United States
Department of
Agriculture

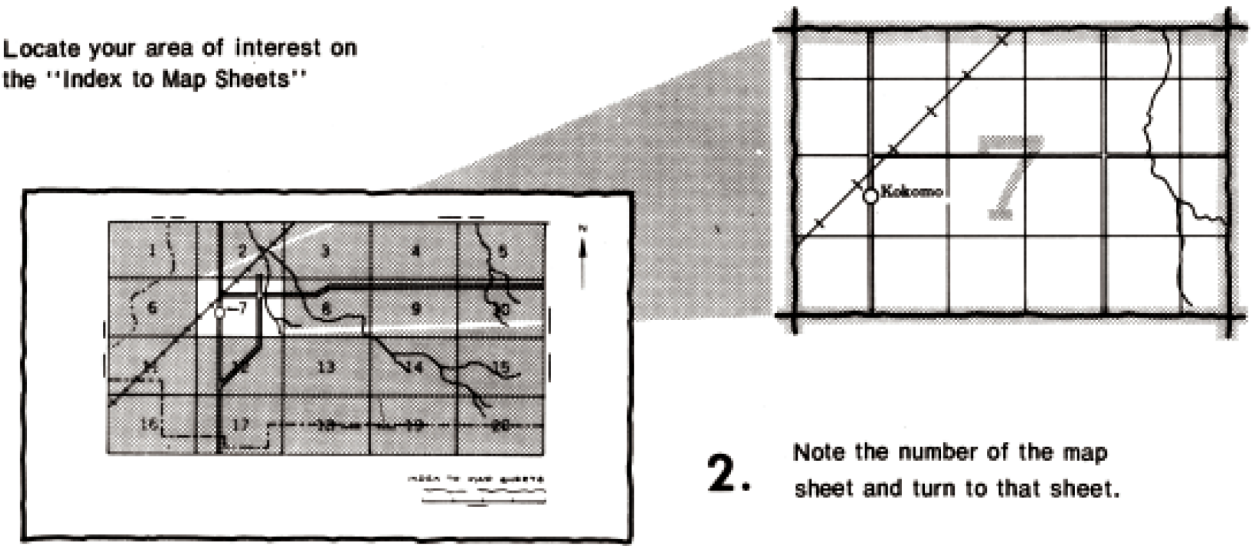
Soil
Conservation
Service

In cooperation with
Iowa Agriculture
and Home Economics
Experiment Station
Cooperative Extension Service
Iowa State University
and Department of
Soil Conservation
State of Iowa

Soil Survey of Carroll County Iowa

HOW TO USE

1. Locate your area of interest on the "Index to Map Sheets"



2. Note the number of the map sheet and turn to that sheet.

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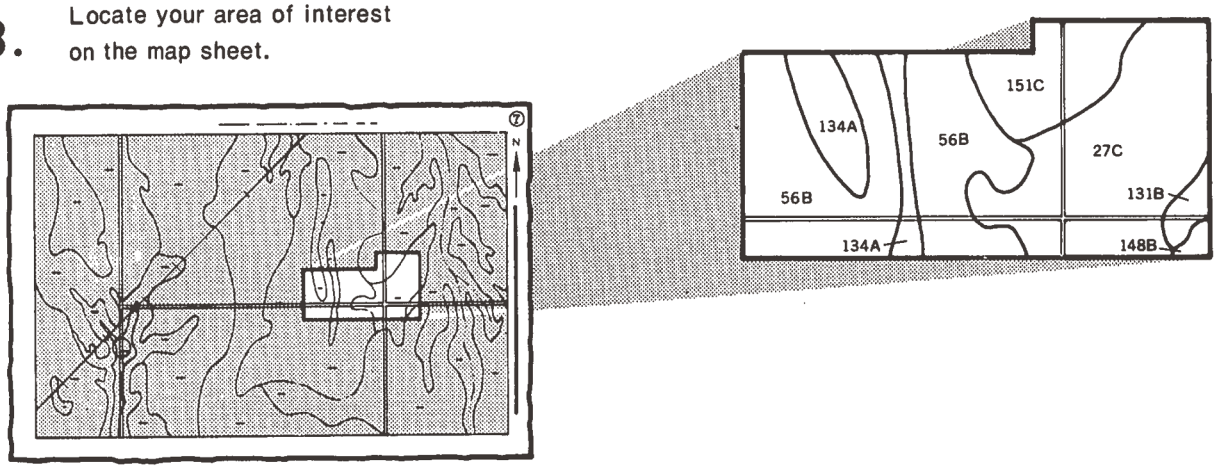

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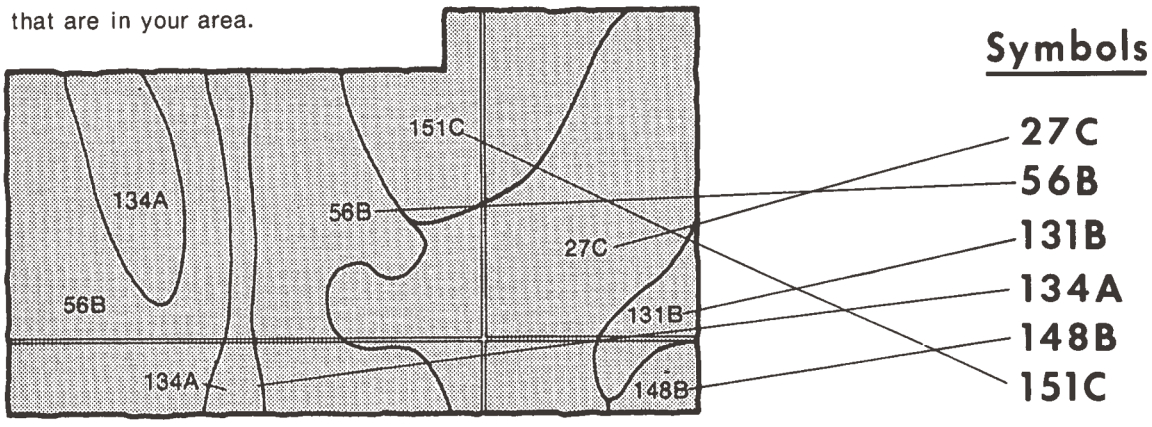
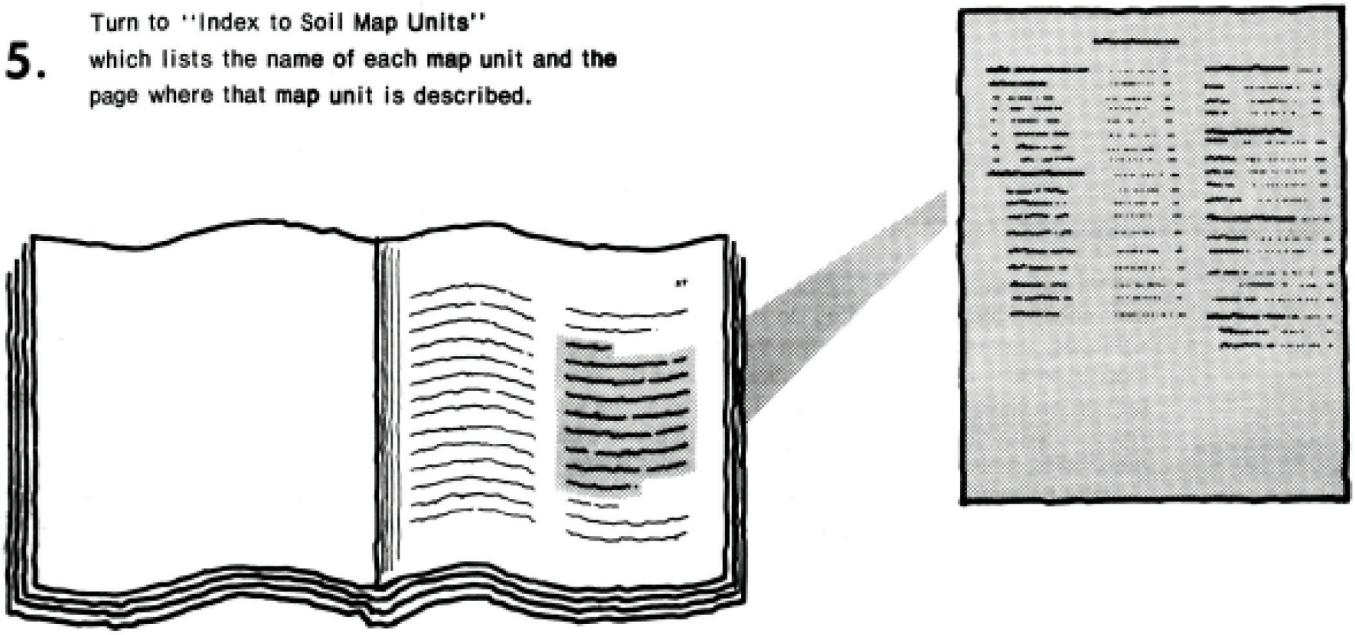
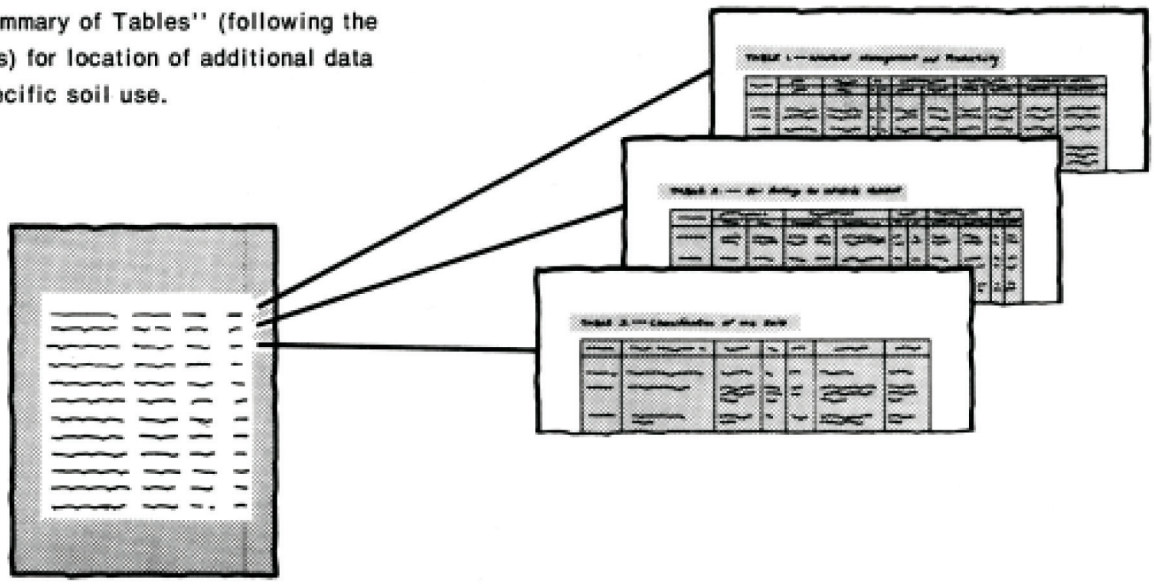


THIS SOIL SURVEY

5. Turn to "Index to Soil Map Units" which lists the name of each map unit and the page where that map unit is described.



6. See "Summary of Tables" (following the Contents) for location of additional data on a specific soil use.



7. Consult "Contents" for parts of the publication that will meet your specific needs. This survey contains useful information for farmers or ranchers, foresters or agronomists; for planners, community decision makers, engineers, developers, builders, or homebuyers; for conservationists, recreationists, teachers, or students; to specialists in wildlife management, waste disposal, or pollution control.

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. In line with Department of Agriculture policies, benefits of this program are available to all, regardless of race, color, national origin, sex, religion, marital status, or age.

This survey was made cooperatively by the Soil Conservation Service and the Iowa Agriculture and Home Economics Experiment Station, Cooperatiave Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa. It is part of the technical assistance furnished to the Carroll County Soil Conservation District. Funds appropriated by Carroll County were used to defray part of the cost of the survey.

Major fieldwork for this soil survey was performed in the period 1974-78. Soil names and descriptions were approved in 1979. Unless otherwise indicated, statements in this publication refer to conditions in the survey area in 1979.

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: The Calco and Spillville soils on the bottom land are used for cultivated crops. The bordering, strongly sloping Storden soils are used for pasture.

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preface

This soil survey contains information that can be used in land-planning programs in Carroll County, Iowa. 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 insure 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 to bedrock. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as 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.

soil survey of
Carroll County, Iowa

By Max A. Sherwood, Soil Conservation Service

Fieldwork by Max A. Sherwood, Robert J. Vobora,
Earl D. Lockridge, Kim C. Goerg, Frank L. Haynes,
and Kirk Johnson, Soil Conservation Service

United States Department of Agriculture,
Soil Conservation Service, in cooperation with
Iowa Agriculture and Home Economics Experiment Station;
Cooperative Extension Service, Iowa State University; and
Department of Soil Conservation, State of Iowa

CARROLL COUNTY is in the west-central part of Iowa. It has a total land area of 573 square miles or 367,296 acres. The population of Carroll County in 1970 was 22,912. Carroll, the county seat, is about 100 miles northwest of Des Moines, Iowa, and about 100 miles southeast of Sioux City, Iowa (fig. 1).

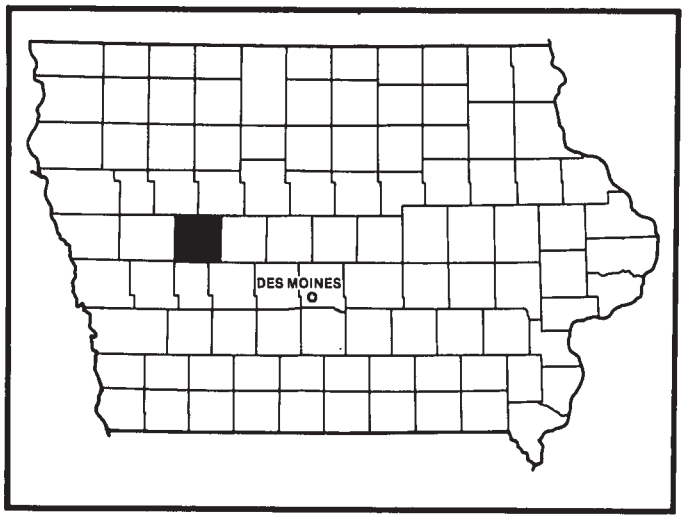

Figure 1.—Location of Carroll County in Iowa.

Most of the acreage in the county is in farms. Corn, soybeans, hay, oats, and pasture are the main crops. Corn, hay, and soybeans are predominant. Much of the grain and forage that is grown on the farms is fed to swine, beef, and dairy cattle that are raised in the county.

Most of the soils in Carroll County formed under prairie grasses and have a surface layer that is quite dark and fertile. The climate is subhumid and continental. Winters are cold and summers are warm. The growing season is long enough for crops grown in the county to mature.

The first soil survey of Carroll County was published in 1926 (*13*). This survey updates the first survey and provides additional information and larger maps that show more detail.

general nature of the county

This section was prepared for those who are not familiar with Carroll County. It discusses the climate, physiography, relief and drainage, history and development, water supply, farming, transportation facilities, and vegetation in the county.

climate

Prepared by the National Climatic Center, Asheville, North Carolina.

Table 1 gives data on temperature and precipitation for the survey area as recorded at Carroll County, Iowa

in the period 1951 to 1977. 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 21 degrees F, and the average daily minimum temperature is 11 degrees. The lowest temperature on record, which occurred at Carroll on January 21, 1970, is -32 degrees. In summer the average temperature is 72 degrees, and the average daily maximum temperature is 85 degrees. The highest recorded temperature, which occurred at Carroll on July 31, 1955, is 105 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 30.7 inches. Of this, 22 inches, or 75 percent, usually falls in April through September, which includes the growing season for most crops. In 2 years out of 10, the rainfall in April through September is less than 17 inches. The heaviest 1-day rainfall during the period of record was 4.85 inches at Carroll on September 26, 1973. Thunderstorms occur on about 50 days each year, and most occur in summer.

Average seasonal snowfall is 30 inches. The greatest snow depth at any one time during the period of record was 28 inches. On an average of 26 days, at least 1 inch of snow is 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 50 percent in winter. The prevailing wind is from the northwest. Average windspeed is highest, 13 miles per hour, in spring.

Tornadoes and severe thunderstorms strike occasionally. These storms are local and of short duration and result in sparse damage in narrow belts. Hailstorms occur at times during the warmer part of the year in irregular patterns and in relatively small areas.

physiography, relief and drainage

The highest elevation in Carroll County is 1,557 feet. It is in the western part of the county. The lowest elevation is about 1,090 feet. It is in the eastern part of the county in the valley of the North Raccoon River. The upland divide that separates the Missouri River watershed from the Mississippi River watershed is mantled by Wisconsin loess and extends in a north-south direction through the western part of Carroll County.

Carroll County has two distinct topographic areas that are divided by the Middle Raccoon River. This river originates in the northwestern part of the county and flows in a southeasterly direction through the city of Carroll and on through Coon Rapids in the southeastern part of the county.

Most of the area north and east of the Middle Raccoon River has the undulating, nearly level to gently rolling topography typical of the Wisconsin (Cary) drift area. It has a few natural drainageways and many enclosed depressions. The greatest variation in relief is along the Bemis end moraine just north of the Middle Raccoon River and along the Altamont end moraine in the northeastern part of the county. The drainage network in the northeastern part of Carroll County is dominated by the Middle and North Raccoon Rivers and by Storm, Purgatory, and Willow Creeks. These creeks flow in a southeasterly direction. This part of the county includes the Clarion-Nicollet-Webster, the Clarion-Storden, the Wadena-Coland-Storden, and part of the Colo-Ackmore-Calco soil associations on the general soil map.

The area south and west of the Middle Raccoon River has topography that is somewhat typical of the Kansan glacial drift plain and is mantled by loess. It has nearly level to gently sloping ridges that have more steeply sloping sides than the Wisconsin drift area and nearly level to gently sloping valleys. It is part of a large upland plain that slopes to the south. The loess mantle is about 25 feet thick on the most stable ridgetops in the western part of the county, but the thickness decreases gradually to the east. The loess and the till plain are dissected by numerous drainageways and streams that generally flow in a southerly direction. The larger streams have well developed tributaries fed by numerous smaller streams. The drainage network in the southwestern part of Carroll County is dominated by the Middle Raccoon and West Nishnabotna Rivers and by Brushy Creek. The Middle Raccoon, Nishnabotna, and East Boyer Rivers originate in the western part of Carroll County. This part of the county includes the Marshall-Exira, the Marshall-Exira-Burchard, the Gara-Knox-Armstrong, and part of the Colo-Ackmore-Calco soil associations on the general soil map.

history and development

Although hunting parties of Indians passed through this area, apparently no Indian tribes permanently settled on the land that was to become Carroll County. The first settler came to Carroll County in 1849. He settled on land that is about 7 miles northeast of where Glidden is now located.

Carroll County was established in 1851, and the county was organized in 1856. The first county seat was at Carrollton, but a few years later it was moved to Carroll, which was on a railroad line.

Most of the settlements were near streams, where water and timber were readily available. In 1856 there

were 251 people in the county. As railroads were built, more towns and farms were established, and by 1875 the population was 5,760. In 1970 the population was 22,912.

The early settlers grew corn and small grain, and had vegetable gardens. They raised cattle, swine, sheep, and chickens. The economy that developed has been and is still largely dependent upon farming. Some light industry, manufacturing, and transportation enterprises, however, are now located in Carroll County.

water supply

The supply of water for municipal, crop, and livestock use is adequate in the northeastern part of Carroll County, which is the area covered by Wisconsin (Cary) glacial till. The water supply is also generally adequate in the southwestern part of the county, but it is sometimes a concern in dry years.

Farm wells are an average of about 30 feet deep in the southwestern part of the county and about 220 feet deep in the northeastern part. Much of the water for livestock use comes from small farm ponds, creeks, or rivers that are in pastureland. In 1977 there were 42 farm ponds in Carroll County. They averaged 1 to 2 acres but ranged from 1/2 acre to 6 acres.

The uplands in the southwestern part of the county are covered by a mantle of Wisconsin loess overlying Kansan glacial till. Water moves downward through the loess, but the underlying glacial till restricts this downward movement. As a result, a perched water table develops in the loess above the glacial till during wet seasons. This perched water seeps out along the loess-till contact line along hillsides. Because of this, wells that take water from this area with a perched water table often have a good supply in spring but a greatly reduced supply during the drier summer months. During extended drought periods, the water supply from these wells may become critical. For this reason, most wells in the southwestern part of the county take water from the alluvial sands that underlie the valleys, rather than from the upland areas that have a perched water table. A rural water supply system is being developed in the southwestern part of Carroll County that is expected to serve about 35 percent of the farms in the county when it is completed.

The principal sources of water supply to wells for both rural and municipal uses in Carroll County are shallow alluvial sands and deeper glacial sands and the Dakota Sandstone in the upper part of the bedrock.

Municipal water supply systems in Carroll County are located at Arcadia, Breda, Carroll, Coon Rapids, Dedham, Glidden, Halbur, Lanesboro, Lidderdale, Manning, Templeton, and Willey. With the exception of Arcadia and Templeton, all of these communities develop their water supply from alluvial and glacial sand, or from the Dakota Sandstone. Some of these wells have produced large quantities of water. At Carroll individual wells have tested as high as 700 to 900 gallons per minute. These conditions do not occur everywhere, however, because the physical character and distribution of these aquifers vary locally. For example, in the upland areas in the southwestern part of the county, where the alluvial and Dakota aquifers are absent, some places may have difficulty in obtaining more than a few gallons of water per minute. Efforts that have been made to drill deeper than the Dakota aquifer have proven impractical, but a promising source for large supplies of good quality drinking water may be the Jordan Sandstone and associated dolomites, which are about 2,100 to 2,400 feet below the surface (*10*).

farming

In 1976, there were 1,227 farms in Carroll County that averaged 287 acres per farm. The total area in farms was 352,738 acres, of which 293,076 acres was used for crops. In 1975, 31,181 acres was in pasture, 1,248 acres in woodland, 11,225 acres in farmsteads, roads, and miscellaneous uses, and 628 acres in small water areas (*3*).

Corn is the primary crop in Carroll County. In 1975, 175,200 acres of corn harvested for grain yielded an average of 83 bushels per acre, and 23,650 acres harvested for silage yielded an average of 16 tons per acre. Soybeans is the second most important crop. In 1975, 85,800 acres of soybeans harvested for grain yielded an average of 35.6 bushels per acre. The average yield of 19,100 acres of oats was 65.2 bushels per acre. Of the 17,100 acres of hay grown in 1975, 13,300 acres was alfalfa (*9*).

Although some cash-grain farms in Carroll County receive most of their income from corn and soybeans, most of the farmers receive about 40 percent of their income from crops and 60 percent from livestock. In 1976, 394,400 hogs were marketed. Also marketed were 115,800 cattle, of which 19,750 were beef cows. Of these, 82,200 were grain-fed. In addition, 1,900 milk cows were sold. During 1976, an average of 45,100 laying hens were raised in Carroll County.

Most of the cattle and hogs are marketed in Denison, Iowa; Omaha, Nebraska; and Sioux City, Iowa but some are sold nearby. Milk and eggs are generally picked up on regular produce truck routes and hauled to processing plants or markets outside of Carroll County. Corn and soybeans are commonly trucked to local grain elevators for storage or market, but some crops are held in storage on the farm for marketing later, or are fed to livestock. Silage and hay are generally fed to livestock on the farm.

Since the 1930's, the farms in Carroll County have declined steadily in number and increased steadily in size.

transportation facilities

Two railroads serve Carroll County. A network of federal, state, and county highways serves all parts of the county. U.S. Highways 30 and 71 provide the major east-west and north-south service. Farm-to-market roads are paved or gravel surfaced throughout the county.

Most communities have freight service by train, and all have service by truck. Bus service is provided to the communities along Highway 30. Airfields for small aircraft are at Carroll and Manning. A landing strip is at Coon Rapids.

vegetation

The native vegetation of Carroll County was mainly prairie grasses (bluestems) and oak-hickory type forest. Prairie grasses were dominant throughout the county, except along the major streams and valleys where forest vegetation was dominant. Native grass areas are generally in pastureland. Native timbered areas are mainly in county or state parks or access areas to rivers in the county.

how this survey was made

Soil scientists made this survey to learn what soils are in the survey area, where they are, and how they can be used. They observed the steepness, length, and shape of slopes; the size of streams and the general pattern of drainage; the kinds of native plants or crops; and the kinds of rock. They dug many holes to study soil profiles. A profile is the sequence of natural layers, or horizons, in a soil. It extends from the surface down into the parent material, which has been changed very little by leaching or by plant roots.

The soil scientists recorded the characteristics of the profiles they studied and compared those profiles with others in nearby counties and in more distant places. They classified and named the soils according to nationwide uniform procedures. They drew the boundaries of the soils on aerial photographs. These photographs show trees, buildings, fields, roads, and other details that help in drawing boundaries accurately. The soil maps at the back of this publication were prepared from aerial photographs.

The areas shown on a soil map are called map units. Most map units are made up of one kind of soil. Some are made up of two or more kinds. The map units in this survey area are described under "General soil map units" and "Detailed soil map units."

While a soil survey is in progress, samples of some soils are taken for laboratory measurements and for engineering tests. All soils are field tested to determine their characteristics. Interpretations of those characteristics may be modified during the survey. Data are assembled from other sources, such as test results, records, field experience, and state and local specialists. For example, data on crop yields under defined management are assembled from farm records and from field or plot experiments on the same kinds of soil.

But only part of a soil survey is done when the soils have been named, described, interpreted, and delineated on aerial photographs and when the laboratory data and other data have been assembled. The mass of detailed information then needs to be organized so that it can be used by farmers, woodland managers, engineers, planners, developers and builders, home buyers, and others.

general soil map units

The general soil map at the back of this publication shows broad areas called soil associations that have a distinctive pattern of soils, relief, and drainage. Each soil association on the general soil map is a unique natural landscape. Typically, a soil 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 other associations 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 soil association differ from place to place in slope, depth, drainage, and other characteristics that affect management.

1. Clarion-Nicollet-Webster association

Nearly level to strongly sloping, well drained, somewhat poorly drained, and poorly drained, loamy and silty soils that formed in glacial till or in local glacial sediment; on uplands

This association consists of soils on a young till plain (fig. 2). Relief varies from short, irregular slopes on the higher areas to slight depressions in the low areas. Surface drainage is not well developed, and runoff water commonly accumulates in some of the lowest areas. Slopes range from 0 to 14 percent (fig. 3).

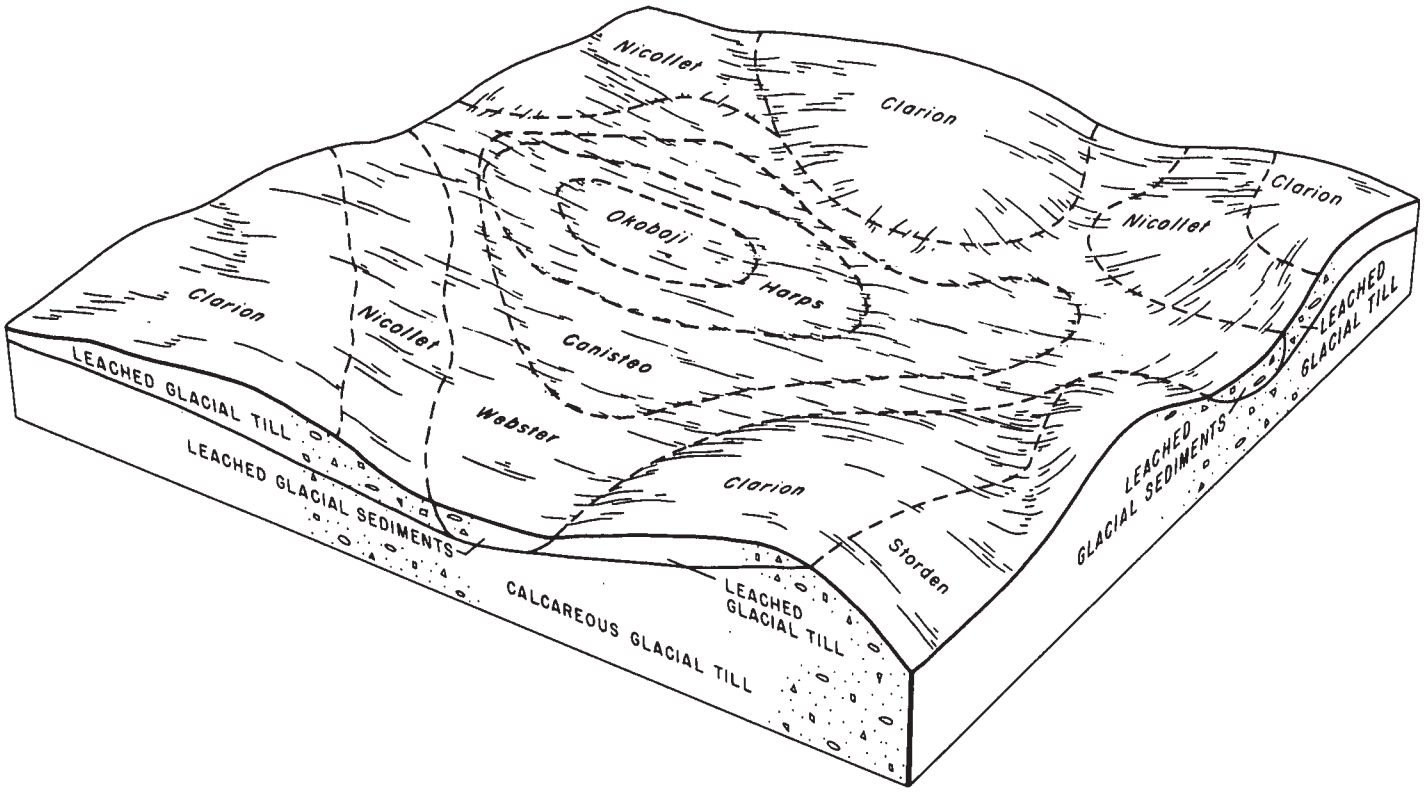

Figure 2.—Typical pattern of soils in the Clarion-Nicollet-Webster association.

Figure 3.—Typical landscape in the Clarion-Nicollet-Webster association. The Clarion soils are on the gently sloping areas, and the Nicollet and Webster soils are on the nearly level to level areas.

This association makes up about 31 percent of the county. About 33 percent is Clarion soils, about 17 percent is Nicollet soils, and about 15 percent is Webster soils. Soils of minor extent make up about 35 percent.

Clarion soils are well drained and are on the higher, steeper areas of the association. Nicollet soils are somewhat poorly drained and are on the lower parts of long, gentle slopes. The nearly level Webster soils are poorly drained and are in the low areas.

Typically, the surface layer of the Clarion soils is black loam about 9 inches thick. The subsurface layer is mixed very dark grayish brown and black loam about 5 inches thick. The subsoil is about 19 inches thick. The upper part is brown, friable loam, and the lower part is dark yellowish brown, mottled, friable loam. The substratum to a depth of about 60 inches is yellowish brown, mottled, calcareous loam.

Typically, the surface layer of the Nicollet soils is black loam about 9 inches thick. The subsurface layer is black and very dark grayish brown loam and clay loam about 13 inches thick. The subsoil is dark grayish brown, mottled, friable clay loam about 8 inches thick. The substratum to a depth of about 60 inches is grayish brown, mottled, friable clay loam and loam.

Typically, the surface layer of the Webster soils is black silty clay loam about 8 inches thick. The subsurface layer is about 13 inches thick. It is black silty clay loam in the upper part and very dark gray clay loam in the lower part. The subsoil is about 24 inches thick. The upper part is dark gray and olive gray clay loam, and the lower part is olive gray, mottled, friable loam. The

substratum to a depth of about 60 inches is olive gray, mottled, calcareous loam.

Canisteo soils are important soils of minor extent. They are poorly drained and have a higher lime content than the major soils. Other soils of minor extent in this association are Calco, Coland, Harps, Okoboji, and Storden soils. Calco and Coland soils are poorly drained and are on bottom lands. Harps soils are poorly drained and are at a slightly higher elevation than the very poorly drained Okoboji soils, which are in closed depressional areas. Storden soils are well drained and are on the steepest slopes. Calco, Harps, and Storden soils have a higher lime content than the other soils.

The soils in this association are used mainly for corn, soybeans, small grains, and hay. Some of the wetter areas and some of the steeper, sloping areas are used for pasture. Fertility, content of organic matter, and available water capacity are high in these soils. The main concerns of management are the improvement of drainage in the low areas and the control of water erosion and maintenance of fertility on the more sloping areas.

2. Clarion-Storden association

Moderately sloping to very steep, well drained, loamy soils that formed in glacial till; on uplands

This association is made up of soils on glacial moraine areas (fig. 4). These areas consist of convex side slopes, knolls, and ridgetops. Surface drainage is well developed. Slopes range from 5 to 40 percent.

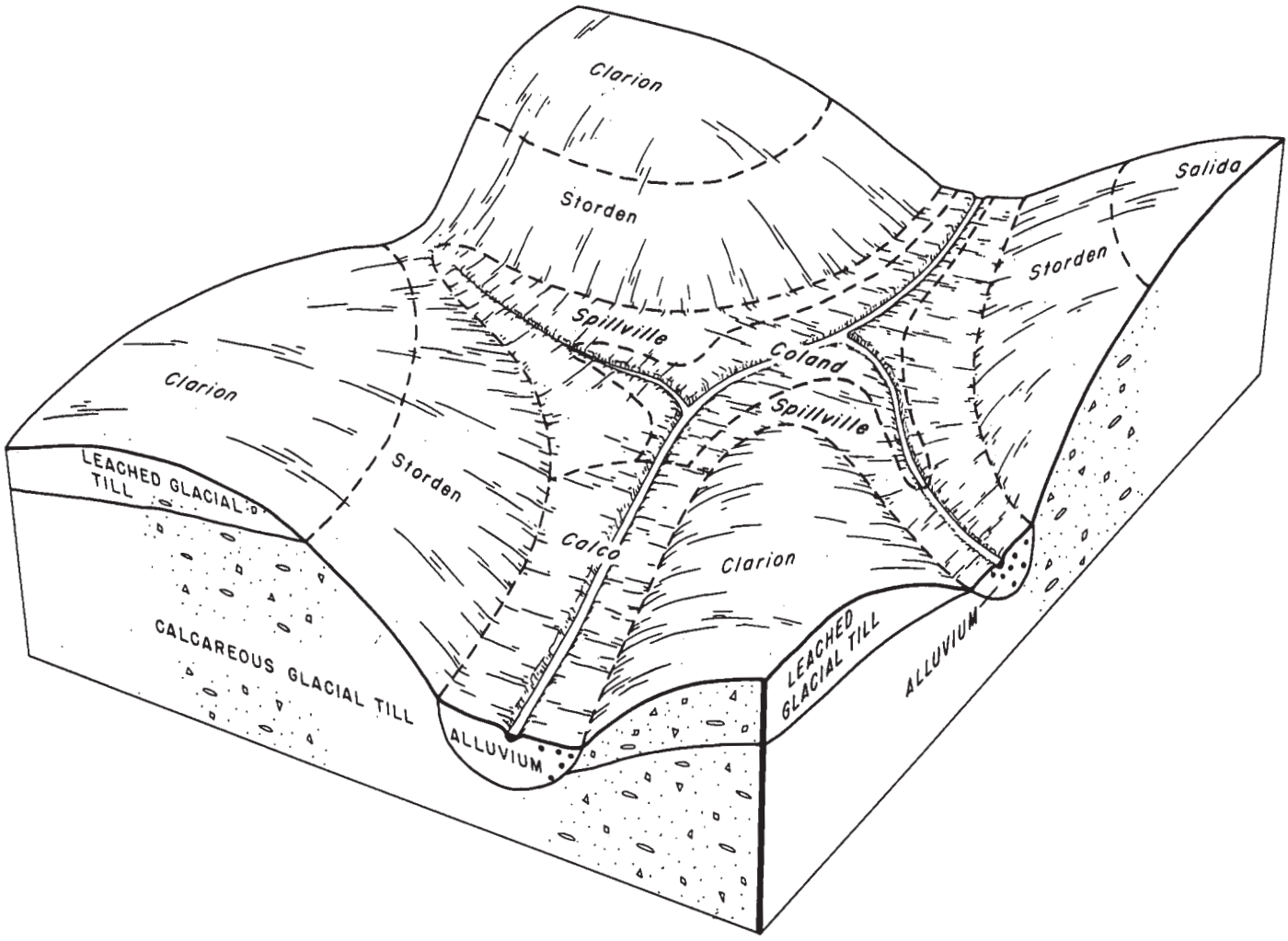

Figure 4.—Typical pattern of soils in the Clarion-Storden association.

This association makes up about 6 percent of the county. About 40 percent is Clarion soils and about 30 percent is Storden soils. Soils of minor extent make up about 30 percent.

Clarion and Storden soils are well drained. The Storden soils are generally on convex side slopes and are downslope from the Clarion soils. Storden soils are calcareous.

Typically, the surface layer of the Clarion soils is very dark grayish brown loam about 8 inches thick. The subsoil is about 16 inches thick. The upper part is brown, friable loam, and the lower part is dark yellowish brown, mottled, friable loam. The substratum to a depth of about 60 inches is yellowish brown, mottled, friable, calcareous loam.

Typically, the surface layer of the Storden soils is very dark grayish brown and dark grayish brown, calcareous loam mixed with streaks and patches of brown subsoil material. It is about 8 inches thick. The substratum to a depth of about 60 inches is yellowish brown, friable, calcareous loam in the upper part and light olive brown, mottled, friable, calcareous loam in the middle and lower parts. Lime accumlations are throughout the soil.

Of minor extent are Calco, Coland, and Spillville soils in bottom lands and Salida soils on uplands. Calco and Coland soils are poorly drained, have a seasonal high water table, and are frequently flooded. Spillville soils are somewhat poorly drained or moderately well drained. The Salida soils are excessively drained and are underlain by sand and gravel. They occur as gravelly knobs or mounds and are generally surrounded by Storden soils.

The soils in this association are used mainly for corn, soybeans, small grains, and hay. The steepest areas are in pasture. Except for Storden and Salida soils, these soils are high in fertility and content of organic matter, and except for Salida soils, they have high available water capacity. The main concerns of management are control of water erosion and maintenance of fertility.

3. Wadena-Coland-Storden association

Nearly level to very steep, well drained and poorly drained, loamy soils that formed in glacial outwash sediment, alluvium, and glacial till; on uplands and bottom lands

This association consists of soils on flood plains, terraces, glacial outwash plains, and valley side slopes (fig. 5). Slopes range from 0 to 40 percent. Many of the glacial outwash areas are underlain by sand and gravel.

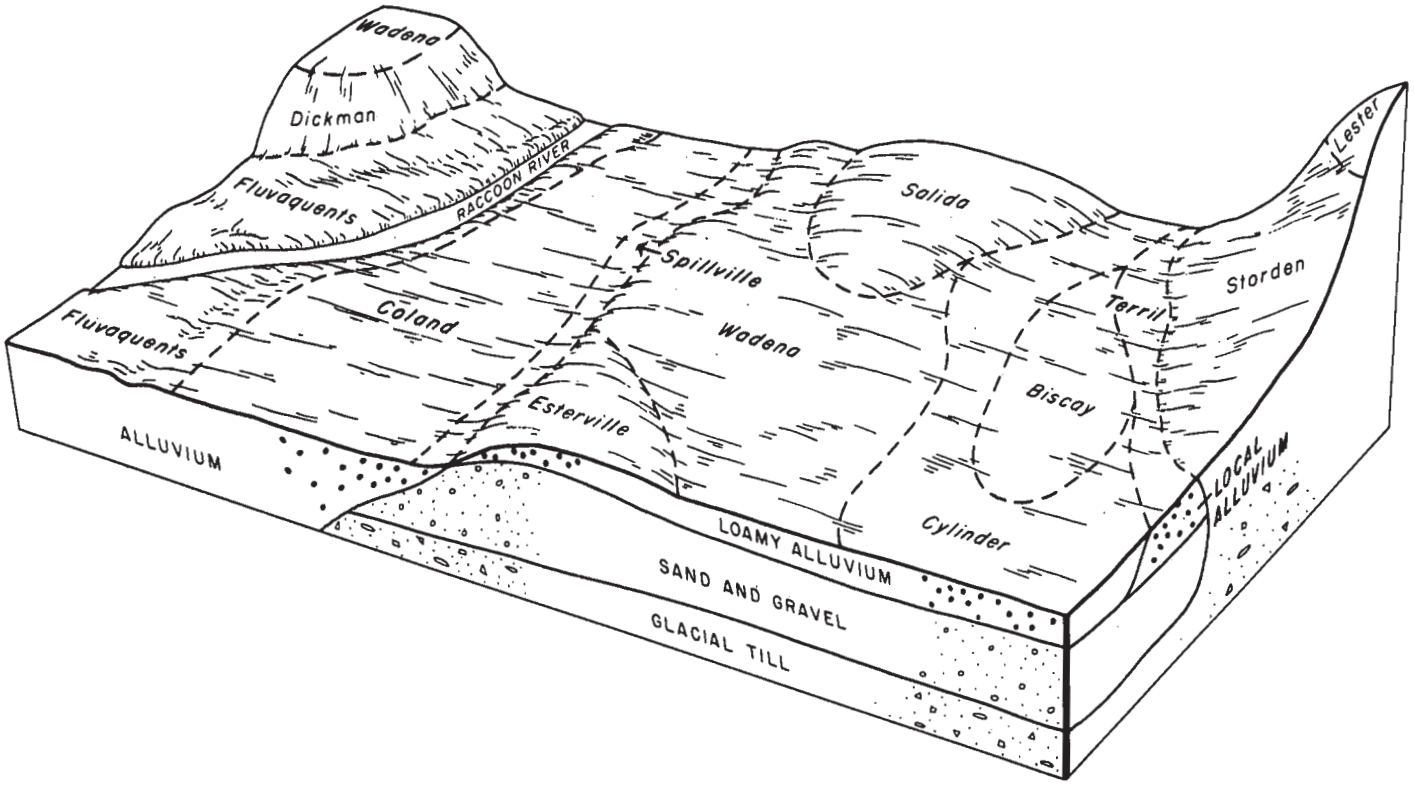

Figure 5.—Typical pattern of soils in the Wadena-Coland-Storden association.

This association makes up about 6 percent of the county. About 18 percent is Wadena soils, 16 percent is Coland soils, and 12 percent is Storden soils. Soils of minor extent make up about 54 percent.

Wadena soils are well drained and are underlain by sand and gravel. They are on outwash plains, valley trains, and benches. Coland soils are poorly drained. They commonly have a seasonal high water table and are frequently flooded. Storden soils are well drained. They are calcareous and are mainly along the sloping sides of valleys.

Typically, the surface layer of the Wadena soils is black loam about 9 inches thick. The subsurface layer is about 8 inches thick. It is black loam in the upper part and very dark grayish brown loam in the lower part. The subsoil is about 17 inches thick. The upper part is brown, friable loam, the middle part is dark yellowish brown, friable loam, and the lower part is brown, friable gravelly loamy sand. The substratum to a depth of about 60 inches is multicolored, calcareous, loose sand and gravel.

Typically, the surface layer of the Coland soils is black clay loam about 8 inches thick. The subsurface layer is black clay loam about 21 inches thick. The mottled subsoil is very dark gray, friable clay loam about 19 inches thick. The substratum to a depth of about 60 inches is gray, friable sandy clay loam.

Typically, the surface layer of the Storden soils is dark grayish brown and very dark grayish brown, calcareous loam mixed with streaks and patches of light olive brown subsoil material. It is about 8 inches thick. The substratum to a depth of about 60 inches is light olive brown and yellowish brown, friable, calcareous loam in the upper part and light olive brown, mottled, friable, calcareous loam in the lower part. Lime accumulations are throughout the soil.

Of minor extent are Biscay, Calco, Cylinder, Estherville, Ridgeport, Salida, Spillville, and Talcot soils. Except for Calco and Spillville soils, all of these soils are underlain by sand and gravel. Biscay, Calco, and Talco soils are poorly drained. Cylinder soils are somewhat poorly drained, and Spillville soils are somewhat poorly drained to moderately well drained. Estherville soils and Ridgeport soils are somewhat excessively drained, and Salida soils are excessively drained. Other soils of minor extent are Terril soils on foot slopes and Dickman and Lester soils on the sides of valleys. Dickman and Lester soils are well drained.

The soils in the valleys in this association are used mainly for corn, soybeans, small grains, and hay, and the soils on the valley sides are used mainly for grasses for hay and pasture. Most of the soils on bottom lands are subject to flooding. These soils vary widely in fertility, content of organic matter, and available water capacity. The main concerns of management are the droughty characteristics of the sandy soils, which are underlain by sand and gravel. Other management concerns are maintenance of fertility and improvement of drainage or protection from flooding of the low, wet areas.

This soil association is used mainly for cultivated farm crops and for pasture. The hazard of flooding in the valleys and steepness of slopes on the sides of valleys are severe limitations. The main concerns of management are improvement of drainage in low areas and control of erosion on the more sloping valley side slopes.

4. Marshall-Exira association

Nearly level to moderately steep, well drained, silty soils that formed in loess; on uplands

This association consists of soils on ridges, side slopes, and valleys (fig. 6). The areas have well developed drainage systems. The broadest and highest ridge separates the Missouri River watershed to the west from the Mississippi River watershed to the east. Slopes range from 0 to 20 percent.

This association makes up about 35 percent of the county. About 60 percent is Marshall soils and about 20 percent is Exira soils. Soils of minor extent make up about 20 percent.

In most places, Marshall soils are at a higher elevation and are upslope from Exira soils. Both soils have a surface layer of friable silty clay loam.

Typically, the surface layer of the Marshall soils is very dark grayish brown silty clay loam mixed with streaks and patches of brown subsoil material. It is about 8 inches thick. The subsoil is about 35 inches thick. The upper part is dark brown and brown, friable silty clay loam, and the lower part is brown and grayish brown, mottled, friable silty clay loam. The substratum to a depth of 60 inches is grayish brown, mottled, friable silt loam.

Typically, the surface layer of the Exira soils is very dark grayish brown, friable silty clay loam mixed with streaks and patches of brown subsoil material. It is about 8 inches thick. The subsoil is about 33 inches thick. The upper part is brown, friable silty clay loam, the middle part is brown and dark yellowish brown, mottled, friable silty clay loam, and the lower part is yellowish brown, mottled, friable silty clay loam. The substratum to a depth of about 60 inches is yellowish brown and grayish brown, friable silty clay loam.

Of minor extent are Ackmore, Colo, Dickman, Judson, and Zook soils. Ackmore, Colo, and Zook soils are poorly drained and are on bottom lands. The sandy Dickman soils are well drained and are on uplands. Judson soils are well drained and are on foot slopes.

The soils in this association are used mainly for corn, soybeans, small grains, and hay. Some soils on bottom lands along drainageways that are frequently flooded are used for pasture. Fertility, content of organic matter, and available water capacity are high in these soils. The main concern of management is control of water erosion.

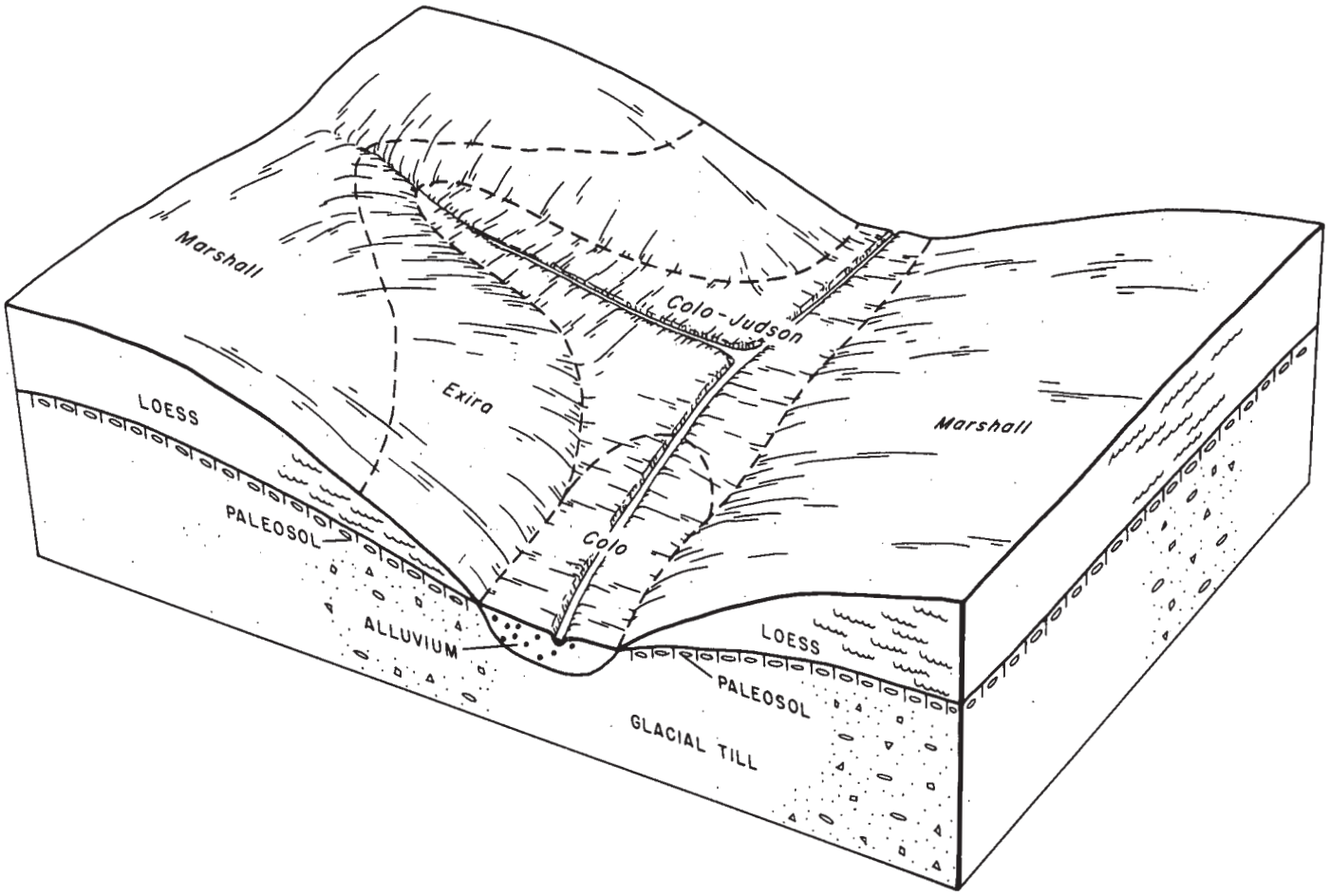

Figure 6.—Typical pattern of soils in the Marshall-Exira association.

5. Marshall-Exira-Burchard association

Nearly level to steep, well drained and moderately well drained, silty and loamy soils that formed in loess and glacial till; on uplands

This association is made up of soils on ridges and side slopes that are dissected by valleys (fig. 7). The ridgetops and upper side slopes consist of silty soils, and the more sloping valley side slopes commonly are glacial till soils that drain into deeply cut valleys. Slopes range from 0 to 25 percent (fig. 8).

This association makes up about 14 percent of the county. About 40 percent is Marshall soils, about 25 percent is Exira soils, and about 15 percent is Burchard soils. Soils of minor extent make up about 20 percent.

In most places, Marshall and Exira soils are at a higher elevation than Burchard soils. Marshall soils are well drained, and Exira soils are well drained or moderately well drained. Both soils have a surface layer of friable silty clay loam and formed in loess. Burchard soils are moderately well drained. They are loamy upland soils that formed in glacial till.

Typically, the surface layer of the Marshall soils is very dark brown silty clay loam mixed with streaks and patches of brown subsoil material. It is about 8 inches thick. The subsoil is about 32 inches thick. The upper part is dark brown and brown, friable silty clay loam, and the lower part is brown and grayish brown, mottled, friable silty clay loam. The substratum to a depth of about 60 inches is grayish brown, mottled, friable silt loam.

Typically, the surface layer of the Exira soils is very dark grayish brown, friable silty clay loam mixed with streaks and patches of brown subsoil material. It is about 8 inches thick. The subsoil is about 28 inches thick. The upper part is brown, friable silty clay loam, the middle part is brown and dark yellowish brown, mottled, friable silty clay loam, and the lower part is yellowish brown,

mottled, friable silty clay loam. The substratum to a depth of about 60 inches is yellowish brown and grayish brown, friable silt loam.

Typically, the surface layer of the Burchard soils is very dark grayish brown clay loam about 7 inches thick. The subsoil is about 15 inches thick. The upper part is brown, firm clay loam, and the lower part is yellowish brown, mottled, firm clay loam. The mottled substratum to a depth of about 60 inches is yellowish brown and grayish brown, firm, calcareous clay loam.

Of minor extent are Ackmore, Adair, Colo, Ida, Judson, Lamoni, and Zook soils. Ackmore, Colo, and Zook soils are poorly drained. They are on bottom lands and formed in alluvium. Adair and Lamoni soils are somewhat poorly drained. They are in uplands and formed in glacial till. Ida soils are well drained. They are in uplands and formed in loess. Judson soils are well drained and are on foot slopes.

Most of the soils in this association are used for soybeans, corn, small grains, and hay. Some areas on bottom lands that are frequently flooded are used for pasture. Hillside seeps commonly develop along the loess-glacial till contact in wet seasons. The main concerns of management are control of water erosion, improvement of drainage in wet areas, and maintenance of tilth and fertility.

6. Colo-Ackmore-Calco association

Nearly level to gently sloping, poorly drained, silty soils that formed in alluvium; on bottom lands

This association consists mainly of silty soils on alluvial flood plains but in some places near the water course are more sandy soils (fig. 9). These soils are subject to flooding. In places, the stream channel has been straightened. Slopes range from 0 to 5 percent.

This association makes up about 6 percent of the county. About 22 percent is Colo soils, 18 percent is Ackmore soils, and 15 percent is Calco soils. Soils of minor extent make up about 45 percent.

Colo, Ackmore, and Calco soils are on bottom lands

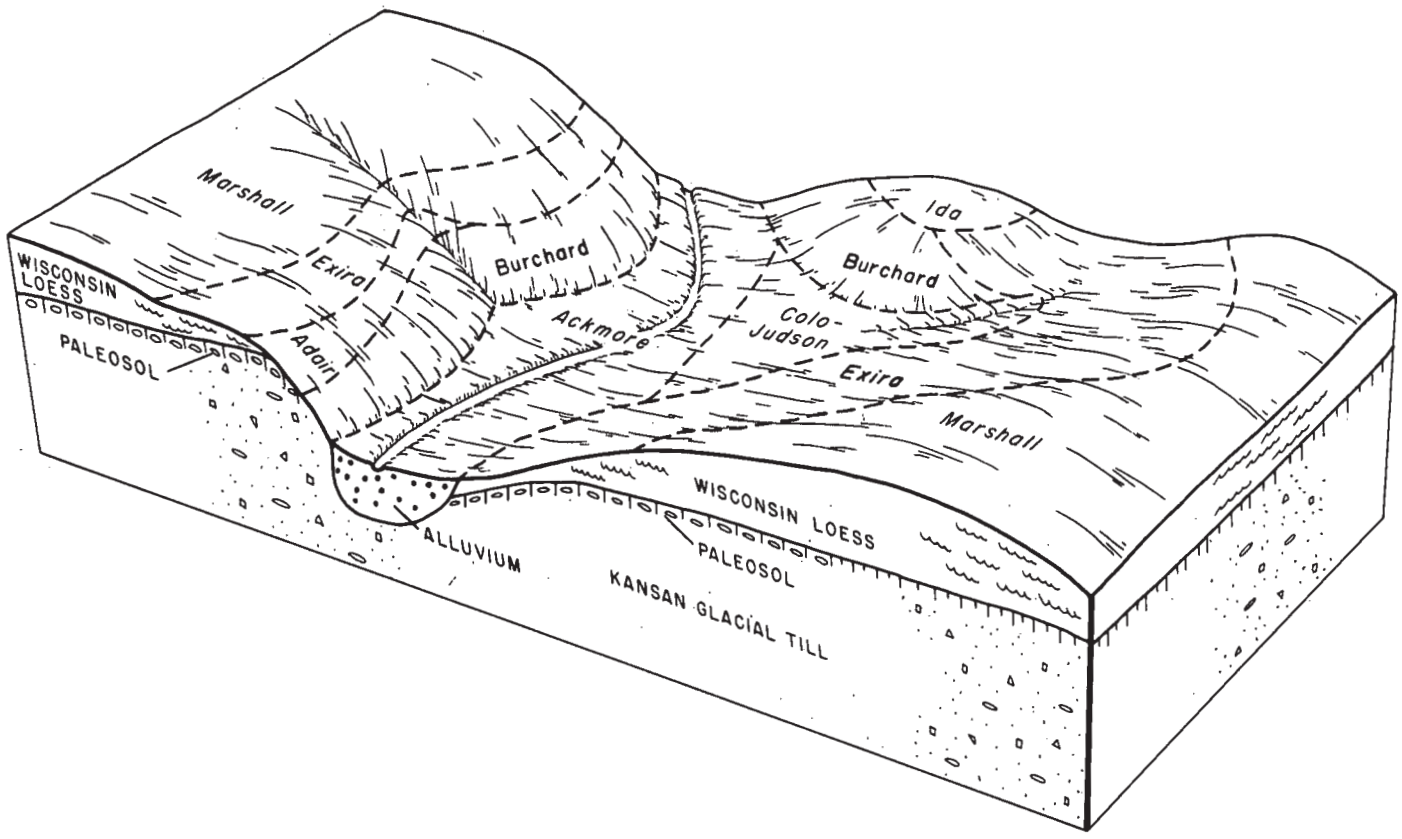

Figure 7—Typical pattern of soils in the Marshall-Exira-Burchard association.

Figure 8.—Typical landscape in the Marshall-Exira-Burchard association. The Exira soils are on the upper part of the slope, and the Burchard soils are on the lower part.

and are poorly drained. They have a seasonal high water table and a silty surface layer. Calco soils have a higher lime content than the other soils.

Typically, the surface layer of the Colo soils is black silty clay loam about 8 inches thick. The subsurface layer is black silty clay loam about 30 inches thick. Below this is a very dark gray, mottled, firm silty clay loam layer about 11 inches thick. The substratum to a depth of about 60 inches is dark gray, mottled, firm silty clay loam.

Typically, the surface layer of the Ackmore soils is very dark grayish brown silt loam about 8 inches thick. The substratum to a depth of about 30 inches is stratified, friable, very dark gray, dark grayish brown, and black silt loam and silty clay loam. Below this to a depth of about 60 inches is a buried soil of black silty clay loam. The upper part is friable, and the lower part is firm.

Typically, the surface layer of the Calco soils is black, calcareous silty clay loam about 8 inches thick. The subsurface layer is black, calcareous silty clay loam about 32 inches thick. The subsoil is very dark gray, friable, calcareous silty clay loam about 8 inches thick. The substratum to a depth of about 60 inches is very dark gray, friable, calcareous silty clay loam.

In the valleys, the soils of minor extent are Biscay, Coland, Cylinder, Judson, Knoke, Marshall, Spillville, Wadena, and Zook soils. Biscay, Cylinder, Coland, Spillville, and Wadena soils are higher in content of sand than the major soils. Biscay, Cylinder, and Wadena soils are on low benches and are underlain by sand and gravel. Biscay and Coland soils are poorly drained. Cylinder soils are somewhat poorly drained. Spillville

soils are mostly somewhat poorly drained, but in places they are moderately well drained. Wadena soils are well drained. Judson soils are on foot slopes and are well drained. Knoke soils are in the uplands and are very poorly drained. Marshall soils are on silty benches that are underlain by alluvium and are well drained.

The soils in this association are used mainly for corn, soybeans, small grains, and hay. Wetness and seasonal flooding are the main limitations to the use of these soils for farming or for other purposes. Most of these soils have been drained.

7. Gara-Knox-Armstrong association

Moderately sloping to very steep, well drained to somewhat poorly drained, loamy and silty soils that formed in glacial till and loess; on uplands

This association is made up of soils on rather narrow ridges and long side slopes that are dissected by valleys (fig. 10). The ridgetops consist of silty soils and the more sloping side slopes are glacial till soils that drain into deeply cut valleys. Slopes range from 4 to 40 percent.

This association makes up about 2 percent of the county. About 40 percent is Gara soils, about 20 percent is Knox soils, and 15 percent is Armstrong soils. Soils of minor extent make up about 25 percent.

Gara soils are on side slopes and are moderately well drained. They have a loam surface layer and formed in glacial till. Knox soils are on ridges above Gara and Armstrong soils and are well drained. They have a silt loam surface layer and formed in loess. Armstrong soils are on the side slopes above Gara soils and are somewhat poorly drained. They have a clayey subsoil and formed in glacial till.

Typically, the surface layer of the Gara soils is dark grayish brown loam about 6 inches thick. The subsoil is about 30 inches thick. The upper part is brown and dark yellowish brown, firm clay loam, the middle part is dark yellowish brown, mottled, firm clay loam; and the lower part is yellowish brown, mottled, firm clay loam. The mottled substratum to a depth of about 60 inches is yellowish brown clay loam.

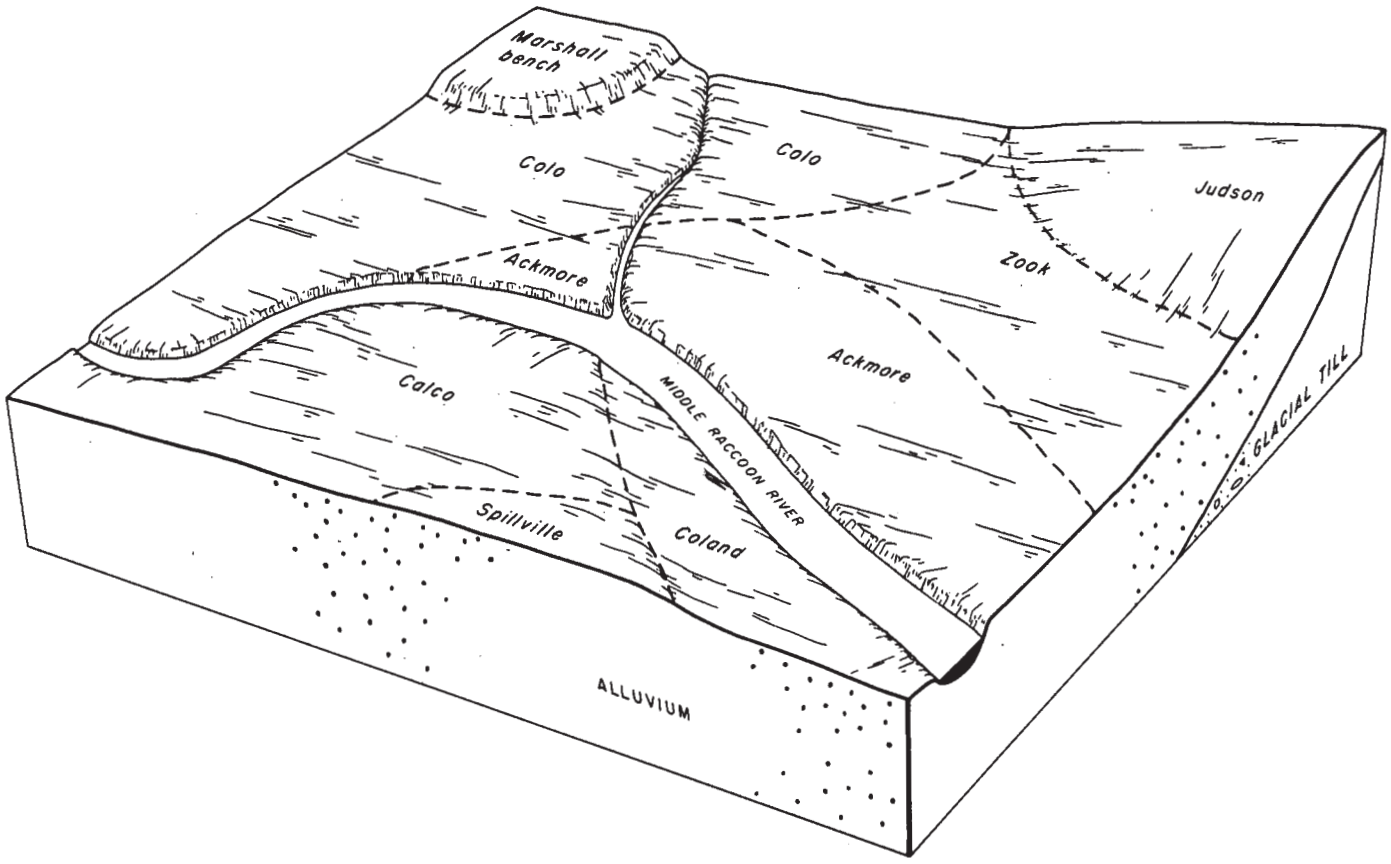

Figure 9.—Typical pattern of soils in the Colo-Ackmore-Calco association.

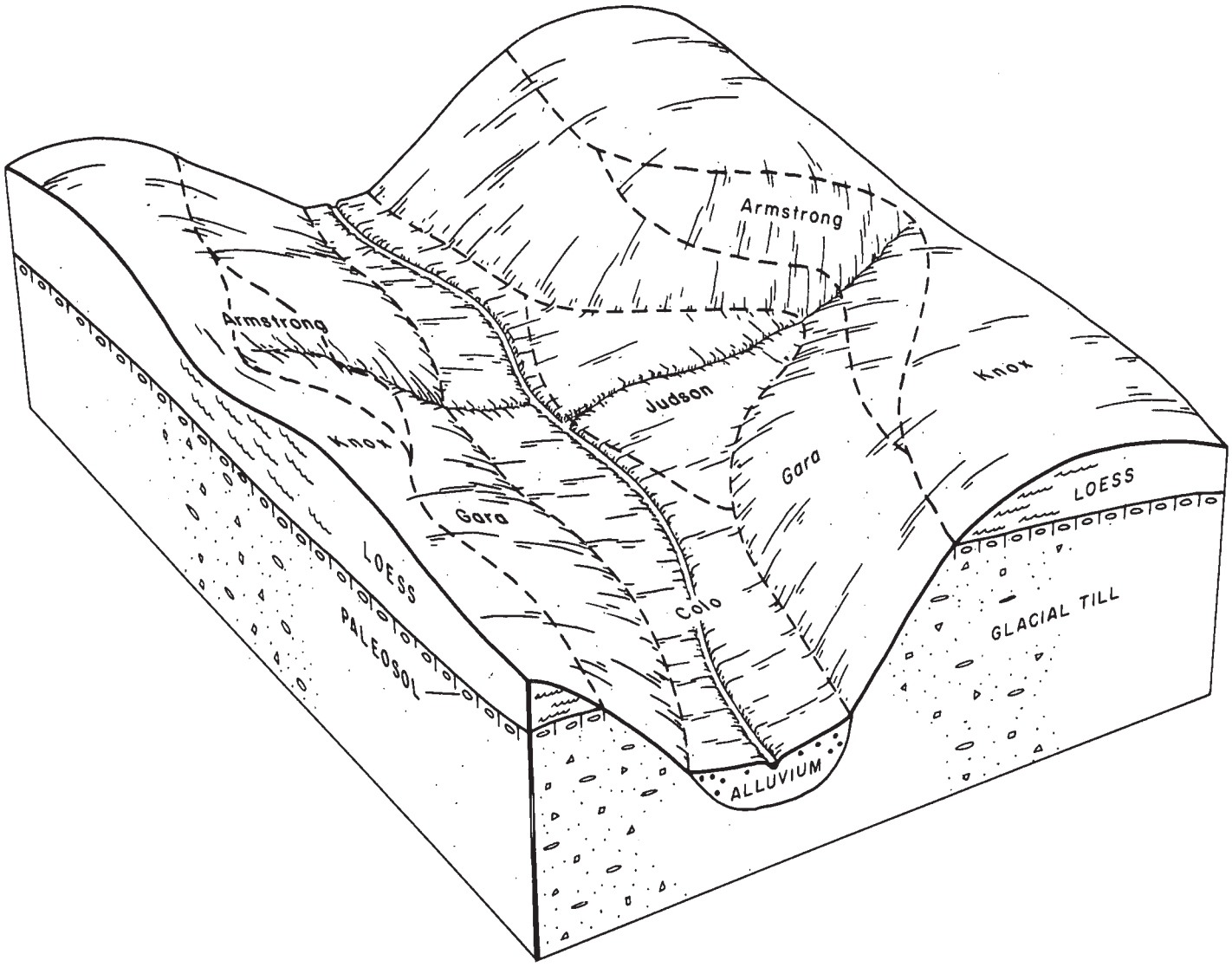

Figure 10.—Typical pattern of soils in the Gara-Knox-Armstrong association.

Typically, the surface layer of the Knox soils is very dark grayish brown silt loam about 6 inches thick. The subsurface layer is brown, friable silt loam about 8 inches thick. The subsoil is dark yellowish brown, mottled, friable silty clay loam about 30 inches thick. The substratum to a depth of about 60 inches is brown, mottled, friable silt loam.

Typically, the surface layer of the Armstrong soils is very dark grayish brown loam about 7 inches thick. The subsoil is about 35 inches thick. The upper part is brown, firm clay loam, the middle part is grayish brown and yellowish brown, firm clay, and the lower part is grayish brown, yellowish brown, and light gray, firm clay loam. A stone line is in the upper part of the subsoil. The mottled substratum to a depth of about 60 inches is light gray and yellowish brown clay loam.

The soils of minor extent in this association are Ackmore, Coland, Colo, Judson, Spillville, and Zook soils. Ackmore, Coland, Colo, and Zook soils are in the valleys on bottom lands and are poorly drained. Spillville soils also are on bottom lands. They are somewhat poorly drained or moderately well drained. Judson soils are on foot slopes and are well drained.

The more sloping soils in this association are used for pasture. Most of the less sloping soils are used for cultivated crops, small grains, and hay. The main concerns of management are control of water erosion and maintenance of fertility.

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 "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 underlying material, 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 underlying material. 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, Clarion loam, 5 to 9 percent slopes, is one of several phases in the Clarion series.

Some map units are made up of two or more major soils. These map units are called soil complexes or undifferentiated groups.

A *soil complex* consists of two or more soils 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. Salida-Storden complex, 5 to 9 percent slopes, 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.

This survey includes *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Pits, gravel, is an example. Miscellaneous areas are shown on the soil maps. Some that are too small to be shown are identified by a special symbol on the soil maps.

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.

1C3—Ida silt loam, 5 to 9 percent slopes, severely eroded. This moderately sloping, well drained soil is on ridges, points of ridges, and side slopes in uplands. Slopes generally are long or grade into adjacent, long slopes. Individual areas range from 2 to 20 acres and are irregular in shape.

Typically, the surface layer is brown, calcareous silt loam about 6 inches thick. Lime nodules are common throughout this layer. The substratum to a depth of about 60 inches is mottled, friable to very friable, calcareous silt loam. The upper part is brown and has common lime nodules, the middle part is light olive brown, and the lower part is light brownish gray. In places the soil is noncalcareous to a depth of 10 to 15 inches and the upper part of the subsoil is not brown.

Included with this soil in mapping are small areas of Adair, Dickman, and Lamoni soils. The clayey Adair and Lamoni soils are on the lower part of the unit and are somewhat poorly drained. The sandy Dickman soils are on the more convex, sloping part of the unit and in places are just above the Adair or Lamoni soils. They are well drained. The included areas make up less than 5 percent of this unit.

This Ida soil is moderately permeable, and surface runoff is rapid. Available water capacity is high. The surface layer is about 0.5 to 1 percent organic matter. Reaction typically is moderately alkaline throughout. The substratum generally is very low in available phosphorus and potassium. This soil is easily tilled.

Most areas of this soil are cultivated, but a few areas are used for hay or pasture. This soil is poorly suited to corn, soybeans, and small grains. It is better suited to grasses and legumes for hay and pasture. If this soil is

used for cultivated crops, the high lime content in the soil increases the possibility of crop damage from herbicides, and damage from further erosion is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, helps to prevent soil loss. Contour farming and terracing are suited to this soil if slopes are long enough. Returning crop residue or the regular addition of other organic matter helps to improve fertility and tilth and increases water infiltration.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing reduces the vegetative cover and increases runoff, which makes the soil more susceptible to erosion. Proper stocking rates and controlled grazing help to keep the pasture and soil in good condition.

This soil is in capability subclass IIIe.

1D3—Ida silt loam, 9 to 14 percent slopes, severely eroded. This strongly sloping, well drained soil is on narrow ridges, points of ridges, and side slopes in uplands. Slopes are long or grade into adjacent, long slopes. Individual areas range from 2 to 20 acres and are irregular in shape.

Typically, the surface layer is brown, calcareous silt loam about 6 inches thick. Lime nodules are common throughout this layer. The mottled substratum to a depth of about 60 inches is friable, calcareous silt loam. The upper part is brown and has common lime nodules, the middle part is light olive brown, and the lower part is light brownish gray. In places the soil is noncalcareous to a depth of 10 to 15 inches and the upper part of the subsoil is not brown.

Included with this soil in mapping are small areas of Adair, Dickman, and Lamoni soils. The clayey Adair and Lamoni soils are on the lower part of the unit and are somewhat poorly drained. The sandy Dickman soils are on the more convex, sloping part of the unit and in places are just above the Adair or Lamoni soils. They are well drained. The included areas make up less than 5 percent of this unit.

This Ida soil is moderately permeable, and surface runoff is rapid. Available water capacity is high. The surface layer is about 0.5 to 1 percent organic matter. Reaction typically is moderately alkaline throughout. The substratum generally is very low in available phosphorus and potassium. This soil is easily tilled.

Most areas of this soil are cultivated, but a few areas are used for hay or pasture. This soil is poorly suited to corn, soybeans, and small grains. It is better suited to grasses and legumes for hay and pasture. If this soil is used for cultivated crops, the high lime content in the soil increases the possibility of crop damage from herbicides, and damage from further erosion is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, helps to prevent soil loss. Contour farming and terracing are suited to this soil if slopes are long enough. Returning crop residue or the regular addition of other organic material helps to improve fertility and tilth and increases water infiltration.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing reduces the vegetative cover and increases runoff, which makes the soil more susceptible to erosion. Proper stocking rates and timely deferment of grazing help to keep the pasture and soil in good condition.

This soil is in capability subclass IIIe.

5B—Ackmore-Judson complex, 1 to 5 percent slopes. These nearly level and gently sloping soils are in valleys and upland drainageways. Individual areas range from 5 to more than 100 acres and are irregular in shape. This map unit is about 60 percent Ackmore soil and 25 percent Judson soil. The poorly drained Ackmore soil is in the lower and less sloping part of the map unit and is subject to flooding. The well drained or moderately well drained Judson soil is fairly uniform in width and is along the upper part of the map unit. It is generally adjacent to and below the steeper, sloping, upland soils. These soils are so intricately mixed or so small that it is not practical to separate them in mapping.

Typically, the surface layer of the Ackmore soil is very dark grayish brown silt loam about 8 inches thick. The subsoil is stratified, very dark gray, dark grayish brown, and black, mottled, friable silt loam about 22 inches thick. The substratum to a depth of about 60 inches is an older buried soil. It is black, friable silty clay loam. In places are small areas of a soil that is similar to the Ackmore soil except the layer of substratum above the buried soil is thinner.

Typically, the surface layer of the Judson soil is black silty clay loam about 8 inches thick. The subsurface layer is black and very dark grayish brown silty clay loam about 17 inches thick. The subsoil is dark brown and brown, friable silty clay loam about 18 inches thick. The substratum to a depth of about 60 inches is brown, mottled, friable silty clay loam. In places are small areas of a soil that is similar to the Judson soil except the subsoil is dark grayish brown.

Included with these soils in mapping are small areas of poorly drained Colo and Zook soils. They are not stratified and do not have a buried layer. These soils are in depressed areas between the Ackmore and Judson soils. The included areas make up about 15 percent of this unit.

The Ackmore and Judson soils are moderately permeable. Surface runoff is slow. The Ackmore soil has a seasonal high water table. The surface layer of the Ackmore soil is about 2 to 4 percent organic matter, and the surface layer of the Judson soil is about 4 to 5 percent. In both soils, reaction typically is medium acid, and the subsoil generally is low in available phosphorus and potassium. These soils are easily tilled unless they are wet.

Most areas of these soils are cultivated. The soils are suited to corn, soybeans, small grains, and grasses for hay or pasture. If these soils are cultivated, wetness caused by flooding or the seasonal high water table is a hazard for the Colo soil. The use of diversion terraces on foot slopes just above this unit and the installation of surface or tile drains help to control excessive wetness.

The use of these soils for pasture or hay is an effective means of controlling erosion in areas that are subject to more frequent flooding. Overgrazing or grazing when the soils are too wet, however, causes surface compaction and puddling and results in lower productivity. Proper stocking rates, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soils in good condition.

These soils are moderately suited to trees, and a few small areas remain in native hardwoods. Because the soils are poorly drained, the use of equipment needs to be restricted to drier times of the year or to the winter months when the ground is frozen. Special high flotation equipment can be used in harvesting or management during wet periods. Because natural and planted seedlings do not survive well, seedlings should be spaced closely together in planting. The surviving trees can be thinned later to achieve the desired stand density. Competing vegetation needs to be controlled during site preparation or by spraying or cutting. Erosion is not a limiting factor on these soils during logging and related road construction.

The soils in this complex are in capability subclass IIw.

6—Okoboji silty clay loam, 0 to 1 percent slopes. This level or nearly level, very poorly drained soil is in slight depressions in uplands. It is subject to ponding (fig. 11). Individual areas are commonly 2 to 5 acres but range to 30 acres or more. Areas generally are somewhat round but are irregular in shape in places.

Typically, the surface layer is black silty clay loam about 8 inches thick, and the subsurface layer is black silty clay loam about 19 inches thick. The subsoil is about 22 inches thick. The upper part is very dark gray, firm silty clay loam, the middle part is olive gray and dark gray, mottled, firm clay loam, and the lower part is gray and olive gray, firm, calcareous silty clay loam. The substratum to a depth of about 60 inches is gray, mottled, friable clay loam. In places in small areas the surface layer is mucky silt loam as much as 20 inches thick or silt loam as much as 24 inches thick.

Included with this soil in mapping at slightly higher elevations are small areas of poorly drained, highly calcareous Harps soil. The included areas make up about 10 percent of this unit.

Permeability is moderately slow in this Okoboji soil, and runoff from the surrounding soils ponds on this soil. The soil has a seasonal high water table. Available water capacity is high. The surface layer is about 9 to 10 percent organic matter, and typically is mildly alkaline in reaction. The subsoil generally is very low in available phosphorus and low or very low in available potassium. This soil is easily tilled unless it is wet.

Figure 11.—Typical area of very poorly drained Okoboji silty clay loam, 0 to 1 percent slopes.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture if it is adequately drained. After heavy rains, this soil is ponded in depressional areas. The surface layer puddles easily if worked when wet. The installation of deep tiling or surface drains is needed to reduce excessive wetness.

This soil is in capability subclass IIIw.

8B—Judson silty clay loam, 2 to 5 percent slopes. This gently sloping, moderately well drained or well drained soil is on foot slopes or alluvial fans. Individual areas range from 3 to 20 acres and are irregular in shape.

Typically, the surface layer is very dark brown silty clay loam about 8 inches thick. The subsurface layer is about 20 inches thick. It is black in the upper part and very dark grayish brown in the lower part. The subsoil is dark brown and brown, friable silty clay loam about 18 inches

thick. The substratum to a depth of about 60 inches is brown, mottled, friable silty clay loam. In places on the lower and more gentle slopes the subsoil is dark grayish brown.

Included with this soil in mapping are small areas of Colo, Exira, and Marshall soils. The Colo soil is poorly drained and is on lower, less sloping areas than Judson soils. The Exira and Marshall soils have a thinner surface layer and less content of organic matter and are along higher, more sloping places in the upper part of the map unit. The included areas make up 5 to 15 percent of this unit.

This Judson soil is moderately permeable, and surface runoff is moderately slow. Available water capacity is high. The surface layer is about 4 to 5 percent organic matter and typically is slightly acid in reaction. The large amount of organic matter helps to maintain a porous topsoil, which increases water infiltration and reduces water runoff. The subsoil generally is low in available phosphorus and potassium. This soil is easily tilled unless it is wet.

Most areas of this soil are cultivated. This soil is suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture. Erosion and siltation resulting from overflow from adjacent uplands are hazards, however, if this soil is used for cultivated crops. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, helps to prevent soil loss and siltation. Erosion control practices, such as contouring and terracing, are suited to this soil. Diversion terraces are also used to control erosion.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and increases runoff. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIe.

8C—Judson silty clay loam, 5 to 9 percent slopes. This moderately sloping, moderately well drained or well drained soil is on foot slopes or alluvial fans. Individual areas range from 3 to 45 acres and are irregular in shape.

Typically, the surface layer is very dark brown silty clay loam about 8 inches thick. The subsurface layer is about 17 inches thick. It is black in the upper part and very dark grayish brown in the lower part. The subsoil is dark brown and brown, friable silty clay loam about 18 inches thick. The substratum to a depth of about 60 inches is brown, mottled, friable silty clay loam. In places the subsoil is dark grayish brown.

Included with this soil in mapping are small areas of Colo, Exira, and Marshall soils. The poorly drained Colo soil is on the lower, less sloping areas. The Exira and Marshall soils have a thinner surface layer and less content of organic matter than Judson soils and are along the higher, more sloping places in the upper part of the unit. The included areas make up about 5 to 15 percent of this unit.

This Judson soil is moderately permeable, and surface runoff is medium. Available water capacity is high. The surface layer is about 4 to 5 percent organic matter and typically is slightly acid in reaction. The large amount of organic matter in the surface layer helps to maintain a porous topsoil, which increases water infiltration and reduces water runoff. The subsoil generally is low in available phosphorus and potassium. This soil is easily tilled unless it is wet.

Most areas of this soil are cultivated. This soil is suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture. Erosion and siltation resulting from overflow from adjacent uplands are hazards, however, if this soil is used for cultivated crops. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, helps to prevent soil loss and siltation. Erosion control practices, such as contouring and terracing, are suited to this soil. Diversion terraces are used.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and increases runoff. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIIe.

9—Marshall silty clay loam, 0 to 2 percent slopes. This nearly level, well drained soil is on ridgetops in uplands. Individual areas range from 5 to more than 80 acres but are commonly less than 20 acres. They are irregular in shape.

Typically, the surface layer is very dark brown silty clay loam about 8 inches thick. The subsurface layer is very dark brown silty clay loam about 10 inches thick. The subsoil is about 42 inches thick. The upper part is dark brown and brown, friable silty clay loam, the middle part is brown, mottled, friable silty clay loam, and the lower part is grayish brown, mottled, friable silty clay loam. In places mottles are common at a depth of less than 30 inches.

Included with this soil in mapping, on ridgetops, are small areas of a nearly level, somewhat poorly drained soil that has a dark grayish brown subsoil. Also included, in slight depressions, are very small areas of a very poorly drained soil that has a light colored subsurface layer. The included areas make up about 10 percent of this unit.

This Marshall soil is moderately permeable, and surface runoff is medium. Available water capacity is high. The surface layer is about 3 to 4 percent organic matter and typically is slightly acid in reaction. The

subsoil generally is low in available phosphorus and potassium. This soil is easily tilled.

Most areas of this soil are cultivated. This soil is suited to corn, soybeans, small grains, and grasses and legumes for hay or pasture. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, helps to prevent soil loss by wind erosion. Returning crop residue or the regular addition of other organic material helps to improve fertility and maintain good tilth.

If this soil is used for pasture, proper stocking rates and restricted use during wet periods help to maintain pasture and soil productivity.

This soil is in capability class I.

9B—Marshall silty clay loam, 2 to 5 percent slopes. This gently sloping, well drained soil is on ridges and side slopes in uplands. Individual areas range from 10 to more than 100 acres and are irregular in shape. Slopes generally are long or grade into adjacent, long slopes.

Typically, the surface layer is very dark brown silty clay loam about 7 inches thick. The subsurface layer is very dark brown and very dark grayish brown silty clay loam about 11 inches thick. The subsoil is about 40 inches thick. The upper part is dark brown and brown, friable silty clay loam, the middle part is brown, mottled, friable silty clay loam, and the lower part is grayish brown, mottled, friable silty clay loam. The substratum to a depth of about 60 inches is grayish brown, mottled, friable silt loam. In places mottles are common at a depth of less than 30 inches.

Included with this soil in mapping, on ridgetops, are small areas of a nearly level, somewhat poorly drained soil that has a dark grayish brown subsoil. Also included are small areas of sandy Dickman soil that are somewhat excessively drained. They are on more convex slopes and have low available water capacity. The included areas make up about 10 percent of the unit.

This Marshall soil is moderately permeable, and surface runoff is medium. The surface layer is about 3 to 4 percent organic matter and typically is slightly acid in reaction. The subsoil generally is low in available phosphorus and potassium. This soil is easily tilled unless it is wet.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture. Erosion is a hazard, however, if this soil is used for cultivated crops. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, helps to prevent soil loss. Erosion control practices, such as contouring and terracing, are suited to this soil. Returning crop residue or the regular addition of other organic material helps to improve fertility, maintain good tilth, and reduce erosion.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and increases runoff. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIe.

9B2—Marshall silty clay loam, 2 to 5 percent slopes, moderately eroded. This gently sloping, well drained soil is on ridges and side slopes in uplands. Slopes generally are long or grade into adjacent, long slopes. Individual areas range from 5 to more than 200 acres and are irregular in shape.

Typically, the surface layer is very dark brown silty clay loam mixed with streaks and patches of brown subsoil material. It is about 8 inches thick. The subsoil is about 37 inches thick. The upper part is brown, friable silty clay loam, and the lower part is brown and grayish brown, mottled, friable silty clay loam. The substratum to a depth of about 60 inches is grayish brown, mottled, friable silt loam. In places mottles are common at a depth of less than 30 inches. In other places the soil has a higher content of silt and lower content of clay.

Included with this soil in mapping are small areas of Adair, Dickman, and Ida soils. The Adair soil is in the lower part of the unit and is somewhat poorly drained. The Dickman and Ida soils are on the more convex, sloping part of the unit and in places are just above the Adair soils. The Dickman soil has low available water capacity. The Ida soil is calcareous. The included areas make up about 5 percent of this unit.

This Marshall soil is moderately permeable, and surface runoff is medium. Available water capacity is high. The surface layer is about 2 to 3 percent organic matter and typically is slightly acid in reaction. The subsoil generally is low in available phosphorus and potassium. This soil is easy to till unless it is wet.

Most areas of this soil are cultivated. This soil is suited to corn, soybeans, small grains, and grasses and legumes for hay or pasture. Damage from further erosion is a hazard, however, if this soil is used for cultivated crops. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, helps to prevent soil loss. Erosion control practices, such as contouring and terracing, are suited to this soil. Returning crop residue or the regular addition of other organic material helps to improve fertility, reduce crusting and the formation of clods, increase water infiltration, and improve tilth.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increases runoff, and results in poorer tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIe.

9C—Marshall silty clay loam, 5 to 9 percent slopes. This moderately sloping, well drained soil is on ridges and side slopes in uplands. Slopes generally are long or grade into adjacent, long slopes. Individual areas range from 2 to 25 acres and are irregular in shape.

Typically, the surface layer is very dark brown silty clay loam about 8 inches thick. The subsurface layer is very dark brown silty clay loam about 5 inches thick. The subsoil is about 36 inches thick. The upper part is dark brown and brown, friable silty clay loam, and the lower part is brown and grayish brown, mottled, friable silty clay loam. The substratum to a depth of about 60 inches is grayish brown, mottled, friable silt loam. In places the surface layer is thinner and mottles are common at a depth of less than 30 inches. In other places the soil has a higher content of silt and lower content of clay.

Included with this soil in mapping are small areas of Adair, Dickman, and Ida soils. The Adair soil is in the lower part of the unit and is somewhat poorly drained. The Dickman and Ida soils are on the more convex, sloping part of the unit and in places are just above the Adair soil. The Dickman soil has low available water capacity. The Ida soil is calcareous. The included areas make up about 5 percent of this unit.

This Marshall soil is moderately permeable, and surface runoff is medium. Available water capacity is high. The surface layer is about 3 to 4 percent organic matter and typically is slightly acid in reaction. The subsoil generally is low in available phosphorus and potassium. This soil is easy to till.

Most areas of this soil are cultivated. This soil is suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture. Erosion is a hazard, however, if this soil is used for cultivated crops. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent soil loss. Erosion control practices, such as contouring and terracing, are suited to this soil. Returning crop residue or the regular addition of other organic material helps to improve fertility and maintain good tilth.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increases runoff, and results in poorer tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIIe.

9C2—Marshall silty clay loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, well drained soil is on ridges and side slopes in uplands. Slopes generally are long or grade into adjacent, long slopes. Individual areas range from 10 to more than 100 acres and are irregular in shape. This soil is generally upslope from drainageways.

Typically, the surface layer is very dark grayish brown silty clay loam mixed with streaks and patches of brown subsoil material. It is about 8 inches thick. The subsoil is about 35 inches thick. The upper part is dark brown and brown, friable silty clay loam, and the lower part is brown and grayish brown, mottled, friable silty clay loam. The substratum to a depth of about 60 inches is grayish brown, mottled, friable silt loam. In places along small drainageways on hillsides the surface layer is thicker and the subsoil is grayer and commonly mottled at a depth of less than 30 inches. In places the soil has a higher content of silt and lower content of clay.

Included with this soil in mapping are small areas of Adair, Dickman, and Ida soils. The Adair soil is in the lower part of the unit and is somewhat poorly drained. The Dickman and Ida soils are on the more convex, sloping part of the unit and in places are just above the Adair soils. The sandy Dickman soil has low available water capacity. The Ida soil is calcareous. The included areas make up about 10 percent of this unit.

This Marshall soil is moderately permeable, and surface runoff is medium. Available water capacity is high. The surface layer is about 2 to 3 percent organic matter and typically is slightly acid in reaction. The subsoil generally is low in available phosphorus and potassium. This soil is in good tilth.

Most areas of this soil are cultivated. This soil is suited to corn, soybeans, small grains, and grasses and legumes for hay or pasture. Damage from further erosion is a hazard, however, if this soil is used for cultivated crops. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent soil loss. Erosion control practices, such as contouring and terracing, are suited to this soil. Returning crop residue or the regular addition of other organic material helps to improve fertility, maintain good tilth, reduce erosion and crusting, and increase water infiltration. Increasing the amount of organic matter in the surface layer also helps to reduce puddling in wet weather and lessen the hardness of soil clods in very dry weather.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increases runoff and erosion, and results in poorer tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIIe.

9D2—Marshall silty clay loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping, well drained soil is on side slopes in uplands. Individual areas range from 5 to more than 100 acres. Slopes generally are long or grade into adjacent, long slopes.

Typically, the surface layer is very dark grayish brown silty clay loam mixed with streaks and patches of brown subsoil material. It is about 8 inches thick. The subsoil is about 32 inches thick. The upper part is dark brown and brown, friable silty clay loam, and the lower part is brown and grayish brown, mottled, friable silty clay loam. The substratum to a depth of about 60 inches is grayish brown, mottled, friable silt loam. In places along small drainageways on hillsides the surface layer is thicker and the subsoil is grayer. In places the soil has a higher content of silt and lower content of clay.

Included with this soil in mapping and making up about 10 percent of the unit are small areas of Adair, Burchard, Dickman, Ida, and Lamoni soils. The Adair and Lamoni soils are on shoulders of ridges or on side slopes in the lower part of the unit. They have slower permeability and are higher in content of clay than Marshall soils. The Dickman and Ida soils are on more convex, sloping places and in places are just above the Adair, Burchard, and Lamoni soils. The sandy Dickman soil has low available water capacity. The Ida soil is calcareous. The Burchard soil is on the lower part of the slope. It has slower permeability than Marshall soils and contains pebbles and gravel-size particles. The included areas make up about 10 percent of this unit.

This Marshall soil is moderately permeable, and surface runoff is rapid. Available water capacity is high. The surface layer is about 2 to 3 percent organic matter and is slightly acid in reaction. The subsoil generally is low in available phosphorus and potassium. This soil is in good tilth.

Most areas of this soil are cultivated. This soil is suited to corn, soybeans, small grains, and grasses and legumes for hay or pasture. Damage from further erosion is a hazard, however, if this soil is used for cultivated crops. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent soil loss. Erosion control practices, such as contouring and terracing, are suited to this soil. Returning crop residue or the regular addition of other organic material helps to improve fertility, maintain good tilth, reduce erosion and crusting, and increase water infiltration. Increasing the amount of organic matter in the surface layer also helps to reduce puddling in wet weather and lessen the hardness of soil clods in very dry weather.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increases runoff and erosion, and results in poorer tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIIe.

9E2—Marshall silty clay loam, 14 to 20 percent slopes, moderately eroded. This moderately steep, well drained soil is on side slopes in uplands. Slopes generally are long or grade into adjacent slopes. Individual areas range from 5 to 20 acres and are irregular in shape.

Typically, the surface layer is very dark grayish brown silty clay loam mixed with streaks and patches of brown subsoil material. It is about 8 inches thick. The subsoil is about 27 inches thick. The upper part is dark brown and brown, friable silty clay loam, and the lower part is grayish brown, mottled, friable silty clay loam. The substratum to a depth of about 60 inches is grayish brown, mottled, friable silt loam. In places the soil is thinner and has more content of silt.

Included with this soil in mapping and making up about 10 percent of the unit are small areas of Adair, Burchard, Dickman, Ida, and Lamoni soils. The Adair and Lamoni soils are on shoulders of ridges or on side slopes in the lower part of the unit. They have slower permeability and are higher in content of clay than Marshall soils. The Dickman and Ida soils are on the more convex, sloping places and in places are just above the Adair, Burchard, and Lamoni soils. The sandy Dickman soil has low available water capacity. The Ida soil is calcareous. The Burchard soil is on the lower part of the slope. It has slower permeability than Marshall soils and contains pebbles and gravel-size particles. The included areas make up about 10 percent of the unit.

This Marshall soil is moderately permeable, and surface runoff is rapid. Available water capacity is high. The surface layer is about 2 to 3 percent organic matter and is slightly acid in reaction. The subsoil generally is low in available phosphorus and potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to grasses and legumes for hay or pasture and has limited suitability for cultivated crops. If the soil is used for cultivated crops, however, damage from further erosion is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Erosion control practices, such as contouring and terracing, are suited to this soil. Returning crop residue or the regular addition of other organic material helps to improve fertility, maintain good tilth, reduce surface crusting, and increase water infiltration. Increasing the amount of organic matter in the surface layer also helps to reduce puddling in wet weather and lessen the hardness of soil clods in very dry weather.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increases runoff and soil erosion, and results in poorer tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use

during wet periods help to keep the pasture and soil in good condition.

This soil is well suited to trees. Tree seeds, cuttings, and seedlings survive and grow well if competing vegetation is removed during site preparation or controlled by spraying, cutting, and girdling. The hazard of erosion is severe if this soil is not protected. Adequate vegetative cover needs to be maintained on the surface of the soil.

This soil is in capability subclass IVe.

11B—Colo-Judson silty clay loams, 2 to 5 percent slopes. These gently sloping, poorly drained and moderately well drained soils are in valleys and upland drainageways. Individual areas range from 10 to more than 40 acres and are irregular in shape. This map unit ranges from 60 to 80 percent Colo soil and from 20 to 25 percent Judson soil. The proportion of Colo soil decreases and the proportion of Judson soil increases in the narrow, upper parts of the valleys. The Colo soil is on the less sloping and lower part of the map unit. It is subject to flooding. The Judson soil is on the higher and more sloping part of the map unit. It is below the steeper upland soils along the edge of the valley. These soils are so intricately mixed or so small that it is not practical to separate them in mapping.

Typically, the surface layer of the Colo soil is black silty clay loam about 8 inches thick. The subsurface layer is black silty clay loam about 30 inches thick. Below this is a very dark gray, mottled, friable silty clay loam layer about 11 inches thick. The substratum to a depth of about 60 inches is dark gray, mottled, friable silty clay loam. In places the surface layer is multicolored, black, dark gray, and grayish brown silt loam overwash.

Typically, the surface layer of the Judson soil is very dark brown silty clay loam about 8 inches thick. The subsurface layer is black and very dark grayish brown silty clay loam about 17 inches thick. The subsoil is dark brown and brown, friable silty clay loam about 18 inches thick. The substratum to a depth of about 60 inches is brown, mottled, friable silty clay loam. In places at the lower end of slopes, the subsoil is dark grayish brown.

Included with these soils in mapping are small areas of Ackmore and Zook soils. These soils are on the flood plain or the more nearly level part of the map unit together with the Colo soil. The Ackmore soil is stratified and has a buried soil. The Zook soil has a higher content of clay than Colo soil. The included areas make up about 15 percent of this unit.

These Colo and Judson soils are moderately permeable. Surface runoff is slow. The Colo soil has a seasonal high water table. Available water capacity is high in both soils. The surface layer of the Judson soil is about 4 to 5 percent organic matter and that of the Colo soil about 5 to 7 percent. In both soils the surface layer typically is neutral or slightly acid in reaction, and the subsoil generally is medium or low in available phosphorus and potassium. These soils are in good tilth.

Most areas of these soils are cultivated. The soils are suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture. If the soils are cultivated, however, wetness caused by flooding or the seasonal high water table is a hazard. The use of diversion terraces on foot slopes above these soils and the installation of surface or tile drains help to control excessive wetness.

The use of these soils for pasture or hay is helpful in areas that are subject to more frequent flooding. Overgrazing or grazing when the soils are too wet, however, causes surface compaction and puddling and results in lower productivity. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soils in good condition.

These soils are in capability subclass IIw.

27B—Terril loam, 2 to 5 percent slopes. This gently sloping, moderately well drained soil is on foot slopes and alluvial fans. Individual areas range from 3 to 10 acres and are generally long and narrow and have somewhat irregular boundaries. These areas extend horizontally along the edges of valleys below steeper sloping uplands.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is black and very dark brown loam about 25 inches thick. The subsoil is about 30 inches thick. The upper part is dark brown, friable loam, and the middle and lower parts are brown, friable loam. In places the surface layer has an accumulation of light colored, sandy overwash sediment several inches thick.

Included with this soil in mapping are small areas of Clarion and Spillville soils. The Clarion soils are on the higher and more sloping part of the map unit. They are lower in content of organic matter than Terril soils. The Spillville soil is on the lower part of the unit and is more poorly drained than Terril soils. The included areas make up about 10 percent of this unit.

This Terril soil is moderately permeable, and surface runoff is medium. Available water capacity is high. The surface layer is about 4 to 5 percent organic matter and typically is slightly acid in reaction. The subsoil generally is very low in available phosphorus and very low or low in available potassium. This soil is easily tilled.

Most areas of this soil are cultivated. The soil is in good tilth. Where the soil is used for cultivated crops, erosion caused by runoff from soils upslope is a hazard. In addition, heavy rains can cause the deposition of eroded sediment from the steeper soils upon young plants. Conservation practices on the soils upslope that reduce runoff and erosion help to protect this Terril soil. Using diversion terraces along the upper edge of this soil, contour farming, and terracing are suitable measures. Returning crop residue or the regular addition of other organic material helps to increase water infiltration.

The use of this soil for pasture or hay is an effective

means of controlling erosion if the pasture is not overgrazed.

This soil is in capability subclass IIe.

27C—Terril loam, 5 to 9 percent slopes. This moderately sloping, moderately well drained soil is on foot slopes and alluvial fans. Individual areas range from 3 to 15 acres and are generally long and narrow and have somewhat irregular boundaries. These areas extend horizontally along the edges of valleys below steeper sloping uplands.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is black and very dark brown loam about 24 inches thick. The subsoil typically is about 28 inches thick. The upper part is dark brown, friable loam, and the middle and lower parts are brown, friable loam. In places the surface layer has an accumulation of lighter colored, sandy overwash sediment several inches thick.

Included with this soil in mapping are small areas of Clarion and Dickman soils. These soils are on the higher and more sloping part of the map unit. They are much lower in content of organic matter than Terril soils. The included areas make up about 10 percent of this unit.

This Terril soil is moderately permeable, and surface runoff is medium. Available water capacity is high. The surface layer is about 4 to 5 percent organic matter and typically is slightly acid in reaction. The subsoil generally is very low in available phosphorus and very low or low in available potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay or pasture. Where the soil is used for cultivated crops, however, erosion caused by runoff from soils upslope is a hazard. In addition, heavy rains can cause the deposition of eroded sediment from the steeper soils upon young plants. Conservation practices on the soils upslope that reduce runoff and erosion help to protect this Terril soil. Using diversion terraces along the upper edge of this soil, contour farming, and terracing are suitable measures. Returning crop residue or the regular addition of other organic material helps to increase water infiltration.

The use of this soil for pasture or hay is an effective means of controlling erosion if the pasture is not overgrazed.

This soil is in capability subclass IIe.

28B—Dickman sandy loam, 2 to 5 percent slopes. This gently sloping, well drained soil is on uplands. Individual areas range from 2 to 30 acres and are irregular in shape.

Typically, the surface layer is very dark brown sandy loam about 8 inches thick. The subsurface layer is very dark brown loam about 4 inches thick. The subsoil is about 30 inches thick. The upper part is dark brown, very friable sandy loam, and the lower part is brown, loose sand. Loamy sand is at a depth of about 20 inches. The substratum to a depth of about 60 inches is dark yellowish brown and brown sand. In places the substratum is fine sand.

Included with this soil in mapping are small areas of Ida soils in the southwestern part of the county and Clarion soils in the northeastern part. These areas are on the less convex, sloping places in the unit. The Ida soil is silty and calcareous, and the Clarion soil is loamy. Both of these soils have slower permeability and higher available water capacity than Dickman soils. The included areas make up about 5 percent of this unit.

Permeability is moderately rapid in this Dickman soil, and surface runoff is slow. Available water capacity is low in the surface layer and subsoil and very low in the substratum. The surface layer is about 2 to 5 percent organic matter and typically is slightly acid in reaction. The subsoil generally is low in available phosphorus and very low to low in available potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay or pasture. It is droughty during dry periods. If the soil is used for cultivated crops, erosion damage caused by wind and water is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Returning crop residue or the regular addition of other organic material helps to improve fertility, maintain good tilth, and reduce erosion.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing destroys the vegetative cover and increases the erosion hazard. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is well suited to trees. However, native hardwoods generally are not suited to soils that have been in cultivation or to soils that are moderately eroded or severely eroded. Hardwoods apparently require a good site and grow better if they are planted on uncultivated soils. Conifers are better suited to eroded or formerly cultivated soils.

This soil is in capability subclass IIIe.

28B2—Dickman sandy loam, 2 to 5 percent slopes, moderately eroded. This gently sloping, well drained soil is on uplands. Individual areas range from 2 to 15 acres and are irregular in shape.

Typically, the surface layer is very dark brown sandy loam mixed with streaks and patches of dark brown subsoil material. It is about 6 inches thick. The subsoil is about 28 inches thick. The upper part is dark brown, very friable sandy loam, and the lower part is dark yellowish brown, loose loamy sand. Loamy sand is at a depth of about 16 inches. The substratum to a depth of about 60 inches is dark yellowish brown and brown sand. In places the substratum is fine sand.

Included with this soil in mapping are small areas of Ida soils in the southwestern part of the county and

Clarion soils in the northeastern part. These soils are on the less steep part of the unit. The Ida soil is silty and calcareous, and the Clarion soil is loamy. Both soils have slower permeability and higher available water capacity than Dickman soils. The included areas make up about 5 percent of this unit.

Permeability is moderately rapid in this Dickman soil, and surface runoff is slow. Available water capacity is low in the surface layer and subsoil and very low in the substratum. The surface layer is about 1 to 2 percent organic matter and typically is medium acid in reaction. The subsoil generally is low in available phosphorus and very low or low in available potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay or pasture. It is droughty during dry periods. If the soil is used for cultivated crops, erosion damage caused by wind and water is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Returning crop residue or the regular addition of other organic material helps to improve fertility, maintain good tilth, and reduce erosion.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing destroys the vegetative cover and increases the erosion hazard. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is well suited to trees. However, native hardwoods generally are not suited to soils that have been in cultivation or to moderately eroded or severely eroded soils. Hardwoods apparently require a good site and grow better if they are planted on uncultivated soils. Conifers are better suited to eroded or formerly cultivated soils.

This soil is in capability subclass IIIe.

28C2—Dickman sandy loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, well drained soil is on uplands. Individual areas range from 2 to 20 acres and are irregular in shape.

Typically, the surface layer is very dark brown sandy loam mixed with streaks and patches of dark brown subsoil material. It is about 6 inches thick. The subsoil is about 25 inches thick. The upper part is dark brown, very friable sandy loam, the middle part is brown, very friable loamy sand, and the lower part is dark yellowish brown, loose loamy sand. Loamy sand is at a depth of about 15 inches. The substratum to a depth of about 60 inches is dark yellowish brown and brown sand. In places the substratum is fine sandy loam.

Included with this soil in mapping are small areas of Marshall soils in the southwestern part of the county and Clarion and Storden soils in the northeastern part. The Marshall soil is on long, convex, sloping places and is silty Clarion and Storden soils are on the steeper places and are loamy. The Storden soil is calcareous. All of these soils have slower permeability and higher available water capacity than Dickman soils. The included areas make up about 10 percent of this unit.

Permeability is moderately rapid in this Dickman soil, and surface runoff is medium. Available water capacity is low in the surface layer and subsoil and very low in the substratum. The surface layer is about 1 to 2 percent organic matter. Reaction typically is medium acid in the surface layer and subsoil. The subsoil generally is low in available phosphorus and very low or low in available potassium. This soil is in good tilth.

Most areas of this soil are cultivated. This soil is suited to corn, soybeans, small grains, and grasses and legumes for hay or pasture. It is droughty during dry periods. If the soil is used for cultivated crops, however, erosion damage caused by wind and water is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Returning crop residue or the regular addition of other organic material helps to improve fertility, maintain good tilth, and reduce erosion.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing destroys the vegetative cover and increases the erosion hazard. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is well suited to trees. However, native hardwoods generally are not suited to soils that have been in cultivation or to moderately eroded or severely eroded soils. Hardwoods apparently require a good site and grow better if they are planted on uncultivated soils. Conifers are better suited to eroded or formerly cultivated soils.

This soil is in capability subclass IVe.

28D2—Dickman sandy loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping, well drained soil is in uplands. Individual areas range from 2 to 20 acres and are irregular in shape.

Typically, the surface layer is very dark brown sandy loam mixed with streaks and patches of brown subsoil material about 6 inches thick. The subsurface layer is dark brown sandy loam about 7 inches thick. The subsoil is about 18 inches thick. The upper part is brown, very friable sandy loam, and the lower part is dark yellowish brown, loose loamy sand. Loamy sand is at a depth of about 32 inches. The substratum to a depth of about 60 inches is dark yellowish brown and brown sand. In places the subtratum is fine sandy loam.

Included with this soil in mapping are small areas of Marshall soils in the southwestern part of the county and Clarion and Storden soils in the northeastern part. The Marshall soil is on the less convex, sloping places and is silty. Clarion and Storden soils are on the steeper places in the unit and are loamy. The Storden soil is calcareous. All of these soils have slower permeability and higher

available water capacity than Dickman soils. Also included are soils that have slopes as steep as 18 percent. The included areas make up about 10 percent of this unit.

Permeability is moderately rapid in this Dickman soil, and surface runoff is medium. Available water capacity is low in the surface layer and subsoil and very low in the substratum. The surface layer is about 1 to 2 percent organic matter and typically is medium acid in reaction. The subsoil generally is low in available phosphorus and very low or low in available potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay or pasture, but it is droughty and productive capacity is greatly limited during dry seasons. If this soil is used for cultivated crops, erosion damage caused by wind and water is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Returning crop residue or the regular addition of other organic material helps to improve fertility, maintain good tilth, and reduce erosion.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing destroys the vegetative cover and increases the erosion hazard. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is well suited to trees. However, native hardwoods generally are not suited to soils that have been in cultivation or to moderately eroded or severely eroded soils. Hardwoods apparently require a good site and grow better if they are planted on uncultivated soils. Conifers are better suited to eroded or formerly cultivated soils.

This soil is in capability subclass IVe.

34B—Estherville sandy loam, 2 to 5 percent slopes. This moderately sloping, somewhat excessively drained soil is shallow to sand or sand and gravel and is on outwash plains, valley trains, or in glacial moraines. Individual areas range from 3 to 40 acres and are irregular in shape.

Typically, the surface layer is very dark gray sandy loam about 6 inches thick. The subsoil is about 18 inches thick. The upper part is dark brown and brown, friable sandy loam, and the lower part is brown, coarse loamy sand. The substratum to a depth of about 60 inches is dark yellowish brown, calcareous, loose sand and gravel in the upper part and multicolored, calcareous, loose sand and gravel in the lower part. Some gravel and cobbles are scattered throughout the profile. In places the surface layer is gravelly loam.

Included with this soil in mapping are small areas of Salida and Wadena soils. The Salida soil is on the more convex, sloping areas, and the Wadena soil is on the less sloping areas. The included areas make up about 15 percent of this unit.

Permeability in this Estherville soil is moderately rapid in the upper part and rapid in the lower part. Surface runoff is slow or medium. Available water capacity is very low. The surface layer is about 2 to 4 percent organic matter and typically is slightly acid in reaction. The subsoil is very low in available phosphorus and potassium. This soil is in fair tilth, but cobbles and gravel interfere with tillage.

The larger areas of this soil are commonly in grass and used for hay or pasture, and the smaller areas of 3 to 5 acres are generally cultivated with the surrounding, more productive soils. This soil is poorly suited to corn, soybeans, and small grains because it is droughty. It is better suited to grasses for hay and pasture or to use as habitat for wildlife. This soil is suited to trees.

The use of this soil for pasture or hay is an effective means of controlling erosion if the pasture is not overgrazed. Leaving the soil idle for use as wildlife habitat is also effective.

This soil is in capability subclass IIIs.

34C2—Estherville sandy loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, somewhat excessively drained soil is shallow to sand or sand and gravel and is on outwash plains, valley trains, or in glacial moraines. Individual areas range from 3 to 30 acres and are irregular in shape.

Typically, the surface layer is very dark gray sandy loam mixed with streaks and patches of brown subsoil material. It is about 5 inches thick. The subsoil is about 15 inches thick. The upper part is dark brown and brown, friable sandy loam, and the lower part is brown, coarse loamy sand. The substratum to a depth of about 60 inches is dark yellowish brown, calcareous, loose sand and gravel in the upper part and multicolored, calcareous, loose sand and gravel in the lower part. Some gravel and cobbles are scattered throughout the profile. In places the surface layer is gravelly loam.

Included with this soil in mapping are small areas of Salida and Wadena soils. The Salida soil is on the more convex, sloping areas, and the Wadena soil is on the less sloping areas. The included areas make up about 15 percent of this unit.

Permeability in this Estherville soil is moderately rapid in the upper part and rapid in the lower part. Surface runoff is slow or medium. Available water capacity is very low. The surface layer is about 1 to 2 percent organic matter and typically is slightly acid in reaction. The subsoil is very low in available phosphorus and potassium. This soil is in fair tilth, but stones and gravel interfere to some extent with tillage.

The larger areas of this soil are commonly in grass for hay or pasture, and the smaller areas of 1 to 3 acres are generally cultivated with the surrounding, more productive soils. This soil is poorly suited to corn, soybeans, and small grains because it is droughty. It is better suited to grasses for hay and pasture or used as

habitat for wildlife. This soil is suited to trees.

The use of this soil for pasture or hay is an effective means of controlling erosion if the pasture is not overgrazed. Leaving the soil idle for use as wildlife habitat is also effective.

This soil is in capability subclass IVs.

48—Knoke mucky silt loam, 0 to 1 percent slopes. This level, very poorly drained soil is on large, flat, or slightly depressed areas that were formerly lake plains. It is subject to ponding. Individual areas range from 50 to more than 100 acres and are irregular in shape.

Typically, the surface layer is black, calcareous mucky silt loam about 9 inches thick. Below this is black, very friable, calcareous silty clay loam about 16 inches thick. The subsoil to a depth of about 60 inches is friable to firm, calcareous silty clay loam. In places the surface layer is not calcareous. In places a light colored layer of ash is between the surface layer and the subsoil. This ash layer is from two inches to several inches thick. In other places the surface layer is silty clay.

Included with this soil in mapping are small areas of Canisteo, Harps, and Okoboji soils. The Canisteo and Harps soils frequently form a convex, shoreline rim around Knoke soils. Okoboji soils are commonly in depressional areas similar to those of Knoke soils. Also included are pits that have been dug in the lower, wet areas. They are several feet deep and several feet across. The included areas make up about 10 percent of this unit.

Permeability is moderately slow in this Knoke soil, and surface runoff is very slow to ponded. The soil has a seasonal high water table. Available water capacity is high. The mucky surface layer is about 10 to 20 percent organic matter. Reaction typically is moderately alkaline in the surface layer and subsoil. The subsoil generally is very low or low in available phosphorus and potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, and small grains if it is adequately drained, but it is better suited to grasses and legumes for hay or pasture. The high lime content in this soil increases the possibility of crop damage from herbicides. If this soil is cultivated, wetness caused by flooding or the seasonal high water table is a hazard. The installation of surface or tile drains helps to control excessive wetness.

This soil is better suited to pasture or hay than to row crops in areas that are subject to frequent ponding. Overgrazing or grazing when this soil is too wet results in lower productivity. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIIw.

54—Zook silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on bottom lands of the larger streams and their tributaries. It is subject to flooding. Individual areas range from 5 to more than 100 acres and are generally oriented along the valley somewhat parallel to the stream channel.

Typically, the surface layer is black silty clay loam about 7 inches thick. The subsurface layer is black silty clay loam and silty clay about 24 inches thick. The subsoil extends to a depth of about 60 inches. The upper part is very dark gray, firm silty clay, and the lower part is dark gray, mottled, firm silty clay. In places the soil is similar to this Zook soil but is more alkaline and has small, soft lime accumulations below a depth of 30 inches. In places the soil is grayer below a depth of 27 inches. In other places the soil has an overwash layer that is several inches thick on the surface.

Included with this soil in mapping are small areas of Ackmore, Calco, Coland, and Colo soils. All of these soils are in positions on the landscape similar to those of Zook soils, but they are more permeable and have less content of clay. In addition, the Calco soil is calcareous. The included areas make up about 10 to 15 percent of this unit.

This Zook soil is slowly permeable. Surface runoff is generally slow, but it is very slow to ponded in depressions or old channels. This soil has a seasonal high water table. Available water capacity is high. The surface layer is about 5 to 7 percent organic matter and typically is slightly acid in reaction. The subsoil is low in available phosphorus and potassium. This soil is in fair tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture. If the soil is cultivated, wetness caused by flooding or the seasonal high water table is a hazard. Using diversion terraces on foot slopes above this soil and installing surface or tile drains help to control excessive wetness.

The use of this soil for pasture or hay is helpful in areas that are subject to frequent flooding. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and puddling and results in lower productivity. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIw.

55—Nicollet loam, 1 to 3 percent slopes. This very gently sloping, somewhat poorly drained soil is in uplands. Individual areas range from 2 to more than 200 acres and are irregular in shape.

Typically, the surface layer is black loam about 9 inches thick. The subsurface layer is black and very dark

grayish brown loam and clay loam about 13 inches thick. The subsoil is dark grayish brown, mottled, friable clay loam about 8 inches thick. The substratum to a depth of about 60 inches is grayish brown, mottled, friable clay loam and loam. In some areas the profile is calcareous. In places the soil has more content of silt, and in other places the subsoil is firm clay loam or silty clay loam.

Included with this soil in mapping are small areas of very poorly drained Okoboji soils in slight depressions. Also included are areas that have slightly higher rises or "humps" of Clarion soils. These areas have a brown subsoil and are well drained. The included areas make up about 15 percent of this unit.

This Nicollet soil is moderately permeable, and surface runoff is slow. The soil has a seasonal high water table. Available water capacity is high. The surface layer is about 4 to 8 percent organic matter and typically is slightly acid in reaction. The subsoil generally is very low in available phosphorus and low or very low in available potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture. If the soil is plowed in the fall and left barren, the surface layer is susceptible to soil blowing. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, helps to prevent excessive soil loss. Returning crop residue or the regular addition of other organic material helps to improve fertility and maintain good tilth.

The use of this soil for pasture or hay is an effective means of controlling wind erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and increases runoff. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability class I.

59C2—Burchard clay loam, 5 to 9 percent slopes, moderately eroded. This deep, moderately sloping, moderately well drained soil is on side slopes and ridges in uplands. Individual areas range from 2 to 10 acres. They are generally long and narrow and have irregular boundaries. These areas extend horizontally along hillsides and around nose slopes.

Typically, the surface layer is very dark grayish brown clay loam mixed with streaks and patches of brown subsoil material. It is about 7 inches thick. The subsoil is about 17 inches thick. The upper part is brown, firm clay loam, and the lower part is yellowish brown, mottled, firm clay loam. The substratum to a depth of about 60 inches is multicolored, calcareous, firm clay loam. In places the soil has a thicker surface layer and greater depth to lime accumulations. In places it is sandy clay loam throughout.

Included with this soil in mapping are small areas of clayey Adair and Lamoni soils on the upper part of the slopes. The included areas make up about 10 percent of the unit.

Permeability is moderately slow in this Burchard soil, and surface runoff is medium. Available water capacity is high. The surface layer is about 2 to 3 percent organic matter and typically is slightly acid. The subsoil generally is low in available phosphorus and high in available potassium. This soil is in fair tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and to grasses and legumes for hay and pasture. If the soil is used for cultivated crops, however, damage from further erosion is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Erosion control practices, such as contouring and terracing, are suited to this soil. Returning crop residue or the regular addition of other organic material helps to improve fertility, reduce crusting and the formation of hard clods on the surface, and increase water infiltration.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and increases runoff and erosion. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIIe.

59D2—Burchard clay loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping, moderately well drained soil is on side slopes in uplands. Slopes generally are long or grade into adjacent, long slopes. Individual areas range from 2 to about 50 acres and are generally long and narrow and have irregular boundaries.

Typically, the surface layer is very dark grayish brown clay loam mixed with streaks and patches of brown subsoil material. It is about 7 inches thick. The subsoil is about 15 inches thick. The upper part is brown, firm clay loam, and the lower part is yellowish brown, mottled, firm clay loam. The mottled substratum to a depth of about 60 inches is yellowish brown and grayish brown, firm, calcareous clay loam. In places the soil is sandy clay loam throughout.

Included with this soil in mapping are small areas of clayey Adair and Lamoni soils. These soils are on the upper part of the slopes. Also included are severely eroded areas where the surface layer consists mainly of subsoil material. These areas are higher in content of clay and lower in content of organic matter than Burchard soil. The included areas make up about 10 percent of this unit.

Permeability is moderately slow in this Burchard soil, and surface runoff is rapid. Available water capacity is

high. The surface layer is about 2 to 3 percent organic matter because of loss of the surface soil by erosion. Reaction typically is slightly acid in the surface layer but varies as a result of liming practices. The subsoil generally is low in available phosphorus and high in available potassium. This soil is in fair tilth.

Most areas of this soil are cultivated, but some areas are in hay or pasture. The soil is suited to corn, soybeans, small grains, and to grasses and legumes for hay and pasture. If the soil is used for cultivated crops, damage from further erosion is a severe hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Farming on the contour, stripcropping (fig. 12), and terracing are suitable practices if the slopes are long enough. Returning crop residue or the regular addition of other organic material helps to improve fertility, reduce crusting and the formation of hard clods on the surface, and increase water infiltration.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing causes excessive runoff and increases erosion. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIIe.

59E2—Burchard clay loam, 14 to 18 percent slopes, moderately eroded. This moderately steep, moderately well drained soil is on side slopes in uplands. Individual areas range from 5 to 60 acres and are generally on the lower part of long slopes.

Typically, the surface layer is very dark grayish brown clay loam mixed with streaks and patches of brown subsoil material. It is about 7 inches thick. The subsoil is about 13 inches thick. The upper part is brown, firm clay loam, and the lower part is yellowish brown, mottled, firm clay loam. The substratum to a depth of about 60 inches is yellowish brown and light gray, mottled, firm, calcareous clay loam. In places the soil is sandy clay loam throughout.

Included with this soil in mapping are small areas of Adair and Lamoni soils. These soils are on the upper part of the slopes. Also included are severely eroded soils where the surface layer consists mainly of subsoil material. They are higher in content of clay and lower in content of organic matter than Burchard soil. The included areas make up about 10 percent of this unit.

Permeability is moderately slow in this Burchard soil, and surface runoff is rapid. Available water capacity is high. The surface layer is about 2 to 3 percent organic matter. Reaction typically is slightly acid in the surface layer but varies widely as a result of liming practices. The subsoil generally is low in available phosphorus and high in available potassium. This soil is in fair tilth.

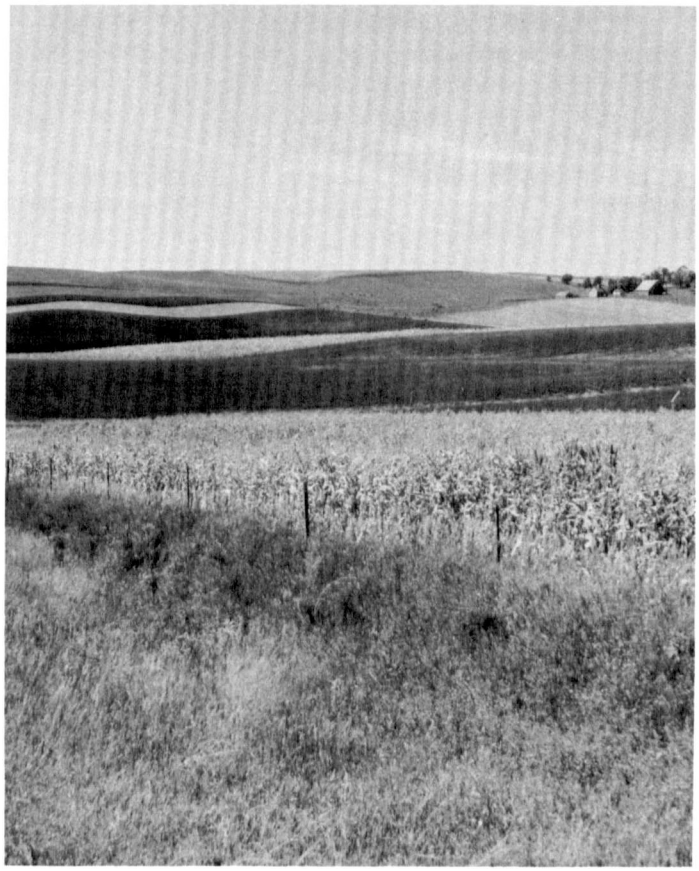

Figure 12.—Stripcropping on the Marshall and Burchard soils helps to control erosion.

Although most areas of this soil are farmed together with the more productive, adjacent soils this soil is poorly suited to corn, soybeans, and small grains. It is better suited to grasses and legumes for hay or pasture. If the soil is used for cultivated crops, damage from further erosion is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Practices such as contouring and terracing also help to control erosion. Returning crop residue or the regular addition of other organic material helps to improve fertility and increase water infiltration.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing increases runoff and reduces protection against erosion. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is well suited to trees. Tree seeds, cuttings, and seedlings survive and grow well if competing

vegetation is removed during site preparation or controlled by spraying, cutting, and girdling. Adequate vegetative cover needs to be maintained on the surface because the erosion hazard is severe if the soil is not protected.

This soil is in capability subclass IVe.

59F2—Burchard clay loam, 18 to 25 percent slopes, moderately eroded. This steep, moderately well drained soil is on side slopes in uplands. Slopes generally are long. Individual areas range from 5 to 20 acres and are generally long and narrow and have irregular boundaries.

Typically, the surface layer is very dark grayish brown clay loam mixed with streaks and patches of brown subsoil material. It is about 6 inches thick. The subsoil is brown, firm clay loam about 11 inches thick. The substratum to a depth of about 60 inches is yellowish brown and light gray, mottled, firm, calcareous clay loam. In places the subsoil is mottled grayish brown and yellowish brown.

Included with this soil in mapping are small areas of Gara soils on some of the north-facing slopes near streams. Also included are small areas of clayey Adair and Lamoni soils on the upper part of the slopes. The included areas make up about 15 percent of this unit.

Permeability is moderately slow in this Burchard soil, and surface runoff is rapid. Available water capacity is high. The surface layer is about 2 to 3 percent organic matter and typically is slightly acid in reaction. The subsoil generally is low in available phosphorus and high in available potassium. This soil is in fair tilth.

Most areas of this soil are used for pasture. The soil is not suited to corn, soybeans, and small grains, but it is well suited to grasses and legumes for hay or pasture. Returning crop residue or the regular addition of other organic material helps to improve fertility, reduce crusting and the formation of hard clods on the surface, and increase water infiltration.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing increases runoff and erosion. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is well suited to trees. Tree seeds, cuttings, and seedlings survive and grow well if competing vegetation is removed during site preparation or controlled by spraying, cutting, and girdling. Adequate vegetative cover needs to be maintained on the surface because the erosion hazard is severe if the soil is not protected.

This soil is in capability subclass VIe.

62C2—Storden loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, well drained soil is on side slopes and some ridges in uplands. Individual areas range from 2 to 30 acres and are irregular in shape.

Typically, the surface layer is dark grayish brown and very dark grayish brown, calcareous loam mixed with streaks and patches of yellowish brown substratum material. It is about 8 inches thick. The substratum to a depth of about 60 inches is yellowish brown, friable, calcareous loam in the upper part and light olive brown, mottled, friable, calcareous loam in the middle and lower parts. Lime accumulations are throughout.

Included with this soil in mapping are small areas of Clarion, Dickman, and Salida soils. The Clarion soil is on the less sloping areas and is well drained. The Dickman soil is on the convex, sloping areas and has a much higher content of sand than Storden soil. The Salida soil is on small, scattered knobs and has more sand and gravel throughout. The included areas make up about 15 percent of this unit.

This Storden soil is moderately permeable, and surface runoff is rapid. Available water capacity is high. The surface layer is about 1 to 2 percent organic matter and typically is moderately alkaline in reaction. It has lime concretions and contains a few stones. The underlying substratum is very low in available phosphorus and potassium. This soil is in good tilth.

Although most areas of this soil are cultivated, the soil is poorly suited to corn, soybeans, and small grains. It is better suited to grasses. If the soil is used for cultivated crops, the high lime content in the soil increases the possibility of crop damage from herbicides, and erosion is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Conservation practices to control erosion, such as contouring and terracing, are difficult to use on this soil because of the uneven, complex, short slopes in most places. Returning crop residue or the regular addition of other organic material helps to improve fertility and increase water infiltration.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing causes surface compaction and increases runoff and erosion. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIIe.

62D2—Storden loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping, well drained soil is on side slopes and some ridges in uplands. Individual areas range from 3 to 50 acres and are irregular in shape.

Typically, the surface layer is very dark grayish brown and dark grayish brown, calcareous loam mixed with streaks and patches of yellowish brown substratum material. It is about 8 inches thick. The substratum to a depth of about 60 inches is yellowish brown, friable,

calcareous loam in the upper part and light olive brown, mottled, friable, calcareous loam in the middle and lower parts. Lime accumulations are throughout.

Included with this soil in mapping are small areas of Clarion, Dickman, and Salida soils. The Clarion soil is on the less sloping areas and is well drained. The Dickman soil is on the convex, sloping areas and has a much higher content of sand than Storden soil. The Salida soil is on small, scattered knobs and has more sand and gravel throughout. The included areas make up about 15 percent of this unit.

This Storden soil is moderately permeable, and surface runoff is rapid. Available water capacity is high. The surface layer is about 1 to 2 percent organic matter and typically is moderately alkaline in reaction. It has lime concretions and contains a few stones. The underlying substratum is very low in available phosphorus and potassium. This soil is in good tilth.

Although some areas of this soil are cultivated, the soil is poorly suited to corn, soybeans, and small grains. It is better suited to grasses. If the soil is used for cultivated crops, the high lime content in the soil increases the possibility of crop damage from herbicides, and, in addition, erosion is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Conservation practices to control erosion, such as contouring and terracing, are difficult to use on this soil because of the uneven, complex, short slopes in most places. Returning crop residue or the regular addition of other organic material helps to improve fertility and increase water infiltration.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing when the soil is too wet causes surface compaction and increases runoff and erosion. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IVe.

62E2—Storden loam, 14 to 18 percent slopes, moderately eroded. This moderately steep, well drained soil is on side slopes in uplands. Individual areas range from 5 to 20 acres and are irregular in shape.

Typically, the surface layer is dark grayish brown and very dark grayish brown, calcareous loam mixed with streaks and patches of yellowish brown substratum material. It is about 6 inches thick. The substratum to a depth of about 60 inches is yellowish brown, friable, calcareous loam in the upper part and light olive brown, mottled, friable, calcareous loam in the middle and lower parts. Lime accumulations are throughout.

Included with this soil in mapping are small areas of Clarion, Dickman, and Salida soils. The Clarion soil is on the less sloping areas and is well drained. The Dickman soil is on convex, sloping areas and has a much higher content of sand than Storden soil. The Salida soil is on small, scattered knobs and has more sand and gravel throughout. The included areas make up about 15 percent of this unit.

This Storden soil is moderately permeable, and surface runoff is rapid. Available water capacity is high. The surface layer is about 1 to 2 percent organic matter and typically is moderately alkaline in reaction. The underlying substratum is very low in available phosphorus and potassium. This soil is in good tilth.

Although some areas of this soil are cultivated, the soil is poorly suited to corn, soybeans, and small grains. It is better suited to grasses. If the soil is used for cultivated crops, the high lime content in the soil increases the possibility of crop damage from herbicides, and, in addition, erosion is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Conservation practices to control erosion, such as contouring and terracing, are difficult to use on this soil because of the uneven, complex, short slopes in most places. Returning crop residue or the regular addition of other organic material helps to improve fertility and increase water infiltration.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and increases runoff and erosion. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IVe.

62F—Storden loam, 18 to 25 percent slopes. This steep, well drained soil is on side slopes in uplands. Individual areas range from 5 to 60 acres and are irregular in shape. This soil generally is on the sides of valleys along the larger drainageways.

Typically, the surface layer is very dark grayish brown and dark grayish brown, calcareous loam mixed with streaks and patches of yellowish brown substratum material. It is about 5 inches thick. The substratum to a depth of about 60 inches is yellowish brown, friable, calcareous loam in the upper part and light olive brown, mottled, friable, calcareous loam in the lower part. It has lime accumulations throughout.

Included with this soil in mapping are small areas of Clarion, Dickman, Lester, and Salida soils. The Clarion soil is on the less sloping areas and is well drained. The Dickman soil is scattered along the sides of valleys in places. It has a much higher content of sand than Storden soil and low available water capacity. The Lester soil is on north- and east-facing slopes in places and is well drained. The Salida soil is on the higher part of the slopes and on knobs and has more sand and gravel than Storden soils. The included areas make up about 15 percent of this unit.

This Storden soil is moderately permeable, and surface runoff is rapid. Available water capacity is high. The surface layer is about 1 percent organic matter and typically is moderately alkaline in reaction. The underlying substratum is very low in available phosphorus and potassium. This soil is in good tilth.

Most areas of this soil are in pasture. The soil is not suited to corn, soybeans, and small grains, but it is suited to grasses. Returning crop residue or the regular addition of other organic material helps to improve fertility and increase water infiltration.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and increases runoff and erosion. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass VIe.

62G—Storden loam, 25 to 40 percent slopes. This very steep, well drained soil is on side slopes in uplands. Individual areas range from 3 to 40 acres and are irregular in shape. This soil generally is on the sides of valleys along larger drainageways.

Typically, the surface layer is very dark grayish brown and dark grayish brown, calcareous loam mixed with streaks and patches of light olive brown substratum material. It is about 5 inches thick. The substratum to a depth of about 60 inches is light olive brown and yellowish brown, friable, calcareous loam in the upper part and light olive brown, mottled, friable, calcareous loam in the lower part. It has lime accumulations throughout.

Included with this soil in mapping are small areas of Clarion, Dickman, Lester, and Salida soils. The Clarion soil is on the less sloping areas and is well drained. The Dickman soil is on side slopes along the major valleys. It has a much higher content of sand than Storden soils and low available water capacity. The Lester soil is on north- and east-facing slopes in places and is well drained. The Salida soil is on the higher part of the slopes and on knobs and has more sand and gravel than Storden soils. The included areas make up about 15 percent of this unit.

This Storden soil is moderately permeable, and surface runoff is very rapid. Available water capacity is high. The surface layer is about 1 to 2 percent organic matter and typically is moderately alkaline in reaction. The underlying substratum is very low in available phosphorus and potassium.

Most areas of this soil are in pasture. The soil is not suited to corn, soybeans, and small grains, but it is suited to grasses. Returning crop residue or the regular addition of other organic material helps to improve fertility and increases water infiltration.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and increases runoff and erosion. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass VIIe.

71D2—Marshall-Dickman complex, 9 to 14 percent slopes, moderately eroded. These strongly sloping, well drained soils are on ridges and side slopes in uplands. Individual areas range from 5 to 20 acres and are irregular in shape. This map unit is about 55 percent Marshall soil and 30 percent Dickman soil. The Dickman soil is in the more convex, sloping areas. It tends to be oval in shape and is surrounded by the Marshall soil. These soils are so intricately mixed or so small that it is not practical to separate them in mapping.

Typically, the surface layer of the Marshall soil is very dark grayish brown silty clay loam mixed with streaks and patches of brown subsoil material. It is about 8 inches thick. The subsoil is about 32 inches thick. The upper part is dark brown and brown, friable silty clay loam, and the lower part is brown and grayish brown, mottled, friable silty clay loam. The substratum to a depth of about 60 inches is brown, mottled, friable silt loam. In places the mottles are higher in the profile than is typical.

Typically, the surface layer of the Dickman soil is very dark brown sandy loam mixed with streaks and patches of brown subsoil material about 6 inches thick. The subsurface layer is dark brown sandy loam about 7 inches thick. The subsoil is about 18 inches thick, but the total depth from the surface to loamy sand is about 32 inches. The upper part is brown, very friable sandy loam, and the lower part is dark yellowish brown, loose loamy sand. The substratum to a depth of about 60 inches is dark yellowish and brown sand.

Permeability is moderate in the Marshall soil, and moderately rapid in the Dickman soil. Surface runoff is medium in both soils. Available water capacity is high in the Marshall soil and low in the Dickman soil. The surface layer of the Marshall soil is about 2 to 4 percent organic matter and that of the Dickman soil about 1 to 3 percent. In both soils, reaction typically is slightly acid or medium acid, and the subsoil generally is low in available phosphorus and low or very low in available potassium. These soils are in good tilth.

Most areas of these soils are cultivated. The soils are suited to corn, soybeans, small grains, and grasses and legumes for hay or pasture, but the Dickman soil is droughty and its productive capacity is greatly limited during dry seasons. If the soils are used for cultivated crops, damage from erosion by wind and water is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed

waterways help to prevent excessive soil loss. Returning crop residue or the regular addition of other organic material helps to improve fertility, maintain good tilth, and reduce erosion.

The use of these soils for pasture or hay is an effective means of controlling erosion. Overgrazing destroys the vegetative cover and increases the erosion hazard. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soils in good condition.

The soils in this complex are in capability subclass IVe.

90—Okoboji mucky silt loam, 0 to 1 percent slopes. This nearly level, very poorly drained soil is in slight depressions in uplands. It is generally in the lower lying areas of the poorly drained Canisteo and Webster soils and is ponded in wet seasons. Individual areas range from 5 to 20 acres but are 40 acres or more in places. Areas generally tend to be somewhat round but are irregularly shaped in places.

Typically, the surface layer is black mucky silt loam about 8 inches thick. The subsurface layer is about 19 inches thick. It is black silty clay loam in the upper part and very dark gray, mottled silty clay loam in the lower part. The subsoil to a depth of about 60 inches is very dark gray, mottled, firm silty clay loam in the upper part and olive gray and gray, mottled, friable, calcareous silty clay loam in the lower part. In small areas in places the surface layer is silty clay loam.

Included with this soil in mapping are small areas of poorly drained, highly calcareous Harps soil on slightly higher lying areas. The included areas make up about 10 percent of this unit.

Permeability is moderately slow in this Okoboji soil, and runoff from the surrounding soils ponds on this soil (see fig. 11). The soil has a seasonal high water table. Available water capacity is high. The surface layer is about 9 to 18 percent organic matter and typically is mildly alkaline in reaction. The subsoil generally is very low in available phosphorus and low or very low in available potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture if it is adequately drained. After heavy rains, water is ponded in depressional areas. The surface layer puddles easily if worked when wet. The installation of deep tiling or surface drains is needed to reduce the excessive wetness.

Many areas of this soil are used for pasture or hay. Restricted use during wet periods helps to keep pasture and soil in good condition.

This soil is in capability subclass IIIw.

95—Harps loam, 0 to 2 percent slopes. This level and nearly level, poorly drained soil is almost entirely on narrow rims around slight depressions or potholes in uplands. Individual areas range from 2 to 10 acres and are generally narrow.

Typically, the surface layer is black, calcareous loam about 7 inches thick. The subsurface layer is very dark gray, calcareous loam about 12 inches thick. The subsoil is about 17 inches thick. The upper part is mixed dark gray, very dark gray, and light olive gray, friable, calcareous loam, and the middle and lower parts are light gray and light olive gray, friable, calcareous loam. The substratum to a depth of about 60 inches is multicolored, light olive gray, strong brown, and yellowish brown, friable, calcareous loam.

Included with this soil in mapping are small areas of very poorly drained Okoboji soils in small depressions. The included areas make up about 10 percent of this unit.

This Harps soil is moderately permeable, and surface runoff is slow. The soil has a seasonal high water table. Available water capacity is high. The surface layer is about 4 to 5 percent organic matter and typically is moderately alkaline in reaction. The subsoil generally is very low in available phosphorus and potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture if it is adequately drained. Special treatment is needed to offset the high content of lime in the soil. The high lime content increases the hazard of crop damage from herbicides. If the soil is plowed in the fall and left barren, the surface layer is susceptible to wind erosion. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, helps to prevent excessive soil loss.

The use of this soil for pasture or hay is an effective means of controlling wind erosion. Restricted use during wet periods helps to keep pasture and soil in good condition.

This soil is in capability subclass IIw.

99C2—Exira silty clay loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, well drained soil is in uplands. Individual areas range from 5 to 40 acres and are generally in coves next to broad, gently sloping ridgetops at high elevations or on long, straight side slopes below shoulder slopes.

Typically, the surface layer is very dark grayish brown, friable silty clay loam mixed with streaks and patches of brown subsoil material. It is about 8 inches thick. The subsoil is about 33 inches thick. The upper part is brown, friable silty clay loam; the middle part is brown and dark yellowish brown, mottled, friable silty clay loam; and the lower part is yellowish brown, mottled, friable silty clay loam. The substratum to a depth of about 60 inches is yellowish brown and grayish brown, friable silt loam. In places along small drainageways on hillsides this soil has a dark gray and gray subsoil.

Included with this soil in mapping are small areas of clayey, somewhat poorly drained Adair and Lamoni soils. These soils are on the lower and more sloping part of the unit. The included areas make up about 10 percent of this unit.

This Exira soil is moderately permeable, and surface runoff is rapid. Available water capacity is high. The surface layer is about 2 to 3 percent organic matter and typically is slightly acid in reaction. The subsoil generally is low in available phosphorus and potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay or pasture. If the soil is used for cultivated crops, further erosion damage is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Erosion control practices, such as contouring and terracing, are suited to this soil. Returning crop residue or the regular addition of other organic material helps to improve fertility, reduce crusting, increase water infiltration, and maintain good tilth. Increasing the amount of organic matter in the surface layer helps to reduce puddling in wet weather and lessen the hardness of soil clods in very dry weather.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increases runoff and erosion, and results in poorer tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIIe.

99D2—Exira silty clay loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping, well drained soil is in uplands. Individual areas range from 5 to 40 acres and are generally in coves next to broad, gently sloping ridgetops at high elevations or on long, straight side slopes that are downslope from convex shoulder slopes.

Typically, the surface layer is very dark grayish brown silty clay loam mixed with streaks and patches of brown subsoil material. It is about 8 inches thick. The subsoil is about 28 inches thick. The upper part is brown, friable silty clay loam, the middle part is brown and dark yellowish brown, mottled, friable silty clay loam, and the lower part is yellowish brown, mottled, friable silty clay loam. The substratum to a depth of about 60 inches is yellowish brown and grayish brown, friable silt loam. In places along drainageways on hillsides, small areas have a thicker surface layer.

Included with this soil in mapping are small areas of clayey Adair and Lamoni soils and areas of severely eroded Marshall soils on the lower and steeper parts of the unit. The included areas make up about 15 percent of this unit.

This Exira soil is moderately permeable, and surface runoff is rapid. Available water capacity is high. The surface layer is about 2 to 3 percent organic matter. Reaction typically is slightly acid in the surface layer and upper part of the subsoil. The subsoil generally is low in available phosphorus and potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay or pasture. If the soil is used for cultivated crops, further damage from erosion is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Erosion control practices, such as contouring and terracing, (fig. 13) are suited to this soil. Returning crop residue or the regular addition of other organic material helps to improve fertility, reduce crusting, increase water infiltration, and maintain good tilth. Increasing the amount of organic matter on the surface helps to reduce puddling in wet weather and lessen the hardness of soil clods in very dry weather.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increases runoff and erosion, and results in poorer tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIIe.

99E2—Exira silty clay loam, 14 to 20 percent slopes, moderately eroded. This moderately steep, well drained soil is in uplands. Individual areas range from 5 to 25 acres and are generally in coves next to broad, gently sloping ridgetops at high elevations or on long, straight side slopes that are downslope from convex shoulder slopes.

Typically, the surface layer is very dark grayish brown silty clay loam mixed with streaks and patches of brown subsoil material. It is about 8 inches thick. The subsoil is about 24 inches thick. The upper part is brown, friable silty clay loam, the middle part is brown and dark yellowish brown, mottled, friable silty clay loam, and the lower part is yellowish brown, mottled, friable silty clay loam. The substratum to a depth of about 60 inches is yellowish brown and grayish brown, friable silty clay loam. In places along small drainageways on hillsides, small areas have a thicker, dark surface layer.

Included with this soil in mapping are small areas of clayey Adair and Lamoni soils on the lower parts of slopes and small areas of severely eroded Marshall soils on the steeper part of the unit. The included areas make up about 15 percent of this unit.

Figure 13.—Tile inlet terrace under construction on the Marshall and Exira soils.

This Exira soil is moderately permeable, and surface runoff is rapid. Available water capacity is high. The surface layer is about 2 to 3 percent organic matter. Reaction typically is slightly acid in the surface layer and upper part of the subsoil. The subsoil generally is low in available phosphorus and potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay or pasture. If the soil is used for cultivated crops, further damage from erosion is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Returning crop residue or the regular addition of other organic material helps to improve fertility, reduce crusting, increase water infiltration, and maintain good tilth. Increasing the amount of organic matter in the surface layer helps to reduce puddling in wet weather and lessen the hardness of soil clods in very dry weather.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increases runoff and erosion, and results in poorer tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IVe.

107—Webster silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on smooth or slightly concave till plains in uplands. Individual areas range from 5 to 20 acres or more and are irregular in shape.

Typically, the surface layer is black silty clay loam about 8 inches thick. The subsurface layer is about 13 inches thick. It is black silty clay loam in the upper part and very dark clay loam in the lower part. The subsoil is about 24 inches thick. The upper part is dark gray and olive gray, mottled, friable clay loam, and the lower part is olive gray, mottled, friable loam. The substratum to a depth of about 60 inches is olive gray, mottled, calcareous loam. In places the surface layer and subsoil have higher content of clay. In other places the substratum has lower content of sand and higher content of silt.

Included with this soil in mapping are small areas of Okoboji, Nicollet, and Canisteo soils. The Okoboji soil is in low places and has a thicker, dark surface layer and higher content of clay in the surface layer and subsoil than Webster soils. The Nicollet soil is on slightly higher areas and is somewhat poorly drained. The Canisteo soil has more lime than Webster soils. The included areas make up about 30 percent of this unit.

This Webster soil is moderately permeable, and surface runoff is slow. The soil has a seasonal high water table. Available water capacity is high. The surface layer is about 6 to 7 percent organic matter and typically is slightly acid in reaction. The subsoil generally is very low in available phosphorus and potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay or pasture. If the soil is cultivated, wetness from the seasonal high water table is a hazard. The use of mechanical practices such as diversion terraces on slopes above this soil and the installation of surface or tile drains help to control excessive wetness.

If this soil is used for pasture, grazing when the soil is too wet causes compaction and surface puddling and results in lower productivity. Proper stocking rates, pasture rotation, timely deferment of grazing and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIw.

108—Wadena loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes. This level and nearly level, well drained soil is on outwash plains, valley trains, and terraces along major streams. Individual areas range from 2 to 50 acres and are irregular in shape.

Typically, the surface layer is black loam about 9 inches thick. The subsurface layer is very dark grayish brown loam about 8 inches thick. The subsoil is about 17 inches thick. The upper part is brown, friable loam, the middle part is dark yellowish brown, friable loam, and the lower part is brown, friable, gravelly loamy sand. The substratum to a depth of about 60 inches is friable, calcareous, loose sand and gravel. In places, especially along the Raccoon River, the substratum is uniform fine sand that extends to a depth of as much as 12 feet or more. In a few small areas the depth to sand and gravel is more than 32 inches. In other places the soil is not calcareous at a depth of less than 40 inches. In places the surface layer and subsoil are sandy loam.

Included with this soil in mapping are small areas of Cylinder and Estherville soils. The Cylinder soil is somewhat poorly drained and is on lower lying areas. The Estherville soil is somewhat excessively drained and is on slightly higher knobs and ridges.

Permeability is moderately rapid in the upper part of this Wadena soil and very rapid in the lower part. Surface runoff is medium. Available water capacity is moderate in the upper part and low in the lower part. The surface layer is about 3 to 4 percent organic matter and typically is slightly acid in reaction. The subsoil generally is very low in available phosphorus and potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture if rainfall is timely. If this soil is used for cultivated crops, conservation practices to conserve moisture are needed. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, is beneficial. If the soil is plowed in the fall and left barren, the surface layer is susceptible to wind erosion. Conservation tillage helps to reduce soil loss. Returning crop residue or the regular addition of other organic material helps to improve fertility, reduce crusting, increase water infiltration, and maintain good tilth.

The use of this soil for pasture or hay is an effective means of controlling wind erosion. Overgrazing, however, causes surface compaction and results in poorer tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIs.

108B—Wadena loam, 24 to 32 inches to sand and gravel, 2 to 5 percent slopes. This gently sloping, well drained soil is on outwash plains, valley trains, and terraces along major streams. Individual areas range from 2 to 20 acres and are irregular in shape.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is very dark grayish brown loam about 8 inches thick. The subsoil is about 17 inches thick. The upper part is brown, friable loam, the middle part is dark yellowish brown, friable loam, and the lower part is brown, gravelly loamy sand. The substratum to a depth of about 60 inches is multicolored, calcareous, loose sand and gravel. In places, especially along the Raccoon River, the substratum is uniform fine

sand that extends to a depth of as much as 12 feet or more. In a few small areas the depth to sand and gravel is 32 inches. In other places the soil is not calcareous at a depth of less than 40 inches. In places the surface layer and subsoil are sandy loam.

Included with this soil in mapping are small areas of Cylinder and Estherville soils. The Cylinder soil is somewhat poorly drained and is on lower lying areas. The Estherville soil is somewhat excessively drained and is on slightly higher knobs and ridges. The included areas make up about 15 percent of this unit.

Permeability is moderately rapid in the upper part of this Wadena soil and very rapid in the lower part. Surface runoff is medium. Available water capacity is moderate in the upper part and low in the lower part. The surface layer is about 3 to 4 percent organic matter. Reaction typically is slightly acid in the surface layer and subsoil. The subsoil generally is very low in available phosphorus and potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture if rainfall is timely. If this soil is used for cultivated crops, conservation practices that conserve moisture are needed. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, is beneficial. Damage from erosion is a hazard. Conservation tillage and grassed waterways help to prevent excessive soil loss. Returning crop residue or the regular addition of other organic material helps to improve fertility, reduce crusting, and increase water infiltration.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing, however, causes increased runoff and results in poorer tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIe.

108C2—Wadena loam, 24 to 32 inches to sand and gravel, 5 to 9 percent slopes, moderately eroded. This moderately sloping, well drained soil is on outwash plains, valley trains, and terraces along major streams. Individual areas range from 2 to 10 acres and are irregular in shape.

Typically, the surface layer is very dark grayish brown loam about 8 inches thick. The subsoil is about 16 inches thick. The upper part is brown, friable loam, the middle part is dark yellowish brown, friable loam, and the lower part is brown, very friable, gravelly loamy sand. The substratum to a depth of about 60 inches is calcareous, loose sand and gravel. In places, especially along the Raccoon River, the substratum is uniform fine sand that extends to a depth of as much as 12 feet or more. In a few small areas the depth to sand and gravel is more than 32 inches. In other places the soil is not calcareous at a depth of less than 40 inches. In places the surface layer and subsoil are sandy loam.

Included with this soil in mapping are small areas of Cylinder and Estherville soils. The Cylinder soil is somewhat poorly drained and is on lower lying areas. The Estherville soil is somewhat excessively drained and is on slightly higher knobs and ridges. The included areas make up about 15 percent of this unit.

Permeability is moderately rapid in the upper part of this Wadena soil and very rapid in the lower part. Surface runoff is medium. Available water capacity is moderate in the upper part and low in the lower part. The surface layer is about 2 to 3 percent organic matter and typically is slightly acid in reaction. The subsoil generally is very low in available phosphorus and potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture if rainfall is timely. If the soil is used for cultivated crops, conservation practices that conserve moisture are needed. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, is beneficial. Damage from further erosion is a hazard. Conservation tillage and grassed waterways help to prevent excessive soil loss. Returning crop residue or the regular addition of other organic material helps to improve fertility, reduce crusting, and increase water infiltration.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing, however, causes increased runoff and results in poorer tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIIe.

133—Colo silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on bottom lands of larger streams and their tributaries. It is subject to flooding. Individual areas range from 20 to more than 100 acres and are irregular in shape.

Typically, the surface layer is black silty clay loam about 8 inches thick. The subsurface layer is black silty clay loam about 30 inches thick. Below this is a layer of very dark gray, mottled, firm silty clay loam about 11 inches thick. The substratum to a depth of about 60 inches is dark gray, mottled, firm silty clay loam. In places the surface layer is lighter colored overwash that has higher content of silt. In other places near the channel the soil is stratified.

Included with this soil in mapping are small areas of Zook soil in low places. They are more clayey and less permeable than Colo soil. The included areas make up about 15 percent of this unit.

Permeability is moderate in this Colo soil. Surface runoff is slow, but it is very slow to ponded in

depressions or old channels. This soil has a seasonal high water table. Available water capacity is high. The surface layer is about 5 to 7 percent organic matter and typically is slightly acid in reaction. The subsoil generally is medium in available phosphorus and potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay or pasture. If the soil is cultivated, wetness caused by flooding or the seasonal high water table is a hazard. The use of diversion terraces on foot slopes above this soil and the installation of surface or tile drains help to control excessive wetness.

In areas that are subject to more frequent flooding, this soil is better suited to pasture or hay than to row crops. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and puddling and results in lower productivity. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIw.

133+—Colo silty clay loam, overwash, 0 to 2 percent slopes. This nearly level, poorly drained soil is on bottom lands of larger streams and their tributaries. It is subject to flooding. Individual areas range from 20 to more than 100 acres and are irregular in shape.

Typically, the overwash surface layer is mixed very dark grayish brown, dark gray, dark grayish brown, and black silty clay loam about 10 inches thick. Below this is a subsurface layer of black silty clay loam about 33 inches thick. The substratum to a depth of about 60 inches is dark gray, mottled, friable silty clay loam. In places the overwash surface layer is more than 10 inches thick.

Included with this soil in mapping are small areas of Ackmore and Zook soils. Ackmore soils are stratified. The more clayey Zook soils are in small depressions or in low lying areas. The included areas make up about 15 percent of this unit.

Permeability is moderate in this Colo soil. Surface runoff is slow, but it is very slow to ponded in depressions. This soil has a seasonal high water table. Available water capacity is high. The surface layer is about 3 to 5 percent organic matter. Reaction typically is slightly acid in the surface layer and subsoil. The subsoil generally is medium in available phosphorus and potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture. If the soil is cultivated, wetness caused by flooding or the seasonal high water table is a hazard. The use of diversion terraces on foot slopes above this soil, the construction of levees, and the installation of surface or tile drains help to control excessive wetness.

In areas that are subject to more frequent flooding, this soil is better suited to pasture or hay than to cultivated crops. Overgrazing or grazing when this soil is too wet, however, causes surface compaction and puddling and results in lower productivity. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIw.

135—Coland clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on bottom lands of the larger streams and their tributaries. It is subject to flooding. Individual areas range from 10 to more than 100 acres.

Typically, the surface layer is black clay loam about 8 inches thick. The subsurface layer is black clay loam about 21 inches thick. The mottled subsoil is very dark gray, friable clay loam about 19 inches thick. The substratum to a depth of about 60 inches is gray, friable sandy clay loam. In places the surface layer is lighter colored sandy loam and is several inches thick.

Included with this soil in mapping are small areas of poorly drained Spillville soils and more clayey Zook soils. The included areas make up about 15 percent of this unit.

This Coland soil is moderately permeable. Surface runoff is slow, but it is very slow to ponded in depressions or old channels. This soil has a seasonal high water table. Available water capacity is high. The surface layer is about 5 to 7 percent organic matter. Reaction typically is neutral in the surface layer and subsoil. The subsoil generally is low in available phosphorus and very low in available potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture. If the soil is cultivated, wetness caused by flooding or the seasonal high water table is a hazard. The use of diversion terraces on foot slopes above this soil and the installation of surface or tile drains help to control excessive wetness.

In areas that are subject to more frequent flooding, this soil is better suited to pasture or hay than to cultivated crops. Overgrazing or grazing when this soil is too wet, however, causes surface compaction and puddling and results in lower productivity. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIw.

138B—Clarion loam, 2 to 5 percent slopes. This gently sloping, well drained soil is on knolls and ridgetops in uplands. Individual areas range from 2 to more than 80 acres.

Typically, the surface layer is black loam about 9 inches thick. The subsurface layer is mixed very dark grayish brown and black loam about 5 inches thick. The subsoil is about 19 inches thick. The upper part is brown, friable loam, and the lower part is dark yellowish brown, mottled, friable loam. The substratum to a depth of about 60 inches is yellowish brown, mottled, friable, calcareous loam. In places in small areas the substratum has higher content of silt and lower content of sand.

Included with this soil in mapping are small areas of somewhat poorly drained Nicollet soil in slightly lower lying areas, and calcareous Storden soils on more convex, sloping areas. The included areas make up about 15 percent of this unit.

This Clarion soil is moderately permeable, and surface runoff is medium. Available water capacity is high. The surface layer is about 3 to 4 percent organic matter and typically is slightly acid in reaction. The subsoil generally is very low in available phosphorus and potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture. If the soil is used for cultivated crops, erosion is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, helps to prevent excessive soil loss. The use of mechanical practices to control erosion, such as contouring and terracing, is somewhat difficult on this soil because of the undulating relief and short slopes. In places, however, these operations are feasible. Returning crop residue or the regular addition of other organic material helps to improve fertility and maintain good tilth.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing causes increased runoff. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIe.

138B2—Clarion loam, 2 to 5 percent slopes, moderately eroded. This gently sloping, well drained soil is on knolls and ridgetops in uplands. Slopes typically are short. Individual areas range from 2 to 40 acres and are irregular in shape.

Typically, the surface layer is black and very dark grayish brown, friable loam mixed with streaks and patches of brown subsoil material. It is about 8 inches thick. The subsoil is about 18 inches thick. The upper and middle parts are brown, friable loam, and the lower part is dark yellowish brown, mottled, friable loam. The substratum to a depth of about 60 inches is yellowish brown, mottled, friable, calcareous loam. In places the surface layer is dark grayish brown and the depth to the calcareous substratum is less. In places the substratum is higher in content of silt and lower in content of sand. In other places the subsoil is higher in content of clay.

Included with this soil in mapping are small areas of somewhat poorly drained Nicollet soils in slightly lower lying places and calcareous Storden soils in more convex, sloping places. The included areas make up about 15 percent of this unit.

This Clarion soil is moderately permeable, and surface runoff is medium. Available water capacity is high. The surface layer is about 2 to 3 percent organic matter. Reaction typically is slightly acid in the surface layer and subsoil. The subsoil generally is very low in available phosphorus and very low in available potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay or pasture. If the soil is used for cultivated crops, further damage from erosion is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, helps to prevent excessive soil loss. The use of mechanical practices to control erosion, such as contouring and terracing, is somewhat difficult on this soil because of the undulating relief and short slopes. In places, however, these operations are feasible. Returning crop residue or the regular addition of other organic material helps to improve fertility, reduce crusting, increase water infiltration, and maintain good tilth.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increases runoff and erosion, and results in poorer tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIe.

138C—Clarion loam, 5 to 9 percent slopes. This moderately sloping, well drained soil is on knolls and side slopes that border streams and in upland drainageways. Slopes typically are short. Individual areas range from 2 to 15 acres and are irregular in shape.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is very dark grayish brown loam about 3 inches thick. The subsoil is about 18 inches thick. The upper and middle parts are brown, friable loam, and the lower part is dark yellowish brown, mottled, friable loam. The substratum to a depth of about 60 inches is yellowish brown, friable, calcareous loam. In places the subsoil has higher content of clay. In places the substratum has higher content of silt.

Included with this soil in mapping are small areas of calcareous Storden soils and sandy Dickman soils on more convex, sloping places. The included areas make up about 10 percent of this unit.

This Clarion soil is moderately permeable, and surface runoff is medium. Available water capacity is high. The surface layer is about 3 to 4 percent organic matter and typically is slightly acid in reaction. The subsoil generally is very low in available phosphorus and potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture. If the soil is used for cultivated crops, erosion is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. In places, the use of mechanical practices to control erosion, such as contouring and terracing, is difficult because of the undulating relief and short slopes. In places, however, these operations are feasible. Returning crop residue to the soil or the regular addition of other organic material helps to improve fertility and maintain good tilth.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and increases runoff and erosion. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIIe.

138C2—Clarion loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, well drained soil is on knolls and side slopes that border streams and in upland drainageways. Slopes typically are short. Individual areas range from 2 to 80 acres and are irregular in shape.

Typically, the surface layer is very dark grayish brown loam mixed with streaks and patches of brown subsoil material. It is about 8 inches thick. The subsoil is about 16 inches thick. The upper part is brown, friable loam, and the lower part is dark yellowish brown, mottled, friable loam. The substratum to a depth of about 60 inches is yellowish brown, mottled, friable, calcareous loam. In places the subsoil is higher in content of clay. In places the substratum is higher in content of silt.

Included with this soil in mapping are small areas of calcareous Storden soil and sandy Dickman and Salida soils on more convex, sloping places. The included areas make up about 15 percent of this unit.

This Clarion soil is moderately permeable, and surface runoff from cultivated areas is rapid. Available water capacity is high. The surface layer is about 2 to 4 percent organic matter and typically is slightly acid in reaction. The subsoil generally is very low in available phosphorus and potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay or pasture. If the soil is used for cultivated crops, further damage from erosion is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. In places, the use of mechanical practices to control erosion, such as contouring and terracing, is difficult because of the undulating relief and short slopes. In places, however, these operations are feasible. Returning crop residue or the regular addition of other organic material helps to improve fertility, reduce crusting, and increase water infiltration.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing, however, increases runoff and erosion and results in poorer tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIIe.

138D2—Clarion loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping, well drained soil is on knolls and side slopes that border streams and in upland drainageways. Slopes typically are short. Individual areas range from 2 to 20 acres and are irregular in shape.

Typically, the surface layer is very dark grayish brown loam mixed with streaks and patches of brown subsoil material. It is about 8 inches thick. The subsoil is about 14 inches thick. The upper part is brown, friable loam, and the lower part is dark yellowish brown, mottled, friable loam. The substratum to a depth of about 60 inches is yellowish brown, mottled, friable, calcareous loam. In places the subsoil is higher in content of clay. In places the substratum is higher in content of silt.

Included with this soil in mapping are small areas of Storden and Dickman soils on the more convex, sloping areas. The Storden soil is calcareous throughout. The Dickman soil is sandy. The included areas make up about 15 percent of this unit.

This Clarion soil is moderately permeable, and surface runoff from cultivated areas is rapid. Available water capacity is high. The surface layer is about 2 to 4 percent organic matter. Reaction typically is slightly acid in the surface layer and upper part of the subsoil. The subsoil generally is very low in available phosphorus and potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay or pasture. If the soil is used for cultivated crops, further damage from erosion is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. In places, the use of mechanical practices to control erosion, such as contouring and terracing, is difficult because of the undulating relief and short slopes. In places, however, these operations are feasible. Returning crop residue or the regular addition of other organic material helps to

improve fertility, reduce crusting, and increase water infiltration.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing, however, increases runoff and erosion. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IVe.

179E2—Gara loam, 14 to 18 percent slopes, moderately eroded. This moderately steep, moderately well drained to well drained soil is on side slopes and nose slopes in uplands. It is on the lower part of the slopes and generally extends down to the drainageway. It extends horizontally along the hillsides. Individual areas range from 10 to more than 40 acres and are long and narrow and have irregular boundaries.

Typically, the surface layer is very dark gray and dark grayish brown loam mixed with streaks and patches of brown subsoil material. It is about 6 inches thick. The subsoil is about 34 inches thick. The upper part is brown and dark yellowish brown, firm clay loam, the middle part is dark yellowish brown, mottled, firm clay loam, and the lower part is yellowish brown, mottled, firm clay loam. The substratum to a depth of about 60 inches is yellowish brown, mottled clay loam that has lime concretions. In places the subsoil is higher in content of sand, and in places it is calcareous at a depth of less than 40 inches.

Included with this soil in mapping are small, linear shaped areas of Armstrong soil along shoulder slopes. Also included are severely eroded areas where the surface layer consists mainly of subsoil material. These areas are higher in content of clay and lower in content of organic matter than Gara soil. The included areas make up about 10 percent of this unit.

Permeability is moderately slow in this Gara soil, and surface runoff is rapid. Available water capacity is high. The surface layer is about 0.5 to 1 percent organic matter and typically is slightly acid in reaction unless the soil is limed. The subsoil is very low or low in available phosphorus and very low in available potassium. This soil is in good tilth.

Although most areas of this soil are cultivated, the soil is not suited to corn, soybeans, and small grains. It is better suited to grasses and legumes for hay or pasture. It is well suited to woodland. If this soil is used for cultivated crops, severe erosion damage is a hazard. Returning crop residue or the regular addition of other organic material helps to improve fertility, reduce erosion, and increase water infiltration.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing, however, causes surface compaction, increases runoff and erosion, and results in reduced productivity. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is well suited to trees. Native hardwoods, however, generally are not suited to soils that have been cultivated or to moderately eroded or severely eroded soils. Hardwoods apparently require a good site and grow better if they are planted on uncultivated soils. Conifers are better suited to eroded or formerly cultivated soils. Tree seeds, cuttings, and seedlings survive and grow well if competing vegetation is removed during site preparation or controlled by prescribed burning or by spraying, cutting, or girdling.

This soil is in capability subclass VIe.

179F—Gara loam, 18 to 25 percent slopes. This steep, moderately well drained to well drained soil is on side slopes and nose slopes in uplands. It is on the lower part of the slopes and generally extends down to the valley or drainageway. It extends horizontally along the hillsides. Individual areas range from 10 to 30 acres but are as large as 60 acres or more. They are long and narrow and have irregular boundaries.

Typically, the surface layer in uncultivated areas is very dark gray loam about 7 inches thick. The subsurface layer is dark grayish brown loam about 4 inches thick. The subsoil is about 32 inches thick. The upper part is brown and dark yellowish brown, firm clay loam, the middle part is dark yellowish brown, mottled, firm clay loam, and the lower part is yellowish brown, mottled, firm clay loam, The mottled substratum to a depth of about 60 inches is calcareous clay loam. In places this soil is calcareous at a depth of less than 30 inches.

Included with this soil in mapping are small areas of Armstrong soil on shoulder slopes. Also included are severely eroded areas where the surface layer consists mainly of subsoil material. These areas are higher in content of clay and lower in content of organic matter than Gara soil. The included areas make up about 10 percent of this unit.

Permeability is moderately slow in this Gara soil, and surface runoff is rapid. Available water capacity is high. The surface layer is about 1 to 2 percent organic matter and typically is slightly acid in reaction unless the soil is limed. The subsoil is very low or low in available phosphorus and very low in available potassium. This soil is in good tilth.

Most areas of this soil are in hay and pasture. The soil is not suited to corn, soybeans, and small grains. It is better suited to grasses and legumes for hay. It is well suited to pasture or woodland. If this soil is used for cultivated crops, severe erosion damage is a hazard.

The use of this soil for pasture or hay is an effective means of controlling erosion if good management is practiced. Overgrazing, however, causes surface compaction, increases runoff and erosion, and results in reduced productivity. Proper stocking rates, pasture

rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is moderately suited to the production of upland oaks and conifers. Trees grow best on north-facing and east-facing, lower slopes and in coves. The use of a cover crop helps reduce the hazard of erosion when establishing new stands, but the cover crop needs to be carefully managed to avoid competition with the seedlings being established. Because steep slopes make the use of equipment difficult and dangerous, much of the work in establishing new stands needs to be done by hand.

This soil is in capability subclass VIIe.

179F2—Gara loam, 18 to 25 percent slopes, moderately eroded. This steep, moderately well drained to well drained soil is on side slopes and nose slopes in uplands. It is on the lower part of the slopes and generally extends down to the valley or drainageway. Individual areas range from 20 to 60 acres or more. They are long and narrow and have irregular boundaries.

Typically, the surface layer is dark grayish brown loam mixed with streaks and patches of brown subsoil material. It is about 6 inches thick. The subsoil is about 30 inches thick. The upper part is brown and dark yellowish brown, firm clay loam, the middle part is dark yellowish brown, mottled, firm clay loam, and the lower part is yellowish brown, mottled, firm clay loam. The mottled substratum to a depth of about 60 inches is yellowish brown clay loam.

Included with this soil in mapping are small areas of Armstrong soil on shoulder slopes. Also included are severely eroded areas where the surface layer consists mainly of subsoil material. These areas are higher in content of clay and lower in content of organic matter than Gara soil. The included areas make up about 10 percent of this unit.

Permeability is moderately slow in this Gara soil, and surface runoff is rapid. Available water capacity is high. The surface layer is about 0.5 to 1 percent organic matter and typically is slightly acid in reaction unless the soil is limed. The subsoil is very low or low in available phosphorus and very low in available potassium. This soil is in good tilth.

Most areas of this soil are in hay or pasture. The soil is not suited to corn, soybeans, and small grains. It is better suited to grasses and legumes for hay. It is well suited to pasture or woodland. If this soil is used for cultivated crops, severe erosion damage is a hazard.

The use of this soil for pasture or hay is an effective means of controlling erosion if good management is practiced. Overgrazing, however, causes surface compaction, increases runoff and erosion, and results in reduced productivity. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is well suited to trees. However, native hardwoods generally are not suited to soils that have been cultivated or to moderately eroded or severely eroded soils. Hardwoods apparently require a good site and grow better if they are planted on uncultivated soils. Conifers are better suited to eroded or formerly cultivated soils. Tree seeds, cuttings, and seedlings survive and grow well if competing vegetation is removed during site preparation or controlled by prescribed burning, spraying, cutting, or girdling.

This soil is in capability subclass VIIe.

179G—Gara loam, 25 to 40 percent slopes. This very steep, moderately well drained to well drained soil is on side slopes and nose slopes in uplands. It is on the lower part of the slopes and generally extends down to the valley or drainageway. It extends horizontally along the hillsides. Individual areas range from 10 to 30 acres but may be more than 100 acres. They are long and narrow and have irregular boundaries.

Typically, the surface layer in uncultivated areas is very dark gray loam about 7 inches thick. The subsurface layer is dark grayish brown loam about 4 inches thick. The subsoil is about 32 inches thick. The upper part is brown and dark yellowish brown, firm clay loam, the middle part is dark yellowish brown, firm clay loam, and the lower part is yellowish brown, firm clay loam. The mottled substratum to a depth of about 60 inches is calcareous, light gray and strong brown clay loam. In places the soil is calcareous at a depth of less than 30 inches.

Included with this soil in mapping are small areas of Armstrong soil on shoulder slopes. Also included are severely eroded areas where the surface layer consists mainly of subsoil material. These areas are higher in content of clay and lower in content of organic matter than Gara soil. The included areas make up about 10 percent of this unit.

Permeability is moderately slow in this Gara soil, and surface runoff is rapid. Available water capacity is high. The surface layer is about 1 to 2 percent organic matter and typically is slightly acid in reaction unless the soil has been limed. The subsoil is very low or low in available phosphorus and very low in available potassium.

Most areas of this soil are in hay or pasture. This soil is not suited to corn, soybeans, and small grains. It is better suited to grasses and legumes for hay. It is well suited to pasture and woodland. If this soil is used for cultivated crops, damage from severe erosion is a hazard.

The use of this soil for pasture or hay is an effective means of controlling erosion if good management is practiced. Overgrazing, however, causes surface compaction, increases runoff and erosion, and results in

reduced productivity. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is moderately suited to the production of upland oaks and conifers. Trees grow best on north-facing and east-facing, lower slopes and in coves. The use of a cover crop may help to reduce the hazard of erosion when establishing new stands, but the cover crop needs to be carefully managed to avoid competition with the seedlings being established. Because steep slopes make the use of equipment difficult and dangerous, much of the work in establishing new stands needs to be done by hand.

This soil is in capability subclass VIIe.

192D2—Adair clay loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping, somewhat poorly drained soil is on side slopes and some ridges in uplands. It runs on the contour along hillslopes, around nose slopes, and into coves at the heads of drainageways. In places, this soil is on the top of extended ridges. Individual areas range from 3 to 25 acres. They are long and narrow and have irregular boundaries.

Typically, the surface layer is very dark grayish brown clay loam mixed with streaks and patches of dark reddish brown subsoil material. It is about 6 inches thick. The subsoil is about 36 inches thick. The upper part is dark reddish brown, mottled, firm clay loam, the middle part is multicolored, very firm clay, and the lower part is multicolored, firm clay loam. The mottled substratum to a depth of about 60 inches is yellowish brown and grayish brown, firm clay loam. In places in small areas the subsoil is less red and contains more gray.

Included with this soil in mapping are small areas of Burchard, Exira, and Ida soils. The Exira and Ida soils are in the higher part of the map unit, and the Burchard soil is in the lower part. All of these soils have better drainage and less clay content than Adair soil. The Exira and Ida soils also contain more silt and less sand. The Ida soil is calcareous. The included areas make up about 15 percent of this unit.

This Adair soil is slowly permeable, and surface runoff is rapid. Available water capacity is high. The surface layer is about 2 to 3 percent organic matter and typically is slightly acid in reaction. The subsoil generally is very low in available phosphorus and potassium. This soil is in fair tilth.

Most areas of this soil are cultivated, but the soil is poorly suited to corn, soybeans, and small grains. It is better suited to grasses and legumes for hay and pasture. If the soil is used for cultivated crops, further damage from erosion is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Contour farming is well suited to this soil. Terracing is only moderately suited because the exposed subsoil is in poor tilth. Returning crop residue or the regular addition of other organic material helps to improve fertility, reduce crusting and the formation of hard clods on the surface, and increase water infiltration.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and increases runoff and erosion. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IVe.

201B—Coland-Spillville complex, 2 to 5 percent slopes. These gently sloping, poorly drained to moderately well drained soils are in valleys and upland drainageways. Individual areas range from 5 to more than 40 acres and are irregular in shape. This map unit is about 60 percent Coland soil and 25 percent Spillville soil. These soils are subject to flooding. The Coland soil typically is in the less sloping places. The Spillville soil is along the higher edge of the unit and is generally just below the steeper sloping, upland soils. These soils are so intricately mixed or so small that it is not practical to separate them in mapping.

Typically, the surface layer of the Coland soil is black clay loam about 8 inches thick. The subsurface layer is black clay loam about 21 inches thick. The mottled subsoil is very dark gray, friable clay loam about 19 inches thick. The substratum to a depth of about 60 inches is gray, friable sandy clay loam. In places the surface layer and subsoil are silty clay loam.

Typically, the surface layer of the Spillville soil is loam about 8 inches thick. The subsurface layer is loam about 38 inches thick. The upper part is black, and the lower part is mottled, very dark grayish brown. The substratum to a depth of about 60 inches is multicolored, friable loam.

Included with these soils in mapping are small areas of Biscay, Calco, and Zook soils. The Biscay soil is underlain by sand and gravel at a depth of less than 42 inches. The Calco soil is calcareous. The Zook soil is in lower lying areas and has a higher content of clay than Coland and Spillville soils. The included areas make up about 15 percent of this unit.

These Coland and Spillville soils are moderately permeable. Surface runoff is slow in most places but is very slow to ponded in depressions or old channels. These soils have a seasonal high water table. Available water capacity is high. In both soils, the surface layer is about 5 to 7 percent organic matter and typically is neutral or medium acid in reaction. The subsoil is generally low in available phosphorus and very low in available potassium. These soils are in good tilth.

Most areas of these soils are cultivated. The soils are suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture. If these soils are cultivated, wetness caused by flooding or the seasonal high water table is a hazard. The use of mechanical practices, such as diversion terraces on foot slopes above these soils and the installation of surface or tile drains, help to control excessive wetness.

These soils are better suited to pasture or hay than to cultivated crops in the areas that are subject to more frequent flooding. Overgrazing or grazing when the soils are too wet, however, causes surface compaction and surface puddling and results in lower productivity. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soils in good condition.

The soils in this complex are in capability subclass IIw.

203—Cylinder loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes. This nearly level, somewhat poorly drained soil is on glacial outwash plains and stream benches. Individual areas range from 2 to more than 20 acres and are irregular in shape.

Typically, the surface layer is black loam about 7 inches thick. The subsurface layer is very dark brown loam about 12 inches thick. The subsoil is about 19 inches thick. The upper part is dark grayish brown, friable clay loam, the middle part is mixed grayish brown and dark grayish brown, friable, gravelly loam, and the lower part is brown, very friable loamy sand. The upper part of the calcareous substratum is pale brown, loamy sand and gravel. Below this to a depth of about 60 inches is multicolored sand or sand and gravel. In places small areas of a similar soil is 40 to 46 inches deep over loamy sand or sand and gravel. In other places the soil is calcareous throughout.

Included with this soil in mapping are small areas of well drained Wadena soil on rises and poorly drained Biscay soils in swales. The included areas make up about 10 percent of this unit.

This Cylinder soil is moderately permeable in the upper part and rapidly to very rapidly permeable in the lower part. Surface runoff is slow. Available water capacity is moderate in the upper part and low in the lower part. The surface layer is about 3 to 5 percent organic matter. Reaction typically is neutral or slightly acid in the surface layer and subsoil. The subsoil generally is very low in available phosphorus and potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture if rainfall is timely. Where the soil is used for cultivated crops, conservation practices that conserve moisture, such as conservation tillage that leaves crop residue on the surface throughout the year, are beneficial. If the soil is plowed in the fall and left barren, the surface layer is susceptible to soil blowing. Conservation tillage helps to reduce soil loss. Returning crop residue or the regular addition of other organic material helps to improve fertility, reduce crusting, and increase water infiltration.

The use of this soil for pasture or hay is an effective means of controlling wind erosion.

This soil is in capability subclass IIs.

236C—Lester loam, 4 to 10 percent slopes. This moderately sloping, well drained soil is on ridgetops in uplands. Individual areas range from 3 to 15 acres and are irregular in shape.

Typically, the surface layer is very dark gray loam about 6 inches thick. The subsurface layer is very dark grayish brown, friable loam about 4 inches thick. The subsoil is about 33 inches thick. The upper and middle parts are brown, friable clay loam, and the lower part is yellowish brown, mottled, friable clay loam. The substratum to a depth of about 60 inches is mottled, friable clay loam. In places in small areas the surface layer is thicker and darker.

Included with this soil in mapping are small areas of Storden soil on more convex, steeper places. The Storden soil is calcareous throughout. The included areas make up about 10 percent of this unit.

This Lester soil is moderately permeable, and surface runoff is medium. Available water capacity is high. The surface layer is about 2 to 4 percent organic matter and typically is slightly acid in reaction. The subsoil generally is medium in available phosphorus and very low in available potassium. This soil is in good tilth.

Most areas of this soil are in timbered pasture. This soil is suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture. If the soil is used for cultivated crops, erosion is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Practices such as contouring and terracing also help to reduce soil erosion. Returning crop residue or the regular addition of other organic material helps to improve fertility and increase water infiltration.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing, however, causes increased runoff and reduces protection against erosion. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is well suited to trees. Tree seeds, cuttings, and seedlings survive and grow well if competing vegetation is removed during site preparation or controlled by spraying, cutting, and girdling. The hazard of erosion is moderate if the soil is not protected. Adequate vegetative cover needs to be maintained on the surface.

This soil is in capability subclass IIIe.

259—Biscay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes. This nearly level, poorly drained and very poorly drained soil is on glacial outwash areas in uplands and in valley terraces that are underlain by sand and gravel. Individual areas range from 5 to more than 20 acres and are irregular in shape.

Typically, the surface layer is black loam about 10 inches thick. The subsurface layer is very dark gray clay loam about 7 inches thick. The subsoil is about 22 inches thick. The upper part is dark gray, friable clay loam, the middle part is gray, friable, sandy, clay loam and the lower part is dark gray, friable, gravelly sandy loam. The substratum to a depth of about 60 inches is dark grayish brown and dark gray sand and gravel. It is calcareous in the lower part. In places in small areas the surface layer and subsoil have a higher content of clay. In places the substratum is silty clay loam. In other places the depth to sand and gravel ranges from 40 to 46 inches.

Included with this soil in mapping are small areas of Cylinder and Talcot soils. The Cylinder soil is somewhat poorly drained. The Talcot soil is calcareous. The included areas make up about 15 percent of this unit.

This Biscay soil is moderately permeable in the upper part and rapidly permeable in the lower part. Surface runoff is slow. This soil has a seasonal high water table. Available water capacity is moderate. The surface layer is about 4 to 8 percent organic matter and typically is neutral in reaction. The subsoil generally is very low in available phosphorus and very low to low in available potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay or pasture. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, helps to prevent excessive soil loss by wind erosion. Returning crop residue or the regular addition of other organic material helps to improve fertility and maintain good tilth.

If this soil is used for pasture, proper stocking rates and controlled grazing during wet periods reduce soil puddling and compaction and help to maintain the pasture and soil productivity.

This soil is in capability subclass IIw.

268C—Knox silt loam, 4 to 9 percent slopes. This moderately sloping, well drained soil is on narrow ridgetops and side slopes in uplands. Slopes are long or grade into adjacent, long slopes. Individual areas range from 3 to 50 acres and are irregular in shape.

Typically, the surface layer is very dark grayish brown silt loam about 6 inches thick. The subsurface layer is brown, friable silt loam about 8 inches thick. The subsoil is dark yellowish brown, mottled, friable silty clay loam about 30 inches thick. The substratum to a depth of about 60 inches is brown, mottled, friable silt loam.

Included with this soil in mapping are small areas of calcareous Ida soils. The Ida soil is generally on the steepest part of the slope. Also included are severely eroded areas where the surface layer consists mainly of subsoil material. These areas are higher in content of clay and lower in content of organic matter than Knox soil. The included areas make up less than 10 percent of this unit.

This Knox soil is moderately permeable, and surface runoff is medium. Available water capacity is high. The surface layer is about 1 to 3 percent organic matter and typically is slightly acid. Reaction varies widely, however, because of use and liming practices. The subsoil generally is medium in available phosphorus and low in available potassium. This soil is in good tilth.

Most areas of this soil are cultivated, but some areas are in trees or pasture. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture. If the soil is used for cultivated crops, further damage from erosion is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Farming on the contour and terracing are suited if the slopes are long enough. Returning crop residue or the regular addition of other organic material helps to improve fertility and tilth, reduce crusting, and increase water infiltration.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing, however, causes excessive runoff and increases erosion. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is suited to trees, and some areas remain in native hardwoods. Tree seeds, cuttings, and seedlings survive and grow well if competing vegetation is removed during site preparation or controlled by spraying, cutting, and girdling. Only a few hazards or limitations are concerns in the planting or harvesting of trees.

This soil is in capability subclass IIIe.

268D2—Knox silt loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping, well drained soil is on side slopes in uplands. Slopes are long or grade into adjacent, long slopes. Individual areas range from 2 to 20 acres and are irregular in shape.

Typically, the surface layer in cultivated areas is very dark grayish brown silt loam mixed with streaks and patches of brown silt loam subsoil material. It is about 8 inches thick. The subsoil is dark yellowish brown, friable silty clay loam about 29 inches thick. The mottled substratum to a depth of about 60 inches is brown, friable silt loam. In places small areas are still in trees. These areas have a surface layer of very dark grayish brown silt loam about 5 inches thick and a subsurface layer of brown, friable silt loam about 5 inches thick.

Included with this soil in mapping are small areas of calcareous Ida soils, loamy Gara soils, and clayey Armstrong soils. These soils are generally on the lower part of the slope. Also included are severely eroded areas where the surface layer consists mainly of subsoil material. These areas are higher in content of clay and lower in content of organic matter than Knox soil. The included areas make up about 15 percent of this unit.

This Knox soil is moderately permeable, and surface runoff is rapid. Available water capacity is high. The surface layer is about 1 to 2 percent organic matter and typically is slightly acid. Reaction varies widely, however, because of use and liming practices. The subsoil generally is medium in available phosphorus and low in available potassium. This soil is in good tilth.

Most areas of this soil are cultivated, but some areas are in trees or pasture. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture. If the soil is used for cultivated crops, further damage from erosion is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Farming on the contour and terracing are suited to this soil if the slopes are long enough. Returning crop residue or the regular addition of other organic material helps to improve fertility and tilth, reduce crusting, and increase water infiltration.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing, however, causes excessive runoff and increases erosion. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is suited to trees, and some areas remain in native hardwoods. Tree seeds, cuttings, and seedlings survive and grow well if competing vegetation is removed during site preparation or controlled by spraying, cutting, and girdling. Steepness of slope and the hazard of erosion are the main concerns in the planting and harvesting of trees.

This soil is in capability subclass IVe.

268E2—Knox silt loam, 14 to 18 percent slopes, moderately eroded. This moderately steep, well drained soil is on side slopes in uplands. Individual areas range from 2 to 20 acres and are irregular in shape. Slopes are long or grade into adjacent, long slopes.

Typically, the surface layer is very dark grayish brown silt loam mixed with streaks and patches of brown subsoil material. It is about 8 inches thick. The subsoil is dark yellowish brown, mottled, friable silty clay loam about 28 inches thick. The substratum to a depth of about 60 inches is brown, mottled, friable silt loam. In places the surface layer consists mostly of dark yellowish brown, silty clay loam subsoil. In other places small areas are still in trees. These areas have a surface layer of very dark grayish brown silt loam about 5 inches thick and a subsurface layer of brown, friable silt loam about 5 inches thick.

Included with this soil in mapping are small areas of loamy Gara soils and clayey Armstrong soils. These soils are on the lower part of the slope. Also included are severely eroded areas where the surface layer consists mostly of subsoil material. These areas are higher in content of clay and lower in content of organic matter than Knox soil. The included areas make up about 15 percent of this unit.

This Knox soil is moderately permeable, and surface runoff is rapid. Available water capacity is high. The surface layer is about 1 to 2 percent organic matter and typically is slightly acid. Reaction varies widely, however, because of use and liming practices. The subsoil generally is medium in available phosphorus and low in available potassium. This soil is in good tilth.

Most areas of this soil are cultivated, but some areas are in trees and pasture. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture. If the soil is used for cultivated crops, damage from further erosion is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Farming on the contour and terracing are suited to this soil if the slopes are long enough. Returning crop residue or the regular addition of other organic material helps to improve fertility and tilth, reduce crusting, and increase water infiltration.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing, however, causes excessive runoff and increases erosion. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is suited to trees, and some areas remain in native hardwoods. Tree seeds, cuttings, and seedlings survive and grow well if competing vegetation is removed during site preparation or controlled by spraying, cutting, and girdling. Steep slopes and the hazard of erosion are the main concerns in the planting and harvesting of trees.

This soil is in capability subclass IVe.

308—Wadena loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes. This gently sloping, well drained soil is on outwash plains, valley trains, and terraces along major streams. Individual areas range from 5 to 20 acres and are irregular in shape.

Typically, the surface layer is black loam about 9 inches thick. The subsurface layer is about 8 inches thick. It is black loam in the upper part and very dark grayish brown loam in the lower part. The subsoil is about 19 inches thick. The upper part is dark brown, friable loam, and the lower part is dark yellowish brown, very friable sandy loam. The substratum to a depth of about 60 inches is grayish brown, pale brown, and dark

yellowish brown and brown, calcareous, loose sand and gravel. In places the depth to sand and gravel ranges from 40 to 46 inches. In other places, especially in the uplands along the North Raccoon River, the substratum is fine sand to a depth of 10 feet or more.

Included with this soil in mapping are small areas of Cylinder soils that are somewhat poorly drained. Cylinder soils generally are on the less sloping parts of the unit. The included areas make up less than 10 percent of this unit.

This Wadena soil is moderately permeable in the upper part and very rapidly permeable in the lower part. Surface runoff is medium. Available water capacity is moderate in the upper part and low in the lower part. The surface layer is about 3 to 4 percent organic matter and typically is slightly acid in reaction. The subsoil generally is very low in available phosphorus and potassium. This soil is in good tilth.

Most areas of this soil are cultivated. This soil is suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture if rainfall is timely. Where the soil is used for cultivated crops, conservation practices that conserve moisture, such as conservation tillage that leaves crop residue on the surface throughout the year, are beneficial. Erosion damage is a hazard. Conservation tillage and grassed waterways help to prevent excessive soil loss. Returning crop residue or the regular addition of other organic material helps to improve fertility and increase water infiltration. Proper stocking rates help to keep the pasture and soil in good condition.

This soil is in capability subclass IIs.

308B—Wadena loam, 32 to 40 inches to sand and gravel, 2 to 5 percent slopes. This gently sloping, well drained soil is on outwash plains, valley trains, and terraces along major streams. Individual areas range from 5 to 30 acres and are irregular in shape.

Typically, the surface layer is black loam about 9 inches thick. The subsurface layer is black loam in the upper part and very dark grayish brown loam in the lower part. It is about 8 inches thick. The subsoil is about 19 inches thick. The upper part is dark brown, friable loam, and the lower part is dark yellowish brown, very friable sandy loam. The substratum to a depth of about 60 inches is grayish brown, pale brown, and dark yellowish brown and brown, calcareous, loose sand and gravel. In places the depth to sand and gravel ranges from 40 to 46 inches. In other places, especially along the North Raccoon River, the substratum is fine sand.

Included wtih this soil in mapping are small areas of Estherville soils. The Estherville soil is thinner and has more sand in the surface and subsoil layers than Wadena soils. It generally is on the more sloping parts of the map unit. The included areas make up less than 10 percent of this unit.

This Wadena soil is moderately permeable in the upper part and very rapidly permeable in the lower part. Surface runoff is medium. Available water capacity is moderate in the upper part and low in the lower part. The surface layer is about 3 to 4 percent organic matter and typically is slightly acid in reaction. The subsoil generally is very low in available phosphorus and potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture if rainfall is timely. Where the soil is used for cultivated crops, conservation practices that conserve moisture, such as conservation tillage that leaves crop residue on the surface throughout the year, are beneficial. Erosion damage is a hazard. Conservation tillage and grassed waterways help to prevent excessive soil loss. Returning crop residue or the regular addition of other organic material helps to improve fertility, reduce crusting, and increase water infiltration.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing, however, causes increased runoff and erosion. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIe.

430—Ackmore silt loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on smooth bottom lands. It is subject to flooding. Individual areas range from 10 to more than 100 acres and are irregular in shape. They are generally oriented along the middle part of the valley somewhat parallel to the stream channel.

Typically, the surface layer is very dark grayish brown silt loam about 8 inches thick. The substratum to a depth of about 30 inches is stratified, friable, very dark gray, dark grayish brown, and black silt loam and silty clay loam. Below this to a depth of about 60 inches is a buried soil of black silty clay loam. The upper part is friable, and the lower part is firm. In places along the stream channel the soil has a higher content of silt and does not have a dark buried soil.

Included with this soil in mapping are small areas of Colo and Zook soils. These soils are not stratified and do not have a buried soil. Zook soils are higher in content of clay than Ackmore soils. They are in the depressed areas of the unit. The included areas make up about 15 percent of this unit.

This Ackmore soil is moderately permeable, and surface runoff is slow. The soil has a seasonal high water table. Available water capacity is high. The surface layer is about 2 to 4 percent organic matter and typically is medium acid in reaction. The subsoil generally is low in available phosphorus and very low in available potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay or pasture. If the soil is cultivated, wetness caused by flooding or the seasonal high water table is a hazard. In places, the use of mechanical practices, such as diversion terraces on foot slopes above the soil, the construction of levees, or the installation of surface or tile drains help to control excessive wetness.

The use of this soil for pasture or hay is an effective means of controlling erosion in areas that are subject to more frequent flooding. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and surface puddling and results in lower productivity. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIw.

485—Spillville loam, 0 to 2 percent slopes. This nearly level, somewhat poorly drained to moderately well drained soil is on smooth bottom lands of larger streams and their tributaries. It is subject to flooding. Individual areas range from 5 to more than 100 acres and are irregular in shape.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is black loam in the upper part and mottled, very dark grayish brown loam in the lower part. It is about 38 inches thick. The substratum to a depth of about 60 inches is multicolored, friable loam. In places sandy loam is at a depth of more than 34 inches. In other places the more sloping areas are better drained.

Included with this soil in mapping are small areas of Coland soil in the lower parts of the map unit and Cylinder soil on low terraces. The Coland soil is poorly drained, and the Cylinder soil is underlain by sand and gravel. The included areas make up about 15 percent of this unit.

This Spillville soil is moderately permeable, and surface runoff is slow. The soil has a seasonal high water table. Available water capacity is high. The surface layer is about 5 to 7 percent organic matter and typically is medium acid in reaction. The subsoil generally is low in available phosphorus and very low in available potassium. This soil is in good tilth.

Most areas of this soil are cultivated. This soil is suited to corn, soybeans, small grains, and grasses and legumes for hay or pasture. If the soil is cultivated, wetness caused by flooding or the seasonal high water table is a hazard. The use of diversion terraces on foot slopes above this soil and the installation of surface or tile drains help to control excessive wetness.

The use of this soil for pasture or hay is an effective means of controlling erosion in areas that are subject to more frequent flooding. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and surface puddling and results in lower productivity. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIw.

485B—Spillville loam, 2 to 5 percent slopes. This gently sloping, somewhat poorly drained to moderately well drained soil is on foot slopes or in fan positions along narrow stream valleys adjacent to uplands. It is subject to flooding. Individual areas range from 2 to 15 acres and are elongated.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is black loam in the upper part and mottled, very dark grayish brown loam in the lower part. It is about 38 inches thick. The substratum to a depth of about 60 inches is multicolored, friable loam. In places the dark surface layer is much thinner. In places along the higher lying parts of the unit on fans, the more sloping areas are better drained.

Included with this soil in mapping are small areas of poorly drained Coland soils in depressions. The included areas make up about 5 percent of this unit.

This Spillville soil is moderately permeable, and surface runoff is slow. The soil has a seasonal high water table. Available water capacity is high. The surface layer is about 5 to 7 percent organic matter. Reaction typically is medium acid in the surface layer and subsoil. The subsoil generally is very low in available phosphorus and potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture. If the soil is cultivated, siltation, runoff, and the seasonal high water table are hazards. The use of mechanical practices, such as contouring and diversion terraces upslope from this soil, and the installation of interceptor tiles to remove seepage water help to offset these hazards.

The use of this soil for pasture or hay helps to control runoff. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and surface puddling and results in lower productivity. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIe.

507—Canisteo silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained, calcareous soil is on low areas or in slight depressions in the uplands. Individual areas range from 10 to more than 80 acres and are irregular in shape.

Typically, the surface layer is black, calcareous silty clay loam about 8 inches thick. The subsurface layer is about 12 inches thick. It is black silty clay loam in the upper part and dark gray and black, calcareous clay loam in the lower part. The mottled subsoil is grayish

brown, friable, calcareous clay loam about 7 inches thick. The mottled substratum to a depth of about 60 inches is grayish brown, friable, calcareous clay loam. In places are small areas of more calcareous Harps soil. In places the subsoil is higher in content of clay. In other places the surface layer is not calcareous.

Included with this soil in mapping are small areas of Okoboji and Webster soils. The Okoboji soil is in slight depressions. It has a higher content of organic matter in the surface layer and a higher content of clay in the subsoil than Canisteo soils. The Webster soil is noncalcareous in the surface layer and upper part of the subsoil. The included areas make up 10 percent of this unit.

This Canisteo soil is moderately permeable, and surface runoff is slow. The soil has a seasonal high water table. Available water capacity is high. The surface layer is about 4 to 6 percent organic matter and typically is mildly alkaline in reaction. The subsoil generally is very low in available phosphorus and potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay or pasture. The high lime content in the soil increases the possibility of crop damage from herbicides. If the soil is cultivated, wetness caused by the seasonal high water table is a hazard. The installation of surface field drains and tile drains help to control excessive wetness.

If this soil is used for pasture, grazing when the soil is too wet causes surface compaction and surface puddling and results in lower productivity. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

This soil is in capability subclass IIw.

509B—Marshall silty clay loam, benches, 2 to 7 percent slopes. This gently sloping and moderately sloping, well drained soil is on loess covered benches in valleys of larger streams. Individual areas range from 2 to 15 acres and are irregular in shape.

Typically, the surface layer is black silty clay loam about 8 inches thick. The subsurface layer is black silty clay loam about 8 inches thick. The subsoil is about 40 inches thick. The upper part is dark brown and brown, friable silty clay loam, and the lower part is brown and grayish brown, mottled, friable silty clay loam. The mottled substratum to a depth of about 60 inches is grayish brown, friable silty clay loam. The loess overlying the sandy alluvium is about 10 feet thick. In places small areas are less sloping and the subsoil is grayer.

This Marshall soil is moderately permeable, and surface runoff is slow. Available water capacity is high. The surface layer is about 3 to 4 percent organic matter and typically is slightly acid in reaction. The subsoil generally is low in available phosphorus and potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture. If the soil is used for cultivated crops, erosion is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, helps to prevent excessive soil loss. In most places, the practice of contouring for erosion control is suited to this soil. Returning crop residue or the regular addition of other organic material helps to improve fertility and maintain good tilth.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and increases runoff. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIe.

559—Talcot silty clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes. This nearly level, poorly drained to very poorly drained soil is on glacial outwash plains and is underlain by sand and gravel. Individual areas range from 5 to 15 acres and are irregular in shape.

Typically, the surface layer is black, calcareous silty clay loam about 8 inches thick. The subsurface layer is about 14 inches thick. The upper part is black clay loam, and the lower part is very dark gray clay loam. The subsoil is about 15 inches thick. The upper and middle parts are multicolored, firm, calcareous clay loam, and the lower part is olive gray, friable, calcareous gravelly loam. The calcareous substratum to a depth of about 60 inches is olive gray to multicolored sand and gravel. In places the depth to sand and gravel ranges from 40 to 48 inches. In places the surface layer is clay loam and the subsoil is higher in content of clay.

Included with this soil in mapping are small areas of poorly drained Biscay soils and somewhat poorly drained Cylinder soils. Cylinder soils are at a slightly higher elevation, and Biscay soils are in positions on the landscape similar to those of Talcot soils. The included areas make up less than 10 percent of this unit.

This Talcot soil is moderately permeable in the surface layer and subsoil and rapidly permeable in the substratum. Surface runoff is slow or ponded. The soil has a seasonal high water table. Available water capacity is moderate. The surface layer is about 4 to 8 percent organic matter and typically is moderately alkaline in reaction. The subsoil generally is very low in available phosphorus and potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture. The high lime content in

the soil increases the possibility of crop damage from herbicides. If the soil is used for cultivated crops, conservation practices that conserve moisture, such as conservation tillage that leaves crop residue on the surface throughout the year, are beneficial. If the soil is plowed in the fall and left barren, the surface layer is susceptible to wind erosion. Conservation tillage helps to reduce soil loss. Returning crop residue or the regular addition of other organic material helps to improve fertility, reduce erosion, and increase water infiltration.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and increases erosion. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIw.

638C2—Clarion-Storden loams, 5 to 9 percent slopes, moderately eroded. These moderately sloping, well drained soils are on side slopes and on some ridges on glacial moraines. Individual areas range from 10 to more than 50 acres and are irregular in shape. This map unit is about 70 percent Clarion soil and 25 percent Storden soil. The Clarion soil is on the smoother side slopes and ridges, and the Storden soil is on the more convex side slopes and ridges. These soils are so intricately mixed or so small that it is not practical to separate them in mapping.

Typically, the surface layer of the Clarion soil is very dark grayish brown loam mixed with streaks and patches of brown subsoil material. It is about 8 inches thick. The subsoil is about 16 inches thick. The upper part is brown, friable loam, and the lower part is dark yellowish brown, mottled, friable loam. The substratum to a depth of about 60 inches is yellowish brown, mottled, friable, calcareous loam.

Typically, the surface layer of the Storden soil is dark grayish brown and very dark grayish brown loam mixed with streaks and patches of brown subsoil material. It is about 8 inches thick. The substratum to a depth of about 60 inches is mottled, friable, calcareous loam that has lime accumulations. The upper part is yellowish brown, and the lower part is light olive brown.

Included with these soils in mapping are small areas of the gravelly Salida soil on the most convex, sloping ridges and knobs, and the somewhat poorly drained Nicollet soil in low places. The included areas make up about 5 percent of this unit.

These Clarion and Storden soils are moderately permeable, and surface runoff is medium to rapid. Available water capacity is high. The surface layer is about 1 to 2 percent organic matter in both soils. Reaction typically is slightly acid in the surface layer of the Clarion soil and moderately alkaline in the Storden soil. The subsoil of the Clarion soil and the substratum of the Storden soil are very low in available phosphorus and potassium. These soils are in good tilth.

Most areas of these soils are cultivated. The soils are suited to corn, soybeans, small grains, grasses, and trees. If the soils are used for cultivated crops, erosion is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. The use of mechanical practices to control erosion, such as contouring and terracing, is difficult because of the undulating relief and uneven side slopes. Returning crop residue or the regular addition of other organic material helps to improve fertility and increase water infiltration.

The use of these soils for pasture or hay is an effective means of controlling erosion if adequate vegetative cover is left on the surface. Overgrazing causes increased runoff and erosion. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soils in good condition.

These soils are in capability subclass IIIe.

638D2—Clarion-Storden loams, 9 to 14 percent slopes, moderately eroded. These strongly sloping, well drained soils are on side slopes and on some ridges on glacial moraines. Individual areas range from 10 to more than 50 acres. This map unit is about 60 percent Clarion soil and 35 percent Storden soil. The Clarion soil is on the smoother side slopes and ridges, and the Storden soil is on the more convex side slopes and ridges. These soils are so intricately mixed or so small that it is not practical to separate them in mapping.

Typically, the surface layer of the Clarion soil is very dark grayish brown loam mixed with streaks and patches of brown subsoil material. It is about 8 inches thick. The subsoil is about 14 inches thick. The upper part is brown, friable loam, and the lower part is dark yellowish brown, mottled, friable loam. The substratum to a depth of about 60 inches is yellowish brown, mottled, friable, calcareous loam.

Typically, the surface layer of the Storden soil is dark grayish brown and very dark grayish brown loam mixed with streaks and patches of brown subsoil material. It is about 8 inches thick. The mottled substratum to a depth of about 60 inches is friable, calcareous loam that has lime accumulations. The upper part is yellowish brown, and the middle and lower parts are light olive brown.

Included with these soils in mapping are small areas of gravelly Salida soil on the most convex, sloping areas and somewhat poorly drained Nicollet soil in the lower lying places. The included areas make up about 5 percent of this unit.

These Clarion and Storden soils are moderately permeable, and surface runoff is medium to rapid. Available water capacity is high. The surface layer is about 1 to 2 percent organic matter in both soils. Reaction typically is slightly acid in the surface layer of

the Clarion soil and moderately alkaline in the Storden soil. The subsoil of the Clarion soil and the substratum of the Storden soil are very low in available phosphorus and potassium.

Most areas of these soils are cultivated. The soils are suited to corn, soybeans, small grains, grasses, and trees. If the soils are used for cultivated crops, further erosion is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. The use of mechanical practices to control erosion, such as contouring and terracing, is difficult because of the undulating relief and uneven side slopes. Returning crop residue or the regular addition of other organic material helps to improve fertility and increase water infiltration.

The use of these soils for pasture or hay is an effective means of controlling erosion if adequate vegetative cover is left on the surface. Overgrazing causes increased runoff and erosion. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soils in good condition.

These soils are in capability subclass IVe.

639C—Salida-Storden complex, 5 to 9 percent slopes. These moderately sloping, excessively drained and well drained soils are on knobs, hilly valley trains, and glacial outwash plains. Individual areas range from 2 to 30 acres and are irregular in shape. This map unit is about 40 percent Salida soil, 30 percent Storden soil, and 30 percent soils of minor extent. The Salida soil is generally on high and more prominent knobs and ridges, and the Storden soil is generally in areas that surround or are adjacent to the knobs and ridges. These soils are so intricately mixed or so small that it is not practical to separate them in mapping.

Typically, the surface layer of the Salida soil is very dark grayish brown, calcareous gravelly sandy loam about 7 inches thick. The subsoil is brown, calcareous, loose, gravelly loamy sand about 8 inches thick. The substratum to a depth of about 60 inches is multicolored, calcareous, loose gravelly sand. In places the surface layer is not calcareous.

Typically, the surface layer of the Storden soil is dark grayish brown and very dark grayish brown, calcareous loam mixed with streaks and patches of brown subsoil material. It is about 8 inches thick. The substratum to a depth of about 60 inches is friable, calcareous loam. The upper part is yellowish brown, and the middle and lower parts are mottled, light olive brown. Lime accumulations are throughout.

Included with these soils in mapping are small areas of Clarion, Estherville, Wadena, and Dickman soils that are thicker than Salida or Storden soils and are not calcareous. They contain less gravel than Salida soil and are on the less prominent, lower lying parts of the map unit. The included areas make up about 30 percent of this unit.

The Salida soil is very rapidly permeable, and the Storden soil is moderately permeable. Surface runoff is slow on the Salida soil and rapid on the Storden soil. Available water capacity is very low in the Salida soil and high in the Storden soil. In both soils the surface layer is about 0.5 to 2 percent organic matter, and typically is mildly alkaline or moderately alkaline in reaction, and the subsoil is very low in available phosphorus and potassium. These soils are in fair tilth because the surface layer is gravelly.

Most of the larger areas of these soils are in grass for hay or pasture, and most of the smaller areas of 2 to 4 acres are generally cultivated with the surrounding, more productive soils. These soils are poorly suited to corn, soybeans, and small grains because they are droughty. They are, however, better suited to grasses for hay and pasture or to habitat for wildlife. These soils are poorly suited to trees.

The use of these soils for pasture or hay is an effective means of controlling erosion if the pasture is not overgrazed. Leaving the soils idle for use as habitat by wildlife is also an effective means of erosion control.

The soils in this complex are in capability subclass IIIe.

639D—Salida-Storden complex, 9 to 16 percent slopes. These strongly sloping and moderately steep, excessively drained and well drained soils are on knobs, hilly valley trains, and glacial outwash plains. Individual areas range from 2 to 30 acres and are irregular in shape. This map unit is about 40 percent Salida soil, 30 percent Storden soil, and 30 percent soils of minor extent. The Salida soil is generally on high and more prominent knobs and ridges, and the Storden soil is generally in areas that surround or are adjacent to the knobs and ridges. These soils are so intricately mixed or so small that it is not practical to separate them in mapping.

Typically, the surface layer of the Salida soil is very dark grayish brown, calcareous, gravelly sandy loam about 7 inches thick. The subsoil is brown, calcareous, loose, gravelly loamy sand about 8 inches thick. The substratum to a depth of about 60 inches is multicolored, calcareous, loose gravelly sand. In places the surface layer is not calcareous.

Typically, the surface layer of the Storden soil is mixed dark grayish brown and very dark grayish brown, calcareous loam mixed with streaks and patches of brown subsoil material. It is about 8 inches thick. The mottled substratum to a depth of about 60 inches is friable, calcareous loam. The upper part is yellowish brown, and the middle and lower parts are light olive brown. Lime accumulations are throughout. In places the surface layer is gravelly loam.

Included with these soils in mapping are small areas of Clarion, Estherville, Wadena, and Dickman soils that are

thicker than Salida or Storden soils and are not calcareous. They are on the less prominent, lower lying parts of the map unit. The included areas make up about 30 percent of this unit.

The Salida soil is very rapidly permeable, and the Storden soil is moderately permeable. Surface runoff is slow on the Salida soil and rapid on the Storden soil. Available water capacity is very low in the Salida soil and high in the Storden soil. In both soils the surface layer is about 0.5 to 2 percent organic matter and reaction typically is mildly alkaline or moderately alkaline, and the subsoil is very low in available phosphorus and potassium. These soils are in fair tilth because the surface layer is gravelly.

Most of the larger areas of these soils are generally in grass for hay or pasture, and most of the smaller areas of 2 to 4 acres are cultivated with the surrounding, more productive soils. The soils are not suited to corn, soybeans, and small grains. Salida soils are droughty and are better suited to grasses for hay and pasture or to habitat for wildlife. These soils are poorly suited to trees.

The use of these soils for pasture or hay is an effective means of controlling erosion if the soils are not overgrazed. Leaving the soils idle for use as habitat by wildlife is also an effective means of erosion control.

The soils in this complex are in capability subclass VIs.

733—Calco silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on low benches and flood plains in bottom lands. It is subject to flooding. Individual areas range from 10 to more than 60 acres and are irregular in shape.

Typically, the surface layer is black, calcareous silty clay loam about 8 inches thick. The subsurface layer is black, calcareous silty clay loam about 32 inches thick. The subsoil is very dark gray, friable, calcareous silty clay loam about 8 inches thick. The substratum to a depth of about 60 inches is very dark gray, friable, calcareous silty clay loam. In places the subsoil is higher in content of clay.

Included with this soil in mapping are small areas of Canisteo, Coland, Colo, and Zook soils. The Canisteo soils are on slightly higher areas or edges of the unit and have a thinner dark surface layer than Calco soils. Coland, Colo, and Zook soils are not calcareous. Zook soils have more content of clay than Calco soils. The included areas make up about 15 percent of this unit.

Permeability is moderate in this Calco soil, and surface runoff is slow. The soil has a seasonal high water table. Available water capacity is high. The surface layer is about 5 to 7 percent organic matter and typically is mildly alkaline in reaction. The subsoil generally is medium in available phosphorus and very low in available potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay or pasture. The high lime content in the soil increases the possibility of crop damage from herbicides. If the soil is cultivated, wetness from flooding or the seasonal high water table is a hazard. The use of diversion terraces on slopes above this soil and the installation of surface or tile drains help to control excessive wetness.

If this soil is used for pasture, grazing when the soil is too wet causes compaction and surface puddling and results in lower productivity. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIw.

822D3—Lamoni silty clay loam, 9 to 14 percent slopes, severely eroded. This strongly sloping, somewhat poorly drained soil is on convex side slopes and some ridges in uplands. Individual areas range from 3 to 25 acres. They are rather long and narrow and have irregular boundaries.

Typically, the surface layer is dark grayish brown silty clay loam about 5 inches thick. The subsoil is about 55 inches thick. The upper part is grayish brown, mottled, very firm clay, the middle part is multicolored, firm clay, and the lower part is multicolored, firm clay loam that has common accumulations of lime. In places the soil is lower in content of sand and higher in content of clay. In places the subsoil is of redder hue.

Included with this soil in mapping are small areas of Burchard soil on the lower part of the map unit. The Burchard soil is less clayey and more permeable than Lamoni soil. The included areas make up about 10 percent of this unit.

Permeability is slow or very slow in this Lamoni soil, and surface runoff is rapid. The soil has a seasonal high water table. Available water capacity is high. The surface layer is about 1 to 2 percent organic matter. Reaction typically is slightly acid in the surface layer and upper part of the subsoil. The subsoil generally is low in available phosphorus and potassium. This soil is difficult to till because it is sticky when wet and hard when dry.

Most areas of this soil are cultivated. The soil is poorly suited to corn, soybeans, and small grains. It is better suited to grasses and legumes for hay or pasture. If the soil is used for cultivated crops, further damage from erosion is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Contour farming is well suited to this soil. Terracing is only moderately suited because of poor tilth of the exposed subsoil. Returning crop residue or the regular addition of other organic material helps to improve fertility, reduce crusting and the formation of hard clods on the surface, and increase water infiltration.

The use of this soil for pasture or hay is an effective means of controlling erosion. Overgrazing or grazing

when the soil is too wet, however, causes surface compaction, increases runoff, and results in poorer tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IVe.

823—Ridgeport sandy loam, 1 to 3 percent slopes. This very gently sloping, somewhat excessively drained soil is on low terraces and bottom lands. It is subject to flooding. Individual areas range from 5 to 50 acres and are irregular in shape. They are generally oriented along the valley somewhat parallel to the stream channel.

Typically, the surface layer is black fine sandy loam about 7 inches thick. The subsurface layer is very dark brown fine sandy loam about 7 inches thick. The subsoil is about 21 inches thick. The upper part is dark brown, very friable fine sandy loam, and the middle and lower parts are multicolored, very friable fine sandy loam. The substratum to a depth of about 60 inches is multicolored sand and gravel. In places the surface layer is loam.

Included with this soil in mapping are small areas of Cylinder, Estherville, and Wadena soils. These soils are underlain by sand and gravel at a depth of less than 42 inches. Cylinder soils are somewhat poorly drained, Estherville soils are somewhat excessively drained, and Wadena soils are well drained. The included areas make up about 15 percent of this unit.

Permeability in this Ridgeport soil is moderately rapid in the solum and rapid and very rapid in the underlying, coarse textured material. Surface runoff is slow. Available water capacity is low. The surface layer is about 1 to 3 percent organic matter. Reaction typically is neutral or slightly acid in the surface layer and subsoil. The subsoil generally is very low in available phosphorus and potassium. This soil is in good tilth.

Most areas of this soil are cultivated. The soil is suited to corn, soybeans, small grains, and grasses and legumes for hay or pasture. If the soil is cultivated, wetness from flooding is a hazard. The use of mechanical practices, such as diversion terraces on foot slopes, help to control excessive wetness. If this soil is plowed in the fall, wind erosion is a slight hazard. The use of conservation tillage, a practice that leaves crop residue on the surface throughout the year, helps to reduce erosion.

The use of this soil for pasture or hay is an effective means of controlling erosion in areas that are subject to more frequent flooding and wind erosion. Overgrazing causes surface compaction and results in lower productivity. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIs.

924D2—Burchard-Adair clay loams, 9 to 14 percent slopes, moderately eroded. These strongly sloping, moderately well drained and somewhat poorly drained soils are on sloping uplands. They extend horizontally along hillsides, around nose slopes, and into heads of drainageways. Individual areas range from 5 to 30 acres. They are generally rather long and narrow and have irregular boundaries. This map unit is about 60 percent Burchard soil and 25 percent Adair soil. The Burchard soil is in the lower part of the unit below the Adair and Lamoni soils. These soils are so intricately mixed or so small that it is not practical to separate them in mapping.

Typically, the surface layer of the Burchard soil is dark brown clay loam mixed with streaks and patches of brown subsoil material. It is about 7 inches thick. The subsoil is about 15 inches thick. The upper part is brown, firm clay loam, and the middle and lower parts are dark yellowish brown and yellowish brown, mottled, firm clay loam. The substratum to a depth of about 60 inches is yellowish brown and grayish brown, mottled, firm, calcareous clay loam that has common lime accumulations. In places the surface layer and subsoil are sandy clay loam.

Typically, the surface layer of the Adair soil is very dark grayish brown clay loam mixed with streaks and patches of yellowish red subsoil material. It is about 6 inches thick. The subsoil is about 36 inches thick. The upper part is yellowish red, very firm clay, the middle part is brown and yellowish red, mottled, very firm clay, and the lower part is multicolored, firm clay loam. The substratum to a depth of about 60 inches is grayish brown and yellowish brown, mottled, firm clay loam. In places in small areas the subsoil is grayer.

Included with these soils in mapping are small areas of Exira and Ida soils. These soils are on less sloping places along the higher or lower parts of the map unit. The Exira and Ida soils have more silt than the Adair and Burchard soils. The Ida soil is calcareous throughout. Also included are severely eroded areas where the surface layer consists mainly of subsoil material. These areas are higher in content of clay and lower in content of organic matter. The included areas make up about 15 percent of this unit.

Permeability is moderately slow in the Burchard soil and slow in the Adair soil. Surface runoff is medium or rapid in both soils. The Adair soil has a seasonal high water table. In both soils the available water capacity is high, and the surface layer is about 1 to 3 percent organic matter and typically is slightly acid in reaction. The subsoil of the Burchard soil generally is low in available phosphorus and high in available potassium, and the subsoil of the Adair soil generally is very low in available phosphorus and potassium. These soils are in fair tilth.

Most areas of these soils are cultivated. The soils are suited to corn, soybeans, small grains, and grasses and legumes for hay or pasture. If the soils are used for

cultivated crops, damage from further erosion is a hazard. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Erosion control practices, such as contouring and terracing, are suited to these soils. Returning crop residue or the regular addition of other organic material helps to improve fertility, reduce crusting and the formation of hard clods on the surface, and increase water infiltration.

The use of these soils for pasture or hay is an effective means of controlling erosion. Overgrazing or grazing when the soils are too wet, however, causes surface compaction, increases runoff and erosion, and results in poorer tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soils in good condition.

These soils are in capability subclass IVe.

924E2—Burchard-Adair clay loams, 14 to 18 percent slopes, moderately eroded. These soils are moderately steep. They are moderately well drained and somewhat poorly drained and are on uplands. Areas extend horizontally along hillsides, around nose slopes, and into heads of drainageways. Individual areas range from 5 to 60 acres. They are generally rather long and narrow and have irregular boundaries. This map unit is about 70 percent Burchard soil and 20 percent Adair soil. The Burchard soil is on the lower lying and steeper parts of the unit below the Adair soil. These soils are so intricately mixed or so small that it is not practical to separate them in mapping.

Typically, the surface layer of the Burchard soil is dark brown clay loam mixed with streaks and patches of brown subsoil material. It is about 6 inches thick. The subsoil is brown and yellowish brown, firm clay loam about 13 inches thick. The substratum to a depth of about 60 inches is brown, yellowish brown, and dark yellowish brown, mottled, firm, calcareous clay loam that has common soft lime accumulations. In places the surface layer is sandy clay loam.

Typically, the surface layer of the Adair soil is very dark grayish brown clay loam mixed with streaks and patches of reddish brown subsoil material. It is about 6 inches thick. The subsoil is about 36 inches thick. The upper part is reddish brown, mottled, firm clay, the middle part is multicolored, very firm clay, and the lower part is multicolored, firm clay loam. The substratum to a depth of about 60 inches is yellowish brown and grayish brown, mottled, firm clay loam. In places in small areas the subsoil is grayer.

Included with these soils in mapping are small areas of Exira and Ida soils. These soils are on less sloping places along the higher or lower edges of the map unit. The Exira and Ida soils have more silt than Adair or Burchard soils. The Ida soil is calcareous throughout. Also included are severely eroded areas where the surface layer consists mainly of subsoil material. These areas are higher in content of clay and lower in content of organic matter. The included areas make up about 10 percent of this unit.

Permeability is moderately slow in the Burchard soil and slow in the Adair soil. Surface runoff is rapid in both soils. The Adair soil has a seasonal high water table. In both soils the available water capacity is high; the surface layer is about 1 to 3 percent organic matter, and reaction typically is slightly acid in the surface layer and upper part of the subsoil. The subsoil of the Burchard soil generally is low in available phosphorus and high in available potassium, and the subsoil of the Adair soil is very low in available phosphorus and potassium. These soils are in fair tilth.

Most areas of these soils are cultivated. The soils are not suited to corn, soybeans, small grains, and grasses and legumes for hay or pasture. If the soils are used for cultivated crops, further damage from erosion is a hazard. Returning crop residue or the regular addition of other organic material helps to improve fertility, reduce crusting and the formation of hard clods on the surface, and increase water infiltration.

The use of these soils for pasture or hay is an effective means of controlling erosion. Overgrazing or grazing when the soils are too wet, however, causes surface compaction, increases runoff and erosion, and results in poorer tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soils in good condition.

These soils are well suited to trees. Tree seeds, cuttings, and seedlings survive and grow well if competing vegetation is removed during site preparation or controlled by spraying, cutting, and girdling; and if erosion is controlled. The hazard of erosion is severe in areas where the soils are not protected. Adequate vegetative cover needs to be maintained on the surface of these soils.

These soils are in capability subclass VIe.

993D2—Gara-Armstrong loams, 9 to 14 percent slopes, moderately eroded. These strongly sloping, somewhat poorly drained to well drained soils are on side slopes in uplands. Slopes generally are long or grade into adjacent, long slopes. Individual areas range from 2 to 40 acres and are irregular in shape. This map unit is about 70 percent Gara soil and 25 percent Armstrong soil. The Armstrong soil is on the upper part of the map unit and is generally a narrow band. The Gara soil is on the middle and lower slopes. These soils are so intricately mixed or so small that it is not practical to separate them in mapping.

Typically, the surface layer of the Gara soil is very dark grayish brown and dark grayish brown loam mixed with streaks and patches of brown subsoil material. It is about 8 inches thick. The subsoil is about 34 inches

thick. The upper part is brown and dark yellowish brown, firm clay loam, the middle part is dark yellowish brown, mottled, firm clay loam, and the lower part is yellowish brown, mottled, firm clay loam. The substratum to a depth of about 60 inches is yellowish brown, mottled clay loam that has lime concretions. In places small areas are still in trees. In these areas the surface layer is very dark gray loam about 5 to 7 inches thick, and the subsurface layer is dark grayish brown and very dark grayish brown, friable loam.

Typically, the surface layer of the Armstrong soil is very dark grayish brown loam mixed with streaks and patches of brown subsoil material. It is about 7 inches thick. The subsoil is about 35 inches thick. The upper part is brown, firm clay loam, the middle part is grayish brown and yellowish brown, firm clay loam, and the lower part is grayish brown, yellowish brown, and light gray, firm clay loam. A stone line is in the upper part of the subsoil. The substratum to a depth of about 60 inches is mottled, light gray and yellowish brown clay loam. In places small areas are still in trees. In these areas the surface layer is very dark gray and black loam about 7 inches thick, and the subsurface layer is grayish brown, friable silt loam about 5 inches thick.

Included with these soils in mapping are small areas of Knox soils. The Knox soil is in the upper part of the map unit and in concave drainageways. Also included are small calcareous areas of steeper soils and small severely eroded areas where the soils are higher in content of clay and lower in content of organic matter. The included areas make up less than 5 percent of this unit.

Permeability is moderately slow in the Gara soil and slow in the Armstrong soil. Surface runoff is rapid in both soils. The Armstrong soil has a seasonal high water table. In both soils the available water capacity is high to moderately high, and the surface layer is about 0.5 to 1.5 percent organic matter. Reaction varies in the surface layer depending on use, type of soil, and liming practices but typically is slightly acid to medium acid. In both soils the subsoil generally is very low in available phosphorus and potassium. These soils are in good tilth.

Most areas of these soils are cultivated, but some areas are in pasture or trees. The soils are not suited to corn, soybeans, and small grains. They are better suited to grasses and legumes for hay or pasture. If the soils are used for cultivated crops, further damage from erosion is a severe hazard. Returning crop residue or the regular addition of other organic material helps to improve fertility and tilth, reduce crusting, and increase water infiltration.

The use of these soils for pasture or hay is an effective means of controlling erosion. Overgrazing causes excessive runoff and increases erosion. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soils in good condition.

These soils are suited to trees, and some areas remain in native hardwoods. Tree seeds, cuttings, and seedlings survive and grow well if competing vegetation is removed during site preparation or controlled by spraying, cutting, and girdling. Strong slopes and the high shrink-swell potential are the main concerns in the planting and harvesting of trees.

These soils are in capability subclass VIe.

993E2—Gara-Armstrong loams, 14 to 18 percent slopes, moderately eroded. These moderately steep, somewhat poorly drained to well drained soils are on side slopes in uplands. Individual areas range from 2 to 40 acres and are irregular in shape. Slopes generally are long or grade into adjacent, long slopes. This map unit is about 70 percent Gara soil and 25 percent Armstrong soil. The Gara soil is on the middle and lower parts of the slopes. The Armstrong soil is generally a narrow band on the upper part of the map unit. These soils are so intricately mixed or so small that it is not practical to separate them in mapping.

Where the Gara soil is cultivated, the surface layer typically is very dark grayish brown and dark grayish brown loam mixed with streaks and patches of brown subsoil material. It is about 6 inches thick. The subsoil is about 34 inches thick. The upper part is brown and dark yellowish brown, firm clay loam, the middle part is dark yellowish brown, mottled, firm clay loam, and the lower part is yellowish brown, mottled, firm clay loam. The substratum to a depth of about 60 inches is yellowish brown, mottled clay loam that has lime concretions. In places small areas are still in trees. In these areas the surface layer is very dark gray, friable loam about 5 to 7 inches thick, and the subsurface layer is dark grayish brown and very dark grayish brown, friable loam.

Typically, the surface layer of the Armstrong soil is very dark grayish brown loam mixed with streaks and patches of brown clay loam subsoil material. It is about 7 inches thick. The subsoil is about 35 inches thick. The upper part is brown, firm clay loam, the middle part is grayish brown and yellowish brown, firm clay loam, and the lower part is grayish brown and yellowish brown and light gray, firm clay loam. A stone line is in the upper part of the subsoil. The mottled substratum to a depth of about 60 inches is light gray and yellowish brown clay loam. In areas that are still in trees, the surface layer is about 8 inches thick. It is very dark gray loam in the upper part and black loam in the lower part. The subsurface layer is grayish brown silt loam about 4 inches thick.

Included with these soils in mapping are small areas of Knox soils. The Knox soil is in concave drainageways and on less sloping areas. Also included are small, severely eroded areas where the surface layer consists mainly of subsoil material. These areas are higher in content of clay and lower in content of organic matter. The included areas make up about 5 percent of this unit.

Permeability is moderately slow in the Gara soil and slow in the Armstrong soil. Surface runoff is rapid in both soils. The Armstrong soil has a seasonal high water table. In both soils the available water capacity is high to moderately high, and the surface layer is about 0.5 to 1.5 percent organic matter. Reaction varies in the surface layer depending on use and liming practices but typically is slightly acid. In both soils the subsoil generally is very low in available phosphorus and potassium.

Most areas of these soils are cultivated, but some areas are in pasture or trees. The soils are not suited to corn, soybeans, small grains, or grasses and legumes for hay or pasture. If the soils are used for cultivated crops, further damage from erosion is a severe hazard. Returning crop residue or the regular addition of other organic material helps to improve fertility and tilth, reduce crusting, and increase water infiltration.

The use of these soils for pasture or hay is an effective means of controlling erosion. Overgrazing causes excessive runoff and increases erosion. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soils in good condition.

These soils are suited to trees, and some areas remain in native hardwoods. Tree seeds, cuttings, and seedlings survive and grow well if competing vegetation is removed during site preparation or controlled by spraying, cutting, and girdling. Moderately steep slopes and the high shrink-swell potential are the main concerns in the planting and harvesting of trees.

These soils are in capability subclass VIe.

2315—Fluvaquents, nearly level. These nearly level, poorly drained to somewhat poorly drained soils are on bottom lands. They are adjacent to the main channel in most places. Individual areas range from 10 to more than 100 acres and are irregular in shape. These soils are along the channel of the larger streams. Some areas are undulating. In these areas differences in elevation range from 1 foot to 3 feet but are as much as 6 or 7 feet in places. The undulating areas range from 15 to 50 feet across. These soils are subject to frequent depositions of alluvial sediment.

Typically, Fluvaquents are stratified, very dark grayish brown, grayish brown, and brown fine sand, loamy sand, sandy loam, silt loam, and silty clay loam to a depth of about 60 inches.

Included with these soils in mapping are small areas of Ackmore, Coland, Colo, Ridgeport, Spillville, and Zook soils. The poorly drained or somewhat poorly drained Ackmore soils and the poorly drained Coland, Colo, and Zook soils are in the slightly lower, slackwater areas, old oxbows, and in small, meandering channels. The somewhat excessively drained Ridgeport soils and the somewhat poorly drained to moderately well drained Spillville soils are on the slightly higher lying areas. Spillville soils have higher content of organic matter and higher available water capacity than Fluvaquents, nearly level.

The soils in this unit differ in permeability, depending upon soil texture. The rate varies from very rapid in the most sandy soil to very slow in the most clayey soil. Surface runoff is medium to very slow. Fluvaquents, nearly level; sandbars; and Coland, Colo, and Zook soils frequently have a seasonal high water table during the spring and at times during the rest of the year. The other soils generally have a seasonal high water table during wet seasons. Soils in this map unit are commonly flooded for brief periods during the spring. Available water capacity varies from high to low. The surface layer is about 1 to 5 percent organic matter and typically is slightly acid or neutral in reaction. The subsoil generally is low in available phosphorus and very low in available potassium. If these soils are protected from flooding, they are easily tilled.

Most areas of this map unit are in timbered pasture. The soils are suited to corn, soybeans, and small grains if they are protected from flooding, but they are better suited to grasses and legumes for hay or pasture. If the soils are cultivated, wetness caused by flooding or the seasonal high water table is a hazard, but the use of levees and the installation of surface or tile drains help to control excessive wetness.

Areas of this soil that are subject to more frequent flooding are better suited to pasture or hay than to other uses. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soils in good condition.

These soils are in capability subclass IIIw.

5010—Pits, gravel. This map unit consists of gravel pits. Some of the pits are in active use, and some have been mined out and abandoned (fig. 14). The pits vary from a few acres to a hundred acres or more. They are mostly on stream benches.

Some of the larger pits have potential for recreation use, especially those that are ponded. They have low potential for most other uses, even though they are filled and graded. Some pits that are filled and graded have fair suitability for pasture or as habitat for wildlife.

This map unit is not assigned to a capability subclass.

5040—Orthents, loamy. These soils have been leveled, reshaped, or relocated during industrial, highway, or residential construction. The original soils are no longer recognizable. In most places, the landscape has been altered. Individual areas range from 5 to 25 acres.

The soil material dominantly is silt loam and silty clay loam. In places the entire profile has been removed, and the surface is calcareous, silt loam material.

Included in mapping are some areas of fill where cement, bricks, and trash have been covered with soil

Figure 14.—Gravel pit in the Wadena soils, exposing layers of sand and gravel.

material and then compacted and leveled. These areas are used as building sites, railroad yards, and highways.

Erosion is the main hazard in new cut and fill areas. Because disturbance results in variable soil and physical conditions, onsite investigation is needed before engineering or agricultural decisions are made concerning these areas.

This map unit is not assigned to a capability subclass.

prime farmland

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

Prime farmland, as defined by the U.S. Department of Agriculture, is the land that is best suited to producing food, feed, forage, fiber, and oilseed crops. It has the soil quality, growing season, and moisture supply needed to economically produce a sustained high yield of crops. If it is properly treated and high level management and acceptable farming methods are used, prime farmland produces the highest yields with minimal inputs of energy and economic resources, and its use results in the least damage to the environment.

Prime farmland in Carroll County may now be in cropland, pastureland, woodland, or other land uses, but not in urban land, built-up land, or water areas. It must either be used for producing food or fiber or be available for these uses.

Prime farmland usually has an adequate and dependable supply of moisture from precipitation or irrigation. It also has favorable temperature and growing season, acceptable acidity or alkalinity, few or no rocks, and is permeable to water and air. Prime farmland 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. For more detailed information on the criteria for prime farmland consult the local staff of the Soil Conservation Service.

About 213,000 acres or nearly 60 percent of Carroll County meets the soil requirements for prime farmland. Areas are throughout the county. Approximately 210,000 acres of this prime farmland is used for crops. Crops grown on this land, mainly corn and soybeans, account for an estimated two-thirds of the county's total agricultural income each year.

A recent trend in land use in some parts of the county has been the loss of some prime farmland to industrial and urban uses. The loss of prime farmland to other uses puts pressure on marginal lands, which generally are more erodible, droughty, difficult to cultivate, and usually less productive.

Soil map units that make up prime farmland in Carroll County are listed in this section. 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 in the back of this publication. The soil qualities that affect use and management are described in the section "Detailed soil map units."

Soils that have limitations, such as a seasonal high water table, flooding, or inadequate rainfall, may qualify as prime farmland if these limitations are overcome by such measures as drainage, flood control, or irrigation. The soil map units in the following list are prime farmland or would be prime farmland if measures were used to overcome the limitations indicated by the footnotes. Onsite evaluation is needed to make sure that these limitations have been overcome by the corrective measures indicated.

430	Ackmore silt loam, 0 to 2 percent slopes [1], [2]
5B	Ackmore-Judson complex, 1 to 5 percent slopes [2]
259	Biscay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes [2]
733	Calco silty Clay loam, 0 to 2 percent slopes [1], [2]
507	Canisteo silty clay loam, 0 to 2 percent slopes [2]
138B	Clarion loam, 2 to 5 percent slopes
138B2	Clarion loam, 2 to 5 percent slopes, moderately eroded
135	Coland clay loam, 0 to 2 percent slopes [2]
201B	Coland-Spillville complex, 2 to 5 percent slopes [2]
133	Colo silty clay loam, 0 to 2 percent slopes [1], [2]
133+	Colo silty clay loam, overwash, 0 to 2 percent slopes [1], [2]
11B	Colo-Judson silty clay loams, 2 to 5 percent slopes [2]
203	Cylinder loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes
95	Harps loam, 0 to 2 percent slope [2]
8B	Judson silty clay loam, 2 to 5 percent slopes
9	Marshall silty clay loam, 0 to 2 percent slopes
9B	Marshall silty clay loam, 2 to 5 percent slopes
9B2	Marshall silty clay loam, 2 to 5 percent slopes, moderately eroded
509B	Marshall silty clay loam, benches, 2 to 7 percent slopes
55	Nicollet loam, 1 to 3 percent slopes
823	Ridgeport sandy loam, 1 to 3 percent slopes
485	Spillville loam, 0 to 2 percent slopes
485B	Spillville loam, 2 to 5 percent slopes
559	Talcot silty clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slope [2]
27B	Terril loam, 2 to 5 percent slopes
108	Wadena loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes
108B	Wadena loam, 24 to 32 inches to sand and gravel, 2 to 5 percent slopes
308	Wadena loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes
308B	Wadena loam, 32 to 40 inches to sand and gravel, 2 to 5 percent slopes
107	Webster silty clay loam, 0 to 2 percent slopes [2]
54	Zook silty clay loam, 0 to 2 percent slopes [1], [2]

[1] Prime farmland where protected from flooding.
[2] Prime farmland where drained.

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 avoid 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 behavior 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 recreation 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 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 all or part of 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

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 "Detailed soil map units." Specific information can be obtained from the local office of the Soil Conservation Service or the Cooperative Extension Service.

Carroll County has a total of 367,296 acres. According to the 1980 Carroll County Conservation District Inventory, 297,900 acres were in crops, 16,600 acres in hay, and 15,340 acres in pasture. Corn, soybeans, and oats are the main crops. Alfalfa or grass-alfalfa mixture is the main hay crop. Most of the permanent pastures are in bluegrass, but some of the pastureland has been renovated and birdsfoot trefoil or crownvetch introduced. Most of the permanant bluegrass pastures are not used as cropland because the soils are too steep for cultivation.

Maximum grass and legume production can be achieved if the hayland and pastureland are correctly treated and properly used. Grazing management and livestock production can be enhanced if warm-season grasses are included in a balanced forage program. Switchgrasses, big bluestem, and indiangrass are suitable warm-season grasses. Proper management practices for established stands include adequate fertilization, weed and brush control, rotational and deferred grazing with a full-season grazing system, proper stocking rates, and adequate watering facilities for livestock. A severe erosion hazard will result if sloping soils used for pasture and hay are renovated and the existing vegetative cover is destroyed. The use of conservation practices, such as conservation tillage, contouring, and grassed waterways, prior to seeding can reduce soil losses. In addition, interseeding grasses and legumes into the existing sod can eliminate the need for destroying the vegetative cover during seedbed preparation.

Soil erosion is the major soil problem on about 70 percent of the cropland and pasture in Carroll County. Adair, Burchard, Dickman, Exira, Gara, Knox, Lamoni, Lester, Marshall, Storden, and Wadena soils are major soils that need erosion control.

Loss of the surface layer through erosion is damaging for two reasons. First, productivity is reduced as the surface layer is lost and part of the subsoil is mixed into the plow layer. Loss of the surface layer is especially damaging on soils that have a subsoil with low fertility,

Clarion and Marshall soils, for example. Erosion also reduces productivity on soils that tend to be droughty, Dickman and Wadena soils, for example. Second, soil erosion on farmland results in sediment entering streams. Control of erosion minimizes the pollution of streams by sediment and improves quality of water for municipal use, for recreation, and for fish and wildlife.

Preparing a good seedbed and tilling is difficult on soils that are severely eroded because the original, friable, silty clay loam surface soil has been eroded away. The clay subsoil exposed on the surface in severely eroded Lamoni soils is sticky if worked when wet and becomes hard and cloddy when dry.

Erosion control practices provide protective surface cover, reduce runoff, and increase water infiltration. A cropping system that keeps vegetative cover on the surface can reduce soil erosion losses to amounts that will not affect the productive capacity of the soils. On livestock farms, which require pasture and hay, legume and grass forage crops in the cropping system reduce erosion on sloping land and also provide nitrogen and improve soil tilth for the following crop.

Examples of major conservation tillage systems include: (1) Chisel-disk—a system which loosens the soil over the entire surface and partially incorporates the residue into the soil. (2) Strip-till or till plant— a system in which seedbed preparation and planting are completed in one operation. In this system, tillage in the row is limited to a strip not wider than one-third of the total area, and a protective cover of crop residue is left on two-thirds of the soil surface. (3) No-till, slot or zero tillage—in this system, preparation of the seedbed and planting can be completed in one operation. Little or no soil is disturbed except in the immediate area of the planted seed row, and a protective cover of crop residue is left on at least 90 percent of the soil surface. Seedbed preparation and planting may be carried out in one or separate operations. Conservation tillage is not practiced unless enough residue can be left on the soil surface after planting to effectively reduce erosion.

Terraces and diversions reduce the length of slope and help to control runoff and erosion. They are most practical on deep, well drained soils that have long, uniform slopes. Many Exira and Marshall soils, for example, are well suited to terracing. Other soils are less suitable for terraces and diversions because of irregularly shaped slopes, steepness, underlying sand or gravel, and clayey glacial till subsoils.

In the Adair and Lamoni soils, adequate measures of erosion control and drainage are difficult to provide because the loamy surface material of these soils is more permeable than the clayey glacial till in the subsoil. In addition, these soils are downslope from the permeable Exira and Marshall soils. As a result, water moving more rapidly in the Exira and Marshall soils and in the loamy material of the Adair and Lamoni soils, tends to accumulate at the till contact where it causes sidehill seepage during wet periods. Because of this difficulty, a combination of terracing and tiling is likely to be most successful in controlling erosion. Gully control structures and grassed waterways are used to control gullying in watercourses.

Terracing is not practical on some Clarion soils that have short, irregular slopes and on the sandy Dickman soils. On these soils, cropping systems that provide substantial vegetative cover and conservation tillage, which leaves residue on the surface, is effective in reducing erosion.

Contouring is the most widely used erosion control practice in Carroll County. It is best adapted to soils that have smooth, uniform slopes, including most areas of the Exira and Marshall soils and some areas of the Clarion soil.

Wind erosion is a hazard on the sandy Dickman soils and on soils that have high lime content, for example, the Calco, Canisteo, Harps, and Knoke soils. Maintaining vegetative cover and surface mulch or roughening the surface soil by proper tillage minimizes wind erosion on these soils.

Soil drainage is a major management need in Carroll County. Poorly drained and somewhat poorly drained soils make up about 30 percent of the total acreage in the county.

The design of surface and subsurface drainage systems varies with the kind of soil. A combination of adequate surface drainage and protection from runoff from the slopes at higher elevation is needed in most areas of somewhat poorly drained and poorly drained soils that are used for intensive row cropping. Drains need to be more closely spaced in soils that have moderately slow permeability than in the soils that are more permeable.

Soil fertility is low or very low in most soils in Carroll County because in most soils the subsoil that is low or very low in available phosphorus and potassium. Most upland soils are acid in the surface layer and require applications of ground limestone to raise the pH level sufficiently for good growth of alfalfa and other crops needing nearly neutral soils for high production. Some soils, however, are high in pH and do not need applications of lime. Canisteo, Harps, Knoke, Storden, and Talcot soils are examples.

Most medium textured, well drained, upland soils that developed under grass vegetation, for example, Clarion, Exira, and Marshall soils, are about 4 percent organic matter in the surface layer. Eroded soils generally are less than 2 percent organic matter. Medium textured, well drained soils that developed under the influence of forest and grass vegetation are about 2 to 3 percent organic matter in the surface layer. Gara, Knox, and Lester soils are examples. The coarse textured Dickman soil on uplands is generally 1 or 2 percent organic matter. The poorly drained upland soils, for example, Canisteo and Webster soils, are from 5 to 6 percent

organic matter in the surface layer. Mucky soils, which are very poorly drained, are about 15 percent organic matter.

Soils that developed from alluvium on bottom lands are commonly slightly acid or neutral but range from medium acid to mildly alkaline in reaction in the surface layer. The organic matter content ranges from about 3 percent in the Ackmore soils to 6 percent in the Coland soils. Alluvial soils in Carroll County are generally low or very low in available phosphorus and potassium in the subsoil. Colo soils, however, are medium.

Applications of lime and fertilizer should be based on the results of soil tests, need of the intended crop, and expected level of yield. The Cooperative Extension Service can help in determining the kinds and amounts of fertilizer and lime to apply.

Soil tilth is an important factor in the germination of seeds and in the infiltration of water into the soil. Soils that are in good tilth are generally high in organic matter, granular, and porous.

Most of the upland soils in the county have a dark surface layer that is moderate to high in organic matter. Generally, the structure of the surface layer is weak, and intense rainfall causes the formation of a crust on the surface. This crust is hard when dry and is less pervious to water. Once the crust forms, it reduces infiltration and increases runoff. Regular additions of crop residue, manure, and other organic material help to improve soil structure and reduce crust formation.

Fall plowing is generally considered an undesirable practice on the soils in this county by conservationists and environmentalists. It increases the hazard of wind erosion if the soils are not protected by cover crops, windbreaks, or snow and, in addition, increases the hazard of erosion early in spring during snowmelt and runoff.

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 5. 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 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 are also 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 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 insures 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 5 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.

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 grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor does it consider 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. Only class and subclass are used in this survey. These levels are defined in the following paragraphs.

Capability classes, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

Class I soils have slight 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.

Capability subclasses are soil groups within one class. They are designated by adding a small letter, *e, w, s,* or *c,* to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is very cold or very dry.

In class I there are no subclasses because the soils of this class have few limitations. Class V contains only the subclasses indicated by *w, s,* or *c* because the soils in class V are subject to little or no erosion. They have other limitations that restrict their use to pasture, woodland, wildlife habitat, or recreation.

Capability units are soil groups within a subclass. The soils in a capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity.

The acreage of soils in each capability class and subclass is shown in table 6. The capability classification of each map unit is given in the section "Detailed soil map units."

woodland management and productivity

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 (woodland suitability) 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 important trees. The number 1 indicates very high productivity; 2, high; 3, moderately high; 4, moderate; and 5, low. The second part of the symbol, a letter, indicates the major kind of soil limitation. The letter *x* indicates stoniness or rockiness; *w*, excessive water in or on the soil; *t*, toxic substances in the soil; *d*, restricted root depth; *c*, clay in the upper part of the soil; *s*, sandy texture; *f*, high content of coarse fragments in the soil profile; and *r*, steep slopes. The letter *o* indicates that limitations or restrictions are insignificant. If a soil has more than one limitation, the priority is as follows: x, w, t, d, c, s, f, and r.

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

Ratings of the *erosion hazard* indicate the risk of loss of soil in well managed woodland. The risk is *slight* if the expected soil loss is small, *moderate* if measures are needed to control erosion during logging and road construction, and *severe* if intensive management or special equipment and methods are needed to prevent excessive loss of soil.

Ratings of *equipment limitation* reflect the characteristics and conditions of the soil that restrict use of the equipment generally needed in woodland management or harvesting. A rating of *slight* indicates that use of equipment is not limited to a particular kind of equipment or time of year; *moderate* indicates a short seasonal limitation or a need for some modification in management or in equipment; and *severe* indicates a seasonal limitation, a need for special equipment or management, or a hazard in the use of equipment.

Seedling mortality ratings indicate the degree to which the soil affects the mortality of tree seedlings. Plant competition is not considered in the ratings. The ratings apply to seedlings from good stock that are properly planted during a period of sufficient rainfall. A rating of *slight* indicates that the expected mortality is less than 25 percent; *moderate*, 25 to 50 percent; and *severe*, more than 50 percent.

Ratings of *plant competition* indicate the degree to which undesirable plants are expected to invade where there are openings in the tree canopy. The invading plants compete with native plants or planted seedlings. A rating of *slight* indicates little or no competition from other plants; *moderate* indicates that plant competition is expected to hinder the development of a fully stocked stand of desirable trees; *severe* indicates that plant competition is expected to prevent the establishment of a desirable stand unless the site is intensively prepared, weeded, or otherwise managed to control undesirable plants.

The *potential productivity* of merchantable or *common trees* on a soil is expressed as a *site index*. This 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.

Trees to plant are those that are suited to the soils and to 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, hold snow on the fields, reduce energy requirements, 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 insure 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 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 sewerlines. The capacity of the soil to absorb septic tank effluent and the ability of the soil to support vegetation are also important. Soils subject to flooding are limited for recreation use by the duration and intensity of flooding and the season when flooding occurs. In planning recreation 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, horseback riding, and bicycling 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

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 flood hazard. Soil temperature and soil moisture are also 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, flood hazard, and slope. Soil temperature and soil moisture are also considerations. Examples of grasses and legumes are fescue, orchardgrass, 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 flood hazard. Soil temperature and soil moisture are also 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 hardwood trees and shrubs are depth of the root zone, the available water capacity, and wetness. Examples of these plants are oak, poplar, cherry, apple, hawthorn, dogwood, hickory, blackberry, and elderberry. 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, seeds, and cones. 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, 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. The 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, 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, 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. The ratings are given in the following tables: 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 need to 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 to 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, shrink-swell potential, available water capacity, and other behavioral characteristics affecting engineering uses.

This information can be used to (1) evaluate the potential of areas for residential, commercial, industrial, and recreation uses; (2) make preliminary estimates of construction conditions; (3) evaluate alternative routes for roads, streets, highways, pipelines, and underground cables; (4) evaluate alternative sites for sanitary landfills, septic tank absorption fields, and sewage lagoons; (5) plan detailed onsite investigations of soils and geology; (6) locate potential sources of gravel, sand, earthfill, and topsoil; (7) plan drainage systems, irrigation systems, ponds, terraces, and other structures for soil and water conservation; and (8) 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 the 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, shrink-swell potential, and organic layers can cause the movement of footings. A high water table, depth to bedrock or to a cemented pan, large stones, and flooding affect the ease of excavation and construction. Landscaping and grading that require cuts and fills of more than 5 to 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. 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), 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 the 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 landfills. 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 effectively filter the effluent. 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 due to rapid permeability of 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 needs to 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 type 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 type 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 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 shrink-swell potential.

Soils rated *good* contain significant amounts of sand or gravel or both. They have at least 5 feet of suitable material, 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 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 the depth to the water table is 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. Sand and gravel 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 up to 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, or stones, 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 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; 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 of 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, or organic matter. 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 potential 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 high content of calcium carbonate. 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, and soil reaction.

Terraces and diversions are embankments or a combination of channels and ridges constructed across a slope to reduce 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 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 characterize key soils.

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

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 "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. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If a soil contains particles coarser than sand, 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, SP-SM.

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 grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. 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 larger than 3 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 oven-dry 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.

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 clay content of 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, and plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earth-moving 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 1/3 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, septic tank absorption fields, and construction where the rate of water movement under saturated conditions affects behavior.

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.

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 change is based on the soil fraction less than 2 millimeters in diameter. The classes are *low*, a change of less than 3 percent; *moderate*, 3 to 6 percent; and *high*, more than 6 percent. *Very high*, greater 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 wind erosion in cultivated areas. The groups indicate the susceptibility of soil to wind erosion and the amount of soil lost. Soils are grouped according to the following distinctions:

1. Sands, coarse 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 sands, loamy fine sands, and loamy very fine sands. These soils are very highly erodible. Crops can be grown if intensive measures to control wind erosion are used.

3. Sandy loams, coarse sandy loams, fine sandy loams, and very fine sandy loams. These soils are highly erodible. Crops can be grown if intensive measures to control wind erosion are used.

4L. Calcareous loamy soils that are less than 35 percent clay and more than 5 percent finely divided calcium carbonate. These soils are erodible. Crops can be grown if intensive measures to control wind erosion are used.

4. Clays, silty clays, 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 wind erosion are used.

5. Loamy soils that are less than 18 percent clay and less than 5 percent finely divided calcium carbonate and sandy clay loams and sandy clays that are less than 5 percent finely divided calcium carbonate. These soils are slightly erodible. Crops can be grown if measures to control wind erosion are used.

6. Loamy soils that are 18 to 35 percent clay and less than 5 percent finely divided calcium carbonate, except silty clay loams. These soils are very slightly erodible. Crops can easily be grown.

7. Silty clay loams that are less than 35 percent clay and less than 5 percent finely divided calcium carbonate. These soils are very slightly erodible. Crops can easily be grown.

8. Stony or gravelly soils and other soils not subject to wind erosion.

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 of 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 intake 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.

Flooding, the temporary inundation of an area, is caused by overflowing streams and by runoff from adjacent slopes. Water standing for short periods after rainfall or snowmelt and water in swamps and marshes are not considered flooding.

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, common, occasional, and frequent. *None* means that flooding is not probable; *rare* that it is unlikely but possible under unusual weather conditions; *common* that it is likely under normal conditions; *occasional* that it occurs on an average of once or less in 2 years; and *frequent* that it occurs on an average of more than once in 2 years. Duration is expressed as *very brief* if less than 2 days, *brief* if 2 to 7 days, and *long* if more than 7 days. Probable dates are expressed in months; November-May, for example, means that flooding can occur during the period November through May.

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 absence of distinctive horizons that form in soils that are not subject to flooding.

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 depth to a seasonal high water table applies to undrained soils. 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, artesian, 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.

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. An artesian water table is under hydrostatic head, generally beneath an impermeable layer. When this layer is penetrated, the water level rises in an uncased borehole. 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.

Only saturated zones within a depth of about 6 feet are indicated. A plus sign preceding the range in depth indicates that the water table is above the surface of the soil. The first numeral in the range indicates how high the water rises above the surface. The second numeral indicates the depth below the surface.

Depth to bedrock is given if bedrock is within a depth of 5 feet. The depth is based on many soil borings and on observations during soil mapping. The rock is specified as either soft or hard. If the rock is soft or fractured, excavations can be made with trenching machines, backhoes, or small rippers. If the rock is hard or massive, blasting or special equipment generally is needed for excavation.

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 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 creates a severe corrosion environment. 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 is also 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 (*29*). 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. In table 18, the soils of the survey area are classified according to the system. The categories are defined in the following paragraphs.

ORDER. Ten 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 (*Arg*, meaning argillic horizon, plus *udolls*, the suborder of the Mollisols that have an 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. Mostly 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 Aquic 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. The soil is compared with similar soils and with nearby soils of other 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 (*27*). Many of the technical terms used in the descriptions are defined in Soil Taxonomy (*29*). 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."

Ackmore series

The Ackmore series consists of poorly drained, moderately permeable soils. These soils formed in silty alluvium on flood plains. Native vegetation was prairie grasses. Slopes range from 0 to 5 percent.

Ackmore soils are similar to Colo soils and are commonly adjacent to Zook soils on the landscape. Colo soils do not have stratification. They have a finer textured surface layer than Ackmore soils and commonly are some distance from the main stream channel.

Typical pedon of Ackmore silt loam, 0 to 2 percent slopes, 21 feet east and 400 feet south of the northwest corner of sec. 34, T. 82 N., R. 35 W.

A1—0 to 8 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak fine granular structure; friable; medium acid; clear smooth boundary.
C—8 to 30 inches; stratified very dark gray (10YR 3/1), dark grayish brown (10YR 4/2), and black (10YR 2/1) silty clay loam and silt loam; few coarse distinct brown (7.5YR 4/4) mottles; moderately thin and medium platy structure parting to weak very fine subangular blocky; friable; slightly acid; clear smooth boundary.
IIAb—30 to 48 inches; black (N 2/0) silty clay loam; weak and moderate fine subangular blocky structure; friable; slightly acid; clear smooth boundary.
IIBb—48 to 60 inches; black (10YR 2/1) silty clay loam; weak medium prismatic structure parting to moderate fine blocky; firm; slightly acid.

The A and C horizons above the IIAb horizon range from 20 to 36 inches in thickness.

The A1 horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2). The A1 and C horizons are silty clay loam or silt loam. The A horizon and C horizon are medium acid to neutral. The C horizon is stratified and ranges from black (10YR 2/1) to grayish brown (10YR 5/2). The IIBb horizon ranges from silty clay loam to silty clay. The IIAb and IIBb horizons are slightly acid or neutral.

Adair series

The Adair series consists of somewhat poorly drained, slowly permeable soils. These soils formed in glacial till and a thin mantle of loess or loess and pedisediment. They are on convex side slopes and some ridges in the uplands. Native vegetation was prairie grasses. Slopes range from 9 to 18 percent.

These Adair soils are taxadjuncts to the Adair series because they do not have a mollic epipedon. This difference does not alter the usefulness and behavior of these soils.

Adair soils are similar to Lamoni soils and are commonly adjacent to Burchard, Exira, Lamoni, and Marshall soils on the landscape. Burchard, Exira, and Marshall soils have less clay in the subsoil than Adair soils. Lamoni soils do not have red hues in the subsoil and are at a slightly higher elevation on the landscape. Exira and Marshall soils are upslope from Adair soils, and Burchard soils are downslope.

Typical pedon of Adair clay loam, 9 to 14 percent slopes, moderately eroded, 1,300 feet west and 1,300 feet south of the northeast corner of sec. 13, T. 82 N., R. 35 W.

Ap—0 to 6 inches; very dark grayish brown (10YR 3/2) clay loam, grayish brown (10YR 5/2) dry; mixed with streaks and patches of dark reddish brown subsoil material; weak fine and medium granular structure; firm; slightly acid; clear smooth boundary.
B1—6 to 9 inches; dark reddish brown (5YR 3/4) clay loam; weak fine subangular blocky structure; firm; dark coatings in root channels; medium acid; clear smooth boundary.
IIB21t—9 to 21 inches; reddish brown (5YR 4/4) and yellowish red (5YR 4/6) clay; moderate fine and medium subangular blocky structure; few fine distinct grayish brown (10YR 5/2) mottles; very firm; thin continuous clay films; band of pebbles at about 10 inches; medium acid; clear smooth boundary.
IIB22t—21 to 30 inches; mottled brown (7.5YR 4/4), yellowish red (5YR 5/6), and light grayish brown (10YR 5/2) clay; weak medium prismatic structure parting to moderate medium and fine subangular blocky; very firm; thin continuous clay films; slightly acid; gradual smooth boundary.
IIB3t—30 to 42 inches; mottled yellowish red (5YR 5/6), brown (7.5YR 4/4), and grayish brown (2.5Y 5/2) clay loam; weak medium and coarse subangular blocky structure; firm; thin discontinuous clay films; common dark stains; neutral; gradual smooth boundary.
IIC1—42 to 51 inches; yellowish brown (10YR 5/6) and grayish brown (10YR 5/2) clay loam; weak medium prismatic structure; firm; neutral; gradual smooth boundary.
IIC2—51 to 60 inches; grayish brown (2.5Y 5/2) clay loam that has common fine faint yellowish brown (10YR 5/4) mottles; weak medium subangular blocky structure; firm; neutral.

The thickness of the solum ranges from 40 to 64 inches.

The Ap horizon is very dark grayish brown (10YR 3/2), dark brown (10YR 3/3), or brown (10YR 4/3). In some pedons, the Ap horizon has small amounts of black (10YR 2/1) or very dark brown (10YR 2/2). The plow layer in cultivated areas is medium acid or slightly acid. The IIB2t horizon is clay loam or clay. The IIB horizon is medium acid to neutral. The IIC horizon is neutral or mildly alkaline. Few pebbles and stones are scattered on the surface. The IIB and IIC horizons are up to 5 percent pebbles and stones.

Armstrong series

The Armstrong series consists of moderately well drained and somewhat poorly drained, slowly permeable soils. These soils formed in glacial till and a thin mantle of loess or loess and pedisediment. They are on convex side slopes in uplands. Native vegetation was prairie

grasses and deciduous trees. Slopes range from 9 to 18 percent.

Armstrong soils are similar to Gara soils and are commonly adjacent to Gara and Knox soils on the landscape. Gara soils do not have red hues and have less clay in the B horizon than Armstrong soils. Knox soils have less sand and clay and are upslope from Armstrong soils.

Typical pedon of Armstrong loam, in an area of Gara-Armstrong loams, 9 to 14 percent slopes, moderately eroded, 360 feet north and 610 feet east of the southwest corner of sec. 22, T. 82 N., R. 34 W.

Ap—0 to 7 inches; very dark grayish brown (10YR 3/2) loam, grayish brown (10YR 5/2) dry; mixed with streaks and patches of brown subsoil material; weak fine granular structure; friable; medium acid; clear smooth boundary.

B21t—7 to 12 inches; dark yellowish brown (10YR 4/4) clay loam; moderate fine subangular blocky structure; thin discontinuous clay films; firm; many light gray (10YR 6/1) dry silt coatings on peds; band of pebbles at 12 inches; strongly acid; clear smooth boundary.

IIB22t—12 to 17 inches; brown (7.5YR 4/4) clay; common fine faint reddish brown (5YR 4/4) mottles; moderate fine and medium subangular blocky and angular blocky structure; firm; thick discontinuous clay films; thick discontinuous light gray (10YR 6/1) dry silt coatings on peds; few coarse sand and gravel; strongly acid; clear smooth boundary.

IIB23t—17 to 22 inches; brown (7.5YR 4/4) light clay that has many fine distinct grayish brown (10YR 5/2) and reddish brown (5YR 4/4) mottles; moderate medium subangular blocky structure parting to moderate fine angular blocky; thin continuous clay films; thin discontinuous light gray (10YR 6/1) silt coatings on peds; firm; strongly acid; clear smooth boundary.

IIB24t—22 to 31 inches; mottled grayish brown (2.5Y 5/2), brown (7.5YR 4/4), and yellowish brown (10YR 5/6) clay loam; weak medium prismatic structure parting to weak fine subangular blocky; firm; thin continuous clay films; few pebbles; strongly acid; gradual wavy boundary.

IIB31—31 to 42 inches; mottled light gray (10YR 6/1) and yellowish brown (10YR 5/4 and 5/6) clay loam; weak medium prismatic structure parting to weak fine subangular blocky; firm; thin continuous clay films; few pebbles; strongly acid; clear wavy boundary.

IIC1—42 to 48 inches; mottled light gray (10YR 6/1) and yellowish brown (10YR 5/4 and 5/6) clay loam; very weak medium angular blocky structure; firm; common pebbles; common lime accumulations; neutral; clear smooth boundary.

IIC2—48 to 60 inches; mottled light gray (10YR 6/1) and yellowish brown (10YR 5/4 and 5/6) clay loam; very weak medium angular blocky structure; firm; common pebbles; many soft fine lime accumulations; violent effervescence in lime spots; mildly alkaline.

The thickness of the solum ranges from 42 to 60 inches. Up to 5 percent gravel and cobbles are in the solum. A few pebbles and cobbles are scattered on the surface.

The Ap horizon is very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2). In places, the Ap horizon is mixed with brown (10YR 4/3) clay loam subsoil material. In uneroded and uncultivated areas, the A1 horizon is 5 to 8 inches thick and is medium acid or slightly acid. In uncultivated areas, the A2 horizon ranges from dark grayish brown (10YR 4/2) to brown (10YR 5/3) and is 3 to 6 inches thick. It is medium acid or slightly acid. If dry, the IIB2t horizon ranges from a nearly continuous gray silt coating to a few coatings in the upper part. The IIB2t horizon ranges from clay loam to clay.

Biscay series

The Biscay series consists of poorly drained soils that have moderate permeability in the upper part of the profile and rapid permeability in the lower part. These soils formed in loamy glacial outwash, which is underlain by sandy and gravelly glacial outwash at a depth of 32 to 40 inches. They are mainly on low stream benches but are also on uplands. Native vegetation was prairie grasses. Slopes range from 0 to 2 percent.

Biscay soils are similar to Talcot soils and are commonly adjacent to Coland, Cylinder, Talcot, and Wadena soils on the landscape. Talcot soils are calcareous in the surface layer. Coland soils do not have sand and gravel at depths of less than 40 inches and are on lower parts of the landscape near the main channel. Cylinder and Wadena soils are in positions on the landscape similar to those of Biscay soils and are better drained.

Typical pedon of Biscay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes, 1,190 feet south and 2,200 feet east of the northwest corner of sec. 28, T. 85 N., R. 33 W.

Ap—0 to 10 inches; black (N 2/0) loam, very dark gray (10YR 3/1) dry; weak medium subangular blocky structure parting to moderate fine granular; friable; neutral; clear smooth boundary.

A3—10 to 17 inches; very dark gray (10YR 3/1) clay loam, gray (10YR 5/1) dry; moderate fine granular structure; friable; neutral; clear smooth boundary.

B21—17 to 28 inches; dark gray (5Y 4/1) clay loam; moderate medium and fine subangular blocky structure; firm; neutral; clear smooth boundary.

B22—28 to 35 inches; gray (5Y 5/1) sandy clay loam; common fine prominent strong brown (7.5YR 5/6) and yellowish brown (10YR 5/6) mottles; moderate medium and fine subangular blocky structure; friable; mildly alkaline; clear smooth boundary.
B3—35 to 39 inches; dark gray (5Y 4/1) gravelly sandy loam; few fine distinct dark yellowish brown (10YR 4/4) mottles; moderate medium subangular blocky structure; friable; neutral; abrupt smooth boundary.
IIC1—39 to 46 inches; dark grayish brown (2.5Y 4/2) sand; many fine distinct yellowish brown (10YR 5/6) mottles; single grain; loose; neutral; abrupt smooth boundary.
IIC2—46 to 50 inches; dark grayish brown (2.5Y 4/2) sand and gravel; few fine distinct yellowish brown (10YR 5/6) mottles; single grain; loose; neutral; abrupt wavy boundary.
IIC3—50 to 60 inches; dark gray (5Y 4/1) sand and gravel; single grain; loose; slight effervescence; moderately alkaline.

The A horizon ranges from black (10YR 2/1 or N 2/0) to very dark gray (10YR 3/1), from loam to clay loam, and from 14 to 22 inches in thickness. The B horizon ranges from dark gray (10YR 4/1 to 5Y 4/1) to olive gray (5Y 4/2 or 5Y 5/2) or gray (5Y 5/1) and from clay loam to sandy clay loam or gravelly sandy loam. Depth to the IIC horizon ranges from 32 to 40 inches. This horizon is dark grayish brown (2.5Y 4/2), dark gray (5Y 4/1), or olive gray (5Y 4/2) sand and gravel. In some pedons, it is loamy sand or sand and is 5 to 10 percent gravel. Depth to free carbonates ranges from 40 to 56 inches.

Burchard series

The Burchard series consists of moderately well drained soils. Permeability is moderately slow. These soils formed in glacial till on uplands. Native vegetation was prairie grasses. Slopes range from 5 to 25 percent.

Burchard soils are commonly adjacent to Adair, Exira, Gara, Lamoni, and Marshall soils on the landscape. Gara soils have a lighter colored surface layer. Adair and Lamoni soils are on convex slopes above the Burchard soils and have more clay in the B horizon. Exira and Marshall soils are on convex slopes above the Burchard soils and formed in loess that is higher in content of silt and lower in content of sand.

Typical pedon of Burchard clay loam, 14 to 18 percent slopes, moderately eroded, 75 feet west and 90 feet south of the northeast corner of sec. 4, T. 82 N., R. 34 W.

Ap—0 to 7 inches; very dark grayish brown (10YR 3/2) light clay loam, brown (10YR 5/3) dry; mixed with streaks and patches of (10YR 4/3) clay loam subsoil material; weak fine granular structure; friable; slightly acid; clear smooth boundary.
B21t—7 to 14 inches; brown (10YR 4/3) clay loam; firm; thin discontinuous clay films; few pebbles; neutral; clear smooth boundary.
B22t—14 to 20 inches; yellowish brown (10YR 5/4) clay loam; few fine faint yellowish brown (10YR 5/6) mottles; moderate fine angular blocky structure; firm; thin discontinuous clay films; few pebbles; neutral; clear smooth boundary.
C1ca—20 to 24 inches; mottled yellowish brown (10YR 5/4), light brownish gray (2.5Y 6/2), and yellowish brown (10YR 5/6) clay loam; weak medium subangular blocky structure; firm; few pebbles; strong effervescence in spots; common soft lime accumulations; moderately alkaline; gradual wavy boundary.
C2ca—24 to 43 inches; light gray (5Y 6/1) clay loam; many medium prominent yellowish brown (10YR 5/4 and 5/6) mottles; weak medium prismatic structure parting to weak medium subangular blocky; friable; few pebbles; many lime accumulations and concretions; strong effervescence; mildly alkaline; gradual wavy boundary.
C3—43 to 60 inches; mottled light olive gray (5Y 6/2), dark yellowish brown (10YR 4/4), and yellowish brown (10YR 5/6) clay loam; massive; friable; few pebbles; common lime accumulations; strong effervescence; mildly alkaline.

The thickness of the solum and depth to carbonates range from 16 to 28 inches.

The Ap horizon is very dark grayish brown (10YR 3/2) or dark brown (10YR 3/3) with brown (10YR 4/3) pockets and streaks. The Ap horizon is clay loam or silty clay loam. It is 5 to 8 inches thick. The B2t horizon has a clay content of 27 to 35 percent. It is brown (10YR 4/3), dark yellowish brown (10YR 4/4), or yellowish brown (10YR 5/4). The C horizon has hue of 10YR, 2.5Y, or 5Y; value of 4, 5, or 6; and chroma of 1 through 6.

Calco series

The Calco series consists of poorly drained, moderately permeable soils. These soils formed in silty, calcareous alluvium on flood plains and low benches. Native vegetation was prairie grasses. Slopes range from 0 to 2 percent.

Calco soils are similar to Canisteo soils and are commonly adjacent to Canisteo, Coland, Colo, and Zook soils on the landscape. Canisteo soils have a thinner mollic epipedon than Calco soils. Coland, Colo, and Zook soils are in positions on the landscape similar to those of Calco soils and are noncalcareous.

Typical pedon of Calco silty clay loam, 0 to 2 percent slopes, 120 feet west and 30 feet south of the northeast corner of sec. 12, T. 83 N., R. 33 W.

Ap—0 to 8 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; weak medium and fine subangular blocky structure parting to moderate fine granular; friable; few fine fragments of snail shells; strong effervescence; mildly alkaline; clear smooth boundary.

A12—8 to 16 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; moderate medium and fine subangular blocky structure; friable; few fine fragments of snail shells; strong effervescence; moderately alkaline; clear smooth boundary.

A13—16 to 25 inches; black (N 2/0) silty clay loam, very dark gray (10YR 3/1) dry; weak coarse subangular blocky structure parting to moderate fine subangular blocky; friable; common fine fragments of snail shells; strong effervescence; moderately alkaline; gradual smooth boundary.

A14—25 to 40 inches; black (N 2/0) silty clay loam, very dark gray (10YR 3/1) dry; moderate medium subangular blocky structure; friable; common fine fragments of snail shells; moderately alkaline; strong effervescence; gradual smooth boundary.

B—40 to 48 inches; very dark gray (10YR 3/1) silty clay loam; common fine faint dark gray (10YR 4/1) mottles; moderate medium and fine subangular blocky structure; friable; common fine fragments of snail shells; slight effervescence; moderately alkaline; gradual smooth boundary.

C—48 to 60 inches; very dark gray (10YR 3/1) light silty clay loam; few fine distinct dark grayish brown (2.5Y 4/2) and few fine prominent strong brown (7.5YR 5/6) mottles; massive with some vertical cleavage; friable; common fine fragments of snail shells; slight effervescence; moderately alkaline.

The thickness of the solum and the thickness of the mollic epipedon are more than 40 inches. The sand content in the upper 40 inches is less than 15 percent. Snail shell fragments are scattered throughout the soil and vary from few to many.

The A horizon ranges from 30 to 42 inches in thickness. The Bg horizon ranges from very dark gray (N 3/0 or 10YR 3/1) to dark gray (10YR 4/1 or N 4/0). Some pedons do not have a Bg horizon. The maximum clay content in the A and B horizons ranges from 30 to 33 percent. The Cg horizon is very dark gray (10YR 3/1 or N 3/0), dark gray (10YR 4/1 or 5Y 4/1), or gray (10YR 5/1 or 5Y 5/1). It is mildly alkaline or moderately alkaline.

Canisteo series

The Canisteo series consists of poorly drained, moderately permeable, calcareous soils formed in glacial till. These soils are in low areas and slight depressions in the uplands. Native vegetation was prairie grasses. Slopes range from 0 to 2 percent.

Canisteo soils are similar to Calco and Webster soils and are commonly adjacent to Calco, Harps, and Nicollet soils. Calco soils have a thicker mollic epipedon than Canisteo soils. Nicollet soils are on more sloping areas and are better drained. Harps soils have more lime. Webster soils are in positions on the landscape similar to those of Canisteo soils and are noncalcareous.

Typical pedon of Canisteo silty clay loam, 0 to 2 percent slopes, 120 feet west and 1,015 feet north of the southeast corner, sec. 9, T. 84 N., R. 33 W.

Ap—0 to 8 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; weak fine subangular blocky structure parting to weak fine granular; friable; strong effervescence; mildly alkaline; clear smooth boundary.

A12—8 to 14 inches; black (10YR 2/1) clay loam, dark gray (10YR 4/1) dry; weak fine granular structure; friable; common very fine snail shell fragments; strong effervescence; mildly alkaline; clear smooth boundary.

A3—14 to 20 inches; mixed very dark gray (10YR 3/1), dark gray (10YR 4/1), and black (10YR 2/1) loam; weak fine subangular blocky structure parting to weak fine granular; friable; about 1 percent fine snail shell fragments; strong effervescence; mildly alkaline; clear smooth boundary.

Bg—20 to 27 inches; grayish brown (2.5Y 5/2) loam; very dark gray (10YR 3/1) tongues, few fine distinct yellowish brown (10YR 5/4) mottles; weak fine subangular blocky structure; friable; common fine gravel; common small snail shell fragments; strong effervescence; mildly alkaline; clear smooth boundary.

C1g—27 to 43 inches; grayish brown (2.5Y 5/2) loam; few fine distinct yellowish brown (10YR 5/4) and 10YR 5/8) mottles; weak fine subangular blocky structure; friable; common fine gravel; few fine dark accumulations (iron and manganese oxides); common lime accumulations; strong effervescence; mildly alkaline; clear smooth boundary.

C2g—43 to 53 inches; grayish brown (2.5Y 5/2) loam; many medium distinct yellowish brown (10YR 5/6) mottles; weak very fine subangular blocky structure; friable; few fine dark accumulations (iron and manganese oxides); few lime accumulations; strong effervescence; mildly alkaline; gradual smooth boundary.

C3g—53 to 60 inches, grayish brown (2.5Y 5/2) loam; many medium distinct yellowish brown (10YR 5/4 and 10YR 5/8) mottles; massive; friable; few fine gravel and few fine dark accumulations (iron and manganese oxides); strong effervescence; mildly alkaline.

The A horizon ranges from black (10YR 2/1 or N 2/0) to very dark gray (10YR 3/1). It is silty clay loam or clay

loam and is about 14 to 24 inches thick. The B2g horizon is olive gray (5Y 4/2 or 5Y 5/2), dark gray (5Y 4/1), or gray (5Y 5/1). The Cg horizon typically is clay loam but ranges to include loam with strata of silt loam, sandy loam, or loamy sand. Reaction is mildly alkaline or moderately alkaline.

Clarion series

The Clarion series consists of well drained, moderately permeable soils. These soils are on convex slopes and formed in glacial till. Native vegetation was prairie grasses. Slopes range from 2 to 14 percent.

Clarion soils commonly are adjacent to Canisteo, Nicollet, Storden, and Webster soils on the landscape. Canisteo, Nicollet, and Webster soils are more poorly drained and are on lower lying areas than Clarion soils. Storden soils do not have a B horizon and are calcareous in the A horizon. Storden soils are well drained and are generally on steeper slopes than Clarion soils.

Typical pedon of Clarion loam, 2 to 5 percent slopes, 75 feet west and 1,500 feet south of the northeast corner of sec. 16, T. 85 N., R. 33 W.

Ap—0 to 9 inches; black (10YR 2/1) loam, dark gray (10YR 4/1) dry; weak fine granular structure; friable; slightly acid; clear smooth boundary.

A3—9 to 14 inches; mixed very dark grayish brown (10YR 3/2) and black (10YR 2/1) loam, grayish brown (10YR 5/2) and dark gray (10YR 4/1) dry; weak fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

B21—14 to 21 inches; brown (10YR 4/3) loam that has very dark grayish brown coatings and few black (10YR 2/1) stains on peds; weak medium subangular blocky structure; friable; about 5 percent gravel; neutral; gradual smooth boundary.

B22—21 to 29 inches; brown (10YR 4/3) loam; weak medium subangular blocky structure; friable; about 5 percent gravel; neutral; clear smooth boundary.

B3—29 to 33 inches; dark yellowish brown (10YR 4/4) loam; few medium and large faint brown (7.5YR 4/4) mottles; weak medium subangular blocky structure; friable; about 5 percent gravel; neutral; clear smooth boundary.

C1—33 to 44 inches; yellowish brown (10YR 5/4) loam; few fine faint grayish brown (10YR 5/2) and few fine prominent yellowish red (5YR 4/8) mottles; very weak medium subangular blocky structure; friable; about 5 percent gravel; common lime nodules; violent effervescence; mildly alkaline; gradual smooth boundary.

C2—44 to 51 inches; yellowish brown (10YR 5/4) loam; common fine distinct light olive gray and strong brown (7.5YR 5/6) mottles; massive; friable; about 5 percent gravel; common lime accumulations; violent effervescence; mildly alkaline; clear smooth boundary.

C3—51 to 55 inches; mottled light brownish gray (2.5Y 6/2) and yellowish brown (10YR 5/4) loam; massive; friable; about 5 percent gravel; many lime nodules; violent effervescence; mildly alkaline; clear smooth boundary.

C4—55 to 60 inches; yellowish brown (10YR 5/4) loam; many medium distinct light brownish gray (2.5Y 6/2) mottles; massive; friable; about 5 percent gravel; common lime accumulations; violent effervescence; mildly alkaline.

The solum thickness and depth to carbonates range from 22 to 40 inches.

The A1 or Ap horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2). The A horizon is generally loam but ranges to silt loam. The B horizon ranges from dark brown (10YR 3/3) to yellowish brown (10YR 5/4). It is loam or clay loam. In some pedons, the lower part of the B horizon and the C horizon are sandy loam. The C horizon is predominantly yellowish brown (10YR 5/4 or 10YR 5/6) or light olive brown (2.5Y 5/4) but ranges to grayish brown (2.5Y 5/2) or light brownish gray (2.5Y 6/2).

The A horizon and the upper part of the B horizon are generally slightly acid or neutral. The lower part of the B horizon is neutral or mildly alkaline and is calcareous in places.

Coland series

The Coland series consists of poorly drained, moderately permeable soils. These soils formed in loamy alluvium on flood plains and in drainageways. Native vegetation was prairie grasses. Slopes range from 0 to 2 percent.

Coland soils are commonly adjacent to Calco, Canisteo, and Spillville soils on the landscape. Calco, Spillville, and Zook soils are in positions on the landscape similar to those of Coland soils. Calco and Canisteo soils are more calcareous. Canisteo soils are at a higher elevation in the uplands. Spillville soils are not so poorly drained as Coland soils.

Typical pedon of Coland clay loam, 0 to 2 percent slopes, 250 feet north and 750 feet west of the southeast corner of sec. 2, T. 84 N., R. 33 W.

A11—0 to 12 inches; black (N 2/0) clay loam, very dark gray (10YR 3/1) dry; weak fine granular structure; friable; neutral; clear smooth boundary.

A12—12 to 21 inches; black (N 2/0) clay loam, very dark gray (10YR 3/1) dry; weak medium granular structure; friable; neutral; clear smooth boundary.

A3—21 to 29 inches; black (N 2/0) clay loam, very dark gray (10YR 3/1) dry; very weak fine subangular blocky structure; friable; neutral; clear smooth boundary.
B2—29 to 40 inches; very dark gray (10YR 3/1) clay loam, dark gray (10YR 4/1) dry; black (10YR 2/1) coatings on peds; moderate fine and medium subangular blocky structure; friable; neutral; gradual smooth boundary.
B3—40 to 48 inches; very dark gray (10YR 3/1) clay loam, gray (10YR 5/1) dry; black (10YR 2/1) coatings on peds; few fine distinct brown (7.5YR 4/4) mottles; weak medium subangular blocky structure; friable; neutral; clear smooth boundary.
Cg—48 to 60 inches; gray (5Y 5/1) sandy clay loam; massive; friable; mildly alkaline.

Clay content in the solum ranges from 27 to 35 percent. The solum is neutral or slightly acid.

The A horizon is 24 to 40 inches thick. It is black (N 2/0 or 10YR 2/1) or very dark gray (10YR 3/1). The B horizon, which does not occur in some profiles, ranges from very dark gray (10YR 3/1 or N 3/0) to gray (10YR 5/1 to 5Y 5/1). Value of 2 or 3 extends to a depth of 36 inches or more. The Cg horizon ranges from very dark gray (N 3/0 or 10YR 3/1) to gray (5Y 5/1) and is clay loam or sandy clay loam. The Cg horizon is neutral or mildly alkaline.

Colo series

The Colo series consists of poorly drained, moderately permeable soils. These soils formed in silty alluvium on flood plains and in drainageways. Native vegetation was prairie grasses. Slopes range from 0 to 2 percent.

Colo soils are similar to Ackmore soils and are commonly adjacent to Ackmore, Calco, Coland, and Zook soils on the landscape. Ackmore soils are stratified in the upper horizons. Calco soils are calcareous. Coland soils have more sand, and Zook soils have more clay than Colo soils.

Typical pedon of Colo silty clay loam, 0 to 2 percent slopes, 237 feet east and 2,116 feet south of the northwest corner of sec. 20, T. 82 N., R 36 W.

A11—0 to 8 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; moderate medium granular structure; friable; slightly acid; gradual smooth boundary.
A12—8 to 21 inches; black (N 2/0) silty clay loam, very dark gray (10YR 3/1) dry; moderate fine subangular blocky structure; friable; slightly acid; gradual smooth boundary.
A13—21 to 33 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; weak fine subangular blocky structure parting to moderate fine granular; friable; slightly acid; gradual smooth boundary.
A14—33 to 38 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; weak medium and fine granular structure; firm; slightly acid; clear smooth boundary.
AC—38 to 49 inches; very dark gray (10YR 3/1) silty clay loam, gray (10YR 5/1) dry; few fine distinct strong brown (7.5YR 5/6) mottles; black (10YR 2/1) coatings on peds; moderate medium and fine subangular blocky structure; firm; slightly acid; gradual smooth boundary.
Cg—49 to 60 inches; dark gray (10YR 4/1) silty clay loam; few fine distinct strong brown (7.5YR 5/6) and light yellowish brown (2.5Y 6/4) mottles; weak medium and fine subangular blocky structure; firm; slightly acid.

The thickness of the solum ranges from 36 to 54 inches.

The A1 horizon ranges from black (N 2/0) to very dark gray (10YR 3/1). Value of 2 or 3 extends to a depth of 36 inches or more. The A horizon is silty clay loam that ranges from 27 to 32 percent clay. It is neutral or slightly acid. The overwash phase of this soil has value of 3 to 5 and chroma of 1 or 2. It is 6 to 16 inches thick. A weak B horizon has developed in some pedons. The Cg horizon is very dark gray (10YR 3/1) or dark gray (10YR 4/1). It is silty clay loam that ranges from 30 to 35 percent clay. The Cg horizon has strong brown, olive, olive brown, or light yellowish brown mottles. It is neutral or slightly acid.

Cylinder series

The Cylinder series consists of somewhat poorly drained soils that are moderately permeable in the upper part of the profile and rapidly or very rapidly permeable in the substrata. These soils formed in loamy glacial outwash or alluvium and the underlying calcareous sand and gravel. They are on glacial outwash plains and stream benches. Native vegetation was prairie grasses. Slopes range from 0 to 2 percent.

Cylinder soils are commonly adjacent to Biscay, Talcot, and Wadena soils on the landscape. Biscay soils are poorly drained, and Wadena soils are well drained. Talcot soils are poorly drained and are mildly alkaline to moderately alkaline throughout the solum. All of these soils are in positions on the landscape similar to those of Cylinder soils.

Typical pedon from an area of Cylinder loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes, 246 feet south and 405 feet west of the northeast corner of sec. 10, T. 83 N., R. 33 W.

Ap—0 to 7 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; black (N 2/0) coatings on peds; weak fine granular structure; friable; slightly acid; clear smooth boundary.

A12—7 to 13 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; black (N 2/0) coatings on peds; weak fine and medium granular structure; friable; slightly acid; clear smooth boundary.
A3—13 to 19 inches; very dark brown (10YR 2/2) light clay loam, dark gray (10YR 4/1) dry; black (10YR 2/1) coatings on peds; weak fine and medium granular structure; friable; slightly acid; clear smooth boundary.
B21—19 to 28 inches; dark grayish brown (2.5Y 4/2) clay loam; very dark grayish brown (10YR 3/2) coatings on peds; weak fine and medium subangular blocky structure; friable; slightly acid; gradual smooth boundary.
B22—28 to 33 inches; mixed grayish brown (2.5Y 5/2) and dark grayish brown (2.5Y 4/2) gravelly loam; weak fine and medium subangular blocky structure; friable; few fine dark accumulations (iron and managanese oxides); slightly acid; clear smooth boundary.
IIB3—33 to 38 inches; brown (10YR 5/3) loamy sand; weak fine subangular blocky structure; very friable; slightly acid; clear smooth boundary.
IIC1—38 to 44 inches; pale brown (10YR 6/3) loamy sand and gravel; weak fine subangular blocky structure; very friable; slight effervescence; mildly alkaline; clear smooth boundary.
IIC2—44 to 60 inches; light brownish gray (10YR 6/2) and light gray (10YR 7/2) sand and gravel with thin lenses of fine sand; single grain; loose; few lime concretions; slight effervescence; mildly alkaline.

The thickness of the solum and the depth to sand and gravel range from 32 to 40 inches.

The A horizon is 12 to 24 inches thick. It ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2) and is loam or light clay loam. The B horizon has hue of 2.5Y to 10YR, value of 4 or 5, and chroma of 2 or 3, with mottles. The C horizon is typically medium and coarse sand and gravel but ranges to loamy sand. In some pedons, the upper part of the C horizon is leached to a depth of several inches.

Dickman series

The Dickman series consists of well drained soils that have moderately rapid permeability in the upper part of the profile and rapid permeability in the lower part. These soils formed in loamy and sandy eolian sediment. They are on convex ridgetops and side slopes in the uplands. Native vegetation was prairie grasses. Slopes range from 2 to 14 percent.

Dickman soils are commonly adjacent to Clarion, Exira, Marshall, and Storden soils on the landscape. All of these soils are in positions on the landscape similar to those of Dickman soils but have less sand and more silt and clay. Storden soils are calcareous.

Typical pedon of Dickman sandy loam, 9 to 14 percent slopes, moderately eroded, 1,200 feet east and 2,100 feet south of the northwest corner of sec. 2, T. 84 N., R. 33 W.

Ap—0 to 6 inches; very dark brown (10YR 2/2) and brown (10YR 4/3) sandy loam, dark grayish brown (10YR 4/2) dry; weak fine granular structure; very friable; medium acid; gradual smooth boundary.
A3—6 to 13 inches; dark brown (10YR 3/3) sandy loam, brown (10YR 5/3) dry; very dark grayish brown (10YR 3/2) coatings on peds; weak fine and medium subangular blocky structure; very friable; medium acid; gradual smooth boundary.
B21—13 to 22 inches; brown (10YR 4/3) sandy loam; weak fine and medium subangular blocky structure; very friable; medium acid; gradual smooth boundary.
B3—22 to 31 inches; dark yellowish brown (10YR 4/4) loamy sand; weak fine subangular blocky structure; loose; medium acid; gradual smooth boundary.
C1—31 to 40 inches; dark yellowish brown (10YR 4/4) sand; single grain; loose; medium acid; gradual smooth boundary.
C2—40 to 60 inches; brown (10YR 5/3) sand; single grain; loose; medium acid.

The solum thickness ranges from 24 to 36 inches. Depth to loamy sand ranges from 12 to 24 inches.

The A horizon is black (10YR 2/1), very dark brown (10YR 2/2), very dark grayish brown (10YR 3/2), or dark brown (10YR 3/3) and is 6 to 14 inches thick. The B horizon typically is brown (10YR 4/3) or dark yellowish brown (10YR 4/4) but ranges to include hue of 7.5YR, with value of 4 or 5 and chroma of 4. The C horizon has hue of 10YR; value of 4, 5, or 6; and chroma of 3 or 5. It is sand or fine sand.

Estherville series

The Estherville series consists of somewhat excessively drained soils that have moderately rapid permeability in the upper part of the profile and rapid permeability in the lower part. These soils formed in loamy glacial outwash sediment that is underlain by sandy and gravelly outwash sediment on benches, valleys, and moraines. Native vegetation was prairie grasses. Slopes range from 2 to 9 percent.

Estherville soils are commonly adjacent to Calco, Coland, Cylinder, and Wadena soils on the landscape. Calco and Coland soils are poorly drained and are near the main stream channel. Cylinder soils are somewhat poorly drained, and Wadena soils are well drained. Both of these soils are on benches and are underlain by sand and gravel.

Typical pedon of Estherville sandy loam, 2 to 5 percent slopes, 1,400 feet west and 620 feet south of the northeast corner of sec. 22, T. 84 N., R. 34 W.

Ap—0 to 6 inches; very dark gray (10YR 3/1) sandy loam, dark gray (10YR 4/1) dry; weak fine subangular blocky and moderate fine granular structure; friable; about 5 percent gravel; slightly acid; clear smooth boundary.

B1—6 to 9 inches; dark brown (10YR 3/3) sandy loam, brown (10YR 5/3) dry; very dark grayish brown (10YR 3/2) coating on peds; weak fine subangular blocky structure; friable; about 5 percent gravel; slightly acid; gradual smooth boundary.

B2—9 to 15 inches; brown (7.5YR 4/4 and 10YR 4/3) sandy loam; weak medium subangular blocky structure; friable; about 10 percent gravel; slightly acid; clear smooth boundary.

B3—15 to 20 inches; brown (10YR 4/3) loamy coarse sand; weak fine subangular blocky structure; very friable; about 10 percent gravel; neutral; clear smooth boundary.

IIC1—20 to 25 inches; dark yellowish brown (10YR 4/4) coarse sand; single grain; loose; about 5 percent gravel; mildly alkaline; clear smooth boundary.

IIC2—25 to 32 inches; variegated brown (10YR 4/3), yellowish brown (10YR 5/4), and light gray (10YR 7/2) coarse sand; single grain; loose; about 12 percent gravel; strong effervescence; moderately alkaline; clear wavy boundary.

IIC3—32 to 36 inches; variegated dark grayish brown (10YR 4/2), yellowish brown (10YR 5/4), and light gray (10YR 7/2) sand and gravel; single grain; loose; about 15 percent gravel; strong effervescence; moderately alkaline; clear wavy boundary.

IIC4—36 to 60 inches; variegated yellowish brown (10YR 5/4), dark yellowish brown (10YR 4/4), and light brownish gray (10YR 6/2) sand and gravel; single grain; loose; about 35 percent gravel; strong effervescence; moderately alkaline.

The solum thickness and depth to carbonates range from 15 to 26 inches. The A and B horizons are 5 to 15 percent gravel.

The A horizon is black (10YR 2/1), very dark brown (10YR 2/2), or very dark grayish brown (10YR 3/2). The B horizon is dark brown (7.5YR 3/2 or 10YR 3/3), brown (7.5YR 4/4 or 10YR 4/3), or dark yellowish brown (10YR 4/4). It is sandy loam or coarse loamy sand. The IIC horizon is 5 to 40 percent gravel. The content of gravel generally increases with depth. The IIC horizon has hue of 10YR; value of 4, 5, or 6; and chroma of 2, 4 or 6. It is mildly alkaline or moderately alkaline.

The Estherville soils in unit 34C2 are taxadjuncts to the Estherville series because they do not have a mollic epipedon. This difference does not alter the usefulness and behavior of these soils.

Exira series

The Exira series consists of well drained, moderately permeable soils on upland side slopes and ridges. These soils formed in loess that has relict mottles. Native vegetation was prairie grasses. Slopes range from 5 to 20 percent.

Exira soils are taxadjuncts to the Exira series because they do not have a mollic epipedon. This difference does not alter the use and behavior of these soils.

Exira soils are similar to Marshall soils and are commonly adjacent to Burchard, Ida, and Marshall soils on the landscape. Burchard soils formed in glacial till and are downslope from Exira soils. Marshall soils do not have mottles at depths of less than 30 inches. Marshall and Ida soils are in positions on the landscape similar to those of Exira soils. Ida soils have more silt and less clay and are calcareous.

Typical pedon of Exira silty clay loam, 5 to 9 percent slopes, moderately eroded, 36 feet north and 1,750 feet west of the southeast corner of sec. 22, T. 82 N., R. 35 W.

Ap—0 to 8 inches; very dark grayish brown (10YR 3/2) silty clay loam, very dark grayish brown (10YR 3/2) rubbed, mixed with streaks and patches of brown (10YR 4/3) subsoil material, grayish brown (10YR 5/2) dry; weak fine subangular blocky structure parting to weak fine granular; friable; slightly acid; clear smooth boundary.

B1—8 to 13 inches; brown (10YR 4/3) silty clay loam, brown (10YR 5/3) dry; thin discontinuous dark brown (10YR 3/3) coating on peds; moderate fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

B21t—13 to 17 inches; brown (10YR 4/3) silty clay loam; moderate fine and medium subangular blocky structure; friable; thin discontinuous clay films; slightly acid; clear smooth boundary.

B22t—17 to 20 inches; brown (10YR 4/3) silty clay loam; few fine faint brown (7.5R 4/4) and few fine distinct grayish brown (2.5Y 5/2) relict mottles; moderate fine and medium subangular blocky structure; friable; few fine dark accumulations (iron and manganese oxides); slightly acid; clear smooth boundary.

B23—20 to 29 inches, dark yellowish brown (10YR 4/4) silty clay loam; many fine distinct grayish brown (2.5Y 5/2) and common fine faint brown (7.5YR 4/4) relict mottles; weak medium subangular blocky structure; friable; common fine dark accumulations (iron and manganese oxides); slightly acid; gradual smooth boundary.

B3—29 to 41 inches; yellowish brown (10YR 5/4) and dark yellowish brown (10YR 4/4) silt loam; many fine distinct grayish brown (2.5Y 5/2) and common fine faint yellowish brown (10YR 5/6 and 5/8) relict mottles; weak medium subangular blocky structure; friable; common fine dark accumulations (iron and manganese oxides); neutral; clear smooth boundary.
C—41 to 60 inches; mixed yellowish brown (10YR 5/4 and 5/6) and grayish brown (2.5Y 5/2) silt loam; massive; friable; common fine dark accumulations (iron and manganese oxides); neutral.

The thickness of the solum ranges from 30 to 44 inches.

The Ap horizon is 5 to 9 inches thick. It typically is very dark grayish brown (10YR 3/2) mixed with brown (10YR 4/3) or dark yellowish brown (10YR 4/4). The Ap horizon ranges from medium acid to neutral. Clay content in the B horizon ranges from 30 to 35 percent. The B horizon is brown (10YR 4/3), dark yellowish brown (10YR 4/4), or yellowish brown (10YR 5/4). Depth to brown (7.5YR 4/4) or grayish brown (2.5Y 5/2) relict mottles ranges from 11 to 25 inches. The C horizon is yellowish brown (10YR 5/4 or 10YR 5/6), grayish brown (2.5Y 5/2), or light brownish gray (2.5Y 6/2). It is silt loam or silty clay loam.

Gara series

The Gara series consists of moderately well drained and well drained soils. Permeability is moderately slow. These soils formed in glacial till on convex side slopes on uplands. Native vegetation was prairie grassses and deciduous trees. Slopes range from 14 to 40 percent.

Gara soils are similar to Armstrong soils and are commonly adjacent to Armstrong, Burchard, and Knox soils. Armstrong soils have more clay and are redder in hue in the B horizon than Gara soils. Burchard soils have a darker A horizon. Knox soils formed in loess on ridges above Armstrong and Gara soils.

Typical pedon of Gara loam, 25 to 40 percent slopes, 2,040 feet south and 2,200 feet west of the northeast corner of sec. 14, T. 82 N., R. 34 W.

A1—0 to 7 inches; very dark gray (10YR 3/1) loam, gray (10YR 5/1) dry; weak fine granular structure; friable; slightly acid; clear smooth boundary.
A2—7 to 11 inches; mixed dark grayish brown (10YR 4/2) and very dark grayish brown (10YR 3/2) loam, light brownish gray (10YR 6/2) dry; very weak thin plates that break to weak fine subangular blocky structure; friable; strongly acid; clear smooth boundary.
B1—11 to 15 inches; brown (10YR 4/3) clay loam; moderate fine subangular blocky structure; firm; thin discontinuous light brownish gray (10YR 6/2) silt coatings on peds; strongly acid; clear smooth boundary.
B21t—15 to 21 inches; dark yellowish brown (10YR 4/4) clay loam; moderate fine and medium subangular blocky structure; firm; common brown (10YR 4/3) clay films on faces of peds; thin discontinuous light brownish gray (10YR 6/2) silt coatings; strongly acid; clear smooth boundary.
B22t—21 to 30 inches; dark yellowish brown (10YR 4/4) clay loam; few fine distinct strong brown (7.5YR 5/6) mottles; thin discontinuous clay films on faces of peds; moderate medium subangular blocky structure; firm; thin nearly continuous light brownish gray (10YR 6/2) silt coatings; strongly acid; clear smooth boundary.
B3t—30 to 43 inches; yellowish brown (10YR 5/4 and 5/6) clay loam; common fine distinct grayish brown (10YR 5/2) mottles; nearly continuous thin clay films on faces of peds; moderate medium subangular blocky structure; firm; thin discontinuous light gray (10YR 6/1) silt coatings; 5 percent gravel; medium acid; clear wavy boundary.
C—43 to 60 inches; yellowish brown (10YR 5/6) clay loam that has common fine distinct light brownish gray (10YR 6/2) mottles; firm; 5 percent gravel; common white lime concretions; strong effervescence; mildly alkaline.

The thickness of the solum ranges from 36 to 60 inches. A few pebbles and stones are scattered on the surface. The solum is as much as 5 percent gravel. The depth to free carbonates is more than 36 inches.

The uneroded A1 horizon is very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2) loam or silt loam. It is 5 to 7 inches thick and is medium acid or slightly acid. The eroded Ap horizon ranges from very dark grayish brown (10YR 3/2) to dark brown (10YR 3/3). The A2 horizon is loam or silt loam. It is 2 to 5 inches thick and is medium acid or strongly acid. The B2t horizon is clay loam and averages 33 to 35 percent clay.

Harps series

The Harps series consists of poorly drained, moderately permeable soils on narrow rims of upland depressions. These soils formed in calcareous, loamy glacial till or in local alluvial sediment. Native vegetation was prairie grasses. Slopes range from 0 to 2 percent.

Harps soils are similar to Canisteo soils and are commonly adjacent to Canisteo, Okoboji, and Webster soils on the landscape. Canisteo soils are less calcareous than Harps soils. The other soils are noncalcareous. Okoboji soils have a cumulic A horizon, a finer textured B horizon, and are in depressional areas. Canisteo and Webster soils are on lower lying, more nearly level areas than Harps soils.

Typical pedon of Harps loam, 0 to 2 percent slopes, 1,470 feet north and 2,230 feet west of the southeast corner of sec. 31, T. 84 N., R. 33 W.

Apca—0 to 7 inches; black (10YR 2/1) loam, dark gray (10YR 4/1) dry; moderate fine subangular blocky structure parting to moderate fine granular; friable; common small snail shell fragments; violent effervescence; moderately alkaline; clear smooth boundary.

A12ca—7 to 13 inches; very dark gray (10YR 3/1) loam, gray (10YR 5/1) dry; weak medium subangular blocky structure parting to moderate fine subangular blocky; friable; common small snail shell fragments; violent effervescence; moderately alkaline; clear smooth boundary.

A3ca—13 to 19 inches; mixed very dark gray (5Y 3/1), dark gray (5Y 4/1), and some gray (5Y 5/1) loam; weak fine subangular blocky structure; friable; common snail shell fragments; violent effervescence; gradual smooth boundary.

B21gca—19 to 24 inches; mixed dark gray (5Y 4/1), very dark gray (5Y 3/1), and light olive gray (5Y 6/2) loam; weak fine subangular blocky structure; friable; violent effervescence; moderately alkaline; gradual smooth boundary.

B22gca—24 to 36 inches; mixed light gray (5Y 6/1) and light olive gray (5Y 6/2) loam; few fine prominent strong brown (7.5YR 5/8) and few fine distinct light olive brown (2.5Y 5/6) mottles; weak fine subangular blocky structure; friable; thin, gray (10YR 5/1) organic stains on root channels; few fine dark accumulations (iron and manganese oxides); less than 5 percent pebbles; common lime concretions; violent effervescence; moderately alkaline; clear smooth boundary.

C1—36 to 50 inches; light olive gray (5Y 6/2) loam; common medium prominent strong brown (7.5YR 5/8) and common fine distinct light olive brown (2.5Y 5/6) mottles; massive; friable; about 2 percent pebbles; common lime concretions; strong effervescence; moderately alkaline; clear smooth boundary.

C2—50 to 60 inches; light olive gray (5Y 6/2), yellowish brown (10YR 5/6), light olive brown (2.5Y 5/4), and strong brown (7.5YR 5/8) loam; massive; friable; few lime concretions; strong effervescence; moderately alkaline.

The A horizon ranges from 10 to 20 inches in thickness and from black (10YR 2/1) to very dark gray (10YR 3/1 or N 3/0). It is loam or clay loam. The B horizon has hue of 5Y or 2.5Y, value of 3 through 6, and chroma of 1 or 2. It typically is loam but the range includes clay loam or sandy clay loam. The C horizon has hue of 7.5YR, 10YR, 2.5Y, or 5Y; value of 5 or 6; and chroma of 2 through 8.

Ida series

The Ida series consists of well drained, moderately permeable soils on uplands. These soils formed in silty, calcareous loess on ridges and on the upper part of side slopes. Native vegetation was prairie grasses. Slopes range from 5 to 14 percent.

Ida soils are commonly adjacent to Exira, Lamoni, and Marshall soils on the landscape. The adjacent soils have more clay and less silt than Ida soils. Exira and Marshall soils have a thicker A horizon, a B horizon, and are leached more deeply than Ida soils. They are in positions on the landscape similar to those of Ida soils.

Typical pedon of Ida silt loam, 9 to 14 percent slopes, severely eroded, 1,000 feet west and 120 feet north of the southeast corner of sec. 35, T. 83 N., R. 35 W.

Ap—0 to 6 inches; brown (10YR 4/3) silt loam, pale brown (10YR 6/3) dry; weak fine granular structure; friable; common lime accumulations of about 5 millimeters; strong effervescence; moderately alkaline; clear smooth boundary.

C1—6 to 9 inches; brown (10YR 4/3) silt loam; weak fine subangular blocky structure; friable; common lime accumulations of about 5 millimeters; strong effervescence; moderately alkaline; clear smooth boundary.

C2—9 to 24 inches; brown (10YR 5/3) silt loam; common fine faint grayish brown (2.5Y 5/2) and few fine distinct strong brown (7.5YR 5/6) mottles; massive; friable; common lime accumulations of about 5 millimeters; strong effervescence; moderately alkaline; gradual smooth boundary.

C3—24 to 54 inches; light olive brown (2.5Y 5/4) silt loam; many medium faint grayish brown (2.5Y 5/2) and many medium distinct yellowish brown (10YR 5/6) mottles; massive; very friable; few fine dark accumulations (iron and manganese oxides); strong effervescence; moderately alkaline; gradual smooth boundary.

C4—54 to 60 inches; light brownish gray (2.5Y 6/2) silt loam; common fine distinct yellowish brown (10YR 5/6) mottles; massive; very friable; few fine dark accumulations (iron and manganese oxides); strong effervescence; moderately alkaline.

The thickness of the solum and thickness of the A horizon is less than 10 inches.

The Ap horizon is brown (10YR 4/3 or 5/3) or dark grayish brown (10YR 4/2). The upper part of the C horizon has hue of 10YR, value of 4 to 6, and chroma of 3 or 4. The lower part of the C horizon has hue of 10YR or 2.5Y, value of 5 or 6, and chroma of 2 to 6. A few to common lime nodules of as much as 2 centimeters in diameter are on the surface.

Judson series

The Judson series consists of moderately well drained and well drained, moderately permeable soils. These soils formed in local alluvium on alluvial fans and foot slopes. Native vegetation was prairie grasses. Slopes range from 1 to 9 percent.

Judson soils are commonly adjacent to Burchard and Marshall soils upslope and to Ackmore and Colo soils downslope. Ackmore and Colo soils are more poorly drained than Judson soils, and Burchard and Marshall soils have a thinner A horizon. Marshall soils formed in loess, and Burchard soils formed in glacial till.

Typical pedon of Judson silty clay loam, 5 to 9 percent slopes, 750 feet south and 120 feet west of the northeast corner of sec. 28, T. 83 N., R. 36 W.

Ap—0 to 8 inches; very dark brown (10YR 2/2) silty clay loam, dark grayish brown (10YR 4/2) dry; weak very fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

A12—8 to 17 inches; black (10YR 2/1) silty clay loam, dark grayish brown (10YR 4/2) dry; weak fine subangular blocky structure parting to weak fine granular; friable; medium acid; clear smooth boundary.

A3—17 to 25 inches; very dark grayish brown (10YR 3/2) silty clay loam, dark grayish brown (10YR 4/2) dry; weak fine subangular blocky structure parting to weak fine granular; friable; medium acid; gradual smooth boundary.

B2—25 to 34 inches; dark brown (10YR 3/3) silty clay loam, grayish brown (10YR 5/2) dry; very dark grayish brown (10YR 3/2) coatings on faces of peds; weak medium subangular blocky structure parting to weak fine and very fine subangular blocky; friable; medium acid; gradual smooth boundary.

B3—34 to 43 inches; brown (10YR 4/3) silty clay loam; weak medium subangular blocky structure parting to moderate very fine subangular blocky; friable; medium acid; gradual smooth boundary.

C—43 to 60 inches; brown (10YR 4/3) silty clay loam; few fine distinct grayish brown (2.5Y 5/2), strong brown (7.5YR 5/6), and dark reddish brown (5YR 3/4) mottles; massive with vertical cleavage; friable; slightly acid.

The thickness of the solum ranges from 40 to 54 inches.

The A horizon is black (10YR 2/1), very dark brown (10YR 2/2), or very dark grayish brown (10YR 3/2) silt loam or silty clay loam. It ranges from 20 to 30 inches in thickness. The B horizon is dark brown (10YR 3/3), brown (10YR 4/3), or dark yellowish brown (10YR 4/4) silty clay loam with a maximum clay content ranging from 30 to 35 percent. The B horizon is slightly acid or medium acid. The C horizon is brown (10YR 4/3) or dark yellowish brown (10YR 4/4) with grayish brown (10YR 5/2 or 2.5Y 5/2), strong brown (7.5YR 5/6), or dark reddish brown (5YR 3/4) mottles.

Knoke series

The Knoke series consists of very poorly drained soils. Permeability is moderately slow. These soils are on large flats in slightly depressed areas that were formerly lake plains. Native vegetation was prairie grasses. Slopes range from 0 to 1 percent.

Knoke soils are similar to Okoboji soils and are commonly adjacent to Calco and Canisteo soils. All of these soils have a lower content of organic matter than Knoke soils. Okoboji soils have a higher clay content and are not calcareous. Calco soils formed in alluvium. Canisteo soils are at a higher elevation and have slightly better drainage than Knoke soils.

Typical pedon of Knoke mucky silt loam, 0 to 1 percent slopes, 2,500 feet north and 1,600 feet east of the southwest corner of sec. 30, T. 83 N., R. 33 W.

Ap—0 to 9 inches; black (N 2/0) mucky silt loam, dark gray (10YR 4/1) dry; weak fine and very fine subangular blocky structure parting to weak fine granular; nonsticky and very friable; few fine snail shell fragments; strong effervescence; moderately alkaline; clear smooth boundary.

A12—9 to 19 inches; black (N 2/0) mucky silty clay loam, dark gray (10YR 4/1) dry; weak very fine and fine subangular blocky structure parting to weak fine granular; slightly sticky and very friable; many fine snail shell fragments; strong effervescence; mildly alkaline; clear smooth boundary.

A13—19 to 25 inches; black (N 2/0) silty clay loam, gray (10YR 5/1) dry; some very fine sand grains; weak very fine and fine subangular blocky structure; very friable; common snail shell fragments; strong effervescence; mildly alkaline; clear smooth boundary.

B21—25 to 34 inches; black (N 2/0) silty clay loam with some very fine sand grains; weak medium subangular blocky structure; friable; few snail shell fragments; strong effervescence; mildly alkaline; clear smooth boundary.

B22—34 to 45 inches; black (N 2/0) heavy silty clay loam; weak fine and medium prismatic structure parting to weak medium subangular blocky; firm; strong effervescence; mildly alkaline; clear smooth boundary.

B3—45 to 60 inches; very dark gray (5Y 3/1) heavy silty clay loam; few medium distinct dark brown (10YR 3/3) and dark grayish brown (2.5Y 4/2) mottles; weak fine and medium prismatic structure parting to weak medium subangular blocky; firm; strong effervescence; mildly alkaline.

The A horizon ranges from 24 to 36 inches in thickness. The upper part is mucky silt loam or mucky silt clay loam ranging from 10 to 20 inches in thickness. The A horizon is black (N 2/0 or 10YR 2/1). The B horizon is black (N 2/0 or 10YR 2/1) or very dark gray (5Y 3/1). It is silty clay loam or silty clay with clay content ranging from 35 to 42 percent. The C horizon is dark gray (5Y 4/1) or olive gray (5Y 5/2). It typically is silty clay loam or clay loam. These soils are mildly alkaline or moderately alkaline throughout.

Knox series

The Knox series consists of well drained, moderately permeable soils. These soils formed in loess on ridgetops and convex side slopes in uplands. Native vegetation was prairie grasses and deciduous trees. Slopes range from 4 to 18 percent.

Knox soils are similar to Marshall soils and are commonly adjacent to Armstrong, Gara, and Marshall soils on the landscape. Armstrong and Gara soils are downslope from Knox soils and have more clay and sand. They formed in glacial till. Marshall soils have a thicker A1 horizon, do not have an A2 horizon, and do not have silt coatings on ped faces in the B horizon.

Typical pedon of Knox silt loam, 4 to 9 percent slopes, 150 feet north and 2,120 feet east of the southwest corner of sec. 22, T. 82 N., R. 34 W.

A1—0 to 6 inches; very dark grayish brown (10YR 3/2) silt loam; grayish brown (10YR 5/2) with dark gray (10YR 4/1) dry coatings; common thin discontinuous black (10YR 2/1) coatings on peds; moderate fine and medium granular structure; friable; slightly acid; clear smooth boundary.

A21—6 to 10 inches; brown (10YR 4/3) silt loam; few thin discontinuous very dark grayish brown (10YR 3/2) coatings on peds; weak fine subangular blocky structure parting to moderate fine and medium granular; friable; strongly acid; clear smooth boundary.

A22—10 to 14 inches; brown (10YR 4/3) silt loam; thin discontinuous very dark grayish brown (10YR 3/2) coatings on peds; weak fine and medium subangular blocky structure parting to moderate fine and medium granular; friable; medium acid; clear smooth boundary.

B21t—14 to 24 inches; dark yellowish brown (10YR 4/4) silty clay loam; gray (10YR 5/1) dry silt coatings on peds; moderate fine and medium subangular blocky structure; friable; thin discontinuous brown (10YR 4/3) clay films; medium acid; gradual wavy boundary.

B22t—24 to 33 inches; dark yellowish brown (10YR 4/4) silty clay loam; weak medium subangular blocky structure; friable; brown (10YR 4/3) thin discontinuous clay films; thin discontinuous gray (10YR 5/1) dry silt coatings; medium acid; gradual wavy boundary.

B3—33 to 44 inches; dark yellowish brown (10YR 4/4) silty clay loam; weak medium and coarse subangular blocky structure; friable; thin discontinuous brown (10YR 4/3) and dark brown (10YR 3/3) clay films; medium acid; gradual wavy boundary.

C1—44 to 52 inches; brown (10YR 5/3) silt loam; few medium faint brown (7.5YR 4/4) mottles; massive; friable; few fine dark accumulations (iron and manganese oxides); medium acid; gradual smooth boundary.

C2—52 to 60 inches; brown (10YR 5/3) silt loam; massive; friable; slightly acid.

The thickness of the solum and the depth to free carbonates range from 36 to more than 60 inches.

The A1 horizon is 5 to 9 inches thick and is medium acid or slightly acid unless limed. In cultivated areas, the Ap horizon has value of 3 and chroma of 2 or 3. The Ap horizon typically includes all or part of the A2 horizon. The A2 horizon has value of 4 or 5 and chroma of 2 or 3. The B2t horizon is silty clay loam with clay content ranging from 30 to 35 percent. It is dark yellowish brown (10YR 4/4) or yellowish brown (10YR 5/4). The B3 horizon is dark yellowish brown (10YR 4/4) or brown (10YR 5/3). It is silty clay loam or silt loam with clay content ranging from 25 to 30 percent. The B horizon is slightly acid or medium acid. The C horizon ranges from medium acid to mildly alkaline.

Lamoni series

The Lamoni series consists of somewhat poorly drained soils on convex, upland side slopes. Permeability is slow or very slow. These soils formed in a thin mantle of loess or pedisediment and in loamy and clayey glacial till. Native vegetation was prairie grasses. Slopes range from 9 to 14 percent.

These Lamoni soils are taxadjuncts to the Lamoni series because they do not have a mollic epipedon and are only slightly acid in the most acid part of the profile. These differences do not alter the usefulness and behavior of the soils.

Lamoni soils are commonly adjacent to Burchard, Exira, Ida, and Marshall soils on the landscape. Exira, Ida, and Marshall soils have better internal drainage and less clay in the B horizon than Lamoni soils. They formed in loess on slopes and ridges above the Lamoni soils. Burchard soils also have less clay in the B horizon but are generally downslope from Lamoni soils.

Typical pedon of Lamoni silty clay loam, 9 to 14 percent slopes, severely eroded, 1,675 feet east and

2,050 feet south of the northwest corner of sec. 22, T. 83 N., R. 34 W.

Ap—0 to 5 inches; dark grayish brown (10YR 4/2) silty clay loam, grayish brown (10YR 5/2) dry; weak fine and medium angular and subangular blocky structure; friable; slightly acid; abrupt smooth boundary.

IIB21t—5 to 21 inches; grayish brown (2.5Y 5/2) clay; few fine faint light olive brown (2.5Y 5/4) and distinct strong brown (7.5YR 5/6) mottles; weak medium angular blocky structure parting to moderate fine angular blocky; very firm; thin discontinuous clay films; slightly acid; gradual smooth boundary.

IIB22t—21 to 30 inches; mottled light olive brown (2.5Y 5/4), gray (10YR 5/1), and strong brown (7.5YR 5/6) clay; moderate medium and fine subangular blocky structure; firm; thin continuous clay films; slightly acid; gradual smooth boundary.

IIB23t—30 to 38 inches; mottled light olive brown (2.5Y 5/4), strong brown (7.5YR 5/6), and gray (10YR 5/1) clay; moderate medium and fine subangular blocky structure; firm; thin discontinuous clay films; few lime accumulations; neutral; clear smooth boundary.

IIB24t—38 to 43 inches; mottled yellowish brown (10YR 5/4 and 5/6), light olive gray (5Y 6/2), and pale olive (5Y 6/3) clay; weak medium subangular blocky structure; firm; thin discontinuous clay films; few lime accumulations; neutral; gradual smooth boundary.

IIB31t—43 to 52 inches; mottled light olive brown (2.5Y 5/4), yellowish brown (10YR 5/6), and strong brown (7.5YR 5/8) clay loam; moderate medium subangular blocky structure; firm; thin discontinuous clay films; common lime accumulations; neutral; clear smooth boundary.

IIB32t—52 to 60 inches; mottled yellowish brown (10YR 5/4 and 5/6) and light gray (10YR 6/1) clay loam; moderate medium subangular blocky structure; firm; thin discontinuous clay films; few fine dark accumulations (iron and manganese oxides); common lime accumulations; neutral.

The solum thickness ranges from 48 to 60 inches or more.

The Ap horizon is very dark gray (10YR 3/1) or dark grayish brown (10YR 4/2) silty clay loam or clay loam. The IIB2t horizon has hue of 5Y, 2.5Y, 10YR, or 7.5YR; value of 5 or 6; and chroma of 1 through 8. It is clay or silty clay with clay content ranging from 40 to 50 percent. The IIB3t horizon is mottled with colors similar to those of the IIB2t horizon. It is clay loam with clay content ranging from 27 to 32 percent.

Lester series

The Lester series consists of well drained, moderately permeable soils in uplands. These soils formed in loam glacial till on ground moraines or terminal moraines. Native vegetation was prairie grasses and deciduous trees. Slopes range from 4 to 10 percent.

Lester soils are commonly adjacent to Clarion and Storden soils on the landscape. Clarion soils have a thicker A1 horizon and do not have an A2 horizon. Storden soils are calcareous throughout and do not have an A2 horizon. Both soils are in positions on the landscape similar to those of Lester soils.

Typical pedon of Lester loam, 4 to 10 percent slopes, 220 feet west and 400 feet south of the northeast corner of sec. 4, T. 84 N., R. 33 W.

A1—0 to 6 inches; very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) dry; black (10YR 2/1) coatings on peds; moderate very fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

A2—6 to 10 inches; dark grayish brown (10YR 4/2) loam; very dark grayish brown (10YR 3/2) coatings on faces of peds; weak fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

B1—10 to 14 inches; brown (10YR 4/3) clay loam; dark brown (10YR 3/3) coatings on peds; moderate fine subangular blocky structure; friable; medium acid; clear smooth boundary.

B21t—14 to 23 inches; brown (10YR 4/3) clay loam; moderate fine subangular blocky structure; friable; common coarse sand at a depth of 19 to 23 inches; thin continuous dark brown (10YR 3/3) clay films; medium acid; gradual smooth boundary.

B22t—23 to 31 inches; brown (10YR 4/3) clay loam; moderate medium and fine subangular blocky structure; friable; thin discontinuous dark brown (10YR 3/3) clay films; neutral; clear smooth boundary.

B23t—31 to 37 inches; dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4) clay loam; weak medium prismatic structure parting to moderate medium subangular blocky; friable; thin discontinuous brown (10YR 4/3) clay films; neutral; gradual smooth boundary.

B3t—37 to 43 inches; yellowish brown (10YR 5/4) clay loam; few fine distinct grayish brown (10YR 5/2) and strong brown (7.5YR 5/8) mottles; friable; thin discontinuous brown (10YR 4/3) clay films; neutral; clear smooth boundary.

C—43 to 60 inches; mottled light brownish gray (2.5Y 6/2), yellowish brown (10YR 5/4 and 5/6), and strong brown (7.5YR 5/8) loam; massive with some vertical cleavage; friable; disseminated lime; mildly alkaline.

The A1 horizon ranges from 4 to 8 inches in thickness and from black (10YR 2/1) to very dark grayish brown (10YR 3/2). The A2 horizon ranges from 3 to 8 inches in thickness and is very dark gray (10YR 3/1) or dark grayish brown (10YR 4/2). In cultivated areas, most or all of the A2 horizon is incorporated into the Ap horizon. The Ap horizon is very dark grayish brown (10YR 3/2). The B horizon is clay loam that has clay content ranging from 27 to 35 percent. It is brown (10YR 4/3), dark yellowish brown (10YR 4/4), or yellowish brown (10YR 5/4). The C horizon has hue of 7.5YR, 10YR, or 2.5Y; value of 5 or 6; and chroma of 2 through 8. The C horizon is mildly alkaline or moderately alkaline.

Marshall series

The Marshall series consists of well drained, moderately permeable soils. These soils formed in loess on convex ridges and side slopes in uplands and on benches in some valleys. Native vegetation was prairie grasses. Slopes range from 0 to 20 percent.

Marshall soils are similar to Exira soils and are commonly adjacent to Burchard, Exira, and Ida soils on the landscape. Exira soils have more mottles in the subsoil at depths of less than 30 inches. Burchard soils formed in glacial till and are downslope from Marshall soils. Ida soils have a thinner A horizon, do not have a B horizon, and are calcareous.

Typical pedon of Marshall silty clay loam, 2 to 5 percent slopes, 900 feet north and 700 feet west of the southeast corner of sec. 6, T. 82 N., R. 35 W.

Ap—0 to 7 inches; very dark brown (10YR 2/2) silty clay loam, grayish brown (10YR 5/2) dry; weak fine and medium granular structure; friable; slightly acid; clear smooth boundary.

A12—7 to 12 inches; very dark brown (10YR 2/2) silty clay loam, dark grayish brown (10YR 4/2) dry; black (10YR 2/1) coatings on peds; weak fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

A3—12 to 18 inches; mixed very dark brown (10YR 2/2) and very dark grayish brown (10YR 3/2) silty clay loam, mixed brown (10YR 5/3) and dark grayish brown (10YR 4/2) dry; weak medium subangular blocky structure parting to weak medium and fine subangular blocky; friable; slightly acid; gradual smooth boundary.

B21—18 to 23 inches; dark brown (10YR 3/3) silty clay loam, brown (10YR 5/3) dry; weak medium and fine subangular blocky structure; friable; slightly acid; gradual smooth boundary.

B22—23 to 31 inches; brown (10YR 4/3) silty clay loam; weak medium prismatic structure parting to moderate fine subangular blocky; friable; slightly acid; gradual smooth boundary.

B23—31 to 36 inches; brown (10YR 4/3) silty clay loam; few medium distinct brownish gray (2.5Y 5/2) and brown (7.5YR 4/4) mottles; weak medium prismatic structure parting to weak fine and medium subangular blocky; friable; slightly acid; clear smooth boundary.

B31—36 to 44 inches; brown (10YR 5/3) silty clay loam; many fine distinct grayish brown (2.5Y 5/2) and brown (7.5YR 4/4) mottles; weak medium prismatic structure parting to weak medium and fine subangular blocky; friable; slightly acid; clear smooth boundary.

B32—44 to 52 inches; grayish brown (2.5Y 5/2) silty clay loam; many fine distinct brown (7.5YR 4/4) and yellowish brown (10YR 5/6) mottles; weak medium prismatic structure; friable; few fine dark accumulations (iron and manganese oxides); neutral; gradual smooth boundary.

B33—52 to 58 inches; grayish brown (2.5Y 5/2) silty clay loam; many fine distinct yellowish brown (10YR 5/4) and brown (7.5YR 4/4) mottles; weak medium subangular blocky structure; friable; many medium dark oxides; neutral; gradual smooth boundary.

C—58 to 60 inches; grayish brown (2.5Y 5/2) silt loam; many fine distinct yellowish brown (10YR 5/4) and brown (7.5YR 4/4) mottles; massive; friable; common fine dark accumulations (iron and manganese oxides); slightly acid.

Solum thickness ranges from 40 to 60 inches.

The A horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2). The B2 horizon is dark brown (10YR 3/3) or brown (10YR 4/3) in the upper part and ranges from brown (10YR 4/3) to yellowish brown (10YR 5/4) in the lower part. In some pedons, a few grayish brown, yellowish brown, and light brownish gray mottles are present in the lower part of the B2 horizon. These mottles are commonly at a depth of more than 30 inches, but in some pedons there are a very few mottles at a depth of 26 inches. The B3 and C horizons have hue of 10YR through 5Y, value of 4 or 5, and chroma of 2 through 6. The grayish colors are considered to be relict mottles. The maximum clay content in the B2 horizon ranges from 32 to 35 percent.

The Marshall soils in map units 9B2, 9C2, 9D2, 9E2, and 71D2 are taxadjuncts to the Marshall series because they do not have a mollic epipedon. This difference does not alter the usefulness or behavior of these soils.

Nicollet series

The Nicollet series consists of somewhat poorly drained, moderately permeable soils that formed in glacial till. These soils are on low convex rises, on the lower parts of long gentle slopes, and in slightly concave positions in the upper parts of drainageways in uplands.

Native vegetation was prairie grasses. Slopes range from 1 to 3 percent.

Nicollet soils are commonly adjacent to Canisteo, Clarion, and Webster soils. Clarion soils are more sloping and are better drained than Nicollet soils. Canisteo and Webster soils are poorly drained and are on lower, more nearly level places on the landscape.

Typical pedon of Nicollet loam, 1 to 3 percent slopes, 116 feet east and 1,200 feet north of the southwest corner of sec. 25, T. 84 N., R. 33 W.

Ap—0 to 9 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak fine and medium subangular blocky structure parting to weak fine granular; friable; slightly acid; gradual smooth boundary.

A12—9 to 16 inches; black (10YR 2/1) loam, dark gray (10YR 4/1) dry; moderate fine subangular blocky structure; friable; slightly acid; gradual smooth boundary.

A3—16 to 22 inches; very dark grayish brown (10YR 3/2) clay loam, dark grayish brown (10YR 4/2) dry; thin discontinuous very dark gray (10YR 3/1) coatings on peds; weak fine subangular blocky structure; friable; slightly acid; gradual smooth boundary.

B2—22 to 30 inches; dark grayish brown (2.5Y 4/2) clay loam; few fine faint olive brown (2.5Y 4/4) mottles; thin discontinuous very dark gray (10YR 3/1) coatings on peds; moderate fine and medium subangular blocky structure; friable; slightly acid; gradual smooth boundary.

C1g—30 to 37 inches; grayish brown (2.5Y 5/2) clay loam; few fine faint light olive brown (2.5Y 5/4) mottles; very weak fine and medium subangular blocky structure; friable; common lime masses; strong effervescence; mildly alkaline; gradual smooth boundary.

C2g—37 to 44 inches; grayish brown (2.5Y 5/2) loam; common medium distinct light olive brown (2.5Y 5/6) mottles; massive; friable; common lime masses; violent effervescence; mildly alkaline; gradual smooth boundary.

C3g—44 to 60 inches; grayish brown (2.5Y 5/2) loam; many medium distinct light olive brown (2.5Y 5/6) mottles; massive; friable; common lime masses; strong effervescence; mildly alkaline.

The A horizon ranges from 12 to 24 inches in thickness. It typically is loam but ranges to include clay loam. The A1 horizon is black (10YR 2/1) or very dark gray (10YR 3/1). The A3 horizon is very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2 or 2.5Y 3/2). The B horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 2 or 4. It is loam or clay loam with clay content ranging from 25 to 30 percent. The A and B horizons are neutral or slightly acid. The C horizon has hue of 2.5Y, value of 5 or 6, and chroma of 2 through 6. It is loam or clay loam with clay content ranging from 22 to 28 percent. The C horizon is mildly alkaline or moderately alkaline and is calcareous.

Okoboji series

The Okoboji series consists of very poorly drained soils. Permeability is moderately slow. These soils formed mainly in silty and loamy alluvium in depressions on till plains. Native vegetation was prairie grasses. Slopes range from 0 to 1 percent.

Okoboji soils are commonly adjacent to Canisteo, Harps, and Webster soils. Canisteo, Harps, and Webster soils do not have a cumulic epipedon and are lower in clay content in the B horizon than Okoboji soils. Canisteo, Harps, and Webster soils are in a slightly higher position on the landscape than Okoboji soils.

Typical pedon of Okoboji silty clay loam, 0 to 1 percent slopes, 1,180 feet west and 1,100 feet south of the northeast corner of sec. 31, T. 85 N., R. 34 W.

Ap—0 to 8 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; weak fine subangular blocky structure parting to moderate fine and medium granular; friable; mildly alkaline; clear smooth boundary.

A12—8 to 27 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; weak fine subangular blocky structure parting to weak medium granular; friable; mildly alkaline; gradual smooth boundary.

B1g—27 to 37 inches; very dark gray (10YR 3/1) silty clay loam, gray (10YR 5/1) dry; few fine dark grayish brown (2.5Y 4/2) mottles and black (10YR 2/1) coatings on peds; moderate fine prismatic structure parting to moderate fine subangular blocky; firm; mildly alkaline; clear smooth boundary.

B21g—37 to 43 inches; mixed olive gray (5Y 5/2) and dark gray (5Y 4/1) clay loam; common large distinct yellowish brown (10YR 5/4) mottles; very dark gray (10YR 3/1) coatings on peds; weak fine prismatic structure parting to moderate medium subangular blocky; firm; few snail shells; mildly alkaline; clear smooth boundary.

B22g—43 to 49 inches; mixed gray (5Y 5/1) and olive gray (5Y 5/2) clay loam; weak fine prismatic structure parting to moderate fine and medium subangular blocky; firm; few black (10YR 2/1) organic clay flows; common soft lime masses; strong effervescence; mildly alkaline; gradual smooth boundary.

Cg—49 to 60 inches; gray (5Y 5/1) clay loam; common large prominent yellowish brown (10YR 5/4) and brown (7.5YR 4/4) mottles; massive; friable; strong effervescence; mildly alkaline.

The A horizon ranges from 24 to 36 inches in thickness. It is black (N 2/0 or 10YR 2/1). The Bg horizon has hue of 10YR or 5Y; value of 3, 4, or 5; and chroma of 1 or 2. It is silty clay loam or clay loam with clay content ranging from 35 to 40 percent. The A and Bg horizons are neutral or mildly alkaline. The Cg horizon has hue of 5Y, value of 4 or 5, and chroma of 1 or 2. It is mildly alkaline or moderately alkaline and is calcareous. The Cg horizon is clay loam or silty clay loam.

Ridgeport series

The Ridgeport series consists of somewhat excessively drained soils on low stream benches. Permeability is moderately rapid in the solum and rapid or very rapid in the underlying material. These soils formed in moderately coarse textured alluvium overlying calcareous sand and gravel. Native vegetation was prairie grasses. Slopes range from 1 to 3 percent.

Ridgeport soils are commonly adjacent to Biscay, Cylinder, Spillville, and Wadena soils. Cylinder and Wadena soils are in positions on the landscape similar to those of Ridgeport soils but have more silt and clay in the solum, are more poorly drained, and have a less permeable solum. Spillville soils have more silt and clay in the solum, have a deeper, less permeable solum, and do not have coarse textured material at a depth of less than 40 inches. Spillville soils are at a lower elevation near the stream channel.

Typical pedon of Ridgeport sandy loam, 1 to 3 percent slopes, 1,300 feet east and 330 feet north of the southwest corner of sec. 27, T. 85 N., R 33 W.

Ap—0 to 7 inches; black (10YR 2/1) sandy loam, dark gray (10YR 4/1) dry; weak fine granular structure; friable; slightly acid; clear smooth boundary.

A12—7 to 14 inches; very dark brown (10YR 2/2) sandy loam, dark gray (10YR 4/1) dry; weak fine and medium granular structure; very friable; neutral; clear smooth boundary.

B1—14 to 19 inches; dark brown (10YR 3/3) sandy loam; thin discontinuous very dark grayish brown (10YR 3/2) coatings on peds; weak medium and fine subangular blocky structure; very friable; neutral; clear smooth boundary.

B21—19 to 26 inches; dark yellowish brown (10YR 4/4) sandy loam; thin discontinuous dark brown (10YR 3/3) coatings on peds; weak medium subangular blocky structure parting to moderate fine subangular blocky; very friable; neutral; gradual smooth boundary.

B22—26 to 35 inches; mixed dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4) sandy loam; thin discontinuous dark brown (10YR 3/3) coatings on peds; weak medium subangular blocky structure parting to moderate fine subangular blocky; very friable; neutral; clear smooth boundary.

IIC1—35 to 40 inches; variegated colors but mainly yellowish brown (10YR 5/4) sand and gravel; single grain; loose; mildly alkaline; strong effervescence; clear smooth boundary.

IIC2—40 to 60 inches; variegated colors but mainly brown (10YR 5/3) and light brownish gray (10YR 6/2) sand and gravel; single grain; loose; mildly alkaline; strong effervescence.

The thickness of the solum and the depth to free carbonates range from 28 to 40 inches. The thickness of the mollic epipedon ranges from 10 to 22 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. The A and B horizons are fine sandy loam or sandy loam. The B horizon has hue of 10YR; value of 3, 4, or 5; and chroma of 3 or 4. The A and B horizons are neutral or slightly acid. The IIC horizon has hue of 10YR; value of 4, 5, or 6; and chroma of 2 through 6. Content of gravel in the IIC horizon ranges from about 35 to 65 percent. It is mildly alkaline or moderately alkaline.

Salida series

The Salida series consists of excessively drained, very rapidly permeable soils. These soils formed mainly in calcareous sand and gravel on knobs, valley trains, and outwash plains. Native vegetation was prairie grasses. Slopes range from 5 to 16 percent.

Salida soils are similar to Estherville soils and are commonly adjacent to Estherville, Storden, and Wadena soils on the landscape. Estherville soils are deeper to sand and gravel than Salida soils. Storden soils formed in loam glacial till. Estherville and Storden soils are in a lower position on the landscape. Wadena soils have less sand in the A and B horizons and are deeper to sand and gravel than Salida soils. They are on outwash plains below the Salida soils.

Typical pedon of Salida gravelly sandy loam, from an area of Salida-Storden complex, 9 to 16 percent slopes, 1,750 feet north and 1,375 feet east of the southwest corner of sec. 26, T. 85 N., R. 33 W.

Ap—0 to 7 inches, very dark grayish brown (10YR 3/2) gravelly sandy loam, grayish brown (10YR 5/2) dry; weak medium granular structure; friable; 18 percent gravel with a few cobbles; strong effervescence; mildly alkaline; abrupt wavy boundary.

B2—7 to 15 inches; brown (10YR 4/3) gravelly loamy coarse sand; single grain; loose; 35 percent gravel with a few cobbles; violent effervescence; mildly alkaline; gradual wavy boundary.

C—15 to 60 inches; variegated brown (10YR 4/3 and 5/3), dark yellowish brown (10YR 4/4), and yellowish brown (10YR 5/4 and 5/6) gravelly coarse sand; loose; 50 percent gravel, a few cobbles; violent effervescence; moderately alkaline.

The solum thickness is 7 to 18 inches. The mollic epipedon ranges from 7 to 9 inches in thickness. The solum is generally calcareous throughout, but the depth to carbonates ranges to 15 inches.

The Ap horizon is very dark brown (10YR 2/2), very dark grayish brown (10YR 3/2), or dark brown (10YR 3/3). The B horizon is brown (10YR 4/3 or 10YR 5/3) or dark yellowish brown (10YR 4/4). It is mildly alkaline or moderately alkaline. The C horizon has hue of 10YR; value of 4, 5, or 6; and chroma of 3 through 6. It is about 35 to 70 percent gravel.

Spillville series

The Spillville series consists of somewhat poorly drained and moderately well drained, moderately permeable soils. These soils formed in alluvium on foot slopes, fans, low benches, and flood plains. Native vegetation was prairie grasses. Slopes range from 0 to 5 percent.

Spillville soils are similar to Terril soils and are commonly adjacent to Biscay, Coland, Cylinder, Ridgeport, and Wadena soils on the landscape. Biscay, Cylinder, and Wadena soils are underlain by sand and gravel below the B horizon. Biscay and Coland soils are poorly drained. Ridgeport soils are somewhat excessively drained and have more sand than Spillville soils. Storden soils formed in glacial till in uplands and are upslope from Spillville soils.

Typical pedon of Spillville loam, 0 to 2 percent slopes, 2,290 feet west and 675 feet north of the southeast corner of sec. 28, T. 85 N., R. 33 W.

Ap—0 to 8 inches; black (10YR 2/1) loam, dark gray (10YR 4/1) dry; weak fine granular structure; friable; medium acid; clear smooth boundary.

A12—8 to 27 inches; black (10YR 2/1) loam, dark gray (10YR 4/1) dry; very weak fine subangular blocky structure parting to weak fine granular; friable; slightly acid; gradual smooth boundary.

A13—27 to 37 inches; black (10YR 2/1) and some very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) dry; weak fine subangular blocky structure parting to weak fine granular; friable; slightly acid; gradual smooth boundary.

A14—37 to 46 inches; very dark grayish brown (10YR 3/2) loam, grayish brown (10YR 5/2) dry; common fine faint brown (10YR 4/3) and dark gray (10YR 4/1) mottles; weak fine and medium subangular blocky structure; friable; neutral; clear smooth boundary.

C1—46 to 52 inches; mixed dark grayish brown (10YR 4/2) and dark gray (10YR 4/1) loam; many fine faint dark yellowish brown (10YR 4/4) mottles; weak very fine subangular blocky structure; friable; few fine dark accumulations (iron and manganese oxides); neutral; clear smooth boundary.

C2—52 to 60 inches; dark gray (10YR 4/1) and gray (10YR 5/1) loam; common fine distinct dark yellowish brown (10YR 4/4) and few fine distinct strong brown (7.5YR 5/6) mottles; friable; few fine dark accumulations (iron and manganese oxides); neutral.

The A horizon ranges from 36 to 52 inches in thickness. It is black (10YR 2/1) or very dark brown (10YR 2/2) in the upper part and very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2) in the lower part. The A horizon typically is loam or, less commonly, is silt loam. The C horizon has hue of 10YR, value of 4 or 5, and chroma of 1 through 6. It is loam or sandy loam and has a clay content ranging from 14 to 24 percent. The C horizon is neutral or slightly acid to a depth of 60 inches or more.

Storden series

The Storden series consists of well drained, moderately permeable soils. These soils formed in calcareous, loam glacial till in uplands. They are on convex side slopes, ridges, and knobs along glacial moraines. Native vegetation was prairie grasses. Slopes range from 5 to 40 percent.

Storden soils are commonly adjacent to Clarion, Lester, and Salida soils on the landscape. Clarion and Lester soils have a thicker A horizon than Storden soils, and they have a noncalcareous B horizon. Clarion and Lester soils are generally on less convex slopes than Storden soils. Salida soils have a mollic epipedon and are underlain by sand and gravel. In addition, Salida soils are on higher knobs and are commonly surrounded by Storden soils.

Typical pedon of Storden loam, 9 to 14 percent slopes, moderately eroded, 100 feet north and 2,090 feet west of the southeast corner of sec. 6, T. 84 N., R. 34 W.

Ap—0 to 8 inches; very dark grayish brown (10YR 3/2) and dark grayish brown (10YR 4/2) loam, grayish brown (10YR 5/2) dry; mixed with streaks and patches of brown (10YR 5/3) silt loam substratum material; weak medium granular structure; friable; few stones and common lime concretions; 10 to 13 percent calcium carbonate equivalent; strong effervescence; moderately alkaline; abrupt smooth boundary.

C1ca—8 to 22 inches; yellowish brown (10YR 5/4) loam; weak fine subangular blocky structure; friable; common lime accumulations and concretions; 15 to 20 percent calcium carbonate equivalent; strong effervescence; moderately alkaline; gradual smooth boundary.

C2ca—22 to 40 inches; yellowish brown (10YR 5/4) loam; few fine faint yellowish brown (10YR 5/6) mottles; massive; friable; common lime accumulations and concretions; about 18 percent calcium carbonate equivalent; strong effervescence; moderately alkaline; gradual smooth boundary.

C3—40 to 60 inches; light olive brown (2.5Y 5/4) loam; few fine distinct light brownish gray (10YR 6/2) and yellowish brown (10YR 5/6) mottles; many medium faint brown (10YR 5/3) mottles; massive; friable; strong effervescence; moderately alkaline.

Thickness of the solum and thickness of the A horizon range from 3 to 9 inches.

The A horizon typically is dark grayish brown (10YR 4/2) but ranges to very dark grayish brown (10YR 3/2) and brown (10YR 4/3 or 10YR 5/3). The C horizon is dark yellowish brown (10YR 4/4), yellowish brown (10YR 5/4), or light olive brown (2.5Y 5/4). The A and C horizons are loam with clay content ranging from 18 to 25 percent. They are moderately alkaline and are calcareous.

Talcot series

The Talcot series consists of poorly drained soils formed in loamy outwash or lacustrine sediment underlain by sand and gravel. Permeability is moderate in the upper part of the profile and rapid in the lower part. These soils are on plane or slightly concave positions on outwash plains or in depressions on stream benches. Native vegetation was prairie grasses. Slopes range from 0 to 2 percent.

Talcot soils are commonly adjacent to Biscay, Calco, Cylinder, and Wadena soils on the landscape. Biscay soils are not calcareous in the surface layer. Cylinder and Wadena soils are not calcareous and are not so poorly drained as Talcot soils. Calco soils are not underlain by sand and gravel at a depth of less than 40 inches. All of these soils are in positions on the landscape similar to those of Talcot soils.

Typical pedon of Talcot silty clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes, 2,060 feet east and 2,240 feet south of the northwest corner of sec. 15, T. 83 N., R. 34 W.

Ap—0 to 8 inches; black (N 2/0) silty clay loam, dark gray (10YR 4/1) dry; moderate fine granular structure; friable; common fine snail shell fragments; strong effervescence; moderately alkaline; clear smooth boundary.

A12—8 to 17 inches; black (N 2/0) clay loam, very dark gray (10YR 3/1) dry; moderate fine granular structure; friable; slight effervescence; moderately alkaline; clear smooth boundary.

A3—17 to 22 inches; very dark gray (10YR 3/1) clay loam, dark gray (10YR 4/1) dry; few fine distinct dark yellowish brown (10YR 4/4) mottles; moderate fine subangular blocky structure; friable; slight effervescence; moderately alkaline; clear smooth boundary.

B21—22 to 28 inches; mixed dark gray (5Y 4/1) and gray (5Y 5/1) clay loam; moderate fine subangular blocky structure; firm; slight effervescence; moderately alkaline; clear smooth boundary.

B22—28 to 35 inches; mixed gray (5Y 5/1) and light gray (5Y 6/1) clay loam; few medium prominent yellowish brown (10YR 5/6) mottles; discontinuous dark gray (5Y 4/1) coatings on peds; weak fine subangular blocky structure; firm; few soft lime accumulations; slight effervescence; moderately alkaline; gradual smooth boundary.

IIC1—35 to 56 inches; olive gray (5Y 5/2) sand and gravel; single grain; loose; lenses of loamy sand at a depth of 43 to 45 inches; strong effervescence; mildly alkaline; abrupt smooth boundary.

IIC2—56 to 60 inches; variegated olive gray (5Y 5/2), strong brown (7.5YR 5/6), and yellowish brown (10YR 5/6 and 5/8) sand and gravel; single grain; loose; common fine dark accumulations (iron and manganese oxides); strong effervescence; moderately alkaline.

The A horizon ranges from 15 to 23 inches in thickness. It is black (N 2/0 or 10YR 2/1) or very dark gray (10YR 3/1). The B horizon is dark gray (5Y 4/1), gray (5Y 5/1), light gray (5Y 6/1), or olive gray (5Y 4/2 or 5/2). The B2 horizon is clay loam or loam. A B3 horizon that is loam, sandy clay loam, or sandy loam is present in some pedons. The IIC horizon has hue of 5Y, 2.5Y, 10YR, or 7.5YR; value of 4 or 6; and chroma of 1 through 8. Content of gravel ranges from 40 to 60 percent. The IIC horizon is mildly alkaline or moderately alkaline and is calcareous.

Terril series

The Terril series consists of moderately well drained, moderately permeable soils that formed in local alluvium derived from glacial till. These soils are on foot slopes and alluvial fans. Native vegetation was prairie grasses. Slopes range from 2 to 9 percent.

Terril soils are similar to Spillville soils and are commonly adjacent to Clarion and Storden soils upslope and to Canisteo, Coland, and Webster soils downslope. Clarion, Canisteo, Storden, and Webster soils have thinner mollic epipedons than Terril soils, and Canisteo, Coland, and Webster soils have grayer subsoils. Spillville

soils have a thicker A horizon and do not have chroma of 3 at a depth of 30 to 36 inches.

Typical pedon of Terril loam, 5 to 9 percent slopes, 570 feet north and 500 feet west of the southeast corner of sec. 25, T. 83 N., R. 34 W.

A11—0 to 8 inches; black (10YR 2/1) loam, dark gray (10YR 4/1) dry; weak fine granular structure; friable; slightly acid; clear smooth boundary.
A12—8 to 16 inches; black (10YR 2/1) loam, dark gray (10YR 4/1) dry; weak fine subangular blocky structure parting to weak fine granular; friable; slightly acid; gradual smooth boundary.
A13—16 to 22 inches; very dark grayish brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) dry; thin discontinuous very dark gray (10YR 3/1) coatings on peds; weak fine subangular blocky structure; friable; slightly acid; clear smooth boundary.
A3—22 to 32 inches; very dark grayish brown (10YR 3/2) loam, grayish brown (10YR 5/2) dry; thin discontinuous very dark gray (10YR 3/1) coatings on peds; weak fine subangular blocky structure; friable; slightly acid; clear smooth boundary.
B21—32 to 38 inches; dark brown (10YR 3/3) loam, brown (10YR 5/3) dry; thin discontinuous very dark grayish brown (10YR 3/2) coatings on peds; weak fine subangular blocky structure; friable; few gravel; neutral; clear smooth boundary.
B22—38 to 47 inches; brown (10YR 4/3) loam; weak medium and fine subangular blocky structure; friable; neutral; gradual smooth boundary.
B23—47 to 57 inches; brown (10YR 4/3) loam; weak medium and fine subangular blocky structure; friable; few gravel; neutral; gradual smooth boundary.
B3—57 to 60 inches; brown (10YR 4/3) loam; weak fine subangular blocky structure; friable; neutral.

Solum thickness ranges from 44 to 63 inches.

The A1 horizon is black (10YR 2/1) or very dark brown (10YR 2/2) in the upper part and very dark brown (10YR 2/2) or very dark grayish brown (10YR 3/2) in the lower part. It ranges from 24 to 36 inches in thickness. Some areas that have recent overwash have surface horizons that are very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2). Matrix colors in the B horizon have value of 3 and chroma of 2 or 3 in the upper part; however, within a depth of 40 inches or less, chroma is 3 or 4 and value is commonly 4. The B horizon is commonly loam or light clay loam.

Wadena series

The Wadena series consists of well drained soils that have moderate permeability in the upper part of the profile and very rapid permeability in the lower part. These soils are on plane to slightly convex positions on outwash plains, valley trains, and stream benches. Wadena soils formed in medium textured glacial sediment and in the underlying sand and gravel. Native vegetation was prairie grasses. Slopes range from 0 to 9 percent.

Wadena soils are commonly adjacent to Cylinder and Estherville soils on the landscape. Cylinder soils are more poorly drained than Wadena soils, and Estherville soils have less clay and more gravel in the solum. These soils are in positions on the landscape similar to those of Wadena soils.

Typical pedon of Wadena loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes, 141 feet east and 820 feet north of the southwest corner of sec. 35, T. 85 N., R. 33 W.

Ap—0 to 9 inches; black (10YR 2/1) loam, dark gray (10YR 4/1) dry; weak medium and fine subangular blocky structure parting to weak fine granular; friable; slightly acid; clear smooth boundary.
A3—9 to 17 inches; very dark grayish brown (10YR 3/2) loam, grayish brown (10YR 5/2) dry; discontinuous very dark gray (10YR 3/1) coatings on peds; weak fine and medium subangular blocky structure; friable; slightly acid; clear smooth boundary.
B21—17 to 23 inches; brown (10YR 4/3) loam; weak medium and fine subangular blocky structure; friable; slightly acid; clear smooth boundary.
B22—23 to 29 inches; dark yellowish brown (10YR 4/4) loam; weak medium and fine subangular blocky structure; friable; about 10 percent gravel; slightly acid; clear smooth boundary.
IIB3—29 to 34 inches; brown (7.5YR 4/4) gravelly loamy sand; weak fine and medium subangular blocky structure; very friable; slightly acid; abrupt smooth boundary.
IIC1—34 to 46 inches; dark grayish brown (10YR 4/2) sand and gravel; single grain; loose; strong effervescence; moderately alkaline; abrupt smooth boundary.
IIC2—46 to 60 inches; mixed brown (10YR 5/3), pale brown (10YR 6/3), and yellowish brown (10YR 5/4) medium and coarse sand and gravel; single grain; loose; strong effervescence; moderately alkaline.

The thickness of the solum and depth to the IIC horizon range from 24 to 40 inches. The mollic epipedon ranges from 12 to 18 inches in thickness.

The B horizon has hue of 10YR in the upper part and hue of 10YR or 7.5YR in the lower part, value of 3 through 5, and chroma of 3 or 4. Some pedons do not have a B3 horizon extending into leached sand and gravel. The sand is typically medium or coarse in these horizons. The IIC horizon is gravelly coarse sand, stratified sand, or coarse sand and gravel of mixed mineralogy. It typically has free carbonates above a depth of 42 inches.

Webster series

The Webster series consists of poorly drained, moderately permeable soils. These soils formed in calcareous glacial till or local alluvium derived from till. They are in irregularly shaped swales, draws, and flats on uplands. Native vegetation was prairie grasses. Slopes range from 0 to 2 percent.

Webster soils are similar to Canisteo soils and are commonly adjacent to Canisteo and Okoboji soils. Canisteo and Harps soils are more calcareous and are in positions on the landscape similar to those of Webster soils. Clarion and Nicollet soils are better drained and are on more sloping uplands. Okoboji soils are in depressional areas and are in a lower lying position than Webster soils.

Typical pedon of Webster silty clay loam, 0 to 2 percent slopes, 920 feet south and 156 feet west of the northeast corner of sec. 8, T. 84 N., R 33 W.

Ap—0 to 8 inches; black (N 2/0) silty clay loam that has moderate sand content, very dark gray (10YR 3/1) dry; weak fine granular structure; friable; slightly acid; clear smooth boundary.

A12—8 to 12 inches; black (N 2/0) silty clay loam that has moderate sand content, very dark gray (10YR 3/1) dry; moderate fine subangular blocky structure parting to moderate fine granular; friable; neutral; clear smooth boundary.

A3—12 to 21 inches; very dark gray (10YR 3/1) clay loam, dark gray (10YR 4/1) dry; discontinuous black (10YR 2/1) coatings on peds; weak fine and very fine subangular blocky structure; friable; neutral; clear smooth boundary.

B1g—21 to 24 inches; dark gray (5Y 4/1) clay loam; few fine distinct yellowish brown (10YR 5/4) mottles; discontinuous black (10YR 2/1) coatings on peds; moderate fine and medium subangular blocky structure; friable; mildly alkaline; gradual smooth boundary.

B2g—24 to 31 inches; olive gray (5Y 4/2) light clay loam; few fine prominent yellowish brown (10YR 5/6) mottles; discontinuous dark gray (5Y 4/1) coatings on peds; weak medium and fine subangular blocky structure; friable; neutral; gradual smooth boundary.

B3g—31 to 45 inches; olive gray (5Y 5/2) loam; common medium prominent yellowish brown (10YR 5/8) and few fine faint dark grayish brown (2.5Y 4/2) mottles; weak medium subangular blocky structure; friable; common fine dark accumulations (iron and manganese oxides); mildly alkaline.

C1g—45 to 51 inches; olive gray (5Y 5/2) loam; few fine distinct light yellowish brown (10YR 5/8) mottles; massive; friable; few fine dark accumulations (iron and manganese oxides); slight effervescence; moderately alkaline; gradual smooth boundary.

C2g—51 to 60 inches; olive gray (5Y 5/2) loam; common medium prominent yellowish brown (10YR 5/8) and few fine faint pale olive (5Y 6/3) mottles; massive; friable; few fine dark accumulations (iron and manganese oxides); strong effervescence; moderately alkaline.

The A horizon ranges from 12 to 24 inches in thickness. It is silty clay loam or clay loam with clay content ranging from 30 to 35 percent. The A1 horizon is black (N 2/0 or 10YR 2/1), and the A3 horizon is very dark gray (10YR 3/1 or 5Y 3/1). The B horizon is loam or clay loam with clay content ranging from 25 to 30 percent. It is dark gray (5Y 4/1), gray (5Y 5/1), or olive gray (5Y 4/2 or 5Y 5/2). The C horizon typically is loam but ranges to clay loam with clay content of less than 30 percent. It is olive gray (5Y 5/2), light olive gray (5Y 6/2), gray (5Y 5/1), or light gray (5Y 6/1). The C horizon is mildly alkaline or moderately alkaline and is calcareous.

Zook series

The Zook series consists of poorly drained, slowly permeable soils that formed in clayey and silty alluvium. These soils are on low, nearly level flood plains and in drainageways. Native vegetation was prairie grasses. Slopes range from 0 to 2 percent.

Zook soils are commonly adjacent to Ackmore, Calco, Canisteo, Coland, and Colo soils on the landscape. All of these soils have less clay at depths of less than 40 inches than Zook soils. Ackmore soils are stratified and have a buried soil. Calco and Canisteo soils are calcareous, and Canisteo soils have a thinner mollic epipedon than Zook soils. Coland soils have a higher content of sand. Ackmore, Calco, and Coland soils are in positions on the landscape similar to those of Zook soils. Cansisteo soils are at a slightly higher elevation.

Typical pedon of Zook silty clay loam, 0 to 2 percent slopes, 595 feet east and 2,470 feet north of the southwest corner of sec. 15, T. 83 N., R. 36 W.

Ap—0 to 7 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; moderate fine granular structure; friable; slightly acid; clear smooth boundary.

A12—7 to 18 inches; black (N 2/0) silty clay loam, very dark gray (2.5Y 3/0) dry; moderate medium and fine granular structure; firm; slightly acid; gradual smooth boundary.

A3—18 to 31 inches; black (N 2/0) silty clay, dark gray (2.5Y 4/0) dry; moderate medium granular structure; firm; slightly acid; gradual smooth boundary.

B2g—31 to 44 inches; very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; moderate medium and fine subangular blocky structure; firm; slightly acid; gradual smooth boundary.

B3g—44 to 60 inches; dark gray (10YR 4/1) silty clay loam; few fine distinct dark yellowish brown (10YR 4/4) mottles; moderate medium subangular blocky structure; firm; slightly acid.

The thickness of the solum ranges from 44 to 60 inches or more.

The A horizon is silty clay loam or silty clay with clay content ranging from 32 to 45 percent. It is 26 to 38 inches thick. The Bg horizon is black (10YR 2/1) or very dark gray (10YR 3/1) at a depth of less than 40 inches and very dark gray (10YR 3/1) or dark gray (10YR 4/1) at a depth of more than 40 inches. It is about 38 to 45 percent content of clay. The Bg horizon is 10 to 40 inches thick and ranges from medium acid to neutral. The Cg horizon is silty clay loam or silty clay with clay content ranging from 36 to 42 percent. It is neutral or mildly alkaline.

formation of the soils

This section lists the factors of soil formation and relates them to the formation of the soils in Carroll County. It also explains the formation of soil horizons and the processes that influence their formation.

factors of soil formation

Soil is produced by the action of soil-forming processes on materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent material, (2) the climate under which the soil material has accumulated and existed since accumulation, (3) the plant and animal life on and in the soil, (4) the relief, or lay of the land, and (5) the length of time the forces of soil formation have acted on the soil material. These characteristics and man's influence on the soils are discussed in this section.

Climate and vegetation are active factors of soil genesis. They act on the parent material that has accumulated through the weathering of rocks and slowly change it into a natural body with genetically related horizons. The effects of climate and vegetation are conditioned by relief. The parent material also affects the kind of profile that can be formed and, in extreme cases, determines it almost entirely. Finally, time is needed for the changing of the parent material into a soil profile. It may be a long or short time, but some time is always required for horizon differentiation. Generally a long time is required for the development of distinct horizons.

The factors of soil genesis 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 other four. Many of the processes of soil development are unknown.

parent material

The soils of Carroll County formed in loess, glacial till, alluvium, and eolian sand. The relationship of some of the major soils to their parent material is shown in figures 2, 4, 5, 6, 7, 9, and 10.

Glacial till and loess are the most extensive soil parent material in the county. Three glaciers have deposited material in Carroll County—the Nebraskan, the Kansan, and the Wisconsin. The Wisconsin glacial till is the most recently deposited and most extensive soil parent material in Carroll County.

The northeastern part of Carroll County, north and east of the Middle Raccoon River, was covered by the Des Moines lobe of the Wisconsin Glaciation. The till, which is the parent material for most of the soils in this part of the county, is friable loam or clay loam and was deposited by the Cary substage of the Wisconsin Glaciation (*18, 19*). Radiocarbon dating taken from the base of the till in the southern part of the lobe indicates that this glaciation took place about 14,000 years ago. The poorly developed surface drainage system and numerous closed depressions give evidence of the geologic youth of the Cary substage. The major soils that formed in Cary till are the Clarion, Storden, and Nicollet series. The Webster, Canisteo, and Harps soils formed in glacial till and in glacial sediment or reworked glacial till over glacial till (*30, 31*). The Okoboji soils formed in reworked glacial till and local alluvium.

The Nebraskan till was the first till to be deposited. It is not identifiable on the landscape because it has been buried by the Kansan till. The Kansan till is exposed on some side slopes and ridges in the southwestern part of Carroll County. The unweathered Kansan till is firm, calcareous clay loam. It contains pebbles, boulders, and sand as well as silt and clay. This till is a heterogeneous mixture and shows little evidence of sorting or stratification. The mineral composition of its components is also heterogeneous (*11*) and is similar to that of particles in unweathered loess.

Some soils formed on the Kansan till plain during the Yarmouth and Sangamon interglacial period before the loess was deposited (*20*). Soils formed during this period are called Yarmouth-Sangamon paleosols.

Some soils formed in the Kansan till during Yarmouth and Sangamon time. These soils were later covered by loess. Geologic erosion has removed the loess from many slopes and exposed these paleosols. In some places, the paleosols have been beveled or truncated and only the lower part of the strongly weathered paleosols remains. This erosion took place prior to deposition of the loess, or before about 25,000 years ago. In other places, erosion has removed all of the paleosol and exposed till that is only slightly weathered at the surface. This erosion took place mostly in postglacial times.

The Adair and Armstrong soils formed in areas where the less strongly sloping, weathered, reddish paleosol

crops out. The Burchard and Gara soils formed in slightly weathered glacial till that has had the overlying paleosols removed by geologic erosion.

Loess is the most extensive parent material in the southwestern part of Carroll County. It is yellowish-brown, wind-deposited material that consists mostly of silt particles but contains smaller amounts of clay and sand. Loess was deposited during the Wisconsin glacial period, which took place about 24,500 to 14,000 years ago (*14*). It was probably blown mainly from the flood plain of the Missouri River along the western boundary of Iowa (*8*). The thickness of the loess and the differences among soils formed in loess are related to the distance from the source of the loess. The loess is thickest in the western part of Carroll County. It is about 12 to 18 feet thick on the most stable parts of the uplands. Loess occurs mostly in the areas on uplands. It is thinner on the side slopes and on the steeper slopes, all or part of it has been removed by erosion. In these places, glacial till is exposed on the surface. The loess in the southwestern and southern parts of Iowa gradually thins and becomes finer textured from west to east.

The Marshall and Exira soils are the most extensive soils in Carroll County that formed from loess. The Ida and Knox soils also formed in loess but are less extensive. This loess and the soils that formed in it in the western and southwestern parts of Iowa have been the subject of much study and investigation (*4, 5, 7, 16, 17, 21, 25, 26, 28*).

Alluvium consists of sediment deposited along major and minor streams, in drainageways, and on benches. The texture of the alluvium varies widely because of differences in the material from which it came and the manner in which it was deposited. In Carroll County, alluvium has been mainly derived from loess, glacial till, and outwash deposited by melt water from glaciers.

Alluvial material that has been transported for only a short distance is called local alluvium. Such alluvium retains many of the characteristics of the soils from which it has washed. Judson soils, for example, generally are at the base of slopes below soils that formed in loess. They are silty and have a texture similar to the soils upslope. The Terril soils also formed in local alluvium but are generally downslope from till-derived soils. They contain more sand than Judson soils because the alluvium in which they formed came from sandier soils.

When rivers and streams overflow their channels, the coarse-textured, sandy material that is carried is deposited first, adjacent to the stream. As the water spreads outward toward the uplands, it moves more slowly, and generally, the farther it spreads from the stream channel, the finer the particles that are deposited, and the finer textured the soils that occur there.

This pattern of deposition is demonstrated on the wider stream bottoms in the northeastern part of the county. Fluvaquents, nearly level, are nearest the streams. The Spillville, Calco, and Coland soils are next, and the Zook soils are generally farthest from the main channel. The Zook soils are the finest textured and most poorly drained of these soils, and they commonly are somewhat lower in elevation than the other soils.

The Wadena and Cylinder soils are in the northeastern part of Carroll County and are generally on benches along streams. They formed in loamy alluvium overlying sand and gravel. This material was deposited by melt water from the receding Cary glacial ice. Other soils that are less prevalent are the Biscay, Talcot, Estherville, and Salida soils. These soils are generally in valleys on benches, but they also occur in outwash areas in uplands.

The soils that formed in silty alluvium are in the southwestern part of the county. They include the Ackmore, Colo, and Zook soils on bottom lands and the Judson soils on foot slopes.

Eolian sand is a parent material that occurs in very small amounts in Carroll County. This sand was deposited by winds during the same period as the loess. Apparently there were sources, probably the nearby stream bottoms, from which the sand was picked up and redeposited. The Dickman soils are the only soils in the county that formed in this material. These soils are mainly in small areas and are surrounded by soils that formed in loess. In Carroll County, the Dickman soils are in the Marshall-Dickman complexes.

climate

According to recent evidence, the soils in Carroll County formed under variable climatic conditions. In the post-Cary glaciation period, which took place about 13,000 to 10,500 years ago, the climate was cool, and the vegetation was dominantly conifers. From 10,500 to 8,000 years ago, a warming trend occurred, and the vegetation changed to mixed forest that was dominantly hardwoods. Beginning about 8,000 years ago, the climate became still warmer and drier, and herbaceous prairie vegetation became dominant. A late change in postglacial climate from relatively dry prairie to moister conditions took place about 3,000 years ago (*12, 30*). The present climate is midcontinental subhumid.

Nearly uniform climate prevails throughout the county; however, some variation occurs in amount of rainfall. The influence of the general climate is modified by local conditions in or near the developing soil. For example, south-facing slopes have a microclimate that is warmer and less humid than the average climate of nearby areas. Because north- and east-facing slopes tend to be cooler and moister than south-facing slopes in Carroll County, natural stands of trees are more likely to grow well. Low-lying or depressional, poorly drained or very poorly drained soils are wetter and colder than most of the soils around them.

Climate has had an important overall influence on the characteristics of the soils in Carroll County, but it has

not caused major differences among them. Local climate differences have influenced the characteristics of the soils, however, and account for some of the differences in soils within the same climatic region.

Weathering of the parent material by water and air is activated by changes in temperature. As a result of weathering, both physical and chemical changes take place in the soil. Rainfall influences the formation of the soils through its effect on the amount of leaching in soils and on the kinds of plants that grow.

Some variations in plant and animal life are the result of variations in temperature, and some variations are caused by changes in soils brought about by climatic conditions. To the extent that such changes occur, climate indirectly influences the soils in bringing about variations in plant and animal life.

plant and animal life

Living organisms are important in soil development. The activities of burrowing animals, worms, crayfish, and micro-organisms, for example, are reflected in soil properties. Differences in the kind of vegetation, however, cause the most marked differences among soils (*29*).

The soils of Carroll County have been influenced by prairie grasses and trees. Tall prairie grasses were the dominant vegetation at the time of settlement. Trees were near most of the major streams and their larger tributaries.

Because grasses have decayed in or on the soil, soils that formed under prairie vegetation typically have a thicker, darker surface layer than soils that formed under trees. In soils that formed under trees, the organic matter, derived principally from leaves, was deposited mainly on the surface. These soils generally are more acid and have more downward movement of bases and clay minerals in the profile than soils that formed under prairie grasses.

The Marshall and Exira soils are typical of soils that formed in loess under prairie vegetation, and the Clarion, Nicollet, and Burchard soils are typical of soils that formed in glacial till. Very poorly drained soils, such as the Okoboji soils, formed under native vegetation of sedges, cattails, and other vegetation tolerant of wetness.

The Knox and Gara soils are among the soils in Carroll County that formed under mixed prairie and forest vegetation. Knox soils formed in loess, and Gara soils formed in glacial till. Where they have not been cultivated, these soils have a thin A1 horizon, an A2 horizon that is distinctly lighter colored than the A1 horizon when dry, and a B horizon that has stronger structure and more evidence of the accumulation of silicate clay than soils that formed under prairie grasses.

Knox and Gara soils have properties intermediate between soils that formed entirely under trees and soils that formed under grass. These soils appear to have formed under prairie grasses but changed their properties when trees later grew in the area. The morphology of these soils reflects the influence of both trees and grass.

relief

Relief, or topography, refers to the lay of the land. In Carroll County, soils range from nearly level to very steep. Relief is an important factor in soil formation because it affects drainage, runoff, the height of the water table, and erosion. A difference in topography is the main cause of the difference in properties in some of the soils in the county.

The thickness and color of the A horizon and the thickness of the solum are related to slope because slope affects erosion and the amount of water that runs off and percolates through the soil. For example, the differences in the thickness and color of the A horizon in the Storden, Clarion, and Nicollet soils, all of which formed in similar parent material, are related to their topography. The thickness of the A horizon increases and the color darkens on these soils as slope decreases. Most areas of the Storden soils are strongly sloping to steep, the Clarion soils are mainly gently sloping or moderately sloping, and the Nicollet soils are very gently sloping. The thickness of the solum increases and depth to carbonates increases from the thinner Storden soil to the thicker Clarion and Nicollet soils. On soils similar to Burchard soils, which have a wide range of slopes, the depth to carbonates and the thickness of the solum become shallower as the percentage of slope increases and the slope becomes more convex.

Relief affects the color of the B horizon through its effect on drainage and soil aeration. The subsoil of a soil that has good drainage generally is brown because iron compounds are well distributed throughout the horizon and are oxidized. On the other hand, the subsoil of soils that have restricted drainage or poor aeration caused by wetness and a high water table is generally grayish and mottled. The Webster and Okoboji soils are poorly drained and very poorly drained, nearly level and depressional soils which show evidence of wetness in the soil profile. The Marshall soils are well drained, sloping soils that have a brownish B horizon. Adair soils are somewhat poorly drained and are grayish brown in the subsoil. The profile characteristics of these soils indicate that they are intermediate in drainage.

The water that percolates through the soils removes clay from the A horizon, and much of this clay accumulates in the B horizon. Generally, even if the soils formed in similar parent material under similar vegetation, differences occur in the amount of water that percolates through the soil. Soils on nearly level areas or in depressions have more water percolating through the profile than soils on slopes where more runoff occurs.

time

The passage of time enables the factors of relief, climate, and plant and animal life to bring about changes

in parent material. Very similar kinds of soils are formed in widely different kinds of parent material if other factors continue to operate over long periods of time. Soil development, however, is generally interrupted by geologic events that expose new material. New parent material has been added to the upland at least three times in most of Carroll County and four times in the northeastern part (*22*). In all parts of the county, the bedrock was first covered by glacial drift from two different glaciers and later covered by loess. In the northeastern part of the county, a third glacier subsequently deposited the present surface material.

The Lamoni soil has a subsoil that is among the most weathered in the county. This soil formed in Kansan till that began to weather during the Yarmouth and Sangamon period. Later, it was covered by loess. More recently, the upper part of the ancient subsoil material has again been exposed to weathering because the loess has been removed by erosion.

The radiocarbon technique for determining the age of carbonaceous material found in loess and till has been useful in dating late Pleistocene events (*15*). Wisconsin loess deposition began about 25,000 years ago and continued to about 14,000 years ago (*6*). Based on these dates, the surface of the nearly level, loess-mantled divides in Iowa is about 14,000 years old. In Carroll County, these stable areas include the nearly level soils and most of the gently sloping soils in divides, mainly the Marshall and Exira soils. Radiocarbon dates from the base of the Cary glacial drift in the southern part of the Des Moines lobe have indicated that the material from this drift was deposited about 14,000 years ago. Thus, all soils formed in this material are not more than 14,000 years old. In many areas in Iowa, including Carroll County, geologic erosion has beveled and, in places, removed material on side slopes and deposited new sediment downslope. The surface layer of nearly level soils on upland divides is older than that on the slopes that bevel and ascend to the divides. Thus, the soils on side slopes are less than 14,000 years old. In Carroll County, the most common soils on side slopes are the Burchard soils in the southwestern part of the county and the Clarion and Storden soils in the northeastern part.

The sediment stripped from side slopes has accumulated to form local alluvium. The age of soils on side slopes is determined by dating the alluvial fill at the base of slopes. In some stream valleys in western Iowa this material is less than 1,800 years old. Some of the soils that formed in alluvium in Carroll County are the Colo, Coland, Calco, Spillville, and Zook series. The Ackmore soils also formed in alluvium, some of which has been deposited since settlement by man.

man's influence on the soils

Important soil changes have taken place in the soils since Carroll County was settled. Breaking of the prairie sod and clearing of the timber have removed and changed the protective vegetative cover.

The most apparent changes are caused by erosion. As the soil was cultivated, surface runoff increased and the rate at which water moved into the soil decreased. This resulted in accelerated erosion that removed part or all of the surface layer from many of the cultivated, sloping soils. In some places, shallow to deep gullies formed.

Erosion has changed not only the thickness of the surface layer, but the structure and consistence of the soil as well. In severely eroded areas, the plow layer often consists partly of the upper part of the subsoil, which is less friable and finer textured than the original surface layer.

Erosion and cultivation also affect the soil by reducing the organic matter content and lowering the fertility of the soil. Even in areas not subject to erosion, compaction by heavy machinery reduces the thickness of the surface layer and changes its structure. The granular structure, so apparent in virgin grassland, breaks down under intensive cultivation.

On the other hand, man has done much to increase productivity, decrease soil loss, and reclaim areas not suitable for crops or pasture. For example, terraces, erosion control structures, and other erosion control practices have slowed and in some places controlled runoff and erosion. The establishment of diversion terraces at the base of slopes, the construction of drainage ditches, and the use of other conservation practices have aided in the prevention of flooding and deposition and have made large areas of bottom land suitable for cultivation.

Through the use of commercial fertilizers and lime, deficiencies in plant nutrients are corrected and as a result many soils are more productive than before they were cultivated.

Erosion is one of the main causes of the reduction of organic matter in soils. However, figures indicate (*24*) that as much as one-third of the organic matter can be lost by causes other than erosion. Management practices have shown that it is not economically feasible to maintain as high a reserve of organic matter as was originally present under native grasses. It is necessary, however, to maintain a safe and economical level for crop production. In the soils lowest in organic matter, control of erosion is the most economical means of increasing and maintaining productivity.

processes of soil horizon differentiation

Horizon differentiation is caused by additions, removals, transfers, and transformations in the soil system (*23*). Each of these changes affects many substances that make up the soils. For example, additions, removals, transfers, or transformations affect the content of organic matter and the soluble salts, carbonates, sesquioxides, or silicate clay minerals in the soils.

In general, these processes tend to promote horizon differentiation, but some changes tend to offset or retard it. These processes, and the changes brought about by them, proceed simultaneously in the soils, and the ultimate nature of the profile is governed by the balance of changes within the profile.

Additions of organic matter are an early step in the process of horizon differentiation in most soils. Soils in Carroll County range from high to very low in the content of organic matter that has accumulated in the A1 horizon. The Knox and Gara soils, for example, have a thin A1 horizon and are low in organic matter content. The Webster and Colo soils have a thick A1 horizon and are high in organic matter content. Some soils that were formerly high in content of organic matter are now low because of erosion.

The removal of substances from parts of the profile is important in the differentiation of soil horizons in Carroll County. Most of the soils have been leached free of calcium carbonates in the upper part of the profile, and some soils have been so strongly leached that they are strongly acid in the surface layer and subsoil. The Calco, Canisteo, Harps, Storden, and Talcot soils are exceptions. These soils are calcareous throughout.

Transfers of substances from one horizon to another are evident in the soils of Carroll County. Phosphorus is removed from the subsoil by plant roots, transferred to parts of the plant growing above the ground, and, subsequently, is added to the surface layer as plant residue.

The translocation of clay is another important transfer process in horizon differentiation. Clay, composed mostly of silicate clay minerals in this area, is carried downward in suspension in percolating water from the A horizon. It accumulates in the B horizon in pores and root channels and as clay films on ped faces.

Transfer of another kind occurs to some extent in clayey soils. It is brought about by shrinking and swelling, which causes the formation of cracks and the incorporation of some materials from the surface layer into the lower part of the profile. The Lamoni and Adair soils have potential for this kind of physical transfer.

Transformations are both physical and chemical. For example, soil particles are weathered to smaller sizes. The reduction of iron is also an example of transformation. This process is called gleying and involves the saturation of soil with water for long periods in areas where there is organic matter. It is characterized by the occurrence of ferrous iron and soils of grayish hue. Reductive, extractable iron, or free iron, is generally at a greater depth in poorly drained soils, such as the Canisteo and Webster soils. Still another kind of transformation is the weathering of the primary apatite mineral present in the parent material to secondary phosphorus compounds.

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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.

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—

	Inches
Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	9 to 12
Very high	More than 12

Bedrock. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Bench terrace. A raised, level or nearly level strip of earth constructed on or nearly on a contour, supported by a barrier of rocks or similar material, and designed to make the soil suitable for tillage and to prevent accelerated erosion.

Bottom land. The normal flood plain of a stream, subject to flooding.

Boulders. Rock fragments larger than 2 feet (60 centimeters) in diameter.

Calcareous soil. A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

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.

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) 15.2 to 38.1 centimeters (6 to 15 inches) long.

Coarse textured soil. Sand or loamy sand.

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.

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 all or part of the 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.

Corrosive. High risk of corrosion to uncoated steel or deterioration of concrete.

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.

Depth to rock (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.

Drumlin. A low, smooth, elongated oval hill, mound, or ridge of compact glacial till. The longer axis is parallel to the path of the glacier and commonly has a blunt nose pointing in the direction from which the ice approached.

Eolian soil material. Earthy parent material accumulated through wind action; commonly refers to sandy material in dunes or to loess in blankets on the surface.

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 the activities of man or other animals or of a catastrophe in nature, for example, fire, that exposes the surface.

Excess lime (in tables). Excess carbonates in the soil that restrict the growth of some plants.

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.

Fine textured soil. Sandy clay, silty clay, and 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 drift (geology). Pulverized and other rock material transported by glacial ice and then deposited. Also the sorted and unsorted material deposited by streams flowing from glaciers.

Glacial outwash (geology). Gravel, sand, and silt, commonly stratified, deposited by glacial melt water.

Glacial till (geology). Unsorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Glaciofluvial deposits (geology). Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and occur as kames, eskers, deltas, and outwash plains.

Gleyed soil. Soil that formed under poor drainage, resulting in the reduction of iron and other elements in the profile and in gray colors and mottles.

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 7.5 centimeters) in diameter. An individual piece is a pebble.

Ground water (geology). Water filling all the unblocked pores of underlying 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.

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 upper case letter represents the major horizons. Numbers or lower case letters that follow represent subdivisions of the major horizons. An explanation of the subdivisions is given in the *Soil Survey Manual*. The major horizons of mineral soil are as follows:
O horizon.—An organic layer of fresh and decaying plant residue at the surface of a mineral soil.
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, a plowed surface horizon, most of which was originally part of a B horizon.
B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of transition from the overlying A 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) prismatic or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these. The combined A and B horizons are generally called the solum, or true soil. If a soil does not have a B horizon, the A horizon alone is the solum.
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 A or B 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, the Roman numeral II precedes the letter C.
R layer.—Consolidated rock beneath the soil. The rock 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.

Lacustrine deposit (geology). Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

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 grained material, dominantly of silt-sized particles, deposited by wind.

Mineral soil. Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

Moraine (geology). An accumulation of earth, stones, and other debris deposited by a glacier. Some types are terminal, lateral, medial, and ground.

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).

Muck. Dark colored, finely divided, well decomposed organic soil material. (See Sapric soil material.)

Munsell notation. A designation of color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color of 10YR hue, value of 6, and chroma of 4.

Neutral soil. A soil having a pH value between 6.6 and 7.3. (See Reaction, soil.)

Outwash, glacial. Stratified sand and gravel produced by glaciers and carried, sorted, and deposited by glacial melt water.

Outwash plain. A landform of mainly sandy or coarse textured material of glaciofluvial origin. An outwash plain is commonly smooth; where pitted, it is generally low in relief.

Parent material. The unconsolidated organic and mineral material in which soil forms.

Peat. Unconsolidated material, largely undecomposed organic matter, that has accumulated under excess moisture. (See Fibric soil material.)

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.

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 0.20 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.

Plasticity index. The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plastic limit. The moisture content at which a soil changes from semisolid to plastic.

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.

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 degree of acidity or alkalinity is expressed as—

	pH
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.

Rock fragments. Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

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.

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 underlying material. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

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.

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.

Small stones (in tables). Rock fragments less than 3 inches (7.5 centimeters) in diameter. Small stones adversely affect the specified use of 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.

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 and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and plant and animal activities are largely confined to the solum.

Stone line. A concentration of coarse fragments in a soil. Generally it is indicative of an old weathered surface. In a cross section, the line may be one fragment or more thick. It generally overlies material that weathered in place and is overlain by recent sediment of variable thickness.

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 grained* (each grain by itself, as in dune sand) or *massive* (the particles adhering without any regular cleavage, as in many hardpans).

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 (A1, A2, or A3) below the surface.

Surface layer. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated at the "plow layer," or the "Ap horizon."

Surface soil. The A horizon. Includes all subdivisions of this horizon. (A1, A2, and A3 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. A terrace in a field is generally built so that the field can be farmed. A terrace intended mainly for drainage has a deep channel that is maintained in permanent sod.

Terrace (geologic). An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea.

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."

Till plain. An extensive flat to undulating area underlain by glacial till.

Tilth, soil. The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

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.

tables

TABLE 1.--TEMPERATURE AND PRECIPITATION

[Recorded in the period 1951-77 at Carroll, Iowa]

Month	Temperature						Precipitation				
				2 years in 10 will have--				2 years in 10 will have--			
	Average daily maximum	Average daily minimum	Average daily	Maximum temperature higher than--	Minimum temperature lower than--	Average number of growing degree days[1]	Average	Less than--	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	26.9	6.9	16.9	53	-24	0	.77	.28	1.15	2	6.9
February	33.8	13.3	23.6	61	-20	0	1.02	.33	1.56	3	6.7
March	43.5	22.6	33.1	77	-8	36	2.19	.95	3.18	6	7.0
April	62.0	35.8	48.9	87	14	97	3.12	1.65	4.31	7	1.0
May	73.4	47.2	60.3	93	25	329	4.28	2.34	5.86	8	.0
June	82.6	56.9	69.8	98	38	594	4.85	2.25	6.96	7	.0
July	87.0	61.0	74.0	100	43	744	3.45	1.31	5.17	6	.0
August	84.6	58.5	71.6	98	40	670	3.70	1.59	5.41	7	.0
September	75.9	49.1	62.3	93	26	369	3.06	1.12	4.61	6	.0
October	65.2	38.6	51.8	88	15	150	2.08	.61	3.25	4	.2
November	46.9	25.2	36.1	73	-3	8	1.36	.24	2.22	3	2.5
December	33.1	14.0	23.6	58	-19	0	.82	.35	1.20	3	5.9
Yearly:											
Average	59.6	35.8	47.7	---	---	---	---	---	---	---	---
Extreme	---	---	---	101	-26	---	---	---	---	---	---
Total	---	---	---	---	---	2,997	30.70	24.12	36.88	62	30.2

[1]A growing degree day is a unit of heat available for plant growth. It can be calculated by adding the maximum and minimum daily temperatures, dividing the sum by 2, and subtracting the temperature below which growth is minimal for the principal crops in the area (50° F).

TABLE 2.--FREEZE DATES IN SPRING AND FALL

[Recorded in the period 1951-77 at Carroll, Iowa]

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--	May 2	May 12	May 22
2 years in 10 later than--	April 27	May 7	May 16
5 years in 10 later than--	April 18	April 27	May 5
First freezing temperature in fall:			
1 year in 10 earlier than--	October 2	September 17	September 13
2 years in 10 earlier than--	October 6	September 23	September 19
5 years in 10 earlier than--	October 15	October 5	September 28

TABLE 3.--GROWING SEASON

[Recorded in the period 1951-77 at Carroll, Iowa]

Probability	Length of growing season if daily minimum temperature is--		
	Higher than 24° F	Higher than 28° F	Higher than 32° F
	Days	Days	Days
9 years in 10	158	139	125
8 years in 10	165	146	132
5 years in 10	179	160	145
2 years in 10	193	173	159
1 year in 10	201	180	166

TABLE 4.--ACREAGE AND PROPORTIONATE EXTENT OF THE SOILS

Map symbol	Soil name	Acres	Percent
1C3	Ida silt loam, 5 to 9 percent slopes, severely eroded	1,470	0.4
1D3	Ida silt loam, 9 to 14 percent slopes, severely eroded	1,220	0.3
5B	Ackmore-Judson complex, 1 to 5 percent slopes	1,095	0.3
6	Okoboji silty clay loam, 0 to 1 percent slopes	1,915	0.5
8B	Judson silty clay loam, 2 to 5 percent slopes	835	0.2
8C	Judson silty clay loam, 5 to 9 percent slopes	725	0.2
9	Marshall silty clay loam, 0 to 2 percent slopes	1,255	0.3
9B	Marshall silty clay loam, 2 to 5 percent slopes	10,775	2.9
9B2	Marshall silty clay loam, 2 to 5 percent slopes, moderately eroded	20,555	5.6
9C	Marshall silty clay loam, 5 to 9 percent slopes	1,755	0.5
9C2	Marshall silty clay loam, 5 to 9 percent slopes, moderately eroded	32,825	8.9
9D2	Marshall silty clay loam, 9 to 14 percent slopes, moderately eroded	24,325	6.6
9E2	Marshall silty clay loam, 14 to 20 percent slopes, moderately eroded	1,050	0.3
11B	Colo-Judson silty clay loams, 2 to 5 percent slopes	35,975	9.8
27B	Terril loam, 2 to 5 percent slopes	1,245	0.3
27C	Terril loam, 5 to 9 percent slopes	505	0.1
28B	Dickman sandy loam, 2 to 5 percent slopes	715	0.2
28B2	Dickman sandy loam, 2 to 5 percent slopes, moderately eroded	255	0.1
28C2	Dickman sandy loam, 5 to 9 percent slopes, moderately eroded	990	0.3
28D2	Dickman sandy loam, 9 to 14 percent slopes, moderately eroded	735	0.2
34B	Estherville sandy loam, 2 to 5 percent slopes	610	0.2
34C2	Estherville sandy loam, 5 to 9 percent slopes, moderately eroded	345	0.1
48	Knoke mucky silt loam, 0 to 1 percent slopes	770	0.2
54	Zook silty clay loam, 0 to 2 percent slopes	2,985	0.8
55	Nicollet loam, 1 to 3 percent slopes	31,970	8.7
59C2	Burchard clay loam, 5 to 9 percent slopes, moderately eroded	270	0.1
59D2	Burchard clay loam, 9 to 14 percent slopes, moderately eroded	3,325	0.9
59E2	Burchard clay loam, 14 to 18 percent slopes, moderately eroded	1,360	0.4
59F2	Burchard clay loam, 18 to 25 percent slopes, moderately eroded	1,185	0.3
62C2	Storden loam, 5 to 9 percent slopes, moderately eroded	1,165	0.3
62D2	Storden loam, 9 to 14 percent slopes, moderately eroded	1,520	0.4
62E2	Storden loam, 14 to 18 percent slopes, moderately eroded	890	0.2
62F	Storden loam, 18 to 25 percent slopes	860	0.2
62G	Storden loam, 25 to 40 percent slopes	1,195	0.3
71D2	Marshall-Dickman complex, 9 to 14 percent slopes, moderately eroded	550	0.2
90	Okoboji mucky silt loam, 0 to 1 percent slopes	520	0.1
95	Harps loam, 0 to 2 percent slopes	1,525	0.4
99C2	Exira silty clay loam, 5 to 9 percent slopes, moderately eroded	14,230	3.9
99D2	Exira silty clay loam, 9 to 14 percent slopes, moderately eroded	15,260	4.2
99E2	Exira silty clay loam, 14 to 20 percent slopes, moderately eroded	1,175	0.3
107	Webster silty clay loam, 0 to 2 percent slopes	17,070	4.6
108	Wadena loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes	1,475	0.4
108B	Wadena loam, 24 to 32 inches to sand and gravel, 2 to 5 percent slopes	1,350	0.4
108C2	Wadena loam, 24 to 32 inches to sand and gravel, 5 to 9 percent slopes, moderately eroded	545	0.2
133	Colo silty clay loam, 0 to 2 percent slopes	4,390	1.2
133+	Colo silty clay loam, overwash, 0 to 2 percent slopes	7,755	2.1
135	Coland clay loam, 0 to 2 percent slopes	5,930	1.6
138B	Clarion loam, 2 to 5 percent slopes	23,535	6.4
138B2	Clarion loam, 2 to 5 percent slopes, moderately eroded	6,275	1.7
138C	Clarion loam, 5 to 9 percent slopes	1,325	0.4
138C2	Clarion loam, 5 to 9 percent slopes, moderately eroded	18,310	5.0
138D2	Clarion loam, 9 to 14 percent slopes, moderately eroded	3,870	1.1
179E2	Gara loam, 14 to 18 percent slopes, moderately eroded	295	0.1
179F	Gara loam, 18 to 25 percent slopes	380	0.1
179F2	Gara loam, 18 to 25 percent slopes, moderately eroded	750	0.2
179G	Gara loam, 25 to 40 percent slopes	335	0.1
192D2	Adair clay loam, 9 to 14 percent slopes, moderately eroded	405	0.1
201B	Coland-Spillville complex, 2 to 5 percent slopes	3,515	1.0
203	Cylinder loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	2,495	0.7
236C	Lester loam, 4 to 10 percent slopes	455	0.1
259	Biscay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	665	0.2
268C	Knox silt loam, 4 to 9 percent slopes	870	0.2
268D2	Knox silt loam, 9 to 14 percent slopes, moderately eroded	720	0.2
268E2	Knox silt loam, 14 to 18 percent slopes, moderately eroded	355	0.1
308	Wadena loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	1,380	0.4
308B	Wadena loam, 32 to 40 inches to sand and gravel, 2 to 5 percent slopes	925	0.3
430	Ackmore silt loam, 0 to 2 percent slopes	6,265	1.7
485	Spillville loam, 0 to 2 percent slopes	2,215	0.6
485B	Spillville loam, 2 to 5 percent slopes	570	0.2

TABLE 4.--ACREAGE AND PROPORTIONATE EXTENT OF THE SOILS--Continued

Map symbol	Soil name	Acres	Percent
507	Canisteo silty clay loam, 0 to 2 percent slopes	12,605	3.4
509B	Marshall silty clay loam, benches, 2 to 7 percent slopes	640	0.2
559	Talcot silty clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	445	0.1
638C2	Clarion-Storden loams, 5 to 9 percent slopes, moderately eroded	785	0.2
638D2	Clarion-Storden loams, 9 to 14 percent slopes, moderately eroded	990	0.3
639C	Salida-Storden complex, 5 to 9 percent slopes	270	0.1
639D	Salida-Storden complex, 9 to 16 percent slopes	675	0.2
733	Calco silty clay loam, 0 to 2 percent slopes	5,160	1.4
822D3	Lamoni silty clay loam, 9 to 14 percent slopes, severely eroded	440	0.1
823	Ridgeport sandy loam, 1 to 3 percent slopes	275	0.1
924D2	Burchard-Adair clay loams, 9 to 14 percent slopes, moderately eroded	1,600	0.4
924E2	Burchard-Adair clay loams, 14 to 18 percent slopes, moderately eroded	1,520	0.4
993D2	Gara-Armstrong loams, 9 to 14 percent slopes, moderately eroded	215	0.1
993E2	Gara-Armstrong loams, 14 to 18 percent slopes, moderately eroded	765	0.2
2315	Fluvaquents, nearly level	3,030	0.8
5010	Pits, gravel	430	0.1
5040	Orthents, loamy	980	0.3
	Water	116	*
	Total	367,296	100.0

* Less than 0.1 percent.

TABLE 5.--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	Corn	Soybeans	Oats	Grass-legume hay	Kentucky bluegrass	Smooth bromegrass	Bromegrass-alfalfa
	Bu	Bu	Bu	Ton	AUM*	AUM*	AUM*
1C3---------- Ida	77	29	54	2.9	2.7	4.7	4.8
1D3---------- Ida	68	26	48	2.6	2.3	4.0	4.3
5B---------- Ackmore-Judson	110	42	67	4.6	3.9	6.4	7.7
6---------- Okoboji	84	32	67	3.4	3.3	4.3	7.3
8B---------- Judson	124	47	93	5.2	4.2	7.3	8.6
8C---------- Judson	119	45	90	5.0	4.1	7.1	8.3
9---------- Marshall	109	41	62	4.6	3.8	6.5	7.6
9B---------- Marshall	107	41	61	4.5	3.8	6.3	7.5
9B2---------- Marshall	105	40	59	4.4	3.6	6.3	7.3
9C---------- Marshall	102	39	58	4.3	3.5	6.1	7.1
9C2---------- Marshall	99	38	56	4.2	3.3	5.9	7.0
9D2---------- Marshall	90	34	51	3.8	3.0	5.3	6.3
9E2---------- Marshall	75	28	42	3.2	2.8	4.5	5.3
11B---------- Colo-Judson	108	42	81	4.3	4.2	5.9	7.2
27B---------- Terril	118	45	94	5.0	4.2	7.0	8.3
27C---------- Terril	113	43	91	4.8	4.2	6.7	8.0
28B, 28B2---------- Dickman	50	20	45	2.5	1.2	3.5	3.7
28C2, 28D2---------- Dickman	45	18	40	2.2	1.2	3.5	3.7
34B---------- Estherville	45	15	35	2.0	2.0	4.3	3.0
34C2---------- Estherville	30	10	30	1.5	1.5	4.1	2.5
48---------- Knoke	82	31	65	3.3	3.3	4.3	5.5

See footnotes at end of table.

TABLE 5.--YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Corn	Soybeans	Oats	Grass-legume hay	Kentucky bluegrass	Smooth bromegrass	Bromegrass-alfalfa
	Bu	Bu	Bu	Ton	AUM*	AUM*	AUM*
54---------- Zook	96	36	72	4.0	4.0	4.0	6.5
55---------- Nicollet	120	40	80	4.5	3.5	5.5	6.5
59C2---------- Burchard	90	34	50	3.8	3.5	5.3	6.3
59D2---------- Burchard	81	31	44	3.4	3.3	4.9	5.6
59E2, 59F2---------- Burchard	---	---	---	2.7	2.1	4.0	4.5
62C2, 62D2---------- Storden	75	22	50	3.5	3.0	5.0	5.0
62E2---------- Storden	50	---	35	2.8	2.2	4.2	4.2
62F---------- Storden	---	---	---	2.5	2.0	4.0	3.7
62G---------- Storden	---	---	---	2.0	1.5	3.5	3.0
71D2---------- Marshall-Dickman	75	28	47	3.3	2.4	4.4	5.4
90---------- Okoboji	84	32	67	3.4	3.3	4.3	7.3
95---------- Harps	95	36	76	4.0	3.3	5.0	6.6
99C2---------- Exira	99	39	56	3.8	3.3	6.3	7.6
99D2---------- Exira	90	34	51	3.4	3.0	5.5	6.3
99E2---------- Exira	75	28	42	2.8	2.8	4.8	5.6
107---------- Webster	110	42	88	4.4	4.2	6.6	7.3
108---------- Wadena	72	27	60	2.7	2.7	4.7	4.8
108B---------- Wadena	70	27	60	2.8	2.7	4.7	4.7
108C2---------- Wadena	62	24	53	2.5	2.3	4.3	4.2
133, 133+---------- Colo	104	40	78	4.2	4.2	6.5	---
135---------- Coland	110	42	83	4.6	3.0	6.0	7.6
138B---------- Clarion	110	42	88	4.6	4.2	6.7	7.6
138B2---------- Clarion	107	41	86	4.5	3.8	6.3	7.5

See footnotes at end of table.

TABLE 5.--YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Corn	Soybeans	Oats	Grass-legume hay	Kentucky bluegrass	Smooth bromegrass	Bromegrass-alfalfa
	Bu	Bu	Bu	Ton	AUM*	AUM*	AUM*
138C---------- Clarion	105	40	84	4.4	3.8	6.3	7.3
138C2---------- Clarion	102	39	82	4.3	3.8	6.2	7.1
138D2---------- Clarion	93	35	74	3.9	3.7	5.5	6.5
179E2---------- Gara	---	---	---	2.2	1.5	3.1	3.8
179F---------- Gara	---	---	---	1.5	1.3	2.9	2.5
179F2---------- Gara	---	---	---	1.2	1.3	2.9	2.0
179G---------- Gara	---	---	---	1.0	1.0	2.5	1.6
192D2---------- Adair	54	20	30	2.3	1.9	2.9	3.8
201B---------- Coland-Spillville	113	43	87	4.8	4.1	6.4	7.9
203---------- Cylinder	88	33	70	3.7	3.3	5.3	6.1
236C---------- Lester	95	33	75	4.5	3.5	5.5	6.5
259---------- Biscay	85	32	60	3.5	3.5	5.2	5.2
268C---------- Knox	89	33	62	4.0	4.0	8.0	8.3
268D2---------- Knox	70	25	57	3.2	3.2	6.4	7.4
268E2---------- Knox	---	---	---	2.8	2.8	5.6	6.6
308---------- Wadena	92	35	74	3.7	3.7	5.7	6.2
308B---------- Wadena	90	34	72	3.6	3.7	5.7	6.0
430---------- Ackmore	106	40	58	4.5	2.8	6.3	7.5
485---------- Spillville	122	46	98	5.1	4.2	7.3	8.6
485B---------- Spillville	120	45	96	5.0	4.1	7.2	8.5
507---------- Canisteo	110	36	75	3.5	3.0	6.1	5.2
509B---------- Marshall	107	41	61	4.5	3.8	6.3	7.5
559---------- Talcot	95	36	76	4.0	3.3	5.0	6.2

See footnotes at end of table.

TABLE 5.--YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Corn	Soybeans	Oats	Grass-legume hay	Kentucky bluegrass	Smooth bromegrass	Bromegrass-alfalfa
	Bu	Bu	Bu	Ton	AUM*	AUM*	AUM*
638C2---- Clarion-Storden	95	35	74	4.1	3.6	4.7	6.6
638D2---- Clarion-Storden	87	30	66	3.8	3.4	4.5	6.0
639C---- Salida-Storden	52	17	45	2.9	2.2	3.3	4.3
639D---- Salida-Storden	40	15	40	2.4	1.7	2.8	3.6
733---- Calco	99	38	84	4.2	4.2	5.3	7.0
822D3---- Lamoni	---	---	---	1.5	1.9	2.9	2.5
823---- Ridgeport	53	20	42	2.2	1.7	3.2	3.6
924D2---- Burchard-Adair	69	26	38	3.0	3.0	4.0	5.0
924E2---- Burchard-Adair	54	16	31	2.5	2.6	3.7	4.6
993D2---- Gara-Armstrong	69	26	37	2.8	2.3	4.0	4.7
993E2---- Gara-Armstrong	54	16	30	2.1	1.5	3.2	3.7
2315**. Fluvaquents							
5010**. Pits							
5040**. Orthents							

* 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.

** See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 6.--CAPABILITY CLASSES AND SUBCLASSES

[Miscellaneous areas are excluded. Absence of an entry indicates no acreage]

Class	Total acreage	Major management concerns (Subclass)		
		Erosion (e)	Wetness (w)	Soil problem (s)
		Acres	Acres	Acres
I	33,225	---	---	---
II	155,307	78,473	71,484	5,350
III	127,431	123,861	2,685	885
IV	12,282	11,784	---	498
V	24,340	---	24,340	---
VI	7,345	6,961	---	384
VII	2,280	2,280	---	---
VIII	---	---	---	---

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				Potential productivity		Trees to plant
		Erosion hazard	Equipment limitation	Seedling mortality	Plant competition	Common trees	Site index	
5B*:								
Ackmore	2w	Slight	Severe	Moderate	Moderate	White oak	65	Eastern white pine, red pine, black walnut, sugar maple, poplar.
Judson.								
28B, 28B2, 28C2, 28D2--- Dickman	3s	Moderate	Slight	Moderate	Slight	Jack pine Red pine Bur oak	50 50 40	Red pine, eastern white pine.
71D2*:								
Marshall.								
Dickman	3s	Moderate	Slight	Moderate	Slight	Jack pine Red pine Bur oak	50 50 40	Red pine, eastern white pine.
179E2, 179F, 179F2, 179G--- Gara	3r	Moderate	Moderate	Slight	Slight	White oak Northern red oak	55 55	Eastern white pine, red pine.
236C--- Lester	2o	Slight	Slight	Slight	Slight	Northern red oak American basswood Black walnut Eastern cottonwood Eastern white pine White oak	69 69 62 92 64 62	Black walnut, northern red oak, American basswood, silver maple, white oak.
268C, 268D2--- Knox	2o	Slight	Slight	Slight	Slight	White oak	65	Green ash, black walnut, yellow-poplar.
268E2--- Knox	2r	Moderate	Moderate	Moderate	Slight	White oak	65	Green ash, black walnut, yellow-poplar.
430--- Ackmore	2w	Slight	Severe	Moderate	Moderate	White oak	65	Eastern white pine, red pine, black walnut, sugar maple.
993D2*:								
Gara	3o	Slight	Slight	Slight	Slight	White oak Northern red oak	55 55	Eastern white pine, red pine.
Armstrong	4c	Slight	Slight	Severe	Slight	White oak Northern red oak	55 55	Eastern white pine, red pine, sugar maple.

See footnote at end of table.

TABLE 7.--WOODLAND MANAGEMENT AND PRODUCTIVITY--Continued

Soil name and map symbol	Ordination symbol	Management concerns				Potential productivity		Trees to plant
		Erosion hazard	Equipment limitation	Seedling mortality	Plant competition	Common trees	Site index	
993E2*:								
Gara	3r	Moderate	Moderate	Slight	Slight	White oak Northern red oak	55 55	Eastern white pine, red pine.
Armstrong	4c	Slight	Slight	Severe	Slight	White oak Northern red oak	55 55	Eastern white pine, red pine, sugar maple, white oak.

* 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 heights, in feet, of--				
	<8	8-15	16-25	26-35	>35
1C3, 1D3---------- Ida	---	Tatarian honeysuckle, Siberian peashrub, Russian-olive.	Eastern redcedar, green ash, common hackberry.	Honeylocust-------	---
5B*: Ackmore----------	Silky dogwood, gray dogwood.	Redosier dogwood, Tatarian honeysuckle, lilac.	Amur maple, eastern redcedar.	Eastern white pine, Norway spruce, common hackberry.	Eastern cottonwood, silver maple.
Judson----------	Silky dogwood, gray dogwood.	Tatarian honeysuckle, redosier dogwood, Siberian peashrub.	Amur maple, eastern redcedar.	Common hackberry, red pine, Norway spruce.	Eastern cottonwood, silver maple.
6---------- Okoboji	---	Tatarian honeysuckle, nannyberry viburnum.	White spruce, blue spruce, Russian-olive, northern white-cedar, eastern redcedar.	Green ash, golden willow, black willow.	Eastern cottonwood, Siberian elm.
8B, 8C---------- Judson	Silky dogwood, gray dogwood.	Tatarian honeysuckle, redosier dogwood, Siberian peashrub.	Amur maple, eastern redcedar.	Common hackberry, red pine, Norway spruce.	Eastern cottonwood, silver maple.
9, 9B, 9B2, 9C, 9C2, 9D2, 9E2---- Marshall	Silky dogwood, gray dogwood.	Lilac, Tatarian honeysuckle, redosier dogwood.	Eastern redcedar, Amur maple.	Red pine, Norway spruce, common hackberry.	Eastern white pine, silver maple.
11B*: Colo----------	Gray dogwood, silky dogwood.	Tatarian honeysuckle, redosier dogwood, Zabel honeysuckle.	Laurel willow, white spruce, Amur maple, northern white-cedar.	Green ash---------	Silver maple, eastern cottonwood.
Judson----------	Silky dogwood, gray dogwood.	Tatarian honeysuckle, redosier dogwood, Siberian peashrub.	Amur maple, eastern redcedar.	Common hackberry, red pine, Norway spruce.	Eastern cottonwood, silver maple.
27B, 27C---------- Terril	Gray dogwood, silky dogwood.	Tatarian honeysuckle, redosier dogwood, lilac.	Amur maple, eastern redcedar.	Common hackberry, Norway spruce, red pine.	Eastern white pine, silver maple.
28B, 28B2, 28C2, 28D2---------- Dickman	---	Siberian peashrub, Tatarian honeysuckle, lilac, Russian-olive.	Eastern redcedar, Austrian pine, common hackberry, red pine, bur oak, ponderosa pine, jack pine.	Green ash---------	---

See footnote at end of table.

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of--				
	<8	8-15	16-25	26-35	>35
34B, 34C2--------- Estherville	---	Eastern redcedar, Russian-olive, silver buffaloberry, Tatarian honeysuckle, Siberian peashrub.	Red pine, jack pine, ponderosa pine, Austrian pine, common hackberry, bur oak.	---	---
48---------- Knoke	---	Lilac, Tatarian honeysuckle, nannyberry viburnum.	Eastern redcedar, northern white-cedar, blue spruce, white spruce.	Green ash, golden willow, black willow.	Eastern cottonwood, Siberian elm.
54---------- Zook	Silky dogwood-----	Gray dogwood, Tatarian honeysuckle, Zabel honeysuckle, American plum, redosier dogwood.	Northern white-cedar, laurel willow, Amur maple.	Green ash---------	Silver maple, eastern cottonwood.
55---------- Nicollet	---	Redosier dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, Siberian crabapple, Amur maple.	Ponderosa pine, eastern white pine, green ash, common hackberry.	Silver maple.
59C2, 59D2-------- Burchard	Peking cotoneaster, lilac.	Amur honeysuckle, skunkbush sumac.	Eastern redcedar, Russian mulberry, green ash, common hackberry, bur oak.	Austrian pine, Scotch pine, honeylocust.	---
59E2, 59F2-------- Burchard	Peking cotoneaster, lilac.	Amur honeysuckle, skunkbush sumac.	Eastern redcedar, Russian mulberry, green ash, common hackberry, bur oak.	Austrian pine, Scotch pine, honeylocust.	---
62C2, 62D2-------- Storden	---	Eastern redcedar, Tatarian honeysuckle, Siberian peashrub, Russian-olive.	Common hackberry, green ash, honeylocust.	Siberian elm------	---
62E2, 62F, 62G---- Storden	---	Eastern redcedar, Tatarian honeysuckle, Siberian peashrub, Russian-olive.	Common hackberry, green ash, honeylocust.	Siberian elm------	---
71D2*: Marshall--------- Dickman----------	Silky dogwood, gray dogwood. ---	Lilac, Tatarian honeysuckle, redosier dogwood. Siberian peashrub, Tatarian honeysuckle, lilac, Russian-olive.	Eastern redcedar, Amur maple. Eastern redcedar, Austrian pine, common hackberry, red pine, jack pine, bur oak, ponderosa pine.	Red pine, Norway spruce, common hackberry. Green ash---------	Eastern white pine, silver maple. ---

See footnote at end of table.

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of--				
	<8	8-15	16-25	26-35	>35
90---------- Okoboji	---	Tatarian honeysuckle, nannyberry viburnum.	Northern white-cedar, Russian-olive, eastern redcedar, white spruce, blue spruce.	Green ash, golden willow, black willow.	Eastern cottonwood, Siberian elm.
95---------- Harps	---	Tatarian honeysuckle, Siberian peashrub.	Northern white-cedar, green ash, eastern redcedar, white spruce, Russian-olive.	Golden willow, black willow.	Eastern cottonwood, Siberian elm.
99C2, 99D2, 99E2-- Exira	Silky dogwood, gray dogwood.	Redosier dogwood, lilac, Tatarian honeysuckle.	Amur maple, eastern redcedar.	Norway spruce, common hackberry, red pine.	Eastern white pine, silver maple.
107---------- Webster	Redosier dogwood, silky dogwood.	Amur privet, Tatarian honeysuckle, American plum.	Austrian pine, northern white-cedar, blue spruce, white spruce, Norway spruce.	Eastern white pine	Eastern cottonwood.
108, 108B, 108C2-- Wadena	---	Amur privet, Siberian peashrub, Siberian crabapple, lilac, Tatarian honeysuckle, American plum.	Eastern redcedar, northern white-cedar.	Eastern white pine, Norway spruce, red pine.	---
133, 133+---------- Colo	Gray dogwood, silky dogwood.	Tatarian honeysuckle, redosier dogwood, Zabel honeysuckle.	Austrian pine, laurel willow, white spruce, Amur maple, northern white-cedar.	Green ash---------	Silver maple, eastern cottonwood.
135---------- Coland	---	Redosier dogwood, Tatarian honeysuckle, silky dogwood, Zabel honeysuckle.	White spruce, northern white-cedar, Amur maple, white fir, Norway spruce.	Green ash---------	Eastern cottonwood, silver maple.
138B, 138B2, 138C, 138C2, 138D2----- Clarion	Gray dogwood, silky dogwood.	Redosier dogwood, Tatarian honeysuckle, lilac.	Amur maple, eastern redcedar.	Red pine, Norway spruce, common hackberry.	Silver maple, eastern white pine.
179E2, 179F, 179F2, 179G------ Gara	Gray dogwood, silky dogwood.	Redosier dogwood, American plum, Tatarian honeysuckle.	Eastern redcedar, Amur maple.	Red pine, Norway spruce, common hackberry.	Eastern white pine, silver maple.
192D2---------- Adair	Silky dogwood, gray dogwood.	Lilac, Tatarian honeysuckle, redosier dogwood.	Eastern redcedar, Amur maple.	Red pine, Norway spruce, common hackberry.	Eastern white pine, silver maple.
201B*: Coland----------	---	Redosier dogwood, Tatarian honeysuckle, silky dogwood, Zabel honeysuckle.	White spruce, northern white-cedar, Amur maple, white fir, Norway spruce.	Green ash---------	Eastern cottonwood, silver maple.

See footnote at end of table.

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of--				
	<8	8-15	16-25	26-35	>35
201B*: Spillville	Gray dogwood, silky dogwood.	Redosier dogwood, Tatarian honeysuckle, lilac.	Amur maple, eastern redcedar.	Common hackberry, red pine, Norway spruce.	Eastern cottonwood, silver maple.
203--- Cylinder	Gray dogwood, silky dogwood.	Redosier dogwood, Tatarian honeysuckle,	Amur maple, eastern redcedar.	Red pine, Norway spruce, common hackberry.	Eastern cottonwood, silver maple.
236C--- Lester	---	Redosier dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, Siberian crabapple, Amur maple, white spruce.	Eastern white pine, green ash, common hackberry, Scotch pine.	Silver maple.
259--- Biscay	---	Northern white-cedar, redosier dogwood, American plum, purpleosier willow, Tatarian honeysuckle.	Amur maple, white spruce.	Common hackberry, green ash, golden willow.	Eastern cottonwood, silver maple.
268C, 268D2, 268E2--- Knox	---	Tatarian honeysuckle, Amur honeysuckle, redosier dogwood, Amur privet, American cranberrybush, silky dogwood.	Eastern redcedar, northern white-cedar, blue spruce.	Eastern cottonwood, silver maple, Scotch pine.	---
308, 308B--- Wadena	---	Siberian peashrub, Siberian crabapple, lilac, Tatarian honeysuckle, Amur privet, American plum.	Eastern redcedar, northern white-cedar, Austrian pine.	Eastern white pine, Norway spruce, red pine.	---
430--- Ackmore	Silky dogwood, gray dogwood.	Redosier dogwood, Tatarian honeysuckle, lilac.	Amur maple, eastern redcedar.	Eastern white pine, Norway spruce, common hackberry.	Eastern cottonwood, silver maple.
485, 485B--- Spillville	Gray dogwood, silky dogwood.	Redosier dogwood, Tatarian honeysuckle, lilac.	Amur maple, eastern redcedar.	Common hackberry, red pine, Norway spruce.	Eastern cottonwood, silver maple.
507--- Canisteo	---	Siberian peashrub, redosier dogwood, Tatarian honeysuckle.	Russian-olive, blue spruce, ponderosa pine, Siberian crabapple, eastern redcedar.	Golden willow, green ash.	Eastern cottonwood, Siberian elm.
509B--- Marshall	Silky dogwood, gray dogwood.	Lilac, Tatarian honeysuckle, redosier dogwood.	Eastern redcedar, Amur maple.	Red pine, Norway spruce, common hackberry.	Eastern white pine, silver maple.
559--- Talcot	---	Siberian peashrub, Tatarian honeysuckle.	Ponderosa pine, Russian-olive, northern white-cedar, eastern redcedar, green ash, white spruce, Russian-olive.	Golden willow, black willow.	Siberian elm, eastern white pine.

See footnote at end of table.

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of--				
	<8	8-15	16-25	26-35	>35
638C2*, 638D2*: Clarion	Gray dogwood, silky dogwood.	Redosier dogwood, Tatarian honeysuckle, lilac.	Amur maple, eastern redcedar.	Red pine, Norway spruce, common hackberry.	Silver maple, eastern white pine.
Storden	---	Tatarian honeysuckle, Siberian peashrub, eastern redcedar, Russian-olive.	Honeylocust, green ash, hackberry.	Green ash, Siberian elm.	---
639C*: Salida	---	Eastern redcedar, Russian-olive, Tatarian honeysuckle, Siberian peashrub.	Common hackberry, honeylocust, green ash.	Siberian elm	---
Storden	---	Eastern redcedar, Tatarian honeysuckle, Siberian peashrub, Russian-olive.	Common hackberry, green ash, honeylocust.	Siberian elm	---
639D*: Salida	---	Eastern redcedar, Russian-olive, Tatarian honeysuckle, Siberian peashrub.	Common hackberry, honeylocust, green ash.	Siberian elm	---
Storden	---	Eastern redcedar, Tatarian honeysuckle, Siberian peashrub, Russian-olive.	Common hackberry, green ash, honeylocust.	Siberian elm	---
733--- Calco	---	Tatarian honeysuckle, Siberian peashrub.	Northern white-cedar, green ash, eastern redcedar, white spruce, Russian-olive.	Golden willow, black willow.	Eastern cottonwood, Siberian elm.
822D3--- Lamoni	Gray dogwood, silky dogwood.	Redosier dogwood, American plum, Tatarian honeysuckle.	Eastern redcedar, Amur maple.	Red pine, Norway spruce, common hackberry.	Eastern white pine, silver maple.
823--- Ridgeport	Gray dogwood, silky dogwood.	Redosier dogwood, Tatarian honeysuckle, American plum.	Eastern redcedar, Amur maple.	Red pine, common hackberry, Norway spruce.	Eastern white pine, silver maple.
924D2*: Burchard	Peking cotoneaster, lilac.	Amur honeysuckle, skunkbush sumac.	Eastern redcedar, Russian mulberry, green ash, common hackberry, bur oak.	Austrian pine, Scotch pine, honeylocust.	---
Adair	Silky dogwood, gray dogwood.	Lilac, Tatarian honeysuckle, redosier dogwood.	Eastern redcedar, Amur maple.	Red pine, Norway spruce, common hackberry.	Eastern white pine, silver maple.

See footnote at end of table.

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of--				
	<8	8-15	16-25	26-35	>35
924E2*:					
Burchard	Peking cotoneaster, lilac.	Amur honeysuckle, redosier dogwood.	Eastern redcedar, Russian mulberry, green ash, common hackberry, bur oak.	Austrian pine, Scotch pine, honeylocust.	---
Adair	Silky dogwood, gray dogwood.	Lilac, Tatarian honeysuckle, redosier dogwood.	Eastern redcedar, Amur maple.	Red pine, Norway spruce, common hackberry.	Eastern white pine, silver maple.
993D2*, 993E2*:					
Gara	Gray dogwood, silky dogwood.	Redosier dogwood, American plum, Tatarian honeysuckle.	Eastern redcedar, Amur maple.	Red pine, Norway spruce, common hackberry.	Eastern white pine, silver maple.
Armstrong	Gray dogwood, silky dogwood.	Redosier dogwood, Tatarian honeysuckle, American plum.	Eastern redcedar, Amur maple.	Red pine, Norway spruce, common hackberry.	Silver maple, eastern white pine.
2315*. Fluvaquents					
5010*. Pits					
5040*. Orthents					

* 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
1C3---------- Ida	Slight----------	Slight----------	Severe: slope.	Severe: erodes easily.	Slight.
1D3---------- Ida	Moderate: slope.	Moderate: slope.	Severe: slope.	Severe: erodes easily.	Moderate: slope.
5B*: Ackmore----------	Severe: floods, wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness, floods.
Judson----------	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
6---------- Okoboji	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding, erodes easily.	Severe: ponding.
8B---------- Judson	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
8C---------- Judson	Slight----------	Slight----------	Severe: slope.	Slight----------	Slight.
9---------- Marshall	Slight----------	Slight----------	Slight----------	Slight----------	Slight.
9B, 9B2---------- Marshall	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
9C, 9C2---------- Marshall	Slight----------	Slight----------	Severe: slope.	Slight----------	Slight.
9D2---------- Marshall	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight----------	Moderate: slope.
9E2---------- Marshall	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.
11B*: Colo----------	Severe: floods, wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness, floods.
Judson----------	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
27B---------- Terril	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
27C---------- Terril	Slight----------	Slight----------	Severe: slope.	Slight----------	Slight.
28B, 28B2---------- Dickman	Slight----------	Slight----------	Moderate: slope.	Slight----------	Moderate: droughty.
28C2---------- Dickman	Slight----------	Slight----------	Severe: slope.	Slight----------	Moderate: droughty.
28D2---------- Dickman	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight----------	Moderate: droughty, slope.

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
34B---------- Estherville	Slight----------	Slight----------	Moderate: slope, small stones.	Slight----------	Moderate: droughty.
34C2---------- Estherville	Slight----------	Slight----------	Severe: slope.	Slight----------	Moderate: droughty.
48---------- Knoke	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.
54---------- Zook	Severe: wetness, floods.	Moderate: floods, wetness.	Severe: wetness, floods.	Moderate: wetness, floods.	Severe: floods.
55---------- Nicollet	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
59C2---------- Burchard	Moderate: percs slowly.	Moderate: percs slowly.	Severe: slope.	Slight----------	Slight.
59D2---------- Burchard	Moderate: slope, percs slowly.	Moderate: slope, percs slowly.	Severe: slope.	Slight----------	Moderate: slope.
59E2, 59F2---------- Burchard	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.
62C2---------- Storden	Slight----------	Slight----------	Severe: slope.	Slight----------	Slight.
62D2---------- Storden	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight----------	Moderate: slope.
62E2, 62F---------- Storden	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.
62G---------- Storden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
71D2*: Marshall----------	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight----------	Moderate: slope.
Dickman----------	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight----------	Moderate: droughty, slope.
90---------- Okoboji	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: excess humus, ponding.	Severe: ponding, excess humus, erodes easily.	Severe: ponding.
95---------- Harps	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
99C2---------- Exira	Slight----------	Slight----------	Severe: slope.	Slight----------	Slight.
99D2---------- Exira	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight----------	Moderate: slope.
99E2---------- Exira	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.
107---------- Webster	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	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
108---------- Wadena	Slight----------	Slight----------	Moderate: small stones.	Slight----------	Slight.
108B---------- Wadena	Slight----------	Slight----------	Moderate: slope, small stones.	Slight----------	Slight.
108C2---------- Wadena	Slight----------	Slight----------	Severe: slope.	Slight----------	Slight.
133, 133+---------- Colo	Severe: floods, wetness.	Moderate: floods, wetness.	Severe: wetness, floods.	Moderate: floods, wetness.	Severe: floods.
135---------- Coland	Severe: floods, wetness.	Moderate: floods, wetness.	Severe: wetness, floods.	Moderate: wetness, floods.	Severe: floods.
138B, 138B2---------- Clarion	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
138C, 138C2---------- Clarion	Slight----------	Slight----------	Severe: slope.	Slight----------	Slight.
138D2---------- Clarion	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight----------	Moderate: slope.
179E2, 179F, 179F2---- Gara	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.
179G---------- Gara	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
192D2---------- Adair	Severe: wetness.	Moderate: wetness, slope, percs slowly.	Severe: slope, wetness.	Moderate: wetness.	Moderate: slope, wetness.
201B*: Coland----------	Severe: floods, wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness, floods.
Spillville----------	Severe: floods.	Slight----------	Moderate: slope, floods.	Slight----------	Moderate: floods.
203---------- Cylinder	Moderate: wetness.	Moderate: wetness.	Moderate: wetness.	Slight----------	Slight.
236C---------- Lester	Slight----------	Slight----------	Severe: slope.	Slight----------	Slight.
259---------- Biscay	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
268C---------- Knox	Slight----------	Slight----------	Severe: slope.	Slight----------	Slight.
268D2---------- Knox	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight----------	Moderate: slope.
268E2---------- Knox	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.
308---------- Wadena	Slight----------	Slight----------	Moderate: small stones.	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
308B---------- Wadena	Slight----------	Slight----------	Moderate: slope, small stones.	Slight----------	Slight.
430---------- Ackmore	Severe: floods, wetness.	Moderate: wetness, floods.	Severe: wetness, floods.	Moderate: wetness, floods.	Severe: floods.
485---------- Spillville	Severe: floods.	Slight----------	Moderate: floods.	Slight----------	Moderate: floods.
485B---------- Spillville	Severe: floods.	Slight----------	Moderate: slope, floods.	Slight----------	Moderate: floods.
507---------- Canisteo	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
509B---------- Marshall	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
559---------- Talcot	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
638C2*:					
Clarion----------	Slight----------	Slight----------	Severe: slope.	Slight----------	Slight.
Storden----------	Slight----------	Slight----------	Severe: slope.	Slight----------	Slight.
638D2*:					
Clarion----------	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight----------	Moderate: slope.
Storden----------	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight----------	Moderate: slope.
639C*:					
Salida----------	Moderate: small stones.	Moderate: small stones.	Severe: slope, small stones.	Slight----------	Severe: droughty.
Storden----------	Slight----------	Slight----------	Severe: slope.	Slight----------	Slight.
639D*:					
Salida----------	Moderate: slope, small stones.	Moderate: slope, small stones.	Severe: slope, small stones.	Slight----------	Severe: droughty.
Storden----------	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight----------	Moderate: slope.
733---------- Calco	Severe: floods, wetness.	Moderate: floods, wetness.	Severe: wetness, floods.	Moderate: wetness, floods.	Severe: floods.
822D3---------- Lamoni	Severe: wetness, percs slowly.	Severe: percs slowly.	Severe: slope, wetness.	Moderate: wetness.	Moderate: wetness, slope.
823---------- Ridgeport	Severe: floods.	Slight----------	Slight----------	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
924D2*:					
Burchard	Moderate: slope, percs slowly.	Moderate: slope, percs slowly.	Severe: slope.	Slight	Moderate: slope.
Adair	Severe: wetness.	Moderate: wetness, slope, percs slowly.	Severe: slope, wetness.	Moderate: wetness.	Moderate: slope, wetness.
924E2*:					
Burchard	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.
Adair	Severe: slope, wetness.	Severe: slope.	Severe: slope, wetness.	Moderate: wetness, slope.	Severe: slope.
993D2*:					
Gara	Moderate: percs slowly, slope.	Moderate: slope, percs slowly.	Severe: slope.	Slight	Moderate: slope.
Armstrong	Severe: wetness.	Moderate: slope, wetness, percs slowly.	Severe: slope, wetness.	Moderate: wetness.	Moderate: slope, wetness.
993E2*:					
Gara	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.
Armstrong	Severe: wetness.	Moderate: slope, wetness, percs slowly.	Severe: slope, wetness.	Moderate: wetness.	Moderate: slope, wetness.
2315*. Fluvaquents					
5010*. Pits					
5040*. Orthents					

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 10.--WILDLIFE HABITAT POTENTIALS

[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 herbaceous plants	Hardwood trees	Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
1C3, 1D3---------- Ida	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
5B*:										
Ackmore----------	Fair	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
Judson----------	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
6---------- Okoboji	Fair	Fair	Fair	Fair	Very poor.	Good	Good	Fair	Fair	Good.
8B---------- Judson	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
8C---------- Judson	Fair	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
9, 9B, 9B2--------- Marshall	Good	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
9C, 9C2, 9D2------- Marshall	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
9E2---------- Marshall	Poor	Fair	Good	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
11B*:										
Colo----------	Good	Fair	Good	Fair	Poor	Fair	Very poor.	Fair	Fair	Poor.
Judson----------	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
27B---------- Terril	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
27C---------- Terril	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
28B, 28B2, 28C2, 28D2---------- Dickman	Fair	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
34B, 34C2---------- Estherville	Fair	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
48---------- Knoke	Fair	Fair	Fair	Poor	Very poor.	Good	Good	Fair	Poor	Good.
54---------- Zook	Good	Fair	Good	Fair	Poor	Good	Good	Fair	Fair	Good.
55---------- Nicollet	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
59C2, 59D2--------- Burchard	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
59E2, 59F2--------- Burchard	Poor	Fair	Good	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
62C2, 62D2, 62E2--- Storden	Fair	Good	Good	Fair	Poor	Very poor.	Very poor.	Fair	Fair	Very poor.

See footnote at end of table.

TABLE 10.--WILDLIFE HABITAT POTENTIALS--Continued

Soil name and map symbol	Potential for habitat elements							Potential as habitat for--		
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
62F, 62G---------- Storden	Poor	Fair	Good	Fair	Poor	Very poor.	Very poor.	Fair	Fair	Very poor.
71D2*: Marshall----------	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
Dickman----------	Fair	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
90---------- Okoboji	Fair	Fair	Fair	Fair	Very poor.	Good	Good	Fair	Fair	Good.
95---------- Harps	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
99C2, 99D2, 99E2--- Exira	Good	Good	Good	Fair	Fair	Poor	Poor	Good	Fair	Poor.
107---------- Webster	Good	Good	Good	Fair	Poor	Good	Good	Good	Fair	Good.
108, 108B---------- Wadena	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
108C2---------- Wadena	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
133, 133+---------- Colo	Good	Fair	Good	Fair	Poor	Good	Good	Fair	Fair	Good.
135---------- Coland	Poor	Fair	Fair	Poor	Poor	Good	Good	Poor	Poor	Good.
138B, 138B2--------- Clarion	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
138C, 138C2, 138D2- Clarion	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
179E2, 179F, 179F2- Gara	Poor	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
179G---------- Gara	Very poor.	Very poor.	Fair	Fair	Fair	Very poor.	Very poor.	Poor	Fair	Very poor.
192D2---------- Adair	Fair	Good	Fair	Fair	Fair	Poor	Poor	Good	Fair	Poor.
201B*: Coland----------	Good	Good	Good	Fair	Fair	Good	Good	Good	Fair	Good.
Spillville---------	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
203---------- Cylinder	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
236C---------- Lester	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
259---------- Biscay	Good	Good	Good	Good	Fair	Good	Good	Good	Fair	Good.
268C, 268D2--------- Knox	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.

See footnote at end of table.

TABLE 10.--WILDLIFE HABITAT POTENTIALS--Continued

Soil name and map symbol	Potential for habitat elements							Potential as habitat for--		
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
268E2--Knox	Poor	Fair	Good	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
308, 308B--Wadena	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
430--Ackmore	Very poor.	Poor	Good	Good	Good	Fair	Fair	Poor	Good	Fair.
485--Spillville	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
485B--Spillville	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
507--Canisteo	Good	Good	Fair	Fair	Fair	Good	Good	Good	Fair	Good.
509B--Marshall	Good	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
559--Talcot	Good	Good	Fair	Fair	Fair	Good	Good	Good	Fair	Good.
638C2*, 638D2*:										
Clarion	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
Storden	Fair	Good	Good	Fair	Poor	Very poor.	Very poor.	Fair	Fair	Very poor.
639C*:										
Salida	Poor	Poor	Poor	Poor	Poor	Very poor.	Very poor.	Poor	Poor	Very poor.
Storden	Fair	Good	Good	Fair	Poor	Very poor.	Very poor.	Fair	Fair	Very poor.
639D*:										
Salida	Very poor.	Poor	Poor	Poor	Poor	Very poor.	Very poor.	Very poor.	Poor	Very poor.
Storden	Fair	Good	Good	Fair	Poor	Very poor.	Very poor.	Fair	Fair	Very poor.
733--Calco	Good	Fair	Good	Poor	Very poor.	Good	Good	Fair	Poor	Fair.
822D3--Lamoni	Fair	Good	Fair	Fair	Fair	Poor	Poor	Good	Fair	Poor.
823--Ridgeport	Fair	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
924D2*:										
Burchard	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
Adair	Fair	Good	Fair	Fair	Fair	Poor	Poor	Good	Fair	Poor.
924E2*:										
Burchard	Poor	Fair	Good	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
Adair	Fair	Good	Fair	Fair	Fair	Poor	Poor	Good	Fair	Poor.

See footnote at end of table.

TABLE 10.--WILDLIFE HABITAT POTENTIALS--Continued

Soil name and map symbol	Potential for habitat elements							Potential as habitat for--		
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
993D2*:										
Gara	Fair	Good	Fair	Good	Good	Very poor.	Poor	Fair	Good	Poor.
Armstrong	Fair	Good	Fair	Good	Fair	Very poor.	Poor	Fair	Good	Very poor.
993E2*:										
Gara	Poor	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
Armstrong	Fair	Good	Fair	Good	Fair	Very poor.	Poor	Fair	Good	Very poor.
2315*. Fluvaquents										
5010*. Pits										
5040*. Orthents										

* 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]

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
1C3---------- Ida	Slight---------	Slight---------	Slight---------	Moderate: slope.	Severe: frost action.	Slight.
1D3---------- Ida	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Severe: frost action.	Moderate: slope.
5B*: Ackmore----------	Severe: wetness.	Severe: floods, wetness.	Severe: floods, wetness, shrink-swell.	Severe: floods, wetness.	Severe: low strength, floods, frost action.	Moderate: wetness, floods.
Judson----------	Slight---------	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength, frost action.	Slight.
6---------- Okoboji	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: low strength, ponding, frost action.	Severe: ponding.
8B---------- Judson	Slight---------	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength, frost action.	Slight.
8C---------- Judson	Slight---------	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: low strength, frost action.	Slight.
9, 9B, 9B2-------- Marshall	Slight---------	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength, frost action.	Slight.
9C, 9C2---------- Marshall	Slight---------	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: low strength, frost action.	Slight.
9D2---------- Marshall	Moderate: slope.	Moderate: shrink-swell, slope.	Moderate: shrink-swell, slope.	Severe: slope.	Severe: low strength, frost action.	Moderate: slope.
9E2---------- Marshall	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, frost action, slope.	Severe: slope.
11B*: Colo----------	Severe: wetness.	Severe: floods, shrink-swell, wetness.	Severe: floods, shrink-swell, wetness.	Severe: floods, shrink-swell, wetness.	Severe: floods, low strength, frost action.	Moderate: wetness, floods.
Judson----------	Slight---------	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength, frost action.	Slight.
27B---------- Terril	Slight---------	Slight---------	Slight---------	Slight---------	Severe: low strength.	Slight.
27C---------- Terril	Slight---------	Slight---------	Slight---------	Moderate: slope.	Severe: low strength.	Slight.
28B, 28B2--------- Dickman	Severe: cutbanks cave.	Slight---------	Slight---------	Slight---------	Slight---------	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
28C2---------- Dickman	Severe: cutbanks cave.	Slight---------	Slight---------	Moderate: slope.	Slight---------	Moderate: droughty.
28D2---------- Dickman	Severe: cutbanks cave.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: droughty, slope.
34B---------- Estherville	Severe: cutbanks cave.	Slight---------	Slight---------	Slight---------	Slight---------	Moderate: droughty.
34C2---------- Estherville	Severe: cutbanks cave.	Slight---------	Slight---------	Moderate: slope.	Slight---------	Moderate: droughty.
48---------- Knoke	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, low strength, shrink-swell.	Severe: ponding.
54---------- Zook	Severe: wetness.	Severe: floods, wetness, shrink-swell.	Severe: floods, wetness, shrink-swell.	Severe: floods, wetness, shrink-swell.	Severe: floods, low strength, frost action.	Severe: floods.
55---------- Nicollet	Moderate: wetness.	Moderate: shrink-swell.	Moderate: wetness.	Moderate: shrink-swell.	Severe: low strength, frost action.	Slight.
59C2---------- Burchard	Slight---------	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: low strength.	Slight.
59D2---------- Burchard	Moderate: slope.	Moderate: shrink-swell, slope.	Moderate: slope, shrink-swell.	Severe: slope.	Severe: low strength.	Moderate: slope.
59E2, 59F2-------- Burchard	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope.	Severe: slope.
62C2---------- Storden	Slight---------	Slight---------	Slight---------	Moderate: slope.	Moderate: frost action.	Slight.
62D2---------- Storden	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope, frost action.	Moderate: slope.
62E2, 62F, 62G---- Storden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
71D2*:						
Marshall---------	Moderate: slope.	Moderate: shrink-swell, slope.	Moderate: shrink-swell, slope.	Severe: slope.	Severe: low strength, frost action.	Moderate: slope.
Dickman----------	Severe: cutbanks cave.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: droughty, slope.
90---------- Okoboji	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: low strength, ponding, frost action.	Severe: ponding.
95---------- Harps	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
99C2---------- Exira	Slight---------	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: low strength, frost action.	Slight.

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
99D2---------- Exira	Moderate: slope.	Moderate: shrink-swell, slope.	Moderate: shrink-swell, slope.	Severe: slope.	Severe: low strength, frost action.	Moderate: slope.
99E2---------- Exira	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, frost action, slope.	Severe: slope.
107---------- Webster	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
108, 108B---------- Wadena	Severe: cutbanks cave.	Slight---------	Slight---------	Slight---------	Slight---------	Slight.
108C2---------- Wadena	Severe: cutbanks cave.	Slight---------	Slight---------	Moderate: slope.	Slight---------	Slight.
133, 133+---------- Colo	Severe: wetness.	Severe: floods, shrink-swell, wetness.	Severe: floods, shrink-swell, wetness.	Severe: floods, shrink-swell, wetness.	Severe: floods, low strength, frost action.	Severe: floods.
135---------- Coland	Severe: wetness.	Severe: floods, wetness, shrink-swell.	Severe: floods, wetness, shrink-swell.	Severe: floods, wetness, shrink-swell.	Severe: floods, low strength, frost action.	Severe: floods.
138B, 138B2------- Clarion	Slight---------	Slight---------	Slight---------	Slight---------	Moderate: frost action.	Slight.
138C, 138C2------- Clarion	Slight---------	Slight---------	Slight---------	Moderate: slope.	Moderate: frost action.	Slight.
138D2---------- Clarion	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope, frost action.	Moderate: slope.
179E2, 179F, 179F2, 179G------ Gara	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope.	Severe: slope.
192D2---------- Adair	Severe: wetness.	Severe: shrink-swell, wetness.	Severe: wetness.	Severe: shrink-swell, wetness, slope.	Severe: low strength, frost action.	Moderate: slope, wetness.
201B*: Coland----------	Severe: wetness.	Severe: floods, wetness, shrink-swell.	Severe: floods, wetness, shrink-swell.	Severe: floods, wetness, shrink-swell.	Severe: floods, low strength, frost action.	Moderate: wetness, floods.
Spillville-------	Moderate: floods, wetness.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: low strength, floods.	Moderate: floods.
203---------- Cylinder	Severe: cutbanks cave, wetness.	Moderate: shrink-swell, wetness.	Severe: wetness.	Moderate: shrink-swell, wetness.	Severe: frost action.	Slight.
236C---------- Lester	Slight---------	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: low strength.	Slight.
259---------- Biscay	Severe: cutbanks cave, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	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
268C---------- Knox	Slight---------	Moderate: shrink-swell.	Slight---------	Moderate: shrink-swell, slope.	Severe: low strength, frost action.	Slight.
268D2---------- Knox	Moderate: slope.	Moderate: shrink-swell, slope.	Moderate: slope.	Severe: slope.	Severe: low strength, frost action.	Moderate: slope.
268E2---------- Knox	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope, frost action.	Severe: slope.
308, 308B--------- Wadena	Severe: cutbanks cave.	Slight---------	Slight---------	Slight---------	Slight---------	Slight.
430---------- Ackmore	Severe: wetness.	Severe: floods, wetness.	Severe: floods, wetness, shrink-swell.	Severe: floods, wetness.	Severe: low strength, floods, frost action.	Severe: floods.
485, 485B--------- Spillville	Moderate: floods, wetness.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: low strength, floods.	Moderate: floods.
507---------- Canisteo	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
509B---------- Marshall	Slight---------	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength, frost action.	Slight.
559---------- Talcot	Severe: cutbanks cave, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
638C2*:						
Clarion----------	Slight---------	Slight---------	Slight---------	Moderate: slope.	Moderate: frost action.	Slight.
Storden----------	Slight---------	Slight---------	Slight---------	Moderate: slope.	Moderate: frost action.	Slight.
638D2*:						
Clarion----------	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope, frost action.	Moderate: slope.
Storden----------	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope, frost action.	Moderate: slope.
639C*:						
Salida----------	Severe: cutbanks cave.	Slight---------	Slight---------	Moderate: slope.	Slight---------	Severe: droughty.
Storden----------	Slight---------	Slight---------	Slight---------	Moderate: slope.	Moderate: frost action.	Slight.
639D*:						
Salida----------	Severe: cutbanks cave.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope.	Severe: droughty.
Storden----------	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope, frost action.	Moderate: slope.

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
733---------- Calco	Severe: wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: low strength, floods.	Severe: floods.
822D3---------- Lamoni	Severe: wetness.	Severe: shrink-swell, wetness.	Severe: shrink-swell, wetness.	Severe: shrink-swell, wetness, slope.	Severe: shrink-swell, low strength.	Moderate: wetness, slope.
823---------- Ridgeport	Severe: cutbanks cave.	Severe: floods.	Severe: floods.	Severe: floods.	Moderate: floods.	Slight.
924D2*:						
Burchard----------	Moderate: slope.	Moderate: shrink-swell, slope.	Moderate: slope, shrink-swell.	Severe: slope.	Severe: low strength.	Moderate: slope.
Adair----------	Severe: wetness.	Severe: shrink-swell, wetness.	Severe: wetness.	Severe: shrink-swell, wetness, slope.	Severe: low strength, frost action.	Moderate: slope, wetness.
924E2*:						
Burchard----------	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope.	Severe: slope.
Adair----------	Severe: wetness, slope.	Severe: shrink-swell, wetness, slope.	Severe: wetness, slope.	Severe: shrink-swell, wetness, slope.	Severe: low strength, slope, frost action.	Severe: slope.
993D2*:						
Gara----------	Moderate: slope.	Moderate: slope, shrink-swell.	Moderate: slope, shrink-swell.	Severe: slope.	Severe: low strength.	Moderate: slope.
Armstrong--------	Severe: wetness.	Severe: shrink-swell, wetness.	Severe: wetness.	Severe: shrink-swell, wetness, slope.	Severe: low strength, frost action.	Moderate: slope, wetness.
993E2*:						
Gara----------	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope.	Severe: slope.
Armstrong--------	Severe: wetness.	Severe: shrink-swell, wetness.	Severe: wetness.	Severe: shrink-swell, wetness, slope.	Severe: low strength, frost action.	Moderate: slope, wetness.
2315*. Fluvaquents						
5010*. Pits						
5040*. Orthents						

* 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," "moderate," "good," "fair," and other terms. Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
1C3---- Ida	Slight----	Severe: slope.	Slight----	Slight----	Good.
1D3---- Ida	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: slope.	Fair: slope.
5B*: Ackmore----	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Poor: wetness, hard to pack.
Judson----	Slight----	Moderate: seepage, slope.	Slight----	Slight----	Good.
6---- Okoboji	Severe: ponding, percs slowly.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: hard to pack, ponding.
8B---- Judson	Slight----	Moderate: seepage, slope.	Slight----	Slight----	Good.
8C---- Judson	Slight----	Severe: slope.	Slight----	Slight----	Good.
9---- Marshall	Slight----	Moderate: seepage.	Slight----	Slight----	Good.
9B, 9B2---- Marshall	Slight----	Moderate: seepage, slope.	Slight----	Slight----	Good.
9C, 9C2---- Marshall	Slight----	Severe: slope.	Slight----	Slight----	Good.
9D2---- Marshall	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: slope.	Fair: slope.
9E2---- Marshall	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
11B*: Colo----	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness, hard to pack.
Judson----	Slight----	Moderate: seepage, slope.	Slight----	Slight----	Good.
27B---- Terril	Slight----	Moderate: seepage, slope.	Slight----	Slight----	Good.
27C---- Terril	Slight----	Severe: slope.	Slight----	Slight----	Good.
28B, 28B2---- Dickman	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.

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
28C2, 28D2---------- Dickman	Severe: poor filter.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.
34B---------- Estherville	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
34C2---------- Estherville	Severe: poor filter.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
48---------- Knoke	Severe: percs slowly, ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: ponding.
54---------- Zook	Severe: percs slowly, wetness, floods.	Severe: wetness, floods.	Severe: wetness, too clayey, floods.	Severe: wetness, floods.	Poor: too clayey, wetness, hard to pack.
55---------- Nicollet	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: wetness.
59C2---------- Burchard	Severe: percs slowly.	Severe: slope.	Moderate: too clayey.	Slight----------	Fair: too clayey.
59D2---------- Burchard	Severe: percs slowly.	Severe: slope.	Moderate: slope, too clayey.	Moderate: slope.	Fair: too clayey, slope.
59E2, 59F2---------- Burchard	Severe: percs slowly, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
62C2---------- Storden	Slight----------	Severe: slope.	Slight----------	Slight----------	Good.
62D2---------- Storden	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: slope.	Fair: slope.
62E2, 62F, 62G------ Storden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
71D2*: Marshall----------	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: slope.	Fair: slope.
Dickman----------	Severe: poor filter.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.
90---------- Okoboji	Severe: ponding, percs slowly.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: hard to pack, ponding.
95---------- Harps	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: hard to pack, wetness.
99C2---------- Exira	Slight----------	Severe: slope.	Slight----------	Slight----------	Good.
99D2---------- Exira	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: slope.	Fair: slope.

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
99E2---------- Exira	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
107---------- Webster	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.
108, 108B---------- Wadena	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
108C2---------- Wadena	Severe: poor filter.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
133, 133+---------- Colo	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness, hard to pack.
135---------- Coland	Severe: floods, wetness.	Severe: floods, wetness, seepage.	Severe: floods, wetness, seepage.	Severe: floods, wetness.	Poor: wetness, hard to pack.
138B, 138B2--------- Clarion	Slight----------	Moderate: slope, seepage.	Slight----------	Slight----------	Good.
138C, 138C2--------- Clarion	Slight----------	Severe: slope.	Slight----------	Slight----------	Good.
138D2---------- Clarion	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: slope.	Fair: slope.
179E2, 179F, 179F2, 179G---------- Gara	Severe: percs slowly, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
192D2---------- Adair	Severe: percs slowly, wetness.	Severe: slope, wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.
201B*: Coland----------	Severe: floods, wetness.	Severe: floods, wetness, seepage.	Severe: floods, wetness, seepage.	Severe: floods, wetness.	Poor: wetness, hard to pack.
Spillville---------	Severe: wetness, floods.	Severe: wetness, seepage, floods.	Severe: wetness, seepage, floods.	Severe: wetness, floods.	Fair: wetness.
203---------- Cylinder	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: too sandy, seepage.
236C---------- Lester	Moderate: percs slowly.	Severe: slope.	Moderate: too clayey.	Slight----------	Fair: too clayey.
259---------- Biscay	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, too sandy, small stones.

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
268C---------- Knox	Moderate: percs slowly.	Moderate: seepage, slope.	Slight----------	Slight----------	Good.
268D2---------- Knox	Moderate: percs slowly, slope.	Severe: slope.	Moderate: slope.	Moderate: slope.	Fair: slope.
268E2---------- Knox	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
308, 308B---------- Wadena	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
430---------- Ackmore	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Poor: wetness, hard to pack.
485, 485B---------- Spillville	Severe: wetness, floods.	Severe: wetness, seepage, floods.	Severe: wetness, seepage, floods.	Severe: wetness, floods.	Fair: wetness.
507---------- Canisteo	Severe: wetness.	Severe: seepage, wetness.	Severe: wetness.	Severe: seepage, wetness.	Poor: wetness.
509B---------- Marshall	Slight----------	Moderate: seepage, slope.	Slight----------	Slight----------	Good.
559---------- Talcot	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, too sandy, wetness.
638C2*: Clarion----------	Slight----------	Severe: slope.	Slight----------	Slight----------	Good.
Storden----------	Slight----------	Severe: slope.	Slight----------	Slight----------	Good.
638D2*: Clarion----------	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: slope.	Fair: slope.
Storden----------	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: slope.	Fair: slope.
639C*: Salida----------	Severe: poor filter.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
Storden----------	Slight----------	Severe: slope.	Slight----------	Slight----------	Good.
639D*: Salida----------	Severe: poor filter.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.

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
639D*: Storden	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: slope.	Fair: slope.
733 Calco	Severe: wetness, floods.	Severe: wetness.	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness.
822D3 Lamoni	Severe: percs slowly, wetness.	Severe: slope.	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack.
823 Ridgeport	Severe: poor filter.	Severe: seepage.	Severe: seepage.	Severe: seepage.	Poor: thin layer.
924D2*: Burchard	Severe: percs slowly.	Severe: slope.	Moderate: slope, too clayey.	Moderate: slope.	Fair: too clayey, slope.
Adair	Severe: percs slowly, wetness.	Severe: slope, wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.
924E2*: Burchard	Severe: percs slowly, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
Adair	Severe: percs slowly, slope, wetness.	Severe: slope, wetness.	Severe: wetness, slope.	Severe: wetness, slope.	Poor: slope, wetness.
993D2*: Gara	Severe: percs slowly.	Severe: slope.	Moderate: too clayey, slope.	Moderate: slope.	Fair: too clayey, slope.
Armstrong	Severe: percs slowly, wetness.	Severe: slope.	Severe: wetness.	Severe: wetness.	Poor: wetness.
993E2*: Gara	Severe: percs slowly, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
Armstrong	Severe: percs slowly, wetness.	Severe: slope.	Severe: wetness.	Severe: wetness.	Poor: wetness.
2315*. Fluvaquents					
5010*. Pits					
5040*. Orthents					

* 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," "poor," "probable," and "improbable." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
1C3 Ida	Good	Improbable: excess fines.	Improbable: excess fines.	Good.
1D3 Ida	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: slope.
5B*: Ackmore	Poor: low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Good.
Judson	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
6 Okoboji	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
8B, 8C Judson	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
9, 9B, 9B2, 9C, 9C2 Marshall	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
9D2 Marshall	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: slope.
9E2 Marshall	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
11B*: Colo	Poor: shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
Judson	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
27B, 27C Terril	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
28B, 28B2, 28C2, 28D2 Dickman	Good	Probable	Improbable: too sandy.	Poor: thin layer.
34B, 34C2 Estherville	Good	Probable	Probable	Poor: small stones, area reclaim.
48 Knoke	Poor: wetness, low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
54 Zook	Poor: shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
55 Nicollet	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
59C2 Burchard	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones.

See footnote at end of table.

TABLE 13.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
59D2---------- Burchard	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones, slope.
59E2, 59F2---------- Burchard	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
62C2---------- Storden	Good----------	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
62D2---------- Storden	Good----------	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones, slope.
62E2, 62F---------- Storden	Fair: slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
62G---------- Storden	Poor: slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
71D2*:				
Marshall----------	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: slope.
Dickman----------	Good----------	Probable----------	Improbable: too sandy.	Poor: thin layer.
90---------- Okoboji	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
95---------- Harps	Fair: low strength, wetness, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Fair: large stones.
99C2---------- Exira	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
99D2---------- Exira	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: slope.
99E2---------- Exira	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
107---------- Webster	Fair: low strength, wetness, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Good.
108, 108B, 108C2------ Wadena	Good----------	Probable----------	Probable----------	Poor: small stones, area reclaim.
133, 133+---------- Colo	Poor: shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
135---------- Coland	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
138B, 138B2, 138C, 138C2---------- Clarion	Good----------	Improbable: excess fines.	Improbable: excess fines.	Good.
138D2---------- Clarion	Good----------	Improbable: excess fines.	Improbable: excess fines.	Fair: slope.

See footnote at end of table.

TABLE 13.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
179E2, 179F, 179F2---- Gara	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
179G---------- Gara	Poor: low strength, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
192D2---------- Adair	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer.
201B*:				
Coland----------	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
Spillville----------	Good----------	Improbable: excess fines.	Improbable: excess fines.	Good.
203---------- Cylinder	Fair: wetness.	Probable----------	Improbable: too sandy.	Fair: area reclaim, small stones, thin layer.
236C---------- Lester	Good----------	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
259---------- Biscay	Fair: wetness.	Probable----------	Probable----------	Poor: area reclaim.
268C---------- Knox	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
268D2---------- Knox	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: slope.
268E2---------- Knox	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
308, 308B---------- Wadena	Good----------	Probable----------	Probable----------	Poor: small stones, area reclaim.
430---------- Ackmore	Poor: low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Good.
485, 485B---------- Spillville	Good----------	Improbable: excess fines.	Improbable: excess fines.	Good.
507---------- Canisteo	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
509B---------- Marshall	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
559---------- Talcot	Fair: wetness.	Probable----------	Probable----------	Fair: small stones, area reclaim, thin layer.
638C2*:				
Clarion----------	Good----------	Improbable: excess fines.	Improbable: excess fines.	Good.
Storden----------	Good----------	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.

See footnote at end of table.

TABLE 13.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
638D2*:				
Clarion	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: slope.
Storden	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones, slope.
639C*:				
Salida	Good	Probable	Probable	Poor: small stones, area reclaim, too sandy.
Storden	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
639D*:				
Salida	Good	Probable	Probable	Poor: small stones, area reclaim, too sandy.
Storden	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones, slope.
733 Calco	Poor: shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
822D3 Lamoni	Poor: low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
823 Ridgeport	Good	Probable	Improbable: too sandy.	Fair: small stones, area reclaim, thin layer.
924D2*:				
Burchard	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones, slope.
Adair	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer.
924E2*:				
Burchard	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
Adair	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer, slope.
993D2*:				
Gara	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: slope, small stones.
Armstrong	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer.
993E2*:				
Gara	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.

See footnote at end of table.

TABLE 13.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
993E2*: Armstrong	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer.
2315*. Fluvaquents				
5010*. Pits				
5040*. Orthents				

* 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]

Soil name and map symbol	Limitations for--		Features affecting--			
	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
1C3---------- Ida	Moderate: seepage, slope.	Severe: piping.	Deep to water	Slope, erodes easily.	Erodes easily	Erodes easily.
1D3---------- Ida	Severe: slope.	Severe: piping.	Deep to water	Slope, erodes easily.	Slope, erodes easily.	Slope, erodes easily.
5B*:						
Ackmore----------	Moderate: seepage, slope.	Severe: hard to pack, wetness.	Floods, slope, frost action.	Wetness, erodes easily, slope.	Wetness, erodes easily.	Wetness, erodes easily.
Judson----------	Moderate: seepage, slope.	Severe: piping.	Deep to water	Slope----------	Erodes easily	Erodes easily.
6---------- Okoboji	Moderate: seepage.	Severe: ponding.	Ponding, frost action.	Ponding, erodes easily.	Erodes easily, ponding.	Wetness, erodes easily.
8B, 8C---------- Judson	Moderate: seepage, slope.	Severe: piping.	Deep to water	Slope----------	Erodes easily	Erodes easily.
9---------- Marshall	Moderate: seepage.	Slight---------	Deep to water	Favorable------	Erodes easily	Erodes easily.
9B, 9B2, 9C, 9C2-- Marshall	Moderate: seepage, slope.	Slight---------	Deep to water	Slope----------	Erodes easily	Erodes easily.
9D2, 9E2---------- Marshall	Severe: slope.	Slight---------	Deep to water	Slope----------	Erodes easily, slope.	Slope, erodes easily.
11B*:						
Colo----------	Moderate: seepage, slope.	Severe: wetness.	Floods, frost action, slope.	Wetness, slope, floods.	Wetness--------	Wetness.
Judson----------	Moderate: seepage, slope.	Severe: piping.	Deep to water	Slope----------	Erodes easily	Erodes easily.
27B, 27C---------- Terril	Moderate: seepage, slope.	Moderate: piping.	Deep to water	Slope----------	Favorable------	Favorable.
28B, 28B2, 28C2--- Dickman	Severe: seepage.	Severe: seepage.	Deep to water	Droughty, soil blowing, slope.	Too sandy, soil blowing.	Droughty.
28D2---------- Dickman	Severe: seepage, slope.	Severe: seepage.	Deep to water	Droughty, soil blowing, slope.	Slope, too sandy, soil blowing.	Slope, droughty.
34B, 34C2--------- Estherville	Severe: seepage.	Severe: seepage.	Deep to water	Droughty, soil blowing, slope.	Too sandy, soil blowing.	Droughty.
48---------- Knoke	Slight---------	Severe: hard to pack, ponding.	Ponding, frost action.	Ponding--------	Ponding, erodes easily.	Wetness, erodes easily.
54---------- Zook	Slight---------	Severe: hard to pack, wetness.	Floods, percs slowly, frost action.	Wetness, percs slowly.	Wetness, percs slowly.	Wetness, percs slowly.

See footnote at end of table.

TABLE 14.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for--		Features affecting--			
	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
55---------- Nicollet	Moderate: seepage.	Severe: piping.	Frost action---	Wetness---------	Wetness---------	Favorable.
59C2---------- Burchard	Moderate: slope.	Slight---------	Deep to water	Slope----------	Favorable------	Favorable.
59D2, 59E2, 59F2-- Burchard	Severe: slope.	Slight---------	Deep to water	Slope----------	Slope----------	Slope.
62C2---------- Storden	Moderate: seepage, slope.	Moderate: piping.	Deep to water	Slope----------	Erodes easily	Erodes easily.
62D2, 62E2, 62F, 62G---------- Storden	Severe: slope.	Moderate: piping.	Deep to water	Slope----------	Slope, erodes easily.	Slope, erodes easily.
71D2*: Marshall---------	Severe: slope.	Slight---------	Deep to water	Slope----------	Erodes easily, slope.	Slope, erodes easily.
Dickman----------	Severe: seepage, slope.	Severe: seepage.	Deep to water	Droughty, soil blowing, slope.	Slope, too sandy, soil blowing.	Slope, droughty.
90---------- Okoboji	Moderate: seepage.	Severe: ponding.	Ponding, frost action.	Ponding, erodes easily.	Erodes easily, ponding.	Wetness, erodes easily.
95---------- Harps	Moderate: seepage.	Severe: wetness.	Frost action---	Wetness---------	Wetness---------	Wetness.
99C2---------- Exira	Moderate: seepage, slope.	Moderate: hard to pack.	Deep to water	Slope----------	Erodes easily	Erodes easily.
99D2, 99E2-------- Exira	Severe: slope.	Moderate: hard to pack.	Deep to water	Slope----------	Slope, erodes easily.	Slope, erodes easily.
107---------- Webster	Moderate: seepage.	Severe: wetness.	Frost action---	Wetness---------	Wetness---------	Wetness.
108---------- Wadena	Severe: seepage.	Severe: seepage, piping.	Deep to water	Favorable------	Too sandy------	Favorable.
108B, 108C2------- Wadena	Severe: seepage.	Severe: seepage, piping.	Deep to water	Slope----------	Too sandy------	Favorable.
133, 133+--------- Colo	Moderate: seepage.	Severe: wetness.	Floods, frost action.	Floods, wetness.	Wetness---------	Wetness.
135---------- Coland	Moderate: seepage.	Severe: wetness.	Floods, frost action.	Wetness, floods.	Wetness---------	Wetness.
138B, 138B2, 138C, 138C2---------- Clarion	Moderate: seepage, slope.	Severe: piping.	Deep to water	Slope----------	Erodes easily	Erodes easily.
138D2---------- Clarion	Severe: slope.	Severe: piping.	Deep to water	Slope----------	Slope, erodes easily.	Slope, erodes easily.
179E2, 179F, 179F2, 179G------ Gara	Severe: slope.	Slight---------	Deep to water	Slope----------	Slope----------	Slope.
192D2---------- Adair	Severe: slope.	Moderate: wetness.	Percs slowly, slope, frost action.	Wetness, percs slowly, slope.	Slope, wetness.	Wetness, slope.

See footnote at end of table.

TABLE 14.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for--		Features affecting--			
	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
201B*:						
Coland	Moderate: seepage.	Severe: wetness.	Floods, frost action.	Wetness, floods.	Wetness	Wetness.
Spillville	Moderate: seepage, slope.	Moderate: piping, wetness.	Deep to water	Slope, floods.	Favorable	Favorable.
203 Cylinder	Severe: seepage.	Severe: seepage, piping.	Frost action, cutbanks cave.	Wetness	Wetness, too sandy.	Favorable.
236C Lester	Moderate: seepage, slope.	Severe: thin layer.	Deep to water	Slope	Erodes easily	Erodes easily.
259 Biscay	Severe: seepage.	Severe: seepage, wetness.	Frost action, cutbanks cave.	Wetness	Wetness, too sandy.	Wetness.
268C Knox	Moderate: seepage, slope.	Severe: piping.	Deep to water	Slope	Erodes easily	Erodes easily.
268D2, 268E2 Knox	Severe: slope.	Severe: piping.	Deep to water	Slope	Slope, erodes easily.	Slope, erodes easily.
308 Wadena	Severe: seepage.	Severe: seepage, piping.	Deep to water	Favorable	Too sandy	Favorable.
308B Wadena	Severe: seepage.	Severe: seepage, piping.	Deep to water	Slope	Too sandy	Favorable.
430 Ackmore	Moderate: seepage.	Severe: hard to pack, wetness.	Floods, frost action.	Wetness, erodes easily.	Wetness, erodes easily.	Wetness, erodes easily.
485 Spillville	Moderate: seepage.	Moderate: piping, wetness.	Deep to water	Floods	Favorable	Favorable.
485B Spillville	Moderate: seepage, slope.	Moderate: piping, wetness.	Deep to water	Slope, floods.	Favorable	Favorable.
507 Canisteo	Severe: seepage.	Severe: wetness.	Frost action	Wetness	Wetness	Wetness.
509B Marshall	Moderate: seepage, slope.	Slight	Deep to water	Slope	Erodes easily	Erodes easily.
559 Talcot	Severe: seepage.	Severe: seepage, wetness.	Frost action, cutbanks cave.	Wetness	Wetness, too sandy.	Wetness.
638C2*:						
Clarion	Moderate: seepage, slope.	Severe: piping.	Deep to water	Slope	Erodes easily	Erodes easily.
Storden	Moderate: seepage, slope.	Moderate: piping.	Deep to water	Slope	Erodes easily	Erodes easily.
638D2*:						
Clarion	Severe: slope.	Severe: piping.	Deep to water	Slope	Slope, erodes easily.	Slope, erodes easily.

See footnote at end of table.

TABLE 14.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for--		Features affecting--			
	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
638D2*:						
Storden	Severe: slope.	Moderate: piping.	Deep to water	Slope	Slope, erodes easily.	Slope, erodes easily.
639C*:						
Salida	Severe: seepage.	Severe: seepage.	Deep to water	Droughty, fast intake, slope.	Too sandy	Droughty.
Storden	Moderate: seepage, slope.	Moderate: piping.	Deep to water	Slope	Erodes easily	Erodes easily.
639D*:						
Salida	Severe: seepage, slope.	Severe: seepage.	Deep to water	Droughty, fast intake, slope.	Slope, too sandy.	Slope, droughty.
Storden	Severe: slope.	Moderate: piping.	Deep to water	Slope	Slope, erodes easily.	Slope, erodes easily.
733 Calco	Moderate: seepage.	Severe: wetness.	Floods, frost action.	Floods, wetness.	Wetness	Wetness.
822D3 Lamoni	Severe: slope.	Moderate: wetness, hard to pack.	Percs slowly, slope.	Wetness, percs slowly, slope.	Slope, wetness, percs slowly.	Slope, wetness, percs slowly.
823 Ridgeport	Severe: seepage.	Severe: piping.	Deep to water	Soil blowing, rooting depth.	Soil blowing	Rooting depth.
924D2*, 924E2*:						
Burchard	Severe: slope.	Slight	Deep to water	Slope	Slope	Slope.
Adair	Severe: slope.	Moderate: wetness.	Percs slowly, slope, frost action.	Wetness, percs slowly, slope.	Slope, wetness.	Wetness, slope.
993D2*, 993E2*:						
Gara	Severe: slope.	Slight	Deep to water	Slope	Slope	Slope.
Armstrong	Severe: slope.	Moderate: wetness.	Percs slowly, frost action, slope.	Wetness, percs slowly, slope.	Slope, percs slowly, wetness.	Percs slowly, slope, wetness.
2315*. Fluvaquents						
5010*. Pits						
5040*. Orthents						

* 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		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
1C3, 1D3--------- Ida	0-60	Silt loam---------	ML, CL	A-4, A-6	0	100	100	95-100	95-100	30-40	5-15
5B*: Ackmore---------	0-30	Silt loam, silty clay loam.	CL, ML	A-4, A-6, A-7	0	100	100	95-100	85-100	25-60	8-30
	30-60	Silty clay loam, silt loam.	CH, CL, MH, ML	A-7, A-6	0	100	100	95-100	85-100	35-60	15-30
Judson----------	0-25	Silty clay loam	CL, CL-ML	A-6, A-7, A-4	0	100	100	100	95-100	25-50	5-25
	25-60	Silty clay loam	CL	A-6, A-7	0	100	100	100	95-100	30-50	15-25
6---------------- Okoboji	0-27	Silty clay loam	CH	A-7	0	100	100	90-100	80-95	55-65	30-40
	27-49	Silty clay loam, clay loam.	CH	A-7	0	100	100	90-100	80-95	55-65	30-40
	49-60	Stratified loam to silty clay loam.	CL, CH	A-7	0-5	95-100	90-100	90-100	75-90	40-55	20-30
8B, 8C----------- Judson	0-25	Silty clay loam	CL, CL-ML	A-6, A-7, A-4	0	100	100	100	95-100	25-50	5-25
	25-60	Silty clay loam	CL	A-6, A-7	0	100	100	100	95-100	30-50	15-25
9, 9B, 9B2, 9C, 9C2, 9D2, 9E2--- Marshall	0-18	Silty clay loam	CL	A-6, A-7	0	100	100	100	95-100	35-50	15-25
	18-58	Silty clay loam	CL	A-7, A-6	0	100	100	100	95-100	35-50	15-25
	58-60	Silt loam---------	CL	A-7, A-6	0	100	100	100	95-100	35-50	15-25
11B*: Colo------------	0-38	Silty clay loam	CL, CH	A-7	0	100	100	90-100	90-100	40-60	15-30
	38-60	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, CL-ML	A-6, A-7, A-4	0	100	100	100	95-100	25-50	5-25
	25-60	Silty clay loam	CL	A-6, A-7	0	100	100	100	95-100	30-50	15-25
27B, 27C--------- Terril	0-32	Loam-------------	CL	A-6	0-5	100	95-100	70-90	60-80	30-40	10-20
	32-60	Clay loam, loam	CL	A-6	0-5	100	95-100	70-95	60-85	25-40	10-20
28B, 28B2, 28C2, 28D2----------- Dickman	0-6	Sandy loam-------	SM, SM-SC	A-2, A-4	0	95-100	95-100	55-95	25-40	20-30	2-8
	6-31	Sandy loam, fine sandy loam, loamy sand.	SM, SM-SC	A-2, A-4	0	95-100	85-100	55-95	25-45	15-25	2-8
	31-60	Stratified fine sand to coarse sand.	SP-SM	A-3, A-2	0	95-100	75-95	50-80	5-10	---	NP
34B, 34C2-------- Estherville	0-6	Sandy loam-------	SM, SM-SC, SC	A-2, A-4	0-5	90-100	80-95	50-75	25-50	20-30	2-10
	6-15	Sandy loam, loam, coarse sandy loam.	SM, SM-SC, SC	A-2, A-4, A-1	0-5	85-100	70-95	40-75	15-45	20-30	2-8
	15-60	Coarse sand, gravelly coarse sand, loamy coarse sand.	SP, SP-SM, SM, GP	A-1	0-10	45-90	40-85	10-40	2-25	---	NP
48--------------- Knoke	0-9	Mucky silt loam	OH, MH	A-7	0	100	100	95-100	90-95	60-90	10-30
	9-19	Silty clay loam, mucky silty clay loam.	MH, OH	A-7	0	100	100	90-100	80-95	55-90	15-40
	19-60	Silty clay loam, silty clay, clay loam.	MH, CH	A-7	0	95-100	95-100	90-100	80-95	55-70	25-40

See footnote at end of table.

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Frag-ments > 3 inches	Percentage passing sieve number--				Liquid limit	Plas-ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
54----------	0-18	Silty clay loam	CH, CL	A-7	0	100	100	95-100	95-100	45-65	20-35
Zook	18-60	Silty clay, silty clay loam.	CH	A-7	0	100	100	95-100	95-100	60-85	35-55
55----------	0-16	Loam----------	OL, ML, CL	A-6, A-7	0	95-100	95-100	85-98	55-85	35-50	10-25
Nicollet	16-37	Clay loam, loam	CL	A-6, A-7	0-5	95-100	95-100	80-95	55-80	35-50	15-25
	37-60	Loam----------	CL, ML	A-6, A-4	0-5	95-100	90-100	75-90	50-75	30-40	5-15
59C2, 59D2, 59E2, 59F2----------	0-7	Clay loam--------	CL	A-6, A-7	0-5	95-100	95-100	85-95	60-80	35-50	14-24
Burchard	7-20	Clay loam--------	CL	A-6, A-7	0-5	95-100	90-100	85-95	65-80	35-50	20-30
	20-60	Clay loam--------	CL	A-6, A-7	0-5	95-100	90-100	85-95	60-80	35-50	15-30
62C2, 62D2, 62E2, 62F, 62G--------	0-8	Loam----------	ML, CL	A-4, A-6	0-5	95-100	95-100	70-85	55-70	30-40	5-15
Storden	8-60	Loam----------	CL-ML, CL	A-4, A-6	0-5	95-100	85-97	70-85	55-70	20-40	5-15
71D2*:											
Marshall--------	0-18	Silty clay loam	CL	A-6, A-7	0	100	100	100	95-100	35-50	15-25
	18-58	Silty clay loam	CL	A-7, A-6	0	100	100	100	95-100	35-50	15-25
	58-60	Silt loam--------	CL	A-7, A-6	0	100	100	100	95-100	35-50	15-25
Dickman---------	0-6	Sandy loam-------	SM, SM-SC	A-2, A-4	0	95-100	95-100	55-95	25-40	20-30	2-8
	6-31	Sandy loam, fine sandy loam, loamy sand.	SM, SM-SC	A-2, A-4	0	95-100	85-100	55-95	25-45	15-25	2-8
	31-60	Stratified fine sand to coarse sand.	SP-SM	A-3, A-2	0	95-100	75-95	50-80	5-10	---	NP
90----------	0-13	Mucky silt loam	OH, MH	A-7	0	100	100	95-100	90-95	60-95	10-30
Okoboji	13-35	Silty clay loam	CH	A-7	0	100	100	90-100	80-95	55-65	30-40
	35-60	Silty clay loam	CH	A-7	0	95-100	95-100	90-100	80-95	55-65	30-40
95----------	0-19	Loam----------	CL, CH	A-6, A-7	0-5	100	95-100	80-90	65-80	30-55	15-35
Harps	19-36	Loam, clay loam, sandy clay loam.	CL, CH	A-6, A-7	0-5	95-100	95-100	80-90	65-80	30-60	15-35
	36-60	Loam----------	CL	A-6	0-5	95-100	90-100	70-80	50-75	25-40	10-25
99C2, 99D2, 99E2-	0-8	Silty clay loam	CL	A-6, A-7	0	100	100	100	95-100	35-50	15-25
Exira	8-29	Silty clay loam	CL, ML	A-7, A-6	0	100	100	100	95-100	35-50	15-25
	29-60	Silty clay loam, silt loam.	CL	A-6, A-7	0	100	100	100	95-100	35-50	15-25
107----------	0-12	Silty clay loam	CL, CH	A-7, A-6	0-5	100	95-100	85-95	70-90	35-60	15-30
Webster	12-45	Clay loam, silty clay loam, loam.	CL	A-6, A-7	0-5	95-100	95-100	85-95	60-80	35-50	15-30
	45-60	Loam, sandy loam, clay loam.	CL	A-6	0-5	95-100	90-100	75-85	50-75	30-40	10-20
108, 108B, 108C2-	0-17	Loam----------	ML	A-4	0	95-100	80-100	75-95	50-65	25-40	2-10
Wadena	17-29	Loam, sandy loam, sandy clay loam.	SM, ML, CL, SC	A-4, A-6	0	95-100	80-100	75-95	40-60	25-40	5-12
	29-60	Sand and gravel, gravelly loamy sand.	SP, SP-SM, GP, GP-GM	A-1, A-3, A-2	0-5	45-100	40-95	10-80	2-10	---	NP
133----------	0-38	Silty clay loam	CL, CH	A-7	0	100	100	90-100	90-100	40-60	15-30
Colo	38-60	Silty clay loam	CL, CH	A-7	0	100	100	90-100	90-100	40-55	20-30
133+----------	0-10	Silty clay loam	CL, CH	A-7	0	100	100	90-100	90-100	40-60	15-30
Colo	10-43	Silty clay loam	CL, CH	A-7	0	100	100	90-100	90-100	40-55	20-30
	43-60	Silty clay loam, clay loam.	CL, CH	A-7	0	100	100	95-100	80-100	40-55	15-30
135----------	0-48	Clay loam--------	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
Coland	48-60	Clay loam, silty clay loam, sandy clay loam.	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30

See footnote at end of table.

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
138B, 138B2, 138C, 138C2, 138D2---------- Clarion	0-14	Loam----------	CL, CL-ML	A-4, A-6	0-5	95-100	95-100	75-90	50-75	25-40	5-15
	14-33	Loam, clay loam	CL, CL-ML	A-4, A-6	0-5	90-100	85-100	75-90	50-75	25-40	5-15
	33-60	Loam, sandy loam	CL, CL-ML, SC, SM-SC	A-4, A-6	0-5	90-100	85-100	75-90	45-70	25-40	5-15
179E2---------- Gara	0-6	Loam----------	CL, CL-ML	A-4, A-6	0	95-100	85-95	75-85	55-70	20-30	5-15
	6-40	Clay loam--------	CL	A-6	0-5	90-95	85-95	70-85	55-75	30-40	15-25
	40-60	Loam, clay loam	CL	A-6, A-7	0-5	90-95	85-95	70-85	55-75	35-45	15-25
179F---------- Gara	0-11	Loam----------	CL, CL-ML	A-4, A-6	0	95-100	85-95	75-85	55-70	20-30	5-15
	11-43	Clay loam--------	CL	A-6	0-5	90-95	85-95	70-85	55-75	30-40	15-25
	43-60	Loam, clay loam	CL	A-6, A-7	0-5	90-95	85-95	70-85	55-75	35-45	15-25
179F2, 179G------ Gara	0-11	Loam----------	CL, CL-ML	A-4, A-6	0	95-100	85-95	75-85	55-70	20-30	5-15
	11-43	Clay loam--------	CL	A-6	0-5	90-95	85-95	70-85	55-75	30-40	15-25
	43-60	Loam, clay loam	CL	A-6, A-7	0-5	90-95	85-95	70-85	55-75	35-45	15-25
192D2---------- Adair	0-9	Clay loam--------	CL	A-6	0	95-100	80-95	75-90	60-80	30-40	10-20
	9-30	Silty clay, clay, clay loam.	CL, CH	A-7	0	95-100	80-95	70-90	55-80	40-55	20-30
	30-60	Clay loam--------	CL	A-6, A-7	0	95-100	80-95	70-90	55-80	35-50	15-25
201B*: Coland----------	0-48	Clay loam--------	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
	48-60	Clay loam, silty clay loam, sandy clay loam.	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
Spillville------	0-46	Loam----------	CL	A-6	0	100	95-100	85-95	60-80	25-40	10-20
	46-60	Sandy clay loam, loam, sandy loam.	CL, CL-ML, SM-SC, SC	A-6, A-4	0	100	95-100	80-90	35-75	20-40	5-15
203---------- Cylinder	0-13	Loam----------	CL	A-6, A-7	0	100	90-100	80-100	50-75	30-50	10-25
	13-28	Loam, clay loam	CL, SC	A-6	0	95-100	80-100	80-95	45-70	30-40	10-20
	28-60	Gravelly coarse sand, loamy sand, gravelly loam.	SP-SM, SM	A-1, A-2, A-3	0-10	75-95	75-95	20-55	5-25	---	NP
236C---------- Lester	0-10	Loam----------	ML, CL	A-6, A-4	0	95-100	90-100	80-95	50-70	30-40	5-15
	10-43	Clay loam, loam	CL	A-7, A-6	0-5	95-100	90-100	80-95	55-75	35-50	15-25
	43-60	Loam, clay loam	CL, CL-ML	A-6, A-4	0-5	95-100	90-100	75-90	50-70	20-40	5-20
259---------- Biscay	0-10	Loam----------	CL, ML	A-7, A-6	0	95-100	95-100	70-90	50-75	35-50	10-25
	10-35	Sandy clay loam, clay loam.	CL, ML	A-6, A-7	0	95-100	90-100	70-90	50-75	30-50	10-20
	35-60	Stratified loamy sand to gravelly coarse sand.	SP, SP-SM, GP, GP-GM	A-1	0-5	45-95	35-95	20-45	2-10	---	NP
268C, 268D2, 268E2---------- Knox	0-14	Silt loam--------	CL-ML, CL	A-4	0	100	100	95-100	90-100	20-30	5-10
	14-44	Silty clay loam, silt loam.	CL	A-6	0	100	100	95-100	95-100	30-40	10-20
	44-60	Silt loam--------	CL-ML, CL	A-4, A-6	0	100	100	95-100	90-100	25-35	5-15
308, 308B-------- Wadena	0-17	Loam----------	ML	A-4	0	95-100	80-100	75-95	50-65	25-40	2-10
	17-29	Loam, sandy loam, sandy clay loam.	SM, ML, CL, SC	A-4, A-6	0	95-100	80-100	75-95	40-60	25-40	5-12
	29-60	Sand and gravel, gravelly loamy sand.	SP, SP-SM, GP, GP-GM	A-1, A-3, A-2	0-5	45-100	40-95	10-80	2-10	---	NP
430---------- Ackmore	0-30	Silt loam, silty clay loam.	CL, ML MH, CH	A-4, A-6, A-7	0	100	100	95-100	85-100	25-60	8-30
	30-60	Silty clay loam, silt loam.	CH, CL, MH, ML	A-7, A-6	0	100	100	95-100	85-100	35-60	15-30

See footnote at end of table.

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
485, 485B-------- Spillville	0-46	Loam----------	CL	A-6	0	100	95-100	85-95	60-80	25-40	10-20
	46-60	Sandy clay loam, loam, sandy loam.	CL, CL-ML, SM-SC, SC	A-6, A-4	0	100	95-100	80-90	35-75	20-40	5-15
507-------------- Canisteo	0-8	Silty clay loam	CL	A-7, A-6	0	100	100	90-100	85-100	35-50	15-25
	8-20	Clay loam, loam, silty clay loam.	CL	A-6, A-7	0	98-100	90-100	85-95	65-85	38-50	25-35
	20-27	Clay loam, loam, sandy loam.	CL, ML, SM, SC	A-6, A-4	0-5	90-100	80-95	60-90	40-80	30-40	5-15
	27-60	Clay loam, loam	CL	A-6	0-5	95-100	90-98	80-95	60-75	30-40	12-20
509B------------- Marshall	0-18	Silty clay loam	CL	A-6, A-7	0	100	100	100	95-100	35-50	15-25
	18-58	Silty clay loam	CL	A-7, A-6	0	100	100	100	95-100	35-50	15-25
	58-60	Silt loam--------	CL	A-7, A-6	0	100	100	100	95-100	35-50	15-25
559-------------- Talcot	0-8	Silty clay loam	CL	A-7	0	100	100	80-90	60-85	40-50	15-25
	8-35	Clay loam, silty clay loam, loam.	CL	A-7	0	95-100	85-100	70-90	60-85	40-50	15-25
	35-60	Stratified loamy sand to gravelly coarse sand.	SP, SP-SM, SW	A-1	0	65-90	50-85	20-50	2-10	---	NP
638C2*, 638D2*: Clarion----------	0-8	Loam----------	CL, CL-ML	A-4, A-6	0-5	95-100	95-100	75-90	50-75	25-40	5-15
	8-33	Loam, clay loam	CL, CL-ML	A-4, A-6	0-5	90-100	85-100	75-90	50-75	25-40	5-15
	33-60	Loam, sandy loam	CL, CL-ML, SC, SM-SC	A-4, A-6	0-5	90-100	85-100	75-90	45-70	25-40	5-15
Storden----------	0-8	Loam----------	ML, CL	A-4, A-6	0-5	95-100	95-100	70-85	55-70	30-40	5-15
	8-60	Loam----------	CL-ML, CL	A-4, A-6	0-5	95-100	85-97	70-85	55-70	20-40	5-15
639C*, 639D*: Salida----------	0-7	Gravelly sandy loam.	SM, SP-SM	A-2, A-1	0-5	85-95	60-75	30-60	12-20	---	NP
	7-15	Gravelly loamy sand, gravelly coarse sand, gravelly loamy coarse sand.	SP, SW, GP, GP-GM	A-1	0-5	50-90	40-60	10-30	0-5	---	NP
	15-60	Very gravelly coarse sand, very gravelly sand.	SP, SW, GP, GP-GM	A-1	0-5	20-70	10-60	5-30	0-5	---	NP
Storden----------	0-8	Loam----------	ML, CL	A-4, A-6	0-5	95-100	95-100	70-85	55-70	30-40	5-15
	8-60	Loam----------	CL-ML, CL	A-4, A-6	0-5	95-100	85-97	70-85	55-70	20-40	5-15
733-------------- Calco	0-40	Silty clay loam	CH, CL	A-7	0	100	100	95-100	85-100	40-60	15-30
	40-60	Silty clay loam, loam, clay loam.	CL	A-7, A-6	0	100	100	90-100	80-100	30-45	10-20
822D3------------ Lamoni	0-5	Silty clay loam	CL	A-6, A-7	0	95-100	95-100	80-95	70-95	35-45	15-25
	5-43	Clay loam, clay	CH	A-7	0	95-100	95-100	90-100	85-100	50-60	25-35
	43-60	Clay loam--------	CL	A-6, A-7	0	95-100	95-100	70-90	55-85	35-50	15-30
823-------------- Ridgeport	0-14	Sandy loam-------	SM, SC, SM-SC	A-2, A-4	0	95-100	90-100	70-90	25-50	15-30	2-10
	14-35	Fine sandy loam, gravelly sandy loam.	SM, SC, SM-SC	A-2, A-4	0	95-100	85-100	65-85	20-45	15-30	2-10
	35-60	Gravelly loamy sand, gravelly sand, sand.	SW, SP, SW-SM, SP-SM	A-1	0-5	80-95	75-95	35-50	2-10	<25	NP-6
924D2*, 924E2*: Burchard---------	0-7	Clay loam--------	CL	A-6, A-7	0-5	95-100	95-100	85-95	60-80	35-50	14-24
	7-20	Clay loam--------	CL	A-6, A-7	0-5	95-100	90-100	85-95	65-80	35-50	20-30
	20-60	Clay loam--------	CL	A-6, A-7	0-5	95-100	90-100	85-95	60-80	35-50	15-30

See footnote at end of table.

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Frag-ments > 3 inches	Percentage passing sieve number--				Liquid limit	Plas-ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
924D2*, 924E2*:											
Adair----------	0-9	Clay loam--------	CL	A-6	0	95-100	80-95	75-90	60-80	30-40	10-20
	9-30	Silty clay, clay, clay loam.	CL, CH	A-7	0	95-100	80-95	70-90	55-80	40-55	20-30
	30-60	Clay loam--------	CL	A-6, A-7	0	95-100	80-95	70-90	55-80	35-50	15-25
993D2*, 993E2*:											
Gara----------	0-6	Loam----------	CL, CL-ML	A-4, A-6	0	95-100	85-95	75-85	55-70	20-30	5-15
	6-40	Clay loam--------	CL	A-6	0-5	90-95	85-95	70-85	55-75	30-40	15-25
	40-60	Loam, clay loam	CL	A-6, A-7	0-5	90-95	85-95	70-85	55-75	35-45	15-25
Armstrong-------	0-7	Loam----------	CL, CL-ML	A-6, A-4	0-5	90-100	80-95	75-90	55-80	20-30	5-15
	7-42	Clay loam, clay, silty clay loam.	CL, CH	A-7	0-5	90-100	80-95	70-90	55-80	45-60	20-30
	42-60	Clay loam--------	CL	A-6	0-5	90-100	80-95	70-90	55-80	30-40	15-20
2315*. Fluvaquents											
5010*. Pits											
5040*. Orthents											

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 16.--PHYSICAL AND CHEMICAL PROPERTIES OF 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		Wind erodibility group	Organic matter
								K	T		
	In	Pct	G/cm3	In/hr	In/in	pH					Pct
1C3, 1D3--- Ida	0-60	18-25	1.20-1.30	0.6-2.0	0.20-0.22	6.6-8.4	Low	0.43	5-4	4L	.5-1
5B*:											
Ackmore---	0-30	25-35	1.25-1.30	0.6-2.0	0.21-0.23	5.6-7.3	Moderate	0.37	5	6	2-4
	30-60	26-35	1.30-1.40	0.6-2.0	0.18-0.20	5.6-7.8	High	0.37			
Judson---	0-25	25-32	1.30-1.35	0.6-2.0	0.21-0.23	6.1-7.3	Moderate	0.28	5	7	4-5
	25-60	30-35	1.35-1.45	0.6-2.0	0.21-0.23	6.1-7.3	Moderate	0.43			
6--- Okoboji	0-27	35-42	1.25-1.30	0.2-0.6	0.21-0.23	6.6-7.8	High	0.37	5	4	9-10
	27-49	35-42	1.30-1.35	0.2-0.6	0.18-0.20	6.6-7.8	High	0.37			
	49-60	20-30	1.40-1.50	0.6-2.0	0.18-0.20	7.4-8.4	Moderate	0.28			
8B, 8C--- Judson	0-25	25-32	1.30-1.35	0.6-2.0	0.21-0.23	5.6-7.3	Moderate	0.28	5	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			
9, 9B, 9B2, 9C, 9C2, 9D2, 9E2--- Marshall	0-18	27-35	1.25-1.30	0.6-2.0	0.21-0.23	5.6-7.3	Moderate	0.32	5	7	2-4
	18-58	27-34	1.30-1.35	0.6-2.0	0.18-0.20	5.6-7.3	Moderate	0.43			
	58-60	22-27	1.30-1.40	0.6-2.0	0.20-0.22	6.6-7.3	Moderate	0.43			
11B*:											
Colo---	0-38	27-32	1.28-1.32	0.6-2.0	0.21-0.23	5.6-7.3	High	0.28	5	7	5-7
	38-60	30-35	1.25-1.35	0.6-2.0	0.18-0.20	6.1-7.3	High	0.28			
Judson---	0-25	25-32	1.30-1.35	0.6-2.0	0.21-0.23	6.1-7.3	Moderate	0.28	5	7	4-5
	25-60	30-35	1.35-1.45	0.6-2.0	0.21-0.23	6.1-7.3	Moderate	0.43			
27B, 27C--- Terril	0-32	18-26	1.35-1.40	0.6-2.0	0.20-0.22	6.1-7.3	Low	0.24	5	6	4-5
	32-60	17-32	1.45-1.70	0.6-2.0	0.16-0.18	6.1-7.8	Low	0.32			
28B, 28B2, 28C2, 28D2--- Dickman	0-6	6-18	1.30-1.40	2.0-6.0	0.13-0.15	5.6-6.5	Low	0.20	3	3	1-5
	6-31	6-18	1.35-1.50	2.0-6.0	0.12-0.14	5.6-7.3	Low	0.20			
	31-60	1-10	1.50-1.60	6.0-20	0.02-0.07	5.6-7.8	Low	0.15			
34B, 34C2--- Estherville	0-6	5-15	1.25-1.35	2.0-6.0	0.13-0.18	5.6-7.3	Low	0.20	3	3	1-4
	6-15	10-18	1.35-1.60	2.0-6.0	0.09-0.14	5.6-7.3	Low	0.20			
	15-60	0-8	1.50-1.65	6.0-20	0.02-0.04	6.6-8.4	Low	0.10			
48--- Knoke	0-9	20-26	1.10-1.20	0.6-2.0	0.24-0.26	7.4-8.4	Moderate	0.28	5	6	10-20
	9-19	27-36	1.30-1.40	0.2-0.6	0.21-0.23	7.4-8.4	High	0.37			
	19-60	35-45	1.35-1.45	0.2-0.6	0.18-0.20	7.4-8.4	High	0.37			
54--- Zook	0-18	32-38	1.30-1.35	0.2-0.6	0.21-0.23	5.6-7.3	High	0.28	5	7	5-7
	18-60	36-45	1.30-1.45	0.06-0.2	0.11-0.13	5.6-7.8	High	0.28			
55--- Nicollet	0-16	24-35	1.15-1.25	0.6-2.0	0.17-0.22	5.6-7.3	Moderate	0.24	5	6	4-8
	16-37	24-35	1.25-1.35	0.6-2.0	0.15-0.19	5.6-7.8	Moderate	0.32			
	37-60	22-28	1.35-1.45	0.6-2.0	0.14-0.19	7.4-7.8	Low	0.32			
59C2, 59D2, 59E2, 59F2--- Burchard	0-7	27-35	1.40-1.60	0.2-0.6	0.17-0.19	5.6-7.3	Moderate	0.28	5	6	2-3
	7-20	27-35	1.40-1.60	0.2-0.6	0.15-0.17	6.6-8.4	Moderate	0.28			
	20-60	27-35	1.40-1.60	0.2-0.6	0.14-0.16	7.4-8.4	Moderate	0.28			
62C2, 62D2, 62E2, 62F, 62G--- Storden	0-8	18-27	1.35-1.45	0.6-2.0	0.20-0.22	7.4-8.4	Low	0.28	5	4L	1-2
	8-60	18-27	1.35-1.65	0.6-2.0	0.17-0.19	7.4-8.4	Low	0.37			

See footnote at end of table.

TABLE 16.--PHYSICAL AND CHEMICAL PROPERTIES OF SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors		Wind erodibility group	Organic matter
								K	T		
	In	Pct	G/cm3	In/hr	In/in	pH					Pct
71D2*:											
Marshall--------	0-18	27-35	1.25-1.30	0.6-2.0	0.21-0.23	5.6-7.3	Moderate-----	0.32	5	7	2-4
	18-58	27-34	1.30-1.35	0.6-2.0	0.18-0.20	5.6-7.3	Moderate-----	0.43			
	58-60	22-27	1.30-1.40	0.6-2.0	0.20-0.22	6.6-7.3	Moderate-----	0.43			
Dickman---------	0-6	6-18	1.30-1.40	2.0-6.0	0.13-0.15	5.6-6.5	Low----------	0.20	3	3	1-3
	6-31	6-18	1.35-1.50	2.0-6.0	0.12-0.14	5.6-7.3	Low----------	0.20			
	31-60	1-10	1.50-1.60	6.0-20	0.02-0.07	5.6-7.8	Low----------	0.15			
90----------	0-8	20-26	1.20-1.25	0.6-2.0	0.24-0.26	6.6-7.8	High---------	0.37	5	4	9-18
Okoboji	8-35	35-42	1.30-1.35	0.2-0.6	0.18-0.20	6.6-7.8	High---------	0.37			
	35-60	35-45	1.35-1.40	0.2-0.6	0.18-0.20	7.4-8.4	High---------	0.37			
95----------	0-19	25-35	1.35-1.40	0.6-2.0	0.19-0.21	7.9-8.4	Moderate-----	0.24	5	4L	4-5
Harps	19-36	18-32	1.40-1.50	0.6-2.0	0.17-0.19	7.9-8.4	Moderate-----	0.32			
	36-60	20-26	1.50-1.70	0.6-2.0	0.17-0.19	7.9-8.4	Moderate-----	0.32			
99C2, 99D2, 99E2-	0-8	28-34	1.25-1.35	0.6-2.0	0.21-0.23	5.6-6.5	Moderate-----	0.32	5-4	7	2-3
Exira	8-29	30-35	1.30-1.35	0.6-2.0	0.18-0.20	5.6-6.5	Moderate-----	0.43			
	29-60	20-30	1.35-1.40	0.6-2.0	0.20-0.22	6.1-7.3	Moderate-----	0.43			
107----------	0-12	26-36	1.35-1.40	0.6-2.0	0.19-0.21	6.1-7.3	Moderate-----	0.24	5	6	6-7
Webster	12-45	25-35	1.40-1.50	0.6-2.0	0.16-0.18	6.6-7.8	Moderate-----	0.32			
	45-60	18-29	1.50-1.70	0.6-2.0	0.17-0.19	7.4-8.4	Moderate-----	0.32			
108, 108B, 108C2-	0-17	18-30	1.30-1.50	0.6-2.0	0.20-0.22	6.1-7.3	Low----------	0.24	4	5	2-4
Wadena	17-29	18-30	1.35-1.50	0.6-2.0	0.14-0.19	5.6-7.3	Low----------	0.32			
	29-60	1-5	1.55-1.65	>6.0	0.02-0.04	6.6-8.4	Low----------	0.10			
133----------	0-38	27-32	1.28-1.32	0.6-2.0	0.21-0.23	5.6-7.3	High---------	0.28	5	7	5-7
Colo	38-60	30-35	1.25-1.35	0.6-2.0	0.18-0.20	6.1-7.3	High---------	0.28			
133+----------	0-10	27-32	1.28-1.32	0.6-2.0	0.21-0.23	5.6-7.3	High---------	0.28	5	7	3-5
Colo	10-43	30-35	1.25-1.35	0.6-2.0	0.18-0.20	6.1-7.3	High---------	0.28			
	43-60	30-35	1.35-1.45	0.6-2.0	0.18-0.20	6.1-7.3	High---------	0.28			
135----------	0-48	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	High---------	0.28	5	7	5-7
Coland	48-60	20-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.8	High---------	0.28			
138B, 138B2, 138C, 138C2, 138D2----------	0-14	18-24	1.40-1.45	0.6-2.0	0.20-0.22	5.1-7.3	Low----------	0.28	5	6	2-4
Clarion	14-33	24-30	1.50-1.70	0.6-2.0	0.17-0.19	5.6-7.8	Low----------	0.37			
	33-60	12-22	1.70-1.80	0.6-2.0	0.17-0.19	7.4-8.4	Low----------	0.37			
179E2, 179F, 179F2, 179G-----	0-11	24-27	1.50-1.55	0.6-2.0	0.20-0.22	5.1-7.3	Moderate-----	0.28	5	6	.5-2
Gara	11-43	30-38	1.55-1.75	0.2-0.6	0.16-0.18	4.5-6.5	Moderate-----	0.28			
	43-60	24-38	1.75-1.85	0.2-0.6	0.16-0.18	6.6-7.8	Moderate-----	0.37			
192D2----------	0-9	27-35	1.45-1.50	0.2-0.6	0.17-0.19	5.6-7.3	Moderate-----	0.32	2	6	2-3
Adair	9-30	38-50	1.50-1.60	0.06-0.2	0.13-0.16	5.1-6.5	High---------	0.32			
	30-60	30-38	1.60-1.85	0.2-0.6	0.14-0.16	5.6-7.8	Moderate-----	0.32			
201B*:											
Coland----------	0-48	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	High---------	0.28	5	7	5-7
	48-60	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.8	High---------	0.28			
Spillville------	0-46	18-26	1.45-1.55	0.6-2.0	0.19-0.21	5.6-7.3	Moderate-----	0.28	5	6	5-7
	46-60	14-24	1.55-1.70	0.6-6.0	0.15-0.18	5.6-7.3	Low----------	0.28			
203----------	0-13	22-32	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Moderate-----	0.24	4	6	3-5
Cylinder	13-28	22-30	1.45-1.60	0.6-2.0	0.17-0.19	6.1-7.3	Moderate-----	0.32			
	28-60	2-12	1.60-1.70	>20	0.02-0.04	6.6-8.4	Low----------	0.10			

See footnote at end of table.

TABLE 16.--PHYSICAL AND CHEMICAL PROPERTIES OF SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors		Wind erodibility group	Organic matter
								K	T		
	In	Pct	G/cm^3	In/hr	In/in	pH					Pct
236C----------	0-10	15-27	1.30-1.40	0.6-2.0	0.20-0.22	5.6-6.5	Low----------	0.28	5	6	2-4
Lester	10-43	20-35	1.45-1.55	0.6-2.0	0.15-0.19	5.1-7.3	Moderate------	0.28			
	43-60	20-30	1.55-1.75	0.6-2.0	0.14-0.19	6.6-7.8	Low----------	0.37			
259----------	0-10	18-30	1.20-1.30	0.6-2.0	0.20-0.22	6.1-7.8	Moderate------	0.28	4	6	4-8
Biscay	10-35	18-30	1.25-1.35	0.6-2.0	0.17-0.19	6.6-7.8	Moderate------	0.28			
	35-60	1-6	1.55-1.65	6.0-20	0.02-0.04	6.6-8.4	Low----------	0.10			
268C, 268D2, 268E2----------	0-14	18-27	1.20-1.30	0.6-2.0	0.22-0.24	5.1-7.3	Low----------	0.32	5	6	1-3
Knox	14-44	25-35	1.30-1.40	0.6-2.0	0.18-0.20	5.6-7.3	Moderate------	0.43			
	44-60	18-27	1.20-1.40	0.6-2.0	0.20-0.22	5.6-7.3	Low----------	0.43			
308, 308B----------	0-17	18-30	1.30-1.50	0.6-2.0	0.20-0.22	6.1-7.3	Low----------	0.24	4	5	3-4
Wadena	17-29	18-30	1.35-1.50	0.6-2.0	0.14-0.19	5.6-7.3	Low----------	0.32			
	29-60	1-5	1.55-1.65	>6.0	0.02-0.04	6.1-8.4	Low----------	0.10			
430----------	0-30	25-35	1.25-1.30	0.6-2.0	0.21-0.23	5.6-7.3	Moderate------	0.37	5	6	2-4
Ackmore	30-60	26-35	1.30-1.40	0.6-2.0	0.18-0.20	5.6-7.8	High----------	0.37			
485, 485B----------	0-46	18-26	1.45-1.55	0.6-2.0	0.19-0.21	5.6-7.3	Moderate------	0.28	5	6	5-7
Spillville	46-60	14-24	1.55-1.70	0.6-6.0	0.15-0.18	5.6-7.3	Low----------	0.28			
507----------	0-8	18-35	1.20-1.30	0.6-2.0	0.20-0.22	7.4-6.4	Moderate------	0.32	5	4L	4-6
Canisteo	8-20	20-35	1.35-1.50	0.6-2.0	0.15-0.19	7.4-8.4	Moderate------	0.32			
	20-27	10-35	1.30-1.50	0.6-6.0	0.12-0.18	7.4-8.4	Low----------	0.32			
	27-60	22-32	1.45-1.60	0.6-2.0	0.14-0.16	7.4-8.4	Low----------	0.32			
509B----------	0-18	27-35	1.25-1.30	0.6-2.0	0.21-0.23	5.6-7.3	Moderate------	0.32	5	7	3-4
Marshall	18-58	27-34	1.30-1.35	0.6-2.0	0.18-0.20	5.6-7.3	Moderate------	0.43			
	58-60	22-27	1.30-1.40	0.6-2.0	0.20-0.22	6.6-7.3	Moderate------	0.43			
559----------	0-8	27-35	1.20-1.30	0.6-2.0	0.18-0.22	7.4-8.4	Moderate------	0.28	4	7	4-8
Talcot	8-35	25-35	1.25-1.35	0.6-2.0	0.17-0.20	7.4-8.4	Moderate------	0.28			
	35-60	1-6	1.55-1.65	6.0-20	0.02-0.04	7.4-8.4	Low----------	0.15			
638C2*, 638D2*:											
Clarion---------	0-8	18-24	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Low----------	0.28	5	6	1-2
	8-33	24-30	1.50-1.70	0.6-2.0	0.17-0.19	5.6-7.8	Low----------	0.37			
	33-60	12-22	1.70-1.80	0.6-2.0	0.17-0.19	7.4-8.4	Low----------	0.37			
Storden---------	0-8	18-27	1.35-1.45	0.6-2.0	0.20-0.22	7.4-8.4	Low----------	0.28	5	4L	1-2
	8-60	18-27	1.35-1.65	0.6-2.0	0.17-0.19	7.4-8.4	Low----------	0.37			
639C*, 639D*:											
Salida----------	0-7	5-15	1.35-1.45	2.0-6.0	0.10-0.12	6.1-8.4	Low----------	0.10	3	8	.5-1
	7-15	2-8	1.50-1.65	>20	0.02-0.04	7.4-8.4	Low----------	0.10			
	15-60	0-5	1.50-1.65	>20	0.02-0.04	7.4-8.4	Low----------	0.10			
Storden---------	0-8	18-27	1.35-1.45	0.6-2.0	0.20-0.22	7.4-8.4	Low----------	0.28	5	4L	1-2
	8-60	18-27	1.35-1.65	0.6-2.0	0.17-0.19	7.4-8.4	Low----------	0.37			
733----------	0-40	28-33	1.25-1.30	0.6-2.0	0.21-0.23	7.4-8.4	High----------	0.28	5	7	5-7
Calco	40-60	22-32	1.30-1.45	0.6-2.0	0.18-0.20	7.4-8.4	Moderate------	0.28			
822D3----------	0-5	27-38	1.45-1.50	0.2-0.6	0.17-0.21	5.1-7.3	Moderate------	0.32	2	7	1-2
Lamoni	5-43	38-50	1.55-1.75	<0.2	0.13-0.17	5.1-7.3	High----------	0.32			
	43-60	32-40	1.75-1.85	0.06-0.2	0.14-0.18	6.1-7.3	High----------	0.32			
823----------	0-14	10-18	1.50-1.55	2.0-6.0	0.14-0.17	5.6-7.3	Low----------	0.24	4	3	1-3
Ridgeport	14-35	10-18	1.55-1.60	2.0-6.0	0.10-0.14	5.6-7.3	Low----------	0.24			
	35-60	2-8	1.60-1.75	>20	0.03-0.05	7.4-8.4	Low----------	0.10			

See footnote at end of table.

TABLE 16.--PHYSICAL AND CHEMICAL PROPERTIES OF SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors		Wind erodibility group	Organic matter
								K	T		
	In	Pct	G/cm³	In/hr	In/in	pH					Pct
924D2*, 924E2*:											
Burchard	0-7	27-35	1.40-1.60	0.2-0.6	0.17-0.19	5.6-7.3	Moderate	0.28	5	6	1-3
	7-20	27-35	1.40-1.60	0.2-0.6	0.15-0.17	6.6-8.4	Moderate	0.28			
	20-60	27-35	1.40-1.60	0.2-0.6	0.14-0.16	7.4-8.4	Moderate	0.28			
Adair	0-9	27-35	1.45-1.50	0.2-0.6	0.17-0.19	5.6-7.3	Moderate	0.32	2	6	1-3
	9-30	38-50	1.50-1.60	0.06-0.2	0.13-0.16	5.1-6.5	High	0.32			
	30-60	30-38	1.60-1.85	0.2-0.6	0.14-0.16	5.6-7.8	Moderate	0.32			
993D2*, 993E2*:											
Gara	0-6	24-27	1.50-1.55	0.6-2.0	0.20-0.22	5.1-7.3	Moderate	0.28	5	6	.5-1.5
	6-40	30-38	1.55-1.75	0.2-0.6	0.16-0.18	4.5-6.5	Moderate	0.28			
	40-60	24-38	1.75-1.85	0.2-0.6	0.16-0.18	6.6-7.8	Moderate	0.37			
Armstrong	0-7	22-27	1.45-1.50	0.6-2.0	0.20-0.22	5.6-7.3	Moderate	0.32	3	6	.5-1.5
	7-42	36-48	1.45-1.55	0.06-0.2	0.11-0.16	4.5-6.5	High	0.32			
	42-60	30-36	1.55-1.75	0.2-0.6	0.14-0.16	5.1-7.8	Moderate	0.32			
2315*. Fluvaquents											
5010*. Pits											
5040*. Orthents											

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 17.--SOIL AND WATER FEATURES

[The definitions of "flooding" and "water table" in the Glossary explain terms such as "rare," "brief," "apparent," and "perched." The symbol > means more than. Absence of an entry indicates that the feature is not a concern]

Soil name and map symbol	Hydrologic group	Flooding			High water table			Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months		Uncoated steel	Concrete
					Ft					
1C3, 1D3---------- Ida	B	None--------	---	---	>6.0	---	---	High-----	Low------	Low.
5B*: Ackmore----------	B	Occasional	Very brief to brief.	Sep-Jun	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Low.
Judson----------	B	None--------	---	---	>6.0	---	---	High-----	Moderate	Low.
6---------- Okoboji	B/D	None--------	---	---	+1-1.0	Apparent	Nov-Jul	High-----	High-----	Low.
8B, 8C---------- Judson	B	None--------	---	---	>6.0	---	---	High-----	Moderate	Low.
9, 9B, 9B2, 9C, 9C2, 9D2, 9E2---- Marshall	B	None--------	---	---	>6.0	---	---	High-----	Moderate	Moderate.
11B*: Colo----------	B/D	Occasional	Very brief to long.	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Moderate.
Judson----------	B	None--------	---	---	>6.0	---	---	High-----	Moderate	Low.
27B, 27C---------- Terril	B	None--------	---	---	>6.0	---	---	Moderate	Moderate	Low.
28B, 28B2, 28C2, 28D2---------- Dickman	A	None--------	---	---	>6.0	---	---	Low------	Low------	Moderate.
34B, 34C2--------- Estherville	B	None--------	---	---	>6.0	---	---	Low------	Low------	Low.
48---------- Knoke	B/D	None--------	---	---	+1-1.0	Apparent	Nov-Jul	High-----	High-----	Low.
54---------- Zook	C/D	Frequent----	Brief to long.	Feb-Nov	1.0-3.0	Apparent	Nov-May	High-----	High-----	Moderate.
55---------- Nicollet	B	None--------	---	---	2.5-5.0	Apparent	Nov-Jul	High-----	High-----	Low.
59C2, 59D2, 59E2, 59F2---------- Burchard	B	None--------	---	---	>6.0	---	---	Moderate	Moderate	Low.
62C2, 62D2, 62E2, 62F, 62G--------- Storden	B	None--------	---	---	>6.0	---	---	Moderate	Low------	Low.
71D2*: Marshall---------	B	None--------	---	---	>6.0	---	---	High-----	Moderate	Moderate.
Dickman----------	A	None--------	---	---	>6.0	---	---	Low------	Low------	Moderate.
90---------- Okoboji	B/D	None--------	---	---	+1-1.0	Apparent	Nov-Jul	High-----	High-----	Low.
95---------- Harps	B/D	None--------	---	---	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Low.

See footnote at end of table.

TABLE 17.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydrologic group	Flooding			High water table			Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months		Uncoated steel	Concrete
					Ft					
99C2, 99D2, 99E2--Exira	B	None	---	---	>6.0	---	---	High	Moderate	Moderate.
107--Webster	B/D	None	---	---	1.0-2.0	Apparent	Nov-Jul	High	High	Low.
108, 108B, 108C2--Wadena	B	None	---	---	>6.0	---	---	Low	Low	Low.
133, 133+--Colo	B/D	Frequent	Very brief to long.	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High	High	Moderate.
135--Coland	B/D	Frequent	Brief	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High	High	Low.
138B, 138B2, 138C, 138C2, 138D2--Clarion	B	None	---	---	>6.0	---	---	Moderate	Low	Low.
179E2, 179F, 179F2, 179G--Gara	C	None	---	---	>6.0	---	---	Moderate	Moderate	Moderate.
192D2--Adair	D	None	---	---	1.0-3.0	Perched	Nov-Jul	High	High	Moderate.
201B*:										
Coland	B/D	Occasional	Brief	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High	High	Low.
Spillville	B	Occasional	Very brief	Feb-Nov	3.0-5.0	Apparent	Nov-Jul	Moderate	High	Moderate.
203--Cylinder	B	None	---	---	2.0-4.0	Apparent	Nov-Jul	High	Moderate	Low.
236C--Lester	B	None	---	---	>6.0	---	---	Moderate	Low	Moderate.
259--Biscay	B/D	None	---	---	1.0-3.0	Apparent	Nov-Jul	High	Moderate	Low.
268C, 268D2, 268E2--Knox	B	None	---	---	>6.0	---	---	High	Low	Low.
308, 308B--Wadena	B	None	---	---	>6.0	---	---	Low	Low	Low.
430--Ackmore	B	Frequent	Very brief to brief.	Sep-Jun	1.0-3.0	Apparent	Nov-Jul	High	High	Low.
485, 485B--Spillville	B	Occasional	Very brief	Feb-Nov	3.0-5.0	Apparent	Nov-Jul	Moderate	High	Moderate.
507--Canisteo	C/D	None	---	---	1.0-3.0	Apparent	Nov-Jul	High	High	Low.
509B--Marshall	B	None	---	---	>6.0	---	---	High	Moderate	Moderate.
559--Talcot	B/D	None	---	---	1.0-2.5	Apparent	Apr-Jul	High	High	Low.
638C2*, 638D2*:										
Clarion	B	None	---	---	>6.0	---	---	Moderate	Low	Low.
Storden	B	None	---	---	>6.0	---	---	Moderate	Low	Low.
639C*, 639D*:										
Salida	A	None	---	---	>6.0	---	---	Low	Low	Low.

See footnote at end of table.

TABLE 17.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydrologic group	Flooding			High water table			Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months		Uncoated steel	Concrete
					Ft					
639C*, 639D*: Storden	B	None	---	---	>6.0	---	---	Moderate	Low	Low.
733 Calco	B/D	Frequent	Brief	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High	High	Low.
822D3 Lamoni	D	None	---	---	1.0-3.0	Perched	Nov-Jul	Moderate	High	Moderate.
823 Ridgeport	B	None to rare	---	---	>6.0	---	---	Low	Low	Low.
924D2*, 924E2*: Burchard	B	None	---	---	>6.0	---	---	Moderate	Moderate	Low.
Adair	D	None	---	---	1.0-3.0	Perched	Nov-Jul	High	High	Moderate.
993D2*, 993E2*: Gara	C	None	---	---	>6.0	---	---	Moderate	Moderate	Moderate.
Armstrong	D	None	---	---	1.0-3.0	Perched	Nov-Jul	High	High	Moderate.
2315*. Fluvaquents										
5010*. Pits										
5040*. Orthents										

* 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
Ackmore	Fine-silty, mixed, nonacid, mesic Aeric Fluvaquents
*Adair	Fine, montmorillonitic, mesic Aquic Argiudolls
Armstrong	Fine, montmorillonitic, mesic Aquollic Hapludalfs
Biscay	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Typic Haplaquolls
Burchard	Fine-loamy, mixed, mesic Typic Argiudolls
Calco	Fine-silty, mixed (calcareous), mesic Cumulic Haplaquolls
Canisteo	Fine-loamy, mixed (calcareous), mesic Typic Haplaquolls
Clarion	Fine-loamy, mixed, mesic Typic Hapludolls
Coland	Fine-loamy, mixed, mesic Cumulic Haplaquolls
Colo	Fine-silty, mixed, mesic Cumulic Haplaquolls
Cylinder	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Aquic Hapludolls
Dickman	Sandy, mixed, mesic Typic Hapludolls
Estherville	Sandy, mixed, mesic Typic Hapludolls
*Exira	Fine-silty, mixed, mesic Typic Hapludolls
Fluvaquents	Sandy and loamy, mixed, mesic Fluvaquents
Gara	Fine-loamy, mixed, mesic Mollic Hapludalfs
Harps	Fine-loamy, mesic Typic Calciaquolls
Ida	Fine-silty, mixed (calcareous), mesic Typic Udorthents
Judson	Fine-silty, mixed, mesic Cumulic Hapludolls
Knoke	Fine, montmorillonitic (calcareous), mesic Cumulic Haplaquolls
Knox	Fine-silty, mixed, mesic Mollic Hapludalfs
*Lamoni	Fine, montmorillonitic, mesic Aquic Argiudolls
Lester	Fine-loamy, mixed, mesic Mollic Hapludalfs
Marshall	Fine-silty, mixed, mesic Typic Hapludolls
Nicollet	Fine-loamy, mixed, mesic Aquic Hapludolls
Okoboji	Fine, montmorillonitic, mesic Cumulic Haplaquolls
Orthents	Loamy, mixed, mesic Udorthents
Ridgeport	Coarse-loamy, mixed, mesic Typic Hapludolls
Salida	Sandy-skeletal, mixed, mesic Entic Hapludolls
Spillville	Fine-loamy, mixed, mesic Cumulic Hapludolls
Storden	Fine-loamy, mixed (calcareous), mesic Typic Udorthents
Talcot	Fine-loamy over sandy or sandy-skeletal, mixed (calcareous), mesic Typic Haplaquolls
Terril	Fine-loamy, mixed, mesic Cumulic Hapludolls
Wadena	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Typic Hapludolls
Webster	Fine-loamy, mixed, mesic Typic Haplaquolls
Zook	Fine, montmorillonitic, mesic Cumulic Haplaquolls

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