by woodland owners or forest managers in planning the use of soils for wood crops. Only those soils suitable for wood crops are listed. The table lists the ordination symbol for each soil. Soils assigned the same ordination symbol require the same general management and have about the same potential productivity.

The first part of the *ordination symbol,* a number, indicates the potential productivity of the soils for an indicator tree species. The number indicates the volume, in cubic meters per hectare per year, which the indicator species can produce. The number 1 indicates low potential productivity; 2 and 3, moderate; 4 and 5, moderately high; 6 to 8, high; 9 to 11, very high; and 12 to 39, extremely high. The second part of the symbol, a letter, indicates the major kind of soil limitation. The letter *R* indicates steep slopes; *X,* stoniness or rockiness; *W,* excess water in or on the soil; *T,* toxic substances in the soil; *D,* restricted rooting depth; *C,* clay in the upper part of the soil; *S,* sandy texture; *F,* a high content of rock fragments in the soil; and *N,* snowpack. The letter *A* indicates that limitations or restrictions are insignificant. If a soil has more than one limitation, the priority is as follows: R, X, W, T, D, C, S, F, and N.

In table 7, *slight, moderate,* and *severe* indicate the degree of the major soil limitations to be considered in management.

Erosion hazard is the probability that damage will occur as a result of site preparation and cutting where the soil is exposed along roads, skid trails, and fire lanes and in log-handling areas. Forests that have been burned or overgrazed also are subject to erosion. Ratings of the erosion hazard are based on the percent of the slope. A rating of *slight* indicates that no particular prevention measures are needed under ordinary conditions. A rating of *moderate* indicates that erosion-control measures are needed in certain silvicultural activities. A rating of *severe* indicates that special precautions are needed to control erosion in most silvicultural activities.

Equipment limitation reflects the characteristics and conditions of the soil that restrict use of the equipment generally needed in woodland management or harvesting. The chief characteristics and conditions considered in the ratings are slope, stones on the surface, rock outcrops, soil wetness, and texture of the surface layer. A rating of *slight* indicates that under normal conditions the kind of equipment and season of use are not significantly restricted by soil factors. Soil wetness can restrict equipment use, but the wet period does not exceed 1 month. A rating of *moderate* indicates that equipment use is moderately restricted because of one or more soil factors. If the soil is wet, the wetness restricts equipment use for a period of 1 to 3 months. A rating of *severe* indicates that equipment use is severely restricted either as to the kind of equipment that can be used or the season of use. If the soil is wet, the wetness restricts equipment use for more than 3 months.

Seedling mortality refers to the death of naturally occurring or planted tree seedlings, as influenced by the kinds of soil, soil wetness, or topographic conditions. The factors used in rating the soils for seedling mortality are texture of the surface layer, depth to a seasonal high water table and the length of the period when the water table is high, rock fragments in the surface layer, effective rooting depth, and slope aspect. A rating of *slight* indicates that seedling mortality is not likely to be a problem under normal conditions. Expected mortality is less than 25 percent. A rating of *moderate* indicates that some problems from seedling mortality can be expected. Extra precautions are advisable. Expected mortality is 25 to 50 percent. A rating of *severe* indicates that seedling mortality is a serious problem. Extra precautions are important. Replanting may be necessary. Expected mortality is more than 50 percent.

Windthrow hazard is the likelihood that trees will be uprooted by the wind because the soil is not deep enough for adequate root anchorage. The main restrictions that affect rooting are a seasonal high water table and the depth to bedrock, a fragipan, or other limiting layers. A rating of *slight* indicates that under normal conditions no trees are blown down by the wind. Strong winds may damage trees, but they do not uproot them. A rating of *moderate* indicates that some trees can be blown down during periods when the soil is wet and winds are moderate or strong. A rating of *severe* indicates that many trees can be blown down during these periods.

The *potential productivity* of merchantable or *common trees* on a soil is expressed as a *site index* and as a *volume* number. The site index is the average height, in feet, that dominant and codominant trees of a given species attain in a specified number of years. The site index applies to fully stocked, even-aged, unmanaged stands. Commonly grown trees are those that woodland managers generally favor in intermediate or improvement cuttings. They are selected on the basis of growth rate, quality, value, and marketability.

The *volume*, a number, is the yield likely to be produced by the most important trees. This number, expressed as cubic feet per acre per year, indicates the amount of fiber produced in a fully stocked, even-aged, unmanaged stand.

The first species listed under common trees for a soil is the indicator species for that soil. It generally is the most common species on the soil and is the one that determines the ordination class.

Trees to plant are those that are suitable for commercial wood production.

Windbreaks and Environmental Plantings

Windbreaks protect livestock, buildings, and yards from wind and snow. They also protect fruit trees and gardens, and they furnish habitat for wildlife. Several rows of low- and high-growing broadleaf and coniferous trees and shrubs provide the most protection.

Field windbreaks are narrow plantings made at right angles to the prevailing wind and at specific intervals across the field. The interval depends on the erodibility of the soil. Field windbreaks protect cropland and crops from wind, help to keep snow on the fields, and provide food and cover for wildlife.

Environmental plantings help to beautify and screen houses and other buildings and to abate noise. The plants, mostly evergreen shrubs and trees, are closely spaced. To ensure plant survival, a healthy planting stock of suitable species should be planted properly on a well prepared site and maintained in good condition.

Table 8 shows the height that locally grown trees and shrubs are expected to reach in 20 years on various soils. The estimates in table 8 are based on measurements and observation of established plantings that have been given adequate care. They can be used as a guide in planning windbreaks and screens. Additional information on planning windbreaks and screens and planting and caring for trees and shrubs can be obtained from local offices of the Soil Conservation Service or the Cooperative Extension Service or from a commercial nursery.

Recreation

The soils of the survey area are rated in table 9 according to limitations that affect their suitability for recreation. The ratings are based on restrictive soil features, such as wetness, slope, and texture of the surface layer. Susceptibility to flooding is considered. Not considered in the ratings, but important in evaluating a site, are the location and accessibility of the area, the size and shape of the area and its scenic quality, vegetation, access to water, potential water impoundment sites, and access to public sewer lines. The capacity of the soil to absorb septic tank effluent and the ability of the soil to support vegetation also are important. Soils subject to flooding are limited for recreational uses by the duration and intensity of flooding and the season when flooding occurs. In planning recreational facilities, onsite assessment of the height, duration, intensity, and frequency of flooding is essential.

In table 9, the degree of soil limitation is expressed as slight, moderate, or severe. *Slight* means that soil properties are generally favorable and that limitations are minor and easily overcome. *Moderate* means that limitations can be overcome or alleviated by planning, design, or special maintenance. *Severe* means that soil properties are unfavorable and that limitations can be offset only by costly soil reclamation, special design, intensive maintenance, limited use, or by a combination of these measures.

The information in table 9 can be supplemented by other information in this survey, for example, interpretations for septic tank absorption fields in table 12 and interpretations for dwellings without basements and for local roads and streets in table 11.

Camp areas require site preparation, such as shaping and leveling the tent and parking areas, stabilizing roads and intensively used areas, and installing sanitary facilities and utility lines. Camp areas are subject to heavy foot traffic and some vehicular traffic. The best soils have mild slopes and are not wet or subject to flooding during the period of use. The surface has few or no stones or boulders, absorbs rainfall readily but remains firm, and is not dusty when dry. Strong slopes and stones or boulders can greatly increase the cost of constructing campsites.

Picnic areas are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas. The best soils for picnic areas are firm when wet, are not dusty when dry, are not subject to flooding during the period of use, and do not have slopes or stones or boulders that increase the cost of shaping sites or of building access roads and parking areas.

Playgrounds require soils that can withstand intensive foot traffic. The best soils are almost level and are not wet or subject to flooding during the season of use. The surface is free of stones and boulders, is firm after rains, and is not dusty when dry. If grading is needed, the depth of the soil over bedrock or a hardpan should be considered.

Paths and trails for hiking and horseback riding should require little or no cutting and filling. The best soils are not wet, are firm after rains, are not dusty when dry, and are not subject to flooding more than once a year during the period of use. They have moderate slopes and few or no stones or boulders on the surface.

Golf fairways are subject to heavy foot traffic and some light vehicular traffic. Cutting or filling may be required. The best soils for use as golf fairways are firm when wet, are not dusty when dry, and are not subject to prolonged flooding during the period of use. They have moderate slopes and no stones or boulders on the surface. The suitability of the soil for tees or greens is not considered in rating the soils.

Wildlife Habitat

Reggie Bennett, wildlife services biologist, Missouri Department of Conservation, helped prepare this section.

Before the land was cultivated, about 83 percent of Atchison County was prairie *(14)*. The prairie on the flood plain along the Missouri River was mainly in areas of poorly drained or very poorly drained soils, such as Blencoe, Luton, Onawa, and Paxico soils. Dominant species on this wetland prairie included prairie cordgrass, phragmites, and various sedges. The prairie in the uplands was mainly on the ridges and side slopes in areas of Higginsville, Ida, Lamoni, Malvern, Marshall, Monona, Sharpsburg, and Shelby soils. Grasses in this tallgrass prairie included big bluestem, switchgrass, and indiangrass. Areas of Hamburg soils on the very steep, west- and south-facing bluffs were vegetated with the more drought-tolerant prairie grasses, such as little bluestem and sideoats grama.

Woodland was extensive on Timula and Hamburg soils in the uplands in the western part of the county. It was common on the flood plain along the Missouri River in areas of the well drained and somewhat excessively drained soils, such as Sarpy and Haynie soils. Woodland was also along or near the smaller rivers and streams throughout the county. This intricate pattern of prairie and woodland was probably a major factor contributing to the abundance of wildlife species in Atchison County before the county was settled.

Nearly all areas in the county that were natural prairie are used as cropland or pasture that is dominated by introduced grasses. A few small areas of natural prairie remain along the edges of fields and drainage ditches and in cemeteries. Woodland remains in most areas of Timula and Hamburg soils. Most previously wooded areas on the flood plain along the Missouri River and along secondary streams have been cleared of trees. Channelization of rivers, such as the Missouri, Tarkio, and Nishnabotna Rivers, has destroyed much of the cover and many of the nesting sites on the flood plains. Flood control and extensive drainage of the soils during agricultural development have drastically degraded and decreased the amount of wetland wildlife habitat on flood plains throughout the county.

Two large areas that are open to the public are managed primarily for wildlife habitat. The Brickyard Hill Wildlife Area is mostly woodland in areas of Timula and Hamburg soils mixed with cropland and grassland on the ridges. Charity Lake, the largest lake in the county, is in this wildlife area (fig. 17). The Tarkio Prairie Natural History Area consists of about 30 acres of native tallgrass prairie. Several public fishing access areas are along the Missouri River. They include the Watson, Langdon Bend, and Hoot Owl Bend areas.

Before the area was settled, the most common wildlife species included wolves, coyote, elk, white-tailed deer, badger, and prairie chickens. The destruction of the tallgrass prairie habitat changed the dominant wildlife species. Wolves, elk, bison, and

Figure 17.—A forested area of Timula-Hamburg silt loams, 30 to 90 percent slopes, along Charity Lake. This area provides important habitat for deer and other wildlife.

prairie chickens no longer inhabit the county. Some species, such as prairie chickens, have been replaced by other species, such as ring-necked pheasant.

In 1987, about 220 fish and wildlife species were known to inhabit Atchison County *(11)*. Of these species, 15 are rare or endangered, including the western fox snake, lake sturgeon, bald eagle, upland sandpiper, river otter, and long-tailed weasel. An additional 161 rare or endangered species are likely to inhabit the county. They include the spadefoot toad, snowy egret, golden shiner, plains hognose snake, and midland smooth softshell turtle.

Hunting is an important recreational activity in the county. The most important game species include ring-necked pheasant, northern bobwhite quail, white-tailed deer, and various species of migratory waterfowl. Turkey hunting appears to be increasing in importance. In the 1987 spring firearms season, 92 turkeys were harvested. In 1983, the number harvested was 57 *(6, 8)*. In 1987, several hundred beaver were trapped and over 3,000 raccoons were harvested. Other furbearers in the county are opossum, skunk, muskrat, mink, red fox, gray fox, and badger *(9)*.

Atchison County is along the Mississippi flyway and thus is visited by an enormous number of migratory waterfowl. As many as 400,000 snow geese and blue geese and more than 100,000 ducks pass through the county in November. The geese and ducks stop and feed on spilled grain and winter wheat, primarily on the flood plain along the Missouri River. Bald eagles also migrate with the waterfowl, feeding on any sick and dying birds.

The Missouri River is fished mainly for carp, flathead catfish, channel catfish, and shovelnose sturgeon by commercial and sport fishermen. Carp and catfish also are in secondary rivers, such as the Nishnabotna River. Game fish, such as largemouth bass, bluegill, black crappie, white crappie, redear sunfish, and white bass, are in area lakes and ponds and in some streams.

Of the wildlife species being reintroduced in Missouri, three species have been released either in Atchison county or close enough to the county to inhabit the area. River otters have been released in Platte County along the Missouri River. They are transient and travel great distances and thus may become established in Atchison County. Riparian zones and wetlands adjacent to major drainageways in the county provide important habitat for the otters *(7)*. Ruffed grouse, which inhabit woodland, were released at Brickyard Hill in 1980; however, none were sighted in 1986 or 1987. The population of greater Canada goose of the eastern prairie is increasing in Missouri because of a 1987 relocation of young birds to Nodaway Lake. The lake is in Nodaway County but is within the 20-mile radius that is the influence zone for this species *(10)*.

Many game species respond favorably to habitat development and management. Both pheasant and quail can inhabit areas that are intensively used for agriculture. They respond well in areas where conservation cropping systems have been applied. In particular, growing native prairie grasses on terraces that have a steep back slope or a narrow base and in grassed waterways provides important nesting areas for pheasant and quail. Trees and brush maintained along field borders, roads, ditches, and other noncropped areas can be used as winter cover. Windbreaks can be established in many of these areas. Woodland also provides cover for turkeys and deer. Maintaining forested buffer strips along streams stabilizes streambanks and provides valuable cover for wildlife species. Beavers benefit from management that improves stream corridors. The recently renewed emphasis on erosion control and wetlands preservation may result in an overall improvement of the wildlife habitat in Atchison County.

Soils affect the kind and amount of vegetation that is available to wildlife as food and cover. They also affect the construction of water impoundments. The kind and abundance of wildlife depend largely on the amount and distribution of food, cover, and water. Wildlife habitat can be created or improved by planting appropriate vegetation, by maintaining the existing plant cover, or by promoting the natural establishment of desirable plants.

In table 10, the soils in the survey area are rated according to their potential for providing habitat for various kinds of wildlife. This information can be used in planning parks, wildlife refuges, nature study areas, and other developments for wildlife; in selecting soils that are suitable for establishing, improving, or maintaining specific elements of wildlife habitat; and in determining the intensity of management needed for each element of the habitat.

The potential of the soil is rated good, fair, poor, or very poor. A rating of *good* indicates that the element or kind of habitat is easily established, improved, or maintained. Few or no limitations affect management, and satisfactory results can be expected. A rating of *fair* indicates that the element or kind of habitat can be established, improved, or maintained in most places. Moderately intensive management is required for satisfactory results. A rating of *poor* indicates that limitations are severe for the designated element or kind of habitat. Habitat can be created, improved, or maintained in most places, but management is difficult and must be intensive. A rating of *very poor* indicates that restrictions for the element or kind of habitat are very severe and that unsatisfactory results can be expected. Creating, improving, or maintaining habitat is impractical or impossible.

The elements of wildlife habitat are described in the following paragraphs.

Grain and seed crops are domestic grains and seed producing herbaceous plants. Soil properties and features that affect the growth of grain and seed crops are depth of the root zone, texture of the surface layer, available water capacity, wetness, slope, surface stoniness, and flooding. Soil temperature and soil moisture also are considerations. Examples of grain and seed crops are corn, wheat, oats, and barley.

Grasses and legumes are domestic perennial grasses and herbaceous legumes. Soil properties and features that affect the growth of grasses and legumes are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, flooding, and slope. Soil temperature and soil moisture also are considerations. Examples of grasses and legumes are fescue, lovegrass, bromegrass, clover, and alfalfa.

Wild herbaceous plants are native or naturally established grasses and forbs, including weeds. Soil properties and features that affect the growth of these plants are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, and flooding. Soil temperature and soil moisture also are considerations. Examples of wild herbaceous plants are bluestem, goldenrod, beggarweed, wheatgrass, and grama.

Hardwood trees and woody understory produce nuts or other fruit, buds, catkins, twigs, bark, and foliage. Soil properties and features that affect the growth of hardwoods and shrubs are depth of the root zone, available water capacity, and wetness. Examples of these plants are oak, poplar, cherry, sweetgum, apple, hawthorn, dogwood, hickory, blackberry, and blueberry. Examples of fruit-producing shrubs that are suitable for planting on soils rated *good* are Russian-olive, autumn-olive, and crabapple.

Coniferous plants furnish browse and seeds. Soil properties and features that affect the growth of coniferous trees, shrubs, and ground cover are depth of the root zone, available water capacity, and wetness. Examples of coniferous plants are pine, spruce, fir, cedar, and juniper.

Wetland plants are annual and perennial wild herbaceous plants that grow on moist or wet sites. Submerged or floating aquatic plants are excluded. Soil properties and features affecting wetland plants are texture of the surface layer, wetness, reaction, salinity, slope, and surface stoniness. Examples of wetland plants are smartweed, wild millet, wildrice, saltgrass, cordgrass, rushes, sedges, and reeds.

Shallow water areas have an average depth of less than 5 feet. Some are naturally wet areas. Others are created by dams, levees, or other water-control structures. Soil properties and features affecting shallow water areas are depth to bedrock, wetness, surface stoniness, slope, and permeability. Examples of shallow water areas are marshes, waterfowl feeding areas, and ponds.

The habitat for various kinds of wildlife is described in the following paragraphs.

Habitat for openland wildlife consists of cropland, pasture, meadows, and areas that are overgrown with grasses, herbs, shrubs, and vines. These areas produce grain and seed crops, grasses and legumes, and wild herbaceous plants. Wildlife attracted to these areas include bobwhite quail, pheasant, meadowlark, field sparrow, cottontail, and red fox.

Habitat for woodland wildlife consists of areas of deciduous plants or coniferous plants or both and associated grasses, legumes, and wild herbaceous plants. Wildlife attracted to these areas include wild turkey, ruffed grouse, woodcock, thrushes, woodpeckers, squirrels, gray fox, raccoon, and deer.

Habitat for wetland wildlife consists of open, marshy or swampy shallow water areas. Some of the wildlife attracted to such areas are ducks, geese, herons, shore birds, muskrat, mink, and beaver.

Engineering

This section provides information for planning land uses related to urban development and to water management. Soils are rated for various uses, and the most limiting features are identified. Ratings are given for building site development, sanitary facilities, construction materials, and water management. The ratings are based on observed performance of the soils and on the estimated data and test data in the "Soil Properties" section.

Information in this section is intended for land use planning, for evaluating land use alternatives, and for planning site investigations prior to design and construction. The information, however, has limitations. For example, estimates and other data generally apply only to that part of the soil within a depth of 5 or 6 feet. Because of the map scale, small areas of different soils may be included within the mapped areas of a specific soil.

The information is not site specific and does not eliminate the need for onsite investigation of the soils or for testing and analysis by personnel experienced in the design and construction of engineering works.

Government ordinances and regulations that restrict certain land uses or impose specific design criteria were not considered in preparing the information in this section. Local ordinances and regulations should be considered in planning, in site selection, and in design.

Soil properties, site features, and observed performance were considered in determining the ratings in this section. During the fieldwork for this soil survey, determinations were made about grain-size distribution, liquid limit, plasticity index, soil reaction, depth to bedrock, hardness of bedrock within 5 or 6 feet of the surface, soil wetness, depth to a seasonal high water table, slope, likelihood of flooding, natural soil structure aggregation, and soil density. Data were collected about kinds of clay minerals, mineralogy of the sand and silt fractions, and the kind of adsorbed cations. Estimates were made for erodibility, permeability, corrosivity, the shrink-swell potential, available water capacity, and other behavioral characteristics affecting engineering uses.

This information can be used to evaluate the potential of areas for residential, commercial, industrial, and recreational uses; make preliminary estimates of construction conditions; evaluate alternative routes for roads, streets, highways, pipelines, and underground cables; evaluate alternative sites for sanitary landfills, septic tank absorption fields, and sewage lagoons; plan detailed onsite investigations of soils and geology; locate potential sources of gravel, sand, earthfill, and topsoil; plan drainage systems, irrigation systems, ponds, terraces, and other structures for soil and water conservation; and predict performance of proposed small structures and pavements by comparing the performance of existing similar structures on the same or similar soils.

The information in the tables, along with the soil maps, the soil descriptions, and other data provided in this survey, can be used to make additional interpretations.

Some of the terms used in this soil survey have a special meaning in soil science and are defined in the "Glossary."

Building Site Development

Table 11 shows the degree and kind of soil limitations that affect shallow excavations, dwellings with and without basements, small commercial buildings, local roads and streets, and lawns and landscaping. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required. Special feasibility studies may be required where the soil limitations are severe.

Shallow excavations are trenches or holes dug to a maximum depth of 5 or 6 feet for basements, graves, utility lines, open ditches, and other purposes. The ratings are based on soil properties, site features, and observed performance of the soils. The ease of digging, filling, and compacting is affected by the depth to bedrock, a cemented pan, or a very firm dense layer; stone content; soil texture; and slope. The time of the year that excavations can be made is affected by the depth to a seasonal high water table and the susceptibility of the soil to flooding. The resistance of the excavation walls or banks to sloughing or caving is affected by soil texture and depth to the water table.

Dwellings and *small commercial buildings* are structures built on shallow foundations on undisturbed soil. The load limit is the same as that for single-family dwellings no higher than three stories. Ratings are made for small commercial buildings without basements, for dwellings with basements, and for dwellings without basements. The ratings are based on soil properties, site features, and observed performance of the soils. A high water table, flooding, shrinking and swelling, and organic layers can cause the movement of footings. A high water table, depth to bedrock or to a cemented pan, large stones, slope, and flooding affect the ease of excavation and construction. Landscaping and grading that require cuts and fills of more than 5 or 6 feet are not considered.

Local roads and streets have an all-weather surface and carry automobile and light truck traffic all year. They have a subgrade of cut or fill soil material; a base of gravel, crushed rock, or stabilized soil material; and a flexible or rigid surface. Cuts and fills are generally limited to less than 6 feet. The ratings are based on soil properties, site features, and observed performance of the soils. The depth to bedrock or to a cemented pan, a high water table, flooding, large stones, and slope affect the ease of excavating and grading. Soil strength (as inferred from the engineering classification of the soil), the shrink-swell potential, frost action potential, and depth to a high water table affect the traffic-supporting capacity.

Lawns and landscaping require soils on which turf and ornamental trees and shrubs can be established and maintained. The ratings are based on soil properties, site features, and observed performance of the soils. Soil reaction, a high water table, depth to bedrock or to a cemented pan, the available water capacity in the upper 40 inches, and the content of salts, sodium, and sulfidic materials affect plant growth. Flooding, wetness, slope, stoniness, and the amount of sand, clay, or organic matter in the surface layer affect trafficability after vegetation is established.

Sanitary Facilities

Table 12 shows the degree and kind of soil limitations that affect septic tank absorption fields, sewage lagoons, and sanitary landfills. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required.

Table 12 also shows the suitability of the soils for use as daily cover for landfill. A rating of *good* indicates that soil properties and site features are favorable for the use and good performance and low maintenance can be expected; *fair* indicates that soil properties and site features are moderately favorable for the use and one or more soil properties or site features make the soil less desirable than the soils rated good; and *poor* indicates that one or more soil properties or site features are unfavorable for the use and overcoming the unfavorable properties requires special design, extra maintenance, or costly alteration.

Septic tank absorption fields are areas in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. Only that part of the soil between depths of 24 and 72 inches is evaluated. The ratings are based on soil properties, site features, and observed performance of the soils. Permeability, a high water table, depth to bedrock or to a cemented pan, and flooding affect absorption of the effluent. Large stones and bedrock or a cemented pan interfere with installation.

Unsatisfactory performance of septic tank absorption fields, including excessively slow absorption of effluent, surfacing of effluent, and hillside seepage, can affect public health. Ground water can be polluted if highly permeable sand and gravel or fractured bedrock is less than 4 feet below the base of the absorption field, if slope is excessive, or if the water table is near the surface. There must be unsaturated soil material beneath the absorption field to filter the effluent effectively. Many local ordinances require that this material be of a certain thickness.

Sewage lagoons are shallow ponds constructed to hold sewage while aerobic bacteria decompose the solid and liquid wastes. Lagoons should have a nearly level floor surrounded by cut slopes or embankments of compacted soil. Lagoons generally are designed to hold the sewage within a depth of 2 to 5 feet. Nearly impervious soil material for the lagoon floor and sides is required to minimize seepage and contamination of ground water.

Table 12 gives ratings for the natural soil that makes up the lagoon floor. The surface layer and, generally, 1 or 2 feet of soil material below the surface layer are excavated to provide material for the embankments. The ratings are based on soil properties, site features, and observed performance of the soils. Considered in the ratings are slope, permeability, a high water table, depth to bedrock or to a cemented pan, flooding, large stones, and content of organic matter.

Excessive seepage resulting from rapid permeability in the soil or a water table that is high enough to raise the level of sewage in the lagoon causes a lagoon to function unsatisfactorily. Pollution results if seepage is excessive or if floodwater overtops the lagoon. A high content of organic matter is detrimental to proper functioning of the lagoon because it inhibits aerobic activity. Slope, bedrock, and cemented pans can cause construction problems, and large stones can hinder compaction of the lagoon floor.

Sanitary landfills are areas where solid waste is disposed of by burying it in soil. There are two types of landfill—trench and area. In a trench landfill, the waste is placed in a trench. It is spread, compacted, and covered daily with a thin layer of soil excavated at the site. In an area landfill, the waste is placed in successive layers on the surface of the soil. The waste is spread, compacted, and covered daily with a thin layer of soil from a source away from the site.

Both types of landfill must be able to bear heavy vehicular traffic. Both types involve a risk of ground-water pollution. Ease of excavation and revegetation should be considered.

The ratings in table 12 are based on soil properties, site features, and observed performance of the soils. Permeability, depth to bedrock or to a cemented pan, a high water table, slope, and flooding affect both types of landfill. Texture, stones and boulders, highly organic layers, soil reaction, and content of salts and sodium affect trench landfills. Unless otherwise stated, the ratings apply only to that part of the soil within a depth of about 6 feet. For deeper trenches, a limitation rated slight or moderate may not be valid. Onsite investigation is needed.

Daily cover for landfill is the soil material that is used to cover compacted solid waste in an area sanitary landfill. The soil material is obtained offsite, transported to the landfill, and spread over the waste.

Soil texture, wetness, coarse fragments, and slope affect the ease of removing and spreading the material during wet and dry periods. Loamy or silty soils that are free of large stones or excess gravel are the best cover for a landfill. Clayey soils are sticky or cloddy and are difficult to spread; sandy soils are subject to soil blowing.

After soil material has been removed, the soil material remaining in the borrow area must be thick enough over bedrock, a cemented pan, or the water table to permit revegetation. The soil material used as final cover for a landfill should be suitable for plants. The surface layer generally has the best workability, more organic matter, and the best potential for plants. Material from the surface layer should be stockpiled for use as the final cover.

Construction Materials

Table 13 gives information about the soils as a source of roadfill, sand, gravel, and topsoil. The soils are rated *good, fair,* or *poor* as a source of roadfill and topsoil. They are rated as a *probable* or *improbable* source of sand and gravel. The ratings are based on soil properties and site features that affect the removal of the soil and its use as construction material. Normal compaction, minor processing, and other standard construction practices are assumed. Each soil is evaluated to a depth of 5 or 6 feet.

Roadfill is soil material that is excavated in one place and used in road embankments in another place. In this table, the soils are rated as a source of roadfill for low embankments, generally less than 6 feet high and less exacting in design than higher embankments.

The ratings are for the soil material below the surface layer to a depth of 5 or 6 feet. It is assumed that soil layers will be mixed during excavating and spreading. Many soils have layers of contrasting suitability within their profile. The table showing engineering index properties provides detailed information about each soil layer. This information can help to determine the suitability of each layer for use as roadfill. The performance of soil after it is stabilized with lime or cement is not considered in the ratings.

The ratings are based on soil properties, site features, and observed performance of the soils. The thickness of suitable material is a major consideration. The ease of excavation is affected by large stones, a high water table, and slope. How well the soil performs in place after it has been compacted and drained is determined by its strength (as inferred from the engineering classification of the soil) and the shrink-swell potential.

Soils rated *good* contain significant amounts of sand or gravel or both. They have at least 5 feet of suitable material, a low shrink-swell potential, few cobbles and stones, and slopes of 15 percent or less. Depth to the water table is more than 3 feet. Soils rated *fair* are more than 35 percent silt- and clay-sized particles and have a plasticity index of less than 10. They have a moderate shrink-swell potential, slopes of 15 to 25 percent, or many stones. Depth to the water table is 1 to 3 feet. Soils rated *poor* have a plasticity index of more than 10, a high shrink-swell potential, many stones, or slopes of more than 25 percent. They are wet and have a water table at a depth of less than 1 foot. They may have layers of suitable material, but the material is less than 3 feet thick.

Sand and *gravel* are natural aggregates suitable for commercial use with a minimum of processing. They are used in many kinds of construction. Specifications for each use vary widely. In table 13, only the probability of finding material in suitable quantity is evaluated. The suitability of the material for specific purposes is not evaluated, nor are factors that affect excavation of the material.

The properties used to evaluate the soil as a source of sand or gravel are gradation of grain sizes (as indicated by the engineering classification of the soil), the thickness of suitable material, and the content of rock fragments. Kinds of rock, acidity, and stratification are given in the soil series descriptions. Gradation of grain sizes is given in the table on engineering index properties.

A soil rated as a probable source has a layer of clean sand or gravel or a layer of sand or gravel that is as much as 12 percent silty fines. This material must be at least 3 feet thick and less than 50 percent, by weight, large stones. All other soils are rated as an improbable source. Coarse fragments of soft bedrock, such as shale and siltstone, are not considered to be sand and gravel.

Topsoil is used to cover an area so that vegetation can be established and maintained. The upper 40 inches of a soil is evaluated for use as topsoil. Also evaluated is the reclamation potential of the borrow area.

Plant growth is affected by toxic material and by such properties as soil reaction, available water capacity, and fertility. The ease of excavating, loading, and spreading is affected by rock fragments, slope, a water table, soil texture, and thickness of suitable material. Reclamation of the borrow area is affected by slope, a water table, rock fragments, bedrock, and toxic material.

Soils rated *good* have friable, loamy material to a depth of at least 40 inches. They are free of stones and cobbles, have little or no gravel, and have slopes of less than 8 percent. They are low in content of soluble salts, are naturally fertile or respond well to fertilizer, and are not so wet that excavation is difficult.

Soils rated *fair* are sandy soils, loamy soils that have a relatively high content of clay, soils that have only 20 to 40 inches of suitable material, soils that have an appreciable amount of gravel, stones, or soluble salts, or soils that have slopes of 8 to 15 percent. The soils are not so wet that excavation is difficult.

Soils rated *poor* are very sandy or clayey, have less than 20 inches of suitable material, have a large amount of gravel, stones, or soluble salts, have slopes of more than 15 percent, or have a seasonal high water table at or near the surface.

The surface layer of most soils is generally preferred for topsoil because of its organic matter content. Organic matter greatly increases the absorption and retention of moisture and nutrients for plant growth.

Water Management

Table 14 gives information on the soil properties and site features that affect water management. The degree and kind of soil limitations are given for pond reservoir areas and for embankments, dikes, and levees. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and are easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increase in construction costs, and possibly increased maintenance are required.

This table also gives for each soil the restrictive features that affect drainage, irrigation, terraces and diversions, and grassed waterways.

Pond reservoir areas hold water behind a dam or embankment. Soils best suited to this use have low seepage potential in the upper 60 inches. The seepage potential is determined by the permeability in the soil and the depth to fractured bedrock or other permeable material. Excessive slope can affect the storage capacity of the reservoir area.

Embankments, dikes, and levees are raised structures of soil material, generally less than 20 feet high, constructed to impound water or to protect land against overflow. In this table, the soils are rated as a source of material for embankment fill. The ratings apply to the soil material below the surface layer to a depth of about 5 feet. It is assumed that soil layers will be uniformly mixed and compacted during construction.

The ratings do not indicate the ability of the natural soil to support an embankment. Soil properties to a depth even greater than the height of the embankment can affect performance and safety of the embankment. Generally, deeper onsite investigation is needed to determine these properties.

Soil material in embankments must be resistant to seepage, piping, and erosion and have favorable compaction characteristics. Unfavorable features include less than 5 feet of suitable material and a high content of stones or boulders, organic matter, or salts or sodium. A high water table affects the amount of usable material. It also affects trafficability.

Drainage is the removal of excess surface and subsurface water from the soil. How easily and effectively the soil is drained depends on the depth to bedrock, to a cemented pan, or to other layers that affect the rate of water movement; permeability; depth to a high water table or depth of standing water if the soil is subject to ponding; slope; susceptibility to flooding; subsidence of organic layers; and the potential for frost action. Excavating and grading and the stability of ditchbanks are affected by depth to bedrock or to a cemented pan, large stones, slope, and the hazard of cutbanks caving. The productivity of the soil after drainage is adversely affected by extreme acidity or by toxic substances in the root zone, such as salts, sodium, or sulfur. Availability of drainage outlets is not considered in the ratings.

Irrigation is the controlled application of water to supplement rainfall and support plant growth. The design and management of an irrigation system are affected by depth to the water table, the need for drainage, flooding, available water capacity, intake rate, permeability, erosion hazard, and slope. The construction of a system is affected by large stones and depth to bedrock or to a cemented pan. The performance of a system is affected by the depth of the root zone, the amount of salts or sodium, and soil reaction.

Terraces and diversions are embankments or a combination of channels and ridges constructed across a slope to control erosion and conserve moisture by intercepting runoff. Slope, wetness, large stones, and depth to bedrock or to a cemented pan affect the construction of terraces and diversions. A restricted rooting depth, a severe hazard of wind erosion or water erosion, an excessively coarse texture, and restricted permeability adversely affect maintenance.

Grassed waterways are natural or constructed channels, generally broad and shallow, that conduct surface water to outlets at a nonerosive velocity. Large stones, wetness, slope, and depth to bedrock or to a cemented pan affect the construction of grassed waterways. A hazard of wind erosion, low available water capacity, restricted rooting depth, toxic substances such as salts or sodium, and restricted permeability adversely affect the growth and maintenance of the grass after construction.

Soil Properties

Data relating to soil properties are collected during the course of the soil survey. The data and the estimates of soil and water features, listed in tables, are explained on the following pages.

Soil properties are determined by field examination of the soils and by laboratory index testing of some benchmark soils. Established standard procedures are followed. During the survey, many shallow borings are made and examined to identify and classify the soils and to delineate them on the soil maps. Samples are taken from some typical profiles and tested in the laboratory to determine grain-size distribution, plasticity, and compaction characteristics.

Estimates of soil properties are based on field examinations, on laboratory tests of samples from the survey area, and on laboratory tests of samples of similar soils in nearby areas. Tests verify field observations, verify properties that cannot be estimated accurately by field observation, and help to characterize key soils.

The estimates of soil properties shown in the tables include the range of grain-size distribution and Atterberg limits, the engineering classification, and the physical and chemical properties of the major layers of each soil. Pertinent soil and water features also are given.

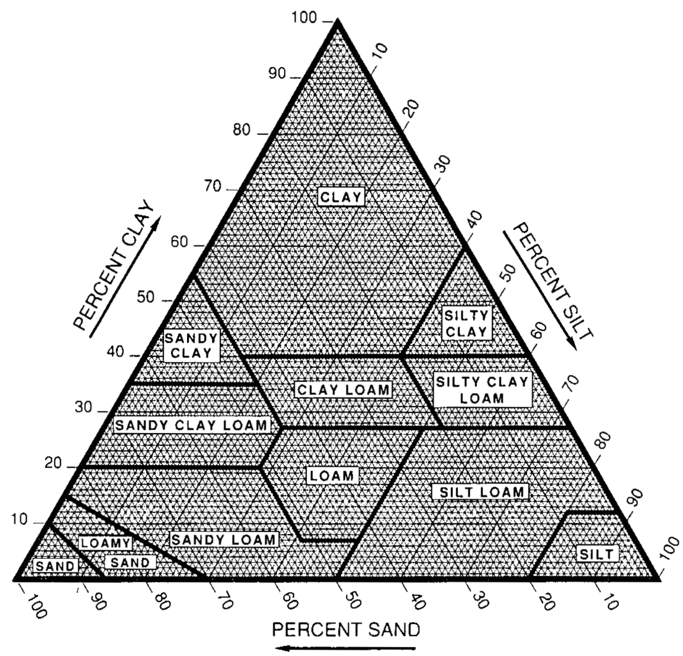

Figure 18.—Percentages of clay, silt, and sand in the basic USDA soil textural classes.

Engineering Index Properties

Table 15 gives estimates of the engineering classification and of the range of index properties for the major layers of each soil in the survey area. Most soils have layers of contrasting properties within the upper 5 or 6 feet.

Depth to the upper and lower boundaries of each layer is indicated. The range in depth and information on other properties of each layer are given for each soil series under the heading "Soil Series and Their Morphology."

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter (fig. 18). "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is as much as about 15 percent, an appropriate modifier is added, for example, "gravelly." Textural terms are defined in the "Glossary."

Classification of the soils is determined according to the Unified soil classification system *(2)* and the system adopted by the American Association of State Highway and Transportation Officials *(1)*.

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to grain-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification, for example, CL-ML.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of grain-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grain and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grain. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest.

Rock fragments 3 to 10 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage.

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than 3 inches in diameter based on an ovendry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field.

Liquid limit and *plasticity index* (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination.

The estimates of grain-size distribution, liquid limit, and plasticity index are generally rounded to the nearest 5 percent. Thus, if the ranges of gradation and Atterberg limits extend a marginal amount (1 or 2 percentage points) across classification boundaries, the classification in the marginal zone is omitted in the table.

Physical and Chemical Properties

Table 16 shows estimates of some characteristics and features that affect soil behavior. These estimates are given for the major layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated content of clay in each major soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The amount and kind of clay greatly affect the fertility and physical condition of the soil. They determine the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, permeability, plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at ⅓-bar moisture tension. Weight is determined after drying the soil at 105 degrees C. In this table, the estimated moist bulk density of each major soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. A bulk density of more than 1.6 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Permeability refers to the ability of a soil to transmit water or air. The estimates indicate the rate of downward movement of water when the soil is saturated. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Permeability is considered in the design of soil drainage systems and septic tank absorption fields.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each major soil layer. The capacity varies, depending on soil properties that affect the retention of water and the depth of the root zone. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Soil reaction is a measure of acidity or alkalinity and is expressed as a range in pH values. The range in pH of each major horizon is based on many field tests. For many soils, values have been verified by laboratory analyses. Soil reaction is important in selecting crops and other plants, in evaluating soil amendments for fertility and stabilization, and in determining the risk of corrosion.

Shrink-swell potential is the potential for volume change in a soil with a loss or gain in moisture. Volume change occurs mainly because of the interaction of clay minerals with water and varies with the amount and type of clay minerals in the soil. The size of the load on the soil and the magnitude of the change in soil moisture content influence the amount of swelling of soils in place. Laboratory measurements of swelling of undisturbed clods were made for many soils. For others, swelling was estimated on the basis of the kind and amount of clay minerals in the soil and on measurements of similar soils.

If the shrink-swell potential is rated moderate to very high, shrinking and swelling can cause damage to buildings, roads, and other structures. Special design is often needed.

The shrink-swell potential classes are based on the change in length of an unconfined clod as moisture content is increased from air-dry to field capacity. The classes are *low*, a change of less than 3 percent; *moderate*, 3 to 6 percent; and *high*, more than 6 percent. *Very high*, more than 9 percent, is sometimes used.

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter (up to 4 percent) and on soil structure and permeability. Values of K range from 0.05 to 0.69. The higher the value, the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their resistance to soil blowing in cultivated areas. The groups indicate the susceptibility to soil blowing. Soils are grouped according to the following distinctions:

1. Coarse sands, sands, fine sands, and very fine sands. These soils are generally not suitable for crops. They are extremely erodible, and vegetation is difficult to establish.

2. Loamy coarse sands, loamy sands, loamy fine sands, loamy very fine sands, and sapric soil material. These soils are very highly erodible. Crops can be grown if intensive measures to control soil blowing are used.

3. Coarse sandy loams, sandy loams, fine sandy loams, and very fine sandy loams. These soils are highly erodible. Crops can be grown if intensive measures to control soil blowing are used.

4L. Calcareous loams, silt loams, clay loams, and silty clay loams. These soils are erodible. Crops can be grown if intensive measures to control soil blowing are used.

4. Clays, silty clays, noncalcareous clay loams, and silty clay loams that are more than 35 percent clay. These soils are moderately erodible. Crops can be grown if measures to control soil blowing are used.

5. Noncalcareous loams and silt loams that are less than 20 percent clay and sandy clay loams, sandy clays, and hemic soil material. These soils are slightly erodible. Crops can be grown if measures to control soil blowing are used.

6. Noncalcareous loams and silt loams that are more than 20 percent clay and noncalcareous clay loams that are less than 35 percent clay. These soils are very slightly erodible. Crops can be grown if ordinary measures to control soil blowing are used.

7. Silts, noncalcareous silty clay loams that are less than 35 percent clay, and fibric soil material. These soils are very slightly erodible. Crops can be grown if ordinary measures to control soil blowing are used.

8. Soils that are not subject to soil blowing because of coarse fragments on the surface or because of surface wetness.

Organic matter is the plant and animal residue in the soil at various stages of decomposition. In table 16, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of organic matter in a soil can be maintained or increased by returning crop residue to the soil. Organic matter affects the available water capacity, infiltration rate, and tilth. It is a source of nitrogen and other nutrients for crops.

Soil and Water Features

Table 17 gives estimates of various soil and water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are used to estimate runoff from precipitation. Soils not protected by vegetation are assigned to one of four groups. They are grouped according to the infiltration of water when the soils are thoroughly wet and receive precipitation from long-duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a permanent high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to two hydrologic groups in table 17, the first letter is for drained areas and the second is for undrained areas.

Flooding, the temporary inundation of an area, is caused by overflowing streams or by runoff from adjacent slopes. Water standing for short periods after rainfall or snowmelt is not considered flooding, nor is water in swamps and marshes.

Table 17 gives the frequency and duration of flooding and the time of year when flooding is most likely.

Frequency, duration, and probable dates of occurrence are estimated. Frequency is expressed as none, rare, occasional, and frequent. *None* means that flooding is not probable; *rare* that it is unlikely but possible under unusual weather conditions (the chance of flooding is nearly 0 percent to 5 percent in any year); *occasional* that it occurs infrequently under normal weather conditions (the chance of flooding is 5 to 50 percent in any year); and *frequent* that it occurs often under normal weather conditions (the chance of flooding is more than 50 percent in any year). Duration is expressed as *very brief* if less than 2 days, *brief* if 2 to 7 days, *long* if 7 days to 1 month, and *very long* if more than 1 month. Probable dates are expressed in months. About two-thirds to three-fourths of all flooding occurs during the stated period.

The information is based on evidence in the soil profile, namely thin strata of gravel, sand, silt, or clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; and little or no horizon development.

Also considered are local information about the extent and levels of flooding and the relation of each soil on the landscape to historic floods. Information on the extent of flooding based on soil data is less specific than that provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

High water table (seasonal) is the highest level of a saturated zone in the soil in most years. The estimates are based mainly on the evidence of a saturated zone, namely grayish colors or mottles in the soil. Indicated in table 17 are the depth to the seasonal high water table; the kind of water table—that is, perched or apparent; and the months of the year that the water table commonly is high. A water table that is seasonally high for less than 1 month is not indicated in table 17. Only saturated zones within a depth of about 6 feet are indicated.

An *apparent* water table is a thick zone of free water in the soil. It is indicated by the level at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil. A *perched* water table is water standing above an unsaturated zone. In places an upper, or perched, water table is separated from a lower one by a dry zone.

Potential frost action is the likelihood of upward or lateral expansion of the soil caused by the formation of segregated ice lenses (frost heave) and the subsequent collapse of the soil and loss of strength on thawing. Frost action occurs when moisture moves into the freezing zone of the soil. Temperature, texture, density, permeability, content of organic matter, and depth to the water table are the most important factors considered in evaluating the potential for frost action. It is assumed that the soil is not insulated by vegetation or snow and is not artificially drained. Silty and highly structured, clayey soils that have a high water table in winter are the most susceptible to frost action. Well drained, very gravelly, or very sandy soils are the least susceptible. Frost heave and low soil strength during thawing cause damage mainly to pavements and other rigid structures.

Risk of corrosion pertains to potential soil-induced electrochemical or chemical action that dissolves or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design may be needed if the combination of factors results in a severe hazard of corrosion. The steel in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than steel in installations that are entirely within one kind of soil or within one soil layer.

For uncoated steel, the risk of corrosion, expressed as *low*, *moderate*, or *high*, is based on soil drainage class, total acidity, electrical resistivity near field capacity, and electrical conductivity of the saturation extract.

For concrete, the risk of corrosion also is expressed as *low*, *moderate*, or *high*. It is based on soil texture, acidity, and amount of sulfates in the saturation extract.

Classification of the Soils

The system of soil classification used by the National Cooperative Soil Survey has six categories *(17)*. Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. Classification is based on soil properties observed in the field or inferred from those observations or from laboratory measurements. Table 18 shows the classification of the soils in the survey area. The categories are defined in the following paragraphs.

ORDER. Eleven soil orders are recognized. The differences among orders reflect the dominant soil-forming processes and the degree of soil formation. Each order is identified by a word ending in *sol*. An example is Mollisol.

SUBORDER. Each order is divided into suborders primarily on the basis of properties that influence soil genesis and are important to plant growth or properties that reflect the most important variables within the orders. The last syllable in the name of a suborder indicates the order. An example is Udoll (*Ud*, meaning humid, plus *oll*, from Mollisol).

GREAT GROUP. Each suborder is divided into great groups on the basis of close similarities in kind, arrangement, and degree of development of pedogenic horizons; soil moisture and temperature regimes; and base status. Each great group is identified by the name of a suborder and by a prefix that indicates a property of the soil. An example is Argiudolls (*Argi*, referring to a clay-rich subsoil, plus *udoll*, the suborder of the Mollisols that has a udic moisture regime).

SUBGROUP. Each great group has a typic subgroup. Other subgroups are intergrades or extragrades. The typic is the central concept of the great group; it is not necessarily the most extensive. Intergrades are transitions to other orders, suborders, or great groups. Extragrades have some properties that are not representative of the great group but do not indicate transitions to any other known kind of soil. Each subgroup is identified by one or more adjectives preceding the name of the great group. The adjective *Typic* identifies the subgroup that typifies the great group. An example is Typic Argiudolls.

FAMILY. Families are established within a subgroup on the basis of physical and chemical properties and other characteristics that affect management. Generally, the properties are those of horizons below plow depth where there is much biological activity. Among the properties and characteristics considered are particle-size class, mineral content, temperature regime, depth of the root zone, consistence, moisture equivalent, slope, and permanent cracks. A family name consists of the name of a subgroup preceded by terms that indicate soil properties. An example is fine, montmorillonitic, mesic Typic Argiudolls.

SERIES. The series consists of soils that have similar horizons in their profile. The horizons are similar in color, texture, structure, reaction, consistence, mineral and chemical composition, and arrangement in the profile. The texture of the surface layer or of the substratum can differ within a series.

Soil Series and Their Morphology

In this section, each soil series recognized in the survey area is described. The descriptions are arranged in alphabetic order.

Characteristics of the soil and the material in which it formed are identified for each series. A pedon, a small three-dimensional area of soil, that is typical of the series in the survey area is described. The detailed description of each soil horizon follows standards in the "Soil Survey Manual" *(15)*. Many of the technical terms used in the descriptions are defined in "Soil Taxonomy" *(17)*. Unless otherwise stated, colors in the descriptions are for moist soil. Following the pedon description is the range of important characteristics of the soils in the series.

The map units of each soil series are described in the section "Detailed Soil Map Units."

Blencoe Series

The Blencoe series consists of very deep, poorly drained soils on high flood plains along the Missouri River. These soils formed in stratified loamy and clayey alluvium. Permeability is slow in the upper part of the profile, moderate in the next part, and very slow in the lower part. Slopes range from 0 to 2 percent.

Typical pedon of Blencoe silty clay loam, clayey substratum, 2,150 feet north and 1,050 feet west of the southeast corner of sec. 36, T. 66 N., R. 42 W.

Ap—0 to 8 inches; very dark grayish brown (10YR 3/2) silty clay loam, dark grayish brown (10YR 4/2) dry; weak fine granular structure; friable; common fine roots; neutral (pH 6.8); clear smooth boundary.

AB—8 to 12 inches; very dark grayish brown (10YR 3/2) silty clay, dark grayish brown (10YR 4/2) dry; weak fine subangular blocky structure; firm; common fine roots; neutral (pH 6.8); clear smooth boundary.

Bg1—12 to 19 inches; dark grayish brown (2.5Y 4/2) silty clay; many fine distinct dark brown (7.5YR 4/4) and few fine faint light brownish gray (10YR 6/2) mottles; moderate medium subangular blocky structure; firm; few fine roots; neutral (pH 7.0); gradual smooth boundary.

Bg2—19 to 30 inches; grayish brown (2.5Y 5/2) silty clay; many medium distinct dark brown (7.5YR 4/4) and few fine faint light brownish gray (2.5Y 6/2) mottles; moderate medium subangular blocky structure; firm; few fine roots; neutral (pH 7.2); gradual smooth boundary.

BCg—30 to 35 inches; dark grayish brown (2.5Y 4/2) silty clay; many medium distinct dark brown (7.5YR 4/4) and many medium faint light brownish gray (2.5Y 6/2) mottles; massive; firm; strong effervescence; mildly alkaline (pH 7.8); clear smooth boundary.

2Cg1—35 to 42 inches; grayish brown (2.5Y 5/2) silt loam; many medium distinct dark brown (7.5YR 4/4) and many medium faint light brownish gray (2.5Y 6/2) mottles; massive; friable; strong effervescence; mildly alkaline (pH 7.8); clear smooth boundary.

2Cg2—42 to 52 inches; stratified grayish brown (2.5Y 5/2) and light brownish gray (2.5Y 6/2) silt loam; massive; friable; strong effervescence; moderately alkaline (pH 8.0); clear smooth boundary.

3Cg3—52 to 60 inches; grayish brown (2.5Y 5/2) silty clay; many large faint light brownish gray (2.5Y 6/2) mottles; massive; friable; strong effervescence; moderately alkaline (pH 8.0).

The depth to carbonates and to the 2C horizon ranges from 25 to 40 inches. Depth to the 3C horizon is 50 to 60 inches.

The A horizon has hue of 10YR or 2.5Y and chroma of 1 or 2. It ranges from 10 to 14 inches in thickness. The Bg horizon has value of 4 or 5. The BC horizon also has value of 4 or 5. Some pedons do not have a BC horizon. The 2C horizon has value of 4 to 6. It is dominantly silt loam or very fine sandy loam, but it has thin strata of silty clay loam in some pedons.

Colo Series

The Colo series consists of very deep, poorly drained, moderately permeable soils on flood plains along secondary streams. These soils formed in silty alluvium. Slopes range from 0 to 2 percent.

Typical pedon of Colo silt loam, 1,200 feet west and 2,300 feet north of the southeast corner of sec. 27, T. 65 N., R. 40 W.

Ap—0 to 8 inches; black (10YR 2/1) silt loam, dark grayish brown (10YR 4/2) dry; weak fine granular structure; friable; common very fine roots; neutral (pH 6.9); abrupt smooth boundary.

A1—8 to 16 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; weak medium subangular blocky structure; friable; common very fine roots; neutral (pH 7.0); gradual smooth boundary.

A2—16 to 25 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; moderate medium subangular blocky structure; friable; common very fine roots; many very fine tubular pores; neutral (pH 7.2); gradual smooth boundary.

Bg1—25 to 36 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; moderate medium prismatic structure; friable; common very fine roots; neutral (pH 7.3); gradual smooth boundary.

Bg2—36 to 56 inches; very dark brown (10YR 2/2) silty clay loam, dark grayish brown (10YR 4/2) dry; few fine prominent strong brown (7.5YR 5/8) and light olive brown (2.5Y 5/6) mottles; weak medium prismatic structure; friable; few very fine roots; neutral (pH 7.3); gradual smooth boundary.

Cg—56 to 60 inches; very dark grayish brown (10YR 3/2) silty clay loam, dark grayish brown (10YR 4/2) dry; common fine prominent strong brown (7.5YR 5/8) and light olive brown (2.5Y 5/6) mottles; massive; friable; few very fine roots; neutral (pH 7.3).

The mollic epipedon is 36 or more inches thick. The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2, or it is neutral in hue and has value of 2 or 3. The lower part of this horizon has mottles in some pedons. The A horizon is silt loam or silty clay loam. The Bg horizon has value of 2 or 3 and chroma of 1 or 2. It commonly has mottles, which have higher value and chroma. Some pedons do not have a Bg horizon. The C horizon has hue of 10YR to 5Y, value of 3 to 5, and chroma of 1 or 2. It is dominantly silt loam or silty clay loam, but it has thin strata of silty clay in some pedons.

Contrary Series

The Contrary series consists of very deep, well drained, moderately permeable soils on uplands. These soils formed in loess (fig. 19). Slopes range from 5 to 14 percent.

Typical pedon of Contrary silt loam, 9 to 14 percent slopes, eroded, 700 feet north and 300 feet east of the southwest corner of sec. 18, T. 66 N., R. 40 W.

Ap1—0 to 2 inches; dark brown (10YR 3/3) silt loam, brown (10YR 5/3) dry; moderate thin platy structure parting to moderate very fine subangular blocky; very friable; many very fine and few fine roots; neutral; abrupt smooth boundary.

Ap2—2 to 7 inches; dark brown (10YR 3/3) silt loam, yellowish brown (10YR 5/4) dry; few fine distinct brown (7.5YR 4/4) mottles; moderate medium subangular blocky structure; very friable; many very fine and few fine roots; few medium wormcasts; neutral (pH 7.0); clear wavy boundary.

Bw1—7 to 12 inches; dark brown (10YR 4/3) silt loam, yellowish brown (10YR 5/4) dry; few fine distinct grayish brown (2.5Y 5/2) and brown (7.5YR 4/4) mottles; weak medium prismatic structure parting to moderate medium subangular blocky; very friable; few fine and common very fine roots; neutral (pH 7.1); gradual wavy boundary.

Bw2—12 to 24 inches; brown (10YR 5/3) silt loam; common fine and few medium distinct grayish brown (2.5Y 5/2) and few fine distinct brown (7.5YR 4/4) mottles; weak coarse prismatic structure parting to weak medium subangular blocky; very friable; few fine and common very fine roots; few distinct black stains; neutral (pH 7.0); gradual wavy boundary.

Bw3—24 to 35 inches; yellowish brown (10YR 5/4) silt loam; common fine and few medium prominent grayish brown (2.5Y 5/2) and few fine distinct brown (7.5YR 4/4) mottles; weak coarse prismatic structure parting to weak medium subangular blocky; very friable; few fine and very fine roots; few distinct black stains; neutral (pH 7.0); diffuse smooth boundary.

C—35 to 60 inches; yellowish brown (10YR 5/4) silt loam; common fine and few medium prominent grayish brown (2.5Y 5/2) and common fine prominent strong brown (7.5YR 5/6) mottles; weak very thick platy structure; very friable; few very fine roots; common distinct black stains; neutral (pH 6.8).

Free carbonates generally are leached to a depth of 60 inches or more. In some pedons, however, they are at a depth of 48 to 60 inches. The gray colors and the mottles are relict features and are not indicative of present drainage conditions.

The A horizon is 4 to 9 inches thick. The Bw horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 2 to 4. It is silt loam or silty clay loam. The C horizon has hue of 10YR or 2.5Y, value of 5 or 6, and chroma of 2 to 4.

Dockery Series

The Dockery series consists of very deep, somewhat poorly drained, moderately permeable soils on flood plains along major secondary streams, such as the Nishnabotna and Tarkio Rivers. These soils formed in silty alluvium. Slopes range from 0 to 2 percent.

Typical pedon of Dockery silt loam, 2,500 feet north and 1,300 feet west of the southeast corner of sec. 25, T. 66 N., R. 42 W.

Ap—0 to 8 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak very fine granular structure; friable; few very fine roots; slightly acid (pH 6.1); clear smooth boundary.

C1—8 to 15 inches; stratified very dark grayish brown (10YR 3/2) and dark grayish brown (10YR 4/2) silt loam; common fine prominent dark brown (7.5YR 4/4) mottles; massive; friable; few very fine roots; slightly acid (pH 6.4); abrupt smooth boundary.

C2—15 to 22 inches; dark grayish brown (10YR 4/2) silt loam; fine very dark gray (10YR 3/1), dark gray (10YR 4/1), and dark brown (10YR 4/3) strata; many fine and medium prominent dark brown (7.5YR 4/4) mottles; massive; friable; few very fine roots; neutral (pH 6.8); abrupt smooth boundary.

Cg1—22 to 33 inches; very dark grayish brown (2.5Y 3/2) silt loam; few fine dark grayish brown (2.5Y 4/2) and grayish brown (2.5Y 5/2) strata; few fine prominent dark brown (7.5YR 4/4) mottles; massive; friable; few very fine roots; slight effervescence; mildly alkaline (pH 7.4); abrupt smooth boundary.

Cg2—33 to 36 inches; stratified very dark grayish brown (2.5Y 3/2), very dark gray (10YR 3/1), and very dark grayish brown (10YR 3/2) silt loam; few fine prominent dark brown (7.5YR 4/4) and few medium prominent dark reddish brown (5YR 3/3) mottles; dominantly massive but weak very fine granular structure in the very dark gray strata; friable; few very fine roots; slight effervescence; mildly alkaline (pH 7.4); abrupt smooth boundary.

Cg3—36 to 39 inches; stratified, dark grayish brown (10YR 4/2 and 2.5Y 4/2) silt loam; few fine distinct dark yellowish brown (10YR 4/4) mottles; massive;

friable; slight effervescence; mildly alkaline (pH 7.4); abrupt smooth boundary.

Cg4—39 to 51 inches; stratified dark grayish brown (2.5Y 4/2) and grayish brown (2.5Y 5/2) silt loam; common medium prominent dark brown (7.5YR 4/4) and reddish brown (5YR 4/4) mottles; massive; friable; mildly alkaline (pH 7.4); abrupt smooth boundary.

Cg5—51 to 60 inches; stratified dark gray (10YR 4/1) and very dark grayish brown (2.5Y 3/2) silty clay loam; fine very dark gray (10YR 3/1) strata; common fine and medium prominent dark reddish brown (5YR 3/3 and 3/4) and reddish brown (5YR 4/4) mottles on vertical fracture planes; massive; friable; neutral (pH 7.2).

The A horizon has chroma of 2 or 3. It is 6 to 10 inches thick. The C horizon has hue of 10YR or 2.5Y, value of 3 to 5, and chroma of 1 to 3. It is typically silt loam or silty clay loam, but in some pedons it has strata of fine and very fine sandy loam in the lower part. Many pedons have a buried silty clay loam A horizon in the lower part. Many have calcareous strata that formed in alluvium from the Nishnabotna River.

Gilliam Series

The Gilliam series consists of very deep, somewhat poorly drained, moderately permeable soils on high flood plains along the Missouri River. These soils formed in silty alluvium. Slopes range from 0 to 2 percent.

Typical pedon of Gilliam silt loam, 2,300 feet west and 100 feet north of the southeast corner of sec. 20, T. 64 N., R. 41 W.

Ap—0 to 10 inches; very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; weak fine subangular blocky structure; friable; common fine roots; neutral (pH 6.6); clear smooth boundary.

Bw—10 to 20 inches; dark grayish brown (2.5Y 4/2) silt loam; few fine distinct grayish brown (10YR 5/2) and prominent dark brown (7.5YR 4/4) mottles; weak fine subangular blocky structure; friable; common fine roots; neutral (pH 7.2); clear smooth boundary.

Cg1—20 to 26 inches; grayish brown (2.5Y 5/2) silt loam; few fine distinct gray (10YR 5/1) and common fine distinct dark yellowish brown (10YR 4/4) mottles; massive; friable; few fine roots; slight effervescence; mildly alkaline (pH 7.6); clear smooth boundary.

Cg2—26 to 43 inches; grayish brown (2.5Y 5/2), stratified silt loam and silty clay loam; few fine distinct gray (10YR 5/1) and dark yellowish brown (10YR 4/4) mottles; moderate fine subangular blocky structure; friable; strong effervescence; mildly alkaline (pH 7.6); clear smooth boundary.

Cg3—43 to 60 inches; grayish brown (2.5Y 5/2), stratified silt loam and silty clay loam; few fine distinct gray (10YR 5/1) and dark brown (7.5YR 4/4) mottles; massive; friable; strong effervescence; moderately alkaline (pH 8.0).

The depth to carbonates ranges from 14 to 26 inches. The A horizon has hue of 10YR or 2.5Y and value of 2 or 3. It is 10 to 16 inches thick. The B horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 2 to 4. It is commonly silt loam but is silty clay loam in some pedons. The C horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 1 or 2.

Hamburg Series

The Hamburg series consists of very deep, somewhat excessively drained, moderately permeable soils on bluffs in the uplands adjacent to the Missouri River valley. These soils formed in calcareous loess. Slopes range from 45 to 90 percent.

Typical pedon of Hamburg silt loam, in an area of Timula-Hamburg silt loams, 30 to 90 percent slopes; 2,200 feet south and 2,000 feet west of the northeast corner of sec. 35, T. 64 N., R. 41 W.

A—0 to 2 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak fine subangular blocky structure; very friable; many very fine roots; moderately alkaline (pH 7.9); clear wavy boundary.

AC—2 to 6 inches; brown (10YR 4/3) silt loam; weak fine subangular blocky structure; very friable; many very fine roots; slight effervescence; moderately alkaline (pH 8.1); diffuse wavy boundary.

C—6 to 60 inches; yellowish brown (10YR 5/4) silt loam; appears massive but has some vertical cleavage; very friable; few nodules of calcium carbonate; strong effervescence; moderately alkaline (pH 8.2).

The depth to free carbonates ranges from 0 to 10 inches. The A horizon has value of 3 or 4 and chroma of 2 or 3. It ranges from 2 to 6 inches in thickness. The C horizon has value of 4 to 6 and chroma of 2 to 4.

Haynie Series

The Haynie series consists of very deep, moderately well drained soils on high and low flood plains along the Missouri River. These soils formed in calcareous, silty and loamy alluvium. Permeability is moderate in the upper part of the profile and rapid in the lower part. Slopes range from 0 to 2 percent.

Typical pedon of Haynie silt loam, sandy substratum, rarely flooded, 2,600 feet west and 200 feet north of the southeast corner of sec. 11, T. 66 N., R. 43 W.

Ap—0 to 6 inches; very dark grayish brown (2.5Y 3/2) silt loam, grayish brown (2.5Y 5/2) dry; weak fine subangular blocky structure; very friable; common fine roots; violent effervescence; mildly alkaline (pH 7.6); clear smooth boundary.

C1—6 to 12 inches; mixed dark grayish brown (2.5Y 4/2) and grayish brown (2.5Y 5/2) silt loam; few fine distinct dark yellowish brown (10YR 4/4) mottles; massive; very friable; common fine roots; violent effervescence; mildly alkaline (pH 7.6); abrupt smooth boundary.

C2—12 to 18 inches; stratified grayish brown (2.5Y 5/2) silt loam and dark grayish brown (2.5Y 4/2) very fine sandy loam; common fine distinct dark yellowish brown (10YR 4/4) mottles; massive; very friable; common fine roots; violent effervescence; mildly alkaline (pH 7.6); abrupt smooth boundary.

C3—18 to 24 inches; grayish brown (2.5Y 5/2) silt loam; few thin very dark gray (10YR 3/1) strata; few fine distinct dark yellowish brown (10YR 4/4) mottles; massive; very friable; common fine roots; violent effervescence; mildly alkaline (pH 7.8); clear smooth boundary.

C4—24 to 31 inches; stratified dark grayish brown (2.5Y 4/2) and grayish brown (2.5Y 5/2) silt loam; few fine distinct dark yellowish brown (10YR 4/4) mottles; massive; very friable; common fine roots; violent effervescence; mildly alkaline (pH 7.8); clear smooth boundary.

C5—31 to 52 inches; stratified dark grayish brown (2.5Y 4/2) and grayish brown (2.5Y 5/2) silt loam; few strata of very fine sandy loam; few fine distinct dark yellowish brown (10YR 4/4) mottles; massive; very friable; few fine roots; violent effervescence; mildly alkaline (pH 7.8); abrupt smooth boundary.

2C6—52 to 60 inches; dark grayish brown (2.5Y 4/2) loamy fine sand; few fine distinct dark yellowish brown (10YR 4/4) mottles; single grain; loose; violent effervescence; moderately alkaline (pH 8.0).

The depth to carbonates is less than 10 inches. The Ap horizon has hue of 10YR or 2.5Y. In some pedons the A horizon is not calcareous. The C horizon has hue of 10YR or 2.5Y and value of 4 or 5. It is typically silt loam or very fine sandy loam, but in some pedons it has thin strata of loamy fine sand.

In Atchison County, Haynie silt loam (map unit 16) has a dark A horizon that is thicker than is definitive for the series. Also, the soil is deeper to carbonates. These differences, however, do not significantly affect the use and management of the soils.

Higginsville Series

The Higginsville series consists of very deep, somewhat poorly drained, moderately permeable soils on uplands. These soils formed in loess. Slopes range from 5 to 14 percent.

The Higginsville soils in this county have a dark surface layer that is thinner than is definitive for the series. Also, they have less of a clay increase in the B horizon. These differences, however, do not significantly affect the use and management of the soils.

Typical pedon of Higginsville silty clay loam, 9 to 14 percent slopes, eroded, 2,200 feet east and 600 feet north of the southwest corner of sec. 14, T. 66 N., R. 39 W.

Ap1—0 to 5 inches; very dark grayish brown (2.5Y 3/2) silty clay loam, dark grayish brown (2.5Y 4/2) dry; weak medium subangular blocky structure parting to moderate fine granular; very friable; few very fine roots; neutral (pH 7.1); clear wavy boundary.

Ap2—5 to 9 inches; very dark grayish brown (2.5Y 3/2) silty clay loam, dark grayish brown (2.5Y 4/2) dry; few fine prominent dark brown (7.5YR 4/4) mottles; moderate medium subangular blocky structure; firm; few very fine roots; neutral (pH 6.8); abrupt wavy boundary.

Bt1—9 to 15 inches; olive brown (2.5Y 4/4) silty clay loam; many fine prominent very dark gray (N 3/0) mottles; moderate fine subangular blocky structure; friable; few very fine roots; very few faint light olive brown clay films on faces of peds; neutral (pH 6.7); clear smooth boundary.

Bt2—15 to 21 inches; brown (10YR 5/3) silty clay loam; few fine distinct strong brown (7.5YR 5/6) and many fine distinct very dark gray (N 3/0) mottles; weak medium subangular blocky structure; friable; few very fine roots; very few faint light olive brown clay films on faces of peds; slightly acid (pH 6.5); clear smooth boundary.

Bt3—21 to 31 inches; yellowish brown (10YR 5/4) silty clay loam; few fine prominent strong brown (7.5YR 5/6), common fine prominent very dark gray (N 3/0), and few fine distinct grayish brown (10YR 5/2) mottles; weak medium subangular blocky structure; friable; few very fine roots; very few faint light olive brown clay films on faces of peds; very few distinct black stains in root channels and pores; neutral (pH 6.7); gradual smooth boundary.

BCg—31 to 44 inches; light olive brown (2.5Y 5/4) silty clay loam; many medium prominent light brownish gray (10YR 6/2) and common fine prominent strong brown (7.5YR 5/6) mottles; weak coarse prismatic structure parting to weak thick platy; friable; few prominent yellowish red iron stains in root channels and pores; very few prominent black stains throughout; neutral (pH 6.7); gradual smooth boundary.

Cg—44 to 60 inches; light olive brown (2.5Y 5/4) silt loam; many medium prominent light brownish gray (10YR 6/2) and common fine prominent strong brown (7.5YR 5/6) mottles; weak thick platy structure; friable; few prominent yellowish red iron stains in root channels and pores; few prominent black stains throughout; neutral (pH 6.9).

The A horizon has a hue of 10YR or 2.5Y, value of 2 or 3, and chroma of 1 or 2. The Bt horizon has a hue of 10YR or 2.5Y, value of 3 to 5, and chroma of 2 to 4. The C horizon has value of 4 or 5. It is silty clay loam or silt loam.

Ida Series

The Ida series consists of very deep, well drained, moderately permeable soils on uplands. These soils formed in calcareous loess (fig. 20). Slopes range from 9 to 25 percent.

Typical pedon of Ida silt loam, 14 to 25 percent slopes, eroded, 1,300 feet east and 750 feet north of the southwest corner of sec. 3, T. 65 N., R. 41 W.

Ap—0 to 4 inches; dark brown (10YR 4/3) silt loam, pale brown (10YR 6/3) dry; weak thick platy structure parting to weak medium subangular blocky; very friable; few very fine roots; slight effervescence; moderately alkaline (pH 8.0); abrupt wavy boundary.

C1—4 to 18 inches; yellowish brown (10YR 5/4) silt loam; common fine and few medium distinct grayish brown (2.5Y 5/2) and few fine distinct yellowish brown (10YR 5/8) mottles; weak medium prismatic structure; very friable; common very fine roots; common prominent black stains throughout; few medium nodules of calcium carbonate; strong effervescence; moderately alkaline (pH 8.0); clear smooth boundary.

C2—18 to 25 inches; grayish brown (2.5Y 5/2) and light olive brown (2.5Y 5/4) silt loam; colors in horizontal bedding planes; few fine and medium distinct yellowish brown (10YR 5/8) mottles; weak medium platy structure having some vertical cleavage; very friable; common very fine roots; few prominent black and dark yellowish brown stains throughout; few medium nodules of calcium carbonate; strong effervescence; moderately alkaline (pH 8.2); diffuse smooth boundary.

C3—25 to 36 inches; yellowish brown (10YR 5/4) silt loam; few fine and medium distinct grayish brown (2.5Y 5/2) and few fine and medium distinct yellowish brown (10YR 5/8) mottles; weak medium platy structure having some vertical cleavage; very friable; common very fine roots; many prominent black and dark yellowish brown stains throughout; few medium nodules of calcium carbonate; strong effervescence; moderately alkaline (pH 8.1); gradual smooth boundary.

C4—36 to 48 inches; light olive brown (2.5Y 5/4) silt loam; few fine and medium distinct grayish brown (2.5Y 5/2) and few fine and medium distinct yellowish brown (10YR 5/8) mottles; weak medium platy structure having some vertical cleavage; very friable; few very fine roots; many prominent black stains throughout; few medium nodules of calcium carbonate; separated from horizon below by a thin grayish brown (2.5Y 5/2) horizontal band; strong effervescence; moderately alkaline (pH 8.1); abrupt smooth boundary.

C5—48 to 60 inches; light olive brown (2.5Y 5/4) silt loam; common fine and few medium distinct grayish brown (2.5Y 5/2) and few fine and medium distinct yellowish brown (10YR 5/8) mottles; weak medium platy structure having some vertical cleavage; very friable; few very fine roots; common prominent black stains throughout; few medium nodules of calcium carbonate; strong effervescence; moderately alkaline (pH 8.1).

Free carbonates are at or near the surface. The A horizon has hue of 2.5Y or 10YR, value of 4 or 5, and chroma of 2 or 3. It is 4 to 8 inches thick. The C horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 2 to 4. In some pedons it does not have mottles in the upper part.

Judson Series

The Judson series consists of very deep, well drained, moderately permeable soils on foot slopes. These soils formed in silty slope alluvium from loess-covered uplands. Slopes range from 2 to 5 percent.

Typical pedon of Judson silt loam, 2 to 5 percent slopes, 1,800 feet west and 550 feet north of the southeast corner of sec. 12, T. 65 N., R. 39 W.

Ap—0 to 7 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak fine subangular blocky structure; friable; medium acid (pH 5.6); clear smooth boundary.

A—7 to 28 inches; mixed black (10YR 2/1) and very dark grayish brown (10YR 3/2) silt loam, very dark grayish brown (10YR 3/2) rubbed, dark grayish brown (10YR 4/2) dry; moderate very fine subangular blocky structure; very friable; few very fine roots; common fine subrounded casts; medium acid (pH 6.0); gradual smooth boundary.

AB—28 to 33 inches; mixed very dark grayish brown (10YR 3/2) and dark brown (10YR 3/3) silty clay loam, very dark grayish brown (10YR 3/2) rubbed, grayish brown (10YR 5/2) dry; moderate very fine subangular blocky structure; very friable; few very fine roots; common fine subrounded casts; medium acid (pH 6.0); clear smooth boundary.

Bw—33 to 60 inches; brown (10YR 4/3) silty clay loam, dark brown (10YR 3/3) on faces of peds, dark brown (10YR 3/3) rubbed; moderate very fine subangular blocky structure; very friable; common fine subrounded casts; few faint clay films on faces of peds; neutral (pH 6.6).

The A horizon has value of 2 or 3 and chroma of 1 or 2. It is 20 to 28 inches thick. The B horizon has value and chroma of 3 or 4. Some pedons have a mottled BC horizon.

Lamoni Series

The Lamoni series consists of very deep, somewhat poorly drained, slowly permeable soils on uplands. These soils formed in a thin mantle of loess and the underlying weathered glacial till. Slopes range from 5 to 14 percent.

The Lamoni soils in this county have a dark A horizon that is thinner than is definitive for the series. Also, they have a higher degree of reaction below the A horizon. These differences, however, do not significantly affect the use and management of the soils.

Typical pedon of Lamoni clay loam, 5 to 9 percent slopes, eroded, 1,750 feet west and 275 feet south of the northeast corner of sec. 20, T. 64 N., R. 38 W.

Ap—0 to 8 inches; very dark grayish brown (10YR 3/2) clay loam, dark grayish brown (10YR 4/2) dry; weak fine granular structure; friable; many fine and very fine roots; neutral (pH 7.0); clear smooth boundary.

BA—8 to 12 inches; mixed very dark grayish brown (10YR 3/2) and dark brown (10YR 4/3) clay loam, dark brown (10YR 4/3) rubbed; weak fine granular structure parting to weak medium subangular blocky; firm; common very fine roots; neutral (pH 7.0); clear smooth boundary.

2Bt1—12 to 21 inches; dark yellowish brown (10YR 4/4) clay loam; common fine distinct grayish brown (10YR 5/2) mottles; moderate medium subangular blocky structure; firm; few very fine roots; few faint clay films on faces of peds; neutral (pH 7.0); gradual smooth boundary.

2Bt2—21 to 33 inches; dark yellowish brown (10YR 4/4) clay loam; many medium prominent grayish brown (2.5Y 5/2) mottles; moderate medium subangular blocky structure; firm; few fine roots; many prominent clay films on faces of peds; common medium prominent black stains in pores and root channels; neutral (pH 7.2); gradual smooth boundary.

2Bt3—33 to 41 inches; dark yellowish brown (10YR 4/4) clay loam; common fine prominent grayish brown (2.5Y 5/2) and few fine prominent strong brown (7.5YR 5/6) mottles; moderate medium subangular blocky structure; firm; few very fine roots; many prominent clay films on faces of peds; neutral (pH 7.2); gradual smooth boundary.

2BCg—41 to 54 inches; olive gray (5Y 5/2) clay loam; common fine prominent strong brown (7.5YR 5/6) mottles; massive; firm; few nodules of calcium carbonate at a depth of 51 inches; mildly alkaline (pH 7.8); gradual smooth boundary.

2Cg—54 to 60 inches; mottled gray (5Y 6/1), olive gray (5Y 5/2), and strong brown (7.5YR 5/6) clay loam; massive; firm; common black stains; strong effervescence; mildly alkaline (pH 7.8).

The depth to free carbonates ranges from 42 to 54 inches. The A horizon has chroma of 1 or 2. The Bt horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 2 to 4. It has high- and low-chroma mottles. It is clay loam or clay. The C horizon also is clay loam or clay.

Luton Series

The Luton series consists of very deep, very poorly drained, very slowly permeable soils on high flood plains along the Missouri River. These soils formed in clayey alluvium. Slopes range from 0 to 2 percent.

Typical pedon of Luton silty clay, 700 feet north and 1,600 feet west of the southeast corner of sec. 28, T. 64 N., R. 41 W.

Ap—0 to 3 inches; very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; moderate very fine granular structure; firm; common fine roots; neutral (pH 7.0); clear smooth boundary.

A1—3 to 10 inches; silty clay, very dark grayish brown (2.5Y 3/2) rubbed; very dark gray (N 3/0) on faces of peds; grayish brown (2.5Y 5/2) dry; moderate fine subangular blocky structure parting to moderate medium angular blocky in the lower part; firm; common fine roots; neutral (pH 6.8); clear smooth boundary.

A2—10 to 15 inches; silty clay, black (N 2/0) and 5 percent very dark grayish brown (2.5Y 3/2) rubbed; grayish brown (2.5Y 5/2) dry; moderate fine subangular blocky structure; firm; few fine roots; neutral (pH 7.0); gradual smooth boundary.

Bg1—15 to 20 inches; dark grayish brown (2.5Y 4/2) silty clay; many fine distinct dark yellowish brown (10YR 4/4) mottles; few fine patches of black (N 2/0) in the upper part; moderate very fine subangular blocky structure; firm; few fine roots; neutral (pH 7.2); gradual smooth boundary.

Bg2—20 to 30 inches; finely mixed dark grayish brown (2.5Y 4/2), olive brown (2.5Y 4/4), and dark gray (5Y 4/1) clay; strong very fine subangular blocky structure; firm; few very fine roots; neutral (pH 7.4); clear smooth boundary.

Cg1—30 to 47 inches; finely mixed dark grayish brown (2.5Y 4/2), olive brown (2.5Y 4/4), and dark gray (5Y 4/1) clay; few fine distinct strong brown (7.5YR 5/6) mottles; strong fine and medium subangular blocky structure; firm; few slickensides; slight effervescence; mildly alkaline (pH 7.8); diffuse smooth boundary.

Cg2—47 to 60 inches; dark gray (5Y 4/1) clay; many medium distinct dark grayish brown (2.5Y 4/2) and common fine faint olive (5Y 4/4) mottles; moderate medium subangular blocky structure; firm; few slickensides; slight effervescence; mildly alkaline (pH 7.8).

The depth to carbonates ranges from 24 to 40 inches. The A horizon has hue of 10YR or 2.5Y, value of 2 or 3, and chroma of 0 to 2, or it is neutral in hue and has value of 2 or 3. It is dominantly 10 to 15 inches thick but ranges from 10 to 22 inches. The B horizon has value of 4 or 5 and chroma of 0 to 2. It is dominantly silty clay or clay, but it has thin strata of silt loam or silty clay loam in some pedons. The C horizon has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 or 2. It is dominantly silty clay or clay, but it has thin strata of silt loam or silty clay loam in some pedons.

Malvern Series

The Malvern series consists of very deep, somewhat poorly drained, slowly permeable soils on uplands. These soils formed in a thin mantle of loess and the underlying clayey loess paleosol (fig. 21). Slopes range from 9 to 14 percent.

The Malvern soils in this county have a dark A horizon that is thinner than is definitive for the series. This difference, however, does not significantly affect the use and management of the soils.

Typical pedon of Malvern silty clay loam, in an area of Malvern-Shelby complex, 9 to 14 percent slopes, severely eroded; 75 feet west and 75 feet south of the northeast corner of sec. 1, T. 66 N., R. 41 W.

Ap—0 to 4 inches; about 80 percent dark brown (10YR 3/3) and 20 percent reddish brown (5YR 4/4) silty clay loam, dark yellowish brown (10YR 4/4) and reddish brown (5YR 5/3) dry; weak medium subangular blocky structure parting to weak fine granular; very friable; common very fine roots; neutral (pH 7.1); clear wavy boundary.

2Bt1—4 to 9 inches; about 90 percent reddish brown (5YR 4/4) and 10 percent dark brown (10YR 3/3) silty clay loam; moderate fine subangular blocky structure; friable; common very fine roots; few prominent black stains and few distinct red clay films on faces of peds; neutral (pH 7.3); clear wavy boundary.

2Bt2—9 to 16 inches; reddish brown (5YR 4/4) silty clay; common fine distinct dark reddish gray (5YR 4/2) mottles; moderate medium subangular blocky structure; firm; few very fine roots; few prominent black stains and common distinct red clay films on faces of peds; common distinct yellowish red pressure faces; neutral (pH 7.1); gradual smooth boundary.

2Bt3—16 to 23 inches; reddish brown (5YR 4/4) silty clay; many fine faint reddish brown (5YR 5/3) and common fine prominent brown (7.5YR 5/2) mottles; weak medium prismatic structure parting to moderate fine and medium subangular blocky; firm; common very fine roots; common prominent black stains and many distinct red clay films on faces of peds; common distinct yellowish red pressure faces; neutral (pH 7.1); gradual wavy boundary.

2Btg1—23 to 32 inches; about 70 percent grayish brown (10YR 5/2) and 30 percent reddish brown (5YR 4/4) silty clay loam; weak coarse prismatic structure parting to moderate fine and medium subangular blocky; very firm; few very fine roots; common prominent black stains on faces of peds; many reddish brown clay films on faces of peds, distinct on horizontal faces and prominent on vertical faces; common prominent yellowish brown pressure faces; neutral (pH 7.2); gradual wavy boundary.

2Btg2—32 to 37 inches; grayish brown (10YR 5/2) silty clay loam, brown (7.5YR 5/4) on faces of peds; weak medium prismatic structure parting to weak fine and medium subangular blocky; very firm; few very fine roots; common prominent black stains on faces of peds; common reddish brown clay films on faces of peds, distinct on horizontal faces and prominent on vertical faces; common prominent yellowish red pressure faces; mildly alkaline

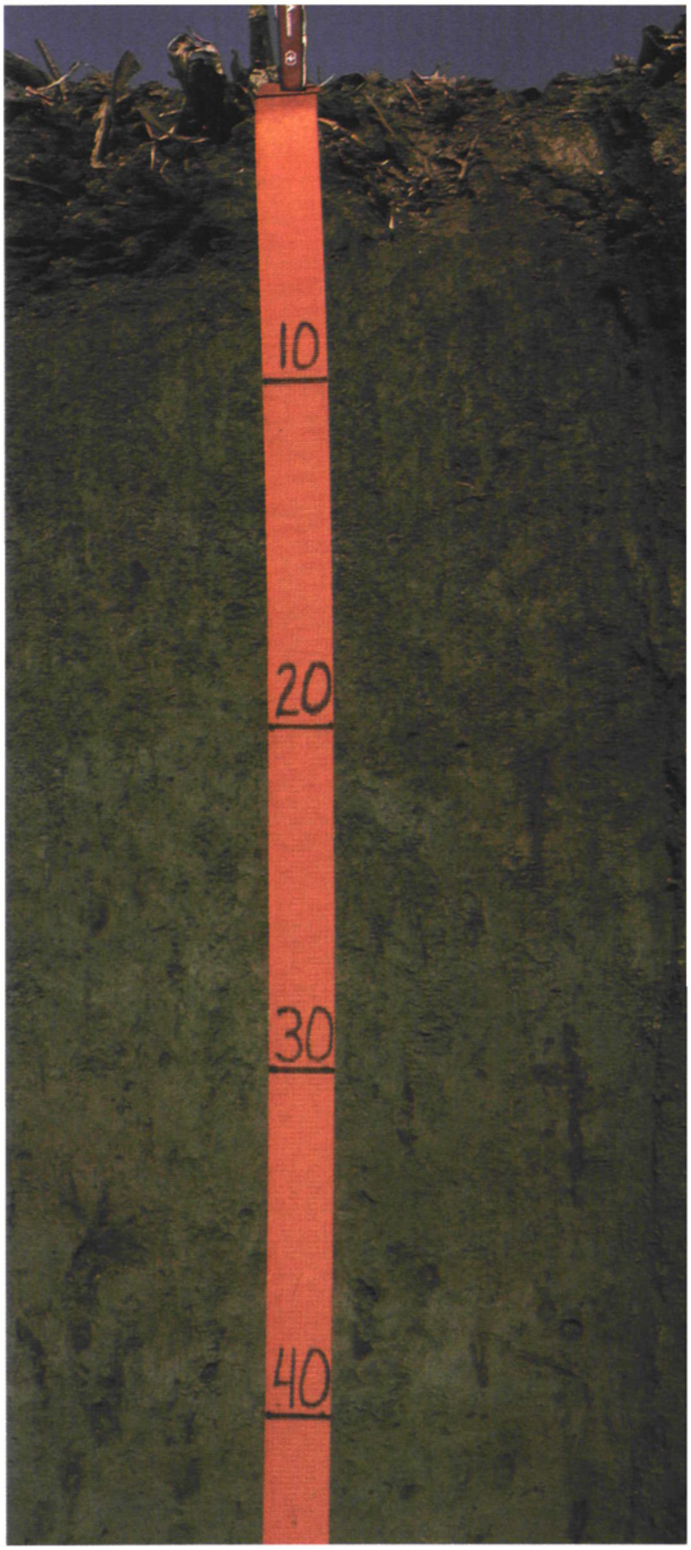

Figure 19.—Typical profile of a Contrary silt loam. The gray colors and mottling pattern are relict features and are not indicative of present drainage conditions. Contrary soils formed in thick loess from which carbonates have been leached to a depth of 60 inches or more. Depth is marked in inches.

Figure 20.—Typical profile of an Ida silt loam. Ida soils typically contain carbonates throughout. They formed in loess on uplands. Depth is marked in inches.

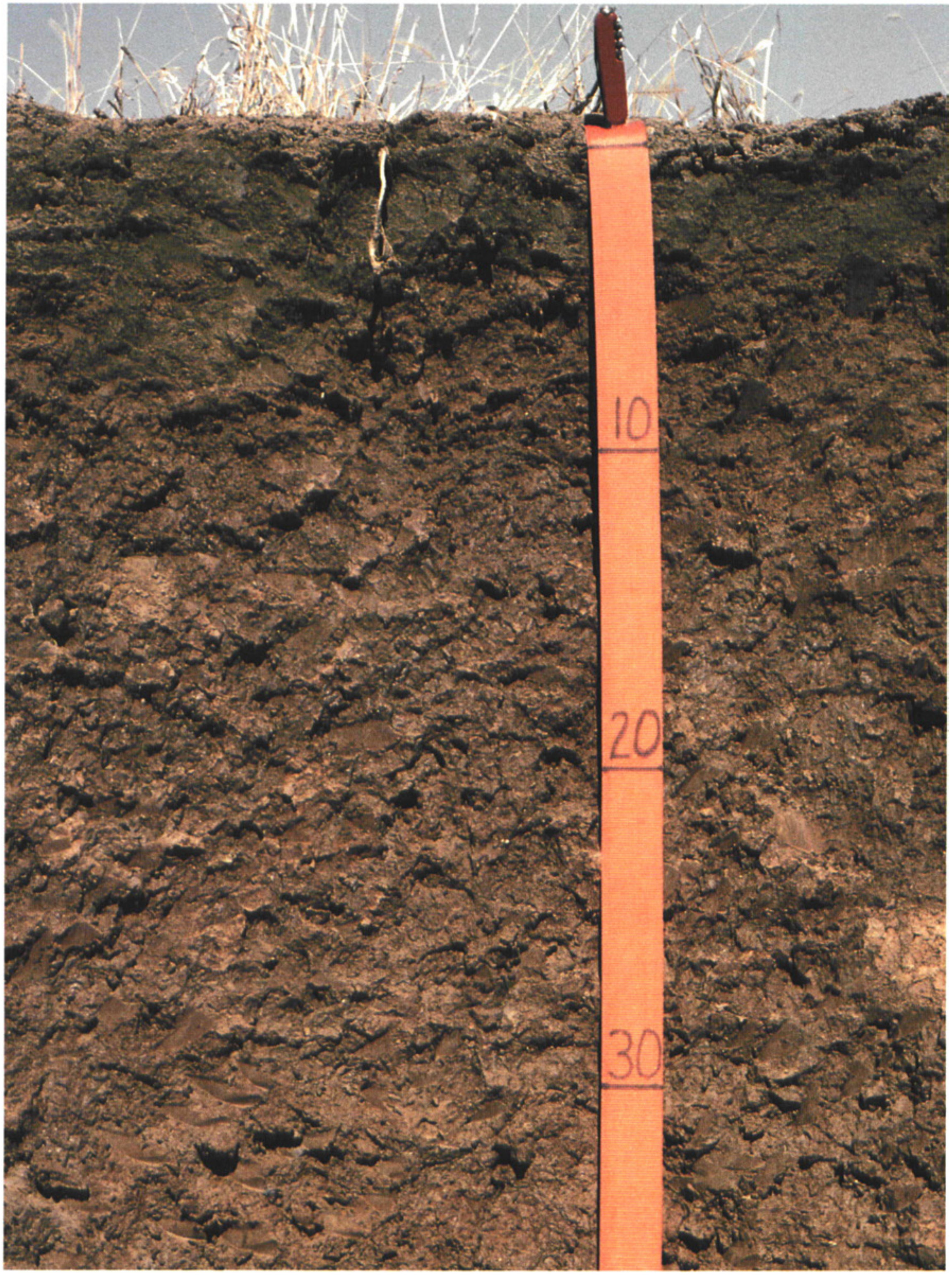

Figure 21.—Typical profile of a Malvern silty clay loam. Malvern soils formed in a thin mantle of loess and an underlying clayey textured paleosol. Depth is marked in inches.

Figure 22.—Typical profile of a Marshall silty clay loam. Marshall soils formed in loess on uplands. Depth is marked in inches.

Figure 23.—Typical profile of a Monona silt loam. Monona soils formed in thick loess on uplands. Depth is marked in inches.

Figure 24.—Typical profile of a Sharpsburg silty clay loam. Sharpsburg soils formed in loess on uplands. Depth is marked in inches.

(pH 7.4); gradual smooth boundary.

2Btg3—37 to 45 inches; grayish brown (10YR 5/2) silty clay loam, yellowish brown (10YR 5/4) on faces of peds; weak medium prismatic structure parting to weak fine and medium subangular blocky; firm; common prominent black stains on faces of peds; common yellowish red clay films on faces of peds, distinct on horizontal faces and prominent on vertical faces; common prominent yellowish brown pressure faces; mildly alkaline (pH 7.8); gradual smooth boundary.

2Btg4—45 to 60 inches; about 60 percent grayish brown (10YR 5/2) and 40 percent yellowish brown (10YR 5/4) silty clay loam; few medium distinct dark yellowish brown (10YR 4/4) mottles; weak medium prismatic structure parting to weak fine and medium subangular blocky; firm; common prominent black stains and common prominent brown clay films on vertical faces of peds; common distinct yellowish brown pressure faces; mildly alkaline (pH 7.7).

The Ap horizon has hue of 10YR or 7.5YR and chroma of 2 or 3. It is 4 to 10 inches thick. The 2B horizon has hue of 10YR, 7.5YR, or 5YR, value of 2 to 6, and chroma of 4 to 6. It is silty clay, clay, or silty clay loam. Some pedons have a 2C horizon, which is silt loam or silty clay loam. This horizon has colors similar to those of the 2B horizon.

Marshall Series

The Marshall series consists of very deep, well drained, moderately permeable soils on uplands (fig. 22). These soils formed in loess. Slopes range from 2 to 14 percent.

Typical pedon of Marshall silt loam, 2 to 5 percent slopes, 350 feet east and 2,320 feet south of the northwest corner of sec. 22, T. 66 N., R. 39 W.

Ap—0 to 8 inches; very dark grayish brown (10YR 3/2) silt loam, brown (10YR 5/3) dry; moderate medium subangular blocky structure; friable; few fine and very fine roots; slightly acid (pH 6.2); clear smooth boundary.

A—8 to 15 inches; very dark grayish brown (10YR 3/2) silty clay loam, very dark brown (10YR 2/2) on faces of peds, very dark grayish brown (10YR 3/2) rubbed, brown (10YR 4/3) dry; moderate fine subangular blocky structure; friable; few fine and very fine roots; neutral (pH 6.6); clear smooth boundary.

AB—15 to 21 inches; mixed very dark grayish brown (10YR 3/2) and dark brown (10YR 4/3) silty clay loam, brown (10YR 4/3) rubbed, yellowish brown (10YR 5/4) dry; moderate very fine subangular blocky structure; friable; neutral (pH 6.8); clear smooth boundary.

Bw1—21 to 28 inches; dark yellowish brown (10YR 4/4) silty clay loam, brown (10YR 4/3) on faces of peds; about 10 percent very dark grayish brown (10YR 3/2) material from the A horizon; moderate very fine subangular blocky structure; friable; few very fine roots; few faint clay films on faces of peds and in pores; neutral (pH 6.8); gradual smooth boundary.

Bw2—28 to 33 inches; dark yellowish brown (10YR 4/4) silty clay loam, dark brown (10YR 4/3) on faces of peds; weak medium prismatic structure parting to moderate very fine subangular blocky; friable; faint clay films on faces of peds and in pores; neutral (pH 7.0); gradual smooth boundary.

Bw3—33 to 53 inches; dark brown (10YR 4/3) silty clay loam; common medium distinct pale red (2.5YR 6/2) and dark brown (7.5YR 4/4) mottles; weak medium prismatic structure parting to weak fine subangular blocky; friable; few very fine roots; few faint clay films on faces of peds and in pores; neutral (pH 7.0); gradual smooth boundary.

BC—53 to 60 inches; yellowish brown (10YR 5/4) silt loam; common fine faint red (2.5YR 6/2) and dark brown (7.5YR 4/4) mottles; weak medium prismatic structure; friable; few fine black manganese stains; neutral (pH 7.2).

The A horizon has value of 2 or 3 and chroma of 1 or 2. The B horizon has value of 3 to 5 and chroma of 3 or 4. The C horizon has hue of 10YR or 2.5Y, value of 5 or 6, and chroma of 2 to 4. It is silty clay loam or silt loam.

Marshall silty clay loam, 5 to 9 percent slopes, eroded, and Marshall silty clay loam, 9 to 14 percent slopes, eroded, have a dark A horizon that is thinner than is definitive for the series. This difference, however, does not significantly affect the use and management of the soils.

McPaul Series

The McPaul series consists of very deep, well drained, moderately permeable soils on flood plains along secondary streams in the Missouri River valley. These soils formed in silty alluvium. Slopes range from 0 to 2 percent.

Typical pedon of McPaul silt loam, 1,650 feet east and 1,300 feet south of the northwest corner of sec. 18, T. 66 N., R. 41 W.

Ap—0 to 7 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (2.5Y 5/2) dry; weak fine granular structure; friable; few fine and very fine roots; slight effervescence; mildly alkaline (pH 7.8); clear smooth boundary.

C—7 to 60 inches; stratified dark grayish brown (10YR 4/2) and brown (10YR 5/3) silt loam; massive; very friable; few fine and very fine roots; iron and manganese stains at depths of 31 and 36 inches; few thin strata of very dark grayish brown (10YR 3/2) silty clay loam; slight effervescence; mildly alkaline (pH 7.8).

The C horizon has value of 4 or 5 and chroma of 2 or 3. It is dominantly silt loam, but in some pedons it has thin strata of silty clay loam in the lower part.

Monona Series

The Monona series consists of very deep, well drained, moderately permeable soils on uplands (fig. 23). These soils formed in loess. Slopes range from 2 to 16 percent.

Typical pedon of Monona silt loam, 2 to 5 percent slopes, 2,000 feet west and 700 feet south of the northeast corner of sec. 17, T. 66 N., R. 41 W.

Ap1—0 to 5 inches; very dark grayish brown (10YR 3/2) silt loam, dark grayish brown (10YR 4/2) dry; weak fine subangular blocky structure parting to weak fine granular; very friable; few very fine and fine roots; medium acid (pH 5.6); abrupt smooth boundary.

Ap2—5 to 12 inches; very dark grayish brown (10YR 3/2) silt loam, dark grayish brown (10YR 4/2) dry; moderate fine subangular blocky structure, weak thin platy in the upper part; very friable; few very fine and fine roots; slightly acid (pH 6.2); clear wavy boundary.

BA—12 to 18 inches; about 60 percent dark brown (10YR 4/3) and 40 percent very dark grayish brown (10YR 3/2) silt loam, dark brown (10YR 3/3) rubbed; moderate fine subangular blocky structure; very friable; few very fine and fine roots; slightly acid (pH 6.4); clear wavy boundary.

Bw1—18 to 25 inches; dark brown (10YR 4/3) silt loam; moderate fine subangular blocky structure; firm; few very fine roots; few faint clay films on vertical faces of peds; common fine rounded casts; neutral (pH 6.8); clear wavy boundary.

Bw2—25 to 36 inches; dark yellowish brown (10YR 4/4) silt loam; moderate fine subangular blocky structure; very friable; few very fine roots; few faint clay films on faces of peds and in pores; few fine rounded casts; neutral (pH 6.7); clear wavy boundary.

Bw3—36 to 48 inches; dark yellowish brown (10YR 4/4) silt loam; common fine distinct light brownish gray (2.5Y 6/2) mottles; weak very fine subangular blocky structure; very friable; few very fine roots; few faint clay films on faces of peds and in pores; very few prominent iron stains; neutral (pH 7.1); clear wavy boundary.

C1—48 to 56 inches; brown (10YR 5/3) silt loam; many fine and medium distinct light brownish gray (2.5Y 6/2) and few fine prominent strong brown (7.5YR 5/6) mottles; weak coarse prismatic structure; very friable; few very fine roots; few prominent iron stains; neutral (pH 7.1); abrupt wavy boundary.

C2—56 to 60 inches; yellowish brown (10YR 5/4) silt loam; many fine and medium distinct light brownish gray (2.5Y 6/2) and common fine distinct strong brown (7.5YR 5/6) mottles; massive; very friable; few prominent iron stains; mildly alkaline (pH 7.4).

The A horizon has value of 2 or 3. It is as much as 18 inches thick. The B horizon has chroma of 3 or 4. The C horizon has value of 4 or 5 and chroma of 4 to 6.

Monona silt loam, 5 to 9 percent slopes, eroded, and Monona silt loam, 9 to 16 percent slopes, eroded, have a dark A horizon that is thinner than is definitive for the series. This difference, however, does not significantly affect the use and management of the soils.

Moville Series

The Moville series consists of very deep, somewhat poorly drained soils on high flood plains along the Missouri River. These soils formed in silty and clayey alluvium. Permeability is moderate in the upper part of the profile and very slow in the lower part. Slopes range from 0 to 2 percent.

Typical pedon of Moville silt loam, 1,200 feet east and 1,600 feet north of the southwest corner of sec. 23, T. 64 N., R. 42 W.

Ap—0 to 8 inches; very dark grayish brown (2.5Y 3/2) silt loam, grayish brown (2.5Y 5/2) dry; few fine distinct dark yellowish brown (10YR 4/4) mottles; weak fine subangular blocky structure; very friable; common fine and very fine roots; slight effervescence; mildly alkaline (pH 7.4); clear smooth boundary.

C1—8 to 15 inches; dark grayish brown (2.5Y 4/2) silt loam; few fine distinct brown (7.5YR 4/4) and gray (10YR 5/1) mottles; massive; very friable; few fine and very fine roots; few thin dark strata; slight effervescence; mildly alkaline (pH 7.6); gradual smooth boundary.

C2—15 to 25 inches; dark grayish brown (2.5Y 4/2) silt loam; common fine distinct brown (7.5YR 4/4) and gray (5Y 5/1) mottles; many fine gray (5Y 5/1) strata; massive; very friable; few fine and very fine roots; slight effervescence; mildly alkaline (pH 7.6); clear smooth boundary.

2Ab—25 to 34 inches; very dark grayish brown (2.5Y 3/2) silty clay; few fine distinct dark brown (7.5YR 4/4) and many fine faint dark grayish brown (2.5Y 4/2) mottles; moderate very fine subangular blocky structure; friable; slight effervescence; mildly alkaline (pH 7.8); clear smooth boundary.

2Cg1—34 to 45 inches; dark gray (5Y 4/1) silty clay; many fine distinct olive brown (2.5Y 4/4) mottles; moderate fine subangular blocky structure; firm; slight effervescence; moderately alkaline (pH 8.0); gradual smooth boundary.

2Cg2—45 to 60 inches; gray (5Y 5/1) silty clay; many medium distinct light olive brown (2.5Y 5/4) and few fine prominent dark brown (7.5YR 4/4) mottles; strong fine subangular blocky structure; firm; few thin strata of silt loam; slight effervescence; moderately alkaline (pH 8.0).

Depth to the 2Ab horizon ranges from 18 to 30 inches. Some pedons have a 2B horizon in the lower part of the profile. This horizon does not have free carbonates.

The A horizon has hue of 10YR or 2.5Y. It is 6 to 10 inches thick. The C horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 2 or 3. The 2Ab horizon has hue of 2.5Y, value of 2 or 3, and chroma of 0 to 2, or it is neutral in hue and has value of 2 or 3. It is 9 to 12 inches thick. It is silty clay or clay. The 2C horizon has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 or 2.

Napier Series

The Napier series consists of very deep, well drained, moderately permeable soils on foot slopes. These soils formed in silty slope alluvium from loess-covered uplands. Slopes range from 2 to 5 percent.

Typical pedon of Napier silt loam, 2 to 5 percent slopes, 2,450 feet east and 2,300 feet south of the northwest corner of sec. 20, T. 66 N., R. 41 W.

Ap—0 to 8 inches; very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; weak fine granular structure; friable; few fine roots; slightly acid (pH 6.1); gradual smooth boundary.

A—8 to 24 inches; very dark grayish brown (10YR 3/2) silt loam, dark grayish brown (10YR 4/2) dry; weak fine granular and weak fine subangular blocky structure; friable; few fine roots; slightly acid (pH 6.4); gradual smooth boundary.

Bw1—24 to 36 inches; dark brown (10YR 3/3) silt loam, grayish brown (10YR 5/2) dry; weak fine subangular blocky and weak fine granular structure; friable; few fine roots; few faint very dark brown organic coatings on faces of peds; neutral (pH 6.6); gradual smooth boundary.

Bw2—36 to 43 inches; dark brown (10YR 4/3) silt loam, brown (10YR 5/3) dry; weak fine subangular blocky structure; friable; few fine roots; few faint very dark grayish brown organic coatings on faces of peds; neutral (pH 6.8); clear smooth boundary.

C—43 to 60 inches; dark brown (10YR 4/3) silt loam, brown (10YR 5/3) dry; massive; friable; few fine roots; neutral (pH 6.8).

The mollic epipedon is 24 to 40 inches thick. The A horizon has value of 2 or 3 and chroma of 1 or 2. The B horizon has chroma of 2 or 3.

Nodaway Series

The Nodaway series consists of very deep, moderately well drained, moderately permeable soils on natural levees on flood plains along secondary streams. These soils formed in silty alluvium. Slopes range from 0 to 2 percent.

Typical pedon of Nodaway silt loam, 1,900 feet east and 300 feet south of the northwest corner of sec. 24, T. 66 N., R. 40 W.

Ap—0 to 9 inches; very dark gray (10YR 3/1) silt loam, dark grayish brown (10YR 4/2) dry; weak fine subangular blocky structure; friable; common fine and very fine roots; neutral (pH 7.3); clear smooth boundary.

C1—9 to 35 inches; stratified very dark gray (10YR 3/1), brown (10YR 5/3), and yellowish brown (10YR 5/4) silt loam; few fine distinct dark brown (7.5YR 4/4) mottles; massive; friable; few very fine roots; few iron stains; slightly acid (pH 6.5); gradual smooth boundary.

C2—35 to 44 inches; stratified very dark gray (10YR 3/1), brown (10YR 5/3), and yellowish brown (10YR 5/4) silt loam; few fine distinct dark brown (7.5YR 4/4) and common fine prominent dark reddish brown (5YR 3/4) mottles; massive; friable; mildly alkaline (pH 7.8); gradual smooth boundary.

2Ab—44 to 60 inches; very dark gray (10YR 3/1) silt loam; weak fine subangular blocky structure; friable; mildly alkaline (pH 7.8).

The A horizon has chroma of 1 or 2. It ranges from 6 to 10 inches in thickness. The C horizon has value of 3 to 5 and chroma of 1 to 4. It is dominantly silt loam, but it has thick strata of silty clay loam in some pedons.

Olmitz Series

The Olmitz series consists of very deep, well drained, moderately permeable soils on foot slopes. These soils formed in loamy local alluvium. Slopes range from 2 to 5 percent.

Typical pedon of Olmitz loam, 2 to 5 percent slopes, 800 feet west and 1,450 north of the southeast corner of sec. 26, T. 65 N., R. 40 W.

Ap—0 to 8 inches; very dark brown (10YR 2/2) loam, dark grayish brown (10YR 4/2) dry; weak fine granular structure; friable; few fine and very fine roots; medium acid (pH 6.0); clear smooth boundary.

A1—8 to 19 inches; very dark brown (10YR 2/2) loam, very dark grayish brown (10YR 3/2) dry; moderate fine granular and weak fine subangular blocky structure; friable; few very fine roots; medium acid (pH 6.0); gradual smooth boundary.

A2—19 to 28 inches; very dark gray (10YR 3/1) loam, very dark grayish brown (10YR 3/2) dry; moderate fine subangular blocky structure; friable; few very fine roots; medium acid (pH 6.0); gradual smooth boundary.

A3—28 to 32 inches; very dark grayish brown (10YR 3/2) clay loam, dark brown (10YR 3/3) dry; moderate medium subangular blocky structure; friable; slightly acid (pH 6.0); gradual smooth boundary.

Bw1—32 to 40 inches; very dark grayish brown (10YR 3/2) clay loam, dark brown (10YR 3/3) dry; weak and moderate fine subangular blocky structure; friable; slightly acid (pH 6.2); gradual smooth boundary.

Bw2—40 to 47 inches; dark grayish brown (10YR 4/2) clay loam; weak fine and medium subangular blocky structure; friable; slightly acid (pH 6.2); gradual smooth boundary.

BC—47 to 60 inches; brown (10YR 4/3) clay loam; weak fine and medium subangular blocky structure; friable; slightly acid (pH 6.2).

The A horizon ranges from 24 to 32 inches in thickness.

Onawa Series

The Onawa series consists of very deep, somewhat poorly drained soils on low flood plains along the Missouri River. These soils formed in calcareous, clayey, silty, and loamy alluvium. Permeability is slow in the upper part of the profile and moderate in the lower part. Slopes range from 0 to 2 percent.

Typical pedon of Onawa silty clay, rarely flooded, 1,400 feet north and 1,700 feet west of the southeast corner of sec. 15, T. 64 N., R. 42 W.

Ap—0 to 9 inches; very dark grayish brown (2.5Y 3/2) silty clay, dark grayish brown (2.5Y 4/2) dry; strong medium subangular blocky structure; firm; common very fine roots; mildly alkaline (pH 7.4); clear smooth boundary.

Cg1—9 to 21 inches; stratified dark grayish brown (2.5Y 4/2) and very dark grayish brown (2.5Y 3/2) silty clay; common fine prominent dark brown (7.5YR 4/4) mottles; moderate fine subangular blocky structure; firm; few very fine roots; violent effervescence; mildly alkaline (pH 7.6); abrupt smooth boundary.

2Cg2—21 to 30 inches; grayish brown (2.5Y 5/2) silt loam; thin strata of silty clay loam; many medium distinct gray (5Y 5/1) and common fine prominent dark brown (7.5YR 4/4) mottles; massive; very friable; violent effervescence; moderately alkaline (pH 8.0); abrupt smooth boundary.

2Cg3—30 to 40 inches; grayish brown (2.5Y 5/2) very fine sandy loam; thin strata of loamy very fine sand; many medium distinct gray (5Y 5/1) and common fine prominent dark brown (7.5YR 4/4) mottles; massive; very friable; violent effervescence; moderately alkaline (pH 8.0); abrupt smooth boundary.

2Cg4—40 to 60 inches; stratified, olive (5Y 5/3) silt loam and very fine sandy loam; few thin dark strata; common fine distinct gray (5Y 5/1) and few fine prominent dark yellowish brown (10YR 4/4) mottles; massive; very friable; violent effervescence; moderately alkaline (pH 8.0).

Depth to the 2Cg horizon generally is 18 to 30 inches but ranges from 15 to 37 inches. Free carbonates are at or near the surface.

The A horizon has hue of 10YR or 2.5Y and chroma of 1 or 2. The Cg horizon has value of 4 or 5. It is silty clay or clay. The 2Cg horizon has value of 4 or 5. It is very fine sandy loam or silt loam.

Paxico Series

The Paxico series consists of very deep, somewhat poorly drained soils on low flood plains along the Missouri River. These soils formed in calcareous, silty and loamy alluvium. Permeability is moderate in the upper part of the profile and moderately rapid in the lower part. Slopes range from 0 to 2 percent.

Typical pedon of Paxico silt loam, 1,000 feet north and 1,800 feet east of the southwest corner of sec. 30, T. 64 N., R. 41 W.

Ap—0 to 8 inches; very dark grayish brown (2.5Y 3/2) silt loam, grayish brown (2.5Y 5/2) dry; few fine distinct dark brown (7.5YR 4/4) mottles; weak very fine subangular blocky structure; very friable; common fine roots; slight effervescence; mildly alkaline (pH 7.4); abrupt smooth boundary.

C—8 to 26 inches; dark grayish brown (2.5Y 4/2) very fine sandy loam; few fine distinct dark brown (7.5YR 4/4) and few medium distinct gray (5Y 5/1) mottles; massive; very friable; few fine roots; strong effervescence; mildly alkaline (pH 7.8); gradual smooth boundary.

Cg1—26 to 40 inches; dark grayish brown (2.5Y 4/2) very fine sandy loam; common fine distinct dark brown (7.5YR 4/4) and common medium distinct gray (5Y 5/1) mottles; massive; very friable; few fine roots; common very thin black strata; strong effervescence; mildly alkaline (pH 7.8); gradual smooth boundary.

2Cg2—40 to 60 inches; dark grayish brown (2.5Y 4/2) loamy fine sand; common medium distinct dark brown (7.5YR 4/4) and few medium distinct gray (5Y 5/1) mottles; massive; very friable; few very thin black strata; strong effervescence; mildly alkaline (pH 7.6).

The depth to carbonates is less than 10 inches. Depth to the 2C horizon is 40 inches or more.

The Ap horizon has hue of 10YR or 2.5Y and value of 3 or 4. In some pedons the A horizon is not calcareous. The C horizon has hue of 10YR or 2.5Y and value of 4 or 5. It is dominantly silt loam or very fine sandy loam, but it has thin strata of silty clay loam or loamy fine sand in some pedons. The 2C horizon is loamy fine sand or fine sand. It has colors similar to those of the C horizon.

Percival Series

The Percival series consists of very deep, somewhat poorly drained soils on low flood plains along the Missouri River. These soils formed in calcareous, clayey and sandy alluvium. Permeability is slow in the upper part of the profile and rapid in the lower part. Slopes range from 0 to 2 percent.

Typical pedon of Percival silty clay, 1,700 feet north and 2,200 feet west of the southeast corner of sec. 36, T. 64 N., R. 42 W.

Ap—0 to 9 inches; very dark grayish brown (2.5Y 3/2) silty clay, grayish brown (2.5Y 5/2) dry; strong fine subangular blocky structure; firm; few fine and very fine roots; slight effervescence; mildly alkaline (pH 7.4); abrupt smooth boundary.

Cg1—9 to 23 inches; stratified, dark grayish brown (2.5Y 4/2) silty clay; few pockets of very dark grayish brown (2.5Y 3/2); few fine prominent dark brown (7.5YR 4/4) mottles; strong very fine subangular blocky structure; firm; few fine and very fine roots; slight effervescence; mildly alkaline (pH 7.6); abrupt smooth boundary.

2Cg2—23 to 60 inches; dark grayish brown (2.5Y 4/2) fine sand; few strata of very fine sandy loam and silt loam; few fine distinct dark yellowish brown (10YR 4/4) and faint grayish brown (2.5Y 5/2) mottles; single grain; loose; strong effervescence; mildly alkaline (pH 7.8).

Depth to the 2Cg horizon ranges from 15 to 30 inches. Free carbonates are at or near the surface.

The A horizon has hue of 10YR or 2.5Y. It ranges from 6 to 9 inches in thickness. The Cg horizon has value of 4 or 5. It is silty clay or clay. The 2C horizon has value of 4 to 6. It is fine sand or loamy fine sand.

Salix Series

The Salix series consists of very deep, moderately well drained, moderately permeable soils on high flood plains along the Missouri and Nishnabotna Rivers. These soils formed in silty alluvium. Slopes range from 0 to 2 percent.

Typical pedon of Salix silty clay loam, 500 feet east and 1,900 feet north of the southwest corner of sec. 12, T. 65 N., R. 42 W.

Ap—0 to 9 inches; very dark grayish brown (10YR 3/2) silty clay loam, dark grayish brown (10YR 4/2) dry; weak fine granular structure; friable; few very fine roots; slightly acid (pH 6.1); clear smooth boundary.

AB—9 to 12 inches; dark brown (10YR 3/3) silty clay loam, pale brown (10YR 6/3) dry; moderate fine subangular blocky structure; friable; few very fine roots; slightly acid (pH 6.4); clear smooth boundary.

Bw—12 to 20 inches; dark grayish brown (10YR 4/2) silty clay loam; few fine prominent dark brown (7.5YR 4/4) mottles; moderate fine subangular blocky structure; friable; few faint clay films on vertical faces of peds; few very fine roots; neutral (pH 6.6); clear smooth boundary.

BC—20 to 24 inches; dark brown (10YR 4/3) silt loam; common fine distinct dark brown (7.5YR 4/4) mottles; massive; friable; strong effervescence; mildly alkaline (pH 7.4); gradual smooth boundary.

C1—24 to 36 inches; dark brown (10YR 4/3) silt loam; common fine distinct dark brown (7.5YR 4/4) and light brownish gray (10YR 6/2) mottles; massive; very friable; few very fine roots; few fine soft masses of calcium carbonate; strong effervescence; mildly alkaline (pH 7.4); gradual smooth boundary.

C2—36 to 52 inches; stratified dark brown (10YR 4/3) and light brownish gray (10YR 6/2) very fine sandy loam; common fine distinct dark brown (7.5YR 4/4) mottles; massive; very friable; few prominent black manganese stains in root channels; few fine soft masses of calcium carbonate; strong effervescence; mildly alkaline (pH 7.4); gradual smooth boundary.

C3—52 to 60 inches; stratified dark brown (10YR 4/3) and light brownish gray (10YR 6/2) very fine sandy loam; common medium distinct dark brown (7.5YR 4/4) mottles; massive; very friable; few prominent black manganese stains in root channels; few fine soft masses of calcium carbonate; strong effervescence; mildly alkaline (pH 7.4).

The depth to free carbonates ranges from 20 to 40 inches. The A horizon has value of 2 or 3. It is 10 to 15 inches thick. The Bw horizon has hue of 10YR or 2.5Y, value of 3 or 4, and chroma of 2 or 3. The C horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 2 or 3. It is dominantly silt loam or very fine sandy loam but has strata of loamy fine sand in some pedons, especially below a depth of 40 inches.

Sarpy Series

The Sarpy series consists of very deep, excessively drained soils on high, convex natural levees on low flood plains along the Missouri River. These soils formed in calcareous, sandy alluvium. Permeability is rapid in the upper part of the profile and moderate in the lower part. Slopes range from 0 to 2 percent.

Typical pedon of Sarpy loamy fine sand, frequently flooded, 1,100 feet west and 1,100 feet north of the southeast corner of sec. 3, T. 7 N., R. 15 E.

A—0 to 8 inches; dark brown (10YR 4/3) loamy fine sand, pale brown (10YR 6/3) dry; massive; very friable; few fine roots; strong effervescence; mildly alkaline (pH 7.5); clear smooth boundary.

C1—8 to 55 inches; grayish brown (2.5Y 5/2) fine sand; many very thin dark grayish brown (2.5Y 4/2) strata; single grain; loose; few fine roots in the upper part; strong effervescence; moderately alkaline (pH 8.2); clear smooth boundary.

C2—55 to 60 inches; dark grayish brown (2.5Y 4/2) loamy fine sand; massive; very friable; strong effervescence; mildly alkaline (pH 8.1).

The A horizon has hue of 10YR or 2.5Y, value of 3 or 4, and chroma of 2 or 3. It ranges from 4 to 9 inches in thickness. Thin layers of loam are common in uncultivated areas. If the soil material in these areas is mixed, however, the texture is loamy fine sand. The C horizon has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 2 to 4. It is typically loamy fine sand or fine sand, but the range includes sand. Some pedons have a 2C horizon below a depth of 50 inches. This horizon is silt loam or silty clay loam.

Sharpsburg Series

The Sharpsburg series consists of very deep, moderately well drained soils on uplands (fig. 24). These soils formed in loess. Permeability is moderately slow. Slopes range from 2 to 9 percent.

Typical pedon of Sharpsburg silty clay loam, 2 to 5 percent slopes, 2,500 feet north and 450 feet east of the southwest corner of sec. 9, T. 65 N., R. 38 W.

Ap—0 to 7 inches; silty clay loam, dark brown (10YR 3/2) rubbed; very dark grayish brown (10YR 3/2) on faces of peds; dark grayish brown (10YR 4/2) dry; moderate medium granular structure; friable; many fine roots; slightly acid (pH 6.1); clear smooth boundary.

AB—7 to 12 inches; very dark grayish brown (10YR 3/2) silty clay loam, dark brown (10YR 3/3) rubbed, dark grayish brown (10YR 4/2) dry; moderate fine subangular blocky structure; friable; few very fine and fine roots; slightly acid (pH 6.2); gradual smooth boundary.

Bt1—12 to 19 inches; dark yellowish brown (10YR 4/4) silty clay loam; moderate medium subangular blocky structure; friable; few very fine roots between peds; many very dark grayish brown (10YR 3/2) organic coatings and few faint dark brown (7.5YR 4/4) clay films on faces of peds; slightly acid (pH 6.3); gradual smooth boundary.

Bt2—19 to 26 inches; yellowish brown (10YR 5/4) silty clay loam; few fine distinct light brownish gray (10YR 6/2) and few fine prominent strong brown (7.5YR 5/6) mottles; weak medium prismatic structure parting to weak medium subangular blocky; friable; few very fine roots; few faint dark brown (7.5YR 4/4) clay films on faces of peds; few fine soft masses of iron and manganese oxides; slightly acid (pH 6.3); gradual smooth boundary.

Bt3—26 to 35 inches; yellowish brown (10YR 5/4) silty clay loam; common fine distinct light brownish gray (10YR 6/2) and common fine prominent strong brown (7.5YR 5/6) mottles; weak medium prismatic structure; friable; few very fine roots; few faint dark brown (7.5YR 4/4) clay films and common distinct yellowish red iron stains on faces of peds; few fine soft masses of iron and manganese oxides; neutral (pH 7.0); gradual smooth boundary.

BC—35 to 51 inches; yellowish brown (10YR 5/4) silty clay loam; common medium distinct light brownish gray (10YR 6/2) and common medium prominent strong brown (7.5YR 5/6) mottles; weak medium prismatic structure; friable; few very fine roots; few distinct coatings of black manganese or iron and manganese oxides on faces of peds; neutral (pH 6.8); gradual smooth boundary.

C—51 to 60 inches; yellowish brown (10YR 5/4) silty clay loam; common medium distinct light brownish gray (10YR 6/2) and common medium prominent strong brown (7.5YR 5/6) mottles; massive; friable; few very fine roots; neutral (pH 6.7).

The Ap horizon has value of 2 or 3. The Bt horizon has hue of 2.5Y or 10YR, value of 4 or 5, and chroma of 2 to 4. It is dominantly silty clay loam, but in some subhorizons the range includes silty clay or silt loam. The C horizon has the same colors as the Bt horizon. It is silt loam or silty clay loam.

Sharpsburg silty clay loam, 5 to 9 percent slopes, eroded, has a dark A horizon that is thinner than is definitive for the series. This difference, however, does not significantly affect the use and management of the soils.

Shelby Series

The Shelby series consists of very deep, well drained soils on uplands. These soils formed in glacial till. Permeability is moderately slow. Slopes range from 5 to 20 percent.

The Shelby soils in this county have a dark A horizon that is thinner than is definitive for the series. This difference, however, does not significantly affect the use and management of the soils.

Typical pedon of Shelby clay loam, 9 to 14 percent slopes, eroded, 100 feet west and 2,000 feet south of the northeast corner of sec. 12, T. 66 N., R. 39 W.

Ap—0 to 7 inches; very dark gray (10YR 3/1) clay loam, dark grayish brown (10YR 4/2) dry; weak fine granular and weak very fine subangular blocky structure; friable; many fine and very fine roots; about 3 percent gravel; neutral (pH 7.3); clear smooth boundary.

BA—7 to 11 inches; dark yellowish brown (10YR 4/4) and very dark brown (10YR 2/2) clay loam, dark brown (10YR 4/3) rubbed; moderate medium subangular blocky structure; friable; common very fine and few fine roots; about 2 percent gravel; neutral (pH 7.2); clear smooth boundary.

Bt1—11 to 17 inches; dark yellowish brown (10YR 4/4) clay loam; few fine mixed areas of very dark brown (10YR 2/2) material; moderate medium subangular blocky structure; friable; few fine and few very fine roots; few faint clay films on faces of peds; about 1 percent gravel; neutral (pH 6.6); gradual smooth boundary.

Bt2—17 to 23 inches; yellowish brown (10YR 5/6) clay loam, dark yellowish brown (10YR 4/4) on faces of peds; weak medium prismatic structure parting to moderate medium subangular blocky; friable; few fine and very fine roots; many faint clay films on faces of peds; few fine black stains; about 1 percent gravel; slightly acid (pH 6.2); gradual smooth boundary.

Bt3—23 to 31 inches; yellowish brown (10YR 5/6) clay loam, dark yellowish brown (10YR 4/4) on faces of peds; few medium distinct light brownish gray (10YR 6/2) mottles; moderate medium prismatic structure; firm; few very fine roots; many prominent clay films on faces of peds; few fine black stains; thin strata of sandy loam at the base of the horizon; about 1 percent gravel; slightly acid (pH 6.2); clear smooth boundary.

Bt4—31 to 45 inches; yellowish brown (10YR 5/6) clay loam; many large distinct light brownish gray (10YR 6/2) mottles; moderate medium prismatic structure; firm; few very fine roots; common distinct clay films on faces of peds; few fine black stains; about 3 percent gravel; neutral (pH 7.0); gradual smooth boundary.

BC—45 to 60 inches; yellowish brown (10YR 5/6) clay loam; many large distinct light brownish gray (10YR 6/2) mottles; weak medium prismatic structure; firm; few faint clay films on vertical faces of peds; few pressure faces on peds; strata of very fine sandy loam at a depth of 55 inches; about 3 percent nodules of calcium carbonate; moderately alkaline (pH 8.0).

The A horizon has chroma of 1 or 2. The Bt horizon has value of 4 or 5 and chroma of 3 to 6.

Timula Series

The Timula series consists of very deep, well drained, moderately permeable soils on highly dissected uplands. These soils formed in calcareous loess. Slopes range from 25 to 60 percent.

Typical pedon of Timula silt loam, 25 to 60 percent slopes, 2,000 feet south and 1,100 feet west of the northeast corner of sec. 35, T. 64 N., R. 41 W.

Oi—0.5 inch to 0; undecomposed and partially decomposed leaf litter, primarily from oak and walnut trees; abrupt smooth boundary.

A1—0 to 3 inches; very dark gray (10YR 3/1) silt loam, dark grayish brown (10YR 4/2) dry; weak very fine granular structure; very friable; many fine roots; mildly alkaline (pH 7.4); clear smooth boundary.

A2—3 to 8 inches; very dark grayish brown (10YR 3/2) silt loam; weak fine subangular blocky structure; very friable; many fine roots; mildly alkaline (pH 7.4); clear smooth boundary.
Bw—8 to 35 inches; dark brown (10YR 4/4) silt loam; weak fine subangular blocky structure; very friable; common very fine roots; mildly alkaline (pH 7.4); clear smooth boundary.
C—35 to 60 inches; yellowish brown (10YR 5/4) silt loam; massive; very friable; few fine and medium nodules of calcium carbonate; strong effervescence; moderately alkaline (pH 8.3).

The depth to free carbonates ranges from 18 to 36 inches. The A horizon has value of 3 or 4 and chroma of 1 to 3. It ranges from 3 to 9 inches in thickness. The B horizon has value of 4 or 5. The C horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 3 or 4.

Zook Series

The Zook series consists of very deep, poorly drained, slowly permeable soils on flood plains along secondary streams. These soils formed in loamy and clayey alluvium. Slopes range from 0 to 2 percent.

Typical pedon of Zook silty clay loam, 1,250 feet east and 2,500 feet north of the southwest corner of sec. 5, T. 66 N., R. 38 W.

Ap—0 to 9 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; weak fine granular structure; friable; common very fine roots; medium acid (pH 6.0); clear smooth boundary.
A1—9 to 16 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; moderate fine subangular blocky structure; friable; common very fine roots; neutral (pH 6.8); gradual smooth boundary.
A2—16 to 24 inches; black (N 2/0) silty clay loam, dark gray (2.5Y 4/0) dry; moderate fine subangular blocky structure; friable; common very fine roots; neutral (pH 7.0); gradual smooth boundary.
A3—24 to 34 inches; very dark gray (10YR 3/1) silty clay, dark gray (2.5Y 4/0) dry; moderate medium subangular blocky structure; friable; common very fine roots; neutral (pH 7.2); gradual smooth boundary.
Bg—34 to 44 inches; very dark gray (10YR 3/1) silty clay; few fine prominent light brownish gray (2.5Y 6/2) mottles; moderate medium subangular blocky structure; firm; few very fine roots; few fine distinct black stains; mildly alkaline (pH 7.4); gradual smooth boundary.
Cg—44 to 60 inches; very dark gray (10YR 3/1) silty clay; common fine prominent light brownish gray (2.5Y 6/2) mottles; massive; firm; few very fine roots; mildly alkaline (pH 7.4).

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 0 to 2, or it is neutral in hue and has value of 2 or 3. It ranges from 26 to 40 inches in thickness. It is silty clay loam or silty clay. The Bg and Cg horizons have hue of 10YR or 2.5Y and value of 2 or 3. They are dominantly silty clay, but the range includes silty clay loam.

Formation of the Soils

Soil is the product of soil-forming processes acting on materials accumulated or deposited by geologic action. The characteristics of the soil at any given point are determined by the physical and mineralogical composition of the parent material; the climate under which the soil has accumulated and existed since accumulation; the plant and animal life on and in the soil; the topography, or lay of the land; and the length of time that the forces of soil formation have acted upon the soil material. Differences between soils can be traced to differences in one or more of these factors.

Climate and plant and animal life are active factors of soil formation. They act upon the parent material and slowly change it into a natural body that has genetically related horizons. The effects of climate and plant and animal life are conditioned by topography. The parent material affects the kind of soil profile that forms and in extreme cases determines it almost entirely. Finally, time is needed to change the parent material into a soil that has distinct horizons. Some time is always required for differentiation of soil horizons. Generally, a long time is required for the formation of distinct horizons.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the others.

Parent Material

Parent material is the unconsolidated mass in which a soil forms. It determines the limits of the chemical and mineralogical composition of the soil. The soils in Atchison County formed in loess, glacial till, or alluvium or in a combination of these parent materials.

Loess is wind-deposited silty material. The loess in Atchison County originated in the Missouri River valley during the ice age. As the glaciers receded, they left behind massive, braided outwash plains covered with silty "glacial flour," which was deposited from the silt-laden glacial meltwaters. Before this young landscape could be stabilized by vegetation, the wind picked up much of the silty material and blew it across the adjacent countryside. Contrary, Hamburg, Higginsville, Ida, Malvern, Marshall, Monona, Sharpsburg, and Timula soils formed in loess.

The thickness of a loess deposit characteristically decreases as the distance from the source of the loess increases. In Atchison County, the thickest deposit of loess is on the bluffs adjacent to the Missouri River valley. The deposit of loess gradually becomes thinner to the east. The loess that the soils in the county formed in is well over 5 feet thick; however, stream dissection has cut into the loess deposit, exposing glacial till on the lower slopes. As the deposit of loess becomes thinner to the east, the amount of glacial till that is exposed increases.

Particle size of the loess also decreases as the distance from the source increases, because wind transports finer particles farther than coarser particles. Therefore, the content of clay in the loess deposit and the corresponding soils increases from west to east in the county. The result is a sequence of Hamburg, Timula, Ida, Monona, Marshall, and Sharpsburg soils from west to east. This sequence is roughly developmental. Hamburg soils are the least developed, and Sharpsburg soils are the most strongly developed. Timula and Ida soils are reversed in the developmental sequence, perhaps because they formed under different vegetation. Apparently the texture of the parent material influences the ease and degree of soil development.

The loess was originally calcareous. It had finely divided particles of calcium carbonate. This carbonate remains in the Hamburg and Ida soils, in the lower part of the Timula soils, and in the Monona soils in some areas.

The loess in Atchison County was not all deposited at the same time. At least two major stages of deposition are recognized in the county. These deposits are Loveland loess and Peoria loess. Loveland loess is the older deposit. It lies below the Peoria loess and is a relatively thin deposit in the county. Malvern soils formed in Loveland loess. Distinct beds, or zones, in the Peoria loess have been recognized in Iowa *(13)*. Similar but not necessarily identical stratigraphic relationships should exist in Atchison County. The Contrary soils formed in Peoria loess in a zone of deoxidized loess that has been exposed on side slopes by stream dissection.

Before the deposition of loess, thick layers of glacial till were deposited over the bedrock in the county. This material is generally yellowish brown and is a heterogeneous mass of sand, silt, clay, and rock fragments that range in size from small pebbles to boulders. The glacial till in Atchison County is pre-Illinoian *(3)*. After the till was deposited, a soil called the Yarmouth surface formed *(13)*. The Yarmouth surface was subsequently buried by loess, but streams have dissected the mantle of loess and exposed the Yarmouth surface in thin bands on side slopes in the eastern part of the county. Lamoni soils formed in the exposed Yarmouth surface. In places further stream dissection removed the Yarmouth surface. This dissection exposed unweathered or slightly weathered Kansan till in downslope areas. Shelby soils formed in this slightly weathered Kansan till and typically are downslope from Lamoni soils.

Alluvium is soil material transported by water. The two types of alluvium in Atchison County are slope alluvium and stream alluvium.

Slope alluvium is transported down a side slope by erosional processes and deposited on gently sloping foot slopes. Judson, Napier, and Olmitz soils formed in slope alluvium. They differ from each other primarily because of the source of the alluvium. Napier soils formed in slope alluvium of silt loam derived from the coarser textured loessial soils, such as Timula, Ida, and Monona soils. Judson soils formed in slope alluvium of silty clay loam derived from the finer textured loessial soils, such as Higginsville, Marshall, and Sharpsburg soils. Olmitz soils formed in loamy slope alluvium derived from the glacial till soils, such as Shelby soils. A thin layer of slope alluvium also may be deposited on side slopes. The strongly sloping Lamoni soils have a thin surface soil that formed in slope alluvium derived from loess.

Stream alluvium is transported by rivers or streams and is deposited on nearly level flood plains. In Atchison County the deposits of stream alluvium are from the Missouri River or from one of the secondary streams that flow into the Missouri River.

Textural sorting is an important characteristic of stream alluvium. During deposition, larger particles fall out of rapidly moving water, finer particles are deposited as the water velocity slows, and clays are deposited in slack-water areas. Generally, during a flood the coarsest particles are deposited near the river and the finer particles are deposited farther from the river. Thus the sandy Sarpy soils are near the Missouri River channel and the clayey Blencoe and Luton soils are farther from the river. Haynie soils are commonly on natural levees adjacent to a channel. Because the Missouri River has meandered across the flood plain in many different channels, its location at the time of deposition is not always clear.

Because a soil profile represents many depositional events and the depositional environment may change over time, most alluvial soils have textural or color stratification within the profile. This stratification is most apparent in medium textured soils, such as Dockery and Haynie soils. Major changes in the course of the river may result in major depositional changes at a given location. Thus the clayey Onawa, Blencoe, and Percival soils, which formed in slack-water deposits, are underlain by medium or coarse textured material that was deposited by moving water. Moville soils, which formed in clayey, slack-water deposits, are overlain by silty sediments deposited by slower moving water.

Alluvium carried by the Missouri River is derived from soils far upstream. It is from the uplands of the many states that are part of the Missouri River watershed. It is calcareous when deposited, and all the soils formed in it are calcareous in some part of the profile. Gilliam, Haynie, Luton, Moville, Onawa, Paxico, Percival, Salix, and Sarpy soils formed in alluvium carried by the Missouri River.

Alluvium carried by secondary streams is derived from the soils in the uplands in Atchison County or the adjacent counties. Except for the soils on the loess bluffs, the soils in the uplands are not calcareous and thus the soils formed in this alluvium are not calcareous. The loess bluffs and McPaul soils, which formed in the calcareous alluvium derived from the loess bluffs, are calcareous. Dockery soils may have strata of alluvium from the Missouri River. This alluvium also is calcareous. The other soils that formed in alluvium carried by secondary streams are the Colo, Nodaway, and Zook soils. Nodaway soils are on natural levees and thus formed in silt loam deposited by slower moving floodwater. Colo soils are heavier silt loam and silty clay loam and formed in material deposited by slowly moving floodwater. Zook soils formed in slack-water deposits of silty clay loam and silty clay.

Climate

The climate in Atchison County is subhumid midcontinental with cold winters and hot summers. Rainfall is adequate to thoroughly moisten and leach the soils, especially in the spring and fall. The soils commonly dry completely in the late summer. This wetting and drying is conducive to the formation of clay films in soils. During the moist months, clay is leached out of the surface soil. It is deposited in the subsoil during the dry months. Higginsville, Lamoni, Malvern, Marshall, Sharpsburg, and Shelby soils all have some clay films in the subsoil. Sharpsburg and Shelby soils formed significant amounts of clay films under the present climate. Lamoni and Malvern soils developed clay films under past climates. Marshall and Higginsville soils have few thin clay films.

Most of the soils in the county are not highly weathered or leached, partly because of the climate. Rainfall has been adequate to leach carbonates completely out of some of the soils and out of the upper part of other soils. Carbonates are not leached at all out of some other soils. Until carbonates are leached from a soil, other soil-forming processes, such as the movement of clay and certain mineralogical transformations, cannot take place. During winter little soil weathering occurs because the soils are cold and frozen. During summer when the high soil temperatures are conducive to chemical weathering processes, relatively little weathering occurs because the soils are generally dry. The net result is that most of the soils in Atchison County are relatively young and unweathered and thus have a high content of bases and primary minerals and are high in natural fertility.

The past climatic conditions have had a profound effect on the soils in an indirect way. During the Pleistocene era, they caused the massive glaciations that deposited both the glacial till and the source material for the loess, which make up much of the parent material in the county.

Plants and Animals

Plants, burrowing animals, insects, bacteria, and fungi are important in the formation of soils. Organic matter is formed as dead vegetation is decomposed in the soil by bacteria and fungi. It binds soil particles into stable aggregates, improves tilth, increases infiltration rates, and slowly releases plant nutrients. Insects and burrowing animals effectively mix vegetation and decomposed organic matter into the soil and increase soil porosity. Plants are important in stabilizing soils against wind erosion and water erosion.

Many of the soils in Atchison County formed mainly under tall prairie grass. These soils have a thick, dark surface layer that has a high content of organic matter because of abundant bacteria and decaying fine grass roots. Higginsville, Lamoni, Malvern, Marshall, Monona, Sharpsburg, and Shelby soils formed on uplands under prairie grasses.

Soils that formed under forest vegetation have a thin, dark surface layer. Most of the organic matter in these soils accumulated from the decomposition of tree leaves. Timula soils and many areas of Hamburg soils formed under forest vegetation.

Human activities have greatly affected the soils in the county. Intensive cultivation has removed the stabilizing prairie grasses and has resulted in extensive erosion on the sloping upland soils. The dark surface layer of nearly all of the cultivated soils on upland slopes is thinner now than it was before cultivation.

Topography

Topography influences soil formation mostly through its effect on drainage, runoff, and erosion and, to some extent, its aspect. Topographic relationships between soils may have important effects on some soils.

Slope has an important effect on soil formation. On the steeper slopes, runoff from rainfall is rapid and a limited amount of water infiltrates the soil. Consequently, there is less leaching and soil development than in less sloping areas. The weak development of the Hamburg and Timula soils may partly be a result of the steep slopes. In areas of the Timula soil, depth to carbonates is generally greater on ridges and foot slopes than on side slopes, probably because leaching is more effective in the less sloping areas.

A higher rate of runoff results in a higher rate of erosion, even under natural, undisturbed conditions. This erosion affects the thickness of the surface layer. In both cultivated and uncultivated areas, soils on nearly level interfluves have a thicker surface layer than that of soils on side slopes. Much of the material carried by the runoff from the side slopes is deposited on the foot slopes. As a result, soils on foot slopes have a very thick surface layer. Examples are Napier, Judson, and Olmitz soils (fig. 25).

Slope aspect can be important in soil formation. Because soils on south- and west-facing slopes receive more direct sunlight, they have a higher rate of evapotranspiration and are more droughty than soils on north- and east-facing slopes. Aspect affects the depth to carbonates in the loess bluffs area in Atchison County. Hamburg soils, which have carbonates at the surface, are commonly on southern exposures. Timula soils, which are partially leached, are commonly on the corresponding north slopes. In areas east of the loess bluffs, the calcareous Ida soils are the dominant soils on the side slopes. Farther east, the noncalcareous Contrary soils are the dominant soils on the side slopes. The fact that the easternmost exposures of Ida soils are on southerly aspects may be significant.

Internal drainage is an important soil characteristic related to topographic position. A seasonal high water table prevents leaching and removal of carbonates and other soluble material. It also alters or inhibits mineralogical development. As oxygen is depleted, iron

Figure 25.—An area of Napier silt loam, 2 to 5 percent slopes, on the foot slopes in the foreground. This soil has a very thick surface layer. An area of Timula-Hamburg silt loams, 30 to 90 percent slopes, is on the bluffs.

compounds are reduced, change color, and become mobile in the soil. As the water table recedes in the summer, the soil is aerated and iron compounds are oxidized. The net effect is a characteristically mottled, gleyed pattern of colors. The mottles commonly are pigmented reddish by oxidized iron.

Soils in low, nearly level topographic positions often have a seasonal high water table. Nearly all of the soils on the flood plains have a seasonal high water table. Within the flood plain, soils on the higher topographic positions have a lower water table than the soils on the lower topographic positions. For example, Haynie and Nodaway soils are on natural levees and have a lower water table than the adjacent Colo and Paxico soils, which are in lower positions.

In the uplands, soils that have a seasonal high water table are commonly in topographic positions that receive surface and subsurface runoff from upslope areas. For example, the somewhat poorly drained Higginsville soils are always downslope from the well drained Marshall soils and are often on concave head slopes. Contrary soils are on side slopes and have the mottled patterns of colors commonly associated with a seasonal high water table. However, they do not have a seasonal high water table. At one time they did, but stream dissection and landscape evolution have effectively drained them.

Time

The degree of profile development reflects the length of time the parent material has been in place and subject to weathering. Young soils show very little profile development or horizon differentiation. Old soils show the effects of the movement of clay and of leaching and have distinct, readily observable horizons.

The youngest soils in Atchison County are those that formed in alluvium. Soils that are subject to flooding, such as the frequently flooded Sarpy, Haynie, and Onawa soils, receive fresh increments of alluvium with every flood.

The flood plain along the Missouri River is made up of a low flood plain and a high flood plain. In geomorphic terms, the low flood plain is the channel belt of the Missouri River and the high flood plain is the meander belt *(12)*. In most places the low and high flood plains are separated by a scarp that is about 10 feet high. Soils on the low flood plain appear to be younger than the soils on the high flood plain, have a thinner surface layer, have not been leached, have carbonates at or near the surface, and exhibit no subsoil development. Examples are Onawa, Paxico, Percival, and Sarpy soils, and Haynie, sandy substratum, soils. Soils on the high flood plain have a slightly thicker surface layer than the soils on the low flood plain, exhibit weak subsoil development, and have been leached of carbonates in the upper part. Examples are Blencoe, Gilliam, Haynie, Luton, and Salix soils.

Peoria loess, which is of Wisconsin age, was deposited roughly 14,000 to 16,000 years ago *(13)*. By geologic standards, it is quite young and the soil development in Peoria loess reflects this. Sharpsburg soils are the most strongly developed of the soils that formed in Peoria loess in Atchison County, but they have relatively weak subsoil development and do not have advanced mineralogical weathering. The very steep Hamburg soils are effectively young and undeveloped in part because of constant geologic erosion.

Malvern soils formed in the Sangamon surface of Loveland loess about 38,000 years ago *(13)*. Soil development was fairly strong at that time, as evidenced by the reddish colors and well developed, clayey subsoil of the Malvern soil. The Sangamon surface, however, was buried by Peoria loess and later exhumed by stream dissection and thus the Malvern soils have not been developing constantly since Sangamon times.

Lamoni soils formed in the Yarmouth surface of the Kansan glacial till, which developed over 150,000 years ago *(13)*. In a manner similar to that of the Malvern soils, Lamoni soils show the strong development of an older soil, but the Yarmouth surface was also covered by loess and thus soil development has not been constant since Yarmouth times. Shelby soils also formed in the old Kansan till, but the Shelby profile formed on recently dissected slopes that are probably only about 11,000 to 14,000 years old.

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Glossary

ABC soil. A soil having an A, a B, and a C horizon.

AC soil. A soil having only an A and a C horizon. Commonly, such soil formed in recent alluvium or on steep, rocky slopes.

Aeration, soil. The exchange of air in soil with air from the atmosphere. The air in a well aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Area reclaim (in tables). An area difficult to reclaim after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Association, soil. A group of soils geographically associated in a characteristic repeating pattern and defined and delineated as a single map unit.

Available water capacity (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 moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as:

Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	9 to 12
Very high	more than 12

Base saturation. The degree to which material having cation-exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, K), expressed as a percentage of the total cation-exchange capacity.

Bedding planes. Fine stratifications, less than 5 millimeters thick, in unconsolidated alluvial, eolian, lacustrine, or marine sediments.

Bedding system. A drainage system made by plowing, grading, or otherwise shaping the surface of a flat field. It consists of a series of low ridges separated by shallow, parallel dead furrows.

Bedrock. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Bottom land. The normal flood plain of a stream, subject to flooding.

Calcareous soil. A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

Capillary water. Water held as a film around soil particles and in tiny spaces between particles. Surface tension is the adhesive force that holds capillary water in the soil.

Catena. A sequence, or "chain," of soils on a landscape that formed in similar kinds of parent material but have different characteristics as a result of differences in relief and drainage.

Cation. An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Cation-exchange capacity. The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity but is more precise in meaning.

Catsteps. Very small, irregular terraces on steep hillsides, especially in pasture, formed by the trampling of cattle or the slippage of saturated soil.

Chiseling. Tillage with an implement having one or more soil-penetrating points that shatter or loosen hard, compacted layers to a depth below normal plow depth.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

Coarse fragments. If round, mineral or rock particles 2 millimeters to 25 centimeters (10 inches) in diameter; if flat, mineral or rock particles (flagstone) 15 to 38 centimeters (6 to 15 inches) long.

Coarse textured soil. Sand or loamy sand.

Colluvium. Soil material, rock fragments, or both moved by creep, slide, or local wash and deposited at the base of steep slopes.

Complex slope. Irregular or variable slope. Planning or establishing terraces, diversions, and other water-control structures on a complex slope is difficult.

Complex, soil. A map unit of two or more kinds of soil in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils are somewhat similar in all areas.

Compressible (in tables). Excessive decrease in volume of soft soil under load.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrated compounds or cemented soil grains. The composition of most concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are common compounds in concretions.

Conservation tillage. A tillage system that does not invert the soil and that leaves a protective amount of crop residue on the surface throughout the year.

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; little affected by moistening.

Contour stripcropping. Growing crops in strips that follow the contour. Strips of grass or close-growing crops are alternated with strips of clean-tilled crops or summer fallow.

Control section. The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is that part of the soil profile between depths of 10 inches and 40 or 80 inches.

Cover crop. A close-growing crop grown primarily to improve and protect the soil between periods of regular crop production, or a crop grown between trees and vines in orchards and vineyards.

Cutbanks cave (in tables). The walls of excavations tend to cave in or slough.

Deferred grazing. Postponing grazing or resting grazing land for a prescribed period.

Depth to bedrock (in tables). Bedrock is too near the surface for the specified use.

Diversion (or diversion terrace). A ridge of earth, generally a terrace, built to protect downslope areas by diverting runoff from its natural course.

Drainage class (natural). Refers to the frequency and duration of periods of saturation or partial saturation during soil formation, 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 classes of natural soil drainage are recognized:

Excessively drained.—Water is removed from the soil very rapidly. Excessively drained soils are commonly very coarse textured, rocky, or shallow. Some are steep. All are free of the mottling related to wetness.

Somewhat excessively drained.—Water is removed from the soil rapidly. Many somewhat excessively drained soils are sandy and rapidly pervious. Some are shallow. Some are so steep that much of the water they receive is lost as runoff. All are free of the mottling related to wetness.

Well drained.—Water is removed from the soil readily, but not rapidly. It is available to plants throughout most of the growing season, and wetness does not inhibit growth of roots for significant periods during most growing seasons. Well drained soils are commonly medium textured. They are mainly free of mottling.

Moderately well drained.—Water is removed from the soil somewhat slowly during some periods. Moderately well drained soils are wet for only a short time during the growing season, but periodically they are wet long enough that most mesophytic crops are affected. They commonly have a slowly pervious layer within or directly below the solum or periodically receive high rainfall, or both.

Somewhat poorly drained.—Water is removed slowly enough that the soil is wet for significant periods during the growing season. Wetness markedly restricts the growth of mesophytic crops unless artificial drainage is provided. Somewhat poorly drained soils commonly have a slowly pervious layer, a high water table, additional water from seepage, nearly continuous rainfall, or a combination of these.

Poorly drained.—Water is removed so slowly that the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the surface for long enough during the growing season that most mesophytic crops cannot be grown unless the soil is artificially drained. The soil is not continuously saturated in layers directly below plow depth. Poor drainage results from a high water table, a slowly pervious layer within the profile, seepage, nearly continuous rainfall, or a combination of these.

Very poorly drained.—Water is removed from the soil so slowly that free water remains at or on the surface during most of the growing season. Unless the soil is artificially drained, most mesophytic crops cannot be grown. Very poorly drained soils are commonly level or depressed and are frequently ponded. Yet, where rainfall is high and nearly continuous, they can have moderate or high slope gradients.

Drainage, surface. Runoff, or surface flow of water, from an area.

Eluviation. The movement of material in true solution or colloidal suspension from one place to another within the soil. Soil horizons that have lost material through eluviation are eluvial; those that have received material are illuvial.

Erosion. The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (geologic). Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of human or animal activities or of a catastrophe in nature, for example, fire, that exposes the surface.

Excess fines (in tables). Excess silt and clay in the soil. The soil is not a source of gravel or sand for construction purposes.

Fallow. Cropland left idle in order to restore productivity through accumulation of moisture. Summer fallow is common in regions of limited rainfall where cereal grains are grown. The soil is tilled for at least one growing season for weed control and decomposition of plant residue.

Fast intake (in tables). The rapid movement of water into the soil.

Fertility, soil. The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Fibric soil material (peat). The least decomposed of all organic soil material. Peat contains a large amount of well preserved fiber that is readily identifiable according to botanical origin. Peat has the lowest bulk density and the highest water content at saturation of all organic soil material.

Field moisture capacity. The moisture content of a soil, expressed as a percentage of the ovendry weight, after the gravitational, or free, water has drained away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity.*

Fine textured soil. Sandy clay, silty clay, or clay.

First bottom. The normal flood plain of a stream, subject to frequent or occasional flooding.

Flood plain. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Foot slope. The inclined surface at the base of a hill.

Frost action (in tables). Freezing and thawing of soil moisture. Frost action can damage roads, buildings and other structures, and plant roots.

Genesis, soil. The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

Glacial till (geology). Unsorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Grassed waterway. A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.

Gravel. Rounded or angular fragments of rock up to 3 inches (2 millimeters to 7.6 centimeters) in diameter. An individual piece is a pebble.

Green manure crop (agronomy). A soil-improving crop grown to be plowed under in an early stage of maturity or soon after maturity.

Ground water (geology). Water filling all the unblocked pores of the material below the water table.

Gully. A miniature valley with steep sides cut by running water and through which water ordinarily runs only after rainfall. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage; a rill is of lesser depth and can be smoothed over by ordinary tillage.

Hemic soil material (mucky peat). Organic soil material intermediate in degree of decomposition between the less decomposed fibric and the more decomposed sapric material.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an uppercase letter represents the major horizons. Numbers or lowercase letters that follow represent subdivisions of the major horizons. The major horizons are as follows:

O horizon.—An organic layer of fresh and decaying plant residue.

A horizon.—The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, any plowed or disturbed surface layer.

E horizon.—The mineral horizon in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these.

B horizon.—The mineral horizon below an O, A, or E horizon. The B horizon is in part a layer of transition from the overlying horizon to the underlying C horizon. The B horizon also has distinctive characteristics, such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) granular, prismatic, or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the overlying horizon. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, an Arabic numeral, commonly a 2, precedes the letter C.

Cr horizon.—Soft, consolidated bedrock beneath the soil.

R layer.—Hard, consolidated bedrock beneath the soil. The bedrock commonly underlies a C horizon but can be directly below an A or a B horizon.

Humus. The well decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups. Refers to soils grouped according to their runoff-producing characteristics. The chief consideration is the inherent capacity of soil bare of vegetation to permit infiltration. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff. Soils are assigned to four groups. In group A are soils having a high infiltration rate when thoroughly wet and having a low runoff potential. They are mainly deep, well drained, and sandy or gravelly. In group D, at the other extreme, are soils having a very slow infiltration rate and thus a high runoff potential. They have a claypan or clay layer at or near the surface, have a permanent high water table, or are shallow over nearly impervious bedrock or other material. A soil is assigned to two hydrologic groups if part of the acreage is artificially drained and part is undrained.

Illuviation. The movement of soil material from one horizon to another in the soil profile. Generally, material is removed from an upper horizon and deposited in a lower horizon.

Infiltration. The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Infiltration capacity. The maximum rate at which water can infiltrate into a soil under a given set of conditions.

Infiltration rate. The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Intake rate. The average rate of water entering the soil under irrigation. Most soils have a fast initial rate; the rate decreases with application time. Therefore, intake rate for design purposes is not a constant but is a variable depending on the net irrigation application. The rate of water intake, in inches per hour, is expressed as follows:

Less than 0.2	very low
0.2 to 0.4	low
0.4 to 0.75	moderately low
0.75 to 1.25	moderate
1.25 to 1.75	moderately high
1.75 to 2.5	high
More than 2.5	very high

Irrigation. Application of water to soils to assist in production of crops. Methods of irrigation are:

Basin.—Water is applied rapidly to nearly level plains surrounded by levees or dikes.

Border.—Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

Controlled flooding.—Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

Corrugation.—Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops or in orchards so that it flows in only one direction.

Drip (or trickle).—Water is applied slowly and under low pressure to the surface of the soil or into the soil through such applicators as emitters, porous tubing, or perforated pipe.

Furrow.—Water is applied in small ditches made by cultivation implements. Furrows are used for tree and row crops.

Sprinkler.—Water is sprayed over the surface through pipes or nozzles from a pressure system.

Subirrigation.—Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.

Wild flooding.—Water, released at high points, is allowed to flow onto an area without controlled distribution.

Leaching. The removal of soluble material from soil or other material by percolating water.

Liquid limit. The moisture content at which the soil passes from a plastic to a liquid state.

Loam. Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Loess. Fine grain material, dominantly of silt-sized particles, deposited by the wind.

Low strength. The soil is not strong enough to support loads.

Medium textured soil. Very fine sandy loam, loam, silt loam, or silt.

Mineral soil. Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

Minimum tillage. Only the tillage essential to crop production and prevention of soil damage.

Miscellaneous area. An area that has little or no natural soil and supports little or no vegetation.

Moderately coarse textured soil. Coarse sandy loam, sandy loam, or fine sandy loam.

Moderately fine textured soil. Clay loam, sandy clay loam, or silty clay loam.

Morphology, soil. The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

Mottling, soil. Irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded 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 of the diameter along the greatest dimension. *Fine* indicates less than 5 millimeters (about 0.2 inch); *medium,* from 5 to 15 millimeters (about 0.2 to 0.6 inch); and *coarse,* more than 15 millimeters (about 0.6 inch).

Munsell notation. A designation of color by degrees of three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with hue of 10YR, value of 6, and chroma of 4.

Neutral soil. A soil having a pH value between 6.6 and 7.3. (See Reaction, soil.)

Nutrient, plant. Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Organic matter. Plant and animal residue in the soil in various stages of decomposition. The organic matter content of a soil, by percentage, in the upper 10 inches of the soil is expressed as:

Very low	less than 0.5
Low	0.5 to 1.0
Moderately low	1.0 to 2.0
Moderate	2.0 to 4.0
High	4.0 to 8.0
Very high	8.0 to 16.0

Parent material. The unconsolidated organic and mineral material in which soil forms.

Ped. An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedon. The smallest volume that can be called "a soil." A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation. The downward movement of water through the soil.

Percs slowly (in tables). The slow movement of water through the soil, adversely affecting the specified use.

Permeability. The quality of the soil that enables water to move downward through the profile. Permeability is measured as the number of inches per hour that water moves downward through the saturated soil. Terms describing permeability are:

Very slow	less than 0.06 inch
Slow	0.06 to 0.2 inch
Moderately slow	0.2 to 0.6 inch
Moderate	0.6 inch to 2.0 inches
Moderately rapid	2.0 to 6.0 inches
Rapid	6.0 to 20 inches
Very rapid	more than 20 inches

Phase, soil. A subdivision of a soil series based on features that affect its use and management. For example, slope, stoniness, and thickness.

pH value. A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Piping (in tables). Formation of subsurface tunnels or pipelike cavities by water moving through the soil.

Plasticity index. The numerical difference between the liquid limit and the plastic limit; the range in moisture content within which the soil remains plastic.

Plastic limit. The moisture content at which a soil changes from semisolid to plastic.

Plowpan. A compacted layer formed in the soil directly below the plowed layer.

Ponding. Standing water on soils in closed depressions. Unless the soils are artificially drained, the water can be removed only by percolation or evapotranspiration.

Poor filter (in tables). Because of rapid permeability, the soil may not adequately filter effluent from a waste disposal system.

Poorly graded. Refers to a coarse grained soil or soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles, density can be increased only slightly by compaction.

Poor outlets (in tables). Refers to areas where surface or subsurface drainage outlets are difficult or expensive to install.

Productivity, soil. The capability of a soil for producing a specified plant or sequence of plants under specific management.

Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.

Reaction, soil. A measure of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degrees of acidity or alkalinity, expressed as pH values, are:

Extremely acid	below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

Relief. The elevations or inequalities of a land surface, considered collectively.

Residuum (residual soil material). Unconsolidated, weathered or partly weathered mineral material that accumulated as consolidated rock disintegrated in place.

Rill. A steep-sided channel resulting from accelerated erosion. A rill is generally a few inches deep and not wide enough to be an obstacle to farm machinery.

Rock fragments. Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

Rooting depth (in tables). Shallow root zone. The soil is shallow over a layer that greatly restricts roots.

Root zone. The part of the soil that can be penetrated by plant roots.

Runoff. The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Sandstone. Sedimentary rock containing dominantly sand-sized particles.

Sapric soil material (muck). The most highly decomposed of all organic soil material. Muck has the least amount of plant fiber, the highest bulk density, and the lowest water content at saturation of all organic soil material.

Sedimentary rock. Rock made up of particles deposited from suspension in water. The chief kinds of sedimentary rock are conglomerate, formed from gravel; sandstone, formed from sand; shale, formed from clay; and limestone, formed from soft masses of calcium carbonate. There are many intermediate types. Some wind-deposited sand is consolidated into sandstone.

Seepage (in tables). The movement of water through the soil. Seepage adversely affects the specified use.

Series, soil. A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer or of the substratum. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Sheet erosion. The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and surface runoff.

Shrink-swell. The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Similar soils. Soils that share limits of diagnostic criteria, behave and perform in a similar manner, and have similar conservation needs or management requirements for the major land uses in the survey area.

Site index. A designation of the quality of a forest site based on the height of the dominant stand at an arbitrarily chosen age. For example, if the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years is 75 feet, the site index is 75 feet.

Slippage (in tables). Soil mass susceptible to movement downslope when loaded, excavated, or wet.

Slope. The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

Slope (in tables). Slope is great enough that special practices are required to ensure satisfactory performance of the soil for a specific use.

Slow intake (in tables). The slow movement of water into the soil.

Slow refill (in tables). The slow filling of ponds, resulting from restricted permeability in the soil.

Soil. A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Soil separates. Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes, in millimeters, of separates recognized in the United States are as follows:

Very coarse sand	2.0 to 1.0
Coarse sand	1.0 to 0.5
Medium sand	0.5 to 0.25
Fine sand	0.25 to 0.10
Very fine sand	0.10 to 0.05
Silt	0.05 to 0.002
Clay	less than 0.002

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A, E, and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the substratum. The living roots and plant and animal activities are largely confined to the solum.

Stripcropping. Growing crops in a systematic arrangement of strips or bands which provide vegetative barriers to wind erosion and water erosion.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates. 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 either *single grain* (each grain by itself, as in dune sand) or *massive* (the particles adhering without any regular cleavage, as in many hardpans).

Stubble mulch. Stubble or other crop residue left on the soil or partly worked into the soil. It protects the soil from wind erosion and water erosion after harvest, during preparation of a seedbed for the next crop, and during the early growing period of the new crop.

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. The part of the soil below the solum.

Subsurface layer. Any surface soil horizon (A, E, AB, or EB) below the surface layer.

Surface layer. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from about 4 to 10 inches (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

Surface soil. The A, E, AB, and EB horizons. It includes all subdivisions of these horizons.

Taxadjuncts. Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use and behavior.

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 water soaks into the soil or flows slowly to a prepared outlet.

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."

Thin layer (in tables). Otherwise suitable soil material that is too thin for the specified use.

Till plain. An extensive area of nearly level to undulating soils underlain by glacial till.

Tilth, soil. The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

Toe slope. The outermost inclined surface at the base of a hill; part of a foot slope.

Topsoil. The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Trace elements. Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, in soils in extremely small amounts. They are essential to plant growth.

Upland (geology). Land at a higher elevation, in general, than the alluvial plain or stream terrace; land above the lowlands along streams.

Weathering. All physical and chemical changes produced in rocks or other deposits at or near the earth's surface by atmospheric agents. These changes result in disintegration and decomposition of the material.

Well graded. Refers to soil material consisting of coarse grain particles that are well distributed over a wide range in size or diameter. Such soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

Wilting point (or permanent wilting point). The moisture content of soil, on an ovendry basis, at which a plant (specifically a sunflower) wilts so much that it does not recover when placed in a humid, dark chamber.

Tables

TABLE 1.--TEMPERATURE AND PRECIPITATION

(Recorded in the period 1951-86 at Tarkio, Missouri)

Month	Temperature						Precipitation				
	Average daily maximum	Average daily minimum	Average daily	2 years in 10 will have-- Maximum temperature higher than--	2 years in 10 will have-- Minimum temperature lower than--	Average number of growing degree days*	Average	2 years in 10 will have-- Less than--	2 years in 10 will have-- More than--	Average number of days with 0.10 inch or more	Average snowfall
	°F	°F	°F	°F	°F	Units	In	In	In		In
January-----	33.5	12.9	23.2	61	-16	0	0.91	0.18	1.47	2	6.9
February----	40.5	19.2	29.9	68	-12	10	1.07	.33	1.68	3	6.2
March-------	50.5	27.9	39.2	82	0	52	2.04	.65	3.16	5	5.7
April-------	65.6	40.9	53.3	89	18	151	3.39	1.94	4.67	7	.8
May---------	76.0	51.9	64.0	93	32	438	4.55	3.01	5.95	8	.0
June--------	84.7	61.0	72.9	99	44	687	5.08	2.67	7.18	8	.0
July--------	89.0	65.2	77.1	103	49	840	3.81	1.34	5.85	6	.0
August------	86.9	62.6	74.8	100	47	769	4.19	1.86	6.18	6	.0
September---	78.8	53.8	66.3	97	33	489	3.92	1.76	5.77	6	.0
October-----	68.5	43.0	55.8	91	21	226	2.63	.78	4.14	5	.0
November----	51.8	29.6	40.7	75	5	17	1.83	.55	2.88	3	1.8
December----	38.3	18.9	28.6	67	-10	11	1.14	.37	1.77	3	6.0
Yearly:											
Average----	63.7	40.6	52.2	---	---	---	---	---	---	---	---
Extreme----	---	---	---	104	-19	---	---	---	---	---	---
Total------	---	---	---	---	---	3,690	34.56	27.34	41.21	62	27.4

* A growing degree day is a unit of heat available for plant growth. It can be calculated by adding the maximum and minimum daily tempertures, dividing the sum by 2, and substracting the temperature below which growth is minimal for the principal crops in the area (50 degrees F).

TABLE 2.--FREEZE DATES IN SPRING AND FALL

(Recorded in the period 1951-86 at Tarkio, Missouri)

Probability	Temperature		
	24 °F or lower	28 °F or lower	32 °F or lower
Last freezing temperature in spring:			
1 year in 10 later than--	Apr. 18	Apr. 26	May 7
2 years in 10 later than--	Apr. 13	Apr. 21	May 2
5 years in 10 later than--	Apr. 2	Apr. 12	Apr. 23
First freezing temperature in fall:			
1 year in 10 earlier than--	Oct. 13	Oct. 3	Sept. 24
2 years in 10 earlier than--	Oct. 21	Oct. 8	Sept. 28
5 years in 10 earlier than--	Nov. 4	Oct. 18	Oct. 8

TABLE 3.--GROWING SEASON

(Recorded in the period 1951-86 at Tarkio, Missouri)

Probability	Daily minimum temperature during growing season		
	Higher than 24 °F	Higher than 28 °F	Higher than 32 °F
	Days	Days	Days
9 years in 10	187	170	148
8 years in 10	196	176	155
5 years in 10	215	188	167
2 years in 10	233	200	179
1 year in 10	242	207	185

TABLE 4.--ACREAGE AND PROPORTIONATE EXTENT OF THE SOILS

Map symbol	Soil name	Acres	Percent
10	Blencoe silty clay loam, clayey substratum	14,600	4.2
11	Colo silt loam	13,306	3.8
12	Colo-Judson silty clay loams, 1 to 5 percent slopes	14,632	4.2
13C2	Contrary silt loam, 5 to 9 percent slopes, eroded	1,784	0.5
13D2	Contrary silt loam, 9 to 14 percent slopes, eroded	17,639	5.1
14	Dockery silt loam	9,912	2.8
15	Gilliam silt loam	2,984	0.9
16	Haynie silt loam	7,823	2.2
17	Haynie silt loam, sandy substratum, rarely flooded	1,478	0.4
18	Haynie silt loam, sandy substratum, frequently flooded	2,318	0.7
19C2	Higginsville silty clay loam, 5 to 9 percent slopes, eroded	9,437	2.7
19D2	Higginsville silty clay loam, 9 to 14 percent slopes, eroded	7,705	2.2
20D2	Ida silt loam, 9 to 14 percent slopes, eroded	8,438	2.4
20E2	Ida silt loam, 14 to 25 percent slopes, eroded	10,755	3.1
21B	Judson silt loam, 2 to 5 percent slopes	4,345	1.2
22C2	Lamoni clay loam, 5 to 9 percent slopes, eroded	3,025	0.9
22D2	Lamoni clay loam, 9 to 14 percent slopes, eroded	2,278	0.7
23	Luton silty clay	11,541	3.3
24D3	Malvern-Shelby complex, 9 to 14 percent slopes, severely eroded	4,220	1.2
25B	Marshall silt loam, 2 to 5 percent slopes	4,998	1.4
25C2	Marshall silty clay loam, 5 to 9 percent slopes, eroded	36,716	10.5
25D2	Marshall silty clay loam, 9 to 14 percent slopes, eroded	26,754	7.7
26	McPaul silt loam	1,867	0.5
27B	Monona silt loam, 2 to 5 percent slopes	892	0.3
27C2	Monona silt loam, 5 to 9 percent slopes, eroded	14,592	4.2
27D2	Monona silt loam, 9 to 16 percent slopes, eroded	14,024	4.0
28	Moville silt loam	2,646	0.8
29B	Napier silt loam, 2 to 5 percent slopes	5,994	1.7
30	Gullied land-Napier complex, 1 to 5 percent slopes	4,873	1.4
31	Nodaway silt loam	3,180	0.9
32B	Olmitz loam, 2 to 5 percent slopes	1,425	0.4
33	Onawa silty clay, rarely flooded	7,524	2.2
34	Onawa silty clay, frequently flooded	1,022	0.3
35	Paxico silt loam	6,632	1.9
36	Percival silty clay	1,897	0.5
37	Salix silty clay loam	2,230	0.6
38	Sarpy loamy fine sand, loamy substratum, rarely flooded	1,199	0.3
39	Sarpy loamy fine sand, frequently flooded	1,983	0.6
40B	Sharpsburg silty clay loam, 2 to 5 percent slopes	3,657	1.0
40C2	Sharpsburg silty clay loam, 5 to 9 percent slopes, eroded	3,162	0.9
41C2	Shelby clay loam, 5 to 9 percent slopes, eroded	3,950	1.1
41D2	Shelby clay loam, 9 to 14 percent slopes, eroded	31,523	9.0
41E2	Shelby clay loam, 14 to 20 percent slopes, eroded	790	0.2
42F	Timula silt loam, 25 to 60 percent slopes	9,107	2.6
43G	Timula-Hamburg silt loams, 30 to 90 percent slopes	1,584	0.5
44	Zook silty clay loam	3,515	1.0
	Water areas less than 40 acres in size	892	0.3
	Water areas more than 40 acres in size	2,432	0.7
	Total	349,280	100.0

TABLE 5.--PRIME FARMLAND

(Only the soils considered prime farmland are listed. Urban or built-up areas of the soils listed are not considered prime farmland. If a soil is prime farmland only under certain conditions, the conditions are specified in parentheses after the soil name)

Map symbol	Soil name
10	Blencoe silty clay loam, clayey substratum
11	Colo silt loam (where drained)
12	Colo-Judson silty clay loams, 1 to 5 percent slopes (where drained)
14	Dockery silt loam
15	Gilliam silt loam
16	Haynie silt loam
17	Haynie silt loam, sandy substratum, rarely flooded
21B	Judson silt loam, 2 to 5 percent slopes
23	Luton silty clay (where drained)
25B	Marshall silt loam, 2 to 5 percent slopes
26	McPaul silt loam
27B	Monona silt loam, 2 to 5 percent slopes
28	Moville silt loam (where drained)
29B	Napier silt loam, 2 to 5 percent slopes
31	Nodaway silt loam
32B	Olmitz loam, 2 to 5 percent slopes
33	Onawa silty clay, rarely flooded
35	Paxico silt loam (where drained)
36	Percival silty clay (where drained)
37	Salix silty clay loam
40B	Sharpsburg silty clay loam, 2 to 5 percent slopes
44	Zook silty clay loam (where drained)

TABLE 6.--LAND CAPABILITY AND YIELDS PER ACRE OF CROPS AND PASTURE

(Yields are those that can be expected under a high level of management. Absence of a yield indicates that the soil is not suited to the crop or the crop generally is not grown on the soil)

Soil name and map symbol	Land capability	Corn	Soybeans	Grain sorghum	Winter wheat	Alfalfa hay	Orchard-grass-alfalfa hay	Smooth bromegrass
		Bu	Bu	Bu	Bu	Tons	Tons	AUM*
10-------------- Blencoe	IIw	137	46	108	55	---	4.5	7.2
11-------------- Colo	IIw	126	42	98	41	---	4.2	6.7
12-------------- Colo-Judson	IIe	128	43	104	52	5.5	4.4	7.0
13C2------------ Contrary	IIIe	110	36	87	44	4.6	3.7	6.0
13D2------------ Contrary	IIIe	98	33	78	40	4.2	3.4	5.5
14-------------- Dockery	IIw	130	44	87	52	---	4.4	7.0
15-------------- Gilliam	IIw	150	50	118	60	6.0	5.0	8.0
16-------------- Haynie	I	130	44	104	52	5.5	4.4	7.0
17-------------- Haynie	I	130	44	104	52	5.5	4.4	7.0
18-------------- Haynie	IIIw	100	35	80	40	---	3.4	5.5
19C2------------ Higginsville	IIIe	128	39	101	51	---	4.3	6.9
19D2------------ Higginsville	IIIe	115	42	91	47	---	3.8	6.1
20D2------------ Ida	IIIe	100	33	78	40	4.0	3.3	5.3
20E2------------ Ida	IVe	90	30	71	36	---	3.0	4.8
21B------------- Judson	IIe	140	46	110	56	5.7	4.6	7.4
22C2------------ Lamoni	IIIe	100	33	78	40	---	3.3	5.3
22D2------------ Lamoni	IVe	88	28	69	34	---	2.8	4.5
23-------------- Luton	IIIw	108	36	85	43	---	3.6	5.8
24D3------------ Malvern-Shelby	IVe	80	28	63	32	---	2.7	4.4

See footnote at end of table.

TABLE 6.--LAND CAPABILITY AND YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Land capability	Corn	Soybeans	Grain sorghum	Winter wheat	Alfalfa hay	Orchard-grass-alfalfa hay	Smooth bromegrass
		Bu	Bu	Bu	Bu	Tons	Tons	AUM*
25B------------- Marshall	IIe	130	43	102	52	5.3	4.3	6.9
25C2------------ Marshall	IIIe	115	40	90	47	4.7	3.8	6.1
25D2------------ Marshall	IIIe	105	35	83	42	4.3	3.5	5.6
26-------------- McPaul	I	120	40	94	48	---	4.0	6.4
27B------------- Monona	IIe	130	43	102	52	5.3	4.3	6.9
27C2------------ Monona	IIIe	115	40	90	47	4.7	3.8	6.1
27D2------------ Monona	IIIe	105	35	83	42	4.3	3.5	5.6
28-------------- Moville	IIw	137	46	108	55	---	4.5	7.2
29B------------- Napier	IIe	130	44	104	52	5.5	4.4	7.0
30-------------- Gullied land-Napier	VIIe	---	---	---	---	---	---	---
31-------------- Nodaway	IIw	122	41	95	49	---	4.1	6.6
32B------------- Olmitz	IIe	128	39	101	51	5.3	4.3	6.9
33-------------- Onawa	IIw	108	36	85	43	---	3.6	5.8
34-------------- Onawa	IIIw	90	30	71	36	---	3.0	4.8
35-------------- Paxico	IIw	137	46	108	55	5.6	4.5	7.2
36-------------- Percival	IIw	105	34	83	42	---	3.5	5.6
37-------------- Salix	I	145	49	116	58	---	4.8	7.7
38-------------- Sarpy	IVs	60	20	47	24	---	2.0	3.2
39-------------- Sarpy	IVw	---	---	---	15	---	---	1.8
40B------------- Sharpsburg	IIe	130	44	104	52	5.5	4.4	7.0

See footnote at end of table.

TABLE 6.--LAND CAPABILITY AND YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Land capability	Corn	Soybeans	Grain sorghum	Winter wheat	Alfalfa hay	Orchard-grass-alfalfa hay	Smooth bromegrass
		Bu	Bu	Bu	Bu	Tons	Tons	AUM*
40C2------------ Sharpsburg	IIIe	115	42	91	47	4.7	7.6	6.1
41C2------------ Shelby	IIIe	113	38	89	45	4.6	3.7	6.0
41D2------------ Shelby	IVe	100	33	78	40	4.3	3.3	5.3
41E2------------ Shelby	VIe	---	---	---	36	---	3.0	4.8
42F------------- Timula	VIIe	---	---	---	---	---	---	3.6
43G------------- Timula-Hamburg	VIIe	---	---	---	---	---	---	3.4
44-------------- Zook	IIw	96	31	75	38	---	3.2	5.2

* Animal unit month: The amount of forage or feed required to feed one animal unit (one cow, one horse, one mule, five sheep, or five goats) for 30 days.

TABLE 7.--WOODLAND MANAGEMENT AND PRODUCTIVITY

(Only the soils suitable for production of commercial trees are listed. Absence of an entry indicates that information was not available)

Soil name and map symbol	Ordination symbol	Management concerns: Erosion hazard	Management concerns: Equipment limitation	Management concerns: Seedling mortality	Management concerns: Windthrow hazard	Potential productivity: Common trees	Potential productivity: Site index	Potential productivity: Volume*	Trees to plant
10 Blencoe	4C	Slight	Severe	Severe	Moderate	Eastern cottonwood	85	91	Eastern cottonwood, green ash, hackberry.
						Green ash	---	---	
						Hackberry	---	---	
14 Dockery	4A	Slight	Slight	Slight	Slight	Pin oak	76	58	Pin oak, pecan, eastern cottonwood.
15 Gilliam	4A	Slight	Slight	Slight	Slight	Pin oak	80	62	Pin oak, eastern cottonwood, pecan.
						Eastern cottonwood	95	116	
16, 17, 18 Haynie	11A	Slight	Slight	Slight	Slight	Eastern cottonwood	110	156	Black walnut, eastern cottonwood, green ash.
						American sycamore	110	---	
						Black walnut	---	---	
						Green ash	---	---	
31 Nodaway	3A	Slight	Slight	Slight	Slight	White oak	65	48	White oak, black walnut, sugar maple.
35 Paxico	11W	Slight	Severe	Moderate	Moderate	Eastern cottonwood	110	156	Black walnut, eastern cottonwood.
						Black walnut	73	---	
						Hackberry	74	---	
						American sycamore	110	---	
38, 39 Sarpy	3S	Slight	Slight	Severe	Slight	Silver maple	90	42	Eastern cottonwood, American sycamore.
						Eastern cottonwood	95	116	
42F Timula	4R	Severe	Severe	Severe	Slight	White oak	70	52	Northern red oak, white oak.
						Northern red oak	---	---	
						Green ash	---	---	
						Bur oak	---	---	
43G**:									
Timula	4R	Severe	Severe	Severe	Slight	White oak	70	52	Northern red oak, white oak.
						Northern red oak	---	---	
						Green ash	---	---	
						Bur oak	---	---	
Hamburg	2R	Severe	Severe	Severe	Slight	White oak	45	30	Black oak, eastern redcedar.
						Bur oak	---	---	
						Eastern redcedar	---	---	
						Post oak	---	---	
						Black oak	---	---	

* Volume is the yield in cubic feet per acre per year calculated at the age of culmination of mean annual increment for fully stocked natural stands.

** See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS

(The symbol < means less than; > means more than. Absence of an entry indicates that trees generally do not grow to the given height on that soil)

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of--				
	<8	8-15	16-25	26-35	>35
10 Blencoe	Redosier dogwood	American plum, common chokecherry.	Eastern redcedar, hackberry.	Honeylocust, silver maple, Austrian pine, green ash, golden willow, northern red oak.	Eastern cottonwood.
11 Colo	Redosier dogwood	American plum, common chokecherry.	Eastern redcedar, hackberry.	Austrian pine, green ash, northern red oak, golden willow, honeylocust, silver maple, eastern cottonwood.	---
12*:					
Colo	Redosier dogwood	American plum, common chokecherry.	Eastern redcedar, hackberry.	Austrian pine, green ash, northern red oak, golden willow, honeylocust, silver maple, eastern cottonwood.	---
Judson	---	Amur honeysuckle, Amur maple, autumn-olive, lilac.	Hackberry, bur oak, green ash, Russian-olive, eastern redcedar.	Honeylocust, Austrian pine, eastern white pine.	---
13C2, 13D2 Contrary	---	Amur honeysuckle, Amur maple, autumn-olive, lilac.	Eastern redcedar, bur oak, hackberry, green ash, Russian-olive.	Austrian pine, eastern white pine, honeylocust.	---
14 Dockery	---	Amur honeysuckle, lilac, autumn-olive, Amur maple.	Eastern redcedar, pin oak.	Austrian pine, eastern white pine, honeylocust, hackberry, green ash.	Eastern cottonwood.
15 Gilliam	Blackhaw	Siberian peashrub	Osage-orange, Washington hawthorn, eastern redcedar, Russian-olive.	Honeylocust, hackberry, bur oak, green ash.	Eastern cottonwood.
16 Haynie	Blackhaw	Siberian peashrub	Washington hawthorn, Russian-olive, Osage-orange, eastern redcedar.	Bur oak, hackberry, green ash, honeylocust.	Eastern cottonwood.

See footnote at end of table.

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of-- <8	8-15	16-25	26-35	>35
17, 18. Haynie	Blackhaw	Siberian peashrub	Russian-olive, Osage-orange, eastern redcedar, Washington hawthorn.	Green ash, hackberry, honeylocust, bur oak.	Eastern cottonwood.
19C2, 19D2. Higginsville	---	Amur honeysuckle, lilac, autumn-olive, Amur maple.	Eastern redcedar	Austrian pine, eastern white pine, honeylocust, hackberry, green ash, pin oak.	Eastern cottonwood.
20D2, 20E2. Ida	Fragrant sumac	Siberian peashrub	Honeylocust, northern catalpa, Osage-orange, Russian-olive, eastern redcedar, green ash, black locust, bur oak.	---	---
21B. Judson	---	Amur honeysuckle, Amur maple, autumn-olive, lilac.	Hackberry, bur oak, green ash, Russian-olive, eastern redcedar.	Honeylocust, Austrian pine, eastern white pine.	---
22C2, 22D2. Lamoni	---	Eastern redcedar, Washington hawthorn, arrowwood, Amur honeysuckle, Amur privet, American cranberrybush.	Austrian pine, green ash, Osage-orange.	Eastern white pine, pin oak.	---
23. Luton	Redosier dogwood	Common chokecherry, American plum.	Hackberry, eastern redcedar.	Silver maple, Austrian pine, golden willow, green ash, honeylocust, northern red oak.	Eastern cottonwood.
24D3*:					
Malvern	Lilac	Amur honeysuckle, Siberian peashrub, Manchurian crabapple, autumn olive.	Austrian pine, eastern redcedar, jack pine, Russian-olive, green ash, hackberry.	Honeylocust	---
Shelby	---	Autumn-olive, lilac, Amur honeysuckle, Amur maple.	Eastern redcedar, Russian-olive, hackberry, bur oak, green ash.	Austrian pine, eastern white pine, honeylocust.	---
25B, 25C2, 25D2. Marshall	---	Autumn-olive, lilac, Amur maple, Amur honeysuckle.	Eastern redcedar, Russian-olive, hackberry, bur oak, green ash.	Austrian pine, eastern white pine, honeylocust.	---

See footnote at end of table.

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of--				
	<8	8-15	16-25	26-35	>35
26. McPaul	Blackhaw	Siberian peashrub	Russian-olive, Osage-orange, Washington hawthorn, eastern redcedar.	Honeylocust, hackberry, green ash, bur oak.	Eastern cottonwood.
27B, 27C2, 27D2. Monona	---	Autumn-olive, lilac, Amur maple, Amur honeysuckle.	Bur oak, hackberry, green ash, Russian-olive, eastern redcedar.	Honeylocust, eastern white pine, Austrian pine.	---
28. Moville	Blackhaw	Siberian peashrub	Washington hawthorn, Russian-olive, Osage-orange, eastern redcedar.	Bur oak, green ash, hackberry, honeylocust.	Eastern cottonwood.
29B. Napier	---	Lilac, Amur honeysuckle, autumn-olive, Amur maple.	Bur oak, eastern redcedar, Russian-olive, hackberry, green ash.	Austrian pine, honeylocust, eastern white pine.	---
30*: Gullied land.					
Napier	---	Lilac, Amur honeysuckle, autumn-olive, Amur maple.	Bur oak, eastern redcedar, Russian-olive, hackberry, green ash.	Austrian pine, honeylocust, eastern white pine.	---
31. Nodaway	---	Amur honeysuckle, autumn-olive, Amur maple, lilac.	Eastern redcedar	Austrian pine, hackberry, honeylocust, green ash, eastern white pine, pin oak.	Eastern cottonwood.
32B. Olmitz	---	Amur maple, lilac, autumn-olive, Amur honeysuckle.	Eastern redcedar, Russian-olive, hackberry, bur oak, green ash.	Austrian pine, eastern white pine, honeylocust.	---
33, 34. Onawa	Blackhaw	Siberian peashrub	Osage-orange, Washington hawthorn, eastern redcedar, Russian-olive.	Hackberry, bur oak, green ash, honeylocust.	Eastern cottonwood.
35. Paxico	Blackhaw	Siberian peashrub	Washington hawthorn, Russian-olive, Osage-orange, eastern redcedar.	Bur oak, hackberry, green ash, honeylocust.	Eastern cottonwood.
36. Percival	Blackhaw	Siberian peashrub	Russian-olive, Osage-orange, Washington hawthorn, eastern redcedar.	Honeylocust, green ash, bur oak, hackberry.	Eastern cottonwood.

See footnote at end of table.

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of-- <8	8-15	16-25	26-35	>35
37 Salix	---	Amur honeysuckle, lilac, Amur maple, autumn-olive.	Eastern redcedar, green ash, bur oak, Russian-olive, hackberry.	Austrian pine, eastern white pine, honeylocust.	---
38 Sarpy	Blackhaw	Washington hawthorn, Siberian peashrub.	Eastern redcedar, Russian-olive, Osage-orange.	Honeylocust, hackberry, green ash, bur oak.	Eastern cottonwood.
39 Sarpy	Blackhaw	Siberian peashrub, Washington hawthorn.	Eastern redcedar, Russian-olive, Osage-orange.	Bur oak, hackberry, green ash, honeylocust.	Eastern cottonwood.
40B, 40C2 Sharpsburg	---	Amur maple, Amur honeysuckle, lilac, autumn-olive.	Green ash, hackberry, bur oak, eastern redcedar, Russian-olive.	Austrian pine, eastern white pine, honeylocust.	---
41C2, 41D2, 41E2 Shelby	---	Autumn-olive, lilac, Amur honeysuckle, Amur maple.	Eastern redcedar, Russian-olive, hackberry, bur oak, green ash.	Austrian pine, eastern white pine, honeylocust.	---
42F Timula	---	Osage-orange, Russian-olive, eastern redcedar, Washington hawthorn.	Honeylocust, northern catalpa, green ash.	---	---
43G*:					
Timula	---	Osage-orange, Russian-olive, eastern redcedar, Washington hawthorn.	Honeylocust, northern catalpa, green ash.	---	---
Hamburg	Fragrant sumac	Siberian peashrub	Eastern redcedar, honeylocust, green ash, Russian-olive, bur oak, Osage-orange, northern catalpa, black locust.	Siberian elm	---
44 Zook	Redosier dogwood	American plum, common chokecherry.	Eastern redcedar, hackberry.	Honeylocust, golden willow, green ash, northern red oak, silver maple, Austrian pine.	Eastern cottonwood.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 9.--RECREATIONAL DEVELOPMENT

(Some terms that describe restrictive soil features are defined in the "Glossary." See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated)

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
10 Blencoe	Severe: flooding, wetness.	Moderate: wetness, percs slowly.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
11 Colo	Severe: flooding, wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness, flooding.
12*:					
Colo	Severe: flooding, wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness, flooding.
Judson	Slight	Slight	Moderate: slope.	Slight	Slight.
13C2 Contrary	Slight	Slight	Severe: slope.	Slight	Slight.
13D2 Contrary	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight	Moderate: slope.
14 Dockery	Severe: flooding.	Moderate: wetness.	Moderate: wetness, flooding.	Slight	Moderate: flooding.
15 Gilliam	Severe: flooding.	Moderate: wetness.	Moderate: wetness.	Moderate: wetness.	Moderate: wetness.
16, 17 Haynie	Severe: flooding.	Slight	Slight	Slight	Slight.
18 Haynie	Severe: flooding.	Moderate: flooding.	Severe: flooding.	Moderate: flooding.	Severe: flooding.
19C2 Higginsville	Moderate: wetness.	Moderate: wetness.	Severe: slope.	Severe: erodes easily.	Moderate: wetness.
19D2 Higginsville	Moderate: slope, wetness.	Moderate: slope, wetness.	Severe: slope.	Severe: erodes easily.	Moderate: wetness, slope.
20D2 Ida	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight	Moderate: slope.
20E2 Ida	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.
21B Judson	Slight	Slight	Moderate: slope.	Slight	Slight.
22C2 Lamoni	Severe: wetness, percs slowly.	Severe: percs slowly.	Severe: slope, wetness, percs slowly.	Severe: erodes easily.	Moderate: wetness.

See footnote at end of table.

TABLE 9.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
22D2 Lamoni	Severe: wetness, percs slowly.	Severe: percs slowly.	Severe: slope, wetness, percs slowly.	Severe: erodes easily.	Moderate: wetness, slope.
23 Luton	Severe: flooding, wetness, percs slowly.	Severe: too clayey, percs slowly.	Severe: too clayey, wetness, percs slowly.	Severe: too clayey.	Severe: too clayey.
24D3*:					
Malvern	Severe: wetness.	Moderate: slope, wetness, percs slowly.	Severe: slope, wetness.	Severe: erodes easily.	Moderate: wetness, slope.
Shelby	Moderate: slope, percs slowly.	Moderate: slope, percs slowly.	Severe: slope.	Severe: erodes easily.	Moderate: slope.
25B Marshall	Slight	Slight	Moderate: slope.	Slight	Slight.
25C2 Marshall	Slight	Slight	Severe: slope.	Slight	Slight.
25D2 Marshall	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight	Moderate: slope.
26 McPaul	Severe: flooding.	Slight	Moderate: flooding.	Slight	Moderate: flooding.
27B Monona	Slight	Slight	Moderate: slope.	Slight	Slight.
27C2 Monona	Slight	Slight	Severe: slope.	Slight	Slight.
27D2 Monona	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight	Moderate: slope.
28 Moville	Severe: flooding, wetness, percs slowly.	Severe: percs slowly.	Severe: wetness, percs slowly.	Moderate: wetness.	Moderate: wetness.
29B Napier	Slight	Slight	Moderate: slope.	Slight	Slight.
30*:					
Gullied land.					
Napier	Slight	Slight	Moderate: slope.	Slight	Slight.
31 Nodaway	Severe: flooding.	Slight	Moderate: flooding.	Slight	Moderate: flooding.
32B Olmitz	Slight	Slight	Moderate: slope.	Slight	Slight.

See footnote at end of table.

TABLE 9.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
33: Onawa	Severe: flooding, too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.
34: Onawa	Severe: flooding, too clayey.	Severe: too clayey.	Severe: too clayey, flooding.	Severe: too clayey.	Severe: flooding, too clayey.
35: Paxico	Severe: flooding.	Moderate: wetness.	Moderate: wetness.	Moderate: wetness.	Moderate: wetness.
36: Percival	Severe: flooding, too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.
37: Salix	Severe: flooding.	Slight	Slight	Slight	Slight.
38: Sarpy	Severe: flooding.	Moderate: too sandy.	Moderate: too sandy.	Moderate: too sandy.	Moderate: droughty.
39: Sarpy	Severe: flooding.	Moderate: flooding.	Severe: flooding.	Moderate: flooding.	Severe: flooding.
40B: Sharpsburg	Moderate: percs slowly.	Moderate: percs slowly.	Moderate: slope, percs slowly.	Slight	Slight.
40C2: Sharpsburg	Moderate: percs slowly.	Moderate: percs slowly.	Severe: slope.	Slight	Slight.
41C2: Shelby	Moderate: percs slowly.	Moderate: percs slowly.	Severe: slope.	Slight	Slight.
41D2: Shelby	Moderate: slope, percs slowly.	Moderate: slope, percs slowly.	Severe: slope.	Slight	Moderate: slope.
41E2: Shelby	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.
42F: Timula	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope, erodes easily.	Severe: slope.
43G*:					
Timula	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope, erodes easily.	Severe: slope.
Hamburg	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope, erodes easily.	Severe: slope.
44: Zook	Severe: flooding, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 10.--WILDLIFE HABITAT

(See text for definitions of "good," "fair," "poor," and "very poor." Absence of an entry indicates that the soil was not rated)

Soil name and map symbol	Potential for habitat elements							Potential as habitat for--		
	Grain and seed crops	Grasses and legumes	Wild herba- ceous plants	Hardwood trees	Conif- erous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
10 Blencoe	Good	Good	Good	Good	Good	Good	Fair	Good	Fair	Fair.
11 Colo	Good	Fair	Good	Fair	Poor	Good	Good	Fair	Fair	Good.
12*:										
Colo	Good	Fair	Good	Fair	Poor	Good	Good	Fair	Fair	Good.
Judson	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
13C2, 13D2 Contrary	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
14 Dockery	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
15 Gilliam	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
16, 17 Haynie	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
18 Haynie	Fair	Fair	Fair	Fair	Fair	Poor	Poor	Fair	Fair	Poor.
19C2 Higginsville	Fair	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
19D2 Higginsville	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
20D2 Ida	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
20E2 Ida	Fair	Good	Good	Fair	Fair	Very poor.	Very poor.	Good	Fair	Very poor.
21B Judson	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
22C2, 22D2 Lamoni	Fair	Good	Fair	Fair	Fair	Poor	Poor	Good	Fair	Poor.
23 Luton	Fair	Fair	Fair	Poor	Very poor.	Good	Good	Fair	Poor	Good.
24D3*:										
Malvern	Fair	Fair	Fair	Fair	Fair	Poor	Poor	Fair	Fair	Poor.
Shelby	Fair	Good	Fair	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
25B Marshall	Good	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.

See footnote at end of table.

TABLE 10.--WILDLIFE HABITAT--Continued

Soil name and map symbol	Potential for habitat elements: Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Wetland plants	Shallow water areas	Potential as habitat for--: Openland wildlife	Woodland wildlife	Wetland wildlife
25C2, 25D2 Marshall	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
26 McPaul	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
27B, 27C2, 27D2 Monona	Good	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
28 Moville	Good	Good	Good	---	---	Good	Good	Good	Good	Good.
29B Napier	Good	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
30*: Gullied land.										
Napier	Good	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
31 Nodaway	Good	Good	Good	Good	Fair	Fair	Poor	Fair	Good	Fair.
32B Olmitz	Good	Good	Fair	Good	Good	Poor	Poor	Good	Good	Poor.
33, 34 Onawa	Fair	Fair	Fair	Poor	Very poor.	Good	Good	Fair	Poor	Good.
35 Paxico	Poor	Fair	Fair	Good	Good	Good	Good	Fair	Good	Fair.
36 Percival	Fair	Fair	Fair	Fair	Poor	Fair	Fair	Fair	Fair	Fair.
37 Salix	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
38, 39 Sarpy	Poor	Poor	Fair	Poor	Poor	Very poor.	Very poor.	Poor	Poor	Very poor.
40B Sharpsburg	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
40C2 Sharpsburg	Fair	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
41C2 Shelby	Fair	Good	Fair	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
41D2 Shelby	Fair	Good	Fair	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
41E2 Shelby	Poor	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
42F Timula	Very poor.	Poor	Good	Good	Good	Very poor.	Very poor.	Very poor.	Good	Very poor.

See footnote at end of table.

TABLE 10.--WILDLIFE HABITAT--Continued

Soil name and map symbol	Potential for habitat elements							Potential as habitat for--		
	Grain and seed crops	Grasses and legumes	Wild herba- ceous plants	Hardwood trees	Conif- erous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
43G*:										
Timula	Very poor.	Poor	Good	Good	Good	Very poor.	Very poor.	Very poor.	Good	Very poor.
Hamburg	Very poor.	Poor	Fair	Fair	Fair	Very poor.	Very poor.	Poor	Fair	Very poor.
44 Zook	Good	Fair	Good	Fair	Poor	Good	Good	Fair	Fair	Good.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 11.--BUILDING SITE DEVELOPMENT

(Some terms that describe restrictive soil features are defined in the "Glossary." See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation)

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
10 Blencoe	Severe: wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: low strength, frost action.	Moderate: wetness.
11 Colo	Severe: wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: low strength, flooding, frost action.	Moderate: wetness, flooding.
12*:						
Colo	Severe: wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: low strength, flooding, frost action.	Moderate: wetness, flooding.
Judson	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength, frost action.	Slight.
13C2 Contrary	Slight	Slight	Slight	Moderate: slope.	Severe: low strength, frost action.	Slight.
13D2 Contrary	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Severe: low strength, frost action.	Moderate: slope.
14 Dockery	Severe: wetness.	Severe: flooding.	Severe: flooding, wetness.	Severe: flooding.	Severe: low strength, flooding, frost action.	Moderate: flooding.
15 Gilliam	Severe: wetness.	Severe: flooding.	Severe: flooding, wetness.	Severe: flooding.	Severe: low strength, frost action.	Moderate: wetness.
16 Haynie	Moderate: wetness.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: low strength, frost action.	Slight.
17 Haynie	Severe: cutbanks cave.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: frost action.	Slight.
18 Haynie	Severe: cutbanks cave.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding, frost action.	Severe: flooding.
19C2 Higginsville	Severe: wetness.	Moderate: wetness, shrink-swell.	Severe: wetness.	Moderate: wetness, shrink-swell, slope.	Severe: low strength, frost action.	Moderate: wetness.

See footnote at end of table.

TABLE 11.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
19D2: Higginsville	Severe: wetness.	Moderate: wetness, shrink-swell, slope.	Severe: wetness.	Severe: slope.	Severe: low strength, frost action.	Moderate: wetness, slope.
20D2: Ida	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Severe: low strength, frost action.	Moderate: slope.
20E2: Ida	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope, frost action.	Severe: slope.
21B: Judson	Slight	Slight	Moderate: shrink-swell.	Slight	Severe: low strength, frost action.	Slight.
22C2: Lamoni	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: shrink-swell, low strength.	Moderate: wetness.
22D2: Lamoni	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell, slope.	Severe: shrink-swell, low strength.	Moderate: wetness, slope.
23: Luton	Severe: wetness.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: shrink-swell, low strength.	Severe: too clayey.
24D3*:						
Malvern	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell, slope.	Severe: shrink-swell, low strength, frost action.	Moderate: wetness, slope.
Shelby	Moderate: slope.	Moderate: shrink-swell, slope.	Moderate: slope, shrink-swell.	Severe: slope.	Severe: low strength.	Moderate: slope.
25B: Marshall	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength, frost action.	Slight.
25C2: Marshall	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: low strength, frost action.	Slight.
25D2: Marshall	Moderate: slope.	Moderate: shrink-swell, slope.	Moderate: slope, shrink-swell.	Severe: slope.	Severe: low strength, frost action.	Moderate: slope.
26: McPaul	Moderate: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: low strength, flooding, frost action.	Moderate: flooding.

See footnote at end of table.

TABLE 11.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
27B-----Monona	Slight	Moderate: shrink-swell.	Slight	Moderate: shrink-swell.	Severe: low strength, frost action.	Slight.
27C2-----Monona	Slight	Moderate: shrink-swell.	Slight	Moderate: shrink-swell, slope.	Severe: low strength, frost action.	Slight.
27D2-----Monona	Moderate: slope.	Moderate: shrink-swell, slope.	Moderate: slope.	Severe: slope.	Severe: low strength, frost action.	Moderate: slope.
28-----Moville	Severe: wetness.	Severe: flooding, wetness.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness.	Severe: low strength, frost action.	Moderate: wetness.
29B-----Napier	Slight	Slight	Slight	Slight	Severe: low strength, frost action.	Slight.
30*: Gullied land.						
Napier	Slight	Slight	Slight	Slight	Severe: low strength, frost action.	Slight.
31-----Nodaway	Moderate: wetness, flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: low strength, flooding, frost action.	Moderate: flooding.
32B-----Olmitz	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength.	Slight.
33-----Onawa	Severe: wetness.	Severe: flooding.	Severe: flooding, wetness.	Severe: flooding.	Severe: low strength, frost action.	Severe: too clayey.
34-----Onawa	Severe: wetness.	Severe: flooding.	Severe: flooding, wetness.	Severe: flooding.	Severe: low strength, flooding, frost action.	Severe: flooding, too clayey.
35-----Paxico	Severe: cutbanks cave, wetness.	Severe: flooding.	Severe: flooding, wetness.	Severe: flooding.	Severe: frost action.	Moderate: wetness.
36-----Percival	Severe: cutbanks cave, wetness.	Severe: flooding.	Severe: flooding, wetness.	Severe: flooding.	Moderate: wetness, flooding, frost action.	Severe: too clayey.
37-----Salix	Moderate: wetness.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: low strength, frost action.	Slight.
38-----Sarpy	Severe: cutbanks cave.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Moderate: flooding.	Moderate: droughty.

See footnote at end of table.

TABLE 11.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
39: Sarpy	Severe: cutbanks cave.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.
40B: Sharpsburg	Moderate: too clayey.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength, frost action.	Slight.
40C2: Sharpsburg	Moderate: too clayey.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: low strength, frost action.	Slight.
41C2: Shelby	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: low strength.	Slight.
41D2: Shelby	Moderate: slope.	Moderate: shrink-swell, slope.	Moderate: slope, shrink-swell.	Severe: slope.	Severe: low strength.	Moderate: slope.
41E2: Shelby	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope.	Severe: slope.
42F: Timula	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope, frost action.	Severe: slope.
43G*:						
Timula	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope, frost action.	Severe: slope.
Hamburg	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope, frost action.	Severe: slope.
44: Zook	Severe: wetness.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: shrink-swell, low strength, wetness.	Severe: wetness.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 12.--SANITARY FACILITIES

(Some terms that describe restrictive soil features are defined in the "Glossary." See text for definitions of "slight," "good," and other terms. Absence of an entry indicates that the soil was not rated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation)

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
10 Blencoe	Severe: wetness, percs slowly.	Moderate: seepage.	Severe: wetness.	Severe: wetness.	Poor: wetness, thin layer.
11 Colo	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Poor: hard to pack, wetness.
12*:					
Colo	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Poor: hard to pack, wetness.
Judson	Moderate: percs slowly.	Moderate: seepage, slope.	Moderate: too clayey.	Slight	Fair: too clayey.
13C2 Contrary	Slight	Severe: slope.	Moderate: too clayey.	Slight	Fair: too clayey.
13D2 Contrary	Moderate: slope.	Severe: slope.	Moderate: slope, too clayey.	Moderate: slope.	Fair: too clayey, slope.
14 Dockery	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Fair: too clayey, wetness.
15 Gilliam	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: too clayey, wetness.
16 Haynie	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: wetness.
17 Haynie	Severe: wetness.	Severe: seepage, wetness.	Severe: seepage, wetness.	Severe: wetness.	Fair: wetness, thin layer.
18 Haynie	Severe: flooding, wetness.	Severe: seepage, flooding, wetness.	Severe: flooding, seepage, wetness.	Severe: flooding, wetness.	Fair: wetness, thin layer.
19C2 Higginsville	Severe: wetness.	Severe: slope, wetness.	Severe: wetness.	Moderate: wetness.	Fair: too clayey, wetness.
19D2 Higginsville	Severe: wetness.	Severe: slope, wetness.	Severe: wetness.	Moderate: wetness, slope.	Fair: too clayey, slope, wetness.

See footnote at end of table.

TABLE 12.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
20D2: Ida	Moderate: percs slowly, slope.	Severe: slope.	Moderate: slope.	Moderate: slope.	Fair: slope.
20E2: Ida	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
21B: Judson	Moderate: percs slowly.	Moderate: seepage, slope.	Moderate: too clayey.	Slight	Fair: too clayey.
22C2, 22D2: Lamoni	Severe: wetness, percs slowly.	Severe: slope.	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack, wetness.
23: Luton	Severe: wetness, percs slowly.	Slight	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack, wetness.
24D3*:					
Malvern	Severe: wetness, percs slowly.	Severe: slope.	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack, wetness.
Shelby	Severe: percs slowly.	Severe: slope.	Moderate: slope, too clayey.	Moderate: slope.	Fair: too clayey, slope.
25B: Marshall	Moderate: percs slowly.	Moderate: seepage, slope.	Moderate: too clayey.	Slight	Fair: too clayey.
25C2: Marshall	Moderate: percs slowly.	Severe: slope.	Moderate: too clayey.	Slight	Fair: too clayey.
25D2: Marshall	Moderate: percs slowly, slope.	Severe: slope.	Moderate: slope, too clayey.	Moderate: slope.	Fair: too clayey, slope.
26: McPaul	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Good.
27B: Monona	Moderate: percs slowly.	Moderate: seepage, slope.	Slight	Slight	Good.
27C2: Monona	Moderate: percs slowly.	Severe: slope.	Slight	Slight	Good.
27D2: Monona	Moderate: percs slowly, slope.	Severe: slope.	Moderate: slope.	Moderate: slope.	Fair: slope.
28: Moville	Severe: wetness, percs slowly.	Moderate: seepage.	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack, wetness.

See footnote at end of table.

TABLE 12.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
29B: Napier	Moderate: percs slowly.	Moderate: seepage, slope.	Slight	Slight	Good.
30*: Gullied land.					
Napier	Moderate: percs slowly.	Moderate: seepage, slope.	Slight	Slight	Good.
31: Nodaway	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Fair: too clayey, wetness.
32B: Olmitz	Moderate: percs slowly.	Moderate: seepage, slope.	Moderate: too clayey.	Slight	Fair: too clayey.
33: Onawa	Severe: wetness.	Severe: seepage, wetness.	Severe: seepage, wetness.	Severe: seepage, wetness.	Fair: wetness.
34: Onawa	Severe: flooding, wetness.	Severe: seepage, flooding, wetness.	Severe: flooding, seepage, wetness.	Severe: flooding, seepage, wetness.	Fair: wetness.
35: Paxico	Severe: wetness.	Severe: seepage, wetness.	Severe: seepage, wetness.	Severe: wetness.	Fair: wetness, thin layer.
36: Percival	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness.	Severe: seepage, wetness.	Poor: seepage, too sandy.
37: Salix	Moderate: flooding, wetness, percs slowly.	Moderate: seepage, wetness.	Severe: wetness.	Moderate: flooding, wetness.	Good.
38: Sarpy	Severe: poor filter.	Severe: seepage.	Severe: too sandy.	Severe: seepage.	Poor: too sandy.
39: Sarpy	Severe: flooding, poor filter.	Severe: seepage, flooding.	Severe: flooding, seepage, too sandy.	Severe: flooding, seepage.	Poor: seepage, too sandy.
40B: Sharpsburg	Severe: percs slowly.	Moderate: seepage, slope.	Moderate: too clayey.	Slight	Fair: too clayey.
40C2: Sharpsburg	Severe: percs slowly.	Severe: slope.	Moderate: too clayey.	Slight	Fair: too clayey.
41C2: Shelby	Severe: percs slowly.	Severe: slope.	Moderate: too clayey.	Slight	Fair: too clayey.

See footnote at end of table.

TABLE 12.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
41D2---------------- Shelby	Severe: percs slowly.	Severe: slope.	Moderate: slope, too clayey.	Moderate: slope.	Fair: too clayey, slope.
41E2---------------- Shelby	Severe: percs slowly, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
42F----------------- Timula	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
43G*:					
Timula-------------	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
Hamburg------------	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
44------------------ Zook	Severe: flooding, wetness, percs slowly.	Severe: flooding.	Severe: flooding, wetness, too clayey.	Severe: flooding, wetness.	Poor: too clayey, hard to pack, wetness.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 13.--CONSTRUCTION MATERIALS

(Some terms that describe restrictive soil features are defined in the "Glossary." See text for definitions of "good," "fair," and other terms. Absence of an entry indicates that the soil was not rated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation)

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
10-------------------- Blencoe	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer.
11-------------------- Colo	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
12*:				
Colo------------------	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
Judson----------------	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
13C2------------------ Contrary	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
13D2------------------ Contrary	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, slope.
14-------------------- Dockery	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
15-------------------- Gilliam	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
16-------------------- Haynie	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
17, 18---------------- Haynie	Good-----------------	Improbable: excess fines.	Improbable: excess fines.	Good.
19C2------------------ Higginsville	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
19D2------------------ Higginsville	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, slope.
20D2------------------ Ida	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: slope.
20E2------------------ Ida	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
21B------------------- Judson	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
22C2, 22D2------------ Lamoni	Poor: shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
23-------------------- Luton	Poor: shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.

See footnote at end of table.

TABLE 13.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
24D3*:				
Malvern	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
Shelby	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones, slope.
25B Marshall	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
25C2 Marshall	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
25D2 Marshall	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, slope.
26 McPaul	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
27B Monona	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
27C2 Monona	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
27D2 Monona	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, slope.
28 Moville	Poor: shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: thin layer.
29B Napier	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
30*: Gullied land.				
Napier	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
31 Nodaway	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
32B Olmitz	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
33, 34 Onawa	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer.
35 Paxico	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
36 Percival	Fair: wetness.	Probable	Improbable: too sandy.	Poor: too clayey.

See footnote at end of table.

TABLE 13.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
37----------------------- Salix	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
38----------------------- Sarpy	Good-----------------	Improbable: excess fines.	Improbable: excess fines.	Poor: too sandy.
39----------------------- Sarpy	Good-----------------	Probable-------------	Improbable: too sandy.	Poor: too sandy.
40B---------------------- Sharpsburg	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
40C2--------------------- Sharpsburg	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
41C2--------------------- Shelby	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones.
41D2--------------------- Shelby	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones, slope.
41E2--------------------- Shelby	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
42F---------------------- Timula	Poor: slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
43G*:				
Timula-------------------	Poor: slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
Hamburg------------------	Poor: slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
44----------------------- Zook	Poor: shrink-swell, low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 14.--WATER MANAGEMENT

(Some terms that describe restrictive soil features are defined in the "Glossary." See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not evaluated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation)

Soil name and map symbol	Limitations for-- Pond reservoir areas	Limitations for-- Embankments, dikes, and levees	Features affecting-- Drainage	Features affecting-- Irrigation	Features affecting-- Terraces and diversions	Features affecting-- Grassed waterways
10---------------- Blencoe	Moderate: seepage.	Severe: piping, wetness.	Percs slowly, frost action.	Wetness, percs slowly.	Erodes easily, wetness.	Wetness, erodes easily, percs slowly.
11---------------- Colo	Moderate: seepage.	Severe: wetness.	Flooding, frost action.	Wetness, flooding.	Wetness--------	Wetness.
12*:						
Colo-------------	Moderate: seepage.	Severe: wetness.	Flooding, frost action.	Wetness, flooding.	Wetness--------	Wetness.
Judson-----------	Moderate: seepage, slope.	Severe: piping.	Deep to water	Slope----------	Erodes easily	Erodes easily.
13C2-------------- Contrary	Moderate: seepage, slope.	Moderate: thin layer, piping.	Deep to water	Slope----------	Erodes easily	Erodes easily.
13D2-------------- Contrary	Severe: slope.	Moderate: thin layer, piping.	Deep to water	Slope----------	Slope, erodes easily.	Slope, erodes easily.
14---------------- Dockery	Moderate: seepage.	Moderate: piping, wetness.	Flooding, frost action.	Wetness, erodes easily.	Erodes easily, wetness.	Erodes easily.
15---------------- Gilliam	Moderate: seepage.	Severe: piping, wetness.	Frost action---	Wetness--------	Wetness--------	Favorable.
16---------------- Haynie	Moderate: seepage.	Severe: piping.	Deep to water	Erodes easily	Erodes easily	Erodes easily.
17---------------- Haynie	Severe: seepage.	Severe: piping.	Deep to water	Erodes easily	Erodes easily	Erodes easily.
18---------------- Haynie	Severe: seepage.	Severe: piping.	Deep to water	Erodes easily, flooding.	Erodes easily	Erodes easily.
19C2-------------- Higginsville	Moderate: seepage, slope.	Moderate: wetness.	Frost action, slope.	Slope, wetness, erodes easily.	Erodes easily, wetness.	Erodes easily.
19D2-------------- Higginsville	Severe: slope.	Moderate: wetness.	Frost action, slope.	Slope, wetness, erodes easily.	Slope, erodes easily, wetness.	Slope, erodes easily.
20D2, 20E2-------- Ida	Severe: slope.	Severe: piping.	Deep to water	Slope----------	Slope, erodes easily.	Slope, erodes easily.
21B--------------- Judson	Moderate: seepage, slope.	Severe: piping.	Deep to water	Slope----------	Erodes easily	Erodes easily.

See footnote at end of table.

TABLE 14.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Features affecting-- Drainage	Irrigation	Terraces and diversions	Grassed waterways
22C2: Lamoni	Moderate: slope.	Moderate: hard to pack, wetness.	Percs slowly, slope.	Slope, wetness, percs slowly.	Erodes easily, wetness.	Wetness, erodes easily.
22D2: Lamoni	Severe: slope.	Moderate: hard to pack, wetness.	Percs slowly, slope.	Slope, wetness, percs slowly.	Slope, erodes easily, wetness.	Wetness, slope, erodes easily.
23: Luton	Slight	Severe: hard to pack, wetness.	Percs slowly	Wetness, slow intake, percs slowly.	Wetness, percs slowly.	Wetness, percs slowly.
24D3*:						
Malvern	Severe: slope.	Severe: hard to pack.	Percs slowly, frost action, slope.	Slope, wetness, percs slowly.	Slope, erodes easily, wetness.	Wetness, slope, erodes easily.
Shelby	Severe: slope.	Slight	Deep to water	Slope, erodes easily.	Slope, erodes easily.	Slope, erodes easily.
25B, 25C2: Marshall	Moderate: seepage, slope.	Slight	Deep to water	Slope	Erodes easily	Erodes easily.
25D2: Marshall	Severe: slope.	Slight	Deep to water	Slope	Slope, erodes easily.	Slope, erodes easily.
26: McPaul	Moderate: seepage.	Severe: piping.	Deep to water	Flooding	Favorable	Favorable.
27B, 27C2: Monona	Moderate: seepage, slope.	Moderate: piping.	Deep to water	Slope	Erodes easily	Erodes easily.
27D2: Monona	Severe: slope.	Moderate: piping.	Deep to water	Slope	Slope, erodes easily.	Slope, erodes easily.
28: Moville	Moderate: seepage.	Severe: hard to pack, wetness.	Percs slowly, frost action.	Wetness, percs slowly, erodes easily.	Erodes easily, wetness, percs slowly.	Wetness, erodes easily, percs slowly.
29B: Napier	Moderate: seepage, slope.	Moderate: piping.	Deep to water	Slope	Erodes easily	Erodes easily.
30*: Gullied land.						
Napier	Moderate: seepage, slope.	Moderate: piping.	Deep to water	Slope	Erodes easily	Erodes easily.
31: Nodaway	Moderate: seepage.	Severe: piping.	Deep to water	Flooding	Erodes easily	Erodes easily.
32B: Olmitz	Moderate: seepage, slope.	Slight	Deep to water	Slope	Favorable	Favorable.

See footnote at end of table.

TABLE 14.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Features affecting-- Drainage	Irrigation	Terraces and diversions	Grassed waterways
33----------------- Onawa	Severe: seepage.	Severe: piping.	Percs slowly, frost action.	Wetness, slow intake, percs slowly.	Erodes easily, wetness.	Erodes easily, percs slowly.
34----------------- Onawa	Severe: seepage.	Severe: piping.	Percs slowly, flooding, frost action.	Wetness, slow intake, percs slowly.	Erodes easily, wetness.	Erodes easily, percs slowly.
35----------------- Paxico	Severe: seepage.	Severe: piping, wetness.	Frost action---	Wetness, erodes easily.	Erodes easily, wetness.	Erodes easily.
36----------------- Percival	Severe: seepage.	Severe: seepage, piping.	Percs slowly, cutbanks cave.	Wetness, droughty, slow intake.	Wetness, too sandy.	Droughty, percs slowly.
37----------------- Salix	Moderate: seepage.	Severe: piping.	Deep to water	Favorable------	Erodes easily	Erodes easily.
38----------------- Sarpy	Severe: seepage.	Severe: piping.	Deep to water	Droughty, fast intake, soil blowing.	Too sandy, soil blowing.	Droughty.
39----------------- Sarpy	Severe: seepage.	Severe: seepage, piping.	Deep to water	Droughty, fast intake.	Too sandy, soil blowing.	Droughty.
40B, 40C2--------- Sharpsburg	Moderate: seepage, slope.	Slight---------	Deep to water	Slope----------	Erodes easily	Erodes easily.
41C2-------------- Shelby	Moderate: slope.	Slight---------	Deep to water	Slope----------	Favorable------	Favorable.
41D2, 41E2-------- Shelby	Severe: slope.	Slight---------	Deep to water	Slope----------	Slope----------	Slope.
42F--------------- Timula	Severe: slope.	Severe: piping.	Deep to water	Slope, erodes easily.	Slope, erodes easily.	Slope, erodes easily.
43G*:						
Timula-----------	Severe: slope.	Severe: piping.	Deep to water	Slope, erodes easily.	Slope, erodes easily.	Slope, erodes easily.
Hamburg----------	Severe: slope.	Severe: piping.	Deep to water	Slope, erodes easily.	Slope, erodes easily.	Slope, erodes easily.
44----------------- Zook	Slight---------	Severe: hard to pack, wetness.	Percs slowly, flooding, frost action.	Wetness, percs slowly.	Erodes easily, wetness, percs slowly.	Wetness, erodes easily, percs slowly.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 15.--ENGINEERING INDEX PROPERTIES

(The symbol < means less than; > means more than. Absence of an entry indicates that data were not estimated)

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments 3-10 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				Pct					Pct	
10--------------- Blencoe	0-8	Silty clay loam	CH	A-7	0	100	100	95-100	95-100	50-70	20-35
	8-35	Silty clay-------	CH	A-7	0	100	100	95-100	95-100	60-85	30-50
	35-52	Silt loam--------	CL, CL-ML	A-4, A-6	0	100	100	95-100	85-100	25-40	5-15
	52-60	Silty clay-------	CH	A-7	0	100	100	95-100	95-100	60-85	30-50
11--------------- Colo	0-8	Silt loam--------	CL, CL-ML	A-4, A-6	0	100	100	95-100	95-100	25-40	5-15
	8-60	Silty clay loam	CL, CH	A-7	0	100	100	90-100	90-100	40-55	20-30
12*:											
Colo------------	0-10	Silty clay loam	CL, CH	A-7	0	100	100	90-100	90-100	40-60	15-30
	10-60	Silty clay loam	CL, CH	A-7	0	100	100	90-100	90-100	40-55	20-30
Judson----------	0-25	Silty clay loam	CL, ML	A-6, A-7	0	100	100	100	95-100	35-50	10-25
	25-60	Silty clay loam	CL	A-6, A-7	0	100	100	100	95-100	30-50	15-25
13C2, 13D2------- Contrary	0-7	Silt loam--------	CL	A-6	0	100	100	90-100	85-90	30-40	10-15
	7-35	Silt loam, silty clay loam.	CL	A-6, A-7	0	100	100	90-100	85-95	30-45	10-20
	35-60	Silt loam--------	CL, ML	A-6, A-4	0	100	100	90-100	85-90	30-40	5-15
14--------------- Dockery	0-8	Silt loam--------	CL-ML, CL	A-4, A-6	0	100	100	90-100	85-100	25-35	5-15
	8-60	Silt loam, silty clay loam.	CL	A-4, A-6	0	100	100	90-100	85-95	25-40	8-20
15--------------- Gilliam	0-10	Silt loam--------	CL	A-6, A-4	0	100	100	95-100	85-100	25-40	8-20
	10-20	Silt loam, silty clay loam, loam.	CL	A-6, A-4	0	100	100	90-100	80-95	25-40	8-20
	20-60	Stratified silty clay loam to loam.	CL-ML, CL	A-4, A-6	0	100	100	90-100	80-95	20-40	5-20
16--------------- Haynie	0-12	Silt loam--------	CL-ML, CL	A-4, A-6	0	100	100	85-100	70-100	25-40	5-15
	12-60	Silt loam, very fine sandy loam.	CL-ML, CL	A-4, A-6	0	100	100	85-100	85-100	25-35	5-15
17, 18----------- Haynie	0-6	Silt loam--------	CL-ML, CL	A-4, A-6	0	100	100	90-100	70-100	25-40	5-15
	6-52	Silt loam, very fine sandy loam.	CL-ML, CL	A-4, A-6	0	100	100	85-100	70-100	25-35	5-15
	52-60	Fine sand, loamy fine sand.	SM	A-2	0	100	100	65-80	20-35	---	NP
19C2, 19D2------- Higginsville	0-9	Silty clay loam	CL	A-6, A-7	0	100	100	95-100	95-100	35-45	15-20
	9-44	Silty clay loam	CL	A-7	0	100	100	95-100	90-100	40-50	15-25
	44-60	Silty clay loam, silt loam.	CL, ML	A-6, A-7	0	100	100	95-100	90-100	35-45	10-20
20D2, 20E2------- Ida	0-4	Silt loam--------	ML, CL	A-4, A-6	0	100	100	95-100	95-100	30-40	5-15
	4-60	Silt loam--------	ML, CL	A-4, A-6	0	100	100	95-100	95-100	30-40	5-15
21B-------------- Judson	0-28	Silt loam--------	CL, CL-ML	A-4, A-6	0	100	100	100	95-100	25-35	5-15
	28-60	Silty clay loam	CL	A-6, A-7	0	100	100	100	95-100	30-50	15-25
22C2, 22D2------- Lamoni	0-8	Clay loam--------	CL	A-6, A-7	0	95-100	95-100	80-95	70-95	35-45	15-25
	8-54	Clay loam, clay	CH	A-7	0	95-100	95-100	90-100	85-100	50-60	25-35
	54-60	Clay loam--------	CL	A-6, A-7	0	95-100	95-100	70-90	55-85	35-50	15-30
23--------------- Luton	0-10	Silty clay-------	CH	A-7	0	100	100	95-100	95-100	60-85	35-60
	10-60	Silty clay, clay	CH	A-7	0	100	100	95-100	95-100	60-85	35-60

See footnote at end of table.

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments 3-10 inches	Percentage passing sieve number-- 4	10	40	200	Liquid limit	Plasticity index
	In				Pct					Pct	
24D3*:											
Malvern----------	0-4	Silty clay loam	CL	A-7	0	100	100	100	95-100	40-50	20-30
	4-23	Silty clay-------	CH	A-7	0	100	100	100	95-100	55-80	30-45
	23-60	Silty clay loam	CL	A-7	0	100	100	100	95-100	40-50	20-30
Shelby-----------	0-6	Clay loam--------	CL	A-6, A-7	0	90-95	85-95	75-90	55-70	35-45	15-25
	6-60	Clay loam--------	CL	A-6, A-7	0-5	90-95	85-95	75-90	55-70	30-45	15-25
25B-------------- Marshall	0-8	Silt loam--------	CL, CL-ML	A-4, A-6	0	100	100	100	95-100	25-40	5-15
	8-53	Silty clay loam	CL	A-7, A-6	0	100	100	100	95-100	35-50	15-25
	53-60	Silt loam, silty clay loam.	CL	A-7, A-6	0	100	100	100	95-100	35-50	15-25
25C2, 25D2------- Marshall	0-8	Silty clay loam	CL	A-6, A-7	0	100	100	100	95-100	35-50	15-25
	8-50	Silty clay loam	CL	A-6, A-7	0	100	100	100	95-100	35-50	15-25
	50-60	Silty clay loam	CL	A-7, A-6	0	100	100	100	95-100	35-50	15-25
26--------------- McPaul	0-60	Silt loam--------	CL, CL-ML	A-4, A-6	0	100	100	95-100	90-100	25-40	5-15
27B, 27C2, 27D2-- Monona	0-18	Silt loam--------	ML, CL	A-6, A-7	0	100	100	95-100	95-100	35-50	10-25
	18-48	Silt loam, silty clay loam.	ML, CL	A-6, A-7	0	100	100	95-100	95-100	35-50	10-25
	48-60	Silt loam--------	CL	A-6	0	100	100	95-100	95-100	30-40	10-20
28--------------- Moville	0-25	Silt loam--------	CL	A-4, A-6	0	100	100	95-100	90-100	30-40	8-18
	25-60	Silty clay, clay	CH	A-7	0	100	100	95-100	95-100	65-85	40-60
29B-------------- Napier	0-24	Silt loam--------	CL	A-4, A-6	0	100	100	95-100	95-100	25-40	8-20
	24-60	Silt loam--------	CL	A-4, A-6	0	100	100	95-100	95-100	25-40	8-20
30*:											
Gullied land.											
Napier-----------	0-24	Silt loam--------	CL	A-4, A-6	0	100	100	95-100	95-100	25-40	8-20
	24-60	Silt loam--------	CL	A-4, A-6	0	100	100	95-100	95-100	25-40	8-20
31--------------- Nodaway	0-9	Silt loam--------	CL, CL-ML	A-4, A-6	0	100	95-100	95-100	90-100	25-35	5-15
	9-60	Silt loam, silty clay loam.	CL, CL-ML	A-4, A-6	0	100	95-100	95-100	90-100	25-40	5-15
32B-------------- Olmitz	0-19	Loam-------------	CL	A-6	0	100	90-100	85-95	60-80	30-40	11-20
	19-32	Loam, clay loam	CL	A-6	0	100	90-100	85-95	60-80	30-40	11-20
	32-60	Clay loam--------	CL	A-6, A-7	0	100	90-100	85-95	60-80	35-45	15-25
33--------------- Onawa	0-9	Silty clay-------	CH	A-7	0	100	100	95-100	95-100	60-85	40-60
	9-21	Silty clay, clay	CH	A-7	0	100	100	95-100	95-100	60-85	40-60
	21-60	Silt loam, very fine sandy loam, loam.	CL, CL-ML	A-4, A-6	0	100	100	95-100	85-100	25-40	5-20
34--------------- Onawa	0-4	Silty clay-------	CH	A-7	0	100	100	95-100	95-100	60-85	40-60
	4-20	Silty clay, clay	CH	A-7	0	100	100	95-100	95-100	60-85	40-60
	20-60	Silt loam, very fine sandy loam, loam.	CL, CL-ML	A-4, A-6	0	100	100	95-100	85-100	25-40	5-20

See footnote at end of table.

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Frag-ments 3-10 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plas-ticity index
	In				Pct					Pct	
35---------------- Paxico	0-8	Silt loam--------	ML, CL-ML, CL	A-4	0	100	100	85-100	75-90	15-30	NP-10
	8-40	Silt loam, very fine sandy loam.	ML, CL-ML, CL	A-4	0	100	100	85-100	80-90	15-30	NP-10
	40-60	Loamy fine sand, fine sandy loam, fine sand.	SM, SC-SM, ML, CL-ML	A-4, A-2	0	100	95-100	70-90	25-55	<25	NP-5
36---------------- Percival	0-9	Silty clay-------	CH	A-7	0	100	100	95-100	95-100	60-85	35-60
	9-23	Silty clay, clay	CH	A-7	0	100	100	95-100	95-100	60-85	35-60
	23-60	Stratified fine sand to loamy fine sand.	SM, SC-SM, SP-SM	A-2	0	100	100	80-95	12-30	<20	NP-5
37---------------- Salix	0-12	Silty clay loam	CL, CH	A-7	0	100	100	95-100	95-100	40-60	20-35
	12-20	Silty clay loam	CL	A-6, A-7	0	100	100	95-100	95-100	35-50	20-30
	20-60	Silt loam, loam, very fine sandy loam.	CL, ML	A-4, A-6	0	100	100	95-100	90-100	30-40	5-15
38---------------- Sarpy	0-4	Loamy fine sand	SM	A-2	0	100	100	65-80	20-35	---	NP
	4-55	Fine sand, loamy fine sand.	SM	A-2	0	100	100	65-80	20-35	---	NP
	55-60	Silt loam--------	CL-ML, CL	A-4, A-6	0	100	100	90-100	70-100	10-30	5-15
39---------------- Sarpy	0-8	Loamy fine sand	SM	A-2-4	0	100	100	60-80	15-35	---	NP
	8-60	Fine sand, loamy fine sand, sand.	SM, SP, SP-SM	A-2-4, A-3	0	100	100	60-80	2-35	---	NP
40B-------------- Sharpsburg	0-12	Silty clay loam	CL, CH	A-7, A-6	0	100	100	100	95-100	35-55	18-32
	12-51	Silty clay loam, silty clay.	CH, CL	A-7	0	100	100	100	95-100	40-60	20-35
	51-60	Silty clay loam	CL	A-7, A-6	0	100	100	100	95-100	35-50	20-30
40C2------------- Sharpsburg	0-7	Silty clay loam	CL, CH	A-7, A-6	0	100	100	100	95-100	35-55	18-32
	7-12	Silty clay loam	CL, CH	A-7, A-6	0	100	100	100	85-100	35-55	18-32
	12-26	Silty clay loam, silty clay.	CH, CL	A-7	0	100	100	100	95-100	40-60	20-35
	26-51	Silty clay loam	CL	A-7, A-6	0	100	100	100	95-100	35-50	20-30
	51-60	Silty clay loam, silt loam.	CL	A-7, A-6	0	100	100	100	95-100	35-50	20-30
41C2, 41D2, 41E2- Shelby	0-7	Clay loam--------	CL	A-6, A-7	0	90-95	85-95	75-90	55-70	35-45	15-25
	7-17	Clay loam--------	CL	A-6, A-7	0	90-95	85-95	75-90	55-70	35-45	15-25
	17-45	Clay loam--------	CL	A-6, A-7	0-5	90-95	85-95	75-90	55-70	30-45	15-25
	45-60	Clay loam--------	CL	A-6, A-7	0-5	90-95	85-95	75-90	55-70	30-45	15-25
42F-------------- Timula	0-8	Silt loam--------	ML, CL-ML	A-4	0	100	100	95-100	85-100	25-35	NP-10
	8-60	Silt loam, silt	ML, CL-ML	A-4	0	100	100	95-100	85-100	25-35	NP-10
43G*:											
Timula-----------	0-4	Silt loam--------	ML, CL-ML	A-4	0	100	100	95-100	85-100	25-35	NP-10
	4-60	Silt loam, silt	ML, CL-ML	A-4	0	100	100	95-100	85-100	25-35	NP-10
Hamburg----------	0-6	Silt loam--------	CL-ML, ML	A-4	0	100	100	100	95-100	<25	NP-5
	6-60	Silt loam, very fine sandy loam, silt.	CL-ML, ML	A-4	0	100	100	100	95-100	<25	NP-5

See footnote at end of table.

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Frag- ments 3-10 inches	Percentage passing sieve number--				Liquid limit	Plas- ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
44----------------- Zook	0-24	Silty clay loam	CH, CL	A-7	0	100	100	95-100	95-100	45-65	20-35
	24-44	Silty clay, silty clay loam.	CH	A-7	0	100	100	95-100	95-100	60-85	35-55
	44-60	Silty clay loam, silty clay, silt loam.	CH, CL, ML, MH	A-7, A-6	0	100	100	95-100	95-100	35-80	10-50

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 16.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS

(The symbol < means less than; > means more than. Entries under "Erosion factors--T" apply to the entire profile. Entries under "Wind erodibility group" and "Organic matter" apply only to the surface layer. Absence of an entry indicates that data were not available or were not estimated)

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodibility group	Organic matter
	In	Pct	g/cc	In/hr	In/in	pH					Pct
10---------------- Blencoe	0-8	35-40	1.40-1.60	0.06-0.2	0.18-0.20	6.1-7.3	High---------	0.28	5	4	2-5
	8-35	40-50	1.35-1.45	0.06-0.2	0.10-0.14	6.6-7.8	High---------	0.28			
	35-52	18-24	1.35-1.40	0.6-2.0	0.20-0.22	6.6-7.8	Moderate-----	0.43			
	52-60	40-55	1.40-1.50	<0.06	0.10-0.13	7.4-8.4	High---------	0.32			
11---------------- Colo	0-8	20-26	1.25-1.30	0.6-2.0	0.22-0.24	5.6-7.3	Moderate-----	0.28	5	6	3-5
	8-60	30-35	1.25-1.35	0.6-2.0	0.18-0.20	5.6-7.3	Moderate-----	0.28			
12*:											
Colo------------	0-10	27-32	1.28-1.32	0.6-2.0	0.21-0.23	5.6-7.3	Moderate-----	0.28	5	7	3-5
	10-60	30-35	1.25-1.35	0.6-2.0	0.18-0.20	5.6-7.3	Moderate-----	0.28			
Judson----------	0-25	27-32	1.30-1.35	0.6-2.0	0.21-0.23	5.6-7.3	Moderate-----	0.28	3	7	4-5
	25-60	30-35	1.35-1.45	0.6-2.0	0.21-0.23	5.6-7.3	Moderate-----	0.43			
13C2, 13D2------- Contrary	0-7	20-27	1.25-1.35	0.6-2.0	0.22-0.24	5.6-7.3	Low----------	0.32	5	6	2-4
	7-35	18-30	1.30-1.40	0.6-2.0	0.20-0.22	5.6-7.3	Low----------	0.43			
	35-60	16-25	1.20-1.40	0.6-2.0	0.20-0.22	6.1-7.3	Low----------	0.43			
14---------------- Dockery	0-8	15-27	1.35-1.45	0.6-2.0	0.22-0.24	5.6-7.3	Low----------	0.37	5	6	2-4
	8-60	18-30	1.35-1.45	0.6-2.0	0.20-0.24	5.6-7.8	Moderate-----	0.37			
15---------------- Gilliam	0-10	15-20	1.25-1.40	0.6-2.0	0.20-0.24	6.6-8.4	Moderate-----	0.28	5	5	2-4
	10-20	15-35	1.30-1.45	0.6-2.0	0.17-0.22	7.4-8.4	Moderate-----	0.28			
	20-60	12-35	1.30-1.45	0.6-2.0	0.17-0.22	7.4-8.4	Moderate-----	0.28			
16---------------- Haynie	0-12	15-25	1.20-1.35	0.6-2.0	0.18-0.23	7.4-8.4	Low----------	0.37	5	4L	1-3
	12-60	15-18	1.20-1.35	0.6-2.0	0.18-0.23	7.4-8.4	Low----------	0.37			
17, 18----------- Haynie	0-6	15-25	1.20-1.35	0.6-2.0	0.18-0.23	6.6-8.4	Low----------	0.37	5	4L	1-3
	6-52	10-18	1.20-1.35	0.6-2.0	0.18-0.23	7.4-8.4	Low----------	0.37			
	52-60	2-5	1.20-1.50	6.0-20	0.05-0.09	7.4-8.4	Low----------	0.15			
19C2, 19D2------- Higginsville	0-9	27-30	1.30-1.40	0.6-2.0	0.20-0.23	5.6-7.3	Moderate-----	0.37	5-4	7	2-3
	9-44	27-35	1.40-1.50	0.6-2.0	0.18-0.20	5.1-6.5	Moderate-----	0.37			
	44-60	25-30	1.50-1.60	0.6-2.0	0.18-0.22	5.1-6.5	Moderate-----	0.37			
20D2, 20E2------- Ida	0-4	18-25	1.20-1.30	0.6-2.0	0.20-0.22	6.6-8.4	Low----------	0.32	5-4	4L	.5-1
	4-60	18-25	1.20-1.30	0.6-2.0	0.20-0.22	7.4-8.4	Low----------	0.43			
21B--------------- Judson	0-28	24-27	1.30-1.35	0.6-2.0	0.21-0.23	5.6-7.3	Low----------	0.28	3	6	4-5
	28-60	30-35	1.35-1.45	0.6-2.0	0.21-0.23	5.6-7.3	Moderate-----	0.43			
22C2, 22D2------- Lamoni	0-8	27-40	1.45-1.50	0.2-0.6	0.17-0.21	5.1-7.3	Moderate-----	0.37	3	7	2-3
	8-54	38-50	1.55-1.65	0.06-0.2	0.13-0.17	5.1-6.5	High---------	0.37			
	54-60	32-40	1.60-1.70	0.06-0.2	0.14-0.18	5.6-7.3	High---------	0.37			
23---------------- Luton	0-10	40-60	1.30-1.35	<0.06	0.12-0.14	6.6-7.8	High---------	0.28	5	4	3-5
	10-60	50-60	1.30-1.35	<0.06	0.12-0.14	6.6-7.8	High---------	0.28			
24D3*:											
Malvern----------	0-4	28-40	1.30-1.40	0.2-0.6	0.21-0.23	5.6-7.3	Moderate-----	0.43	2	7	1-2
	4-23	40-50	1.40-1.50	0.06-0.2	0.12-0.14	6.1-7.3	High---------	0.43			
	23-60	28-38	1.45-1.55	0.2-0.6	0.18-0.20	6.1-7.3	Moderate-----	0.43			

See footnote at end of table.

TABLE 16.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodibility group	Organic matter
	In	Pct	g/cc	In/hr	In/in	pH					Pct
24D3*:											
Shelby----------	0-6	27-35	1.50-1.55	0.2-0.6	0.16-0.18	5.1-7.3	Moderate-----	0.37	4	6	1-2
	6-60	30-35	1.55-1.65	0.2-0.6	0.16-0.18	5.1-7.3	Moderate-----	0.37			
25B-------------- Marshall	0-8	25-27	1.25-1.30	0.6-2.0	0.21-0.23	5.6-7.3	Low----------	0.28	5	6	3-4
	8-53	27-34	1.30-1.35	0.6-2.0	0.18-0.20	5.6-7.3	Moderate-----	0.43			
	53-60	22-30	1.30-1.40	0.6-2.0	0.20-0.22	6.6-7.3	Moderate-----	0.43			
25C2, 25D2------- Marshall	0-8	27-35	1.25-1.30	0.6-2.0	0.21-0.23	5.6-7.3	Moderate-----	0.32	5	7	2-3
	8-50	27-34	1.30-1.35	0.6-2.0	0.18-0.20	5.6-7.3	Moderate-----	0.32			
	50-60	27-34	1.30-1.35	0.6-2.0	0.18-0.20	5.6-7.3	Moderate-----	0.43			
26--------------- McPaul	0-60	10-18	1.20-1.30	0.6-2.0	0.21-0.23	7.4-8.4	Low----------	0.32	5	4L	1-2
27B-------------- Monona	0-18	20-27	1.25-1.30	0.6-2.0	0.22-0.24	5.6-7.3	Moderate-----	0.28	5	6	3-4
	18-48	24-28	1.30-1.35	0.6-2.0	0.20-0.22	6.1-7.3	Moderate-----	0.43			
	48-60	18-24	1.35-1.40	0.6-2.0	0.20-0.22	6.6-8.4	Low----------	0.43			
27C2, 27D2------- Monona	0-18	20-27	1.25-1.30	0.6-2.0	0.22-0.24	5.6-7.3	Moderate-----	0.32	5	6	2-3
	18-48	24-28	1.30-1.35	0.6-2.0	0.20-0.22	6.1-7.3	Moderate-----	0.43			
	48-60	18-24	1.35-1.40	0.6-2.0	0.20-0.22	6.6-8.4	Low----------	0.43			
28--------------- Moville	0-25	10-18	1.25-1.30	0.6-2.0	0.21-0.23	7.4-8.4	Low----------	0.37	4	4L	1-3
	25-60	50-60	1.35-1.45	<0.06	0.11-0.13	6.6-7.8	High---------	0.28			
29B-------------- Napier	0-24	20-27	1.20-1.25	0.6-2.0	0.22-0.24	6.1-7.3	Low----------	0.28	5	6	3-4
	24-60	20-27	1.25-1.30	0.6-2.0	0.20-0.22	6.1-8.4	Low----------	0.43			
30*:											
Gullied land.											
Napier----------	0-24	20-27	1.20-1.25	0.6-2.0	0.22-0.24	6.1-7.3	Low----------	0.28	5	6	3-4
	24-60	20-27	1.25-1.30	0.6-2.0	0.20-0.22	6.1-8.4	Low----------	0.43			
31--------------- Nodaway	0-9	18-27	1.25-1.35	0.6-2.0	0.20-0.23	6.1-7.3	Low----------	0.32	5	6	2-3
	9-60	18-28	1.25-1.35	0.6-2.0	0.20-0.23	6.1-7.8	Moderate-----	0.43			
32B-------------- Olmitz	0-19	24-27	1.40-1.45	0.6-2.0	0.19-0.21	5.6-7.3	Moderate-----	0.24	5	6	3-4
	19-32	24-30	1.40-1.45	0.6-2.0	0.19-0.21	5.6-7.3	Moderate-----	0.28			
	32-60	27-34	1.45-1.55	0.6-2.0	0.15-0.17	5.1-6.5	Moderate-----	0.28			
33--------------- Onawa	0-9	40-55	1.30-1.35	0.2-0.6	0.12-0.14	7.4-8.4	High---------	0.28	5	4	2-3
	9-21	50-60	1.30-1.40	0.06-0.2	0.12-0.14	7.4-8.4	High---------	0.28			
	21-60	12-18	1.40-1.50	0.6-6.0	0.20-0.22	7.4-8.4	Low----------	0.43			
34--------------- Onawa	0-4	40-55	1.30-1.35	0.2-0.6	0.12-0.14	7.4-8.4	High---------	0.32	5	4	2-3
	4-20	50-60	1.30-1.40	0.06-0.2	0.12-0.14	7.4-8.4	High---------	0.32			
	20-60	12-18	1.40-1.50	0.6-6.0	0.20-0.22	7.4-8.4	Low----------	0.43			
35--------------- Paxico	0-8	5-18	1.20-1.50	0.6-2.0	0.15-0.23	6.6-8.4	Low----------	0.37	5	4L	1-3
	8-40	5-18	1.20-1.50	0.6-2.0	0.15-0.23	7.4-8.4	Low----------	0.37			
	40-60	2-15	1.40-1.60	2.0-6.0	0.10-0.17	7.4-8.4	Low----------	0.17			
36--------------- Percival	0-9	40-60	1.30-1.35	0.06-0.2	0.10-0.12	7.4-8.4	High---------	0.28	4	4	1-3
	9-23	40-60	1.30-1.35	0.06-0.2	0.10-0.12	7.4-8.4	High---------	0.28			
	23-60	2-12	1.30-1.50	6.0-20	0.02-0.04	7.4-8.4	Low----------	0.15			
37--------------- Salix	0-12	27-30	1.25-1.30	0.6-2.0	0.21-0.23	6.1-7.8	Moderate-----	0.28	5	7	3-4
	12-20	28-38	1.30-1.35	0.6-2.0	0.18-0.20	6.1-7.8	Moderate-----	0.43			
	20-60	16-22	1.35-1.45	0.6-2.0	0.20-0.22	6.6-8.4	Low----------	0.43			

See footnote at end of table.

TABLE 16.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodibility group	Organic matter
	In	Pct	g/cc	In/hr	In/in	pH					Pct
38---------------- Sarpy	0-4	2-5	1.20-1.50	6.0-20	0.05-0.09	6.6-8.4	Low-----------	0.15	5	2	<1
	4-55	2-5	1.20-1.50	6.0-20	0.05-0.09	6.6-8.4	Low-----------	0.15			
	55-60	15-25	1.20-1.35	0.6-2.0	0.18-0.23	6.6-8.4	Low-----------	0.28			
39---------------- Sarpy	0-8	2-5	1.20-1.50	6.0-20	0.05-0.09	6.6-8.4	Low-----------	0.17	5	2	<1
	8-60	2-5	1.20-1.50	6.0-20	0.05-0.09	7.4-8.4	Low-----------	0.15			
40B--------------- Sharpsburg	0-12	27-36	1.30-1.35	0.6-2.0	0.21-0.23	5.1-7.3	Moderate-----	0.32	5	7	3-4
	12-51	36-42	1.35-1.40	0.2-0.6	0.18-0.20	5.1-6.0	Moderate-----	0.43			
	51-60	30-38	1.40-1.45	0.6-2.0	0.18-0.20	5.1-6.5	Moderate-----	0.43			
40C2-------------- Sharpsburg	0-7	27-36	1.30-1.35	0.6-2.0	0.21-0.23	5.1-7.3	Moderate-----	0.32	5	7	3-4
	7-12	27-36	1.30-1.35	0.6-2.0	0.21-0.23	5.1-7.3	Moderate-----	0.43			
	12-26	36-42	1.35-1.40	0.2-0.6	0.18-0.20	5.1-6.0	Moderate-----	0.43			
	26-51	30-38	1.40-1.45	0.6-2.0	0.18-0.20	5.1-6.5	Moderate-----	0.43			
	51-60	25-32	1.40-1.45	0.6-2.0	0.18-0.20	6.1-6.5	Moderate-----	0.43			
41C2, 41D2, 41E2- Shelby	0-7	27-35	1.50-1.55	0.2-0.6	0.16-0.18	5.1-7.3	Moderate-----	0.32	5	6	2-3
	7-17	30-35	1.50-1.55	0.2-0.6	0.16-0.18	5.1-7.3	Moderate-----	0.28			
	17-45	30-35	1.55-1.65	0.2-0.6	0.16-0.18	5.1-7.3	Moderate-----	0.28			
	45-60	30-35	1.55-1.65	0.2-0.6	0.16-0.18	6.6-8.4	Moderate-----	0.37			
42F--------------- Timula	0-8	10-18	1.30-1.60	0.6-2.0	0.20-0.24	6.1-7.8	Low-----------	0.37	5-4	5	1-2
	8-60	10-18	1.40-1.60	0.6-2.0	0.18-0.20	7.4-8.4	Low-----------	0.37			
43G*:											
Timula-----------	0-4	10-18	1.30-1.60	0.6-2.0	0.20-0.24	6.1-7.8	Low-----------	0.37	5-4	5	1-2
	4-60	10-18	1.40-1.60	0.6-2.0	0.18-0.20	7.4-8.4	Low-----------	0.37			
Hamburg----------	0-6	6-12	1.20-1.30	0.6-2.0	0.20-0.24	6.6-8.4	Low-----------	0.43	5	4L	.5-2
	6-60	6-12	1.20-1.30	0.6-2.0	0.17-0.22	7.4-8.4	Low-----------	0.43			
44---------------- Zook	0-24	35-40	1.30-1.35	0.2-0.6	0.21-0.23	5.6-7.3	High----------	0.37	5	7	5-7
	24-44	36-45	1.30-1.45	0.06-0.2	0.11-0.13	5.6-7.8	High----------	0.28			
	44-60	20-45	1.30-1.45	0.06-0.6	0.11-0.22	5.6-7.8	High----------	0.28			

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 17.--SOIL AND WATER FEATURES

("Flooding" and "water table" and terms such as "rare," "brief," "apparent," and "perched" are explained in the text. The symbol < means less than; > means more than. Absence of an entry indicates that the feature is not a concern or that data were not estimated)

Soil name and map symbol	Hydro-logic group	Flooding			High water table			Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months		Uncoated steel	Concrete
					Ft					
10---------------- Blencoe	D	Rare--------	---	---	1.0-3.0	Apparent	Nov-Jun	High-----	High-----	Low.
11---------------- Colo	B/D	Occasional	Very brief to long.	Nov-Jun	1.0-3.0	Apparent	Nov-Jun	High-----	High-----	Moderate.
12*:										
Colo-------------	B/D	Occasional	Very brief to long.	Nov-Jun	1.0-3.0	Apparent	Nov-Jun	High-----	High-----	Moderate.
Judson-----------	B	None--------	---	---	>6.0	---	---	High-----	Moderate	Low.
13C2, 13D2-------- Contrary	B	None--------	---	---	>6.0	---	---	High-----	Moderate	Moderate.
14---------------- Dockery	C	Occasional	Brief to long.	Nov-Jun	2.0-3.0	Apparent	Nov-Jun	High-----	Moderate	Low.
15---------------- Gilliam	C	Rare--------	---	---	1.5-3.0	Apparent	Nov-Jun	High-----	High-----	Low.
16---------------- Haynie	B	Rare--------	---	---	3.0-6.0	Apparent	Nov-Jun	High-----	Low------	Low.
17---------------- Haynie	B	Rare--------	---	---	3.0-6.0	Apparent	Nov-Jun	High-----	Low------	Low.
18---------------- Haynie	B	Frequent----	Brief to long.	Nov-Jun	3.0-6.0	Apparent	Nov-Jun	High-----	Low------	Low.
19C2, 19D2-------- Higginsville	C	None--------	---	---	1.5-3.0	Perched	Nov-May	High-----	Moderate	Moderate.
20D2, 20E2-------- Ida	B	None--------	---	---	>6.0	---	---	High-----	Low------	Low.
21B--------------- Judson	B	None--------	---	---	>6.0	---	---	High-----	Moderate	Low.
22C2, 22D2-------- Lamoni	C	None--------	---	---	1.0-3.0	Perched	Nov-May	Moderate	High-----	Moderate.
23---------------- Luton	D	Rare--------	---	---	1.0-3.0	Apparent	Nov-Jun	Moderate	High-----	Low.
24D3*:										
Malvern----------	C	None--------	---	---	1.0-3.0	Perched	Nov-May	High-----	High-----	Moderate.
Shelby-----------	B	None--------	---	---	>6.0	---	---	Moderate	Moderate	Moderate.
25B, 25C2, 25D2--- Marshall	B	None--------	---	---	>6.0	---	---	High-----	Moderate	Moderate.
26---------------- McPaul	B	Occasional	Very brief	Nov-Jun	>6.0	---	---	High-----	Low------	Low.

See footnote at end of table.

TABLE 17.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydrologic group	Flooding: Frequency	Flooding: Duration	Flooding: Months	High water table: Depth	High water table: Kind	High water table: Months	Potential frost action	Risk of corrosion: Uncoated steel	Risk of corrosion: Concrete
					Ft					
27B, 27C2, 27D2: Monona	B	None	---	---	>6.0	---	---	High	Low	Low.
28: Moville	C	Rare	---	---	1.0-3.0	Apparent	Nov-Jun	High	High	Low.
29B: Napier	B	None	---	---	>6.0	---	---	High	Low	Low.
30*: Gullied land.										
Napier	B	None	---	---	>6.0	---	---	High	Low	Low.
31: Nodaway	B	Occasional	Very brief to brief.	Nov-Jun	3.0-5.0	Apparent	Nov-Jun	High	Moderate	Low.
32B: Olmitz	B	None	---	---	>6.0	---	---	Moderate	Moderate	Moderate.
33: Onawa	D	Rare	---	---	2.0-4.0	Apparent	Nov-Jun	High	High	Low.
34: Onawa	D	Frequent	Brief	Nov-Jun	2.0-4.0	Apparent	Nov-Jun	High	High	Low.
35: Paxico	B	Rare	---	---	1.5-3.0	Apparent	Nov-Jun	High	High	Low.
36: Percival	C	Rare	---	---	2.0-4.0	Apparent	Nov-Jun	Moderate	High	Low.
37: Salix	B	Rare	---	---	4.0-6.0	Apparent	Nov-Jun	High	Moderate	Low.
38: Sarpy	A	Rare	---	---	>6.0	---	---	Low	Low	Low.
39: Sarpy	A	Frequent	Brief to long.	Nov-Jun	>6.0	---	---	Low	Low	Low.
40B, 40C2: Sharpsburg	B	None	---	---	>6.0	---	---	High	Moderate	Moderate.
41C2, 41D2, 41E2: Shelby	B	None	---	---	>6.0	---	---	Moderate	Moderate	Moderate.
42F: Timula	B	None	---	---	>6.0	---	---	High	Low	Low.
43G*:										
Timula	B	None	---	---	>6.0	---	---	High	Low	Low.
Hamburg	B	None	---	---	>6.0	---	---	High	Low	Low.
44: Zook	C/D	Occasional	Brief to long.	Nov-Jun	0-3.0	Apparent	Nov-Jun	High	High	Moderate.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 18.--CLASSIFICATION OF THE SOILS

(An asterisk in the first column indicates that the soil is a taxadjunct to the series. See text for a description of those characteristics of the soil that are outside the range of the series)

Soil name	Family or higher taxonomic class
Blencoe	Clayey over loamy, montmorillonitic, mesic Aquic Hapludolls
Colo	Fine-silty, mixed, mesic Cumulic Haplaquolls
Contrary	Fine-silty, mixed, mesic Dystric Eutrochrepts
Dockery	Fine-silty, mixed, nonacid, mesic Aquic Udifluvents
Gilliam	Fine-silty, mixed, mesic Fluvaquentic Hapludolls
Hamburg	Coarse-silty, mixed (calcareous), mesic Typic Udorthents
Haynie	Coarse-silty, mixed (calcareous), mesic Mollic Udifluvents
*Higginsville	Fine-silty, mixed, mesic Aquic Argiudolls
Ida	Fine-silty, mixed (calcareous), mesic Typic Udorthents
Judson	Fine-silty, mixed, mesic Cumulic Hapludolls
*Lamoni	Fine, montmorillonitic, mesic Aquic Argiudolls
Luton	Fine, montmorillonitic, mesic Vertic Haplaquolls
*Malvern	Fine, montmorillonitic, mesic Aquic Argiudolls
Marshall	Fine-silty, mixed, mesic Typic Hapludolls
McPaul	Coarse-silty, mixed (calcareous), mesic Mollic Udifluvents
Monona	Fine-silty, mixed, mesic Typic Hapludolls
Moville	Coarse-silty over clayey, mixed (calcareous), mesic Aeric Fluvaquents
Napier	Fine-silty, mixed, mesic Cumulic Hapludolls
Nodaway	Fine-silty, mixed, nonacid, mesic Mollic Udifluvents
Olmitz	Fine-loamy, mixed, mesic Cumulic Hapludolls
Onawa	Clayey over loamy, montmorillonitic (calcareous), mesic Aquic Udifluvents
Paxico	Coarse-silty, mixed (calcareous), mesic Aeric Fluvaquents
Percival	Clayey over sandy or sandy-skeletal, montmorillonitic (calcareous), mesic Aquic Udifluvents
Salix	Fine-silty, mixed, mesic Typic Hapludolls
Sarpy	Mixed, mesic Typic Udipsamments
Sharpsburg	Fine, montmorillonitic, mesic Typic Argiudolls
*Shelby	Fine-loamy, mixed, mesic Typic Argiudolls
Timula	Coarse-silty, mixed, mesic Typic Eutrochrepts
Zook	Fine, montmorillonitic, mesic Cumulic Haplaquolls

*U.S. G.P.O:1994-300-438:80514/SCS

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