United States
Department of
Agriculture

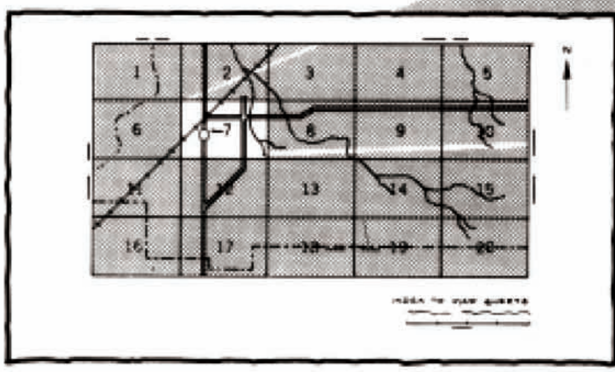
Soil
Conservation
Service

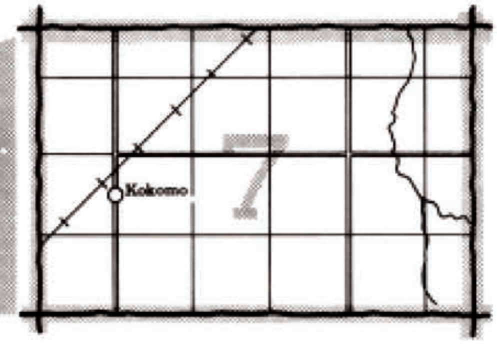
In Cooperation with
Iowa Agriculture and
Home Economics
Experiment Station;
Cooperative Extension
Service, Iowa State
University; and Department
of Soil Conservation,
State of Iowa

Soil Survey of Kossuth County Iowa

HOW TO USE

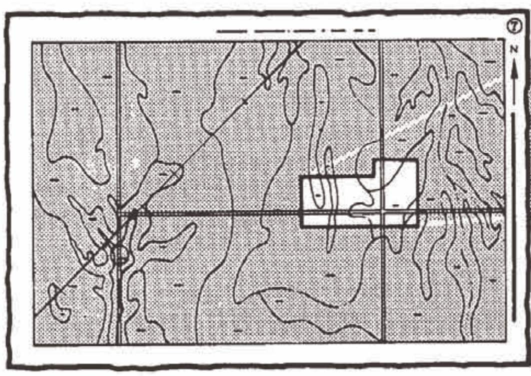
1. Locate your area of interest on the "Index to Map Sheets"

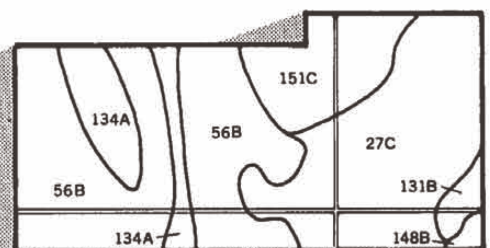




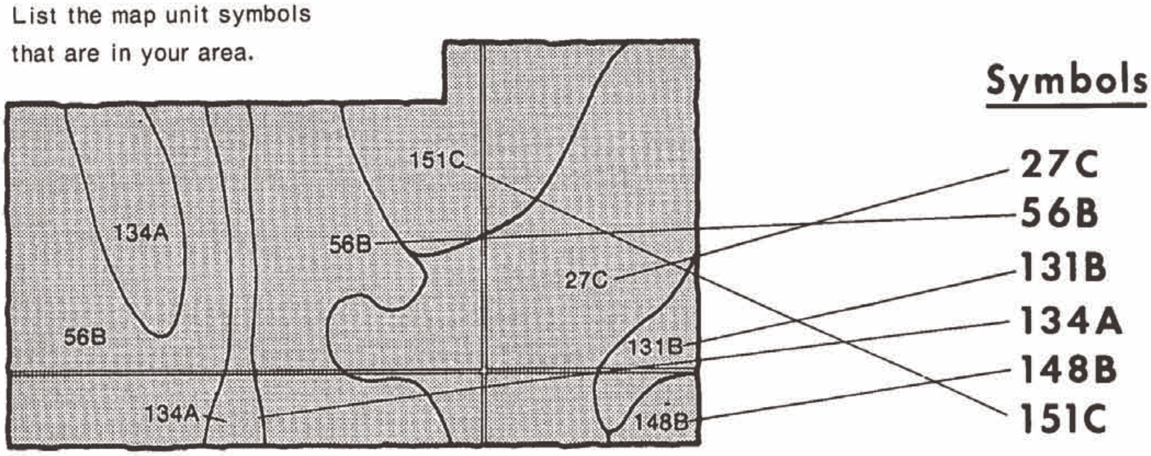
2. Note the number of the map sheet and turn to that sheet.

3. Locate your area of interest on the map sheet.



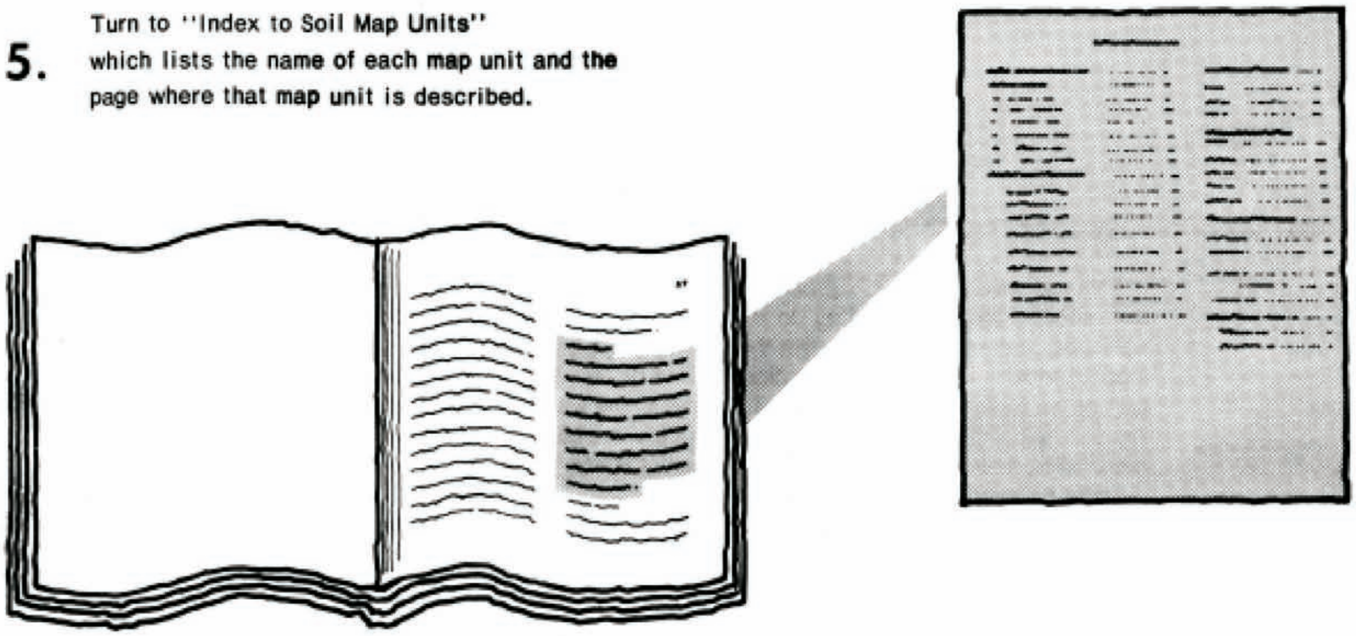


4. List the map unit symbols that are in your area.

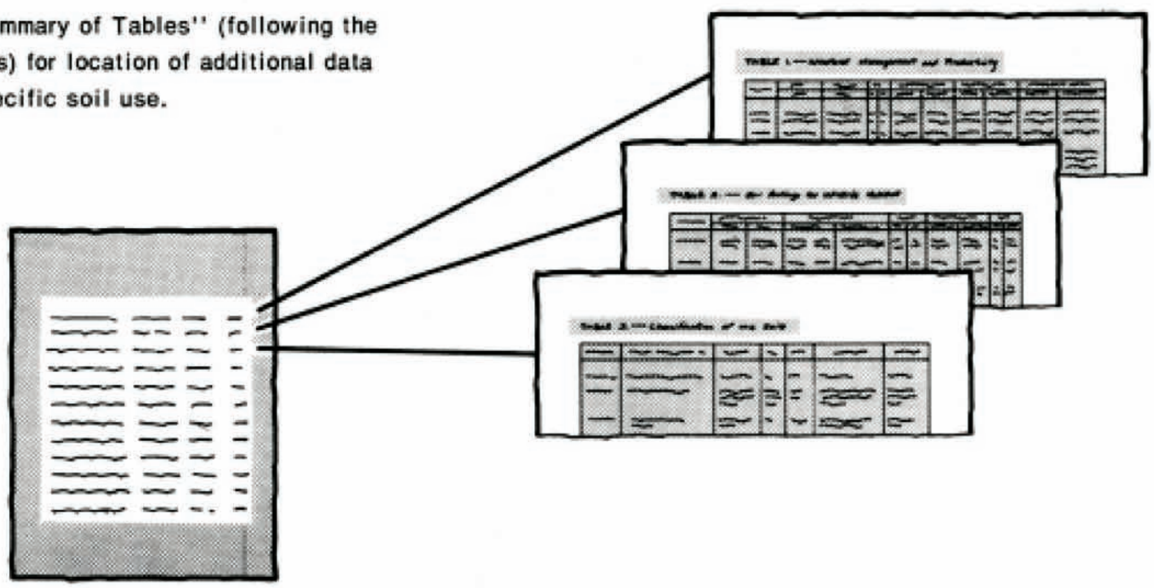


THIS SOIL SURVEY

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.

Major fieldwork for this soil survey was performed in the period 1972-1978. Soil names and descriptions were approved in 1979. Unless otherwise indicated, statements in this publication refer to conditions in the survey area in 1979. This survey was made cooperatively by the Soil Conservation Service; the Iowa Agriculture and Home Economics Experiment Station; the Cooperative Extension Service, Iowa State University; and the Department of Soil Conservation, State of Iowa. It is part of the technical assistance furnished to the Kossuth County Soil Conservation District. Funds appropriated by Kossuth County were used to defray part of the cost of the survey.

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.

This survey supersedes the soil survey of Kossuth County published in 1925 (*16*).

Cover: Corn and soybeans on Nicollet loam, 1 to 3 percent slopes. In most areas, this soil is intensively row cropped.

Contents

soil series

Issued January 1983

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Summary of tables

Preface

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

This soil survey is designed for many different users. Farmers 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
Kossuth County, Iowa

By Robert G. Jones, Soil Conservation Service

Fieldwork by Robert G. Jones, Rodney L. Jensen, Willie D. Bragg,
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Robert W. Wilson, and Daniel T. Muhs
Soil Conservation Service

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

General nature of the survey area

KOSSUTH COUNTY is in the north-central part of Iowa (fig. 1). It has a total area of 626,560 acres, or 979 square miles. Algona, the county seat, is in the south-central part of the county.

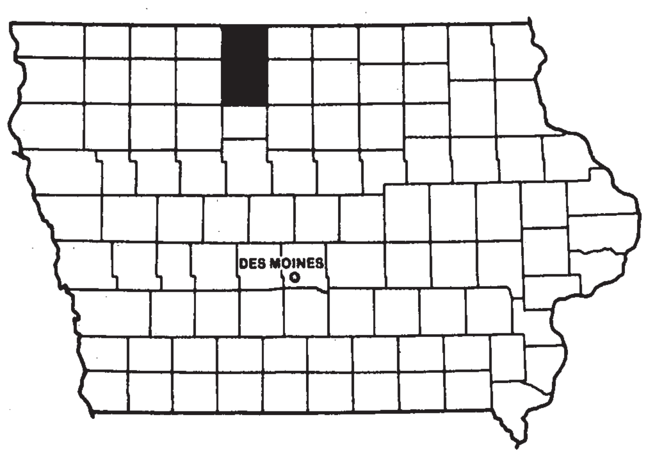


Figure 1.—Location of Kossuth County in Iowa.

Settlement of Kossuth County began in 1855. The population was 26,630 in 1940 but had declined to 24,481 by 1970.

Farming is the main enterprise in Kossuth County. The principal crops are corn and soybeans. Oats, hay, and pasture are also important crops, but to a lesser extent. These crops, along with beef cattle and hog production, are the principal sources of income. Dairy and poultry products are additional important sources of income.

Large deposits of sand and gravel along the East Fork Des Moines River and in a few glacial outwash areas are mined for commercial use.

Climate

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

Kossuth County is cold in winter and is quite hot with occasional cool spells in summer. Precipitation during the winter frequently occurs as snowstorms. During the warm months, it is mainly showers, often heavy, that occur when warm, moist air moves in from the south. The total annual rainfall is normally adequate for corn, soybeans, and small grain.

Table 1 gives data on temperature and precipitation for the survey area as recorded at Algona in the period 1951 to 1973. 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 19 degrees F, and the average daily minimum temperature is 9 degrees. The lowest temperature on record, which occurred at Algona on January 21, 1970, is -21 degrees. In summer the average temperature is 71 degrees, and the average daily maximum temperature is 83 degrees. The highest recorded temperature, which occurred at Algona on July 31, 1955, is 101 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 29.22 inches. Of this, 21 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 7.17 inches at Algona on August 31, 1962. Thunderstorms occur on about 50 days each year, and most occur in summer.

Average seasonal snowfall is 38 inches. The greatest snow depth at any one time during the period of record was 31 inches. On an average of 30 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 55 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 cause sparse damage in narrow belts. Hailstorms occur at times during the warmer part of the year in irregular patterns and in relatively small areas.

Transportation

Transportation facilities are mostly adequate for existing and any likely new enterprises. Every farm in the county is served by a graded and surfaced road. Most roads are surfaced with gravel. The main farm-to-market roads are surfaced mainly with bituminous material. All federal and state highways are concrete or concrete with a bituminous surface.

Four federal and state highway systems cross the county. Two systems cross most of the county from north to south and two cross from east to west. Another north-south system extends partly across the county on the eastern border and connects to one of the east-west systems. Short spurs extend from the north-south highway system to the towns of Lu Verne and Ledyard, and one spur extends from the east-west highway system to the towns of Titonka and Whittemore. Other towns and settlements not on these systems are served by the county road system.

Several railroads serve parts of the county. The Chicago, Milwaukee, St. Paul, and Pacific Railroad crosses the county from east to west and serves Algona, Whittemore, and Wesley. The Chicago, Rock Island and Pacific also crosses the county from east to west and serves Swea City and Lakota. The Chicago and North Western runs north and south serving Algona, Burt, Ledyard, Irvington, Galbraith, and Lu Verne. Titonka is served by a spur of the Chicago, Rock Island, and Pacific from the east. Lone Rock and Fenton are without rail service.

A small airport is near Algona.

Business and Industry

Industry provides markets for farm products within the county. Every town has at least one feed mill and grain elevator. Packing plants provide hog buying stations at most of the towns, and cattle buyers operate throughout the county. An organized livestock auction is in Algona, and several towns have frozen food locker plants. Industry, most of it in Algona, provides employment for several hundred people.

Businesses that service and sell farm equipment and supplies are throughout the county, as are seed and farm supply businesses. Veterinarian services are readily available.

Water resources

Kossuth County has a good supply of underground water. The wells that are properly drilled rarely fail because of seasonal lack of water or periods of drought. Some wells are less than 100 feet deep, but many are as deep as 300 feet or more. Shallow wells and sand points are dependable sources of water in a few areas where the substratum is gravelly. Water quality is generally good, but a few shallow wells have high nitrate levels.

A few wells in areas where the substratum is gravelly provide water for irrigation of a few acres. A few thousand acres are suitable for irrigation. These areas generally are found bordering the East Fork Des Moines

River and in two outwash areas, one near the town of Whittemore and the other near St. Benedict.

A few springs, seepy areas, and artesian wells are in the county. A few of these have been developed as a source of water for livestock in pasture. Most of these are in the north end of the county.

Goose Lake and Burt Lake and nearby marshy areas are used for hunting. Buffalo Creek State Game Management area and a marsh area north of Union Slough provide hunting opportunities. West Fork Des Moines River, gravel pits, and farm ponds provide fishing and other recreational opportunities. Some fishing is done in Burt Lake. Also, Smith Lake, a manmade facility, provides fishing and other recreational activities. Another manmade lake is privately owned.

Camping and picnic areas have been developed, mostly around Smith Lake and around one large gravel pit area near Whittemore. Further development is possible, and additional manmade lakes could be developed on some sites in the county.

Relief and drainage

The northern three-fourths of the county is dominated by a ground moraine. It is characterized by numerous small depressions and potholes within nearly level to strongly sloping terrain. Union Slough, a major National Wildlife Refuge, is near the center of this area. The strongest relief and roughest land surface, with the exception of areas bordering streams, can be found in the extreme northwest corner of the county. Here, some slopes are steep. Burt Lake, Eagle Lake (dry), Goose Lake, and two or three small marshes are in this area.

The southern one-quarter of the county is mostly a glacial lake plain. Except for areas along streams and in the extreme southwest corner, it is nearly level and mostly free of potholes and depressions. Those that do occur are very shallow, with little change in elevation. This area is several feet lower than the area to the north.

These two areas are separated by the Algona end moraine, which extends from east to west across the lower part of the county (*10*). It is a distinct landscape feature. The Humboldt end moraine extends across the southwest corner of the county. It is not readily discernible, but has a physiographic pattern much like that of the northern part of the county.

To the south, Kossuth County is drained by the East Fork Des Moines River and its tributaries. Four Mile Creek, Plum Creek, Lindner Creek, Buffalo Creek, Purcell Creek, Mud Creek and Black Cat Creek, Calamus Creek, Eddy Creek, Missouri Creek, Lotts Creek, Hine Creek, and Truiner Creek also drain parts of the county to the south, but do not join the East Fork Des Moines River within the county. The East and West Forks, Blue Earth River, South Creek, and Union Slough Outlet provide the major drainage for about the northern one-quarter or less of the county. These streams drain to the north.

In places, the channels of some of these streams have been straightened and deepened. In addition, manmade ditches provide surface drainage and outlets for underground drainage systems.

Farming

The Iowa Agricultural Statistics for 1978 (*4*) shows that the total farmland in Kossuth County was 609,400 acres. Of this land, 526,500 acres was used for harvest row crops, small grain, and hay. Of the remaining 82,900 acres, 16,002 acres was cropland used for pasture. The rest was in permanent pasture, woods, lots, buildings, roads, and idle land.

Corn, with 279,600 acres planted, made up the largest acreage of crops in Kossuth County. The average yield was 94.5 bushels per acre. Soybeans was the second largest crop, with 217,300 acres planted and an average yield of 33.9 bushels per acre. Kossuth County farmers produced an average of 70.9 bushels of oats on 16,200 acres and 13,400 acres of hay of all types.

Beef cattle and hogs are the livestock most extensively raised in Kossuth County. In 1977, 39,500 grain-fed cattle and 362,500 hogs were sold. In the same year, 49,100 sows farrowed. Beef cows totaled 10,200 and milk cows 3,000 in 1978. There were a few sheep and lambs and 224,000 laying hens.

In recent years, the number of farms has declined, but there has been an increase in the size of farms and in the number of people living on farms. In 1978, Kossuth County had 2,100 farms with an average size of 289 acres.

Many farms in the county derive a large part of their income from sales of livestock, especially hogs and beef cattle. Only a few of the farms, however, have beef cows. Most farms are of the cash grain type and derive most of their income from the sale of corn and soybeans. Dairying is a major enterprise on a few farms.

The number of dairy farms has been decreasing in recent years, but the size of the remaining herds has increased. Some poultry is also raised in Kossuth County. A recent trend has been to fewer but larger poultry operations, mainly to laying units. Commercial broiler and turkey production has all but vanished. Sheep are raised on a few farms, and sheep numbers have declined somewhat in recent years.

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, 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 association differ from place to place in slope, depth, drainage, and other characteristics that affect management.

Soil descriptions

1. Kossuth-Canisteo-Ottosen association

Nearly level and very gently sloping, poorly drained and somewhat poorly drained soils that formed in glacial till sediments, lacustrine sediments, and glacial till; on uplands

In this soil association the relief generally is less than 10 feet, but along the fringes it ranges to about 20 feet. The landscape is generally free of depressions. The few depressions in this map unit are shallow and generally do not have the characteristic rim of highly calcareous Harps soil. Most parts of this association do not have a natural drainage pattern but are extensively drained by underground drainage systems. Drainage ditches provide outlets for most of these drains. Some drains extend to small streams that have been deepened to provide adequate outlets. Slopes range from 0 to 3 percent.

This soil association makes up about 11 percent of the county. About 35 percent of the association is Kossuth soils, 25 percent is Canisteo soils, 15 percent is Ottosen soils, and the remaining 25 percent is soils of minor extent (fig. 2).

The poorly drained Kossuth soils are on broad flats that have plane slopes. They are commonly slightly higher on the landscape than the adjacent Canisteo soils and are noncalcareous. The poorly drained Canisteo soils in this association are also mainly on broad flats, but tend to have a slightly concave surface. The somewhat poorly drained Ottosen soils are on slightly convex slopes that rise above the low-lying Kossuth or Canisteo soils.

Typically, the surface layer of the Kossuth soils is black silty clay loam about 9 inches thick. The subsurface layer is black and very dark gray silty clay loam about 14 inches thick. The subsoil is about 17 inches thick. It is olive gray, firm silty clay loam in the upper part and olive gray, mottled, friable clay loam and loam in the lower part. The mottled substratum to a depth of 60 inches is olive gray, calcareous loam.

Typically, the surface layer of the Canisteo soils is black clay loam about 8 inches thick. The subsurface layer is black and very dark gray clay loam about 15 inches thick. The subsoil is about 16 inches thick. It is olive gray, mottled clay loam. The substratum to a depth of about 60 inches is mottled olive gray and light olive gray clay loam. The soil is calcareous throughout the profile.

Typically, the surface layer of the Ottosen soils is black clay loam about 8 inches thick. The subsurface layer is black and very dark grayish brown clay loam about 10 inches thick. The subsoil is about 15 inches thick. It is dark grayish brown, firm clay loam in the upper part and olive gray and olive, mottled, friable clay loam in the lower part. The substratum to a depth of about 60 inches is olive gray, mottled loam.

The soils of minor extent in this association are mostly Okoboji, Bode, Clarion, Nicollet, and Webster soils. The Okoboji soils are very wet soils in depressions and are often ponded in spring and after heavy rains. In this association, the Okoboji and Harps soils are surrounded by Canisteo soils. The higher parts of some of the rises and gentle slopes along the few natural drains are occupied by the well drained Bode clay loam soils. Most of the Clarion, Nicollet, and Webster soils are on the perimeter of this association. The well drained Clarion loam soils are on the highest rises. The somewhat poorly drained Nicollet loam soils are on landscape positions similar to those of the Ottosen soils. The poorly drained Webster soils are on landscape positions similar to those of the Kossuth soils.

This association is well suited to all cultivated crops commonly grown in the county. Yields are generally among the highest in the county, and crops respond well to additions of fertilizer. Most of the acreage of this association is used for row crops. Corn and soybeans

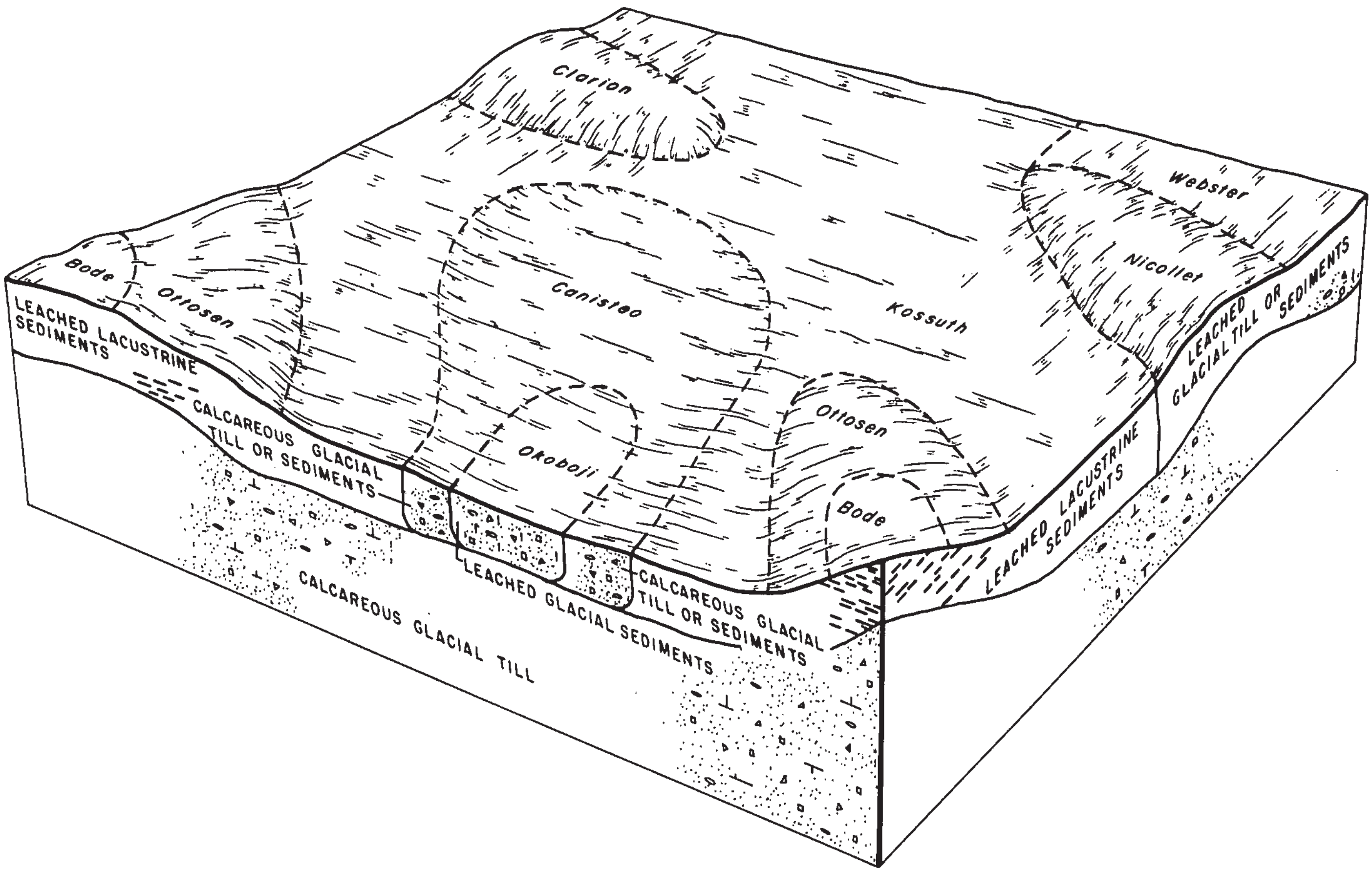


Figure 2.—Pattern of soils and parent materials in the Kossuth-Canisteo-Ottosen association.

are the main crops. Some oats and crops for rotation hay and pasture, mostly alfalfa and alfalfa-grass mixtures, are also grown. A few areas are in native prairie grasses, which are harvested for hay or used as pasture. Organic matter content and available water capacity are high.

The main concerns of cropland management are maintaining and improving drainage and maintaining tilth and fertility. Flooding and ponding are common on some of the minor soils of this association in late winter and early spring and following heavy rains. A few areas of Bode and Clarion soils, particularly those adjacent to drainageways, need water-erosion control practices. Soil blowing is a concern in areas where large tracts are fall plowed and the surface is left bare. Particular attention to fertility needs is necessary on the Harps soils if optimum yields are to be obtained. Most areas are drained, but additional drainage is needed in some places. Because of the high content of clay and low content of sand, the soils of this association remain wet and sticky for long periods following rains. The amount of power required for tillage is higher in this association than in other associations.

2. Nicollet-Canisteo-Webster association

Very gently sloping and nearly level, somewhat poorly drained and poorly drained soils that formed in glacial till sediments and glacial till; on uplands

In this soil association the landscape is that of a gently undulating ground moraine, consisting of swales and rises. Difference in elevation is only about 5 to 10 feet. Slopes are generally short and are steeper in a few places around the many scattered potholes and along the drainageways. Several creeks flow through areas of this association and make good outlets for tile drains. The creeks have narrow and indistinct flood plains. Slopes range from 0 to 3 percent.

This soil association makes up about 23 percent of the county. About 25 percent of the association is Nicollet soils, 20 percent is Canisteo soils, 20 percent is Webster soils, and the remaining 35 percent is soils of minor extent (fig. 3).

The Nicollet soils are somewhat poorly drained. Some areas are on slightly convex rises on broad flats of Canisteo or Webster soils. Other areas are on intermediate levels between the well drained Clarion soils and the poorly drained Canisteo or Webster soils. The Canisteo soils are poorly drained and are on broad flats and in swales. They commonly surround areas of depressional soils. A natural drainage network has not fully developed in areas of Canisteo soils, and surface drainage is slow. The poorly drained Webster soils are also on broad flats and in swales. They are slightly higher on the landscape than the calcareous Canisteo soils.

Typically, the surface layer of the Nicollet soils is black loam about 8 inches thick. The subsurface layer is black and very dark gray loam about 5 inches thick. The mottled subsoil is about 26 inches thick. It is dark grayish brown, friable loam in the upper part and light olive brown, friable loam in the lower part. The substratum is mottled olive loam.

Typically, the surface layer of the Canisteo soils is black clay loam about 8 inches thick. The subsurface layer is black and very dark gray clay loam about 15 inches thick. The subsoil is olive gray mottled clay loam about 16 inches thick. The substratum is olive gray and light olive gray mottled clay loam. The soil is calcareous throughout the profile.

Typically, the surface layer of the Webster soils is black silty clay loam about 8 inches thick. The subsurface layer, about 11 inches thick, is black and very dark gray silty clay loam. The mottled subsoil is about 19 inches thick. The upper part is olive gray silty clay loam, and the lower part is olive gray and gray clay loam. The substratum to a depth of 60 inches is an olive gray and light olive gray, mottled, calcareous loam.

The soils of minor extent in this association are Clarion, Okoboji, Harps, Crippin, and Storden soils. Clarion soils are on knobs. Okoboji soils are very wet

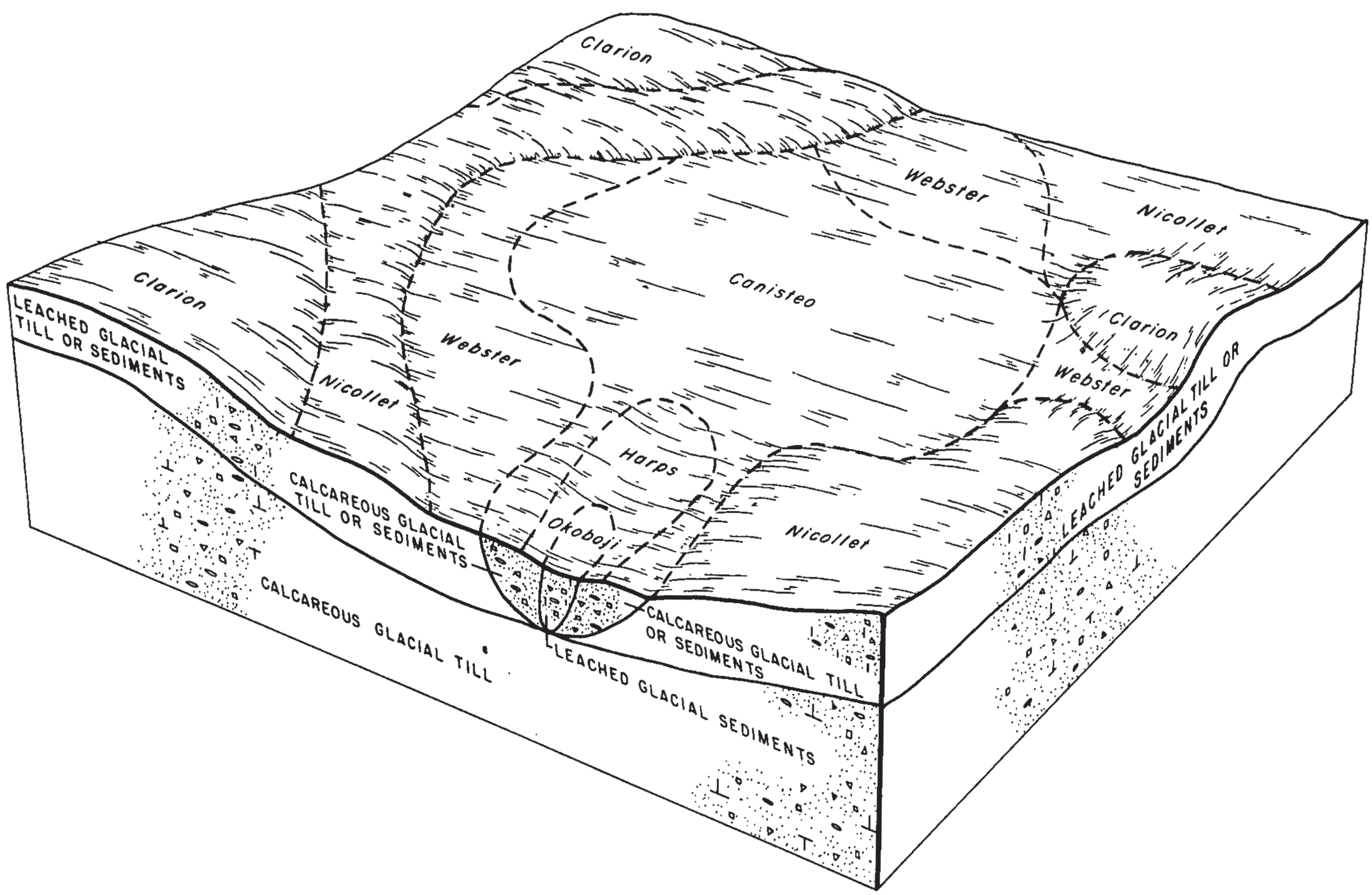


Figure 3.—Pattern of soils and parent materials in the Nicollet-Canisteo-Webster association.

soils in depressions and are commonly ponded in spring and after heavy rains. The nearly level, highly calcareous, poorly drained Harps soils are on rims around depressions. The Okoboji and Harps soils are commonly surrounded by Canisteo soils. The somewhat poorly drained Crippin soils are mainly on slightly convex knolls within large areas of Canisteo soils, but some areas border Okoboji or Harps soils. The well drained Storden soils are on gently sloping to strongly sloping convex side slopes and ridge crests. They typically border drainageways.

This association is well suited to row crops, and most of the acreage is used for crops. Corn and soybeans are the main crops. Some oats and crops for rotation hay and pasture, including alfalfa and alfalfa-grass mixtures, are also grown. Organic matter content and available water capacity are high, except on Clarion soils, which have a moderate content of organic matter. Crops respond well to fertilization.

The main concerns of cropland management are improving drainage and maintaining tilth and fertility. Erosion is a hazard in a few areas of Clarion soils and on the Storden soils. Flooding and ponding are common on some of the minor soils of this association in late winter and early spring and following heavy rains. Low fertility and herbicide carry-over from one year to the next are concerns on the included Harps soils. Most areas are tile drained, but additional tile is needed in places. Soil blowing is a concern in areas where large tracts are fall plowed and the surface is left bare.

3. Clarion-Nicollet-Canisteo association

Moderately sloping to nearly level, well drained, somewhat poorly drained, and poorly drained soils that formed in glacial till sediments and glacial till; on uplands

In this soil association the landscape is that of a gently rolling ground moraine, consisting of swales and rises. Difference in elevation is about 5 to 20 feet. Slopes are steeper in a few places around some of the many scattered potholes and bordering some of the streams and drainageways. Several of the major streams flow

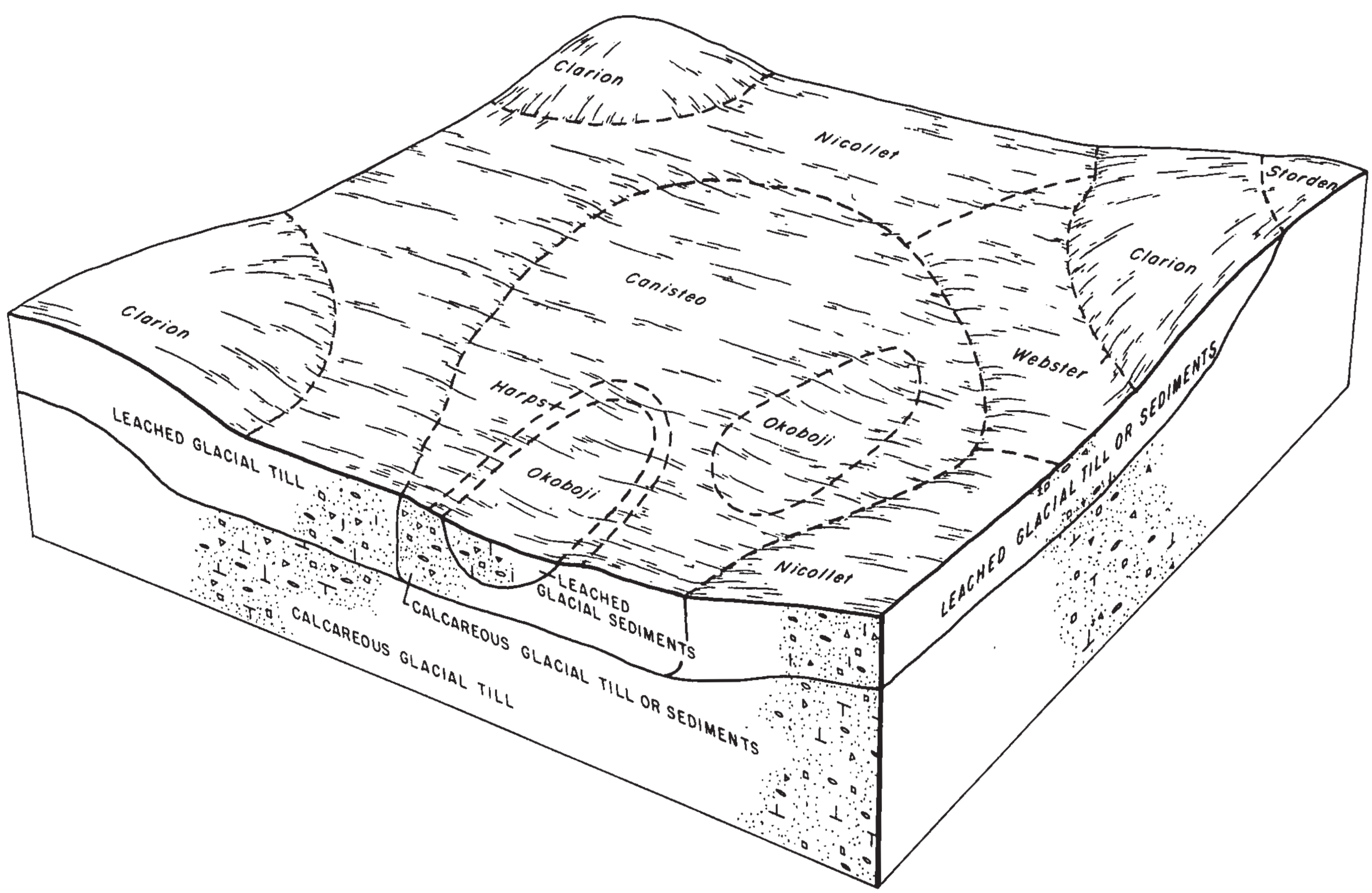


Figure 4.—Pattern of soils and parent materials in the Clarion-Nicollet-Canisteo association.

through areas of this association. Their channels have been straightened and deepened in places and make good outlets for tile drains. Most of the streams have narrow, indistinct flood plains. Slopes range from 0 to 9 percent.

This soil association makes up about 44 percent of the county. About 35 percent of the association is Clarion soils, 20 percent is Nicollet soils, 20 percent is Canisteo soils, and the remaining 25 percent is soils of minor extent (fig. 4).

Clarion soils are well drained and gently undulating to moderately sloping. They are at higher elevations on convex slopes. They are also on low, short-sloped, irregularly shaped ridges that rise above the nearly level Canisteo or Nicollet soils. Nicollet soils are somewhat poorly drained. They are on low, slightly convex rises on broad flats of Canisteo soils. In other areas, Nicollet soils are on intermediate levels between the well drained Clarion soils and the poorly drained Canisteo soils. The poorly drained Canisteo soils are on low, broad flats and in swales. They commonly surround areas of depressional soils. A natural drainage network has not fully developed, and surface drainage is slow.

Typically, the surface layer of the Clarion soils is black loam about 8 inches thick. The subsurface layer is black and very dark brown loam about 8 inches thick. The subsoil is about 18 inches thick. In the upper and middle parts it is dark brown and dark yellowish brown, friable loam. In the lower part, it is yellowish brown, mottled, friable loam. The mottled substratum is light olive brown and dark yellowish brown, calcareous loam.

Typically, the surface layer of the Nicollet soils is black loam about 8 inches thick. The subsurface layer is black and very dark gray loam about 5 inches thick. The mottled subsoil is about 26 inches thick. It is dark grayish brown, friable loam in the upper part and light olive brown, friable loam in the lower part. The substratum is mottled olive loam.

Typically, the surface layer of the Canisteo soils is black clay loam about 8 inches thick. The subsurface layer is black and very dark gray clay loam about 15 inches thick. The subsoil is olive gray mottled clay loam about 16 inches thick. The substratum is olive gray and light olive gray mottled clay loam. The soil is calcareous throughout the profile.

The soils of minor extent in this association are mainly Storden, Crippin, Okoboji, Harps, and Webster soils in the uplands, and Colo, Coland, and Spillville soils along the stream bottoms. The well drained, gently sloping to strongly sloping convex Storden soils are on side slopes and ridge crests. They border drainageways and are adjacent to Clarion soils. The somewhat poorly drained Crippin soils are mainly on slightly convex knolls within large areas of Canisteo soils, but some areas border Okoboji or Harps soils. The very poorly drained Okoboji soils are very wet soils in depressions and are commonly ponded in spring or after heavy rains. The nearly level, highly calcareous, poorly drained Harps soils are on rims around depressions. The Harps soils and the Okoboji soils are commonly surrounded by Canisteo soils. Webster soils, which formed in glacial till sediments and are noncalcareous, are mostly on higher parts of broad flats that have a drainage network partly developed. Colo, Coland, and Spillville soils are on the present or former flood plains of the creeks.

This association is well suited to crops, and most of its acreage is used as cropland. Corn and soybeans are the main crops. Some oats and crops for rotation hay and pasture, including alfalfa and alfalfa-grass mixtures, are also grown. A few areas of this association, mostly along creeks and around farmsteads, are in permanent pasture. Organic matter content is moderate to high, and available water capacity is high. Crops respond well to fertilization.

The sloping soils need protection from water erosion. The irregular pattern of slopes makes contour tillage and terracing somewhat difficult in some places. Soil blowing is a hazard in areas where large tracts are fall plowed and the surface is left bare. The nearly level, poorly drained soils and the very poorly drained soils in depressions are generally tile drained. Many areas need improved drainage. Maintaining fertility and tilth are other important management concerns. Low fertility and herbicide carry-over from one year to the next are concerns on the Harps and Storden soils.

4. Nicollet-Clarion-Okoboji association

Moderately sloping to level, somewhat poorly drained, well drained, and very poorly drained soils that formed in glacial till or glacial till sediments; on uplands

In this soil association the landscape is that of a level to gently rolling ground moraine, consisting of swales and rises. The difference in elevation ranges from about 5 to 30 feet. This association is characterized by numerous potholes and depressions. It typically is depressional to moderately sloping but ranges to steep. The steeper slopes are around the many potholes and large depressions, drainageways, and streams. Most of the stream channels have been straightened and deepened and make good outlets for tile drains. Slopes range from 0 to 9 percent.

This soil association makes up about 7 percent of the county. About 20 percent of the association is Nicollet soils, 20 percent is Clarion soils, 15 percent is Okoboji soils, and 45 percent is soils of minor extent (fig. 5).

Some areas of the somewhat poorly drained Nicollet soils are at intermediate levels, and other areas of the Nicollet soils are on slightly convex rises on broad flats. The well drained Clarion soils are on the high parts of the upland. They are on convex slopes on the gently sloping to moderately sloping landscape. Other areas

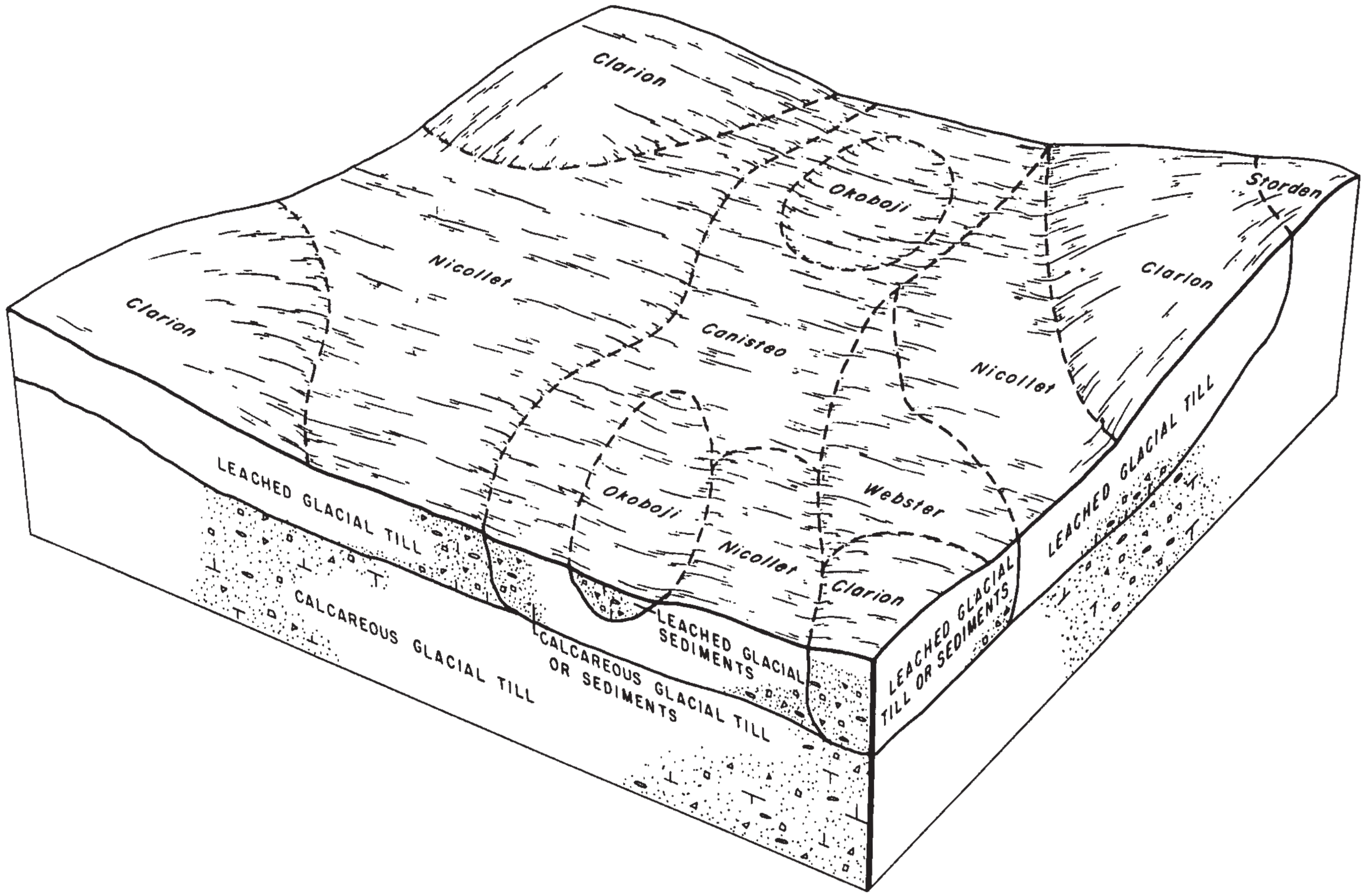


Figure 5.—Pattern of soils and parent materials in the Nicollet-Clarion-Okoboji association.

are on low, short-sloped, irregular convex ridges that rise above the nearly level Nicollet soils. The very poorly drained Okoboji soils are in depressions and are commonly ponded in spring and after heavy rains.

Typically, the surface layer of the Nicollet soils is black loam about 8 inches thick. The subsurface layer is black and very dark gray loam about 5 inches thick. The mottled subsoil is about 26 inches thick. It is dark grayish brown, friable loam in the upper part and light olive brown, friable loam in the lower part. The substratum is mottled olive loam.

Typically, the surface layer of the Clarion soils is black loam about 8 inches thick. The subsurface layer is black and very dark brown loam about 8 inches thick. The subsoil is about 18 inches thick. In the upper and middle parts it is dark brown and dark yellowish brown, friable loam. In the lower part it is yellowish brown, mottled, friable loam. The mottled substratum is light olive brown and dark yellowish brown, calcareous loam.

Typically, the surface layer of the Okoboji soils is black silty clay loam about 9 inches thick. The subsurface layer is black silty clay loam about 26 inches thick. The subsoil is very dark gray, dark gray, and olive gray, mottled, friable silty clay loam about 14 inches thick. The substratum is olive gray and gray mottled silty clay loam.

The soils of minor extent in this association are mostly the Canisteo, Storden, Crippin, Harps, Webster, and Palms soils. The poorly drained, calcareous Canisteo soils are on the higher parts of broad flats. The well drained Storden soils are on gently sloping to strongly sloping convex side slopes and ridge crests. They border drainageways, streams, and depressions, and are adjacent to Clarion soils. Crippin soils are mainly on slightly convex knolls within large areas of Canisteo soils, but some areas border Okoboji or Harps soils. Harps loam, a highly calcareous soil, is on the nearly level rims surrounding the Okoboji soils in depressions. Webster soils are noncalcareous and are mostly on the higher parts of broad flats that have a drainage network partly developed. Palms soils are in the larger depressions, some of which are not drained.

This association is well suited to row crops, and most of its acreage is used for crops. Corn and soybeans are the main crops. Some oats and crops for hay and pasture, including alfalfa and alfalfa-grass mixtures, are also grown. A few steep areas are in permanent pasture. A few of the large depressions are not drained, and a few of these are managed as marshes for wildlife habitat. Organic matter content in the included Storden soil is moderately low, in the Clarion soil is moderate, and in the other soils is high. Available water capacity is high in all of these soils, but the steeper Storden soils seldom reach their water-holding capacity because water readily runs off.

Measures to control soil blowing and water-erosion are needed on the soils in this association. A few scattered areas of sandy soils are particularly susceptible to blowing. The irregular pattern of slopes makes contour tillage and terracing difficult in some places. Improved drainage is needed in many areas. Maintaining and improving fertility and tilth are also important. Low fertility and herbicide carry-over from one year to the next are concerns on some of the soils of minor extent, particularly the included Storden and Harps soils.

5. Clarion-Storden-Colo association

Moderately steep to nearly level, well drained and poorly drained soils that formed in glacial till or alluvium; on uplands and bottom lands

This soil association is in one elongated area in the middle of the county. It is on slopes adjacent to major streams and on flood plains, and it is from about one to two miles wide. Old meandering stream channels dissect parts of the association. Slopes range from 0 to 18 percent.

This association makes up about 8 percent of the county. About 25 percent of the association is Clarion soils, 20 percent is Storden soils, 15 percent is Colo soils, and 40 percent is soils of minor extent.

The well drained Clarion soils are on the high parts of the uplands, mostly on gentle and moderate slopes at or near the borders of the association. A few steeper areas are adjacent to drainageways that cut back into the uplands. The well drained Storden soils are mainly on the strongly sloping to steep side slopes adjacent to the bottom lands. They are also on steep side slopes adjacent to drainageways that cut back into the uplands. Colo soils are poorly drained alluvial soils that are commonly further from the stream than other alluvial soils in this association. Some areas of Colo soils, however, are dissected by old meandering stream channels.

Typically, the surface layer of the Clarion soils is black loam about 8 inches thick. The subsurface layer is black and very dark brown loam about 8 inches thick. The subsoil is about 18 inches thick. In the upper and middle parts it is dark brown and dark yellowish brown, friable loam. In the lower part it is yellowish brown, mottled, friable loam. The mottled substratum is light olive brown and dark yellowish brown, calcareous loam.

Typically, Storden soils have a surface layer about 8 inches thick. It is brown loam mixed with some streaks and pockets of light olive brown substratum material. The mottled substratum to a depth of 60 inches is light olive brown and yellowish brown loam in the upper part and grayish brown loam in the lower part. The soil is calcareous throughout.

Typically, the surface layer of the Colo soils is black silty clay loam about 5 inches thick. The subsurface layer is black silty clay loam about 45 inches thick. The substratum is very dark gray clay loam to a depth of about 60 inches.

The soils of minor extent in this association are mostly Dickman, Spillville, Nicollet, Webster, Calco, and Coland soils and Aquolls. Well drained Dickman soils are typically on the highest parts of the landscape and are sandy loam and loamy sand. Spillville soils are alluvial soils and are generally adjacent to the stream channel. The somewhat poorly drained Nicollet soils are at intermediate levels in the uplands, between Clarion soils and the poorly drained Webster soils in swales. Coland soils are alluvial soils similar to Colo soils. Colo and Coland soils are on similar positions on the bottom lands and are commonly adjacent. Coland soils are clay loam. Calco soils are calcareous and are on positions similar to those of the Colo soils. In this association, most of the Calco soils are in the north part. Aquolls are flooded much of the time.

This association is used for general farming and raising livestock. Beef cow-calf herds are fairly common. Soils on the uplands range from well suited to poorly suited to row crops. Corn and soybeans are the main crops. Much of the acreage is better suited to hay and pasture crops. The steeper areas are generally in pasture. Oats and crops for rotation hay and pasture, such as alfalfa and alfalfa-grass mixtures, are commonly grown. The content of organic matter is moderately low in the Storden soils and moderate in the Clarion soils. Available water capacity is high, but the steeper Storden soils seldom reach their water-holding capacity because water readily runs off.

Some of the acreage in the bottom lands is used intensively for row crops, commonly corn and soybeans. Productivity is variable in the cultivated areas, depending on the frequency of flooding and on drainage. Most frequently flooded areas support trees, brush, and, in some areas, grass. These bottom land soils, particularly the Colo and Spillville soils, are high in organic matter content and available water capacity.

The main concerns of management are erosion control on the sloping soils and flood protection and drainage improvement on the bottom lands. The irregular pattern of slope makes contour tillage and terracing difficult in some places. Maintenance of tilth and the level of organic matter is needed on the Clarion and Storden soils. Flood protection is difficult in most areas of the bottom lands, but drainage can be improved in many places. Installing underground drains is generally beneficial on the Colo soils and the minor soils on the bottom lands. In places, however, suitable outlets are not available.

6. Spillville-Estherville-Storden association

Nearly level to steep, somewhat poorly drained to somewhat excessively drained soils that formed in alluvium, glacial till, or glacial outwash; on bottom lands, foot slopes, uplands, and benches

This soil association is in two elongated areas, consisting of a flood plain and the adjacent benches and uplands. The steeper slopes are generally in the south part, and commonly, small natural waterways extend up the side slopes. This association is generally about one mile wide. Slopes range from 0 to 25 percent.

This soil association makes up about 3 percent of the county. About 35 percent is Spillville soils, 25 percent is Estherville soils, 15 percent is Storden soils, and 25 percent is soils of minor extent.

The moderately well drained to somewhat poorly drained Spillville soils are alluvial soils adjacent to the stream channel. The stream channel meanders through areas of these soils, and old meandering channels and oxbows limit the use of these soils. These Spillville soils are the first to be flooded. The somewhat excessively drained Estherville soils are on benches, most of which are high enough that they are not flooded. These soils are mostly nearly level to gently sloping, but are strongly sloping in some of the areas where they join the bottom lands and are adjacent to drainageways. The well drained, moderately sloping to steep Storden soils are on the side slopes adjacent to bottom lands and benches.

Typically, the surface layer of the Spillville soils is black loam about 9 inches thick. The subsurface layer is black loam about 30 inches thick. The next layer is very dark gray fine sandy loam about 12 inches thick. The substratum is very dark gray fine sandy loam to a depth of 60 inches.

Typically, the surface layer of the Estherville soils is black sandy loam about 7 inches thick. The subsurface layer is black and very dark brown sandy loam about 5 inches thick. The subsoil is about 8 inches thick. It is very friable sandy loam in the upper part and gravelly sandy loam in the lower part. It is dark yellowish brown and dark brown. The substratum is brown and dark yellowish brown loamy coarse sand and gravel.

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

Soils of minor extent in this association are mostly Colo, Coland, Zook, Cylinder, Ridgeport, and Clarion soils. Colo, Coland, and Zook soils are poorly drained alluvial soils that generally border the Spillville soils, but in places the Coland and Colo soils are adjacent to the stream. These soils are generally used as farmland. Cylinder soils are somewhat poorly drained soils that are on low benches adjacent to Estherville soils. Some are in swales within areas of Estherville soils. Ridgeport soils are on benches, commonly adjacent to the Estherville soils. Clarion soils are on gentle and moderate slopes in the uplands, adjacent to the Storden soils.

Much of the acreage of this association is used for pasture or is left idle. Beef cow-calf herds are common. Most areas that are flooded frequently support little besides timber and brush. Some of the alluvial soils that are not cut by meandering channels are farmed intensively to row crops, commonly corn and soybeans. Productivity of the cultivated areas is variable, depending on the frequency of flooding and on drainage. Most of the Storden areas are used for pasture. Pasture improvement or renovation is difficult because of the steepness of slope. The Estherville soils, on the benches, are used for row crops, hay, and pasture. They are suited to crops, but crop growth varies because of droughtiness. Estherville soils are better suited to small grains, hay, or pasture crops than to row crops. The Storden and Estherville soils are generally moderately low or low in organic matter content. The Storden soils have high available water capacity, but they seldom reach their water-holding capacity because of runoff. Estherville soils have very low or low available water capacity. The alluvial Spillville soils are high in both content of organic matter and available water capacity.

On the bottom lands, the main management needs are flood protection and drainage improvement. Flood protection is difficult in most areas, but in places drainage can be improved on the areas of the minor soils that are cultivated. The Estherville soils are droughty, and practices to conserve moisture and to prevent soil blowing are needed. Minimum tillage methods that leave residue on the surface are effective in controlling erosion. Erosion control and fertility improvement practices are needed on the Storden soils.

7. Spillville-Storden-Lester association

Nearly level to very steep, well drained to somewhat poorly drained soils that formed in alluvium or glacial till; on bottom lands, foot slopes, and uplands

In this soil association the landscape consists mostly of steep slopes and a flood plain. Many of the slopes and much of the flood plain are covered by trees. The steeper slopes generally parallel the stream. Commonly, small drainageways extend into the uplands. Slopes range from 0 to 40 percent.

This soil association makes up about 2 percent of the county. About 25 percent of the association is Spillville soils, 25 percent is Storden soils, 25 percent is Lester soils, and 25 percent is soils of minor extent.

The moderately well drained and somewhat poorly drained Spillville soils are on nearly level bottom lands and low foot slopes that have gradient of 2 to 5 percent. Meander channels and oxbows are common in areas of these soils that are on bottom lands. The well drained Storden soils are on the moderately sloping to very steep slopes adjacent to the bottom lands. In this association, the Storden soils are predominantly on southeast- and east-facing slopes in the north part and on west-facing slopes in the south part of the association. In places, they are intermingled with the Lester soils. The well drained Lester soils are on gently sloping to very steep convex slopes. They are mostly on east-facing slopes, but in the north part they are also commonly on north-facing slopes.

Typically, the surface layer of the Spillville soils is black loam about 9 inches thick. The subsurface layer is black loam about 30 inches thick. The next layer is very dark gray fine sandy loam about 12 inches thick. The substratum is very dark gray fine sandy loam to a depth of 60 inches.

Typically, the surface layer of the Storden soils is about 8 inches thick. It is very dark brown loam and has streaks and pockets of very dark grayish brown and brown substratum material. The substratum is mostly light olive brown and yellowish brown loam in the upper part and brown and grayish brown loam in the lower part. This soil is calcareous throughout.

Typically, the surface layer of the Lester soils is very dark brown loam about 5 inches thick. The subsurface layer is about 8 inches thick. It is dark grayish brown and very dark grayish brown loam. The friable subsoil is about 32 inches thick. The upper part is brown loam. The middle and lower parts are brown and dark yellowish brown loam. The substratum is mostly light olive brown, light yellowish brown, and dark yellowish brown, friable, calcareous loam.

The soils of minor extent in this association are mostly the Clarion, Colo, and Le Sueur soils. The Clarion soils are on ridgetops, commonly adjacent to the Le Sueur soils in this association. The somewhat poorly drained Le Sueur soils are on nearly plane slopes that have gradient of 1 to 3 percent. Some are slightly convex. Le Sueur soils are adjacent to both Clarion and Lester soils, and commonly lie between the two on the landscape. Colo soils are alluvial soils and are adjacent to Spillville soils on the broader bottom lands. In the narrow drainageways, these two soils are closely intermingled.

Most of the acreage of this association is used for general farming and raising livestock. Beef cow-calf herds are fairly common (fig. 6). The soils on uplands, except for some of the minor soils, are poorly suited to row crops. Most of the steeper areas are in mixed native hardwoods and native grass. Wooded areas are used both as wildlife habitat and housing sites. Grassland areas are used for grazing livestock. Slope and the hazard of erosion are the main limitations for most uses. Some areas of the bottom lands are intensively used for row crops, commonly corn and soybeans. Commonly, areas that are flooded are in mixed trees, brush, and grass. Storden and Lester soils are moderately low in organic matter. Spillville soils are high in organic matter. All of the major soils have high available water capacity, but the Storden and Lester soils on steeper slopes seldom reach their water-holding capacity because water readily runs off.

The main concerns of management are erosion control on the sloping soils and flood protection and drainage improvement on the bottom lands. Steep slopes and numerous upland waterways make pasture renovation difficult or impossible. Overgrazing is a concern in areas used as pasture because it causes rapid development of erosion and gullying. Flood protection is difficult in most bottom land areas, but in places drainage can be improved and oxbows and old meandering streams can be filled.

8. Spicer-Fieldon-Coland association

Nearly level, poorly drained soils that formed in lacustrine sediments and glacial outwash or in alluvium; on uplands and bottom lands

This soil association consists mostly of nearly level, poorly drained soils. Relief is low. Depressions in this association are shallow and generally elongated, and they commonly do not have the narrow rim of highly calcareous soils that characteristically surrounds depressions. However, they are associated with highly calcareous soils. A natural drainage system has not developed in this association, but much of the area is extensively drained by underground drainage systems. Outlets have been provided by deepening the channels of drainage ditches and small streams. Slopes range from 0 to 2 percent.

This soil association makes up about 2 percent of the county. About 13 percent of the association is Spicer soils, 12 percent is Fieldon soils, 10 percent is Coland soils, and the remaining 65 percent is soils of minor extent.

The nearly level, poorly drained Spicer soils are on broad flats that have plane to slightly concave slopes. They are slightly higher on the landscape than the adjacent Fieldon soils, which are also poorly drained and on broad flats. The nearly level, poorly drained Coland soils are on bottom lands along the small streams and

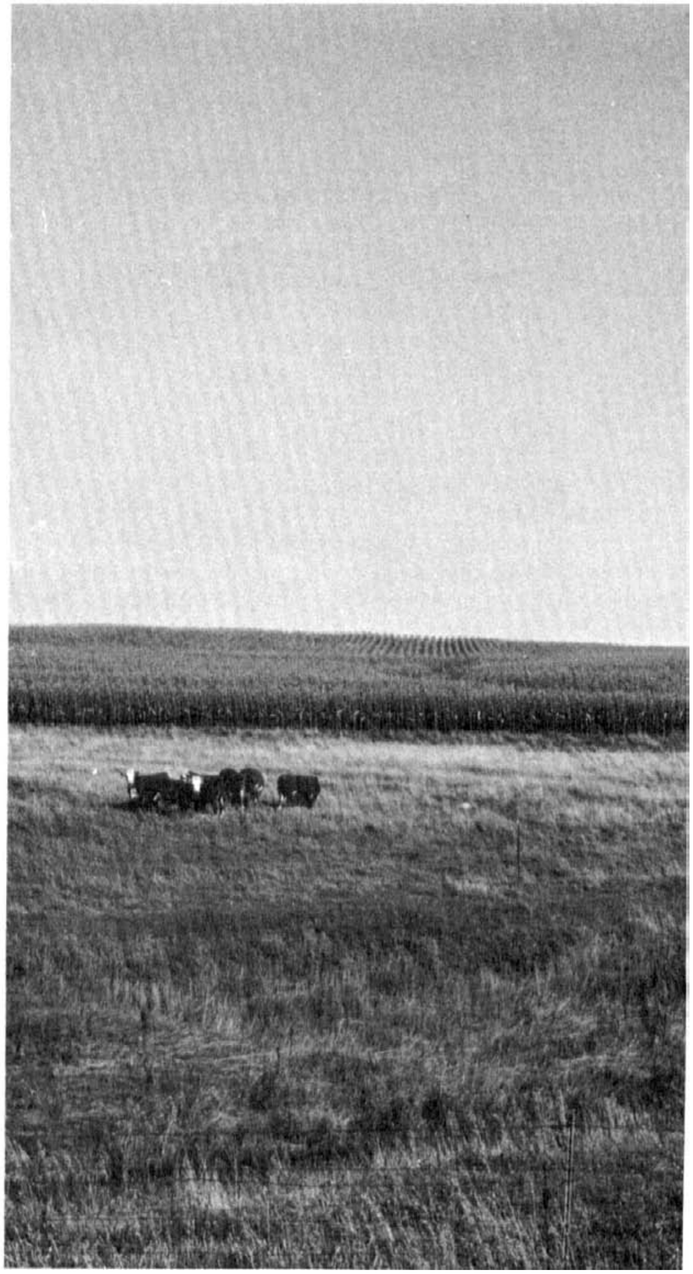


Figure 6.—Beef cows grazing on native grass pasture in the Spillville-Storden-Lester association. Spillville soils are in the foreground.

drainageways that flow through this soil association. Most areas of Coland soil are briefly flooded during seasons of high rainfall.

Typically, the surface layer of the Spicer soils is black silty clay loam about 9 inches thick. The subsurface layer is black and very dark gray silt loam about 10 inches thick. The mottled subsoil is silty clay loam and silt loam about 23 inches thick. The upper part is olive gray and dark gray. The middle and lower parts are olive gray. The substratum is olive gray and light olive gray silt loam to a depth of 60 inches.

Typically, the surface layer of the Fieldon soils is black loam about 8 inches thick. The subsurface layer is black and very dark gray loam about 10 inches thick. The subsoil is about 27 inches thick. The upper part is dark gray to olive gray loam. The lower part has olive gray and light olive gray mottled very fine sand in its upper part and stratified sand and silt in its lower part.

Typically, the surface layer of the Coland soils is black clay loam about 8 inches thick. The subsurface layer is black and very dark gray, mottled clay loam about 40 inches thick. The mottled substratum to a depth of about 60 inches is very dark gray clay loam.

The important soils of minor extent are Harpster soils, which make up about 9 percent of the map unit; Waldorf soils, which make up 8 percent; and Lemond soils, which make up 8 percent. Other minor soils make up about 40 percent of the association. They include Truman, Dickman, Corwith, Harcot, Mayer, Kossuth, Ottosen, Canisteo, and Okoboji soils.

The Harpster soils are highly calcareous, poorly drained soils that are closely associated with the major soils. They have a substratum of silt loam or very fine sand. The Waldorf soils are poorly drained and are on nearly level, plane to slightly concave slopes. They are generally at slightly higher elevations than the major soils and are higher in clay content. They typically are neutral in reaction. Lemond soils are poorly drained, calcareous soils that have a substratum of sand and gravel. Truman and Dickman soils are very gently sloping and gently sloping, well drained soils near drainageways. They are silt loam and sandy loam. Harcot and Mayer soils are poorly drained, calcareous soils that have a substratum of sand and gravel. Kossuth and Ottosen soils are poorly drained and somewhat poorly drained soils that formed in sediments on nearly level slopes. Canisteo soils are poorly drained, calcareous soils that formed in glacial till. Okoboji soils are very poorly drained soils that formed in slight depressions.

This association is well suited to all cultivated crops commonly grown in the county. Most of the acreage in this association is used for row crops. Corn and soybeans are the main crops. Some oats and crops for rotation hay and pasture, mostly alfalfa and alfalfa-grass mixtures, are also grown. Organic matter content and available water capacity are high. Crops respond well to additions of fertilizer. Because most of the soils in this association are calcareous, higher than normal rates of some fertilizers are needed to maintain highest yields. Additionally, care is needed when using some herbicides. Soybeans grown on many of these soils typically show symptoms of chlorosis because of the low availability of iron in these soils.

The main concerns of cropland management are maintaining and improving drainage and maintaining tilth and fertility. Some flooding and ponding are common on some soils during periods of heavy rain, especially in very early spring. Most areas are drained, but additional drainage is needed in some places. Some of the minor soils need protection from erosion, particularly from soil blowing. Particular attention to fertility is needed on the highly calcareous soils if optimum yields are to be obtained.

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, 2 to 5 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.

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. Clarion-Estherville complex, 5 to 9 percent slopes, moderately eroded, is an example.

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

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.

Soil descriptions

6—Okoboji silty clay loam, 0 to 1 percent slopes. This level, very poorly drained soil is in shallow upland depressions or sloughs. It is subject to ponding. Individual areas are typically circular and range from 2 to 12 acres in size. A few areas range up to 20 acres in size.

Typically, the surface layer is black silty clay loam about 9 inches thick. The subsurface layer is black silty clay loam about 26 inches thick. The subsoil is very dark gray, dark gray, and olive gray, mottled, friable silty clay loam about 14 inches thick. The substratum to a depth of 60 inches is olive gray and gray, mottled silty clay loam. In some places the organic matter content is higher. In some areas the soil has a slightly calcareous surface layer or has more sand in the surface layer.

Included with this soil in mapping are a few small rises containing Harps soils that are calcareous throughout. Also included in mapping are areas on stream benches and glacial outwash where the substratum consists of sand or sand and gravel. These areas make up less than 10 percent of this map unit.

Permeability of this soil is moderately slow. A seasonal high water table ranges from 12 inches below the surface to 12 inches above the surface. The available water capacity is high. The plow layer contains about 9 to 11 percent organic matter. The shrink-swell potential is high. The subsoil is generally very low in available phosphorus and low to very low in available potassium. Reaction is typically mildly alkaline or neutral in the surface layer and neutral or mildly alkaline in the subsoil.

Most areas of this soil are cultivated. Most of the acreage is artificially drained by surface intakes, shallow ditches, and underground drains. In places, it is difficult to find outlets deep enough for underground drains to function adequately. Crop growth is variable. This soil is moderately suited to row crops if drainage is adequate. Many areas are ponded in spring and after heavy rains. In some years water ponds long enough to drown out crops (fig. 7). If this occurs early in the season, the land can be tilled and replanted. Even where artificial drainage is adequate for good crop growth, tillage is delayed after heavy rains. The surface layer puddles easily if the soil is worked when wet. In many areas, production can be increased by improving the drainage system.

This soil is poorly suited to some legumes, especially alfalfa. Ponding and soil heaving in winter frequently drown out or kill crops. If this soil is used for hay and improved pasture, grasses and legumes that tolerate excessive wetness should be substituted for those more commonly grown. Grazing when the soil is wet can cause surface compaction and poor tilth.

Undrained areas are generally used for permanent pasture. Production in most areas can be increased by improving drainage and planting grasses that tolerate wetness and periods of ponding. Some areas are suited to development as wildlife habitat. This soil is generally managed in conjunction with the adjacent soils.

This soil is in capability subclass IIIw.

28—Dickman fine sandy loam, 0 to 2 percent slopes. This nearly level, well drained soil is mainly in the uplands and on high benches near the larger streams. Individual areas are irregular in shape and range from 2 to 20 acres in size.

Typically, the surface layer is very dark grayish brown fine sandy loam about 9 inches thick. The subsurface layer is very dark grayish brown sandy loam about 6 inches thick. The subsoil extends to a depth of about 40 inches. It is brown sandy loam in the upper part and brown and dark yellowish brown loamy fine sand and very fine sand in the lower part. The substratum to a depth of 60 inches is brown and dark yellowish brown fine and medium sand.

Included with this soil in mapping and making up less than 5 percent of the map unit are a few small, low-lying, slightly concave wetter soils.

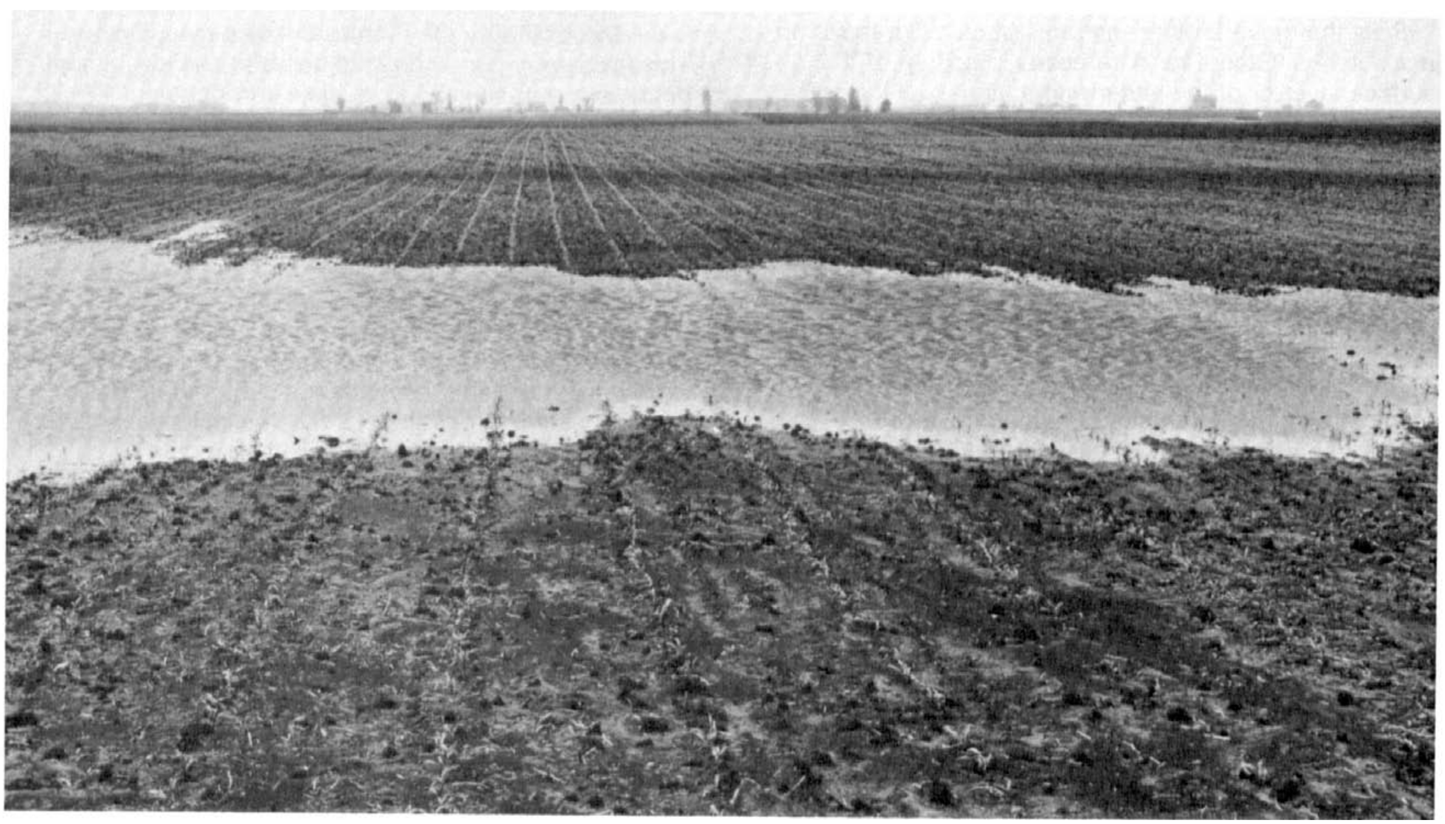


Figure 7.—Small depression, or pothole, of Okoboji silty clay loam, 0 to 1 percent slopes. This soil is frequently ponded after rains, and crops are often killed or damaged.

Permeability of this soil is moderately rapid in the upper part of the profile and rapid in the lower part. Surface runoff is slow, and available water capacity is low. The plow layer contains about 2 to 3 percent organic matter. The supply of available phosphorus is generally low, and the supply of available potassium is very low to low. Reaction is typically neutral or slightly acid.

Most areas of this soil are cultivated because they are small and generally are closely associated with soils that are better suited to cultivation. This soil is poorly suited to cultivated crops, and if it is used for cultivated crops, there is a hazard of erosion damage. This soil is better suited to small grains than to row crops. Soil blowing is a hazard because the surface dries quickly after tillage. Windblown sand damages young plants in some years. Conservation tillage, which leaves crop residue on the surface, helps prevent excessive soil loss. Returning crop residue to the soil or adding other organic material on a regular basis helps to improve fertility, maintain tilth, and improve available water capacity.

The use of this soil for pastureland or hayland is also effective in controlling erosion. Overgrazing, however, increases runoff and exposes the surface layer to soil blowing. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during extremely dry periods help to keep the pasture and soil in good condition.

This soil is in capability subclass IIIs.

28B—Dickman fine sandy loam, 2 to 5 percent slopes. This gently sloping, well drained soil is mainly in the uplands and on high benches near the larger streams. Individual areas are irregular in shape and range from 2 to 30 acres in size.

Typically, the surface layer is very dark grayish brown fine sandy loam about 6 inches thick. The subsurface layer is very dark grayish brown sandy loam about 5 inches thick. The subsoil extends to a depth of about 40 inches. It is brown sandy loam in the upper part, brown loamy fine sand in the middle part, and brown and dark yellowish brown loamy fine sand in the lower part. The substratum to a depth of about 60 inches is brown and dark yellowish brown fine and medium sand. In places the surface and subsurface layers, combined, are less than 10 inches thick, and the depth to fine or medium sand is less. In some places the substratum is loamy at a depth of about 40 inches.

Permeability is moderately rapid in the upper part of the profile and rapid in the lower part, and available water capacity is low. Surface runoff is slow. The plow layer contains about 2 to 3 percent organic matter. The supply of available phosphorus is generally low, and the supply of available potassium is very low to low. Reaction is typically neutral or slightly acid.

Most areas of this soil are cultivated because they are small and generally are closely associated with soils that are better suited to cultivation. This soil is poorly suited to cultivated crops. It is better suited to small grains than to row crops. Soil blowing is a hazard because the surface dries quickly after tillage. Windblown sand damages young plants in some years. Conservation tillage, which leaves crop residue on the surface, helps prevent excessive soil loss. Controlling erosion by the use of mechanical practices, such as terracing, is difficult because of the instability and erodibility of this soil. Also, adequate compaction of the terrace wall is difficult to obtain. Returning crop residue to the soil or adding other organic material on a regular basis helps to improve fertility, maintain tilth, and increase the available water capacity.

The use of this soil for pastureland or hayland is also effective in controlling erosion. Overgrazing, however, increases runoff and exposes the surface layer to soil blowing. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during extremely dry periods help to keep the pasture productive and the soil in good condition.

This soil is in capability subclass IIIe.

28C2—Dickman fine sandy loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, somewhat excessively drained soil is mainly in the uplands and on high benches near the larger streams. Individual areas are irregular in shape and range from 5 to 30 acres in size.

Typically, the surface layer is about 9 inches thick. It is very dark grayish brown and dark brown fine sandy loam mixed with some streaks and pockets of dark brown subsoil material. The subsoil extends to a depth of about 30 inches. It is dark yellowish brown and yellowish brown. It is sandy loam in the upper part and loamy fine and medium sand in the lower part. The substratum to a depth of about 60 inches is brown and yellowish brown fine and medium sand. In places the surface layer is thinner, and the depth to fine and medium sand is less. In some places the substratum is loamy at a depth of 3 feet.

Permeability of this soil is moderately rapid in the upper part of the profile and rapid in the lower part. Surface runoff is slow, and available water capacity is low. The plow layer contains about 2 percent organic matter. The supply of available phosphorus is generally low, and the supply of available potassium is low to very low. Reaction is typically neutral or slightly acid.

Most areas of this soil are cultivated because they are small and generally are closely associated with soils that are better suited to cultivation. A few larger areas are managed separately.

This soil is poorly suited to cultivated crops, and if it is used for cultivated crops, there is a hazard of further erosion damage. This soil is better suited to small grains than to row crops. Soil blowing is a hazard because the surface dries quickly after tillage. Blown sand damages young plants in some years. Conservation tillage, which leaves crop residue on the surface, helps prevent excessive soil loss. Controlling erosion by the use of mechanical practices, such as terracing, is difficult. Also, deep cuts may expose the sandy subsoil, which is low in organic matter, fertility, and available water capacity. Returning crop residue to the soil or adding other organic material on a regular basis helps to improve fertility, maintain tilth, and increase available water capacity.

The use of this soil for pastureland or hayland is also effective in controlling erosion. Overgrazing, however, increases runoff and exposes the surface layer to soil blowing. Proper stocking rates, pasture rotations, timely deferment of grazing, and restricting grazing during extremely dry periods help to keep the pasture productive and the soil in good condition.

This soil is in capability subclass IVe.

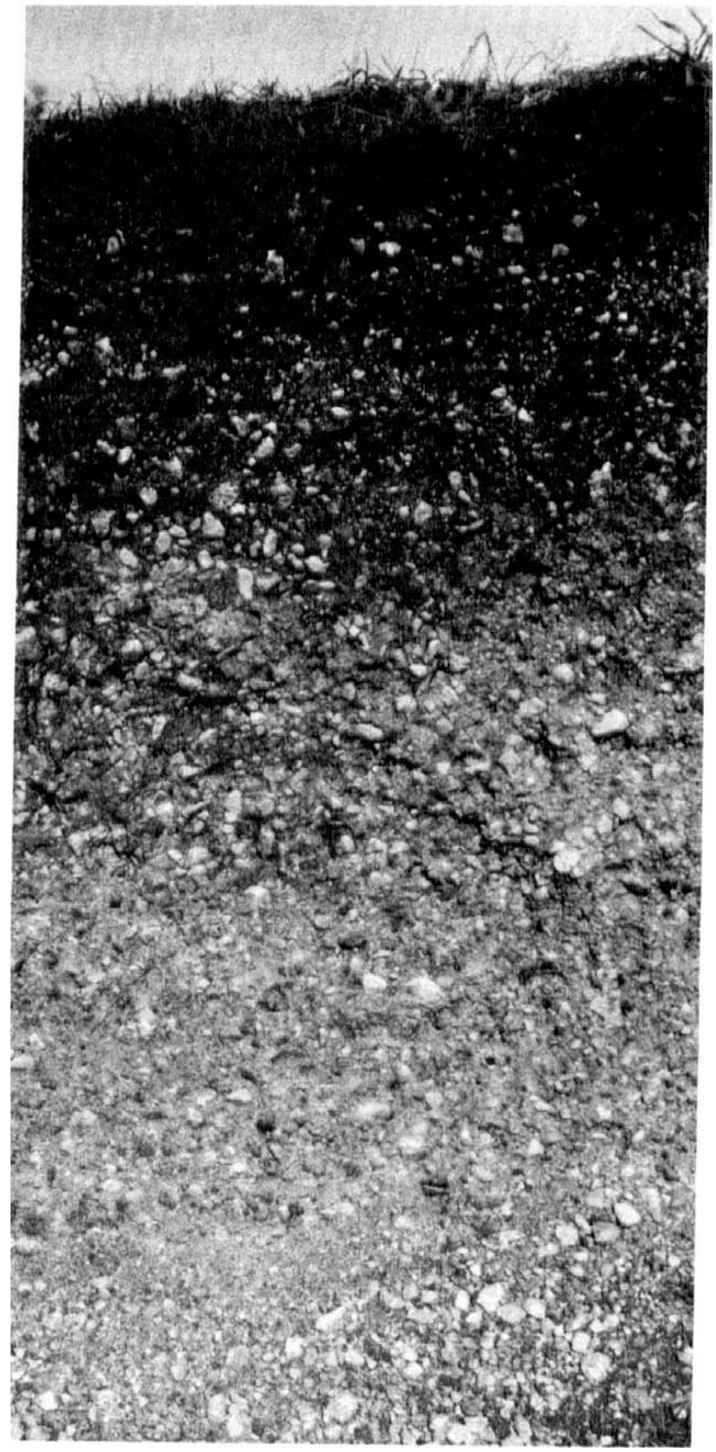
34—Estherville sandy loam, 0 to 2 percent slopes. This nearly level, somewhat excessively drained soil is on uplands, outwash areas, and stream benches. Slopes are plane to slightly convex. Individual areas are irregular in shape and commonly range from 5 to 20 acres in size.

Typically, the surface layer is black sandy loam about 7 inches thick. The subsurface layer is black and very dark brown sandy loam about 5 inches thick. The subsoil is about 8 inches thick. It is dark yellowish brown, brown, and dark brown very friable sandy loam in the upper part and gravelly sandy loam in the lower part. The substratum to a depth of 60 inches is brown and dark yellowish brown loamy coarse sand and gravel (fig. 8). In places the surface layer and subsoil are thicker and deeper to the sand and gravel substratum. In other places the surface layer is loam. A few small areas in the south-central part of the county have a subsoil that ranges from strong brown to yellowish red.

Included with this soil in mapping are some small areas of Salida soils which are coarser in texture, less fertile, and lower in organic matter content. These soils are mainly on slightly raised areas that have convex slopes. Also included are some small areas of Hanska and Linder soils which are in slight depressions. They are wetter than the Estherville soil and are subject to ponding briefly after rains. Included soils make up about 5 to 10 percent of this map unit.

Permeability of this soil is moderately rapid in the solum and rapid in the substratum. Surface runoff is slow. Available water capacity is very low. The plow layer contains about 2 to 3 percent organic matter. Reaction typically ranges from neutral to medium acid in the solum. The subsoil is generally very low in available phosphorus and potassium. This soil has good tilth.

Most areas of this soil are cultivated. Many areas are used for hay crops and as rotation pasture. This soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay or pasture. It is better suited to small grains, grasses, and legumes than to cultivated row crops because available water is limited



during parts of most growing seasons. If this soil is cultivated, soil blowing can often be a hazard because the surface dries quickly after tillage. Blown sand may damage young plants in some years. Minimum tillage, which leaves crop residue on the surface, slows drying, reduces the hazard of soil blowing, and helps to conserve available water for plant use.

The use of this soil for pastureland or hayland is also effective in controlling soil blowing. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture productive.

This soil is in capability subclass IIIs.

34B—Estherville sandy loam, 2 to 5 percent slopes. This gently sloping, somewhat excessively drained soil is on uplands, outwash areas, and stream benches. Slopes are generally short. Individual areas are commonly irregular in shape and range from 5 to 15 acres in size.

Typically, the surface layer is black sandy loam about 7 inches thick. The subsurface layer is black and very dark brown sandy loam about 5 inches thick. The subsoil is about 8 inches thick. It is yellowish brown, very friable sandy loam in the upper part and dark brown, gravelly sandy loam in the lower part. The substratum to a depth of about 60 inches is brown and dark yellowish brown loamy coarse sand and gravel that is moderately alkaline. In places the surface layer and subsoil are thicker and deeper, and in a few other areas the soil is thinner and shallower to the sand and gravel substratum. Other places have a surface layer of loam. In some areas of this soil in the south-central part of the county the subsoil ranges from strong brown to yellowish red.

Included with this soil in mapping and making up about 5 percent of the map unit are some small areas of Salida soils. Salida soils are coarser in texture and are less fertile and lower in organic matter content. These are mainly on the steepest parts of the slope.

Permeability of this soil is moderately rapid in the solum and rapid in the substratum. The available water capacity is very low. The plow layer contains about 2 to 3 percent organic matter. Reaction typically ranges from neutral to medium acid in the solum. The subsoil is generally very low in available phosphorus and potassium. This soil has good tilth.

This soil is used for hay, rotation pasture, and row crops. It is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay or pasture. Because of limited available water, this soil is better suited to small grains, grasses, and legumes than to cultivated row crops. If this soil is used for cultivated crops, there is a hazard of erosion. Terraces should not be constructed on this soil because the sand and gravel substratum is likely to be exposed. In cultivated areas, soil blowing can often be a hazard because the surface dries quickly after tillage. Blown sand may damage young plants in some years. Conservation tillage, which leaves crop residue on the surface, slows drying, reduces the hazard of soil blowing, and helps conserve available water for plant use. Returning crop residue to the soil or adding other organic material on a regular basis helps improve fertility and maintain good tilth.

The use of this soil for pastureland or hayland is also effective in controlling erosion. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture productive.

This soil is in capability subclass IIIe.

34C2—Estherville sandy loam, 5 to 14 percent slopes, moderately eroded. This moderately sloping and strongly sloping, somewhat excessively drained soil is on upland outwash areas and stream benches. Slopes are generally short. Individual areas are irregular in shape and typically range from 2 to 10 acres in size.

Typically, the surface layer is very dark brown sandy loam about 7 inches thick. The subsoil, about 8 inches thick, is very friable, sandy loam in the upper part and gravelly sandy loam in the lower part. It is dark yellowish brown, brown, and dark brown. The substratum to a depth of 60 inches is brown and dark yellowish brown loamy sand and gravel that is moderately alkaline. In places the surface layer and subsoil are thicker. In other places the surface layer is loam. In some areas in the south-central part of the county the subsoil ranges in color from strong brown to yellowish red.

Included with this soil in mapping are some small areas of Salida soils that are coarser in texture and are less fertile and lower in organic matter content. These are mainly on the steepest parts of the slope. Also included are a few areas of sandy soils that are deeper to coarser sand and gravel than the Estherville soil. The included soils make up 5 to 10 percent of this map unit.

Permeability of this soil is moderately rapid in the solum and rapid in the substratum. Surface runoff is slow. Available water capacity is very low. The plow layer contains about 1 to 2 percent organic matter. Reaction typically ranges from neutral to medium acid in the solum. The subsoil is generally very low in available phosphorus and potassium. This soil has good tilth.

This soil is used for hay, rotation pasture, and row crops. It is poorly suited to corn, soybeans, and small grains and to legumes and grasses for hay and pasture. Because of limited available water, this soil is better suited to small grains, grasses, and legumes than to cultivated row crops. If this soil is used for cultivated crops, there is a hazard of erosion. Such practices as planting crops on the contour and minimum tillage help to control erosion and conserve moisture. Terraces should not be constructed on this soil because the sand and gravel substratum is likely to be exposed. If this soil is cultivated, soil blowing can often be a hazard because the surface dries quickly after tillage. Blown sand may damage young plants in some years. Conservation tillage, which leaves crop residue on the surface, slows drying and reduces the hazard of soil blowing. Returning crop residue to the soil or adding other organic material on a regular basis helps to improve fertility and maintain good tilth.

The use of this soil for pastureland or hayland is also effective in controlling erosion. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture productive.

This soil is in capability subclass IVe.

52B—Bode clay loam, 2 to 5 percent slopes. This gently sloping, well drained soil is on convex knolls and side slopes that border lake plains on the uplands. Slopes are short to moderate. Most areas are dissected by shallow drainageways. Individual areas are irregular in shape and typically range from 10 to 25 acres in size. A few areas range from 5 to 50 acres or more.

Typically, the surface layer is black clay loam about 8 inches thick. The subsurface layer is black and very dark grayish brown clay loam about 9 inches thick. The subsoil, about 22 inches thick, is dark brown, dark yellowish brown, and brown. It is friable clay loam in the upper part and friable loam in the lower part. The substratum to a depth of 60 inches is mottled grayish brown and yellowish brown, calcareous loam. In places the surface layer is loam. In places the soil has a substratum that contains silty sediments ranging from about 3 to 8 feet in thickness.

Included with this soil in mapping and making up less than 5 percent of the map unit are a few small areas of calcareous Storden soils. Storden soils have a thinner surface layer and are calcareous at or near the surface.

Permeability of this soil is moderate, and surface runoff is medium. Available water capacity is high. The plow layer contains about 3 to 4 percent organic matter content. The subsoil is generally low to very low in phosphorus and very low in potassium. Reaction is typically neutral in both the surface layer and the subsoil. Tilth is good and is fairly easily maintained if the soil is not worked when too wet.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. If the soil is used for cultivated crops, there is a hazard of erosion. Conservation tillage and winter cover help prevent excessive soil loss. Controlling erosion by mechanical practices, such as contouring and terracing, works well on this soil. Returning crop residue to the soil or adding other organic material on a regular basis helps to improve fertility and maintain good tilth.

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

This soil is in capability subclass IIe.

54—Zook silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on broad bottom lands along major streams in the county. It is generally adjacent to soils on the foot slopes below upland side slopes, and it is generally one of the bottom land soils farthest from the stream channel. This soil is subject to flooding. Individual areas of this unit are irregular in shape and range from 2 to 30 acres in size.

Typically, the surface layer is black silty clay loam about 6 inches thick. The subsurface layer is black silty clay loam and silty clay about 32 inches thick. The subsoil to a depth of 60 inches is firm black and very dark gray silty clay in the upper part and very dark gray, mottled silty clay loam in the lower part. In places loam or clay loam material is at a depth of about 45 inches.

Permeability of this soil is slow, and surface runoff is slow. Available water capacity is high. The surface layer contains about 5 to 7 percent organic matter. The supply of available phosphorus is very low, and the supply of available potassium is very low to low. This soil has a high shrink-swell potential. Reaction is neutral to slightly acid. A seasonal high water table is at a depth of 12 to 36 inches, and most areas are flooded during periods of high rainfall.

Most areas of this soil are cultivated where drainage is adequate. Undrained or partly drained areas are in pasture. This soil is moderately well suited to corn, soybeans, and small grains and to grasses for hay and pasture. It is poorly suited to most legumes. Flooding, wetness, and soil heaving in late winter and early spring reduce stands and cause low production. Adequate drainage and protection from flooding are needed for optimum growth of row crops. Returning crop residue to the soil or adding other organic material on a regular basis helps to improve fertility and tilth.

This soil is suited to use as pastureland. Overgrazing or grazing when this soil is too wet causes surface compaction, reduces water infiltration, and results in poorer tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture productive and the 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 mainly on convex slopes in the uplands. A few areas are in concave positions between undulating, well drained soils. Individual areas are irregular in shape and generally range from 3 to 20 acres in size. A few individual areas are as large as about 100 acres in size.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is black and very dark gray loam about 5 inches thick. The mottled subsoil is about 26 inches thick. It is dark grayish brown, friable loam in the upper part and light olive brown, friable loam in the lower part. The substratum is mottled olive loam. In places the surface layer and the subsoil are thinner. In places the substratum is silty or fine sandy loam.

Included with this soil in mapping are small areas of Clarion and Storden soils. These are on the highest, most convex part of the slopes and are not as dark in color as this Nicollet soil. Also included are small areas of Webster, Rolfe, and Okoboji soils that are level or slightly depressional. They are wetter than the Nicollet soil, and the Okoboji and Rolfe soils are subject to ponding after rains. The included soils make up less than 10 percent of this map unit.

Permeability of this soil is moderate, and surface runoff is slow. Available water capacity is high. The plow layer contains about 4 to 6 percent organic matter. Reaction is typically neutral to slightly acid. The subsoil is very low to low in available phosphorus and potassium. This soil has good tilth.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay or pasture. Erosion

Figure 9.—Minimum tillage on Nicollet loam, 1 to 3 percent slopes.

generally is not a problem on this soil, but soil blowing may occur if the soil is fall plowed. Conservation tillage, which leaves crop residue on the surface, helps prevent excessive soil loss from soil blowing (fig. 9). Returning crop residue to the soil and delaying tillage when the soil is wet help maintain good tilth. This soil generally is not drained, but in some areas artificial drainage would improve timeliness of operations.

If this soil is used for pastureland, overgrazing or grazing when the soil is wet can cause compaction and poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture productive and the soil in good condition.

This soil is in capability class I.

62C2—Storden loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, well drained soil is on short, convex side slopes and on sharply convex knobs on the uplands. Individual areas of this soil are irregular in shape and typically range from about 5 to 10 acres in size. A few areas on side slopes adjacent to streams and drainageways are long and narrow and range up to about 20 acres in size.

Typically, the surface layer is about 8 inches thick. It is very dark grayish brown loam, mixed with some streaks and patches of dark brown and brown substratum material. The mottled substratum to a depth of 60 inches is yellowish brown and light olive brown in the upper part and brown and grayish brown in the lower part. It is friable, calcareous loan. In places where the soil has not been plowed the surface soil is dark colored and about 12 inches thick. In places the light colored substratum is exposed.

Included with this soil in mapping are a few small areas of Salida and Dickman soils. Both of these soils are droughty and erode more easily than Storden soils. They generally are on the higher, more sharply convex slopes. Salida soils contain gravel, and Dickman soils are sandy. Also included are a few small areas of soils that have a silty substratum. The included soils make up less than 10 percent of the map unit.

Permeability of this soil is moderate, and surface runoff is medium. Available water capacity is high. The plow layer contains about 1 to 2 percent organic matter. Reaction is commonly moderately alkaline throughout, and this soil has an excess of lime carbonates. This soil is very low in available phosphorus and potassium. The high concentration of lime carbonates reduces the effectiveness of fertilizer and some herbicides. The supply of available iron is sometimes deficient in this soil, and in places the availability of other minor elements may be low.

Most areas of this soil are cultivated, but some areas are in pasture. This soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. If the soil is used for cultivated crops, there is a hazard of erosion. Conservation tillage, which leaves crop residue on the surface, and grassed waterways help prevent excessive soil loss. Controlling erosion by the use of mechanical practices, such as contouring and terracing, is difficult in places because of irregular topography and short slopes. Returning crop residue to the soil or adding other organic material on a regular basis helps to increase organic matter content, improve fertility, and maintain good tilth.

The use of this soil for pastureland or hayland is also effective in 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 restricting grazing during wet periods help to keep the pasture productive and the 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 short, convex side slopes and on sharply convex knobs and ridges in the rolling to hilly uplands throughout the county. Individual areas of this soil are irregular in shape, and most areas range from 5 to 10 acres in size. However, some areas are as large as about 30 acres. Some areas, on side slopes adjacent to streams and drainageways, are long and narrow.

Typically, the surface layer, about 8 inches thick, is very dark grayish brown and brown loam, mixed with some streaks and pockets of light olive brown substratum material. The mottled substratum to a depth of about 60 inches is yellowish brown, light olive brown, and grayish brown in the upper part and brown and grayish brown in the lower part. It is friable, calcareous loam. In places that have not been plowed the soil commonly has a very dark gray surface layer about 10 inches thick. In places the light colored substratum is exposed.

Included with this soil in mapping are a few small areas of Salida and Dickman soils. These soils are generally on the more sharply convex parts of the slope. Both the Salida and Dickman soils are more droughty and erode more readily than the Storden soil. Also included are a few small areas of soils that have a silty substratum. The included soils make up less than 10 percent of this map unit.

Permeability of this soil is moderate, and surface runoff is rapid. Available water capacity is high. The plow layer contains about 1 to 2 percent organic matter. Reaction is commonly moderately alkaline throughout, and there is an excess of lime carbonates. The soil is very low in available phosphorus and potassium. The high concentration of lime carbonates reduces the effectiveness of fertilizer and some herbicides.

Many areas of this soil are used for cultivated crops, but this soil is frequently in pasture. This soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. If this soil is used for cultivated crops, there is a severe erosion hazard. Conservation tillage, which leaves crop residue on the soil or mixed in the surface layer, and grassed waterways help prevent excessive soil loss. Controlling erosion by the use of mechanical practices, such as contouring and terracing, is difficult in places because of irregular topography and short slopes. Because of the excess of lime carbonates in this soil, applications of fertilizer and herbicides in amounts that are larger than normal are needed to maintain desirable yields. The supply of available iron is sometimes deficient in this soil, and in places other minor elements may be low in availability. Returning crop residue to the soil or adding other organic material on a regular basis helps to increase organic matter content, improve fertility, and maintain good tilth.

The use of this soil for pastureland or hayland is also effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increases runoff, and results in poor tilth. Proper stocking rates, pasture rotation, and timely deferment of grazing keep the pasture productive and the soil in good condition.

This soil is in capability subclass IIIe.

62E2—Storden loam, 14 to 18 percent slopes, moderately eroded. This moderately steep, well drained soil is on hills and ridges in the uplands and on slopes along drainageways and small streams. Some areas are dissected by shallow drainageways. Individual areas of this soil are irregular in shape and commonly range from 5 to 10 acres in size. However, some areas are as large as about 30 acres. Some areas, on side slopes and adjacent to streams and drainageways, are long and narrow.

Typically, the surface layer is about 7 inches thick. It is very dark brown loam mixed with some streaks and pockets of very dark grayish brown and brown substratum material. The mottled substratum is yellowish brown and light olive brown in the upper part and brown and grayish brown in the lower part. It is friable, calcareous loam.

Included with this soil in mapping are a few small areas of Clarion, Salida, and Dickman soils. Clarion soils have a thicker and darker surface layer and are leached or have carbonates to a depth of 18 inches or more. Salida and Dickman soils are commonly on the more sharply convex parts of the slope. Both of these soils contain more sand, are more droughty, and erode more readily than the Storden soil. Also included are a few small areas of soils that have a silty substratum. The included soils make up less than 5 to 10 percent of this map unit.

Permeability of this soil is moderate, and surface runoff is very rapid. Available water capacity is high, but often this potential is not reached because of rapid runoff and reduced surface infiltration. The surface layer contains about 1 to 2 percent organic matter. Reaction is generally moderately alkaline throughout, and there is an excess of lime carbonates. This soil is very low in available phosphorus and potassium.

Many areas of this soil are used for cultivated crops because they are associated with soils that are better suited to this use. Most areas that border drainageways and streams are in pasture.

This soil is poorly suited to corn and soybeans. It is better suited to small grains and to grasses and legumes for hay and pasture. If this soil is used for cultivated crops, there is a severe erosion hazard. Practices that control runoff and allow more water to enter the soil help prevent excessive soil loss and improve pasture and crop growth. Conservation tillage, which leaves crop residue on the surface, and grassed waterways help prevent soil loss. Controlling erosion by the use of mechanical practices, such as contouring and terracing, is difficult in places because of irregular topography and short, steep slopes. An excess of lime carbonates in this soil reduces the effectiveness of fertilizer and herbicides. The supply of available iron is sometimes deficient, and in places other minor elements may be low in availability. Returning crop residue to the soil or adding other organic material on a regular basis helps to increase organic matter content, improve fertility, and maintain good tilth.

The use of this soil for pastureland or hayland is also effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increases runoff, and results in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture productive and the 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 mostly on short, convex side slopes adjacent to drainageways and streams in the uplands. A few areas are on steep hills and ridges in other parts of the uplands. Some areas are dissected by shallow drainageways. Many areas of this soil along drainageways and streams are long and narrow. Other areas are irregular in shape. Individual areas range from about 5 to 15 acres in size.

Typically, the surface layer is very dark gray, very dark grayish brown, and very dark brown loam about 7 inches thick. The mottled substratum to a depth of 60 inches is yellowish brown and light olive brown in the upper part and brown and grayish brown in the lower part. It is friable, calcareous loam. In places erosion has exposed the light colored substratum.

Included with this soil in mapping and making up less than 5 percent of the map unit are a few small areas of Salida and Dickman soils. These soils are commonly on the more sharply convex slopes. They contain more sand, are more droughty, and erode more readily than this Storden soil. Also included are a few small areas of soils that have a silty substratum.

Permeability of this soil is moderate, and surface runoff is very rapid. Available water capacity is high, but often this potential is not reached because of rapid runoff and reduced surface infiltration. The surface layer contains about 1 to 2 percent organic matter. Reaction is generally moderately alkaline throughout, and there is an excess of lime carbonates. This soil is very low in available phosphorus and potassium. The high concentration of lime carbonates in this soil limits the effectiveness of fertilizer and some herbicides.

Almost all of the acreage of this soil is used for pasture. Scattered trees are in a few areas along streams. This soil is generally not suited to cultivated crops because of the steep slopes and severe erosion hazard. This soil is best suited to use as pasture. Erosion is a hazard, and low fertility limits plant growth. Crops often do not have enough water during periods of low rainfall because of rapid runoff.

Practices such as improving fertility and controlling runoff so that more water can enter the soil improve crop growth. Overstocking and overgrazing the pasture reduce the protective vegetative cover and cause deterioration of the grasses. Under these conditions, weeds invade and compete with grasses for available water and plant nutrients. Proper stocking rates, uniform grazing, timely deferment of grazing, and use of a planned grazing system help keep the pasture and the soil in good condition. Ungrazed areas provide habitat for some species of wildlife. Adding fertilizer increases pasture production dramatically. If this is done along with renovation to establish more desirable and productive plant species, more uniform and greater total production can be achieved. An excess of lime carbonates in this soil adversely affects the response of plants to fertilizer and herbicides.

This soil is in capability subclass VIe.

62G—Storden loam, 25 to 40 percent slopes. This very steep, well drained soil is mostly on short, convex side slopes adjacent to drainageways and streams in the uplands. Some areas are dissected by shallow drainageways. Most areas are long and narrow and range from about 5 to 15 acres in size.

Typically, the surface layer is very dark gray, very dark brown, and very dark grayish brown loam about 5 inches thick. The mottled substratum to a depth of 60 inches is yellowish brown and light olive brown in the upper part and brown and grayish brown in the lower part. It is friable, calcareous loam. In a few areas erosion has exposed the light colored substratum.

Included with this soil in mapping and making up less than 5 percent of the map unit are a few small areas of Salida and Dickman soils. These soils are commonly on the highest, most sharply convex parts of the slopes. Both these soils contain more sand, are more droughty, and erode more readily than the Storden soil.

Permeability of this soil is moderate, and surface runoff is very rapid. Available water capacity is high, but this potential is seldom reached because of rapid runoff and reduced surface infiltration. The surface layer contains about 1 to 2 percent organic matter. Reaction is commonly moderately alkaline throughout, and there is an excess of lime carbonates. The soil is very low in available phosphorus and potassium.

Almost all of the acreage of this soil is in native vegetation of prairie grasses. A few scattered trees are in a few areas. Most areas are used for livestock grazing. Some areas have been left idle and provide habitat for wildlife. This soil is not suited to row crops and is best suited to use as pastureland. Erosion is a severe hazard, and low fertility limits plant growth. Plants often lack water during periods of low rainfall because of rapid runoff.

Management that improves fertility and controls runoff so that more water can enter this soil improves crop growth and reduces erosion. Overstocking and overgrazing the pasture reduce the protective vegetative cover and cause deterioration of the grasses. Under these conditions, weeds invade and compete with grasses for available water and plant nutrients. Proper stocking rates, uniform grazing, timely deferment of grazing, and use of a planned grazing system help keep the pasture productive and the soil in good condition. Ungrazed areas provide habitat for some species of wildlife.

Steepness of slope prohibits renovation of pasture to establish more desirable and productive plant species. The excess of lime carbonates reduces the effectiveness of fertilizer and herbicides. Sites that could be used for livestock ponds are available in many areas of this soil. This soil is not suited to cultivation because of steepness of slope.

This soil is in capability subclass VIIe.

73C2—Salida gravelly sandy loam, 2 to 9 percent slopes, moderately eroded. This gently sloping to moderately sloping, excessively drained soil is on upland knolls, outwash plains, and stream benches. In the uplands and on outwash plains, areas of this soil are generally small and irregular in shape. The areas on stream benches are on escarpments or the edges of breaks. Most of those areas are generally long and narrow. Areas of this soil range from about 2 to 10 acres in size. Slopes are generally short and convex. Gravel-sized particles, small rocks, and pebbles are commonly on the surface.

Typically, the surface layer is about 7 inches thick. It is very dark grayish brown gravelly sandy loam, mixed with some streaks and pockets of dark grayish brown and brown subsoil material. The subsoil is about 5 inches thick in undisturbed areas. It is brown or dark brown, calcareous gravelly loamy sand. In cultivated fields the subsoil has commonly been mixed with the surface layer. The substratum to a depth of 60 inches is multicolored, calcareous sand and gravel. Some severely eroded areas have a surface layer that is less than 3 inches thick, and in places the substratum is exposed. In some areas the soil is less sloping and commonly has a slightly thicker surface layer. These areas are typically about 5 acres in size. Small areas of sandy soils that are leached of carbonates to a depth of about 20 inches are on the lower part of the slope.

Permeability of this soil is very rapid, and surface runoff is slow. Available water capacity is very low. The surface layer contains about 1 percent or less organic matter. Reaction is commonly mildly alkaline in the surface layer and moderately alkaline in the subsoil. The supply of available phosphorus and potassium is very low.

Many areas of this soil are cultivated, but other areas are associated with steeper soils and are used for pasture. This soil is very poorly suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Many areas are used for cultivated crops because they occur in small irregularly shaped areas with other soils that are better suited to crops. Stones and gravel on the surface hinder tillage operations in cultivated areas of this soil. Soil blowing can be severe when this soil is tilled and the surface layer is left bare. Conservation tillage, or leaving crop residue on the surface, reduces the hazard of erosion and helps to conserve water. Row crops can be planted on the contour. In cultivated fields a few areas are commonly left in grass, which is grazed in the fall along with the residue from row crops. These areas also provide habitat for wildlife. Larger areas are left idle or used as pasture. They can be improved for forage production and wildlife by planting desirable species that tolerate drought. If pastures are properly managed, native bluestem grasses eventually move onto this soil. Controlled grazing and harvesting are essential to maintain desirable plant species and satisfactory forage production.

This soil is in capability subclass IVs.

73E2—Salida gravelly sandy loam, 9 to 25 percent slopes, moderately eroded. This strongly sloping to steep, excessively drained soil is on knobs and hills in the uplands and on outwash plains or high stream benches. In the uplands, areas of this map unit are generally small and irregular in shape. The areas on outwash plains or stream benches are on side slopes bordering drainageways and on breaks or escarpments to bottom lands. Most of those areas are generally long and narrow. Areas of this map unit range from about 6 to 12 acres in size. Gravel-sized particles, small rocks, and pebbles are commonly on the surface.

The surface layer is about 8 inches thick. It is very dark grayish brown gravelly sandy loam, mixed with some streaks and pockets of dark brown and brown subsoil material. The subsoil, about 6 inches thick, is dark brown and dark yellowish brown, calcareous gravelly loamy sand. The substratum to a depth of 60 inches is mixed dark brown and dark yellowish brown, calcareous sand and gravel. Some severely eroded areas have a surface layer less than 3 inches thick, and in places the substratum is exposed. Also in places are small areas of sandy soils that are leached of carbonates to a depth of about 20 inches.

Permeability of this soil is very rapid, and surface runoff is medium. Available water capacity is very low. The surface layer contains about 1 percent or less organic matter. Reaction is commonly mildly alkaline in the surface layer and moderately alkaline in the subsoil and substratum. The supply of available phosphorus and potassium is very low.

Most of the acreage of this soil is in native grass and is used as pasture or is left idle. Stones and gravel in the surface layer hinder tillage operations in cultivated areas.

Grassland is the best use for this soil. Major management concerns are the hazard of erosion, low fertility, and the very low available water capacity. Maintaining an adequate vegetative cover helps prevent excessive soil loss and improves the soil's available water capacity by reducing runoff and the rate of drying. Adding fertilizer improves plant growth, but the fertilizer should be applied in the fall or very early in spring before a lack of water limits growth. If pastures are properly managed, native bluestem grasses eventually move onto this soil. Proper stocking rates, timely deferment of grazing, and use of a planned, uniform rotational grazing system are needed to help maintain desirable plant species and to keep the vegetation and the soil productive and in good condition. If properly managed, this soil is well suited to wildlife habitat.

This soil is in capability subclass VIe.

90—Okoboji mucky silt loam, 0 to 1 percent slopes. This level, very poorly drained mucky soil is in shallow upland depressions or sloughs. It is subject to ponding. Individual areas of this unit are circular in shape and typically range from 10 to 20 acres in size. A few areas range up to 50 acres.

Typically, the surface layer is black mucky silt loam about 10 inches thick. The subsurface layer, which extends to a depth of about 3 feet, is black mucky silt loam and silty clay loam. The mottled substratum to a depth of 60 inches is dark grayish brown, grayish brown, and gray, calcareous clay loam. In places the soil has a dark colored subsoil that extends to a depth of 60 inches or more.

Included in some areas of this soil and making up less than 5 percent of the map unit are a few small rises consisting of Harps soils. These soils are calcareous throughout and are distinctly lighter in color when dry.

Permeability of this Okoboji soil is moderately slow. The seasonal high water table ranges from 12 inches below the surface to 12 inches above the surface. The available water capacity is high. The plow layer contains about 9 to 18 percent or more organic matter. The shrink-swell potential is high. The subsoil is generally very low in available phosphorus and low to very low in available potassium. Reaction is typically neutral in the surface layer of this Okoboji soil, and it is mildly alkaline or neutral in the subsoil. The surface layer has good tilth because of the high organic matter content.

Most of the acreage of this soil is cultivated. This soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Most of the acreage is artificially drained or partly drained and is cultivated. Surface intakes, shallow ditches, and underground drains are used. In places it is difficult to find outlets deep enough for these drains to function adequately. Many areas are ponded in spring and after heavy rains. In some years water ponds long enough to drown out crops. If this occurs early in the season, the land can be tilled and replanted. Even where artificial drainage is adequate for good crop growth, tillage is delayed after heavy rains.

Because this soil is in low-lying areas and has a high organic matter content, it is slow to warm in spring and loses heat rapidly from the surface. Because of this crops are subject to frost damage late in spring and early in fall. On areas of this soil that are large enough to be managed separately, the use of early maturing varieties helps reduce crop losses due to late planting and early frost. This soil has excellent tilth and can be tilled in a wide range of moisture content. The surface layer is less dense and compacted than in other Okoboji soils, making preparation of a desirable seedbed easier. Fall plowing should be avoided in large areas because soil blowing is a hazard if the soil is not protected. Production can be improved in many areas by improving the drainage system. On this soil the application rate of some herbicides should be increased over the rate used for surrounding soils and other Okoboji soils because this soil's higher organic matter content reduces the effectiveness of the herbicides.

This soil is poorly suited to some legumes, especially alfalfa. Ponding of water and soil heaving in winter frequently kill crops. If this soil is used for hay and improved pasture, grasses and legumes that tolerate wetness should be substituted for those more commonly grown. Grazing when the soil is wet should be avoided to prevent crop damage. Undrained areas are generally used for permanent pasture or left idle, depending on the depth and duration of ponding. Productivity on most areas can be increased by improving drainage and planting more desirable grasses that tolerate wetness and periods of ponding. Some undrained areas provide habitat for wildlife. Most drained areas of this soil are suited to development as cropland. This soil is generally managed in conjunction with the adjacent soils, but some areas are managed separately.

This soil is in capability subclass IIIw.

95—Harps clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is in the uplands, on convex rims that border depressions. It is highly calcareous. This Harps soil has a distinctly grayer surface layer than the adjacent soils when dry (fig. 10). Some areas are on slightly convex slopes in larger areas of Canisteo soils. Individual areas are irregular in shape and range from 5 to about 25 acres.

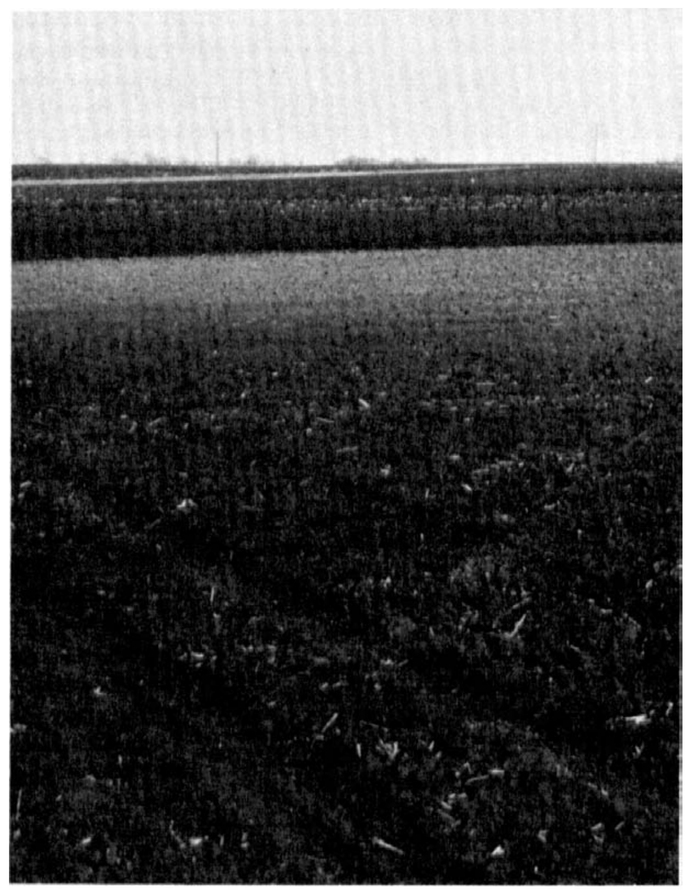


Figure 10.—Light colored Harps clay loam, 0 to 2 percent slopes, surrounding darker colored Okoboji soils in the foreground. Special management is required to compensate for the high lime content of Harps soils.

Typically, the surface layer is black clay loam about 9 inches thick. The subsurface layer is very dark gray clay loam about 5 inches thick. It contains numerous snail shell fragments. The mottled subsoil, about 20 inches thick, is dark gray, olive gray, and gray clay loam in the upper part and olive gray, olive, and light olive gray loam in the lower part. The substratum to a depth of 60 inches is olive gray loam that has yellowish brown mottles. This soil is calcareous and high in lime throughout. In places the surface layer is loam. In places very fine sand is at a depth below 30 inches.

Included with this soil in mapping and making up less than 5 percent of the map unit are some small areas of Okoboji soils in slight depressions. They are wetter than this Harps soil and tend to pond after rains.

Permeability of this soil is moderate, and surface runoff is slow. Available water capacity is high. A seasonal high water table is at a depth of 12 to 36 inches. The plow layer contains about 4 to 5 percent organic matter. Reaction is moderately alkaline. This soil is very low in available phosphorus and potassium. Available iron is also seriously deficient, and some minor elements are likely to be in short supply.

Most areas of this soil are cultivated. This soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. If this soil is used for cultivated crops, adequate drainage is needed to reduce wetness and provide proper aeration for plants that require a deep root zone. Underground drains work well, but in some places, providing adequate outlets is a problem. An excess of lime carbonates in this soil reduces the effectiveness of fertilizer, and special fertilization may be needed.

Some crops, particularly soybeans, show dramatic visual evidence of iron deficiency when grown on this soil. In years of excessive rainfall, crops may be lost on some areas of this soil because of ponding on the adjacent Palms Muck and Okoboji soils. Excessive tillage readily destroys the weak soil structure, and this soil is subject to blowing if the surface is left bare and becomes dry. Conservation tillage, which leaves crop residue on the surface, and the regular addition of other organic material help improve structure and reduce soil blowing.

If this soil is used for pasture, proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture productive and the soil in good condition. Because most areas of this soil are small, they are managed with the surrounding Canisteo soils and the adjacent Palms muck and Okoboji soils.

This soil is in capability subclass IIw.

107—Webster silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is in upland swales and draws on the undulating till plain. Individual areas of this unit are irregular in shape and range from 5 to 80 acres in size.

Typically, the surface layer is black silty clay loam about 8 inches thick. The subsurface layer, about 11 inches thick, is black and very dark gray silty clay loam. The mottled subsoil is about 19 inches thick. The upper part is olive gray silty clay loam, and the lower part is olive gray and gray clay loam. The substratum to a depth of 60 inches is olive gray and light olive gray, mottled, calcareous loam. In places the subsoil is thinner and the depth to carbonates is much less. In places the soil has a surface layer of clay loam.

Included with this soil in mapping are some small areas of Okoboji, Rolfe, and Clarion soils. Okoboji and Rolfe soils are in small depressions. They are wetter than this soil and tend to pond after rains. Clarion soils are on small, sharply convex areas and are well drained. Also included are a few small areas of Harps soils. These soils are calcareous throughout and are distinctly lighter in color when dry. The included areas make up less than 10 percent of this map unit.

Permeability of this soil is moderate, and surface runoff is slow. The seasonal high water table is at a depth of 12 to 24 inches. Available water capacity is high. The surface layer contains about 6 to 7 percent organic matter. Reaction is typically neutral in the surface layer and upper part of the subsoil. It ranges from neutral to moderately alkaline in the lower part of the subsoil. The subsoil is commonly very low to low in available phosphorus and potassium.

Most areas of this soil are cultivated. A few small undrained areas are in pasture. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Drainage is essential for optimum crop production and can be improved by the installation of underground drains. Such drains function well in this soil. If this soil is plowed when wet, the surface layer puddles easily and becomes cloddy and hard to work when dry. If large areas are fall plowed, soil blowing is a hazard if the surface is left bare. Conservation tillage, which leaves crop residue on the surface, helps prevent soil blowing.

Most areas of this soil that are not drained sufficiently for dependable row crops are used for pasture. Overgrazing or grazing when the soil is too wet causes surface compaction and poor tilth and reduces the water infiltration rate. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture productive and the 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 nearly level, well drained soil is on slightly convex slopes on glacial outwash areas, stream benches, and valley trains. Individual areas are irregular in shape and range from 3 to 15 acres or more in size.

Typically, the surface layer is black loam about 9 inches thick. The subsurface layer is black and very dark brown loam in the upper part and very dark brown and very dark grayish brown loam in the lower part. The subsurface layer is about 7 inches thick. The subsoil, about 11 inches thick, is loam in the upper part and sandy loam in the lower part. It is dark yellowish brown. The substratum to a depth of 60 inches is dark yellowish brown and yellowish brown in the upper part and grayish brown and brown in the lower part. It is calcareous sand and gravel. In places the entire subsoil is sandy loam. In places shale fragments are scattered throughout the profile.

Included with this soil in mapping and making up 5 to 10 percent of the map unit are small areas of Estherville soils. They are on the slightly higher parts of the landscape and contain more gravel at a shallower depth than Wadena soils.

Permeability is moderate in the solum and rapid in the substratum. Available water capacity is low to moderate. Surface runoff is slow. The surface layer contains about 3 to 4 percent organic matter. The supply of available phosphorus is very low, and the supply of available potassium is very low to low. The surface soil has good tilth. This soil warms up quickly in the spring and can be worked soon after rains.

Most areas of this soil are cultivated. This soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. It is better suited to small grains, grasses, and legumes than to cultivated crops because of droughtiness during parts of most growing seasons. Erosion by water is generally not a problem; but because the surface dries quickly after tillage, soil blowing is a hazard. Blown sand may damage young plants in some years. Conservation tillage, which leaves crop residue on the surface, slows drying and helps prevent soil blowing.

The use of this soil for pastureland or hayland is also an effective way to control soil blowing. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture productive and the 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 convex slopes on glacial outwash areas, stream benches, and valley trains. Individual areas have irregular shapes and range from 3 to 12 acres or more in size.

Typically, this Wadena soil has a black and very dark brown loam surface layer about 8 inches thick. The subsurface layer is very dark brown and very dark grayish brown loam about 6 inches thick. The subsoil, about 12 inches thick, is dark yellowish brown. It is loam in the upper part and sandy loam in the lower part. The substratum to a depth of 60 inches is commonly dark yellowish brown, brown, and yellowish brown. It is calcareous sand and gravel. In places the entire subsoil is sandy loam. In other places shale fragments are throughout the profile.

Included with this soil in mapping and making up less than 5 percent of the map unit are small areas of Salida soils. They are on the more sharply convex areas of some slopes and contain more sand and gravel at a shallower depth than the Wadena soil.

Permeability is moderate in the solum and rapid in the substratum. Surface runoff is slow. Available water capacity is low to moderate. The surface layer contains about 3 to 4 percent organic matter. The supply of available phosphorus is very low, and the supply of available potassium is very low to low. The surface has good tilth. This soil warms up quickly in the spring and can be worked soon after rains.

Most areas of this soil are cultivated. This soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture, especially in years when rainfall is below average or if rains are untimely. For this reason it is better suited to small grains, grasses, and legumes than to cultivated crops. If this soil is used for row crops, erosion is a hazard. Soil blowing is sometimes a hazard because the surface dries quickly after tillage. Blown sand may damage young plants in some years. Conservation tillage, which leaves crop residue on the surface, slows drying and helps prevent soil blowing and water erosion.

The use of this soil for pastureland or hayland is also an effective way to control soil blowing. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture productive and the soil in good condition.

This soil is in capability subclass IIe.

133—Colo silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on flood plains. This soil is subject to flooding. Areas along the smaller streams are commonly long and narrow and are on both sides of the stream. Some areas of this soil are as large as about 50 acres. Other areas along the larger streams are irregular in shape and typically range from about 10 to 35 acres in size.

Typically, the surface layer is black silty clay loam about 5 inches thick. The subsurface layer is black silty clay loam about 45 inches thick. The substratum is very dark gray clay loam to a depth of 60 inches. In places the surface layer is thinner. In places the soil contains more sand throughout the surface layer and substratum.

Permeability of this soil is moderate, and the available water capacity is high. Surface runoff is slow. The surface layer contains about 5 to 7 percent organic matter. The shrink-swell potential is high. Reaction is neutral throughout the profile. This soil has a seasonal high water table at a depth of 12 to 36 inches. The subsoil is medium to low in available phosphorus and low in available potassium.

Most areas of this soil are cultivated, but areas that are flooded too often are in pasture. This soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture where drainage is adequate. Flooding drowns out legumes in some years. Flooding commonly occurs early in spring and in most areas does not often limit this soil's use for row crops. Underground drains work well. In some places shallowness of the stream channel makes providing adequate outlets difficult. Returning crop residue to the soil or adding other organic material on a regular basis helps to improve fertility, reduce crusting, and increase water infiltration.

This soil is moderately well suited to pastureland or hayland. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and poor tilth. Proper stocking rates, rotational grazing, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture productive and the soil in good condition.

This soil is in capability subclass IIw.

133B—Colo silty clay loam, 2 to 4 percent slopes. This gently sloping, poorly drained soil is on low-lying, concave foot slopes and alluvial fans throughout the county. It also is in narrow upland drainageways. This soil is subject to flooding. Areas along the larger streams are irregular in shape and range from 5 to about 25 acres in size.

Typically, the surface layer is black silty clay loam about 5 inches thick. The subsurface layer is black silty clay loam about 31 inches thick. Ths substratum to a depth of 60 inches is dark gray silty clay loam. Thin lenses of sand or silt are common. In places the surface layer is thinner and the sand content is higher. In places glacial till is at a depth of about 40 inches.

Included with this soil in mapping and making up less than 5 percent of the map unit are a few areas of Spillville soils. They are in narrow areas on the foot slopes and are better drained.

Permeability of this soil is moderate, and surface runoff is medium. Reaction is neutral or slightly acid throughout the profile except in areas where the substratum is calcareous till. This soil has high available water capacity. It receives runoff from adjacent slopes and has a high water table at a depth of 12 to 36 inches unless artificially drained. The plow layer contains about 5 to 7 percent organic matter. This soil has high shrink-swell potential. It is medium to low in available phosphorus and low in available potassium.

Most areas of this soil are cultivated. A few areas are in pasture. This soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. If this soil is used for cultivated crops, it should be protected from erosion and adequately drained. Conservation tillage, which leaves crop residue on the surface, and grassed waterways help prevent excessive soil loss. Terraces and diversions can be placed on adjacent slopes to prevent runoff from collecting on this soil. During periods of heavy rainfall, some areas of this soil are flooded for short periods, but this generally does not interfere with cropping or damage growing crops. Returning crop residue to the soil or adding other organic material on a regular basis helps to improve fertility and maintain good tilth.

If this soil is used for pastureland, proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture productive and the 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 first bottoms. It is subject to flooding. Areas along the smaller streams are commonly long and narrow and parallel both sides of the stream. In some places these streams have been straightened and deepened to provide drainage outlets. An old meander channel that is somewhat lower than the surrounding soil is in some areas of this soil. Some individual areas are as large as about 80 acres. Areas along the larger streams are irregular in shape and typically range from 15 to 35 acres in size.

Typically, the surface layer is black clay loam about 8 inches thick. The subsurface layer is black and mottled, very dark gray clay loam about 40 inches thick. The mottled substratum to a depth of 60 inches is very dark gray clay loam. In places the surface layer extends to a depth of 50 inches or more. In places loamy sand is at a depth of 36 inches.

Included with this soil in mapping and making up less than 5 percent of the map unit are some small areas of soils that are slightly calcareous. These are mainly in slightly depressional areas or in areas adjacent to stream channels.

Permeability of this soil is moderate, and available water capacity is high. Surface runoff is slow. The surface layer contains about 5 to 7 percent organic matter. This soil has high shrink-swell potential. Reaction is neutral or slightly acid throughout the profile. This soil has a seasonal high water table at a depth of 12 to 36 inches. It is medium to low in available phosphorus and low in available potassium.

Most areas of this soil are cultivated. Areas that are flooded too frequently or that are not adequately drained are in pasture. This soil is moderately suited to corn, soybeans, and small grains and to grasses for hay and pasture. Because seasonal flooding drowns out some legumes, this soil is poorly suited to these crops. Flooding commonly occurs early in spring and generally does not limit this soil's usefulness for row crops in most areas. Adequate drainage and protection from flooding should be provided for optimum crop growth.

Underground drains work well, but in some places, shallowness of the stream channel makes providing adequate outlets difficult.

This soil is suited to pastureland or hayland. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture productive and the 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 convex knolls and on ridgetops. It has complex slopes that are short and irregular. Typical areas are irregular in shape and range from 10 to 40 acres in size.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is black and very dark brown loam about 8 inches thick. The subsoil, about 18 inches thick, is dark brown and dark yellowish brown, friable loam in the upper part and yellowish brown, mottled, friable loam in the lower part. The substratum to a depth of 60 inches is light olive brown and dark yellowish brown, mottled, calcareous loam. In places the subsoil is thicker, and the depth to calcareous material is 50 inches or more. In some places the subsoil is lower in clay and higher in sand content. In other places, mostly in the north part of the county, are areas where carbonates are highly concentrated at a depth of about 25 to 30 inches.

Included with this soil in mapping are a few small areas of Storden, Dickman, and Salida soils, which are less fertile and lower in organic matter content. Storden soils are mainly on the most convex parts of the slope. Dickman and Salida soils are mainly on the highest point of the slopes. Included are a few small areas of Rolfe soils, which are in depressions, tend to pond after rains, and remain wet for long periods in early spring. The included areas make up less than 10 percent of the map unit.

Permeability of this soil is moderate, and surface runoff is medium. Available water capacity is high. The plow layer contains about 3 to 4 percent organic matter. Reaction is typically slightly acid or neutral in the surface layer and upper part of the subsoil. The subsoil is generally very low to low in available phosphorus and very low in available potassium. This soil has good tilth.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. If the soil is used for cultivated crops, there is a hazard of erosion. Conservation tillage, which leaves crop residue on the surface, terracing, and contouring help prevent excessive soil loss. Controlling erosion by the use of mechanical practices, such as contouring and terracing, is difficult in some places because of irregular topography and short slopes, but in many places these practices are suitable. Returning crop residue to the soil or adding other organic material on a regular basis helps to improve fertility, reduce soil erosion, reduce crusting, maintain good tilth, and increase water infiltration.

The use of this soil for pastureland or hayland is also effective in controlling erosion. Overgrazing, however, causes surface compaction, increases runoff, results in poor tilth, and reduces production. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture and the soil in good condition.

This soil is well suited to trees and windbreaks. Seedlings grow well if competing vegetation is controlled or removed. Site preparation that disturbs the soil increases the erosion hazard.

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 on convex side slopes that border streams and upland drainageways. Slopes are typically short. Individual areas are irregular in shape and range from 2 to 15 acres in size.

Typically, the surface layer is black loam about 6 inches thick. The subsurface layer is black and very dark brown loam and is about 4 to 6 inches thick. The subsoil, about 16 inches thick, is dark brown and brown, friable loam in the upper part and yellowish brown, mottled, friable loam in the lower part. The mottled substratum to a depth of 60 inches is light olive brown and dark yellowish brown, calcareous loam. In some places the subsoil is thicker, and the depth to calcareous material is 50 inches or more. In places the surface layer is less than 6 inches thick.

Permeability of this soil is moderate, and surface runoff is medium. Available water capacity is high. The surface layer contains about 3 to 4 percent organic matter. Reaction is typically slightly acid or neutral in the surface layer and upper part of the subsoil. The subsoil is generally very low to low in available phosphorus and very low in available potassium. This soil has good tilth.

Most of the acreage of this soil is in pasture and farmsteads. A few areas are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. If the soil is used for cultivated crops, there is a hazard of erosion. Conservation tillage, terracing, contouring, winter cover, and grassed waterways help prevent excessive soil loss. Controlling erosion by the use of mechanical practices, such as contouring and terracing, is difficult in some places because of irregular topography and short slopes, but in most places these practices are suitable. Returning crop residue to the soil or adding other organic material on a regular basis helps to maintain fertility and good tilth.

The use of this soil for pastureland or hayland is also effective in 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 restricting grazing during wet periods help to keep the pasture and the soil in good condition.

This soil is well suited to trees and windbreaks. Seedlings survive and grow well if competing vegetation is controlled or removed. Site preparation that disturbs the soil increases the erosion hazard.

This soil is in capability subclass IIIe.

138C2—Clarion loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, well drained, moderately permeable soil is on knolls and convex side slopes that border streams and upland drainageways. Slopes are typically short and commonly irregular. Individual areas are irregular in shape and range from 2 to 20 acres in size.

Typically, the surface layer is about 8 inches thick. It is very dark brown loam mixed with some streaks and pockets of dark brown subsoil material. The subsoil is about 16 inches thick. It is dark brown or brown, friable loam in the upper part and yellowish brown, mottled, friable loam in the lower part. The substratum to a depth of 60 inches is yellowish brown, olive brown, and light olive brown, mottled, calcareous loam. In places the soil is lower in clay and higher in sand content. In some places the subsoil is thicker and the depth to calcareous material is 50 inches or more. In other places the surface layer and the upper part of the subsoil are clay loam.

Included with this soil in mapping are a few small areas of Storden soils that are lower in organic matter content. These are mainly on the steepest parts of slopes. Also included are small areas of Dickman and Salida soils that are more droughty. The included soils make up less than 10 percent of the map unit.

Permeability of this soil is moderate, and surface runoff is medium. Available water capacity is high. The plow layer contains about 2 to 3 percent organic matter. Reaction is typically slightly acid or neutral in the surface layer and upper part of the subsoil. The subsoil is

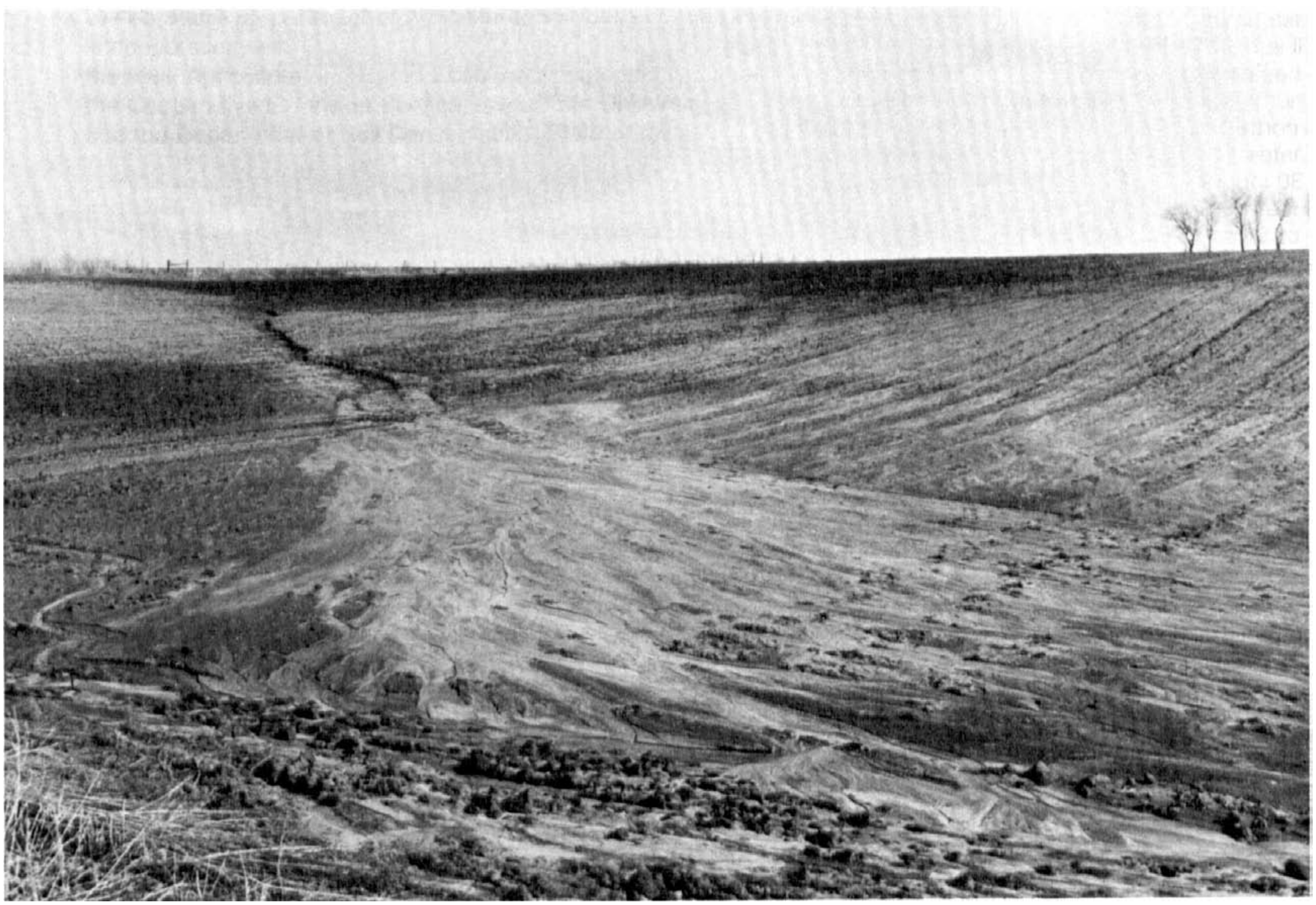


Figure 11.—Erosion on Clarion loam, 5 to 9 percent slopes, moderately eroded.

generally very low to low in available phosphorus and very low in available potassium. The plow layer typically has fair tilth.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay or pasture. If the soil is used for cultivated crops, there is a hazard of further erosion damage (fig. 11). Conservation tillage, which leaves crop residue on the surface, terracing (fig. 12), and grassed waterways help prevent excessive soil loss. Controlling erosion by the use of mechanical practices, such as contouring and terracing, is difficult in places because of irregular topography and short slopes, but in many places these practices are suitable. Returning crop residue to the soil or adding other organic material on a regular basis helps to improve fertility, reduce crusting, and increase water infiltration.

The use of the soil for pastureland or hayland is also effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increases runoff, and results in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture productive and the soil in good condition.

This soil is also well suited to trees and windbreaks. Seedlings survive and grow well if competing vegetation is controlled or removed. Site preparation that disturbs the soil increases the erosion hazard.

This soil is in capability subclass IIIe.

138D2—Clarion loam, 9 to 14 percent slopes, moderately eroded. This is a strongly sloping, well

Figure 12.—Parallel seeded backslope terraces help to control runoff and erosion on Clarion loam, 5 to 9 percent slopes, moderately eroded.

drained, moderately permeable soil. Some areas are on convex side slopes bordering drainageways in the stream valleys and uplands. Other areas of this soil are in hilly areas in other parts of the county. Slopes are typically short. Individual areas are commonly irregular in shape and range from 3 to 25 acres in size.

Typically, the surface layer is about 8 inches thick. It is very dark brown loam mixed with some streaks and pockets of dark brown subsoil material. The subsoil is about 14 inches thick. It is dark brown to yellowish brown, friable loam. The substratum to a depth of 60 inches is yellowish brown to light olive brown, friable, calcareous loam. In places the subsoil is thicker and deeper to calcareous glacial till. In places the subsoil has more sand and less clay. In some places the surface layer is less than 3 inches thick.

Included with this soil in mapping and making up less than 5 percent of the map unit are a few small areas of Dickman, Salida, and Storden soils that are more droughty and lower in organic matter content. These soils are mainly on the steepest parts of the slope.

Permeability of this soil is moderate, and surface runoff is rapid. Available water capacity is high. The surface layer contains about 2 to 3 percent organic matter. Reaction is typically slightly acid or neutral in the surface layer and upper part of the subsoil. The subsoil is generally very low to low in available phosphorus and very low in available potassium.

Most areas of this soil are cultivated. This soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay or pasture. If the soil is used for cultivated crops, there is a hazard of further erosion damage. Conservation tillage, which leaves crop residue on the surface, and grassed waterways help prevent excessive soil loss. Controlling erosion by the use of mechanical practices, such as contouring and terracing, is difficult in places because areas of this soil are small and irregular in shape and have irregular slopes. In many places, however, these practices are suitable. Returning crop residue to the soil or adding other organic material on a regular basis helps to improve fertility, reduce crusting, and increase water infiltration.

The use of the soil for pastureland or hayland is also very effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increases runoff, and results in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture productive and the soil in good condition.

This soil is in capability subclass IIIe.

150—Hanska loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on outwash plains, valley trains, and stream benches. Slopes are nearly level to slightly convex. In places they are crossed by shallow, concave swales and low, convex rises. Small quantities of fine gravel-sized particles are commonly in the surface layer. Individual areas are irregular in shape and range from 3 to 20 acres in size.

Typically, the surface layer is black loam about 7 inches thick. The subsurface layer is black and very dark gray, mottled loam about 13 inches thick. The subsoil is about 6 inches thick. It is grayish brown and dark grayish brown, mottled, friable sandy loam. The substratum to a depth of 60 inches is multicolored, calcareous sand that contains about 5 percent gravel. The depth to sand and gravel typically is between 24 and 32 inches. In places the depth to sand and gravel is less than 24 inches. In places the surface layer is sandy loam.

Included with this soil in mapping and making up less than 5 percent of the map unit are a few small areas of somewhat poorly drained Linder soils on some low convex rises.

Permeability is moderately rapid in the solum and rapid in the substratum. This soil has a seasonal high water table at a depth of 0 to 36 inches. The plow layer contains about 4 to 5 percent organic matter. Reaction is neutral to slightly acid in the surface layer, and in the subsoil is typically neutral. The subsoil is generally very low in available phosphorus and potassium. This soil has good tilth.

Most areas of this soil are used for row crops. This soil is moderately suited to corn or soybeans. In undrained areas a high water table restricts the rooting zone. Drainage is needed for dependable crop production. When drained, however, areas of this soil are moderately droughty, and crops suffer from a lack of water, especially if rainfall is below average or if rains are not timely. Underground drains work well, but care is needed to avoid overdraining this soil. Instability of the substratum makes installation of drains difficult, and suitable outlets are not available in some places. If this soil is plowed in the fall and the surface left bare, soil blowing is a serious hazard. Conservation tillage, which leaves crop residue on the surface, and adding other organic material help to improve fertility, prevent soil blowing, and conserve available water.

Because of the limited amount of available water during critical parts of the growing season for corn and soybeans, this soil may be better suited to small grains and to grasses and legumes for hay and pasture. Small grains and grasses and legumes generally mature early in the growing season, before a lack of available water limits growth. If this soil is used for pastureland, proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture productive and the soil in good condition.

Some areas of this soil are adjacent to old gravel pits and other areas suited to development as wildlife areas. This soil is well suited to development for some, mostly wetland, wildlife habitats. Some trees and shrubs grow well on this soil.

This soil is in capability subclass IIw.

181B—Clarion-Estherville complex, 2 to 5 percent slopes. This complex of gently sloping, well drained and somewhat excessively drained soils is on irregular, convex side slopes and ridges. Individual areas are irregular in shape and range from about 5 to 15 acres in size. This complex contains about 50 percent Clarion soils, about 30 percent Estherville soils, and about 20 percent soils of minor extent. Areas of these soils are so intricately mixed or so small that it is not practical to separate them at the scale used in mapping.

Typically, the surface layer of the Clarion soils is black loam about 8 inches thick. The subsurface layer is black and very dark brown loam about 8 inches thick. The subsoil is about 18 inches thick. The upper and middle parts are dark brown and dark yellowish brown, friable loam, and the lower part is yellowish brown, mottled, friable loam. The substratum to a depth of 60 inches is dark yellowish brown, olive brown, and light olive brown, mottled loam.

Typically, the Estherville soils have a surface layer that is black sandy loam about 7 inches thick. The subsurface layer is black and very dark brown sandy loam about 5 inches thick. The subsoil is about 8 inches thick. It is dark brown and dark yellowish brown sandy loam in the upper part and dark brown gravelly sandy loam in the lower part. The substratum to a depth of 60 inches is brown and dark yellowish brown, calcareous sand and gravel.

Included in mapping and making up about 20 percent of the map unit are areas of soils that are extremely variable in texture and depth of leaching. These included soils occur randomly on the same positions as the Clarion and Estherville soils in this complex.

Permeability of the Clarion soils is moderate. Permeability of the Estherville soils is moderately rapid in the solum and rapid in the substratum. Surface runoff is medium on both soils. Available water capacity is high in the Clarion soils and very low or low in the Estherville soils. Organic matter content in the surface layer is about 3 to 4 percent in the Clarion soils and about 2 to 3 percent in the Estherville soils. The supply of available phosphorus is generally very low to low in the Clarion soils and very low in the Estherville soils. The supply of available potassium is very low in both soils.

Most of the acreage of this soil complex is cultivated. The Clarion soils are well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. The Estherville soils are poorly suited to these crops, and when used for row crops, need to be protected from water erosion and soil blowing. Terracing and contouring are made difficult by irregular slopes. Also, terrace construction on the Estherville soils is likely to expose the sand and gravel substratum. However, conservation tillage, which leaves crop residue on the surface, is effective in helping to prevent excessive soil loss.

The use of these soils for pastureland or hayland is also effective in 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 restricting grazing during wet periods help to keep the pasture productive and the soil in good condition.

These soils are in capability subclass IIIe.

181C2—Clarion-Estherville complex, 5 to 9 percent slopes, moderately eroded. This complex of moderately sloping, well drained and somewhat excessively drained soils is on irregular, convex side slopes and ridges. Individual areas are irregular in shape and range from about 8 to 20 acres in size. This complex is about 45 percent Clarion soils, 30 percent Estherville soils, and about 25 percent soils of lesser extent. Areas of these soils are so intricately mixed or so small that it is not practical to separate them at the scale used in mapping.

Typically, the surface layer of the Clarion soils is about 8 inches thick. It is very dark brown loam mixed with some streaks and pockets of dark brown subsoil material. The subsoil, about 16 inches thick, is dark brown and brown, friable loam in the upper part. The lower part is yellowish brown, mottled, friable loam. The substratum to a depth of 60 inches is yellowish brown, olive brown, and light olive brown, mottled loam.

Typically, the Estherville soils in this complex have a surface layer of very dark brown sandy loam about 7 inches thick. The subsoil, which is about 8 inches thick, is dark brown, dark yellowish brown, and brown. It is very friable sandy loam in the upper part and gravelly sandy loam in the lower part. The substratum to a depth of 60 inches is brown and dark yellowish brown, calcareous sand and gravel.

Included in mapping and making up about 25 percent of the map unit are small areas of Storden soils and areas of soils that are extremely variable in texture and depth of leaching. The included soils occur randomly on the same positions as the Clarion and Estherville soils in this complex.

Permeability of the Clarion soils is moderate. Permeability of the Estherville soils is moderately rapid in the solum and rapid in the substratum. Surface runoff is medium. Available water capacity is high in the Clarion soils and very low to low in the Estherville soils. Organic matter content in the surface layer is about 3 to 4 percent in Clarion soils and about 2 to 3 percent in the Estherville soils. The supply of available phosphorus is generally very low to low in the Clarion soils and very low in the Estherville soils. The supply of available potassium is very low in both soils.

Most of the acreage of this soil complex is cultivated. The Clarion soils are moderately suited to corn, soybeans, and small grains and to legumes for hay and pasture. The Estherville soils are poorly suited to these crops, and when used for row crops, need to be protected from water erosion and soil blowing. Terracing and contouring are difficult in most places because of the size and shape of areas and the short, irregular slopes. Also, terrace construction is likely to expose the sand and gravel substratum. However, conservation tillage, which leaves crop residue on the surface, is effective in helping to prevent excessive soil loss.

Using the soils in this complex for pastureland or hayland is also effective in 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 restricting grazing during wet periods help to keep the pasture productive and the soil in good condition.

These soils are in capability subclass IIIe.

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 upland outwash areas and stream terraces. Individual areas of this unit are irregular in shape and typically range from 2 to 20 acres in size. Some areas range up to 100 acres.

Typically, the surface layer is black loam about 9 inches thick. The subsurface layer is black loam about 8 inches thick. The next layer, about 6 inches thick, is very dark gray and dark grayish brown, friable loam. The subsoil is about 14 inches thick. The upper part is dark grayish brown, friable loam; and the lower part is dark grayish brown, grayish brown, and light olive brown, mottled, friable gravelly loam. The substratum to a depth of 60 inches is calcareous sand and gravel that grades from olive gray to dark yellowish brown and very dark grayish brown. In places the soil does not have a transition zone between the subsurface layer and subsoil. In places the soil has more sand in the subsoil than is typical. In a few places the surface layer is clay loam.

Included with this soil in mapping and making up less than 5 percent of the map unit are a few small areas of somewhat poorly drained Linder soils and poorly drained Hanska soils. Linder soils are at slightly higher elevations and are shallower to sand and gravel; and Hanska soils are in small, concave, wet areas. Also included are areas of soils that are calcareous throughout the profile and are at slightly lower elevations.

Permeability is moderate in the solum and very rapid in the substratum. Surface runoff is slow. This soil has a seasonal high water table at a depth of 24 to 48 inches. The organic matter content is 4 to 5 percent in the surface layer. The Cylinder soil is generally low to very low in available potassium and very low in available phosphorus. The available water capacity is moderate, and reaction ranges from slightly acid to neutral in the surface layer and from neutral to mildly alkaline in the subsoil. This soil has good tilth.

Most areas of this soil are cultivated. This soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Water erosion generally is not a problem on this soil, but because the surface dries quickly, soil blowing is a hazard. Blown sand may damage young plants in some years. Conservation tillage, which leaves crop residue on the soil's surface, helps prevent excessive soil blowing. Returning crop residue to the soil or adding other organic material on a regular basis helps to improve fertility, reduce crusting, and increase water infiltration.

The use of this soil for pastureland or hayland is effective in controlling soil blowing. Overgrazing, however, causes surface compaction, increases runoff, results in poor tilth, and reduces production. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture productive and the soil in good condition.

This soil is in capability subclass IIs.

221—Palms muck, 0 to 1 percent slopes. This level, very poorly drained, organic soil is in upland depressions that formerly contained water much of the time. Some areas are in former lakebeds that have been drained. This soil is subject to ponding. Individual areas are typically circular in shape and range from 15 to 50 acres in size. A few areas in former lakebeds range to about 160 acres in size.

Typically, the organic surface layer is black sapric material about 10 inches thick. The subsurface layer is black sapric material about 18 inches thick. The underlying mineral material to a depth of 60 inches is friable, silty clay loam that is mainly black. Some areas have a thinner surface layer. In a few areas the mucky material extends to a depth of more than 40 inches.

Permeability is moderately slow. This soil has a seasonal high water table that ranges from 12 inches below the surface to 12 inches above the surface. Available water capacity is high. The surface layer contains about 20 to 25 percent organic matter. The supply of available phosphorus is low, and the supply of available potassium is very low. In some places trace elements may be deficient for some crops. Reaction ranges from slightly acid to mildly alkaline.

Most of the acreage of this soil is artificially drained and used for row crops. This soil is moderately suited to row crops if adequately drained. Surface intakes and shallow ditches are used in addition to underground drains. In places it is difficult to find outlets deep enough for drains to function adequately. Runoff from adjacent slopes readily ponds on this soil, and in periods of excessive rainfall, crops are sometimes damaged or destroyed before tile drains can remove the excess water. If this occurs early in the season, the land can be tilled and replanted. This soil is slow to warm in spring, and planting may be delayed. Because this soil is in low-lying areas and loses heat rapidly from the surface, frost often injures crops late in spring and early in fall. Using early maturing varieties helps reduce crop losses caused by late planting and early frost. Row crops grow fairly well where this soil is adequately drained and fertilized and otherwise well managed. Tilth is excellent, and this soil can be tilled within a wide range of moisture content. Fall plowing should be avoided because the surface readily blows when dry if it is not protected. The rates of application of some herbicides should be increased on this soil because the high organic matter content causes the herbicides to be less effective.

Small grains tend to lodge badly and to produce grain of poor quality. Legumes for hay grow poorly on this soil and are often winter killed.

Partially drained areas of this soil are suited to permanent pasture consisting of bluegrass, bromegrass, and reed canarygrass. Undrained areas generally are suited to wildlife habitat.

This soil is in capability subclass IIIw.

224—Linder loam, 0 to 2 percent slopes. This nearly level, somewhat poorly drained soil is on slightly convex or concave slopes on upland outwash plains and stream benches. Individual areas are irregular in shape and range from 2 to 20 acres in size.

Typically, the surface layer is black loam about 9 inches thick. The subsurface layer is very dark grayish brown loam about 5 inches thick. The subsoil is about 12 inches thick. It is dark grayish brown, friable sandy loam in the upper 8 inches and mottled, olive brown, very friable loamy sand in the lower 4 inches. The substratum to a depth of 60 inches is calcareous sand and gravel. It is yellowish brown in the upper part; dark brown, brown, and dark yellowish brown in the middle part; and dark yellowish brown in the lower part. The sand and gravel are shallower in places. In places the sand and gravel are less than 2 feet thick. These areas are located where stream terraces merge with the uplands.

Included with this soil in mapping and making up less than 10 percent of the map unit are a few small areas of somewhat excessively drained Estherville soils and poorly drained Hanska soils. Estherville soils are on higher, better drained positions, and Hanska soils are on small, concave, wetter areas. Also included are soils similar to the Linder soil that are calcareous throughout the profile and are at slightly lower elevations.

Permeability is moderate or moderately rapid in the solum and very rapid in the substratum. Surface runoff is slow. This soil has a seasonal high water table at a depth of 24 to 48 inches. Available water capacity is low. The organic matter content is 3 to 4 percent in the surface layer. Reaction is typically slightly acid to neutral in the surface layer and neutral to mildly alkaline in the subsoil. This soil is generally very low in available phosphorus and potassium. The surface soil has good tilth.

Most areas of this soil are cultivated. This soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. It is better suited to small grains, grasses, and legumes than to cultivated crops because available water is not sufficient during parts of most growing seasons. Erosion by water generally is not a problem on this soil, but because the surface dries quickly, soil blowing is a hazard. Blown sand may damage young plants in some years. Conservation tillage, which leaves crop residue on the soil surface, helps prevent excessive soil blowing. Returning crop residue to the soil or adding other organic material on a regular basis helps to improve fertility, reduce crusting, and increase water infiltration.

The use of this soil for pastureland or hayland is effective in controlling soil blowing. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture productive and the soil in good condition.

This soil is in capability subclass IIs.

236B—Lester loam, 2 to 5 percent slopes. This gently sloping, well drained soil is on upland ridgetops and convex side slopes that border drainageways. Slopes are typically short. Individual areas are irregular in shape and range from 3 to 30 acres in size.

Typically, the surface layer is very dark brown loam about 5 inches thick. The subsurface layer is about 8 inches thick. It is dark grayish brown and very dark grayish brown loam. The subsoil is about 32 inches thick. The upper part is brown, friable loam. The middle and lower parts are brown and dark yellowish brown loam. The substratum to a depth of 60 inches is light olive brown, light yellowish brown, and dark yellowish brown, friable, calcareous loam. In places the surface layer is thinner and lighter colored. In places the subsoil is thicker and has more clay.

Included with this soil in mapping and making up less than 5 percent of the map unit are small areas of somewhat poorly drained Le Sueur soils and the very poorly drained Rolfe soils. Le Sueur soils are on nearly level areas that have slightly convex slopes and at the head of drainageways that have concave slopes. Rolfe soils are in small upland depressions that are subject to ponding.

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

Most areas of this soil are in pasture and timber, but some areas are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. If this soil is used for cultivated crops, there is a hazard of erosion damage. Conservation tillage, which leaves crop residue on the surface, and grassed waterways help prevent excessive soil loss. Controlling erosion by the use of mechanical practices, such as contouring and terracing, is difficult in places because of irregular topography and short slopes. However, in most places these practices are suitable. Returning crop residue to the soil or adding other organic material on a regular basis helps to improve fertility, reduces crusting, and increases water infiltration.

The use of this soil for pastureland or hayland is also effective in controlling erosion. Overgrazing or grazing when the soil is too wet causes surface compaction, increases runoff, and results in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting use during wet periods help to keep the pasture productive and the soil in good condition.

This soil is well suited to trees, and many areas are in native hardwoods. These areas provide excellent habitat for various kinds of wildlife. They are also popular sites for home building. In many areas domestic livestock are allowed to graze. This practice damages young seedlings and reduces the value of the areas for wildlife habitat. In a few places, competing vegetation limits seedling growth and survival. If grazing is controlled and competing vegetation removed or controlled, seedlings survive and grow well. This soil has no other hazards or limitations to use as woodland.

This soil is in capability subclass IIe.

236C—Lester loam, 5 to 9 percent slopes. This moderately sloping, well drained soil is on upland ridgetops and convex side slopes that border drainageways. Slopes are typically short. Individual areas are irregular in shape and range from 3 to 10 acres in size.

Typically, the surface layer is black and very dark brown loam about 5 inches thick. The subsurface layer, about 4 inches thick, is dark grayish brown loam. In cultivated areas the surface layer is very dark grayish brown loam about 8 inches thick. The subsoil is about 26 inches thick. The upper part is dark grayish brown and brown loam; the middle part is brown and dark yellowish brown, firm loam; and the lower part is yellowish brown, friable loam. The substratum to a depth of 60 inches is light yellowish brown, friable, calcareous loam. In places the surface layer is thinner and lighter colored. In places the subsoil is thicker and higher in clay content. In some areas, the soil is steeper and has a slightly thinner surface layer.

Also included with this soil in mapping are a few small areas of somewhat poorly drained Le Sueur soils and very poorly drained Rolfe soils. Le Sueur soils are in small, natural, concave drainageways that extend into the upland. Rolfe soils are in small upland depressions at the head of some of these drainageways. Both the Le Sueur and Rolfe soils are wetter than this Lester soil, and the Rolfe soil is subject to ponding after rains. The included soils make up less than 15 percent of this map unit.

Permeability is moderate. Surface runoff is moderately rapid, and available water capacity is high. The surface layer contains about 2 to 3 percent organic matter. Reaction is typically neutral or slightly acid in the surface layer and medium acid in the subsoil. This soil is generally low in available phosphorus and very low in available potassium.

Most areas of this soil are in timber or mixed timber and grass, but some areas are under cultivation. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. If this soil is used for cultivated crops, there is a hazard of erosion damage. Conservation tillage, which leaves crop residue on the surface, and grassed waterways help prevent excessive soil loss. Controlling erosion by the use of mechanical practices, such as contouring and terracing, is difficult in some places because of short slopes and irregular topography, but in most places, these practices are well suited. Returning crop residue or adding other organic material on a regular basis helps to improve fertility, reduces crusting, and increases water infiltration.

The use of this soil for pastureland or hayland is also effective in controlling erosion. Overgrazing or grazing when the soil is too wet causes surface compaction, increases runoff, and results in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture productive and the soil in good condition.

This soil is well suited to trees. Areas of native hardwoods provide excellent habitat for various kinds of wildlife. They are also popular sites for home building. In many areas domestic livestock are allowed to graze. This practice damages young seedlings and reduces the value of the areas for wildlife habitat. In a few places competing vegetation limits seedling growth and survival. If grazing is controlled and competing vegetation removed or controlled, seedlings survive and grow well. Erosion needs to be controlled when sites are prepared for planting seedlings.

This soil is in capability subclass IIIe.

236F—Lester loam, 18 to 40 percent slopes. This steep to very steep, well drained soil is on convex side slopes of uplands that border streams and drainageways. Slopes are typically short. Individual areas are irregular in shape and range from 3 to 10 acres in size.

Typically, the surface layer is black and very dark gray loam about 3 inches thick. The subsoil is about 24 inches thick. The upper part is dark brown and brown, friable loam; the middle part is brown and dark yellowish brown, firm loam or clay loam; and the lower part is yellowish brown, friable loam. The substratum to a depth of 60 inches is yellowish brown, friable, calcareous loam. In places the soil has a thicker, darker colored surface layer.

Included with this soil in mapping are a few small areas of well drained Storden soils and some thick-surfaced, somewhat poorly drained soils that are in small, concave drainageways that extend into the uplands. Storden soils are on the steepest, most convex part of the slope and are calcareous. Included soils make up less than 15 percent of the map unit.

Permeability is moderate, and surface runoff is very rapid. Available water capacity is high. The surface layer contains 1 to 2 percent organic matter. Reaction is typically slightly acid or neutral in the surface and subsurface layers. Reaction in the subsoil is typically medium acid in the upper part and slightly acid in the lower part. This soil is generally low in available phosphorus and very low in available potassium. The surface layer has fair tilth.

Nearly all areas of this soil are in timber or pasture. This soil is best suited to these uses. Major management concerns are related to the hazard of erosion and to low fertility. The amount of water available for plant growth is commonly low because of rapid runoff. Management should maintain an adequate vegetative cover, help prevent excessive soil loss, and improve the soil's water supplying capacity by reducing runoff and the rate of drying. Growth of vegetation, except for trees, generally is poor and total production is low. If this soil is used for pastureland, proper stocking rates, timely deferment of grazing, and planned, uniform rotational grazing is needed to help maintain desirable plant species and to keep the vegetation productive and the soil in a good condition. Grazing can damage trees and seedlings and reduce their value as timber and as habitat for wildlife. This soil is well suited to use as wildlife habitat because most areas have been left in their natural state.

This soil is in capability subclass VIe.

259—Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes. This nearly level, poorly drained soil is on glacial outwash plains, valley trains, and stream benches. It formed in loamy glacial outwash underlain by calcareous sand and gravel. Slopes are nearly level to slightly convex. In places they are crossed by shallow concave swales and low convex rises. Individual areas of this soil are irregular in shape and range from about 3 to 40 acres in size.

Typically, the surface layer is black clay loam that is about 8 inches thick. The subsurface layer is black clay loam about 11 inches thick. The subsoil is about 20 inches thick. It is olive gray and dark grayish brown, friable clay loam in the upper part and multicolored clay loam and loam in the middle and lower parts. The substratum to a depth of 60 inches is olive gray, calcareous sand and gravel. In places the depth to sand and gravel is greater than 40 inches. These areas commonly have a dark surface layer that is somewhat deeper than 24 inches. In places the subsoil is sandy loam.

Permeability is moderate in the solum and rapid in the substratum. This soil has a seasonal high water table at a depth of 12 to 36 inches and is poorly drained. Some areas are flooded during periods of high rainfall. Other areas receive local runoff from higher land. Surface runoff is slow. Root development and available water capacity are somewhat limited by the underlying calcareous sand and gravel. The available water capacity is moderate. The plow layer contains about 5 to 7 percent organic matter. Reaction is typically neutral in the surface layer and the subsoil. The subsoil is generally very low to low in available potassium. It is generally very low in available phosphorus.

Most areas of this soil are used for row crops. This soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Drainage is essential for optimum crop production. Drainage can be improved by the installation of underground drains. These drains function well, but in some places instability of the substratum makes installation difficult. This soil not only is seasonally wet but also is droughty, especially if rainfall is below average or if rains are not timely. This soil is subject to soil blowing, especially if it is plowed in fall and its surface is left bare. Conservation tillage, which leaves crop residue on the surface, helps prevent soil blowing and conserve moisture. If this soil is used for pastureland, proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help maintain desirable plant species and keep the pasture productive and the soil in good condition.

This soil is in capability subclass IIw.

274—Rolfe silt loam, 0 to 1 percent slopes. This level, very poorly drained soil is in shallow depressions in the upland stream benches. It is subject to ponding. Individual areas of this soil are circular in shape and range from 2 to 10 acres in size.

Typically, the surface layer is black silt loam about 10 inches thick. The subsurface layer is dark gray and very dark gray silt loam about 14 inches thick. It is distinctly lighter in color when dry. The subsoil is about 43 inches thick. The upper part of the subsoil is dark gray and very dark gray, mottled firm silty clay; the middle part is olive gray, mottled, firm silty clay and silty clay loam; and the lower part is olive gray, dark gray, and gray, mottled, friable silty clay loam. The substratum to a depth of 60 inches is olive gray, gray, and dark gray, mottled, calcareous clay loam. In places the subsurface layer is thinner and not as prominent as in other profiles.

Permeability is moderate in the upper part of the profile and slow in the lower part of the profile. Surface runoff is very slow and periodically is ponded. The available water capacity is high. The plow layer contains about 3 to 4 percent organic matter. This soil has a seasonal high water table that ranges from 12 inches below the surface to 12 inches above the surface. The shrink-swell potential is high. The subsoil is generally very low in available phosphorus and low to very low in available potassium. Reaction is typically slightly acid in the surface and subsurface layers and neutral in the subsoil. In some places, reaction is slightly acid in the subsoil. If this soil is plowed when wet, the surface puddles easily and becomes cloddy and hard to work when dry.

Most areas of this soil are cultivated. If adequately drained, this soil is moderately suited to row crops, small grains, and grasses for pasture. It is poorly suited to legumes. Most of the acreage is used for row crops.

Most of the acreage of this soil has been improved by artificial drainage because this soil occurs in areas of other soils that are well suited to row cropping. Most areas, however, are ponded in spring and after heavy rains. Underground drains do not remove water adequately because the subsoil is high in clay and is slowly permeable. Drains need to be more closely spaced in this soil than in other depressional soils in the county. Shallow surface ditches and surface intakes for underground drains are needed to remove excess surface water and reduce ponding. Even when drainage is improved, this soil is slower to dry than surrounding soils, and tillage is often delayed in spring and after heavy rains. Crop growth is only moderate, and winter killing and drowning out of legumes are common. Hay and pasture crops that tolerate wetness and short periods of ponding are needed on this soil. This soil is generally managed with the surrounding soils.

This soil is in capability subclass IIIw.

288—Ottosen clay loam, 1 to 3 percent slopes. This very gently sloping, somewhat poorly drained soil is on gentle, convex slopes or on slightly concave positions in the uplands. Individual areas of this unit are irregular in shape and typically range from 10 to 50 acres in size. A few areas range from 5 to 100 acres or more.

Typically, the surface layer is black clay loam about 8 inches thick. The subsurface layer is black and very dark grayish brown clay loam about 10 inches thick. The subsoil is about 15 inches thick. It is dark grayish brown, firm clay loam in the upper part and olive gray and olive, mottled, friable clay loam in the lower part. The substratum to a depth of 60 inches is olive gray, mottled loam. In places the surface layer and subsoil are thinner.

Included with this soil in mapping and making up about 5 percent of the map unit are small areas of well drained Clarion and Storden soils. These are on the higher, more convex parts of the slopes. Also included in mapping are a few small, nearly level areas of Webster or Kossuth soils and small areas of Okoboji or Rolfe soils in slight depressions. All these included soils are wetter than this Ottosen soil, and the Okoboji and Rolfe soils are subject to ponding after rains.

Permeability is moderately slow, and surface runoff from cultivated areas is slow. A seasonal high water table is at a depth of 24 to 48 inches, and available water capacity is high. The plow layer contains about 5 to 6 percent organic matter. This Ottosen soil is low to very low in both available phosphorus and potassium. Reaction is typically slightly acid in the surface layer and ranges from slightly acid to moderately alkaline in the subsoil.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Most of the acreage is in row crops. Erosion generally is not a problem on this soil, but if large tracts are fall plowed, soil blowing may occur. Conservation tillage, which leaves crop residue on the surface, helps prevent excessive soil loss from soil blowing. This soil generally is not drained, but in areas where it borders Kossuth or Webster soils, it is wet in years of above-average rainfall. Drainage improves timeliness of fieldwork.

Tilth is normally good on this soil. Returning crop residue to the soil and avoiding tillage when the soil is wet help to maintain good tilth. If this soil is used for pastureland, overgrazing or grazing when the soil is wet can cause surface compaction and poor tilth.

This soil is in capability class I.

308—Wadena loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes. This nearly level, well drained soil is on slightly convex slopes on upland glacial outwash areas and stream benches. Individual areas are irregular in shape and range from about 5 to 20 acres in size.

Typically, the surface layer is black loam about 9 inches thick. The subsurface layer is black, very dark brown, and very dark grayish brown loam about 7 inches thick. The subsoil, about 22 inches thick, is dark yellowish brown and yellowish brown. It is loam, except for the last few inches, which is sandy loam. The substratum to a depth of 60 inches is dark yellowish brown, brown, and yellowish brown, calcareous sand and gravel. In places the subsoil is sandy loam throughout. In places shale fragments are throughout the profile.

Included with this soil in mapping are a few small areas of Wadena soils that are 24 to 32 inches deep to sand and gravel and are more droughty. These areas make up about 10 percent of the map unit.

Permeability is moderate in the upper part of the profile and very rapid in the lower part of the profile. Available water capacity is moderate. The surface layer contains about 3 to 4 percent organic matter. The content of available phosphorus and potassium is very low to low. The surface soil has good tilth. This soil warms up quickly in the spring and can be worked soon after rains.

Most areas of this soil are cultivated. This soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Droughtiness frequently limits crop growth in parts of most growing seasons, especially in years when rainfall is below average or if rains are untimely. Small grains and legumes for hay and pasture generally do better than row crops. Soil blowing is a hazard if the soil is plowed in the fall. Blowing sand may damage young plants in some years. Conservation tillage, which leaves crop residue on the surface, slows drying and helps prevent soil blowing.

The use of this soil for pastureland or hayland is also an effective way to control soil blowing. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture productive and the 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 convex slopes on upland glacial outwash areas and stream benches. Individual areas are irregular in shape and range from 5 to 15 acres in size.

Typically, the surface layer is black loam about 6 inches thick. The subsurface layer is black, very dark brown, and very dark grayish brown loam. It is 2 to 8 inches thick in most areas. The subsoil, about 22 inches thick, is dark yellowish brown and yellowish brown. It is loam in the upper part and commonly is sandy loam in the last few inches. The substratum to a depth of 60 inches is dark yellowish brown, brown, and yellowish brown, calcareous sand and gravel. In places, depth to sand and gravel is greater than 40 inches.

Included with this soil in mapping and making up about 5 percent of the map unit are small areas of Estherville and Salida soils. These soils are on the more sharply convex parts of the slope and in places are adjacent to small drainageways that extend into areas of this Wadena soil. These soils are shallower to sand and gravel and are more droughty than the Wadena soil.

Permeability is moderate in the upper part of the profile and rapid in the lower part of the profile. Surface runoff is medium. Available water capacity is moderate. The surface layer contains about 3 to 4 percent organic matter. The supply of available phosphorus is very low, and the supply of available potassium is very low to low. The surface layer has good tilth. This soil warms up quickly in the spring and can be worked soon after rains.

Most areas of this soil are cultivated. This soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. A lack of available water frequently limits crop growth in parts of most growing seasons, especially in years when rainfall is below average or when rains are untimely. Small grains and legumes for hay and pasture generally do better than row crops. Soil blowing and water erosion are hazards if this soil is plowed in the fall. Blowing sand may damage young plants in some years. Conservation tillage, which leaves crop residue on the surface, slows drying and helps prevent soil blowing and erosion. Some areas have slopes that can be farmed on the contour. Terraces are ordinarily not constructed on this soil because of the danger of exposing the sand and gravel substratum.

The use of this soil for pastureland and hayland is also an effective way to control soil blowing and water erosion. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture productive and the soil in good condition.

This soil is in capability subclass IIe.

325—Le Sueur loam, 1 to 3 percent slopes. This very gently sloping, somewhat poorly drained soil is on convex ridgetops and side slopes. Individual areas are irregular in shape and range from 5 to 20 acres in size.

Typically, the surface layer is very dark gray loam about 6 inches thick. The subsurface layer is very dark gray loam about 7 inches thick. The subsoil is about 31 inches thick. The upper part of the subsoil is dark grayish brown, friable loam; the middle part is dark grayish brown, olive brown, firm clay loam; and the lower part is light olive brown and dark grayish brown, friable clay loam. The substratum to a depth of 60 inches is dark grayish brown and grayish brown, calcareous light clay loam. In places the subsurface layer is dark grayish brown and is light gray or white when dry.

Included with this soil in mapping and making up less than 5 percent of the map unit are small areas of well drained Lester soils. These are on the higher, more convex parts of the slope. Also included are small areas of Rolfe and Okoboji soils in slight depressions. They are wetter than this Le Sueur soil and are subject to ponding after rains.

Permeability of this soil is moderate, and surface runoff is slow. A seasonal high water table is at a depth of 24 to 48 inches. Available water capacity is high. The surface soil contains about 2 to 4 percent organic matter. This Le Sueur soil is generally very low in both available phosphorus and potassium. Reaction typically is medium acid. This soil has good tilth.

Most areas of this soil are cultivated, but other areas remain in native vegetation. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Erosion generally is not a problem on this soil, but soil blowing may be a problem if the soil is fall plowed Conservation tillage, which leaves crop residue on the surface, helps prevent excessive soil blowing. This soil is slightly wet during periods of high rainfall, but wetness does not limit crop growth. However, many areas are drained to improve timeliness of field operations. Returning crop residue to the soil and avoiding working the soil when it is wet help maintain good tilth.

The use of this soil for pastureland or hayland is also effective in controlling soil blowing. If this soil is used for pastureland, overgrazing or grazing when the soil is wet can cause surface compaction and poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture productive and the soil in good condition.

This soil is in capability class I.

330—Kingston silty clay loam, 0 to 3 percent slopes. This very gently sloping, somewhat poorly drained and moderately well drained soil is on slightly convex slopes on uplands. Individual areas are irregular in shape and range from 5 to 15 acres in size.

Typically, the surface layer is black silty clay loam about 8 inches thick. The subsurface layer is black silty clay loam about 11 inches thick. A transition layer, about 5 inches thick, is mixed very dark gray, light olive brown, and dark grayish brown silty clay loam. The subsoil, about 13 inches thick, is light olive brown silt loam. The substratum to a depth of 60 inches is light olive brown and olive gray, mottled silt loam. In places the glacial till is within 60 inches.

Included with this soil in mapping and making up less than 5 percent of the map unit are a few small areas of well drained Truman soils and poorly drained Waldorf soils. Truman soils are at slightly higher elevations, and Waldorf soils are on the lower parts of the slope.

Permeability of this soil is moderate, and surface runoff is slow. A seasonal high water table is at a depth of 30 to 60 inches, and the available water capacity is high. The surface layer contains about 5 to 6 percent organic matter. Reaction is neutral to slightly acid in the surface layer and neutral to mildly alkaline in the subsoil. The content of available phosphorus and potassium is generally very low.

Most of the acreage of this soil is cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. There is a slight erosion hazard on some of the steeper areas. Conservation tillage, which leaves crop residue on the surface, helps prevent soil loss. This soil has good tilth, but if worked when too wet it puddles and becomes hard and cloddy when dry. This Kingston silty clay loam is one of the most productive soils in the county.

If this soil is used for pastureland, overgrazing or grazing when it is too wet can cause surface compaction and poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture productive and the soil in good condition.

This soil is in capability class I.

335—Harcot loam, 0 to 2 percent slopes. This nearly level, highly calcareous, poorly drained soil is in low-lying glacial outwash areas on stream benches. Some areas are on narrow, convex rims surrounding slight depressions. Individual areas of this soil are irregular in shape. Most areas are 5 to 30 acres in size, but a few areas range to about 80 acres in size.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is very dark gray loam about 12 inches thick. When dry, this soil has a distinctly grayer surface layer than the adjacent soils. The subsoil, which is about 14 inches thick, is olive gray, mottled loam and sandy loam. The substratum to a depth of 60 inches is olive and olive gray, mottled sand and gravel. This soil is calcareous and high in lime carbonates throughout. In places sand and gravel are at a depth of less than 30 inches.

Included with this soil in mapping and making up less than 5 percent of the map unit are small areas of soils in slight depressions. These soils are wetter than this Harcot soil and are subject to ponding after rains.

Permeability of this soil is moderate in the solum and very rapid in the substratum. Surface runoff is slow. This soil has a seasonal high water table at a depth of 12 to 24 inches, and available water capacity is moderate. The plow layer contains about 5 to 6 percent organic matter. Reaction is moderately alkaline. The supply of available phosphorus and potassium is very low. The supply of available iron is also seriously deficient, and some minor elements are likely to be in short supply.

Most areas of this soil are cultivated. This soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. When this soil is used for cultivated crops, adequate drainage is needed to reduce wetness and provide proper aeration and a deep root zone for plants. Underground drains work well, but installation can be difficult because of the instability of the substratum. An excess of lime carbonates in this soil reduces the effectiveness of fertilizers and herbicides.

In some years of excessive rainfall, crops may be lost on some areas of this soil because of ponding of the adjacent depressions. Excessive tillage readily destroys the weak soil structure, and this soil is subject to soil blowing when the surface dries and is left bare. Conservation tillage, which leaves crop residue on the surface, and adding other organic material on a regular basis help improve the soil's structure and reduce soil blowing.

If this soil is used for pasture, proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture and soil in good condition. Because most areas of this soil are small, they are managed in conjunction with the adjacent soils.

This soil is in capability subclass IIw.

339B—Truman silt loam, 2 to 5 percent slopes. This gently sloping, well drained soil is on upland convex ridges and side slopes on uplands. Most areas are near streams, but a few small areas are on or adjacent to outwash plains. Individual areas are irregular in shape, and most areas range from 3 to 10 acres in size.

Typically, the surface layer is very dark brown silt loam about 10 inches thick. The subsurface layer is dark brown and very dark grayish brown silt loam about 7 inches thick. The subsoil is about 24 inches thick. It is brown, dark yellowish brown, and yellowish brown silt loam. The substratum to a depth of 60 inches is yellowish brown, calcareous silt loam. In places the surface layer is very fine sandy loam.

Included with this soil in mapping are small areas of steeper soils. They have a thinner surface layer and are commonly calcareous in the subsoil. Also included are a few small areas of Dickman soils that have a lower available water capacity. The included soils make up less than 5 percent of this map unit.

Permeability is moderate, and surface runoff is medium. Available water capacity is high. The surface layer contains about 4 to 5 percent organic matter. Reaction is typically neutral in the surface layer and the upper part of the subsoil. Reaction in the middle and lower parts of the subsoil ranges from neutral to moderately alkaline. This soil is generally low in both available phosphorus and potassium.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. If this soil is used for cultivated crops, there is a hazard of erosion. Areas plowed in fall are susceptible to soil blowing if the surface is left bare. Many areas have slopes that can be terraced and farmed on the contour. Conservation tillage, which leaves crop residue on the surface, and constructing grassed waterways where needed help prevent excessive soil loss. Returning crop residue to the soil and adding other organic material on a regular basis help to improve fertility, maintain good tilth, and increase water infiltration.

The use of this soil for pastureland or hayland is also an effective way to control erosion. Overgrazing or grazing when the soil is too wet can cause surface compaction, expose the surface layer to soil blowing and water erosion, and result in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture productive and the soil in good condition.

This soil is in capability subclass IIe.

348—Fieldon loam, 0 to 2 percent slopes. This nearly level, poorly drained, calcareous soil is on outwash plains, glacial lake plains, and upland concave slopes. In places, shallow concave swales and low convex rises cross the slopes. Individual areas of this unit are irregular in shape and range from 5 to 20 acres in size.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is black and very dark gray loam about 10 inches thick. The subsoil is about 27 inches thick. The upper part is dark gray and olive gray loam, and the lower part is olive gray and light olive gray, mottled very fine sandy loam. The mottled substratum to a depth of 60 inches is gray, olive gray, and light olive gray loamy fine sand and very fine sand in the upper part and stratified sand and silt in the lower part. In places the surface layer is thicker and the substratum and lower part of the subsoil are silt loam. In places the surface layer is more calcareous and lighter colored.

Included with this soil in mapping and making up less than 5 percent of the map unit are some small areas of Okoboji soils, which are in slight depressions. They are wetter than this Fieldon soil and are subject to ponding after rains.

Permeability is moderate in the solum and rapid in the substratum. The seasonal high water table ranges from 12 to 36 inches. Surface runoff is slow, and some areas are briefly ponded. Available water capacity is high. The plow layer contains about 4 to 5 percent organic matter. This soil is generally very low to low in available phosphorus and very low in available potassium. This soil is calcareous throughout. Reaction is typically mildly or moderately alkaline.

Most areas of this soil are drained and cultivated, but a few small, undrained areas are in pasture. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Most of the acreage is in row crops. Drainage is essential for optimum crop production. Underground drains function well in this soil, but installation may be difficult because of the instability of the substratum. An excess of lime in this soil reduces the effectiveness of fertilizer and herbicides. This soil is subject to soil blowing if it is plowed in fall and the surface is left bare. Conservation tillage, which leaves crop residue on the surface, helps to prevent soil blowing, improve fertility, and maintain good tilth. If this soil is used for pastureland, overgrazing or grazing when the soil is wet can cause surface compaction and poor tilth.

This soil is in capability subclass IIw.

349—Darfur loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on plane to slightly concave slopes on upland outwash areas and lake plains. Areas of this soil are irregular in shape, and most are somewhat elongated. They range from about 5 to 30 acres in size.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is black loam in the upper part and very dark gray and very dark grayish brown loam in the lower part. It is about 14 inches thick. The subsoil is fine sandy loam to a depth of 40 inches and loamy fine and very fine sand between depths of 40 and 49 inches. The upper part is dark grayish brown and olive gray, and the lower part is olive gray and olive. The substratum to a depth of 60 inches is olive gray and olive, mottled loamy fine sand.

Permeability is moderate in the upper part of the profile and moderately rapid in the lower part of the profile. Surface runoff is slow. This soil has a seasonal high water table at a depth of 12 to 36 inches, but available water capacity is only moderate. The surface layer contains 4.5 to 5.5 percent organic matter. Reaction is neutral to slightly acid in the surface layer and the upper part of the subsoil. Reaction in the lower part of the subsoil and in the substratum is neutral to mildly alkaline. The subsoil is generally very low in available phosphorus and potassium. The surface layer is friable and easily tilled, but if worked when too wet, it becomes cloddy and hard when dry.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Because this soil is poorly drained and has a seasonal high water table, artificial drainage is needed for dependable crop production. Underground drainage systems work well, but installation may be difficult because of instability of the substratum. Conservation tillage, which leaves crop residue on the surface, helps prevent soil blowing.

The use of this soil for pastureland and hayland is also effective in preventing soil blowing. Overgrazing or grazing when the soil is too wet cause surface compaction, poorer tilth, and a lower water infiltration rate. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture productive and the soil in good condition.

This soil is in capability subclass IIw.

354—Aquolls, ponded. These soils are covered with water most of the time, and because of this, they have not been examined in great detail. Texture of these soils is variable. Most areas have several inches of organic material over mineral material. Some larger areas have two or more feet of organic material, and commonly, this material is calcareous. In some smaller areas where water is not as deep as in other areas silty clay loam material is at the surface. In Kossuth County, Aquolls, ponded, are in depressions, commonly adjacent to lakes and to Union Slough. The vegetation is cattail, lily, and other marsh plants. Aquolls, ponded, have no value for farming, but are important as habitat for waterfowl, muskrats, and other wetland wildlife.

Most areas of Aquolls are in the northern part of the county. Some areas that are mostly marshy have been designated as game refuges and public shooting grounds.

This soil is in capability subclass VIIw.

388—Kossuth silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on lake plains and low-relief ground moraines. Most areas are smooth and commonly do not contain depressions and drainageways. Areas of this map unit are generally broad and are irregular in shape. The areas typically range from 20 to 80 acres in size. Some areas, however, are as small as 10 acres, and some are as large as 300 acres or more.

Typically, the surface layer is black silty clay loam about 9 inches thick. The subsurface layer is black and very dark gray silty clay loam about 14 inches thick. The subsoil is about 17 inches thick. It is olive gray, firm silty clay loam in the upper part and olive gray, mottled, friable clay loam and loam in the lower part. The substratum to a depth of 60 inches is olive gray calcareous loam with common to many yellowish brown mottles. In places silty material is below a depth of 40 inches.

Included with this soil in mapping and making up less than 5 percent of the map unit are a few depressional soils that contain slightly more clay, are wetter, and have a thicker surface soil than the Kossuth soil.

Permeability is moderately slow, and surface runoff is slow. Some small areas are briefly ponded during wet periods. This soil has a seasonal high water table at a depth of 12 to 24 inches and high available water capacity. The plow layer contains about 6 to 7 percent organic matter. The shrink-swell potential is high. Reaction is typically neutral in the surface soil and the upper part of the subsoil and mildly alkaline to moderately alkaline in the lower part of the subsoil. The subsoil is generally very low in both available phosphorus and potassium.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Because of the seasonal high water table and poor natural drainage of this soil, the installation of underground drains is essential for optimum crop production. These drains function more slowly in this Kossuth soil than in the surrounding Webster or Canisteo soils because the fine textured subsoil restricts water movement. Drains must be more closely spaced in this soil to adequately remove excess water. The surface of this soil is subject to soil blowing if it is plowed in fall and left bare. Conservation tillage, which leaves crop residue on the surface, helps prevent soil blowing and improves fertility.

If this soil is used for pastureland, overgrazing or grazing when the soil is wet can damage forage plants and cause surface compaction, which results in poor tilth and a reduction in the water infiltration rate. Proper stocking, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture productive and the soil in good condition.

This soil is in capability subclass IIw.

389—Waldorf silty clay, silty substratum, 0 to 2 percent slopes. This nearly level, poorly drained, moderately slowly permeable soil is on glacial lake plains. Individual areas are irregular in shape and range from 5 to 30 acres in size.

Typically, the surface layer is black silty clay about 10 inches thick. The subsoil is olive gray. It is silty clay in the upper and middle parts and silty clay loam in the lower part. The substratum is calcareous, light olive gray and olive gray silt loam. In places the surface soil is darker and thicker. Also in places the surface layer is moderately alkaline.

Permeability of this soil is moderately slow. Surface runoff is slow, and some areas are ponded briefly. This soil has a seasonal high water table at a depth of 0 to 36 inches. Available water capacity is high. The surface layer contains 6 to 8 percent organic matter. The shrink-swell potential is high. The surface layer is firm, and preparing a good seedbed is somewhat difficult, especially if the soil is tilled when too wet. Reaction is typically neutral to a depth of about 3 feet. Reaction in the lower part of the subsoil and in the substratum is mildly or moderately alkaline. The availability of phosphorus and potassium in the subsoil is very low.

Most areas of this soil are cultivated. This soil is moderately well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. If this soil is tilled when too wet, the surface layer puddles easily and becomes cloddy and hard when dry. The root zone is deep, but in wet seasons it is restricted by a high water table in areas that are inadequately drained. Underground drains function more slowly in this soil than in most others in the county and must be more closely spaced. Soil heaving commonly damages legumes, and in some areas the legumes are drowned out by ponding. If large areas are plowed in fall, the surface needs protection to prevent soil blowing. Conservation tillage, which leaves crop residue on the surface, helps reduce soil blowing. Few areas are used for pasture, but if this soil is used this way, overgrazing or grazing when the soil is too wet causes surface compaction and poor tilth and damages crops. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture productive and the soil in good condition.

This soil is in capability subclass IIw.

485—Spillville loam, 0 to 2 percent slopes. This nearly level, moderately well drained and somewhat poorly drained soil is adjacent to major streams and rivers in the county. It is subject to flooding. Individual areas are irregular in shape and range from 5 to 50 acres in size. A few areas are as large as 65 acres.

Typically, the surface layer is black loam about 9 inches thick. The subsurface layer is black loam about 30 inches thick. The next layer is dark gray fine sandy loam about 12 inches thick. The substratum is very dark gray fine sandy loam to a depth of 60 inches. In places the surface layer is thinner and contains more sand, and the substratum is loamy sand.

Included with this soil in mapping and making up less than 5 percent of the map unit are a few small areas of Colo and Coland soils. Both of these soils are poorly drained, contain more clay, and are commonly at slightly lower elevations. Colo soils have less sand.

Permeability of the Spillville soil is moderate, and surface runoff is slow. A seasonal high water table is at a depth of 12 to 36 inches, and available water capacity is high. The surface soil contains about 5 to 6 percent organic matter. Reaction is typically neutral throughout the profile. This soil is low in available phosphorus and potassium.

In most areas this soil is cultivated. It is moderately suited to corn, soybeans, and small grains and to grasses for hay and pasture. Because flooding drowns out legumes, this soil is poorly suited to these crops. Flooding commonly occurs in early spring and generally does not limit the use of this soil for row crops in most areas. Returning crop residue to the soil or adding other organic materials on a regular basis helps to improve fertility and increase water infiltration.

Low areas that are flooded often or for long periods are used for pastureland. Overgrazing or grazing when the soil is too wet causes surface compaction and poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture and the soil in good condition.

This soil is in capability subclass IIw.

485B—Spillville loam, 2 to 5 percent slopes. This gently sloping, moderately well drained and somewhat poorly drained soil is on low, concave foot slopes and alluvial fans throughout the county. It is subject to flooding. It is generally downslope from more sloping Clarion or Storden soils and upslope from soils on bottom lands and benches. In many places, it is upslope from Nicollet or Webster soils. Individual areas are long and narrow and range from 5 to 10 acres in size. A few areas range up to 25 acres.

Typically, the surface layer is black loam about 9 inches thick. The subsurface layer is black loam about 27 inches thick. The substratum to a depth of 60 inches is dark brown or dark yellowish brown loam. In places the surface layer is thinner and the substratum is browner. In places glacial till is at a depth of 40 inches.

Included with this soil in mapping and making up less than 5 percent of the map unit are soils that are slightly steeper and well drained. These soils erode more readily than this Spillville loam.

Permeability of the Spillville soil is moderate, and surface runoff is medium. A seasonal high water table is at a depth of 36 to 60 inches, and available water capacity is high. The surface layer contains 5 to 6 percent organic matter. Reaction is neutral or slightly acid throughout the profile. This soil is low in both available phosphorus and potassium.

Most areas of this soil are cultivated. This soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Most of the acreage of this soil is used for cultivated crops, but some areas that are adjacent to steep soils are used for pasture. If this soil is used for cultivated crops, there is a hazard of erosion. Conservation tillage, which leaves crop residue on the surface, helps prevent excessive soil loss and maintain soil tilth. Diversion terraces can be installed upslope of the Spillville soil to control runoff. Gullies may form in shallow drainageways. They can be shaped and seeded and used for waterways. This soil is managed with surrounding soils.

The use of this soil for pasture or hayland is effective in controlling erosion. Overgrazing or grazing this soil when it is too wet causes surface compaction and poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture and the soil in good condition.

This soil is in capability subclass IIe.

506—Wacousta silty clay loam, 0 to 1 percent slopes. This level, very poorly drained soil is in shallow upland depressions. It is subject to ponding. Individual areas of this unit are circular in shape and typically range from 8 to 20 acres in size.

Typically, the surface layer is black silty clay loam about 8 inches thick. The subsurface layer is black and very dark gray silty clay loam about 4 inches thick. The subsoil is only about 2 inches thick. It is olive gray and dark gray, mottled, friable silty clay loam. The substratum to a depth of 25 inches is olive gray and olive, mottled silty clay loam and silt loam. Below this to a depth of 60 inches the substratum consists of olive gray coarse silt loam with very fine sandy loam strata and gray and olive gray clay loam. In places the surface is mucky silt loam.

Included with this soil in mapping and making up about 10 percent of the map unit are small areas of Harps soils. The soils are on small rises and are calcareous.

Permeability of this soil is moderate, and surface runoff is slow. The seasonal high water table ranges from 12 inches below the surface to 12 inches above the surface. Available water capacity is high. Organic matter content is 8 to 10 percent in the surface layer. The surface layer has high shrink-swell potential. Reaction in the surface layer is neutral or mildly alkaline, and the substratum is mildly or moderately alkaline and contains free carbonates. The content of available phosphorus and potassium is very low. This soil commonly has good tilth, but in most areas, if worked when too wet, the surface layer puddles and becomes hard and cloddy when dry.

Most areas of this soil are cultivated. This soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Because ponding often drowns out legumes and delays planting, drainage is essential for crop production. Underground drainage works well. Drainage in some areas needs to be supplemented by shallow surface ditches, or surface intakes to the underground drainage system, or a combination of both.

Areas in which drainage cannot be improved to make crop yields dependable can be used for pasture and hay production. However, crops selected for pasture and hay should tolerate wetness as well as ponding. If this soil is used for pasture, grazing when the soil is too wet causes soil compaction and damages crops. Proper stocking, timely deferment of grazing, and restricting grazing during wet periods help to maintain stands and keep pastures productive. Some undrained areas can be developed for wildlife habitat.

This soil is in capability subclass IIIw.

507—Canisteo clay loam, 0 to 2 percent slopes. This nearly level, poorly drained, moderately permeable, calcareous soil is on irregularly shaped, concave upland swales and draws. Depressions are a common feature of the landscape. Individual areas of this unit are irregular in shape and range from 5 to 80 acres in size.

Typically, the surface layer is black clay loam about 8 inches thick. The subsurface layer is black and very dark gray clay loam about 15 inches thick. The subsoil is about 16 inches thick. It is olive gray, mottled, friable clay loam. The substratum to a depth of 60 inches is mottled olive gray and light olive gray clay loam. In places the surface layer is thicker. This soil is calcareous throughout the profile. In places the soil has a silty clay loam surface layer.

Included with this soil in mapping and making up about 5 percent of the map unit are some small depressions of Okoboji or Rolfe soils and small areas of Harps soils. Okoboji and Rolfe soils are wetter than this Canisteo soil and are subject to ponding after rains. Harps soils are highly calcareous and are distinctively lighter in color when dry.

Permeability of this soil is moderate, and surface runoff is slow. Many areas pond briefly. This soil has a seasonal high water table at a depth of 12 to 36 inches. The available water capacity is high. The plow layer contains about 6 to 8 percent organic matter. Canisteo soils are generally very low in both available phosphorus and potassium. Available iron is low in places because of the excess lime. This soil is calcareous throughout the profile. Reaction is typically mildly or moderately alkaline.

Most areas of this soil have been drained and are cultivated. A few small, undrained areas are in pasture. If adequately drained, this soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Drainage can be improved by installing underground drains, which function well in this soil. If this soil is plowed when wet, the surface puddles easily and becomes cloddy and hard to work when dry. Soil blowing is a hazard if large areas are plowed in fall and the surface is left bare. An excess of lime affects this soil's response to common fertilizers. Conservation tillage, which leaves crop residue on the surface, helps to prevent blowing and improves fertility.

This soil is also suited to pastureland or hayland. Proper stocking rates, rotational grazing, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture productive and the soil in good condition.

This soil is in capability subclass IIw.

511—Blue Earth mucky silt loam, 0 to 1 percent slopes. This level, highly calcareous, very poorly drained soil is in depressions that formerly contained water much of the time. It is subject to ponding. Some areas are in former shallow lakebeds that have been drained. Individual areas are circular in shape and range from about 10 to 30 acres in size.

Typically, the surface layer is black mucky silt loam about 9 inches thick. The mucky material below that extends to a depth of about 48 inches. It is black and very dark gray and is mottled. The upper part is highly calcareous, mucky silt loam. The lower part is calcareous, mucky silty clay loam that contains about 15 percent organic matter. The substratum to a depth of 60 inches is gray, calcareous clay loam that has olive mottles. In places the surface and subsurface layers are silty clay loam and high in organic matter. In places the surface layer is neutral in reaction.

Included with this soil in mapping and making up less than 5 percent of the map unit are soils that are sand or sandy loam to a depth of about 36 inches or more. These soils border the perimeter of this unit and have a lower available water capacity.

Permeability of this soil is moderate in the upper part of the profile and is moderately slow in the lower part of the profile. Available water capacity is high, and some areas are subject to ponding. The surface layer contains about 10 to 25 percent organic matter. This soil is highly calcareous. The content of available phosphorus and potassium is very low. The supply of iron and some other trace elements may be low for some crops. The effectiveness of fertilizers and some herbicides is reduced by the high concentration of lime carbonates. During periods of high rainfall, runoff from adjacent slopes ponds on this soil.

Adequately drained areas of this soil are used for row crops. Undrained areas are commonly used as wildlife habitat. This soil is moderately suited to cultivated crops. Because of the very low availability of some plant nutrients, the high organic matter content, and the high concentration of lime carbonates, special emphasis should be given to the fertility program. Because this soil is slow to warm in spring, planting is often delayed. Frost commonly injures crops late in spring and early in fall. Soil blowing can be a problem if the surface is left bare, especially when larger areas are fall plowed. Conservation tillage, which leaves crop residue on the surface, helps to reduce soil blowing. Small grains tend to lodge badly and to produce grain of poor quality.

Partly drained areas of this soil are suited to permanent pastures consisting of species, such as reed canarygrass, that tolerate wetness. Legumes for hay grow poorly on this soil and are often winter killed. Undrained areas are generally suited only to wildlife habitat.

This soil is in capability subclass IIIw.

559—Talcot clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes. This nearly level, poorly drained soil is on stream benches and upland outwash areas. Individual areas of this map unit are irregular in shape and range from about 3 to 40 acres in size.

Typically, the surface layer is black clay loam about 8 inches thick. The subsurface layer is black clay loam in the upper part and very dark gray clay loam in the lower part. It is about 15 inches thick. The subsoil is an olive gray, mottled clay loam about 17 inches thick. The substratum to a depth of 60 inches is olive gray, calcareous sand and gravel. In places the substratum is at a depth of slightly more than 40 inches deep, and these places commonly have a dark surface soil that is more than 24 inches deep.

Permeability of this soil is moderate in the solum and rapid in the substratum. A seasonal high water table is at a depth of 12 inches to 30 inches, and available water capacity is moderate. Root development and available water capacity are somewhat limited by the underlying calcareous sand and gravel. The plow layer contains about 5 to 7 percent organic matter. This soil is mildly or moderately alkaline throughout. Talcot soils are generally very low in available phosphorus and very low to low in available potassium.

Most areas of this soil are used for row crops. This soil is moderately well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Drainage is needed for optimum crop production. Drainage can be improved by installing underground drains. These drains function well, but in some places, instability of the substratum makes installation difficult. Care is needed to avoid overdrainage. Available water capacity is only moderate, and crops do not have sufficient water, especially if rainfall is below average or if rains are not timely.

This soil is subject to soil blowing, especially if it is plowed in fall and the surface is left bare. Conservation tillage, which leaves crop residue on the surface, helps to prevent soil blowing and conserve moisture.

If this soil is used for pastureland, proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help maintain desirable plant species and keep the pasture productive and the soil in good condition.

This soil is in capability subclass IIw.

585B—Colo-Spillville complex, 2 to 5 percent slopes. This complex of gently sloping, moderately well drained, somewhat poorly drained, and poorly drained soils is in narrow drainageways throughout the county. It is subject to flooding. Individual areas are long and narrow and range from about 6 to 40 acres or more in size. They contain 55 to 60 percent Colo soils and 35 to 40 percent Spillville soils. This complex is generally bordered by strongly sloping to steep Clarion or Storden soils.

The Colo soils are adjacent to the channel of small streams. Typically, the Colo soils have a surface layer of black silty clay loam about 5 inches thick. The subsurface layer is black silty clay loam about 45 inches thick. The substratum is very dark gray clay loam to a depth of 60 inches.

The Spillville soils are on the outer parts of the complex, along the base of slopes. Typically, the Spillville soils have a surface layer of black loam about 9 inches thick. The subsurface layer is black and very dark brown loam about 30 inches thick. The next layer is dark gray fine sandy loam about 12 inches thick. The substratum to a depth of 60 inches is dark grayish brown loam. In places the surface soil is as thin as 30 inches.

Included in mapping and making up 5 to 10 percent of some areas are small areas of the Zook soils and some well drained soils. Zook soils are in the lower depressional areas adjacent to the stream. The well drained soils are on the same landscape positions as the Spillville soils, but are slightly steeper.

Permeability of the Colo and Spillville soils is moderate, and surface runoff is slow. Both soils have high available water capacity. The surface layer of the Colo soils contains 6 to 7 percent organic matter, and that of the Spillville soils contain 5 to 6 percent. Colo soils have a seasonal high water table at a depth of 12 to 36 inches. Spillville soils have a seasonal high water table at a depth of 36 to 60 inches.

Some areas of this soil complex are cultivated. The soils generally are moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. In many areas, however, they are poorly suited because they are adjacent to steeper soils that are poorly suited or unsuited to cultivated crops. Some areas are not easily accessible, and some are cut by meandering stream channels; these areas are in pasture. In areas that are cultivated, erosion is a hazard; and in some areas, gully formation is a hazard. In some areas, terraces can be constructed and the soils can be farmed on the contour with the adjacent sloping soils. In places, grassed waterways are needed. In other areas, straightening stream channels and improving drainage can make the soils more suitable for farming.

In most areas that are used as pastureland, renovating the pasture and establishing more productive species in accessible areas can increase production. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture productive and the soil in good condition.

These soils are in capability subclass IIw.

638B—Clarion-Storden loams, 2 to 5 percent slopes. This map unit consists of gently sloping, well drained soils that are mostly on low, convex knolls. These soils have short, irregular slopes. A few areas are on ridgetops. Individual areas are irregular in shape and range from 4 to 8 acres in size, but a few are as large as about 15 acres.

In most areas, this unit is about 55 percent Clarion loam and 35 percent Storden loam. The Storden soils are typically upslope from the Clarion soils. Individual areas are so intricately mixed or so small that it is not practical to separate them at the scale used in mapping.

Typically, the Clarion soil has a surface layer of black loam about 8 inches thick. The subsurface layer is black and very dark brown loam about 8 inches thick. The subsoil is about 18 inches thick. In the upper and middle parts it is dark brown and dark yellowish brown, friable loam. It is yellowish brown, mottled, friable loam in the lower part. The mottled substratum to a depth of 60 inches is light olive brown and dark yellowish brown, calcareous loam. In places the subsoil is thinner, and it is only about 20 inches deep to carbonates.

Typically, the Storden soil has a surface layer about 8 inches thick. It is typically very dark gray, calcareous loam. The mottled substratum is yellowish brown and light olive brown, calcareous loam. In some places the surface layer is thinner and lighter in color.

Included with these soils in mapping and making up about 10 percent of the map unit are small areas of somewhat poorly drained Crippin soils. They are nearly level and are lower on the landscape than either the Clarion or Storden soils.

These soils have moderate permeability. Surface runoff is medium. Available water capacity is high. The Clarion soil contains about 3 to 4 percent and Storden soils about 1 to 2 percent organic matter in the plow layer. Reaction in the Clarion soils is typically slightly acid or neutral in the surface and upper part of the subsoil. Reaction is typically moderately alkaline throughout the Storden soils, and these soils contain an excess of lime carbonates. In the Clarion soils, the supply of available phosphorus is generally very low to low and the supply of available potassium is very low in the subsoil. The supply of available phosphorus and that of potassium are very low in the substratum of the Storden soils.

Most areas of these soils are cultivated. These soils are well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. If they are used for cultivated crops, there is a hazard of erosion. Conservation tillage, which leaves crop residue on the surface, helps prevent excessive soil loss. Controlling erosion by the use of mechanical practices, such as contouring and terracing, is difficult in most places because of irregular topography and short slopes, but in a few places these practices are suited. Returning crop residue to the soil or adding other organic material on a regular basis helps to improve fertility, reduce soil erosion, reduce crusting, and maintain good tilth.

The use of these soils for pastureland or hayland is also effective in controlling erosion. Overgrazing, however, causes surface compaction, increases runoff, results in poorer tilth, and reduces production. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture productive and the soils in good condition.

These soils are in capability subclass IIe.

639C2—Storden-Salida complex, 5 to 9 percent slopes, moderately eroded. This complex of moderately sloping, well drained and excessively drained soils is on irregular, convex upland ridges and side slopes. Some areas are dissected by shallow drainageways. Individual areas are irregular in shape, range from about 5 to 15 acres in size, and are about 50 percent Storden soils and about 35 percent Salida soils. Salida soils typically are on the higher points of narrow, convex ridges and on sharp slope breaks. Salida soils commonly have gravel-sized particles on the surface. Storden soils commonly are on the broader parts of the ridgetops and on the convex side slopes. The areas of these two soils are so small or so intricately mixed that it is not practical to separate them at the scale used in mapping.

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

Typically, the Salida soils have a surface layer about 8 inches thick. It is very dark grayish brown gravelly sandy loam, mixed with some streaks and pockets of dark grayish brown and brown gravelly sandy loam. The subsoil is about 5 inches thick. It is brown or dark brown, calcareous, gravelly loamy sand. The substratum is multicolored, calcareous sand and gravel. About 20 percent of the acreage of this unit has slope that ranges from 2 to 5 percent. In places the lower slopes are leached in the upper part of the solum.

Included with these soils in mapping and making up about 10 percent of the map unit are small areas of Clarion soils that are calcareous. These included soils generally occur on the lower part of side slopes and in dips or on lower levels of ridgetops.

Permeability is moderate in the Storden soils and very rapid in the Salida soils. Runoff is moderately rapid on the Storden soils and is slow on the Salida soils. Available water capacity is high in the Storden soils and very low in the Salida soils. In the plow layer of Storden soils the content of organic matter is about 2 percent, and in that of the Salida soils it is only about 1 percent or less. Reaction is commonly moderately alkaline throughout both these soils, and these soils contain excess lime. Both are very low in available phosphorus and potassium. Stones and gravel in the surface layer of Salida soils often hinder tillage operations.

Most areas of these soils are cultivated. The Storden soils in this complex are moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. The Salida soils are very poorly suited to these crops. If used for cultivated crops, both of these soils are subject to water erosion and the Salida soils are readily blown by wind, especially when the surface is left bare. Conservation tillage, which leaves crop residue on the surface, and grassed waterways help prevent excessive soil loss. Controlling erosion by the use of mechanical practices, such as contouring and terracing, is difficult in places because of irregular topography and short slopes. Sand and gravel in the Salida soils may cause construction difficulties. An excess of lime carbonates in these soils reduces the effectiveness of fertilizer and herbicides. The supply of available iron is sometimes deficient in these soils, and in places other minor elements may be low in availability. Returning crop residue to the soil or adding other organic material on a regular basis helps to increase organic matter content, improves fertility, and maintains good tilth.

The use of these soils for pastureland or hayland is also effective in controlling erosion. Overgrazing or grazing when the soils are too wet, however, causes surface compaction, poorer tilth, and increased runoff, particularly on the Storden soils. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture productive and the soils in good condition.

These soils are in capability subclass IIIe.

639D2—Storden-Salida complex, 9 to 14 percent slopes, moderately eroded. This complex of strongly sloping, well drained and excessively drained soils is on irregular, convex upland ridges and side slopes. Some areas are dissected by shallow drainageways. Individual areas are irregular in shape and range from about 5 to 15 acres in size. They contain about 50 percent Storden soils and about 35 percent Salida soils. Salida soils typically are on the higher points of narrow convex ridges and on sharp slope breaks. Salida soils commonly have gravel-sized particles on the surface. Storden soils commonly are on the broader ridgetops and on the convex side slopes. The areas of these soils are so small or so intricately mixed that it is not practical to separate them at the scale used in mapping.

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

Typically, the Salida soils have a surface layer of very dark grayish brown gravelly sandy loam, mixed with some streaks and patches of dark brown and brown subsoil material about 8 inches thick. The subsoil, about 6 inches thick, is dark brown and dark yellowish brown, calcareous, gravelly loamy sand. The substratum is mixed dark brown and dark yellowish brown, calcareous sand and gravel. In places the lower slopes are leached to a depth of 20 inches.

Included with these soils in mapping and making up about 10 percent of the map unit are small areas of Storden soils that are not calcareous. These included soils generally are on the lower part of side slopes and in dips or on lower levels of ridgetops.

Permeability is moderate in the Storden soils and very rapid in the Salida soils. Runoff is rapid on the Storden soils and is slow on the Salida soils. Available water capacity is high in the Storden soils, but often this potential is not reached because of rapid runoff and reduced surface infiltration. Available water capacity is very low in the Salida soils. Even though most of the water that falls on the surface is absorbed, much of it rapidly drains through the soil and out of the plant root zone. In the plow layer of Storden soils the content of organic matter is about 2 percent, and in that of Salida soils it is only about 1 percent. These soils are commonly moderately alkaline throughout, and they contain excess lime. Both soils are very low in available phosphorus and potassium. Stones and gravel in the surface of Salida soils hinder tillage operations.

Many areas of these soils are cultivated. The Storden soils of this complex are moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. The Salida soils are very poorly suited to these crops. If used for cultivated crops, both soils are subject to severe water erosion. The Salida soils are readily blown by wind, especially when the surface is bare. Conservation tillage, which leaves crop residue on the surface, and grassed waterways help prevent excessive soil loss. Controlling erosion by the use of mechanical practices, such as contouring and terracing, is difficult in places because of irregular topography and short slopes. Sand and gravel in the Salida soils may cause construction difficulties. An excess of lime carbonates in these soils reduces the effectiveness of fertilizer and herbicides. The supply of available iron is sometimes deficient in these soils, and in places other minor elements may be low in availability. Returning crop residue to the soil or adding other organic material on a regular basis helps to increase organic matter content, improves fertility, and maintains good tilth.

The use of these soils for pastureland or hayland is also effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, poorer tilth, and increased runoff, especially on the Storden soils. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture productive and the soils in good condition.

These soils are in capability subclass IVe.

654—Corwith loam, 1 to 3 percent slopes. This very gently sloping, somewhat poorly drained soil is on lake plains and outwash areas on the uplands. Slopes are convex. Individual areas are irregular in shape and typically range from 3 to 10 acres in size.

Typically, the surface layer is black and very dark brown loam about 9 inches thick. The subsurface layer is very dark grayish brown loam about 5 inches thick. The subsoil is about 17 inches thick. The upper part is dark grayish brown and very dark grayish brown, friable, calcareous silt loam. The middle and lower parts are dark grayish brown, very dark grayish brown, yellowish brown, and brown, friable, calcareous silt loam that is high in very fine sand. The substratum is multicolored, friable, calcareous silt loam to a depth of 60 inches. In places the surface soil is thicker. In places the lower part of the subsoil and the substratum are very fine sand.

Included with this soil in mapping and making up about 10 percent of the map unit are poorly drained areas of Fieldon and Darfur soils. These soils are on the lower part of the slopes.

Permeability of this soil is moderate, and surface runoff is slow. Available water capacity is high. This soil has a seasonal high water table at a depth of 24 to 48 inches. The surface layer contains 5 to 6 percent organic matter. The subsoil is very low in both available phosphorus and potassium. Reaction is typically moderately alkaline throughout.

Most of the acreage of this soil is cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Water erosion generally is not a problem, but if this soil is plowed in fall, soil blowing is a hazard. Conservation tillage, which leaves crop residue on the surface, and adding organic material on a regular basis prevent soil blowing and help maintain tilth and productivity. This soil generally is not artificially drained, but in some areas artificial drainage would improve timeliness of operations.

The use of this soil for pastureland or hayland is also effective in controlling soil blowing. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increased runoff, and poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture productive and the soil in good condition.

This soil is in capability class I.

655—Crippin loam, 1 to 3 percent slopes. This very gently sloping, somewhat poorly drained soil is on low, slightly convex ridges throughout the county. Individual areas commonly range from 3 to 10 acres in size, but a few areas are as large as 20 acres.

Typically, the surface layer is black loam about 9 inches thick. The subsurface layer is black and very dark gray loam about 6 inches thick. The subsoil is about 19 inches thick and is dark grayish brown in the upper part and multicolored in the lower part. It is typically friable, calcareous loam. The substratum is mottled, light olive brown and olive gray loam to a depth of 60 inches. In places the subsoil is clay loam or silty clay loam. Also in places the surface is thinner.

Included with this soil in mapping and making up less than 5 percent of the map unit are small areas of Storden and Clarion soils. Storden soils are well drained and are lower in organic matter. These are on the highest part of the slope and commonly are lighter in color. Clarion soils are slightly higher on the landscape than this Crippin soil and are well drained.

Permeability of this soil is moderate, and surface runoff is slow. The seasonal high water table is at a depth of 24 to 48 inches, and available water capacity is high. The plow layer contains about 5 to 6 percent organic matter. Reaction ranges from mildly to moderately alkaline. The subsoil is very low to low in available phosphorus and very low in available potassium. The surface layer typically has good tilth.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, and small grains and to legumes for hay or pasture. If this soil is plowed in fall and the surface left bare, soil blowing may be a problem. Conservation tillage, which leaves crop residue on the surface, helps prevent excessive soil loss. This soil generally is not drained, but in some areas artificial drainage would improve timeliness of operations.

If this soil is used for pasture, overgrazing or grazing when the soil is wet is likely to cause surface compaction and result in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting use during wet periods help keep the pasture productive and the soil in good condition.

This soil is in capability class I.

658—Mayer loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes. This nearly level, poorly drained soil is on upland outwash plains and stream benches. Slopes are nearly plane, and in places they are crossed by shallow, concave swales and low, convex rises. Small quantities of fine gravel-sized particles are commonly present in the surface layer. Individual areas are irregular in shape and range from about 5 to 35 acres in size.

Typically, the surface layer is black loam about 7 inches thick. The subsurface layer is black and very dark gray loam about 13 inches thick. The subsoil, about 10 inches thick, is dark gray and olive gray, friable loam. The substratum to a depth of 60 inches is olive gray, mottled, calcareous sand and gravel. In places sand and gravel are as deep as 36 inches.

Included with this soil in mapping and making up less than 5 percent of the map unit are a few small areas of depressional soils. These soils are wetter and are subject to ponding after rains. Also included are a few areas of highly calcareous soils that have a dark gray surface layer when dry. Availability of nutrients is lower in these areas.

Permeability is moderate in the solum and rapid in the substratum. Surface runoff is slow. A seasonal high water table is at a depth of 12 to 36 inches. Root development and available water capacity are limited by the underlying sand and gravel. The available water capacity is moderate. The surface layer contains about 4 to 5 percent organic matter. Reaction is commonly moderately alkaline throughout. The subsoil is very low in available phosphorus and potassium.

Most areas of this soil are used for row crops. This soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Drainage is needed to make cropland dependable. If this soil is drained, however, it is somewhat droughty and crops suffer from insufficient water, especially if rainfall is below average or if rains are not timely. Because of this, the soil is better suited to small grains and to grasses and legumes for hay and pasture. Drainage can be improved by the installation of underground drains, which function well, but in some places instability of the substratum makes installation difficult. Care is needed to avoid overdraining. If this soil is plowed in the fall and the surface is left bare, soil blowing is a serious hazard in the spring. Conservation tillage, which leaves crop residue on the surface, and adding other organic material help prevent soil blowing, improve fertility, and conserve available water. The supply of available iron may be low in places.

The use of this soil for pastureland or hayland is also effective in controlling soil blowing. If this soil is used for pastureland, proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help maintain desirable plant species and keep the pasture productive and the soil in good condition.

This soil is in capability subclass IIw.

733—Calco silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on bottom lands throughout the county. Areas along the smaller streams are commonly long and narrow, and parallel both sides of the stream. The soil is subject to flooding. Individual areas along smaller streams are commonly 100 acres or more in size. In most places these streams have been straightened and deepened to provide outlets for underground drainage systems. In some places this has left the old meander channel, which is 8 to 15 feet lower than the surrounding soils and is difficult to farm. Other areas, typically those along larger streams, are irregular in shape and commonly range from 10 to 20 acres in size, but a few areas are larger.

Typically, the surface layer is black silty clay loam about 8 inches thick. The subsurface layer is black and very dark gray silty clay loam about 42 inches thick. The substratum to a depth of 60 inches or more is olive gray, mottled, calcareous clay loam. In places this soil has up to 10 inches of moderately dark colored loamy overwash. In places sand is below a depth of 40 inches.

Permeability of this soil is moderate, and surface runoff is slow. Most areas are subject to seasonal flooding, mainly in early spring. The available water capacity is high. This soil has a seasonal high water table at a depth of 12 to 36 inches. The plow layer contains about 5 to 7 percent organic matter. Shrink-swell potential is high in the surface layer. The content of available phosphorus and potassium is very low to low. Available iron for some crops may be low in places.

Where this soil has been adequately drained, it is used for cultivated crops. Undrained areas are used for pasture. This soil is moderately suited to row crops. Wetness is a major limitation because of flooding and the high water table. Underground drains function well if outlets are satisfactory. Seasonal flooding drowns out most legumes.

This soil is suited to pastureland or hayland. Proper stocking rates, rotational grazing, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture productive and the soil in good condition.

This soil is in capability subclass IIw.

823—Ridgeport sandy loam, 0 to 2 percent slopes. This nearly level, somewhat excessively drained soil is on outwash plains and stream benches. Individual areas are irregular in shape. They range in size from about 5 to 15 acres on outwash plains, and on stream benches they are as large as about 100 acres.

Typically, the surface layer is black sandy loam about 8 inches thick. The subsurface layer is black sandy loam about 3 inches thick. The subsoil, about 22 inches thick, is sandy loam. It is dark brown and very dark grayish brown in the upper part, dark brown and brown in the middle part, and brown and dark yellowish brown in the lower part. The substratum to a depth of 60 inches is very dark grayish brown, dark brown, brown, and yellowish brown, calcareous sand and gravel. In places, significant quantities of shale fragments are in the lower part of the solum and in the substratum.

Permeability is moderately rapid in the solum and very rapid in the substratum, and surface runoff is slow. Available water capacity is low. The surface layer contains about 1 to 2 percent organic matter. Reaction is typically neutral to slightly acid. This soil is very low in available phosphorus and potassium.

Most areas of this soil are cultivated. This soil is moderately suited to row crops. It is better suited to small grains and to grasses and legumes for hay and pasture. Growth of row crops is only moderate or poor because of a lack of available water, especially in years when rainfall is below average or rains are not timely. Soil blowing is commonly a hazard because the surface dries quickly after tillage. Blowing sand sometimes damages young plants. Conservation tillage, which leaves crop residue on the surface, effectively prevents or reduces soil blowing and conserves available water for crop use. Returning crop residue to the soil and adding other organic material on a regular basis help to improve available water capacity and slow drying.

The use of this soil for pastureland or hayland is also effective in controlling soil blowing. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during extremely wet or extremely dry periods help to keep the pasture productive and the soil in good condition.

This soil is in capability subclass IIIs.

823B—Ridgeport sandy loam, 2 to 5 percent slopes. This gently sloping, somewhat excessively drained soil is on outwash plains and stream benches. On stream benches, it is generally between other Ridgeport soils and steeper soils that are adjacent to bottom land soils. Most areas on benches are elongated and range from 5 to 15 acres in size. On outwash plains, most areas are irregular in shape and only about 5 to 8 acres in size. Slopes are short and convex.

Typically, the surface layer is black and very dark brown sandy loam about 8 inches thick. The subsoil, about 20 inches thick, is dark brown, brown, and dark yellowish brown sandy loam. The substratum to a depth of 60 inches is multicolored, calcareous sand and gravel. In some areas of this soil, significant quantities of shale fragments are highly concentrated in the middle and lower parts of the subsoil.

Included in mapping and making up less than 5 percent of the map unit are small areas of Salida soils that are calcareous at or near the surface. These areas are commonly on higher, more convex slopes.

Permeability is moderately rapid in the solum and rapid in the substratum. Surface runoff is medium, and the available water capacity is low. The surface layer contains about 1 to 2 percent organic matter. Reaction is typically neutral to slightly acid. This soil is very low in available phosphorus and potassium.

In most areas this soil is cultivated. This soil is only moderately suited to row crops. It is better suited to small grains and to grasses and legumes for hay and pasture. Growth of crops, particularly row crops, is only moderate or poor because of droughtiness, especially in years when rainfall is below average or rains are not timely. Soil blowing is commonly a hazard because the surface dries quickly after tillage. Blowing sand sometimes damages young plants. If this soil is used for row crops, erosion from runoff is also a hazard. Conservation tillage, which leaves crop residue on the surface, is effective in reducing erosion and soil blowing. Returning crop residue to the soil and adding other organic material on a regular basis help to improve available water capacity, slow drying, and reduce soil blowing.

The use of this soil for pastureland or hayland is also effective in controlling erosion and soil blowing. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during extremely wet periods help to keep the pasture productive and the soil in good condition.

This soil is in capability subclass IIIe.

823C2—Ridgeport sandy loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, somewhat excessively drained soil is on outwash areas in the uplands. Slopes are short and convex. Individual areas are irregular in shape and range from about 2 to 15 acres in size.

Typically, the surface layer is very dark brown and very dark grayish brown sandy loam about 8 inches thick. The subsoil is about 22 inches thick. It is dark brown, brown, yellowish brown, and dark grayish brown sandy loam. The substratum to a depth of 60 inches is multicolored, calcareous sand and gravel, in many places mixed with shale. In many places large quantities of shale fragments are throughout the profile.

Included in mapping and making up less than 5 percent of the map unit are small areas of Salida soils on the more convex parts of the slope. These soils are calcareous at or near the surface.

Permeability is moderately rapid in the solum and very rapid in the substratum. Surface runoff is medium. Available water capacity is low. The surface layer contains about 1 to 2 percent organic matter. Reaction is typically neutral to slightly acid, but some horizons are moderately acid in some areas. The availability of both phosphorus and potassium is very low.

Most areas of this soil are cultivated. This soil is only moderately suited to row crops. It is better suited to small grains and to grasses and legumes for hay and pasture. Water erosion is a serious hazard, and blowing sand is often a problem, sometimes damaging young plants. Conservation tillage, which leaves crop residue on the surface, is effective in reducing water erosion and soil blowing. Returning crop residue to the soil and adding other organic material on a regular basis help to improve available water capacity, slow drying, and reduce soil blowing.

The use of this soil for pastureland or hayland is also effective in controlling water erosion and soil blowing. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during extremely wet periods help to keep the pasture productive and the soil in good condition.

This soil is in capability subclass IIIe.

879—Fostoria loam, 0 to 2 percent slopes. This nearly level, somewhat poorly drained soil occurs mainly on slightly convex or concave slopes on outwash plains. Individual areas are irregular in shape and range from 2 to 10 acres in size.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is black and very dark grayish brown loam about 10 inches thick. The mottled subsoil, about 23 inches thick, is dark grayish brown, friable loam in the upper part. In the middle part it is mainly brown and olive brown, friable loam, and in the lower part it is mainly light brownish gray, very friable sandy loam. The substratum to a depth of 60 inches is light brownish gray, mottled, friable, calcareous silt loam and loamy sand. In places thin layers of sand and gravel are in the lower part of the profile. Other places have shale fragments dispersed throughout the soil profile.

Included with this soil in mapping and making up less than 5 percent of the map unit are small areas of poorly drained Darfur and well drained Dickman soils. Darfur soils are on small, concave, wet areas. Dickman soils are on the better drained parts of the slopes.

Permeability of this soil is moderate, and surface runoff is slow. This soil has a seasonal high water table at a depth of 24 to 48 inches, and the available water capacity is high. The organic matter content is about 5 to 6 percent in the plow layer. Reaction is typically slightly acid in the plow layer and neutral in the subsoil. The Fostoria soil is generally very low to low in available phosphorus and potassium. This soil has good tilth.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Erosion generally is not a problem on this soil, but if the soil is fall plowed, soil blowing may be a problem. Conservation tillage, which leaves crop residue on the surface, helps prevent excessive soil blowing. This soil generally is not artificially drained, but in some areas artificial drainage would improve timeliness of operations.

The use of this soil for pasture and hayland is also effective in preventing soil blowing. If this soil is used for pasture, proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help keep the pasture productive and the soil in good condition.

This soil is in capability class I.

895—Lemond loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on upland outwash plains and stream benches. Slopes are nearly plane to convex, and in places they are crossed by shallow, concave swales and low, convex rises. Individual areas are irregular in shape and range from about 5 to 30 acres in size.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is black and very dark gray loam about 6 inches thick. The next layer is very dark gray loam and dark gray and olive gray sandy loam about 4 inches thick. The subsoil is about 12 inches thick. The upper part is olive gray, friable sandy loam, and the lower part is olive gray and olive, mottled gravelly loamy sand. The substratum to a depth of 60 inches is multicolored, calcareous loamy sand, sand, and gravel. In places sand and gravel are as deep as 38 inches. In places the surface layer is sandy loam.

Included in mapping and making up less than 5 percent of the map unit are a few areas of highly calcareous Harcot soils that have a lighter colored surface layer when dry. The available nutrient supply is lower in these areas.

Permeability is moderately rapid in the solum and rapid in the substratum. This soil has a seasonal high water table at a depth of 0 to 36 inches. Available water capacity is moderate, and surface runoff is slow. Root development and the available water capacity are limited by the underlying sand and gravel. The plow layer contains about 4 to 5 percent organic matter. Reaction is commonly moderately alkaline throughout. The subsoil is very low in available phosphorus and potassium.

Most areas of this soil are used for cultivated crops. This soil is moderately suited to corn and soybeans. In most years it is better suited to small grains and grasses and to legumes for hay and pasture than to corn because of limited amounts of available water. This soil has a seasonal high water table, and in some areas, drainage is needed to make cropland dependable, but care is needed to avoid overdraining. Drainage can be improved by installing underground drains. These function well in this soil but are difficult to install in some places because of instability in the substratum. Typically, available water capacity is moderate, but because of the shallowness to sand and gravel, it is low in some areas. Available water is insufficient for crops, especially if rainfall is below average or if rains are not timely. This soil is subject to soil blowing, especially if it is plowed in fall and the surface is left bare. Conservation tillage, which leaves crop residue on the surface, helps prevent soil blowing and conserve moisture.

If this soil is used for pastureland, proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help maintain desirable plant species and keep the pasture productive and the soil in good condition.

This soil is in capability subclass IIw.

1032—Spicer silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on broad flats. Slopes range from slightly concave to slightly convex. Individual areas are irregular in shape and range from about 25 to 80 acres in size. A few areas are as small as 10 acres.

Typically, the surface layer is black silty clay loam about 9 inches thick. The subsurface layer is black and very dark gray silt loam about 10 inches thick. The mottled subsoil, about 23 inches thick, is silt loam and silty clay loam. The upper part is olive gray and dark gray, and the middle and lower parts are olive gray. The substratum is olive gray and light olive gray silt loam to a depth of about 60 inches.

Included with this soil in mapping and making up less than 5 percent of the map unit are a few small depressions that contain Okoboji and Harpster soils. Okoboji soils are wetter than this soil and tend to pond after rains. The highly calcareous Harpster soils are distinctly lighter in color when dry and are adjacent to Okoboji soils in depressions. These soils have a lower supply of available nutrients than the Spicer silty clay loam.

Permeability of this soil is moderate, and surface runoff is slow. A seasonal high water table is at a depth of 12 to 36 inches, and available water capacity is high. The surface layer contains about 5 to 7 percent organic matter. Reaction is mildly or moderately alkaline throughout. The subsoil is commonly very low in available phosphorus and potassium. The surface layer is friable and easily tilled, but if worked when too wet it becomes cloddy and hard when dry.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Drainage is essential for optimum crop production. Underground drainage systems work well. Areas that are plowed in fall are subject to soil blowing. Conservation tillage, which leaves crop residue on the surface, helps prevent soil blowing. The high concentration of lime carbonates in this soil reduces the effectiveness of fertilizer and herbicides. Also, available iron is low in places because of the excess lime.

The use of this soil for pastureland and hayland is also effective in preventing soil blowing. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, poorer tilth, and a lower water infiltration rate. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture productive and the soil in good condition.

This soil is in capability subclass IIw.

1133—Colo silty clay loam, channeled, 0 to 2 percent slopes. This nearly level, poorly drained soil is on bottom lands adjacent to major streams and rivers in the county. It is subject to flooding. Individual areas are dissected by oxbows and meandering stream channels and are among the first to flood whenever streams overflow. Some areas are long and narrow, paralleling the stream, and range from about 25 to 50 acres in size. Where oxbows are more numerous, areas of this soil are wide and are larger.

Typically, the surface layer is black silty clay loam about 5 inches thick. The subsurface layer is black silty clay loam about 45 inches thick. The substratum is very dark gray to gray silty clay loam to a depth of about 60 inches. In places the surface layer is thinner and contains more sand. In places clay loam or sandy loam is at a depth of about 40 inches.

Included in mapping and making up less than 5 percent of the map unit are a few small areas of moderately well drained or somewhat poorly drained Spillville soils. They contain less clay and are adjacent to the stream channels.

Permeability of this soil is moderate, and surface runoff is slow. Available water capacity is high. This soil has a seasonal high water table at a depth of 12 to 36 inches. The surface layer contains about 5 to 7 percent organic matter. Reaction is neutral to slightly acid throughout the profile. The supply of available phosphorus is medium to low, and the supply of available potassium is low.

Flooding is a severe hazard on this soil, and therefore most areas of this soil remain in native grasses, brush, and trees. The areas in grasses are used for pasture or are idle. Some areas provide good habitat for some wildlife. If flooding were controlled, old stream channels filled, and trees and brush cleared, this soil would be well suited to row crops or hayland; however, the expense would be prohibitive. Some areas are mostly in grass and provide good grazing for livestock. Overgrazing or grazing when the soil is too wet causes surface compaction and poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture productive and the soil in good condition.

This soil is in capability subclass Vw.

1135—Coland clay loam, channeled, 0 to 2 percent slopes. This nearly level, poorly drained soil is on bottom lands adjacent to major streams and rivers in the county. It is subject to flooding. Areas of this soil are dissected by oxbows and meandering stream channels, and these areas are among the first to flood whenever streams overflow. Some areas are long and narrow, paralleling the streams. Oxbows are numerous throughout. Individual areas of this soil are wide and range from 20 to 45 acres in size.

Typically, the surface layer is black clay loam about 8 inches thick. The subsurface layer is black and very dark gray clay loam about 40 inches thick. The substratum to a depth of about 60 inches is very dark gray to gray loam that grades to sandy loam as depth increases. In places the soil has a loamy overwash about 10 inches thick. In places the surface layer extends to a depth of 50 inches or more.

Included with this soil in mapping and making up less than 5 percent of the map unit are a few small areas of soils that are calcareous. These areas are mainly adjacent to old oxbows. They are lower in available nutrients. Also included are a few small areas of Spillville soils that are adjacent to the stream. Spillville soils are better drained than Coland soils.

Permeability of this soil is moderate, and surface runoff is slow. This soil has a seasonal high water table at a depth of 12 to 36 inches, and available water capacity is high. The surface layer contains about 5 to 7 percent organic matter. Reaction is neutral or slightly acid throughout the profile. The supply of available phosphorus is medium to low, and the supply of available potassium is low.

Most areas of this soil are used for pasture. If flooding could be controlled, old stream channels filled, trees and brush cleared, and adequate drainage provided, this soil would be well suited to row crops.

Flooding is a severe hazard on this soil, and most areas are in native grasses, brush, and trees. Some areas provide good habitat for some kinds of wildlife. Other areas that are mostly in grass provide good grazing for livestock. Overgrazing or grazing when the soil is too wet causes surface compaction and poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture productive and the soil in good condition.

This soil is in capability subclass Vw.

1485—Spillville loam, channeled, 0 to 2 percent slopes. This nearly level, moderately well drained and somewhat poorly drained soil is on bottom lands adjacent to major streams and rivers in this county. It is subject to flooding. Areas of this soil are dissected by oxbows and meandering stream channels, and these areas are among the first flooded whenever streams overflow. Some areas are long and narrow, paralleling the stream. Individual areas of this unit are irregular in shape and typically range from 10 to 100 acres in size. A few areas are as large as 150 acres in size.

Typically, the surface layer is black loam about 9 inches thick. The subsurface layer is black and very dark gray loam about 30 inches thick. The next layer is very dark gray, mottled fine sandy loam about 12 inches thick. The substratum is very dark gray and very dark brown sandy loam to a depth of 60 inches. In places the surface layer is thinner and contains more sand, and the substratum is loamy sand.

Included with this soil in mapping and making up less than 5 percent of the map unit are a few small areas of poorly drained Colo and Coland soils. Colo and Coland soils both contain more clay than Spillville soils, and generally are in old stream channels.

Permeability is moderate, and surface runoff is slow. A seasonal high water table is at a depth of 36 to 60 inches, and available water capacity is high. The surface layer contains about 4 to 6 percent organic matter. Reaction is neutral to slightly acid throughout the profile. This soil is low in available phosphorus and potassium.

Most areas of this soil are in trees and grass. This soil is best suited to pasture or wildlife. Flooding is a severe hazard on this soil, and therefore most areas remain in grasses, brush, and trees. Removing trees and brush helps to improve stands of desirable pasture grasses. Overgrazing or grazing when this soil is too wet causes surface compaction and poor tilth. Proper stocking rates, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture and the soil in good condition. If flooding could be controlled, old stream channels filled, and trees and brush cleared, this soil would be well suited to row crops.

This soil is in capability subclass Vw.

1595—Harpster silt loam, 0 to 2 percent slopes. This nearly level, highly calcareous, poorly drained soil is on convex rims surrounding some depressions and on nearly level flats surrounding small, shallow depressions. Most areas are 10 to 25 acres in size, but a few are as large as 60 acres or more. The smaller areas surrounding depressions are almost circular. Larger areas are irregular in shape.

Typically, the surface layer is highly calcareous, black silt loam about 8 inches thick. The subsurface layer is silt loam about 13 inches thick. It is black and very dark gray in the upper part and very dark gray and very dark grayish brown in the lower part. The subsoil, about 20 inches thick, is olive gray, mottled, calcareous silt loam. The substratum to a depth of 60 inches is olive gray, mottled, calcareous silt loam. In places the surface layer is loam or sandy loam. In places the depth to a clay loam substratum is less than 40 inches.

Included in mapping and making up less than 5 percent of the map unit are small areas of Okoboji soils in depressions. These soils are wetter than this Harpster soil, and they are subject to ponding.

Permeability of this soil is moderate, and surface runoff is slow. A seasonal high water table is at a depth of 12 to 36 inches, and available water capacity is high. The surface layer contains about 5 to 6 percent organic matter. Reaction is commonly moderately alkaline throughout. The subsoil is very low in available phosphorus and potassium. The supply of available iron is low for some crops because of the excess lime.

Most areas of this soil are cultivated. This soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Drainage is essential for optimum crop production, and underground drainage systems work well. Most of the acreage of this soil is tilled in fall, and if the surface is left bare or unprotected, it blows readily when dry. Conservation tillage, which leaves crop residue on the surface, helps prevent soil blowing. The concentration of lime carbonates in this soil reduces the effectiveness of fertilizer and herbicides.

Using this soil as pastureland or hayland is effective in preventing soil blowing. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, poorer tilth, and a lower water infiltration rate. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricting grazing during wet periods help to keep the pasture productive and the soil in good condition.

This soil is in capability subclass IIw.

5010—Pits, gravel. Gravel pits are areas where gravel occurs in sufficient quality and quantity to warrant its removal. Large areas of sand and gravel are on level to nearly level stream benches. Individual areas of this map unit are irregular in size, ranging from 2 to 30 acres. One area, in the eastern part of Cresco township, is about 70 acres in size. Many gravel pits in the county are abandoned because most of the gravel suitable for road surfacing has been removed.

The gravel has been strip mined, and the mined areas now have little or no value for farmland. These areas could be reclaimed for farmland if the spoil is leveled off and overburden returned. Some of the abandoned pits are filled with water, and these, in most cases, support a varied aquatic life. During the migration season, ducks and geese use the ponds as resting and feeding areas. The fish in the mine pits include bullheads, largemouth and smallmouth bass, sunfish, and northern pike.

This land is used primarily for public recreation. With the help of landscaping, these areas have excellent potential as sites for picnicking, hunting, fishing, snowmobiling, motorcycle trails, and camping.

5040—Orthents, loamy. These nearly level to moderately steep, somewhat excessively drained to moderately well drained soils are in cut and fill areas. Individual areas are commonly rectangular in shape and range from 1 to 15 acres in size.

Typically, the cut areas have a soil profile and characteristics similar to the Storden soils. The upper 5 feet is yellowish brown and grayish brown friable and firm loam. Cobblestones and pebbles are common on the surface in many areas. In some areas 4 to 10 inches of topsoil has been redistributed over the borrow areas. The surface color in these areas ranges from very dark gray to dark brown.

Many sites are on the edges of fields adjacent to roads and primary paved highways. In many places, small pockets of sand and gravel have been removed for roadfill or building site use. The cut areas are now mostly used as cropland. Commonly, Orthents in these areas are very low in organic matter content and in available nutrients. In most of these areas the soils have very poor tilth. Returning crop residue to the soil and regularly adding other organic material improve tilth, slow drying, and improve available water capacity.

Filled areas have a variety of soil characteristics, depending on the source of the fill material. Most filled areas are not used for agricultural purposes. They are primarily used for roads or building sites. Most areas have been built up to a level surface with fairly steep marginal slopes. Onsite investigation to determine engineering properties is needed if Orthents are used in construction.

Orthents are not assigned to a capability group.

Prime farmland

In this section, prime farmland is defined and discussed, and the prime farmland soils in Kossuth County are listed.

Prime farmland is one of several kinds of important farmland 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 acreage of high-quality farmland is limited, and the U.S. Department of Agriculture recognizes that government at local, state, and federal levels, as well as individuals, must encourage and facilitate the wise use of our nation's prime farmland.

Prime farmland soils, as defined by the U.S. Department of Agriculture, are soils that are best suited to producing food, feed, forage, fiber, and oilseed crops. Such soils have properties that are favorable for the economic production of sustained high yields of crops. The soils need only to be treated and managed using acceptable farming methods. The moisture supply, of course, must be adequate, and the growing season has to be sufficiently long. Prime farmland soils produce the highest yields with minimal inputs of energy and economic resources, and farming these soils results in the least damage to the environment.

Prime farmland soils may presently be in use as cropland, pasture, or woodland, or they may be in other uses. They either are used for producing food or fiber or are available for these uses. Urban or built-up land and water areas cannot be considered prime farmland.

Prime farmland soils usually get an adequate and dependable supply of moisture from precipitation or irrigation. The temperature and growing season are favorable. The acidity or alkalinity level of the soils is acceptable. The soils have few or no rocks and are permeable to water and air. They are not excessively erodible or saturated with water for long periods and are not flooded during the growing season. The slope ranges mainly from 0 to 6 percent.

Soils that have a high water table, are subject to flooding, or receive inadequate rainfall may qualify as prime farmland soils if the limitations are overcome by drainage, flood control, or irrigation. Onsite evaluation is necessary to determine the effectiveness of corrective measures. More information on the criteria for prime farmland soils can be obtained at the local office of the Soil Conservation Service.

Prime farmland in Kossuth County

About 419,935 acres, or nearly 78.5 percent of the county, is prime farmland. Areas are throughout the county. Approximately 410,000 acres of this prime farmland is used for crops. Crops grown on this land, mainly corn and soybeans, account for most of the county's total agricultural income each year.

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

The following map units, or soils, make up prime farmland in Kossuth County. On some soils included in the list, appropriate measures have been applied to overcome wetness. The location of each map unit is shown on the detailed soil maps at the back of this publication. The extent of each unit is given in table 4. The soil qualities that affect use and management are described in the section "Detailed soil map units." This list does not constitute a recommendation for a particular land use.

52B	Bode clay loam, 2 to 5 percent slopes
54	Zook silty clay loam, 0 to 2 percent slopes (where drained)
55	Nicollet loam, 1 to 3 percent slopes
95	Harps clay loam, 0 to 2 percent slopes (where drained)
107	Webster silty clay loam, 0 to 2 percent slopes (where drained)
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
133	Colo silty clay loam, 0 to 2 percent slopes (where drained)
133B	Colo silty clay loam, 2 to 4 percent slopes (where drained)
135	Coland clay loam, 0 to 2 percent slopes (where drained)
138B	Clarion loam, 2 to 5 percent slopes
150	Hanska loam, 0 to 2 percent slopes (where drained)
181B	Clarion-Estherville complex, 2 to 5 percent slopes

203 Cylinder loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes
236B Lester loam, 2 to 5 percent slopes
259 Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes (where drained)
288 Ottosen clay loam, 1 to 3 percent slopes
308 Wadena loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes
308B Wadena loam, 32 to 40 inches to sand and gravel, 2 to 5 percent slopes
325 Le Sueur loam, 1 to 3 percent slopes
330 Kingston silty clay loam, 0 to 3 percent slopes
335 Harcot loam, 0 to 2 percent slopes (where drained)
339B Truman silt loam, 2 to 5 percent slopes
348 Fieldon loam, 0 to 2 percent slopes (where drained)
349 Darfur loam, 0 to 2 percent slopes (where drained)
388 Kossuth silty clay loam, 0 to 2 percent slopes (where drained)
389 Waldorf silty clay, silty substratum, 0 to 2 percent slopes (where drained)
485 Spillville loam, 0 to 2 percent slopes
485B Spillville loam, 2 to 5 percent slopes
507 Canisteo clay loam, 0 to 2 percent slopes (where drained)
559 Talcot clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes (where drained)
585B Colo-Spillville complex, 2 to 5 percent slopes (where drained)
638B Clarion-Storden loams, 2 to 5 percent slopes
654 Corwith loam, 1 to 3 percent slopes
655 Crippin loam, 1 to 3 percent slopes
658 Mayer loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes (where drained)
733 Calco silty clay loam, 0 to 2 percent slopes (where drained)
879 Fostoria loam, 0 to 2 percent slopes
895 Lemond loam, 0 to 2 percent slopes (where drained)
1032 Spicer silty clay loam, 0 to 2 percent slopes (where drained)
1595 Harpster silt loam, 0 to 2 percent slopes (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 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.

According to the Iowa Agricultural Statistics, in 1978 about 609,400 acres in the survey area was used for agricultural purposes (*4*). Of this total, approximately 496,900 acres was used for corn and soybeans, 16,200 acres was used for oats, 13,400 acres was used for hay, and 16,002 acres was cropland used for pasture. The rest was idle or was used for farmsteads, roads, or miscellaneous crops.

Food production could be increased by extending the latest crop production technology to all cropland in the county. The soil survey can facilitate the application of such technology. Many soils on benches have been irrigated, and the irrigated acreage is likely to increase. However, the irrigation potential is limited by a lack of readily available water. Soils that are dramatically benefited by irrigation are not extensive in the county, or are in small, irregularly shaped areas.

More land is being used each year for urban development. Good land use should be based upon the properties and capabilities of soils.

Erosion is the major soil problem on about 28 percent of the cropland and pasture in Kossuth County. If the slope is 3 percent or greater, erosion is a hazard.

Loss of the surface layer by erosion reduces productivity and causes damage to the environment. As the surface layer is lost, tillage operations incorporate part of the less fertile subsoil into the plow layer. In soils that are shallow over sand and gravel, erosion reduces the area available for root development. Erosion also reduces productivity on soils that tend to be droughty, such as Dickman soils, and stream pollution results when the eroded sediment enters streams. Controlling erosion can improve the quality of water for municipal use, for recreation, and for fish and wildlife.

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

Maximum grass and legume production can be accomplished by planting pasture and hay, and by using proper management practices for established stands. These include adequate fertilization, weed and brush control, rotational and deferred grazing with full season grazing systems, proper stocking rates, and adequate livestock watering facilities. A severe erosion hazard exists when sloping pasture and haylands are renovated by destroying the vegetative cover. If cultivated crops are to be grown prior to seeding, soil losses can be reduced by using conservation tillage, contouring, and grassed waterways. In addition, interseeding grasses and legumes into existing sod eliminates the need to destroy vegetative cover for seedbed preparation.

Contouring is also effectively used as an erosion control practice in the county. It is best suited to soils with smooth, uniform slopes. Many slopes are so short, steep, and irregular that neither contour tillage or terracing is practical in some areas of the county. On these areas, cropping systems that provide adequate vegetative cover are needed to control erosion.

Terraces and diversions reduce the length of slope and thus reduce runoff and erosion. They are best adapted to well drained soils that have straight slopes that are gently to moderately sloping. Sloping Clarion, Storden, Bode, Truman, and Lester soils are well suited for terracing. Salida, Estherville, Ridgeport, Wadena, and Dickman soils are sandy or have sand and gravel substratums that generally make terracing impractical.

Conservation tillage practices, which leave crop residue on the surface, help to increase infiltration, slow runoff, and reduce the hazard of erosion. These practices can be adapted to all tillable soils in the county.

Examples of major conservation tillage systems include: (1) no-tillage, or slot or zero tillage, whereby preparation of the seedbed and planting are completed in one operation. There is little or no soil disturbance except in the immediate area of the planted seed row. A protective cover of crop residue is left on at least 90 percent of the soil surface. (2) Strip tillage, whereby seedbed preparation and planting are, again, completed in one operation. Tillage in the row is limited to a strip not wider than one-third of the total area. A protective cover of crop residue is left on two-thirds of the soil surface. (3) Chisel-disk or rotary tillage, whereby soil is loosened over the entire surface and crop residue is partly incorporated into the soil. Seedbed preparation and planting may be in one operation or separate operations. Conservation tillage is not being practiced unless enough residue is left on the soil surface after planting to effectively reduce erosion.

Soil blowing is a hazard, particularly on the moderately coarse textured Dickman, Ridgeport, and Salida soils. Soil blowing can damage young plants growing on these soils in a few hours if winds are strong and the surface is bare. Maintaining an adequate vegetative cover, using surface mulch, or maintaining a rough surface by using appropriate tillage methods minimizes soil blowing on these soils.

Information for the design and application of erosion control practices for each kind of soil can be obtained at the local office of the Soil Conservation Service.

Drainage is a management need on about 52.7 percent of the acreage used for crops and pasture in Kossuth County. The very poorly drained Blue Earth, Okoboji, Palms, Rolfe, and Wacousta soils are in depressions and are so wet in their natural state that production of crops common to the area is generally not possible. These soils make up about 65,475 acres in the county. However, in many areas these soils have been artificially drained and are presently being cropped.

The poorly drained soils—those of the Biscay, Calco, Canisteo, Coland, Colo, Darfur, Fieldon, Hanska, Harcot, Harps, Harpster, Kossuth, Lemond, Mayer, Spicer, Talcot, Waldorf, and Zook series—are so wet that, unless they are artificially drained, crops are damaged in most years. These soils make up about 263,670 acres in the county. All of these soils are more productive and more easily managed when drained.

Intensive row cropping on very poorly drained soils generally requires a combination of tile drainage and tile intakes, and, in some places, surface drainage. Tile drains are generally adequate on poorly drained soils. Drains need to be more closely spaced in soils that have slow permeability than in the more permeable soils, and care is needed to avoid overdraining soils that formed in outwash, such as Biscay, Harcot, Lemond, Mayer, and Talcot. Tile drainage is very slow in Okoboji, Rolfe, and Waldorf soils. Finding satisfactory outlets for a tile drainage system is difficult in some areas of Blue Earth, Colo, Calco, Coland, Okoboji, Palms, and Zook soils.

Information on drainage design for each kind of soil is available at the local office of the Soil Conservation Service.

Fertility is low for most soils in Kossuth County. Most of the upland soils, for example, are low or very low in available phosphorus and potash.

The amount of nitrogen available to plants is related to the content of organic matter. Most of the soils are typically moderate to high in content of organic matter. The very poorly drained Blue Earth and Palms soils are very high in organic matter; and the Dickman, Lester, Ridgeport, Salida and Storden soils are low or very low. Except for the Dickman, Estherville, Hanska, Lemond, Linder, Mayer, Ridgeport, and Wadena soils, which have limited available water capacity, other Kossuth County soils are very productive if an adequate amount of fertilizer is applied.

Soils in Kossuth County range from medium acid to moderately alkaline. The mildly to moderately alkaline soils—Blue Earth, Calco, Canisteo, Corwith, Crippin, Fieldon, Harcot, Harps, Harpster, Salida, Storden, Mayer, Lemond, Spicer, and Talcot soils, for example—have free carbonates in the surface layer. High pH, or alkalinity, reduces the levels of available phosphorus, potassium, and some micronutrients. Many areas of upland soils, particularly Clarion, Nicollet, Ottosen, Lester, and Le Sueur soils, are slightly acid or medium acid and need applications of ground limestone to raise the pH level for optimum crop growth and availability of nutrients. On all soils, additions of limestone and fertilizers should be based on results of soil tests, on the needs of the crop, and on yield goals. The use and rate of application of herbicides are also affected by the content of organic matter, pH level, carbonates, and soil texture. The Cooperative Extension Service can help in determining the kinds and amounts of fertilizer, herbicides, and limestone to apply.

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

Most of the well drained and somewhat poorly drained soils used for intensive row crops have a loam surface layer. Most of these soils generally have good tilth, and good seedbeds are easily obtained. The loamy well drained Storden soils have a low content of organic matter and poor tilth. Intense rainfall readily runs off the surface of these soils, causing erosion. Regular additions of crop residue, manure, and other organic material can help to increase organic matter, improve tilth, and reduce runoff.

In areas of most of the poorly drained soils and the somewhat poorly drained Ottosen soils, which contain more clay in the surface layer, good seedbeds are more difficult to obtain. Fall plowing is common on these soils because freezing and thawing promotes good tilth, and good seedbeds are more easily obtained than if the soils are plowed in the spring. However, if large areas are fall plowed, soil blowing can be a problem in the spring as the soil surface dries. Leaving alternate protective strips or leaving residue on the surface or mixed in the surface layer helps to reduce soil blowing. Chisel plowing is an alternate method of tillage that is effective in reducing soil blowing.

Field crops suited to the soils and climate of the county include many that are not commonly grown. At present, the most commonly grown crops are corn and soybeans. Grain sorghum, sunflowers, sugar beets, sweet corn, popcorn, and canning peas are among the crops that can be grown if economic and other conditions are favorable. Oats is the most common close-growing crop, but rye, barley, wheat, and flax could be grown. A variety of forage crops could also be grown, and seed production from such crops is feasible.

Specialty crops are not commonly grown in the county, except for a few small apple orchards and some sweet corn and canning peas. Most of the well drained soils are suited to orchards and nursery plants, and most of the upland soils are suited to sweet corn, canning peas, and other specialty crops. Some of the soils that are high in organic matter are well suited to potatoes.

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, rangeland, woodland, wildlife habitat, or recreation.

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."

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 (fig. 13).

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 7 shows the height that locally grown trees and shrubs are expected to reach in 20 years on various soils. The estimates in table 7 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 8 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 8, 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 8 can be supplemented by other information in this survey, for example, interpretations for septic tank absorption fields in table 11 and interpretations for dwellings without basements and for local roads and streets in table 10.

Camp areas require site preparation such as shaping and leveling the tent and parking areas, stabilizing roads and intensively used areas, and installing sanitary

Figure 13.—Part of a good multipurpose windbreak around a farmstead on Nicollet and Clarion soils. In the foreground are three rows of deciduous trees. In the background are two rows of honeysuckle. Beyond the honeysuckle are two rows of conifers.

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

Kossuth County has a large and varied population of wildlife. White-tailed deer, squirrel, ringneck pheasant, Hungarian partridge, and various waterfowl are the main game in the county, although there are many other species of mammals and birds. Fishing is generally limited to a few man-made lakes and farm ponds and to the East Fork Des Moines River. Smallmouth bass, catfish, northern pike, bullhead, and sunfish are the main species.

In the past, waterfowl habitat in the county was

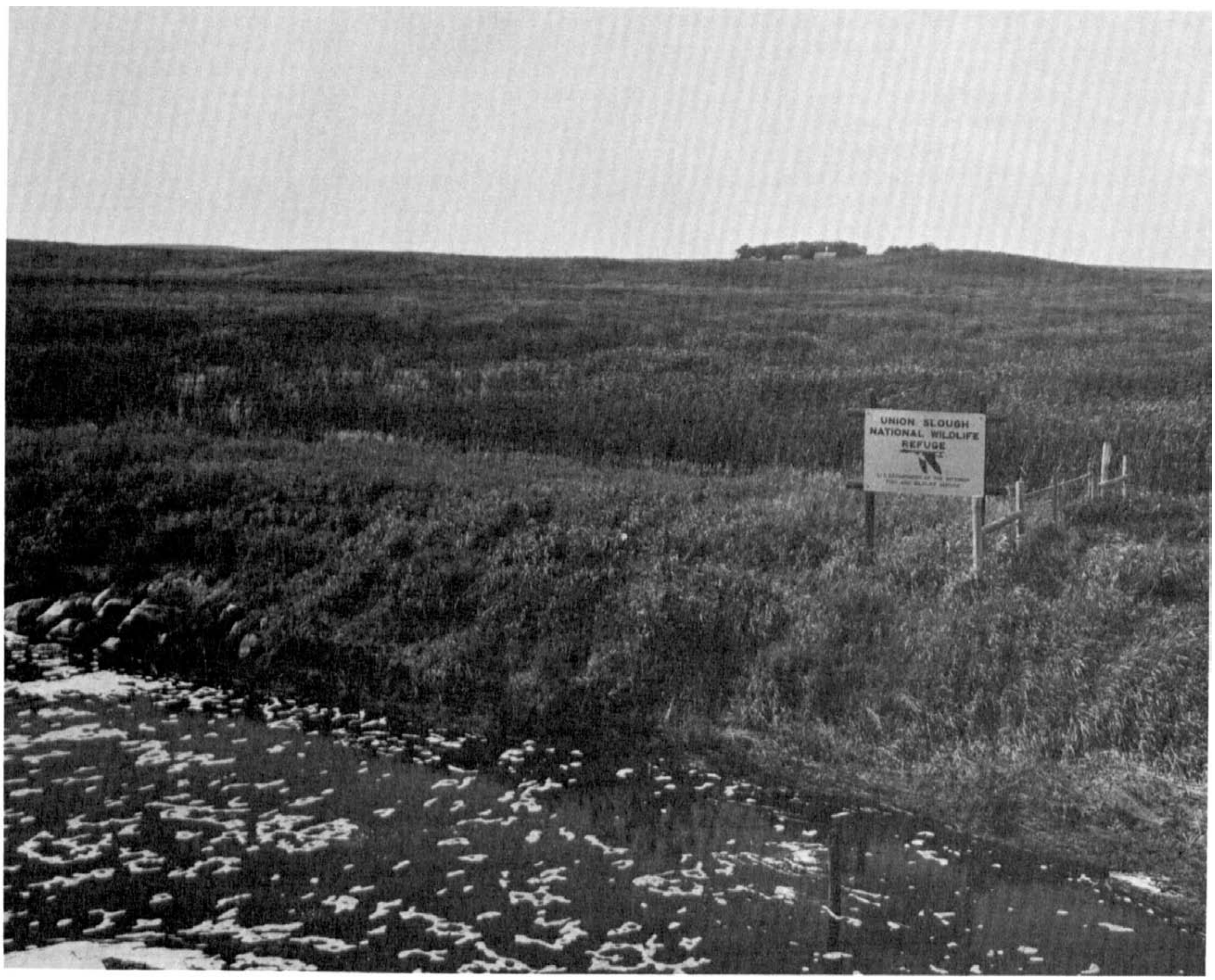


Figure 14.—Wildlife habitat at Union Slough National Wildlife Refuge.

excellent. Intensive farming and the draining of many small sloughs and potholes have reduced this habitat. However, many migratory ducks and geese continue to rest and feed each fall in the remaining wetlands, particularly in Union Slough (fig. 14), a National Wildlife Refuge, and in the adjacent areas developed for this purpose.

Most of the white-tailed deer and squirrel are in wooded areas adjacent to rivers, creeks, and Union Slough. Some deer are attracted to wooded areas surrounding lakes and other larger marshes in the county.

Whitetail jackrabbit, cottontail, red fox, mink, beaver, and muskrat find food and cover in various parts of the survey area. Among the common songbirds are robin, English sparrow, meadow larks, blackbirds, mourning dove, purple martin, wrens, bluebirds, chickadees, brown thrasher, swallows, orioles, woodpeckers, and starlings.

The introduced ringneck pheasant and Hungarian partridge have adapted well to this county. The numbers vary from year to year, depending on the amount of nesting cover. Lack of cover in winter and at nesting time and severe weather at nesting time greatly reduce the number of pheasant. The best pheasant range is on associations 4 and 5, which are shown on the general soil map and described under the heading "General soil map units." These associations contain wet and marshy areas that provide the needed winter cover, as well as nesting areas along the edges of fields.

Pheasant is somewhat less abundant on the remaining soil associations. Many of the soils are nearly level or gently sloping, and much of the acreage is farmed intensively. Consequently, little food and cover is available for pheasant in winter or in the nesting season.

Nesting cover is the most critical factor affecting the number of pheasant. The most successful nestings in intensively farmed areas are in road ditches and along fence lines, but these are few and produce only a limited number of pheasant. Studies by the Iowa Conservation Commission have shown that pheasant populations can be significantly increased if the plant cover in ditches and along fence lines is left unclipped until early in summer.

Winter cover can be provided through farmstead windbreaks and wildlife plantings. Winter cover should be near a source of food, such as a few rows of grain left in a field adjacent to a windbreak or other planting that is suitable for wildlife habitat.

Small, oddly shaped areas, unsuitable for farming, can provide excellent wildlife habitat. The strongly sloping to steep Salida, Storden, and Estherville soils, as well as marshes and depressional soils in associations 4 and 5, are most likely to have these odd areas. Good wildlife habitat in the other associations may be found in such areas as small steep, eroded, or gravelly areas of cropland; gravel pits; railroad rights-of-way; or tracts of land cut off from the rest of a field by a stream or drainage ditch.

The type of existing cover and location of the odd areas should be inspected to determine if any additional seeding or planting is needed. Developing many of these small areas for wildlife habitat requires only protection from fire and grazing. For others, planting and maintenance may be necessary. A satisfactory wildlife habitat consists of low-growing cover, such as locally adapted grasses and legumes, to provide nesting sites and some food; a taller cover of grasses and shrubs to supply refuge and resting areas; and clumps of evergreen trees and shrubs to provide the best winter cover.

Maintenance of the wildlife areas is most important. Areas should not be mowed before midsummer in order to protect the ground-nesting birds and rabbits. To maintain an adequate ground cover of grasses and legumes, it may be necessary to control invading woody plants by chemical or mechanical means. Reseeding is needed occasionally. Landowners who wish to plant and maintain wildlife areas that provide good nesting, adequate food, and weather protection may obtain assistance in planning from the Soil Conservation Service or the wildlife management biologist of the Iowa Conservation Commission.

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 9, 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 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 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 10 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 11 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 11 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, 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 11 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 11 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 12 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 12, 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 13 gives information on the soil properties and site features that affect water management. The degree and kind of soil limitations are given for pond reservoir areas and for embankments, dikes, and levees. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and are easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increase in construction costs, and possibly increased maintenance are required.

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

Pond reservoir areas hold water behind a dam or embankment. Soils best suited to this use have low seepage potential in the upper 60 inches. The seepage potential is determined by the permeability 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 a 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. These results are reported in table 17.

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 14 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. The AASHTO classification for soils tested, with group index numbers in parentheses, is given in table 17.

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 15 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 15, 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 16 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 16 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 16 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 16.

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.

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.

Engineering index test data

Table 17 shows laboratory test data for several pedons sampled at carefully selected sites in the survey area. The pedons are typical of the series and are described in the section "Soil series and their morphology." The soil samples were tested by the Iowa Department of Transportation Soils Laboratory.

The testing methods generally are those of the American Association of State Highway and Transportation Officials (AASHTO).

The tests and methods are: AASHTO classification—M 145 (AASHTO); Mechanical analysis—T 88 (AASHTO); Liquid limit—T 89 (AASHTO), D 423 (ASTM); Moisture density, Method A—T 99 (AASHTO), D 698 (ASTM).

Classification of the soils

The system of soil classification used by the National Cooperative Soil Survey has six categories (*18*). 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 Hapludolls (*Hapl*, meaning minimal horizonation, plus *udoll*, 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 Hapludolls.

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-loamy, mixed, mesic Typic Hapludolls.

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 (*17*). Many of the technical terms used in the descriptions are defined in Soil Taxonomy (*18*). 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."

Biscay series

The Biscay series consists of poorly drained, moderately permeable over rapidly permeable soils on stream benches. These soils formed in loamy material and in the underlying calcareous sandy sediments. They formed under a native vegetation of water-tolerant grasses. Slopes range from 0 to 2 percent.

Biscay soils are similar to Mayer and Talcot soils and are commonly adjacent to Cylinder, Lemond, Mayer, and Talcot soils. Mayer, Talcot, and Lemond soils are calcareous throughout the solum. These soils are on landscape positions similar to those of the Biscay soils. Cylinder soils have a browner B horizon and are better drained. They are on higher lying areas on the stream benches.

Typical pedon of Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes; 160 feet north and 980 feet west of the SE corner of sec. 9, T. 94 N., R. 30 W.

Ap—0 to 8 inches; black (N 2/0) clay loam, black (N 2/0) dry; weak fine granular structure; friable; neutral; abrupt smooth boundary.

A12—8 to 14 inches; black (N 2/0) clay loam, black (N 2/0) dry; weak fine and medium granular structure; friable; neutral; clear smooth boundary.

A13—14 to 19 inches; black (10YR 2/1) clay loam, black (10YR 2/1) dry; common medium distinct olive brown (2.5Y 4/4) mottles; weak fine subangular blocky structure parting to weak fine granular; friable; few dark grayish brown (2.5Y 4/2) wormcasts; neutral; gradual smooth boundary.

B1g—19 to 26 inches; olive gray (5Y 4/2) and dark grayish brown (2.5Y 4/2) clay loam; common medium distinct olive brown (2.5Y 4/4) and light olive brown (2.5Y 5/6) mottles; weak fine subangular blocky structure; friable; common dark concretions (manganese oxides); neutral; clear smooth boundary.

B21—26 to 34 inches; mottled dark grayish brown (2.5Y 4/2), light olive brown (2.5Y 5/6), yellowish brown (10YR 5/6), and strong brown (7.5YR 5/8) clay loam; weak medium prismatic structure parting to weak fine subangular blocky; friable; few fine tubular pores; few dark concretions (manganese oxides); neutral; gradual smooth boundary.

B22—34 to 39 inches; mottled yellowish brown (10YR 5/6) and brownish yellow (10YR 6/8) loam; some dark grayish brown (10YR 4/2) in the upper part; weak medium prismatic structure parting to weak fine subangular blocky; friable; few dark concretions (iron and manganese oxides); few pebbles; neutral; clear smooth boundary.

IIC1—39 to 49 inches; mottled olive gray (5Y 5/2), light olive brown (2.5Y 5/6), and dark grayish brown (2.5Y 4/2) loamy sand; single grained; loose; about 5 percent gravel; slight effervescence; moderately alkaline; clear smooth boundary.

IIC2g—49 to 60 inches; olive gray (5Y 5/2) loamy sand; few medium distinct light olive brown (2.5Y 5/6) mottles; single grained; loose; about 10 percent gravel; few calcium carbonate accumulations in soft rounded masses and in powdery streaks; slight effervescence; moderately alkaline.

The solum thickness, depth to carbonates, and depth to loamy sand or coarser texture range from 32 to 40 inches.

The A horizon ranges from 16 to 24 inches in thickness. It is loam or clay loam and has hue of 10YR or 2.5Y, value of 2 or 3, and chroma of 1; or it is neutral and has value of 2 or 3.

The B horizon has hue of 5Y or 2.5Y, value of 4 or 5, and chroma of 1 to 3. The B horizon typically is loam or clay loam throughout, but the lower part in some places is sandy loam with gravel. It typically is neutral in reaction; but in some pedons it is mildly alkaline, and in some pedons it contains free carbonates in the lower part.

The IIC horizon has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 to 6. It is loamy sand or sand and commonly contains 5 to 35 percent gravel. The IIC horizon typically is mildly or moderately alkaline, but in some pedons the upper few inches is neutral.

Blue Earth series

The Blue Earth series consists of very poorly drained, moderately permeable over moderately slowly permeable soils in depressions and old shallow lakebeds. These soils formed in coprogenous earth under a native vegetation of sedges, reeds, and other water-tolerant grasses. Slopes range from 0 to 1 percent.

Blue Earth soils are commonly adjacent to Canisteo and Harps soils. Canisteo and Harps soils contain more clay and are lower in organic matter content. Canisteo soils are on slightly higher lying areas above the Blue Earth soils. Harps soils are on rims of depressions surrounding the Blue Earth soils.

Typical pedon of Blue Earth mucky silt loam, 0 to 1 percent slopes; 1,400 feet west and 580 feet south of the NE corner of sec. 10, T. 100 N., R. 29 W.

LCop—0 to 9 inches; black (N 2/0) mucky silt loam, coprogenous earth, black (10YR 2/1) and very dark gray (10YR 3/1) dry; weak fine granular structure; very friable; common fine roots; common fine snail shell fragments; strong effervescence; mildly alkaline; abrupt smooth boundary.

LCo2—9 to 18 inches; very dark gray (10YR 3/1) and black (10YR 2/1) mucky silt loam, coprogenous earth, very dark gray (10YR 3/1) dry; few fine reddish brown (5YR 4/4) mottles; weak fine and very fine granular structure; very friable; common fine roots; common fine snail shell fragments; violent effervescence; moderately alkaline; gradual smooth boundary.

LCo3—18 to 24 inches; black (10YR 2/1) and very dark gray (10YR 3/1) mucky silt loam, coprogrenous earth, very dark gray (10YR 3/1) dry; few fine prominent reddish brown (5YR 4/3) mottles; weak very fine subangular blocky and weak fine granular structure; friable; common fine roots; many fine and medium snail shell fragments; violent effervescence; moderately alkaline; clear smooth boundary.

LCo4—24 to 38 inches; black (10YR 2/1) mucky silty clay loam, coprogrenous earth; few fine prominent dark brown (7.5YR 3/2) mottles; weak medium and coarse subangular blocky structure; friable; common fine roots; common fine and medium snail shell fragments; few fine dark concretions (iron oxides); violent effervescence; moderately alkaline; clear smooth boundary.

LCo5—38 to 48 inches; black (10YR 2/1) mucky silty clay loam, coprogenous earth, very dark gray (10YR 3/1) dry; few fine prominent dark brown (7.5YR 3/2) mottles; weak coarse subangular blocky structure; friable; few fine tubular pores; few fine snail shell fragments; few thin dark gray (10YR 4/1) lenses of fine sand; few dark reddish concretions (iron oxides); strong effervescence; mildly alkaline; abrupt wavy boundary.

IIC—48 to 60 inches; gray (5Y 5/1) clay loam; common medium and coarse distinct olive (5Y 5/3) mottles; massive; friable; few fine root pores; few fine pebbles; few dark reddish concretions (iron oxides); few fine calcium carbonate accumulations in soft rounded masses; violent effervescence; moderately alkaline.

The thickness of the coprogenous earth and the depth to loamy glacial till or glacial lacustrine sediments range from 30 to over 60 inches.

The LCo horizon ranges from black (N 2/0 or 10YR 2/1) to very dark brown (10YR 2/2) or very dark gray (10YR 3/1 or N 3/0) in color. The underlying material ranges from very dark grayish brown (2.5Y 3/2) to olive gray (5Y 5/2). This material is commonly clay loam, but in some pedons it is loam or silty clay loam.

Bode series

The Bode series consists of well drained, moderately permeable soils. These soils formed in glacial or lacustrine sediments and in the underlying glacial till under a native vegetation of grasses. Slopes range from 2 to 5 percent.

Bode soils are similar to Clarion soils and are commonly adjacent to Clarion, Nicollet, and Ottosen soils. Clarion soils contain less clay in the A horizon and the upper B horizon. Nicollet and Ottosen soils have a grayer upper B horizon and are not as well drained. Clarion soils are on landscape positions similar to those of the Bode soils. Nicollet and Ottosen soils are on lower lying areas.

Typical pedon of Bode clay loam, 2 to 5 percent slopes; 66 feet east and 2,184 feet south of the NW corner of sec. 27, T. 94 N., R. 30 W.

Ap—0 to 8 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) dry; weak fine and medium granular structure; friable; common fine roots; neutral; abrupt smooth boundary.

A12—8 to 12 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) dry; weak fine and medium granular structure; friable; few fine roots; neutral; clear smooth boundary.

A3—12 to 17 inches; very dark grayish brown (10YR 3/2) clay loam, very dark gray (10YR 3/1) dry; black (10YR 2/1) and very dark gray (10YR 3/1) coatings on faces of peds; weak fine subangular blocky structure parting to weak fine and medium granular; friable; few fine roots; few fine tubular pores; neutral; gradual smooth boundary.

B21—17 to 24 inches; dark brown (10YR 3/3) clay loam; very dark grayish brown (10YR 3/2) coatings on faces of peds; weak fine and medium subangular blocky structure; friable; few fine roots; few fine tubular pores; neutral; gradual smooth boundary.

B22—24 to 31 inches; dark yellowish brown (10YR 4/4) and brown (10YR 4/3) clay loam; dark brown (10YR 3/3) coatings on faces of peds; weak medium and fine subangular blocky structure; friable; few fine roots; few fine tubular pores; few shale fragments; neutral; gradual smooth boundary.

IIB3—31 to 39 inches; dark yellowish brown (10YR 4/4) and brown (10YR 4/3) loam; few dark brown (10YR 3/3) coatings on faces of peds; weak medium subangular blocky structure; friable; few fine roots; few fine tubular pores; few shale fragments; neutral; gradual smooth boundary.

IIC—39 to 60 inches; mottled yellowish brown (10YR 5/4), grayish brown (2.5Y 5/2), and light olive brown (2.5Y 6/4) loam; massive; friable; few fine roots; few fine tubular pores; few dark concretions (iron and manganese oxides); few fine calcium carbonate accumulations in soft rounded masses; slight effervescence; mildly alkaline.

The thickness of the solum ranges from 18 to 50 inches. The glacial or lacustrine sediments are 24 to 40 inches thick. The depth to free carbonates typically is the same as thickness of the solum. The 10- to 40-inch control section averages between 28 and 35 percent clay and from 25 to 45 percent sand.

The A1 or Ap horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. The A3 horizon has hue of 10YR, value of 2 or 3, and chroma of 2.

The B horizon has hue of 10YR or 2.5Y, value of 3 or 4, and chroma of 3 or 4. It typically is free of mottles to a depth of 30 inches or more. The A and B horizons are neutral or slightly acid.

The IIC horizon commonly has a mottled matrix that has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 2 through 8. It is mildly alkaline or moderately alkaline.

Calco series

The Calco series consists of poorly drained, moderately permeable soils on bottom lands. These soils formed in calcareous silty and loamy alluvium under a native vegetation of water-tolerant grasses. Slopes range from 0 to 2 percent.

Calco soils are similar to Coland and Colo soils and are commonly adjacent to Coland, Colo, and Zook soils. Coland, Colo, and Zook soils are not calcareous. Coland soils contain more sand than Calco soils. Zook soils have more clay in the solum. They are on landscape positions similar to those of the Calco soils.

Typical pedon of Calco silty clay loam, 0 to 2 percent slopes; 1,200 feet west and 1,720 feet north of the SE corner of sec. 6, T. 97 N., R. 27 W.

Ap—0 to 8 inches; black (N 2/0) silty clay loam, black (10YR 2/1) dry; weak fine granular structure; friable; common fine roots; slight effervescence; mildly alkaline; abrupt smooth boundary.

A12—8 to 17 inches; black (N 2/0) silty clay loam, black (10YR 2/1) dry; weak fine subangular blocky structure parting to weak fine granular; friable; few fine roots; few fine pores; few fine snail shell fragments; strong effervescence; moderately alkaline; gradual smooth boundary.

A13—17 to 32 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; weak fine subangular blocky structure parting to moderate very fine subangular blocky; firm; few fine roots; few fine pores; common fine snail shells; few fine strong brown (7.5YR 5/6) organic stains; strong effervescence; moderately alkaline; gradual smooth boundary.

A14g—32 to 50 inches; very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) dry; weak very fine subangular blocky structure; friable; few fine roots; few fine pores; few fine snail shell fragments; few fine strong brown (7.5YR 5/6) organic stains in old root channels; strong effervescence; mildly alkaline; gradual smooth boundary.

Cg—50 to 60 inches; olive gray (5Y 4/2) clay loam; few fine prominent yellowish brown (10YR 5/8) mottles; massive; friable; few fine roots; few fine tubular pores; few fine snail shell fragments; few fine light gray (10YR 7/1) calcium carbonate accumulations in thread-like streaks; violent effervescence; moderately alkaline.

The solum is 40 to 50 inches thick.

The A horizon ranges from about 30 to 50 inches in thickness. It is black (N 2/0 or 10YR 2/1) in the upper part and black (10YR 2/1) or very dark gray (10YR 3/1) in the lower part.

Some pedons have a Bg horizon that ranges from very dark gray (10YR 3/1) to gray (5Y 5/1) and has few to many mottles. It is silty clay loam or clay loam and is 0 to 10 inches thick.

The Cg horizon is mottled silty clay loam or clay loam. The Cg horizon commonly has hue of 5Y, value of 3, 4, or 5, and chroma of 0, 1, or 2.

Canisteo series

The Canisteo series consists of poorly drained, moderately permeable soils in upland swales. These soils formed in calcareous glacial till sediments or glacial till under a native vegetation of water-tolerant grasses. Slopes range from 0 to 2 percent.

Canisteo soils are similar to Webster soils and are commonly adjacent to Blue Earth, Crippin, Harps, Nicollet, Okoboji, and Webster soils. Unlike Canisteo soils, Webster soils are not calcareous in the solum. Blue Earth soils formed in coprogenous earth. Crippin soils are not as poorly drained. Harps soils are higher in calcium carbonates. Nicollet soils have a browner upper B horizon and are not calcareous. Okoboji soils have a thicker A horizon and are not calcareous. Blue Earth and Okoboji soils are in depressions below Canisteo soils. Harps soils are on rims of depressions. Crippin and Nicollet soils are on higher lying areas. Webster soils are on similar landscape positions.

Typical pedon of Canisteo clay loam, 0 to 2 percent slopes; 200 feet east and 2,440 feet south of the NW corner of sec. 11, T. 97 N., R. 27 W.

Ap—0 to 8 inches; black (N 2/0) clay loam, black (10YR 2/1) dry; weak fine granular structure; friable; few fine roots; few fine snail shell fragments; strong effervescence; moderately alkaline; abrupt smooth boundary.

A12—8 to 15 inches; black (10YR 2/1) clay loam, black (10YR 2/1) dry; weak fine and very fine granular structure; friable; few fine roots; few fine pores; violent effervescence; moderately alkaline; gradual smooth boundary.

A3—15 to 23 inches; very dark gray (5YR 3/1) clay loam, dark gray (10YR 4/1) dry; few fine faint olive gray (5Y 5/2) mottles; weak fine subangular blocky structure parting to weak fine granular; friable; few fine roots; few fine pores; violent effervescence; moderately alkaline; abrupt smooth boundary.

B2g—23 to 30 inches; olive gray (5Y 5/2) clay loam; few fine distinct yellowish brown (10YR 5/8) and few fine prominent strong brown (7.5YR 5/8) mottles; weak fine subangular blocky structure; friable; few fine roots; few fine pores; black (10YR 2/1) and very dark gray (10YR 3/1) krotovinas; common concretions (manganese oxides); few fine calcium carbonate accumulations in soft rounded masses; violent effervescence; moderately alkaline; gradual smooth boundary.

B3gca—30 to 39 inches; olive gray (5Y 5/2) clay loam; common fine prominent strong brown (7.5YR 5/8) mottles; weak medium subangular blocky structure; friable; few fine pores; black (10YR 2/1) and very dark gray (10YR 3/1) krotovinas; common dark concretions (manganese oxides); common fine calcium accumulations in soft rounded masses; violent effervescence; moderately alkaline; abrupt wavy boundary.

Cg—39 to 60 inches; mottled olive gray (5Y 5/2), light olive gray (5Y 6/2), strong brown (7.5YR 5/8), and brownish yellow (10YR 6/8) clay loam; massive; friable; few fine shale fragments; few fine calcium carbonate accumulations in soft rounded masses; common few dark concretions (manganese oxides); violent effervescence; moderately alkaline.

The thickness of the solum ranges from 20 to 40 inches. Reaction is mildly or moderately alkaline in all horizons.

The A1 horizon is black (N 2/0 or 10YR 2/1), and the A3 horizon is very dark gray (N 3/0 or 10YR or 5Y 3/1). The A horizon typically is clay loam but ranges to silty clay loam. The A horizon ranges from about 14 to 24 inches in thickness.

The B horizon typically has hue of 5Y but ranges in hue to 2.5Y. It has value of 4 or 5 and chroma of 1 or 2. Texture of the B horizon typically is clay loam but ranges to silty clay loam.

The C horizon has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 2 through 4. Texture typically is loam or clay loam.

Clarion series

The Clarion series consists of well drained, moderately permeable soils on convex upland knolls, ridges, and side slopes. These soils formed in glacial till under a native vegetation of grasses. Slopes range from 2 to 14 percent.

Clarion soils are similar to Bode soils and are commonly adjacent to Bode, Estherville, Nicollet, Storden, and Webster soils. Bode soils have a higher clay content in the A and upper B horizons. Estherville soils are higher in sand content. Nicollet and Webster soils have a grayer B horizon and are not as well drained. Storden soils are calcareous and do not have a B horizon. Bode, Estherville, and Storden soils are on landscape positions similar to those of the Clarion soils. Nicollet and Webster soils are on lower lying areas.

Typical pedon of Clarion loam, 2 to 5 percent slopes; 1,200 feet north and 219 feet east of the SW corner of sec. 22, T. 97 N., R. 29 W.

Ap—0 to 8 inches; black (10YR 2/1) loam, black (10YR 2/1) and very dark gray (10YR 3/1) dry; weak fine granular structure; friable; common fine roots; neutral; abrupt smooth boundary.

A12—8 to 16 inches; black (10YR 2/1) and very dark brown (10YR 2/2) loam, very dark gray (10YR 3/1) and very dark grayish brown (10YR 3/2) dry; weak fine subangular blocky structure parting to weak fine and very fine granular; friable; few fine roots; neutral; gradual smooth boundary.

B1—16 to 23 inches; dark brown (10YR 3/3) loam, very dark grayish brown (10YR 3/2) coatings on faces of peds; weak fine and very fine subangular blocky structure parting to weak fine and very fine granular; friable; mixing of very dark gray (10YR 3/1) and black (10YR 2/1) by worms; few fine roots; neutral; gradual smooth boundary.

B2—23 to 30 inches; dark yellowish brown (10YR 4/4) loam, dark brown (10YR 3/3) and brown (10YR 4/3) coatings on faces of peds; weak fine and medium subangular blocky structure parting to weak fine subangular blocky; friable; few fine roots; few dark concretions (manganese oxides); few pebbles; neutral; gradual smooth boundary.

B3—30 to 34 inches; yellowish brown (10YR 5/4) loam; few faint fine light yellowish brown (10YR 6/4) mottles; weak medium prismatic structure parting to weak fine and medium subangular blocky; friable; few dark concretions (iron and manganese oxides); few fine calcium carbonate accumulations, 5 mm in diameter, in soft rounded masses; strong effervescence; mildly alkaline; gradual smooth boundary.

C1—34 to 44 inches; light olive brown (2.5Y 5/4) loam; massive; friable; few dark concretions (iron and manganese oxides); few fine calcium carbonate accumulations in soft rounded masses; violent effervescence; moderately alkaline; gradual smooth boundary.

C2—44 to 54 inches; light olive brown (2.5Y 5/4) and dark yellowish brown (10YR 4/4) loam; few fine distinct strong brown (7.5YR 5/8) mottles; massive; friable; few dark concretions (iron and manganese oxides); few fine and medium calcium carbonate accumulations in soft rounded masses; violent effervescence; moderately alkaline; gradual smooth boundary.

C3—54 to 60 inches; light olive brown (2.5Y 5/4) loam; common fine distinct strong brown (7.5YR 5/8) and common fine faint olive (5Y 5/3) mottles; massive; friable; few dark concretions (iron and manganese oxides); common fine calcium carbonate accumulations in soft rounded masses; violent effervescence; moderately alkaline.

The solum thickness ranges from 18 to 50 inches. The depth to carbonates generally is between 18 and 40 inches, but it ranges to about 50 inches.

The A horizon is black (10YR 2/1), very dark brown (10YR 2/2), or very dark grayish brown (10YR 3/2) and ranges from 7 to 18 inches in thickness. The A horizon typically is loam in texture, but in some pedons the A horizon is sandy loam.

The B horizon ranges from dark brown (10YR 3/3) and brown (10YR 4/3) to yellowish brown (10YR 5/4 and 10YR 5/6). Texture in the B horizon is loam or clay loam.

The C horizon has hue of 2.5Y or 10YR, value of 4 or 5, and chroma of 4 to 6.

Coland series

The Coland series consists of poorly drained, moderately permeable soils on bottom lands. These soils formed in loamy alluvium under a native vegetation of water-tolerant grasses. Slopes range from 0 to 2 percent.

Coland soils are similar to Calco and Colo soils and are commonly adjacent to Calco, Spillville, and Zook soils. Calco soils are calcareous. Colo soils are lower in content of sand and Spillville soils are higher. Zook soils have a higher clay content in the solum and a lower sand content. These soils are on landscape positions similar to those of the Coland soils.

Typical pedon of Coland clay loam, 0 to 2 percent slopes; 1,020 feet north and 212 feet west of the SE corner of sec. 31, T. 94 N., R. 29 W.

Ap—0 to 8 inches; black (10YR 2/1) clay loam, black (10YR 2/1) and very dark gray (10YR 3/1) dry; black (N 2/0) coatings on faces of peds; moderate fine granular structure; friable; few fine roots; few fine pores; neutral; clear smooth boundary.

A12—8 to 16 inches; black (10YR 2/1) clay loam, black (10YR 2/1) and very dark gray (10YR 3/1) dry; black (N 2/0) coatings on faces of peds; weak fine granular structure; friable; few fine roots; few fine pores; neutral; gradual smooth boundary.

A13—16 to 29 inches; black (10YR 2/1) clay loam, black (10YR 2/1) and very dark gray (10YR 3/1) dry; black (N 2/0) coatings on some peds; weak fine granular structure; friable; few fine roots; neutral; gradual smooth boundary.

A14—29 to 48 inches; black (10YR 2/1) and very dark gray (10YR 3/1) clay loam, very dark gray (10YR 3/1) and dark gray (10YR 4/1) dry; few fine faint very dark grayish brown (2.5Y 3/2) mottles; weak fine and medium subangular blocky structure parting to weak fine and medium granular; friable; neutral; diffuse smooth boundary.

Cg—48 to 60 inches; very dark gray (5Y 3/1) clay loam; common fine faint dark grayish brown (2.5Y 4/2) mottles; massive; friable; neutral.

The solum thickness ranges from 36 to 48 inches. Free carbonates are commonly absent to a depth of 60 inches, but are present in the substratum of some pedons.

The A horizon is black (N 2/0 or 10YR 2/1) in the upper part and very dark gray (N 3/0 or 10YR 3/1) in the lower part. It is 36 to 50 inches thick and has texture of silty clay loam or clay loam.

The Cg horizon has hue of 5Y or 2.5Y, value of 2 through 5, and chroma of 1 or less.

Colo series

The Colo series consists of poorly drained, moderately permeable soils on bottom land and upland drainageways. These soils formed in silty alluvium under a native vegetation of water-tolerant grasses. Slopes range from 0 to 5 percent.

Colo soils are similar to Calco, Coland, and Zook soils and are commonly adjacent to Calco, Spillville, and Zook soils. Calco soils are calcareous. Coland soils are higher in sand content. Zook soils are higher in clay content. These soils are on landscape positions similar to those of the Colo soils.

Typical pedon of Colo silty clay loam, 0 to 2 percent slopes; 1,140 feet west and 279 feet north of the SE corner of sec. 24, T. 96 N., R. 29 W.

Ap—0 to 5 inches; black (N 2/0) silty clay loam, black (10YR 2/1) dry; weak fine granular structure; friable; few dark concretions (manganese oxides); neutral; clear smooth boundary.

A12—5 to 15 inches; black (10YR 2/1) silty clay loam, black (10YR 2/1) and very dark gray (10YR 3/1) dry; black (N 2/0) coatings on faces of peds; moderate fine granular and weak very fine subangular blocky structure; firm; few dark concretions (manganese oxides); neutral; gradual smooth boundary.

A13—15 to 28 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; black (N 2/0) coatings on faces of peds; weak fine subangular blocky structure parting to weak fine granular; firm; neutral; gradual smooth boundary.

A14—28 to 36 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; black (N 2/0) coatings on faces of peds; few fine faint very dark gray (10YR 3/1) and few fine distinct very dark grayish brown (2.5Y 3/2) mottles; weak fine subangular blocky structure; firm; few fine tubular pores; few dark concretions (iron and manganese oxides); neutral; gradual smooth boundary.

A15—36 to 50 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; black (N 2/0) coatings on faces of peds; weak fine subangular blocky structure; firm; common fine tubular pores; neutral; diffuse smooth boundary.

Cg—50 to 60 inches; very dark gray (10YR 3/1) clay loam; massive; firm; neutral.

The thickness of the solum ranges from 36 to 54 inches. The mollic epipedon is 36 or more inches in thickness.

The A horizon is black (N 2/0 or 10YR 2/1) or very dark gray (10YR 3/1). Clay content ranges from 27 to 35 percent.

The Cg horizon ranges from very dark gray (10YR 3/1) to gray (5Y 5/1). It is clay loam or silty clay loam.

Corwith series

The Corwith series consists of somewhat poorly drained, moderately permeable soils that are on glacial lake plains and outwash areas on uplands. These soils formed in loamy and silty sediments under a native vegetation of grasses. Slopes range from 1 to 3 percent.

Corwith soils are similar to Crippin and Kingston soils and are commonly adjacent to Crippin, Fostoria, and Spicer soils. Crippin and Fostoria soils are higher in content of sand. Kingston and Spicer soils are higher in content of silt and lower in sand. Kingston and Fostoria soils are not calcareous. Crippin and Fostoria soils are on landscape positions similar to those of the Corwith soils. Spicer soils are in lower lying areas.

Typical pedon of Corwith loam, 1 to 3 percent slopes; 2,440 feet north and 315 feet east of the SW corner of sec. 35, T. 95 N., R. 30 W.

Ap—0 to 9 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak fine granular structure; friable; few fine roots; slight effervescence; moderately alkaline; abrupt smooth boundary.

A12—9 to 14 inches; very dark grayish brown (10YR 3/2) loam, dark gray (10YR 4/1) dry; very dark gray (10YR 3/1) coatings on faces of peds; weak fine subangular blocky structure parting to weak fine granular; friable; few fine roots; strong effervescence; moderately alkaline; gradual smooth boundary.

B1—14 to 18 inches; very dark grayish brown (10YR 3/2) and dark grayish brown (10YR 4/2) silt loam; very dark gray (10YR 3/1) coatings on faces of peds; weak fine subangular blocky structure parting to weak fine granular; friable; few fine roots; strong effervescence; moderately alkaline; gradual smooth boundary.

B2—18 to 24 inches; mottled yellowish brown (10YR 5/4) and dark grayish brown (10YR 4/2) silt loam; weak medium subangular blocky structure parting to weak fine subangular blocky; friable; strong effervescence; moderately alkaline; gradual smooth boundary.

B3—24 to 31 inches; mottled yellowish brown (10YR 5/4) and dark grayish brown (10YR 4/2) silt loam; common fine distinct pale brown (10YR 6/3) mottles; weak medium subangular blocky structure; friable; few fine tubular pores; few dark concretions (iron oxides); strong effervescence; moderately alkaline; gradual wavy boundary.

C—31 to 60 inches; mottled light brownish gray (2.5Y 6/2), pale brown (10YR 6/3), light yellowish brown (2.5Y 6/4), brown (7.5YR 4/4), and strong brown (7.5YR 5/6) silt loam; massive; friable; few fine tubular pores; few dark reddish brown concretions (iron oxides); few fine light gray (10YR 7/2) calcium carbonate accumulations in thread-like streaks; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 24 to 40 inches. Reaction in the solum is mildly or moderately alkaline.

The A horizon is black (N 2/0 or 10YR 2/1), very dark brown (10YR 2/2), very dark gray (10YR 3/1), or very dark grayish brown (10YR 3/2). It typically is 10 to 14 inches thick but ranges from 10 to 18 inches in thickness.

The B1 horizon typically has hue of 10YR or 2.5Y, value of 3 or 5, and chroma of 2 but ranges to value of 2 or 3 with chroma of 1. The B2 horizon typically has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 2 to 4. The B3 horizon has hue of 10YR to 5Y, value of 4 or 5, and chroma of 2 to 6. Faint to distinct mottles are few or common in parts or all of the B horizon of some pedons. The B horizon typically is loam or silt loam.

The C horizon typically is silt loam or very fine sandy loam but ranges to include loamy fine sand. The C horizon has hue of 10YR to 5Y, value of 4 to 6, and chroma of 2 to 8.

Crippin series

The Crippin series consists of somewhat poorly drained, moderately permeable soils on slightly convex slopes on uplands. These soils formed in glacial till under a native vegetation of grasses. Slopes range from 1 to 3 percent.

Crippin soils are similar to Corwith, Fostoria, and Nicollet soils and are commonly adjacent to Canisteo and Corwith soils. Corwith and Fostoria soils are higher in sand content. Fostoria and Nicollet soils are not calcareous. Canisteo soils have a grayer B horizon and are poorly drained. Corwith soils are on landscape positions similar to those of the Crippin soils. Canisteo soils are on lower lying areas.

Typical pedon of Crippin loam, 1 to 3 percent slopes; 1,480 feet east and 13 feet south of the NW corner of sec. 36, T. 97 N., R. 30 W.

Ap—0 to 9 inches; black (10YR 2/1) loam, black (10YR 2/1) dry; weak fine granular structure; friable; few small pebbles; common fine accumulations of calcium carbonate in soft rounded masses; slight effervescence; moderately alkaline; abrupt smooth boundary.

A12—9 to 15 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak fine subangular blocky structure parting to weak fine granular; friable; few fine roots; few fine tubular pores; few fine calcium carbonate accumulations in soft rounded masses; strong effervescence; moderately alkaline; clear smooth boundary.

B1—15 to 21 inches; dark grayish brown (2.5Y 4/2) loam; very dark grayish brown (10YR 3/2) and black (10YR 2/1) coatings on faces of peds; weak fine subangular blocky structure; friable; few fine roots; few fine tubular pores; few fine calcium carbonate accumulations in soft rounded masses; few dark concretions (iron oxides); strong effervescence; moderately alkaline; gradual smooth boundary.

B21—21 to 26 inches; mottled olive brown (2.5Y 4/4), light olive brown (2.5Y 5/4), and light brownish gray (2.5Y 6/2) loam; weak medium subangular blocky structure parting to weak fine subangular blocky; friable; few fine roots; few tubular pores; few fine calcium carbonate accumulations in soft rounded massses; few dark concretions (iron and manganese oxides); strong effervescence; moderately alkaline; clear smooth boundary.

B22—26 to 30 inches; mottled light olive brown (2.5Y 5/4), grayish brown (2.5Y 5/2), and yellowish brown (10YR 5/6) loam; weak fine prismatic structure parting to weak fine subangular blocky; friable; few fine roots; few tubular pores; few fine calcium carbonate accumulations in soft rounded masses; few dark concretions (iron and manganese oxides); strong effervescence; moderately alkaline; gradual smooth boundary.

B3—30 to 34 inches; light olive brown (2.5Y 5/4) loam; common fine distinct light brownish gray (2.5Y 6/2) mottles; weak fine subangular blocky structure; friable; few fine tubular pores; few fine calcium carbonate accumulations in soft rounded masses and in thread-like streaks; few dark reddish brown concretions (iron oxides); strong effervescence; moderately alkaline; gradual smooth boundary.

C1ca—34 to 40 inches; mottled light olive brown (2.5Y 5/4), olive gray (5Y 5/2), and yellowish brown (10YR 5/6) loam; massive; friable; few fine tubular pores; few dark reddish brown concretions (iron oxides); common fine and medium calcium carbonate accumulations in soft rounded masses and in thread-like streaks; violent effervescence; moderately alkaline; gradual wavy boundary.

C2ca—40 to 60 inches; mottled light olive brown (2.5Y 5/4), olive gray (5Y 5/2), and yellowish brown (10YR 5/6) loam; massive; friable; few fine tubular pores; common dark reddish brown concretions (iron oxides); many fine and medium calcium carbonate accumulations in soft rounded masses and in thread-like streaks; violent effervescence; moderately alkaline.

The solum thickness typically is 30 to 36 inches, but it ranges from 20 to 48 inches.

The Ap or A1 horizon typically is black (N 2/0 or 10YR 2/1) but ranges to very dark gray (10YR 3/1). Some pedons contain an A3 horizon that ranges from black (10YR 2/1 or N 2/0) to very dark grayish brown (10YR 3/2). The total thickness of the A horizon is 10 to 20 inches.

The B horizon is loam or clay loam. Colors in the upper part of the B horizon are dark grayish brown (10YR or 2.5Y 4/2) or very dark grayish brown (10YR 3/2). The lower part of the B horizon is grayish brown (2.5Y 5/2) or light olive brown (2.5Y 5/4).

The C horizon has hue of 10YR to 5Y, value of 4 or 5, and chroma of 2 to 4.

Cylinder series

The Cylinder series consists of somewhat poorly drained, moderately permeable over rapidly permeable soils on upland outwash areas and on stream benches. These soils formed in loamy alluvium and the underlying sand and gravel. They formed under a native vegetation of grasses. Slopes range from 0 to 2 percent.

Cylinder soils are similar to Linder soils and are commonly adjacent to Biscay, Hanska, and Wadena soils. Linder soils have less clay in the solum. Biscay and Hanska soils are grayer in the upper part of the B horizon and are more poorly drained. They are on lower lying areas on the landscape. Wadena soils have a browner B horizon and are better drained. They are on higher lying areas on the landscape.

Typical pedon of Cylinder loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes; 211 feet south and 200 feet east of the NW corner of sec. 26, T. 95 N., R. 27 W.

Ap—0 to 9 inches; black (N 2/0) loam, black (10YR 2/1) dry; weak fine granular structure; friable; few fine roots; neutral; abrupt smooth boundary.

A12—9 to 17 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak medium and fine granular structure; friable; few fine roots; few fine pores; neutral; clear smooth boundary.

AB—17 to 23 inches; mixed very dark grayish brown (10YR 3/2) and dark grayish brown (2.5Y 4/2) loam; some very dark gray (10YR 3/1) coatings on faces of peds; weak fine and medium granular structure in the upper part that grades to weak fine subangular blocky in the lower part; friable; few fine roots; few fine pores; neutral; clear smooth boundary.

B2—23 to 30 inches; dark grayish brown (2.5Y 4/2) loam; common fine faint olive brown (2.5Y 4/4) and few medium distinct yellowish brown (10YR 5/6) mottles; weak fine subangular blocky structure; friable; few fine tubular pores; common dark concretions (manganese oxides); neutral; gradual smooth boundary.

B3—30 to 37 inches; mottled dark grayish brown (2.5Y 4/2), light olive brown (2.5Y 5/4), yellowish brown (10YR 5/6), and few fine faint olive (5Y 5/3) mottles; weak fine subangular blocky structure; friable; common gravel up to 1 inch in diameter; slight effervescence in spots; neutral; abrupt wavy boundary.

IIC1—37 to 42 inches; olive gray (5Y 5/2) sand and gravel; single grained; loose; strong effervescence; mildly alkaline; abrupt wavy boundary.

IIC2—42 to 60 inches; dark yellowish brown (10YR 4/4) and very dark grayish brown (2.5Y 3/2) sand and gravel; single grained; loose; strong effervescence; mildly alkaline.

The solum thickness and the depth to carbonates range from 32 to 40 inches.

The A horizon ranges from about 10 to 24 inches in thickness. It is commonly black (N 2/0 or 10YR 2/1) or very dark brown (10YR 2/2) in the upper part and very dark grayish brown (10YR or 2/5Y 3/2) or very dark gray (10YR 3/1) in the lower part. It typically is loam, but clay loam is within the range.

The B horizon ranges from dark grayish brown (2.5Y 4/2) or grayish brown (2.5Y 5/2) and brown (10YR 4/3) to light olive brown (2/5Y 5/4). Mottles typically are few or common in the B horizon and have hue of 10YR or 2.5Y and value and chroma of 4 through 6.

Darfur series

The Darfur series consists of poorly drained, moderately permeable over moderately rapidly permeable soils on upland outwash areas and lake plains. These soils formed in glacial sediments under a native vegetation of water-tolerant grasses. Slopes range from 0 to 2 percent.

Darfur soils are similar to Fieldon and Hanska soils and are commonly adjacent to Dickman, Fostoria, and Webster soils. Fieldon soils have free carbonates in the solum. Hanska soils have more coarse material in the lower part of the B horizon and in the C horizon. Dickman soils are more sandy throughout and are better drained. Fostoria soils are not as coarse textured in the C horizon and also are better drained. Dickman and Fostoria soils are on higher lying areas. Webster soils have more clay and less sand in the lower part of the B horizon and in the C horizon. They are on landscape positions similar to those of the Darfur soils.

Typical pedon of Darfur loam, 0 to 2 percent slopes; 80 feet north and 2,340 feet west of the SE corner of sec. 8, T. 94 N., R. 27 W.

Ap—0 to 8 inches; black (10YR 2/1) loam, black (10YR 2/1) dry; weak fine granular structure; friable; common fine roots; few fine pores; slightly acid; abrupt smooth boundary.

A12—8 to 16 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak fine and very fine granular structure; friable; few fine roots; few fine pores; neutral; gradual smooth boundary.

A13—16 to 22 inches; very dark gray (10YR 3/1) loam, very dark gray (10YR 3/1) and dark gray (10YR 4/1) dry; weak fine and very fine granular structure; friable; few fine roots; few fine pores; neutral; clear wavy boundary.

B21g—22 to 26 inches; dark grayish brown (2.5Y 4/1) fine sandy loam; dark gray (5Y 4/1) coatings on faces of peds; few fine faint light olive brown (2.5Y 5/4) and few fine distinct yellowish brown (10YR 5/6) mottles; weak fine subangular blocky structure; very friable; few fine roots; few dark concretions (iron oxides); neutral; gradual smooth boundary.

B22g—26 to 32 inches; dark grayish brown (2.5Y 4/2) fine sandy loam; common fine distinct yellowish brown (10YR 5/6) mottles; weak fine and medium subangular blocky structure; very friable; few fine roots; few dark concretions (iron and manganese oxides); neutral; gradual smooth boundary.

B23g—32 to 40 inches; olive gray (5Y 5/2) fine sandy loam; weak medium and fine subangular blocky structure; very friable; few black concretions (manganese oxides); neutral; gradual smooth boundary.

C1g—40 to 49 inches; olive gray (5Y 5/2) loamy fine sand; common fine faint olive (5Y 5/3) and few fine distinct yellowish brown (10YR 5/4) mottles; weak medium and coarse subangular blocky structure; very friable; few dark concretions (manganese oxides); mildly alkaline; clear wavy boundary.

C2g—49 to 60 inches; olive gray (5Y 5/2) loamy fine sand; common fine distinct olive (5Y 5/3) mottles; single grained; loose; mildly alkaline.

The solum thickness ranges from 20 to 50 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is 14 to 24 inches thick. Texture ranges from loam to fine sandy loam, and reaction is neutral or slightly acid.

The B horizon ranges from loam or fine sandy loam in the upper part to fine sandy loam or loamy fine sand in the lower part. It has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 or 2. Reaction is neutral or mildly alkaline.

The C horizon has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 1 or 2. Texture ranges from loamy fine sand to fine sandy loam. Reaction in the C horizon ranges from neutral to moderately alkaline.

Dickman series

The Dickman series consists of well drained, moderately rapidly permeable over rapidly permeable soils on uplands and stream benches. These soils formed in loamy and sandy glacial outwash material on convex slopes. They formed under a native vegetation of grasses. Slopes range from 0 to 9 percent.

Dickman soils are similar to Estherville soils and are commonly adjacent to Darfur, Estherville, Salida, and Storden soils. Estherville soils have gravel in the C horizon. Darfur soils have a grayer B horizon and are poorly drained. Salida soils have coarser-textured material throughout and contain free carbonates. Storden soils contain free carbonates and have more clay and less sand. Darfur soils are in low-lying areas below Dickman soils. Estherville, Salida, and Storden soils are on landscape positions similar to those of the Dickman soils.

Typical pedon of Dickman fine sandy loam, 2 to 5 percent slopes; 1,520 feet north and 1,290 feet east of the SW corner of sec. 1, T. 94 N., R. 29 W.

Ap—0 to 6 inches; very dark grayish brown (10YR 3/2) fine sandy loam, very dark grayish brown (10YR 3/2) and dark grayish brown (10YR 4/2) dry; very dark brown (10YR 2/2) coatings on faces of peds; weak fine granular structure; friable; few fine roots; neutral; abrupt smooth boundary.

A12—6 to 11 inches; very dark grayish brown (10YR 3/2) fine sandy loam, very dark grayish brown (10YR 3/2) and dark grayish brown (10YR 4/2) dry; very dark brown (10YR 2/2) coatings on faces of peds; weak fine granular structure; few fine roots; friable; neutral; clear smooth boundary.

B2—11 to 17 inches; brown (10YR 4/3) sandy loam; dark brown (10YR 3/3) coatings on faces of peds; weak fine subangular blocky structure parting to weak fine granular; friable; few fine roots; slightly acid; gradual smooth boundary.

B31—17 to 28 inches; brown (10YR 4/3) loamy fine sand; weak coarse subangular blocky structure; very friable; slightly acid; gradual wavy boundary.

B32—28 to 40 inches; brown (10YR 4/3) and dark yellowish brown (10YR 4/4) loamy fine sand; weak coarse subangular blocky structure parting to single grained; loose; slightly acid; gradual wavy boundary.

C—40 to 60 inches; brown (10YR 4/3) and dark yellowish brown (10YR 4/4) fine and medium sand; single grained; loose; slightly acid.

The thickness of the solum ranges from 30 to 50 inches. The depth to free carbonates is 48 inches or more.

The A horizon is 10 to 20 inches thick. It ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2). Texture is commonly sandy loam or fine sandy loam.

In the B2 horizon color ranges from dark brown (10YR 3/3) to yellowish brown (10YR 5/4). Texture in the B horizon ranges from sandy loam and fine sandy loam in the upper part to loamy fine and medium sand in the lower part.

The C horizon has hue of 7.5YR, 10YR, or 2.5Y, value of 4 to 6, and chroma of 3 or 4. Texture ranges from fine to coarse sand.

Estherville series

The Estherville series consists of somewhat excessively drained, moderately rapidly permeable over rapidly permeable soils on convex knolls on uplands, outwash areas, and stream benches. These soils formed in loamy and sandy glacial outwash under a native vegetation of grasses. Slopes range from 0 to 14 percent.

Estherville soils are similar to Dickman and Salida soils and are commonly adjacent to Clarion, Dickman, Salida, Ridgeport, and Wadena soils. Dickman soils do not have gravel in the solum. Salida soils are shallower to sand and gravel. Clarion soils contain more clay and less sand throughout. Ridgeport soils are deeper to sand and gravel. Wadena soils have more clay in the A horizon and in the upper part of the B horizon and are deeper to sand and gravel. These soils are on landscape positions similar to those of the Estherville soils.

Typical pedon of Estherville sandy loam, 2 to 5 percent slopes; 2,376 feet south and 300 feet east of the NW corner of sec. 17, T. 95 N., R. 30 W.

Ap—0 to 7 inches; black (10YR 2/1) sandy loam, very dark gray (10YR 3/1) dry; weak fine and medium granular structure; friable; common fine roots; few tubular pores; about 2 percent fine gravel; neutral; abrupt smooth boundary.

A12—7 to 12 inches; black (10YR 2/1) and very dark brown (10YR 2/2) sandy loam, very dark gray (10YR 3/1) and very dark grayish brown (10YR 3/2) dry; weak medium and coarse subangular blocky structure parting to weak medium granular; friable; common fine roots; about 2 percent fine gravel; neutral; abrupt smooth boundary.

B2—12 to 16 inches; dark yellowish brown (10YR 4/4) sandy loam; weak coarse subangular blocky structure parting to weak fine subangular blocky; friable; few fine roots; few fine tubular pores; about 5 percent fine gravel; neutral; clear smooth boundary.

B3—16 to 20 inches; dark brown (7.5YR 3/2 and 4/4) gravelly sandy loam; weak medium and coarse subangular blocky structure; very friable; few fine roots; few dark concretions (iron oxides); about 10 percent gravel; neutral; clear wavy boundary.

IIC—20 to 60 inches; brown (10YR 4/3) and dark yellowish brown (10YR 4/4) loamy coarse sand and gravel; single grained; loose; few dark concretions (iron oxides); strong effervescence; moderately alkaline.

The thickness of the solum and the depth to carbonates range from about 15 to 30 inches.

The A horizon ranges from 9 to 18 inches in thickness. The A1 horizon typically is black (10YR 2/1) but ranges to very dark brown (10YR 2/2) or very dark gray (10YR 3/1). The A3 horizon, where present, typically is very dark gray (10YR 3/1), but in some pedons it is very dark grayish brown (10YR 3/2).

The B2 horizon has hue of 10YR, value of 3 or 4, and chroma of 3 or 4. It is sandy loam or loam and contains about 5 to 15 percent gravel. The B3 horizon ranges in texture from sandy loam to loamy coarse sand or gravelly sandy loam. It has hue of 10YR or 7.5YR, value of 3 or 4, and chroma of 2 through 4. Reaction in the A and B horizons ranges from neutral to medium acid. The depth to the underlying sand and gravel ranges from 15 to 24 inches.

The IIC horizon has mixed colors ranging from dark brown (10YR 3/3) to yellowish brown (10YR 5/6). Texture ranges from loamy sand to gravel.

Fieldon series

The Fieldon series consists of poorly drained, moderately permeable over rapidly permeable soils on concave slopes on uplands. These soils formed in loamy lacustrine or glacial outwash sediments under a native vegetation of water-tolerant grasses. Slopes range from 0 to 2 percent.

Fieldon soils are similar to Darfur and Lemond soils and are commonly adjacent to Harcot, Harpster, and Spicer soils. Darfur soils do not have free carbonates in the solum. Lemond and Harcot soils have more gravel in the C horizon than the Fieldon soils. Harpster soils have less sand in the lower part of the B horizon and in the C horizon. Spicer soils have more clay and less sand throughout the profile. These soils are on landscape positions similar to those of the Fieldon soils.

Typical pedon of Fieldon loam, 0 to 2 percent slopes; 1,940 feet north and 60 feet west of the SE corner of sec. 12, T. 97 N., R. 27 W.

Ap—0 to 8 inches; black (10YR 2/1) loam, black (10YR 2/1) dry; few black (N 2/0) coatings on faces of peds; weak fine granular structure; friable; few fine roots; strong effervescence; moderately alkaline; abrupt smooth boundary.

A12—8 to 13 inches; black (10YR 2/1) loam, black (10YR 2/1) and very dark gray (10YR 3/1) dry; few black (N 2/0) coatings on faces of peds; weak fine granular structure; friable; few fine roots; few fine pores; strong effervescence; moderately alkaline; clear smooth boundary.

A3—13 to 18 inches; very dark gray (10YR 3/1) loam, very dark gray (10YR 3/1) and dark gray (10YR 4/1) dry; weak fine subangular blocky and weak fine granular structure; friable; black (10YR 2/1) krotovinas about 2 cm in diameter; few fine roots; few fine pores; strong effervescence; moderately alkaline; gradual smooth boundary.

B2g—18 to 23 inches; mottled dark gray (5Y 4/1) and olive gray (5Y 5/2) loam; weak medium subangular blocky structure parting to weak fine subangular blocky; friable; black (10YR 2/1) krotovinas; few fine roots; few fine pores; strong effervescence; moderately alkaline; gradual smooth boundary.

B31g—23 to 29 inches; olive gray (5Y 5/2) loam; weak fine subangular blocky structure; very friable; black (10YR 2/1) krotovinas; few fine pores; strong effervescence; moderately alkaline; gradual smooth boundary.

B32g—29 to 39 inches; mottled olive gray (5Y 5/2), light olive gray (5Y 6/2), and yellowish brown (10YR 5/8) very fine sandy loam; weak fine and medium subangular blocky structure; very friable; few fine pores; common dark concretions (manganese oxides); slight effervescence; moderately alkaline; clear smooth boundary.

C1g—39 to 45 inches; mottled olive gray (5Y 5/2), light olive gray (5Y 6/2), and yellowish brown (10YR 5/8) fine sandy loam; single grained; loose; few fine pores; few dark concretions (manganese oxides); slight effervescence; moderately alkaline; clear smooth boundary.

C2g—45 to 53 inches; olive gray (5Y 5/2) loamy fine sand; few fine distinct yellowish brown (10YR 5/8) mottles; single grained; loose; few dark concretions (manganese oxides); strong effervescence; moderately alkaline; clear smooth boundary.

C3g—53 to 59 inches; gray (5Y 5/1) and olive gray (5Y 5/2) fine sand; few fine distinct yellowish brown (10YR 5/8) mottles; single grained; loose; few dark concretions (manganese oxides); strong effervescence; moderately alkaline; clear smooth boundary.

IIC—59 to 66 inches; gray (5Y 5/1), olive gray (5Y 5/2), and light olive gray (5Y 6/2) stratified sand and silt; common medium distinct yellowish brown (10YR 5/8) mottles; single grained; loose; few dark concretions (manganese oxides); strong effervescence; moderately alkaline.

The solum thickness ranges from about 25 to 40 inches. Reaction is mildly or moderately alkaline in all horizons.

The A horizon is black (10YR 2/1) and very dark gray (10YR 3/1) and ranges from 14 to 24 inches thick.

The B horizon has hue of 2.5Y or 5Y, value of 4, 5, or 6, and chroma of 1 or 2. The thickness of the B horizon ranges from 7 to 30 inches. The B horizon ranges from loam or sandy loam to very fine sandy loam or loamy fine sand.

The C horizon has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 1 through 3. Texture ranges from fine sand to loamy fine sand with some strata of silt loam.

Fostoria series

The Fostoria series consists of somewhat poorly drained, moderately permeable soils on upland outwash areas. These soils formed in loamy glacial sediments under a native vegetation of grasses. Slopes range from 0 to 2 percent.

Fostoria soils are similar to Crippin, Nicollet, and Ottosen soils and are commonly adjacent to Corwith, Darfur, and Truman soils. Crippin soils have free carbonates. Nicollet soils do not have the stratification in the C horizon. Ottosen soils contain more clay in the A horizon and upper part of the B horizon. Corwith soils are lower in sand content and contain free carbonates. Darfur soils have a grayer B horizon and are poorly drained. Truman soils have a browner B horizon and contain less sand throughout the profile. Corwith soils are on landscape positions similar to those of the Fostoria soils. Darfur soils are on lower lying areas, and Truman soils are on convex slopes above Fostoria soils.

Typical pedon of Fostoria loam, 0 to 2 percent slopes; 205 feet west and 2,481 feet south of the NE corner of sec. 9, T. 100 N., R. 28 W.

Ap—0 to 8 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) and very dark grayish brown (10YR 3/2) dry; weak fine granular structure; friable; few fine roots; slightly acid; abrupt smooth boundary.

A12—8 to 14 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak fine and very fine granular structure; friable; few fine roots; few dark reddish concretions (iron oxides); neutral; clear smooth boundary.

A3—14 to 18 inches; very dark grayish brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) dry; few very dark gray (10YR 3/1) coatings on faces of peds; weak fine subangular blocky structure parting to weak fine granular; friable; few fine roots; few fine tubular pores; slightly acid; clear smooth boundary.

B21—18 to 22 inches; dark grayish brown (10YR 4/2) loam; few fine distinct light olive brown (2.5Y 5/4) mottles; weak fine subangular blocky structure; friable; few fine roots; few dark reddish concretions (iron oxides); neutral; clear smooth boundary.

B22—22 to 26 inches; brown (10YR 4/3) loam; few dark grayish brown (10YR 4/2) coatings on faces of peds; few fine distinct yellowish brown (10YR 5/4) mottles; weak fine subangular blocky structure; friable; few fine roots; few fine tubular pores; few dark reddish brown concretions (iron oxides); neutral; gradual smooth boundary.

B23—26 to 32 inches; mottled brown (10YR 4/3), olive brown (2.5Y 4/4), grayish brown (10YR 5/2), and yellowish brown (10YR 5/6) loam; weak fine and medium subangular blocky structure; friable; few fine roots; few fine tubular pores; few dark concretions (iron and manganese oxides); neutral; gradual smooth boundary.

C1—32 to 41 inches; mottled light brownish gray (2.5Y 6/2), yellowish brown (10YR 5/6), and light olive brown (2.5Y 5/6) sandy loam; weak medium subangular blocky structure; very friable; few fine tubular pores; few dark reddish brown concretions (iron oxides); neutral; gradual smooth boundary.

C2—41 to 52 inches; mottled light brownish gray (2.5Y 6/2) and yellowish brown (10YR 5/4) stratified sandy loam and loamy sand; single grained; loose; neutral; abrupt wavy boundary.

C3—52 to 54 inches; mottled light brownish gray (2.5Y 6/2), dark grayish brown (10YR 4/2), and dark yellowish brown (10YR 4/4) silt loam; common medium faint reddish brown (5YR 4/4) mottles and stains; massive; friable; few dark concretions (manganese oxides); few fine light gray (10YR 7/1) calcium carbonate accumulations in soft rounded masses; strong effervescence; moderately alkaline; abrupt wavy boundary.

C4—54 to 60 inches; mottled light brownish gray (2.5Y 6/2) and yellowish brown (10YR 5/4) loamy sand; single grained; loose; strong effervescence; moderately alkaline.

The solum is 30 to 48 inches thick. The depth to carbonates is commonly the same as the thickness of the solum, but it ranges from 24 to 52 inches.

The A horizon typically is black (N 2/0 or 10YR 2/1) but ranges to dark grayish brown (10YR 3/2). The A horizon is 12 to 20 inches thick.

The B horizon has hue of 2.5Y or 10YR, value of 4 to 5, and chroma of 2, but it grades to chroma of 3 or 4 as depth increases. Mottles are few or common and have hue of 10YR to 5Y, value of 4 to 6, and chroma of 4 to 8. The texture in the B horizon typically is loam or clay loam and ranges to silt loam in the lower part.

The C horizon is silt loam, loam, or sandy loam. It commonly has strata of loamy sand 2 to 6 inches thick. The C horizon has hue of 10YR or 2.5Y, value of 4 through 6, and chroma of 1 through 6.

Hanska series

The Hanska series consists of poorly drained, moderately rapidly permeable over rapidly permeable soils. These soils are on upland glacial outwash areas and on stream benches. They formed in loamy sediments over sandy alluvium under a native vegetation of water-tolerant grasses. Slopes range from 0 to 2 percent.

Hanska soils are similar to Darfur soils and are commonly adjacent to Cylinder, Lemond, Linder, and Mayer soils. Darfur soils have less gravel in the lower part of the solum and in the C horizon than the Hanska soils. Cylinder and Linder soils have a browner B horizon and are better drained than the Hanska soils. They are on slightly higher lying positions on the landscape. Lemond and Mayer soils are calcareous. They are on landscape positions similar to those of the Hanska soils.

Typical pedon of Hanska loam, 0 to 2 percent slopes; 32 feet south and 1,949 feet west of the NE corner of sec. 32, T. 98 N., R. 29 W.

Ap—0 to 7 inches; black (N 2/0) loam, black (10YR 2/1) dry; weak fine and very fine granular structure; friable; few fine roots; few dark concretions (manganese oxides); neutral; abrupt smooth boundary.

A12—7 to 12 inches; black (N 2/0) loam, black (10YR 2/1) dry; common fine faint very dark grayish brown (10YR 3/2) mottles; weak fine and very fine granular structure; friable; few fine roots; few dark concretions (manganese oxides); neutral; gradual smooth boundary.

A3—12 to 20 inches; very dark gray (10YR 3/1) loam, very dark gray (10YR 3/1) and very dark grayish brown (10YR 3/2) dry; common fine distinct dark grayish brown (10YR 4/2) and few fine faint grayish brown (2.5Y 5/2) mottles; weak fine and very fine subangular blocky structure parting to weak fine granular; friable; few fine roots; few fine tubular pores; few dark concretions (manganese oxides); slightly acid; gradual wavy boundary.

B2g—20 to 26 inches; grayish brown (2.5Y 5/2) and dark grayish brown (2.5Y 4/2) sandy loam; common fine faint light olive brown (2.5Y 5/4) mottles; weak fine and very fine subangular blocky structure; friable; common dark concretions (manganese oxides); neutral; gradual wavy boundary.

IIC1g—26 to 33 inches; grayish brown (2.5Y 5/2), light olive brown (2.5Y 5/4), and pale olive (5Y 6/3) sand with about 5 percent fine gravel; few fine faint light brownish gray (2.5Y 6/2) mottles; single grained; loose; few dark reddish concretions (iron oxides) and few dark concretions (manganese oxides); neutral; gradual wavy boundary.

IIC2g—33 to 38 inches; grayish brown (2.5Y 5/2), light brownish gray (2.5Y 6/2), and dark grayish brown (2.5Y 4/2) sand with about 5 percent fine gravel; few fine faint olive (5Y 5/3) and few fine prominent dark brown (7.5YR 3/2) mottles; single grained; loose; common dark concretions (manganese oxides) and few dark reddish brown concretions (iron oxides); slight effervescence; mildly alkaline; gradual wavy boundary.

IIC3g—38 to 60 inches; grayish brown (2.5Y 5/2), light brownish gray (2.5Y 6/2), and gray (5Y 6/1) sand with about 5 percent fine gravel; few fine distinct light olive brown (2.5Y 5/4) mottles; single grained; loose; few dark concretions (manganese oxides); few medium shale fragments; slight effervescence; mildly alkaline.

The solum thickness typically is 24 to 32 inches but ranges to about 40 inches.

The A horizon is 12 to 22 inches thick. Typically, it is black (N 2/0 or 10YR 2/1) in the upper part and black (10YR 2/1) and very dark gray (10YR 3/1) in the lower part.

The B2 horizon ranges from dark gray (5Y 4/1) or gray (5Y 5/1) to grayish brown (2.5Y 5/2) or olive gray (5Y 4/2 or 5/2). Texture in the B horizon is commonly sandy loam or, less commonly, loam. Some pedons have a IIB3 horizon, which typically is loamy sand but may be sand.

The IICg horizon is loamy sand or sand that contains some gravel. It has hue of 2.5Y or 5Y, value of 3 through 6, and chroma of 1 through 4.

Harcot series

The Harcot series consists of poorly drained, moderately permeable over very rapidly permeable soils. These soils are on upland glacial outwash areas on stream benches. They formed in loamy sediments over sand and gravel under a native vegetation of grasses. Slopes range from 0 to 2 percent.

Harcot soils are similar to Harps soils and are commonly adjacent to Fieldon, Harpster, and Talcot soils. Harps and Harpster soils do not have sand and gravel in the substratum. Fieldon soils have a lower content of calcium carbonate and fewer coarse fragments in the substratum. Talcot soils have a lower content of calcium carbonate. These soils are on landscape positions similar to those of the Harcot soils.

Typical pedon of Harcot loam, 0 to 2 percent slopes; 87 feet south and 900 feet west of the NE corner of sec. 13, T. 97 N., R. 27 W.

Apca—0 to 8 inches; black (10YR 2/1) loam, dark gray (10YR 4/1) dry; weak fine granular structure; friable; few fine roots; few fine snail shell fragments; violent effervescence; moderately alkaline; abrupt smooth boundary.

A12ca—8 to 13 inches; very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) and gray (10YR 5/1) dry; black (10YR 2/1) coatings on faces of peds; weak fine granular structure; friable; few fine roots; few fine snail shell fragments; violent effervescence; moderately alkaline; clear smooth boundary.

A3ca—13 to 20 inches; very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) and gray (10YR 5/1) dry; few fine distinct olive gray (5Y 5/2) and dark grayish brown (10YR 4/2) mottles; weak medium subangular blocky structure parting to weak fine granular; friable; few fine roots; few fine tubular pores; violent effervescence; moderately alkaline; gradual smooth boundary.

B21g—20 to 24 inches; olive gray (5Y 4/2 and 5/2) loam; common fine faint olive (5Y 5/3) mottles; weak fine and medium subangular blocky structure; friable; few fine roots; few fine tubular pores; few dark concretions (manganese oxides); violent effervescence; moderately alkaline; clear smooth boundary.

B22g—24 to 31 inches; olive gray (5Y 5/2) loam; common fine faint olive (5Y 5/3) and few fine distinct olive brown (2.5Y 4/4) mottles; weak fine subangular blocky structure; friable; few fine roots; few fine tubular pores; few dark concretions (manganese oxides); few calcium carbonate accumulations in soft rounded masses and powdery streaks; violent effervescence; moderately alkaline; clear wavy boundary.

B3g—31 to 34 inches; olive gray (5Y 5/2) sandy loam; common fine faint olive (5Y 5/3) mottles; weak medium and coarse subangular blocky structure; very friable; few fine tubular pores; few dark concretions (manganese oxides); about 2 percent fine gravel; strong effervescence; mildly alkaline; clear wavy boundary.

IIC—34 to 60 inches; olive (5Y 5/3) and olive gray (5Y 5/2) sand and gravel; single grained; loose; common dark concretions (manganese oxides); strong effervescence; mildly alkaline.

The solum typically is 24 to 40 inches thick and is terminated by underlying sand and gravel.

The A1 horizon typically is loam but ranges to clay loam. It is black (N 2/0 or 10YR 2/1) or very dark gray (10YR 3/1). The A3 horizon is very dark gray (10YR 3/1 or 5Y 3/1) or very dark grayish brown (2.5Y 3/2) or dark olive gray (5Y 3/2). The total thickness of the A horizon ranges from 16 to 24 inches.

The B2 horizon typically is loam but ranges to clay loam or sandy clay loam. Clay content ranges from about 18 to 30 percent. The B2 horizon has hue of 10YR, 2.5Y, or 5Y, value of 4 or 5, and chroma of 1 or 2. The B3 horizon is loam, sandy clay loam, or sandy loam.

The IIC horizon is loamy sand, sand, gravelly sand, or sand and gravel. The IIC horizon has hue of 10YR to 5Y, value of 5 or 6, and chroma of 1 through 6.

Harps series

The Harps series consists of poorly drained, moderately permeable soils. These soils are on rims of depressions on broad upland flats. They formed in glacial till or glacial sediments under a native vegetation of water-tolerant grasses. Slopes range from 0 to 2 percent.

Harps soils are similar to Harcot and Harpster soils and are commonly adjacent to Blue Earth, Canisteo, Okoboji, Palms, and Wacousta soils. Harcot soils have sand and gravel in the substratum. Harpster soils contain more silt and less sand. Blue Earth soils formed in coprogenous earth and contain less clay. Canisteo soils have a lower content of calcium carbonates. Okoboji soils have a thicker A horizon and are not calcareous. Palms soils formed in organic material. Wacousta soils have less sand throughout and are not calcareous. Blue Earth, Okoboji, Palms, and Wacousta soils are in depressions below Harps soils. Canisteo soils are in swales near the Harps soils.

Typical pedon of Harps clay loam, 0 to 2 percent slopes; 88 feet north and 2,615 feet west of the SE corner of sec. 21, T. 100 N., R. 28 W.

Apca—0 to 9 inches; black (10YR 2/1) clay loam, dark gray (10YR 4/1) and gray (10YR 5/1) dry; weak fine granular structure; friable; few fine roots; common very fine snail shells; violent effervescence; moderately alkaline; abrupt smooth boundary.

A12ca—9 to 14 inches; very dark gray (10YR 3/1) light clay loam, dark gray (10YR 4/1) and gray (10YR 5/1) dry; black (10YR 2/1) coatings on faces of peds; weak fine subangular blocky structure parting to weak fine and very fine granular; friable; few fine roots; few very fine snail shells; violent effervescence; moderately alkaline; gradual smooth boundary.

B1gca—14 to 20 inches; mottled dark gray (5Y 4/1), olive gray (5Y 5/2), and gray (5Y 5/1) clay loam; weak fine and very fine subangular blocky structure; friable; few fine tubular pores; few fine gray (5Y 6/1) calcium carbonate accumulations in soft rounded masses and in thread-like streaks; few fine snail shells; violent effervescence; moderately alkaline; gradual smooth boundary.

B2gca—20 to 26 inches; mottled olive gray (5Y 5/2) and olive (5Y 5/3) loam; weak fine and very fine subangular blocky structure; friable; few fine roots; few fine tubular pores; few dark concretions (manganese oxides); few fine light gray (5Y 7/2) calcium carbonate accumulations in soft rounded masses and a few fine accumulations in thread-like streaks; violent effervescence; moderately alkaline; gradual smooth boundary.

B3gca—26 to 34 inches; mottled olive gray (5Y 5/2), light olive gray (5Y 6/2), and yellowish brown (10YR 5/6) loam; weak fine subangular blocky structure; very friable; few fine tubular pores; few calcium carbonate accumulations in soft rounded masses; few shale fragments; few dark concretions (iron oxides); few very dark gray (5Y 3/1) and dark gray (5Y 4/1) kortovinas; violent effervescence; moderately alkaline; gradual wavy boundary.

C1g—34 to 42 inches; olive gray (5Y 5/2) loam; common fine distinct yellowish brown (10YR 5/6) and few fine prominent strong brown (7.5YR 5/6) mottles; massive; friable; few fine calcium carbonate accumulations in soft rounded masses; few shale fragments; few dark concretions (iron oxides); strong effervescence; moderately alkaline; gradual wavy boundary.

C2g—42 to 60 inches; olive gray (5Y 5/2) loam; many medium distinct yellowish brown (10YR 5/6) mottles; massive; friable; few fine pores; few dark concretions (manganese oxides); few fine calcium carbonate accumulations in soft rounded masses; few small pebbles; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 30 to 48 inches.

The A1 or Ap horizon is loam or clay loam. The A horizon is 10 to 16 inches thick. When moist, it has color ranging from black (10YR 2/1) to very dark gray (10YR 3/1 or N 3/0). When dry, this horizon is dark gray (10YR 4/1) or gray (10YR 5/1).

The B horizon is loam, clay loam, or sandy clay loam in texture. The B2 horizon has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 1 to 3.

The C horizon typically is loam but ranges to clay loam or sandy clay loam.

Harpster series

The Harpster series consists of poorly drained, moderately permeable soils on rims of depressions on outwash plains on uplands. These soils formed in silty glacial sediments under a native vegetation of water-tolerant grasses. Slopes range from 0 to 2 percent.

Harpster soils are similar to Harps soils and are commonly adjacent to Fieldon, Harcot, and Spicer soils. Harps, Fieldon, and Harcot soils have more sand in the solum and substratum. Spicer soils have a lower content of calcium carbonate. Fieldon and Spicer soils are in swales near the Harpster soils. Harcot soils are on outwash areas on stream benches below the Harpster soils.

Typical pedon of Harpster silt loam, 0 to 2 percent slopes; 1,590 feet west and 420 feet north of the SE corner of sec. 21, T. 95 N., R. 27 W.

Apca—0 to 8 inches; black (10YR 2/1) silt loam, dark gray (10YR 4/1) dry; weak fine and very fine granular structure; friable; few fine snail shell fragments; violent effervescence; moderately alkaline; abrupt smooth boundary.

A12ca—8 to 16 inches; black (10YR 2/1) and very dark gray (10YR 3/1) silt loam, dark gray (10YR 4/1) dry; weak fine and very fine granular structure; friable; few fine snail shell fragments; violent effervescence; moderately alkaline; clear smooth boundary.

A13ca—16 to 21 inches; very dark gray (10YR 3/1) and very dark grayish brown (10YR 3/2) silt loam, dark gray (10YR 4/1) and gray (10YR 5/1) dry; common fine faint dark grayish brown (2.5Y 4/2) mottles; weak fine subangular blocky structure parting to weak fine granular; friable; few fine pores; few fine calcium carbonate accumulations in soft rounded masses; violent effervescence; moderately alkaline; clear smooth boundary.

B21g—21 to 28 inches; olive gray (5Y 5/2) silt loam; few fine distinct light olive brown (2.5Y 5/6) and olive (5Y 5/4) mottles; weak fine and very fine subangular blocky structure; friable; few fine pores; few dark concretions (manganese oxides); few fine calcium carbonate accumulations in soft rounded masses; violent effervescence; moderately alkaline; gradual smooth boundary.

B22g—28 to 34 inches; olive gray (5Y 5/2) silt loam; common fine prominent yellowish brown (10YR 5/8) and few fine faint olive (5Y 5/3) mottles; weak fine and very fine subangular blocky structure; friable; few fine pores; few dark concretions (manganese oxides); few fine calcium carbonate accumulations in soft rounded masses and in thread-like streaks; violent effervescence; moderately alkaline; gradual smooth boundary.

B3g—34 to 41 inches; olive gray (5Y 5/2) silt loam; many fine prominent yellowish brown (10YR 5/8) mottles; weak fine and very fine subangular blocky structure; very friable; few fine pores; few dark concretions (manganese oxides); few fine calcium carbonate accumulations in soft rounded masses and in thread-like streaks; violent effervescence; moderately alkaline; gradual smooth boundary.

Cg—41 to 60 inches; olive gray (5Y 5/2) silt loam; many fine and medium prominent yellowish brown (10YR 5/6) mottles; massive; very friable; few fine pores; few dark concretions (manganese oxides); few fine calcium carbonate accumulations in soft rounded masses and in thread-like streaks; violent effervescence; moderately alkaline.

The solum ranges from about 24 to 44 inches in thickness.

The A horizon is 12 to 22 inches thick. It ranges from silt loam to silty clay loam. It is black (10YR 2/1) and very dark gray (10YR 3/1) and ranges to very dark grayish brown (10YR 3/2) in the lower part. Calcium carbonate content ranges from 15 to 25 percent.

The B horizon has hue of 10YR, 2.5Y, and 5Y, value of 4 or 5, and chroma of 1 or 2. It typically is silt loam but ranges to silty clay loam and loam in the lower part in some pedons. Calcium carbonate content ranges from 10 to 15 percent.

The C horizon typically is silt loam but ranges to loam or clay loam. It has hue of 5Y or 2.5Y, value of 4 or 5, and chroma of 1 to 3.

Kingston series

The Kingston series consists of moderately well drained and somewhat poorly drained, moderately permeable soils on slightly convex upland slopes. These soils formed in silty lacustrine sediments under a native vegetation of grasses. Slopes range from 0 to 3 percent.

Kingston soils are similar to Corwith soils and are commonly adjacent to Kossuth, Truman, and Waldorf soils. Corwith soils contain less clay in the solum and are calcareous. Kossuth and Waldorf soils have a grayer B horizon and are poorly drained. They are in lower lying areas on the landscape. Truman soils have a browner B horizon and are better drained. They are on convex slopes above Kingston soils.

Typical pedon of Kingston silty clay loam, 0 to 3 percent slopes; 800 feet west and 60 feet south of the NE corner of sec. 10, T. 100 N., R. 27 W.

Ap—0 to 8 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; weak fine and medium granular structure; friable; common fine roots; neutral; abrupt smooth boundary.

A12—8 to 15 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; weak fine and medium granular structure; friable; common fine roots; neutral; gradual smooth boundary.

A13—15 to 19 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; black (N 2/0) coatings on faces of peds; weak fine subangular blocky structure parting to weak fine granular; friable; few fine roots; neutral; clear smooth boundary.

B1—19 to 24 inches; dark grayish brown (2.5Y 4/2) and light olive brown (2.5Y 5/4) silty clay loam; black (10YR 2/1) and very dark gray (10YR 3/1) coatings on faces of peds; weak medium subangular blocky structure; friable; few fine roots; neutral; gradual smooth boundary.

B2—24 to 31 inches; light olive brown (2.5Y 5/4) silt loam; weak medium subangular blocky structure parting to weak very fine subangular blocky; friable; few fine roots; few fine tubular pores; mildly alkaline; clear smooth boundary.

B3—31 to 37 inches; light olive brown (2.5Y 5/4) silt loam; few fine faint yellowish brown (10YR 5/8) and light brownish gray (2.5Y 6/2) mottles; weak medium subangular blocky structure; friable; common fine tubular pores; few dark concretions (iron oxides); slight effervescence; mildly alkaline; gradual smooth boundary.

C—37 to 60 inches; mottled light olive brown (2.5Y 5/4), olive gray (5Y 5/2), and yellowish brown (10YR 5/6) silt loam; massive; friable; few dark concretions (iron and manganese oxides); few calcium carbonate accumulations in soft rounded masses and in streaks; slight effervescence; moderately alkaline.

The solum thickness and the depth to free carbonates range from about 24 to 40 inches. Secondary accumulations of free carbonates are in the lower part of the B horizon and in the C horizon of most pedons.

The A horizon is 12 to 22 inches thick. It is black (10YR 2/1) to very dark gray (10YR 3/1). It typically is silty clay loam but ranges to silt loam. It is neutral to slightly acid.

The B horizon has hue of 10YR or 2.5Y, value of 3 or 4 in the upper part and 4 or 5 in the lower part, and chroma of 2 or 3 in the upper part and 2 through 4 in the lower part. Texture is silty clay loam or silt loam. Reaction is neutral to mildly alkaline.

The C horizon has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 2 through 4.

Kossuth series

The Kossuth series consists of poorly drained, moderately slowly permeable soils on level to slightly concave slopes on uplands. These soils formed in silty and loamy lacustrine and glacial till sediment under a native vegetation of water-tolerant grasses. Slopes range from 0 to 2 percent.

Kossuth soils are similar to Waldorf and Webster soils and are commonly adjacent to Canisteo, Kingston, and Ottosen soils. Waldorf soils have more clay and less sand in the solum than the Kossuth soils. Webster and Canisteo soils contain more sand and less clay. Kingston and Ottosen soils have a browner upper B horizon than Kossuth soils and are better drained. Canisteo soils are at slightly lower elevations than Kossuth soils. Kingston and Ottosen soils are on higher lying areas.

Typical pedon of Kossuth silty clay loam, 0 to 2 percent slopes, 2,170 feet west and 102 feet south of the NE corner of sec. 15, T. 94 N., R. 29 W.

Ap—0 to 9 inches; black (10YR 2/1 and N 2/0) silty clay loam, very dark gray (10YR 3/1) dry; weak fine granular structure; friable; common fine and medium roots; neutral; abrupt smooth boundary.

A12—9 to 18 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; black (N 2/0) coatings on faces of peds; weak fine subangular blocky structure parting to moderate fine granular; firm; common fine roots; neutral; gradual smooth boundary.

A3—18 to 23 inches; very dark gray (5Y 3/1) silty clay loam, dark gray (5Y 4/1) dry; black (5Y 2/1) and very dark gray (5Y 3/1) coatings on faces of peds; common fine faint dark gray (5Y 4/1) and few fine distinct gray (5Y 5/1) and olive gray (5Y 5/2) mottles; weak fine prismatic structure parting to moderate fine and very fine subangular blocky; firm; common fine roots; neutral; clear wavy boundary.

B21—23 to 30 inches; olive gray (5Y 4/2) silty clay loam; weak fine prismatic structure parting to weak fine subangular blocky; firm; common fine roots; few thin discontinuous clay films; few dark concretions (iron and manganese oxides); neutral; gradual smooth boundary.

IIB22g—30 to 36 inches; olive gray (5Y 5/2) with some olive (5Y 5/3) clay loam; few fine distinct light olive brown (2.5Y 5/6) mottles; weak medium prismatic structure parting to weak fine and medium subangular blocky; friable; few dark concretions (iron and manganese oxides); neutral; gradual smooth boundary.

IIB3g—36 to 40 inches; olive gray (5Y 5/2) loam; common fine faint olive (5Y 5/3) and few fine faint light olive brown (2.5Y 5/6) mottles; weak medium subangular blocky structure; friable; few fine roots; few dark concretions (iron and manganese oxides); few fine calcium carbonate accumulations in soft rounded masses; slight effervescence; mildly alkaline; gradual smooth boundary.

IIC1g—40 to 48 inches; olive gray (5Y 5/2) loam; common fine and medium distinct yellowish brown (10YR 5/6) mottles; massive; friable; few fine roots; few concretions (iron and manganese oxides); few fine calcium carbonate accumulations in soft rounded masses; strong effervescence; moderately alkaline; gradual smooth boundary.

IIC2gca—48 to 60 inches; olive gray (5Y 5/2) loam; many fine distinct yellowish brown (10YR 5/6) and few fine prominent strong brown (7.5YR 5/8) mottles; massive; friable; few fine roots; few concretions (iron and manganese oxides); common fine calcium carbonate accumulations in soft rounded masses; strong effervescence; moderately alkaline.

The thickness of the solum and the depth to carbonates typically are 30 to 42 inches but range from 24 to 48 inches.

The Ap and A12 horizons are black (N 2/0 or 10YR 2/1). The A3 horizon is black (10YR 2/1) or very dark gray (10YR 3/1 or 5Y 3/1). The A horizon ranges from 14 to 24 inches in thickness. It typically is silty clay loam and contains 35 to 40 percent clay. Reaction is slightly acid or neutral.

The B horizon typically has hue of 5Y or 2.5Y, value of 4 or 5, and chroma of 1 or 2. Textures are silty clay loam or silty clay in the B21 horizon and clay loam or loam in the IIB horizon. Reaction is slightly acid or neutral in the B21 horizon and neutral or mildly alkaline in the IIB horizon.

The C horizon typically has hue of 5Y or 2.5Y, value of 4 or 5, and chroma of 1 or 2.

Lemond series

The Lemond series consists of poorly drained soils on upland outwash plains and stream benches. Permeability is moderately rapid in the solum and rapid in the substratum. These soils formed in loamy glacial outwash sediments and the underlying sandy sediments. They formed under a native vegetation of water-tolerant grasses. Slopes range from 0 to 2 percent.

The Lemond soils in Kossuth County are tax adjuncts to the Lemond series because they have a slightly higher gravel content below a depth of 24 inches than is described for the series.

Lemond soils are similar to Fieldon soils and are commonly adjacent to Biscay, Hanska, and Mayer soils. Fieldon soils have more fine sand in their solum than the Lemond soils. Biscay and Hanska soils do not have free carbonates in the solum. Mayer soils contain more clay in the solum than the Lemond soils. Biscay soils are on stream benches below Lemond soils. Hanska and Mayer soils are on landscape positions similar to those of the Lemond soils.

Typical pedon of Lemond loam, 0 to 2 percent slopes; 516 feet north and 126 feet east of the SW corner of sec. 10, T. 95 N., R. 30 W.

Ap—0 to 8 inches; black (N 2/0) loam, black (10YR 2/1) and very dark gray (10YR 3/1) dry; weak fine granular structure; friable; few fine and medium roots; strong effervescence; moderately alkaline; abrupt smooth boundary.

A12—8 to 14 inches; black (N 2/0) and very dark gray (N 3/0) loam, very dark gray (10YR 3/1) and dark gray (10YR 4/1) dry; weak fine subangular blocky structure parting to weak fine and very fine granular; friable; few fine and medium roots; strong effervescence; moderately alkaline; gradual smooth boundary.

AB—14 to 18 inches; mixed very dark gray (N 3/0) loam (A3) and dark gray (5Y 4/1) and olive gray (5Y 5/2) sandy loam (B1); weak medium subangular blocky structure parting to weak fine subangular blocky; friable; few fine roots; few fine calcium carbonate accumulations in soft rounded masses; strong effervescence; moderately alkaline; clear smooth boundary.

B2gca—18 to 24 inches; olive gray (5Y 5/2) sandy loam; few fine distinct light olive brown (2.5Y 5/4 and 5/6) mottles; weak fine prismatic structure parting to weak very fine subangular blocky; friable; common fine calcium carbonate accumulations in soft rounded masses; strong effervescence; moderately alkaline; clear smooth boundary.

IIC1gca—24 to 30 inches; olive gray (5Y 5/2) and olive (5Y 5/3) gravelly loamy sand; few fine prominent strong brown (7.5YR 5/8) mottles; weak fine subangular blocky structure; very friable; few concretions (iron and manganese oxides); common fine and few medium calcium carbonate accumulations in soft rounded masses; about 50 percent gravel; strong effervescence; moderately alkaline; gradual wavy boundary.

IIC2gca—30 to 34 inches; olive gray (5Y 5/2) and olive (5Y 5/3) gravelly loamy sand; common medium to coarse distinct yellowish brown (10YR 5/8) and olive yellow (5Y 6/6) mottles; single grained; loose; common fine and medium calcium carbonate accumulations in soft rounded masses; few concretions (iron and manganese oxides); 20 percent gravel; strong effervescence; moderately alkaline; gradual wavy boundary.

IIC3gca—34 to 44 inches; dark gray (5Y 4/1) and olive gray (5Y 5/2) gravelly loamy sand; single grained; loose; common fine and medium calcium carbonate accumulations in soft rounded masses; about 25 percent gravel; few concretions (iron and manganese oxides); strong effervescence; moderately alkaline; gradual wavy boundary.

IIC4ca—44 to 60 inches; very dark grayish brown (2.5Y 3/2), dark grayish brown (2.5Y 4/2), and olive brown (2.5Y 4/4) sand and gravel; single grained; loose; common fine and medium calcium carbonate accumulations in soft rounded masses; few concretions (iron and manganese oxides); strong effervescence; moderately alkaline.

The thickness of the solum ranges from 20 to 38 inches.

The A horizon is about 14 to 20 inches thick. It has hue of 10YR, value of 2 or 3, and chroma of 1, or it is neutral and has value of 2 or 3. The texture typically is loam but ranges to sandy loam or coarse sandy loam.

The B horizon typically is olive gray (5Y 5/2) or olive (5Y 5/3), but the range includes hue of 2.5Y, value of 4 or 5, and chroma of 1 or 2. Texture ranges from sandy loam to gravelly loamy sand.

The IIC horizon has hue of 5Y or 2.5Y, value of 3 through 5, and chroma of 1 through 4.

Lester series

The Lester series consists of well drained, moderately permeable soils on upland ridges and side slopes. These soils formed in glacial till under a native vegetation of mixed grasses and trees. Slopes range from 2 to 40 percent.

Lester soils are commonly adjacent to Le Sueur and Storden soils. Le Sueur soils have a grayer upper B horizon than the Lester soils and are not as well drained. They are on concave, lower lying areas. Storden soils are calcareous and do not have a B horizon. They are on landscape positions similar to those of the Lester soils.

Typical pedon of Lester loam, 2 to 5 percent slopes; 780 feet west and 940 feet south of the NE corner of sec. 15, T. 95 N., R. 29 W.

A1—0 to 5 inches; very dark brown (10YR 2/2) loam, dark gray (10YR 4/1) dry; black (10YR 2/1) coatings on faces of peds; weak fine and very fine subangular blocky structure parting to weak fine granular; friable; few gray (10YR 5/1) silt coatings on faces of peds; slightly acid; clear smooth boundary.

A21—5 to 8 inches; dark grayish brown (10YR 4/2) loam, grayish brown (10YR 5/2) and gray (10YR 5/1) dry; black (10YR 2/1) coatings on faces of peds; weak coarse platy structure parting to weak very fine and fine subangular blocky; friable; common continuous light gray (10YR 7/1) silt coatings on faces of peds; slightly acid; clear smooth boundary.

A22—8 to 13 inches; mixed dark grayish brown (10YR 4/2) and very dark grayish brown (10YR 3/2) loam, light gray (10YR 6/1) and light brownish gray (10YR 6/2) dry; weak coarse platy structure parting to weak very fine subangular blocky; friable; common continuous light gray (10YR 7/1) silt coatings on faces of peds; slightly acid; clear smooth boundary.

B1—13 to 17 inches; brown (10YR 4/3) loam; very dark grayish brown (10YR 4/2) coatings on faces of peds; moderate fine subangular blocky structure; friable; common continuous light gray (10YR 7/1) silt coatings on faces of peds; medium acid; gradual smooth boundary.

B21t—17 to 23 inches; mixed brown (10YR 4/3) and dark yellowish brown (10YR 4/4) loam; very dark grayish brown (10YR 3/2) and dark brown (10YR 3/3) coatings on faces of peds; moderate fine subangular blocky structure; firm; thin discontinuous very dark grayish brown (10YR 3/2) clay films; nearly continuous light gray (10YR 7/1) silt coatings on faces of peds; few dark concretions (iron and manganese oxides); medium acid; gradual boundary.

B22t—23 to 27 inches; dark yellowish brown (10YR 4/4) loam; dark brown (10YR 3/3) coatings on faces of peds; weak coarse prismatic structure parting to weak medium and fine subangular blocky; firm; few fine tubular pores; nearly continuous very dark brown (10YR 2/2) clay films; few thin discontinuous light gray (10YR 7/1) silt coatings on faces of peds; slightly acid; gradual smooth boundary.

B31—27 to 34 inches; dark yellowish brown (10YR 4/4) loam; weak coarse prismatic structure; friable; few fine tubular pores; few thin discontinuous light gray (10YR 6/1) silt coatings on faces of peds; few dark concretions (iron and manganese oxides); slightly acid; gradual smooth boundary.

B32—34 to 45 inches; dark yellowish brown (10YR 4/4) loam; weak coarse prismatic structure; friable; few fine tubular pores; common dark concretions (iron and manganese oxides); neutral; gradual smooth boundary.

C—45 to 60 inches; mottled light olive brown (2.5Y 5/4), light yellowish brown (2.5Y 6/4), and dark yellowish brown (10YR 4/4) loam; massive; friable; few fine tubular pores; common dark concretions (iron and manganese oxides); few olive gray (5Y 5/2) calcium carbonate accumulations in soft rounded masses; slight effervescence; mildly alkaline.

The thickness of the solum and the depth to free carbonates range from 20 to 54 inches.

The A1 horizon is black (10YR 2/1) or very dark brown (10YR 2/2) and is 4 to 8 inches thick. Some pedons have an Ap horizon, which is very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2). The A2 horizon typically is dark grayish brown (10YR 4/2) or very dark grayish brown (10YR 3/2) but ranges to very dark gray (10YR 3/1) or dark gray (10YR 4/1). It is 2 to 8 inches thick and is loam or silt loam. Reaction in the A horizon is slightly acid to medium acid.

The upper part of the B horizon is brown (10YR 4/3) or dark yellowish brown (10YR 4/4). The lower part ranges to brown (10YR 5/3), yellowish brown (10YR 5/4), or light olive brown (2.5Y 5/4). Texture in the B horizon ranges from loam to clay loam. Reaction in the B horizon is slightly acid or medium acid.

The C horizon has hue of 2.5Y, value of 4 through 6, and chroma of 3 to 6. It is loam or clay loam.

Le Sueur series

The Le Sueur series consists of somewhat poorly drained, moderately permeable soils on slightly convex upland slopes. These soils formed in glacial till under a native vegetation of mixed grasses and trees. Slopes range from 1 to 3 percent.

Le Sueur soils are commonly adjacent to Lester and Nicollet soils. Lester soils have a browner B horizon than the Le Sueur soils and are better drained. They are on convex slopes above Le Sueur soils. Nicollet soils have a thicker A1 horizon and do not have an A2 horizon. They are on landscape positions similar to those of the Le Sueur soils.

Typical pedon of Le Sueur loam, 1 to 3 percent slopes; 40 feet west and 1,920 feet south of the NE corner of sec. 15, T. 95 N., R. 29 W.

A11—0 to 6 inches; very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) dry; black (10YR 2/1) coatings on faces of peds; weak fine and very fine granular structure; friable; common fine roots; few gray (10YR 6/1) silt coatings in lower part of horizon; medium acid; abrupt smooth boundary.

A12—6 to 10 inches; very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) dry; black (10YR 2/1) coatings on faces of peds; weak medium and fine granular structure; friable; few fine roots; few fine tubular pores; few dark reddish brown concretions (iron oxides); common gray (10YR 6/1) silt coatings on faces of peds; medium acid; abrupt smooth boundary.

A2—10 to 13 inches; very dark gray (10YR 3/1) loam, gray (10YR 5/1) dry; few dark grayish brown (2.5Y 4/2) coatings on faces of peds; very weak coarse platy structure parting to weak fine and very fine subangular blocky; friable; few fine roots; few fine tubular pores; few dark concretions (iron and manganese oxides); many gray (10YR 6/1) silt coatings; medium acid; abrupt smooth boundary.

B1—13 to 18 inches; dark grayish brown (2.5Y 4/2) loam, very dark gray (10YR 3/1) and dark gray (10YR 4/1) coatings on faces of peds; weak medium subangular blocky structure; friable; few fine roots; few fine tubular pores; few dark concretions (iron and manganese oxides); many gray (10YR 6/1) silt coatings; medium acid; clear smooth boundary.

B21t—18 to 23 inches; dark grayish brown (2.5Y 4/2) loam; very dark grayish brown (2.5Y 3/2) coatings on faces of peds; few fine faint dark yellowish brown (10YR 4/4) mottles; weak fine prismatic structure parting to weak fine and medium subangular blocky; firm; few fine roots; few fine tubular pores; thin discontinuous very dark gray (10YR 3/1) clay films; few concretions (manganese oxides); many gray (10YR 6/1) and light gray (10YR 7/1) silt coatings; very dark gray (10YR 3/1) clay fills and organic stains in old root channels; medium acid; gradual smooth boundary.

B22t—23 to 35 inches; mixed dark grayish brown (2.5Y 4/2) and olive brown (2.5Y 4/4) clay loam; very dark grayish brown (2.5Y 3/2) coatings on faces of peds; few fine faint yellowish brown (10YR 5/6) mottles; weak medium prismatic structure parting to moderate fine and medium subangular and angular blocky; firm; few fine roots; few fine tubular pores; few thin very dark gray (10YR 3/1) discontinuous clay films; many gray (10YR 6/1) and light gray (10YR 7/1) silt coatings; medium acid; gradual smooth boundary.

B3t—35 to 44 inches; mixed light olive brown (2.5Y 5/4) and dark grayish brown (2.5Y 4/2) clay loam; few fine faint yellowish brown (10YR 5/6) and grayish brown (2.5Y 5/2) mottles; weak medium prismatic structure; friable; few fine tubular pores; thin continuous very dark grayish brown (2.5Y 3/2) clay films; common dark concretions (iron and manganese oxides); black (10YR 2/1) clay fills in old root channels and pores; medium acid; abrupt wavy boundary.

C—44 to 60 inches; mixed dark grayish brown (2.5Y 4/2) and grayish brown (2.5Y 5/2) clay loam; common fine distinct yellowish brown (10YR 5/6) and few fine distinct dark brown (7.5YR 4/4) mottles; massive; friable; few dark concretions (iron and manganese oxides); few fine calcium carbonate accumulations in soft rounded masses and thread-like streaks; strong effervescence; moderately alkaline.

The thickness of the solum and the depth to free carbonates range from 28 to 55 inches. Reaction in the solum typically is medium acid, but in some pedons is slightly acid.

The A horizon is very dark gray (10YR 3/1) or black (10YR 2/1). It is about 10 to 18 inches thick. Some pedons have an A3 horizon that is very dark grayish brown (10YR 3/2). The A horizon typically is loam, but in a few pedons the texture is clay loam.

The B1 horizon has hue of 10YR or 2.5Y, value of 4, and chroma of 2 or 3. The B2 horizon typically has hue of 2.5Y or 10YR, value of 4 or 5, and chroma of 2 or 3. The B3 horizon has hue of 2.5Y, value of 4 or 5, and chroma of 2 through 4. The B horizon has texture of clay loam or loam.

The C horizon has hue of 2.5Y, value of 4 or 5, and chroma of 2 through 4.

Linder series

The Linder series consists of somewhat poorly drained soils on uplands and on stream benches. These soils formed in loamy and sandy glacial outwash under a native vegetation of grasses. Permeability is moderate or moderately rapid in the solum and very rapid in the substratum. Slopes range from 0 to 2 percent.

Linder soils are similar to Cylinder soils and are commonly adjacent to Cylinder, Hanska, and Wadena soils. Cylinder soils have more clay and less sand in the B horizon. Hanska soils have a grayer B horizon and are more poorly drained. Wadena soils have a browner B horizon and are better drained. Cylinder soils are on landscape positions similar to those of the Linder soils. Hanska soils are on lower lying areas and Wadena soils are on higher lying areas than Linder soils.

Typical pedon of Linder loam, 0 to 2 percent slopes; 880 feet east and 1,460 feet south of the NW corner of sec. 23, T. 94 N., R. 30 W.

Ap—0 to 9 inches; black (N 2/0) loam; black (10YR 2/1) dry; weak fine granular structure; friable; common fine roots; neutral; abrupt smooth boundary.

A3—9 to 14 inches; very dark grayish brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) dry; black (10YR 2/1) and very dark gray (10YR 3/1) coatings on faces of peds; weak fine granular structure; friable; common fine roots; few fine tubular pores; neutral; clear smooth boundary.

B21—14 to 18 inches; dark grayish brown (2.5Y 4/2) sandy loam; very dark grayish brown (2.5Y 3/2) coatings on faces of peds; few fine distinct dark yellowish brown (10YR 4/4) mottles; weak fine subangular blocky structure parting to weak fine and medium granular; friable; few fine roots; about 2 percent gravel; neutral; clear smooth boundary.

B22—18 to 22 inches; dark grayish brown (2.5Y 4/2) sandy loam; few fine prominent yellowish brown (10YR 5/8) mottles; weak medium and fine subangular blocky structure; friable; few fine roots; few dark concretions (manganese oxides); about 2 percent gravel; neutral; clear smooth boundary.

IIB3—22 to 26 inches; olive brown (2.5Y 4/4) loamy sand; common fine and medium prominent yellowish brown (10YR 5/8) mottles; weak medium and coarse subangular blocky structure parting to weak fine subangular blocky; very friable; common dark concretions (iron and manganese oxides); about 5 percent gravel; neutral; clear wavy boundary.

IIC1—26 to 30 inches; yellowish brown (10YR 5/4) gravelly loamy sand; single grained; loose; common dark concretions (iron and manganese oxides); slight effervescence; mildly alkaline; gradual smooth boundary.

IIC2—30 to 47 inches; dark brown (10YR 3/3), brown (10YR 4/3), and dark yellowish brown (10YR 4/4) gravelly coarse sand; single grained; loose; common dark concretions (manganese oxides); slight effervescence; mildly alkaline; gradual wavy boundary.

IIC3—47 to 60 inches; dark yellowish brown (10YR 4/4) sand and gravel; single grained; loose; few dark concretions (manganese oxides); strong effervescence; moderately alkaline.

The solum thickness and the depth to carbonates typically are 24 to 30 inches but range from 20 to about 42 inches. Reaction in the A and B horizons typically ranges from slightly acid to mildly alkaline.

The A horizon is 10 to 20 inches thick. It is loam or sandy loam. The Ap or A1 horizon is black (10YR 2/1 or N 2/0) or very dark brown (10YR 2/2). The A3 horizon is very dark grayish brown (10YR or 2.5Y 3/2), very dark brown (10YR 2/2), or very dark gray (10YR 3/1).

The B horizon typically is dark grayish brown (2.5Y 4/2), olive brown (2.5Y 4/3), or grayish brown (2.5Y 5/2). The B horizon is commonly sandy loam but ranges to loamy sand.

The IIC horizon is commonly 5 to 30 percent gravel, and some strata have about 50 percent gravel. The IIC horizon has hue of 10YR or 2.5Y, value of 3 through 5, and chroma of 2 through 4.

Mayer series

The Mayer series consists of poorly drained soils on stream benches and on uplands. These soils formed in loamy glacial outwash and the underlying sandy outwash. They formed under a native vegetation of water-tolerant grasses. Permeability is moderate in the solum and rapid in the substratum. Slopes range from 0 to 2 percent.

Mayer soils are similar to Biscay and Talcot soils and are commonly adjacent to Biscay, Hanska, and Lemond soils. Biscay and Talcot soils have more clay in the B horizon than the Mayer soils. Hanska soils are not calcareous. Lemond soils have less clay in the solum. These soils are on landscape positions similar to those of the Mayer soils.

Typical pedon of Mayer loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes; 1,164 feet south and 32 feet west of the NE corner of sec. 23, T. 95 N., R. 30 W.

Ap—0 to 7 inches; black (5Y 2/1) loam, black (10YR 2/1) dry; weak fine granular structure; friable; few fine roots; few fine calcium carbonate accumulations in soft rounded masses; strong effervescence; moderately alkaline; abrupt smooth boundary.

A12—7 to 14 inches; black (5Y 2/1) loam, black (10YR 2/1) dry; weak fine and very fine granular structure; friable; few fine roots; few fine calcium carbonate accumulations in soft rounded masses; few fine snail shell fragments; strong effervescence; moderately alkaline; gradual smooth boundary.

A3—14 to 20 inches; very dark gray (5Y 3/1) loam, very dark gray (10YR 3/1) dry; black (5Y 2/1) coatings on about 25 percent of peds; few fine faint olive gray (5Y 4/2) mottles; weak fine subangular blocky structure parting to weak fine and very fine granular; friable; few fine tubular pores; few fine roots; few fine calcium carbonate accumulations in soft rounded masses; strong effervescence; moderately alkaline; gradual smooth boundary.

B21—20 to 25 inches; dark gray (5Y 4/1) loam; very dark gray (5Y 3/1) coatings on 75 percent of peds; few fine faint olive gray (5Y 5/2) mottles; weak fine and very fine subangular blocky structure; friable; few fine tubular pores; few fine and medium calcium carbonate accumulations in soft rounded masses; few dark concretions (iron and manganese oxides); strong effervescence; moderately alkaline; clear smooth boundary.

B22—25 to 30 inches; dark gray (5Y 4/1) and olive gray (5Y 5/2) loam; few fine faint olive (5Y 5/6) mottles; weak fine and medium subangular blocky structure; friable; few fine tubular pores; common fine and few medium calcium carbonate accumulations in soft rounded masses; few fine shale fragments; about 2 percent gravel; few dark concretions (iron and manganese oxides); strong effervescence; moderately alkaline; clear smooth boundary.

IIC1ca—30 to 35 inches; olive gray (5Y 5/2 and 5Y 4/2) loamy sand; few fine faint olive (5Y 5/3 and 5/4) mottles; single grained; very friable; 2 percent fine gravel; few dark concretions (iron and manganese oxides); common fine calcium carbonate accumulations in soft rounded masses; strong effervescence; moderately alkaline; gradual smooth boundary.

IIC2—35 to 40 inches; olive gray (5Y 5/2) sand and gravel; few fine faint olive (5Y 5/3 and 5/4) and few fine prominent strong brown (7.5YR 5/6) mottles; single grained; loose; few fine calcium carbonate accumulations in soft rounded masses; few dark concretions (iron and manganese oxides); strong effervescence; moderately alkaline; gradual smooth boundary.

IIC3—40 to 45 inches; olive gray (5Y 4/2) gravelly loamy sand; single grained; loose; few fine shale fragments; few dark concretions (manganese oxides); strong effervescence; moderately alkaline; gradual smooth boundary.

IIC4—45 to 60 inches; olive gray (5Y 5/2) and light olive gray (5Y 6/2) sand; single grained; loose; about 5 percent gravel; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 20 to 36 inches.

The A horizon is about 14 to 24 inches thick. It ranges from black (N 2/0, 10YR 2/1, or 5Y 2/1) in the upper part to very dark gray (N 3/0, 10YR 3/1, or 5Y 3/1) in the lower part. The texture typically is loam and ranges to sandy clay loam.

The B horizon typically ranges from dark gray (5Y 4/1) to olive gray (5Y 5/2), but some pedons have hue of 2.5Y or 10YR, value of 4 or 5, and chroma of 1 or 2. The texture of the B horizon ranges from loam to sandy clay loam with some gravel.

The IIC horizon has hue of 10YR, 5Y, or 2.5Y, value of 3 through 5, and chroma of 1 through 3.

Nicollet series

The Nicollet series consists of somewhat poorly drained, moderately permeable soils on uplands. These soils formed in glacial till under a native vegetation of grasses. Slopes range from 1 to 3 percent.

Nicollet soils are similar to Crippin and Fostoria soils and are commonly adjacent to Bode, Canisteo, Clarion, and Webster soils. Crippin soils are calcareous. Fostoria soils have a stratified C horizon. Bode and Clarion soils have a browner B horizon and are better drained. They are on convex slopes above Nicollet soils. Canisteo and Webster soils have a grayer B horizon and are poorly drained. They are in concave swales below Nicollet soils.

Typical pedon of Nicollet loam, 1 to 3 percent slopes; 1,449 feet north and 18 feet west of the SE corner of sec. 35, T. 96 N., R. 30 W.

Ap—0 to 8 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak fine granular structure; friable; common fine roots; neutral; abrupt smooth boundary.

A12—8 to 13 inches; black (10YR 2/1) and very dark gray (10YR 3/1) loam, very dark gray (10YR 3/1) dry; weak medium granular structure parting to weak fine and very fine granular; friable; few fine roots; neutral; clear smooth boundary.

B1—13 to 19 inches; dark grayish brown (10YR 4/2) and very dark grayish brown (10YR 3/2) loam; very dark gray (10YR 3/1) and a few black (10YR 2/1) coatings on faces of peds; weak medium subangular blocky structure parting to weak fine and very fine subangular blocky; friable; few fine roots; neutral; gradual smooth boundary.

B21—19 to 27 inches; dark grayish brown (10YR 4/2) heavy loam; very dark grayish brown (2.5Y 3/2) coatings on faces of peds; few fine distinct yellowish brown (10YR 5/4) mottles; weak medium and coarse subangular blocky structure parting to weak fine subangular blocky; friable; few fine roots; few dark concretions (iron oxides); few small pebbles; neutral; gradual smooth boundary.

B22—27 to 33 inches; light olive brown (2.5Y 5/4) loam; dark grayish brown (2.5Y 4/2) coatings on faces of peds; few fine distinct yellowish brown (10YR 5/6) mottles; weak medium subangular blocky structure; friable; few fine roots; few dark concretions (iron oxides); few small pebbles; neutral; gradual wavy boundary.

B3—33 to 39 inches; light olive brown (2.5Y 5/4) loam; olive (5Y 5/3) coatings on faces of some peds; common fine distinct yellowish brown (10YR 5/6) mottles; weak medium prismatic structure parting to weak fine subangular blocky; friable; few fine calcium carbonate accumulations in soft rounded masses; few small shale fragments; slight effervescence; mildly alkaline; gradual wavy boundary.

C—39 to 60 inches; olive (5Y 5/3) loam; common fine distinct light olive brown (2.5Y 5/6), yellowish brown (10YR 5/8), and few fine faint olive gray (5Y 5/2) mottles; massive; few fine tubular pores; few dark concretions (iron and manganese oxides); few fine calcium carbonate accumulations in soft rounded masses; strong effervescence; moderately alkaline.

The thickness of the solum and the depth to free carbonates range from 20 to 48 inches.

The A horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2) clay loam or loam. It is 12 to 18 inches thick.

The B horizon is dark grayish brown (10YR 4/2 or 2.5Y 4/2) and very dark grayish brown (10YR 3/2) in the upper part. The lower part of the B horizon has hue of 2.5Y, value of 4 or 5, and chroma of 2 to 4.

The C horizon is grayish brown (2.5Y 5/2), light olive brown (2.5Y 5/4), olive gray (5Y 5/2), or olive (5Y 5/3). Reaction is slightly acid to neutral in the A horizon and in the upper part of the B horizon. Reaction in the lower part of the B horizon and in the C horizon is neutral to mildly or moderately alkaline.

Okoboji series

The Okoboji series consists of very poorly drained, moderately slowly permeable soils in upland depressions. These soils formed in glacial till sediments under a native vegetation of water-tolerant grasses. Slopes range from 0 to 1 percent.

Okoboji soils are similar to Zook soils and are commonly adjacent to Canisteo, Harps, and Wacousta soils. Zook soils have a thicker A horizon and are deeper to carbonates. Canisteo and Harps soils are calcareous and have a thinner A horizon. Canisteo soils are in swales above Okoboji soils, and Harps soils are on rims of depressions above Okobcji soils. Wacousta soils contain less clay and have a thinner A horizon. They are on landscape positions similar to those of the Okoboji soils.

Typical pedon of Okoboji silty clay loam, 0 to 1 percent slopes; 270 feet north and 12 feet east of the SW corner of sec. 8, T. 97 N., R. 30 W.

Ap—0 to 9 inches; black (N 2/0) silty clay loam, black (10YR 2/1) dry; weak fine granular structure; friable; common fine and few medium roots; some partially decomposed plant fibers; mildly alkaline; abrupt smooth boundary.

A12—9 to 13 inches; black (N 2/0) silty clay loam, black (10YR 2/1) dry; weak fine and very fine granular structure; friable; few fine roots; mildly alkaline; gradual smooth boundary.

A13—13 to 22 inches; black (N 2/0) silty clay loam, black (10YR 2/1) dry; weak very fine subangular blocky and weak fine and very fine granular structure; friable; few fine roots; few dark concretions (iron and manganese oxides); mildly alkaline; gradual smooth boundary.

A14—22 to 29 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; black (N 2/0) coatings on faces of peds; weak fine subangular blocky structure parting to weak very fine subangular blocky and weak fine granular; friable; few fine roots; few fine tubular pores; few dark concretions (iron and manganese oxides); mildly alkaline; gradual smooth boundary.

A15—29 to 35 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; few fine distinct olive (5Y 5/4) and olive gray (5Y 5/2) mottles; weak fine subangular blocky structure parting to weak fine granular; friable; few fine roots; few fine tubular pores; few dark concretions (iron and manganese oxides); mildly alkaline; gradual smooth boundary.

B1g—35 to 41 inches; very dark gray (5Y 3/1) silty clay loam, dark gray (5Y 5/1) dry; black (5Y 2/1) coatings on faces of peds; few fine distinct olive (5Y 5/4 and 5/3) and olive gray (5Y 5/2) mottles; weak fine and very fine subangular blocky structure; friable; few fine tubular pores; few dark concretions (iron and manganese oxides); few medium calcium carbonate accumulations in soft rounded masses; neutral; gradual smooth boundary.

B2g—41 to 47 inches; very dark gray (5Y 3/1) silty clay loam, dark gray (5Y 4/1) dry; black (5Y 2/1) coatings on faces of peds; few fine distinct olive (5Y 5/3), dark gray (5Y 4/1), and light olive brown (2.5Y 5/6) mottles; weak fine and medium subangular blocky structure; friable; few dark concretions (iron and manganese oxides); few fine calcium carbonate accumulations in soft rounded masses; neutral; abrupt wavy boundary.

B3g—47 to 49 inches; dark gray (5Y 4/1) and olive gray (5Y 5/2) silty clay loam; few fine faint olive (5Y 5/3 and 5/6) mottles; weak medium and coarse subangular blocky structure; friable; few fine tubular pores; few concretions (iron and manganese oxides); few fine calcium carbonate accumulations in soft rounded masses; neutral; clear smooth boundary.

Cg—49 to 60 inches; olive gray (5Y 5/2) and gray (5Y 5/1) silty clay loam; few fine prominent yellowish brown (10YR 5/6) mottles; massive; friable; few fine tubular pores; few dark concretions (iron and manganese oxides); few fine calcium carbonate accumulations in soft rounded masses; slight effervescence; mildly alkaline.

The solum thickness ranges from about 40 to 60 inches.

The A horizon ranges from about 24 to 36 inches in thickness. Texture ranges from silty clay loam to silt loam.

The B horizon is commonly 12 to 18 inches thick and very dark gray (5Y 3/1 or 2.5Y 3/1) in the upper part and dark gray (5Y 4/1), gray (5Y 5/1), or olive gray (5Y 5/2) in the lower part. Reaction is neutral or mildly alkaline in the A and B horizons.

The C horizon is commonly dark gray (5Y 4/1), gray (5Y 5/1), or olive gray (5Y 5/2). Texture typically is silty clay loam, but some pedons have thin layers of clay loam, loam, or silt loam.

Ottosen series

The Ottosen series consists of somewhat poorly drained, moderately slowly permeable soils on slightly concave upland slopes. These soils formed in loamy glacial or lacustrine sediments and the underlying loamy glacial till. They formed under a native vegetation of grasses. Slopes range from 1 to 3 percent.

Ottosen soils are similar to Fostoria soils and are commonly adjacent to Bode and Kossuth soils. Fostoria soils contain less clay and have more stratification in the lower part of the B horizon and in the C horizon. Bode soils have a browner B horizon and are on convex slopes above Ottosen soils. Kossuth soils have a grayer B horizon and are poorly drained. They are on concave slopes below Ottosen soils.

Typical pedon of Ottosen clay loam, 1 to 3 percent slopes; 1,000 feet south and 1,400 feet east of the NW corner of sec. 19, T. 94 N., R. 29 W.

Ap—0 to 8 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) dry; weak fine and very fine granular structure; friable; few fine roots; slightly acid; abrupt smooth boundary.

A12—8 to 12 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) dry; weak fine and very fine granular structure; friable; few fine roots; slightly acid; clear smooth boundary.

A3—12 to 18 inches; very dark grayish brown (2.5Y 3/2) clay loam, grayish brown (2.5Y 5/2) dry; black (10YR 2/1) and very dark gray (10YR 3/1) coatings on faces of peds; some dark grayish brown (2.5Y 4/2) clay loam in lower part; weak fine subangular blocky structure parting to weak fine and medium granular; friable; few fine roots; slightly acid; gradual wavy boundary.

B2—18 to 28 inches; dark grayish brown (2.5Y 4/2) clay loam; few fine faint yellowish brown (10YR 5/6) mottles; weak fine prismatic structure parting to weak fine and medium subangular blocky; firm; few fine roots; few dark concretions (iron and manganese oxides); some very dark grayish brown (2.5Y 3/2) wormcasts; slightly acid; gradual smooth boundary.

B3—28 to 33 inches; olive gray (5Y 5/2) and olive (5Y 5/3) clay loam; common fine faint light olive brown (2.5Y 5/6) and common fine distinct yellowish brown (10YR 5/8) mottles; weak medium prismatic structure parting to weak fine and medium subangular blocky; friable; few dark concretions (iron and manganese oxides); few calcium carbonate accumulations in soft rounded masses and thread-like powdery streaks; strong effervescence; moderately alkaline; gradual smooth boundary.

IIC—33 to 60 inches; olive gray (5Y 5/2) loam; common fine distinct yellowish brown (10YR 5/6) mottles; massive; friable; few dark concretions (iron and manganese oxides); few calcium carbonate concretions in soft rounded masses and thread-like powdery streaks; strong effervescence; moderately alkaline.

The solum thickness and the depth to free carbonates typically are 28 to 45 inches and range from 24 to 50 inches. Clay content in the 10- to 40-inch control section ranges from 30 to 35 percent.

The A horizon is 12 to 24 inches thick. The Ap and A12 horizons are black (N 2/0 or 10YR 2/1). The A3 horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2). The A horizon is clay loam or silty clay loam. Reaction in the A horizon ranges from medium acid to neutral.

The upper part of the B horizon has hue of 10YR or 2.5Y, value of 4, and chroma of 2. The lower part of the B horizon has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 2 to 4. Mottles range from 10YR to 2.5Y in hue, 4 to 6 in value, and 4 to 8 in chroma. Reaction in the B horizon typically is slightly acid or neutral, but in the lower part of the B3 horizon in some pedons, reaction is mildly alkaline or moderately alkaline.

The IIC horizon has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 2 to 4.

Palms series

The Palms series consists of very poorly drained, moderately slowly permeable soils in depressions on uplands. These soils formed in organic material and the underlying silty sediments. They formed under a native vegetation of sedges, reeds, and other water-tolerant grasses. Slopes range from 0 to 1 percent.

The Palms soils are commonly adjacent to Canisteo, Harps, and Okoboji soils. None of these soils contain organic material. Canisteo and Harps soils are calcareous. Canisteo soils are in swales above Palms soils. Harps soils are on rims of depressions surrounding Palms soils. Okoboji soils are on landscape positions similar to those of the Palms soils.

Typical pedon of Palms muck, 0 to 1 percent slopes; 2,340 feet east and 50 feet south of the NW corner of sec. 12, T. 100 N., R. 29 W.

Oa1—0 to 10 inches; black (N 2/0) broken face and rubbed sapric material, about 5 percent fibers, less than 5 percent rubbed, black (10YR 2/1) dry; weak fine and very fine granular structure; slightly sticky; fibers are herbaceous; many fine and few medium densely matted roots; slightly acid; abrupt smooth boundary.

Oa2—10 to 16 inches; black (N 2/0) sapric material, about 5 percent fibers rubbed, black (10YR 2/1) dry; weak fine and medium granular structure; slightly sticky; fibers are herbaceous; many fine roots; many small fragments of undecayed organic matter giving horizon a brownish cast; slightly acid; clear smooth boundary.

Oa3—16 to 23 inches; black (5Y 2/1) sapric material, less than 5 percent rubbed, black (10YR 2/1) dry; weak fine granular structure; very friable; common fine roots; few dark olive gray (5Y 3/2) undecomposed streaks of organic matter; slightly acid; gradual smooth boundary.

Oa4—23 to 28 inches; black (5Y 2/1) sapric material, less than 5 percent fibers rubbed, black (10YR 2/1) dry; massive; friable; few fine roots; few fine tubular pores; few dark concretions (iron oxides); neutral; clear smooth boundary.

IIC1—28 to 36 inches; black (N 2/0) silty clay loam; massive; friable; few fine and medium tubular pores; few fine roots; few fine partially decayed plant stems; neutral; gradual smooth boundary.

IIC2—36 to 46 inches; black (10YR 2/1 and 5Y 2/1) silty clay loam; massive; friable; few fine tubular pores; common fine snail shell fragments; slight effervescence; mildly alkaline; gradual smooth boundary.

IIC3—46 to 60 inches; dark gray (5Y 4/1) and very dark gray (5Y 3/1) silty clay loam; few fine faint gray (5Y 5/1) and few fine distinct olive (5Y 4/4) mottles; massive; friable; few dark concretions (iron and manganese oxides); common fine snail shell fragments; strong effervescence; moderately alkaline.

The Oa horizon typically is about 20 to 32 inches thick but in some pedons is as much as 50 inches thick. It ranges from black (N 2/0 to 10YR 2/1 or 5Y 2/1) to very dark brown (10YR 2/2). Reaction is slightly acid to mildly alkaline.

The IIC horizon ranges from black (N 2/0 to 10YR 2/1 or 5Y 2/1) in the upper part to olive gray (5Y 4/2 to 5Y 5/2) in the lower part. It typically is silty clay loam, but in some pedons it is silt loam, loam, or clay loam. Reaction is neutral to moderately alkaline.

Ridgeport series

The Ridgeport series consists of somewhat excessively drained soils on stream benches. These soils formed in loamy sediments and the underlying sand and gravel. They formed under a native vegetation of grasses. Permeability is moderately rapid in the solum and very rapid in the substratum. Slopes range from 0 to 9 percent.

Ridgeport soils are commonly adjacent to Estherville and Wadena soils. Estherville soils are shallower to calcareous sand and gravel. Wadena soils have more clay in the A and B horizon. These soils are on landscape positions similar to those of the Ridgeport soils.

Typical pedon of Ridgeport sandy loam, 0 to 2 percent slopes; 2,616 feet south and 1,760 feet west of the NE corner of sec. 2, T. 94 N., R. 29 W.

Ap—0 to 8 inches; black (10YR 2/1) sandy loam, very dark gray (10YR 3/1) dry; weak fine and very fine granular structure; friable; common fine and medium roots; neutral; abrupt smooth boundary.

A12—8 to 11 inches; black (10YR 2/1) sandy loam, very dark gray (10YR 3/1) dry; weak fine subangular blocky structure parting to weak fine and very fine granular; friable; few fine roots; neutral; gradual smooth boundary.

B1—11 to 15 inches; dark brown (7.5YR 3/2) and very dark grayish brown (10YR 3/2) sandy loam, grayish brown (10YR 5/2) dry; weak fine subangular blocky structure parting to weak fine granular; friable; few fine roots; few fine pores; slightly acid; gradual smooth boundary.

B21—15 to 19 inches; dark brown (10YR 3/3) and brown (10YR 4/3) sandy loam; very dark grayish brown (10YR 3/2) coatings on faces of peds; few fine faint strong brown (7.5YR 5/6) mottles; weak fine and very fine subangular blocky structure; friable; very few fine roots; few fine gravels; neutral; gradual smooth boundary.

B22—19 to 26 inches; brown (10YR 4/3) sandy loam; very dark grayish brown (10YR 3/2) coatings on faces of peds; weak fine and very fine prismatic structure parting to weak fine subangular blocky; friable; very few fine roots; few dark concretions (iron and manganese oxides); neutral; clear smooth boundary.

B23—26 to 33 inches; brown (10YR 4/3) and dark yellowish brown (10YR 4/4) sandy loam; few fine faint yellowish brown (10YR 5/6) mottles; weak fine and medium prismatic structure; friable; few shale fragments; few dark concretions (iron and manganese oxides); many fine gravels; slightly acid; clear smooth boundary.

IIC—33 to 60 inches; mixed brown (10YR 4/3 and 10YR 5/3) and yellowish brown (10YR 5/6) sand and gravel; single grained; loose; slight effervescence; moderately alkaline.

The solum thickness ranges from about 30 to 40 inches. Reaction in the solum is commonly neutral or slightly acid, but in some pedons the A horizon and the upper part of the B horizon are medium acid. The depth to sand and gravel is commonly between 26 and 36 inches.

The A horizon ranges from 10 to 18 inches in thickness. It is commonly very dark brown (10YR 2/2) or black (10YR 2/1) but ranges to very dark gray (10YR 3/1) and very dark grayish brown (10YR 3/2).

The B horizon has hue of 7.5YR or 10YR, value of 3, 4, or 5, and chroma of 2 through 4. Texture is commonly sandy loam in the B1 and B2 horizons and sandy loam or loamy sand in the B3 horizon.

The IIC horizon is sand and gravel, gravelly sand, or gravelly loamy sand.

Rolfe series

The Rolfe series consists of very poorly drained, slowly permeable soils in upland depressions and stream benches. These soils formed in silty and loamy glacial till sediments under a native vegetation of sedges, reeds, and other water-tolerant grasses. Slopes range from 0 to 1 percent.

Rolfe soils are commonly adjacent to Nicollet and Webster soils. Nicollet and Webster soils are not as poorly drained. They also do not have an A2 horizon. They are on higher lying areas than Rolfe soils.

Typical pedon of Rolfe silt loam, 0 to 1 percent slopes; 1,022 feet east and 2,475 feet south of the NW corner of sec. 35, T. 95 N., R. 29 W.

Ap—0 to 10 inches; black (10YR 2/1) silt loam, dark gray (10YR 4/1) dry; some mixing of dark gray (10YR 4/1) peds in lower part; weak fine and very fine granular structure; friable; common fine roots; few fine tubular pores; few dark concretions (iron oxides); slightly acid; abrupt smooth boundary.

A21—10 to 13 inches; dark gray (10YR 4/1) silt loam, light gray (10YR 6/1), and gray (10YR 5/1) dry; weak medium platy structure parting to weak thin platy; friable; some mixing of black (10YR 2/1) peds in upper part of horizon; few fine roots; few fine tubular pores; few dark concretions (iron oxides); common fine light gray (10YR 7/1) silt coats on faces of peds; slightly acid; abrupt smooth boundary.

A22—13 to 17 inches; dark gray (10YR 4/1) and very dark gray (10YR 3/1) silt loam, light gray (10YR 7/1) and gray (5Y 5/1) dry; weak thick platy structure parting to weak thin and medium platy; friable; few fine roots; few fine and medium tubular pores; few dark concretions (iron oxides); common fine light gray (10YR 7/1) silt coats on faces of peds; slightly acid; clear smooth boundary.

A23—17 to 24 inches; very dark gray (10YR 3/1) and dark gray (10YR 4/1) silt loam, dark gray (5Y 4/1) and light gray (10YR 6/1) dry; weak thick platy structure parting to weak fine and very fine subangular blocky; friable; few fine roots; few fine and medium tubular pores; few dark concretions (iron oxides); common fine light gray (10YR 7/1) silt coats on faces of peds; slightly acid; abrupt wavy boundary.

B21tg—24 to 33 inches; very dark gray (10YR 3/1) and dark gray (10YR 4/1) silty clay; black (10YR 2/1) coatings on faces of peds; few fine faint dark brown (10YR 3/3) mottles; strong fine and very fine angular blocky structure; firm; very few fine tubular pores; few fine roots; thick continuous black (10YR 2/1) clay films; very dark grayish brown (10YR 3/2) stains in vertical root channels; few dark concretions (iron oxides); neutral; gradual smooth boundary.

B22tg—33 to 41 inches; olive gray (5Y 5/2) silty clay; very dark gray (5Y 3/1) and dark gray (5Y 4/1) coatings on faces of peds; moderate fine and very fine angular blocky structure; firm; few fine roots; few fine tubular pores; thick continuous very dark gray (10YR 3/1) clay films; few dark concretions (iron and manganese oxides); neutral; clear smooth boundary.

B23tg—41 to 46 inches; olive gray (5Y 5/2) silty clay loam; very dark gray (5Y 3/1) and dark gray (5Y 4/1) coatings on faces of peds; few fine distinct olive (5Y 5/4) and strong brown (7.5YR 5/6) mottles; weak medium prismatic structure parting to weak fine subangular blocky; firm; few fine roots; few fine tubular pores; few dark concretions (iron and manganese oxides); thin nearly continuous very dark gray (5Y 3/1) clay films; neutral; gradual smooth boundary.

B31tg—46 to 59 inches; olive gray (5Y 5/2) silty clay loam; few fine faint olive (5Y 5/3) and few fine distinct strong brown (7.5YR 5/6) mottles; weak medium prismatic structure; friable; few dark concretions (iron and manganese oxides); few fine calcium carbonate accumulations in soft rounded masses in the lower part of the horizon; thin discontinuous very dark gray (10YR 3/1) clay films; many very dark gray (10YR 3/1) clay films in old root channels; neutral; gradual smooth boundary.

B32tg—59 to 67 inches; gray (5Y 5/1), dark gray (5Y 4/1), and olive gray (5Y 5/2) silty clay loam; few fine prominent brown (7.5YR 5/4) and few fine distinct strong brown (7.5YR 5/6) mottles; weak medium prismatic structure; friable; few dark concretions (manganese oxides); few fine calcium carbonate accumulations in soft rounded masses; neutral; gradual smooth boundary.

Cg—67 to 72 inches; gray (5Y 5/1), dark gray (5Y 4/1), and olive gray (5Y 5/2) clay loam; few fine distinct olive (5Y 5/4) and light olive gray (5Y 6/2) mottles; massive; friable; few dark concretions (iron and manganese oxides); few fine calcium carbonate accumulations in soft rounded masses; slight effervescence in spots; neutral.

The solum thickness and the depth to carbonates range from about 40 to over 60 inches.

The Ap or A1 horizon is 6 to 10 inches thick and is silt loam, loam, or silty clay loam in texture. It is black (10YR 2/1) or very dark gray (10YR 3/1). The A2 horizon is 5 to 15 inches thick and is dark gray (10YR 4/1) and very dark gray (10YR 3/1). The A2 horizon is silt loam or loam. Reaction in the A1 and A2 horizons is slightly acid to medium acid.

The B horizon is very dark gray (10YR 3/1) to olive gray (5Y 5/2). It is silty clay in the upper part and silty clay loam to clay loam in the lower part.

The C horizon typically is clay loam or loam.

Salida series

The Salida series consists of excessively drained, very rapidly permeable soils on upland knolls, outwash plains, and stream benches. These soils formed in loamy and sandy glacial outwash under a native vegetation of grasses. Slopes range from 2 to 25 percent.

Salida soils are similar to Estherville soils and are commonly adjacent to Clarion, Dickman, and Storden soils. Estherville soils have a thicker solum overlying sand and gravel. Clarion and Storden soils formed in loamy glacial till and do not have a sand and gravel substratum. Dickman soils do not have free carbonates and coarse fragments in the solum. These soils are on landscape positions similar to those of the Salida soils.

Typical pedon of Salida gravelly sandy loam, 9 to 25 percent slopes, moderately eroded; 1,800 feet west and 300 feet south of the NE corner of sec. 2, T. 94 N., R. 29 W.

Ap—0 to 8 inches; very dark grayish brown (10YR 3/2), dark brown (10YR 3/3), and brown (10YR 4/3) gravelly sandy loam, dark grayish brown (10YR 4/2) dry; weak medium and coarse granular structure; very friable; common dark reddish brown concretions (iron oxides); common fine roots; slight effervescence; mildly alkaline; clear smooth boundary.

B2—8 to 14 inches; dark yellowish brown (10YR 4/4) gravelly loamy sand; single grained; loose; clay bridging between sand grains; common fine roots; many dark reddish brown concretions (iron oxides); common fine roots; slight effervescence; mildly alkaline; clear smooth boundary.

C1—14 to 40 inches; dark brown (10YR 3/3) and dark yellowish brown (10YR 4/4) sand and gravel; single grained; loose; slight effervescence; mildly alkaline; gradual smooth boundary.

C2—40 to 60 inches; dark brown (10YR 3/3) and dark yellowish brown (10YR 4/4) sand and gravel; single grained; loose; strong efffervescence; moderately alkaline.

The thickness of the solum ranges from 7 to 20 inches. The depth to free carbonates is less than 14 inches, and most pedons are calcareous throughout.

The A horizon is about 7 to 10 inches thick. It is very dark brown (10YR 2/2), very dark grayish brown (10YR 3/2), dark brown (10YR 3/3), or brown (10YR 4/3).

The B horizon has hue of 10YR, value of 3 or 4, and chroma of 3 or 4. It is gravelly sandy loam or gravelly loamy sand. Reaction ranges from neutral to moderately alkaline in the A and B horizons.

The C horizon typically has hue of 10YR, value of 3 to 6, and chroma of 2 to 4.

Spicer series

The Spicer series consists of poorly drained, moderately permeable soils. These soils are in upland swales. They formed in calcareous silty lacustrine sediments under a native vegetation of water-tolerant grasses. Slopes range from 0 to 2 percent.

Spicer soils are commonly adjacent to Corwith, Fieldon, Kingston, and Waldorf soils. Corwith and Fieldon soils contain more sand throughout than the Spicer soils. Kingston soils have a browner B horizon and are better drained. Waldorf soils are not calcareous in the A horizon and in the upper part of the B horizon. Corwith and Kingston soils are on slightly higher lying areas than Spicer soils. Fieldon and Waldorf soils are on landscape positions similar to those of the Spicer soils.

Typical pedon of Spicer silty clay loam, 0 to 2 percent slopes; 575 feet south and 30 feet west of the NE corner of sec. 33, T. 95 N., R. 28 W.

Ap—0 to 9 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; weak fine granular structure; friable; few fine snail shell fragments; strong effervescence; mildly alkaline; abrupt smooth boundary.

A12—9 to 14 inches; black (10YR 2/1) and very dark gray (10YR 3/1) silt loam; very dark gray (10YR 3/1) and dark gray (10YR 4/1) dry; weak fine granular structure; friable; few fine snail shell fragments; strong effervescence; mildly alkaline; gradual smooth boundary.

A3—14 to 19 inches; black (10YR 2/1) and very dark gray (10YR 3/1) silt loam, dark gray (10YR 4/1) dry; common fine distinct olive (5Y 5/3) mottles; weak fine subangular blocky structure parting to weak fine and very fine granular; friable; strong effervescence; moderately alkaline; clear wavy boundary.

B21g—19 to 26 inches; dark gray (5Y 4/1) and olive gray (5Y 5/2) silt loam; many fine distinct olive (5Y 5/3) and few fine prominent strong brown (7.5YR 5/8) mottles; weak fine and medium subangular blocky structure; friable; few dark concretions (manganese oxides); strong effervescence; moderately alkaline; clear smooth boundary.

B22gca—26 to 33 inches; olive gray (5Y 5/2) light silty clay loam; few fine prominent strong brown (7.5YR 5/8) mottles; weak medium and fine subangular blocky structure; friable; common fine calcium carbonate accumulations in soft rounded masses; few dark concretions (manganese oxides); violent effervescence; moderately alkaline; gradual smooth boundary.

B3gca—33 to 42 inches; olive gray (5Y 5/2) light silty clay loam; common medium prominent strong brown (7.5YR 5/6) mottles; weak medium and fine subangular blocky structure; friable; common fine calcium carbonate accumulations in soft rounded masses; few dark concretions (manganese oxides); violent effervescence; moderately alkaline; gradual smooth boundary.

Cgca—42 to 60 inches; olive gray (5Y 5/2) and light olive gray (5Y 6/2) silt loam; common fine faint olive (5Y 5/3) and few fine prominent strong brown (7.5YR 5/8) mottles; massive; friable; common fine calcium carbonate accumulations in soft rounded masses; few dark concretions (manganese oxides); violent effervescence; moderately alkaline.

The thickness of the solum ranges from about 30 to 46 inches. Reaction in the solum is mildly or moderately alkaline.

The A horizon is 12 to 18 inches thick. It is mostly black (10YR 2/1) and very dark gray (10YR 3/1) but in a few pedons is black (N 2/0). Texture is silty clay loam or silt loam.

The B horizon has hue of 5Y, value of 4 and 5, and chroma of 1 or 2. Texture is silt loam or silty clay loam.

The C horizon is silt loam or silty clay loam. It has hue of 5Y, value of 5 or 6, and chroma of 1 or 2.

Spillville series

The Spillville series consists of moderately well drained and somewhat poorly drained, moderately permeable soils on bottom lands and foot slopes. These soils formed in loamy alluvium under a native vegetation of grasses. Slopes range from 0 to 5 percent.

Spillville soils are commonly adjacent to Coland, Colo, and Zook soils. Coland soils contain more clay in the solum. Colo and Zook soils contain less sand and more clay. These soils are poorly drained and are on lower lying areas on the bottom lands.

Typical pedon of Spillville loam, 0 to 2 percent slopes; 1,240 feet west and 1,920 feet north of the SE corner of sec. 35, T. 95 N., R. 29 W.

Ap—0 to 9 inches; black (10YR 2/1) loam with some very dark brown (10YR 2/2), very dark gray (10YR 3/1) dry; weak fine and very fine subangular blocky structure; friable; few fine roots; few dark concretions (iron oxides); neutral; abrupt smooth boundary.

A12—9 to 17 inches; black (10YR 2/1) loam, very dark brown (10YR 2/2) dry; weak fine subangular blocky structure parting to weak fine and very fine granular; friable; few fine roots; few fine tubular pores; few dark concretions (iron and manganese oxides); neutral; gradual smooth boundary.

A13—17 to 34 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak medium prismatic structure parting to weak fine and very fine subangular blocky; friable; few fine roots; few fine tubular pores; few dark concretions (iron oxides); neutral; gradual smooth boundary.

A14—34 to 39 inches; black (10YR 2/1) and very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) dry; weak medium prismatic structure parting to weak fine subangular blocky; friable; few fine roots; few fine tubular pores; few dark concretions (iron oxides); neutral; gradual smooth boundary.

AC—39 to 51 inches; very dark gray (10YR 3/1) fine sandy loam, gray (10YR 5/1) dry; few fine faint very dark grayish brown (10YR 3/2) mottles; weak medium prismatic structure; friable; few fine tubular pores; few dark concretions (iron and manganese oxides); neutral; gradual smooth boundary.

C—51 to 60 inches; very dark gray (10YR 3/1) fine sandy loam; few medium faint very dark grayish brown (10YR 3/2) mottles; massive; very friable; few fine tubular pores; neutral.

The solum thickness ranges from about 30 to 56 inches. The depth to carbonates typically is more than 48 inches. Reaction is commonly neutral or slightly acid throughout the profile.

The A horizon is commonly black (10YR 2/1) or very dark brown (10YR 2/2), but it ranges to very dark gray (10YR 3/1) in the lower part. It is 30 to 56 inches thick.

The C horizon typically is very dark gray (10YR 3/1) but ranges to very dark grayish brown (10YR 3/2 or 2.5Y 3/2), dark gray (10YR 4/1), or dark grayish brown (10YR 4/2 or 2.5Y 4/2). It is loam, sandy loam, or clay loam.

Storden series

The Storden series consists of well drained, moderately permeable soils on convex upland knobs and side slopes. These soils formed in glacial till under a native vegetation of grasses. Slopes range from 5 to 40 percent.

In Kossuth County, the Storden soils in map units 62C2, 62F, 62G, and 638B differ from Storden soils in other places by having a darker colored surface layer than that described for the series.

Storden soils are commonly adjacent to Clarion, Dickman, Lester, and Salida soils. Clarion and Dickman soils have a thicker A horizon than the Storden soils and are not calcareous. Dickman soils are higher in sand content throughout. Lester soils have a B2t horizon and are not calcareous in the solum. Salida soils contain more sand and gravel in the B and C horizons. These soils are on landscape positions similar to those of the Storden soils.

Typical pedon of Storden loam, 9 to 14 percent slopes, moderately eroded; 78 feet east and 1,370 feet north of the SW corner of sec. 4, T. 96 N., R. 29 W.

Ap—0 to 8 inches, very dark grayish brown (10YR 3/2) and brown (10YR 4/3) loam, dark grayish brown (10YR 4/2) and brown (10YR 5/3) dry; mixed with some lumps and pieces of light olive brown (2.5Y 5/4) substratum material; weak fine and medium granular structure; friable; common fine roots; few pebbles; slight effervescence; moderately alkaline; abrupt smooth boundary.

C1ca—8 to 13 inches; light olive brown (2.5Y 5/4) and yellowish brown (10YR 5/4) loam; few fine prominent brown (7.5YR 4/4) and few fine distinct yellowish brown (10YR 5/6 and 5/8) mottles; weak medium subangular blocky structure parting to weak fine and very fine subangular blocky; friable; common fine roots; few pebbles; common fine and few medium calcium carbonate accumulations in soft rounded masses; few fine tubular pores; common dark concretions (iron oxides); strong effervescence; moderately alkaline; clear smooth boundary.

C2ca—13 to 19 inches; yellowish brown (10YR 5/4) and grayish brown (2.5Y 5/2) loam; common medium distinct yellowish brown (10YR 5/6) and few fine prominent strong brown (7.5YR 5/8) mottles; massive; friable; few fine roots; few fine tubular pores; common fine calcium carbonate accumulations in soft rounded masses; few fine calcium carbonate accumulations in thread-like streaks along cleavage planes; common dark concretions (iron and manganese oxides); strong effervescence; moderately alkaline; gradual smooth boundary.

C3ca—19 to 60 inches; brown (10YR 5/3) and grayish brown (10YR 5/2) loam; massive; friable; few fine tubular pores; common dark concretions (iron oxides); common fine calcium carbonate accumulations in soft rounded masses; strong effervescence; moderately alkaline.

The thickness of the solum generally is the same as the thickness of the A horizon and ranges from about 3 to 10 inches.

The A horizon is very dark brown (10YR 2/2), very dark gray (10YR 3/1), very dark grayish brown (10YR 3/2), or dark brown (10YR 3/3) loam or clay loam. Eroded pedons typically have an Ap horizon that is very dark grayish brown (10YR 3/2), dark brown (10YR 3/3), brown (10YR 4/3), or yellowish brown (10YR 5/4).

Some pedons have an AC horizon that is brown (10YR 4/3), dark yellowish brown (10YR 4/4), or yellowish brown (10YR 5/4) up to 6 inches thick.

The C horizon has hue of 10YR or 2.5Y, value of 5 or 6, and chroma of 2 through 6.

Talcot series

The Talcot series consists of poorly drained soils on stream benches and outwash areas on uplands. These soils formed in loamy sediments and the underlying sand and gravel. They formed under a native vegetation of water-tolerant grasses. Permeability is moderate in the solum and rapid in the substratum. Slopes range from 0 to 2 percent.

Talcot soils are similar to Biscay and Mayer soils and are commonly adjacent to Biscay and Harcot soils. Unlike Talcot soils, Biscay soils do not have free carbonates in the upper part of the solum. Mayer soils contain less clay in the solum than the Talcot soils. Harcot soils have a higher content of free carbonates. These soils are on landscape positions similar to those of the Talcot soils.

Typical pedon of Talcot clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes; 1,420 feet south and 57 feet east of the NW corner of sec. 26, T. 95 N., R. 27 W.

Ap—0 to 8 inches; black (N 2/0) clay loam, black (10YR 2/1) dry; weak fine granular structure; friable; common fine roots; few fine snail shells; violent effervescence; mildly alkaline; abrupt smooth boundary.

A12—8 to 16 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) dry; weak medium granular structure parting to weak fine granular; friable; few fine roots; few fine snail shells; few fine pores; violent effervescence; mildly alkaline; gradual smooth boundary.

A3—16 to 23 inches; very dark gray (10YR 3/1) clay loam; dark gray (10YR 4/1) dry; weak fine subangular blocky structure parting to weak very fine granular; friable; some olive gray (5Y 4/2) wormcasts; few fine roots; few fine pores; slight effervescence; mildly alkaline; gradual wavy boundary.

B21g—23 to 31 inches; olive gray (5Y 4/2) with tongues of very dark gray (10YR 3/1) clay loam; few fine distinct yellowish brown (10YR 5/8) mottles; weak fine subangular blocky structure; friable; few fine roots; about 5 percent gravel; few dark concretions (iron and manganese oxides); few fine calcium carbonate accumulations in soft rounded masses and few calcium carbonate coatings on some of the gravels; slight effervescence; moderately alkaline; clear smooth boundary.

B22g—31 to 40 inches; olive gray (5Y 5/2) clay loam; few fine distinct light olive brown (2.5Y 5/6) mottles; weak medium subangular blocky structure; friable; few fine roots; about 10 percent gravel; few dark concretions (iron and manganese oxides); few fine calcium carbonate accumulations in soft rounded masses; few calcium carbonate coatings on some of the gravels; violent effervescence; mildly alkaline; abrupt smooth boundary.

IIC—40 to 60 inches; olive gray (5Y 5/2 and 5Y 4/2) sand and gravel; single grained; loose; about 50 percent gravel; violent effervescence; mildly alkaline.

The thickness of the solum and the depth to the IIC horizon range from 32 to 40 inches. Reaction in the solum is mildly alkaline or moderately alkaline.

The A horizon is about 14 to 24 inches thick. Typically, it ranges from black (N 2/0 or 10YR 2/1) to very dark gray (10YR 3/1 or N 3/0). In some pedons it has hue of 5Y. The texture in this horizon ranges from clay loam to silty clay loam.

The B horizon ranges from dark gray (5Y 4/1) to olive gray (5Y 5/2). The texture of the B horizon typically is clay loam, but it ranges to loam or sandy clay loam in the lower part of some pedons.

The C horizon has hue of 5Y or 2.5Y, value of 4 or 5, and chroma of 2 through 6.

Truman series

The Truman series consists of well drained, moderately permeable soils on convex upland slopes. These soils formed in silty sediments under a native vegetation of grasses. Slopes range from 2 to 5 percent.

Truman soils are commonly adjacent to Dickman, Fostoria, and Kingston soils. Dickman and Fostoria soils contain more sand throughout than the Truman soils. Fostoria and Kingston soils have a grayer B horizon than the Truman soils and are not as well drained. Dickman soils are on landscape positions similar to those of the Truman soils. Fostoria and Kingston soils are on slightly concave slopes below Truman soils.

Typical pedon of Truman silt loam, 2 to 5 percent slopes; 380 feet west and 1,530 feet south of the NE corner of sec. 9, T. 100 N., R. 28 W.

Ap—0 to 10 inches; very dark brown (10YR 2/2) silt loam, very dark gray (10YR 3/1) dry; black (10YR 2/1) coatings on faces of peds; weak fine and very fine granular structure; friable; few fine roots; neutral; abrupt smooth boundary.

A3—10 to 17 inches; dark brown (10YR 3/3) and very dark grayish brown (10YR 3/2) silt loam, dark grayish brown (10YR 4/2) and brown (10YR 4/3) dry; very dark grayish brown (10YR 3/2) and very dark gray (10YR 3/1) coatings on faces of peds; weak fine subangular blocky structure parting to weak fine granular; friable; neutral; gradual smooth boundary.

B1—17 to 22 inches; brown (10YR 4/3) and dark yellowish brown (10YR 4/4) silt loam; very dark grayish brown (10YR 3/2) coatings on faces of peds; weak medium subangular blocky structure; friable; neutral; gradual smooth boundary.

B21—22 to 32 inches; dark yellowish brown (10YR 4/4) silt loam; weak coarse subangular blocky structure; friable; few fine tubular pores; few dark concretions (manganese oxides); mildly alkaline; gradual smooth boundary.

B22—32 to 41 inches; yellowish brown (10YR 5/4) silt loam; few fine distinct light brownish gray (10YR 6/2) mottles; weak coarse subangular blocky structure; friable; few dark concretions (iron and manganese oxides); slight effervescence; mildly alkaline; gradual wavy boundary.

Cca—41 to 60 inches; yellowish brown (10YR 5/4) silt loam; common coarse faint yellowish brown (10YR 5/8) mottles; massive; friable; few fine tubular pores; common fine to medium light brownish gray (10YR 6/2) calcium carbonate accumulations in soft rounded masses and in streaks; strong effervescence; moderately alkaline.

The thickness of the solum and the depth to free carbonates range from 38 to 56 inches.

The A horizon is 10 to 18 inches thick and is black (10YR 2/1), very dark brown (10YR 2/2), very dark grayish brown (10YR 3/2), or dark brown (10YR 3/3). It is neutral to slightly acid in reaction.

The B horizon ranges from silt loam to silty clay loam. The upper B horizon is brown (10YR 4/3), dark yellowish brown (10YR 4/4), or yellowish brown (10YR 5/4). The lower part of the B horizon is dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4 or 5/6).

The C horizon typically is silt loam, but in some pedons it is high in very fine sand. It is mildly or moderately alkaline in reaction.

Wacousta series

The Wacousta series consists of very poorly drained, moderately permeable soils in upland depressions. These soils formed in silty lacustrine sediments under water-tolerant grasses. Slopes range from 0 to 1 percent.

Wacousta soils are commonly adjacent to Canisteo, Harps, and Okoboji soils. Canisteo and Harps soils contain more sand than Wacousta soils and are calcareous. Okoboji soils have a thicker A horizon and contain more clay in the B horizon. Canisteo soils are in swales above Wacousta soils. Harps soils are on rims of depressions above Wacousta soils. Okoboji soils are in landscape positions similar to those of the Wacousta soils.

Typical pedon of Wacousta silty clay loam, 0 to 1 percent slopes; 2,040 feet south and 2,560 feet east of the NW corner of sec. 24, T. 97 N., R. 28 W.

Ap—0 to 8 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; weak fine granular structure; friable; few fine roots; neutral; abrupt smooth boundary.

A12—8 to 12 inches; black (10YR 2/1) and very dark gray (10YR 3/1) silty clay loam, very dark gray (10YR 3/1) and dark gray (10YR 4/1) dry; weak fine granular structure; friable; some mixing of olive gray (5Y 5/2) in the lower part; few fine roots; few fine pores; neutral; abrupt wavy boundary.

Bg—12 to 14 inches; olive gray (5Y 5/2) and dark gray (5Y 4/1) silty clay loam; few fine faint olive (5Y 5/3) mottles; weak fine subangular blocky structure; friable; few fine roots; few fine pores; few dark concretions (iron and manganese oxides); neutral; clear smooth boundary.

C1g—14 to 20 inches; olive gray (5Y 5/2) and olive (5Y 5/3) silty clay loam; few fine distinct light olive brown (2.5Y 5/4 and 5/6) mottles; massive; friable; few fine roots; few fine pores; few dark concretions (iron and manganese oxides); few fine calcium carbonate accumulations in soft rounded masses; violent effervescence; moderately alkaline; clear smooth boundary.

C2g—20 to 25 inches; olive gray (5Y 5/2) silt loam; few fine prominent yellowish brown (10YR 5/6) mottles; few fine roots; few fine to medium pores; few dark concretions (iron and manganese oxides); few calcium carbonate accumulations in soft rounded masses; violent effervescence; moderately alkaline; gradual smooth boundary.

C3g—25 to 41 inches; olive gray (5Y 5/2) silt loam with very fine sandy loam strata; common fine to coarse prominent yellowish brown (10YR 5/8) mottles; massive; very friable; few fine pores; few dark concretions (iron and manganese oxides); few fine calcium carbonate accumulations in soft rounded masses; violent effervescence; moderately alkaline; effervescence; gradual smooth boundary.

C4g—41 to 60 inches; gray (5Y 5/1) and olive gray (5Y 5/2) clay loam; many fine prominent light olive brown (2.5Y 5/4) and few fine prominent strong brown (7.5YR 5/8) mottles; few fine pores; common dark concretions (iron and manganese oxides); few calcium carbonate accumulations in thread-like streaks; violent effervescence; moderately alkaline.

The solum thickness ranges from 10 to 24 inches. The depth to free carbonates ranges from about 12 to 20 inches.

The A horizon ranges from silt loam to silty clay loam and is about 8 to 18 inches thick. Reaction in the A horizon is neutral or mildly alkaline.

The Bg horizon ranges from very dark gray (10YR 3/1) to olive gray (5Y 5/2) or gray (5Y 5/1). It is silt loam or silty clay loam.

The C horizon typically is silty clay loam and silt loam but has stratified layers that include very fine sandy loam to about 40 inches. Texture typically is loam or clay loam below a depth of 40 inches.

Wadena series

The Wadena series consists of well drained soils on upland outwash areas and stream benches. These soils formed in loamy glacial outwash overlying sand and gravel. Permeability is moderate in the loamy material and very rapid in the underlying sand and gravel. Slopes range from 0 to 5 percent.

Wadena soils are commonly adjacent to Cylinder, Estherville, Linder, and Ridgeport soils. Cylinder and Linder soils have a grayer upper B horizon and are not as well drained. They are on lower lying areas below Wadena soils. Estherville and Ridgeport soils have less clay in the A and upper B horizons. They are on landscape positions similar to those of the Wadena soils.

Typical pedon of Wadena loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes; 1,320 feet south and 1,480 feet west of the NE corner of sec. 23, T. 95 N., R. 27 W.

Ap—0 to 9 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak fine and very fine granular structure; very friable; slightly acid; abrupt smooth boundary.

A12—9 to 13 inches; black (10YR 2/1) and very dark brown (10YR 2/2) loam, very dark gray (10YR 3/1) and very dark grayish brown (10YR 3/2) dry; weak fine and very fine granular structure; very friable; slightly acid; gradual smooth boundary.

A3—13 to 16 inches; very dark brown (10YR 2/2) and very dark grayish brown (10YR 3/2) loam, very dark grayish brown (10YR 3/2) and dark grayish brown (10YR 4/2) dry; weak fine subangular blocky structure parting to weak fine and very fine granular; very friable; slightly acid; clear wavy boundary.

B21—16 to 22 inches; dark yellowish brown (10YR 4/4) loam; weak medium and fine subangular blocky structure; very friable; few fine gravels; slightly acid; clear smooth boundary.

B3—22 to 27 inches; dark yellowish brown (10YR 4/4) sandy loam; weak medium subangular blocky structure; very friable; about 5 percent gravel; neutral; gradual smooth boundary.

IIC1—27 to 32 inches; dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4) sand and gravel; single grained; loose; slight effervescence; mildly alkaline; gradual smooth boundary.

IIC2—32 to 60 inches; mixed grayish brown (10YR 5/2) and brown (10YR 5/3) sand and gravel; single grained; loose; strong effervescence; mildly alkaline.

The thickness of the solum is 24 to 40 inches. The depth to free carbonates ranges from about 30 to 46 inches.

The A horizon ranges from 12 to 18 inches thick. It ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2). Reaction in the A horizon is slightly acid or neutral.

The B horizon ranges from dark brown (10YR 3/3) to dark yellowish brown (10YR 4/4) in the upper part and is brown (10YR 4/3 to 7.5YR 4/4) to yellowish brown (10YR 5/4) in the lower part. It ranges from loam to gravelly sandy loam. Reaction in the B horizon typically is neutral to slightly acid.

The IIC horizon typically has hue of 10YR, value of 4 through 6, and chroma of 2 through 4.

Waldorf series

The Waldorf series consists of poorly drained, moderately slowly permeable soils on glacial lake plains. These soils formed in clayey and silty lacustrine sediments under a native vegetation of water-tolerant grasses. Slopes range from 0 to 2 percent.

Waldorf soils are similar to Kossuth soils and are commonly adjacent to Kingston, Ottosen, and Spicer soils. Kossuth and Ottosen soils contain more sand in the A and B horizons than the Waldorf soils. Kingston and Ottosen soils have a browner B horizon than the Waldorf soils and are not a poorly drained. Spicer soils are calcareous. Kossuth and Spcier soils are on landscape positions similar to those of the Waldorf soils. Kingston and Ottosen soils are slightly higher on the landscape than Waldorf soils.

Typical pedon of Waldorf silty clay, silty substratum, 0 to 2 percent slopes; 642 feet south and 12 feet east of the NW corner of sec. 11, T. 100 N., R. 27 W.

Ap—0 to 10 inches; black (10YR 2/1) silty clay, very dark gray (10YR 3/1) dry; black (N 2/0) coatings on faces of peds; moderate fine granular structure; firm; few fine roots; neutral; abrupt smooth boundary.

A12—10 to 17 inches; black (5Y 2/1) silty clay, very dark gray (10YR 3/1) dry; moderate fine granular structure with some moderate very fine subangular blocky in the lower part; firm; few fine roots; neutral; clear smooth boundary.

A3—17 to 21 inches; very dark gray (5Y 3/1) silty clay, dark gray (5Y 4/1) dry; black (5Y 2/1) coatings on faces of peds; moderate fine granular and very fine subangular blocky structure; firm; few fine roots; neutral; clear smooth boundary.

B21g—21 to 26 inches; olive gray (5Y 4/2) silty clay; very dark gray (5Y 3/1) and black (5Y 2/1) coatings on faces of peds; weak fine and medium prismatic structure parting to moderate fine and very fine angular; firm; few fine roots; neutral; clear smooth boundary.

B22g—26 to 35 inches; olive gray (5Y 5/2) silty clay; olive gray (5Y 4/2) coatings on faces of peds; few fine faint light olive brown (2.5Y 5/4) mottles; weak medium prismatic structure parting to moderate fine angular blocky; firm; few fine roots; neutral; clear smooth boundary.

B3g—35 to 42 inches; olive gray (5Y 5/2) silty clay loam; common fine distinct yellowish brown (10YR 5/6) mottles; weak fine subangular and angular blocky structure; friable; few fine tubular pores; slight effervescence; moderately alkaline; clear smooth boundary.

Cg—42 to 60 inches; light olive gray (5Y 6/2) and olive gray (5Y 5/2) silt loam; common fine distinct yellowish brown (10YR 5/6) mottles; massive; few fine tubular pores; few dark concretions (manganese oxides); strong effervescence; moderately alkaline.

The solum thickness ranges from 32 to 48 inches. The depth to carbonates ranges between 32 and 55 inches. The mollic epipedon ranges between 16 and 24 inches in thickness.

The A horizon has hue of 10YR, 2.5Y, or 5Y, value of 2 or 3, and chroma of 0 or 1. It is silty clay or silty clay loam. Reaction is neutral or slightly acid.

The B horizon has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 or 2. Texture ranges from silty clay to silty clay loam. The B horizon ranges in reaction from neutral in the upper part to moderately alkaline in the B3 horizon.

The C horizon has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 1 or 2. It is silt loam or silty clay loam. Reaction is mildly to moderately alkaline.

Webster series

The Webster series consists of poorly drained, moderately permeable soils on upland swales. These soils formed in glacial sediments and glacial till under a native vegetation of water-tolerant grasses. Slopes range from 0 to 2 percent.

Webster soils are similar to Canisteo and Kossuth soils and are commonly adjacent to Canisteo, Clarion, Harps, Nicollet, and Rolfe soils. Kossuth soils have more clay in the A and upper B horizon. Canisteo and Harps soils are calcareous throughout the solum. Nicollet soils have a browner B horizon and are not as poorly drained. Rolfe soils have a gray A2 horizon and are more poorly drained. Canisteo soils are on landscape positions similar to those of the Webster soils. Clarion and Nicollet soils are on higher lying areas. Harps soils are nearby on rims of depressions. Rolfe soils are in depressions below Webster soils.

Typical pedon of Webster silty clay loam, 0 to 2 percent slopes; 1,279 feet south and 280 feet west of the NE corner of sec. 13, T. 97 N., R. 30 W.

Ap—0 to 8 inches; black (N 2/0) silty clay loam, black (10YR 2/1) dry; weak fine granular structure; friable; neutral; abrupt smooth boundary.

A12—8 to 15 inches; black (N 2/0) silty clay loam, black (5Y 2/1) dry; weak fine and very fine granular structure; friable; neutral; clear smooth boundary.

A3—15 to 19 inches; black (10YR 2/1) and very dark gray (10YR 3/1) silty clay loam, very dark gray (10YR 3/1) and dark gray (10YR 4/1) dry; weak very fine subangular blocky structure parting to weak fine and very fine granular; friable; few fine tubular pores; neutral; clear smooth boundary.

B21g—19 to 23 inches; olive gray (5Y 4/2 and 5/2) silty clay loam; very dark gray (5Y 3/1) and dark olive gray (5Y 3/2) coatings on faces of peds; few fine faint olive (5Y 5/3) mottles; weak fine subangular blocky structure parting to weak very fine subangular blocky; friable; few fine tubular pores; few dark concretions (iron and manganese oxides); neutral; gradual smooth boundary.

B22g—23 to 29 inches; olive gray (5Y 5/2) and gray (5Y 5/1) clay loam; dark olive gray (5Y 3/2) and olive gray (5Y 4/2) coatings on faces of peds; few fine faint olive (5Y 5/4) mottles; weak fine prismatic structure parting to weak fine and very fine subangular blocky; friable; few fine tubular pores; few dark concretions (iron and manganese oxides); few fine calcium carbonate accumulations in soft rounded masses in lower part; neutral; gradual smooth boundary.

B3g—29 to 38 inches; olive gray (5Y 5/2) clay loam; common fine faint olive (5Y 5/3) and pale olive (5Y 6/3) and a few fine distinct light olive brown (2.5Y 5/6) mottles; weak medium prismatic structure parting to weak fine and medium subangular blocky; friable; few fine tubular pores; few dark concretions (iron and manganese oxides); few fine and medium calcium carbonate accumulations in soft rounded masses; moderately alkaline; strong effervescence; gradual smooth boundary.

Cg—38 to 60 inches; olive gray (5Y 5/2) and light olive gray (5Y 6/2) loam; common fine distinct light olive brown (2.5Y 5/6), few fine prominent dark reddish brown (5Y 3/3), and common fine distinct strong brown (7.5YR 5/8) mottles; massive; friable; few fine tubular pores; few dark concretions (iron and manganese oxides); common fine to medium calcium carbonate accumulations in soft rounded masses; moderately alkaline; strong effervescence.

The thickness of the solum typically ranges from 24 to 50 inches. The depth to free carbonates ranges from 26 to 46 inches.

The A horizon is 16 to 24 inches thick. The Ap and A1 horizons are black (N 2/0 or 10YR 2/1), and the A3 horizon is black (N 2/0 or 10YR 2/1) to very dark gray (N 3/0 or 10YR 3/1). Color value of 3 does not extend below 24 inches except as discontinuous coatings on faces of peds.

The B horizon ranges from dark grayish brown (2.5Y 4/2) to dark gray (5Y 4/1) and gray (5Y 5/1) or olive gray (5Y 5/2). Texture in the B horizon is clay loam or silty clay loam.

The C horizon is similar in color to the B horizon except that colors of light olive gray (5Y 6/2) and olive (5Y 5/3) are in some pedons.

Zook series

The Zook series consists of poorly drained, slowly permeable soils on bottom lands. These soils formed in silty and clayey alluvium under a native vegetation of water-tolerant grasses. Slopes range from 0 to 2 percent.

Zook soils are similar to Colo and Okoboji soils and are commonly adjacent to Calco, Coland, Colo, and Spillville soils. Colo soils contain less clay in the solum. Okoboji soils have a thinner A horizon. Calco soils contain less clay and are calcareous. Coland soils contain less clay and more sand. These soils are on landscape positions similar to those of the Zook soils.

Typical pedon of Zook silty clay loam, 0 to 2 percent slopes; 2,800 feet south and 60 feet west of the NE corner of sec. 10, T. 95 N., R. 29 W.

Ap—0 to 6 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; weak fine and very fine granular structure; friable; neutral; abrupt smooth boundary.

A12—6 to 12 inches; black (N 2/0) silty clay loam, black (10YR 2/1) and very dark gray (10YR 3/1) dry; weak fine and very fine granular structure; friable; neutral; gradual smooth boundary.

A13—12 to 24 inches; black (N 2/0) silty clay loam, very dark gray (10YR 3/1) dry; moderate medium and fine granular structure; firm; slightly acid; gradual smooth boundary.

A3—24 to 38 inches; black (N 2/0) silty clay, very dark gray (10YR 3/1) dry; moderate medium prismatic structure parting to moderate fine subangular and angular blocky; firm; neutral; gradual smooth boundary.

B21—38 to 45 inches; black (10YR 2/1) and very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; moderate medium prismatic structure parting to moderate fine and medium angular blocky; firm; neutral; gradual smooth boundary.

B22—45 to 60 inches; very dark gray (10YR 3/1) silty clay loam, gray (10YR 5/1) dry; few fine distinct gray (10YR 5/1) mottles; weak coarse prismatic structure parting to moderate medium angular blocky; firm; neutral.

The solum thickness ranges from about 45 inches to more than 60 inches. The depth to carbonates is generally more than 50 inches.

The A horizon ranges from 30 to 40 inches in thickness. Its color ranges from black (N 2/0 or 10YR 2/1) to very dark gray (10YR 3/1). Texture ranges from silty clay loam in the upper part to silty clay in the lower part.

Color in the B horizon ranges from very dark gray (10YR 3/1) to black (10YR 2/1).

Formation of the soils

In this section the factors that affect the formation of soils in Kossuth County are discussed, and the processes of soil horizon differentiation are explained.

Factors of soil formation

Soil is produced by soil-forming processes acting on materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point in time 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 topography, and (5) the length of time the forces of soil formation have acted on the soil material. Human activities also affect soil formation.

The active factors of soil formation are climate and plant and animal life. These factors act on the parent material and slowly develop it into a natural body that has genetically related horizons. The effects of plant and animal life are tempered by relief. The parent material also affects the kind of soil profile that is formed and in extreme cases determines it almost entirely. Finally, time is needed for a soil profile to develop from the parent material. It may be short or long, but some time is always required for the differentiation of soil horizons. Usually a long time is required for distinct horizons to develop.

These factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effects of any one unless conditions are specified for the other four. Additionally, many of the processes of soil development are unknown.

Parent material

Soils in Kossuth County developed in glacial till, glacial outwash, alluvium, organic deposits, wind- or water-deposited sand, and lacustrine sediments. The bedrock beneath these materials has been buried so deeply that it has had no influence on the soils.

Kossuth County has been subjected to three major glaciations: the Nebraskan, the Kansan, and the Wisconsin. In Kossuth County, the Kansan and Nebraskan tills have been removed by subsequent glaciation, or they are buried and not observable.

Kossuth County lies within the area covered by the Des Moines lobe of the Late Wisconsin Glaciation (*20*). It was formerly believed that the Des Moines lobe was laid down in two substages, the Cary and the Mankato (*10,9*). According to this view, Kossuth County would lie within the Mankato Substage, which is the youngest or most recent substage. More recent evidence, however, indicates that most if not all of the Des Moines lobe in Iowa is of Cary age (*10,11*). Two major end moraines of the Cary Substage extend into Kossuth County (*10*). The Algona moraine is prominent, extending from east to west across the county. It marks a distinct change of elevation, the northern part being several feet higher than the southern part. The Humboldt moraine extends across the southwest corner of the county. Radiocarbon dating has indicated that the Cary Substage was being deposited about 13,000 years ago (*3*). Evidence for the relative recency of the Cary Substage is the absence of deep weathering, the presence of unleached calcareous till at a shallow depth, the very poorly organized surface drainage, and the presence of many closed depressions. The following paragraphs discuss the different kinds of parent material and how it relates to some of the soils.

Glacial till. The major soils that formed in glacial till are the Clarion, Nicollet, and Storden soils. Salida soils formed in morainic areas where sandy and gravelly knobs are surrounded by glacial till. The Canisteo and Webster soils formed in glacial till and in glacial till sediments or in reworked glacial till overlying till (*21*). Okoboji and Rolfe soils formed in glacial till sediments.

In a few places, road cuts and other construction activities have exposed the unweathered till. This is often referred to locally as "blue clay." It is a firm, calcareous loam or clay loam and contains pebbles, boulders, and sand, as well as silt and clay. It is a heterogeneous mixture and shows little evidence of sorting or stratification.

Outwash. Outwash materials deposited by glacial melt water are an important part of Kossuth County's geologic deposits. Extensive deposits of sand and gravel are on benches along the East Fork Des Moines River. Similar deposits of lesser extent and depth are along other streams. Algona outwash spreads from the terminus of the Algona end moraine (*10*). The most extensive deposits are near Whittemore and St. Benedict. The Biscay, Cylinder, Estherville, Hanska, Lemond, Linder, Mayer, Talcot, and Wadena soils developed in outwash materials.

Alluvium. This consists of sediment that has been deposited along major and minor streams and drainageways, as well as at the base of some steep slopes. The alluvium varies widely in texture because of differences in material from which the alluvium came and in the manner in which it was deposited. In Kossuth County, the main source of alluvium has been glacial till.

Some of the alluvial material has been transported only short distances and is called local alluvium. Such alluvium retains many of the characteristics of the soils from which it has washed. Sloping Spillville soils, for example, are at the base of slopes below soils that formed in glacial till.

As the rivers and streams overflow their channels, the coarse textured or sandy material is deposited first, adjacent to the stream. As the water spreads outward toward the uplands, it moves more slowly, and silt and very fine sand are deposited. During high floods, the water spreads slowly toward the outer border of the flood plains and carries particles of very fine silt and clay. These particles have settled over the years, and soils have formed in them.

This pattern is repeated in many places, especially on the bottom of the East Fork Des Moines River. Spillville soils, especially the Spillville loam, channeled, are composed of the coarser textured and generally most recently deposited materials. They are commonly adjacent to the stream. Colo and Zook soils are finer textured and more poorly drained. They are commonly away from the main channel, and are somewhat lower in elevation. However, because the East Fork Des Moines River has little difference in elevation as it flows through the county, Colo and Zook soils are also commonly adjacent to the channel.

Organic deposits. Palms Muck and Blue Earth soils formed in accumulated organic matter in old lakebeds or swamps that supported a heavy growth of aquatic plants and other vegetation that grew under conditions of excess wetness. The vegetation partly decomposed and accumulated in fairly thick beds under water. In places, deposits more than 4 feet thick have been observed in Kossuth County. Ordinarily, glacial drift or finer textured local alluvium lies beneath the organic material.

Wind- or water-deposited sandy material Most of this material was probably deposited by water, but most areas have been reworked to some extent by wind. The Dickman soils developed in these deposits. Truman soils developed in similar materials but are silty rather than sandy.

Lacustrine or glacial lake sediments. Water-sorted sediments, laid down in what is believed to be glacial lake basins, are the parent materials of soils in a small area of the extreme northeast part of the county and in a large area of the south part of the county. Most deposits are about 3 feet thick and are underlain by medium to moderately fine textured glacial till or glacial till sediments. The area in the northeast is on what is probably the remnant of the high water area of glacial Lake Minnesota (*12*), which covered an extensive area in adjacent Faribault County, Minnesota. Soils formed in this material are mainly the Waldorf and Kingston soils. In the south part of the county, soils that formed in these kinds of deposits are mainly the Kossuth and Ottosen soils. This area is believed to be a shallow glacial lake of short duration, and it is likely that melt water flowed through continuously.

Climate

Climate influences the formation of soils in many ways. Rainfall affects the amount of leaching in soils and helps determine the kind of vegetation that grows on soils. Temperature affects the growth of plants, the activity of micro-organisms, and the speed of chemical actions in the soils. Climate is responsible for many of the differences between soils of Kossuth County and soils in other parts of the world. The major differences among soils within the county, however, can be attributed to factors other than climate.

Available information indicates that the soils in Kossuth County have been developing under a midcontinental, subhumid climate for the last 5,000 years (*9*). Between 5,000 and 16,000 years ago, the climate was conducive to forest vegetation.

Lane (*6*) assumes that the succession of vegetation in post-Mankato time, about 11,000 years ago to the present, has been due to change in climate. From the succession of vegetation, Lane infers three shifts in climate; first, warming conditions accompanying a change from coniferous to deciduous trees; second, a gradual desiccation of climate just prior to the appearance of grasses; and finally, the continuation of a grassland climate, including a second dry period. The climatic inferences of recent work by Walker and Brush (*19*) are the same as those of Lane.

The influence of general climate is modified by local conditions in and around the soils. For example, the low-lying areas of poorly drained Webster soils and areas of very poorly drained soils in depressions such as the Okoboji soils are wetter and colder than most areas around them. South- and west-facing slopes are slightly warmer and less humid on the average than nearby areas. These contrasts account for some of the differences in soils within the same general climatic region.

Plant and animal life

Plant and animal life are important factors in formation of soils. Plant life is especially important. Differences in the kinds of vegetation commonly cause marked differences between soils (*7*). As plants grow and die, their remains are added to the soil. Burrowing animals, earthworms, bacteria, protozoa, and fungi help convert these raw plant remains into organic matter. Many kinds of micro-organisms are needed to transform organic remains into stable humus from which plants can obtain nutrients. Humus gives the surface soil its dark color.

Because grasses have many roots and tops that have decayed on or in the soil, soils that formed under prairie vegetation have a thick, dark colored surface layer. In contrast, soils that formed under trees have a thinner, lighter colored surface layer because the organic matter, derived mainly from leaves, was deposited only on the surface of the soil. Soils that have formed under shifting or mixed grass and timber vegetation are intermediate in color.

Tall prairie grasses were the main native vegetation in Kossuth County at the time of settlement. According to Ruhe and Scholtes (*9*), the environment of Iowa has been conducive to prairie vegetation for the past 5,000 years. Before that time, however, from 5,000 to 16,000 years ago, a cooler, more moist climate existed that was more favorable to forest vegetation. Dark colored soils, such as the Webster, Nicollet, and Clarion soils, formed more recently under prairie vegetation. The vegetation in potholes and other depressions was sedge, cattail, rush, and other similar plants.

At present, areas adjacent to streams and lakes in Kossuth County are wooded. In places, the trees have existed long enough to have had a significant effect on the morphology of the soils. Lester and Le Sueur soils formed under trees for at least part of their development.

Studies by Cardoso (*3*) and McCracken (*8*) provide detailed information on the effects of vegetation on soils similar to those in Kossuth County.

Relief

Topography is an important cause of differences among soils. Indirectly, it influences soil formation through its efffect on drainage, runoff, and erosion. If slope is steep, more water runs off the surface and less soaks into the soil. Less leaching of carbonates occurs and less clay is moved from the surface layer into the subsoil. Soil erosion increases as slopes become steeper. Much of the acreage of Kossuth County is nearly level to moderately sloping, but many areas are strongly sloping to steep.

Slope aspect, as well as gradient, has an influence on soil development. South-facing slopes generally are warmer and drier than north-facing slopes; consequently, they support more vegetation.

The topography in Kossuth County is geologically immature, as shown by the large numbers of potholes and other depressions and by the absence of minor upland streams. The county has two main types of morainic topography. One is a complex of short, uneven slopes, with many small, indistinct drainage patterns. This kind of topography is prevalent in parts of the northern part of the county, and its dominant soils are Storden and Clarion. The other dominant topography, which occurs throughout the county, is a series of flat topped, smooth-sided hills. The major soils on this topography are the Clarion, Nicollet, and Webster soils. Areas adjacent to the major streams are dissected but have little headward extension. A third, minor topography also occurs, mostly in the southern part of Kossuth County. It is a nearly level glacial lake plain. The dominant soils are Kossuth and Ottosen, and the lesser soils are Waldorf and Kingston.

Differences in relief or topography are a main reason for the differing soil properties of some of the soils in the county. Even though soils may have formed in the same parent material, topography influences the color, thickness of the solum, and horizonation of the soils. This influence can be seen in the Storden, Clarion, and Nicollet soils, which formed in the same kind of parent material and under similar vegetation; they differ because of differences in topographic position. For example, the thickness and color of the surface layer and the thickness of the solum of these soils are related to slope. In these soils, the surface layer becomes thicker and darker in color as the slope becomes less steep. The Storden soils are typically on the steepest slopes, the Clarion soils on the intermediate slopes, and the Nicollet soils on nearly level topography. The thickness of the solum also typically increases from the Storden to the Clarion to the Nicollet soil.

Topography affects the color of the subsoil through its effect on drainage and soil aeration. A soil that has good drainage generally has a brown subsoil because iron compounds are oxidized and well distributed throughout the horizon. Clarion soils are sloping and have a brownish subsoil. On the other hand, in nearly level or depressed areas, the soils are wet and frequently have a gray or mottled subsoil because of poor aeration and restricted drainage. Webster soils are an example. In some depressional areas, water collects and is impounded for a period of time. As the water percolates through the soil, clay from the surface is deposited in the subsoil. This process accelerates the development of soils that are very poorly drained and that have a distinct, light colored subsurface layer and a gray subsoil. Rolfe soils are an example.

Spillville soils, 2 to 5 percent slopes, are on foot slopes and have properties related to the higher lying soils from which they receive sediment.

Soils of the Colo, Spillville, and Zook series are on bottom lands. Although they are nearly level, their microrelief affects runoff, depth to water table, and the rate at which they receive new sediment. Colo soils are at low elevations and generally are some distance from major stream channels. They have a high water table and some impound water for short periods of time. Spillville soils are better drained and less clayey than Colo soils.

Time

Geologically, the soils of Kossuth County are young. The radiocarbon technique for determining the age of carbonaceous material found in till has made it possible to determine the approximate age of soils and Pleistocene deposits in Iowa. Studies by Ruhe and Scholtes provide much of the information on the age of soils in Iowa (*9,10,11*).

The age of the Cary Substage of the Late Wisconsin Glaciation has been determined to be 13,000 years. Thus, all soils formed in it are as young or younger than 13,000 years old. Soils formed in the Cary till include Storden, Clarion, Nicollet, and Webster soils.

Recently, however, radiocarbon dating of two wood fragments found embedded in till showed that one of these fragments is about 11,740 years old and the other is 12,000 years (*5*). These dates are about 1,000 years younger than dates previously attributed to the Des Moines glacial lobe and pre-Algona moraine outwash from the same presumed stratigraphic horizon (*9,11*).

In much of Iowa, including Kossuth County, erosion has beveled the side slopes of uplands, and, in places, soil material has been removed and deposited on lower lying slopes (*10,11*). This sediment has accumulated to form local alluvium. The nearly level uplands have an older surface layer at the summit than on the side slopes. The side slopes are less than 13,000 years old and in some places less than 3,000 years old (*20*). Clarion and Storden soils are on summits and side slopes. Some Spillville soils formed in local alluvium.

The soils on benches that formed from glacial outwash, such as Wadena or Cylinder soils, are less than about 13,000 years old (*10*). Soils that developed from alluvium range in age from the recently deposited materials which make up a part of Spillville loam, channeled and Spillville soils to the older sediment in which soils such as Colo and Zook formed. This older sediment is not older than about 13,000 years and is probably much younger.

Soils such as Clarion, Storden, and other soils on side slopes are subject to geologic erosion, which continually exposes fresh materials. The materials in these soils, therefore, show a wide range in age, from that of the parent material to that of the most recent sediment.

Horizons in Kossuth County soils range from well to poorly defined. These differences are caused partly by the intensity of weathering and partly by the resistance of soil materials to weathering. Rolfe soils, which are nearly level, were exposed to intense weathering and as a result show distinct layers or horizons. Gently sloping Clarion soils have moderately distinct horizons, and Storden soils, which formed on steep slopes, are calcareous throughout and show little horizon development.

The presence of water can affect the development of soil horizons. Webster soils have poorly differentiated horizons because they are in areas where a fluctuating water table modifies the normal effect of time. Soils that formed in alluvial deposits adjacent to major streams have little or no horizon development.

Human activities

Important changes have taken place in Kossuth County soils since the county was settled. Breaking the prairie sod and draining some of the many depressions affected the soil's protective cover.

The most apparent changes are those caused by water erosion. As the land was brought under cultivation, the surface runoff increased and the rate at which water moved into the soil decreased. This process accelerated erosion, which has removed part or all of the surface layer from much of the cultivated sloping land. In some places, a few shallow gullies have formed.

Erosion has changed not only the thickness of the surface layer but its structure as well. In severely eroded areas, the plow layer often consists partly of the upper part of the subsoil and, in the Storden soils, the upper part of the substratum.

Erosion and cultivation also affect the soil by reducing the organic matter content and water holding capacity and by 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 alters the soil's structure. The granular structure so apparent in virgin grassland breaks down under intensive cropping.

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 the runoff and soil erosion. Stream straightening, deepening and removing obstacles, and other practices have helped prevent flooding and have made some areas along streams more suitable for cultivation.

Through the use of commercial fertilizers and lime, deficiencies in plant nutrients can be corrected so that some soils are more productive than they were in the virgin state.

Erosion is one of the main causes of the reduction of organic matter in soils. However, figures indicate that as much as one third can be lost by causes other than erosion (*15*). 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 soils lowest in organic matter, this is best done by control of the major cause of loss—erosion by water.

Formation of horizons

In Kossuth County, morphology is expressed by faint soil horizons in most soils. The Storden, Clarion, Webster, and Canisteo soils have faint horizons; Waldorf soils have intermediate horizons; and the Rolfe soils have prominent horizons. Some soils have a marked difference between the texture of the solum and an underlying IIC horizon. Examples are Wadena, Cylinder, Linder, and Biscay soils.

Horizon differentiation in soils is the result of one or more of the following processes: accumulation of organic matter, leaching of calcium carbonate and other bases, formation and translocation of silicate clay minerals, reduction and transfer of iron, and accumulation of calcium carbonates (*14*). In most of the soils of the county, two or more of these processes have been active in the formation of horizons.

Most soils in Kossuth County have some accumulation of organic matter in the upper part that forms the A1 horizon. In places where the A1 horizon formed in organic deposits, it has a high organic matter content, as in the Palms soil. Some of the mineral soils that have a high organic matter content are the Okoboji, Webster, Canisteo, and Colo soils. These soils have a thick A1 horizon. The Salida, Estherville, and Storden soils have a low organic matter content and a faint, thin A1 horizon. The Clarion and Wadena soils have a moderate organic matter content.

Leaching of calcium carbonates and other bases has occurred in many soils in the county. Leaching generally occurs before and during the translocation of silicate clay minerals. Many of the soils in Kossuth County, including the Clarion and Nicollet soils, have been leached of calcium carbonate to a shallow depth, but little clay has been moved downward in their profiles. The Rolfe soils generally are more strongly leached throughout their profiles and have a distinct accumulation of silicate clay in the B horizon.

The translocation of silicate clay minerals has contributed to the prominent horizonation in the Rolfe soils. The B horizon of this soil has more clay than the A horizon and, in many places, dark colored clay coatings on the faces of peds and along root channels. The eluviated A2 horizon has platy structure, has less clay, and is lighter colored than the B horizon, especially when dry. The leaching of bases and the translocation of clay have been more important processes of horizon differentiation in these soils than the accumulation of organic matter.

Horizonation is faintly expressed in the Harps and Canisteo soils. Carbonates have accumulated in the surface layer and subsoil. The calcium carbonate equivalent of Harps soils ranges from 15 to 40 percent.

Gleying, or the process of reduction and transfer of iron, is evident in the poorly drained and very poorly drained soils (*13*). The Okoboji, Webster, Biscay, Harps, and Canisteo soils have a gleyed Bg horizon that is gray. Some soils have reddish-brown concretions of iron.

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Glossary

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Area reclaim (in tables). An area difficult to reclaim after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Association, soil. A group of soils geographically associated in a characteristic repeating pattern and defined and delineated as a single map unit.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as—

	Inches
Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	9 to 12
Very high	More than 12

Base saturation. The degree to which material having cation exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, K), expressed as a percentage of the total cation exchange capacity.

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.

Capillary water. Water held as a film around soil particles and in tiny spaces between particles. Surface tension is the adhesive force that holds capillary water in the soil.

Cation. An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Cation-exchange capacity. The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity, but is more precise in meaning.

Chiseling. Tillage with an implement having one or more soil-penetrating points that loosen the subsoil and bring clods to the surface. A form of emergency tillage to control soil blowing.

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.

Claypan. A slowly permeable soil horizon that contains much more clay than the horizons above it. A claypan is commonly hard when dry and plastic or stiff when wet.

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.

Cobblestone (or cobble). A rounded or partly rounded fragment of rock 3 to 10 inches (7.5 to 25 centimeters) in diameter.

Colluvium. Soil material, rock fragments, or both moved by creep, slide, or local wash and deposited at the base of steep slopes.

Complex slope. Irregular or variable slope. Planning or constructing terraces, diversions, and other water-control measures on a complex slope is difficult.

Complex, soil. A map unit of two or more kinds of soil in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils are somewhat similar in all areas.

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.

Coprogenous earth (sedimentary peat). Fecal material deposited in water by aquatic organisms. The Lco horizon is a limnic layer that contains many fecal pellets.

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.

Cutbanks cave (in tables). The walls of excavations tend to cave in or slough.

Deferred grazing. Postponing grazing or arresting grazing for a prescribed period.

Dense layer (in tables). A very firm, massive layer that has a bulk density of more than 1.8 grams per cubic centimeter. Such a layer affects the ease of digging and can affect filling and compacting.

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.

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 alkali (in tables). Excess exchangeable sodium in the soil. The resulting poor physical properties restrict the growth of plants.

Fallow. Cropland left idle in order to restore productivity through accumulation of moisture. Summer fallow is common in regions of limited rainfall where cereal grains are grown. The soil is tilled for at least one growing season for weed control and decomposition of plant residue.

Fast intake (in tables). The rapid movement of water into the soil.

Fertility, soil. The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Fibric soil material (peat). The least decomposed of all organic soil material. Peat contains a large amount of well preserved fiber that is readily identifiable according to botanical origin. Peat has the lowest bulk density and the highest water content at saturation of all organic soil material.

Field moisture capacity. The moisture content of a soil, expressed as a percentage of the ovendry weight, after the gravitational, or free, water has drained away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity.*

Fine textured soil. Sandy clay, silty clay, 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.

Forb. Any herbaceous plant not a grass or a sedge.

Fragile (in tables). A soil that is easily damaged by use or disturbance.

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.

Glaciolacustrine deposits. Material ranging from fine clay to sand derived from glaciers and deposited in glacial lakes mainly by glacial melt water. Many deposits are interbedded or laminated.

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.

Gravelly soil material. Material that is 15 to 50 percent, by volume, rounded or angular rock fragments, not prominently flattened, up to 3 inches (7.5 centimeters) in diameter.

Green manure crop (agronomy). A soil-improving crop grown to be plowed under in an early stage of maturity or soon after maturity.

Ground water (geology). Water filling all the unblocked pores of 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.

Impervious soil. A soil through which water, air, or roots penetrate slowly or not at all. No soil is absolutely impervious to air and water all the time.

Intake rate. The average rate of water entering the soil under irrigation. Most soils have a fast initial rate; the rate decreases with application time. Therefore, intake rate for design purposes is not a constant but is a variable depending on the net irrigation application. The rate of water intake in inches per hour is expressed as follows:

Less than 0.2	very low
0.2 to 0.4	low
0.4 to 0.75	moderately low
0.75 to 1.25	moderate
1.25 to 1.75	moderately high
1.75 to 2.5	high
More than 2.5	very high

Irrigation. Application of water to soils to assist in production of crops. Methods of irrigation are—

Border.—Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

Basin.—Water is applied rapidly to nearly level plains surrounded by levees or dikes.

Controlled flooding.—Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

Corrugation.—Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops or in orchards so that it flows in only one direction.

Drip (or trickle).—Water is applied slowly and under low pressure to the surface of the soil or into the soil through such applicators as emitters, porous tubing, or perforated pipe.

Furrow.—Water is applied in small ditches made by cultivation implements. Furrows are used for tree and row crops.

Sprinkler.—Water is sprayed over the soil surface through pipes or nozzles from a pressure system.

Subirrigation.—Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.

Wild flooding.—Water, released at high points, is allowed to flow onto an area without controlled distribution.

Lacustrine deposit (geology). Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

Large stones (in tables). Rock fragments 3 inches (7.5 centimeters) or more across. Large stones adversely affect the specified use of the soil.

Leaching. The removal of soluble material from soil or other material by percolating water.

Liquid limit. The moisture content at which the soil passes from a plastic to a liquid state.

Loam. Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Loess. Fine grained material, dominantly of silt-sized particles, deposited by wind.

Low strength. The soil is not strong enough to support loads.

Medium textured soil. Very fine sandy loam, loam, silt loam, or silt.

Mineral soil. Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

Minimum tillage. Only the tillage essential to crop production and prevention of soil damage.

Miscellaneous area. An area that has little or no natural soil and supports little or no vegetation.

Moderately coarse textured soil. Sandy loam and fine sandy loam.

Moderately fine textured soil. Clay loam, sandy clay loam, and silty clay loam.

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.)

Nutrient, plant. Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Organic matter. Plant and animal residue in the soil in various stages of decomposition.

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.)

Ped. An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedon. The smallest volume that can be called "a soil." A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation. The downward movement of water through the soil.

Percs slowly (in tables). The slow movement of water through the soil adversely affecting the specified use.

Permeability. The quality of the soil that enables water to move downward through the profile. Permeability is measured as the number of inches per hour that water moves downward through the saturated soil. Terms describing permeability are:

Very slow	less than 0.06 inch
Slow	0.06 to 0.20 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.

pH value. A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Piping (in tables). Formation of subsurface tunnels or pipelike cavities by water moving through the soil.

Plasticity index. The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plastic limit. The moisture content at which a soil changes from semisolid to plastic.

Ponding. Standing water on soils in closed depressions. The water can be removed only by percolation or evapotranspiration.

Poorly graded. Refers to a coarse grained soil or soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles, density can be increased only slightly by compaction.

Poor outlets (in tables). Refers to areas where surface or subsurface drainage outlets are difficult or expensive to install.

Productivity, soil. The capability of a soil for producing a specified plant or sequence of plants under specific management.

Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.

Reaction, soil. A measure of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The 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.

Rill. A steep sided channel resulting from accelerated erosion. A rill is generally a few inches deep and not wide enough to be an obstacle to farm machinery.

Rock fragments. Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

Rooting depth (in tables). Shallow root zone. The soil is shallow over a layer that greatly restricts roots.

Root zone. The part of the soil that can be penetrated by plant roots.

Runoff. The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Sapric soil material (muck). The most highly decomposed of all organic soil material. Muck has the least amount of plant fiber, the highest bulk density, and the lowest water content at saturation of all organic soil material.

Sedimentary rock. Rock made up of particles deposited from suspension in water. The chief kinds of sedimentary rock are conglomerate, formed from gravel; sandstone, formed from sand; shale, formed from clay; and limestone, formed from soft masses of calcium carbonate. There are many intermediate types. Some wind-deposited sand is consolidated into sandstone.

Seepage (in tables). The movement of water through the soil. Seepage adversely affects the specified use.

Series, soil. A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer or of the underlying material. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Sheet erosion. The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and runoff water.

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.

Silica. A combination of silicon and oxygen. The mineral form is called quartz.

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.

Slippage (in tables). Soil mass susceptible to movement downslope when loaded, excavated, or wet.

Slope. The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

Slow intake (in tables). The slow movement of water into the soil.

Slow refill (in tables). The slow filling of ponds, resulting from restricted permeability in the soil.

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.

Soil separates. Mineral particles less than 2 mm in equivalent diameter and ranging between specified size limits. The names and sizes of separates recognized in the United States are as follows:

	Millimeters
Very coarse sand	2.0 to 1.0
Coarse sand	1.0 to 0.5
Medium sand	0.5 to 0.25
Fine sand	0.25 to 0.10
Very fine sand	0.10 to 0.05
Silt	0.05 to 0.002
Clay	less than 0.002

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A 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.

Stones. Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter.

Stony. Refers to a soil containing stones in numbers that interfere with or prevent tillage.

Stripcropping. Growing crops in a systematic arrangement of strips or bands which provide vegetative barriers to wind and water erosion.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single 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 layer.

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 as the "plow layer," or the "Ap horizon."

Surface soil. *The A horizon. Includes all subdivisions of this horizon (A1, A2, and A3).*

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.

Terminal moraine. A belt of thick glacial drift that generally marks the termination of important glacial advances.

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."

Thin layer (in tables). Otherwise suitable soil material too thin for the specified use.

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.

Toe slope. The outermost inclined surface at the base of a hill; part of a foot slope.

Topsoil. The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Trace elements. Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, are in soils in extremely small amounts. They are essential to plant growth.

Unstable fill (in tables). Risk of caving or sloughing on banks of fill material.

Upland (geology). Land at a higher elevation, in general, than the alluvial plain or stream terrace; land above the lowlands along streams.

Variant, soil. A soil having properties sufficiently different from those of other known soils to justify a new series name, but occurring in such a limited geographic area that creation of a new series is not justified.

Variegation. Refers to patterns of contrasting colors assumed to be inherited from the parent material rather than to be the result of poor drainage.

Weathering. All physical and chemical changes produced in rocks or other deposits at or near the earth's surface by atmospheric agents. These changes result in disintegration and decomposition of the material.

Well graded. Refers to soil material consisting of coarse grained particles that are well distributed over a wide range in size or diameter. Such soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

Tables

TABLE 1.--TEMPERATURE AND PRECIPITATION

[Recorded in the period 1951-73 at Algona, Iowa]

Month	Temperature						Precipitation				
	Average daily maximum	Average daily minimum	Average daily	2 years in 10 will have-- Maximum temperature higher than--	2 years in 10 will have-- Minimum temperature lower than--	Average number of growing degree days[1]	Average	2 years in 10 will have-- Less than--	2 years in 10 will have-- More than--	Average number of days with 0.10 inch or more	Average snowfall
	°F	°F	°F	°F	°F	Units	In	In	In		In
January----	23.5	4.6	14.1	46	-24	0	.68	.27	1.01	3	6.7
February---	30.1	11.1	20.6	50	-19	0	1.08	.25	1.72	3	7.9
March------	39.8	20.8	30.3	72	-9	27	1.82	.71	2.70	6	11.5
April------	58.9	35.4	47.2	87	16	67	2.58	1.27	3.64	6	.9
May--------	71.8	47.0	59.4	91	26	306	3.87	2.41	5.17	8	.0
June-------	81.3	57.3	69.3	97	41	579	4.45	2.73	5.99	7	.0
July-------	84.1	60.8	72.5	98	46	698	3.76	1.86	5.31	7	.0
August-----	82.6	58.7	70.7	96	42	642	3.60	1.68	5.16	6	.0
September--	73.8	49.5	61.6	91	31	348	3.14	.99	4.84	7	.0
October----	63.5	39.6	51.6	87	19	152	1.96	.60	3.04	5	.0
November---	44.5	25.2	34.9	70	-4	7	1.35	.32	2.16	3	2.9
December---	29.8	12.4	21.3	55	-22	0	.93	.40	1.36	3	8.3
Yearly:											
Average--	57.0	35.2	46.1	---	---	---	---	---	---	---	---
Extreme--	---	---	---	99	-24	---	---	---	---	---	---
Total----	---	---	---	---	---	2,826	29.22	23.05	35.01	64	38.2

[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 1951-73 at Algona, 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--	April 24	May 9	May 17
2 years in 10 later than--	April 19	May 3	May 12
5 years in 10 later than--	April 10	April 23	May 3
First freezing temperature in fall:			
1 year in 10 earlier than--	October 10	September 30	September 23
2 years in 10 earlier than--	October 15	October 5	September 27
5 years in 10 earlier than--	October 25	October 16	October 6

TABLE 3.--GROWING SEASON

[Recorded in the period 1951-73 at Algona, Iowa]

Probability	Daily minimum temperature during growing season		
	Higher than 24° F	Higher than 28° F	Higher than 32° F
	Days	Days	Days
9 years in 10	178	152	140
8 years in 10	184	160	145
5 years in 10	197	175	155
2 years in 10	209	190	165
1 year in 10	215	197	170

TABLE 4.--ACREAGE AND PROPORTIONATE EXTENT OF THE SOILS

Map symbol	Soil name	Acres	Percent
6	Okoboji silty clay loam, 0 to 1 percent slopes	44,525	7.1
28	Dickman fine sandy loam, 0 to 2 percent slopes	1,045	0.2
28B	Dickman fine sandy loam, 2 to 5 percent slopes	4,045	0.6
28C2	Dickman fine sandy loam, 5 to 9 percent slopes, moderately eroded	455	0.1
34	Estherville sandy loam, 0 to 2 percent slopes	900	0.1
34B	Estherville sandy loam, 2 to 5 percent slopes	1,505	0.2
34C2	Estherville sandy loam, 5 to 14 percent slopes, moderately eroded	675	0.1
52B	Bode clay loam, 2 to 5 percent slopes	1,360	0.2
54	Zook silty clay loam, 0 to 2 percent slopes	885	0.1
55	Nicollet loam, 1 to 3 percent slopes	101,415	16.2
62C2	Storden loam, 5 to 9 percent slopes, moderately eroded	7,360	1.2
62D2	Storden loam, 9 to 14 percent slopes, moderately eroded	6,280	1.0
62E2	Storden loam, 14 to 18 percent slopes, moderately eroded	2,105	0.3
62F	Storden loam, 18 to 25 percent slopes	1,010	0.2
62G	Storden loam, 25 to 40 percent slopes	825	0.1
73C2	Salida gravelly sandy loam, 2 to 9 percent slopes, moderately eroded	285	0.1
73E2	Salida gravelly sandy loam, 9 to 25 percent slopes, moderately eroded	280	0.1
90	Okoboji mucky silt loam, 0 to 1 percent slopes	13,530	2.2
95	Harps clay loam, 0 to 2 percent slopes	38,810	6.2
107	Webster silty clay loam, 0 to 2 percent slopes	46,885	7.5
108	Wadena loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes	515	0.1
108B	Wadena loam, 24 to 32 inches to sand and gravel, 2 to 5 percent slopes	790	0.1
133	Colo silty clay loam, 0 to 2 percent slopes	4,250	0.7
133B	Colo silty clay loam, 2 to 4 percent slopes	560	0.1
135	Coland clay loam, 0 to 2 percent slopes	4,805	0.8
138B	Clarion loam, 2 to 5 percent slopes	75,500	12.0
138C	Clarion loam, 5 to 9 percent slopes	1,525	0.2
138C2	Clarion loam, 5 to 9 percent slopes, moderately eroded	25,280	4.0
138D2	Clarion loam, 9 to 14 percent slopes, moderately eroded	2,590	0.4
150	Hanska loam, 0 to 2 percent slopes	635	0.1
181B	Clarion-Estherville complex, 2 to 5 percent slopes	965	0.2
181C2	Clarion-Estherville complex, 5 to 9 percent slopes, moderately eroded	425	0.1
203	Cylinder loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	1,825	0.3
221	Palms muck, 0 to 1 percent slopes	4,530	0.7
224	Linder loam, 0 to 2 percent slopes	885	0.1
236B	Lester loam, 2 to 5 percent slopes	795	0.1
236C	Lester loam, 5 to 9 percent slopes	455	0.1
236F	Lester loam, 18 to 40 percent slopes	745	0.1
259	Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	1,890	0.3
274	Rolfe silt loam, 0 to 1 percent slopes	270	0.1
288	Ottosen clay loam, 1 to 3 percent slopes	8,580	1.4
308	Wadena loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	355	0.1
308B	Wadena loam, 32 to 40 inches to sand and gravel, 2 to 5 percent slopes	505	0.1
325	Le Sueur loam, 1 to 3 percent slopes	205	0.1
330	Kingston silty clay loam, 0 to 3 percent slopes	650	0.1
335	Harcot loam, 0 to 2 percent slopes	3,275	0.5
339B	Truman silt loam, 2 to 5 percent slopes	535	0.1
348	Fieldon loam, 0 to 2 percent slopes	6,450	1.0
349	Darfur loam, 0 to 2 percent slopes	1,565	0.2
354	Aquolls, ponded	860	0.1
388	Kossuth silty clay loam, 0 to 2 percent slopes	24,095	3.8
389	Waldorf silty clay, silty substratum, 0 to 2 percent slopes	2,185	0.3
485	Spillville loam, 0 to 2 percent slopes	1,395	0.2
485B	Spillville loam, 2 to 5 percent slopes	4,185	0.7
506	Wacousta silty clay loam, 0 to 1 percent slopes	1,680	0.3
507	Canisteo clay loam, 0 to 2 percent slopes	114,780	18.3
511	Blue Earth mucky silt loam, 0 to 1 percent slopes	940	0.2
559	Talcot clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	1,890	0.3
585B	Colo-Spillville complex, 2 to 5 percent slopes	2,540	0.4
638B	Clarion-Storden loams, 2 to 5 percent slopes	5,490	0.9
639C2	Storden-Salida complex, 5 to 9 percent slopes, moderately eroded	520	0.1
639D2	Storden-Salida complex, 9 to 14 percent slopes, moderately eroded	445	0.1
654	Corwith loam, 1 to 3 percent slopes	1,400	0.2
655	Crippin loam, 1 to 3 percent slopes	17,075	2.7
658	Mayer loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes	910	0.1
733	Calco silty clay loam, 0 to 2 percent slopes	2,245	0.4
823	Ridgeport sandy loam, 0 to 2 percent slopes	1,065	0.2
823B	Ridgeport sandy loam, 2 to 5 percent slopes	1,475	0.2
823C2	Ridgeport sandy loam, 5 to 9 percent slopes, moderately eroded	270	0.1
879	Fostoria loam, 0 to 2 percent slopes	2,315	0.4

TABLE 4.--ACREAGE AND PROPORTIONATE EXTENT OF THE SOILS--Continued

Map symbol	Soil name	Acres	Percent
895	Lemond loam, 0 to 2 percent slopes	410	0.1
1032	Spicer silty clay loam, 0 to 2 percent slopes	2,155	0.3
1133	Colo silty clay loam, channeled, 0 to 2 percent slopes	1,530	0.2
1135	Coland clay loam, channeled, 0 to 2 percent slopes	1,180	0.2
1485	Spillville loam, channeled, 0 to 2 percent slopes	4,045	0.6
1595	Harpster silt loam, 0 to 2 percent slopes	1,270	0.2
5010	Pits, gravel	595	0.1
5040	Orthents, loamy	690	0.1
	Water	1,390	0.2
	Total	626,560	100.0

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	Kentucky bluegrass	Grass-legume hay	Bromegrass-alfalfa	Smooth bromegrass
	Bu	Bu	Bu	AUM*	Ton	AUM*	AUM*
6------------------------ Okoboji	88	32	67	3.3	3.4	4.3	4.3
28----------------------- Dickman	45	18	50	1.2	2.5	3.7	---
28B---------------------- Dickman	40	16	45	1.2	2.5	3.7	---
28C2--------------------- Dickman	35	14	40	1.2	2.2	3.7	---
34----------------------- Estherville	42	17	40	2.0	2.0	3.0	---
34B---------------------- Estherville	37	15	35	2.0	2.0	2.5	---
34C2--------------------- Estherville	27	9	29	1.2	1.4	2.0	---
52B---------------------- Bode	103	39	77	3.8	4.3	7.1	---
54----------------------- Zook	96	36	72	4.0	4.0	---	4.0
55----------------------- Nicollet	113	40	80	3.5	4.5	6.5	---
62C2--------------------- Storden	88	33	71	3.0	3.5	5.0	---
62D2--------------------- Storden	79	23	65	3.0	3.5	5.0	---
62E2--------------------- Storden	65	---	50	2.5	3.0	4.5	---
62F---------------------- Storden	---	---	---	2.0	2.5	3.7	---
62G---------------------- Storden	---	---	---	1.5	---	---	---
73C2--------------------- Salida	35	14	40	1.5	2.5	3.7	---
73E2--------------------- Salida	---	---	---	1.0	2.0	3.0	---
90----------------------- Okoboji	90	32	67	3.3	3.4	4.3	4.3
95----------------------- Harps	90	30	72	3.3	4.0	6.6	---
107---------------------- Webster	110	42	80	4.2	4.4	7.3	---
108---------------------- Wadena	62	22	55	2.7	2.7	3.8	---
108B--------------------- Wadena	60	22	55	2.7	2.8	3.8	---

See footnote at end of table.

TABLE 5.--YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Corn	Soybeans	Oats	Kentucky bluegrass	Grass-legume hay	Bromegrass-alfalfa	Smooth bromegrass
	Bu	Bu	Bu	AUM*	Ton	AUM*	AUM*
133 Colo	104	33	76	3.0	4.2	---	---
133B Colo	102	39	76	4.2	4.0	6.6	5.3
135 Coland	110	42	78	4.1	4.6	4.4	6.0
138B Clarion	110	42	80	4.2	4.6	7.6	---
138C Clarion	105	40	80	3.8	4.4	7.3	---
138C2 Clarion	102	39	79	3.8	4.3	7.1	---
138D2 Clarion	93	35	74	3.7	3.9	6.5	---
150 Hanska	75	28	60	---	3.5	5.2	---
181B Clarion-Estherville	84	31	67	3.3	3.6	5.6	---
181C2 Clarion-Estherville	72	27	61	2.8	3.2	5.1	---
203 Cylinder	93	31	75	3.8	4.3	7.1	6.2
221 Palms	84	28	65	---	---	---	---
224 Linder	61	23	42	2.3	2.5	4.1	3.7
236B Lester	105	35	80	3.5	4.5	6.5	---
236C Lester	95	33	75	3.5	4.5	6.5	---
236F Lester	---	---	---	1.5	---	---	---
259 Biscay	95	32	60	3.5	3.5	5.2	---
274 Rolfe	86	30	69	3.3	3.0	5.0	4.5
288 Ottosen	111	43	80	4.0	4.7	7.8	---
308 Wadena	88	32	74	3.7	3.7	6.2	---
308B Wadena	86	31	72	3.7	3.6	6.0	---
325 Le Sueur	10	38	80	3.3	4.5	6.7	---
330 Kingston	113	40	80	3.5	4.5	6.7	---

See footnote at end of table.

TABLE 5.--YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Corn	Soybeans	Oats	Kentucky bluegrass	Grass-legume hay	Bromegrass-alfalfa	Smooth bromegrass
	Bu	Bu	Bu	AUM*	Ton	AUM*	AUM*
335 Harcot	80	30	64	3.1	3.2	6.0	4.8
339B Truman	110	42	88	4.0	4.5	---	---
348 Fieldon	88	31	78	3.0	3.5	5.0	---
349 Darfur	93	32	80	3.6	3.5	5.2	---
354. Aquolls							
388 Kossuth	110	40	83	4.0	4.2	---	5.9
389 Waldorf	115	40	80	---	4.0	6.0	---
485 Spillville	110	42	80	4.2	5.1	8.6	7.3
485B Spillville	105	41	80	4.1	5.0	8.5	7.2
506 Wacousta	90	32	67	2.0	4.0	---	4.3
507 Canisteo	105	36	80	3.0	3.5	5.2	---
511 Blue Earth	75	30	---	---	3.0	---	3.8
559 Talcot	95	36	76	3.3	4.0	---	5.0
585B Colo-Spillville	105	36	78	3.5	4.7	6.2	6.5
638B Clarion-Storden	99	35	73	3.7	4.1	6.5	---
639C2, 639D2 Storden-Salida	58	19	46	2.4	3.1	4.5	---
654 Corwith	93	32	79	4.1	3.9	7.0	---
655 Crippin	110	37	80	4.2	4.3	7.1	6.5
658 Mayer	80	32	60	3.2	3.0	5.0	---
733 Calco	99	38	84	4.2	4.2	7.0	5.3
823 Ridgeport	53	20	42	1.7	2.2	3.6	3.2
823B Ridgeport	51	19	41	1.5	2.1	3.5	3.1
823C2 Ridgeport	43	16	36	1.1	1.8	3.0	2.7

See footnote at end of table.

TABLE 5.--YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Corn	Soybeans	Oats	Kentucky bluegrass	Grass-legume hay	Bromegrass-alfalfa	Smooth bromegrass
	Bu	Bu	Bu	AUM*	Ton	AUM*	AUM*
879----------------------- Fostoria	96	36	77	3.7	4.0	6.6	5.8
895----------------------- Lemond	65	28	60	---	3.5	5.0	---
1032---------------------- Spicer	110	36	80	---	4.0	6.0	---
1133---------------------- Colo	---	---	---	3.0	---	---	---
1135---------------------- Coland	---	---	---	2.5	---	---	---
1485---------------------- Spillville	---	---	---	3.8	---	---	---
1595---------------------- Harpster	100	32	76	---	5.0	6.8	---
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.

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	131,640	---	---	---
II	351,556	90,881	257,095	3,580
III	120,479	50,103	65,475	4,901
IV	4,085	2,560	---	1,525
V	13,262	---	13,262	---
VI	1,290	1,010	---	280
VII	1,570	1,570	---	---
VIII	---	---	---	---

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS

[The symbol < means less than; > means more than. Absence of an entry indicates that trees generally do not grow to the given height on that soil]

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of--				
	<8	8-15	16-25	26-35	>35
6 Okoboji	---	Northern white-cedar, Siberian peashrub, lilac, Tatarian honeysuckle.	Hackberry, eastern redcedar, bur oak, white spruce.	Honeylocust, golden willow, green ash.	Eastern cottonwood.
28, 28B, 28C2 Dickman	Siberian peashrub, Tatarian honeysuckle, lilac.	Eastern redcedar, hackberry, Manchurian crabapple.	Green ash, honeylocust, eastern white pine, jack pine, Russian-olive, bur oak.	---	---
34, 34B, 34C2 Estherville	Lilac, Tatarian honeysuckle, Siberian peashrub.	Eastern redcedar, hackberry, Manchurian crabapple.	Honeylocust, jack pine, eastern white pine, green ash, bur oak, Russian-olive.	---	---
52B Bode	---	Redosier dogwood, lilac, gray dogwood, Siberian peashrub.	Eastern redcedar, Amur maple, hackberry, northern white-cedar, blue spruce, Russian-olive.	Eastern white pine, green ash.	---
54 Zook	---	Silky dogwood, Amur honeysuckle, American cranberrybush, Amur privet.	Norway spruce, northern white-cedar, Austrian pine, blue spruce, white fir, Washington hawthorn.	Eastern white pine	Pin oak.
55 Nicollet	---	Redosier dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, blue spruce, Amur maple.	Austrian pine, eastern white pine, green ash, hackberry.	Silver maple.
62C2, 62D2, 62E2, 62F, 62G Storden	American plum	Eastern redcedar, hackberry, Tatarian honeysuckle, Siberian peashrub.	Honeylocust, green ash, Russian-olive.	Siberian elm	---
73C2, 73E2 Salida	Lilac	Tatarian honeysuckle, Siberian pea-shrub, eastern redcedar.	Hackberry, white spruce, red pine, jack pine.	---	---
90 Okoboji	---	Northern white-cedar, Siberian peashrub, lilac, Tatarian honeysuckle.	Hackberry, eastern redcedar, bur oak, white spruce.	Honeylocust, golden willow, green ash.	Eastern cottonwood.
95 Harps	---	Tatarian honeysuckle, northern white-cedar, Siberian peashrub, lilac.	Hackberry, white spruce, eastern redcedar, bur oak.	Golden willow, honeylocust, green ash.	Eastern cottonwood.

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of--				
	<8	8-15	16-25	26-35	>35
107 Webster	---	Redosier dogwood, American plum, Tatarian honeysuckle.	Hackberry, Amur maple, northern white-cedar, tall purple willow, white spruce.	Golden willow, green ash.	Eastern cottonwood, silver maple.
108, 108B Wadena	Siberian peashrub, lilac, Tatarian honeysuckle.	Eastern redcedar, hackberry, Manchurian crabapple.	Jack pine, honeylocust, bur oak, Russian-olive, green ash, eastern white pine.	---	---
133, 133B Colo	---	Redosier dogwood, American plum, Tatarian honeysuckle.	White fir, white spruce, hackberry, Amur maple, tall purple willow.	Green ash, golden willow.	Silver maple, eastern cottonwood.
135 Coland	---	Redosier dogwood, Tatarian honeysuckle, American plum.	White spruce, hackberry, northern white-cedar, tall purple willow, Amur maple.	Golden willow, green ash.	Eastern cottonwood, silver maple.
138B, 138C, 138C2, 138D2 Clarion	---	Gray dogwood, redosier dogwood, lilac, Siberian peashrub.	Northern white-cedar, blue spruce, Amur maple, Russian-olive, eastern redcedar, hackberry.	Green ash, eastern white pine.	---
150 Hanska	---	Tatarian honeysuckle, American plum, redosier dogwood.	Northern white-cedar, white spruce, tall purple willow, Amur maple, hackberry.	Golden willow, green ash.	Eastern cottonwood, silver maple.
181B*, 181C2*: Clarion	---	Gray dogwood, redosier dogwood, lilac, Siberian peashrub.	Northern white-cedar, blue spruce, Amur maple, Russian-olive, eastern redcedar, hackberry.	Green ash, eastern white pine.	---
Estherville	Lilac, Tatarian honeysuckle, Siberian peashrub.	Eastern redcedar, hackberry, Manchurian crabapple.	Honeylocust, jack pine, eastern white pine, green ash, bur oak, Russian-olive.	---	---
203 Cylinder	---	Redosier dogwood, Tatarian honeysuckle, lilac.	Blue spruce, northern white-cedar, Amur maple, white spruce.	Austrian pine, eastern white pine, green ash, hackberry.	Silver maple.
221 Palms	Common ninebark, whitebelle honeysuckle.	Amur honeysuckle, Amur privet, silky dogwood, nannyberry viburnum, Tatarian honeysuckle.	Tall purple willow	Golden willow, black willow.	Imperial Carolina poplar.

See footnote at end of table.

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of--				
	<8	8-15	16-25	26-35	>35
224. Linder	---	Redosier dogwood, Tatarian honeysuckle, lilac.	Blue spruce, Amur maple, white spruce, northern white-cedar.	Eastern white pine, Austrian pine, green ash, hackberry.	Silver maple.
236B, 236C, 236F. Lester	---	Redosier dogwood, Siberian peashrub, lilac, gray dogwood.	Hackberry, eastern redcedar, northern white-cedar, Amur maple, Russian-olive, blue spruce.	Eastern white pine, green ash.	---
259. Biscay	---	Redosier dogwood, American plum, Tatarian honeysuckle.	Northern white-cedar, Amur maple, white spruce, hackberry, tall purple willow.	Green ash, golden willow.	Eastern cottonwood, silver maple.
274. Rolfe	---	Redosier dogwood, Tatarian honeysuckle, American plum.	Amur maple, northern white-cedar, hackberry, white spruce, tall purple willow.	Golden willow, green ash.	Silver maple, eastern cottonwood.
288. Ottosen	---	Redosier dogwood, lilac, Tatarian honeysuckle.	Northern white-cedar, blue spruce, white spruce, Amur maple.	Hackberry, eastern white pine, Austrian pine, green ash.	Silver maple.
308, 308B. Wadena	Siberian peashrub, lilac, Tatarian honeysuckle.	Eastern redcedar, hackberry, Manchurian crabapple.	Jack pine, honeylocust, bur oak, Russian-olive, green ash, eastern white pine.	---	---
325. Le Sueur	---	Redosier dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, blue spruce, Amur maple.	Austrian pine, eastern white pine, green ash, hackberry.	Silver maple.
330. Kingston	---	Lilac, Tatarian honeysuckle, redosier dogwood.	Northern white-cedar, white spruce, Amur maple, blue spruce.	Austrian pine, eastern white pine, green ash, hackberry.	Silver maple.
335. Harcot	---	Lilac, Tatarian honeysuckle, Siberian peashrub, northern white-cedar.	White spruce, eastern redcedar, bur oak, hackberry.	Honeylocust, green ash, golden willow.	Eastern cottonwood.
339B. Truman	---	Gray dogwood, redosier dogwood, Siberian peashrub, lilac.	Northern white-cedar, blue spruce, hackberry, Russian-olive, eastern redcedar, Amur maple.	Eastern white pine, green ash.	---

See footnote at end of table.

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of--				
	<8	8-15	16-25	26-35	>35
348 Fieldon	---	Northern white-cedar, lilac, Tatarian honeysuckle, Siberian peashrub.	White spruce, eastern redcedar, bur oak, hackberry.	Honeylocust, green ash, golden willow.	Eastern cottonwood.
349 Darfur	---	Redosier dogwood, Tatarian honeysuckle, American plum.	Northern white-cedar, white spruce, tall purple willow, Amur maple, hackberry.	Golden willow, green ash.	Eastern cottonwood, silver maple.
354*. Aquolls					
388 Kossuth	---	Redosier dogwood, American plum, Tatarian honeysuckle.	Tall purple willow, Amur maple, hackberry, white spruce, northern white-cedar.	Golden willow, green ash.	Eastern cottonwood, silver maple.
389 Waldorf	---	Redosier dogwood, Tatarian honeysuckle, American plum.	Northern white-cedar, white spruce, Amur maple, tall purple willow, hackberry.	Golden willow, green ash.	Eastern cottonwood, silver maple.
485, 485B Spillville	---	Redosier dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, blue spruce, Amur maple.	Hackberry, eastern white pine, Austrian pine, green ash.	Silver maple.
506 Wacousta	---	Northern white-cedar, Tatarian honeysuckle, Siberian peashrub, lilac.	Hackberry, eastern redcedar, bur oak, white spruce.	Golden willow, honeylocust, green ash.	Eastern cottonwood.
507 Canisteo	---	Siberian peashrub, Tatarian honeysuckle, lilac, northern white-cedar.	Hackberry, bur oak, white spruce, eastern redcedar.	Golden willow, honeylocust, green ash.	Eastern cottonwood.
511 Blue Earth	---	Northern white-cedar, lilac, Tatarian honeysuckle, Siberian peashrub.	Hackberry, bur oak, white spruce, eastern redcedar.	Green ash, golden willow, green ash.	Eastern cottonwood.
559 Talcot	---	Northern white-cedar, Tatarian honeysuckle, Siberian peashrub, lilac.	Hackberry, white spruce, bur oak, eastern redcedar.	Green ash, golden willow, honeylocust.	Eastern cottonwood.
585B*: Colo	---	Redosier dogwood, American plum, Tatarian honeysuckle.	White fir, white spruce, hackberry, Amur maple, tall purple willow.	Green ash, golden willow.	Silver maple, eastern cottonwood.

See footnote at end of table.

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of--				
	<8	8-15	16-25	26-35	>35
585B*:					
Spillville	---	Redosier dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, blue spruce, Amur maple.	Hackberry, eastern white pine, Austrian pine, green ash.	Silver maple.
638B*:					
Clarion	---	Gray dogwood, redosier dogwood, lilac, Siberian peashrub.	Northern white-cedar, blue spruce, Amur maple, Russian-olive, eastern redcedar, hackberry.	Green ash, eastern white pine.	---
Storden	American plum	Eastern redcedar, hackberry, Tatarian honeysuckle, Siberian peashrub.	Honeylocust, green ash, Russian-olive.	Siberian elm	---
639C2*, 639D2*:					
Storden	American plum	Eastern redcedar, hackberry, Tatarian honeysuckle, Siberian peashrub.	Honeylocust, green ash, Russian-olive.	Siberian elm	---
Salida	Lilac	Tatarian honey-suckle, Siberian peashrub, eastern redcedar.	Hackberry, white spruce, red pine, jack pine.	---	---
654 Corwith	---	Lilac, Tatarian honeysuckle, northern white-cedar, Siberian peashrub.	White spruce, hackberry, eastern redcedar, bur oak.	Green ash, honeylocust, golden willow.	Eastern cottonwood.
655 Crippin	---	Northern white-cedar, Tatarian honeysuckle, Siberian peashrub, lilac.	Hackberry, white spruce, eastern redcedar, bur oak.	Golden willow, green ash, honeylocust.	Eastern cottonwood.
658 Mayer	---	Tatarian honeysuckle, northern white-cedar, Siberian peashrub, lilac.	Hackberry, bur oak, white spruce, eastern redcedar.	Golden willow, green ash, honeylocust.	Eastern cottonwood.
733 Calco	Lilac	Siberian peashrub, Tatarian honeysuckle.	Hackberry, ponderosa pine, eastern redcedar, Russian-olive.	Green ash, honeylocust, green ash, golden willow.	Eastern cottonwood.
823, 823B, 823C2 Ridgeport	Tatarian honeysuckle, lilac, Siberian peashrub.	Eastern redcedar, hackberry, Manchurian crabapple.	Eastern white pine, jack pine, honeylocust, Russian-olive, bur oak, green ash.	---	---

See footnote at end of table.

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of--				
	<8	8-15	16-25	26-35	>35
879--------------- Fostoria	----	Redosier dogwood, lilac, Tatarian honeysuckle.	Northern white-cedar, Amur maple, white spruce, blue spruce.	Austrian pine, eastern white pine, green ash, hackberry.	Silver maple.
895--------------- Lemond	---	Northern white-cedar, Tatarian honeysuckle, Siberian peashrub, lilac.	Bur oak, hackberry, white spruce, eastern redcedar.	Golden willow, honeylocust, green ash.	Eastern cottonwood.
1032-------------- Spicer	---	Tatarian honeysuckle, lilac, Siberian peashrub, northern white-cedar.	Bur oak, hackberry, white spruce, eastern redcedar.	Golden willow, honeylocust, green ash.	Eastern cottonwood.
1133-------------- Colo	---	Redosier dogwood, American plum, Tatarian honeysuckle.	White fir, white spruce, hackberry, Amur maple, tall purple willow.	Green ash, golden willow.	Silver maple, eastern cottonwood.
1135-------------- Coland	---	Redosier dogwood, Tatarian honeysuckle, American plum.	White spruce, hackberry, northern white-cedar, tall purple willow, Amur maple.	Golden willow, green ash.	Eastern cottonwood, silver maple.
1485-------------- Spillville	---	Redosier dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, blue spruce, Amur maple.	Hackberry, eastern white pine, Austrian pine, green ash.	Silver maple.
1595-------------- Harpster	---	Lilac, Siberian peashrub, northern white-cedar, Tatarian honeysuckle.	Hackberry, white spruce, bur oak, eastern redcedar.	Hackberry, golden willow, green ash.	Eastern cottonwood.
5010*. Pits					
5040*. Orthents					

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 8.--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
6 Okoboji	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding, erodes easily.	Severe: ponding.
28 Dickman	Slight	Slight	Slight	Slight	Moderate: droughty.
28B Dickman	Slight	Slight	Moderate: slope.	Slight	Moderate: droughty.
28C2 Dickman	Slight	Slight	Severe: slope.	Slight	Moderate: droughty.
34 Estherville	Slight	Slight	Moderate: small stones.	Slight	Moderate: droughty.
34B Estherville	Slight	Slight	Moderate: slope, small stones.	Slight	Moderate: droughty.
34C2 Estherville	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight	Moderate: droughty, slope.
52B Bode	Slight	Slight	Moderate: slope.	Slight	Slight.
54 Zook	Severe: wetness, flooding.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness, flooding.
55 Nicollet	Slight	Slight	Moderate: slope.	Slight	Slight.
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.
73C2 Salida	Moderate: small stones.	Moderate: small stones.	Severe: small stones.	Slight	Severe: droughty.
73E2 Salida	Severe: slope.	Severe: slope.	Severe: slope, small stones.	Moderate: slope.	Severe: 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.
107 Webster	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
108 Wadena	Slight	Slight	Moderate: small stones.	Slight	Slight.

TABLE 8.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
108B Wadena	Slight	Slight	Moderate: slope, small stones.	Slight	Slight.
133 Colo	Severe: flooding, wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: flooding, wetness.
133B Colo	Severe: flooding, wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness, flooding.
135 Coland	Severe: flooding, wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness, flooding.
138B 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.
150 Hanska	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.
181B*:					
Clarion	Slight	Slight	Moderate: slope.	Slight	Slight.
Estherville	Slight	Slight	Moderate: slope, small stones.	Slight	Moderate: droughty.
181C2*:					
Clarion	Slight	Slight	Severe: slope.	Slight	Slight.
Estherville	Slight	Slight	Severe: slope.	Slight	Moderate: droughty.
203 Cylinder	Moderate: wetness.	Moderate: wetness.	Moderate: wetness.	Slight	Slight.
221 Palms	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: ponding, excess humus.
224 Linder	Moderate: wetness.	Moderate: wetness.	Moderate: wetness.	Slight	Slight.
236B Lester	Slight	Slight	Moderate: slope.	Slight	Slight.
236C Lester	Slight	Slight	Severe: slope.	Slight	Slight.
236F Lester	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
259 Biscay	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
274 Rolfe	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: excess humus, ponding.	Severe: ponding, excess humus.	Severe: ponding.

See footnote at end of table.

TABLE 8.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
288 Ottosen	Moderate: wetness, percs slowly.	Moderate: wetness, percs slowly.	Moderate: slope, wetness, percs slowly.	Slight	Slight.
308 Wadena	Slight	Slight	Moderate: small stones.	Slight	Slight.
308B Wadena	Slight	Slight	Moderate: slope, small stones.	Slight	Slight.
325 Le Sueur	Moderate: wetness.	Moderate: wetness.	Moderate: slope, wetness.	Slight	Slight.
330 Kingston	Slight	Slight	Slight	Slight	Slight.
335 Harcot	Severe: flooding, wetness, excess humus.	Severe: excess humus.	Severe: excess humus, wetness.	Severe: excess humus.	Moderate: wetness.
339B Truman	Slight	Slight	Moderate: slope.	Slight	Slight.
348 Fieldon	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
349 Darfur	Severe: wetness, excess humus.	Severe: excess humus.	Severe: excess humus, wetness.	Severe: excess humus.	Moderate: wetness.
354*. Aquolls					
388 Kossuth	Severe: wetness.	Moderate: wetness, percs slowly.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
389 Waldorf	Severe: wetness, too clayey.	Severe: wetness, too clayey.	Severe: too clayey, wetness.	Severe: wetness, too clayey.	Severe: wetness, too clayey.
485 Spillville	Severe: flooding.	Slight	Moderate: flooding.	Slight	Moderate: flooding.
485B Spillville	Severe: flooding.	Slight	Moderate: slope, flooding.	Slight	Moderate: flooding.
506 Wacousta	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.
507 Canisteo	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
511 Blue Earth	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: excess humus, ponding.	Severe: ponding, excess humus.	Severe: ponding.
559 Talcot	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.

See footnote at end of table.

TABLE 8.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
585B*:					
Colo	Severe: flooding, wetness.	Moderate: flooding, wetness.	Severe: wetness, flooding.	Moderate: flooding, wetness.	Severe: flooding.
Spillville	Severe: flooding.	Slight	Moderate: slope, flooding.	Slight	Moderate: flooding.
638B*:					
Clarion	Slight	Slight	Moderate: slope.	Slight	Slight.
Storden	Slight	Slight	Moderate: slope.	Slight	Slight.
639C2*:					
Storden	Slight	Slight	Severe: slope.	Slight	Slight.
Salida	Moderate: small stones.	Moderate: small stones.	Severe: slope, small stones.	Slight	Severe: droughty.
639D2*:					
Storden	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight	Moderate: slope.
Salida	Moderate: slope, small stones.	Moderate: slope, small stones.	Severe: slope, small stones.	Slight	Severe: droughty.
654 Corwith	Moderate: wetness.	Moderate: wetness.	Moderate: slope, wetness.	Slight	Slight.
655 Crippin	Moderate: wetness.	Moderate: wetness.	Moderate: slope, wetness.	Slight	Slight.
658 Mayer	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
733 Calco	Severe: flooding, wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: flooding, wetness.
823 Ridgeport	Slight	Slight	Slight	Slight	Slight.
823B Ridgeport	Slight	Slight	Moderate: slope.	Slight	Slight.
823C2 Ridgeport	Moderate: slope.	Slight	Severe: slope.	Slight	Slight.
879 Fostoria	Moderate: wetness.	Moderate: wetness.	Moderate: wetness.	Slight	Slight.
895 Lemond	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.
1032 Spicer	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
1133 Colo	Severe: flooding, wetness.	Moderate: flooding, wetness.	Severe: wetness, flooding.	Moderate: flooding, wetness.	Severe: flooding.

See footnote at end of table.

TABLE 8.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
1135------------------ Coland	Severe: flooding, wetness.	Moderate: flooding, wetness.	Severe: wetness, flooding.	Moderate: wetness, flooding.	Severe: flooding.
1485------------------ Spillville	Severe: flooding.	Moderate: flooding.	Severe: flooding.	Moderate: flooding.	Severe: flooding.
1595------------------ Harpster	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.
5010*. Pits					
5040*. Orthents					

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 9.--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
6 Okoboji	Fair	Fair	Fair	Fair	Very poor.	Good	Good	Fair	Fair	Good.
28, 28B, 28C2 Dickman	Fair	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
34, 34B, 34C2 Estherville	Fair	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
52B Bode	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
54 Zook	Good	Fair	Good	Fair	Poor	Good	Good	Fair	Fair	Good.
55 Nicollet	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
62C2, 62D2, 62E2 Storden	Fair	Good	Good	Fair	Poor	Very poor.	Very poor.	Fair	Fair	Very poor.
62F, 62G Storden	Poor	Fair	Good	Fair	Poor	Very poor.	Very poor.	Fair	Fair	Very poor.
73C2 Salida	Poor	Poor	Poor	Poor	Poor	Very poor.	Very poor.	Poor	Poor	Very poor.
73E2 Salida	Very poor.	Poor	Poor	Poor	Poor	Very poor.	Very poor.	Very poor.	Poor	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.
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.
133 Colo	Good	Fair	Good	Fair	Poor	Good	Good	Fair	Fair	Good.
133B Colo	Good	Fair	Good	Fair	Poor	Fair	Very poor.	Fair	Fair	Poor.
135 Coland	Good	Good	Good	Fair	Fair	Good	Good	Good	Fair	Good.
138B 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.
150 Hanska	Fair	Fair	Fair	Fair	Fair	Good	Good	Fair	Fair	Good.

TABLE 9.--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
181B*:										
Clarion	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
Estherville	Fair	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
181C2*:										
Clarion	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
Estherville	Fair	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
203 Cylinder	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
221 Palms	Good	Poor	Poor	Poor	Poor	Good	Good	Fair	Poor	Good.
224 Linder	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
236B Lester	Good	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
236C Lester	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
236F Lester	Poor	Fair	Good	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
259 Biscay	Good	Good	Good	Good	Fair	Good	Good	Good	Fair	Good.
274 Rolfe	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
288 Ottosen	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
308, 308B Wadena	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
325 Le Sueur	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
330 Kingston	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
335 Harcot	Good	Fair	Fair	Poor	Poor	Good	Good	Fair	Poor	Good.
339B Truman	Good	Good	Good	Good	Fair	Poor	Very poor.	Good	Good	Very poor.
348 Fieldon	Good	Good	Good	Good	Fair	Good	Good	Good	Good	Good.
349 Darfur	Fair	Fair	Fair	Fair	Fair	Good	Good	Fair	Fair	Good.
354*. Aquolls										

See footnote at end of table.

TABLE 9.--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
388----------------- Kossuth	Good	Good	Good	Fair	Poor	Good	Good	Good	Fair	Good.
389----------------- Waldorf	Good	Good	Fair	Fair	Fair	Good	Good	Good	Fair	Good.
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.
506----------------- Wacousta	Good	Good	Fair	Good	Good	Poor	Poor	Good	Good	Poor.
507----------------- Canisteo	Good	Good	Fair	Fair	Fair	Good	Good	Good	Fair	Good.
511----------------- Blue Earth	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Poor	Good.
559----------------- Talcot	Good	Good	Fair	Fair	Fair	Good	Good	Good	Fair	Good.
585B*:										
Colo---------------	Good	Fair	Good	Fair	Poor	Fair	Very poor.	Fair	Fair	Poor.
Spillville---------	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
638B*:										
Clarion------------	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
Storden------------	Good	Good	Good	Fair	Poor	Very poor.	Very poor.	Good	Fair	Very poor.
639C2*, 639D2*:										
Storden------------	Fair	Good	Good	Fair	Poor	Very poor.	Very poor.	Fair	Fair	Very poor.
Salida-------------	Poor	Poor	Poor	Poor	Poor	Very poor.	Very poor.	Poor	Poor	Very poor.
654----------------- Corwith	Good	Good	Good	Good	Fair	Poor	Very poor.	Good	Good	Poor.
655----------------- Crippin	Good	Good	Good	Good	Fair	Fair	Poor	Good	Good	Poor.
658----------------- Mayer	Good	Good	Fair	Fair	Fair	Good	Good	Good	Fair	Good.
733----------------- Calco	Good	Fair	Good	Poor	Very poor.	Good	Good	Fair	Poor	Fair.
823, 823B, 823C2--- Ridgeport	Fair	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
879----------------- Fostoria	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
895----------------- Lemond	Good	Good	Fair	Fair	Fair	Good	Good	Good	Fair	Good.

See footnote at end of table.

TABLE 9.--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
1032---------------- Spicer	Good	Good	Fair	Fair	Poor	Good	Good	Good	Fair	Good.
1133---------------- Colo	Good	Fair	Good	Fair	Poor	Good	Good	Fair	Fair	Good.
1135---------------- Coland	Poor	Fair	Fair	Poor	Poor	Good	Good	Poor	Poor	Good.
1485---------------- Spillville	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
1595---------------- Harpster	Fair	Fair	Good	Fair	Fair	Good	Fair	Fair	Fair	Fair.
5010*. Pits										
5040*. Orthents										

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 10.--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
6----------------- Okoboji	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: low strength, ponding, frost action.	Severe: ponding.
28, 28B----------- Dickman	Severe: cutbanks cave.	Slight---------	Slight---------	Slight---------	Slight---------	Moderate: droughty.
28C2-------------- Dickman	Severe: cutbanks cave.	Slight---------	Slight---------	Moderate: slope.	Slight---------	Moderate: droughty.
34, 34B----------- Estherville	Severe: cutbanks cave.	Slight---------	Slight---------	Slight---------	Slight---------	Moderate: droughty.
34C2-------------- Estherville	Severe: cutbanks cave.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: droughty, slope.
52B--------------- Bode	Slight---------	Moderate: shrink-swell.	Slight---------	Moderate: shrink-swell.	Severe: low strength.	Slight.
54---------------- Zook	Severe: wetness.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, low strength, frost action.	Moderate: wetness, flooding.
55---------------- Nicollet	Moderate: wetness.	Moderate: shrink-swell.	Moderate: wetness.	Moderate: shrink-swell.	Severe: low strength, frost action.	Slight.
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.
73C2-------------- Salida	Severe: cutbanks cave.	Slight---------	Slight---------	Moderate: slope.	Slight---------	Severe: droughty.
73E2-------------- Salida	Severe: cutbanks cave, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: 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.
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.
133--------------- Colo	Severe: wetness.	Severe: flooding, shrink-swell, wetness.	Severe: flooding, shrink-swell, wetness.	Severe: flooding, shrink-swell, wetness.	Severe: flooding, low strength, frost action.	Moderate: flooding, wetness.

TABLE 10.--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
133B Colo	Severe: wetness.	Severe: flooding, shrink-swell, wetness.	Severe: flooding, shrink-swell, wetness.	Severe: flooding, shrink-swell, wetness.	Severe: flooding, low strength, frost action.	Moderate: wetness, flooding.
135 Coland	Severe: wetness.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, low strength, frost action.	Moderate: wetness, flooding.
138B 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.
150 Hanska	Severe: cutbanks cave, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness, frost action.	Severe: wetness.
181B*:						
Clarion	Slight	Slight	Slight	Slight	Moderate: frost action.	Slight.
Estherville	Severe: cutbanks cave.	Slight	Slight	Slight	Slight	Moderate: droughty.
181C2*:						
Clarion	Slight	Slight	Slight	Moderate: slope.	Moderate: frost action.	Slight.
Estherville	Severe: cutbanks cave.	Slight	Slight	Moderate: slope.	Slight	Moderate: droughty.
203 Cylinder	Severe: cutbanks cave, wetness.	Moderate: shrink-swell, wetness.	Severe: wetness.	Moderate: shrink-swell, wetness.	Severe: frost action.	Slight.
221 Palms	Severe: excess humus, ponding.	Severe: ponding, low strength.	Severe: ponding, low strength.	Severe: ponding, low strength.	Severe: ponding, frost action.	Severe: ponding, excess humus.
224 Linder	Severe: cutbanks cave, wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Severe: frost action.	Slight.
236B Lester	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength.	Slight.
236C Lester	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: low strength.	Slight.
236F Lester	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope.	Severe: slope.
259 Biscay	Severe: cutbanks cave, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
274 Rolfe	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: low strength, ponding, frost action.	Severe: ponding.

See footnote at end of table.

TABLE 10.--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
288 Ottosen	Severe: wetness.	Moderate: wetness, shrink-swell.	Severe: wetness.	Moderate: wetness, shrink-swell.	Severe: frost action, low strength.	Slight.
308, 308B Wadena	Severe: cutbanks cave.	Slight	Slight	Slight	Slight	Slight.
325 Le Sueur	Severe: wetness.	Moderate: wetness, shrink-swell.	Severe: wetness.	Moderate: wetness, shrink-swell.	Severe: frost action, low strength.	Slight.
330 Kingston	Moderate: wetness.	Slight	Moderate: wetness.	Slight	Severe: frost action.	Slight.
335 Harcot	Severe: cutbanks cave, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: frost action.	Moderate: wetness.
339B Truman	Slight	Moderate: shrink-swell.	Slight	Moderate: shrink-swell.	Severe: low strength, frost action.	Slight.
348 Fieldon	Severe: cutbanks cave, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: frost action.	Moderate: wetness.
349 Darfur	Severe: cutbanks cave, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: frost action.	Moderate: wetness.
354*. Aquolls						
388 Kossuth	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: shrink-swell, frost action, low strength.	Moderate: wetness.
389 Waldorf	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: low strength, wetness, frost action.	Severe: wetness, too clayey.
485, 485B Spillville	Moderate: flooding, wetness.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: low strength, flooding.	Moderate: flooding.
506 Wacousta	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: low strength, ponding, frost action.	Severe: ponding.
507 Canisteo	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
511 Blue Earth	Severe: excess humus, ponding.	Severe: ponding, low strength.	Severe: ponding.	Severe: ponding, low strength.	Severe: low strength, ponding, frost action.	Severe: ponding.
559 Talcot	Severe: cutbanks cave, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
585B*:						
Colo	Severe: wetness.	Severe: flooding, shrink-swell, wetness.	Severe: flooding, shrink-swell, wetness.	Severe: flooding, shrink-swell, wetness.	Severe: flooding, low strength, frost action.	Severe: flooding.

See footnote at end of table.

TABLE 10.--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
585B*:						
Spillville	Moderate: flooding, wetness.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: low strength, flooding.	Moderate: flooding.
638B*:						
Clarion	Slight	Slight	Slight	Slight	Moderate: frost action.	Slight.
Storden	Slight	Slight	Slight	Slight	Moderate: frost action.	Slight.
639C2*:						
Storden	Slight	Slight	Slight	Moderate: slope.	Moderate: frost action.	Slight.
Salida	Severe: cutbanks cave.	Slight	Slight	Moderate: slope.	Slight	Severe: droughty.
639D2*:						
Storden	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope, frost action.	Moderate: slope.
Salida	Severe: cutbanks cave.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope.	Severe: droughty.
654 Corwith	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Severe: frost action.	Slight.
655 Crippin	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Severe: frost action, low strength.	Slight.
658 Mayer	Severe: wetness, cutbanks cave.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: frost action, low strength.	Moderate: wetness.
733 Calco	Severe: wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: low strength, flooding.	Moderate: flooding, wetness.
823, 823B Ridgeport	Severe: cutbanks cave.	Slight	Slight	Slight	Slight	Slight.
823C2 Ridgeport	Severe: cutbanks cave.	Slight	Slight	Moderate: slope.	Slight	Slight.
879 Fostoria	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Severe: frost action, low strength.	Slight.
895 Lemond	Severe: cutbanks cave, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness, frost action.	Severe: wetness.
1032 Spicer	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: frost action, low strength.	Moderate: wetness.
1133 Colo	Severe: wetness.	Severe: flooding, shrink-swell, wetness.	Severe: flooding, shrink-swell, wetness.	Severe: flooding, shrink-swell, wetness.	Severe: flooding, low strength, frost action.	Severe: flooding.
1135 Coland	Severe: wetness.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, low strength, frost action.	Severe: flooding.

See footnote at end of table.

TABLE 10.--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
1485---------------- Spillville	Moderate: flooding, wetness.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: low strength, flooding.	Severe: flooding.
1595---------------- Harpster	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: low strength, ponding, frost action.	Severe: ponding.
5010*. Pits						
5040*. Orthents						

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 11.--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
6: Okoboji	Severe: ponding, percs slowly.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: hard to pack, ponding.
28, 28B: Dickman	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.
28C2: Dickman	Severe: poor filter.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.
34, 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.
52B: Bode	Slight	Moderate: seepage, slope.	Slight	Slight	Good.
54: Zook	Severe: percs slowly, wetness, flooding.	Severe: wetness, flooding.	Severe: wetness, too clayey, flooding.	Severe: wetness, flooding.	Poor: too clayey, wetness, hard to pack.
55: Nicollet	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: wetness.
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.
73C2: Salida	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
73E2: Salida	Severe: poor filter, slope.	Severe: seepage, slope.	Severe: seepage, slope, too sandy.	Severe: seepage, slope.	Poor: seepage, too sandy, small stones.
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.
107: Webster	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.

TABLE 11.--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
108, 108B----------- Wadena	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
133, 133B----------- Colo	Severe: wetness, flooding.	Severe: wetness, flooding.	Severe: wetness, flooding.	Severe: wetness, flooding.	Poor: wetness, hard to pack.
135----------------- Coland	Severe: flooding, wetness.	Severe: flooding, wetness, seepage.	Severe: flooding, wetness, seepage.	Severe: flooding, wetness.	Poor: wetness, hard to pack.
138B---------------- 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.
150----------------- Hanska	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, too sandy, wetness.
181B*:					
Clarion------------	Slight-----------	Moderate: slope, seepage.	Slight-----------	Slight-----------	Good.
Estherville--------	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
181C2*:					
Clarion------------	Slight-----------	Severe: slope.	Slight-----------	Slight-----------	Good.
Estherville--------	Severe: poor filter.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
203----------------- Cylinder	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: too sandy, seepage.
221----------------- Palms	Severe: subsides, ponding.	Severe: seepage, excess humus, ponding.	Severe: ponding, excess humus.	Severe: ponding, seepage.	Poor: ponding, excess humus.
224----------------- Linder	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, small stones, too sandy.
236B---------------- Lester	Moderate: percs slowly.	Moderate: seepage, slope.	Moderate: too clayey.	Slight-----------	Fair: too clayey.

See footnote at end of table.

TABLE 11.--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
236C Lester	Moderate: percs slowly.	Severe: slope.	Moderate: too clayey.	Slight	Fair: too clayey.
236F Lester	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
259 Biscay	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, too sandy, small stones.
274 Rolfe	Severe: ponding, percs slowly.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: ponding.
288 Ottosen	Severe: percs slowly, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: wetness.
308, 308B Wadena	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
325 Le Sueur	Severe: wetness.	Severe: wetness.	Moderate: wetness, too clayey.	Moderate: wetness.	Fair: too clayey, wetness.
330 Kingston	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: wetness, too clayey.
335 Harcot	Severe: wetness, poor filter.	Severe: seepage, flooding, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, too sandy, wetness.
339B Truman	Slight	Moderate: seepage, slope.	Slight	Slight	Good.
348 Fieldon	Severe: wetness.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, too sandy, wetness.
349 Darfur	Severe: wetness.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: too sandy, wetness.
354*. Aquolls					
388 Kossuth	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.
389 Waldorf	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack, wetness.
485, 485B Spillville	Severe: wetness, flooding.	Severe: wetness, seepage, flooding.	Severe: wetness, seepage, flooding.	Severe: wetness, flooding.	Fair: wetness.

See footnote at end of table.

TABLE 11.--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
506 Wacousta	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: ponding.
507 Canisteo	Severe: wetness.	Severe: seepage, wetness.	Severe: wetness.	Severe: seepage, wetness.	Poor: wetness.
511 Blue Earth	Severe: ponding.	Severe: ponding.	Severe: ponding, excess humus.	Severe: ponding.	Poor: hard to pack, ponding.
559 Talcot	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, too sandy, wetness.
585B*:					
Colo	Severe: wetness, flooding.	Severe: wetness, flooding.	Severe: wetness, flooding.	Severe: wetness, flooding.	Poor: wetness, hard to pack.
Spillville	Severe: wetness, flooding.	Severe: wetness, seepage, flooding.	Severe: wetness, seepage, flooding.	Severe: wetness, flooding.	Fair: wetness.
638B*:					
Clarion	Slight	Moderate: slope, seepage.	Slight	Slight	Good.
Storden	Slight	Moderate: seepage, slope.	Slight	Slight	Good.
639C2*:					
Storden	Slight	Severe: slope.	Slight	Slight	Good.
Salida	Severe: poor filter.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
639D2*:					
Storden	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: slope.	Fair: slope.
Salida	Severe: poor filter.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
654 Corwith	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: wetness.
655 Crippin	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: wetness.
658 Mayer	Severe: wetness.	Severe: wetness, seepage.	Severe: wetness, seepage, too sandy.	Severe: wetness, seepage.	Poor: wetness, too sandy, seepage.
733 Calco	Severe: wetness, flooding.	Severe: wetness.	Severe: wetness, flooding.	Severe: wetness, flooding.	Poor: wetness.

See footnote at end of table.

TABLE 11.--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
823, 823B, 823C2---- Ridgeport	Severe: poor filter.	Severe: seepage.	Severe: seepage.	Severe: seepage.	Poor: thin layer.
879---- Fostoria	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: wetness.
895---- Lemond	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, too sandy, wetness.
1032---- Spicer	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.
1133---- Colo	Severe: wetness, flooding.	Severe: wetness, flooding.	Severe: wetness, flooding.	Severe: wetness, flooding.	Poor: wetness, hard to pack.
1135---- Coland	Severe: flooding, wetness.	Severe: flooding, wetness, seepage.	Severe: flooding, wetness, seepage.	Severe: flooding, wetness.	Poor: wetness, hard to pack.
1485---- Spillville	Severe: wetness, flooding.	Severe: wetness, seepage, flooding.	Severe: wetness, seepage, flooding.	Severe: wetness, flooding.	Fair: wetness.
1595---- Harpster	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: hard to pack, ponding.
5010*. Pits					
5040*. Orthents					

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 12.--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
6 Okoboji	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
28, 28B, 28C2 Dickman	Good	Probable	Improbable: too sandy.	Poor: thin layer.
34, 34B, 34C2 Estherville	Good	Probable	Probable	Poor: small stones, area reclaim.
52B Bode	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones.
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.
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.
73C2 Salida	Good	Probable	Probable	Poor: small stones, area reclaim, too sandy.
73E2 Salida	Fair: slope.	Probable	Probable	Poor: small stones, area reclaim, too sandy.
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.
107 Webster	Fair: low strength, wetness, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Good.
108, 108B Wadena	Good	Probable	Probable	Poor: small stones, area reclaim.

TABLE 12.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
133, 133B 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, 138C, 138C2 Clarion	Good	Improbable: excess fines.	Improbable: excess fines.	Good.
138D2 Clarion	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: slope.
150 Hanska	Poor: wetness.	Probable	Improbable: too sandy.	Poor: wetness.
181B*, 181C2*:				
Clarion	Good	Improbable: excess fines.	Improbable: excess fines.	Good.
Estherville	Good	Probable	Probable	Poor: small stones, area reclaim.
203 Cylinder	Fair: wetness.	Probable	Improbable: too sandy.	Fair: area reclaim, small stones, thin layer.
221 Palms	Poor: wetness.	Improbable: excess humus, excess fines.	Improbable: excess humus, excess fines.	Poor: wetness, excess humus.
224 Linder	Fair: wetness.	Probable	Improbable: too sandy.	Poor: small stones, area reclaim.
236B, 236C Lester	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
236F Lester	Poor: slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
259 Biscay	Fair: wetness.	Probable	Probable	Poor: area reclaim.
274 Rolfe	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer, wetness.
288 Ottosen	Fair: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones.
308, 308B Wadena	Good	Probable	Probable	Poor: small stones, area reclaim.
325 Le Sueur	Fair: low strength, wetness, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Good.
330 Kingston	Fair: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.

See footnote at end of table.

TABLE 12.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
335 Harcot	Fair: wetness.	Probable	Improbable: too sandy.	Fair: small stones, area reclaim, thin layer
339B Truman	Fair: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
348 Fieldon	Fair: wetness.	Probable	Improbable: too sandy.	Fair: thin layer.
349 Darfur	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Fair: thin layer.
354*. Aquolls				
388 Kossuth	Fair: wetness, shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones.
389 Waldorf	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, wetness.
485, 485B Spillville	Good	Improbable: excess fines.	Improbable: excess fines.	Good.
506 Wacousta	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
507 Canisteo	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
511 Blue Earth	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
559 Talcot	Fair: wetness.	Probable	Probable	Fair: small stones, area reclaim, thin layer.
585B*:				
Colo	Poor: shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
Spillville	Good	Improbable: excess fines.	Improbable: excess fines.	Good.
638B*:				
Clarion	Good	Improbable: excess fines.	Improbable: excess fines.	Good.
Storden	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
639C2*:				
Storden	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
Salida	Good	Probable	Probable	Poor: small stones, area reclaim, too sandy.

See footnote at end of table.

TABLE 12.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
639D2*:				
Storden	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones, slope.
Salida	Good	Probable	Probable	Poor: small stones, area reclaim, too sandy.
654 Corwith	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
655 Crippin	Fair: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
658 Mayer	Fair: wetness.	Probable	Probable	Fair: area reclaim, thin layer.
733 Calco	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
823, 823B, 823C2 Ridgeport	Good	Probable	Improbable: too sandy.	Fair: small stones, area reclaim, thin layer.
879 Fostoria	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
895 Lemond	Poor: wetness.	Probable	Improbable: too sandy.	Poor: wetness.
1032 Spicer	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
1133 Colo	Poor: shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
1135 Coland	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
1485 Spillville	Good	Improbable: excess fines.	Improbable: excess fines.	Good.
1595 Harpster	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
5010*. Pits				
5040*. Orthents				

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 13.--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-- Pond reservoir areas	Embankments, dikes, and levees	Features affecting-- Drainage	Irrigation	Terraces and diversions	Grassed waterways
6 Okoboji	Moderate: seepage.	Severe: ponding.	Ponding, frost action.	Ponding, erodes easily.	Erodes easily, ponding.	Wetness, erodes easily.
28 Dickman	Severe: seepage.	Severe: seepage.	Deep to water	Droughty, soil blowing.	Too sandy, soil blowing.	Droughty.
28B, 28C2 Dickman	Severe: seepage.	Severe: seepage.	Deep to water	Droughty, soil blowing, slope.	Too sandy, soil blowing.	Droughty.
34 Estherville	Severe: seepage.	Severe: seepage.	Deep to water	Droughty, soil blowing.	Too sandy, soil blowing.	Droughty.
34B Estherville	Severe: seepage.	Severe: seepage.	Deep to water	Droughty, soil blowing, slope.	Too sandy, soil blowing.	Droughty.
34C2 Estherville	Severe: seepage, slope.	Severe: seepage.	Deep to water	Droughty, soil blowing, slope.	Slope, too sandy, soil blowing.	Slope, droughty.
52B Bode	Moderate: seepage, slope.	Severe: piping.	Deep to water	Slope	Favorable	Favorable.
54 Zook	Slight	Severe: hard to pack, wetness.	Flooding, percs slowly, frost action.	Wetness, percs slowly.	Not needed	Not needed.
55 Nicollet	Moderate: seepage.	Severe: piping.	Frost action	Wetness	Wetness	Favorable.
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.
73C2 Salida	Severe: seepage.	Severe: seepage.	Deep to water	Droughty, fast intake, slope.	Too sandy	Droughty.
73E2 Salida	Severe: seepage, slope.	Severe: seepage.	Deep to water	Droughty, fast intake, slope.	Slope, too sandy.	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.
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 Wadena	Severe: seepage.	Severe: seepage, piping.	Deep to water	Slope	Too sandy	Favorable.
133 Colo	Moderate: seepage.	Severe: wetness.	Flooding, frost action.	Flooding, wetness.	Wetness	Wetness.

TABLE 13.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Features affecting-- Drainage	Irrigation	Terraces and diversions	Grassed waterways
133B-------------- Colo	Moderate: seepage, slope.	Severe: wetness.	Flooding, frost action, slope.	Wetness, slope, flooding.	Wetness--------	Wetness.
135--------------- Coland	Moderate: seepage.	Severe: wetness.	Flooding, frost action.	Wetness, flooding.	Wetness--------	Wetness.
138B, 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.
150--------------- Hanska	Severe: seepage.	Severe: seepage, wetness.	Frost action, cutbanks cave.	Wetness--------	Wetness, too sandy.	Wetness.
181B*, 181C2*:						
Clarion----------	Moderate: seepage, slope.	Severe: piping.	Deep to water	Slope----------	Erodes easily	Erodes easily.
Estherville------	Severe: seepage.	Severe: seepage.	Deep to water	Droughty, soil blowing, slope.	Too sandy, soil blowing.	Droughty.
203--------------- Cylinder	Severe: seepage.	Severe: seepage, piping.	Frost action, cutbanks cave.	Wetness--------	Wetness, too sandy.	Favorable.
221--------------- Palms	Severe: seepage.	Severe: excess humus, ponding.	Ponding, subsides.	Ponding, soil blowing.	Ponding, soil blowing.	Wetness.
224--------------- Linder	Severe: seepage.	Severe: seepage, piping.	Frost action, cutbanks cave.	Wetness, droughty.	Wetness, too sandy.	Droughty.
236B, 236C-------- Lester	Moderate: seepage, slope.	Severe: thin layer.	Deep to water	Slope----------	Erodes easily	Erodes easily.
236F-------------- Lester	Severe: slope.	Severe: thin layer.	Deep to water	Slope----------	Slope erodes easily.	Slope, erodes easily.
259--------------- Biscay	Severe: seepage.	Severe: seepage, wetness.	Frost action, cutbanks cave.	Wetness--------	Wetness, too sandy.	Wetness.
274--------------- Rolfe	Moderate: seepage.	Severe: ponding.	Ponding, percs slowly, frost action.	Ponding, percs slowly.	Ponding--------	Wetness, percs slowly.
288--------------- Ottosen	Moderate: seepage.	Moderate: piping, wetness.	Frost action---	Wetness--------	Wetness--------	Favorable.
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.
325--------------- Le Sueur	Moderate: seepage.	Moderate: wetness.	Frost action---	Wetness--------	Wetness--------	Favorable.

See footnote at end of table.

TABLE 13.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Features affecting-- Drainage	Irrigation	Terraces and diversions	Grassed waterways
330 Kingston	Moderate: seepage.	Severe: piping.	Frost action	Wetness	Erodes easily, wetness.	Erodes easily.
335 Harcot	Severe: seepage.	Severe: seepage, piping, wetness.	Frost action, cutbanks cave.	Wetness, rooting depth.	Wetness, too sandy.	Wetness, rooting depth.
339B Truman	Moderate: seepage, slope.	Severe: piping.	Deep to water	Slope	Erodes easily	Erodes easily.
348 Fieldon	Severe: seepage.	Severe: seepage, piping, wetness.	Frost action, cutbanks cave.	Wetness	Wetness, too sandy.	Wetness.
349 Darfur	Severe: seepage.	Severe: seepage, piping, wetness.	Frost action, cutbanks cave.	Wetness	Wetness, too sandy.	Wetness.
354*. Aquolls						
388 Kossuth	Moderate: seepage.	Severe: wetness.	Frost action	Wetness	Wetness	Wetness.
389 Waldorf	Moderate: seepage.	Severe: hard to pack, wetness.	Frost action	Wetness, slow intake.	Wetness	Wetness.
485 Spillville	Moderate: seepage.	Moderate: piping, wetness.	Deep to water	Flooding	Favorable	Favorable.
485B Spillville	Moderate: seepage, slope.	Moderate: piping, wetness.	Deep to water	Slope, flooding.	Favorable	Favorable.
506 Wacousta	Moderate: seepage.	Severe: piping, ponding.	Ponding, frost action.	Ponding	Not needed	Not needed.
507 Canisteo	Severe: seepage.	Severe: wetness.	Frost action	Wetness	Wetness	Wetness.
511 Blue Earth	Moderate: seepage.	Severe: piping, excess humus, ponding.	Ponding, frost action.	Ponding	Ponding	Wetness.
559 Talcot	Severe: seepage.	Severe: seepage, wetness.	Frost action, cutbanks cave.	Wetness	Wetness, too sandy.	Wetness.
585B*:						
Colo	Moderate: seepage, slope.	Severe: wetness.	Flooding, frost action, slope.	Wetness, slope, flooding.	Wetness	Wetness.
Spillville	Moderate: seepage, slope.	Moderate: piping, wetness.	Deep to water	Slope, flooding.	Favorable	Favorable.
638B*:						
Clarion	Moderate: seepage, slope.	Severe: piping.	Deep to water	Slope	Erodes easily	Erodes easily.

See footnote at end of table.

TABLE 13.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Features affecting-- Drainage	Irrigation	Terraces and diversions	Grassed waterways
638B*:						
Storden	Moderate: seepage, slope.	Moderate: piping.	Deep to water	Slope	Erodes easily	Erodes easily.
639C2*:						
Storden	Moderate: seepage, slope.	Moderate: piping.	Deep to water	Slope	Erodes easily	Erodes easily.
Salida	Severe: seepage.	Severe: seepage.	Deep to water	Droughty, fast intake, slope.	Too sandy	Droughty.
639D2*:						
Storden	Severe: slope.	Moderate: piping.	Deep to water	Slope	Slope, erodes easily.	Slope, erodes easily.
Salida	Severe: seepage, slope.	Severe: seepage.	Deep to water	Droughty, fast intake, slope.	Slope, too sandy.	Slope, droughty.
654 Corwith	Moderate: seepage.	Severe: piping.	Frost action	Wetness, rooting depth.	Erodes easily, wetness.	Erodes easily, rooting depth.
655 Crippin	Moderate: seepage.	Moderate: wetness.	Frost action	Wetness	Wetness, erodes easily.	Erodes easily.
658 Mayer	Severe: seepage.	Severe: seepage, wetness.	Frost action, cutbanks cave.	Wetness	Wetness, too sandy.	Wetness.
733 Calco	Moderate: seepage.	Severe: wetness.	Flooding, frost action.	Flooding, wetness.	Wetness	Wetness.
823 Ridgeport	Severe: seepage.	Severe: piping.	Deep to water	Soil blowing, rooting depth.	Soil blowing	Rooting depth.
823B, 823C2 Ridgeport	Severe: seepage.	Severe: piping.	Deep to water	Soil blowing, rooting depth, slope.	Soil blowing	Rooting depth.
879 Fostoria	Moderate: seepage.	Moderate: wetness, piping.	Frost action	Wetness	Wetness, erodes easily.	Erodes easily.
895 Lemond	Severe: seepage.	Severe: seepage, piping, wetness.	Frost action, cutbanks cave.	Wetness	Wetness, too sandy.	Wetness.
1032 Spicer	Moderate: seepage.	Severe: wetness.	Frost action	Wetness	Wetness	Wetness.
1133 Colo	Moderate: seepage.	Severe: wetness.	Flooding, frost action.	Flooding, wetness.	Wetness	Wetness.
1135 Coland	Moderate: seepage.	Severe: wetness.	Flooding, frost action.	Wetness, flooding.	Wetness	Wetness.
1485 Spillville	Moderate: seepage.	Moderate: piping, wetness.	Deep to water	Flooding	Favorable	Favorable.
1595 Harpster	Moderate: seepage.	Severe: ponding.	Ponding, frost action.	Ponding	Ponding	Wetness.
5010*. Pits						

See footnote at end of table.

TABLE 13.--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
5040*. Orthents						

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 14.--ENGINEERING INDEX PROPERTIES

[The symbol < means less than; > means more than. Absence of an entry indicates that data were not estimated]

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments > 3 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				Pct					Pct	
6----------------- Okoboji	0-29	Silty clay loam	CH	A-7	0	100	100	90-100	80-95	55-65	30-40
	29-49	Silty 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
28, 28B, 28C2---- Dickman	0-11	Fine sandy loam	SM, SM-SC	A-2, A-4	0	95-100	95-100	55-95	25-40	20-30	2-8
	11-40	Sandy loam, fine sandy loam.	SM, SM-SC	A-2, A-4	0	95-100	85-100	55-95	25-45	15-25	2-8
	40-60	Stratified fine sand to coarse sand.	SP-SM	A-3, A-2	0	95-100	75-95	50-80	5-10	---	NP
34, 34B, 34C2---- Estherville	0-12	Sandy loam-------	SM, SM-SC, SC	A-2, A-4	0-5	90-100	80-100	50-75	25-50	20-30	2-10
	12-20	Sandy loam, coarse sandy loam, gravelly sandy loam.	SM, SM-SC, SC	A-2, A-4, A-1	0-5	85-100	80-95	40-75	15-45	20-30	2-8
	20-60	Coarse sand, gravelly coarse sand, sand and gravel.	SP, SP-SM, SM	A-1	0-10	55-90	50-85	10-40	2-25	---	NP
52B-------------- Bode	0-17	Clay loam--------	CL	A-6, A-7	0	95-100	95-100	75-90	55-80	35-50	15-25
	17-31	Clay loam, loam	CL	A-6, A-7	0	95-100	90-100	75-90	55-80	35-50	15-25
	31-60	Loam-------------	CL, CL-ML	A-4, A-6	0-5	90-100	90-95	75-90	50-75	25-40	5-15
54--------------- Zook	0-24	Silty clay loam	CH, CL	A-7	0	100	100	95-100	95-100	45-65	20-35
	24-60	Silty clay, silty clay loam.	CH	A-7	0	100	100	95-100	95-100	60-85	35-55
55--------------- Nicollet	0-13	Loam-------------	OL, ML, CL	A-6, A-7	0	95-100	95-100	85-98	55-85	35-50	10-25
	13-39	Clay loam, loam	CL	A-6, A-7	0-5	95-100	95-100	80-95	55-80	35-50	15-25
	39-60	Loam-------------	CL, ML	A-6, A-4	0-5	95-100	90-100	75-90	50-75	30-40	5-15
62C2, 62D2, 62E2, 62F, 62G-------- 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
73C2, 73E2------- Salida	0-8	Gravelly sandy loam.	SM, SP-SM	A-2, A-1	0-5	85-95	60-75	30-60	12-20	---	NP
	8-14	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
	14-60	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
90--------------- Okoboji	0-13	Mucky silt loam	OH, MH	A-7	0	100	100	95-100	90-95	60-95	10-30
	13-42	Silty clay loam	CH	A-7	0	100	100	90-100	80-95	55-65	30-40
	42-60	Stratified loam to silty clay loam.	CL, CH	A-7	0-5	95-100	90-100	90-100	75-90	40-55	20-30
95--------------- Harps	0-14	Clay loam--------	CL, CH	A-6, A-7	0-5	100	95-100	80-90	65-80	30-55	15-35
	14-34	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
	34-60	Loam-------------	CL	A-6	0-5	95-100	90-100	70-80	50-75	25-40	10-25
107-------------- Webster	0-15	Silty clay loam	CL, CH	A-7, A-6	0-5	100	95-100	85-95	70-90	35-60	15-30
	15-29	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
	29-60	Loam, sandy loam, clay loam.	CL	A-6	0-5	95-100	90-100	75-85	50-75	30-40	10-20

TABLE 14.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Frag- ments > 3 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plas- ticity index
	In				Pct					Pct	
108, 108B--------- Wadena	0-13	Loam--------------	ML	A-4	0	95-100	80-100	75-95	50-65	25-40	2-10
	13-27	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
	27-60	Sand and gravel	SP, SP-SM, GP, GP-GM	A-1, A-3, A-2	0-5	45-100	40-95	10-80	2-10	---	NP
133, 133B--------- Colo	0-50	Silty clay loam	CL, CH	A-7	0	100	100	90-100	90-100	40-60	15-30
	50-60	Silty clay loam, clay loam.	CL, CH	A-7	0	100	100	90-100	90-100	40-55	20-30
135--------------- 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.	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
138B, 138C, 138C2, 138D2---- Clarion	0-16	Loam--------------	CL, CL-ML	A-4, A-6	0-5	95-100	95-100	75-90	50-75	25-40	5-15
	16-34	Loam, clay loam	CL, CL-ML	A-4, A-6	0-5	90-100	85-100	75-90	50-75	25-40	5-15
	34-60	Loam--------------	CL, CL-ML	A-4, A-6	0-5	90-100	85-100	75-90	50-70	25-40	5-15
150--------------- Hanska	0-20	Loam--------------	ML, CL, CL-ML	A-4	0	98-100	95-100	80-95	50-65	<25	2-10
	20-26	Sandy loam, coarse sandy loam, loam.	SM, SM-SC, SC	A-4	0	98-100	95-100	65-80	35-50	<20	2-8
	26-60	Loamy sand, loamy coarse sand, sand.	SP-SM, SM	A-2, A-3	0	95-100	90-100	50-75	5-25	<20	NP
181B*, 181C2*: Clarion----------	0-16	Loam--------------	CL, CL-ML	A-4, A-6	0-5	95-100	95-100	75-90	50-75	25-40	5-15
	16-34	Loam, clay loam	CL, CL-ML	A-4, A-6	0-5	90-100	85-100	75-90	50-75	25-40	5-15
	34-60	Loam--------------	CL, CL-ML	A-4, A-6	0-5	90-100	85-100	75-90	50-70	25-40	5-15
Estherville------	0-12	Sandy loam--------	SM, SM-SC, SC	A-2, A-4	0-5	90-100	80-100	50-75	25-50	20-30	2-10
	12-20	Sandy loam, coarse sandy loam, gravelly sandy loam.	SM, SM-SC, SC	A-2, A-4, A-1	0-5	85-100	80-95	40-75	15-45	20-30	2-8
	20-60	Coarse sand, gravelly coarse sand, sand and gravel.	SP, SP-SM, SM	A-1	0-10	55-90	50-85	10-40	2-25	---	NP
203--------------- Cylinder	0-17	Loam--------------	CL	A-6, A-7	0	100	90-100	80-100	50-75	30-50	10-25
	17-37	Loam, clay loam, gravelly loam.	CL, SC	A-6	0	95-100	80-100	80-95	45-70	30-40	10-20
	37-60	Gravelly coarse sand, loamy sand, sand and gravel.	SP-SM, SM	A-1, A-2, A-3	0-10	75-95	75-95	20-55	5-25	---	NP
221--------------- Palms	0-28	Sapric material	PT	---	---	---	---	---	---	---	---
	28-60	Clay loam, silty clay loam.	CL-ML, CL	A-4, A-6	0	85-100	80-100	70-95	50-90	25-40	5-20
224--------------- Linder	0-14	Loam--------------	CL, SC	A-4, A-6	0	100	95-100	80-95	35-80	25-40	8-15
	14-22	Sandy loam, loamy sand.	SC, SM-SC	A-2, A-4	0	95-100	80-100	45-75	30-45	20-30	5-10
	22-60	Loamy sand, sand and gravel.	SP, SP-SM	A-1	0-5	75-95	30-95	25-50	2-12	---	NP
236B, 236C, 236F- Lester	0-13	Loam--------------	ML, CL	A-6, A-4	0	95-100	90-100	80-95	50-70	30-40	5-15
	13-45	Clay loam, loam	CL	A-7, A-6	0-5	95-100	90-100	80-95	55-75	35-50	15-25
	45-60	Loam, clay loam	CL, CL-ML	A-6, A-4	0-5	95-100	90-100	75-90	50-70	20-40	5-20

See footnote at end of table.

TABLE 14.--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	
259-------------- Biscay	0-19	Clay loam--------	CL, ML	A-7, A-6	0	95-100	95-100	70-90	50-75	35-50	10-25
	19-39	Loam, clay loam	CL, ML	A-6, A-7	0	95-100	90-100	70-90	50-75	30-50	10-20
	39-60	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
274-------------- Rolfe	0-24	Silt loam--------	OL, CL, ML	A-6, A-4	0	100	95-100	90-100	80-95	30-40	5-15
	24-72	Silty clay, clay loam, silty clay loam.	CH	A-7	0	100	95-100	90-100	75-95	50-65	25-35
288-------------- Ottosen	0-18	Clay loam--------	CL, CH	A-7	0	95-100	95-100	90-100	65-85	40-55	20-30
	18-33	Clay loam, silty clay loam.	CL, CH	A-7	0	95-100	95-100	90-100	65-85	40-55	20-30
	33-60	Loam-------------	CL	A-4, A-6	0-5	90-100	90-100	80-95	60-75	25-40	8-20
308, 308B-------- Wadena	0-13	Loam-------------	ML	A-4	0	95-100	80-100	75-95	50-65	25-40	2-10
	13-36	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
	36-60	Sand and gravel	SP, SP-SM, GP, GP-GM	A-1, A-3, A-2	0-5	45-100	40-95	10-80	2-10	---	NP
325-------------- Le Sueur	0-13	Loam-------------	CL, ML, CL-ML	A-6, A-4	0	95-100	95-100	90-100	70-85	20-40	5-15
	13-44	Clay loam, loam, silty clay loam.	CL	A-6, A-7	0	95-100	95-100	85-100	60-80	35-50	15-25
	44-60	Loam, clay loam	CL-ML, CL	A-6, A-4	0-5	95-100	90-100	80-95	55-75	20-40	5-20
330-------------- Kingston	0-24	Silty clay loam	ML, OL, CL-ML, CL	A-4	0	100	100	95-100	85-98	25-35	5-10
	24-37	Silty clay loam, silt loam.	CL	A-6, A-7	0	100	100	95-100	85-98	35-45	12-20
	37-60	Silt loam, silty clay loam.	CL-ML, CL	A-4, A-6	0	100	100	95-100	85-98	25-35	5-12
335-------------- Harcot	0-20	Loam-------------	CH, CL, OH, OL	A-7	0	95-100	90-95	80-90	55-75	40-55	15-25
	20-34	Loam, clay loam, sandy loam.	CL	A-6	0	95-100	90-95	75-85	55-75	30-40	10-20
	34-60	Fine sand, gravelly sand, sand and gravel.	SP, SM, SP-SM	A-1	0-5	80-95	75-95	40-50	3-25	---	NP
339B------------- Truman	0-17	Silt loam--------	ML	A-4	0	100	100	95-100	80-98	30-40	5-10
	17-41	Silt loam, silty clay loam.	ML, CL	A-4, A-6, A-7	0	100	100	95-100	80-98	30-45	5-20
	41-60	Silt loam--------	CL, CL-ML	A-4, A-6	0	100	100	95-100	75-95	25-40	4-15
348-------------- Fieldon	0-18	Loam-------------	CL-ML, CL, ML	A-4	0	100	100	85-95	50-75	20-32	NP-10
	18-45	Fine sandy loam, very fine sandy loam, loam.	ML, SM	A-4	0	100	100	70-90	35-60	<30	NP-5
	45-60	Fine sand, loamy fine sand, silt.	SM, SP-SM	A-2, A-3	0	100	100	75-85	5-35	---	NP
349-------------- Darfur	0-22	Loam-------------	OL, ML	A-4	0	100	100	100	60-80	25-40	NP-10
	22-40	Fine sandy loam	SM, SM-SC	A-4	0	100	100	40-100	35-50	20-30	NP-5
	40-60	Stratified fine sand to fine sandy loam.	SM	A-2, A-4	0	100	100	40-100	15-40	---	---
354*. Aquolls											
388-------------- Kossuth	0-18	Silty clay loam	CL, CH	A-7	0	95-100	95-100	80-85	75-85	40-60	20-30
	18-36	Silty clay loam, clay loam.	CL, CH	A-7	0	95-100	95-100	80-85	75-85	45-65	25-35
	36-60	Loam-------------	CL	A-4, A-6	0-5	95-100	90-100	70-85	50-70	25-40	8-20

See footnote at end of table.

TABLE 14.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Frag- ments > 3 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plas- ticity index
	In				Pct					Pct	
389------------- Waldorf	0-21	Silty clay--------	ML, MH	A-7	0	100	100	95-100	90-100	45-65	14-30
	21-42	Silty clay, silty clay loam.	MH	A-7	0	100	100	95-100	95-100	50-70	20-35
	42-60	Silty clay loam, silty clay, silt loam.	MH, CL, ML, CH	A-7, A-6	0	100	100	95-100	90-100	35-65	11-30
485, 485B-------- Spillville	0-39	Loam-------------	CL	A-6	0	100	95-100	85-95	60-80	25-40	10-20
	39-60	Sandy clay loam, loam, fine sandy loam.	CL, CL-ML, SM-SC, SC	A-6, A-4	0	100	95-100	80-90	35-75	20-40	5-15
506-------------- Wacousta	0-12	Silty clay loam	CH, CL	A-7	0	100	100	95-100	95-100	40-65	20-40
	12-41	Silty clay loam, silt loam.	CH, CL	A-7	0	100	100	90-100	90-100	40-60	20-35
	41-60	Silt loam, silty clay loam, clay loam.	CL, ML	A-6, A-4	0-5	95-100	95-100	85-100	80-90	30-40	5-15
507-------------- Canisteo	0-23	Clay loam--------	CL	A-7, A-6	0	100	100	90-100	85-100	35-50	15-25
	23-39	Clay loam, loam, silty clay loam.	CL	A-6, A-7	0	98-100	90-100	85-95	65-85	38-50	25-35
	39-60	Clay loam, loam	CL, ML, SM, SC	A-6, A-4	0-5	90-100	80-95	60-90	40-80	30-40	5-15
511-------------- Blue Earth	0-24	Mucky silt loam, silty clay loam.	OL, ML	A-5	0	95-100	95-100	85-95	80-95	41-50	2-8
	24-60	Mucky silty clay loam, clay loam, mucky silt loam.	OL, ML	A-5	0	95-100	80-100	80-95	80-95	41-50	2-8
559-------------- Talcot	0-23	Clay loam--------	CL	A-7	0	100	100	80-90	60-85	40-50	15-25
	23-40	Clay loam, silty clay loam.	CL	A-7	0	95-100	85-100	70-90	60-85	40-50	15-25
	40-60	Stratified loamy sand to gravelly coarse sand, sand and gravel.	SP, SP-SM, SW	A-1	0	65-90	50-85	20-50	2-10	---	NP
585B*:											
Colo------------	0-50	Silty clay loam	CL, CH	A-7	0	100	100	90-100	90-100	40-60	15-30
	50-60	Silty clay loam	CL, CH	A-7	0	100	100	90-100	90-100	40-55	20-30
Spillville------	0-51	Loam-------------	CL	A-6	0	100	95-100	85-95	60-80	25-40	10-20
	51-60	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
638B*:											
Clarion---------	0-16	Loam-------------	CL, CL-ML	A-4, A-6	0-5	95-100	95-100	75-90	50-75	25-40	5-15
	16-34	Loam, clay loam	CL, CL-ML	A-4, A-6	0-5	90-100	85-100	75-90	50-75	25-40	5-15
	34-60	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
639C2*, 639D2*:											
Storden---------	0-6	Loam-------------	ML, CL	A-4, A-6	0-5	95-100	95-100	70-85	55-70	30-40	5-15
	6-60	Loam-------------	CL-ML, CL	A-4, A-6	0-5	95-100	85-97	70-85	55-70	20-40	5-15
Salida----------	0-9	Gravelly sandy loam.	SM, SP-SM	A-2, A-1	0-5	85-95	60-75	30-60	12-20	---	NP
	9-14	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
	14-60	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

See footnote at end of table.

TABLE 14.--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	
654-------------- Corwith	0-14	Loam-------------	ML	A-4	0	100	100	95-100	70-90	20-40	NP-10
	14-31	Loam, silt loam	ML	A-4	0	100	100	95-100	70-95	20-40	NP-10
	31-60	Silt loam, very fine sandy loam.	ML, CL-ML	A-4	0	100	100	90-100	65-95	20-30	NP-5
655-------------- Crippin	0-15	Loam-------------	CL	A-6, A-7	0	95-100	95-100	80-90	60-80	30-45	10-20
	15-34	Loam, clay loam	CL	A-6	0-5	95-100	90-100	80-90	60-80	30-40	10-20
	34-60	Loam, clay loam	CL	A-6	2-5	90-100	85-100	75-90	55-80	30-40	10-20
658-------------- Mayer	0-20	Loam-------------	CL, ML	A-6, A-4	0-2	95-100	85-100	70-90	50-85	30-40	5-15
	20-30	Loam, sandy clay loam.	CL, SC, ML, SM	A-6, A-4	0-5	90-100	85-100	70-90	40-85	30-40	5-15
	30-60	Sand and gravel	SP, SW, SP-SM	A-1	0-10	65-95	45-85	20-45	2-10	<20	NP
733-------------- Calco	0-50	Silty clay loam	CH, CL	A-7	0	100	100	95-100	85-100	40-60	15-30
	50-60	Silty clay loam, clay loam.	CL	A-7, A-6	0	100	100	90-100	80-100	30-45	10-20
823, 823B, 823C2- Ridgeport	0-11	Sandy loam-------	SM, SC, SM-SC	A-2, A-4	0	95-100	90-100	70-90	25-50	15-30	2-10
	11-33	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
	33-60	Sand and gravel	SW, SP, SW-SM, SP-SM	A-1	0-5	80-95	75-95	35-50	2-10	<25	NP-6
879-------------- Fostoria	0-18	Loam-------------	CL, CL-ML	A-4, A-6	0	100	100	95-100	80-95	25-40	5-15
	18-60	Loam, sandy loam, loamy sand.	CL	A-6	0-5	100	100	75-100	55-95	30-40	10-20
895-------------- Lemond	0-14	Loam-------------	ML, SM, CL, SC	A-4	0	98-100	95-100	80-95	40-65	<25	2-10
	14-24	Sandy loam, loamy sand.	SM, SM-SC	A-2, A-4	0	98-100	95-100	65-80	25-40	<25	NP-7
	24-60	Sand and gravel	SP-SM, SP	A-3, A-1, A-2	0-10	90-100	85-100	35-85	2-10	---	NP
1032------------- Spicer	0-9	Silty clay loam, silt loam.	ML	A-7, A-6	0	100	100	95-100	90-100	35-50	10-20
	9-42	Silt loam, silty clay loam.	ML	A-7, A-6	0	100	100	95-100	85-100	35-50	10-20
	42-60	Silt loam, silty clay loam.	ML	A-4, A-6	0	100	100	95-100	85-100	30-40	5-12
1133------------- Colo	0-50	Silty clay loam	CL, CH	A-7	0	100	100	90-100	90-100	40-60	15-30
	50-60	Silty clay loam	CL, CH	A-7	0	100	100	90-100	90-100	40-55	20-30
1135------------- Coland	0-38	Clay loam--------	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
	38-60	Clay loam, silty clay loam.	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
1485------------- Spillville	0-39	Loam-------------	CL	A-6	0	100	95-100	85-95	60-80	25-40	10-20
	39-60	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
1595------------- Harpster	0-21	Silt loam--------	CL, CH	A-7	0	100	95-100	95-100	90-100	45-60	20-35
	21-60	Silt loam--------	CL, CH	A-7	0	100	95-100	95-100	85-100	40-60	20-35
5010*. Pits											
5040*. Orthents											

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 15.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS

[The symbol > means more than. Entries under "Erosion factors--T" apply to the entire profile. Entries under "Wind erodibility group" and "Organic matter" apply only to the surface layer. Absence of an entry indicates that data were not available or were not estimated]

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodibility group	Organic matter
	In	Pct	G/cm3	In/hr	In/in	pH					Pct
6----------------- Okoboji	0-29	35-42	1.25-1.30	0.2-0.6	0.21-0.23	6.6-7.8	High----------	0.37	5	4	9-18
	29-49	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			
28, 28B, 28C2---- Dickman	0-11	6-18	1.30-1.40	2.0-6.0	0.13-0.15	5.6-7.3	Low-----------	0.20	3	3	2-5
	11-40	6-18	1.35-1.50	2.0-6.0	0.12-0.14	5.6-7.3	Low-----------	0.20			
	40-60	1-10	1.50-1.60	6.0-20	0.02-0.07	5.6-7.8	Low-----------	0.15			
34, 34B, 34C2---- Estherville	0-12	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
	12-20	10-18	1.35-1.60	2.0-6.0	0.09-0.14	5.6-7.3	Low-----------	0.20			
	20-60	0-8	1.50-1.65	6.0-20	0.02-0.04	6.6-8.4	Low-----------	0.10			
52B-------------- Bode	0-17	32-36	1.40-1.50	0.6-2.0	0.17-0.19	6.1-7.3	Moderate------	0.28	5	5	3-4
	17-31	28-35	1.50-1.70	0.6-2.0	0.15-0.19	6.1-7.3	Moderate------	0.28			
	31-60	22-27	1.70-1.80	0.6-2.0	0.17-0.19	6.6-8.4	Low-----------	0.28			
54--------------- Zook	0-24	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
	24-60	36-45	1.30-1.45	0.06-0.2	0.11-0.13	5.6-7.8	High----------	0.28			
55--------------- Nicollet	0-13	24-32	1.15-1.25	0.6-2.0	0.17-0.22	5.6-7.3	Moderate------	0.24	5	6	4-8
	13-39	24-32	1.25-1.35	0.6-2.0	0.15-0.19	5.6-8.4	Moderate------	0.32			
	39-60	22-28	1.35-1.45	0.6-2.0	0.14-0.19	7.4-8.4	Low-----------	0.32			
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			
73C2, 73E2------- Salida	0-8	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
	8-14	2-8	1.50-1.65	>20	0.02-0.04	7.4-8.4	Low-----------	0.10			
	14-60	0-5	1.50-1.65	>20	0.02-0.04	7.4-8.4	Low-----------	0.10			
90--------------- Okoboji	0-13	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
	13-42	35-42	1.30-1.35	0.2-0.6	0.18-0.20	6.6-7.8	High----------	0.37			
	42-60	20-30	1.40-1.50	0.6-2.0	0.18-0.20	7.4-8.4	Moderate------	0.28			
95--------------- Harps	0-14	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
	14-34	18-32	1.40-1.50	0.6-2.0	0.17-0.19	7.9-8.4	Moderate------	0.32			
	34-60	20-26	1.50-1.70	0.6-2.0	0.17-0.19	7.9-8.4	Moderate------	0.32			
107-------------- Webster	0-15	26-36	1.35-1.40	0.6-2.0	0.19-0.21	6.6-7.3	Moderate------	0.24	5	6	6-7
	15-29	25-35	1.40-1.50	0.6-2.0	0.16-0.18	6.6-7.8	Moderate------	0.32			
	29-60	18-29	1.50-1.70	0.6-2.0	0.17-0.19	7.4-8.4	Moderate------	0.32			
108, 108B-------- Wadena	0-13	18-30	1.30-1.50	0.6-2.0	0.20-0.22	6.1-7.3	Low-----------	0.24	4	5	3-6
	13-27	18-30	1.35-1.50	0.6-2.0	0.14-0.19	5.6-7.3	Low-----------	0.32			
	27-60	1-5	1.55-1.65	>6.0	0.02-0.04	6.6-8.4	Low-----------	0.10			
133, 133B-------- Colo	0-50	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
	50-60	30-35	1.25-1.35	0.6-2.0	0.18-0.20	6.1-7.3	High----------	0.28			
135-------------- 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	6.1-7.3	High----------	0.28			
138B, 138C, 138C2, 138D2---- Clarion	0-16	18-24	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Low-----------	0.28	5	6	2-4
	16-34	24-30	1.50-1.70	0.6-2.0	0.17-0.19	5.6-7.8	Low-----------	0.37			
	34-60	18-22	1.70-1.80	0.6-2.0	0.17-0.19	7.4-8.4	Low-----------	0.37			
150-------------- Hanska	0-20	6-18	1.30-1.40	2.0-6.0	0.20-0.22	6.1-7.8	Low-----------	0.28	4	5	4-8
	20-26	6-18	1.35-1.50	2.0-6.0	0.10-0.13	6.1-7.3	Low-----------	0.28			
	26-60	2-10	1.50-1.60	6.0-20	0.08-0.10	6.1-7.8	Low-----------	0.17			

TABLE 15.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodibility group	Organic matter
	In	Pct	G/cm3	In/hr	In/in	pH					Pct
181B*, 181C2*:											
Clarion---------	0-16	18-24	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Low-----------	0.28	5	6	3-4
	16-34	24-30	1.50-1.70	0.6-2.0	0.17-0.19	5.6-7.8	Low-----------	0.37			
	34-60	12-22	1.70-1.80	0.6-2.0	0.17-0.19	7.4-8.4	Low-----------	0.37			
Estherville-----	0-12	5-15	1.25-1.35	2.0-6.0	0.13-0.18	5.6-7.3	Low-----------	0.20	3	3	2-4
	12-20	10-18	1.35-1.60	2.0-6.0	0.09-0.14	5.6-7.3	Low-----------	0.20			
	20-60	0-8	1.50-1.65	6.0-20	0.02-0.04	6.6-8.4	Low-----------	0.10			
203-------------- Cylinder	0-17	22-32	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Moderate-----	0.24	4	6	4-5
	17-37	18-30	1.45-1.60	0.6-2.0	0.17-0.19	6.1-7.3	Moderate-----	0.32			
	37-60	2-12	1.60-1.70	>20	0.02-0.04	7.4-8.4	Low-----------	0.10			
221-------------- Palms	0-28	---	0.25-0.45	0.2-6.0	0.35-0.45	5.1-7.8	-------------	----	2	3	20-50
	28-60	18-35	1.45-1.75	0.2-2.0	0.14-0.22	6.1-8.4	Low-----------	----			
224-------------- Linder	0-14	14-18	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.8	Low-----------	0.24	4	5	3-4
	14-22	10-18	1.45-1.55	2.0-6.0	0.15-0.17	6.1-7.8	Low-----------	0.24			
	22-60	2-8	1.55-1.75	>20	0.02-0.04	7.4-8.4	Low-----------	0.10			
236B, 236C, 236F- Lester	0-13	15-27	1.30-1.40	0.6-2.0	0.20-0.22	5.6-6.5	Low-----------	0.28	5	6	1-4
	13-45	20-35	1.45-1.55	0.6-2.0	0.15-0.19	5.1-6.5	Moderate-----	0.28			
	45-60	20-30	1.55-1.75	0.6-2.0	0.14-0.19	6.6-7.8	Low-----------	0.37			
259-------------- Biscay	0-19	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
	19-39	18-30	1.25-1.35	0.6-2.0	0.17-0.19	6.6-7.8	Moderate-----	0.28			
	39-60	1-6	1.55-1.65	6.0-20	0.02-0.04	6.6-8.4	Low-----------	0.10			
274-------------- Rolfe	0-24	22-28	1.35-1.40	0.6-2.0	0.22-0.24	5.1-7.3	Moderate-----	0.28	5	6	3-5
	24-72	38-45	1.40-1.50	0.06-0.2	0.11-0.13	6.1-7.3	High---------	0.28			
288-------------- Ottosen	0-18	32-40	1.35-1.45	0.2-0.6	0.19-0.22	5.6-7.3	Moderate-----	0.28	5	7	5-6
	18-33	30-40	1.45-1.55	0.2-0.6	0.17-0.19	6.1-8.4	Moderate-----	0.28			
	33-60	22-27	1.55-1.85	0.6-2.0	0.17-0.19	7.4-8.4	Low-----------	0.28			
308, 308B-------- Wadena	0-13	18-30	1.30-1.50	0.6-2.0	0.20-0.22	6.1-7.3	Low-----------	0.24	4	5	3-6
	13-30	18-30	1.35-1.50	0.6-2.0	0.14-0.19	5.6-7.3	Low-----------	0.32			
	30-60	1-5	1.55-1.65	>6.0	0.02-0.04	6.6-8.4	Low-----------	0.10			
325-------------- Le Sueur	0-13	20-27	1.30-1.40	0.6-2.0	0.20-0.24	5.6-7.3	Low-----------	0.24	5	6	2-4
	13-44	24-35	1.30-1.45	0.6-2.0	0.15-0.19	5.1-6.5	Moderate-----	0.32			
	44-60	24-30	1.50-1.65	0.6-2.0	0.15-0.19	7.4-8.4	Moderate-----	0.32			
330-------------- Kingston	0-24	18-32	1.20-1.30	0.6-2.0	0.18-0.24	5.6-7.3	Low-----------	0.28	5	7	4-8
	24-37	18-32	1.25-1.35	0.6-2.0	0.16-0.20	5.6-7.8	Moderate-----	0.37			
	37-60	18-32	1.25-1.35	0.6-2.0	0.16-0.20	7.4-8.4	Low-----------	0.37			
335-------------- Harcot	0-20	24-29	1.35-1.40	0.6-2.0	0.20-0.22	7.9-8.4	Moderate-----	0.28	4	6	5-6
	20-34	18-30	1.40-1.60	0.6-2.0	0.17-0.19	7.9-8.4	Moderate-----	0.28			
	34-60	2-8	1.60-1.75	>20	0.05-0.07	6.6-7.8	Low-----------	0.15			
339B------------- Truman	0-17	18-28	1.25-1.35	0.6-2.0	0.20-0.23	6.1-7.3	Low-----------	0.32	5	6	4-8
	17-41	18-32	1.30-1.45	0.6-2.0	0.18-0.21	6.1-7.8	Moderate-----	0.43			
	41-60	18-25	1.35-1.45	0.6-2.0	0.18-0.20	7.4-8.4	Low-----------	0.43			
348-------------- Fieldon	0-18	15-22	1.25-1.40	0.6-2.0	0.18-0.20	7.4-8.4	Low-----------	0.28	5	4L	5-8
	18-45	10-18	1.35-1.55	0.6-2.0	0.15-0.17	7.4-8.4	Low-----------	0.28			
	45-60	0-10	1.40-1.60	6.0-20	0.05-0.07	7.4-8.4	Low-----------	0.28			
349-------------- Darfur	0-22	18-25	1.20-1.35	0.6-2.0	0.20-0.22	6.1-7.3	Low-----------	0.20	5	5	5-8
	22-40	13-18	1.35-1.50	2.0-6.0	0.15-0.17	6.6-7.8	Low-----------	0.20			
	40-60	5-15	1.45-1.60	2.0-6.0	0.08-0.10	6.6-8.4	Low-----------	0.20			
354*. Aquolls											

See footnote at end of table.

TABLE 15.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodibility group	Organic matter
	In	Pct	G/cm3	In/hr	In/in	pH					Pct
388------------- Kossuth	0-18	32-42	1.35-1.45	0.2-0.6	0.21-0.23	6.1-7.3	High---------	0.28	5	4	6-7
	18-36	35-42	1.45-1.55	0.2-0.6	0.18-0.20	6.1-7.8	High---------	0.28			
	36-60	23-27	1.55-1.80	0.6-2.0	0.17-0.19	7.4-8.4	Moderate-----	0.28			
389------------- Waldorf	0-21	35-45	1.20-1.30	0.2-2.0	0.18-0.25	6.1-7.3	Moderate-----	0.28	5	4	6-8
	21-42	40-55	1.25-1.35	0.2-0.6	0.13-0.16	6.6-7.8	High---------	0.28			
	42-60	24-45	1.25-1.35	0.2-2.0	0.20-0.22	7.4-8.4	Moderate-----	0.28			
485, 485B-------- Spillville	0-39	18-26	1.45-1.55	0.6-2.0	0.19-0.21	5.6-7.3	Moderate-----	0.28	5	6	4-6
	39-60	14-24	1.55-1.70	0.6-6.0	0.15-0.18	5.6-7.3	Low----------	0.28			
506------------- Wacousta	0-12	27-35	1.20-1.25	0.6-2.0	0.21-0.23	6.1-7.8	High---------	0.28	5	7	8-10
	12-41	24-35	1.25-1.30	0.6-2.0	0.18-0.20	7.4-7.8	High---------	0.43			
	41-60	18-30	1.30-1.40	0.6-2.0	0.20-0.22	7.4-8.4	Moderate-----	0.43			
507------------- Canisteo	0-23	18-35	1.20-1.30	0.6-2.0	0.20-0.22	7.4-8.4	Moderate-----	0.32	5	4L	4-8
	23-39	20-35	1.35-1.50	0.6-2.0	0.15-0.19	7.4-8.4	Moderate-----	0.32			
	39-60	10-35	1.30-1.50	0.6-6.0	0.12-0.18	7.4-8.4	Low----------	0.32			
511------------- Blue Earth	0-24	18-32	0.20-0.80	0.6-6.0	0.18-0.24	7.4-8.4	Moderate-----	0.28	5	5	10-25
	24-60	18-32	0.20-0.80	0.6-2.0	0.18-0.24	7.4-8.4	Low----------	0.28			
559------------- Talcot	0-23	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
	23-40	25-35	1.25-1.35	0.6-2.0	0.17-0.20	7.4-8.4	Moderate-----	0.28			
	40-60	1-6	1.55-1.65	6.0-20	0.02-0.04	7.4-8.4	Low----------	0.15			
585B*:											
Colo-----------	0-50	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
	50-60	30-35	1.25-1.35	0.6-2.0	0.18-0.20	6.1-7.3	High---------	0.28			
Spillville------	0-51	18-26	1.45-1.55	0.6-2.0	0.19-0.21	5.6-7.3	Moderate-----	0.28	5	6	4-6
	51-60	14-24	1.55-1.70	0.6-6.0	0.15-0.18	5.6-7.3	Low----------	0.28			
638B*:											
Clarion---------	0-16	18-24	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Low----------	0.28	5	6	3-4
	16-34	24-30	1.50-1.70	0.6-2.0	0.17-0.19	5.6-7.8	Low----------	0.37			
	34-60	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			
639C2*, 639D2*:											
Storden---------	0-6	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
	6-60	18-27	1.35-1.65	0.6-2.0	0.17-0.19	7.4-8.4	Low----------	0.37			
Salida----------	0-9	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
	9-14	2-8	1.50-1.65	>20	0.02-0.04	7.4-8.4	Low----------	0.10			
	14-60	0-5	1.50-1.65	>20	0.02-0.04	7.4-8.4	Low----------	0.10			
654------------- Corwith	0-14	18-24	1.35-1.40	0.6-2.0	0.20-0.22	6.6-7.8	Low----------	0.28	5	6	5-6
	14-31	12-20	1.40-1.55	0.6-2.0	0.20-0.22	7.9-8.4	Low----------	0.28			
	31-60	5-15	1.40-1.75	0.6-2.0	0.17-0.19	6.6-8.4	Low----------	0.43			
655------------- Crippin	0-15	22-28	1.35-1.40	0.6-2.0	0.20-0.22	6.6-8.4	Low----------	0.28	5	6	5-6
	15-34	24-30	1.40-1.55	0.6-2.0	0.17-0.19	7.4-8.4	Low----------	0.28			
	34-60	22-28	1.55-1.75	0.6-2.0	0.17-0.19	7.9-8.4	Low----------	0.37			
658------------- Mayer	0-20	18-27	1.25-1.35	0.6-2.0	0.20-0.22	7.4-8.4	Low----------	0.28	4	4L	4-8
	20-30	18-27	1.25-1.35	0.6-2.0	0.16-0.19	7.4-8.4	Low----------	0.28			
	30-60	1-5	1.55-1.65	6.0-20	0.02-0.04	7.4-8.4	Low----------	0.15			
733------------- Calco	0-50	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
	50-60	22-32	1.30-1.45	0.6-2.0	0.18-0.20	7.4-8.4	Moderate-----	0.28			
823, 823B, 823C2- Ridgeport	0-11	10-18	1.50-1.55	2.0-6.0	0.14-0.17	5.6-7.3	Low----------	0.24	4	3	1-2
	11-33	10-18	1.55-1.60	2.0-6.0	0.10-0.14	5.6-7.3	Low----------	0.24			
	33-60	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 15.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodibility group	Organic matter
	In	Pct	G/cm3	In/hr	In/in	pH					Pct
879----------- Fostoria	0-18	25-30	1.35-1.40	0.6-2.0	0.20-0.22	6.1-7.3	Low----------	0.24	5	6	5-6
	18-60	25-30	1.40-1.75	0.6-2.0	0.20-0.22	6.6-8.4	Low----------	0.43			
895----------- Lemond	0-14	6-18	1.30-1.40	2.0-6.0	0.20-0.22	7.4-8.4	Low----------	0.28	5	4L	4-8
	14-24	6-18	1.35-1.50	2.0-6.0	0.10-0.13	7.4-8.4	Low----------	0.28			
	24-60	1-10	1.50-1.70	6.0-20	0.05-0.07	7.4-8.4	Low----------	0.15			
1032---------- Spicer	0-9	18-35	1.20-1.30	0.6-2.0	0.18-0.24	7.4-8.4	Moderate-----	0.28	5	4L	4-8
	9-42	18-35	1.25-1.35	0.6-2.0	0.16-0.22	7.4-8.4	Moderate-----	0.28			
	42-60	18-35	1.25-1.35	0.6-2.0	0.16-0.22	7.4-8.4	Low----------	0.28			
1133---------- Colo	0-50	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
	50-60	30-35	1.25-1.35	0.6-2.0	0.18-0.20	6.1-7.3	High---------	0.28			
1135---------- Coland	0-38	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
	38-60	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	High---------	0.28			
1485---------- Spillville	0-39	18-26	1.45-1.55	0.6-2.0	0.19-0.21	5.6-7.3	Moderate-----	0.28	5	6	4-6
	39-60	14-24	1.55-1.70	0.6-6.0	0.15-0.18	5.6-7.3	Low----------	0.28			
1595---------- Harpster	0-21	22-35	1.05-1.25	0.6-2.0	0.21-0.24	7.4-8.4	Moderate-----	0.28	5	4L	5-6
	21-60	23-27	1.20-1.50	0.6-2.0	0.18-0.22	7.4-8.4	Moderate-----	0.28			
5010*. Pits											
5040*. Orthents											

TABLE 16.--SOIL AND WATER FEATURES

["Flooding" and "water table" and terms such as "brief," "apparent," and "perched" are explained in the text. The symbol > means more than. Absence of an entry indicates that the feature is not a concern or that data were not estimated]

Soil name and map symbol	Hydro-logic group	Flooding			High water table			Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months		Uncoated steel	Concrete
					Ft					
6----------------- Okoboji	B/D	None---------	---	---	+1-1.0	Apparent	Nov-Jul	High-----	High-----	Low.
28, 28B, 28C2----- Dickman	A	None---------	---	---	>6.0	---	---	Low------	Low------	Moderate.
34, 34B, 34C2----- Estherville	B	None---------	---	---	>6.0	---	---	Low------	Low------	Low.
52B--------------- Bode	B	None---------	---	---	>6.0	---	---	Moderate	Moderate	Low.
54---------------- Zook	C/D	Occasional	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.
62C2, 62D2, 62E2, 62F, 62G--------- Storden	B	None---------	---	---	>6.0	---	---	Moderate	Low------	Low.
73C2, 73E2-------- Salida	A	None---------	---	---	>6.0	---	---	Low------	Low------	Low.
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-Jun	High-----	High-----	Low.
107--------------- Webster	B/D	None---------	---	---	1.0-2.0	Apparent	Nov-Jul	High-----	High-----	Low.
108, 108B--------- Wadena	B	None---------	---	---	>6.0	---	---	Low------	Low------	Low.
133--------------- Colo	B/D	Occasional	Very brief to long.	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Moderate.
133B-------------- Colo	B/D	Occasional	Very brief to long.	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Moderate.
135--------------- Coland	B/D	Occasional	Brief to long.	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Low.
138B, 138C, 138C2, 138D2------------ Clarion	B	None---------	---	---	>6.0	---	---	Moderate	Low------	Low.
150--------------- Hanska	C	None---------	---	---	0-3.0	Apparent	Nov-Jun	High-----	High-----	Low.
181B*, 181C2*:										
Clarion-----------	B	None---------	---	---	>6.0	---	---	Moderate	Low------	Low.
Estherville------	B	None---------	---	---	>6.0	---	---	Low------	Low------	Low.
203--------------- Cylinder	B	None---------	---	---	2.0-4.0	Apparent	Nov-Jul	High-----	Moderate	Low.
221--------------- Palms	A/D	None---------	---	---	+1-1.0	Apparent	Nov-May	High-----	High-----	Moderate.

See footnote at end of table.

TABLE 16.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydro-logic group	Flooding: Frequency	Flooding: Duration	Flooding: Months	High water table: Depth	High water table: Kind	High water table: Months	Potential frost action	Risk of corrosion: Uncoated steel	Risk of corrosion: Concrete
					Ft					
224----------------- Linder	B	None---------	---	---	2.0-4.0	Apparent	Nov-Jul	High-----	Moderate	Low.
236B, 236C, 236F-- Lester	B	None---------	---	---	>6.0	---	---	Moderate	Low-------	Moderate.
259----------------- Biscay	B/D	None---------	---	---	1.0-3.0	Apparent	Nov-Jun	High-----	Moderate	Low.
274----------------- Rolfe	C	None---------	---	---	+1-1.0	Apparent	Nov-Jul	High-----	High-----	Moderate.
288----------------- Ottosen	B	None---------	---	---	2.0-4.0	Apparent	Nov-Jul	High-----	High-----	Low.
308, 308B--------- Wadena	B	None---------	---	---	>6.0	---	---	Low-------	Low-------	Low.
325----------------- Le Sueur	B	None---------	---	---	2.0-4.0	Perched	Nov-May	High-----	High-----	Low.
330----------------- Kingston	B	None---------	---	---	2.5-5.0	Apparent	Nov-Jul	High-----	High-----	Low.
335----------------- Harcot	B/D	Rare---------	---	---	1.0-2.0	Apparent	Nov-Jul	High-----	High-----	Low.
339B--------------- Truman	B	None---------	---	---	>6.0	---	---	High-----	Low-------	Low.
348----------------- Fieldon	B/D	None---------	---	---	1.0-3.0	Apparent	Nov-Jun	High-----	High-----	Low.
349----------------- Darfur	B/D	None---------	---	---	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Low.
354*. Aquolls										
388----------------- Kossuth	B/D	None---------	---	---	1.0-2.0	Apparent	Nov-Jul	High-----	High-----	Low.
389----------------- Waldorf	C/D	None---------	---	---	0-3.0	Apparent	Nov-Jun	High-----	High-----	Low.
485, 485B--------- Spillville	B	Occasional	Brief-----	Feb-Nov	3.0-5.0	Apparent	Nov-Jul	Moderate	High-----	Moderate.
506----------------- Wacousta	B/D	None---------	---	---	+1-1.0	Apparent	Nov-Jul	High-----	High-----	Low.
507----------------- Canisteo	C/D	None---------	---	---	1.0-3.0	Apparent	Oct-Jul	High-----	High-----	Low.
511----------------- Blue Earth	B/D	None---------	---	---	+2-1.0	Apparent	Jan-Dec	High-----	High-----	Low.
559----------------- Talcot	B/D	None---------	---	---	1.0-2.5	Apparent	Nov-Jul	High-----	High-----	Low.
585B*: Colo---------------	B/D	Occasional	Very brief to long.	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Moderate.
Spillville--------	B	Occasional	Very brief	Feb-Nov	3.0-5.0	Apparent	Nov-Jul	Moderate	High-----	Moderate.
638B*: Clarion-----------	B	None---------	---	---	>6.0	---	---	Moderate	Low-------	Low.

See footnote at end of table.

TABLE 16.--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					
638B*:										
Storden	B	None	---	---	>6.0	---	---	Moderate	Low	Low.
639C2*, 639D2*:										
Storden	B	None	---	---	>6.0	---	---	Moderate	Low	Low.
Salida	A	None	---	---	>6.0	---	---	Low	Low	Low.
654 Corwith	E	None	---	---	2.0-4.0	Apparent	Nov-Jul	High	High	Low.
655 Crippin	B	None	---	---	2.0-4.0	Apparent	Nov-Jun	High	High	Low.
658 Mayer	B/D	None	---	---	1.0-3.0	Apparent	Oct-Jun	High	High	Low.
733 Calco	B/D	Occasional	Brief	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High	High	Low.
823, 823B, 823C2 Ridgeport	B	None	---	---	>6.0	---	---	Low	Low	Low.
879 Fostoria	B	None	---	---	2.0-4.0	Apparent	Nov-Jul	High	High	Low.
895 Lemond	B/D	None	---	---	0-3.0	Apparent	Nov-May	High	High	Low.
1032 Spicer	B/D	None	---	---	1.0-3.0	Apparent	Nov-Jun	High	High	Low.
1133 Colo	B/D	Frequent	Very brief to long.	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High	High	Moderate.
1135 Coland	B/D	Frequent	Very brief to long.	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High	High	Low.
1485 Spillville	B	Frequent	Very brief to long.	Feb-Nov	3.0-5.0	Apparent	Nov-Jul	Moderate	High	Moderate.
1595 Harpster	B/D	None	---	---	1.0-3.0	Apparent	Nov-Jul	High	High	Low.
5010*. Pits										
5040*. Orthents										

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 17.--ENGINEERING INDEX TEST DATA

[Tests performed by the Iowa Department of Transportation, Soils Laboratory, according to standard procedures of the American Association of State Highway and Transportation Officials (AASHTO)]

Soil name and location	Parent material	Report number AAD6-	Depth	Horizon	Moisture density: Maximum dry density	Moisture density: Optimum moisture	Percentage passing sieve--: 1 in	3/4 in	3/8 in	No. 4	No. 10	No. 40	No. 200	Liquid limit	Plasticity index	AASHTO classification
			In		Lb/cu ft	Pct								Pct		
Canisteo clay loam: 36 feet north and 1,200 feet west of the SE corner, sec. 29, T. 95 N., R. 29 W.	Calcareous loam glacial till of Late Wisconsin age.	3320	0-10	Ap	93	25				100	99	98	87	58	34	A-7-6(20)
		3321	31-38	B22g	106	18			100	99	99	95	73	39	22	A-6(12)
		3322	48-60	Cg	110	16			100	99	99	96	87	35	14	A-6(10)
Canisteo clay loam: 100 feet north and 200 feet east of the SE corner, NW1/4 sec. 11, T. 97 N., R. 27 W. (Modal)	Calcareous loam glacial till of Wisconsin age.	3326	0-8	Ap	99	22			100	99	99	97	67	45	22	A-7-6(12)
		3327	23-30	B2g	109	17				100	97	94	67	38	19	A-6(10)
		3328	39-60	Cg	110	16				100	97	96	69	35	15	A-6(9)
Estherville sandy loam: 300 feet east and 264 feet north of the SW corner, NW1/4 sec. 17, T. 95 N., R. 30 W. (Modal)	Glacial alluvium.	3302	0-7	Ap	110	16		100	99	98	96	86	45	27	6	A-4(2)
		3303	12-16	B2	118	13		100	99	94	84	78	37	24	4	A-4(0)
		3304	20-60	IIC1	134	8	97	93	76	60	37	25	8	20	0	A-1-a(0)
Kossuth silty clay loam: 54 feet north and 430 feet west of the SE corner, sec. 33, T. 95 N., R. 29 W.	Wisconsin-age lacustrine sediments over Wisconsin-age glacial till.	3294	0-9	Ap	91	26					100	99	86	50	23	A-7-6(15)
		3295	29-33	B22g	95	24						100	92	55	30	A-7-6(19)
		3296	40-48	IIC1g	110	16				100	99	98	74	36	18	A-6(11)
Nicollet loam: 129 feet north and 18 feet west of the SE corner, NW1/4SE1/4 sec. 35, T. 96 N., R. 30 W. (Modal)	Glacial till.	3299	0-8	Ap	97	23					100	98	70	41	15	A-7-6(9)
		3300	27-33	B22	101	21				100	99	95	70	45	22	A-7-6(13)
		3301	39-60	C	110	16			100	99	97	92	66	34	14	A-6(8)

TABLE 17.--ENGINEERING INDEX TEST DATA--Continued

Soil name and location	Parent material	Report number AAD6-	Depth	Horizon	Moisture density: Maximum dry density	Moisture density: Optimum moisture	Percentage passing sieve--: 1 in	3/4 in	3/8 in	No. 4	No. 10	No. 40	No. 200	Liquid limit	Plasticity index	AASHTO classification
			In		Lb/cu ft	Pct								Pct		
Okoboji mucky silt loam: 25 feet east and 1,320 feet north of the SW corner, sec. 8, T. 97 N., R. 30 W.	Water-worked sediments from Wisconsin-age loam glacial till.	3308	0-9	Ap	95	24					100	99	84	49	29	A-7-6(17)
		3309	13-19	B2g	100	21					100	99	87	45	23	A-7-6(14)
		3310	49-60	C2	102	20					100	99	89	44	23	A-7-6(14)
Okoboji silty clay loam: 270 feet north and 12 feet east of the SW corner, sec 8, T. 97 N., R. 30 W. (Modal)	Water-worked sediments from Wisconsin-age loam glacial till.	3305	0-9	Ap	72	38						100	90	67	16	A-7-5(14)
		3306	35-41	A13	92	26						100	94	53	30	A-7-6(19)
		3307	49-53	C3	90	27						100	97	54	28	A-7-6(18)
Storden loam: 78 feet east and 40 feet north of the SW corner, NW1/4SW1/4 sec. 4, T. 96 N., R. 29 W. (Modal)	Calcareous loam glacial till of Late Wisconsin age.	3297	0-6	Ap	105	18			100	99	96	91	58	40	13	A-6(6)
		3298	6-13	C1	108	17		100	98	97	95	94	63	34	14	A-6(7)
Webster silty clay loam: 81 feet north and 280 feet west of the SE corner, NE1/4NE1/4 sec. 13, T. 97 N., R. 30 W.	Loamy glacial till and local alluvium.	3311	0-8	Ap	95	24					100	99	74	47	21	A-7-6(14)
		3312	23-29	B2g	108	17				100	99	97	66	40	23	A-6(11)
		3313	38-60	C	98	22				100	99	98	81	39	18	A-6(11)

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
Aquolls	Mixed, mesic Haplaquolls
Biscay	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Typic Haplaquolls
Blue Earth	Fine-silty, mixed (calcareous), mesic Mollic Fluvaquents
Bode	Fine-loamy, mixed, mesic Typic Hapludolls
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
Corwith	Coarse-silty, mixed, mesic Aquic Hapludolls
Crippin	Fine-loamy, mixed, mesic Aquic Hapludolls
Cylinder	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Aquic Hapludolls
Darfur	Coarse-loamy, mixed, mesic Typic Haplaquolls
Dickman	Sandy, mixed, mesic Typic Hapludolls
Estherville	Sandy, mixed, mesic Typic Hapludolls
Fieldon	Coarse-loamy, mixed (calcareous), mesic Typic Haplaquolls
Fostoria	Fine-loamy, mixed, mesic Aquic Hapludolls
Hanska	Coarse-loamy, mixed, mesic Typic Haplaquolls
Harcot	Fine-loamy over sandy or sandy-skeletal, mesic Typic Calciaquolls
Harps	Fine-loamy, mesic Typic Calciaquolls
Harpster	Fine-silty, mesic Typic Calciaquolls
Kingston	Fine-silty, mixed, mesic Aquic Hapludolls
Kossuth	Fine-loamy, mixed, mesic Typic Haplaquolls
*Lemond	Coarse-loamy, mixed (calcareous), mesic Typic Haplaquolls
Lester	Fine-loamy, mixed, mesic Mollic Hapludalfs
Le Sueur	Fine-loamy, mixed, mesic Aquic Argiudolls
Linder	Coarse-loamy, mixed, mesic Aquic Hapludolls
Mayer	Fine-loamy over sandy or sandy-skeletal, mixed (calcareous), mesic Typic Haplaquolls
Nicollet	Fine-loamy, mixed, mesic Aquic Hapludolls
Okoboji	Fine, montmorillonitic, mesic Cumulic Haplaquolls
Orthents	Loamy, mixed, mesic Typic Udorthents
Ottosen	Fine-loamy, mixed, mesic Aquic Hapludolls
Palms	Loamy, mixed, euic, mesic Terric Medisaprists
Ridgeport	Coarse-loamy, mixed, mesic Typic Hapludolls
Rolfe	Fine, montmorillonitic, mesic Typic Argialbolls
Salida	Sandy-skeletal, mixed, mesic Entic Hapludolls
Spicer	Fine-silty, mixed (calcareous), mesic Typic Haplaquolls
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
Truman	Fine-silty, mixed, mesic Typic Hapludolls
Wacousta	Fine-silty, mixed, mesic Typic Haplaquolls
Wadena	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Typic Hapludolls
Waldorf	Fine, montmorillonitic, mesic Typic Haplaquolls
Webster	Fine-loamy, mixed, mesic Typic Haplaquolls
Zook	Fine, montmorillonitic, mesic Cumulic Haplaquolls

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