United States Department of Agriculture

Natural Resources Conservation Service

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

Soil Survey of Emmet County, Iowa

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How To Use This Soil Survey

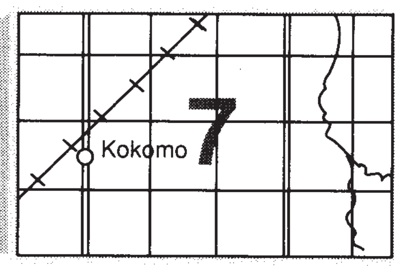
General Soil Map

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

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

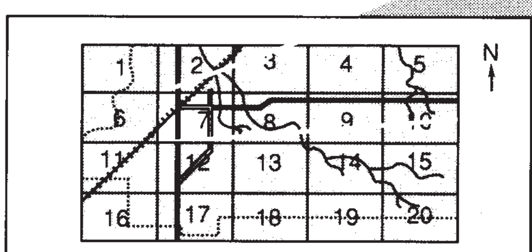
Detailed Soil Maps

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



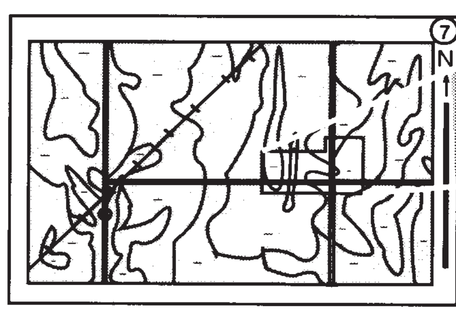
MAP SHEET

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

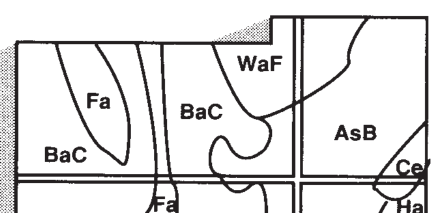


INDEX TO MAP SHEETS

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



MAP SHEET



AREA OF INTEREST

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

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 Natural Resources Conservation Service (formerly the Soil Conservation Service) has leadership for the Federal part of the National Cooperative Soil Survey.

Major fieldwork for this soil survey was completed in the period 1982-1988. Soil names and descriptions were approved in 1989. Unless otherwise indicated, statements in this publication refer to conditions in the survey area in 1989. This survey was made cooperatively by the Natural Resources Conservation Service and the Iowa Agriculture and Home Economics Experiment Station and Cooperative Extension Service, Iowa State University, and the Division of Soil Conservation, Iowa Department of Agriculture and Land Stewardship. It is part of the technical assistance furnished to the Emmet County Soil Conservation District. Funds appropriated by Emmet 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.

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Cover: Terracing is a common practice in Emmet County. These terraces are in an area of Storden and Clarion soils.

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Issued November 1997

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Preface

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

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

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are shallow 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 Natural Resources Conservation Service or the Cooperative Extension Service.

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Soil Survey of Emmet County, Iowa

By Robert Jones, Natural Resources Conservation Service

Fieldwork by Robert Jones, John Hempel, Gary Hilmer, and Mary Dugan, Natural Resources Conservation Service

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

EMMET COUNTY is in the north-central part of Iowa (fig. 1). It has a total area of 257,000 acres, or about 402 square miles. Estherville, the county seat, is in the west-central part of the county.

The county is chiefly agricultural. The principal crops are corn and soybeans, but oats and hay are also grown. Beef cattle and hogs are other important sources of agricultural income.

The landscape in the county is similar to that in other counties in north-central Iowa. In general, the area is an undulating or rolling prairie. In places, such as along the West Fork of the Des Moines River, there are high, steep hills. These hills "are characteristic and best displayed west of the Des Moines, yet they are by no means lacking in other places. They are prominent north of Estherville, about Dolliver, and extending in broken series in a southeasterly direction past Armstrong" (MacBride, 1905). These hills are a result of glacial ice. The more level part of the county is known as a Wisconsin Drift Plain. Elevation in the county ranges from about 1,225 to 1,480 feet above sea level.

This soil survey updates an earlier survey published in 1924 (Stevenson and Brown, 1924). It provides additional information and has larger maps, which show the soils in greater detail.

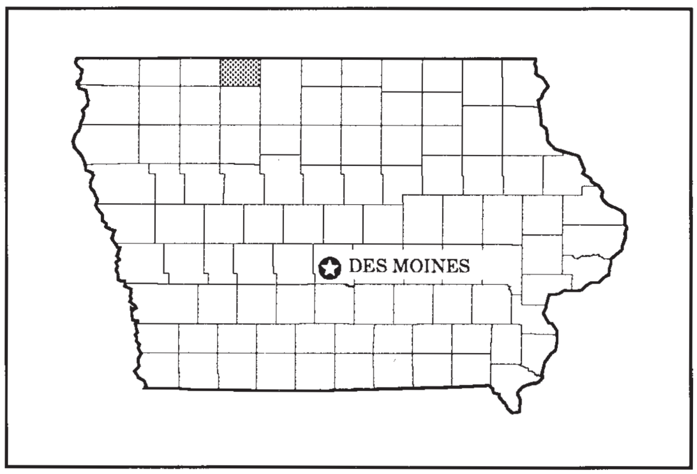

Figure 1.—Location of Emmet County in Iowa.

General Nature of the County

This section provides general information about Emmet County. It describes history, relief and drainage, transportation facilities, business and industry, natural resources, farming, and climate.

History

Emmet County was created on January 15, 1851, by an act of the Iowa Legislature. It was attached to Webster County for judicial and election purposes until 1859, when it was organized as a separate county. By 1860, the county had a population of 105, and by 1880 the population had reached 1,550 (History of Emmet County).

The early settlers found life in Emmet County to be difficult at best. The long, harsh winters, the considerable distance from more populated areas, and the fear of attack from hostile Indians were just some of the problems the settlers had to overcome. Early settlers of Emmet County established their homes along lakes and streams because the water, fuel, and protection afforded by these areas were prime necessities of life on the frontier.

By the close of 1881, railroad track had been laid to Emmetsburg from Fort Dodge. In June of 1882, Emmet County was at last provided with railroad transportation. At this point a new era of migration and growth for Emmet County began.

In the early days, farming was restricted to the high areas because there were many swamps. Drainage and reclamation of swamp lands began in 1882, when a legislative act was passed enabling property holders to petition the board of supervisors for the construction of ditches and drains. The supervisors were given the power to assess taxes for the property benefited. The first drainage districts were established in 1900, and by 1917 the number had reached 117.

Relief and Drainage

The eastern two-thirds of the county is dominated by a ground moraine characterized by numerous small depressions and potholes. It generally is nearly level to moderately sloping, but it is steeper in scattered areas, mainly along the East Fork of the Des Moines River, in the eastern part of Iowa Lake Township, and adjacent to lakes and marshes. Tuttle Lake, Iowa Lake, Ingham Lake, High Lake, Burr Oak Lake, and Swan Lake are in this area. Ryan Lake, Grass Lake, Birch Lake, and the East Swan Lake area are marshes. Relief in these areas is low to moderate, generally less than about 30 feet.

The western third of the county is dominated by the Altamont Moraine and the alluvial and terrace soils adjacent to the West Fork of the Des Moines River. Along the Altamont Moraine is a series of high-relief hummocks that generally are relatively broad and flat topped. They are typically the highest part of the landscape. Some are slightly concave. Most of these areas contain fine textured lacustrine soils. A few moderate-sized depressions that contain organic soils are in this part of the county. Twelve Mile Lake, Fourmile Lake, and Cheever Lake are in this area. Relief ranges to 75 feet or more. Kames, eskers, and kettles are common geological features.

Natural drainage in the western third of the county is somewhat more developed than in the eastern two-thirds. A series of small upland drainageways interconnect to larger ones at different landscape levels and eventually lead to the West Fork of the Des Moines River, which drains much of the landscape. This part of the county typically contains soils that are dark and somewhat finer textured than the soils in similar landscape positions in other parts of the county. The area generally is drained by the West Fork of the Des Moines River, School Creek, Unnamed Creek, and several drainage ditches, one of which drains into the adjacent county to the west.

The eastern two-thirds of the county is drained by Brown Creek, Jack Creek, and Drainage Ditch 60, all of which flow into the West Fork of the Des Moines River, and by the East Fork of the Des Moines River, including its principal tributaries, Soldier Creek and Black Cat Creek. Several drainage ditches connect to these streams as well as to the rivers. Generally, the southwestern half of this part of the county drains southwest to the West Fork of the Des Moines River and the northeastern half drains southeasterly to the East Fork of the Des Moines River. A small part of the northeast corner of the county drains north into Iowa Lake.

The channels of the smaller streams generally have been straightened and deepened. Together with various drainage ditches, these streams provide outlets for tile drains and for surface drains. Except for soils in depressions, most of the upland soils are drained adequately for dependable crop production.

Transportation Facilities

Transportation facilities generally are adequate for the economic enterprises in the county. Every farm is served by a graded and surfaced road. Most of the roads are surfaced with gravel. The main farm-to-market roads are surfaced with bituminous material. Federal and State highways are concrete or concrete surfaced with bituminous material.

State Highway 9 generally runs east and west across the middle part of the county; State Highway 4 generally runs north and south near the western side of the county; and State Highway 15 generally runs north and south near the eastern border of the county. All of the towns in the county generally are interconnected by a network of hard-surfaced farm-to-market roads.

Only two railroads serve the county. One runs east and west across the county, serving Estherville, Gruver, and Armstrong, and the other runs north and south and serves Estherville and Wallingford.

A regional bus system serves the county. Every trading center is served by motor freight lines. A small airport is located near Estherville.

Business and Industry

Industry provides markets for farm products in the county. Most towns, except the very smallest, have a grain elevator, a feed mill, and a fertilizer distribution plant. Packing plants provide hog buying stations in many towns in the county. Cattle buyers also serve the county, and nearby livestock auction facilities provide markets. A small packing plant is operational in Estherville, and frozen food locker plants are available within the county.

Businesses that sell and service farm machinery and supplies operate in several towns in the county. Veterinarian services are readily available. Industry provides many jobs in Estherville and Armstrong.

Natural Resources

Agricultural land is the primary natural resource in Emmet County. Other natural resources include water, trees, sand and gravel, and wildlife.

Emmet County has a good supply of underground water. Wells that are properly drilled rarely fail because of a seasonal lack of water or during periods of drought. Some wells are less than 100 feet deep, but some are 400 feet deep or more. Shallow wells and sand points are dependable sources of water in a few areas where the substratum is gravelly. Water quality generally is good, but many wells have higher nitrate levels than are desirable. A few have other contaminants.

A few thousand acres have potential for irrigation. Two or three farms are currently being irrigated. Water from wells and from the West Fork of the Des Moines River is being used. The best potential for irrigation is along the West Fork of the Des Moines River and, to a lesser extent, along the East Fork of the Des Moines River. A few other outwash areas have limited potential. These areas have soils that are seasonally droughty.

Several areas in Emmet County have been developed for wildlife habitat. Cheever Lake, Eagle Lake, Grass Lake, Birch Lake, and Ryan Lake are primarily marshy areas that provide wildlife habitat. Additionally, there are marshy areas near Burr Oak, High, Ingham, Swan, Tuttle, Fourmile, and Iowa Lakes as well as along both rivers and other streams. Smaller marshy areas are scattered throughout the county. These marshy areas provide many opportunities for hunting and trapping. Recently, the Iowa Conservation Commission has been restoring small wetlands as a part of the Food Security Act of 1985. Funds and cooperation with the U.S. Fish and Wildlife Service are part of this restoration. A few manmade farm ponds, several gravel pits, Twelve Mile Lake, High Lake, Ingham Lake, Swan Lake, Tuttle Lake, Iowa Lake, and the West and East Forks of the Des Moines River provide opportunities for fishing.

Defiance State Park at Estherville and Okamanpidan State Park at Tuttle Lake are among the parks in Emmet County. Other parks have been developed by the county at Tuttle Lake and High Lake, and some parks have been developed in various towns. These parks generally provide facilities for a variety of activities, including camping, fishing, boating, and picnicking.

Native oak and other trees are harvested on a limited basis in the county. Several sand and gravel pits are currently being operated in the county, principally along the West Fork of the Des Moines River. The sand and gravel are used extensively as road-surfacing material and as concrete aggregate.

Opportunities for hunting, fishing, and trapping are available throughout the county. Migratory waterfowl, ducks, rabbits, squirrels, pheasant, and partridge are commonly hunted. Several species of fish are in the lakes and streams, including walleye, northern pike, bass, crappies, perch, and bullheads. Muskrats, raccoons, and mink are among the species commonly trapped. Red fox is a commonly hunted species.

Farming

In 1985, Emmet County had 240,800 acres of farmland on 690 farms (Iowa Department of Agriculture, 1986). Of this land, 237,400 acres was used for row crops, small grain, or hay. The rest was used for permanent pasture, woods, lots, buildings, or roads or was idle land. Corn was planted on 131,000 acres. It yielded an average of 133.1 bushels per acre. Soybeans were planted on 92,700 acres. They yielded an average of 36.1 bushels per acre. Oats were grown on 9,200 acres and had an average yield of 80.7 bushels per acre. About 2,300 acres was used for alfalfa hay.

Beef cattle and hogs are the most extensively raised livestock in the county. In 1985, about 16,500 grain-fed cattle and 133,000 hogs were sold. In the same year, 10,000 sows were farrowed. There were 5,600 beef cattle and 500 milk cows. The county also had about 1,300 sheep and 26,000 laying hens.

In recent years the number of people living on farms and the number of farms have declined. The size of the average farm has increased. In 1985, the county had 690 farms, which averaged 349 acres in size. In 1985, about 5,818 people lived on farms (Iowa Development Commission, 1986).

Most farms are cash-grain enterprises. Farmers derive most of their income from the sale of corn and soybeans. Many, however, derive a large part of their income from the sale of livestock, especially hogs and beef cattle.

Dairying is a major enterprise on a few farms. The number of dairy farms has decreased more rapidly in recent years than the number of some other farm types, but the size of herds has increased. Some poultry is raised, mostly laying hens. Commercial broiler and turkey production is minimal. Sheep are raised on a few farms, and a few of these farms are sizable operations. Most farmers, however, use sheep to help control grass and weeds in groves and around farmsteads.

Climate

Table 1 gives data on temperature and precipitation for the survey area as recorded at Estherville in the period 1961 to 1990. 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 16.4 degrees F and the average daily minimum temperature is 20.9 degrees. The lowest temperature on record, which occurred at Estherville on January 21, 1970, is -36 degrees. In summer, the average temperature is 69.8 degrees and the average daily maximum temperature is 81.1 degrees. The highest recorded temperature, which occurred at Estherville on July 7, 1955, is 104 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 (40 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 27.77 inches. Of this, 17.80 inches, or about 64 percent, usually falls in April through September. The growing season for most crops falls within this period. The heaviest 1-day rainfall during the period of record was 5.80 inches on August 30, 1962. Thunderstorms occur on about 44 days each year, and most occur in July.

The average seasonal snowfall is 32.9 inches. The greatest snow depth at any one time during the period of record was 40 inches. The heaviest 1-day snowfall on record was 18 inches on February 19, 1962. On the average, 43 days of the year have at least 1 inch of snow on the ground. The number of such days varies greatly from year to year.

The average relative humidity in midafternoon is about 60 percent. Humidity is higher at night, and the average at dawn is about 81 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, 13.2 miles per hour, in April.

How This Survey Was Made

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

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

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

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

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

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

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

Map Unit Composition

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

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

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

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General Soil Map Units

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

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

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

Soil Descriptions

1. Clarion-Canisteo-Nicollet Association

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

This association consists of soils on convex knolls and ridgetops, on low broad flats and in concave swales, and on convex slopes and in concave positions between undulating areas of well drained soils (fig. 2). A few small creeks and several drainage ditches flow through this association and provide outlets for tile drains. The landscape is characteristic of a ground moraine and is nearly level to gently rolling. The steepest slopes border some of the many potholes in the area. Slopes range from 0 to 9 percent.

This association makes up about 20 percent of the county. It is about 30 percent Clarion soils, 30 percent Canisteo soils, 20 percent Nicollet soils, and 20 percent soils of minor extent.

Clarion soils are well drained and are gently sloping to moderately sloping. They are on convex knolls and ridgetops. Canisteo soils are nearly level and are poorly drained. They are on low broad flats and in concave swales. They commonly surround areas of depressional soils. The very gently sloping Nicollet soils are somewhat poorly drained. They are commonly on slightly convex rises on broad flats in areas of Canisteo soils. In places, Nicollet soils are on intermediate levels between the well drained Clarion soils and the poorly drained Canisteo soils. In these positions, slopes are mostly slightly concave. A natural drainage network has not fully developed, and surface drainage is generally slow.

Typically, the surface layer of the Clarion soils is black, friable loam about 8 inches thick. The subsurface layer is friable loam about 11 inches thick. The upper part is very dark brown, and the lower part is very dark brown and dark brown. The subsoil is friable loam about 23 inches thick. The upper part is brown, the next part is dark yellowish brown and yellowish brown, and the lower part is mottled dark yellowish brown and olive brown and is calcareous. The substratum to a depth of about 60 inches is light olive brown, calcareous loam. It is mottled.

Typically, the surface layer of the Canisteo soils is black, friable, calcareous clay loam about 8 inches thick. The subsurface layer is black and very dark gray, friable, calcareous clay loam about 12 inches thick. The subsoil is friable, calcareous clay loam about 20 inches thick. It is mottled. The upper part is gray and dark gray, and the lower part is gray and olive gray. The substratum extends to a depth of about 60 inches. It is mottled. The upper part is gray and olive gray clay loam, and the lower part is gray and olive gray loam.

Typically, the surface layer of the Nicollet soils is black, friable loam about 8 inches thick. The subsurface layer is black and very dark brown, friable loam about 10 inches thick. The subsoil is friable clay loam about 24 inches thick. The upper part is dark grayish brown and very dark gray, the next part is dark grayish brown, and the lower part is mottled dark grayish brown and grayish brown. The substratum to a depth of about 60 inches is mottled olive gray and olive, calcareous loam.

The minor soils in this association are mainly the Crippin, Harps, Okoboji, Palms, Storden, and Webster

Figure 2.—An area of the Clarion-Canisteo-Nicollet association. Canisteo soils are in the center; the ponded area is Okoboji silty clay loam. Nicollet soils are adjacent to the Canisteo soils, and Clarion soils are in the background.

soils. The somewhat poorly drained, calcareous Crippin soils are mainly on slightly convex knolls within large areas of Canisteo soils, but some areas border Okoboji or Harps soils. The nearly level, highly calcareous, poorly drained Harps soils are on rims around depressions. Harps soils are commonly surrounded by Canisteo soils. The very poorly drained Okoboji soils are very wet soils in potholes and depressions and are commonly ponded in spring or after heavy rains. The very poorly drained Palms soils are very wet soils in the larger depressions and potholes. They formed in well decomposed organic material. The well drained, gently sloping to strongly sloping, convex Storden soils are on side slopes and ridgecrests. They border drainageways and are adjacent to Clarion soils. The poorly drained Webster soils, which formed in noncalcareous glacial till, are mostly on the higher parts of broad flats that have a partly developed drainage network.

This association is well suited to crops, and most of the acreage is used as cropland. Corn and soybeans are the main crops. They are the only crops grown on some farms. Some oats and crops for rotation, hay, and pasture, including alfalfa and alfalfa-grass mixtures, are grown on some livestock farms. A few areas of this association, mostly along creeks and around farmsteads, are used for permanent pasture. Some areas adjacent to lakeshores support native hardwoods.

Erosion and wetness are the major management concerns in cultivated areas. The sloping soils need protection from water erosion. The irregular pattern of slopes makes tilling on the contour and terracing difficult. A system of conservation tillage that leaves crop residue on the surface helps to control erosion in most areas. Soil blowing is a hazard in areas where large tracts are plowed in the fall and the surface is left bare. The nearly level, poorly drained and very poorly drained soils generally are drained by tile systems. Improved drainage is needed in many areas. Surface intakes in depressional soils help to prevent crop damage caused by ponding during periods of high rainfall. Timely tillage maintains tilth and helps to prevent compaction in areas of the wetter soils.

2. Clarion-Storden-Nicollet Association

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

This association consists of soils on very gently sloping to moderately sloping ridges and strongly sloping to very steep side slopes that are commonly dissected by upland drainageways. Differences in elevation are greatest in this association. Elevation ranges to about 100 feet or more. The major part of this association is on the hummocky Altamont Moraine. Hummocks and depressions characterize the knob-and-kettle topography. Numerous ponds and marshes are in low areas between knolls. They have no natural drainage outlets. Other parts of this association border soils on flood plains and terraces along the major rivers. Slopes range from about 2 to 40 percent.

This association makes up about 20 percent of the county. It is about 35 percent Clarion soils, 20 percent Storden soils, 20 percent Nicollet soils, and 25 percent soils of minor extent (fig. 3).

The well drained Clarion soils are on convex knolls, ridgetops, and side slopes. The well drained Storden soils are mainly on strongly sloping to steep side slopes on the hummocky Altamont landscape and in areas bordering rivers and streams. The somewhat poorly drained Nicollet soils are in concave positions between undulating areas of well drained soils and on intermediate levels between the Clarion and Storden soils and poorly drained soils.

Typically, the surface layer of the Clarion soils is black, friable loam about 10 inches thick. The subsurface layer is about 8 inches thick. It is very dark brown and dark brown, friable loam. The subsoil is friable loam about 20 inches thick. The upper part is brown, the next part is dark yellowish brown and yellowish brown, and the lower part is mottled yellowish brown and olive brown. The substratum to a depth of about 60 inches is light olive brown, calcareous loam. It is mottled.

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

Typically, the surface layer of the Nicollet soils is black, friable loam about 8 inches thick. The subsurface layer is black and very dark brown, friable loam about 10 inches thick. The subsoil is friable clay loam about 24 inches thick. The upper part is dark grayish brown and very dark gray, the next part is dark grayish brown, and the lower part is mottled dark grayish brown and grayish brown. The substratum to a depth of about 60 inches is mottled olive gray and olive, calcareous loam.

The minor soils in this association are the Blue Earth, Canisteo, Collinwood, Harps, Lester, Okoboji, Palms, Spillville, Vinje, Waldorf, and Webster soils. The very poorly drained Blue Earth soils formed in coprogenous earth. They are in depressions and in old shallow lakebeds on uplands. The poorly drained, nearly level, calcareous Canisteo soils are in low, broad, concave areas. The somewhat poorly drained Collinwood soils formed in silty lacustrine sediments. They typically are in swales and in concave positions on summits. The calcareous Harps soils are on rims surrounding Okoboji, Palms, or Blue Earth soils. The well drained Lester soils formed in noncalcareous glacial till. They are on upland ridgetops and convex side slopes that border rivers and creeks. They commonly support timber. The very poorly drained Okoboji and Palms soils are very wet soils in potholes and depressions and are commonly ponded in spring or after heavy rains. Undrained areas provide good habitat for wetland wildlife and waterfowl. The somewhat poorly drained to moderately well drained Spillville soils formed in colluvium. They are on foot slopes. The well drained Vinje soils formed in silty lacustrine sediment. They occur as convex areas on summits. The poorly drained Waldorf soils formed in lacustrine sediments. They are in low, concave positions on the highest parts of the landscape or in the broader low-lying areas on the lower parts of the landscape. The poorly drained Webster soils formed in noncalcareous glacial till. They are in areas that have a partly developed drainage network.

This association is used mainly for general farming. It ranges from well suited to poorly suited to row crops. Corn and soybeans are the main crops grown in gently sloping or level areas. Oats and crops for rotation, hay, and pasture, such as alfalfa and alfalfa-grass mixtures,

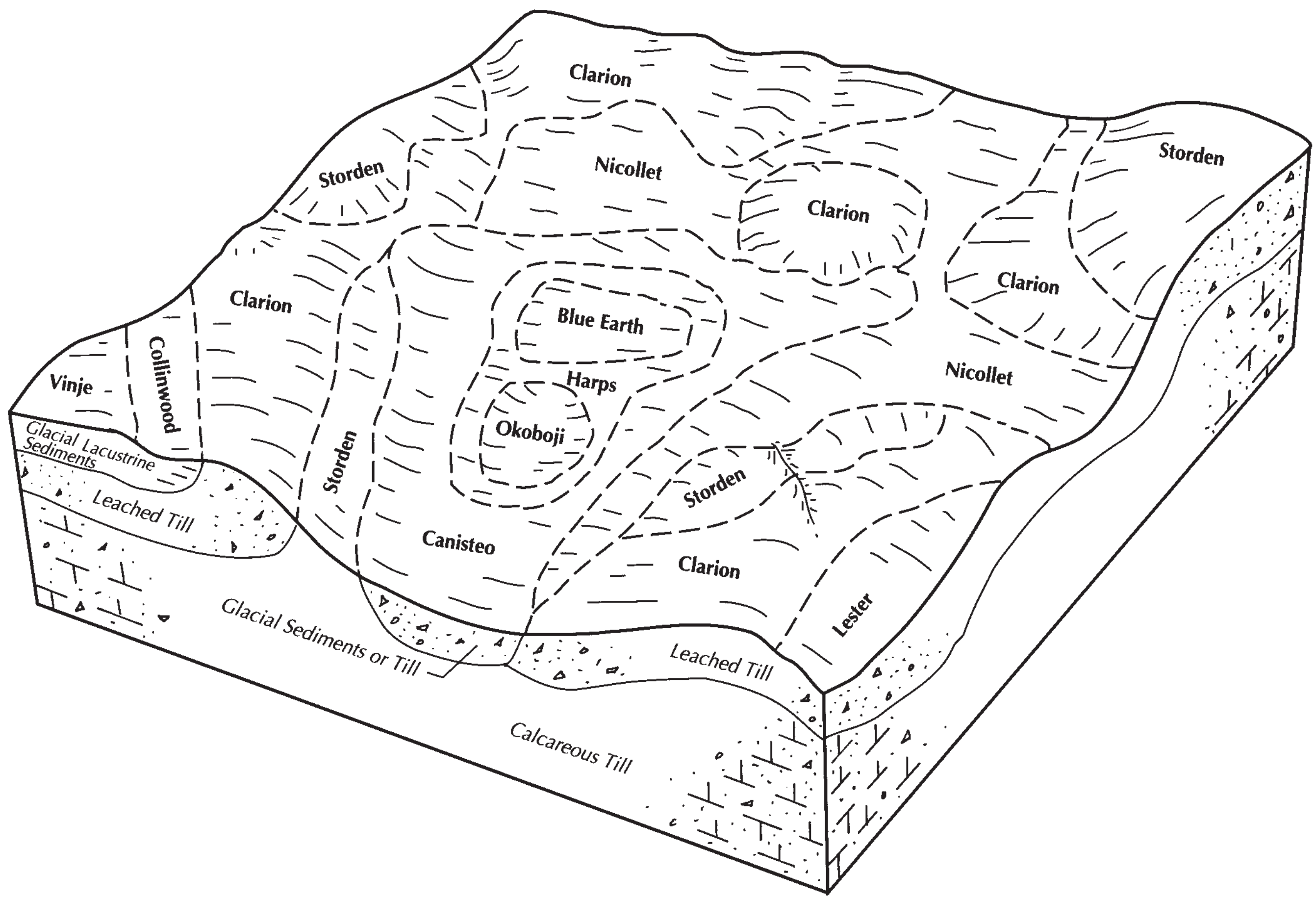

Figure 3.—Typical pattern of soils and parent material in the Clarion-Storden-Nicollet association.

are commonly grown. The steepest slopes commonly support permanent pasture. Cow-calf herds commonly are on farms in this association. Much of the acreage is best suited to hay and pasture crops. Many areas along the major rivers support good stands of native hardwoods, chiefly oak.

Erosion and wetness are the major management concerns in cultivated areas. The sloping soils need protection from water erosion. The irregular pattern of slopes makes tilling on the contour and terracing difficult. In select areas, however, these practices can be used very effectively. A system of conservation tillage that leaves crop residue on the surface helps to control erosion in most areas. Soil blowing is a hazard in areas where large tracts are plowed in the fall and the surface is left bare. The nearly level, poorly drained and very poorly drained soils are generally drained by tile systems. Improved drainage is needed in many areas. Surface intakes in depressional soils help to prevent crop damage caused by ponding during periods of high rainfall. Timely tillage maintains tilth and helps to prevent compaction in areas of the wetter soils.

3. Estherville-Wadena-Linder Association

Nearly level to moderately sloping, somewhat excessively drained, well drained, and somewhat poorly drained, loamy soils that formed in glacial outwash; on stream terraces and uplands

This association consists of several relatively small, elongated areas adjacent to the flood plain. The areas to the west of the flood plain are on high stream terraces. In most places the landscape is nearly level or gently sloping. It is mostly moderately sloping where it is adjacent to the lower lying alluvial soils. Areas to the east of the flood plain are mostly areas of high glacial outwash on uplands. The major soils formed mostly in loamy sediments over sand and gravel. Slopes range from 0 to 9 percent.

This association makes up about 3 percent of the county. It is about 35 percent Estherville soils, 10 percent Wadena soils, 10 percent Linder soils, and 45 percent soils of minor extent.

The well drained or somewhat excessively drained Estherville soils are on stream terraces, most of which are high enough that they are not subject to flooding. The soils are mostly nearly level to gently sloping, but they are strongly sloping in some of the areas where they join flood plains and are adjacent to drainageways. The well drained Wadena soils are in landscape positions similar to those of the Estherville soils. The somewhat poorly drained Linder soils are mostly in nearly level, slightly concave swales that are slightly lower than the Estherville and Wadena soils.

Typically, the surface layer of the Estherville soils is very dark brown, very friable sandy loam about 8 inches thick. The subsurface layer is very dark grayish brown, very friable sandy loam about 7 inches thick. The subsoil is dark brown and very dark brown, friable sandy loam about 5 inches thick. The substratum to a depth of about 60 inches is dark brown and brown, calcareous gravelly loamy sand.

Typically, the surface layer of the Wadena soils is very dark brown and black, friable loam about 8 inches thick. The subsurface layer is very dark brown, friable loam about 6 inches thick. The subsoil is about 16 inches thick. The upper part is dark brown, friable loam; the next part is brown, friable loam; and the lower part is brown, loose gravelly loamy sand. The substratum to a depth of about 60 inches is brown and dark yellowish brown, calcareous gravelly sand.

Typically, the surface layer of the Linder soils is black, friable loam about 8 inches thick. The subsurface layer is about 8 inches thick. The upper part is black, friable loam, and the lower part is very dark brown and very dark grayish brown, friable sandy loam. The subsoil is dark grayish brown, friable sandy loam about 11 inches thick. It is mottled in the lower part. The substratum to a depth of about 60 inches is grayish brown, calcareous gravelly sand. It is mottled.

The minor soils in this association are the Biscay, Dickman, Fostoria, Ridgeport, Salida, Spillville, Terril, and Waldorf soils. The poorly drained and very poorly drained, nearly level Biscay soils are in concave or slightly convex areas. They formed in loamy sediments overlying calcareous sand and gravel. The well drained Dickman soils are on plane or convex slopes. They formed in wind-deposited or water-reworked sand. The somewhat poorly drained Fostoria soils are on plane or slightly concave slopes. They formed in loamy sediments. The somewhat excessively drained Ridgeport soils are on plane or convex slopes. They formed in sandy sediments overlying calcareous sand and gravel. The excessively drained Salida soils formed in calcareous, sandy and gravelly deposits on convex ridges and the upper side slopes. The somewhat poorly drained Spillville and well drained Terril soils formed in colluvium and alluvium. They are on foot slopes. The poorly drained Waldorf soils are in nearly level, slightly concave positions on stream terraces away from the river. They formed in silty and clayey sediments.

This association is marginally suited to row crops. Growth of row crops varies from year to year, depending on moisture conditions. These soils become droughty in periods of low rainfall. They are better suited to small grain, hay, or pasture than to row crops. Many different areas within this association are excellent sources of sand and gravel and are being mined on a continuing basis for that purpose.

Droughtiness and erosion are the main management concerns in cultivated areas. In some areas, pivot irrigation is used to relieve stress caused by low moisture conditions. Soil blowing can be especially acute in areas where the soils are plowed in the fall and the surface is left bare. A system of conservation tillage that leaves crop residue on the surface helps to control erosion and conserves moisture in most areas. The nearly level, poorly drained soils in this association are drained by tile systems. Timely tillage in these areas maintains tilth and helps to prevent compaction.

4. Clarion-Nicollet-Canisteo Association

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

This association consists of a nearly level to rolling ground moraine of swales, ridges, and knolls. Differences in elevation range from about 5 to 20 feet on the ridges and knolls. Slopes generally are short and irregular. In the swales, slopes are gentle or nearly level. Drainageways are fairly well defined, but there are numerous depressions of varying size. Several small lakes and sloughs and marsh areas are in parts of this association. A few small creeks and several drainage ditches flow through the association and provide outlets for tile drains. The steepest slopes border the small creeks and some of the small lakes and depressions. Slopes typically range from about 1 to 14 percent.

This association makes up about 39 percent of the county. It is about 25 percent Clarion soils, 25 percent Nicollet soils, 25 percent Canisteo soils, and 25 percent soils of minor extent.

Clarion soils are well drained and are on gently sloping to strongly sloping knolls, side slopes, and ridgetops. The very gently sloping Nicollet soils are somewhat poorly drained. They are on intermediate levels between the well drained Clarion soils and poorly drained soils and in concave positions between undulating areas of well drained soils. The nearly level, poorly drained, calcareous Canisteo soils are in low, broad, slightly concave or level areas.

Typically, the surface layer of the Clarion soils is black, friable loam about 8 inches thick. The subsurface layer is very dark brown and dark brown, friable loam about 6 inches thick. The subsoil is friable loam about 16 inches thick. The upper part is brown, the next part is dark yellowish brown and yellowish brown, and the lower part is mottled dark yellowish brown and olive brown and is calcareous. The substratum to a depth of about 60 inches is light olive brown, calcareous loam. It is mottled.

Typically, the surface layer of the Nicollet soils is black, friable loam about 8 inches thick. The subsurface layer is black and very dark brown, friable loam about 10 inches thick. The subsoil is friable clay loam about 24 inches thick. The upper part is dark grayish brown and very dark gray, the next part is dark grayish brown, and the lower part is mottled dark grayish brown and grayish brown. The substratum to a depth of about 60 inches is mottled olive gray and olive, calcareous loam.

Typically, the surface layer of the Canisteo soils is black, friable, calcareous clay loam about 8 inches thick. The subsurface layer is black and very dark gray, friable, calcareous clay loam about 12 inches thick. The subsoil is friable, calcareous clay loam about 20 inches thick. The upper part is mottled gray and dark gray, and the lower part is mottled gray and olive gray. The substratum extends to a depth of about 60 inches. It is mottled. It is gray and olive gray clay loam in the upper part and gray and olive gray loam in the lower part.

The minor soils in this association are the Crippin, Harps, Okoboji, Palms, Storden, and Webster soils. The somewhat poorly drained Crippin soils are mainly in slightly convex areas that are on intermediate levels between the well drained Clarion soils and the poorly drained Canisteo soils. They may also border Okoboji or Harps soils or occur as convex knolls within large areas of Canisteo soils. The nearly level, highly calcareous, poorly drained Harps soils are on rims around depressions. The very poorly drained Okoboji soils are very wet soils in potholes and depressions and are commonly ponded in spring or after heavy rains. The very poorly drained Palms soils are very wet soils in the larger depressions and potholes. They formed in well decomposed organic material. The well drained, gently sloping to strongly sloping Storden soils are on side slopes and ridgecrests. They commonly border drainageways and are adjacent to Clarion soils. The poorly drained Webster soils formed in noncalcareous glacial till. They are mostly on the higher parts of broad flats that have a partly developed drainage network.

Most of this association is well suited to crops, and most of the acreage is used as cropland. Soils that are moderately sloping to strongly sloping are only moderately suited or poorly suited to row crops. Corn and soybeans are the main crops. They are the only crops grown on some farms. Some oats and crops for rotation, hay, or pasture, including alfalfa and alfalfa-grass mixtures, are grown on some livestock farms. A few areas in this association, mostly along creeks and around farms, support permanent pasture. Some areas adjacent to lakeshores support stands of native hardwoods.

Erosion and wetness are the major management concerns in cultivated areas. The sloping soils need protection from water erosion. The irregular pattern of slopes makes tilling on the contour and terracing difficult. In select areas, however, these practices can be used very effectively. A system of conservation tillage that leaves crop residue on the surface helps to control erosion in most areas. Soil blowing is a hazard in areas where large tracts are plowed in the fall and the surface is left bare. The nearly level, poorly drained soils generally are drained by tile systems. Improved drainage is needed in many areas. Surface intakes in depressional soils help to prevent crop damage caused by ponding during periods of high rainfall. Timely tillage maintains tilth and helps to prevent compaction in areas of the wetter soils.

5. Canisteo-Nicollet-Clarion Association

Level to moderately sloping, well drained, somewhat poorly drained, and poorly drained, loamy soils that formed in glacial till or glacial till sediments; on uplands

This association is a level to gently rolling ground moraine consisting of swales and rises. It is characterized by numerous potholes and depressions, one or two of which are very large. The difference in elevation typically ranges from about 5 to 20 feet. Along the northeast corner of the county, however, the range in elevation is greater than is typical and slopes are steeper. Slopes are also steeper in a few places around some of the scattered potholes. A few drainage ditches extend into the association and provide outlets for tile drains. Slopes typically range from 0 to 9 percent.

This association makes up about 7 percent of the county. It is about 30 percent Canisteo soils, 25 percent Nicollet soils, 20 percent Clarion soils, and 25 percent soils of minor extent (fig. 4).

The poorly drained, nearly level, calcareous Canisteo soils are in low, broad, concave areas. Nicollet soils are somewhat poorly drained and are in concave positions between undulating areas of well drained soils and on

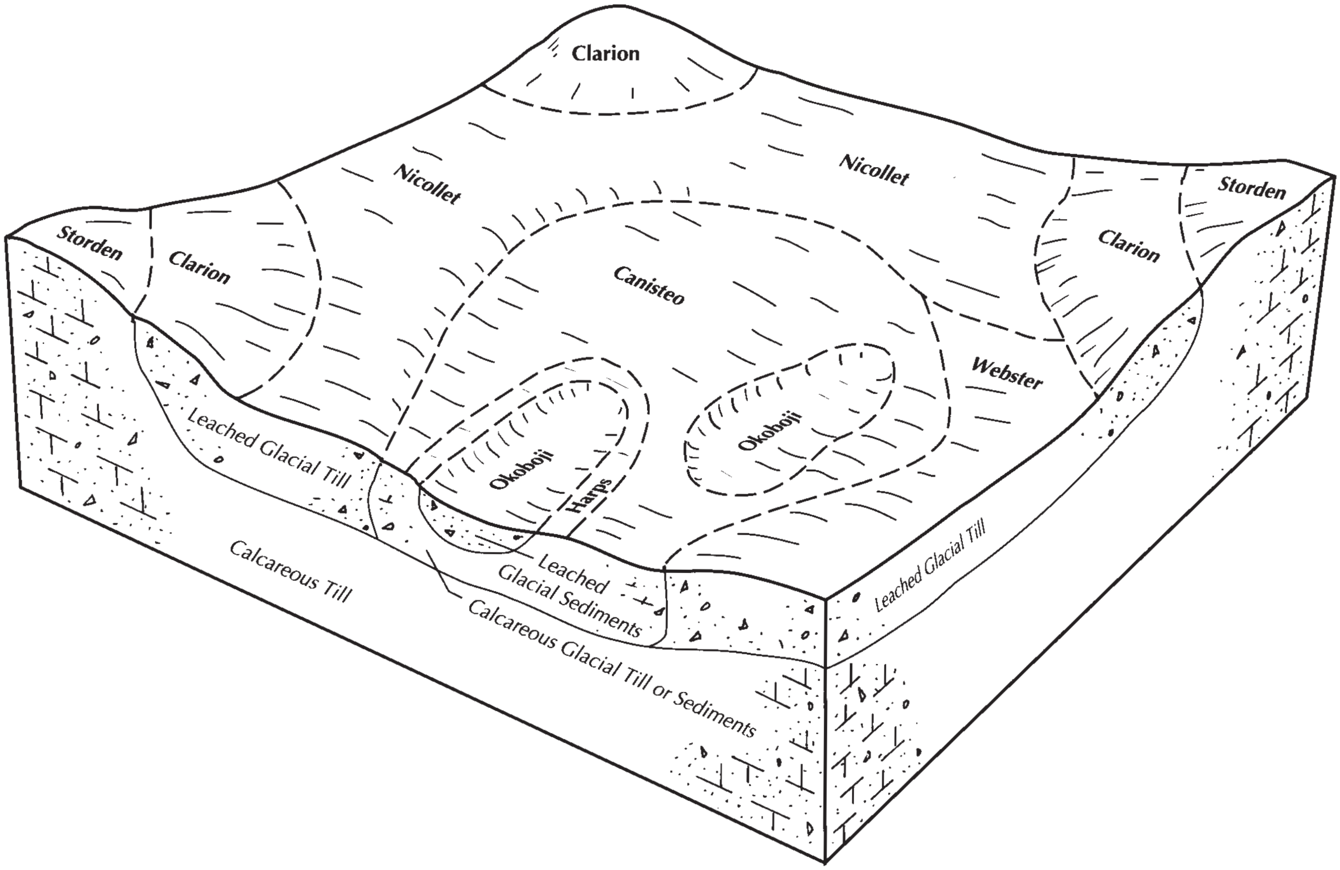

Figure 4.—Typical pattern of soils and parent material in the Canisteo-Nicollet-Clarion association.

intermediate levels between the well drained Clarion soils and poorly drained soils. The well drained Clarion soils are on convex knolls, ridgetops, and side slopes.

Typically, the surface layer of the Canisteo soils is black, friable, calcareous clay loam about 8 inches thick. The subsurface layer is black and very dark gray, friable, calcareous clay loam about 12 inches thick. The subsoil is friable, calcareous clay loam about 20 inches thick. The upper part is mottled gray and dark gray, and the lower part is mottled gray and olive gray. The substratum extends to a depth of about 60 inches. It is mottled. It is gray and olive gray clay loam in the upper part and gray and olive gray loam in the lower part.

Typically, the surface layer of the Nicollet soils is black, friable loam about 8 inches thick. The subsurface layer is black and very dark brown, friable loam about 10 inches thick. The subsoil is friable clay loam about 24 inches thick. The upper part is dark grayish brown and very dark gray, the next part is dark grayish brown, and the lower part is mottled dark grayish brown and grayish brown. The substratum to a depth of about 60 inches is mottled olive gray and olive, calcareous loam.

Typically, the surface layer of the Clarion soils is black, friable loam about 10 inches thick. The subsurface layer is about 8 inches thick. It is very dark brown and dark brown, friable loam. The subsoil is friable loam about 20 inches thick. The upper part is brown, the next part is dark yellowish brown and yellowish brown, and the lower part is mottled yellowish brown and olive brown. The substratum to a depth of about 60 inches is light olive brown, calcareous loam. It is mottled.

The minor soils in this association are the Crippin, Harps, Okoboji, Palms, Storden, and Webster soils. The somewhat poorly drained, calcareous Crippin soils are mainly on slightly convex knolls within large areas of Canisteo soils, but in some areas they border Okoboji or Harps soils. The nearly level, highly calcareous, poorly drained Harps soils are on rims around depressions. The very poorly drained Okoboji and Palms soils are very wet soils in the larger depressions and potholes. Okoboji soils formed in glacial till sediments. Palms soils formed in well decomposed organic material. The well drained, gently sloping to strongly sloping, convex Storden soils are on ridgecrests and side slopes. They commonly border drainageways and are adjacent to Clarion soils. The poorly drained Webster soils formed in noncalcareous glacial till. They are mostly on the higher parts of broad flats that have a partly developed drainage network.

The major management concerns in this association are wetness and erosion. The irregular pattern of slopes makes tilling on the contour and terracing difficult. In select areas, however, these practices can be used very effectively. A system of conservation tillage that leaves crop residue on the surface helps to control erosion in most areas. Soil blowing is a hazard in areas where large tracts are plowed in the fall and the surface is left bare. The nearly level, poorly drained and very poorly drained soils generally are drained by tile systems. Improved drainage is needed in many areas. Surface intakes in depressional soils help to prevent crop damage caused by ponding during periods of high rainfall. Timely tillage maintains tilth and helps to prevent compaction in areas of the wetter soils.

6. Canisteo-Nicollet-Okoboji Association

Level to very gently sloping, poorly drained, somewhat poorly drained, and very poorly drained, loamy and silty soils that formed in glacial till and glacial till sediments; on uplands

This association is a level to very gently sloping ground moraine consisting of swales, flats, and depressions. It is characterized by a number of small depressions and potholes. The difference in elevation typically ranges from 5 to 10 feet. A few drainage ditches extend into the association and provide outlets for tile drains. Slopes typically range from 0 to 3 percent.

This association makes up about 9 percent of the county. It is about 40 percent Canisteo soils, 25 percent Nicollet soils, 8 percent Okoboji soils, and 27 percent soils of minor extent (fig. 5).

The nearly level, poorly drained, calcareous Canisteo soils are on low, broad flats and in concave swales. Nicollet soils are somewhat poorly drained. They are typically on slightly convex rises on broad flats in areas of Canisteo soils. In places they are on intermediate levels between the well drained Clarion soils and the poorly drained Canisteo soils. The very poorly drained Okoboji soils are very wet soils in potholes and depressions and commonly are ponded in spring or after heavy rains.

Typically, the surface layer of the Canisteo soils is black, friable, calcareous clay loam about 8 inches thick. The subsurface layer is black and very dark gray, friable, calcareous clay loam about 12 inches thick. The subsoil is friable, calcareous clay loam about 20 inches thick. The upper part is mottled gray and dark gray, and the lower part is mottled gray and olive gray. The substratum extends to a depth of about 60 inches. It is mottled. It is gray and olive gray clay loam in the upper part and gray and olive gray loam in the lower part.

Typically, the surface layer of the Nicollet soils is black, friable loam about 8 inches thick. The subsurface layer is black and very dark brown, friable loam about 10 inches thick. The subsoil is friable clay loam about 24 inches thick. The upper part is dark grayish brown and very dark gray, the next part is dark grayish brown, and the lower part is mottled dark grayish brown and grayish brown. The substratum to a depth of about 60 inches is mottled olive gray and olive, calcareous loam.

Typically, the surface layer of the Okoboji soils is black, friable silty clay loam about 8 inches thick. The subsurface layer is black, very dark gray, and dark gray, friable silty clay loam about 28 inches thick. The subsoil, to a depth of about 48 inches, is very dark gray, dark gray, and olive gray, friable silty clay loam. The substratum to a depth of about 60 inches is mottled gray and olive gray silty clay loam.

The minor soils in this association are the Biscay, Clarion, Crippin, Harps, Linder, Palms, and Webster soils. The poorly drained Biscay and somewhat poorly drained Linder soils are on stream terraces. The well drained, gently sloping to moderately sloping, convex Clarion soils are on knolls and side slopes. The somewhat poorly drained, calcareous Crippin soils are mainly on slightly convex knolls within large areas of Canisteo soils, but in some areas they border Okoboji or Harps soils. The nearly level, highly calcareous, poorly drained Harps soils are on rims around depressions (fig. 6). They are commonly surrounded by Canisteo soils. The very poorly drained Palms soils are very wet soils in large depressions and potholes. They formed in well decomposed organic material. The poorly drained Webster soils formed in noncalcareous glacial till. They are mostly on the higher parts of broad flats that have a partly developed drainage network.

This association is well suited to row crops, and most of the acreage is used as cropland. Corn and soybeans are the main crops. They are the only crops grown on most farms. Some oats and crops for rotation, hay, and pasture, including alfalfa and alfalfa-grass mixtures, are grown on some livestock farms. A few areas of this association, mostly along creeks and around farmsteads, support permanent pasture. Some areas adjacent to old lakebeds support native hardwoods.

Wetness is the major management concern in areas of this association. The more sloping soils need

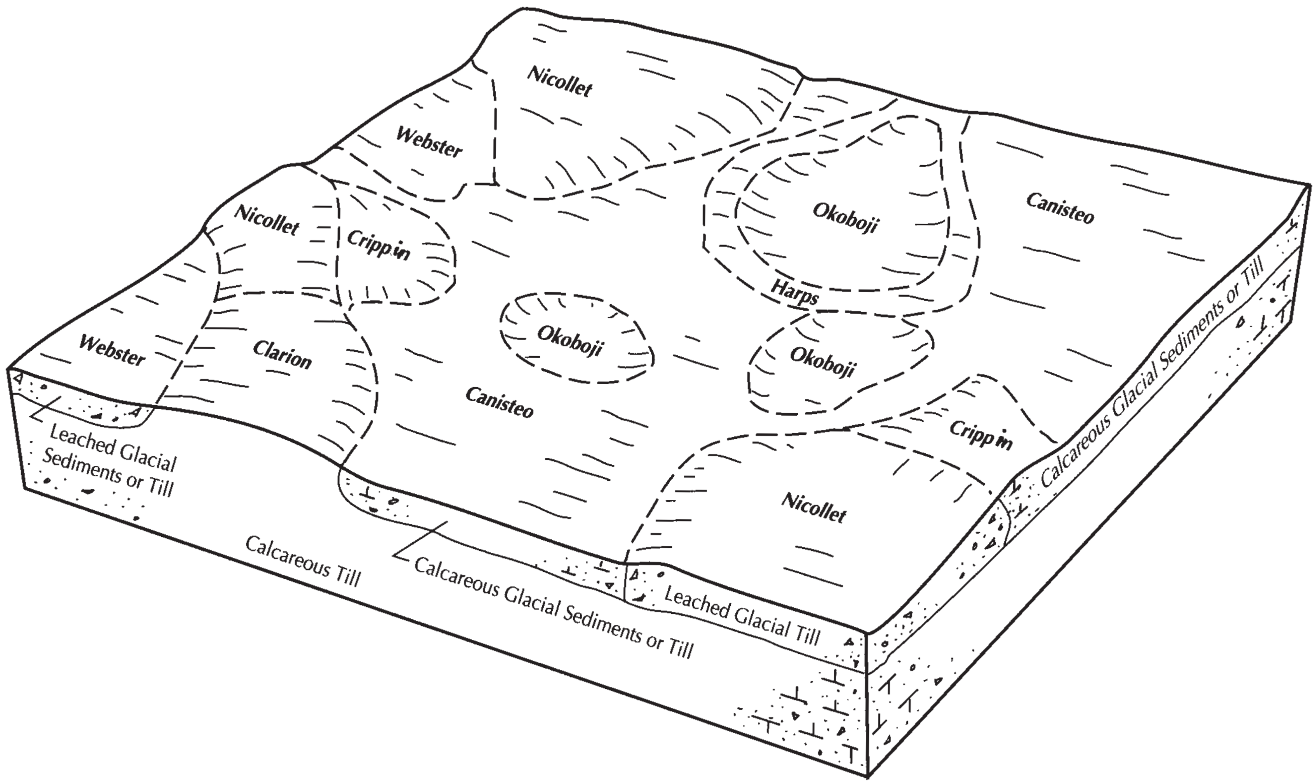

Figure 5.—Typical pattern of soils and parent material in the Canisteo-Nicollet-Okoboji association.

protection from water erosion. The irregular pattern of slopes makes tilling on the contour and terracing difficult. A system of conservation tillage that leaves crop residue on the surface helps to control erosion in most areas. Conservation tillage also helps to minimize ponding in areas of depressional soils. Grassed waterways are also highly effective in controlling erosion and runoff. Soil blowing is a hazard in areas where large tracts are plowed in the fall and the surface is left bare. The nearly level, poorly drained and very poorly drained soils generally are drained by tile systems. Improved drainage is needed in many areas. Surface intakes in depressional soils help to prevent crop damage caused by ponding during periods of high rainfall. Timely tillage maintains tilth and helps to prevent compaction in areas of the wetter soils.

7. Millington-Spillville-Colo Association

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

This association consists of an elongated area that is the flood plain of the West Fork of the Des Moines River and a small area in the eastern part of the county along the East Fork of the Des Moines River. Generally, the soils are covered by a mixed stand of timber and grass. In some places, however, the timber stand is so dense that there is little or no grass. In other places where trees are less dense or have been removed, grass grows abundantly. Millington soils generally parallel the stream channel, and there are old meanders and oxbows. In places the present channel meanders. Spillville soils are slightly higher on the landscape than the Millington soils. They typically do not border the present stream channel. Slopes generally range from 0 to 2 percent, and differences in elevation are small.

This association makes up about 2 percent of the county. It is about 30 percent Millington soils, 25 percent Spillville soils, 18 percent Colo soils, and 27 percent soils of minor extent (fig. 7).

The poorly drained Millington soils border the stream channel. They are in the lower positions on the landscape and are the first areas in this association to be flooded. They are commonly cut by old meander channels and oxbows. The somewhat poorly drained to moderately well drained Spillville soils are slightly higher on the landscape than the Millington soils. They

Figure 6.—An area of the Canisteo-Nicollet-Okoboji association. The minor Harps soils commonly are on rims surrounding the Okoboji soils, which are in depressions. Canisteo soils are in the foreground, and Nicollet soils are in the background.

commonly border the Millington soils and are adjacent to soils on terraces or uplands. The poorly drained Colo soils are on flood plains. They are farther from streams than the Spillville soils.

Typically, the surface layer of the Millington soils is black, friable silt loam about 3 inches thick. The subsurface layer is black, calcareous, friable silty clay loam about 11 inches thick. It has thin strata of very fine sand or silt. The subsoil is about 18 inches thick. It is black, very dark gray, and dark grayish brown, calcareous, friable loam and has a few thin strata of very fine sand. The substratum to a depth of about 60 inches is very dark gray and dark gray, calcareous loam. It has thin strata of very fine sand in the upper part.

Typically, the surface layer of the Spillville soils is black, friable loam about 9 inches thick. The subsurface layer is friable loam about 43 inches thick. The upper part is black, the next part is black, very dark brown, and very dark grayish brown, and the lower part is very dark grayish brown and is mottled. The substratum to a depth of about 60 inches is mottled dark grayish brown and brown loam.

Typically, the surface layer of the Colo soils is black, firm silty clay loam about 7 inches thick. The subsurface layer is firm silty clay loam about 45 inches thick. The upper part is black, and the lower part is very dark gray. The substratum to a depth of about 60 inches is mottled very dark gray, dark gray, and olive gray clay loam.

The minor soils in this association are the Biscay, Coland, and Linder soils. The poorly drained Biscay and somewhat poorly drained Linder soils are on stream terraces. They formed in coarse textured alluvium. Coland soils are adjacent to the major soils and typically are in landscape positions that are intermediate between those of the major soils. They formed in medium textured alluvium.

Most areas of this association support native vegetation and are used for pasture along with the adjacent steeply sloping upland soils. Because of frequent flooding, most of this association is not suited to cultivated crops. Some areas of Spillville soils and some areas of minor soils are used for row crops. These areas are high enough on the landscape to escape some minor flooding, but cropping is often delayed because of flooding and wetness. In some years cropping is entirely prohibited because of the frequency or duration of flooding. These soils have a high water-holding capacity.

Millington soils are mostly covered with trees, except for a few areas that have been cleared. The main tree species is silver maple, but willow, box elder, and cottonwood also grow. Under present management these areas provide very little economic return, but they do provide good habitat for openland and woodland wildlife. Appropriate timber stand improvement methods could improve the production of timber in these areas. Such methods include selective harvesting; removing the less desirable species, such as willow and box elder; and planting the more desirable species, such as green ash, black walnut, cedar, and varieties of poplar, including cottonwood. These methods also enhance wildlife habitat.

Areas of Spillville soils and some of the minor soils generally support only a few scattered trees. Grass

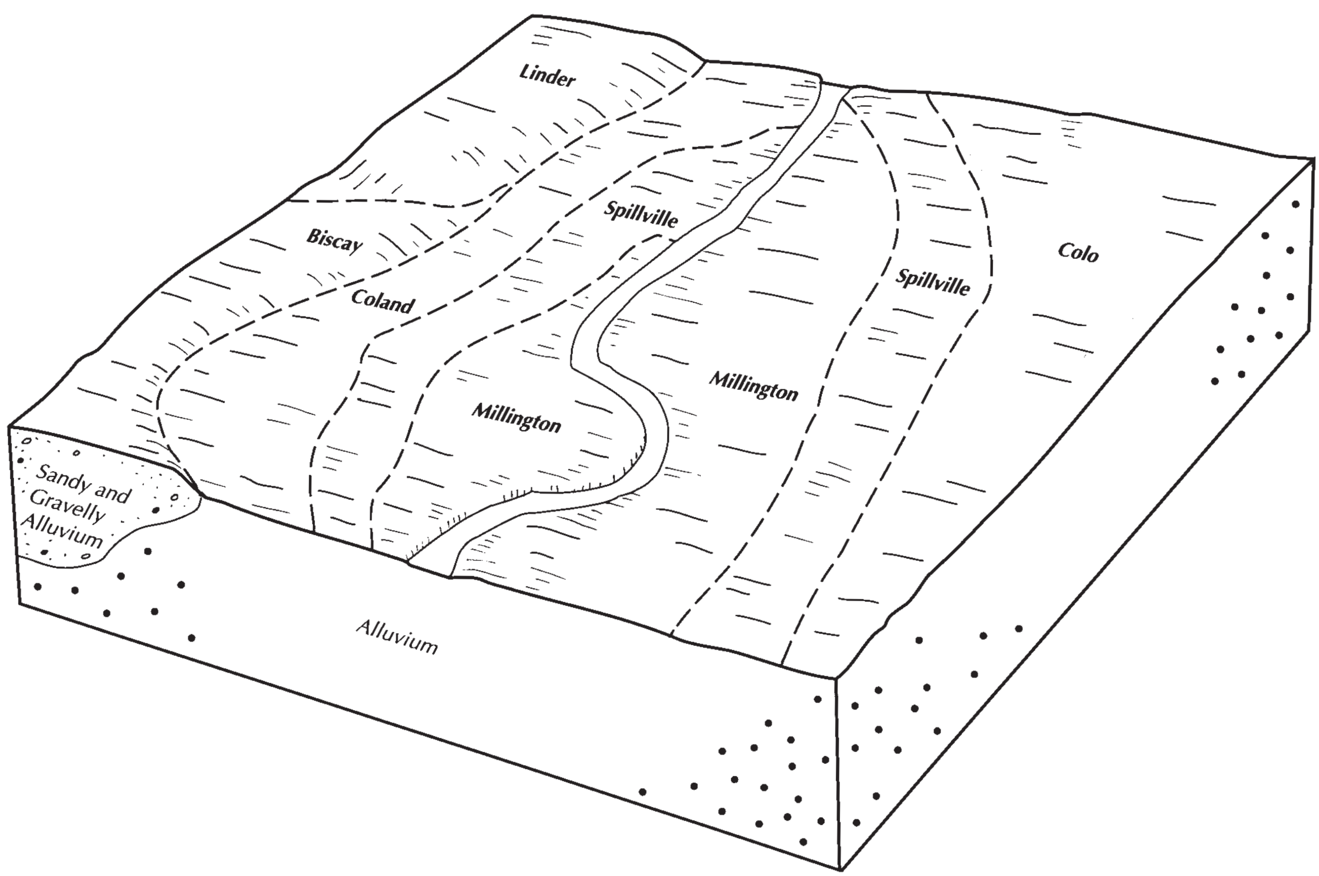

Figure 7.—Typical pattern of soils and parent material in the Millington-Spillville-Colo association.

grows well on these soils and generally provides good grazing.

The flooding is the major management concern affecting most uses. Controlling the flooding is difficult and is generally not economically feasible.

Detailed Soil Map Units

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

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

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

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

Soils of one series can differ in texture of the surface layer or of the substratum. They also can differ in slope, stoniness, salinity, wetness, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Clarion loam, 2 to 5 percent slopes, is a phase of 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, or one or more soils and a miscellaneous area, in such an intricate pattern or in such small areas that they cannot be shown separately on the soil maps. The pattern and proportion of the soils are somewhat similar in all areas. Clarion-Storden complex, 9 to 14 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, sand and 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 nearly level, very poorly drained soil is in shallow upland depressions. It is subject to ponding (fig. 8). Areas typically range from 2 to 6 acres in size, but some range from 12 to 50 acres. Most areas are circular, but some are elongated.

Typically, the surface layer is black, friable silty clay loam about 8 inches thick. The subsurface layer is black, very dark gray, and dark gray, friable silty clay loam about 28 inches thick. The subsoil, to a depth of about 48 inches, is very dark gray, dark gray, and olive gray, friable silty clay loam. The substratum to a depth of about 60 inches is mottled gray and olive gray silty clay loam. In places the surface layer is slightly calcareous.

Included with this soil in mapping are a few soils on glacial outwash terraces that have a clay loam solum and a sandy substratum. These soils make up about 5 percent of the unit.

Permeability is moderately slow in the Okoboji soil, and runoff is very slow or ponded. Available water capacity is high. This soil has a seasonal high water table. The content of organic matter in the surface layer

Figure 8.—Ponding occurs frequently in areas of Okoboji silty clay loam, 0 to 1 percent slopes. In some years the ponding can damage crops.

is about 9 to 12 percent. The shrink-swell potential is high. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas of this soil are cultivated. Most areas are artificially drained by tile, and some have surface intakes. A few areas have shallow ditches. In places, it is difficult to find outlets deep enough for the proper functioning of tile drains. This soil is moderately suited to cultivated crops in areas where drainage is adequate. Crop growth is variable. In wetter years the ponding is of sufficient duration to drown out crops. If the crop damage occurs early in the season, the crops can be 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 frost heave in winter frequently drown out or kill crops. If this soil is used for hay or improved pasture, grasses, such as reed canarygrass, and legumes that tolerate excessive wetness should be substituted for the plants more commonly grown. Grazing when the soil is wet causes surface compaction and poor tilth.

Undrained areas generally are 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 generally is managed in conjunction with areas of adjacent soils.

The wetness is the main limitation if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. A drainage system is needed. Species that can withstand wetness should be selected for planting.

The land capability classification is IIIw.

27—Terril loam, 0 to 2 percent slopes. This nearly level, moderately well drained soil is on high terraces and alluvial fans. It is typically adjacent to Wadena and Estherville soils and, in places, to other Terril soils. Areas range from 10 to 30 acres in size and are irregularly shaped.

Typically, the surface layer is black, friable loam about 9 inches thick. The subsurface layer is friable loam about 30 inches thick. The upper part is black, and the lower part is black, dark brown, very dark brown, and very dark grayish brown. The subsoil extends to a depth of 60 inches or more. It is friable loam. The upper part is brown, and the lower part is dark yellowish brown. In places loamy sand or sand that has as much as 15 percent coarse fragments is at a depth of about 45 inches.

Permeability is moderate, and runoff is slow. Much of the water that falls on this soil is absorbed. Available water capacity is high. The content of organic matter in the surface layer is about 3.5 to 4.5 percent. The subsoil generally has a very low supply of available phosphorus and a very low or low supply of available potassium.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. A system of conservation tillage that leaves crop residue on the surface helps to maintain good tilth. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to prevent surface crusting, and increases the rate of water infiltration.

A cover of pasture plants or hay is effective in maintaining tilth. 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 restricted use during wet periods help to keep the pasture in good condition.

If this soil is used for windbreaks or ornamental plantings, soil blowing is a moderate hazard before the trees and shrubs are established. It can be controlled, however, by a permanent plant cover or surface mulch.

The land capability classification is I.

27B—Terril loam, 2 to 5 percent slopes. This gently sloping, moderately well drained soil is on low concave foot slopes and alluvial fans. It generally is downslope from the more sloping Clarion and Storden soils and upslope from soils on flood plains and terraces. In many places, it is upslope from Delft, Nicollet, or Webster soils. Slopes generally are short. Areas range mainly from 3 to 10 acres in size, but a few areas are as large as 15 acres or more. Individual areas are long and narrow.

Typically, the surface layer is black, friable loam about 9 inches thick. The subsurface layer is friable loam about 28 inches thick. The upper part is black, and the lower part is black, dark brown, very dark brown, and very dark grayish brown. The subsoil extends to a depth of 60 inches or more. It is friable loam. The upper part is brown, and the lower part is dark yellowish brown.

Included with this soil in mapping are small areas of the somewhat poorly drained Spillville soils on foot slopes. These soils are in slightly lower positions on the landscape than those of the Terril soil. They make up about 5 percent of the unit.

Permeability is moderate in the Terril soil, and runoff is medium. Available water capacity is high. The content of organic matter in the surface layer is about 3 or 4 percent. The subsoil generally has a very low supply of available phosphorus and a very low or low supply of available potassium.

Most areas are cultivated. Some areas adjacent to steep soils are used for pasture. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. If cultivated crops are grown, erosion is a hazard. A system of conservation tillage that leaves crop residue on the surface and grassed waterways help to control erosion and soil blowing. In places, crops are subject to damage by overwash and siltation unless they are protected from runoff from the soils higher on the landscape. Establishing terraces or diversions on the higher slopes helps to control runoff. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to prevent surface crusting, and increases the rate of water infiltration.

A cover of pasture plants or hay is effective in controlling erosion. 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 restricted use during wet periods help to keep the pasture in good condition.

If this soil is used for windbreaks or ornamental plantings, erosion is a moderate hazard before the trees and shrubs are established. It can be controlled, however, by a permanent plant cover or surface mulch.

The land capability classification is IIe.

27C—Terril loam, 5 to 9 percent slopes. This moderately sloping, moderately well drained soil is on slightly concave to slightly convex foot slopes. It generally is downslope from the more sloping Clarion and Storden soils. Areas range from 4 to 12 acres in size and are long and narrow.

Typically, the surface layer is black, friable loam about 9 inches thick. The subsurface layer is friable loam about 27 inches thick. The upper part is black, and the lower part is black, dark brown, very dark brown, and very dark grayish brown. The subsoil extends to a depth of 60 inches or more. It is friable loam. It is brown in the upper part and dark yellowish brown in the lower part.

Permeability is moderate, and runoff is medium. Available water capacity is high. The content of organic matter in the surface layer is about 3 to 4 percent. The subsoil generally has a very low supply of available phosphorus and a low or very low supply of available potassium.

Most areas are cultivated. Areas adjacent to soils that are too steep to be cultivated generally are used for pasture. This soil is suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. If cultivated crops are grown, erosion is a hazard. It can be controlled, however, by a system of conservation tillage that leaves crop residue on the surface, grassed waterways, contour farming, or terraces or by a combination of these practices. In places, crops are subject to damage by overwash and siltation unless they are protected from runoff from the soils higher on the landscape. Establishing terraces or diversions helps to control runoff and thus helps to prevent the crop damage caused by the deposition of sediment. Good tilth generally can be easily maintained.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet causes surface compaction and poor tilth. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture in good condition.

If this soil is used for windbreaks or ornamental plantings, erosion is a moderate hazard before the trees and shrubs are established. It can be controlled, however, by a permanent plant cover or surface mulch.

The land capability classification is IIIe.

28—Dickman sandy loam, 0 to 2 percent slopes. This nearly level, well drained soil is mainly on uplands and on stream terraces. Areas range from about 3 to 10 acres in size and are irregularly shaped.

Typically, the surface layer is very dark brown, very friable sandy loam about 10 inches thick. The subsurface layer is very dark brown and dark brown, very friable sandy loam about 6 inches thick. The subsoil is about 20 inches thick. The upper part is dark brown, very friable sandy loam, and the lower part is yellowish brown and dark yellowish brown, very friable loamy sand. The substratum to a depth of about 60 inches is dark yellowish brown, yellowish brown, and brown sand. In a few places the soil is slightly depressional and has a somewhat thicker and darker surface layer. In other places the subsoil is sandy loam throughout.

Permeability is moderately rapid in the solum and rapid in the substratum. Runoff is slow. Available water capacity is low. The content of organic matter in the surface layer is about 1.5 to 2.5 percent. The subsoil generally has a very low supply of available phosphorus and a very low or low supply of available potassium.

Most areas are cultivated along with areas of associated soils that are better suited to cultivation. This soil is poorly suited to cultivated crops. It is better suited to the production of small grain. Water erosion and soil blowing are serious hazards if cultivated crops are grown. Also, droughtiness is a limitation. Windblown sand damages young plants in some years. A system of conservation tillage that leaves crop residue on the surface helps to prevent excessive soil loss. Using mechanical erosion-control practices, such as terraces, is difficult because of the instability of the soil and the hazard of erosion. Also, adequate compaction of the terrace wall is difficult to achieve. Returning crop residue to the soil or regularly adding other organic material helps to maintain tilth, improves fertility, and increases the rate of water infiltration.

A cover of pasture plants or hay is effective in controlling erosion. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during extremely dry periods help to keep the pasture in good condition. Because the soil warms rapidly in the spring, the pasture can be grazed early in the season.

The land capability classification is IIIs.

28B—Dickman sandy loam, 2 to 5 percent slopes. This gently sloping, well drained soil is mainly in the uplands and on terraces near the larger streams. Most areas range from 2 to 20 acres in size and are irregularly shaped.

Typically, the surface layer is very dark brown, very friable sandy loam about 10 inches thick. The subsurface layer is very dark brown and dark brown, very friable sandy loam about 4 inches thick. The subsoil is about 18 inches thick. The upper part is dark brown, very friable sandy loam, and the lower part is yellowish brown and dark yellowish brown, very friable loamy sand. The substratum to a depth of about 60 inches is dark yellowish brown, yellowish brown, and brown sand. In places, slopes are steeper and the surface layer is thinner.

Included with this soil in mapping are a few areas that have loamy glacial till at a depth of about 3 feet. These areas make up about 5 percent of the unit.

Permeability is moderately rapid in the solum of the Dickman soil and rapid in the substratum. Runoff is slow. Available water capacity is low. The content of organic matter in the surface layer is about 1.5 to 2.5 percent. The subsoil generally has a very low supply of available phosphorus and a very low or low supply of available potassium.

Most areas are cultivated along with areas of associated soils that are better suited to cultivation. This soil is better suited to the production of small grain than to cultivated crops. Water erosion and soil blowing are serious hazards if cultivated crops are grown. Also, droughtiness is a limitation. Windblown sand damages young plants in some years. A system of conservation tillage that leaves crop residue on the surface helps to prevent excessive soil loss. Using mechanical erosion-control practices, such as terraces, is difficult because of the instability of the soil and the hazard of erosion. Also, adequate compaction of the terrace wall is difficult to achieve. Returning crop residue to the soil or regularly adding other organic material helps to maintain tilth, improves fertility, and increases the rate of water infiltration.

A cover of pasture plants or hay is effective in controlling erosion. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during extremely dry periods help to keep the pasture in good condition. Because the soil warms rapidly in the spring, the pasture can be grazed early in the season.

The land capability classification is IIIe.

34—Estherville sandy loam, 0 to 2 percent slopes. This gently sloping, somewhat excessively drained soil is on knolls and on sides of terraces and ridges. Slopes typically are short and convex. Areas range from 2 to 10 acres in size and are irregularly shaped.

Typically, the surface layer is very dark brown, very friable sandy loam about 8 inches thick. The subsurface layer is very dark grayish brown, very friable sandy loam about 7 inches thick. The subsoil is dark brown and very dark brown, friable sandy loam about 5 inches thick. The substratum to a depth of about 60 inches is dark brown and brown, calcareous gravelly loamy sand. In places the substratum is dominantly loamy sand or sand in which the content of gravel is less than 10 percent.

Permeability is moderately rapid in the surface soil and subsoil and very rapid in the substratum. Runoff is slow or medium. Available water capacity is low. The content of organic matter in the surface layer is about 3 to 4 percent. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated or used for pasture. Some areas are used as wildlife habitat. This soil is poorly suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. It is droughty because of the sandy and gravelly substratum. A system of conservation tillage that leaves crop residue on the surface conserves moisture and helps to prevent excessive soil loss. In places, contour farming helps to control erosion. This soil is not suitable for terraces because sand and gravel are too close to the surface. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material improves fertility and conserves moisture.

If this soil is used for pasture, overgrazing reduces the extent of the protective plant cover and thus increases the runoff rate and the hazard of erosion.

If this soil is used for trees and shrubs grown as windbreaks, ornamental plantings, or plantings for wildlife, the low available water capacity is a concern. Also, erosion is a slight hazard before the trees and shrubs are established. Only the species that are tolerant of low soil moisture should be selected for planting. A permanent plant cover helps to control erosion.

The land capability classification is IIIs.

34C2—Estherville sandy loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, somewhat excessively drained soil is on glacial outwash side slopes and at the edges of stream terraces. Most areas range from about 2 to 8 acres in size and are longer than they are wide.

Typically, the surface layer is very dark brown, very friable sandy loam about 8 inches thick. It is mixed with streaks and pockets of dark brown and very dark brown subsoil material. The subsoil is dark brown and very dark brown, friable sandy loam about 4 inches thick. The substratum to a depth of about 60 inches is dark brown and brown, calcareous gravelly loamy sand.

Permeability is moderately rapid in the upper part and very rapid in the substratum. Runoff is medium. Available water capacity is low. The content of organic matter in the surface layer is about 1 to 2 percent. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is marginally suited to corn, soybeans, and small grain. It is better suited to grasses and legumes for hay and pasture, but an even distribution of rainfall is needed. If cultivated crops are grown, further erosion is a hazard. Soil blowing is also a hazard in areas where the surface is not protected by plants or crop residue. Also, droughtiness is a limitation. It damages corn and soybeans more frequently than small grain. A system of conservation tillage that leaves crop residue on the surface helps to control erosion and soil blowing and conserves moisture. In areas where slopes are sufficiently long and wide, contour farming also helps to control erosion. Terraces generally are not constructed on this soil because the cuts would expose the coarse textured, unproductive material in most areas. The root development of most plants is restricted by the sand and gravel at a depth of 15 to 24 inches. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material helps to maintain tilth, improves fertility, helps to prevent surface crusting, and increases the rate of water infiltration.

A cover of pasture plants or hay is effective in controlling erosion. Proper stocking rates and deferred grazing during droughty periods are the main management needs. Because the soil warms rapidly in the spring, the pasture can be grazed early in the season. Cool-season grasses tend to be more productive than warm-season grasses.

The land capability classification is IVe.

55—Nicollet loam, 1 to 3 percent slopes. This very gently sloping, somewhat poorly drained soil is on convex slopes in the uplands. A few areas are in concave positions between undulating areas of well drained soils. Areas range mainly from 3 to 20 acres in size, but a few areas range to about 100 acres. Individual areas are irregularly shaped.

Typically, the surface layer is black, friable loam about 8 inches thick. The subsurface layer is black and very dark brown, friable loam about 10 inches thick. The subsoil is friable clay loam about 24 inches thick. The upper part is dark grayish brown and very dark gray, the next part is dark grayish brown, and the lower part is mottled dark grayish brown and grayish brown. The substratum to a depth of about 60 inches is mottled olive gray and olive, calcareous loam.

Included with this soil in mapping are small areas of the well drained Clarion and Storden soils. These soils are on the highest, most convex part of the slopes and are not as dark as the Nicollet soil. Also included are small areas of the poorly drained Webster soils and the very poorly drained Okoboji soils that are level or slightly depressional. Okoboji soils are subject to ponding after rains. Included soils make up about 10 percent of the unit.

Permeability is moderate in the Nicollet soil, and runoff is slow. Available water capacity is high. This soil has a seasonal high water table. The content of organic matter in the surface layer is about 5 to 6 percent. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. In places, runoff from adjacent slopes accumulates on this soil and causes sedimentation (fig. 9). The seasonal wetness can delay fieldwork. Installing tile drains helps to overcome the wetness. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material helps to maintain tilth, improves fertility, and increases the rate of water infiltration.

A cover of pasture plants or hay is effective in maintaining good tilth. Overgrazing or grazing when the soil is wet causes surface compaction and poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

The seasonal high water table is a moderate limitation if this soil is used for trees and shrubs grown as windbreaks or ornamental plantings. It generally can be overcome, however, by selecting the species that can withstand occasional wetness or by installing a drainage system.

The land capability classification is 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 in the uplands (fig. 10). Areas range from 5 to 10 acres in size and are irregularly shaped.

Typically, the surface layer is very dark brown, very dark grayish brown, and brown, friable, calcareous loam about 8 inches thick. It is mixed with streaks and pockets of light olive brown substratum material. The substratum to a depth of about 60 inches is mottled, light olive brown, calcareous loam. In places where this soil has not been plowed, the surface layer is darker and is about 10 inches thick.

Included with this soil in mapping are a few small areas of Dickman and Salida soils. These soils are droughty and are more susceptible to erosion than the Storden soil. They generally are on the higher, more sharply convex slopes. Dickman soils have more sand than the Storden soil, and Salida soils contain gravel. Also included are the severely eroded Storden soils, which generally are in scattered areas. These soils have a low content of organic matter. More intensive management is needed to maintain fertility on these soils than on the less eroded Storden soils. Included soils make up less than 5 percent of the unit.

Permeability is moderate in the Storden soil, and

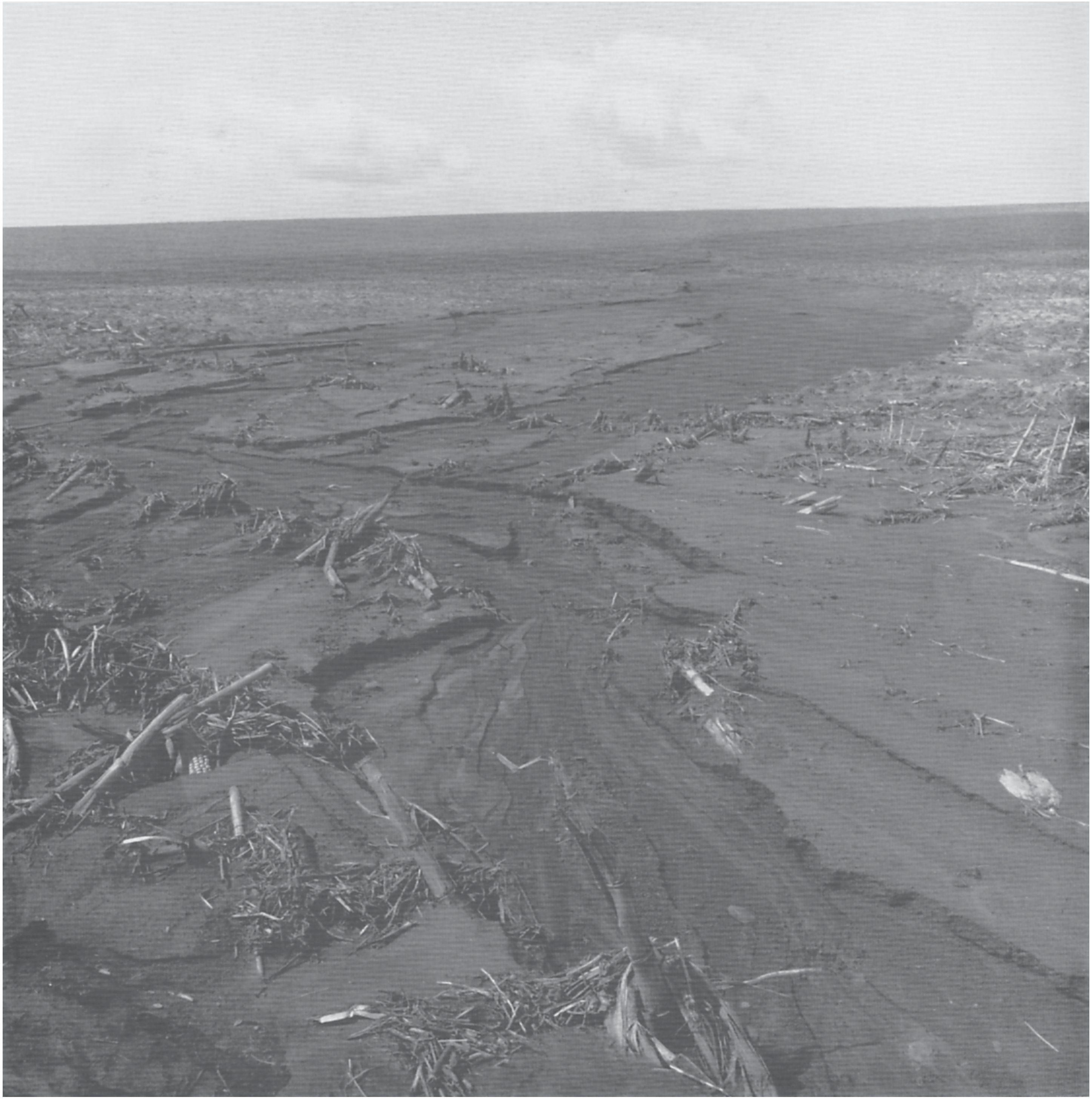

Figure 9.—Erosion and sedimentation in an area of Nicollet loam, 1 to 3 percent slopes. Grassed waterways help to prevent this type of damage.

runoff is medium. Available water capacity is high. The content of organic matter in the surface layer ranges mainly from about 1.7 to 2.7 percent, but in severely eroded areas it ranges from 0.7 to 1.7 percent. The

Figure 10.—The light colored soil in the center is Storden loam, 5 to 9 percent slopes, moderately eroded. Clarion soils are in the foreground, and other Storden soils are on the steeper slopes in the background.

subsoil generally has a very low supply of available phosphorus and potassium. The response to fertilizer and to some herbicides is adversely affected by the high concentration of lime carbonates.

Most areas are cultivated. Some areas are used as pasture. This soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. If the soil is used for cultivated crops, further erosion is a hazard. Grassed waterways and a system of conservation tillage that leaves crop residue on the surface help to prevent excessive soil loss. In places, using mechanical erosion-control practices, such as contour farming and terraces, is difficult because of the irregular topography and short slopes. Excess lime carbonates adversely affect the response to fertilizer and herbicides. The supply of available iron is inadequate in some areas of this soil, and the supply of other minor elements may be low. Good tilth generally can be easily maintained, but excessive tillage during seedbed preparation may dry the surface layer and result in poor stands. Returning crop residue to the soil or regularly adding other organic material increases the organic matter content, improves fertility, and helps to maintain good tilth.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet causes surface compaction, increases the runoff rate, and results in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

If this soil is used for trees and shrubs grown as windbreaks or ornamental plantings, erosion is a severe hazard before the trees and shrubs are established. It can be controlled, however, by a permanent plant cover or surface mulch.

The land capability classification is IIIe.

62D2—Storden loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping, well drained soil is on convex side slopes and on sharply convex knobs and ridges in the rolling to hilly uplands throughout the county. Most areas range from 5 to 10 acres in size, but a few are as large as 30 acres. Individual areas are irregularly shaped or, on side slopes, are long and narrow. Some areas are dissected by shallow field waterways.

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

Included with this soil in mapping are a few small areas of Dickman and Salida soils. These soils are generally on the more sharply convex part of the slope. They are more droughty and more susceptible to erosion than the Storden soil. Also included are the severely eroded Storden soils, which generally are in scattered areas. These soils have a low content of organic matter. More intensive management is needed to maintain fertility on these soils than on the less eroded Storden soils. Included soils make up less than 10 percent of the unit.

Permeability is moderate in the Storden soil, and runoff is rapid. Available water capacity is high. The content of organic matter in the surface layer is mainly about 1.7 to 2.7 percent, but in severely eroded areas it is about 0.7 to 1.7 percent. The subsoil generally has a very low supply of available phosphorus and potassium. The response to fertilizer and to some herbicides is adversely affected by the high concentration of lime carbonates.

Most areas are cultivated, but some areas are used as pasture. This soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. If the soil is used for cultivated crops, further erosion is a hazard. Grassed waterways and a system of conservation tillage that leaves crop residue on the surface help to prevent excessive soil loss. In places, using mechanical erosion-control practices, such as contour farming and terraces, is difficult because of the irregular topography and short slopes. Excess lime carbonates adversely affect response to fertilizer and herbicides. Larger additions of fertilizer are needed to maintain desirable yields. The supply of available iron is inadequate in some areas of this soil, and in places the supply of other minor elements may be low. Good tilth generally can be easily maintained, but excessive tillage during seedbed preparation may dry the surface layer and result in poor stands. Returning crop residue to the soil or regularly adding other organic material increases the organic matter content, improves fertility, and helps to maintain tilth.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet causes surface compaction, increases the runoff rate, and results in poor tilth. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture in good condition.

If this soil is used for trees or shrubs grown as windbreaks or ornamental plantings, erosion is a severe hazard before the trees and shrubs are established. It can be controlled, however, by a permanent plant cover or surface mulch.

The land capability classification is IIIe.

62D3—Storden loam, 9 to 14 percent slopes, severely 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. Most areas range from 5 to 10 acres in size, but a few are as large as 30 acres. Individual areas are irregularly shaped or, on side slopes, are long and narrow. Some areas are dissected by shallow field waterways.

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

Included with this soil in mapping are a few small areas of Dickman and Salida soils. These soils are generally on the more sharply convex parts of the slope. They are more droughty and more susceptible to erosion than the Storden soil. Included areas make up less than 10 percent of the unit.

Permeability is moderate in the Storden soil, and runoff is rapid. Available water capacity is high. The content of organic matter in the surface layer is about 0.7 to 1.7 percent. The subsoil generally has a very low supply of available phosphorus and potassium. Response to fertilizer and to some herbicides is adversely affected by the high concentration of lime carbonates.

Most areas are cultivated. Because of the damage caused by previous erosion, however, this soil is better suited to hay or pasture. The soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. If the soil is used for cultivated crops, further erosion is a serious hazard. Grassed waterways and a system of conservation tillage that leaves crop residue on the surface help to prevent excessive soil loss. In places, using mechanical erosion-control practices, such as contour farming and terraces, is difficult because of the irregular topography and short slopes. Excess lime carbonates adversely affect response to fertilizer and herbicides. Larger additions of fertilizer are needed to maintain desirable yields. The supply of available iron is inadequate in some areas of this soil, and the supply of other minor elements may be low in some places. The poor tilth commonly results in poor stands. Returning crop residue to the soil or regularly adding other organic material increases the organic matter content and improves fertility and tilth.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet causes surface compaction, increases the runoff rate, and results in poor tilth. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture in good condition.

If this soil is used for trees or shrubs grown as windbreaks or ornamental plantings, erosion is a severe hazard before the trees and shrubs are established. It can be controlled, however, by a permanent plant cover or surface mulch.

The land capability classification is IVe.

62E—Storden loam, 14 to 18 percent slopes. This moderately steep, well drained soil is on hills or ridges in the uplands. It typically borders large depressions, upland drainageways, and side slopes adjacent to alluvial soils along streams. Most areas range from about 6 to 14 acres in size and are long and narrow or irregularly shaped. A few areas range to about 30 acres in size. Many areas are dissected by shallow field waterways.

Typically, the surface layer is very dark gray and very dark grayish brown, friable, calcareous loam about 9 inches thick. The substratum to a depth of about 60 inches is mottled, light olive brown, calcareous loam. On some sharply convex knobs and in areas bordering field waterways, the surface layer is only about 4 inches thick. In some places erosion has exposed the light olive brown substratum at the surface. In other places plowing has mixed the light olive brown substratum material into the surface layer.

Permeability is moderate, and runoff is very rapid. Available water capacity is high, but it may be affected by the runoff rate and the reduced rate of infiltration. The content of organic matter in the surface layer is about 2.5 to 3.5 percent. The substratum generally has a very low supply of available phosphorus and potassium. Response to fertilizer and to some herbicides is adversely affected by the high concentration of lime carbonates.

Most areas are used for pasture, but a few small areas are cultivated because they extend into other areas that are better suited to cultivation. This soil is poorly suited to corn, soybeans, and small grain. It is moderately suited to grasses and legumes for hay and pasture. If cultivated crops are grown, erosion is a hazard. It can be controlled, however, by terraces or contour farming in combination with a system of conservation tillage that leaves crop residue on the surface and crop rotations that include meadow crops. Good tilth generally can be easily maintained if erosion is controlled and the content of organic matter is maintained. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to maintain tilth, and increases the rate of water infiltration.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing, however, causes surface compaction, increases the runoff rate, results in poor tilth, and reduces forage production. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture in good condition.

If this soil is used for trees or shrubs grown as windbreaks or ornamental plantings, erosion is a severe hazard before the trees and shrubs are established. It can be controlled, however, by a permanent plant cover or surface mulch.

The land capability classification is IVe.

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 side slopes adjacent to drainageways and small streams. Some areas are dissected by shallow drainageways. Individual areas of this soil range mainly from 5 to 10 acres in size and are irregularly shaped. Some areas are as large as about 30 acres. Some areas on side slopes are long and narrow.

Typically, the surface layer is very dark brown, very dark grayish brown, and brown, friable, calcareous loam about 8 inches thick. It is mixed with streaks and pockets of light olive brown substratum material. In places the light olive brown substratum is exposed. The substratum to a depth of about 60 inches is mottled, light olive brown, calcareous loam. In some areas the surface layer is very dark gray and very dark grayish brown, friable, calcareous loam about 4 to 9 inches thick.

Included with this soil in mapping are a few small areas of Clarion, Dickman, and Salida soils. Clarion soils have a thicker, darker surface layer than the Storden soil and are leached to a depth of 18 inches or more. Dickman and Salida soils are generally on the more sharply convex part of the slope. They contain more sand, are more droughty, and are more susceptible to erosion than the Storden soil. Also included are the severely eroded Storden soils, which generally are in scattered areas. These soils have a low content of organic matter. More intensive management is needed to maintain fertility on these soils than on the less eroded Storden soils. Included soils make up about 5 to 10 percent of the unit.

Permeability is moderate in the Storden soil, and runoff is very rapid. Available water capacity is high, but it is affected by the runoff rate and the reduced rate of water infiltration. The content of organic matter in the surface layer is mainly about 1.7 to 2.7 percent, but in severely eroded areas it is about 0.7 to 1.7 percent. The subsoil generally has a very low supply of available phosphorus and potassium. Response to fertilizer and to some herbicides is adversely affected by the high concentration of lime carbonates.

Most areas are cultivated along with areas of associated soils that are better suited to cultivation. Many areas that border drainageways and streams are used as pasture. This soil is poorly suited to corn and soybeans. It is better suited to small grain and to grasses and legumes for hay and pasture. If the soil is used for cultivated crops, further erosion is a hazard. Practices that control runoff and allow more water to enter the soil help to prevent excessive soil loss and improve pasture and crop growth. Grassed waterways and a system of conservation tillage that leaves crop residue on the surface are appropriate practices. In places, using mechanical erosion-control practices, such as contour farming and terraces, is difficult because of the irregular topography and short slopes. Excess lime carbonates adversely affect response to fertilizers and herbicides. The supply of available iron is inadequate in some areas of this soil, and the supply of other minor elements may be low in some places. Returning crop residue to the soil or regularly adding other organic material increases the organic matter content, improves fertility, and helps to maintain tilth.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing when the soil is too wet causes surface compaction, increases the runoff rate, and results in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

If this soil is used for trees or shrubs grown as windbreaks or ornamental plantings, erosion is a severe hazard before the trees and shrubs are established. It can be controlled, however, by a permanent plant cover or surface mulch.

The land capability classification is IVe.

62F—Storden loam, 18 to 25 percent slopes. This steep, well drained soil is on hills or ridges in the uplands. It commonly borders large depressions, upland drainageways, and streams. Most areas range from 6 to 12 acres in size, but a few are as large as 30 acres. Individual areas are irregularly shaped. Some areas are dissected by shallow field waterways.

Typically, the surface layer is very dark gray and very dark grayish brown, friable, calcareous loam about 8 inches thick. The substratum to a depth of about 60 inches is mottled, light olive brown, calcareous loam. On some sharply convex knobs, the surface layer is about 3 inches thick. In places erosion has exposed the light olive brown substratum.

Included with this soil in mapping are a few small areas of Dickman and Salida soils. These soils generally are on the more sharply convex part of slopes. They contain more sand, are more droughty, and are more susceptible to erosion than the Storden soil. Also included are a few small areas that have a silty substratum. Included areas make up less than 5 percent of the unit.

Permeability is moderate in the Storden soil, and runoff is very rapid. Available water capacity is high, but it can be affected by the runoff rate and the reduced rate of water infiltration. The content of organic matter in the surface layer is about 2.5 to 3.5 percent. The subsoil generally has a very low supply of available phosphorus and potassium. Response to fertilizer and to some herbicides is adversely affected by the high concentration of lime carbonates.

Most areas are used for pasture, but some areas are used as cropland. This soil is poorly suited to cultivated crops because of the steep slopes and the severe hazard of erosion. Some relatively small areas are cultivated because they are associated with soils that are better suited to cultivation. The soil is better suited to grasses and legumes for hay and pasture, but it is too erodible for unlimited grazing. Operating farm machinery is hazardous because of the slope. In areas where farm machinery can be used, fertilizer can be applied and pastures can be renovated.

Maintaining a cover of pasture or hay is effective in controlling erosion. Improving fertility and controlling runoff greatly enhance crop growth. Overstocking and overgrazing reduce the vegetative cover and cause deterioration of the stand. Under these conditions, weeds invade and compete for available water and plant nutrients. Proper stocking rates, uniform grazing, timely deferment of grazing, and a planned grazing system help to keep the pasture in good condition. Ungrazed areas provide habitat for some species of wildlife. Areas that support native grasses can be renovated so that more desirable and productive plant species are established. Warm-season grasses, such as switchgrass and indiangrass, are suitable in areas of this soil.

If this soil is used for trees or shrubs grown as windbreaks or ornamental plantings, erosion is a severe hazard before the trees and shrubs are established. It can be controlled, however, by a permanent plant cover or surface mulch. Planting is difficult because of the slope.

The land capability classification is VIe.

62G—Storden loam, 25 to 40 percent slopes. This very steep, well drained soil is on short, convex side slopes adjacent to drainageways and streams in the uplands. Some areas border large depressions and areas of marsh. Most areas are dissected by shallow drainageways. Most areas range from 5 to 15 acres in size, but a few are as large as 30 acres. Individual areas are long and narrow.

Typically, the surface layer is very dark gray and very dark grayish brown, friable, calcareous loam about 8 inches thick. The substratum to a depth of about 60 inches is mottled, light olive brown, calcareous loam. In a few places erosion has exposed the light olive brown substratum.

Included with this soil in mapping are a few small areas of Dickman and Salida soils. These soils commonly are on the highest, most sharply convex part of the slope. They contain more sand, are more droughty, and are more susceptible to erosion than the Storden soil. Included soils make up less than 5 percent of the unit.

Permeability is moderate in the Storden soil, and runoff is very rapid. Available water capacity is high, but it can be affected by the runoff rate. The content of organic matter in the surface layer is about 2.5 to 3.5 percent. The subsoil generally has a very low supply of available phosphorus and potassium. This soil contains an excess of calcium carbonates throughout.

Most areas are used as pasture. 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 poorly suited to hay because the slopes generally are too steep for the use of farm machinery. Erosion is a severe hazard, and low fertility limits plant growth. Plants may lack water during periods of low rainfall because of the runoff rate. Sites that could be used for livestock ponds or erosion-control ponds are available in many areas of this soil.

Management that improves fertility and controls runoff enhances crop growth and helps to prevent erosion. Overstocking or overgrazing reduces the protective vegetative cover and causes 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 a planned grazing system help to keep the pasture in good condition. Ungrazed areas provide habitat for some species of wildlife.

Trees or shrubs can be planted by hand but generally cannot be planted by machine because of the equipment limitation.

The land capability classification is VIIe.

72—Estherville loam, 0 to 2 percent slopes. This nearly level, somewhat excessively drained soil is in broad, smooth glacial outwash areas and on stream terraces. Most areas range from about 2 to 50 acres in size and are irregularly shaped.

Typically, the surface layer is black, friable loam about 8 inches thick. The subsurface layer is very dark brown, friable loam about 7 inches thick. The subsoil is very dark brown and dark brown, friable sandy loam about 7 inches thick. The substratum to a depth of about 60 inches is dark brown, brown, and dark yellowish brown, calcareous gravelly loamy sand. In places the subsoil is sandy loam throughout.

Included with this soil in mapping are a few small areas of the well drained Wadena soils that have sand and gravel at a depth of 24 to 32 inches. These soils are in level or slightly concave areas. Also included are small areas of soils on the higher convex slopes that have sand and gravel at a depth of 10 to 15 inches. Some of these soils have a surface layer of gravelly loam or gravelly sandy loam. Included soils make up about 10 percent of the unit.

Permeability is moderately rapid in the upper part of the Estherville soil and very rapid in the substratum. Runoff is slow. Available water capacity is low. The content of organic matter in the surface layer is about 3 to 4 percent. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. A few areas are used for hay or pasture. This soil is suited to corn, soybeans, and small grain. A few areas are irrigated and produce good yields. Good irrigation management is needed for optimum use of water and to maintain an adequate fertility balance. The soil is well suited to grasses and legumes for hay and pasture, but an even distribution of rainfall is needed. Droughtiness is the main limitation. It damages corn and soybeans more frequently than small grain. Soil blowing is a hazard in areas where the surface is not protected by plants or crop residue. A system of conservation tillage that leaves crop residue on the surface conserves moisture and helps to control soil blowing. The root development of most plants is restricted by the sand and gravel at a depth of 15 to 24 inches. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material helps to maintain tilth, improves fertility, helps to prevent surface crusting, and increases the rate of water infiltration.

A cover of pasture plants or hay is effective in controlling erosion. Proper stocking rates and deferred grazing during droughty periods are the main management needs. Because the soil warms rapidly in the spring, the pasture can be grazed early in the season.

The land capability classification is IIIs.

72B—Estherville loam, 2 to 5 percent slopes. This gently sloping, somewhat excessively drained soil is in glacial outwash areas and on stream terraces. Most areas range from about 2 to 25 acres in size and generally are long and narrow.

Typically, the surface layer is black, friable loam about 8 inches thick. The subsurface layer is very dark brown, friable sandy loam about 6 inches thick. The subsoil is very dark brown and dark brown, friable sandy loam about 4 inches thick. The substratum to a depth of about 60 inches is dark brown, brown, and dark yellowish brown, calcareous gravelly loamy sand.

Included with this soil in mapping are small areas of the well drained Wadena soils that have sand and gravel at a depth of 24 to 32 inches. Also included are a few areas of Estherville soils on the steeper slopes. Included areas make up about 10 percent of the unit.

Permeability is moderately rapid in the upper part of the Estherville soil and very rapid in the substratum. Runoff is slow or medium. Available water capacity is low. The content of organic matter in the surface layer is about 3 to 4 percent. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. A few areas are used for hay or pasture. This soil is suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture, but an even distribution of rainfall is needed. If cultivated crops are grown, erosion is a hazard. Soil blowing is a hazard in areas where the surface is not protected by plants or crop residue. Also, droughtiness is a limitation. It damages corn and soybeans more frequently than small grain. A system of conservation tillage that leaves crop residue on the surface helps to control erosion and soil blowing and conserves moisture. In areas where slopes are sufficiently long and wide, contour farming also helps to control erosion. Terraces generally are not constructed on this soil because the cuts would expose the coarse textured, unproductive material in most areas. The root development of most plants is restricted by sand and gravel at a depth of 15 to 24 inches. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material helps to maintain tilth, improves fertility, helps to prevent surface crusting, and increases the rate of water infiltration.

A cover of pasture plants or hay is effective in controlling erosion. Proper stocking rates and deferred grazing during droughty periods are the main management needs. Because the soil warms rapidly in the spring, the pasture can be grazed early in the season.

The land capability classification is IIIe.

73B—Salida gravelly loamy sand, 2 to 5 percent slopes. This gently sloping, excessively drained soil is on upland knolls and stream terraces. Slopes generally are short and convex. Areas range from about 3 to 25 acres in size and are irregularly shaped. Some small rocks and pebbles generally are on the surface.

Typically, the surface layer is black and very dark grayish brown, very friable, calcareous gravelly loamy sand about 8 inches thick. The subsoil is brown and dark yellowish brown, calcareous, very friable gravelly loamy sand about 8 inches thick. The substratum to a depth of about 60 inches is brown, yellowish brown, and dark yellowish brown. The upper part is calcareous very gravelly sand, and the lower part is calcareous very gravelly coarse sand. In places sand and gravel from the substratum have been mixed with the surface layer.

Permeability is very rapid, and runoff is slow. Available water capacity is very low. The content of organic matter in the surface layer is about 1.5 to 2.5 percent. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is poorly suited to corn, soybeans, and small grain. In some years small grain grows well if rainfall is timely and the seeding is completed very early. Crop growth generally is poor, however, because of low fertility and the limited amount of available water. When the soil is tilled, the surface layer dries rapidly. Also, the tilled areas are highly susceptible to soil blowing, which can damage young seedlings. A system of conservation tillage that leaves crop residue on the surface and regular additions of other organic material conserve moisture, improve fertility, and help to control soil blowing.

This soil is better suited to a permanent cover of grasses than to cultivated crops. Some areas are small, however, and are adjacent to soils that are well suited to cultivated crops. As a result, managing some areas separately is difficult. These small areas can be improved so that they provide excellent wildlife habitat. For example, planting warm-season grasses in these areas improves the habitat for wildlife.

The land capability classification is IIIs.

73C2—Salida gravelly loamy sand, 5 to 9 percent slopes, moderately eroded. This moderately sloping, excessively drained soil is on upland knobs and outwash plains. Slopes generally are short and convex. Most areas range from about 2 to 6 acres in size and are irregularly shaped.

Typically, the surface layer is very dark grayish brown, calcareous, very friable gravelly loamy sand about 8 inches thick. It is mixed with streaks and pockets of brown and dark yellowish brown subsoil material. The subsoil is brown and dark yellowish brown, very friable, calcareous gravelly loamy sand about 6 inches thick. The substratum to a depth of about 60 inches is brown, yellowish brown, and dark yellowish brown. The upper part is calcareous very gravelly sand, and the lower part is calcareous very gravelly coarse sand.

Permeability is very rapid, and runoff is slow. Available water capacity is very low. The content of organic matter in the surface layer is about 1 to 2 percent. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated along with adjacent soils that are better suited to row crops. This soil is poorly suited to corn, soybeans, and small grain. When the soil is tilled, the surface layer dries rapidly. Also, the tilled areas are susceptible to soil blowing, which can damage young seedlings. A system of conservation tillage that leaves crop residue on the surface and regular additions of other organic material conserve moisture, improve fertility, and help to control soil blowing. Crop growth generally is poor because of low fertility and the limited amount of available water.

This soil is better suited to a permanent cover of grasses than to cultivated crops. Some areas are small, however, and are adjacent to soils that are well suited to cultivated crops. As a result, managing some areas separately is difficult. A few areas in cultivated fields are left with a cover of grass, and the grass is grazed in the fall along with crop residue. These areas also provide habitat for wildlife. They can be improved by planting adapted warm-season grasses. If the soil is left undisturbed, native bluestem grasses eventually establish themselves in many areas.

The land capability classification is IVs.

73D2—Salida gravelly loamy sand, 9 to 14 percent slopes, moderately eroded. This strongly sloping, excessively drained soil is on the edges of glacial outwash terraces, on stream terraces, and on short upland side slopes adjacent to streams and the larger drainageways. Most areas range from 2 to 8 acres in size and are longer than they are wide.

Typically, the surface layer is very dark grayish brown, calcareous, very friable gravelly loamy sand about 8 inches thick. It is mixed with streaks and pockets of brown and dark yellowish brown subsoil material. The subsoil is brown and dark yellowish brown, calcareous, very friable gravelly loamy sand about 6 inches thick. The substratum to a depth of about 60 inches is brown, yellowish brown, and dark yellowish brown. The upper part is calcareous very gravelly sand, and the lower part is calcareous very gravelly coarse sand.

Permeability is very rapid, and runoff is medium. Available water capacity is very low. The content of organic matter in the surface layer is mainly about 1 to 2 percent, but in severely eroded areas it is less than 1 percent. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated or are used for hay or pasture. This soil is very poorly suited to corn, soybeans, and small grain. Tilling and harvesting hay are difficult, however, because of the small stones and the uneven topography. The soil is best suited to pasture, but an even distribution of rainfall is needed. When the soil is tilled, the surface layer dries rapidly. The tilled areas are highly susceptible to soil blowing. Also, the crops are damaged by drought. Most tillage methods are impractical because of the small stones in the surface layer. Good tilth generally can be easily maintained. In cultivated areas, returning crop residue to the soil or regularly adding other organic material helps to maintain tilth, improves fertility, helps to prevent surface crusting, and increases the rate of water infiltration.

A cover of pasture plants is effective in controlling erosion. Proper stocking rates and deferred grazing during droughty periods are the main management needs. Because the soil warms rapidly in the spring, the pasture can be grazed early in the season. In areas where reseeding is needed, cool-season grasses generally are planted.

The land capability classification is IVe.

73G—Salida gravelly loamy sand, 18 to 40 percent slopes. This very steep, excessively drained soil is on the edges of glacial outwash terraces, on stream terraces, and on upland side slopes adjacent to streams and the larger drainageways. Most areas range from 2 to 15 acres in size and are longer than they are wide.

Typically, the surface layer is black and very dark grayish brown, very friable, calcareous gravelly loamy sand about 6 inches thick. The subsoil is brown and dark yellowish brown, very friable, calcareous gravelly loamy sand about 6 inches thick. The substratum to a depth of about 60 inches is brown, dark yellowish brown, and yellowish brown. The upper part is calcareous very gravelly sand, and the lower part is calcareous gravelly coarse sand.

Included with this soil in mapping are small areas of the calcareous Storden soils that have slopes of 18 to 40 percent. These soils are loamy throughout and are more productive than the Salida soil. They make up less than 5 percent of the unit.

Permeability is very rapid in the Salida soil, and runoff is rapid. Available water capacity is very low. The content of organic matter in the surface layer is mainly about 1.5 to 2.5 percent, but in eroded areas it is less than 1 percent. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are used for pasture, but some areas are used for cultivated crops. This soil is best suited to pasture, but an even distribution of rainfall is needed. The soil is very poorly suited to cultivated crops and hay because of the steep slopes and a severe hazard of erosion. Tilling and harvesting hay are difficult, however, because of small stones and the uneven topography. When the soil is tilled, the surface layer dries rapidly and soil blowing is a serious hazard. Good tilth generally can be easily maintained.

A cover of pasture plants helps to control erosion and soil blowing. Proper stocking rates and deferred grazing during droughty periods are needed. Because the soil warms rapidly in the spring, the pasture can be grazed early in the season. Conventional farm equipment cannot be easily used to control weeds and brush in most areas because of the very steep slopes.

The land capability classification is VIIe.

90—Okoboji mucky silt loam, 0 to 1 percent slopes. This level, very poorly drained soil is in shallow upland depressions or sloughs. It is subject to ponding. Most areas range from 5 to 12 acres in size, but some are as large as 20 acres. Individual areas are circular.

Typically, the surface layer is black, friable mucky silt loam about 18 inches thick. The subsurface layer is black, friable silty clay loam about 18 inches thick. The subsoil to a depth of about 60 inches is mottled, very dark gray, friable silty clay loam. In places the mucky surface layer is about 22 inches thick.

Permeability is moderately slow, and runoff is very slow or ponded. Available water capacity is high. This soil has a seasonal high water table. The content of organic matter in the surface layer is about 12 to 18 percent. The subsoil generally has a very low supply of available phosphorus and a low or very low supply of available potassium.

Most areas are cultivated. If adequately drained, this soil is moderately suited to corn, soybeans, small grain, and grasses. Surface drains remove excess ponded water. Most of the acreage is artificially drained or partly drained and is cultivated. Surface intakes, shallow ditches, and tile drains are used. In places, outlets that are deep enough for adequate functioning of the drains are difficult to find. Many areas are ponded long enough to drown out crops. If the crops are drowned early in the season, the soil can be tilled and replanted. Even where artificial drainage is adequate for good crop growth, tillage is delayed after heavy rains. Because the soil is in low-lying areas and has a high organic matter content, it warms slowly in spring and loses heat rapidly from the surface. As a result, crops are subject to frost damage in late spring and early fall. In areas of this soil that are large enough to be managed separately, the use of early maturing varieties helps to minimize crop losses caused by late planting and early frost. The soil has excellent tilth and can be tilled throughout a wide range in moisture content. The surface layer is less dense and compacted than that in other Okoboji soils, and thus preparation of a desirable seedbed is easier. Plowing in the fall should be avoided in large areas because soil blowing is a hazard if the surface is not protected. Production can be improved in many areas by improving the drainage system. The application rate of some herbicides should be higher than that used for surrounding soils and other Okoboji soils because the organic matter content reduces the effectiveness of the herbicides.

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

The wetness is the main limitation if this soil is used for trees and shrubs grown as windbreaks or ornamental plantings. A drainage system is needed. Species that can withstand wetness should be selected for planting.

The land capability classification is IIIw.

95—Harps clay loam, 1 to 3 percent slopes. This very gently sloping, poorly drained, highly calcareous soil is on rims of upland depressions. When dry, it has a distinctly grayer surface layer than the adjacent soils. Some areas are on slightly convex slopes in the larger areas of Canisteo soils. Individual areas of this soil range from 5 to 15 acres in size and are irregularly shaped.

Typically, the surface layer is black, calcareous, friable clay loam about 8 inches thick. The subsurface layer is black, very dark gray, and dark gray, calcareous, friable clay loam about 13 inches thick. The subsoil is olive gray, calcareous, friable loam about 14 inches thick. The substratum to a depth of about 60 inches is olive gray, calcareous loam. In places very fine sand is below a depth of 30 inches.

Included with this soil in mapping are some small areas of the very poorly drained Okoboji soils in slight depressions. These soils are wetter than the Harps soil and are subject to ponding after periods of rainfall. They make up about 5 percent of the unit.

Permeability is moderate in the Harps soil, and runoff is slow. Available water capacity is high. This soil has a seasonal high water table. The content of organic matter in the surface layer is about 4.5 to 5.5 percent. The subsoil generally has a very low supply of available phosphorus and potassium. The supply of available iron is also seriously low, and some minor elements are likely to be in short supply.

Most areas are cultivated. This soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. If the 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. Tile 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. Excess lime carbonates also affect the response of some herbicides, and the growth of crops can be adversely affected by using herbicides that have a carryover effect on the next year's crop. Some crops, particularly soybeans, show dramatic visual symptoms of iron deficiency in areas of this soil. In years of excessive rainfall, crops may be damaged by water that ponds on the adjacent Palms and Okoboji soils. Excessive tillage destroys the weak soil structure. As a result, the soil is subject to soil blowing when the surface dries if the soil is not protected. A system of conservation tillage that leaves crop residue on the surface and regular additions of other organic material improve soil structure and help to control soil blowing.

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

The seasonal high water table and the excess lime are the main limitations if this soil is used for trees and shrubs grown as windbreaks or ornamental plantings. Only the species that can withstand wet, calcareous conditions should be selected for planting.

The land capability classification is IIw.

107—Webster silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on the undulating till plain in concave upland swales and draws. Individual areas range from 5 to 30 acres in size and are irregularly shaped.

Typically, the surface layer is black, friable silty clay loam about 8 inches thick. The subsurface layer is black, friable silty clay loam and clay loam about 15 inches thick. The subsoil is friable clay loam about 18 inches thick. The upper part is mottled dark gray and olive gray, the next part is olive gray, and the lower part is mottled olive gray and gray. The substratum to a depth of about 60 inches is olive gray and gray, mottled, calcareous clay loam. In some places, the subsoil is thinner and the depth to lime is much shallower. In other places the surface layer is clay loam.

Included with this soil in mapping are some small areas of the very poorly drained Okoboji soils. These soils are in small depressions. They are wetter than the Webster soil and are subject to ponding after periods of rainfall. Also included are a few small areas of Harps soils. These soils are calcareous throughout and are distinctly lighter in color when dry than the Webster soil. Included soils make up less than 10 percent of the unit.

Permeability is moderate in the Webster soil, and runoff is slow. Available water capacity is high. This soil has a seasonal high water table. The content of organic matter in the surface layer is about 6 to 7 percent. The subsoil generally has a very low or low supply of available phosphorus and potassium.

Most areas are cultivated. A few small undrained areas are used as pasture. If adequately drained, this soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Drainage is essential for optimum crop production. Drainage can be improved by installing tile. Tile drains function well in areas of this soil. If the soil is plowed when wet, the surface layer puddles easily and becomes cloddy and hard to work when it dries. If large areas are plowed in the fall, soil blowing is a hazard

Figure 11.—A grassed waterway in an area of Webster silty clay loam, 0 to 2 percent slopes. Clarion loam, 2 to 5 percent slopes, is on the adjacent slopes.

unless the surface is protected by plant cover. A system of conservation tillage that leaves crop residue on the surface helps to prevent soil blowing. In some concave areas, runoff water from the steeper adjacent soils concentrates on this soil and causes crop damage, erosion, and siltation. Terraces, contour farming, conservation tillage, or a combination of these practices on adjacent soils and grassed waterways in areas where runoff water concentrates help to prevent this damage (fig. 11). Returning crop residue to the soil or regularly adding other organic material helps to control soil blowing, minimizes surface crusting, and increases the rate of water infiltration.

Most areas of this soil that are not drained sufficiently for row crops are used as pasture. Overgrazing or grazing when the soil is too wet causes surface compaction and poor tilth and reduces the rate of water infiltration. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

The wetness is the main limitation if this soil is used for trees and shrubs grown as windbreaks or ornamental plantings. A drainage system is needed. Species that can withstand wetness should be selected for planting.

The land capability classification is 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 in glacial outwash areas and on stream terraces. Individual areas range from about 5 to 20 acres in size and are irregularly shaped.

Typically, the surface layer is very dark brown and black, friable loam about 8 inches thick. The subsurface layer is very dark brown, friable loam about 6 inches thick. The subsoil is about 16 inches thick. The upper part is dark brown, friable loam; the next part is brown, friable loam; and the lower part is brown, loose gravelly loamy sand. The substratum to a depth of about 60 inches is brown and dark yellowish brown, calcareous gravelly sand.

Included with this soil in mapping are small areas of Wadena soils that are 32 to 40 inches deep to sand and gravel. These soils are less droughty than the major Wadena soil. They make up about 10 percent of the map unit.

Permeability is moderate in the upper part of the Wadena soil and very rapid in the lower part. Runoff is medium. Available water capacity is moderate. The content of organic matter in the surface layer is about 3.5 to 4.5 percent. The subsoil generally has a very low or low supply of available phosphorus and potassium.

This soil warms quickly in the spring and can be worked soon after rains.

Most areas are cultivated. This soil is moderately suited to corn, soybeans, and small grain 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 grain and legumes for hay and pasture generally grow better than row crops. A system of conservation tillage that leaves crop residue on the surface slows drying and conserves moisture. Good tilth generally can be easily maintained.

Using this soil for pasture or hay is effective in controlling soil blowing. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture in good condition.

If this soil is used for trees and shrubs grown as windbreaks, ornamental plantings, or plantings for wildlife, the limited available water capacity is a concern. Also, erosion is a slight hazard before the trees and shrubs are established. Only the species that can grow well in conditions of low soil moisture should be selected for planting. Maintaining a permanent plant cover helps to control erosion.

The land capability classification is IIs.

133—Colo silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is at the lower elevations on the flood plain. It is occasionally flooded for very brief to long periods unless it is protected. Areas range mainly from 5 to 100 acres in size, but some are as large as 300 acres. Individual areas are irregularly shaped.

Typically, the surface layer is black, firm silty clay loam about 7 inches thick. The subsurface layer is firm silty clay loam about 52 inches thick. The upper part is black, and the lower part is dark gray. The substratum to a depth of about 60 inches is mottled very dark gray, dark gray, and olive gray clay loam. In some places the substratum is calcareous. In other places the surface layer is overlain by about 12 inches of recently deposited silt loam.

Included with this soil in mapping are small areas of well drained or moderately well drained soils. These soils are slightly higher on the landscape than the Colo soil. Also, they can be tilled more easily and dry out more rapidly after rains. They make up less than 10 percent of the unit.

Permeability is moderate in the Colo soil, and runoff is slow. Available water capacity is high. This soil has a seasonal high water table. The content of organic matter in the surface layer is about 5 to 7 percent. The subsurface layer generally has a medium supply of available phosphorus and a very low to medium supply of available potassium.

Some areas are cultivated. This soil is suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. A drainage system is needed to reduce the wetness and provide good aeration and a deep root zone for plants. Tile drains work well if they are properly installed and if an adequate outlet is available. Tilth generally is fair in the surface layer. Returning crop residue to the soil or regularly adding other organic material and deferring tillage when the soil is wet improve tilth and fertility, help to prevent surface crusting, and increase the rate of water infiltration.

Some areas are used for pasture because they are low lying and cannot be adequately drained for dependable crop production. If this soil is used for pasture, overgrazing or grazing during wet periods causes surface compaction and poor tilth and reduces forage production.

The land capability classification is IIw.

135—Coland clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is mostly on the flood plains or former flood plains along streams throughout the county. It is subject to occasional flooding for brief periods. In a few places water is ponded for short periods in shallow former meander channels during early spring and periods of high rainfall. In most places the channels have been straightened and deepened for drainage outlets. In some areas the old meander channel is somewhat lower than the surrounding soil. Areas of this soil range mainly from 15 to 35 acres in size, but a few areas are as large as about 80 acres. Most areas are long and narrow and generally parallel both sides of the stream. A few areas along the larger streams are irregularly shaped.

Typically, the surface layer is black, friable clay loam about 9 inches thick. The subsurface layer is friable clay loam about 52 inches thick. The upper part is black, and the lower part is very dark gray and is mottled. The substratum to a depth of about 60 inches is dark gray clay loam and is mottled.

Included with this soil in mapping are areas of soils that are calcareous throughout. These soils commonly are intermingled with areas of the Coland soil and thus are in similar positions on the landscape. Most of the included areas are adjacent to old meander channels. Many have loam at a depth of about 30 inches. These included soils make up about 10 percent of the unit. Also included are areas of soils that have contrasting sand and gravel between depths of 36 and 46 inches. These soils are in the same positions on the landscape as the Coland soil. They have a somewhat lower available water capacity than the Coland soil. They make up about 5 percent of the unit.

Permeability is moderate in the Coland soil, and runoff is slow. Available water capacity is high. This soil has a seasonal high water table. The content of organic matter in the surface layer is about 5 to 7 percent. The substratum generally has a low supply of available phosphorus and potassium.

Most areas are cultivated. Some areas near farmsteads are used for permanent pasture, mostly bluegrass. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture if it is adequately drained and if flooding is controlled. Special care generally is needed to maintain good tilth in the surface layer. Chisel plowing increases the infiltration rate by making the surface more pervious to water. Cultivating when the soil is too wet causes surface compaction and cloddiness. Because stream channels have been straightened and deepened for tile outlets in most places, flooding generally is no longer a problem, except in a few places. However, adequate drainage by tile is needed for optimum crop production. Tile drains function well, and good outlets are readily available. Returning crop residue to the soil or regularly adding other organic material helps to control soil blowing and prevent surface crusting and increases the infiltration rate. Water-tolerant grasses and legumes are the best pasture plants.

If this soil is used for pasture or hay, proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

The seasonal high water table and the flooding are the main concerns if this soil is used for trees and shrubs grown as windbreaks or ornamental plantings. Only the species that can withstand the wetness and the flooding should be selected for planting.

The land capability classification is 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. Areas range mainly from 10 to 25 acres in size, but a few areas range from 4 to 40 acres in size and are irregularly shaped.

Typically, the surface layer is black, friable loam about 8 inches thick. The subsurface layer is friable loam about 11 inches thick. The upper part is very dark brown, and the lower part is very dark brown and dark brown. The subsoil is friable loam about 23 inches thick. The upper part is brown, the next part is dark yellowish brown and yellowish brown, and the lower part is mottled dark yellowish brown and olive brown and is calcareous. The substratum to a depth of about 60 inches is light olive brown, calcareous loam. It is mottled. In a few places the surface layer is less than 7 inches thick and is mixed with dark brown subsoil material.

Included with this soil in mapping are a few small areas of Dickman, Salida, and Storden soils. These soils are commonly on the highest, most convex parts of the slope. They are about 1 acre or less in size. They have a lower content of organic matter than the Clarion soil and are less fertile. Dickman and Salida soils have more sand throughout than the Clarion soil and are droughty. Gravel in the surface layer of the Salida soils may hinder tillage. Included soils make up about 5 percent of the unit.

Permeability is moderate in the Clarion soil, and runoff is medium. Available water capacity is high. The content of organic matter in the surface layer is about 3 to 4 percent. The subsoil generally has a very low or low supply of available phosphorus and a very low supply of available potassium.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. If cultivated crops are grown, erosion is a hazard. A system of conservation tillage that leaves crop residue on the surface, terraces, and contour farming help to prevent excessive soil loss. Contour farming and terraces are practical in most areas but are not feasible in undulating areas where slopes are short. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to control erosion, helps to prevent surface crusting, maintains good tilth, and increases the rate of water infiltration.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing, however, causes surface compaction, increases the runoff rate, results in poor tilth, and reduces production. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture in good condition.

If this soil is used for trees and shrubs grown as windbreaks or ornamental plantings, erosion is a slight hazard before the trees and shrubs are established. It can be controlled, however, by a permanent plant cover or surface mulch.

The land capability classification is IIe.

138C—Clarion loam, 5 to 9 percent slopes. This moderately sloping, well drained soil is on knolls and convex side slopes. Slopes generally are short. Areas range from 2 to 15 acres in size and are irregularly shaped.

Typically, the surface layer is black, friable loam about 10 inches thick. The subsurface layer is about 8 inches thick. It is very dark brown and dark brown, friable loam. The subsoil is friable loam about 20 inches thick. The upper part is brown, the next part is dark yellowish brown and yellowish brown, and the lower part is mottled yellowish brown and olive brown. The substratum to a depth of about 60 inches is light olive brown, calcareous loam. It is mottled. In a few places the surface layer is less than 7 inches thick and is mixed with brown subsoil material.

Permeability is moderate, and runoff is medium. Available water capacity is high. The content of organic matter in the surface layer is about 3 to 4 percent. The subsoil generally has a very low or low supply of available phosphorus and potassium.

Most areas are used for pasture or farmsteads. A few areas are cultivated. This soil is moderately well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. If cultivated crops are grown, erosion is a hazard. A system of conservation tillage that leaves crop residue on the surface, winter cover crops, and grassed waterways help to prevent excessive soil loss. Contour farming and terraces are practical in some areas but are not feasible in undulating areas where slopes are short. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material improves fertility and helps to maintain good tilth.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increases the runoff rate, and results in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

This soil is well suited to trees and shrubs grown as windbreaks and ornamental plantings and in wildlife areas. Seedlings survive and grow well if competing vegetation is controlled or removed. Erosion is a hazard. Site preparation that disturbs the soil increases the hazard of erosion. Limited site preparation, the use of herbicides, and the use of mulch help to control runoff and erosion.

The land capability classification is IIIe.

138C2—Clarion loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, well drained soil is on knolls and convex side slopes. Slopes typically are short and irregular. Areas range from 2 to 20 acres in size and are irregularly shaped.

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

Included with this soil in mapping are a few small areas of Dickman, Salida, and Storden soils. These soils are less fertile than the Clarion soil and have a lower content of organic matter. They are mainly on the steepest parts of slopes. Dickman and Salida soils are droughty and are less productive than the Clarion soil. Included soils make up less than 5 percent of the unit.

Permeability is moderate in the Clarion soil, and runoff is moderately rapid. Available water capacity is high. The content of organic matter in the surface layer is about 2.2 to 3.2 percent. The subsoil generally has a very low or low supply of available phosphorus and a very low supply of available potassium.

Most areas are cultivated. This soil is moderately well suited to corn, soybeans, and small grain and is well suited to grasses and legumes for hay or pasture. If cultivated crops are grown, further erosion is a hazard. A system of conservation tillage that leaves crop residue on the surface helps to prevent excessive soil loss, and grassed waterways help to prevent gully erosion. Contour farming and terraces are practical in some areas but are not feasible in undulating areas where slopes are short (fig. 12). Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to prevent crusting, and increases the rate of water infiltration. Generally, more nutrients are needed to maintain high yields and to maintain or improve soil tilth on this soil than on Clarion soils that are less eroded.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, results in surface compaction, increases the runoff rate, and results in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

This soil is well suited to trees and shrubs grown as ornamental plantings or in wildlife areas. Seedlings survive and grow well if competing vegetation is controlled or removed. Erosion is a hazard if site preparation disturbs the soil. Limiting site preparation, using herbicides, and providing a cover of mulch are effective in reducing runoff and erosion.

The land capability classification is IIIe.

138D—Clarion loam, 9 to 14 percent slopes. This strongly sloping, well drained soil is on upland ridges

Figure 12.—Parallel terraces that have a grassed back slope and tile intakes help to control runoff and erosion in an area of Clarion loam, 5 to 9 percent slopes, moderately eroded. Using hay crops in a rotation also helps to control erosion.

and side slopes. Slopes generally are short. Areas range from 2 to 7 acres in size and are irregularly shaped.

Typically, the surface layer is black, friable loam about 8 inches thick. The subsurface layer is very dark brown and dark brown, friable loam about 6 inches thick. The subsoil is friable loam about 16 inches thick. The upper part is brown, the next part is dark yellowish brown and yellowish brown, and the lower part is mottled dark yellowish brown and olive brown and is calcareous. The substratum to a depth of about 60 inches is light olive brown, calcareous loam. It is mottled.

Included with this soil in mapping are small areas of the calcareous Storden soils on the more sharply convex parts of the slope. These soils make up less than 10 percent of the unit.

Permeability is moderate in the Clarion soil, and runoff is rapid. Available water capacity is high. The content of organic matter in the surface layer is about 3 to 4 percent. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are used for hay and pasture. Some areas are adjacent to farmsteads, and a few have been cultivated for a few years. This soil is suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. If cultivated crops are grown, erosion is a hazard. A system of conservation tillage that leaves crop residue on the surface helps to control erosion and soil blowing. In areas that are continuously row cropped, however, these practices may not be adequate. Contour farming and terraces are practical in some areas but are not feasible in undulating areas where slopes are short and irregular. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material helps to maintain fertility and tilth.

Most areas of this soil are adjacent to soils that are used as pasture. Pasture is generally the most practical use of this soil. A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and deterioration of tilth and increases the runoff rate. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

This soil is well suited to trees and shrubs grown as windbreaks and ornamental plantings and in wildlife areas. Seedlings survive and grow well if competing vegetation is controlled or removed. Erosion is a hazard. Site preparation that disturbs the soil increases the hazard of erosion. Limiting site preparation, using herbicides, and providing a cover of mulch help to control runoff and erosion.

The land capability classification is IIIe.

138D2—Clarion loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping, well drained soil is on knolls and convex side slopes. Slopes generally are short. Areas range from 3 to 25 acres in size and are irregularly shaped.

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

Included with this soil in mapping are a few small areas of Dickman, Salida, and Storden soils. These soils are less fertile than the Clarion soil and have a lower content of organic matter. Dickman and Salida soils are on the highest parts of slopes, and Storden soils are mainly on the steepest parts of slopes. Also included are the severely eroded Clarion soils, which generally are in scattered areas. These soils have a low content of organic matter. More intensive management is needed to maintain fertility on these soils than on the less eroded Clarion soils. Included soils make up about 15 percent of the unit.

Permeability is moderate in the Clarion soil, and runoff is rapid. Available water capacity is high. The content of organic matter in the surface layer is about 2.2 to 3.2 percent. The subsoil generally has a very low or low supply of available phosphorus and a very low supply of available potassium.

Most areas are cultivated. This soil is moderately well suited to corn, soybeans, and small grain and is well suited to grasses and legumes for hay and pasture. If cultivated crops are grown, further erosion is a hazard. Grassed waterways and a system of conservation tillage that leaves crop residue on the surface help to prevent excessive soil loss. Contour farming and terraces are practical in some areas but are not feasible in areas where slopes are short. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to prevent crusting, and increases the rate of water infiltration. Generally, more nutrients are needed to maintain high yields and to maintain or improve soil tilth on this soil than on Clarion soils that are less eroded.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increases the runoff rate, and results in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

This soil is suited to trees and shrubs grown as windbreaks and ornamental plantings and in wildlife areas. Seedlings survive and grow well if competing vegetation is controlled or removed. Erosion is a severe hazard if large areas are disturbed during site preparation. Limiting site preparation, using herbicides, and providing a cover of mulch help to control runoff and erosion.

The land capability classification is IIIe.

221—Palms muck, 0 to 1 percent slopes. This level, very poorly drained soil generally is in upland depressions that formerly contained water much of the time. Some areas are in lakebeds that have been drained. The soil is subject to ponding. Areas range mainly from 8 to 30 acres in size, but a few range to about 50 acres. Individual areas are circular or irregularly shaped.

Typically, the surface layer is black muck about 8 inches thick. The subsurface layer is about 21 inches thick. The upper part is black, friable muck. The lower part is black, friable mucky silty clay loam. The substratum to a depth of about 60 inches is silty clay loam. The upper part is very dark gray and is mottled. The lower part is mottled gray and olive gray. In places thin layers of undecomposed organic material are below a depth of about 2 feet. In areas where steep slopes surround this soil, 10 to 20 inches of loamy overwash covers the outer part.

Permeability is moderately rapid in the upper part and moderate in the substratum. Runoff is very slow. Available water capacity is very high. This soil has a seasonal high water table. The content of organic matter in the surface layer is more than 20 percent. The substratum generally has a low supply of available phosphorus and a very low supply of available potassium. In places the supply of trace elements may be inadequate for some crops.

Most areas are artificially drained and are used for cultivated crops. This soil is moderately suited to cultivated crops if drainage is adequate. Surface intakes and shallow ditches are used in addition to tile drains. In some places, finding outlets deep enough for adequate functioning of the drains is difficult. Runoff from adjacent slopes readily ponds in areas of this soil, and during periods of excessive rainfall the crops may be damaged or destroyed before tile can remove the excess water. If this crop damage occurs early in the season, the land can be tilled and replanted. The soil warms slowly in spring, and planting is often delayed. Because the soil is in low-lying areas and loses heat rapidly from the surface, frost can injure crops in late spring and early fall. The use of early maturing varieties helps to prevent losses caused by late planting and early frost. Cultivated crops grow fairly well if the soil is adequately drained and fertilized and is otherwise well managed. Tilth is excellent, and the soil can be tilled throughout a wide range in moisture content. Plowing in the fall can increase the hazard of soil blowing if the soil is dry and is not protected. Controlling grass and weeds can be difficult. The application rates of some herbicides should be increased because the high content of organic matter limits the effectiveness of the herbicide. Small grain tends to lodge and thus produces grain of poor quality. Legumes for hay do not grow well in areas of this soil. Winterkill is common.

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

This soil is poorly suited to trees because of the seasonal high water table. The soil remains wet for long periods after rainfall. Special equipment commonly is needed. Operating this equipment is difficult, however, because of the spongy surface layer. A drainage system is needed to reduce the seedling mortality rate.

The land capability classification is IIIw.

224—Linder loam, 24 to 32 inches to sand and gravel, 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 terraces. Individual areas range from about 3 to 20 acres in size and are irregularly shaped.

Typically, the surface layer is black, friable loam about 8 inches thick. The subsurface layer is about 8 inches thick. The upper part is black, friable loam, and the lower part is very dark brown and very dark grayish brown, friable sandy loam. The subsoil is dark grayish brown, friable sandy loam about 11 inches thick. It is mottled in the lower part. The substratum to a depth of about 60 inches is grayish brown, calcareous gravelly sand. It is mottled.

Included with this soil in mapping are a few small areas of Estherville soils. These soils are somewhat excessively drained or well drained and are on the higher parts of convex ridges. They make up less than 5 percent of the unit.

Permeability is moderately rapid in the solum of the Linder soil and very rapid in the substratum. Runoff is slow. This soil has a seasonal high water table. Available water capacity is low. The content of organic matter in the surface layer is about 3.5 to 4.5 percent. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. It is better suited to small grain, grasses, and legumes than to cultivated crops because the available water capacity is not sufficient during parts of most growing seasons for the optimum production of corn and soybeans. Water erosion generally is not a problem on this soil, but soil blowing is a hazard because the surface dries quickly. Blowing sand may damage young plants in some years. A system of conservation tillage that leaves crop residue on the surface helps to prevent excessive soil blowing.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet causes surface compaction, increases the runoff rate, and results in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

The land capability classification is IIs.

236B—Lester loam, 2 to 5 percent slopes. This gently sloping, well drained soil is on ridgetops and convex side slopes. Slopes typically are short. Areas range from 3 to 30 acres in size and are irregularly shaped.

Typically, the surface layer is very dark grayish brown, friable loam about 7 inches thick. The subsurface layer is dark grayish brown, friable loam about 5 inches thick. The subsoil is about 35 inches thick. The upper part is brown, dark grayish brown, and dark yellowish brown, friable loam and clay loam. The next part is dark yellowish brown and yellowish brown, firm clay loam. The lower part is yellowish brown, friable clay loam. The substratum to a depth of about 60 inches is light olive brown, calcareous loam.

Permeability is moderate, and runoff is medium. Available water capacity is high. The content of organic matter in the surface layer is about 2.5 to 3.5 percent. The subsoil generally has a low supply of available phosphorus and a very low supply of available potassium.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. If cultivated crops are grown, erosion is a hazard. Grassed waterways and a system of conservation tillage that leaves crop residue on the surface help to prevent excessive soil loss. Tilth generally is fair in the surface layer. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to prevent crusting, and increases the rate of water infiltration.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet causes surface compaction, increases the runoff rate, and results in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

This soil is well suited to trees. A few areas support native hardwoods and grasses. These areas provide excellent habitat for various kinds of wildlife and are popular as homesites. Some areas are grazed by domestic livestock. This grazing can damage young seedlings and reduce the value for wildlife habitat. In a few places, competing grass vegetation limits the growth and survival of tree seedlings. If grazing is controlled and if competing vegetation is removed or controlled, seedlings survive and grow well. Erosion control is needed during site preparation.

The land capability classification is IIe.

236C—Lester loam, 5 to 9 percent slopes. This moderately sloping, well drained soil is on ridgetops and convex side slopes. Slopes typically are short. Areas range from 3 to 10 acres in size and are irregularly shaped.

Typically, the surface layer is very dark grayish brown, friable loam about 6 inches thick. The subsurface layer is dark grayish brown, friable silt loam about 4 inches thick. The subsoil is about 33 inches thick. The upper part is brown, dark grayish brown, and dark yellowish brown, friable loam and clay loam. The next part is dark yellowish brown and yellowish brown, firm clay loam. The lower part is yellowish brown, friable clay loam. The substratum to a depth of about 60 inches is light olive brown, calcareous loam. In places the surface layer is thinner.

Permeability is moderate, and runoff is medium. Available water capacity is high. The content of organic matter in the surface layer is about 2.5 to 3.5 percent. The subsoil generally has a low supply of available phosphorus and a very low supply of available potassium.

Most areas are used as wooded pasture. Some areas are cultivated. This soil is moderately well suited to corn, soybeans, and small grain and is well suited to grasses and legumes for hay and pasture. If cultivated crops are grown, erosion is a hazard. Grassed waterways and a system of conservation tillage that leaves crop residue on the surface help to prevent excessive soil loss. Contour farming and terraces are practical in most areas but are not feasible in undulating areas where slopes are short. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to prevent crusting, and increases the rate of water infiltration.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet causes surface compaction, increases the runoff rate, and results in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

This soil is well suited to trees. Many areas support native hardwoods and grasses. These areas provide excellent habitat for various kinds of wildlife and are popular as homesites. Some areas are grazed by domestic livestock. This grazing can damage young seedlings and reduce the value for wildlife habitat. In a few places, competing grass vegetation limits the growth and survival of tree seedlings. If grazing is controlled and if competing vegetation is removed or controlled, seedlings survive and grow well. Erosion control is needed during site preparation.

The land capability classification is IIIe.

236D—Lester loam, 9 to 14 percent slopes. This strongly sloping, well drained soil is on convex side slopes. Areas range from 8 to 20 acres in size and are irregularly shaped.

Typically, the surface layer is very dark grayish brown, friable loam about 5 inches thick. The subsurface layer is dark grayish brown, friable loam about 3 inches thick. The subsoil is about 30 inches thick. The upper part is dark yellowish brown, friable clay loam; the next part is dark yellowish brown and yellowish brown, firm clay loam; and the lower part is yellowish brown, friable clay loam. The substratum to a depth of about 60 inches is light olive brown, calcareous loam. In a few eroded areas, the surface layer is mainly mixed yellowish brown and dark yellowish brown and the calcareous substratum is at a shallower depth.

Included with this soil in mapping are a few small areas of the well drained Storden soils and areas of somewhat poorly drained soils. The somewhat poorly drained soils are in small, natural, concave drainageways that extend into the uplands. Storden soils are on the steep, most convex part of the slope. Included soils make up less than 5 percent of the unit.

Permeability is moderate in the Lester soil, and runoff is rapid. Available water capacity is high. The content of organic matter in the surface layer is about 2.5 to 3.5 percent. The subsoil generally has a low supply of available phosphorus and a very low supply of available potassium.

Most areas are cultivated. This soil is poorly suited to corn, soybeans, and small grain but is well suited to grasses and legumes for hay and pasture. If cultivated crops are grown, further erosion is a hazard. Grassed waterways and a system of conservation tillage that leaves crop residue on the surface help to prevent excessive soil loss. Contour farming and terraces are practical in most areas but are not feasible in undulating areas where slopes are short. In severely eroded areas, preparing a good seedbed is difficult because the clay loam subsoil, which has a low content of organic matter, is exposed. Tilth generally is fair in the surface layer. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to prevent crusting, and increases the rate of water infiltration.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet causes surface compaction, increases the runoff rate, and results in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

This soil is well suited to trees. A few areas support native hardwoods and grass. These areas provide excellent habitat for various kinds of wildlife. Some areas are around building sites, and other areas are grazed by domestic livestock. This grazing can damage young seedlings and reduce the value for wildlife habitat. In a few places competing grass vegetation limits the growth and survival of tree seedlings. If grazing is controlled and if competing vegetation is removed or controlled, seedlings survive and grow well. Erosion control is needed during site preparation. Limiting site preparation and using mulch cover help to control erosion.

The land capability classification is IIIe.

236F—Lester loam, 18 to 25 percent slopes. This steep, well drained soil is on convex side slopes in the uplands. Slopes typically are short. Areas range from 15 to 20 acres in size and are irregularly shaped or elongated.

Typically, the surface layer is very dark grayish brown, friable loam about 4 inches thick. The subsurface layer is dark grayish brown, friable loam about 3 inches thick. The subsoil is about 26 inches thick. The upper part is dark yellowish brown, friable clay loam; the next part is dark yellowish brown and yellowish brown, firm clay loam; and the lower part is yellowish brown, friable clay loam. The substratum to a depth of about 60 inches is light olive brown, calcareous loam. In some places erosion has exposed the yellowish brown subsoil. In other places slopes are not so steep.

Included with this soil in mapping are a few small areas of the well drained Storden soils. These soils are on the steepest, most convex part of the slope. They are calcareous. They make up about 10 percent of the unit.

Permeability is moderate in the Lester soil, and runoff is very rapid. Available water capacity generally is high. The content of organic matter in the surface layer is about 2.5 to 3.5 percent. The subsoil generally has a low supply of available phosphorus and a very low supply of available potassium.

Nearly all areas of this soil support timber or mixed timber and grass. This soil is best suited to woodland. The hazard of erosion and low fertility are the main management concerns. The available water capacity is frequently low because of the very rapid runoff rate. Management that maintains an adequate vegetative cover helps to prevent excessive soil losses and improves the water-supplying capacity by reducing the runoff rate and the rate of drying. Except for trees, the growth of most kinds of vegetation generally is poor. Total production is low.

If this soil is used for grazing, proper stocking rates, timely deferment of grazing, and pasture rotation are needed to maintain desirable plant species and to keep the pasture in good condition.

Grazing can damage trees and tree seedlings and reduce the value of this soil for timber and as habitat for wildlife. If grazing is controlled, new seedlings survive and grow well. Erosion control is needed during site preparation. Limiting site preparation and providing mulch cover help to control erosion. Slopes are so steep in some areas that the use of equipment is hazardous.

This soil is well suited to wildlife habitat because most areas are left in their natural state.

The land capability classification is VIe.

236G—Lester loam, 25 to 40 percent slopes. This very steep, well drained soil is on convex side slopes in the uplands. Slopes typically are short. Areas range from 15 to 20 acres in size and are irregularly shaped or elongated.

Typically, the surface layer is very dark grayish brown, friable loam about 3 inches thick. The subsurface layer is dark grayish brown, friable loam about 3 inches thick. The subsoil is about 22 inches thick. The upper part is dark yellowish brown and yellowish brown, friable clay loam, and the lower part is yellowish brown, friable, calcareous loam. The substratum to a depth of about 60 inches is light olive brown, calcareous loam. In a few places erosion has exposed the yellowish brown subsoil. In most areas the surface layer is somewhat thicker on the lower part of the slope.

Included with this soil in mapping are a few small areas of the well drained Storden soils. These soils are on the steepest, most convex part of the slope. They are calcareous. They make up about 10 percent of the unit.

Permeability is moderate in the Lester soil, and runoff is very rapid. Available water capacity is high. The content of organic matter in the surface layer is about 2.5 to 3.5 percent. The subsoil generally has a low supply of available phosphorus and a very low supply of available potassium.

Nearly all areas of this soil support timber or mixed timber and grass. This soil is best suited to woodland. The hazard of erosion and low fertility are the main management concerns. The available water capacity is frequently low because of the very rapid runoff rate. Management that maintains an adequate vegetative cover helps to prevent excessive soil losses and improves the water-supplying capacity by reducing the runoff rate and the rate of drying. Except for trees, the growth of most kinds of vegetation generally is poor. Total production is low.

If this soil is used for grazing, proper stocking rates, timely deferment of grazing, and pasture rotation are needed to help maintain desirable plant species and to keep the pasture in good condition.

Grazing can damage trees and tree seedlings and reduce the value of this soil for timber and as habitat for wildlife. If grazing is controlled, new seedlings survive and grow well. Erosion control is needed during site preparation. Limiting site preparation and providing mulch cover help to control erosion. In some areas the use of equipment is extremely hazardous because of the slope.

This soil is well suited to wildlife habitat because most areas are left in their natural state.

The land capability classification is VIIe.

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 stream terraces. It formed in loamy glacial outwash and is underlain by calcareous sand and gravel. Slopes are nearly level to slightly convex. Areas generally range from 4 to 20 acres in size and are irregularly shaped.

Typically, the surface layer is black, friable clay loam about 8 inches thick. The subsurface layer is black and very dark gray, friable clay loam about 11 inches thick. The subsoil is about 19 inches thick. The upper part is mottled olive gray and dark gray, friable loam; the next part is olive gray and olive, friable loam; and the lower part is olive gray, very friable sandy loam. The substratum to a depth of about 60 inches is olive gray, calcareous gravelly loamy sand. In some areas the depth to sand and gravel is more than 40 inches. In these areas the dark surface layer commonly is somewhat more than 24 inches thick. In some places the subsoil is sandy loam. In other places the substratum is fine and medium sand.

Permeability is moderate in the solum and rapid in the lower part of the substratum. Runoff is slow. Available water capacity is moderate. This soil has a seasonal high water table. The content of organic matter in the surface layer is about 5.5 to 6.5 percent. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. If adequately drained, this soil is moderately well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. It is seasonally wet but also is slightly droughty during some periods because of the gravelly substratum. Tile drains remove excess water. In some years, however, the drainage system removes the water that the crop needs later in the growing season. Tile drains function well, but installation is difficult because of the instability of the substratum. The soil is subject to soil blowing, especially if it is plowed in the fall and the surface is left bare. A system of conservation tillage that leaves crop residue on the surface helps to prevent soil blowing and conserves moisture. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material improves fertility, conserves moisture, and helps to control soil blowing.

If this soil is used as pasture, proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to maintain desirable plant species and help to keep the pasture in good condition.

Figure 13.—This marsh in an area of Aquolls, ponded, provides good natural habitat for waterfowl and other wetland wildlife.

The seasonal high water table is the main limitation if this soil is used for trees and shrubs grown as windbreaks or ornamental plantings, but the droughtiness also is a limitation in some years. Almost any species suited to the climate can be grown if a drainage system is installed and if irrigation water is applied as needed.

The land capability classification is IIw.

354—Aquolls, ponded. These very poorly drained soils are in depressional areas on flood plains and low terraces adjacent to major streams and rivers and in shallow depressional areas on uplands. They are subject to ponding because of runoff from adjacent areas. Areas of these soils typically range from 5 to 40 acres in size and are irregularly shaped. A few larger areas surround shallow water areas that are managed as marshes.

Typically, the surface layer is black silty clay loam or clay loam about 10 inches thick. The subsurface layer is black, very dark gray, or dark gray silty clay loam, clay loam, loam, or sandy loam about 30 inches thick. The substratum to a depth of about 60 inches is very dark gray, dark gray, or gray silty clay loam, clay loam, loam, sandy loam, or loamy sand.

Permeability varies but generally is moderately slow to very slow. Available water capacity generally is moderate or high. In most areas, either small ponds are evident or the water table is at or near the surface throughout the year. The content of organic matter in the surface layer ranges from about 10 to more than 20 percent.

Most areas are idle or are used as wildlife habitat (fig. 13). These soils generally are suited to wetland wildlife habitat. They are unsuited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Providing adequate drainage is very difficult because suitable outlets are not available.

The land capability classification is VIIw.

384—Collinwood silty clay loam, 0 to 2 percent slopes. This nearly level, somewhat poorly drained soil is on plane or slightly convex slopes in the uplands. Most areas range from 5 to 30 acres in size and are irregularly shaped.

Typically, the surface layer is black, friable silty clay loam about 8 inches thick. The subsurface layer is black and very dark grayish brown, firm silty clay loam about 15 inches thick. The subsoil is dark grayish brown, firm silty clay about 16 inches thick. The substratum to a depth of about 60 inches is mottled dark grayish brown, grayish brown, and olive gray silty clay loam.

Included with this soil in mapping are a few small areas of the poorly drained Waldorf soils in the lower lying swales and in slight depressions. These areas can delay fieldwork unless they are drained. They make up less than 5 percent of the unit.

Permeability is slow in the Collinwood soil, and runoff also is slow. Available water capacity is high. This soil has a seasonal high water table. The shrink-swell potential is high. The content of organic matter in the surface layer is about 5 to 6 percent. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Because of the seasonal high water table, most areas are drained. Drainage improves the timeliness of fieldwork. Tile drains do not always function well. They should be more closely spaced than in areas of soils that have less clay in the subsoil. Soil blowing is a hazard in areas where the surface is not protected by plants or crop residue. It can be controlled, however, by a system of conservation tillage that leaves crop residue on the surface. Maintaining good tilth in the surface layer typically requires special care. Returning crop residue to the soil or regularly adding other organic material improves fertility and tilth, helps to prevent surface crusting, and increases the rate of water infiltration.

A cover of pasture plants or hay is effective in controlling soil blowing. Overgrazing or grazing when the soil is too wet causes surface compaction, reduces the rate of water infiltration, and increases the runoff rate. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

The land capability classification is IIw.

390—Waldorf silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on the concave tops of hummocks and in adjacent swales on moraines. Most areas range from 5 to 40 acres in size and are irregularly shaped. The swales are long and narrow and commonly connect to large depressions.

Typically, the surface layer is black, friable silty clay loam about 8 inches thick. The subsurface layer is black, friable silty clay about 12 inches thick. The subsoil is dark gray and olive gray, mottled, firm silty clay about 22 inches thick. The substratum extends to a depth of about 60 inches. It is mottled. It is olive gray silty clay in the upper part and olive gray, calcareous silty clay loam in the lower part. In places the surface layer is clay loam.

Included with this soil in mapping are small areas of the very poorly drained Okoboji soils and a few small areas of the somewhat poorly drained Collinwood soils. Okoboji soils are in depressions. Collinwood soils are on low rises or at the outer margins that are slightly more sloping. Included soils make up about 10 percent of the unit.

Permeability is slow in the Waldorf soil, and runoff also is slow. This soil is ponded for short periods in some areas. Available water capacity is high. The soil has a seasonal high water table at or near the surface. The shrink-swell potential is high. The content of organic matter in the surface layer is about 6 to 7 percent. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. A few areas are used for hay or pasture. If adequately drained, this soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. If the soil is tilled when wet, the surface layer puddles easily and becomes cloddy and hard when it dries. Plowing in the fall is common because freezing and thawing break down the clods, thereby resulting in better structure and improved tilth. The root zone is deep, but it is restricted by a high water table during wet seasons in areas that are not adequately drained. Because of the high clay content, tile drains function more slowly in this soil than in many other soils in the county, and thus the drains should be more closely spaced. Frost heave frequently damages legumes, and in some areas ponding drowns out legumes. If large areas are plowed in the fall, protecting the surface helps to prevent soil blowing. A system of conservation tillage that leaves crop residue on the surface helps to control soil blowing. If drainage tile is installed and tillage is deferred when the soil is wet, good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material helps to maintain tilth, improves fertility, helps to prevent surface crusting, and increases the rate of water infiltration.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet causes surface compaction and poor tilth. Proper stocking rates, pasture rotation, and restricted use during wet periods help to keep the pasture in good condition.

The land capability classification is IIw.

485—Spillville loam, 0 to 2 percent slopes. This nearly level, moderately well drained or somewhat poorly drained soil is on flood plains. It is subject to occasional flooding for very brief periods. Areas range from 15 to about 30 acres in size and are irregularly shaped.

Typically, the surface layer is black, friable loam about 9 inches thick. The subsurface layer is friable loam about 43 inches thick. The upper part is black; the next part is black, very dark brown, and very dark grayish brown; and the lower part is very dark grayish brown and is mottled. The substratum to a depth of 60 inches or more is mottled dark grayish brown and brown loam. In places, the surface layer is thinner and contains more sand and the substratum is loamy sand.

Included with this soil in mapping are a few small areas of Coland and Colo soils. These soils contain more clay than the Spillville soil. Colo soils are in the same positions on the landscape as the Spillville soil but are farther from streams. Also, they have less sand. Included soils make up less than 5 percent of the unit.

Permeability is moderate in the Spillville soil, and runoff is slow. Available water capacity is high or very high. This soil has a seasonal high water table. The content of organic matter in the surface layer is about 4 to 5 percent. The substratum generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. If protected from flooding, this soil is suited to intensive cropping of corn, soybeans, and small grain and to grasses or legumes for hay or pasture. Because of flooding in early spring, planting may be delayed and crop yields may be reduced in some years. Yields generally are high in most years. Because weed seeds carried by floodwater may be deposited in areas of this soil, weed control is important. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to control soil blowing, and increases the rate of water infiltration.

Some areas are used for pasture or hay. 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 restricted use during wet periods help to keep the pasture in good condition.

The high water table and the flooding are the main limitations if this soil is used for trees and shrubs grown as windbreaks, ornamental plantings, or wildlife plantings. Unless the flooding can be controlled, species that tolerate wetness should be planted.

The land capability classification is IIw.

485B—Spillville loam, 2 to 5 percent slopes. This gently sloping, moderately well drained soil is on low, concave foot slopes and alluvial fans. It generally is downslope from the more sloping Clarion and Storden soils and upslope from soils on flood plains and terraces. In many places it is upslope from Nicollet or Webster soils. Areas of this soil range mainly from 3 to 8 acres in size, but a few areas are as large as 15 acres. Individual areas are long and narrow.

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

Permeability is moderate, and runoff is medium. Available water capacity is high. This soil has a seasonal high water table. The content of organic matter in the surface layer is about 3.5 to 4.5 percent. The subsoil generally has a low supply of available phosphorus and potassium.

Most areas are cultivated, and some areas are used as pasture. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Erosion is a hazard in areas where excess water runs across the soil. A system of conservation tillage that leaves crop residue on the surface helps to prevent excessive soil loss and maintains tilth. Diversion terraces can be used to divert runoff water from the adjacent hillsides. Gullies may form in shallow drainageways. They can be shaped and seeded and used as waterways. This soil is typically managed along with areas of surrounding soils. Returning crop residue to the soil or regularly adding other organic material helps to control erosion, helps to prevent surface crusting, and increases the rate of water infiltration.

A cover of pasture plants or hay is effective in controlling erosion. 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 restricted use during wet periods help to keep the pasture in good condition.

If this soil is used for windbreaks or ornamental plantings, erosion is a slight hazard before the trees and shrubs are established. It can be controlled, however, by a permanent plant cover or surface mulch.

Unless flooding is controlled, only the species that can withstand wetness should be planted.

The land capability classification is IIe.

507—Canisteo clay loam, 0 to 2 percent slopes. This nearly level, poorly drained, calcareous soil is on the undulating till plain and in concave upland swales and draws. Areas range from 5 to 80 acres in size and are irregularly shaped.

Typically, the surface layer is black, friable, calcareous clay loam about 8 inches thick. The subsurface layer is black and very dark gray, friable, calcareous clay loam about 12 inches thick. The subsoil is friable, calcareous clay loam about 20 inches thick. The upper part is mottled gray and dark gray, and the lower part is mottled gray and olive gray. The substratum to a depth of about 60 inches is mottled gray and olive gray. It is clay loam in the upper part and loam in the lower part. In places the surface layer and the subsoil are silty clay loam.

Included with this soil in mapping are some small areas of Okoboji soils in depressions. These soils are wetter than the Canisteo soil and are subject to ponding after periods of rainfall. Also included are small areas of the highly calcareous Harps soils. These soils are distinctly lighter in color when dry than the Canisteo soil. Included soils make up about 5 percent of the unit.

Permeability is moderate in the Canisteo soil, and runoff is slow to ponded. Available water capacity is high. This soil has a seasonal high water table. The content of organic matter in the surface layer is about 6 to 7 percent. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated, but a few small undrained areas are used as pasture. If adequately drained, this soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Tile drains remove excess subsurface water. Special care generally is needed to maintain good tilth in the surface layer. Cultivating when the soil is too wet causes surface compaction and cloddiness. Soil blowing is a hazard if large areas are plowed in the fall and the surface is left bare. Returning crop residue to the soil or regularly adding other organic material helps to control soil blowing, helps to prevent surface crusting, improves fertility, and increases the rate of water infiltration. The high content of lime in the soil adversely affects the availability of plant nutrients and the response to fertilizer. Excess lime carbonates also affect the response to some herbicides. The growth of some crops can be adversely affected by herbicides that have a carryover effect for the subsequent crop year.

This soil is suited to pasture plants and hay. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

The wetness and the excess lime are the main limitations if this soil is used for trees and shrubs grown as windbreaks or ornamental plantings. Only the species that can tolerate the wet, calcareous conditions should be selected for planting.

The land capability classification is IIw.

508—Calcousta mucky silt loam, 0 to 1 percent slopes. This nearly level, very poorly drained, calcareous soil is in depressional areas that are basins of former lakes on the glacial till plain. Some larger depressions are drained by drainage ditches, but other areas are frequently ponded, especially in early spring. Individual areas of this soil range from about 5 to 25 acres in size and are mainly somewhat circular. In the larger depressions they are irregularly shaped.

Typically, the surface layer is black, friable mucky silt loam about 10 inches thick. The subsurface layer is black, friable, calcareous mucky silt loam about 3 inches thick. The subsoil is mottled, olive gray, friable, calcareous silty clay loam about 6 inches thick. The substratum to a depth of about 60 inches is mottled, olive gray, calcareous silty clay loam that has strata of clay loam. In places the substratum has thin strata of very fine sandy loam and very fine sand. In a few places the substratum has wedge-shaped pockets of sand. In some areas the surface layer is noncalcareous.

Permeability is moderate, and runoff is ponded. Available water capacity is high. This soil has a seasonal high water table. The content of organic matter in the surface layer ranges from about 8 to 10 percent. The subsoil generally has a very low supply of available phosphorus and potassium. The soil generally has an excess of calcium carbonates throughout.

Most areas are cultivated. Most areas are artificially drained by tile, and some areas have surface intakes. A few of the larger depressions are crossed by drainage ditches, and shallow surface drains help to remove excess surface water. In a few places, tile outlets are not adequate and drainage is slow. If drained, this soil is moderately suited to row crops. Crop growth is variable, and in the wetter years the soil is ponded long enough to drown out crops in some areas. If the crop damage occurs early enough in the season, the soil can be tilled and replanted. Even where artificial drainage is adequate for good crop growth, tillage is delayed after heavy rains. Excess carbonates in some areas adversely affect the availability of some plant nutrients. Special fertilization is needed. Increasing the rates of phosphorus and potassium can provide additional yields. The high content of organic matter and the excess calcium carbonates affect the response to some herbicides. These herbicides should be used carefully. Because of the high content of organic matter in the surface layer in many areas, soil blowing is a serious problem during dry periods if the surface is left bare. A system of conservation tillage that leaves crop residue on the surface helps to control soil blowing.

The seasonal high water table and the excess calcium carbonates are the main limitations if this soil is used for trees and shrubs grown as windbreaks or ornamental plantings. Only the species that can withstand the wet, calcareous conditions should be selected for planting.

The land capability classification is IIIw.

511—Blue Earth mucky silt loam, 0 to 1 percent slopes. This level, very poorly drained, highly calcareous soil is in depressions that formerly contained water much of the time. Some areas are in former shallow lakebeds that have been drained. The soil is subject to ponding. Most areas range from about 10 to 100 acres in size and are circular.

Typically, the surface layer is black, very friable, calcareous mucky silt loam about 9 inches thick. The substratum to a depth of about 60 inches is calcareous mucky silt loam. It is mottled black, very dark gray, and dark olive gray in the upper part; mottled very dark gray and dark gray in the next part; and black and very dark gray and mottled in the lower part. In some places the surface layer and the substratum are silty clay loam and have a high content of organic matter. In other places gray clay loam, loam, sandy loam, or silty clay loam is within a depth of 60 inches.

Permeability is moderate. Runoff is ponded. Available water capacity is very high. This soil has a seasonal high water table near or above the surface. The content of organic matter in the surface layer is more than 15 percent. The subsoil generally has a very low supply of available phosphorus and potassium. The supply of iron and some other trace elements may be too low for some crops. Response to fertilizer and to some herbicides is adversely affected by the high concentration of lime carbonates. During periods of high rainfall, runoff from adjacent slopes may pond in some areas of this soil.

Areas that are adequately drained are cultivated. Undrained areas commonly are used as wildlife habitat. This soil is moderately suited to cultivated crops. Because of the very low availability of some plant nutrients, the high content of organic matter, and the high concentration of lime carbonates, special emphasis should be given to the fertility program and to the selection and use of herbicides. The high content of organic matter and the concentration of carbonates affect herbicide response. Because the soil warms slowly in the spring, planting may be delayed. Frost may injure crops in late spring and early fall. Soil blowing may be a hazard if the surface is left bare, especially if large areas are plowed in the fall. A system of conservation tillage that leaves crop residue on the surface helps to control soil blowing. Small grain tends to lodge and thus produces grain of poor quality.

A cover of pasture plants or hay is effective in controlling erosion. The grasses that can tolerate excess wetness, such as reed canarygrass, grow best. Maintaining most legume stands is difficult because of winterkill and root and crown diseases. Proper stocking rates, pasture rotation, and restricted use during wet periods help to keep the pasture in good condition.

The land capability classification is IIIw.

511B—Blue Earth mucky silt loam, 1 to 5 percent slopes. This gently sloping, very poorly drained, highly calcareous soil is mainly on the edges of stream terraces and on foot slopes below the uplands. A few areas are in upland drainageways. The soil formed where water has accumulated on the surface after moving laterally through soil material. Areas have been kept wet enough over a period of many years to support vegetation that tolerates excessive wetness. Organic deposits have accumulated to a depth of 28 feet. Individual areas of this soil range from about 3 to 75 acres in size and are elongated.

Typically, the surface layer is black, very friable, calcareous mucky silt loam about 8 inches thick. The substratum to a depth of about 60 inches is calcareous mucky silt loam. It is mottled black, very dark gray, and dark olive gray in the upper part; mottled very dark gray and dark gray in the next part; and black and very dark gray and mottled in the lower part. In some places the surface layer and the substratum are silty clay loam and have a high content of organic matter. In other places gray clay loam, loam, sandy loam, or silty clay loam is within a depth of 60 inches.

Permeability is moderate. Runoff is ponded. Available water capacity is very high. This soil has a seasonal high water table near the surface. The content of organic matter in the surface layer is greater than 15 percent. The subsoil generally has a very low supply of available phosphorus and potassium. The supply of iron and some other trace elements may be too low for some crops. Response to fertilizer and to some herbicides is adversely affected by the high concentration of lime carbonates. During periods of high rainfall, runoff from adjacent slopes ponds in some areas of this soil.

Areas that are adequately drained are cultivated. Undrained areas commonly are used for wildlife habitat. This soil is moderately suited to cultivated crops.

Because of the very low availability of some plant nutrients, the high content of organic matter, and the concentration of lime carbonates, special emphasis should be given to the fertility program and to the selection and use of herbicides. The high content of organic matter and the concentration of carbonates affect herbicide response. Because the soil warms slowly in the spring, planting may be delayed. Frost commonly injures crops in late spring and early fall. Soil blowing may be a hazard if the surface is left bare, especially if large areas are plowed in the fall. A system of conservation tillage that leaves crop residue on the surface helps to control soil blowing. Small grain tends to lodge and thus produces grain of poor quality.

A cover of pasture plants or hay is effective in controlling erosion. The grasses that can tolerate excessive wetness, such as reed canarygrass, grow best. Maintaining most legume stands is difficult because of winterkill and root and crown diseases. Proper stocking rates, pasture rotation, and restricted use during wet periods help to keep the pasture in good condition.

The land capability classification is IIIw.

524—Linder loam, 32 to 40 inches to sand and gravel, 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 terraces. Areas range from about 3 to 20 acres in size and are irregularly shaped.

Typically, the surface layer is black, friable loam about 8 inches thick. The subsurface layer is about 10 inches thick. The upper part is black, friable loam, and the lower part is very dark brown and very dark grayish brown, friable sandy loam. The subsoil is dark grayish brown, friable sandy loam about 19 inches thick. It is mottled. The substratum extends to a depth of about 60 inches. It is mottled dark grayish brown and grayish brown, calcareous gravelly loamy sand in the upper part and grayish brown, calcareous gravelly sand in the lower part. In some of the higher convex areas, the soil is somewhat better drained.

Included with this soil in mapping are a few small areas of the poorly drained Biscay soils in slight depressions. These soils make up less than 5 percent of the unit.

Permeability is moderately rapid in the solum of the Linder soil and very rapid in the substratum. Runoff is slow. This soil has a seasonal high water table. Available water capacity is low or moderate. The content of organic matter in the surface layer is about 3 to 4 percent. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. It is better suited to small grain, grasses, and legumes than to cultivated crops because of the limited available water capacity during parts of most growing seasons. Water erosion generally is not a concern on this soil, but soil blowing is a hazard because the surface dries quickly. Blowing sand may damage young plants in some years. A system of conservation tillage that leaves crop residue on the surface helps to prevent excessive soil blowing.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet causes surface compaction, increases the runoff rate, and results in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

The land capability classification is IIs.

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 terraces and in upland outwash areas. Individual areas range from about 4 to 30 acres in size and are irregularly shaped.

Typically, the surface layer is black, calcareous, friable clay loam about 9 inches thick. The subsurface layer is calcareous, friable clay loam about 14 inches thick. The upper part is black, and the lower part is mottled black and very dark gray. The subsoil is about 16 inches thick. The upper part is mottled olive gray and dark gray, calcareous, friable clay loam, and the lower part is mottled olive gray and dark gray, friable, calcareous loam. The substratum to a depth of about 60 inches is olive gray, olive, and gray, calcareous gravelly loamy sand. In some areas the substratum is at a depth of slightly more than 40 inches. In these areas the dark surface soil commonly is more than 24 inches thick. In a few places the subsoil is slightly darker.

Permeability is moderate in the solum and rapid in the substratum. Runoff is slow. Available water capacity is moderate. This soil has a seasonal high water table. Root development and available water capacity are somewhat limited by the underlying calcareous sand and gravel. The content of organic matter in the surface layer is about 5.5 to 6.5 percent. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is moderately well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Drainage is needed for optimum crop production. Drainage can be improved by installing tile drains. These drains function well, but in some places installation is difficult because of the instability of the substratum. Overdrainage should be avoided. Because of the limited available water capacity, crops do not have sufficient moisture, especially if rainfall is below average or if rains are not timely. The soil is subject to soil blowing, especially if it is plowed in the fall and the surface is left bare. A system of conservation tillage that leaves crop residue on the surface helps to prevent soil blowing and conserves moisture.

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

The land capability classification is IIw.

585B—Coland-Spillville complex, 2 to 5 percent slopes. These gently sloping soils are in small valleys and upland drainageways. The Coland soil is poorly drained and is subject to occasional flooding for brief periods. The Spillville soil is moderately well drained. Individual areas of these soils generally range from 5 to 10 acres in size, but a few areas are larger. The areas are about 60 percent Coland soil and 40 percent Spillville soil. The two soils occur as areas so intricately mixed or so small that mapping them separately is not practical. Areas of these soils generally are bordered by the strongly sloping to steep Clarion or Storden soils.

Typically, the surface layer of the Coland soil is black, friable clay loam about 9 inches thick. The subsurface layer is friable clay loam about 52 inches thick. The upper part is black, and the lower part is very dark gray and is mottled. The substratum to a depth of about 60 inches is dark gray clay loam. It is mottled.

Typically, the surface layer of the Spillville soil is black, friable loam about 9 inches thick. The subsurface layer is friable loam about 43 inches thick. The upper part is black; the next part is black, very dark brown, and very dark grayish brown; and the lower part is very dark grayish brown and is mottled. The substratum to a depth of about 60 inches is mottled dark grayish brown and brown loam. In places the substratum has thin layers of sandy loam, sandy clay loam, or silt loam.

Permeability is moderate in the Coland and Spillville soils, and runoff is slow. Available water capacity is high. These soils have a seasonal high water table. The content of organic matter in the surface layer of the Coland soil is about 5 to 7 percent. The content of organic matter in the surface layer of the Spillville soil is about 4 to 5 percent. The subsoil of both soils generally has a low supply of available phosphorus and potassium.

Most areas are cultivated, but some areas are used as pasture (fig. 14). These soils are well suited to corn, soybeans, and small grain and to grasses and legumes for hay or pasture. Wetness and flooding can be concerns in areas of the Coland soil, especially where excess water runs onto the soil from areas on adjoining hillsides. Diversion terraces can be built along the upper edges of this unit to control runoff, and the soils can be farmed on the contour along with the adjacent sloping soils. Grassed waterways can also be used in areas where gully erosion is a problem. In other places, straightening stream channels can make the soils more suitable for farming. Tile drains can be installed in many places to reduce wetness on the Coland soil.

Some areas are not easily accessible by farm machinery or are cut by meandering stream channels or drainageways that cannot be crossed with farm equipment. These areas are used as pasture or are left idle. In most areas that are used as pasture, renovating the pasture and establishing the more productive species in accessible areas can increase production. Proper stocking rates, timely deferment of grazing, pasture rotation, and restricted use during wet periods help to keep the pasture in good condition.

The seasonal high water table, the wetness, and the flooding are the main concerns if these soils are used for trees and shrubs grown as windbreaks, ornamental plantings, or wildlife plantings. Adequate drainage is needed, and species that are tolerant of wet conditions should be selected.

The land capability classification is IIw.

638B—Clarion-Storden complex, 2 to 5 percent slopes. These gently sloping, well drained soils are mostly on low, convex knolls. A few areas are on ridgetops. The soils have short, irregular slopes. Individual areas range from 3 to 12 acres in size and are irregularly shaped. Most areas are about 65 percent Clarion soil, 25 percent Storden soil, and 10 percent soils of minor extent. About half of the acreage of the Storden soil is moderately eroded. The Storden soil is typically upslope from the Clarion soil. The two soils occur as areas so intricately mixed or so small that mapping them separately is impractical.

Typically, the surface layer of the Clarion soil is black, friable loam about 8 inches thick. The subsurface layer is friable loam about 11 inches thick. The upper part is very dark brown, and the lower part is very dark brown and dark brown. The subsoil is friable loam about 23 inches thick. The upper part is brown, the next part is dark yellowish brown, and the lower part is mottled dark yellowish brown and olive brown and is calcareous. The substratum to a depth of about 60 inches is light olive brown, calcareous loam. It is mottled. In a few eroded areas, the surface layer is mostly dark grayish brown mixed with streaks

Figure 14.—A pasture in an area of Coland-Spillville complex, 2 to 5 percent slopes. The Coland soil is adjacent to the stream channel.

and pockets of yellowish brown.

Typically, the surface layer of the Storden soil is very dark brown, very dark grayish brown, and brown, calcareous loam about 10 inches thick. The substratum to a depth of about 60 inches is light olive brown, calcareous loam. It is mottled. In a few places the lighter colored substratum is exposed at the surface.

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

Permeability is moderate in the Clarion and Storden soils, and runoff is medium. Available water capacity is high. The content of organic matter in the surface layer of the Clarion soil is about 3 to 4 percent. The content of organic matter in the surface layer of the Storden soil is about 2.5 to 3.5 percent. The subsoil of the Clarion soil generally has a very low or low supply of available phosphorus and a very low supply of available potassium. The subsoil of the Storden soil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. These soils are well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. If they are used for cultivated crops, erosion is a hazard. A system of conservation tillage that leaves crop residue on the surface helps to prevent excessive soil loss. Using mechanical erosion-control measures, such as contour farming and terraces, is difficult in most places because of the irregular topography and short slopes. In some places, however, these practices are feasible. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to control erosion, helps to prevent crusting, and maintains good tilth.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing, however, causes surface compaction, increases the runoff rate, results in poor tilth, and reduces production. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture in good condition.

The land capability classification is IIe.

638C2—Clarion-Storden complex, 5 to 9 percent slopes, moderately eroded. These moderately sloping, well drained soils are on knobs, convex side slopes, and ridges in the uplands. Individual areas range from 5 to more than 50 acres in size and are irregularly shaped. They are typically about 55 percent Clarion soil, 40 percent Storden soil, and 5 percent soils of minor extent. The Clarion soil is on the smoother side slopes and ridges. The Storden soil is on the more convex knobs and side slopes. The two soils occur as areas so intricately mixed or so small that mapping them separately is impractical.

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

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

Included with these soils in mapping are small areas of Dickman and Salida soils. These included soils are more droughty than the major soils. Dickman soils are on convex nose slopes and low-lying knobs. Salida soils are in scattered areas, mostly on convex knobs. They have gravel in the surface layer, which interferes with tillage. Included soils make up about 5 percent of the unit.

Permeability is moderate in the Clarion and Storden soils, and runoff is medium. Available water capacity is high. The content of organic matter in the surface layer of the Clarion soil is about 2.2 to 3.2 percent. The content of organic matter in the surface layer of the Storden soil is about 1.7 to 2.7 percent. The subsoil of the Clarion soil and the substratum of the Storden soil generally have a very low supply of available phosphorus and potassium.

Most areas are cultivated. A few areas are used as pasture. These soils are moderately well suited to corn, soybeans, and small grain and are well suited to grasses and legumes for hay and pasture. If they are used for cultivated crops, further erosion is a hazard. A system of conservation tillage that leaves crop residue on the surface helps to prevent excessive soil loss. Using mechanical erosion-control measures, such as contour farming and terraces, is difficult in most places because of the irregular topography and short slopes. A considerable amount of cutting and filling may be needed if terraces are constructed. Tilth generally is fair in the surface layer. Returning crop residue to the soil or regularly adding other organic material helps to control erosion, improves fertility, and increases the rate of water infiltration. In spite of the high available water capacity, much of the rainfall runs off areas of the Storden soil and crops grow poorly during dry periods. Because of the high lime content and the low content of organic matter in the Storden soil, response to fertilizer may be lower than in areas of other soils. Larger amounts of fertilizer are needed to maintain desirable yields. Excessive tillage during seedbed preparation may dry the surface layer and can result in poor stands. The supply of iron and other minor nutrients may be inadequate for some crops. Some crops can be easily damaged by using herbicides that have a carryover effect for the subsequent crop year.

A cover of pasture plants or hay is effective in controlling erosion if adequate plant cover is maintained. Overgrazing increases runoff and erosion. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture in good condition.

These soils are suited to trees and shrubs for windbreaks, ornamental plantings, and wildlife plantings. Excess lime carbonates affect the growth of some species. Limiting site preparation and providing mulch cover help to control runoff and erosion.

The land capability classification is IIIe.

638D2—Clarion-Storden complex, 9 to 14 percent slopes, moderately eroded. These strongly sloping, well drained soils are on convex side slopes and nose slopes on glacial moraines. Individual areas range from 5 to 30 acres in size and are irregularly shaped. They are typically about 55 percent Clarion soil, 40 percent Storden soil, and 5 percent soils of minor extent. The Clarion soil is on the smoother side slopes. The Storden soil is on the more convex part of the slopes. The two soils occur as areas so intricately mixed or so small that mapping them separately is impractical.

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

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

Included with these soils in mapping are small areas of Dickman and Salida soils. These included soils are more droughty than the major soils. Dickman soils are on convex nose slopes and low-lying knobs. Salida soils are in scattered areas, mostly on convex knobs. They have gravel in the surface layer, which interferes with tillage. Included soils make up about 5 percent of the unit.

Permeability is moderate in the Clarion and Storden soils, and runoff is rapid. Available water capacity is high. The content of organic matter in the surface layer of the Clarion soil is about 2.2 to 3.2 percent. The content of organic matter in the surface layer of the Storden soil is about 1.7 to 2.7 percent. The subsoil of the Clarion soil and the substratum of the Storden soil generally have a very low supply of available phosphorus and potassium.

Most areas are cultivated. A few areas are used as pasture. These soils are moderately well suited to corn, soybeans, and small grain and are well suited to grasses and legumes for hay and pasture. If they are used for cultivated crops, further erosion is a hazard. Grassed waterways and a system of conservation tillage that leaves crop residue on the surface help to prevent excessive soil loss. Using mechanical erosion-control measures, such as contour farming and terraces, is difficult in most places because of the irregular topography and short slopes. A considerable amount of cutting and filling is generally needed if terraces are constructed. Tilth generally is fair in the surface layer. Returning crop residue to the soil or regularly adding other organic material helps to control erosion, improves fertility, and increases the rate of water infiltration. In spite of the high available water capacity, much of the rainfall runs off areas of the Storden soil and crops grow poorly during dry periods. Because of the high lime content and the low content of organic matter in areas of the Storden soil, response to fertilizer commonly is lower than in other soils. Larger applications are needed to maintain desirable yields. Excessive tillage during seedbed preparation may dry the surface layer and can result in poor stands. The supply of iron and other minor nutrients may be inadequate for some crops. Some crops can be easily damaged by using herbicides that have a carryover effect for the subsequent crop year.

A cover of pasture plants or hay is effective in controlling erosion if an adequate plant cover is maintained. Overgrazing increases runoff and erosion. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture in good condition.

These soils are suited to trees and shrubs for windbreaks, ornamental plantings, and wildlife plantings. Excess lime carbonates affect the growth of some species. Limiting site preparation and providing mulch cover help to control runoff and erosion.

The land capability classification is IIIe.

638E2—Clarion-Storden complex, 14 to 18 percent slopes, moderately eroded. These moderately steep, well drained soils are on convex side slopes and nose slopes on glacial moraines. Some areas border small streams, some of which have been straightened and deepened. Individual areas range from 5 to 30 acres in size and are irregularly shaped. They are typically about 50 percent Clarion soil, 40 percent Storden soil, and 10 percent soils of minor extent. The Clarion soil is on the smoother side slopes. The Storden soil is on the more complex side slopes and nose slopes. The two soils occur as areas so intricately mixed or so small that mapping them separately is impractical.

Typically, the surface layer of the Clarion soil is black and very dark brown, friable loam about 8 inches thick. It is mixed with streaks and pockets of brown subsoil material. The subsoil is friable loam about 12 inches thick. The upper part is brown and dark yellowish brown, and the lower part is olive brown and is calcareous. The substratum to a depth of about 60 inches is light olive brown, calcareous loam. It is mottled.

Typically, the surface layer of the Storden soil is very dark brown, very dark grayish brown, and brown, friable, calcareous loam about 7 inches thick. It is mixed with streaks and pockets of light olive brown substratum material. The substratum to a depth of about 60 inches is light olive brown, friable loam. It is mottled. In places the surface layer is brown and light olive brown.

Included with these soils in mapping are small areas of Dickman and Salida soils. These included soils are typically on the more convex side slopes, nose slopes, and low-lying knobs. They are droughty. Salida soils have gravel in the surface layer, which may interfere with tillage. Included soils make up about 10 percent of the unit.

Permeability is moderate in the Clarion and Storden soils, and runoff is rapid. Available water capacity is high. Because of the runoff rate, however, much of the rainfall does not enter the soils. The content of organic matter in the surface layer of the Clarion soil is about 2.2 to 3.2 percent. The content of organic matter in the surface layer of the Storden soil is about 1.7 to 2.7 percent. The subsoil of the Clarion soil and the substratum of the Storden soil generally have a very low supply of available phosphorus and potassium.

Areas of these soils are used for cultivated crops or for pasture. The soils are poorly suited to cultivated crops because of the steep slopes and the severe hazard of erosion. They are better suited to small grain and to grasses and legumes for hay and pasture (fig. 15). The use of equipment is hazardous because of the slope. If the soils are used for cultivated crops, a system of conservation tillage that leaves crop residue on the surface, no-till farming, and grassed waterways help to prevent excessive soil loss. These practices also increase the amount of water available for crop use by slowing runoff and allowing more water to enter the soil. Returning crop residue to the soil or regularly adding other organic material reduces the runoff rate, improves fertility, and increases the rate of water infiltration. Because of the high lime content and the low content of organic matter in the Storden soil, response to fertilizer is lower than in areas of other soils. Larger applications are needed to maintain desirable yields. Excessive tillage during seedbed preparation may dry the surface layer and can result in poor stands. The supply of iron and other minor nutrients may be inadequate for some crops. Some crops can be easily damaged by using herbicides that have a carryover effect for the subsequent crop year.

A cover of pasture plants or hay is effective in controlling erosion if an adequate plant cover is maintained. Overgrazing increases runoff and erosion. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture in good condition.

These soils are suited to trees and shrubs for windbreaks, ornamental plantings, and wildlife plantings. Excess lime carbonates affect the growth of some species. Limiting site preparation and providing mulch cover help to control runoff and erosion.

The land capability classification is IVe.

639D2—Storden-Salida complex, 5 to 14 percent slopes, moderately eroded. These moderately sloping to strongly sloping, well drained and excessively drained soils are on irregular, convex upland ridges and side slopes. Some areas are dissected by shallow drainageways. Individual areas range from about 5 to 15 acres in size and are irregularly shaped. They typically are about 50 percent Storden soil, 40 percent Salida soil, and 10 percent soils of minor extent. In places the percentages of the Storden and Salida soils are about equal. The Storden soil commonly is on the broader ridgetops and on convex side slopes. The Salida soil typically is on the higher parts of narrow convex ridges and on sharp slope breaks. It commonly has gravel-sized particles on the surface. The Storden and Salida soils occur as areas so intricately mixed or so small that mapping them separately is impractical.

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

Typically, the surface layer of the Salida soil is very dark grayish brown, calcareous, very friable gravelly loamy sand about 8 inches thick. It is mixed with streaks and pockets of brown and dark yellowish brown subsoil material. The subsoil is brown and dark yellowish brown, calcareous, very friable gravelly loamy sand about 6 inches thick. The substratum to a depth of about 60 inches is brown, yellowish brown, and dark yellowish brown. The upper part is calcareous very gravelly sand, and the lower part is calcareous very gravelly coarse sand.

Included with these soils in mapping are small areas of Clarion soils. Clarion soils are in positions on the slope similar to those of the Storden soil. Also included are areas that are less sloping than the major soils. Included areas make up about 10 percent of the unit.

Permeability is moderate in the Storden soil and very rapid in the Salida soil. Runoff is rapid on the Storden soil and medium on the Salida soil. Available water capacity generally is high in the Storden soil, but it may be lower in some areas because of the runoff rate and the reduced rate of water infiltration. Available water capacity is very low in the Salida soil. Although most of the water that falls on the surface of the Salida soil is absorbed, much of it rapidly runs through the soil and out of the root zone. The content of organic matter in the surface layer of the Storden soil is about 1.7 to 2.7 percent. The content of organic matter in the surface layer of the Salida soil is about 1 to 2 percent. The

Figure 15.—Bales of bromegrass-alfalfa hay in an area of Clarion-Storden complex, 14 to 18 percent slopes, moderately eroded.

subsoil of both soils generally has a very low supply of available phosphorus and potassium. Stones and gravel in the surface layer of the Salida soil can hinder tillage.

Some areas are cultivated, but most areas support grasses. The Storden soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. The Salida soil is very poorly suited to these crops. If these soils are used for cultivated crops, the hazard of water erosion is severe. The Salida soil is subject to soil blowing, especially if the surface is left bare. A system of conservation tillage that leaves crop residue on the surface helps to prevent excessive soil loss. Using erosion-control measures, such as terraces and contour farming, is difficult in places because of the irregular topography and short slopes. Constructing terraces is not practical in areas of the Salida soil because of the instability of the sand and gravel. An excess of lime carbonates in both soils reduces the effectiveness of fertilizer and some herbicides. The supply of available iron is inadequate in some areas, and the availability of other minor elements may be limited. Returning crop residue to the soil or regularly adding other organic material increases the content of organic matter, improves fertility, and helps to maintain good tilth.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soils are too wet causes surface compaction, increases the runoff rate, and results in poor tilth. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture in good condition.

The land capability classification is IVe.

655—Crippin loam, 1 to 3 percent slopes. This very gently sloping, somewhat poorly drained soil is on slight convex knolls. Most areas range from 3 to 10 acres in size and are irregularly shaped or long and narrow.

Typically, the surface layer is black, friable, calcareous loam about 9 inches thick. The subsurface layer is very dark brown and very dark grayish brown, friable, calcareous loam about 14 inches thick. The subsoil is calcareous, friable loam about 23 inches thick. The upper part is mottled dark grayish brown and olive brown, and the lower part is mottled olive brown and light olive brown. The substratum to a depth of about 60 inches is light olive brown, calcareous loam. It is mottled. In some places the surface layer is thinner. In other places the substratum is silt loam or stratified silt loam and very fine sand. In a few areas the surface layer is leached.

Included with this soil in mapping are small areas of the calcareous Storden soils. These soils have a lower content of organic matter than the Crippin soil. They are on the highest part of the slope. Generally, they are distinctly lighter in color than the Crippin soil. Also included in mapping are small areas of Clarion and Harps soils. Clarion soils are in the higher landscape positions and are well drained. The highly calcareous Harps soils are on the lower part of the slope and typically are adjacent to potholes. Included soils make up about 10 percent of the unit.

Permeability is moderate in the Crippin soil, and runoff is slow. Available water capacity is high. This soil has a seasonal high water table. The content of organic matter in the surface layer is about 5 to 6 percent. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Most areas are not drained, but in some areas an artificial drainage system improves the timeliness of fieldwork. If tillage is deferred when the soil is wet, good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material helps to maintain tilth, improves fertility, helps to prevent surface crusting, and increases the rate of water infiltration.

A cover of pasture plants or hay is effective in maintaining tilth. Overgrazing or grazing when the soil is too wet causes surface compaction and poor tilth, increases the runoff rate, and reduces forage production. Proper stocking rates, pasture rotation, and restricted use during wet periods help to keep the pasture in good condition.

The land capability classification is I.

707—Delft clay loam, 1 to 3 percent slopes. This very gently sloping, poorly drained soil is at the base of slopes and in narrow drainageways. Individual areas range from 3 to 5 acres in size and are elongated.

Typically, the surface layer is black, friable clay loam about 10 inches thick. The subsurface layer is friable clay loam about 34 inches thick. The upper part is black, and the lower part is very dark gray and is mottled. The subsoil to a depth of about 60 inches is mottled very dark gray, dark olive gray, and olive gray, firm clay loam.

Included with this soil in mapping are small areas of the poorly drained Canisteo and very poorly drained Okoboji soils. Canisteo soils are at slightly higher elevations than the Delft soil. They are calcareous throughout. Okoboji soils are in small depressions and are subject to frequent ponding during wet periods. Included soils make up less than 10 percent of the unit.

Permeability is moderately slow in the Delft soil, and runoff is very slow or slow. Available water capacity is high. This soil has a seasonal high water table. The content of organic matter in the surface layer is about 6 to 8 percent. The subsoil generally has a low or very low supply of available phosphorus and potassium.

Most areas are cultivated. If adequately drained, this soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Wetness is the main concern in areas used as cropland. Because this soil is in the lower areas and remains wet longer than other soils, tillage is often delayed. In most areas runoff water from adjacent soils on the steeper slopes accumulates and runs across this soil. Many areas do not have well defined drainageways. A drainage system is needed to reduce wetness, improve aeration, and provide a deeper root zone for plants. In some areas, adequate outlets for tile lines are not readily available. In places, shaping the land and establishing grassed waterways help to remove surface water and improve the timeliness of tillage. Controlling the runoff from the higher adjacent soils helps to control wetness on this soil. Good tilth is harder to maintain than on adjacent soils. Returning crop residue to the soil or regularly adding other organic material and deferring tillage when the soil is wet help to maintain tilth, improve fertility, help to prevent surface compaction, and increase the rate of water infiltration.

Using this soil for hay or pasture is effective in controlling erosion. The varieties that can tolerate periodic wet conditions should be seeded. Overgrazing or grazing when the soil is wet causes surface compaction and poor tilth and reduces forage production.

The land capability classification is IIw.

733—Calco silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on flood plains along some of the larger streams in the county. Most areas are somewhat elongated, and some areas parallel both sides of the stream. Most areas of this soil are somewhat lower on the landscape than the adjacent soils. Most areas are occasionally flooded during periods of high rainfall. Some areas are flooded for brief periods, but a few areas are flooded for longer periods of time. Individual areas of this soil range from about 10 to 30 acres in size and are elongated.

Typically, the surface layer is black, calcareous, friable silty clay loam about 9 inches thick. The subsurface layer is friable silty clay loam about 38 inches thick. The upper part is black, the next part is mottled black and dark gray, and the lower part is mottled black and dark grayish brown. The substratum to a depth of about 60 inches is mottled dark gray and gray silty clay loam. In places the soil is dark to a depth of more than 60 inches.

Included with this soil in mapping are small areas of loamy soils that are calcareous. These soils are adjacent to stream channels. They make up less than 5 percent of the unit.

Permeability is moderate in the Calco soil, and runoff is slow. Available water capacity is high. This soil has a seasonal high water table. The content of organic matter in the surface layer is about 5 to 7 percent. The soil typically is calcareous throughout. The subsoil generally has a very low supply of available phosphorus and potassium. In places the supply of available iron may be too low for some crops.

Most areas are cultivated, but areas that are frequently flooded or are flooded for longer periods are used as pasture. Areas that are drained and are not flooded too frequently or for too long in the spring are well suited to corn and soybeans. The wetness caused by flooding and by the seasonal high water table is a limitation. Measures that control flooding and reduce wetness improve yields and the timeliness of fieldwork. In places, removing trees and brush and straightening stream channels can minimize the effects of flooding. Tile drains function well if suitable outlets are available. Because of the flooding and the early season wetness, small grain and legumes for hay and pasture are generally not grown on this soil. Good tilth generally can be maintained if the soil is not worked when it is wet.

This soil is suited to pasture. In some areas grazing is limited by the flooding. Overgrazing or grazing when the soil is too wet reduces forage production and causes poor tilth and surface compaction.

The land capability classification is IIw.

787B—Vinje silty clay loam, 2 to 5 percent slopes. This gently sloping, well drained soil is on convex rises and side slopes in the uplands. Individual areas range from about 4 to 10 acres in size and are irregularly shaped.

Typically, the surface layer is black, friable silty clay loam about 7 inches thick. The subsurface layer is silty clay loam about 10 inches thick. The upper part is very dark grayish brown and is friable, and the lower part is dark brown and brown and is firm. The subsoil is brown, firm silty clay about 19 inches thick. It is mottled in the lower part. The substratum to a depth of about 60 inches is friable silty clay loam. The upper part is mottled light olive gray and pale olive, and the lower part is mottled olive gray, light olive gray, and pale olive. In places the substratum is loam or clay loam at a depth of about 30 inches. In a few nearly level areas, the surface soil is thicker and darker. In these areas the soil is less well drained.

Permeability is moderately slow, and runoff is medium. Available water capacity is high. The content of organic matter in the surface layer is about 3.5 to 4.5 percent. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. The high content of clay reduces the rate of water infiltration, increases the runoff rate, and makes proper seedbed preparation difficult. If the soil is used for row crops, erosion is a hazard. A system of conservation tillage that leaves crop residue on the surface, contour farming, terraces, and grassed waterways help to prevent excessive soil loss. In places contour farming and terraces are not practical because of the irregular topography and short slopes. Working the soil when it is too wet causes the surface to become hard and cloddy as it dries. Tilth generally is fair in the surface layer. Returning crop residue to the soil or regularly adding other organic material improves fertility and tilth, increases the rate of water infiltration, and reduces the runoff rate.

A cover of pasture plants or hay is effective in controlling erosion and improves tilth. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increases the runoff rate, and results in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

The land capability classification is IIe.

811—Muskego muck, 0 to 2 percent slopes. This level, very poorly drained soil is in depressions associated with old glacial lake basins. It is subject to ponding. Individual areas range from 15 to 80 acres in size and are circular.

Typically, the surface and subsurface layers are black, very friable muck about 25 inches thick. The substratum to a depth of about 60 inches is calcareous, very friable mucky silt loam. The upper part is dark gray and gray, and the lower part is very dark gray and dark olive gray. In places thin layers of sand or loam are within a depth of 60 inches.

Permeability is moderately rapid in the upper part and slow in the substratum. Runoff is very slow or ponded. Available water capacity is very high. This soil has a seasonal high water table and is ponded during some periods of high rainfall and in the spring. The content of organic matter in the surface layer is more than 20 percent. The substratum generally has a very low supply of available phosphorus and potassium. The supply of trace elements may be inadequate for some crops.

Much of the acreage of this soil has been artificially drained and is used for cultivated crops. If adequately drained, this soil is moderately suited to corn, soybeans, and small grain. It is poorly suited to legumes for hay and pasture. Runoff from adjacent slopes readily ponds in some areas of this soil. In periods of excessive rainfall, crops are sometimes damaged or destroyed before the tile can remove the excess water. If this damage occurs early in the season, the soil can be tilled and replanted. The soil warms slowly in the spring, and planting is often delayed. Because the soil is in low-lying areas and loses heat rapidly from the surface, frost can injure crops in late spring and early fall. The use of early maturing varieties can minimize losses resulting from late planting or early frost. Row crops grow fairly well if drainage is adequate and the soil is fertilized and otherwise well managed. Small grain, however, tends to lodge and thus produces grain of poor quality. The growth of crops generally is better in years of below average rainfall. Tilth is excellent, and the soil can be tilled throughout a wide range in moisture content. The selection of herbicides and rates of application should be carefully considered. The high content of organic matter reduces the effectiveness of many herbicides.

Legumes for hay and pasture grow poorly on this soil and are highly susceptible to winterkill. Partially drained areas are commonly used as pasture. Many grasses are well suited to the soil and can grow well. Species that tolerate wetness, such as reed canarygrass, generally are more productive and easier to manage than other species. Rotation grazing and deferred grazing during wet periods help to prevent surface compaction and help to keep the grass more productive. Areas that are not drained sufficiently for use as pasture provide good habitat for wildlife.

This soil is poorly suited to trees because it has a seasonal high water table and remains wet for long periods after rainfall. Special equipment commonly is needed. Operating this equipment is difficult, however, because of the spongy surface layer. A drainage system is needed to reduce the seedling mortality rate.

The land capability classification is IIIw.

823—Ridgeport sandy loam, 1 to 3 percent slopes. This nearly level, somewhat excessively drained soil is on plane or slightly convex slopes on glacial outwash plains and stream terraces. Areas range from about 5 to 50 acres in size and are irregularly shaped.

Typically, the surface layer is very dark brown, very friable sandy loam about 8 inches thick. The subsurface layer is very dark brown and very dark grayish brown, very friable sandy loam about 4 inches thick. The subsoil is about 24 inches thick. The upper part is dark brown, very friable sandy loam, and the lower part is dark brown, loose gravelly sandy loam. The substratum to a depth of about 60 inches is yellowish brown, calcareous gravelly sand. In places the substratum is at a depth of less than 32 inches. In some areas the surface layer is sand.

Included with this soil in mapping are small areas of somewhat poorly drained soils in slightly concave positions and areas that have loamy glacial till at depths between 36 and 60 inches. The included areas are somewhat less droughty than the Ridgeport soil and are more productive. They make up less than 5 percent of the unit.

Permeability is moderately rapid in the solum of the Ridgeport soil and very rapid in the coarse textured substratum. Runoff is slow. Available water capacity is low. The content of organic matter in the surface layer is about 2 to 3 percent. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. The low available water capacity limits crop growth in parts of most growing seasons, especially during years when rainfall is below average or if rains are untimely. Small grain and legumes for hay and pasture generally grow 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. A system of conservation tillage that leaves crop residue on the surface slows drying and helps to prevent soil blowing. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material conserves moisture, improves fertility, and helps to maintain tilth.

A cover of pasture plants or hay is effective in controlling soil blowing. If this soil is used as pasture, overgrazing causes surface compaction. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture in good condition.

The land capability classification is IIIs.

828B—Zenor sandy loam, 2 to 5 percent slopes. This gently sloping, somewhat excessively drained soil is on upland knolls and side slopes in glacial outwash areas. Areas range from 3 to 10 acres in size and are irregularly shaped.

Typically, the surface layer is very dark grayish brown, friable sandy loam about 7 inches thick. The subsurface layer also is very dark grayish brown, friable sandy loam. It is about 6 inches thick. The subsoil is about 21 inches thick. The upper part is dark yellowish brown, very friable sandy loam, and the lower part is dark yellowish brown and yellowish brown, very friable loamy sand. The substratum to a depth of about 60 inches is yellowish brown loamy sand.

Included with this soil in mapping are a few small areas of Clarion and Storden soils. These soils are in landscape positions similar to those of the Zenor soil. They are more productive than the Zenor soil. Clarion soils are loam throughout. Storden soils are calcareous loam throughout. Included soils make up about 10 percent of the unit.

Permeability is moderately rapid in the upper part of the Zenor soil and very rapid in the lower part. Runoff is slow. Available water capacity is moderate. The content of organic matter in the surface layer is about 1.5 to 2.5 percent. The subsoil generally has a low supply of available phosphorus and a very low supply of available potassium.

Most areas are cultivated. If erosion is controlled, this soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. It tends to be droughty. A system of conservation tillage that leaves crop residue on the surface, contour farming, stripcropping, and a cropping sequence that includes grasses and legumes help to prevent excessive soil loss. Terraces generally are not constructed on this soil because the cuts would expose the coarser textured subsoil material. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material improves fertility and tilth and conserves moisture.

If this soil is used as pasture, overgrazing increases the runoff rate. Proper stocking rates and pasture rotation help to keep the pasture in good condition.

The land capability classification is IIe.

828C2—Zenor sandy loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, somewhat excessively drained soil is on upland knolls and side slopes in glacial outwash areas. Areas range from 5 to 20 acres in size and are irregularly shaped.

Typically, the surface layer is very dark grayish brown, friable sandy loam about 7 inches thick. It is mixed with a few streaks and pockets of dark yellowish brown subsoil material. The subsoil is about 27 inches thick. The upper part is dark yellowish brown, very friable sandy loam, and the lower part is dark yellowish brown and yellowish brown, very friable loamy sand. The substratum to a depth of about 60 inches is yellowish brown loamy sand. In some places the surface layer is very dark grayish brown loam about 11 inches thick. In other places the slopes are somewhat steeper.

Included with this soil in mapping are a few small areas of Clarion, Salida, and Storden soils. These soils are in landscape positions similar to those of the Zenor soil. Clarion and Storden soils are loam throughout. They are more productive than the Zenor soil. Salida and Storden soils are calcareous. Salida soils are coarser textured and are more droughty and less productive than the Zenor soil. Included soils make up about 15 percent of the unit.

Permeability is moderately rapid in the upper part of the Zenor soil and very rapid in the lower part. Runoff is medium. Available water capacity is moderate. The content of organic matter in the surface layer is about 1 to 2 percent. The subsoil generally has a low supply of available phosphorus and a very low supply of available potassium.

Most areas are cultivated. If erosion is controlled, this soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. It tends to be droughty. A system of conservation tillage that leaves crop residue on the surface, contour farming, stripcropping, and a cropping sequence that includes grasses and legumes help to prevent excessive soil loss. Terraces generally are not constructed on this soil because the cuts would expose the coarser textured subsoil. Tilth generally is fair in the surface layer. Returning crop residue to the soil or regularly adding other organic material improves fertility and tilth and conserves moisture. More intense management is needed on this soil than on the less eroded Zenor soils to help maintain productivity and improve tilth.

If this soil is used as pasture, overgrazing increases the runoff rate. Proper stocking rates and pasture

rotation help to keep the pasture in good condition.
The land capability classification is IIIe.

879—Fostoria loam, 0 to 2 percent slopes. This nearly level, somewhat poorly drained soil is on slightly convex or concave slopes on stream terraces and in outwash areas. Most areas range from 4 to 10 acres in size and are irregularly shaped.

Typically, the surface layer is black, friable loam about 8 inches thick. The subsurface layer is friable loam about 10 inches thick. The upper part is black, and the lower part is very dark brown. The subsoil is friable loam about 29 inches thick. The upper part is mottled very dark grayish brown and very dark brown, the next part is dark grayish brown and is mottled, and the lower part is mottled dark grayish brown and olive gray. The substratum to a depth of 60 inches is loam. The upper part is yellowish brown, and the lower part is mottled olive gray and olive. In some places thin layers of sand and gravel are in the lower part of the profile. In other places the surface layer is sandy loam. In a few areas the substratum is silty clay or silty clay loam.

Permeability is moderate, and runoff is slow. Available water capacity is high. This soil has a seasonal high water table. The content of organic matter in the surface layer is about 5 to 6 percent. The subsoil generally has a very low or low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Erosion generally is not a problem on this soil. A system of conservation tillage that leaves crop residue on the surface helps to maintain good tilth. The soil generally is not drained, but in some areas artificial drainage would improve the timeliness of fieldwork. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material helps to maintain tilth, improves fertility, helps to prevent surface crusting, and increases the rate of water infiltration.

A cover of pasture plants or hay is effective in controlling soil blowing. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

The land capability classification is I.

956—Okoboji-Harps complex, 0 to 2 percent slopes. These nearly level and gently sloping, poorly drained and very poorly drained soils are in upland depressions and on rims surrounding the depressions. Areas range from about 10 to 25 acres in size and are irregularly shaped. They are about 45 percent Okoboji soil, 40 percent Harps soil, and 15 percent soils of minor extent. The Okoboji and Harps soils occur as areas so intricately mixed or so small that mapping them separately is impractical.

Typically, the surface layer of the Okoboji soil is black, friable silty clay loam about 8 inches thick. The subsurface layer is black, very dark gray, and dark gray, friable silty clay loam about 28 inches thick. The subsoil is very dark gray, dark gray, and olive gray, friable silty clay loam about 12 inches thick. The substratum to a depth of about 60 inches is mottled gray and olive gray silty clay loam. In places the surface layer is slightly calcareous.

Typically, the surface layer of the Harps soil is black, calcareous, friable clay loam about 8 inches thick. The subsurface layer is black, very dark gray, and dark gray, calcareous, friable clay loam about 13 inches thick. The calcareous subsoil is mottled, olive gray, friable loam about 14 inches thick. The substratum to a depth of about 60 inches is olive gray, mottled, calcareous loam.

Included with these soils in mapping are some small areas of the calcareous Canisteo soils in the slightly higher positions. Canisteo soils are less calcareous than the Harps soil. They make up about 15 percent of the unit.

Permeability is moderately slow in the Okoboji soil and moderate in the Harps soil. Available water capacity is high in both soils. These soils have a seasonal high water table. The content of organic matter in the surface layer of the Okoboji soil is about 9 to 12 percent. The content of organic matter in the surface layer of the Harps soil is about 4.5 to 5.5 percent. The subsoil of both soils generally has a very low supply of available phosphorus and potassium. In areas of the Harps soil, the supply of available iron is also seriously inadequate and the supply of some minor elements is likely to be low.

Most areas are cultivated. Drainage is needed for crop production, and most areas are artificially drained by tile. Surface intakes are used in some areas of the Okoboji soil. The Okoboji and Harps soils are moderately suited to corn and soybeans and to grasses and legumes for hay and pasture. In the wetter years, the soils are subject to ponding for long enough periods that crops are drowned out on the Okoboji soil. An excess of lime carbonates in the Harps soil reduces the effectiveness of fertilizers, and special fertilization may be needed for optimum production. The excess lime carbonates also affect the response of some herbicides. Also, the growth of crops can be adversely affected by using herbicides that have a carryover effect for the subsequent crop year. Excessive tillage readily destroys the weak soil structure of the Harps soil. If the surface is left bare, soil blowing is a hazard as the soil dries.

Improved drainage could increase production in some areas.

The Okoboji soil is poorly suited to some legumes, especially alfalfa. Ponding and frost heave in winter frequently drown out or kill crops. If these soils are used for hay or improved pasture, grasses, such as reed canarygrass, and legumes that can tolerate excessive wetness should be substituted for the species that are more commonly grown. Grazing when the soils are wet causes surface compaction and poor tilth.

Wetness and the high content of lime carbonates are the main limitations if these soils are used for trees and shrubs grown as windbreaks or ornamental plantings. Species that can tolerate these conditions should be selected.

The land capability classification is IIIw.

1133—Colo silty clay loam, channeled, 0 to 2 percent slopes. This nearly level, poorly drained soil is on flood plains adjacent to major streams and rivers. It is frequently flooded for very brief to long periods. It is dissected by oxbows and meandering stream channels and is among the first soils to be flooded when streams overflow their banks. Most areas range from about 25 to 100 acres in size and are long and somewhat narrow. Areas where oxbows are more numerous, however, are wider.

Typically, the surface layer is black, firm silty clay loam about 7 inches thick. The subsurface layer is firm silty clay loam about 45 inches thick. The upper part is black, and the lower part is very dark gray. The substratum to a depth of about 60 inches is mottled very dark gray, dark gray, and olive gray clay loam. In some places the substratum is calcareous. In other places the surface layer is overlain by about 12 inches of recently deposited silt loam.

Included with this soil in mapping are a few small areas of Millington and Spillville soils adjacent to the stream channel. These soils are in the same positions on the landscape as the Colo soil. They contain less clay than the Colo soil. Millington soils are calcareous throughout. Included soils make up about 15 percent of the unit.

Permeability is moderate in the Colo soil, and runoff is slow. This soil has a seasonal high water table. Available water capacity is high. The content of organic matter in the surface layer is about 5 to 7 percent. The subsurface layer generally has a medium supply of available phosphorus and a very low supply of available potassium.

Flooding is frequent on this soil. As a result, most areas support grasses and trees. If flooding is not too severe, most areas provide good grazing for livestock. Some low-lying areas, however, have been left idle. These areas provide habitat for wildlife.

In areas used as pasture, overgrazing or grazing when the soil is too wet causes surface compaction and poor tilth. Proper stocking rates, pasture rotation, and timely deferment of grazing during wet periods help to keep the pasture in good condition.

The land capability classification is Vw.

1458—Millington silt loam, channeled, 0 to 2 percent slopes. This nearly level, poorly drained, calcareous soil is on flood plains along the larger streams. It is subject to frequent flooding for brief periods. Areas range from 5 to more than 100 acres in size and are irregularly shaped.

Typically, the surface layer is black, friable silt loam about 3 inches thick. The subsurface layer is black, calcareous, friable silty clay loam about 11 inches thick. It has thin strata of very fine sand or silt. The subsoil is about 18 inches thick. It is black, very dark gray, and dark grayish brown, calcareous, friable loam and has a few thin strata of very fine sand. The substratum to a depth of about 60 inches is very dark gray and dark gray, calcareous loam. It has thin strata of very fine sand in the upper part.

Permeability is moderate, and runoff is slow. Available water capacity is high. This soil has a seasonal high water table and is flooded in early spring in most years and whenever abnormally high rains occur. Old meander channels and oxbows typically hold water well into the summer. The content of organic matter in the surface layer is about 4 to 6 percent. The subsoil generally has a low supply of available phosphorus and a very low supply of available potassium.

Almost all of the acreage of this soil supports trees. Some areas have a thick stand of trees and are excellent habitat for upland and woodland wildlife. Old meanders and oxbows provide habitat for wetland wildlife. In areas where the stands of trees are thin and some grass grows, this soil is used as pasture. Because of the frequency and duration of flooding, the soil is unsuited to row crops, small grain, or legumes for hay and pasture. Some grasses are suitable for pasture, but in most areas the use of machinery is difficult or impossible.

The main trees on this soil are silver maple, willow, box elder, and cottonwood. Under present management, these species provide very little economic return, but areas of this soil provide good wildlife habitat. Using appropriate timber stand improvement methods could improve sites for potential economic production of woodland and enhance wildlife habitat. Such methods include selective harvesting; removing the less desirable species; and planting the more desirable species, such as green ash, black walnut, cedar, and varieties of poplar, including cottonwood.

The land capability classification is Vw.

1585—Coland-Spillville complex, channeled, 0 to 2 percent slopes. These nearly level, poorly drained and somewhat poorly drained soils are on flood plains adjacent to major streams and rivers. They are subject to frequent flooding for brief or very brief periods. Areas are dissected by oxbows and meandering stream channels. These soils are among the first to be flooded when streams overflow their banks. Most areas range from 25 to 50 acres in size and are long and somewhat narrow. The two soils occur as areas so intricately mixed or so small that mapping them separately is impractical.

Typically, the surface layer of the Coland soil is black, friable clay loam about 9 inches thick. The subsurface layer also is black, friable clay loam. It is about 52 inches thick. Below this is a transitional layer of very dark gray, mottled, friable clay loam about 10 inches thick. The substratum to a depth of about 60 inches is dark gray clay loam. It is mottled.

Typically, the surface layer of the Spillville soil is black, friable loam about 9 inches thick. The subsurface layer is friable loam about 43 inches thick. The upper part is black; the next part is black, very dark brown, and very dark grayish brown; and the lower part is very dark grayish brown and is mottled. The substratum to a depth of about 60 inches is mottled dark grayish brown and brown loam. In places the substratum is dark grayish brown sandy loam.

Included with these soils in mapping are some small areas of the calcareous Millington soils. These included soils are in and adjacent to old bayous. They are stratified, silty soils. They make up about 10 percent of the unit.

Permeability is moderate in the Coland and Spillville soils, and runoff is slow. These soils have a seasonal high water table. Available water capacity is high on both soils. The content of organic matter in the surface layer is about 4 to 7 percent. The subsurface layer of both soils generally has a very low supply of available phosphorus and potassium.

Flooding is frequent on these soils. As a result, most areas support grasses and trees. If flooding is not too severe, most areas provide good grazing for livestock. Some low-lying areas, however, have been left idle. These areas provide habitat for wildlife.

In areas used as pasture, overgrazing or grazing when the soils are too wet causes surface compaction and poor tilth. Proper stocking rates, pasture rotation, and timely deferment of grazing during wet periods help to keep the pasture in good condition.

The land capability classification is Vw.

1707B—Delft-Terril complex, 2 to 5 percent slopes. These gently sloping soils are on foot slopes and in narrow concave swales and intermittent drainageways in the uplands. The poorly drained Delft soil is near the center of the mapped areas, and the well drained Terril soil is at the base of upland slopes along the boundary of the mapped areas. Individual areas of these soils typically range from about 4 to 8 acres in size and are elongated. They are about 50 percent Delft soil, 40 percent Terril soil, and 10 percent soils of minor extent. The Delft and Terril soils occur as areas so intricately mixed or so small that mapping them separately is not practical.

Typically, the surface layer of the Delft soil is black, friable clay loam about 10 inches thick. The subsurface layer is friable clay loam about 34 inches thick. The upper part is black, and the lower part is very dark gray and is mottled. The subsoil to a depth of about 60 inches is mottled very dark gray, dark olive gray, and olive gray, firm clay loam.

Typically, the surface layer of the Terril soil is black, friable loam about 9 inches thick. The subsurface layer is friable loam about 28 inches thick. The upper part is black, and the lower part is black, dark brown, very dark brown, and very dark grayish brown. The subsoil to a depth of about 60 inches is friable loam. The upper part is brown, and the lower part is dark yellowish brown.

Included with these soils in mapping are small areas of the somewhat poorly drained Spillville soils on foot slopes. These included soils are in positions on the landscape between those of the Terril and Delft soils. They make up about 10 percent of the unit.

Permeability is moderately slow in the Delft soil and moderate in the Terril soil. Runoff is slow on the Delft soil and moderate on the Terril soil. Available water capacity is high in both soils. The Delft soil has a seasonal high water table. The content of organic matter in the surface layer of the Delft soil is about 5 to 8 percent. The content of organic matter in the surface layer of the Terril soil is about 4 to 5 percent. The subsoil of the Delft soil generally has a low or very low supply of available phosphorus and potassium. The subsoil of the Terril soil generally has a very low supply of available phosphorus and a low or very low supply of available potassium.

Most areas are cultivated. If the Delft soil is adequately drained, these soils are well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Most areas receive runoff from adjacent side slopes and thus are subject to siltation. Accumulated water runs across the Delft soil. Diversions and grassed waterways help to control erosion and prevent gullying. A drainage system reduces wetness, improves the timeliness of fieldwork, and helps to maintain tilth. Maintaining tilth generally is easy on the Terril soil but is more difficult on the Delft soil, especially if the soil is worked when wet.

These soils are well suited to pasture plants or hay. Varieties that can tolerate the periodic wetness should be seeded. Overgrazing or grazing when the soils are wet causes surface compaction and poor tilth and reduces forage production.

The land capability classification is IIw.

5010—Pits, sand and gravel. This map unit consists of areas where sand and gravel occur in sufficient quality and quantity to warrant their removal. Areas of sand and gravel occur on level or nearly level stream terraces and in areas of glacial outwash. Individual areas of this unit range from 2 to 30 acres in size and are irregularly shaped. Some pits are abandoned because most of the gravel suitable for road surfacing has been removed.

The sand and gravel are strip mined, and the areas now have little value as farmland. Some of these areas could be reclaimed for farmland if they were leveled and the overburden returned. Most of the water-filled abandoned pits support a variety of 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 bass, smallmouth bass, sunfish, and northern pike. A large area of several pits near the town of Leland is maintained as a park and is intensively used for fishing.

The primary use of this unit is for recreation, but some areas are on private property. If the areas are landscaped and trees, shrubs, and grasses are planted, the potential for picnicking, hunting, fishing, snowmobiling, motorcycle trails, and camping is excellent.

No land capability classification is assigned.

5040—Orthents, loamy. These nearly level to moderately sloping, somewhat excessively drained to moderately well drained soils are in areas that have been cut and filled. Individual areas of this unit range from 1 to 15 acres in size and are rectangular.

Typically, the cut areas have soil profiles and characteristics similar to those of the Storden soils. The upper 5 feet is yellowish brown and grayish brown, friable and firm, calcareous loam. In some areas, however, cuts are deeper and seasonal wetness is a problem. Cobbles 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 color of the surface layer in these areas ranges from very dark gray to dark brown.

Many cut and fill sites are on the edge of fields adjacent to roads and paved highways. In many places small pockets of sand and gravel have been removed for roadfill or for use on building sites. Some areas are used as cropland. Generally, the sites are very low in organic matter content and available nutrients. Most areas have very poor tilth. Many areas have poor bearing capacity and do not readily support farm equipment as soon after rains or during the wetter periods as the adjacent soils. Returning crop residue to the soil and regularly adding other organic material improve tilth, slow drying, and increase the available water capacity.

Filled areas have a variety of soil characteristics, depending on the source of the fill material. Many fill areas are not used for agricultural purposes. Most are used for building up areas for roads or building sites. They are mainly built up to a level surface. A few areas have fairly steep marginal slopes. Onsite investigation is needed to determine engineering properties for construction uses.

No land capability classification is assigned.

5043—Orthents, loamy, reclaimed, 2 to 9 percent slopes. These nearly level to moderately sloping, somewhat excessively drained to moderately well drained soils are in former gravel pits that have been filled and partially leveled. Individual areas range from about 5 to 100 acres in size and are irregularly shaped.

Typically, these areas have soil profiles that are similar to those of the Estherville, Salida, and Storden soils. Most areas have a restored surface layer that is about 4 to 8 inches thick. It consists of the original surface soil mixed with loamy or gravelly substratum material. The surface texture typically is loam or sandy loam that contains varying amounts of gravel particles. The color typically ranges from very dark grayish brown to yellowish brown. The substratum ranges from yellowish brown loam to sand and gravel.

Some areas are used for row crops, but other areas support grass. In a few areas, trees and brush have become established. These sites are generally very low in organic matter content and available nutrients. Most have poor tilth. Some have poor bearing capacity and do not readily support farm equipment, especially when they are wet and during periods immediately after rains. Some slightly depressional areas are subject to ponding and dry slowly. Eliminating low areas by grading would improve the suitability of these areas for row crops and would make them easier to manage. Returning crop residue to the soil and regularly adding other organic material improve tilth, slow drying, and increase the available water capacity.

No land capability classification is assigned.

Prime Farmland

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

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

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

About 180,000 acres in the survey area, or nearly 70 percent of the total acreage, meets the soil requirements for prime farmland. Scattered areas of this land are throughout the county, but most are in the southern part, mainly in associations 1, 2, 4, and 6, which are described under the heading "General Soil Map Units."

A recent trend in land use in some parts of the county has been the loss of some prime farmland to industrial and urban uses. The loss of prime farmland to other uses puts pressure on marginal lands, which generally are more erodible, droughty, and less productive and cannot be easily cultivated.

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

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

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Use and Management of the Soils

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

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

Information in this section can be used to plan the use and management of soils for crops and pasture; as woodland; as sites for buildings, sanitary facilities, highways and other transportation systems, and parks and other recreational facilities; and for wildlife habitat. It can be used to identify the potentials and limitations of each soil for specific land uses and to help 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 Natural Resources Conservation Service is explained; and the estimated yields of the main crops and hay and pasture plants are listed for each soil.

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

In 1986, 240,800 acres in Emmet County was used for agricultural purposes (Iowa Department of Agriculture, 1986). Of this total, approximately 131,000 acres was used for corn, 92,700 acres for soybeans, 9,200 acres for oats, and 4,500 acres for hay. The rest of the acreage was woodland, idle land, farmsteads, or roads or was used for miscellaneous crops.

Erosion is a major problem on about 101,685 acres, or 40.2 percent, of the cropland and pasture in the county. If the slope is 3 percent or greater, erosion caused by water runoff is a hazard. Measures that control erosion are needed on Clarion, Dickman, Lester, Salida, Storden, Terril, Vinje, and Zenor soils.

Loss of the surface layer through erosion reduces the productivity of soils and results in sedimentation in streams and lakes. Productivity is reduced as the surface layer is lost and part of the subsoil is incorporated into the surface layer. Loss of the surface layer is especially damaging on soils in which the subsurface layers are very low in fertility. Storden soils are examples. Erosion on soils that have a fine textured subsoil, such as Vinje soils, exposes soil material that is lower in fertility, has poor tilth, and has a lower rate of water infiltration. As a result, preparing a good seedbed is much more difficult than on other soils and the hazard of erosion is much more severe. Erosion also reduces the productivity of soils that tend to be droughty, such as Dickman, Linder, Ridgeport, and Salida soils. Controlling erosion helps to maintain the productivity of the soils and improves the quality of water for municipal and recreational uses and for

Figure 16.—Corn and soybeans planted in alternate strips on ridges in an area of Nicollet loam, 1 to 3 percent slopes. Clarion loam, 2 to 5 percent slopes, is in the background.

fish and other kinds of wildlife.

Erosion-control practices provide a protective surface cover, reduce the runoff rate, and increase the rate of water infiltration. A cropping system that keeps vegetative cover on the soil for extended periods can hold soil losses to amounts that will not reduce the productive capacity of the soils. On livestock farms, including legume and grass forage crops in the cropping system reduces the hazard of erosion on sloping land and also provides nitrogen and improves tilth for the following crops.

A system of conservation tillage that leaves crop residue on the surface is effective in controlling erosion. The major kinds of conservation tillage systems include no-till, strip-till or till plant, and chisel-disk or rotary tillage. No-till, or slot or zero tillage, is a system in which the seedbed is prepared and the seed planted in one operation. The surface is disturbed only in the immediate area of the planted seed row. A protective cover of crop residue is left on 90 percent of the soil surface. Strip-till or till plant, or ridge planting, also is a system in which the seedbed is prepared and the seed planted in one operation (fig. 16). Tillage 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 surface. Chisel-disk or rotary tillage is a system in which the soil is loosened throughout the field and part of the crop residue is incorporated into the soil. Preparing the seedbed and planting may be one or separate operations. Conservation tillage is effective only if the amount of crop residue left on the surface after planting is enough to control erosion.

Terraces and diversions reduce the length of slopes and thus reduce the runoff rate and the hazard of erosion. They are most practical on deep, well drained soils that have long, uniform slopes. In places, gully-control structures and grassed waterways are needed (fig. 17). Grassed waterways slow runoff, trap sediments, and prevent gullies. In Emmet County the slopes generally are not very uniform, but many areas are suited to terraces, including areas of Clarion, Lester, and Storden soils. Other soils, such as Vinje soils, are less suited because they have a fine textured subsoil; but terraces are still feasible in some areas. Terraces generally are not practical on soils that are coarse textured or moderately coarse textured in the surface layer or are shallow to such textures. These soils include Dickman, Ridgeport, and Salida soils.

Soil blowing is a serious hazard in areas of Dickman, Estherville, Ridgeport, and Salida soils. It is a somewhat less serious hazard in areas of Biscay, Harps, and Linder soils. Except for the Harps soils, these soils tend to dry quickly, and the sandy material in the surface layer is readily blown by the wind. Harps soils are susceptible to soil blowing because they have weak structure. Blowing sand can damage young plants growing on these soils in a few hours if winds are strong and the surface is bare. Soil blowing is also a serious hazard on the organic Blue Earth, Calcousta, Muskego, and Palms soils if the surface layer is left bare. Soil blowing can be controlled by maintaining a plant cover, providing surface mulch, or using tillage methods that keep the surface rough. Organic soils are particularly susceptible to soil blowing if they are tilled in the fall. On these soils, establishing windbreaks of suitable shrubs helps to control soil blowing.

Drainage is a management need on 104,280 acres, or 41 percent, of the soils used for crops and pasture in Emmet County. The very poorly drained Blue Earth, Calcousta, Muskego, Okoboji, and Palms soils are so wet in their natural state that production of crops common to the county generally is not possible. These soils make up about 25,915 acres in the county. Most of the acreage of these soils has been artificially drained and is presently being cropped. In extremely wet years, however, many areas are flooded and crops are lost or are not planted. The poorly drained soils, such as Biscay, Canisteo, Coland, Colo, Delft, Harps, Talcot, Waldorf, and Webster soils, are so wet that unless they are artificially drained crops are damaged in most years. These soils make up about 78,365 acres. All of these soils are more productive and can be more easily managed if they are drained. Except for areas of Colo soils, most areas have been drained. Improved

Figure 17.—This water- and sediment-control basin helps to control erosion and sedimentation in the waterway. Bromegrass grown in an area of Clarion loam, 5 to 9 percent slopes, moderately eroded, below the structure provides additional protection from runoff and erosion.

drainage is needed in some places.

The design of both surface and subsurface drainage systems varies depending on the kind of soil. Intensive row cropping on the very poorly drained soils generally requires a combination of tile drainage and surface intakes and, in some places, surface drainage. Tile drains generally are adequate on the poorly drained soils. Drains should be more closely spaced in soils that have slow or very slow permeability than in the more permeable soils. Care is needed to avoid overdraining soils that formed in outwash or soils that have a sandy substratum, such as Biscay soils. Tile drainage is very slow in Okoboji and Waldorf soils because these soils have a fine textured subsoil and many outlets that are not satisfactory. Finding satisfactory outlets for a tile drainage system is also difficult in some areas of very poorly drained soils, such as Blue Earth, Muskego, and Palms soils. In many areas of the poorly drained Coland and Colo soils, satisfactory outlets for tile are not available. Adequate outlets for drains generally are more readily available on other poorly drained soils, but in many areas improved drainage is needed for optimum crop production. Information on the design and application of erosion-control practices and drainage systems for each kind of soil is available at the local office of the Natural Resources Conservation Service.

Organic soils oxidize and subside when their pore space is filled with air. Drainage systems that keep the water table at a level required for crops during the growing season and raise the water level to the surface during other parts of the year minimize the oxidation and subsidence of these soils. Such drainage systems are generally not available, however, and after a few years the tile in some areas becomes too shallow for satisfactory drainage.

Soil fertility is determined by the supply of available phosphorus and potassium in the subsoil, by the pH level, and by the content of organic matter in the surface layer. The supply of available phosphorus is low or very low in most of the soils in the county. In most of the soils in the county, reaction ranges from slightly acid or neutral to moderately alkaline in the subsoil. In a few soils that formed under native vegetation of mixed trees and grass, such as Lester soils, reaction in the subsoil ranges to medium acid. Applications of ground limestone are needed in areas of these soils and in many other soils in the county to raise the pH level sufficiently for crops, particularly alfalfa. On all soils, additions of limestone and fertilizer should be based on the results of soil tests, on the needs of the crop, and on desired yields.

Many soils in Emmet County contain excess carbonates in the surface layer and throughout the solum. These include the Blue Earth, Canisteo, Crippin, Harps, Salida, and Storden soils. The high pH level of these soils also reduces the level of available phosphorus, potassium, and some micronutrients. Harps soils have a particularly low supply of these nutrients.

The amount of nitrogen available to plants is related to the content of organic matter. Most of the well drained and somewhat poorly drained upland soils that formed under native vegetation of prairie grass, such as Clarion and Nicollet soils, have a moderate or high content of organic matter. Storden soils, however, generally have a very low content of organic matter. The very poorly drained Blue Earth, Calcousta, Muskego, Okoboji, and Palms soils have a very high content of organic matter. The poorly drained soils have a high content of organic matter. Soils that formed under native vegetation of mixed trees and grass generally have a lower content of organic matter than soils that have similar drainage and texture characteristics but that formed under prairie grasses. The well drained Lester soils, for example, have a low to moderate content of organic matter. Eroded soils generally have a very low organic matter content. Moderately coarse textured soils, such as Dickman, Estherville, Ridgeport, and Salida soils, have a very low or low content of organic matter.

Except for Biscay, Dickman, Estherville, Linder, Ridgeport, Salida, and Zenor soils, which have a limited available water capacity, most soils in Emmet County have a high or very high available water capacity and generally are very productive if adequate amounts and proper ratios of fertilizer are applied. The application of herbicides and the rate of application are affected by the content of organic matter, the pH level, carbonates, and soil texture. Applications of both lime and fertilizers should be based on the results of soil tests, on the needs of the intended crops, and on the expected yields. 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, in the infiltration of water into the soil, and in the preparation of good seedbeds. Soils that have good tilth generally have a high content of organic matter and are granular and porous.

Many of the well drained and somewhat poorly drained soils used for intensive row cropping have a surface layer of loam. Clarion and Nicollet soils are examples. The lighter colored Lester soils also have a surface layer of loam, but they are lower in organic matter content, have weaker surface structure, and have a greater tendency to form a crust during periods of intense rainfall. The crust is hard when dry. It reduces the rate of water infiltration and increases the rate of runoff. Other soils, such as Storden soils, are also low or very low in organic matter content and have poor tilth. Intense rainfall readily runs off the surface of these soils and results in erosion. Regular additions of crop residue, manure, and other organic material improve soil structure and help to prevent crusting. Crop rotations that include legumes and grasses improve tilth and reduce the hazard of erosion. The finer textured, well drained soils, such as Vinje soils, generally have somewhat poorer tilth than the well drained, medium textured soils. They generally are sticky when wet and hard and cloddy when dry. Careful management and timely fieldwork are needed to maintain good seedbeds on these soils. These soils also can benefit from regular additions of organic material, such as crop residue and manure. Crop rotations that include legumes and grasses are also highly beneficial on these soils. They can improve tilth and reduce the hazard of erosion.

Preparing a good seedbed is somewhat difficult on the somewhat poorly drained Collinwood and poorly drained Waldorf soils, which have a high clay content in the surface layer. Fall plowing is common on these soils and in many other areas of poorly drained soils. Freezing and thawing promote good tilth, and thus good seedbeds are more easily obtained than if the soils are plowed in the spring. If large areas are plowed in the fall, however, 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 control soil blowing. Chisel plowing is an alternate method of tillage that is effective in controlling soil blowing. Ridge planting is also very suitable in areas of these soils.

Most of the permanent pastures in the county consist of bluegrass, but many also support trees and brush. Some pastures have been renovated and consist of legume-grass mixtures, such as alfalfa and bromegrass. Most of the areas that are used as pastures are not practical for use as cropland because the soils are too steep for cultivation, are too wet, or are frequently flooded or because the soils support trees.

Forage production could be improved by pasture renovation, which would establish the more productive grasses and legumes. Improved drainage is needed in many areas, and in some areas removing or thinning brush and trees may be needed. Forage production could also be enhanced by planting warm-season grasses, including switchgrass, big bluestem, and indiangrass. The management needed for established stands includes applications of fertilizer, control of weeds and brush, rotation and deferred grazing in a full-season grazing system, proper stocking rates, and adequate livestock watering facilities. Erosion is a serious hazard in areas that have steep slopes if the protective plant cover is destroyed when pasture and hayland are renovated. If cultivated crops are grown prior to reseeding, soil losses can be minimized by contour farming, grassed waterways, and a system of conservation tillage or no-till farming that leaves crop residue on the surface. Interseeding grasses and legumes into the existing sod eliminates the need for destroying the plant cover during seedbed preparation.

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 are the most common close-growing crops, but wheat, barley, rye, 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 small acreage of sweet corn and canning peas. Sunflowers are sometimes grown when hail or wetness destroys or delays the planting of other crops, such as soybeans. Most of the upland soils are suited to a variety of specialty crops, such as orchards and trees. Some of the organic soils are 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 6. In any given year, yields may be higher or lower than those indicated in the table because of variations in rainfall and other climatic factors. The land capability classification also is shown in the table.

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

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

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

Land Capability Classification

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

In the capability system, soils are generally grouped at three levels—capability class, subclass, and unit (USDA, 1961). Only class and subclass are used in this survey.

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

Class I soils have few limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants or that require special conservation practices, or both.

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

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

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

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

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

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 hazard is the risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is very cold or very dry.

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

The capability classification of the map units in this survey area is given in the section "Detailed Soil Map Units" and in the yields table.

Corn Suitability Rating (CSR)

The corn suitability rating for each soil is given in table 6. Corn suitability ratings provide a relative ranking of all soils mapped in the state of Iowa based on their potential to be utilized for the intensive production of row crops. The CSR is an index that can be used to rate the potential production of one soil compared with another over a period of time. The CSR considers average weather conditions and frequency of use of the soil for row crops. Ratings range from 5 for soils that have severe limitations affecting the production of row crops to 100 for soils that have no physical limitations, have minimal slopes, and can be continuously row cropped. The ratings listed in table 6 assume adequate management, natural weather conditions (no irrigation), artificial drainage where required, and no land leveling or terracing. They also assume that soils lower on the landscape are not affected by frequent, damaging floods. The weighted CSR for a given field can be modified by the occurrence of sandy spots, local deposits, rock and gravel outcrops, field boundaries, and noncrossable drainageways. Even though predicted average yields will change with time, the CSR's are expected to remain relatively constant in relation to one another.

The CSR's in Emmet County range from 84 for Spillville loam, 0 to 2 percent slopes, to 5 for several soils, including Salida gravelly loamy sand, 5 to 9 percent slopes, moderately eroded. No ratings are provided for miscellaneous areas because of the variability of properties and use of these areas.

Woodland Management and Productivity

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

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

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

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

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

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

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

Plant competition ratings indicate the degree to which undesirable species are expected to invade and grow when openings are made in the tree canopy. The main factors that affect plant competition are depth to the water table and the available water capacity. A rating of *slight* indicates that competition from undesirable plants is not likely to prevent natural regeneration or suppress the more desirable species. Planted seedlings can become established without undue competition. A rating of *moderate* indicates that competition may delay the establishment of desirable species. Competition may hamper stand development, but it will not prevent the eventual development of fully stocked stands. A rating of *severe* indicates that competition can be expected to prevent regeneration unless precautionary measures are applied.

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

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

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

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

Windbreaks and Environmental Plantings

Windbreaks protect livestock, buildings, and yards from wind and snow. They also protect fruit trees and gardens, and they furnish habitat for wildlife. Several rows of low- and high-growing broadleaf and coniferous trees and shrubs provide the most protection (fig. 18).

Field windbreaks are narrow plantings made at right angles to the prevailing wind and at specific intervals across the field. The interval depends on the erodibility of the soil. Field windbreaks protect cropland and crops from wind, help to keep snow on the fields, 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 ensure plant survival, a healthy planting stock of suitable species should be planted properly on a well prepared site and maintained in good condition.

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

Recreation

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

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

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

Camp areas require site preparation, such as shaping and leveling the tent and parking areas, stabilizing roads and intensively used areas, and installing sanitary facilities and utility lines. Camp areas are subject to heavy foot traffic and some vehicular traffic. The best soils are gently sloping 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

Figure 18.—An older, established windbreak on the right is being improved by additional rows of evergreens in the middle and shrubs and deciduous trees on the left.

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 should be considered.

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

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

Wildlife Habitat

Emmet County has a large and varied population of wildlife. White-tailed deer, squirrel, ringneck pheasant, Hungarian partridge, and various species of waterfowl are the main game in the county, although there are many other species of mammals and birds. Of the waterfowl, teal and woodducks appear to be among the more consistently plentiful. Fishing generally is limited to gravel pits, the Winnebago River, and Rice Lake. Smallmouth bass, catfish, northern pike, bullheads, and sunfish are the main species.

In the past, waterfowl habitat in the county was excellent. Intensive farming and the draining of many small sloughs and potholes have reduced the extent of this habitat, but many migratory ducks and geese continue to rest and feed each fall in the remaining wetlands, particularly in the Cheever, Eagle, High, Ingham, Iowa, Tuttle, and Twelve Mile Lake areas (fig. 19). Canada geese have been reintroduced around Ingham and High Lakes, and many nest in nearby wetlands.

Most of the white-tailed deer and squirrels are in the wooded areas, but many squirrels are also around farmsteads. Some deer are also attracted to brushy areas near drainage ditches, along small streams, and in marshy areas. Cottontail rabbit, red fox, mink, beaver, muskrat, and raccoon find food and cover in various parts of the county. Among the common songbirds are robins, English sparrows, meadowlarks, blackbirds, mourning doves, purple martins, wrens, chickadees, brown thrashers, 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 weather conditions and 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 pheasants. The best pheasant range is probably in areas of association 5, which is shown on the general soil map and described under the heading "General Soil Map Units." These areas include steep land with more desirable cover, and some contain or are adjacent to wet marshy areas that provide the needed winter cover as well as nesting areas along the edges of fields.

Pheasants are somewhat less abundant in areas of the other 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 pheasants in winter or for nesting.

Nesting cover is the most critical factor affecting the number of pheasants. The most successful nestings in intensively farmed areas are in road ditches and along fence lines, but these areas are few and produce only a limited number of pheasants. 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 summer.

Winter cover can be provided through farmstead windbreaks and wildlife plantings. Winter cover should be near a source of food. A few rows of grain left in a field adjacent to a windbreak or other wildlife planting would provide excellent habitat conditions.

Small, odd-shaped areas that are unsuitable for farming can provide excellent wildlife habitat. The strongly sloping to steep Storden soils and the moderately steep and steep Salida soils, as well as marshes and depressional soils, are most likely to have these odd areas. Other soils may have small, steep, severely eroded or gravelly areas used as cropland or may have small gravel pits, railroad right-of-ways, or tracts of land cut off from the rest of a field by a stream or drainage ditch. Such areas are also well suited to wildlife habitat.

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

Maintenance of the wildlife area is most important. Areas should not be mowed before midsummer so that the ground-nesting birds and rabbits are protected. Controlling invading woody plants by chemical or mechanical means may be necessary to maintain an adequate ground cover of grasses and legumes. Reseeding is needed occasionally. Additional information and assistance with planting and maintaining wildlife areas that will provide good nesting, adequate food, and weather protection are available from the Natural Resources Conservation Service or from 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 10, the soils in the survey area are rated

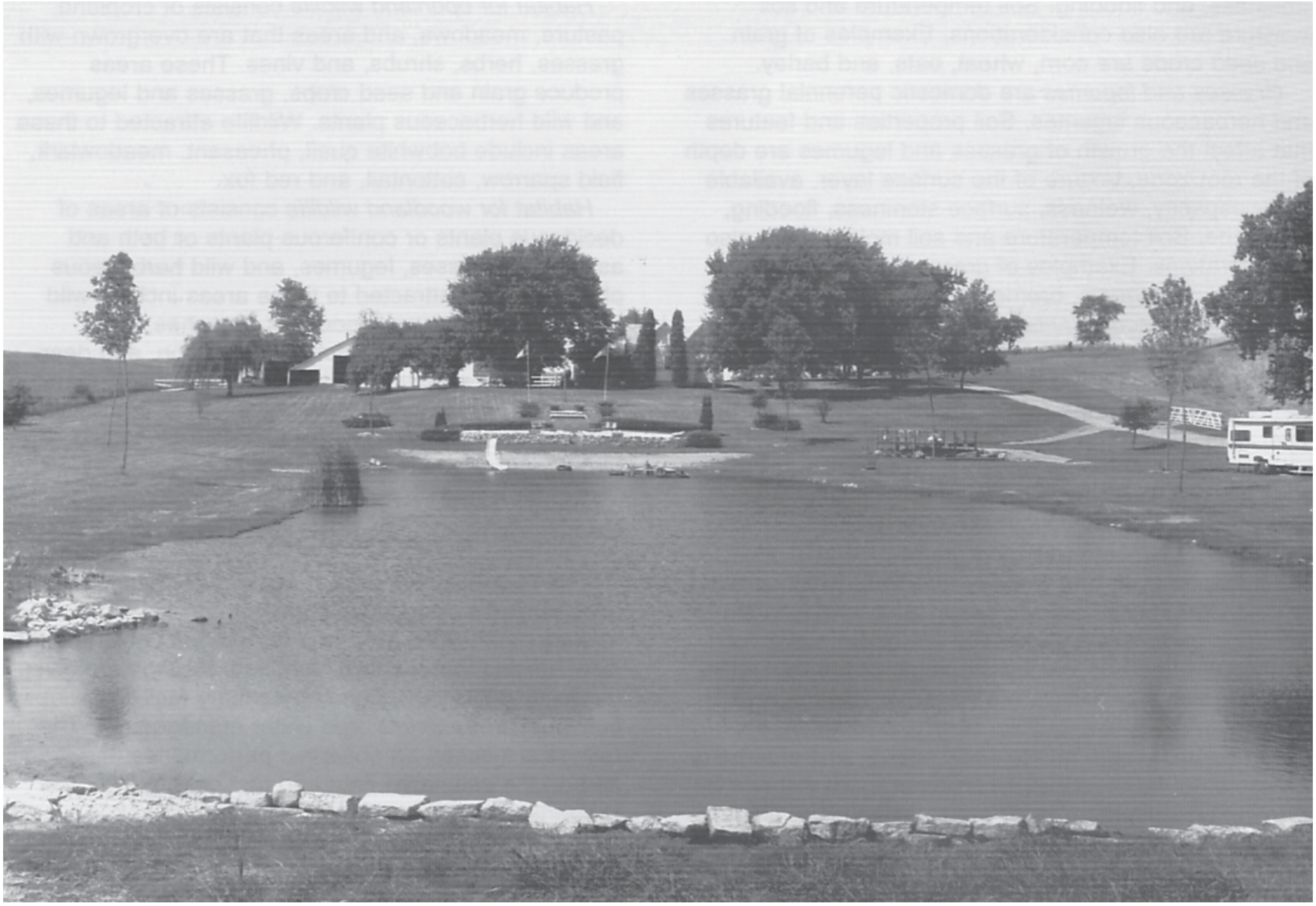

Figure 19.—A dugout pond in an undrained area of Okoboji silty clay loam, 0 to 1 percent slopes. Ponds such as this one provide recreation, water for livestock, and fire protection for the farmstead and are important for wildlife habitat.

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

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

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

Grain and seed crops are domestic grains and seed-producing herbaceous plants. Soil properties and features that affect the growth of grain and seed crops are depth of the root zone, texture of the surface layer, available water capacity, wetness, slope, surface stoniness, and flooding. Soil temperature and soil moisture 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, flooding, 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 flooding. 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, available water capacity, and wetness. Examples of these plants are oak, poplar, cherry, sweetgum, 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 and seeds. Soil properties and features that affect the growth of coniferous trees, shrubs, and ground cover are depth of the root zone, available water capacity, and wetness. Examples of coniferous plants are pine, spruce, fir, cedar, and juniper.

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

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

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

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

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

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

Engineering

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

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

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

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

Soil properties, site features, and observed performance were considered in determining the ratings in this section. During the fieldwork for this soil survey, determinations were made about grain-size distribution, liquid limit, plasticity index, soil reaction, depth to bedrock, hardness of bedrock within 5 or 6 feet of the surface, soil wetness, depth to a seasonal high water table, slope, likelihood of flooding, natural soil structure aggregation, and soil density. Data were collected about kinds of clay minerals, mineralogy of the sand and silt fractions, and the kinds 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 evaluate the potential of areas for residential, commercial, industrial, and recreational uses; make preliminary estimates of construction conditions; evaluate alternative routes for roads, streets, highways, pipelines, and underground cables; evaluate alternative sites for sanitary landfills, septic tank absorption fields, and sewage lagoons; plan detailed onsite investigations of soils and geology; locate potential sources of gravel, sand, earthfill, and topsoil; plan drainage systems, irrigation systems, ponds, terraces, and other structures for soil and water conservation; and predict performance of proposed small structures and pavements by comparing the performance of existing similar structures on the same or similar soils.

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

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

Building Site Development

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

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

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

Local roads and streets have an all-weather surface and carry automobile and light truck traffic all year. They have a subgrade of cut or fill soil material; a base of gravel, crushed rock, or stabilized soil material; and a flexible or rigid surface. Cuts and fills are generally limited to less than 6 feet. The ratings are based on soil properties, site features, and observed performance of the soils. Depth to bedrock, 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, the available water capacity in the upper 40 inches, and the content of calcium carbonate affect plant growth. Flooding, wetness, slope, stoniness, and the amount of sand, clay, or organic matter in the surface layer affect trafficability after vegetation is established.

Sanitary Facilities

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

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

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

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

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

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

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

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

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

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

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

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

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

Construction Materials

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

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

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

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

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

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

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

A soil rated as a probable source has a layer of clean sand or gravel or a layer of sand or gravel that is 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 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, and bedrock.

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 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 high water table at or near the surface.

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

Water Management

Table 14 gives information on the soil properties and site features that affect water management. The degree and kind of soil limitations are given for pond reservoir areas; embankments, dikes, and levees; and aquifer-fed excavated ponds. 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, 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.

Aquifer-fed excavated ponds are pits or dugouts that extend to a ground-water aquifer or to a depth below a permanent water table. Excluded are ponds that are fed only by surface runoff and embankment ponds that impound water 3 feet or more above the original surface. Excavated ponds are affected by depth to a permanent water table, permeability of the aquifer, and quality of the water as inferred from the salinity of the soil. Depth to bedrock and the content of large stones affect the ease of excavation.

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 or to other layers that affect the rate of water movement, permeability, depth to a high water table or depth of standing water if the soil is subject to ponding, slope, susceptibility to flooding, subsidence of organic layers, and the potential for frost action. Excavating and grading and the stability of ditchbanks are affected by depth to bedrock, large stones, slope, and the hazard of cutbanks caving. The productivity of the soil after drainage is adversely affected by extreme acidity. Availability of drainage outlets is not considered in the ratings.

Terraces and diversions are embankments or a combination of channels and ridges constructed across a slope to control erosion and conserve moisture by intercepting runoff. Slope, wetness, large stones, and depth to bedrock affect the construction of terraces and diversions. A restricted rooting depth, a severe hazard of soil blowing 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 affect the construction of grassed waterways. A hazard of soil blowing, low available water capacity, restricted rooting depth, and restricted permeability adversely affect the growth and maintenance of the grass after construction.

Soil Properties

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

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

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

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

Engineering Index Properties

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

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

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

Classification of the soils is determined according to the Unified soil classification system (ASTM, 1993) and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO, 1986).

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

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

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

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

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

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

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

Physical and Chemical Properties

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

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated 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, plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

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

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

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

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

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

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

Shrink-swell potential classes are based on the change in length of an unconfined clod as moisture content is increased from air-dry to field capacity. The classes are *low*, a change of less than 3 percent; *moderate*, 3 to 6 percent; and *high*, more than 6 percent. *Very high*, 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 soil blowing in cultivated areas. The groups indicate the susceptibility to soil blowing. Soils are grouped according to the following distinctions:

1. Coarse sands, sands, fine sands, and very fine sands. These soils are generally not suitable for crops. They are extremely erodible, and vegetation is difficult to establish.

2. Loamy coarse sands, loamy sands, loamy fine sands, loamy very fine sands, and sapric soil material. These soils are very highly erodible. Crops can be grown if intensive measures to control soil blowing are used.

3. Coarse sandy loams, sandy loams, fine sandy loams, and very fine sandy loams. These soils are highly erodible. Crops can be grown if intensive measures to control soil blowing are used.

4L. Calcareous loams, silt loams, clay loams, and silty clay loams. These soils are erodible. Crops can be grown if intensive measures to control soil blowing are used.

4. Clays, silty clays, noncalcareous clay loams, and silty clay loams that are more than 35 percent clay. These soils are moderately erodible. Crops can be grown if measures to control soil blowing are used.

5. Noncalcareous loams and silt loams that are less than 20 percent clay and sandy clay loams, sandy clays, and hemic soil material. These soils are slightly erodible. Crops can be grown if measures to control soil blowing are used.

6. Noncalcareous loams and silt loams that are more than 20 percent clay and noncalcareous clay loams that are less than 35 percent clay. These soils are very slightly erodible. Crops can be grown if ordinary measures to control soil blowing are used.

7. Silts, noncalcareous silty clay loams that are less than 35 percent clay, and fibric soil material. These soils are very slightly erodible. Crops can be grown if ordinary measures to control soil blowing are used.

8. Soils that are not subject to soil blowing because of coarse fragments on the surface or because of surface wetness.

Soil and Water Features

Table 17 gives estimates of various soil and water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are used to estimate runoff from precipitation. Soils not protected by vegetation are assigned to one of four groups. They are grouped according to the infiltration of water when the soils are thoroughly wet and receive precipitation from long-duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a permanent high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to two hydrologic groups in table 17, the first letter is for drained areas and the second is for undrained areas.

Flooding, the temporary inundation of an area, is caused by overflowing streams or by runoff from adjacent slopes. Water standing for short periods after rainfall or snowmelt is not considered flooding, nor is water in swamps and marshes.

Table 17 gives the frequency and duration of flooding and the time of year when flooding is most likely.

Frequency, duration, and probable dates of occurrence are estimated. Frequency is expressed as none, rare, occasional, and frequent. *None* means that flooding is not probable; *rare* that it is unlikely but possible under unusual weather conditions (the chance of flooding is nearly 0 percent to 5 percent in any year); *occasional* that it occurs infrequently under normal weather conditions (the chance of flooding is 5 to 50 percent in any year); and *frequent* that it occurs often under normal weather conditions (the chance of flooding is more than 50 percent in any year). Duration is expressed as *very brief* if less than 2 days, *brief* if 2 to 7 days, *long* if 7 days to 1 month, and *very long* if more than 1 month. Probable dates are expressed in months. About two-thirds to three-fourths of all flooding occurs during the stated period.

The information is based on evidence in the soil profile, namely thin strata of gravel, sand, silt, or clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; and little or no horizon development.

Also considered are local information about the extent and levels of flooding and the relation of each soil on the landscape to historic floods. Information on the extent of flooding based on soil data is less specific than that provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

High water table (seasonal) is the highest level of a saturated zone in the soil in most years. The estimates are based mainly on the evidence of a saturated zone, namely grayish colors or mottles in the soil. Indicated in table 17 are depth to the seasonal high water table; the kind of water table—that is, perched or apparent; and the months of the year that the water table commonly is high. A water table that is seasonally high for less than 1 month is not indicated in table 17.

An *apparent* water table is a thick zone of free water in the soil. It is indicated by the level at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil. A *perched* water table is water standing above an unsaturated zone. In places an upper, or perched, water table is separated from a lower one by a dry zone.

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

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

Potential frost action is the likelihood of upward or lateral expansion of the soil caused by the formation of segregated ice lenses (frost heave) and the subsequent collapse of the soil and loss of strength on thawing. Frost action occurs when moisture moves into the freezing zone of the soil. Temperature, texture, density, permeability, content of organic matter, and depth to the water table are the most important factors considered in evaluating the potential for frost action. It is assumed that the soil is not insulated by vegetation or snow and is not artificially drained. Silty and highly structured, clayey soils that have a high water table in winter are the most susceptible to frost action. Well drained, very gravelly, or very sandy soils are the least susceptible. Frost heave and low soil strength during thawing cause damage mainly to pavements and other rigid structures.

Risk of corrosion pertains to potential soil-induced electrochemical or chemical action that dissolves or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design may be needed if the combination of factors results in a severe hazard of corrosion. The steel in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than steel in installations that are entirely within one kind of soil or within one soil layer.

For uncoated steel, the risk of corrosion, expressed as *low, moderate,* or *high,* is based on soil drainage class, total acidity, electrical resistivity near field capacity, and electrical conductivity of the saturation extract.

For concrete, the risk of corrosion is also expressed as *low, moderate,* or *high.* It is based on soil texture, acidity, and amount of sulfates in the saturation extract.

Classification of the Soils

The system of soil classification used by the National Cooperative Soil Survey has six categories (USDA, 1975). Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. Classification is based on soil properties observed in the field or inferred from those observations or from laboratory measurements. Table 18 shows the classification of the soils in the survey area. The categories are defined in the following paragraphs.

ORDER. Eleven soil orders are recognized. The differences among orders reflect the dominant soil-forming processes and the degree of soil formation. Each order is identified by a word ending in *sol.* An example is Entisol.

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 Aquent (*Aqu*, meaning water, plus *ent*, from Entisol).

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 Fluvaquents (*Fluv*, meaning flood plain, plus *aquent*, the suborder of the Entisols that has an aquic 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. An example is Mollic Fluvaquents.

FAMILY. Families are established within a subgroup on the basis of physical and chemical properties and other characteristics that affect management. Generally, the properties are those of horizons below plow depth where there is much biological activity. Among the properties and characteristics considered are particle-size class, mineral content, temperature regime, depth of the root zone, consistence, moisture equivalent, slope, and permanent cracks. A family name consists of the name of a subgroup preceded by terms that indicate soil properties. An example is fine-silty, mixed (calcareous), mesic Mollic Fluvaquents.

SERIES. The series consists of soils that have similar horizons in their profile. The horizons are similar in color, texture, structure, reaction, consistence, mineral and chemical composition, and arrangement in the profile. The texture of the surface layer or of the substratum can differ within a series.

Soil Series and Their Morphology

In this section, each soil series recognized in the survey area is described. The descriptions are arranged in alphabetic order.

Characteristics of the soil and the material in which it formed are identified for each series. A pedon, a small three-dimensional area of soil, that is typical of the series in the survey area is described. The detailed description of each soil horizon follows standards in the "Soil Survey Manual" (USDA, 1993). Many of the technical terms used in the descriptions are defined in "Soil Taxonomy" (USDA, 1975). 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 soils on stream terraces. These soils formed in loamy material over calcareous sandy sediments. The native vegetation was prairie grasses. Permeability is moderate in the upper part and rapid in the lower part. Slopes are 0 to 2 percent.

Typical pedon of Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes, 1,000 feet east and 480 feet north of the southwest corner of sec. 9, T. 100 N., R. 33 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; neutral; abrupt smooth boundary.

A1—8 to 14 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) dry; weak fine and medium granular structure; friable; neutral; clear smooth boundary.

A2—14 to 19 inches; black (10YR 2/1) and very dark gray (10YR 3/1) clay loam; some dark gray (10YR 4/1) in the upper part; weak medium granular structure; friable; neutral; clear smooth boundary.

Bg1—19 to 25 inches; olive gray (5Y 5/2) and dark gray (5YR 4/1) loam; few fine prominent light olive brown (2.5Y 5/4) mottles; weak fine subangular blocky structure; friable; common fine tubular pores; neutral; clear smooth boundary.

Bg2—25 to 34 inches; olive gray (5Y 5/2) and olive (5Y 5/3) loam; weak medium subangular blocky structure; friable; common fine tubular pores; few dark reddish brown (5YR 3/4) oxide concretions; neutral; clear smooth boundary.

BCg—34 to 38 inches; olive gray (5Y 5/2 and 4/2) sandy loam; weak coarse subangular blocky structure; very friable; few dark reddish brown (5YR 3/4) oxide concretions; few calcium carbonate accumulations in soft rounded masses and occurring as coatings on some pebbles; slight effervescence in places; neutral; gradual wavy boundary.

2C—38 to 60 inches; olive gray (5Y 5/2 and 4/2) gravelly loamy sand; single grained; loose; about 20 percent gravel; few calcium carbonate accumulations in soft rounded masses and occurring as coatings on some pebbles; strong effervescence; moderately alkaline.

The thickness of the solum, the depth to carbonates, and the depth to loamy sand or coarser textured material range from 32 to 40 inches.

The A horizon ranges from 16 to 24 inches in thickness. It has hue of 10YR or 2.5Y, value of 2 or 3, and chroma of 1. The B horizon has hue of 5Y or 2.5Y, value of 4 or 5, and chroma of 1 to 3. It typically is loam or clay loam in the upper part. The lower few inches is commonly sandy loam that contains some gravel. In some pedons the B horizon contains free carbonates in the lower part. The 2C horizon has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 to 6. It is calcareous loamy sand or sand and commonly contains 5 to 35 percent gravel.

Blue Earth Series

The Blue Earth series consists of deep, very poorly drained, moderately permeable soils in depressions and in old shallow lakebeds on uplands. These soils formed in coprogenous earth. The native vegetation was sedges, reeds, and grasses. Slopes range from 0 to 5 percent.

Typical pedon of Blue Earth mucky silt loam, 0 to 1 percent slopes, 1,080 feet east and 2,240 feet north of the southwest corner of sec. 5, T. 99 N., R. 34 W.

Ap—0 to 9 inches; black (N 2/0) mucky silt loam (coprogenous earth), dark gray (10YR 4/1) dry; weak fine and medium granular structure; very friable; few distinct dark brown (7.5YR 4/4) organic stains; common snail-shell fragments; strong effervescence; slightly alkaline; abrupt smooth boundary.

Cg1—9 to 18 inches; black (N 2/0) mucky silt loam (coprogenous earth), dark gray (10YR 4/1) and gray (10YR 5/1) dry; massive; very friable; common prominent yellowish red (5YR 4/6) and dark brown (7.5YR 4/4) organic stains along joints and in old root pores; many snail-shell fragments; few fine plant fibers that disappear on rubbing; violent effervescence; moderately alkaline; clear smooth boundary.

Cg2—18 to 28 inches; very dark gray (5Y 3/1) and dark olive gray (5Y 3/2) mucky silt loam (coprogenous earth), gray (5Y 5/1) dry; massive; very friable; common prominent yellowish red (5Y 4/6) and dark red (2.5YR 3/6) organic stains in old root pores; many snail-shell fragments; few fine plant fibers that disappear on rubbing; violent effervescence; moderately alkaline; diffuse smooth boundary.

Cg3—28 to 45 inches; very dark gray (5Y 3/1) and dark gray (5Y 4/1) mucky silt loam (coprogenous earth), gray (5Y 5/1 and 6/1) dry; massive; very friable; common prominent yellowish red (5YR 4/6) and dark red (2.5YR 3/6) organic stains in old root pores; many snail-shell fragments; violent effervescence; moderately alkaline; clear smooth boundary.

Cg4—45 to 60 inches; black (10YR 2/1) and very dark gray (10YR 3/1) mucky silt loam (coprogenous earth), dark gray (10YR 4/1) and gray (10YR 5/1) dry; few fine prominent reddish brown (5YR 4/4) mottles; massive; very friable; common fine faint very dark brown (10YR 2/2) organic stains; common snail-shell fragments; strong effervescence; slightly alkaline.

The coprogenous earth typically has hue of 10YR, 2.5Y, or 5Y or is neutral in hue. It has value of 2 to 4 and chroma of 0 or 1. It typically is mucky silt loam or mucky silty clay loam. In most pedons decomposed plant fibers are at the surface or below the plow layer. The organic matter content commonly is between 10 and 30 percent. Distinct or prominent mottles and organic stains are common in all layers. The underlying C material contains free carbonates and ranges from very dark grayish brown (2.5Y 3/2) to olive gray (5Y 5/2). The soil material typically is mucky silt loam, but the range includes silty clay loam, loam, or clay loam. Thin layers of sandy material are in some pedons. Olive (5Y 5/3 and 5/4) mottles are common.

Calco Series

The Calco series consists of poorly drained, moderately permeable, calcareous soils on flood plains. These soils formed in silty alluvium. The native vegetation was prairie grasses. Slopes are 0 to 2 percent.

Typical pedon of Calco silty clay loam, 0 to 2 percent slopes, 40 feet east and 980 feet south of the northwest corner of sec. 11, T. 100 N., R. 33 W.

Ap—0 to 9 inches; black (N 2/0) silty clay loam, black (2.5Y 2/1) dry; weak fine and very fine granular structure; friable; few very fine roots; few snail-shell fragments; strong effervescence; moderately alkaline; abrupt smooth boundary.

A1—9 to 22 inches; black (N 2/0) silty clay loam, black (2.5Y 2/1) dry; moderate fine and very fine granular structure; friable; few very fine roots; few snail-shell fragments; strong effervescence; moderately alkaline; diffuse smooth boundary.

A2—22 to 31 inches; black (N 2/0) silty clay loam, black (2.5Y 2/1) dry; few fine distinct olive gray (5Y 4/2) mottles; moderate fine and very fine granular structure; friable; few very fine roots; few fine pores; few snail-shell fragments; strong effervescence; moderately alkaline; gradual smooth boundary.

A3—31 to 38 inches; silty clay loam, 70 percent black (10YR 2/1) and 30 percent very dark gray (10YR 3/1); weak fine subangular blocky and fine and very fine granular structure; friable; few fine roots; few snail-shell fragments; slight effervescence; moderately alkaline; gradual smooth boundary.

AB—38 to 47 inches; silty clay loam, 60 percent black (10YR 2/1) and 40 percent dark grayish brown (10YR 4/2); common fine prominent olive yellow (5Y 5/4) mottles; weak fine subangular blocky structure; friable; few snail-shell fragments; few fine pores; slight effervescence; moderately alkaline; gradual smooth boundary.

Cg—47 to 60 inches; mixed dark gray (5Y 4/1) and gray (5Y 5/1) silty clay loam; few fine distinct olive gray (5Y 4/4) and dark brown (7.5YR 4/4) mottles; massive; friable; few calcium carbonate accumulations in soft rounded masses; few very dark brown (7.5YR 3/2) organic fills in old root channels; few fine yellowish red (5YR 4/6) oxide concretions; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 36 to 50 inches. The mollic epipedon is more than 36 inches thick.

The A horizon ranges from 30 to 50 inches thick. It typically is black (N 2/0 or 10YR 2/1) or very dark gray (10YR 3/1). It is silty clay loam that has a clay content ranging between 28 and 35 percent. An AB or Bg horizon is below a depth of 36 inches in many pedons. This horizon, if it occurs, is black (10YR 2/1) or very dark gray (10YR 3/1) to dark gray (10YR or 5Y 4/1), dark grayish brown (10YR 4/2), or olive gray (5Y 4/2). The Cg horizon typically is dark gray (5Y 4/2) and gray (5Y 5/1) but ranges to grayish brown (2.5Y 5/2). It typically is silty clay loam, but in some pedons it is clay loam or loam.

Calcousta Series

The Calcousta series consists of deep, very poorly drained, moderately permeable soils in basins of former lakes. These soils formed in silty lacustrine sediments on the glacial till plain. The native vegetation was sedges and grasses tolerant of excess wetness. Slopes are 0 to 1 percent.

Typical pedon of Calcousta mucky silt loam, 0 to 1 percent slopes, 2,560 feet east and 120 feet south of the northwest corner of sec. 34, T. 100 N., R. 31 W.

Ap—0 to 10 inches; black (10YR 2/1) mucky silt loam, dark gray (10YR 4/1) dry; weak medium and fine granular structure; very friable; few very fine roots; weak effervescence; slightly alkaline; abrupt smooth boundary.

A—10 to 13 inches; black (10YR 2/1) mucky silt loam, dark gray (10YR 4/1) dry; weak medium and fine granular structure; friable; few very fine roots; weak effervescence; slightly alkaline; abrupt wavy boundary.

Bg—13 to 19 inches; olive gray (5Y 4/2 and 5/2) silty clay loam; a few dark olive gray (5Y 3/2) coatings on faces of some peds; common medium prominent pale olive (5Y 6/4) and few fine distinct olive (5Y 5/4) mottles; weak medium subangular blocky structure; friable; few small pebbles; few very fine roots; few very fine yellowish red (5YR 5/6) oxides;

few strong brown (7.5YR 5/6) fills and coatings in old root pores; few fine tubular pores; strong effervescence; moderately alkaline; gradual smooth boundary.

Cg1—19 to 48 inches; olive gray (5Y 5/2) silty clay loam; common fine prominent strong brown (7.5YR 5/6) mottles; massive; friable; few small pebbles; few dark brown (7.5YR 4/2) fills in old root channels; few fine and very fine root pores; strong effervescence; moderately alkaline; diffuse smooth boundary.

Cg2—48 to 60 inches; olive gray (5Y 5/2) silty clay loam; common medium prominent light olive brown (2.5Y 5/6) mottles; massive; friable; few small pebbles; few thin strata of clay loam; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 10 to 24 inches. The thickness of the mollic epipedon ranges from 8 to 16 inches. Free carbonates are in all parts of the solum and in the C horizon.

The Ap or A horizon is black (N 2/0, 10YR 2/1, or 2.5Y 2/1). It typically is mucky silt loam, but in some pedons it is silty clay loam or silt loam. The Bg horizon has hue of 5Y, value of 4 to 6, and chroma of 1 or 2. It has mottles. It typically is silty clay loam but is silt loam in a few pedons. The Cg horizon has hue of 5Y, value of 5 or 6, and chroma of 1 or 2 and is mottled. The upper part is silty clay loam or silt loam, and the lower part is clay loam. Strata of fine sandy loam are in many pedons, and pockets of fine sand or loam are in some pedons.

Canisteo Series

The Canisteo series consists of poorly drained, moderately permeable soils in the uplands. These soils formed in calcareous glacial till or glacial till sediments. The native vegetation was grasses. Slopes are 0 to 2 percent.

Typical pedon of Canisteo clay loam, 0 to 2 percent slopes, 60 feet east and 2,240 feet south of the northwest corner of sec. 10, T. 99 N., R. 33 W.

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

A1—8 to 15 inches; black (N 2/0) clay loam, very dark gray (10YR 3/1) dry; few fine faint very dark gray (5Y 3/1) mottles; weak fine and medium granular structure; friable; few very fine roots; strong effervescence; moderately alkaline; gradual smooth boundary.

A2—15 to 20 inches; black (10YR 2/1) and very dark gray (10YR 3/1) clay loam, very dark gray (5Y 3/1) and gray (5Y 5/1) dry; few fine faint dark gray (5Y 4/1) mottles; weak fine and medium granular structure with some weak fine subangular blocky; friable; few very fine roots; few fine pores; strong effervescence; moderately alkaline; clear smooth boundary.

Bg1—20 to 26 inches; clay loam, 70 percent gray (5Y 5/1) and 30 percent dark gray (5Y 4/1); few fine streaks and pockets of very dark gray (5Y 3/1); weak fine and medium subangular blocky structure; friable; few very fine roots; few fine pores; strong effervescence; moderately alkaline; gradual smooth boundary.

Bg2—26 to 34 inches; gray (5Y 5/1) and olive gray (5Y 5/2) clay loam; few fine faint olive (5Y 5/3) mottles; weak medium prismatic structure parting to weak medium subangular blocky; friable; few very fine roots; few fine pores; strong effervescence; moderately alkaline; gradual smooth boundary.

Bg3—34 to 40 inches; gray (5Y 5/1) and olive gray (5Y 5/2) clay loam; few fine faint olive (5Y 5/3) and few fine distinct yellowish brown (10YR 5/8) mottles; weak medium prismatic structure parting to weak medium subangular blocky; friable; few soft calcium carbonate accumulations in rounded masses; few fine pores; violent effervescence; moderately alkaline; gradual smooth boundary.

Cg1—40 to 48 inches; gray (5Y 5/1) and olive gray (5Y 5/2) clay loam; few fine faint olive (5Y 5/3) and few fine distinct yellowish brown (10YR 5/8) mottles; some weak medium and coarse prismatic structure in the upper part; friable; few black (10YR 2/1) and yellowish red (5YR 4/6) concretions of oxide; few black (10YR 2/1) manganese stains on faces of peds; common soft accumulations of calcium carbonate in rounded masses; few very dark gray (5Y 3/1) and dark gray (5Y 4/1) organic fills in some cracks and pores; few fine pores; violent effervescence; moderately alkaline; clear wavy boundary.

Cg2—48 to 60 inches; light olive brown (2.5Y 5/4) and olive gray (5Y 5/2) loam; common fine faint yellowish brown (10YR 5/6) mottles; massive; friable; few fine pebbles; few fine and medium yellowish red (5YR 4/6) and black (10YR 2/1) concretions of oxide; few fine tubular pores; violent effervescence; moderately alkaline.

The thickness of the solum ranges from 20 to 50 inches. Free carbonates generally are throughout the profile, except for the upper 10 inches in a few pedons.

The A horizon is black (N 2/0, 10YR 2/1) or very dark gray (10YR 3/1, N 3/0). It typically is clay loam, but the range includes loam or silty clay loam. It ranges from about 10 to 20 inches in thickness. Tongues of material from this horizon commonly extend into the lower horizon. The B horizon typically has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 or 2. In a few pedons it has hue of 10YR, value of 4 or 5, and chroma of 1. It typically is clay loam, loam, or silty clay loam. In a few pedons the lower part of the horizon is sandy loam. Mottles typically are in some part of the Bg horizon. The C horizon has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 2 to 4. It commonly has mottles. It typically is clay loam or loam, but in some pedons it is sandy loam.

Clarion Series

The Clarion series consists of deep, well drained, moderately permeable soils on convex knolls, undulating ridgetops, and side slopes in the uplands. These soils formed in glacial till. The native vegetation was prairie grasses. Slopes range from 2 to 18 percent.

Typical pedon of Clarion loam, 2 to 5 percent slopes, 2,290 feet west and 2,480 feet south of the northeast corner of sec. 13, T. 99 N., R. 34 W.

Ap—0 to 8 inches; black (10YR 2/1) loam (about 26 percent clay), very dark gray (10YR 3/1) dry; weak fine subangular blocky structure parting to weak fine granular; friable; common fine roots; neutral; clear smooth boundary.

A—8 to 14 inches; very dark brown (10YR 2/2) loam (about 27 percent clay), very dark gray (10YR 3/1) dry; black (10YR 2/1) coatings on faces of peds; weak fine and medium subangular blocky structure parting to weak medium granular; friable; common fine roots; neutral; clear smooth boundary.

AB—14 to 19 inches; very dark brown (10YR 2/2) and dark brown (10YR 3/3) clay loam (about 29 percent clay), dark grayish brown (10YR 4/2) and brown (10YR 4/3) dry; few thin discontinuous black (10YR 2/1) coatings on faces of peds; weak fine and medium subangular blocky structure; friable; few fine pebbles; common fine roots; neutral; clear smooth boundary.

Bw1—19 to 25 inches; brown (10YR 4/3) loam (about 26 percent clay); thick continuous very dark grayish brown (10YR 3/2) and dark brown (10YR 3/3) coatings on faces of peds; weak fine and medium subangular blocky structure; friable; few fine pebbles; few fine roots; few black (10YR 2/1) wormcasts; neutral; gradual smooth boundary.

Bw2—25 to 37 inches; dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4) loam (about 26 percent clay); thick discontinuous dark brown (10YR 3/3) coatings on faces of peds; weak fine and medium prismatic structure parting to moderate fine and medium subangular blocky; friable; few fine pebbles; few fine roots; few black (10YR 2/1) wormcasts; neutral; gradual wavy boundary.

BC—37 to 42 inches; dark yellowish brown (10YR 4/4) and olive brown (2.5Y 4/4) loam (about 25 percent clay); few fine faint gray (2.5Y 5/1) and few fine distinct strong brown (7.5YR 5/6) mottles; weak fine and medium subangular blocky structure; friable; few fine pebbles; few fine roots; few fine accumulations of calcium carbonate in soft rounded masses; few dark concretions of iron and manganese oxides; strong effervescence; slightly alkaline; abrupt smooth boundary.

C—42 to 60 inches; light olive brown (2.5Y 5/4) loam (about 24 percent clay); common fine and medium distinct grayish brown (2.5Y 5/2), common fine and medium faint yellowish brown (10YR 5/6), and few fine and medium distinct strong brown (7.5YR 5/6) mottles; massive; few fine pebbles; friable; few fine roots; common medium accumulations of calcium carbonate in soft rounded masses; common dark concretions of iron and manganese oxides; violent effervescence; moderately alkaline.

The thickness of the solum ranges from 19 to 50 inches and is commonly the same as the depth to free carbonates. Thickness of the mollic epipedon ranges from 10 to 22 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It typically is loam, but clay loam also is common. The B horizon has hue of 10YR, value of 3 to 5, and chroma of 3 or 4. It is loam or clay loam. The C horizon has hue of 10YR or 2.5Y, value of 5 or 6, and chroma of 2 to 6. It is loam or sandy loam.

The Clarion soils in map units 138C2, 138D2, 638C2, 638D2, and 638E2 are taxadjuncts because the dark surface layer is too thin to qualify as a mollic epipedon. These soils are classified as fine-loamy, mixed, mesic Typic Eutrochrepts.

Coland Series

The Coland series consists of poorly drained, moderately permeable soils on flood plains. These soils formed in moderately fine textured alluvium. The native vegetation was grasses tolerant of excessive wetness. Slopes range from 0 to 5 percent.

Typical pedon of Coland clay loam, 0 to 2 percent slopes, 910 feet east and 100 feet south of the northwest corner of sec. 6, T. 98 N., R. 33 W.

Ap—0 to 9 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) dry; weak medium and fine granular structure; friable; common fine roots;

neutral; abrupt smooth boundary.

A1—9 to 18 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) dry; weak very fine subangular blocky and moderate fine and medium granular structure; friable; common fine roots; neutral; gradual smooth boundary.

A2—18 to 24 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) dry; weak fine and very fine subangular blocky structure parting to weak medium and fine granular; friable; common fine roots; neutral; gradual smooth boundary.

A3—24 to 34 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) dry; weak fine and medium subangular blocky structure parting to weak medium granular; friable; common fine roots; neutral; gradual smooth boundary.

A4—34 to 42 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) dry; weak medium subangular blocky structure parting to weak very fine subangular and medium granular; friable; common fine roots; few fine tubular pores; neutral; gradual smooth boundary.

AC—42 to 52 inches; very dark gray (10YR 3/1) clay loam; few fine faint dark grayish brown (10YR 4/2) mottles; weak medium prismatic structure parting to weak medium subangular blocky; friable; few fine roots; few fine pores; neutral; gradual smooth boundary.

Cg—52 to 60 inches; dark gray (5Y 4/1) clay loam; few fine faint olive (5Y 5/3) mottles; weak coarse prismatic structure; friable; few fine roots; few fine and common very fine tubular pores; neutral.

The solum ranges from 36 to 48 inches in thickness. Free carbonates commonly do not occur in the solum but are in the substratum in some pedons.

The A horizon commonly is black (N 2/0 or 10YR 2/1), but in some pedons it is very dark gray (N 3/0 or 10YR 3/1) in the lower part. The clay content of the A horizon ranges from about 30 to 35 percent. The AC horizon has hue of 10YR to 5Y or is neutral in hue. It has value of 2 to 4 and chroma of 0 or 1. The Cg horizon has hue of 2.5Y or 5Y or is neutral in hue. It has value of 2 to 5 and chroma of 1 or less. It has common mottles and oxide concretions. It typically is clay loam, but in places it is loam that has thin strata of sand or sandy loam.

Collinwood Series

The Collinwood series consists of deep, somewhat poorly drained, slowly permeable soils on plane or slightly convex slopes in the uplands. These soils formed in clayey and silty glacial lacustrine sediments 4 to 8 feet thick over glacial till. The native vegetation was prairie grasses. Slopes are 0 to 2 percent.

Typical pedon of Collinwood silty clay loam, 0 to 2 percent slopes, 130 feet east and 1,000 feet north of the southwest corner of sec. 22, T. 98 N., R. 34 W.

Ap—0 to 8 inches; black (10YR 2/1) silty clay loam (35 percent clay), very dark gray (10YR 3/1) and very dark grayish brown (10YR 3/2) dry; weak fine and medium granular structure; friable; slightly acid; abrupt smooth boundary.

A—8 to 16 inches; black (10YR 2/1) silty clay loam (36 percent clay), very dark gray (10YR 3/1) and very dark grayish brown (10YR 3/2) dry; weak very fine subangular blocky structure parting to moderate fine and medium granular; firm; few fine tubular pores; slightly acid; clear smooth boundary.

AB—16 to 23 inches; very dark grayish brown (10YR 3/2) silty clay loam (38 percent clay), dark gray (10YR 4/1) and dark grayish brown (10YR 4/2) dry; some very dark gray (10YR 3/1) in the upper part; dark grayish brown (10YR 4/2) mixing in the lower part; black (10YR 2/1) coatings on faces of peds; weak very fine subangular blocky structure parting to moderate fine and medium granular; firm; few fine tubular pores; slightly acid; clear smooth boundary.

Btg1—23 to 31 inches; dark grayish brown (2.5Y 4/2) silty clay loam (39 percent clay); discontinuous black (10YR 2/1) organic coatings on faces of peds; common fine distinct light olive brown (2.5Y 5/6) mottles; weak medium prismatic structure parting to moderate very fine subangular blocky; firm; common thin continuous very dark gray (10YR 3/1) clay films on faces of peds; few fine tubular pores; neutral; clear smooth boundary.

Btg2—31 to 39 inches; dark grayish brown (2.5Y 4/2) silty clay loam (39 percent clay); few discontinuous black (10YR 2/1) organic coatings on faces of peds; common fine distinct light olive brown (2.5Y 5/6) mottles; weak medium prismatic structure parting to moderate very fine subangular blocky; firm; common thin continuous very dark gray (10YR 3/1) clay films on faces of peds; few fine tubular pores; neutral; clear smooth boundary.

Cg1—39 to 52 inches; dark grayish brown (2.5Y 4/2), grayish brown (2.5Y 5/2), and olive gray (5Y 5/2) silty clay loam (35 percent clay); common fine prominent dark brown (7.5YR 4/4) and common fine distinct light olive brown (2.5Y 5/6) mottles; massive; firm; few dark concretions of iron and manganese oxides; few accumulations of calcium carbonate in soft rounded masses and occurring as powdery streaks; few fine tubular pores; strong effervescence; moderately alkaline; clear wavy boundary.

Cg2—52 to 60 inches; grayish brown (2.5Y 5/2) silty clay loam (35 percent clay); common medium prominent dark brown (7.5YR 4/4) and few fine prominent strong brown (7.5YR 5/8) mottles; massive; firm; few dark concretions of iron and manganese oxides; common accumulations of calcium carbonate in soft rounded masses and occurring as powdery streaks; few fine tubular pores; violent effervescence; moderately alkaline.

The thickness of the solum and the depth to free carbonates range from 24 to 46 inches. The mollic epipedon ranges from 14 to 24 inches in thickness.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1. It typically is silty clay loam, but the range includes silty clay. The upper part of the Btg horizon has hue of 10YR or 2.5Y, value of 3 to 5, and chroma of 2. The lower part has hue of 2.5Y, value of 3 to 5, and chroma of 2 to 4. This horizon typically is silty clay loam, but the range includes silty clay or clay. The Cg horizon has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 2 to 4. It typically is silty clay loam or silty clay, but the range includes clay or silt loam in the lower part.

Colo Series

The Colo series consists of poorly drained, moderately permeable soils on bottom land. These soils formed in silty alluvium. The native vegetation was water-tolerant grasses. Slopes are 0 to 2 percent.

Typical pedon of Colo silty clay loam, 0 to 2 percent slopes, 60 feet east and 840 feet south of the northwest corner of sec. 33, T. 98 N., R. 32 W.

Ap—0 to 7 inches; black (N 2/0) silty clay loam, black (10YR 2/1) dry; weak fine and very fine granular structure; friable; few very fine tubular pores; neutral; abrupt smooth boundary.

A1—7 to 12 inches; black (N 2/0) silty clay loam, black (10YR 2/1) dry; weak fine and very fine granular structure; friable; few very fine tubular pores; neutral; gradual smooth boundary.

A2—12 to 21 inches; black (N 2/0) silty clay loam, black (10YR 2/1) dry; moderate fine granular and very fine subangular blocky structure; friable; few very fine tubular pores; neutral; diffuse smooth boundary.

A3—21 to 30 inches; black (N 2/0) silty clay loam, black (10YR 2/1) and very dark gray (10YR 3/1) dry; moderate fine granular and very fine subangular blocky structure with some very fine angular blocky; friable; few very fine tubular pores; neutral; diffuse smooth boundary.

A4—30 to 40 inches; black (N 2/0) silty clay loam, very dark gray (10YR 3/1) dry; weak fine granular and very fine subangular blocky structure; friable; few fine dark reddish brown (5YR 3/4) oxide concretions; common very fine tubular pores; neutral; gradual smooth boundary.

AC—40 to 52 inches; very dark gray (5Y 3/1) silty clay loam; weak fine subangular blocky and fine granular structure; friable; common fine dark reddish brown (5YR 3/4) oxide concretions; neutral; gradual smooth boundary.

Cg—52 to 60 inches; clay loam, 50 percent olive gray (5Y 5/2) and 50 percent very dark gray (5Y 3/1) and dark gray (5Y 4/1); massive; friable; many fine or medium distinct dark brown (7.5YR 4/4) to strong brown (7.5YR 5/6) mottles; few clay fills in old root pores; slightly acid.

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). The content of clay in this horizon ranges from 27 to 35 percent. The Cg horizon ranges from very dark gray (10YR 31) to gray (5Y 5/1) or olive gray (5Y 5/2). It is clay loam or silty clay loam.

Crippin Series

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

Typical pedon of Crippin loam, 1 to 3 percent slopes, 90 feet west and 2,070 feet north of the southeast corner of sec. 3, T. 99 N., R. 33 W.

Ap—0 to 9 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) and dark gray (10YR 4/1) dry; weak fine and medium granular structure; friable; common fine roots; slight effervescence; slightly alkaline; abrupt smooth boundary.

A—9 to 17 inches; very dark brown (10YR 2/2) loam, very dark gray (10YR 3/1) and dark gray (10YR 4/1) dry; black (10YR 2/1) coatings on faces of peds; weak very fine and fine subangular blocky structure parting to weak medium granular; friable; few fine roots; slight effervescence; slightly alkaline; clear smooth boundary.

AB—17 to 23 inches; very dark grayish brown (2.5Y 3/2) loam, dark grayish brown (2.5Y 4/2) dry; weak very fine and fine subangular blocky structure; friable; few fine roots; strong effervescence; moderately alkaline; gradual smooth boundary.

Bw1—23 to 31 inches; mixed dark grayish brown (2.5Y 4/2) and olive brown (2.5Y 4/4) loam; very dark grayish brown (2.5Y 3/2) coatings on faces of peds; weak fine and medium subangular blocky structure; friable; few small pebbles; few fine roots; strong effervescence; moderately alkaline; clear smooth boundary.

Bw2—31 to 40 inches; dark grayish brown (2.5Y 4/2) and olive brown (2.5Y 4/4) loam; few very dark grayish brown (2.5Y 3/2) coatings on faces of peds; weak medium and coarse subangular blocky structure; friable; few small pebbles; few accumulations of calcium carbonate in rounded masses; few fine tubular pores; few very dark grayish brown (10YR 3/2) organic fills in root channels; strong effervescence; moderately alkaline; gradual smooth boundary.

BC—40 to 46 inches; olive brown (2.5Y 4/4) and light olive brown (2.5Y 5/4) loam; common fine distinct yellowish brown (10YR 5/6) and olive gray (5Y 5/2) mottles; weak coarse subangular blocky structure; friable; few small pebbles; few dark concretions of iron and manganese oxides; few accumulations of calcium carbonate in streaks and pockets; violent effervescence; moderately alkaline; gradual smooth boundary.

C—46 to 60 inches; light olive brown (2.5Y 5/4) loam; common fine distinct yellowish brown (10YR 5/8) and few fine distinct olive gray (5Y 5/2) mottles; massive; friable; few small pebbles; few dark concretions of iron and manganese oxides; violent effervescence; moderately alkaline.

The thickness of the solum typically ranges from 30 to 46 inches, but it can range from 20 to 48 inches.

The A horizon has hue of 10YR or is neutral in hue. It has value of 2 or 3 and chroma of 0 or 1. The total thickness of the A horizon is 12 to 23 inches. The upper part of the Bw horizon has hue of 10YR or 2.5Y, value of 3 or 4, and chroma of 2. The lower part has hue of 2.5Y, value of 4 or 5, and chroma of 2. The C horizon has hue of 10YR to 5Y, value of 4 or 5, and chroma of 2 to 4. The profile typically is loam throughout, but the range includes clay loam.

Delft Series

The Delft series consists of deep, poorly drained, moderately slowly permeable soils on the lower foot slopes and in narrow upland drainageways. These soils formed in local alluvium and glacial till. The native vegetation was prairie grasses. Slopes range from 1 to 3 percent.

Typical pedon of Delft clay loam, 1 to 3 percent slopes, 40 feet north and 940 feet west of the southeast corner of sec. 21, T. 99 N., R. 34 W.

Ap—0 to 10 inches; black (10YR 2/1) clay loam (33 percent clay), very dark gray (10YR 3/1) dry; weak fine and medium granular structure; friable; few small pebbles; neutral; abrupt smooth boundary.

A1—10 to 18 inches; black (N 2/0) clay loam (33 percent clay), black (10YR 2/1) dry; weak very fine subangular blocky and weak medium granular structure; friable; few small pebbles; few fine roots; neutral; gradual smooth boundary.

A2—18 to 29 inches; black (N 2/0) clay loam (33 percent clay), black (10YR 2/1) dry; weak very fine subangular blocky and moderate medium and fine granular structure; friable; few small pebbles; few fine roots; neutral; gradual smooth boundary.

A3—29 to 36 inches; black (N 2/0) clay loam (34 percent clay), black (10YR 2/1) and very dark gray (10YR 3/1) dry; few fine faint dark grayish brown (2.5Y 4/2) mottles; weak fine and very fine subangular blocky structure parting to moderate fine granular; friable; few fine pebbles; few fine roots; neutral; gradual smooth boundary.

A4—36 to 44 inches; very dark gray (5Y 3/1) clay loam (38 percent clay); common fine distinct olive gray (5Y 5/2) mottles; moderate fine and medium subangular blocky structure; friable; few fine pebbles; few very fine dark brown (7.5YR 4/4) concretions of oxide; neutral; gradual smooth boundary.

Bg1—44 to 50 inches; very dark gray (5Y 3/1), dark olive gray (5Y 3/2), and olive gray (5Y 5/2) clay loam (39 percent clay); common fine distinct strong brown (7.5YR 5/8) and few fine faint olive (5Y 5/4) mottles; weak medium subangular blocky structure; firm; neutral; clear smooth boundary.

Bg2—50 to 60 inches; olive gray (5Y 5/2) clay loam (39 percent clay); common fine prominent strong brown (7.5YR 5/8) mottles; weak medium subangular blocky structure; firm; common dark olive gray (5Y 3/2) fills in old pores; neutral.

The thickness of the solum ranges from 30 to 60 inches. The depth to free carbonates ranges from about 30 to more than 60 inches. The thickness of the mollic epipedon typically is 30 to 50 inches but ranges from 24 to more than 60 inches.

The A horizon has hue of 10YR, 5Y, or 2.5Y, value of 2 or 3, and chroma of 1 or is neutral in hue and has value of 2 or 3 and chroma of 0. It typically is clay loam but the range includes loam or silty clay loam. The Bg horizon has hue of 5Y or 2.5Y, value of 4 or 5, and chroma of 1 or 2. Most or all parts of the B horizon are mottled. This horizon typically is clay loam, but the range includes loam. The C horizon has hue of 5Y or

2.5Y, value of 4 or 5, and chroma of 1 or 2 and is mottled. It typically is clay loam, but the range includes loam and sandy loam.

The Delft soils in this survey area have a thicker solum and a greater depth to carbonates than are defined as the range for the series.

Dickman Series

The Dickman series consists of deep, well drained and moderately well drained soils on uplands, outwash plains, and terraces. Permeability is moderately rapid in the solum and rapid in the substratum. These soils formed in windblown materials. The native vegetation was prairie grasses. Slopes range from 0 to 5 percent.

Typical pedon of Dickman sandy loam, 2 to 5 percent slopes, 300 feet west and 1,180 feet north of the southeast corner of sec. 8, T. 100 N., R. 34 W.

Ap—0 to 10 inches; very dark brown (10YR 2/2) sandy loam, dark grayish brown (10YR 4/2) dry; weak fine and medium granular structure; very friable; common fine roots; medium acid; abrupt smooth boundary.

A—10 to 14 inches; sandy loam, very dark brown (10YR 2/2) in the upper part and dark brown (10YR 3/3) in the lower part, dark grayish brown (10YR 4/2) dry; weak fine subangular blocky structure parting to weak medium granular; very friable; common fine roots; slightly acid; clear smooth boundary.

Bw—14 to 20 inches; dark brown (7.5YR 4/4) sandy loam; dark yellowish brown (10YR 3/4) coatings on faces of peds; weak fine subangular blocky structure; very friable; thin very discontinuous dark yellowish brown (10YR 3/4) clay films; common fine roots; slightly acid; gradual smooth boundary.

BC—20 to 32 inches; dark yellowish brown (10YR 4/4) and yellowish brown (10YR 4/6) loamy sand; weak fine and medium subangular blocky structure parting to single grained; very friable; neutral; clear smooth boundary.

C1—32 to 48 inches; dark yellowish brown (10YR 4/4) and yellowish brown (10YR 4/6) sand; single grained; loose; neutral; clear smooth boundary.

C2—48 to 60 inches; brown (10YR 4/3) and yellowish brown (10YR 4/6) sand; common fine faint dark grayish brown (2.5Y 4/2) mottles; single grained; loose; slightly acid.

The thickness of the solum typically ranges from 30 to 50 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. Total thickness of the A horizon is 10 to 20 inches. This horizon is coarse sandy loam, fine sandy loam, or sandy loam. The B horizon has hue of 10YR or 7.5YR and value and chroma of 3 or 4. It ranges from coarse sandy loam to loamy fine sand. The BC horizon has hue of 10YR, 7.5YR, or 2.5Y, value of 4 to 6, and chroma of 2 to 6. It is fine sand, coarse sand, or sand. The C horizon has colors and textures similar to those of the BC horizon. It commonly is stratified.

Estherville Series

The Estherville series consists of deep, well drained or somewhat excessively drained soils on glacial outwash terraces and stream terraces. These soils formed in loamy material over calcareous sand and gravel (fig. 20). Permeability is moderately rapid in the solum and very rapid in the substratum. The native vegetation was prairie grasses. Slopes range from 0 to 9 percent.

Typical pedon of Estherville loam, 2 to 5 percent slopes, 2,200 feet west and 300 feet north of the southeast corner of sec. 3, T. 99 N., R. 34 W.

Ap—0 to 8 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak medium granular structure; friable; few fine roots; slightly acid; clear smooth boundary.

A—8 to 14 inches; very dark brown (10YR 2/2) sandy loam, dark grayish brown (10YR 4/2) dry; weak fine granular structure; friable; very few fine roots; slightly acid; gradual smooth boundary.

Bw—14 to 18 inches; very dark brown (10YR 2/2) and dark brown (10YR 3/3) sandy loam (about 10 percent gravel), dark grayish brown (10YR 4/2) and dark yellowish brown (10YR 4/4) dry; weak fine granular structure; friable; slightly acid; gradual smooth boundary.

2C1—18 to 29 inches; dark brown (10YR 3/3) gravelly loamy sand; single grained; loose; 25 percent gravel; strong effervescence; slightly alkaline; gradual smooth boundary.

2C2—29 to 60 inches; brown (10YR 4/3) and dark yellowish brown (10YR 4/4) gravelly loamy sand; 35 percent gravel; strong effervescence; slightly alkaline.

The thickness of the solum and the depth to free carbonates range from 15 to 30 inches. The loamy mantle and the mollic epipedon are 10 to 20 inches thick.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is sandy loam or loam. The Bw horizon has hue of 10YR or 7.5YR and value and chroma of 3 or 4. It averages less than 18 percent clay. The 2C horizon has hue of 10YR or 7.5YR, value of 4 to 7, and chroma of 2 to 6. The fine-earth fraction

Figure 20.—A profile of Estherville loam. Sand and gravel are at a depth of about 18 inches.

typically is sand. The 2C horizon typically is calcareous throughout.

Fostoria Series

The Fostoria series consists of deep, somewhat poorly drained, moderately permeable soils on uplands and high stream terraces. These soils formed in loamy sediments. The native vegetation was prairie grasses. Slopes are 0 to 2 percent.

Typical pedon of Fostoria loam, 0 to 2 percent slopes, 800 feet east and 2,500 feet north of the southwest corner of sec. 32, T. 98 N., R. 33 W.

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

A1—8 to 13 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; medium acid; gradual smooth boundary.

A2—13 to 18 inches; very dark brown (10YR 2/2) loam, very dark gray (10YR 3/1) and dark gray (10YR 4/1) dry; few very dark grayish brown (10YR 3/2) peds mixed by worms; black (10YR 2/1) coatings on faces of peds; weak fine subangular blocky structure parting to weak fine and medium granular; friable; few fine roots; few fine and medium pores; medium acid; gradual smooth boundary.

BA—18 to 23 inches; mixed very dark grayish brown (10YR 3/2) and very dark brown (10YR 2/2) loam; black (10YR 2/1) coatings on faces of some peds; few fine faint dark yellowish brown (10YR 4/4) mottles; weak fine subangular blocky structure parting to weak medium granular; friable; few fine roots; common fine and few medium pores; slightly acid; gradual smooth boundary.

Bw1—23 to 29 inches; dark grayish brown (10YR 4/2) loam mixed with very dark grayish brown (10YR 3/2); common medium faint olive brown (2.5Y 4/4) and few fine distinct light olive brown (2.5Y 5/4 and 5/6) mottles; weak medium subangular blocky structure; friable; common fine and few medium pores; very dark brown (10YR 2/2) fills in some old pores; slightly acid; clear smooth boundary.

Bw2—29 to 37 inches; dark grayish brown (2.5Y 4/2) loam; high content of sand; many medium distinct yellowish brown (10YR 5/6) mottles; weak medium and coarse subangular blocky structure; friable; common fine and medium black (N 2/0) oxides, some encircled with 2- to 3-millimeter bands of yellowish red (5YR 5/6) stains; common fine and few medium pores; slightly acid; clear smooth boundary.

Bw3—37 to 47 inches; dark grayish brown (2.5Y 4/2) and olive gray (5Y 4/2) loam; common fine distinct light olive brown (2.5Y 5/4) mottles; weak medium prismatic structure parting to weak medium subangular blocky; friable; few fine black (N 2/0) concretions of oxide, some encircled with 2- to 3-millimeter bands of yellowish brown (10YR 5/6) stains; common fine and few medium pores; very dark grayish brown (7.5YR 3/2) fills in a few old root pores; slightly acid; clear smooth boundary.

C1—47 to 56 inches; stratified yellowish brown (10YR 5/4 and 5/6) loam that has common fine olive gray (5Y 5/2) mottles and yellowish brown (10YR 5/4 to 5/8) sandy loam that has common fine distinct dark brown (7.5YR 4/4) mottles; massive; friable; slightly acid; clear smooth boundary.

C2—56 to 60 inches; olive gray (5Y 5/2) and olive (5Y 5/3) loam; common fine prominent red (2.5YR 4/6) and dark reddish brown (5YR 3/3 and 3/4) mottles; massive; friable; few black (N 2/0) and dark reddish brown (2.5YR 3/4) concretions of oxide; slight effervescence; slightly alkaline.

The thickness of the solum typically ranges from 30 to 48 inches. The depth to free carbonates commonly corresponds to the thickness of the solum, but in some pedons the upper part of the substratum is free of carbonates.

The A or Ap horizon typically is black (10YR 2/1 or N 2/0), but the lower part of the A horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2). The A horizon typically is loam, but in some pedons it is clay loam (27 to 31 percent clay). The upper part of the B horizon typically has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 2. In some pedons it has coatings of organic matter on peds or is mixed very dark grayish brown. The lower part typically has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 2, but in some pedons it has chroma of 3 or 4. It has few or common mottles. The B horizon typically is loam, but silt loam or clay loam subhorizons are in some pedons. The C horizon typically is loam or sandy loam, but in some pedons it is silt loam. Thin lenses of loamy sand are in some pedons. In some pedons, glacial till is at a depth of about 60 inches.

Harps Series

The Harps series consists of deep, poorly drained, calcareous, moderately permeable soils on narrow rims of depressions and on slight rises within poorly defined swales. These soils formed in calcareous glacial till. The native vegetation was prairie grasses. Slopes range from 1 to 3 percent.

Typical pedon of Harps clay loam, 1 to 3 percent slopes, 290 feet west and 980 feet south of the northeast corner of sec. 8, T. 99 N., R. 32 W.

Ap—0 to 8 inches; black (10YR 2/1) clay loam (29 percent clay), dark gray (10YR 4/1) dry; weak fine and medium granular structure; friable; violent effervescence; slightly alkaline; abrupt smooth boundary.

Ak—8 to 15 inches; black (10YR 2/1) loam (27 percent clay), dark gray (10YR 4/1) dry; weak fine and medium granular structure; friable; violent effervescence; slightly alkaline; clear smooth boundary.

ABk—15 to 21 inches; very dark gray (5Y 3/1) and dark gray (5Y 4/1) clay loam (29 percent clay); few fine distinct olive gray (5Y 5/2) mottles; weak fine subangular blocky structure parting to weak fine and medium granular; friable; violent effervescence; slightly alkaline; clear wavy boundary.

Bgk1—21 to 26 inches; loam (26 percent clay), 80 percent olive gray (5Y 5/2) and 20 percent dark gray (5Y 4/1); few fine distinct olive (5Y 5/0) mottles; weak medium subangular blocky structure; friable; few small pebbles; very dark gray (10YR 3/1) and dark gray (10YR 4/1) krotovinas; common fine pores; violent effervescence; slightly alkaline; gradual smooth boundary.

Bgk2—26 to 35 inches; olive gray (5Y 5/2) loam (26 percent clay); common fine distinct yellowish brown (10YR 5/6) mottles; weak medium subangular blocky structure; friable; few small pebbles; common soft accumulations of calcium carbonate in round masses; dark gray (10YR 4/1) krotovinas; common fine pores; violent effervescence; slightly alkaline; gradual smooth boundary.

C1—35 to 46 inches; olive gray (5Y 5/2) loam (26 percent clay); many fine prominent strong brown (7.5YR 5/6) mottles; massive; friable; few small pebbles; few dark concretions of iron and manganese oxides; common fine pores; violent effervescence; slightly alkaline; gradual smooth boundary.

C2—46 to 60 inches; olive gray (5Y 5/2) loam (26 percent clay); many medium prominent yellowish brown (10YR 5/8) and few fine prominent strong brown (7.5YR 5/6) mottles; massive; friable; few small pebbles; few dark concretions of iron and manganese oxide; violent effervescence; slightly alkaline.

The thickness of the solum typically ranges from 30 to 50 inches.

The A horizon has hue of 10YR or is neutral in hue. It has value of 2 or 3 and chroma of 0 or 1. Total thickness of the A horizon is 12 to 21 inches. Some pedons have an AB horizon that dominantly has hue of 5Y or 10YR or is neutral in hue and has value of 3 and chroma of 0 or 1. This horizon typically is loam or clay loam and contains 25 to 35 percent clay. The B horizon has hue of 10YR, 2.5Y, or 5Y, value of 5 or 6, and chroma of 1 or 2. It typically is loam, but the range includes clay loam and sandy clay loam. The C horizon has colors similar to those of the B horizon, except that colors with high chroma are dominant in the upper part.

Lester Series

The Lester series consists of well drained, moderately permeable soils on upland ridges and side slopes. These soils formed in glacial till. The native vegetation was mixed grasses and trees. Slopes range from 2 to 40 percent.

Typical pedon of Lester loam, 5 to 9 percent slopes, 1,220 feet west and 140 feet south of the northeast corner of sec. 16, T. 99 N., R. 34 W.

A—0 to 6 inches; very dark grayish brown (10YR 3/2) loam, grayish brown (10YR 5/2) dry; weak fine and medium granular structure; friable; common fine and medium roots; neutral; gradual smooth boundary.

E—6 to 10 inches; dark grayish brown (10YR 4/2) loam, light gray (10YR 7/1) dry; mixed with a few streaks and pockets of very dark grayish brown (10YR 3/2) material from the surface layer and brown (10YR 4/3) subsoil material; weak medium platy and weak medium and fine granular structure; friable; common fine and medium roots; neutral; clear smooth boundary.

BE—10 to 13 inches; brown (10YR 4/3) and dark grayish brown (10YR 4/2) loam; weak medium subangular blocky and weak medium platy structure; friable; common fine and medium roots; few fine yellowish red (5YR 4/6) concretions of oxide; few very dark grayish brown fills (wormcasts); neutral; clear smooth boundary.

Bt1—13 to 20 inches; dark yellowish brown (10YR 4/4) clay loam; weak medium and fine subangular blocky structure; friable; few small pebbles; few thin discontinuous dark yellowish brown (10YR 3/4 and 4/4) clay films on faces of peds; common medium and fine roots; few very dark grayish brown (10YR 3/2) wormcasts; medium acid; clear smooth boundary.

Bt2—20 to 29 inches; dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4) clay loam; moderate medium prismatic structure parting to weak medium subangular blocky; firm; few small pebbles; common thin discontinuous and continuous dark yellowish brown (10YR 3/4 and 4/4) clay films on faces of peds; common medium and fine roots; few dark brown (7.5YR 3/2) organic fills in root pores; few fine dark yellowish brown (10YR 4/4) and few very dark grayish brown (10YR 3/2) wormcasts; medium acid; gradual smooth boundary.

Bt3—29 to 39 inches; dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4) clay loam; moderate medium prismatic structure parting to weak medium subangular blocky; firm; few small pebbles; common thin and medium continuous dark brown (7.5YR 3/2) clay films on faces of peds and lining root pores; few fine roots; few fine black (10YR 2/1) and yellowish red (5YR 4/6) concretions of oxide; medium acid; gradual smooth boundary.

BC—39 to 43 inches; yellowish brown (10YR 5/4) clay loam; weak medium prismatic structure; friable; few small pebbles; few thin and medium discontinuous dark brown (7.5YR 3/2) clay films on prism faces and fills in root pores; few fine yellowish red (5YR 4/6) concretions of oxide; medium acid; gradual smooth boundary.

C—43 to 60 inches; light olive brown (2.5Y 5/4) loam; massive; few small pebbles; friable; few fine black (10YR 2/1) and yellowish red (5YR 4/6) concretions of oxide; few soft accumulations of calcium carbonate in streaks and in rounded masses; few dark brown (7.5YR 3/2) clay fills in old root pores; strong effervescence; moderately alkaline.

The thickness of the solum and the depth to free carbonates range from about 20 to 50 inches.

The Ap horizon typically is very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2). The A horizon is black (10YR 2/1) to very dark grayish brown (10YR 3/2) and is about 4 to 10 inches thick. The A and Ap horizons are loam or clay loam. The E horizon typically is dark grayish brown (10YR 4/2) but ranges from very dark brown (10YR 3/2) to very dark gray (10YR 3/1) or dark gray (10YR 4/1). It is 2 to 8 inches thick. It typically is loam or silt loam. The upper part of the Bt horizon is brown (10YR 4/3) or dark yellowish brown (10YR 4/4). The lower part has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 3 or 4. The Bt horizon typically is clay loam, but in a few pedons it is loam. It has few or common clay films in the lower part. Some pedons have few thin discontinuous clay films in the upper part of the Bt horizon. The C horizon has hue of 2.5Y, value of 4 to 6, and chroma of 3 to 6. It is loam or clay loam. Soft accumulations of calcium carbonates are in most pedons.

Linder Series

The Linder series consists of somewhat poorly drained soils in outwash areas and on stream terraces. These soils formed in loamy glacial outwash over calcareous sand and gravel. Permeability is moderately rapid in the solum and very rapid in the substratum. The native vegetation was prairie grasses. Slopes are 0 to 2 percent.

Typical pedon of Linder loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes, 40 feet west and 2,460 feet north of the southeast corner of sec. 20, T. 100 N., R. 34 W.

Ap—0 to 8 inches; black (10YR 2/1) loam (25 percent clay), very dark gray (10YR 3/1) dry; weak fine granular structure; friable; few fine roots; neutral; abrupt smooth boundary.

A1—8 to 13 inches; black (10YR 2/1) loam (21 percent clay), very dark gray (10YR 3/1) dry; few black (N 2/0) coatings on faces of peds; weak fine subangular blocky structure parting to weak fine and medium granular; friable; few fine roots; neutral; clear smooth boundary.

A2—13 to 18 inches; very dark brown (10YR 2/2) and very dark grayish brown (10YR 3/2) sandy loam (18 percent clay); black (10YR 2/1) coatings on faces of peds; weak fine subangular blocky structure parting to weak fine and medium granular; friable; few fine roots; neutral; clear smooth boundary.

Bw1—18 to 25 inches; dark grayish brown (2.5Y 4/2) sandy loam (15 percent clay); some very dark grayish brown (2.5Y 3/2) mixing of material from the surface layer; common fine faint light olive brown (2.5Y 5/4) and common fine distinct dark brown (7.5YR 4/4) mottles; weak fine and medium subangular blocky structure; friable; few fine roots; about 2 percent coarse fragments; neutral; clear smooth boundary.

Bw2—25 to 31 inches; dark grayish brown (2.5Y 4/2) sandy loam (10 percent clay); common fine distinct dark brown (7.5YR 4/4) and yellowish brown (10YR 5/6) and few fine faint light olive brown (2.5Y 5/4) mottles; weak fine subangular blocky structure; friable; few fine roots; few dark concretions of iron and manganese oxides; 2 to 5 percent coarse fragments; neutral; clear smooth boundary.

Bw3—31 to 37 inches; dark grayish brown (2.5Y 4/2) sandy loam (13 percent clay); common fine and medium distinct strong brown (7.5YR 5/6) and few fine distinct yellowish brown (10YR 5/6) mottles; weak fine and medium subangular blocky structure; friable; common dark concretions of iron and manganese oxides; 2 to 5 percent coarse fragments; neutral; gradual smooth boundary.

2C1—37 to 40 inches; dark grayish brown (2.5Y 4/2) and grayish brown (2.5Y 5/2) gravelly loamy sand (8 percent clay); common medium faint light olive brown (2.5Y 5/4) and common medium distinct yellowish brown (10YR 5/6) mottles; some very weak medium and coarse subangular blocky structure; friable; common dark concretions of iron and manganese oxides; few fine soft accumulations of calcium carbonate in soft rounded masses and occurring as coatings on coarse fragments; 2 to 5 percent coarse fragments; slight effervescence; slightly alkaline; gradual smooth boundary.

2C2—40 to 52 inches; grayish brown (2.5Y 5/2) gravelly sand (6 percent clay); single grained; loose; few fine soft accumulations of calcium carbonate in soft rounded masses and occurring as coatings on coarse fragments; clay bridging and coatings on sand grains and coarse fragments; about 5 percent coarse fragments; slight effervescence; slightly alkaline; gradual smooth boundary.

2C3—52 to 60 inches; grayish brown (2.5Y 5/2) gravelly sand; single grained; loose; few fine soft accumulations of calcium carbonate in soft rounded masses and occurring as coatings on coarse fragments; clay bridging and coatings on sand grains and coarse fragments; about 15 percent coarse fragments; strong effervescence; moderately alkaline.

The thickness of the solum and the depth to calcareous sand and gravel range from 24 to 40 inches.

The A horizon ranges from about 10 to 20 inches in thickness. The upper part is black (10YR 2/1) or very dark brown (10YR 2/2), and the lower part is very dark grayish brown (10YR 3/2 or 2.5Y 3/2) or very dark gray (10YR 3/1). This horizon is loam or sandy loam. The B horizon commonly has hue of 2.5Y, value of 4 or 5, and chroma of 2 or 3, but in some pedons it has hue of 10YR, value of 4 or 5, and chroma of 2. It typically is sandy loam. Some pedons have a BC horizon, which is loamy sand or sand and has some gravel. The 2C horizon typically is loamy sand or loamy coarse sand and has a gravel content of 5 to 30 percent. It has hue of 10YR or 2.5Y, value of 3 to 5, and chroma of 2 to 6. It generally has slight to strong effervescence, but it is leached in the upper few inches in some pedons.

Millington Series

The Millington series consists of poorly drained, calcareous, moderately permeable soils on flood plains near large streams. These soils formed in alluvial material. The native vegetation was marsh and prairie grasses. Slopes are 0 to 2 percent.

Typical pedon of Millington silt loam, channeled, 0 to 2 percent slopes, 3,500 feet west and 80 feet north of the southeast corner of sec. 30, T. 99 N., R. 33 W.

A1—0 to 3 inches; black (10YR 2/1) silt loam that has dark grayish brown (2.5Y 4/2) strata, very dark gray (10YR 3/1) dry; moderate fine and medium granular structure; friable; few fine roots; slight effervescence; slightly alkaline; abrupt smooth boundary.

A2—3 to 14 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; moderate fine and medium granular structure parting to weak very fine subangular blocky; friable; few fine roots; slight effervescence; slightly alkaline; clear smooth boundary.

Bg1—14 to 24 inches; black (10YR 2/1) and very dark gray (10YR 3/1) silty clay loam that has very thin strata of very dark grayish brown (10YR 3/2) very fine sand, very dark gray (10YR 3/1) and dark gray (10YR 4/1) dry; weak very fine subangular blocky structure parting to weak fine granular; friable; slight effervescence; slightly alkaline; clear smooth boundary.

Bg2—24 to 32 inches; black (10YR 2/1), very dark gray (10YR 3/1), and dark grayish brown (10YR 4/2) loam; a few thin strata of very fine sand; few fine distinct dark yellowish brown (10YR 3/6) mottles; weak fine granular structure; friable; slight effervescence; slightly alkaline; gradual smooth boundary.

C1—32 to 41 inches; loam, about 80 percent very dark gray (10YR 3/1) and 20 percent dark gray (5Y 4/1); some grayish brown (10YR 5/2) strata of very fine sand; common fine distinct dark yellowish brown (10YR 3/6) mottles; weak fine granular structure; friable; few fine pores; slight effervescence; slightly alkaline; gradual smooth boundary.

C2—41 to 60 inches; loam, about 80 percent very dark gray (10YR 3/1) and 20 percent dark gray (5Y 4/1); massive; friable; slight effervescence; slightly alkaline.

The thickness of the solum typically ranges from 24 to 40 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It commonly is silt loam, but the range includes loam, silty clay loam, or clay loam. The Bg horizon commonly has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It contains mottles with higher chroma. It has textures similar to those of the A horizon, but it also has strata of sandy loam. The C horizon has gleyed colors and varied textures.

Muskego Series

The Muskego series consists of very poorly drained soils in depressional areas associated with old glacial lake basins and on stream bottoms. These soils formed in highly decomposed herbaceous material. Permeability is moderately rapid in the upper part and slow in the lower part. The native vegetation was grasses, reeds, and sedges. Slopes are 0 to 2 percent.

Typical pedon of Muskego muck, 0 to 2 percent slopes, 690 feet west and 2,300 feet south of the northeast corner of sec. 35, T. 98 N., R. 34 W.

Oap—0 to 9 inches; black (10YR 2/1) muck, very dark gray (10YR 3/1) dry; moderate fine and medium granular structure; very friable; neutral; abrupt smooth boundary.

Oa1—9 to 16 inches; black (10YR 2/1) muck, black (10YR 2/1) dry; weak fine subangular blocky structure parting to moderate fine and medium granular; very friable; neutral; gradual smooth boundary.

Oa2—16 to 25 inches; black (10YR 2/1) muck; weak thick platy structure parting to weak fine subangular blocky; very friable; few fine pores; dark reddish brown (5YR 3/3) organic fills in root pores; neutral; abrupt smooth boundary.

C1—25 to 36 inches; dark gray (5Y 4/1) and gray (5Y 5/1) mucky silt loam (coprogenous earth); massive; very friable; few fine pores; common dark reddish brown (5YR 3/3) organic fills in root pores; many snail-shell fragments; violent effervescence; moderately alkaline; gradual smooth boundary.

C2—36 to 43 inches; dark gray (5Y 4/1) and gray (5Y 5/1) mucky silt loam (coprogenous earth); massive; very friable; few fine pores; few black (N 2/0) accumulations of partially decomposed organic material; common dark reddish brown (5YR 3/3) organic fills in root pores; many snail-shell fragments; dark yellowish brown (10YR 3/4) stains around root pores; violent effervescence; moderately alkaline; clear wavy boundary.

C3—43 to 54 inches; very dark gray (5Y 3/1) and dark olive gray (5Y 3/2) mucky silt loam (coprogenous earth); massive; very friable; few fine pores; few black (N 2/0) accumulations of partially decomposed organic material; few dark reddish brown (5YR 3/3) organic fills in root pores; common snail-shell fragments; violent effervescence; moderately alkaline; gradual smooth boundary.

C4—54 to 60 inches; very dark gray (5Y 3/1) and dark olive gray (5Y 3/2) mucky silt loam (coprogenous earth); massive; very friable; few dark reddish brown (5YR 3/3) organic stains; many snail-shell fragments; violent effervescence; moderately alkaline.

The depth to coprogenous earth commonly is 24 to 36 inches but ranges from 16 to 45 inches. The surface tier is black (10YR 2/1) or very dark brown (10YR 2/2). The subsurface tiers have hue of 10YR or 7.5YR or are neutral in hue. They have value of 2 or 3 and chroma of 0 to 3. They consist mainly of sapric material. The C horizon has hue of 10YR, 2.5Y, or 5Y, value of 2 to 5, and chroma of 1 to 3.

Nicollet Series

The Nicollet series consists of deep, somewhat poorly drained, moderately permeable soils on slightly convex or plane slopes on glacial till plains and moraines. These soils formed in glacial till. The native vegetation was prairie grasses. Slopes range from 1 to 3 percent.

Typical pedon of Nicollet loam, 1 to 3 percent slopes, 60 feet east and 340 feet north of the southwest corner of sec. 32, T. 100 N., R. 32 W.

Ap—0 to 8 inches; black (10YR 2/1) loam (26 percent clay), very dark gray (10YR 3/1) dry; black (N 2/0) coatings on faces of peds; weak fine and medium granular structure; friable; common fine roots; neutral; abrupt smooth boundary.

A1—8 to 14 inches; black (10YR 2/1) and very dark brown (10YR 2/2) loam (26 percent clay), very dark gray (10YR 3/1) dry; black (N 2/0) coatings on faces of peds; moderate fine and medium granular structure; friable; common fine roots; neutral; clear smooth boundary.

A2—14 to 18 inches; black (10YR 2/1) and very dark brown (10YR 2/2) loam (26 percent clay), very dark gray (10YR 3/1) dry; mixed with some streaks and pockets of dark grayish brown (2.5Y 4/2) subsurface material; black (N 2/0) coatings on faces of peds; weak fine subangular blocky structure parting to moderate fine and medium granular; friable; common fine roots; neutral; clear smooth boundary.

BA—18 to 23 inches; dark grayish brown (2.5Y 4/2) and very dark gray (10YR 3/1) clay loam (27 percent clay); black (10YR 2/1) discontinuous coatings on faces of peds; weak fine subangular blocky structure parting to weak medium granular; friable; common fine roots; neutral; clear smooth boundary.

Bg1—23 to 29 inches; dark grayish brown (2.5Y 4/2) clay loam (28 percent clay); mixed with some streaks and pockets of very dark gray (10YR 3/1) and very dark grayish brown (10YR 3/2) material from the surface layer; weak medium prismatic structure parting to weak fine and medium subangular blocky; friable; common fine roots; few dark concretions of iron and manganese oxides; neutral; clear smooth boundary.

Bg2—29 to 36 inches; dark grayish brown (2.5Y 4/2) clay loam (28 percent clay); mixed with some streaks and pockets of very dark grayish brown (10YR 3/2) material from the surface layer; common fine faint olive brown (2.5Y 4/4) mottles; weak medium prismatic structure parting to weak fine and medium subangular blocky; friable; common dark concretions of iron and manganese oxides; common very fine and fine inped tubular pores; neutral; gradual smooth boundary.

Bg3—36 to 42 inches; dark grayish brown (2.5Y 4/2) and grayish brown (2.5Y 5/2) clay loam (29 percent clay); common fine prominent strong brown (7.5YR 5/6) and few fine prominent yellowish brown (10YR 5/8) mottles; weak medium prismatic structure parting to weak medium subangular blocky; friable; common dark concretions of iron and manganese oxides; common very fine and fine inped tubular pores; neutral; clear smooth boundary.

Cg1—42 to 47 inches; olive gray (5Y 5/2) and olive (5Y 5/3) loam; common fine prominent yellowish brown (10YR 5/8) mottles; massive; friable; common accumulations of calcium carbonate in streaks; strong effervescence; moderately alkaline; clear smooth boundary.

Cg2—47 to 60 inches; olive gray (5Y 5/2) and olive (5Y 5/3) loam; many medium prominent yellowish brown (10YR 5/6) mottles; massive; friable; few dark concretions of iron and manganese oxides; common accumulations of calcium carbonate in streaks; 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 upper part of the B horizon is dark grayish brown (10YR 4/2 or 2.5Y 4/2) and very dark grayish brown (10YR 3/2). The lower part 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 or neutral in the A horizon and in the upper part of the B horizon. It ranges from neutral to moderately alkaline in the lower part of the B horizon and in the C horizon.

Okoboji Series

The Okoboji series consists of very poorly drained, moderately slowly permeable soils in shallow upland depressions. These soils formed in glacial till sediments. The native vegetation was water-tolerant grasses. Slopes are 0 to 2 percent.

Typical pedon of Okoboji silty clay loam, 0 to 1 percent slopes, 1,500 feet north and 30 feet west of the southeast corner of sec. 36, T. 98 N., R. 32 W.

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

A1—8 to 17 inches; black (N 2/0) silty clay loam, black (10YR 2/1) dry; weak very fine subangular blocky and weak fine granular structure; friable; few fine roots; neutral; gradual smooth boundary.

A2—17 to 26 inches; black (N 2/0) silty clay loam, black (10YR 2/1) and very dark gray (10YR 3/1) dry; weak fine subangular blocky structure parting to weak very fine granular; friable; few fine roots; neutral; gradual smooth boundary.

A3—26 to 33 inches; black (N 2/0) silty clay loam, very dark gray (10YR 3/1) and dark gray (10YR 4/1) dry; weak fine and very fine subangular blocky structure parting to moderate fine granular; friable; few fine roots; common very fine pores; neutral; gradual smooth boundary.

A4—33 to 36 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) and dark gray (10YR 4/1) dry; weak medium subangular blocky structure parting to weak very fine subangular blocky and weak fine granular; friable; few fine roots; few very fine pores; neutral; gradual smooth boundary.

Bg1—36 to 43 inches; silty clay loam, about 80 percent very dark gray (5Y 3/1) and 20 percent olive gray (5Y 4/2); few fine distinct olive (5Y 5/3) mottles; weak fine and very fine subangular blocky and weak fine granular structure; friable; few fine roots; few very fine pores; neutral; gradual smooth boundary.

Bg2—43 to 48 inches; dark gray (5Y 4/1) and olive gray (5Y 5/2) silty clay loam; common fine distinct olive (5Y 5/6) and few fine prominent strong brown (7.5YR 5/6) mottles; weak fine and medium subangular blocky structure; friable; very dark gray (5Y 3/1) krotovina; few fine roots; few fine pores; neutral; gradual smooth boundary.

Cg—48 to 60 inches; gray (5Y 5/1) and olive gray (5Y 5/2) silty clay loam; common fine distinct olive (5Y 5/6) and few fine prominent strong brown (7.5YR 5/6) mottles; massive; friable; very dark gray (5Y 3/1) krotovina; few dark olive gray (5Y 3/2) fills in old pores; few fine roots; few fine pores; slightly alkaline.

The thickness of the solum ranges from about 40 to 60 inches.

The A horizon ranges from about 24 to 36 inches in thickness. It is black (N 2/0 or 10YR 2/1). It is silty clay loam, silt loam, or mucky silt loam. The Bg1 horizon has hue of 10YR, 5Y, or 2.5Y or is neutral in hue. It has value of 3 or 4 and chroma of 0 or 1. The Bg2 or Bg3 horizon has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 or 2. The Bg horizon typically has mottles with value of 4 to 6 and chroma of 2 to 8. It typically is silty clay loam. The Cg horizon is dark gray (5Y 4/1), gray (5Y 5/1), or olive gray (5Y 5/2). It typically has mottles with the same value and hue as those in the Bg horizon. It typically is silty clay loam, but in some pedons it has thin layers of clay loam, loam, or silt loam.

Palms Series

The Palms series consists of very poorly drained soils in depressions. These soils formed in organic material over silty sediments. Permeability is moderately rapid in the upper part and moderate in the substratum. The native vegetation was water-tolerant sedges, reeds, and grasses. Slopes are 0 to 1 percent.

Typical pedon of Palms muck, 0 to 1 percent slopes, 2,600 feet east and 340 feet north of the southwest corner of sec. 2, T. 99 N., R. 32 W.

Oap—0 to 8 inches; sapric material (muck), black (N 2/0) broken face and rubbed, black (10YR 2/1) dry; about 5 percent fibers, less than 5 percent rubbed; weak fine granular structure; slightly sticky; herbaceous fibers; few fine roots; neutral; abrupt smooth boundary.

Oa1—8 to 13 inches; sapric material (muck), black (N 2/0) broken face and rubbed, black (10YR 2/1) dry; about 5 percent fibers, less than 5 percent rubbed; weak fine granular structure; slightly sticky; herbaceous fibers; few fine roots; neutral; gradual smooth boundary.

Oa2—13 to 22 inches; sapric material (muck), black (10YR 2/1) broken face and rubbed, very dark gray (10YR 3/1) dry; about 5 percent fibers, less than 5 percent rubbed; weak very fine subangular blocky structure parting to weak fine and very fine granular; slightly sticky; herbaceous fibers; few fine roots; very few snail-shell fragments; neutral; gradual smooth boundary.

A—22 to 29 inches; black (N 2/0) mucky silty clay loam, very dark gray (10YR 3/1) dry; weak fine subangular blocky structure parting to weak fine granular; friable; few fine roots; common fine and very fine pores; few dark brown (7.5YR 4/4) iron stains lining some pores; neutral; gradual smooth boundary.

2C—29 to 34 inches; very dark gray (5Y 3/1) silty clay loam; some wedges of olive gray (5Y 5/2) (30 percent); common fine distinct olive (5Y 5/3) mottles; mainly weak medium prismatic structure but some weak medium subangular blocky structure in the upper part; friable; few fine roots; common fine and very fine pores; common reddish brown (5YR 4/4) stains and fills in pores; common snail-shell fragments; slight effervescence; slightly alkaline; gradual wavy boundary.

2Cg1—34 to 42 inches; gray (5Y 5/1) and olive gray (5Y 5/2) silty clay loam; common fine faint olive (5Y 5/4) mottles; massive; friable; few fine roots; common fine and very fine pores; common reddish brown (5YR 4/4) and few black (N 2/0) fills in old pores; strong effervescence; moderately alkaline; diffuse wavy boundary.

2Cg2—42 to 60 inches; gray (5Y 5/1) and olive gray (5Y 5/2) silty clay loam; common fine faint olive (5Y 5/4) and common fine and medium distinct yellowish brown (10YR 5/8) mottles; common horizontally oriented layers of yellowish red (5YR 5/6 to 5/8); few medium pores; strong effervescence; moderately alkaline.

The Oa horizon typically ranges from about 18 to 29 inches in thickness, but in a few pedons it is as thick as 49 inches. It is derived primarily from herbaceous plant material that is mixed with mineral material. It is black (N 2/0, 10YR or 5Y 2/1) or very dark brown (10YR 2/2). The A horizon has colors similar to those of the Oa horizon. It is mucky silty clay loam. The 2C horizon has hue of 10YR, 2.5Y, or 5Y, value of 3 to 6, and chroma of 1 or 2. It is dominantly silty clay loam or clay loam, but the range includes loam or silt loam. Some pedons contain thin strata of fine sand, loamy sand, or silt. The 2C horizon averages less than 35 percent clay.

Ridgeport Series

The Ridgeport series consists of somewhat excessively drained soils on glacial outwash in the uplands and on stream terraces. These soils formed in moderately coarse textured material over calcareous sand and gravel. Permeability is moderately rapid in the upper part and very rapid in the underlying sand and gravel. The native vegetation was prairie grasses. Slopes range from 1 to 3 percent.

Typical pedon of Ridgeport sandy loam, 1 to 3 percent slopes, 1,950 feet north and 580 feet east of the southwest corner of sec. 33, T. 98 N., R. 33 W.

Ap—0 to 8 inches; very dark brown (10YR 2/2) sandy loam, very dark gray (10YR 3/1) dry; black (10YR 2/1) coatings on faces of peds; weak medium and fine granular structure; very friable; common fine roots; about 3 percent coarse fragments (gravel); neutral; abrupt smooth boundary.

A—8 to 12 inches; very dark brown (10YR 2/2) and very dark grayish brown (10YR 3/2) sandy loam, very dark gray (10YR 3/1) and dark gray (10YR 4/1) dry; mixed with some streaks and pockets of dark brown (10YR 3/3) subsoil material; weak fine subangular blocky structure parting to weak fine and medium granular; very friable; common fine roots; about 5 percent coarse fragments (gravel); medium acid; clear smooth boundary.

BA—12 to 18 inches; dark brown (10YR 3/3) sandy loam; weak medium and fine subangular blocky structure; very friable; common fine roots; about 5 percent coarse fragments (gravel); slightly acid; gradual smooth boundary.

Bw1—18 to 24 inches; dark brown (7.5YR 4/4) sandy loam; weak medium subangular blocky structure; very friable; few fine roots; about 7 percent coarse fragments (gravel); neutral; gradual smooth boundary.

Bw2—24 to 30 inches; dark brown (7.5YR 4/4) sandy loam; weak medium subangular blocky structure; very friable; few fine roots; about 10 percent coarse fragments (gravel); neutral; gradual smooth boundary.

BC—30 to 36 inches; dark brown (7.5YR 4/4) gravelly sandy loam; single grained; dark brown (7.5YR 4/4) coatings on coarse sand and gravel; some bridging between sand grains; about 20 percent gravel; 2 to 3 percent fragments more than 3 inches in diameter; neutral; clear smooth boundary.

C—36 to 60 inches; yellowish brown (10YR 5/4) gravelly sand; single grained; about 30 percent gravel; moderately alkaline; strong effervescence.

The thickness of the solum typically ranges from 30 to 40 inches and is mainly the same as the depth to loamy sand, gravelly loamy sand, gravelly sandy loam, or sand and gravel. In a few pedons, however, the solum extends a few inches into the coarse textured material.

The Ap and A horizons typically are black (10YR 2/1) or very dark brown (10YR 3/2). In some pedons they are very dark gray (10YR 2/2) or very dark grayish brown (10YR 3/2) in the lower part. They typically are sandy loam about 10 to 16 inches thick. The BA horizon is sandy loam. It has hue of 10YR or 7.5YR, value of 3 or 4, and chroma of 2 to 4. It commonly has ped coatings that have value of 2 or 3. The Bw horizon has hue of 10YR or 7.5YR, value of 3 to 5, and chroma of 3 or 4. In some pedons it has ped coatings that have value of 2 to 4. The Bw horizon is sandy loam. The clay content ranges from about 10 to 18 percent. The content of sand in the BA horizon and the upper part of the Bw horizon ranges from 60 to 75 percent, and that in the lower part of the Bw horizon or the BC horizon ranges from 60 to about 80 percent. Some pedons have a thinner BC horizon or a 2BC horizon. The 2BC horizon is loamy sand, gravelly loamy sand, or gravelly sandy loam. The 2C horizon has hue of 10YR or 7.5YR, value of 4 or 5, and chroma of 4 to 6. In some pedons it has a few high- or low-chroma mottles. It is mostly calcareous, but it is commonly neutral in the upper few inches. It typically is loamy sand or sand that contains about 10 to 35 percent gravel.

Salida Series

The Salida series consists of excessively drained, very rapidly permeable soils on knobs, kames, and eskers in the uplands and on high stream terraces. These soils formed in loamy and sandy glacial outwash sediments. The native vegetation was prairie grasses. Slopes range from 2 to 40 percent.

The Salida soils in this survey area have a dark surface layer that is too thin to qualify as a mollic epipedon. These soils are classified as sandy-skeletal, mixed, mesic Typic Eutrochrepts.

Typical pedon of Salida gravelly loamy sand, 9 to 14 percent slopes, moderately eroded, 2,080 feet east and 2,600 feet south of the northwest corner of sec. 20, T. 98 N., R. 33 W.

Ap—0 to 8 inches; very dark grayish brown (10YR 3/2) gravelly loamy sand, dark gray (10YR 4/1) dry; mixed with streaks and pockets of brown (10YR 4/3) and dark yellowish brown (10YR 4/4) subsoil material; weak medium and coarse subangular blocky structure parting to weak coarse granular; very friable; few fine roots; strong effervescence; slightly alkaline; clear smooth boundary.

Bw—8 to 14 inches; brown (10YR 4/3) and dark yellowish brown (10YR 4/4) gravelly loamy sand; weak medium and coarse subangular blocky structure; very friable; common tongues of very dark grayish brown (10YR 3/2); clay coatings on sand grains; few fine red (2.5YR 4/8) concretions of oxide; few fine roots; strong effervescence; slightly alkaline; clear wavy boundary.

C1—14 to 38 inches; variegated brown (10YR 4/3), yellowish brown (10YR 5/4 and 5/6), and dark yellowish brown (10YR 4/4) very gravelly sand; some clay bridging and clay coatings on sand grains; single grained; loose; strong effervescence; slightly alkaline; diffuse wavy boundary.

C2—38 to 60 inches; variegated brown (10YR 4/3), yellowish brown (10YR 5/4 and 5/6), and dark yellowish brown (10YR 4/4) very gravelly coarse sand; some clay bridging and clay coatings on sand grains; single grained; loose; strong effervescence; slightly alkaline.

The thickness of the solum ranges from 7 to 20 inches. The depth to free carbonates is less than 14 inches. Most pedons are calcareous throughout. The control section contains more than 35 percent coarse fragments of mixed lithology.

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 Bw horizon has hue of 10YR and value and chroma of

3 or 4. It is gravelly sand or gravelly loamy sand. The C horizon has hue of 10YR, value of 3 to 6, and chroma of 2 to 4. In some pedons it has strata that vary in content of gravel.

Spillville Series

The Spillville series consists of moderately well drained to somewhat poorly drained, moderately permeable soils on flood plains and low foot slopes. These soils formed in loamy alluvium and colluvium. The native vegetation was dominantly prairie grasses. A few trees are in areas of bottom land. Slopes range from 0 to 5 percent.

Typical pedon of Spillville loam, 0 to 2 percent slopes, 510 feet west and 100 feet north of the southeast corner of sec. 33, T. 98 N., R. 33 W.

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

A1—9 to 18 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak fine granular structure; friable; few fine tubular pores; very few fine roots; neutral; diffuse smooth boundary.

A2—18 to 28 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak fine and medium granular structure with some weak very fine subangular blocky; friable; few fine tubular pores; very few fine roots; neutral; diffuse smooth boundary.

A3—28 to 37 inches; black (10YR 2/1) and very dark brown (10YR 2/2) loam, very dark gray (10YR 3/1) and dark gray (10YR 4/1) dry; weak fine and medium granular structure with some weak very fine subangular blocky; friable; very few fine tubular pores; very few fine roots; neutral; diffuse smooth boundary.

A4—37 to 44 inches; very dark grayish brown (10YR 3/2) loam; black (10YR 2/1) and very dark brown (10YR 2/2) coatings on exterior of peds, dark gray (10YR 4/1) dry; weak medium subangular blocky structure parting to weak medium and fine granular; friable; few fine dark brown (7.5YR 3/2) oxide concretions; very few fine pores; neutral; gradual smooth boundary.

AC—44 to 52 inches; very dark grayish brown (10YR 3/2) loam; very dark gray (10YR 3/1) coatings on exterior of peds; few fine faint dark grayish brown (10YR 4/2) mottles; weak medium subangular blocky structure; friable; few fine dark brown (7.5YR 3/2) oxide concretions; very few fine pores; neutral; gradual smooth boundary.

C—52 to 60 inches; dark grayish brown (10YR 4/2) and brown (10YR 4/3) loam; few fine faint yellowish brown (10YR 5/4) mottles; massive; friable; few very fine reddish brown (5YR 4/6) oxide concretions; very few fine pores; neutral.

The thickness of the solum ranges from about 30 to more than 56 inches. The depth to carbonates typically is more than 48 inches, but a few pedons are calcareous at a depth of about 40 inches.

The A horizon commonly is black (10YR 2/1), very dark brown (10YR 2/2), very dark gray (10YR 3/1), or very dark grayish brown (10YR 3/2). It is 30 to 56 inches thick. It is commonly loam, but a few pedons have thin layers that are clay loam in the lower part. The C horizon commonly has hue of 10YR or 2.5Y, value of 3 or 4, and chroma of 1 to 3. It typically is loam but is sandy loam in some pedons.

Storden Series

The Storden series consists of well drained, calcareous, moderately permeable soils on sharply convex knobs and side slopes in rolling areas on uplands. These soils formed in calcareous glacial till. The native vegetation was prairie grasses. Slopes range from 2 to 40 percent.

Typical pedon of Storden loam, 14 to 18 percent slopes, moderately eroded, 1,780 feet west and 102 feet north of the southeast corner of sec. 34, T. 98 N., R. 34 W.

Ap—0 to 8 inches; very dark brown (10YR 2/2), very dark grayish brown (10YR 3/2), and brown (10YR 4/3) loam, very dark grayish brown (10YR 3/2) and brown (10YR 5/3) dry; mixed with some streaks and pockets of light olive brown (2.5Y 5/4) substratum material; weak fine and medium granular structure; friable; few fine roots; strong effervescence; moderately alkaline; abrupt smooth boundary.

C1—8 to 14 inches; light olive brown (2.5Y 5/4) loam; discontinuous very dark grayish brown (10YR 3/2) coatings on faces of peds; few fine distinct strong brown (7.5YR 5/6) mottles; weak fine subangular blocky structure parting to weak medium granular; friable; few fine roots; few dark concretions of iron and manganese oxides; violent effervescence; moderately alkaline; diffuse smooth boundary.

C2—14 to 20 inches; light olive brown (2.5Y 5/4) loam; few discontinuous very dark grayish brown (10YR 3/2) coatings on faces of peds; few fine distinct strong brown (7.5YR 5/6) mottles; massive; friable; few dark concretions of iron and manganese oxides few accumulations of calcium carbonate in soft rounded masses; violent effervescence; moderately alkaline; diffuse wavy boundary.

C3—20 to 60 inches; light olive brown (2.5Y 5/4) loam; few fine distinct strong brown (7.5YR 5/6) mottles; massive; friable; few dark concretions of iron and manganese oxides; few accumulations of calcium carbonate in soft rounded masses; violent effervescence; moderately alkaline.

The thickness of the solum ranges from about 3 to 10 inches and generally is the same as the thickness of the A horizon.

The A horizon has hue of 10YR, value of 2 to 4, and chroma of 2 or 3. The C horizon has hue of 10YR or 2.5Y, value of 5 or 6, and chroma of 3 to 6. It typically is loam throughout.

Talcot Series

The Talcot series consists of poorly drained, calcareous soils on stream terraces and in outwash areas on uplands. These soils formed in loamy sediments underlain by sand and gravel. Permeability is moderate in the solum and rapid in the substratum. The native vegetation was water-tolerant grasses. Slopes are 0 to 2 percent.

Typical pedon of Talcot clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes, 570 feet south and 210 feet east of the northwest corner of sec. 13, T. 100 N., R. 33 W.

Ap—0 to 9 inches; black (N 2/0) clay loam (about 28 percent clay), black (10YR 2/1) dry; weak medium granular structure; friable; common fine roots; slight effervescence; slightly alkaline; abrupt smooth boundary.

A1—9 to 18 inches; black (N 2/0 and 10YR 2/1) clay loam (about 28 percent clay), black (10YR 2/1) dry; weak medium granular structure with some weak fine subangular blocky structure in the lower part; friable; common fine roots; slight effervescence; slightly alkaline; gradual smooth boundary.

A2—18 to 23 inches; black (10YR 2/1) and very dark gray (10YR 3/1) clay loam (about 27 percent clay), very dark gray (10YR 3/1) dry; few medium distinct olive gray (5Y 5/2) mottles; weak medium granular and weak fine subangular blocky structure; friable; few fine roots; slight effervescence; slightly alkaline; clear wavy boundary.

Bg1—23 to 30 inches; olive gray (5Y 5/2) and dark gray (5Y 4/1) clay loam (about 28 percent clay), some very dark gray (5Y 3/1) in the upper part; common fine prominent light olive brown (2.5Y 5/4 and 5/6) mottles; weak fine and medium subangular blocky structure; friable; strong effervescence; moderately alkaline; clear smooth boundary.

Bg2—30 to 35 inches; olive gray (5Y 5/2) and dark gray (5Y 4/1) clay loam; common fine and medium distinct light olive brown (2.5Y 5/6) mottles; weak medium and coarse subangular blocky structure; friable; strong effervescence; moderately alkaline; clear smooth boundary.

Bg3—35 to 39 inches; olive gray (5Y 5/2) and dark gray (5Y 4/1) loam; common fine faint light olive brown (2.5Y 5/4) mottles; weak coarse subangular blocky structure; friable; few accumulations of calcium carbonate in soft rounded masses; strong effervescence; moderately alkaline; clear smooth boundary.

2Cg—39 to 60 inches; olive gray (5Y 5/2), olive (5Y 5/3), and gray (5Y 5/1) gravelly loamy sand; single grained; loose; coatings of calcium carbonate on some gravel particles; strong effervescence; moderately alkaline.

The thickness of the solum and depth to the 2C horizon range from 32 to 40 inches.

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. It is clay loam or silty clay loam. The Bg horizon ranges from dark gray (5Y 4/1) to olive gray (5Y 5/2). It typically is clay loam in the upper part and loam or sandy clay loam in the lower part. The 2Cg horizon has hue of 5Y or 2.5Y, value of 4 or 5, and chroma of 2 to 6. It is sand or loamy sand and contains up to about 35 percent gravel.

Terril Series

The Terril series consists of deep, moderately well drained, moderately permeable soils on foot slopes and alluvial fans. These soils formed in local loamy alluvium and colluvium derived from glacial till. The native vegetation was prairie grasses. Slopes range from 0 to 9 percent.

Typical pedon of Terril loam, 5 to 9 percent slopes, 375 feet east and 60 feet south of the northwest corner of sec. 25, T. 99 N., R. 34 W.

Ap—0 to 9 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak very fine subangular blocky structure parting to moderate fine and medium granular; friable; neutral; abrupt smooth boundary.

A1—9 to 15 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak very fine and fine subangular blocky structure parting to moderate fine and medium granular; friable; neutral; gradual smooth boundary.

A2—15 to 23 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak medium prismatic and fine and medium subangular blocky structure parting to weak medium granular; friable; neutral; gradual smooth boundary.

A3—23 to 32 inches; black (10YR 2/1) and dark brown (10YR 3/3) loam, very dark gray (10YR 3/1) dry; weak medium prismatic structure parting to weak fine and medium subangular blocky; friable; neutral; gradual smooth boundary.

A4—32 to 36 inches; very dark brown (10YR 2/2) and very dark grayish brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) and very dark grayish brown (10YR 3/2) dry; weak medium prismatic structure parting to moderate fine and medium subangular blocky; friable; neutral; clear smooth boundary.

BA—36 to 43 inches; brown (10YR 4/3) loam; thin discontinuous very dark grayish brown (10YR 3/2) coatings on faces of peds; weak medium prismatic structure parting to weak fine and medium subangular blocky; friable; few fine tubular pores; neutral; gradual smooth boundary.

Bw—43 to 50 inches; dark yellowish brown (10YR 4/4) loam; common dark yellowish brown (10YR 3/4) and few very dark grayish brown (10YR 3/2) coatings on faces of peds; weak medium prismatic structure parting to weak medium subangular blocky; friable; few fine tubular pores; neutral; gradual smooth boundary.

BC—50 to 60 inches; dark yellowish brown (10YR 4/4) loam; weak medium prismatic structure; friable; thin discontinuous dark brown (10YR 4/3) clay coatings on vertical faces of peds; common fine tubular pores; neutral.

The thickness of the solum ranges from 36 to more than 60 inches. The thickness of the mollic epipedon ranges from 24 to 36 inches. The BC horizon is below a depth of 40 inches. The soil is commonly free of carbonates to a depth of at least 50 inches, except where glacial till is above this depth.

The A horizon has hue of 10YR or 2.5Y. The upper part has value of 2 and chroma of 1 or 2, and the lower part has value of 2 or 3 and chroma of 2. This horizon is loam. The BC horizon has hue of 10YR, value of 4, and chroma of 3 or 4. It is loam or clay loam. The C horizon has hue of 10YR, value of 4 to 6, and chroma of 3 or 4. It is loam or clay loam.

Vinje Series

The Vinje series consists of deep, well drained and moderately well drained, moderately slowly permeable soils on convex slopes in the uplands. These soils formed in silty or clayey glacial lacustrine sediments overlying glacial till. The native vegetation was tall prairie grasses. Slopes range from 2 to 5 percent.

Typical pedon of Vinje silty clay loam, 2 to 5 percent slopes, 2,700 feet west and 940 feet south of the northeast corner of sec. 28, T. 99 N., R. 34 W.

Ap—0 to 7 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; weak fine granular structure; friable; common fine roots; slightly acid; abrupt smooth boundary.

A—7 to 12 inches; very dark grayish brown (10YR 3/2) silty clay loam, very dark gray (10YR 3/1) and dark grayish brown (10YR 4/2) dry; black (10YR 2/1) coatings on faces of peds; weak very fine subangular blocky structure parting to moderate fine granular; friable; common fine roots; slightly acid; clear smooth boundary.

AB—12 to 17 inches; dark brown (10YR 3/3) and brown (10YR 4/3) silty clay loam, brown (10YR 4/3) and dark grayish brown (10YR 4/2) dry; very dark gray (10YR 3/1) and very dark grayish brown (10YR 3/2) coatings on faces of peds; weak fine subangular blocky structure parting to moderate fine and medium granular; firm; common fine roots; slightly acid; clear smooth boundary.

Bt1—17 to 23 inches; brown (10YR 4/3) silty clay; some black (10YR 2/1) organic fills in the upper part; weak medium prismatic structure parting to moderate fine and very fine subangular blocky; firm; thin continuous dark brown (10YR 3/3) clay films on vertical faces of peds; few fine roots; slightly acid; clear smooth boundary.

Bt2—23 to 28 inches; brown (10YR 4/3) silty clay; weak medium prismatic structure parting to moderate fine subangular blocky; firm; thin continuous dark brown (10YR 3/3) clay films on vertical faces of peds; few dark concretions of iron and manganese oxides; slightly acid; clear smooth boundary.

BC—28 to 36 inches; brown (10YR 4/3) silty clay; few fine faint grayish brown (10YR 5/2) and few fine distinct strong brown (7.5YR 5/6) mottles; weak fine prismatic structure parting to weak fine and medium subangular blocky; friable; few thin patchy dark brown (10YR 3/3) clay films on faces of peds; few dark concretions of iron and manganese oxides; slightly alkaline; clear smooth boundary.

C1—36 to 50 inches; light olive gray (5Y 6/2) and pale olive (5Y 6/3) silty clay loam; common medium prominent strong brown (7.5YR 5/6) mottles; massive; friable; common dark concretions of iron and manganese oxides; common soft accumulations of calcium carbonate in rounded masses; few fine tubular pores with yellowish red (5YR 4/6) iron pipestems; strong effervescence; moderately alkaline; diffuse smooth boundary.

C2—50 to 60 inches; olive gray (5Y 5/2), light olive gray (5Y 6/2), and pale olive (5Y 6/3) silty clay loam; common medium prominent strong brown (7.5YR 5/6) mottles; massive; friable; common dark concretions of iron and manganese oxides; common soft accumulations of calcium carbonate in soft rounded masses; few fine tubular pores with yellowish red (5YR 4/6) iron pipestems; strong effervescence; moderately alkaline.

The thickness of the solum and the depth to free carbonates typically are 34 to 50 inches but range from 30 to 60 inches. The thickness of the moderately fine textured and fine textured sediments typically is about 40 to more than 60 inches. The content of clay in the sediments typically ranges from about 35 to 45 percent, but in a few pedons some horizons contain 50 percent or more. The content of sand typically ranges from 5 to 15 percent and is mostly fine sand or very fine sand. The mollic epipedon is 10 to 20 inches thick.

The Ap or A horizon typically is black (10YR 2/1) to very dark grayish brown (10YR 3/2). It typically is silty clay loam. The B horizon typically has hue of 10YR, value of 3 to 5, and chroma of 3 or 4, but in some pedons the lower part has hue of 2.5Y and value of 4 or 5. This horizon typically is silty clay or silty clay loam, but in some pedons the lower part is silt loam or loam. The C horizon has hue of 10YR, 5Y, or 2.5Y, value of 4 to 6, and chroma of 2 to 4. It typically is silty clay loam, but in a few pedons it is silt loam or silty clay. It is in lacustrine sediments. The 2C horizon, if it occurs, is in glacial till. It typically is loam.

Wadena Series

The Wadena series consists of well drained soils in upland outwash areas and on stream terraces. 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. The native vegetation was prairie grasses. Slopes are 0 to 2 percent.

Typical pedon of Wadena loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes, 300 feet east and 110 feet south of the northwest corner of sec. 21, T. 100 N., R. 34 W.

Ap—0 to 8 inches; very dark brown (10YR 2/2) loam, very dark gray (10YR 3/1) dry; black (10YR 2/1) coatings on faces of peds; weak medium and fine granular structure; friable; common fine roots; slightly acid; abrupt smooth boundary.

A—8 to 14 inches; very dark brown (10YR 2/2) loam, very dark gray (10YR 3/1) dry; black (10YR 2/1) coatings on faces of peds; weak medium and fine granular structure; friable; common fine roots; slightly acid; clear smooth boundary.

Bw1—14 to 19 inches; dark brown (10YR 3/3) loam; very dark grayish brown (10YR 3/2) coatings on faces of peds; weak fine subangular blocky structure; friable; common fine roots; slightly acid; clear smooth boundary.

Bw2—19 to 26 inches; brown (10YR 4/3) loam; weak fine and medium subangular blocky structure; friable; few fine roots; few fine red (2.5YR 4/6) concretions of oxide; neutral; abrupt wavy boundary.

BC—26 to 30 inches; brown (10YR 4/3) gravelly loamy sand; single grained; loose; moderately alkaline; slight effervescence; gradual wavy boundary.

2C—30 to 60 inches; brown (10YR 4/3) and dark yellowish brown (10YR 4/4) gravelly sand; single grained; loose; few stones 3 to 4 inches across; moderately alkaline; strong effervescence.

The thickness of the solum ranges from 24 to 32 inches. The depth to free carbonates ranges from about 24 to 36 inches.

The A horizon ranges from 10 to 18 inches in thickness. It is loam or clay loam. It ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2). The B horizon has hue of 10YR or 7.5YR, value of 3 to 5, and chroma of 3 or 4. It is loam or clay loam in the upper part and loam, sandy loam, or sandy clay loam in the lower part. A thin BC horizon of gravelly loamy sand or gravelly sandy loam is in some pedons. The 2C horizon has hue of 10YR or 7.5YR, value of 4 to 6, and chroma of 2 to 4. It is sand or coarse sand. The content of gravel ranges to about 50 percent. Some pedons contain 5 to 10 percent shale fragments, and many pedons contain a few rounded stones ranging from 3 to 4 inches to 8 to 10 inches in diameter.

Waldorf Series

The Waldorf series consists of deep, poorly drained, slowly permeable soils on the nearly level parts of lacustrine-mantled areas at high elevations in the Altamont Moraine. A few areas are in adjacent swales. These soils formed in fine textured or moderately fine textured glacial lacustrine sediments. The native vegetation was grasses. Slopes are 0 to 2 percent.

Typical pedon of Waldorf silty clay loam, 0 to 2 percent slopes, 2,510 feet east and 1,290 feet south of the northwest corner of sec. 28, T. 99 N., R. 34 W.

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

A1—8 to 14 inches; black (10YR 2/1) silty clay, 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 and medium granular; friable; few fine roots; slightly acid; gradual smooth boundary.

A2—14 to 20 inches; black (10YR 2/1) silty clay, very dark gray (10YR 3/1) dry; black (N 2/0) coatings on faces of peds; few fine distinct olive gray (5Y 4/2) mottles; weak fine subangular blocky structure parting to moderate medium and fine granular; friable; few fine roots; slightly acid; clear wavy boundary.

Bg1—20 to 24 inches; dark gray (5Y 4/1) and olive gray (5Y 4/2) silty clay; black (5Y 2/1) and very dark gray (5Y 3/1) coatings on faces of peds; few fine distinct light olive brown (2.5Y 5/4) and common fine faint olive (5Y 5/3) mottles; weak fine subangular blocky structure; firm; slightly acid; clear smooth boundary.

Bg2—24 to 33 inches; dark gray (5Y 4/1) and olive gray (5Y 4/2) silty clay; common black (5Y 2/1) coatings on vertical faces of peds; common fine distinct red (2.5Y 5/4), few fine distinct yellowish brown (10YR 5/6), and common medium faint olive (5Y 5/3) mottles; weak medium prismatic structure parting to moderate very fine and fine subangular blocky; firm; common dark concretions of iron and manganese oxides; neutral; gradual smooth boundary.

Bg3—33 to 42 inches; olive gray (5Y 4/2 and 5/2) silty clay; few black (5Y 2/1) coatings on faces of peds; common fine distinct yellowish brown (10YR 5/6) and common medium faint olive (5Y 5/3) mottles; weak medium prismatic structure parting to moderate medium subangular blocky; firm; few dark concretions of iron and manganese oxides; neutral; clear smooth boundary.

Cg1—42 to 52 inches; olive gray (5Y 4/2 and 5/2) silty clay; common medium prominent strong brown (7.5YR 5/8) and common medium faint olive (5Y 5/3) mottles; massive; firm; few very dark grayish brown (10YR 3/2) organic fills in root channels; neutral; clear smooth boundary.

Cg2—52 to 60 inches; olive gray (5Y 5/2) silty clay loam; common medium and coarse prominent strong brown (7.5YR 5/8) and common medium faint olive (5Y 5/3) mottles; massive; firm; few dark concretions of iron and manganese oxides; slight effervescence; moderately alkaline.

The thickness of the solum ranges from 26 to 48 inches. The depth to free carbonates ranges from 26 to 55 inches. The mollic epipedon is 16 to 24 inches in thickness. The 10- to 40-inch control section typically averages between 40 and 50 percent clay.

The A horizon has hue of 10YR, 2.5Y, or 5Y or is neutral in hue. It has value of 2 or 3 and chroma of 0 or 1. It is silty clay loam or silty clay. The B horizon has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 or 2. It typically is silty clay, but the range includes silty clay loam or clay. It has common mottles. The C horizon has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 1 or 2 and commonly has mottles. It is typically silty clay loam, silty clay, or clay, but the range includes silt loam.

Webster Series

The Webster series consists of deep, poorly drained, moderately permeable soils in swales on uplands. These soils formed in glacial sediments and glacial till. The native vegetation was water-tolerant grasses. Slopes are 0 to 2 percent.

Typical pedon of Webster silty clay loam, 0 to 2 percent slopes (fig. 21), 670 feet east and 2,500 feet south of the northwest corner of sec. 12, T. 99 N., R. 34 W.

Ap—0 to 8 inches; black (N 2/0) silty clay loam (high content of sand), black (10YR 2/1) dry; weak medium and fine granular structure; friable; common fine roots; neutral; abrupt smooth boundary.

A1—8 to 14 inches; black (N 2/0) silty clay loam (high content of sand), black (10YR 2/1) dry; weak very fine subangular blocky structure parting to weak fine and medium granular; friable; few fine roots; neutral; gradual smooth boundary.

A2—14 to 23 inches; black (N 2/0 and 5Y 2.5/1) clay loam, black (5Y 2.5/1) and very dark gray (5Y 3/1) dry; few fine faint dark gray (5Y 4/1) mottles; weak medium subangular blocky structure parting to moderate fine and medium granular; friable; few fine roots; neutral; clear smooth boundary.

BA—23 to 30 inches; dark gray (5Y 4/1) and olive gray (5Y 5/2) clay loam; weak medium subangular blocky structure parting to weak medium granular in the upper part; friable; few fine roots; neutral; clear smooth boundary.

Bg1—30 to 34 inches; clay loam, olive gray (5Y 5/2) with some mixing of dark gray (5Y 4/1); weak medium subangular blocky structure; friable; few very fine strong brown (7.5YR 5/8) and black (10YR 2/1) concretions of oxide; neutral; gradual smooth boundary.

Bg2—34 to 41 inches; olive gray (5Y 5/2) and gray (5Y 5/1) clay loam; common fine prominent yellowish brown (10YR 5/8) mottles; weak medium subangular blocky structure; friable; common fine

Figure 21.—Typical profile of Webster silty clay loam, 0 to 2 percent slopes. The light colored, calcareous substratum is at a depth of about 34 inches.

and medium black (10YR 2/1) and few fine yellowish red (5YR 4/6) concretions of oxide; few accumulations of calcium carbonate in soft rounded masses and fine streaks; strong effervescence; moderately alkaline; gradual smooth boundary.

Cg1—41 to 56 inches; olive gray (5Y 5/2) and gray (5Y 5/1) clay loam; common fine prominent yellowish brown (10YR 5/8) mottles; massive; friable; common fine and medium black (10YR 2/1) and few fine yellowish red (5YR 4/6) concretions of oxide; common fine accumulations of calcium carbonate in soft rounded masses and fine streaks; strong effervescence; moderately alkaline; gradual smooth boundary.

Cg2—56 to 60 inches; olive gray (5Y 5/2) and gray (5Y 5/1) clay loam; common medium prominent light olive brown (2.5Y 5/6) mottles; massive; friable; common fine and medium black (10YR 2/1) and few fine yellowish red (5YR 4/6) concretions of oxide; common fine accumulations of calcium carbonate in soft rounded masses and fine streaks; strong effervescence; moderately alkaline.

The thickness of the solum typically ranges from 30 to 50 inches. The depth to free carbonates is commonly the same as the thickness of the solum, but in some pedons the BC horizon contains free carbonates.

The A horizon is black (N 2/0 or 10YR 2/1). It is 14 to 24 inches thick. It is silty clay loam or clay loam. The BA and Bg horizons have hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 or 2. These horizons are clay loam, loam, or silty clay loam. The Cg horizon typically has colors similar to those of the B horizon, but in some pedons the range includes light olive gray (5Y 6/2 and 5/3). The Cg horizon commonly is clay loam, but the range includes loam.

Zenor Series

The Zenor series consists of somewhat excessively drained soils on uplands. These soils formed in glacial outwash. The native vegetation was prairie grasses. Permeability is moderately rapid in the upper part and very rapid in the underlying sand and gravel. Slopes range from 2 to 9 percent.

Typical pedon of Zenor sandy loam, 5 to 9 percent slopes, moderately eroded, 150 feet east and 2,500 feet north of the southwest corner of sec. 33, T. 99 N., R. 34 W.

Ap—0 to 7 inches; very dark grayish brown (10YR 3/2) sandy loam, very dark grayish brown (10YR 3/2) and dark grayish brown (10YR 4/2) dry; few streaks and pockets of dark yellowish brown (10YR 4/4) subsoil material; some very dark brown (10YR 2/2) coatings on faces of peds; weak fine and medium granular structure; friable; few very fine roots; neutral; abrupt smooth boundary.

BA—7 to 13 inches; dark grayish brown (10YR 4/2) sandy loam, very dark grayish brown (10YR 3/2) and dark grayish brown (10YR 4/2) dry; common streaks and pockets of dark yellowish brown (10YR 4/4); very dark brown (10YR 2/2) coatings on faces of peds; weak fine and medium granular structure; friable; few very fine roots; few fine pores; neutral; abrupt smooth boundary.

Bw1—13 to 18 inches; dark yellowish brown (10YR 4/4 and 4/6) sandy loam; few dark brown (10YR 3/3) coatings on faces of peds; weak medium subangular blocky structure; very friable; few small pebbles; few very fine roots; few fine pores; neutral; clear smooth boundary.

Bw2—18 to 23 inches; dark yellowish brown (10YR 4/4) sandy loam; few dark brown (10YR 3/3) coatings on faces of peds; weak medium and coarse subangular blocky structure; very friable; few small pebbles; few very fine roots; few fine pores; neutral; gradual smooth boundary.

Bw3—23 to 27 inches; brown (10YR 4/3) and dark yellowish brown (10YR 4/4) sandy loam; few dark brown (10YR 3/3) coatings on faces of peds; very weak medium and coarse subangular blocky structure; very friable; few small pebbles; few very fine roots; slightly acid; clear wavy boundary.

BC—27 to 34 inches; dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4) loamy sand; few fine faint strong brown (7.5YR 5/6) mottles; very weak medium and coarse subangular blocky structure; very friable; few black (10YR 2/1) oxides and stains; few fine yellowish red (5YR 4/6) oxides; few small pebbles and about 3 to 4 percent fragments 1 to 2 inches in diameter; slight effervescence; moderately alkaline; gradual smooth boundary.

C1—34 to 44 inches; yellowish brown (10YR 5/4) loamy sand; massive; very friable; few fine yellowish red (5YR 4/6) oxides; few very dark gray (10YR 3/1) and very dark grayish brown (10YR 3/2) worm mixings; about 3 to 5 percent coarse fragments; slight effervescence; moderately alkaline; clear wavy boundary.

C2—44 to 60 inches; yellowish brown (10YR 5/4) loamy sand; common fine faint yellowish brown (10YR 5/8) mottles; massive; very friable; few small pebbles; few fine yellowish red (5YR 4/6) and black (10YR 2/1) concretions of oxide; common black (10YR 2/1) streaks of manganese stains; few threadlike streaks and soft rounded masses of calcium carbonates; few thin (about ¼ inch) strata of silt and sand; slight effervescence; moderately alkaline.

The thickness of the solum and the depth to free carbonates range from 20 to 40 inches.

The Ap and A horizons typically have hue of 10YR, value of 2 or 3, and chroma of 1 or 2. They are sandy loam or loam. The AB horizon is very dark grayish brown (10YR 3/2) or dark brown (10YR 3/3) and commonly has mixings of brown (10YR 4/3). It is sandy loam or loam. The Bw horizon typically has hue of 10YR, value of 4 or 5, and chroma of 4 to 6, but in some pedons it is brown (10YR 4/3). It is sandy loam or loam. The BC horizon is sandy loam or loamy sand. It has colors similar to those of the Bw horizon. The C horizon commonly has hue of 10YR, but in some pedons it has hue of 7.5YR or 2.5Y. It has value of 5 or 6 and chroma of 3 to 6. It is sandy loam, loamy sand, gravelly loamy sand, or gravelly sand. Strata of silt are in some pedons.

The Zenor soil in map unit 828C2 is a taxadjunct because the dark surface layer is too thin to qualify as a mollic epipedon. This soil is classified as coarse-loamy, mixed, mesic Dystric Eutrochrepts.

Formation of the Soils

In this section, the factors that have affected the formation of soils in Emmet County are described and the processes of horizon differentiation are explained.

Factors of Soil Formation

Soil forms through processes that act on deposited or accumulated geologic material. The characteristics of the soil at any given point are determined by the physical and mineralogical composition of the parent material; the climate under which the soil material has accumulated and existed since accumulation; the plant and animal life on and in the soil; the relief, or lay of the land; and the length of time that the forces of soil formation have acted on the soil material (Jenny, 1941). 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 change it into a natural body that has genetically related horizons. The effects of plant and animal life are conditioned by relief. The parent material affects the kind of soil profile that forms and, in extreme cases, determines it almost entirely. Finally, time is needed for the formation of a soil. Some time is always needed for the differentiation of soil horizons. The amount of time needed is determined by the rate of the soil-forming processes. A long time period generally is needed for the formation of distinct horizons.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effects of any one factor unless conditions are specified for the others.

Parent Material

The accumulation of parent material is the first step in the formation of a soil. The soils in Emmet County formed in material that was transported from the site of the parent rock and redeposited at a new location through the actions of glacial ice, water, wind, and gravity.

The parent materials in the county are glacial till, glacial outwash, alluvium, organic deposits, wind- or water-deposited sandy material, and glaciolacustrine sediment. The bedrock beneath these materials has been buried so deeply that it has had no influence on the soils. In Emmet County the thickness of glacial drift generally ranges from about 200 to more than 300 feet (Munter and others, 1983).

Glacial till is unsorted sediment in which particles range in size from clay to boulders (Ruhe, 1969). It is the most important parent material in the county. The earliest glaciations in Iowa began sometime before 2.2 million years ago (Hallberg, 1980a and 1980b).

The survey area was probably glaciated several times during the earliest pre-Illinoian stages (Hallberg, 1980a), but deposits from these earlier glaciations were either removed by later glacial erosion or are now deeply buried beneath younger deposits.

Glacial deposits of the youngest glacial stage, the Wisconsinan, make up most of the surface and near-surface parent materials in the uplands. They were deposited by the Des Moines Lobe of the continental ice sheet approximately 12,000 to 14,000 years ago (Kemmis and others, 1981; Ruhe, 1969).

The upland topography and parent materials vary throughout the county as a result of this glaciation. A broad belt of hummocky topography on the Altamont Moraine is in the western part of the county. It extends across the county from north to south and ranges from about 5 to 7 miles wide on the west side of the West Fork of the Des Moines River.

The hummocky topography on this end moraine probably formed primarily through supraglacial deposition (Kemmis, 1981), since the soils and landscape are similar to that on end moraines along the eastern side of the Des Moines Lobe. As a result, the parent material in the uplands varies locally. Most areas are dominated by glacial till. The till is a heterogeneous mixture, indicating its glacial origin, and shows little evidence of sorting or stratification. Kame-like knobs, glacial eskers, and kettles are common landforms in these areas. Lacustrine deposits predominate on many of the higher, flat-topped hummocks. These are believed to be remnants of former ice-walled lakes (Parizek, 1969). Salida and Zenor soils formed in sandy deposits in these areas. Clarion, Lester, and Storden soils are the dominant soils that formed in glacial till. Collinwood, Vinje, and Waldorf soils formed in lacustrine deposits.

To the east of the Altamont Moraine, in the eastern two-thirds of the county, is a ground moraine characterized by a low-relief topography of swells and swales. In the uplands in this part of the county, Clarion, Nicollet, and Storden soils formed in glacial till and Canisteo and Webster soils formed in glacial till or in alluvium derived from till on adjacent slopes.

Outwash deposited by glacial meltwater streams is an important geological deposit in the county. Most of the larger deposits are associated with the West Fork of the Des Moines River and the East Fork of the Des Moines River. Lesser deposits are adjacent to minor streams and in other areas deposited by flowing glacial meltwater on the ground moraine. Outwash deposits are also in glaciofluvial features, such as kames and eskers. Estherville, Linder, Ridgeport, Salida, and Wadena soils formed in outwash material. The surficial material typically is loam or sandy loam but ranges to clay loam. It typically has only a few coarse fragments, except in areas that are strongly sloping to steep. This layer typically ranges from 15 to 40 inches thick and is underlain by stratified sandy and gravelly outwash. In most places glacial till lies beneath these sediments, but on terraces along the West Fork of the Des Moines River, there is a layer of older alluvium or lacustrine sediments a few feet in thickness.

Alluvium is material deposited by water. The major areas of alluvium in the county are along major streams. Smaller areas are along the smaller streams, along the larger upland drainageways, and at the base of some steep slopes. Soils that formed in alluvium make up about 4 percent of the county. Colo, Coland, Millington, Spillville, and Terril soils are examples.

Most of the alluvium in the county is silty clay loam, clay loam, silt loam, or loam. The variation in texture is a result of differences in source material, in the manner in which the material was deposited, and in the way the material was sorted at the time of deposition.

Some of the alluvial material has been transported only short distances. This material is called local alluvium or colluvium. It retains many of the characteristics of the soils from which it was washed. The sloping Spillville and Terril soils, for example, are at the base of slopes below soils that formed in glacial till.

Coland clay loam, Colo silty clay loam, Millington silt loam, channeled, and Spillville loam are the main soils along the West and East Forks of the Des Moines River. The alluvium in these areas varies in texture partly because of its landscape position in relation to present and former stream channels. Generally, alluvium adjacent to a present or former stream channel has the highest content of sand and the lowest content of clay. An example is Millington silt loam, channeled, which formed in alluvium adjacent to channels, and Colo silty clay loam and Coland clay loam, which formed in alluvium generally somewhat removed from the channels.

Organic material accumulated in former lakebeds and swamps and on fens and seepy side hills. These areas supported a heavy growth of aquatic plants and other vegetation that grew under excessively wet conditions. The vegetation partly decomposed and accumulated in thin or moderately thick beds under water. In 1924, the depth of the organic material was reported to be from 14 inches to 5 feet in the large area of organic soils in Iowa Lake Township (Stevenson and Brown, 1924). At that time, the material was reported to be peat. Presently these organic deposits are classified as muck. Also, the thickness presently ranges from about 8 to 30 inches. Additional drainage no doubt lowered the water table, causing the organic material to further decompose and subside. Also, evidence indicates that the area had been burned. This burning would have contributed to a reduction in depth of the organic material. In most places, significant quantities of inorganic material are mixed with the organic material. Many of these areas have been drained. Blue Earth, Muskego, and Palms soils are examples of soils that formed in these areas. Calcousta soils in Emmet County formed in lacustrine sediments that have significant quantities of organic material in the surface layer. In the Blue Earth and Muskego soils, the organic material has been somewhat modified by aquatic animal life. The ponded Aquolls also contain organic deposits of varying thickness. Many of the drained sloughs have been burned by fires that destroyed much of the organic material. The thicker organic material is in fens on side slopes in the uplands and on terraces where ground water reaches the surface. Two areas, each larger than 100 acres, are in Emmet County. Both of these areas are along the West Fork of the Des Moines River, one toward the northern end of the county and the other near the southern end. The organic material in these locations is as much as 28 feet in thickness. Blue Earth mucky silt loam, 1 to 5 percent slopes, is in these areas.

Sandy material in Emmet County was deposited by wind or water, mainly by water. In most areas, however, the material has been reworked to some extent by the wind. Dickman soils formed in these deposits.

Glaciolacustrine sediment, which dominantly is fine textured, is the parent material of a number of soils in the county. The sediments were deposited in shallow depressions or lakes on the glacial surface, which probably was an area of ice-walled lakes at the time of glaciation (Kemmis, 1981). In places, a low ridge or rim surrounding these areas formed when the ice melted. Other areas have smooth, rounded side slopes.

Ranging from about 3 to 22 feet in thickness, the glaciolacustrine sediment caps various knobs of the Altamont Moraine in the western part of the county. These knobs typically are flat topped and generally are on the highest part of the landscape. The material has a consistent two-fold stratigraphy. The upper part is massive, fine textured material in which modern soils formed. The lower part generally is a relatively thin layer of silt or stratified sand that commonly has a band of pebbles. Stratified deposits or till is below the upper sediments. Collinwood, Vinje, and Waldorf soils formed in areas where this sediment mantles knobs or hummocks. The soils on ridges and the upper side slopes surrounding these areas typically are included with areas of Clarion soils, but these included soils commonly have a higher content of clay than is typical for Clarion soils.

Fine textured lacustrine sediment is deposited in a few swales between knobs in this same area. Waldorf soils are in these swales. Soils in other swales and upland drainageways in this part of the county commonly have a somewhat higher clay content than soils in similar landscape positions in other parts of the county. Delft soils are common in these areas.

Similar landscape features occur on the ground moraine in other parts of the county, particularly in the north-central part, where circular knobs of low relief, about 10 to 12 feet, rise above the surrounding landscape. These knobs are similar to glacial ice contact rings and ridges described by Parizek (Parizek, 1969). The main soils in these areas are Clarion, Nicollet, and Webster soils. In some of these areas, Nicollet and Webster soils have a somewhat lower content of sand than is typical and are somewhat stratified in places below a depth of about 50 inches.

Plant and Animal Life

Vegetation and animal life are important factors of soil formation. Vegetation has played a particularly important role in the formation of the soils in Emmet County. Many changes in vegetation took place in the area during the postglacial period. Forest vegetation, dominated by spruce and larch, grew on the soils until about 11,000 to 11,500 years ago. This type of vegetation was followed by deciduous forest, which covered the area until about 9,500 years ago. At that time, prairie vegetation began to dominate (Baker and Van Zandt, 1978; Kim). During the past 8,000 years, most of the soils in the survey area have been influenced by prairie grasses. Only a few were influenced by trees. Big bluestem and little bluestem were probably the main grasses. The main trees were oak, but ash, elm, maple, and other species are in some areas.

Variations in the kind of vegetation commonly cause marked differences among soils (McComb and others, 1961). As plants grow and die, their remains are added to the soil. Burrowing animals, earthworms, bacteria, protozoa, other microbes, and fungi help to convert these 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.

Large burrowing animals, such as badgers, foxes, and pocket gophers, significantly affect soil formation in small areas. Small animals, such as earthworms, also influence soil formation. They move up and down in the soil as the soil moisture and temperature change. In many soils in the county, earthworms have moved material from one horizon to another.

Because grasses have many roots and tops that decay on or below the surface, soils that formed under prairie vegetation have a thick, dark surface layer. In contrast, soils that formed under trees have a thinner, lighter colored surface layer because the organic matter, derived mainly from leaves, accumulated only on the surface. Soils that formed under mixed grasses and trees are generally intermediate in color.

Dark soils, such as Clarion, Nicollet, and Webster soils, formed under prairie vegetation. Lester soils formed under mixed grasses and trees. None of the soils in Emmet County appears to have formed under forest vegetation.

Climate

Emmet County has a midcontinental, subhumid climate (Shaw and Waite, 1964).

Climate influences the formation of soils in many ways. Rainfall affects the extent of leaching in soils and helps to determine the kind of vegetation that grows on the soils. Temperature affects the growth of plants, the activity of micro-organisms, and the rate of chemical actions in the soils. Temperature and moisture conditions affect the rate at which parent material weathers. The amount and seasonal distribution of precipitation help to determine the depth to which calcium carbonates, other soluble minerals, and clay are moved downward through the soil and the rate of erosion. Precipitation also affects the depth to the water table in poorly drained and somewhat poorly drained soils. The depth to the water table, in turn, influences the depth of development in the subsoil. In areas where the water table is near the surface during most of the year, the subsoil does not develop to so great a depth as it does in areas where the water table is lower.

Soils form more rapidly in a warm climate than in a cold climate. They also form more rapidly in a wet climate than in a dry climate. Except for climatic differences resulting from topography, the soils in Emmet County formed under about the same climate. The climate has not been the same, however, during the entire period of soil formation.

The formation of the soils in Emmet County began about 13,000 years ago, after the glaciation in Iowa ended and a warming trend began (Ruhe and Scholtes, 1959). A coniferous forest became established rapidly in the open environment immediately following glaciation. Spruce and larch were the dominant species. The climate since that time has varied considerably (Baker and Van Zandt, 1978; Kim). From about 12,000 to 11,500 years ago, ash, fir, and other deciduous species began to colonize and increase as the climate became slightly warmer and more moist. Beginning around 10,000 to 9,500 years ago, as the climate continued to warm and become drier, deciduous forest replaced the mixed conifer-hardwood forest. By about 8,300 years ago, as the climate still continued to warm and become drier, prairie vegetation became dominant. Studies suggest that the warmest and driest period in central Iowa occurred about 6,500 to 4,000 years ago (Kim). Since that time period, the climate has become slightly cooler and more moist. During the past 3,000 years, it has been generally similar to the present climate (Kim).

The recent climate in parts of Emmet County has been conducive to mixed prairie grasses and deciduous forest. Areas that support this type of vegetation generally border the West and East Forks of the Des Moines River and the larger lakes and marshes. These areas provide a relatively humid environment, which favors deciduous trees.

In the rest of the county, the soils do not have any characteristics indicating that they were ever forested. Evidently, the rapid geologic erosion that accompanied major climatic changes removed the soils that formed under forest vegetation. Therefore, present soil landscapes generally are less than about 8,000 years old. Most of the soil features relating to the prairie environment have developed during the last 3,000 years of relative erosional stability (Kim). Clarion, Nicollet, Okoboji, and Webster soils are among those that formed under prairie vegetation.

The effect of climate on soils is modified by local conditions, such as relief. For example, the microclimate in areas of the low-lying, poorly drained Webster and Canisteo soils is cooler and wetter than that in areas of the well drained adjacent soils, such as Clarion soils. The microclimate in areas of Storden and other soils on the steeper slopes is drier than that in areas of the adjacent Clarion soils on gentle slopes. South- and west-facing slopes generally are slightly warmer and less humid than nearby areas. These variations account for some of the differences among soils within the same general climatic region. Partly because of these microclimate conditions, areas adjacent to larger streams and lakes support native trees.

Relief

Relief is an important cause of differences among soils. It indirectly influences soil formation through its effect on drainage, runoff, and erosion. More water runs off the surface in the steeper areas, and less soaks into the soil. As a result, less leaching of carbonates occurs in the soils in these areas and less clay is moved from the surface layer into the subsoil. Also, because the hazard of erosion is more severe on the steeper slopes, soil material is constantly being removed, sometimes as fast as it is being formed. Much of the acreage in Emmet County is nearly level to moderately sloping, but many areas are strongly sloping to steep.

Aspect also affects soil formation. South-facing slopes generally are warmer and drier than north-facing slopes. In Emmet County, other relief characteristics, such as steepness, length, and shape of slopes, affect soil formation more than aspect.

The topography in Emmet County resulted from the movement and melting of the Cary glacial ice. The topography is geologically immature, as is evidenced by a large number of small depressions, potholes, or other depressions and the lack of minor upland streams.

Several distinct types of Cary glacial topography are in Emmet County, including end moraines, ground moraines, outwash plains, and stream terraces.

End moraine topography formed in areas where the margin of glacial ice seasonally advanced and retreated, forming a series of aligned ridges, hills, swales, and depressions. Generally, most of Emmet County west of the West Fork of the Des Moines River is on the Altamont end moraine. This area is hummocky in places and has high relief. Clarion and Storden soils are the main soils on side slopes and some hilltops and ridgetops. Generally, the highest part of the landscape is a series of relatively broad flat-topped ridges. These ridges are believed to have been an area of ice-walled lakes at the time of glaciation (Kemmis, 1981; Parizek, 1969). Soils in these areas formed in the glaciolacustrine sediments that were in these former lakes. They include Collinwood, Vinje, and Waldorf soils. The drained depressions dominantly contain Okoboji and Palms soils. Several undrained marshes are in this part of the county.

Most of the eastern two-thirds of the county has the topography of a ground moraine. Ground moraines formed in areas where the glacial ice melted. Because the ice melted unevenly, the landscape is characterized by randomly oriented ridges and knobs interspersed with broad, smooth areas, depressions, and swales. Relief is relatively low. Canisteo, Clarion, Nicollet, and Webster soils are the major soils in these areas.

Outwash plains and stream terraces formed as a result of action by glacial meltwater. They typically have low relief. Estherville, Linder, Ridgeport, Talcot, and Wadena soils formed in these areas. Two areas of "kettle" terraces are in Emmet County. Both are on the east side of the West Fork of the Des Moines River. One is located about 4 miles north of Estherville, and the other is about 2 miles southeast of Wallingford. These areas are hummocky and have higher relief than other terraces. They have several levels of textures.

Variations in relief are a major reason for the differing soil properties among some of the soils in the county. Topography affects the color, the thickness of the solum, and the horizonation of the soils. For example, Clarion, Nicollet, and Storden soils formed in the same kind of parent material and under similar vegetation, but they differ from each other because of variations in topography. The thickness and color of the surface layer and the thickness of the solum are related to slope. The surface layer is thicker and darker in the less sloping areas. Clarion soils typically are on the intermediate slopes, Nicollet soils are in nearly level areas, and Storden soils are on the steepest slopes. The solum typically is thinnest in the Storden soils and thickest in the Nicollet soils.

Topography affects the color of the subsoil through its effects on drainage and soil aeration. A well drained soil generally has a brown subsoil because iron compounds are oxidized and well distributed throughout the horizon. The sloping Clarion soils are examples. Soils in nearly level or depressional areas are wet and commonly have a gray or mottled subsoil because of poor aeration and restricted drainage. Canisteo and Webster soils are examples.

Coland and Colo soils are on flood plains. Although they are nearly level, their microrelief affects runoff, the depth to the water table, and the rate at which they receive new sediment.

Time

Geologically, the soils of Emmet 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. Published studies provide information about the age of soils in Iowa (Ruhe, 1956; Ruhe, 1969; Ruhe and others, 1957; Ruhe and Scholtes, 1959).

The radiocarbon technique indicates that the most recent Wisconsinan glaciation in north-central Iowa occurred 14,000 to 12,000 years ago (Hallberg, 1980a; Ruhe, 1969). The soils in Emmet County formed after this glaciation. Soil formation began at widely differing times, depending on evolution of the local landscape.

In much of Iowa, including Emmet County, erosion has leveled the side slopes of uplands, and in places soil material has been removed and deposited on lower lying slopes (Ruhe, 1969; Ruhe and Scholtes, 1959). This sediment accumulated as local alluvium on foot slopes. The sloping Spillville and Terril soils formed in this alluvium. The uplands have an older surface on the summits than on the side slopes. The side slopes are less than 13,000 years old and in places are less than 3,000 years old (Kim).

Clarion, Storden, and other soils on side slopes are subject to geologic erosion, which continually exposes fresh material. As a result, the age of these soils ranges from that of the parent material to that of the most recent sediment.

The soils that formed in glacial outwash on terraces, such as Ridgeport and Estherville soils, are less than 13,000 years old (Ruhe, 1969). The age of the soils that formed in alluvium ranges from that of the recently deposited material in areas of Millington silt loam to that of the slightly older sediment in which Coland clay loam formed. The older sediment is less than about 13,000 years old and is probably much younger.

Human Activities

Important changes have taken place in the soils since Emmet County was settled. Breaking the prairie sod and draining some of the many depressions and small lakes affected the protective cover of vegetation.

The most drastic changes are those caused by water erosion. Cultivation increases the runoff rate and thus the susceptibility to erosion, which removes topsoil, organic matter, and plant nutrients. Sheet or rill erosion, the most prevalent kind of erosion in the county, removes only a fraction of an inch at a time. Plowing and cultivation generally destroy the evidence of this loss. Over a period of years, however, much eroded soil is deposited on the lower slopes and foot slopes. The sloping Spillville and Terril soils formed in this eroded material. In other areas, shallow and deep gullies have formed. As cultivation increased, the runoff rate increased and the rate at which water moved into the soil decreased. As a result, accelerated erosion has removed part or all of the original surface layer from sloping soils in some areas.

Erosion has changed not only the thickness of the surface layer but also its structure. In severely eroded areas, the plow layer consists of the upper part of the subsoil mixed with the remaining surface layer or, in the case of Storden soils, the upper part of the substratum mixed with small amounts of the remaining surface layer.

Erosion and cultivation also reduce the organic matter content, available water capacity, and fertility level of the soil. Even in the areas not subject to erosion, compaction by heavy machinery reduces the thickness of the surface layer and alters soil structure. The granular structure apparent in soils that support virgin grassland breaks down somewhat under intensive cropping. As a result, the surface becomes hard when it is dry.

Erosion is one of the main reasons for the reduction of the organic matter content in soils. As much as a third of the organic matter, however, is lost through causes other than erosion (Smith and others, 1950). Cultivation and cropping reduce the content and in places redistribute the organic matter. Maintaining as high a content of organic matter as was originally present under native grasses generally is not feasible. The content should be high enough, however, to maintain economical crop production.

Human activities also have increased the productivity of soils, minimized soil loss in places, and reclaimed areas that otherwise are not suitable for crops or pasture. For example, terraces and similar measures have slowed runoff and thus have helped to control erosion. Flooding has been controlled in areas where streams have been straightened and deepened and obstacles to floodwater have been removed. As a result of these measures, some areas along streams are better suited to cultivated crops than they originally were. Drainage ditches have provided outlets for tile drains and drained depressions and small lakes. They have improved the suitability of the soils for most agricultural uses, but they have also destroyed the native habitat for some wildlife species. Applications of commercial fertilizers and lime have corrected deficiencies in plant nutrients so that some soils are more productive than they were in their natural state.

Processes of Horizon Differentiation

Soil horizons are faintly or moderately expressed in most soils in Emmet County. Canisteo, Storden, and Webster soils have faint horizons; Clarion and Nicollet soils have slightly more distinct horizons; and Lester soils have somewhat more distinct horizons. Some soils have a marked difference in texture between the solum and an underlying 2C horizon. Soils that formed in outwash, such as Estherville soils, and soils that formed in two kinds of parent materials, such as Vinje soils, are examples.

Horizon differentiation results from soil-forming processes. These processes are the accumulation of organic matter, the leaching of calcium carbonates and other bases, the accumulation of calcium carbonates, the formation and translocation of silicate clay minerals, and the reduction and transfer of iron (Simonson, 1959). Each of these processes helps to determine the kind of soil horizons that form and the rate of soil formation. As most soils form, organic matter is added, soluble salts or bases and carbonates are removed, clay is transferred from the surface downward, and primary minerals are transformed into secondary minerals that can be used by plants. In general, these processes tend to promote horizon differentiation. Some changes, however, tend to offset or retard horizon differentiation. The processes and resulting changes proceed simultaneously in soils, and thus the ultimate nature of the profile is governed by the balance of these processes within the soil.

In most of the soils in Emmet County, some organic matter has accumulated in the A horizon. The accumulation of organic matter is one of the first evidences of horizon differentiation. In soils that formed in organic deposits, the A horizon has a very high organic matter content. Examples are Muskego and Palms soils. Some mineral soils have a high organic matter content and a thick A horizon. Examples are Canisteo, Colo, Okoboji, and Webster soils. Clarion soils have a moderate organic matter content. Lester and Storden soils have a relatively lower organic matter content and have a faint, thin A horizon.

Leaching of calcium carbonates and other bases has occurred in many soils in Emmet County. Leaching generally occurs before and during the translocation of silicate clay minerals. Percolating water removes soluble salts and calcium carbonates from the upper horizons. The depth to which calcium carbonates precipitate generally is an indication of the usual depth to which water percolates or the depth to the water table in part of the year. A B horizon forms as carbonates are moved downward. This leaching has occurred to a moderate depth in Clarion and Nicollet soils. Lester soils generally are more strongly leached and to a somewhat greater depth. The removal of calcium carbonates has progressed much more slowly or not at all in Storden soils because erosion removes most of the surface layer and organic matter as the soils form. Thus, only minimal horizonation has occurred in these soils.

Horizons are faintly expressed in Canisteo and Harps soils. Carbonates have accumulated in the upper horizons, partly because of the upward movement of water in the profile, which retards leaching and transformations and results in weakly developed upper horizons. The calcium carbonate equivalent in Harps soils ranges from about 15 to 40 percent.

The formation and translocation of silicate clay minerals have contributed to the development of more prominent horizons in Lester soils. The B horizon of these soils has more clay than the A horizon, and in many areas dark coatings are on faces of peds and in and along root channels. In places an eluviated E horizon has platy structure, has less clay than the A or B horizon, and is lighter in color, especially when the soil is dry. The leaching of bases and the translocation of clay have been more dominant processes of horizonation in these soils than the accumulation of organic matter. The depth to which clay is moved is related to the depth of water percolation during the growing season (Runge, 1973).

Transfers of compounds from lower horizons to upper horizons also occur. For example, phosphorus is removed from the subsoil by plant roots, is transferred to the parts of the plants above ground, and subsequently is returned to the surface in plant residue.

Transformations occur in all horizons, but the rate of transformation is most rapid in the surface layer. During the growing season, organic matter is broken down and transformed into simpler chemical compounds and elements. Also, primary minerals are transformed into secondary mineral elements. As a result of most transformations, the elements are more available to plants. For example, if the pH level is near 7, the primary mineral apatite is weathered to secondary phosphorus compounds that plants can use (Hsu and Jackson, 1960; Runge and Riecken, 1966). At a higher pH level, however, this transformation is slowed and other phosphorus compounds that are not available to plants are formed. As a result, soils with a pH of more than 7, such as Canisteo and Harps soils, have a lower supply of available phosphorus than soils that have a pH level near 7, such as Nicollet and Webster soils.

Gleying, or the reduction and transfer of iron, is evident in poorly drained and very poorly drained soils (Simonson and others, 1957). Canisteo, Harps, Okoboji, and Webster soils, for example, have a gleyed B horizon. The iron in this horizon is transformed from an oxidized form to a reduced form that is soluble and can be moved with water. This process results in gray or olive colors. In places these 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:

Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	9 to 12
Very high	more than 12

Bottom land. The normal flood plain of a stream, subject to flooding.

Calcareous soil. A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

Capillary water. Water held as a film around soil particles and in tiny spaces between particles. Surface tension is the adhesive force that holds capillary water in the soil.

Cation. An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Chiseling. Tillage with an implement having one or more soil-penetrating points that shatter or loosen hard, compacted layers to a depth below normal plow depth.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

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 2 millimeters to 38 centimeters (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 (7.6 to 25 centimeters) in diameter.

Colluvium. Soil material or rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

Complex slope. Irregular or variable slope. Planning or establishing terraces, diversions, and other water-control structures on a complex slope is difficult.

Complex, soil. A map unit of two or more kinds of soil in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils are somewhat similar in all areas.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrated compounds or cemented soil grains. The composition of most concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are common compounds in concretions.

Conservation tillage. A tillage system that does not invert the soil and that leaves a protective amount of crop residue on the surface throughout the year.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are:

Loose.—Noncoherent when dry or moist; does

not hold together in a mass.
Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.
Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.
Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.
Sticky.—When wet, adheres to other material and tends to stretch somewhat and pull apart rather than to pull free from other material.
Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.
Soft.—When dry, breaks into powder or individual grains under very slight pressure.
Cemented.—Hard; little affected by moistening.

Contour stripcropping. Growing crops in strips that follow the contour. Strips of grass or close-growing crops are alternated with strips of clean-tilled crops or summer fallow.

Control section. The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is that part of the soil profile between depths of 10 inches and 40 or 80 inches.

Coprogenous earth (sedimentary peat). Fecal material deposited in water by aquatic organisms.

Corrosion. Soil-induced electrochemical or chemical action that dissolves or weakens concrete or uncoated steel.

Cover crop. A close-growing crop grown primarily to improve and protect the soil between periods of regular crop production, or a crop grown between trees and vines in orchards and vineyards.

Cutbanks cave (in tables). The walls of excavations tend to cave in or slough.

Deferred grazing. Postponing grazing or resting grazing land for a prescribed period.

Depth, soil. Generally, the thickness of the soil over bedrock. Very deep soils are more than 60 inches deep over bedrock; deep soils, 40 to 60 inches; moderately deep, 20 to 40 inches; shallow, 10 to 20 inches; and very shallow, less than 10 inches.

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 human or animal activities or of a catastrophe in nature, for example, fire, that exposes the surface.

Erosion phases. The degree of erosion of a map unit is indicated in the map symbol. A map symbol consists of numbers or a combination of numbers and a letter. The initial letters represent the kind of soil. A capital letter following these numbers indicates the class of slope. (Symbols without a slope letter are for nearly level soils or miscellaneous areas.) Symbols that have a slope letter may be followed by a final number. A final number of 2 indicates that the soil is moderately eroded. Only 3 to 7 inches remains of the surface layer or of the surface layer and the subsurface layer combined. In tilled areas, some of the material from the AB and B horizons is mixed with the surface layer. A final number of 3 indicates that the soil is severely eroded. Less than 3 inches remains of the surface layer or of the surface layer and the subsurface layer combined. In tilled areas, most of the material from the AB and B horizons is mixed with the surface layer and thus the surface layer is much lighter in color. A symbol having a slope letter but no final number following the slope letter indicates that the soil is not eroded or is only slightly eroded. More than 7 inches remains of the surface layer or of the surface layer and the subsurface layer combined.

Esker (geology). A narrow, winding ridge of stratified gravelly and sandy drift deposited by a stream flowing in a tunnel beneath a glacier.

Excess fines (in tables). Excess silt and clay in the soil. The soil is not a source of gravel or sand for construction purposes.

Fertility, soil. The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Fibric soil material (peat). The least decomposed of all organic soil material. Peat contains a large amount of well preserved fiber that is readily identifiable according to botanical origin. Peat has the lowest bulk density and the highest water content at saturation of all organic soil material.

Field moisture capacity. The moisture content of a soil, expressed as a percentage of the ovendry weight, after the gravitational, or free, water has drained away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity*.

Fine textured soil. Sandy clay, silty clay, or clay.

First bottom. The normal flood plain of a stream, subject to frequent or occasional flooding.

Flood plain. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Foot slope. The inclined surface at the base of a hill.

Forb. Any herbaceous plant not a grass or a sedge.

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 meltwater.

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 meltwater. 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 7.6 centimeters) in diameter. An individual piece is a pebble.

Gravelly soil material. Material that is 15 to 35 percent, by volume, rounded or angular rock fragments, not prominently flattened, up to 3 inches (7.6 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 the material below the water table.

Gully. A miniature valley with steep sides cut by running water and through which water ordinarily runs only after rainfall. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage; a rill is of lesser depth and can be smoothed over by ordinary tillage.

Hemic soil material (mucky peat). Organic soil material intermediate in degree of decomposition between the less decomposed fibric and the more decomposed sapric material.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an uppercase letter represents the major horizons. Numbers or lowercase letters that follow represent subdivisions of the major horizons. The major horizons are as follows:

O horizon.—An organic layer of fresh and decaying plant residue.

A horizon.—The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, any plowed or disturbed surface layer.

E horizon.—The mineral horizon in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these.

B horizon.—The mineral horizon below an O, A, or E horizon. The B horizon is in part a layer of transition from the overlying horizon to the underlying C horizon. The B horizon also has distinctive characteristics, such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) granular, prismatic, or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the overlying horizon. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, an Arabic numeral, commonly a 2, precedes the letter C.

Cr horizon.—Soft, consolidated bedrock beneath the soil.

R layer.—Hard, consolidated bedrock beneath the soil. The bedrock commonly underlies a C horizon but can be directly below an A or a B horizon.

Humus. The well decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups. Refers to soils grouped according to their runoff-producing characteristics. The chief consideration is the inherent capacity of soil bare of vegetation to permit infiltration. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff. Soils are assigned to four groups. In group A are soils having a high infiltration rate when thoroughly wet and having a low runoff potential. They are mainly deep, well drained, and sandy or gravelly. In group D, at the other extreme, are soils having a very slow infiltration rate and thus a high runoff potential. They have a claypan or clay layer at or near the surface, have a permanent high water table, or are shallow over nearly impervious bedrock or other material. A soil is assigned to two hydrologic groups if part of the acreage is artificially drained and part is undrained.

Illuviation. The movement of soil material from one horizon to another in the soil profile. Generally, material is removed from an upper horizon and deposited in a lower horizon.

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.

Infiltration. The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Infiltration capacity. The maximum rate at which water can infiltrate into a soil under a given set of conditions.

Infiltration rate. The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Intake rate. The average rate of water entering the soil under irrigation. Most soils have a fast initial rate; the rate decreases with application time. Therefore, intake rate for design purposes is not a constant but is a variable depending on the net irrigation application. The rate of water intake, in inches per hour, is expressed as follows:

Less than 0.2	very low
0.2 to 0.4	low
0.4 to 0.75	moderately low
0.75 to 1.25	moderate
1.25 to 1.75	moderately high
1.75 to 2.5	high
More than 2.5	very high

Invaders. On range, plants that encroach into an area and grow after the climax vegetation has been reduced by grazing. Generally, invader plants follow disturbance of the surface.

Irrigation. Application of water to soils to assist in production of crops. Methods of irrigation are:

Basin.—Water is applied rapidly to nearly level plains surrounded by levees or dikes.

Border.—Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

Controlled flooding.—Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

Corrugation.—Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops or in orchards so that it flows in only one direction.

Drip (or trickle).—Water is applied slowly and under low pressure to the surface of the soil or into the soil through such applicators as emitters, porous tubing, or perforated pipe.

Furrow.—Water is applied in small ditches made by cultivation implements. Furrows are used for tree and row crops.

Sprinkler.—Water is sprayed over the 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.

Kame (geology). An irregular, short ridge or hill of stratified glacial drift.

Lacustrine deposit (geology). Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

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 the wind.

Low strength. The soil is not strong enough to support loads.

Medium textured soil. Very fine sandy loam, loam, silt loam, or silt.

Mineral soil. Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

Minimum tillage. Only the tillage essential to crop production and prevention of soil damage.

Miscellaneous area. An area that has little or no natural soil and supports little or no vegetation.

Moderately coarse textured soil. Coarse sandy loam, sandy loam, or fine sandy loam.

Moderately fine textured soil. Clay loam, sandy clay loam, or silty clay loam.

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, finely divided, well decomposed organic soil material. (See Sapric soil material.)

Munsell notation. A designation of color by degrees of three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with hue of 10YR, value of 6, and chroma of 4.

Neutral soil. A soil having a pH value between 6.6 and

7.3. (See Reaction, soil.)

Nutrient, plant. Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Organic matter. Plant and animal residue in the soil in various stages of decomposition. The percentage of organic matter is estimated for tilled surface horizons, from the surface to a depth of 7 inches. Organic matter values apply to soils under cultivation for more than 20 years.

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.

Pan. A compact, dense layer in a soil that impedes the movement of water and the growth of roots. For example, *hardpan, fragipan, claypan, plowpan,* and *traffic pan.*

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 movement of water through the soil.

Percs slowly (in tables). The slow movement of water through the soil, adversely affecting the specified use.

Permeability. The quality of the soil that enables water to move downward through the profile. Permeability is measured as the number of inches per hour that water moves downward through the saturated soil. Terms describing permeability are:

Very slow	less than 0.06 inch
Slow	0.06 to 0.2 inch
Moderately slow	0.2 to 0.6 inch
Moderate	0.6 inch to 2.0 inches
Moderately rapid	2.0 to 6.0 inches
Rapid	6.0 to 20 inches
Very rapid	more than 20 inches

Phase, soil. A subdivision of a soil series based on features that affect its use and management, such as slope, stoniness, and thickness.

Phosphorus. The amount of phosphorus available to plants at a depth of 30 to 42 inches is expressed in parts per million and based on the weighted average of air-dried soil samples. Terms describing the amount of available phosphorus are:

Very low	less than 7.5 ppm
Low	7.5 to 13.0 ppm
Medium	13.0 to 22.5 ppm
High	more than 22.5 ppm

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.

Plowpan. A compacted layer formed in the soil directly below the plowed layer.

Ponding. Standing water on soils in closed depressions. Unless the soils are artificially drained, the water can be removed only by percolation or evapotranspiration.

Poor filter (in tables). Because of rapid permeability, the soil may not adequately filter effluent from a waste disposal system.

Poorly graded. Refers to a coarse grained soil or soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles, density can be increased only slightly by compaction.

Potassium. The amount of potassium available to plants at a depth of 12 to 24 inches is expressed in parts per million and based on the weighted average of air-dried soil samples. Terms describing the amount of available potassium are:

Very low	less than 50 ppm
Low	50 to 79 ppm
Medium	79 to 125 ppm
High	more than 125 ppm

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 reactior because it is neither acid nor alkaline. The degrees of acidity or alkalinity, expressed as pH values, are:

Extremely acid	below 4.5
Very strongly acid	4.5 to 5.0

Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Slightly 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.

Seepage (in tables). The movement of water through the soil. Seepage adversely affects the specified use.

Series, soil. A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer or of the substratum. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Shale. Sedimentary rock formed by the hardening of a clay deposit.

Sheet erosion. The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and surface runoff.

Shrink-swell. The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Silica. A combination of silicon and oxygen. The mineral form is called quartz.

Silica-sesquioxide ratio. The ratio of the number of molecules of silica to the number of molecules of alumina and iron oxide. The more highly weathered soils or their clay fractions in warm-temperate, humid regions, and especially those in the tropics, generally have a low ratio.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Similar soils. Soils that share limits of diagnostic criteria, behave and perform in a similar manner, and have similar conservation needs or management requirements for the major land uses in the survey area.

Site index. A designation of the quality of a forest site based on the height of the dominant stand at an arbitrarily chosen age. For example, if the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years is 75 feet, the site index is 75 feet.

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. In this survey, classes for simple slopes are as follows:

Level	0 to 1 percent
Nearly level	0 to 2 percent
Very gently sloping	1 to 3 percent
Gently sloping	2 to 5 percent
Moderately sloping	5 to 9 percent
Strongly sloping	9 to 14 percent
Moderately steep	14 to 18 percent
Steep	18 to 25 percent
Very steep	more than 25 percent

Classes for complex slopes are as follows:

Level	0 to 1 percent
Nearly level	0 to 2 percent
Gently undulating	1 to 3 percent
Undulating	2 to 5 percent
Gently rolling	5 to 9 percent
Rolling	9 to 14 percent
Hilly	14 to 18 percent
Steep	18 to 25 percent
Very steep	more than 25 percent

Slope (in tables). Slope is great enough that special practices are required to ensure satisfactory performance of the soil for a specific use.

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 (7.6 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 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes, in millimeters, of separates recognized in the United States are as follows:

Very coarse sand	2.0 to 1.0
Coarse sand	1.0 to 0.5
Medium sand	0.5 to 0.25
Fine sand	0.25 to 0.10
Very fine sand	0.10 to 0.05
Silt	0.05 to 0.002
Clay	less than 0.002

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A, E, and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the substratum. The living roots and plant and animal activities are largely confined to the solum.

Stone line. A concentration of coarse fragments in a soil. Generally, it is indicative of an old weathered surface. In a cross section, the line may be one fragment or more thick. It generally overlies material that weathered in place and is overlain by recent sediment of variable thickness.

Stones. Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter if rounded or 15 to 24 inches (38 to 60 centimeters) in length if flat.

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 soil blowing 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).

Stubble mulch. Stubble or other crop residue left on the soil or partly worked into the soil. It protects the soil from soil blowing and water erosion after harvest, during preparation of a seedbed for the next crop, and during the early growing period of the new crop.

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. The part of the soil below the solum.

Subsurface layer. Any surface soil horizon (A, E, AB, or EB) below the surface layer.

Surface layer. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from about 4 to 10 inches (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

Surface soil. The A, E, AB, and EB horizons. It includes all subdivisions of these horizons.

Taxadjuncts. Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use and behavior.

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that water soaks into the soil or flows slowly to a prepared outlet.

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). A layer of otherwise suitable soil material that is too thin for the specified use.

Tilth, soil. The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

Topsoil. The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Trace elements. Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, in soils in extremely small amounts. They are essential to plant growth.

Upland (geology). Land at a higher elevation, in general, than the alluvial plain or stream terrace;

land above the lowlands along streams.

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.

Wilting point (or permanent wilting point). The moisture content of soil, on an ovendry basis, at which a plant (specifically a sunflower) wilts so much that it does not recover when placed in a humid, dark chamber.

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Tables

TABLE 1.--TEMPERATURE AND PRECIPITATION

(Recorded in the period 1961-90 at Estherville, 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*	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-----	22.6	3.2	12.9	51	-25	0	0.70	0.17	1.22	1	6.6
February----	28.0	8.6	18.3	56	-21	3	.78	.15	1.36	1	7.1
March-------	40.1	21.3	30.7	75	-8	45	1.74	.71	2.60	4	6.5
April-------	56.5	34.5	45.5	87	15	220	2.78	1.37	4.01	5	1.9
May---------	70.5	46.5	58.5	91	27	574	3.32	2.06	4.45	7	.0
June--------	79.5	56.4	68.0	97	40	839	4.14	2.52	5.59	7	.0
July--------	83.4	60.9	72.1	97	46	996	3.49	1.44	5.22	6	.0
August------	80.5	57.9	69.2	96	43	903	3.52	1.97	4.89	6	.0
September---	72.1	48.4	60.3	93	29	607	3.33	1.44	4.95	6	.0
October-----	60.4	36.7	48.6	85	18	295	2.00	.70	3.07	4	.5
November----	43.1	24.3	33.7	71	-2	60	1.23	.24	2.00	2	3.5
December----	26.7	9.1	17.9	55	-19	2	.74	.27	1.14	2	6.8
Yearly:											
Average---	55.3	34.0	44.6	---	---	---	---	---	---	---	---
Extreme---	---	---	---	99	-26	---	---	---	---	---	---
Total-----	---	---	---	---	---	4,545	27.77	22.41	31.74	51	32.9

* 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 (40 degrees F).

TABLE 2.--FREEZE DATES IN SPRING AND FALL

(Recorded in the period 1961-90 at Estherville, 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--	Apr. 20	May 8	May 16
2 years in 10 later than--	Apr. 16	May 3	May 12
5 years in 10 later than--	Apr. 8	Apr. 23	May 3
First freezing temperature in fall:			
1 year in 10 earlier than--	Oct. 6	Sept. 24	Sept. 20
2 years in 10 earlier than--	Oct. 12	Sept. 29	Sept. 24
5 years in 10 earlier than--	Oct. 23	Oct. 9	Oct. 2

TABLE 3.--GROWING SEASON

(Recorded in the period 1961-90 at Estherville, 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	175	145	134
8 years in 10	183	153	140
5 years in 10	198	168	152
2 years in 10	213	184	164
1 year in 10	221	192	171

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	9,105	3.5
27	Terril loam, 0 to 2 percent slopes	290	0.1
27B	Terril loam, 2 to 5 percent slopes	270	0.1
27C	Terril loam, 5 to 9 percent slopes	260	0.1
28	Dickman sandy loam, 0 to 2 percent slopes	230	0.1
28B	Dickman sandy loam, 2 to 5 percent slopes	535	0.2
34	Estherville sandy loam, 0 to 2 percent slopes	220	0.1
34C2	Estherville sandy loam, 5 to 9 percent slopes, moderately eroded	345	0.1
55	Nicollet loam, 1 to 3 percent slopes	59,370	23.1
62C2	Storden loam, 5 to 9 percent slopes, moderately eroded	620	0.2
62D2	Storden loam, 9 to 14 percent slopes, moderately eroded	1,370	0.5
62D3	Storden loam, 9 to 14 percent slopes, severely eroded	375	0.1
62E	Storden loam, 14 to 18 percent slopes	445	0.2
62E2	Storden loam, 14 to 18 percent slopes, moderately eroded	980	0.4
62F	Storden loam, 18 to 25 percent slopes	950	0.4
62G	Storden loam, 25 to 40 percent slopes	1,350	0.5
72	Estherville loam, 0 to 2 percent slopes	875	0.3
72B	Estherville loam, 2 to 5 percent slopes	1,640	0.6
73B	Salida gravelly loamy sand, 2 to 5 percent slopes	615	0.2
73C2	Salida gravelly loamy sand, 5 to 9 percent slopes, moderately eroded	245	0.1
73D2	Salida gravelly loamy sand, 9 to 14 percent slopes, moderately eroded	215	0.1
73G	Salida gravelly loamy sand, 18 to 40 percent slopes	260	0.1
90	Okoboji mucky silt loam, 0 to 1 percent slopes	3,770	1.5
95	Harps clay loam, 1 to 3 percent slopes	6,850	2.7
107	Webster silty clay loam, 0 to 2 percent slopes	15,780	6.1
108	Wadena loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes	410	0.2
133	Colo silty clay loam, 0 to 2 percent slopes	1,680	0.7
135	Coland clay loam, 0 to 2 percent slopes	570	0.2
138B	Clarion loam, 2 to 5 percent slopes	49,348	19.2
138C	Clarion loam, 5 to 9 percent slopes	1,330	0.5
138C2	Clarion loam, 5 to 9 percent slopes, moderately eroded	8,230	3.2
138D	Clarion loam, 9 to 14 percent slopes	320	0.1
138D2	Clarion loam, 9 to 14 percent slopes, moderately eroded	820	0.3
221	Palms muck, 0 to 1 percent slopes	11,620	4.5
224	Linder loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes	260	0.1
236B	Lester loam, 2 to 5 percent slopes	795	0.3
236C	Lester loam, 5 to 9 percent slopes	825	0.3
236D	Lester loam, 9 to 14 percent slopes	235	0.1
236F	Lester loam, 18 to 25 percent slopes	260	0.1
236G	Lester loam, 25 to 40 percent slopes	950	0.4
259	Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	405	0.2
354	Aquolls, ponded	1,880	0.7
384	Collinwood silty clay loam, 0 to 2 percent slopes	690	0.3
390	Waldorf silty clay loam, 0 to 2 percent slopes	700	0.3
485	Spillville loam, 0 to 2 percent slopes	560	0.2
485B	Spillville loam, 2 to 5 percent slopes	2,240	0.9
507	Canisteo clay loam, 0 to 2 percent slopes	27,405	10.7
508	Calcousta mucky silt loam, 0 to 1 percent slopes	1,430	0.6
511	Blue Earth mucky silt loam, 0 to 1 percent slopes	1,505	0.6
511B	Blue Earth mucky silt loam, 1 to 5 percent slopes	230	0.1
524	Linder loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	575	0.2
559	Talcot clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	200	0.1
585B	Coland-Spillville complex, 2 to 5 percent slopes	1,800	0.7
638B	Clarion-Storden complex, 2 to 5 percent slopes	1,975	0.8
638C2	Clarion-Storden complex, 5 to 9 percent slopes, moderately eroded	5,500	2.1
638D2	Clarion-Storden complex, 9 to 14 percent slopes, moderately eroded	4,200	1.6
638E2	Clarion-Storden complex, 14 to 18 percent slopes, moderately eroded	1,305	0.5
639D2	Storden-Salida complex, 5 to 14 percent slopes, moderately eroded	230	0.1
655	Crippin loam, 1 to 3 percent slopes	5,875	2.3
707	Delft clay loam, 1 to 3 percent slopes	360	0.1
733	Calco silty clay loam, 0 to 2 percent slopes	250	0.1
787B	Vinje silty clay loam, 2 to 5 percent slopes	650	0.3
811	Muskego muck, 0 to 2 percent slopes	310	0.1
823	Ridgeport sandy loam, 1 to 3 percent slopes	490	0.2

TABLE 4.--ACREAGE AND PROPORTIONATE EXTENT OF THE SOILS--Continued

Map symbol	Soil name	Acres	Percent
828B	Zenor sandy loam, 2 to 5 percent slopes	385	0.1
828C2	Zenor sandy loam, 5 to 9 percent slopes, moderately eroded	260	0.1
879	Fostoria loam, 0 to 2 percent slopes	435	0.2
956	Okoboji-Harps complex, 0 to 2 percent slopes	810	0.3
1133	Colo silty clay loam, channeled, 0 to 2 percent slopes	890	0.3
1458	Millington silt loam, channeled, 0 to 2 percent slopes	1,690	0.7
1585	Coland-Spillville complex, channeled, 0 to 2 percent slopes	445	0.2
1707B	Delft-Terril complex, 2 to 5 percent slopes	680	0.3
5010	Pits, sand and gravel	550	0.2
5040	Orthents, loamy	132	0.1
5043	Orthents, loamy, reclaimed, 2 to 9 percent slopes	240	0.1
	Water	5,100	2.0
	Total	257,000	100.0

TABLE 5.--PRIME FARMLAND

(Only the soils considered prime farmland are listed. Urban or built-up areas of the soils listed are not considered prime farmland. If a soil is prime farmland only under certain conditions, the conditions are specified in parentheses after the soil name)

Map symbol	Soil name
27	Terril loam, 0 to 2 percent slopes
27B	Terril loam, 2 to 5 percent slopes
55	Nicollet loam, 1 to 3 percent slopes
95	Harps clay loam, 1 to 3 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
133	Colo silty clay loam, 0 to 2 percent slopes (where drained)
135	Coland clay loam, 0 to 2 percent slopes (where drained)
138B	Clarion loam, 2 to 5 percent slopes
224	Linder loam, 24 to 32 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)
384	Collinwood silty clay loam, 0 to 2 percent slopes
390	Waldorf silty clay loam, 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)
524	Linder loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes
559	Talcot clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes (where drained)
585B	Coland-Spillville complex, 2 to 5 percent slopes (where drained)
638B	Clarion-Storden complex, 2 to 5 percent slopes
655	Crippin loam, 1 to 3 percent slopes
707	Delft clay loam, 1 to 3 percent slopes (where drained)
733	Calco silty clay loam, 0 to 2 percent slopes (where drained)
787B	Vinje silty clay loam, 2 to 5 percent slopes
879	Fostoria loam, 0 to 2 percent slopes
1707B	Delft-Terril complex, 2 to 5 percent slopes (where drained)

TABLE 6.--LAND CAPABILITY, CORN SUITABILITY RATING, AND YIELDS PER ACRE OF CROPS AND PASTURE

(Yields are those that can be expected under a high level of management. Absence of a yield indicates that the soil is not suited to the crop or the crop generally is not grown on the soil)

Soil name and map symbol	Land capability	Corn suitability rating	Corn	Soybeans	Oats	Bromegrass-alfalfa hay	Kentucky bluegrass	Smooth bromegrass	Bromegrass-alfalfa
		RV*	Bu	Bu	Bu	Tons	AUM**	AUM**	AUM**
6----------------- Okoboji	IIIw	53	105	34	74	3.2	2.6	4.3	5.3
27----------------- Terril	I	79	134	48	94	5.6	3.3	5.5	9.4
27B---------------- Terril	IIe	74	131	42	92	5.5	3.2	5.4	9.2
27C---------------- Terril	IIIe	61	126	40	88	5.3	3.1	5.2	8.9
28----------------- Dickman	IIIs	38	71	23	50	3.0	1.7	2.9	5.0
28B---------------- Dickman	IIIe	33	68	22	48	2.9	1.7	2.8	4.8
34----------------- Estherville	IIIs	23	44	14	31	1.8	1.1	1.8	3.0
34C2--------------- Estherville	IVe	7	33	11	23	1.4	0.8	1.4	2.3
55----------------- Nicollet	I	82	142	45	99	5.7	3.5	5.8	9.5
62C2--------------- Storden	IIIe	47	111	36	78	4.7	2.7	4.6	7.8
62D2--------------- Storden	IIIe	38	102	33	71	4.3	2.5	4.2	7.2
62D3--------------- Storden	IVe	34	94	30	66	3.9	2.3	3.9	6.5
62E---------------- Storden	IVe	32	89	28	62	3.7	2.2	3.6	6.2
62E2--------------- Storden	IVe	29	85	27	59	3.6	2.1	3.5	6.0

See footnotes at end of table.

TABLE 6.--LAND CAPABILITY, CORN SUITABILITY RATING, AND YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Land capability	Corn suitability rating	Corn	Soybeans	Oats	Bromegrass-alfalfa hay	Kentucky bluegrass	Smooth bromegrass	Bromegrass-alfalfa
		RV*	Bu	Bu	Bu	Tons	AUM**	AUM**	AUM**
62F----------------- Storden	VIe	11	---	---	---	3.3	1.9	3.2	5.5
62G----------------- Storden	VIIe	5	---	---	---	---	1.8	---	---
72------------------ Estherville	IIIs	35	77	25	54	3.2	1.9	3.2	5.3
72B----------------- Estherville	IIIe	31	74	24	52	3.1	1.8	3.0	5.2
73B----------------- Salida	IIIs	18	41	13	29	1.7	1.0	1.7	2.8
73C2---------------- Salida	IVs	5	33	11	23	1.4	0.8	1.4	2.3
73D2---------------- Salida	IVe	5	---	---	---	1.0	0.6	1.0	1.7
73G----------------- Salida	VIIe	5	---	---	---	---	0.5	---	---
90------------------ Okoboji	IIIw	54	107	34	75	3.2	2.6	4.4	5.3
95------------------ Harps	IIw	57	113	36	79	3.4	2.8	4.6	5.7
107----------------- Webster	IIw	77	131	42	92	3.9	3.2	5.4	6.5
108----------------- Wadena	IIs	50	89	28	62	3.7	2.2	3.6	6.2
133----------------- Colo	IIw	73	124	40	87	3.7	3.1	5.1	6.2
135----------------- Coland	IIw	73	124	40	87	3.7	3.1	5.1	6.2
138B---------------- Clarion	IIe	74	131	42	92	5.5	3.2	5.4	9.2
138C---------------- Clarion	IIIe	61	126	40	88	5.3	3.1	5.2	8.9

See footnotes at end of table.

TABLE 6.--LAND CAPABILITY, CORN SUITABILITY RATING, AND YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Land capability	Corn suitability rating	Corn	Soybeans	Oats	Bromegrass-alfalfa hay	Kentucky bluegrass	Smooth bromegrass	Bromegrass-alfalfa
		RV*	Bu	Bu	Bu	Tons	AUM**	AUM**	AUM**
138C2: Clarion	IIIe	59	122	39	85	5.1	3.0	5.0	8.5
138D: Clarion	IIIe	52	117	37	82	4.9	2.9	4.8	8.2
138D2: Clarion	IIIe	50	113	36	79	4.7	2.8	4.6	7.8
221: Palms	IIIw	45	104	33	73	3.1	2.6	4.3	5.2
224: Linder	IIs	46	90	29	63	3.6	2.2	3.7	6.0
236B: Lester	IIe	70	124	40	87	5.2	3.1	5.1	8.7
236C: Lester	IIIe	56	119	38	83	5.0	2.9	4.9	8.4
236D: Lester	IIIe	47	110	35	77	4.6	2.7	4.5	7.7
236F: Lester	VIe	20	---	---	---	3.5	2.0	3.4	5.8
236G: Lester	VIIe	9	---	---	---	---	1.9	3.2	---
259: Biscay	IIw	70	119	38	83	3.6	2.9	4.9	6.0
354: Aquolls	VIIw	5	---	---	---	---	---	---	---
384: Collinwood	IIw	69	117	37	82	4.7	2.9	4.8	7.8
390: Waldorf	IIw	63	101	32	71	3.0	2.5	4.1	5.0
485: Spillville	IIw	84	142	45	99	5.7	3.5	5.8	9.5
485B: Spillville	IIe	79	139	44	97	5.6	3.4	5.7	9.4

See footnotes at end of table.

TABLE 6.--LAND CAPABILITY, CORN SUITABILITY RATING, AND YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Land capability	Corn suitability rating	Corn	Soybeans	Oats	Bromegrass-alfalfa hay	Kentucky bluegrass	Smooth bromegrass	Bromegrass-alfalfa
		RV*	Bu	Bu	Bu	Tons	AUM**	AUM**	AUM**
507------------------ Canisteo	IIw	73	127	41	89	3.8	3.1	5.2	6.3
508------------------ Calcousta	IIIw	64	107	34	75	3.2	2.6	4.4	5.3
511------------------ Blue Earth	IIIw	50	75	24	53	2.3	1.8	3.1	3.8
511B----------------- Blue Earth	IIIw	45	72	23	50	2.2	1.8	3.0	3.7
524------------------ Linder	IIs	54	106	34	74	4.2	2.6	4.3	7.0
559------------------ Talcot	IIw	65	113	36	79	3.4	2.8	4.6	5.7
585B----------------- Coland-Spillville	IIw	60	125	40	94	3.8	3.1	5.1	6.3
638B----------------- Clarion-Storden	IIe	68	126	40	88	5.3	3.1	5.2	8.9
638C2---------------- Clarion-Storden	IIIe	53	117	37	82	4.9	2.9	4.8	8.2
638D2---------------- Clarion-Storden	IIIe	44	108	35	76	4.5	2.7	4.4	7.5
638E2---------------- Clarion-Storden	IVe	34	91	29	64	3.8	2.2	3.7	6.3
639D2---------------- Storden-Salida	IVe	18	65	21	46	2.7	1.6	2.7	4.5
655------------------ Crippin	I	77	136	44	95	5.4	3.3	5.6	9.0
707------------------ Delft	IIw	73	124	40	87	3.7	3.1	5.1	6.2
733------------------ Calco	IIw	68	118	38	83	3.5	2.9	4.8	5.8
787B----------------- Vinje	IIe	62	111	36	78	4.7	2.7	4.6	7.8

See footnotes at end of table.

TABLE 6.--LAND CAPABILITY, CORN SUITABILITY RATING, AND YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Land capability	Corn suitability rating	Corn	Soybeans	Oats	Bromegrass-alfalfa hay	Kentucky bluegrass	Smooth bromegrass	Bromegrass-alfalfa
		RV*	Bu	Bu	Bu	Tons	AUM**	AUM**	AUM**
811---------------- Muskego	IIIw	42	97	31	68	2.9	2.4	4.0	4.8
823---------------- Ridgeport	IIIs	34	70	22	49	2.9	1.7	2.9	4.8
828B--------------- Zenor	IIIe	45	80	26	56	3.4	2.0	3.3	5.7
828C2-------------- Zenor	IIIe	29	72	23	50	3.0	1.8	3.0	5.0
879---------------- Fostoria	I	68	116	37	81	4.6	2.9	4.8	7.7
956---------------- Okoboji-Harps	IIIw	54	108	35	76	3.2	2.7	4.4	5.3
1133--------------- Colo	Vw	25	---	---	---	---	3.0	---	---
1458--------------- Millington	Vw	25	---	---	---	---	3.8	---	---
1585--------------- Colo-Spillville	Vw	25	---	---	---	---	3.4	---	---
1707B-------------- Delft-Terril	IIw	73	126	40	88	3.8	3.1	5.2	6.3
5010. Pits									
5040, 5043. Orthents									

* Relative value: The value for corn suitability rating (CSR).

** Animal unit month: The amount of forage or feed required to feed one animal unit (one cow, one horse, one mule, five sheep, or five goats) for 30 days.

TABLE 7.--WOODLAND MANAGEMENT AND PRODUCTIVITY

(Only the soils suitable for production of commercial trees are listed. Absence of an entry indicates that information was not available)

Soil name and map symbol	Ordination symbol	Management concerns					Potential productivity			Trees to plant
		Erosion hazard	Equipment limitation	Seedling mortality	Windthrow hazard	Plant competition	Common trees	Site index	Productivity class*	
221----------------- Palms	2W	Slight	Severe	Severe	Severe	Severe	Red maple-----------	55	2	Northern whitecedar, tamarack.
							Silver maple--------	80	2	
							White ash-----------	---	---	
							Quaking aspen-------	---	---	
							Northern whitecedar-	---	---	
							Tamarack------------	61	4	
							Black ash-----------	---	---	
236C, 236D--------- Lester	5A	Slight	Slight	Slight	Slight	Severe	Northern red oak----	70	5	Black walnut, northern red oak, white oak, silver maple.
							American basswood---	70	5	
							Black walnut--------	62	---	
							Eastern cottonwood--	90	7	
							Eastern white pine--	65	10	
							White oak-----------	60	4	
236F, 236G--------- Lester	5R	Moderate	Moderate	Slight	Slight	Severe	Northern red oak----	70	5	Black walnut, northern red oak, white oak, silver maple.
							American basswood---	70	5	
							Black walnut--------	62	---	
							Eastern cottonwood--	90	7	
							Eastern white pine--	65	10	
							White oak-----------	60	4	
811----------------- Muskego	3W	Slight	Severe	Severe	Severe	Severe	Tamarack------------	50	3	---

* Productivity class is the yield in cubic meters per hectare per year calculated at the age of culmination of mean annual increment for fully stocked natural stands.

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS

(Only the soils suitable for windbreaks and environmental plantings are listed. 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	---	Redosier dogwood	Black ash, tall purple willow.	Black willow, white willow, golden willow.	---
27, 27B, 27C------ Terril	---	Gray dogwood, Siberian peashrub, redosier dogwood, lilac.	Honeylocust, Russian-olive, Amur maple, blue spruce, northern whitecedar, eastern redcedar.	Eastern white pine, green ash.	---
55---------------- Nicollet	---	Redosier dogwood, lilac.	Northern whitecedar, white spruce, blue spruce, Amur maple.	Austrian pine, eastern white pine, green ash, hackberry.	Silver maple.
62C2, 62D2, 62D3, 62E, 62E2, 62F, 62G-------------- Storden	American plum-----	Eastern redcedar, hackberry, Siberian peashrub.	Honeylocust, green ash, Russian-olive.	Siberian elm------	---
90---------------- Okoboji	---	Redosier dogwood	Black ash, tall purple willow.	Black willow, white willow, golden willow.	---
95---------------- Harps	---	Lilac, northern whitecedar, Siberian peashrub.	Hackberry, white spruce, eastern redcedar, bur oak.	Golden willow, honeylocust, green ash.	Eastern cottonwood.
107--------------- Webster	---	Redosier dogwood, American plum, cotoneaster.	Hackberry, Amur maple, northern whitecedar, tall purple willow, white spruce.	Golden willow, green ash.	Eastern cottonwood, silver maple.
108--------------- Wadena	Siberian peashrub, lilac.	Eastern redcedar, Russian-olive, hackberry, Manchurian crabapple.	Jack pine, eastern white pine, bur oak, green ash.	---	---
133--------------- Colo	---	Redosier dogwood, American plum.	White fir, white spruce, hackberry, Amur maple, tall purple willow.	Green ash, golden willow.	Silver maple, eastern cottonwood.

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of--				
	<8	8-15	16-25	26-35	>35
138B, 138C, 138C2, 138D, 138D2------ Clarion	---	Gray dogwood, redosier dogwood, lilac, Siberian peashrub.	Northern whitecedar, blue spruce, Amur maple, Russian-olive, eastern redcedar, hackberry.	Green ash, eastern white pine.	---
221--------------- Palms	---	Silky dogwood, common ninebark, nannyberry viburnum, American cranberrybush.	Northern whitecedar, Black Hills spruce, Manchurian crabapple, white spruce.	Eastern white pine, Norway spruce, green ash.	Imperial Carolina poplar.
224--------------- Linder	---	Redosier dogwood, lilac.	Northern whitecedar, blue spruce, Amur maple, white spruce.	Eastern white pine, Austrian pine, green ash, hackberry.	Silver maple.
236B, 236C, 236D, 236F, 236G------- Lester	---	Redosier dogwood, Siberian peashrub, lilac, gray dogwood.	Hackberry, eastern redcedar, northern whitecedar, Amur maple, Russian-olive, blue spruce.	Eastern white pine, green ash.	---
259--------------- Biscay	---	Redosier dogwood, American plum, cotoneaster.	Northern whitecedar, Amur maple, white spruce, hackberry, tall purple willow.	Green ash, golden willow.	Eastern cottonwood, silver maple.
384--------------- Collinwood	---	Northern whitecedar, Siberian peashrub, cotoneaster, lilac, eastern redcedar.	White spruce, Austrian pine, hackberry, Russian-olive, bur oak.	Eastern white pine, green ash.	---
390--------------- Waldorf	---	Redosier dogwood	Northern whitecedar, white spruce, Amur maple, tall purple willow, hackberry, American plum.	Golden willow-----	Eastern cottonwood, silver maple, green ash.
485--------------- Spillville	---	Redosier dogwood, lilac.	Northern whitecedar, white spruce, blue spruce, Amur maple.	Hackberry, eastern white pine, Austrian pine, green ash.	Silver maple.

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of--				
	<8	8-15	16-25	26-35	>35
507 Canisteo	---	Siberian peashrub, cotoneaster, lilac, northern whitecedar.	Hackberry, bur oak, white spruce, eastern redcedar.	Golden willow, honeylocust, green ash.	Eastern cottonwood.
508 Calcousta	---	Northern whitecedar, Siberian peashrub, lilac.	Hackberry, white spruce, eastern redcedar, bur oak.	Honeylocust, golden willow, green ash.	Eastern cottonwood.
511 Blue Earth	---	Redosier dogwood	Black ash, tall purple willow.	Golden willow, white willow.	---
524 Linder	---	Redosier dogwood, lilac.	Northern whitecedar, blue spruce, Amur maple, white spruce.	Eastern white pine, Austrian pine, green ash, hackberry.	Silver maple.
559 Talcot	Lilac	Siberian peashrub	Hackberry, ponderosa pine, blue spruce, Russian-olive, eastern redcedar.	Honeylocust, golden willow, green ash.	Eastern cottonwood.
585B:					
Coland	---	Redosier dogwood, cotoneaster, American plum.	White spruce, hackberry, northern whitecedar, tall purple willow, Amur maple.	Golden willow, green ash.	Eastern cottonwood, silver maple.
Spillville	---	Redosier dogwood, lilac.	Northern whitecedar, white spruce, blue spruce, Amur maple.	Hackberry, eastern white pine, Austrian pine, green ash.	Silver maple.
638B, 638C2, 638D2, 638E2:					
Clarion	---	Gray dogwood, redosier dogwood, lilac, Siberian peashrub.	Northern whitecedar, blue spruce, Amur maple, Russian-olive, eastern redcedar, hackberry.	Green ash, eastern white pine.	---
Storden	American plum	Eastern redcedar, hackberry, Siberian peashrub.	Honeylocust, green ash, Russian-olive.	Siberian elm	---
639D2:					
Storden	American plum	Eastern redcedar, hackberry, Siberian peashrub.	Honeylocust, green ash, Russian-olive.	Siberian elm	---
Salida.					

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of--				
	<8	8-15	16-25	26-35	>35
655------------- Crippin	---	Northern whitecedar, cotoneaster, Siberian peashrub, lilac.	Hackberry, white spruce, eastern redcedar, bur oak.	Golden willow, green ash, honeylocust.	Eastern cottonwood.
707------------- Delft	---	American plum, redosier dogwood.	Hackberry, Amur maple, white spruce, northern whitecedar, tall purple willow.	Green ash, golden willow.	Silver maple, eastern cottonwood.
733------------- Calco	---	Lilac, Amur honeysuckle, Siberian peashrub, northern whitecedar.	Hackberry, eastern redcedar, bur oak, white spruce.	Honeylocust, golden willow, green ash.	Eastern cottonwood.
787B------------ Vinje	Gray dogwood, silky dogwood.	Redosier dogwood, American plum.	Russian-olive, Amur maple, eastern redcedar.	Red pine, Norway spruce, hackberry.	Silver maple.
811------------- Muskego	---	Nannyberry viburnum, silky dogwood, common ninebark, northern whitecedar, American cranberrybush, redosier dogwood, late lilac.	White spruce, Japanese tree lilac, Manchurian crabapple.	Siberian crabapple	Imperial Carolina poplar.
828B, 828C2------- Zenor	Siberian peashrub, lilac.	Manchurian crabapple, hackberry, eastern redcedar.	Honeylocust, bur oak, jack pine, green ash, Russian-olive, eastern white pine.	---	---
879------------- Fostoria	---	Redosier dogwood, lilac.	White spruce, blue spruce, northern whitecedar, Amur maple.	Austrian pine, green ash, eastern white pine, hackberry.	Silver maple.
956:					
Okoboji----------	---	Redosier dogwood	Black ash, tall purple willow.	Black willow, white willow, golden willow.	---
Harps------------	---	Lilac, northern whitecedar, Siberian peashrub.	Hackberry, white spruce, eastern redcedar, bur oak.	Golden willow, honeylocust, green ash.	Eastern cottonwood.
1133------------ Colo	---	Redosier dogwood, American plum.	White fir, white spruce, hackberry, Amur maple, tall purple willow.	Green ash, golden willow.	Silver maple, eastern cottonwood.

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of--				
	<8	8-15	16-25	26-35	>35
1458: Millington	---	Northern whitecedar, lilac, Siberian peashrub.	Hackberry, white spruce, eastern redcedar.	Honeylocust, silver maple, green ash, red maple, white ash.	Eastern cottonwood.
1585: Coland	---	Redosier dogwood, cotoneaster, American plum.	White spruce, hackberry, northern whitecedar, tall purple willow, Amur maple.	Golden willow, green ash.	Eastern cottonwood, silver maple.
Spillville	---	Redosier dogwood, lilac.	Northern whitecedar, white spruce, blue spruce, Amur maple.	Hackberry, eastern white pine, Austrian pine, green ash.	Silver maple.
1707B: Delft	---	American plum, redosier dogwood.	Hackberry, Amur maple, white spruce, northern whitecedar, tall purple willow.	Green ash, golden willow.	Silver maple, eastern cottonwood.
Terril.					

TABLE 9.--RECREATIONAL DEVELOPMENT

(Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated)

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
6 Okoboji	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.
27 Terril	Slight	Slight	Slight	Slight	Slight.
27B Terril	Slight	Slight	Moderate: slope.	Slight	Slight.
27C Terril	Slight	Slight	Severe: slope.	Slight	Slight.
28 Dickman	Slight	Slight	Slight	Slight	Moderate: droughty.
28B Dickman	Slight	Slight	Moderate: slope.	Slight	Moderate: droughty.
34 Estherville	Slight	Slight	Moderate: small stones.	Slight	Moderate: droughty.
34C2 Estherville	Slight	Slight	Severe: slope.	Slight	Moderate: droughty.
55 Nicollet	Moderate: wetness.	Moderate: wetness.	Moderate: slope, wetness.	Slight	Slight.
62C2 Storden	Slight	Slight	Severe: slope.	Slight	Slight.
62D2, 62D3 Storden	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight	Moderate: slope.
62E, 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.
72 Estherville	Slight	Slight	Moderate: small stones.	Slight	Moderate: droughty.
72B Estherville	Slight	Slight	Moderate: slope, small stones.	Slight	Moderate: droughty.
73B Salida	Slight	Slight	Severe: small stones.	Slight	Severe: droughty.
73C2 Salida	Slight	Slight	Severe: slope, small stones.	Slight	Severe: droughty.
73D2 Salida	Moderate	Moderate	Severe: slope, small stones.	Slight	Severe: droughty.

TABLE 9.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
73G: Salida	Severe: slope.	Severe: slope.	Severe: slope, small stones.	Severe: slope.	Severe: slope.
90: Okoboji	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.
95: Harps	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.
107: Webster	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.
108: Wadena	Slight	Slight	Slight	Slight	Slight.
133: Colo	Severe: flooding, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.
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.
138D, 138D2: Clarion	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight	Moderate: slope.
221: Palms	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: excess humus, ponding.	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.
236D: Lester	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight	Moderate: slope.
236F: Lester	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.
236G: Lester	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
259: Biscay	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.
354: Aquolls	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.

TABLE 9.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
384-------------------- Collinwood	Moderate: wetness.	Moderate: wetness.	Moderate: wetness.	Slight----------	Slight.
390-------------------- Waldorf	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.
485-------------------- Spillville	Severe: flooding.	Slight----------	Moderate: flooding.	Slight----------	Moderate: flooding.
485B------------------- Spillville	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
507-------------------- Canisteo	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.
508-------------------- Calcousta	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.
511-------------------- Blue Earth	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.
511B------------------- Blue Earth	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.
524-------------------- Linder	Moderate: wetness.	Moderate: wetness.	Moderate: wetness.	Slight----------	Slight.
559-------------------- Talcot	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
585B:					
Coland---------------	Severe: flooding, wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness, flooding.
Spillville-----------	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
638B:					
Clarion--------------	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
Storden--------------	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
638C2:					
Clarion--------------	Slight----------	Slight----------	Severe: slope.	Slight----------	Slight.
Storden--------------	Slight----------	Slight----------	Severe: slope.	Slight----------	Slight.
638D2:					
Clarion--------------	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight----------	Moderate: slope.
Storden--------------	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight----------	Moderate: slope.
638E2:					
Clarion--------------	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.

TABLE 9.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
638E2:					
Storden	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.
639D2:					
Storden	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight	Moderate: slope.
Salida	Moderate	Moderate	Severe: slope, small stones.	Slight	Severe: droughty.
655 Crippin	Moderate: wetness.	Moderate: wetness.	Moderate: slope, wetness.	Slight	Slight.
707 Delft	Severe: wetness.	Moderate: wetness, percs slowly.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
733 Calco	Severe: flooding, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.
787B Vinje	Moderate: percs slowly.	Moderate: percs slowly.	Moderate: slope, percs slowly.	Slight	Slight.
811 Muskego	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: excess humus, ponding.	Severe: ponding, excess humus.	Severe: ponding, excess humus.
823 Ridgeport	Slight	Slight	Moderate: slope.	Slight	Moderate: droughty.
828B Zenor	Slight	Slight	Moderate: slope, small stones.	Slight	Moderate: droughty.
828C2 Zenor	Slight	Slight	Severe: slope.	Slight	Moderate: droughty.
879 Fostoria	Moderate: wetness.	Moderate: wetness.	Moderate: wetness.	Slight	Slight.
956:					
Okoboji	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.
Harps	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.
1133 Colo	Severe: flooding, wetness.	Severe: wetness.	Severe: wetness, flooding.	Severe: wetness.	Severe: wetness, flooding.
1458 Millington	Severe: flooding, ponding.	Severe: ponding.	Severe: ponding, flooding.	Severe: ponding.	Severe: ponding, flooding.

TABLE 9.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
1585:					
Coland----------------	Severe: flooding, wetness.	Moderate: flooding, wetness.	Severe: wetness, flooding.	Moderate: wetness, flooding.	Severe: flooding.
Spillville-----------	Severe: flooding.	Moderate: flooding.	Severe: flooding.	Moderate: flooding.	Severe: flooding.
1707B:					
Delft-----------------	Severe: wetness.	Moderate: wetness, percs slowly.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
Terril---------------	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
5010------------------ Pits	Severe: too sandy.	Severe: too sandy.	Severe: too sandy.	Severe: too sandy.	Severe: droughty.
5040, 5043------------ Orthents	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.

TABLE 10.--WILDLIFE HABITAT

(See text for definitions of "good," "fair," "poor," and "very poor." Absence of an entry indicates that the soil was not rated)

Soil name and map symbol	Potential for habitat elements							Potential as habitat for--		
	Grain and seed crops	Grasses and legumes	Wild 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.
27, 27B Terril	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
27C Terril	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
28, 28B Dickman	Fair	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
34, 34C2 Estherville	Fair	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
55 Nicollet	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
62C2, 62D2, 62D3, 62E, 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.
72, 72B Estherville	Fair	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
73B, 73C2, 73D2 Salida	Poor	Poor	Poor	Poor	Poor	Very poor.	Very poor.	Poor	Poor	Very poor.
73G Salida	Very poor.	Very poor.	Poor	Very poor.	Very poor.	Very poor.	Very poor.	Very poor.	Very 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 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.
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 Clarion	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.

TABLE 10.--WILDLIFE HABITAT--Continued

Soil name and map symbol	Potential for habitat elements: Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Wetland plants	Shallow water areas	Potential as habitat for--: Openland wildlife	Woodland wildlife	Wetland wildlife
138D, 138D2: Clarion	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
221: Palms	Poor	Poor	Poor	Poor	Poor	Good	Good	Poor	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, 236D: Lester	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
236F, 236G: 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.
354. Aquolls										
384. Collinwood										
390: 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.
507: Canisteo	Good	Good	Fair	Fair	Fair	Good	Good	Good	Fair	Good.
508: Calcousta	Good	Good	Fair	Good	Good	Good	Good	Good	Good	Good.
511: Blue Earth	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Poor	Good.
511B: Blue Earth	Poor	Poor	Poor	Poor	Poor	Good	Good	Poor	Poor	Good.
524: Linder	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
559: Talcot	Good	Good	Fair	Fair	Fair	Good	Good	Good	Fair	Good.
585B:										
Coland	Good	Good	Good	Fair	Fair	Good	Good	Good	Fair	Good.
Spillville	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.

TABLE 10.--WILDLIFE HABITAT--Continued

Soil name and map symbol	Potential for habitat elements							Potential as habitat for--		
	Grain and seed crops	Grasses and legumes	Wild herba- ceous plants	Hardwood trees	Conif- erous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
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.
638C2:										
Clarion	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
Storden	Fair	Good	Good	Fair	Poor	Very poor.	Very poor.	Fair	Fair	Very poor.
638D2:										
Clarion	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
Storden	Fair	Good	Good	Fair	Poor	Very poor.	Very poor.	Fair	Fair	Very poor.
638E2:										
Clarion	Poor	Fair	Good	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
Storden	Fair	Good	Good	Fair	Poor	Very poor.	Very poor.	Fair	Fair	Very poor.
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.
655 Crippin	Good	Good	Good	Good	Fair	Fair	Poor	Good	Good	Poor.
707 Delft	Good	Good	Good	Fair	Fair	Good	Good	Good	Fair	Good.
733 Calco	Good	Fair	Good	Poor	Very poor.	Good	Good	Fair	Poor	Fair.
787B Vinje	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
811 Muskego	Good	Fair	Poor	Poor	Poor	Good	Good	Fair	Poor	Good.
823 Ridgeport	Fair	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
828B, 828C2 Zenor	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.
956:										
Okoboji	Fair	Fair	Fair	Fair	Very poor.	Good	Good	Fair	Fair	Good.

TABLE 10.--WILDLIFE HABITAT--Continued

Soil name and map symbol	Potential for habitat elements: Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Wetland plants	Shallow water areas	Potential as habitat for--: Openland wildlife	Woodland wildlife	Wetland wildlife
956:										
Harps	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
1133 Colo	Good	Fair	Good	Fair	Poor	Good	Good	Fair	Fair	Good.
1458 Millington	Good	Good	Good	Good	Fair	Good	Good	Good	Good	Good.
1585:										
Coland	Poor	Fair	Fair	Poor	Poor	Good	Good	Poor	Poor	Good.
Spillville	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
1707B:										
Delft	Good	Good	Good	Fair	Fair	Good	Good	Good	Fair	Good.
Terril	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
5010 Pits	Very poor.	Very poor.	Very poor.	Very poor.	Very poor.	Very poor.	Very poor.	Very poor.	Very poor.	Very poor.
5040, 5043. Orthents										

TABLE 11.--BUILDING SITE DEVELOPMENT

(Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation)

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
6----------------- Okoboji	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: shrink-swell, low strength, ponding.	Severe: ponding.
27, 27B----------- Terril	Slight---------	Slight---------	Slight---------	Slight---------	Severe: low strength.	Slight.
27C--------------- Terril	Slight---------	Slight---------	Slight---------	Moderate: slope.	Severe: low strength.	Slight.
28, 28B----------- Dickman	Severe: cutbanks cave.	Slight---------	Slight---------	Slight---------	Slight---------	Moderate: droughty.
34---------------- Estherville	Severe: cutbanks cave.	Slight---------	Slight---------	Slight---------	Slight---------	Moderate: droughty.
34C2-------------- Estherville	Severe: cutbanks cave.	Slight---------	Slight---------	Moderate: slope.	Slight---------	Moderate: droughty.
55---------------- Nicollet	Severe: wetness.	Moderate: wetness, shrink-swell.	Severe: wetness.	Moderate: wetness, shrink-swell.	Severe: low strength, frost action.	Slight.
62C2-------------- Storden	Slight---------	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Moderate: shrink-swell, low strength.	Slight.
62D2, 62D3-------- Storden	Moderate: slope.	Moderate: shrink-swell, slope.	Moderate: slope, shrink-swell.	Severe: slope.	Moderate: shrink-swell, low strength, slope.	Moderate: slope.
62E, 62E2, 62F, 62G-------------- Storden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
72, 72B----------- Estherville	Severe: cutbanks cave.	Slight---------	Slight---------	Slight---------	Slight---------	Moderate: droughty.
73B--------------- Salida	Severe: cutbanks cave.	Slight---------	Slight---------	Slight---------	Slight---------	Severe: droughty.
73C2-------------- Salida	Severe: cutbanks cave.	Slight---------	Slight---------	Moderate: slope.	Slight---------	Severe: droughty.
73D2-------------- Salida	Severe: cutbanks cave.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope.	Severe: droughty.
73G--------------- Salida	Severe: cutbanks cave, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe.
90---------------- Okoboji	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: shrink-swell, low strength, ponding.	Severe: ponding.

TABLE 11.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
95----------------- Harps	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, wetness, frost action.	Severe: wetness.
107---------------- Webster	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, wetness, frost action.	Severe: wetness.
108---------------- Wadena	Severe: cutbanks cave.	Slight---------	Slight---------	Slight---------	Slight---------	Slight.
133---------------- Colo	Severe: wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: low strength, wetness, flooding.	Severe: wetness.
135---------------- Coland	Severe: wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: low strength, flooding, frost action.	Moderate: wetness, flooding.
138B--------------- Clarion	Moderate: wetness.	Slight---------	Moderate: wetness.	Slight---------	Moderate: frost action.	Slight.
138C, 138C2-------- Clarion	Moderate: wetness.	Slight---------	Moderate: wetness.	Moderate: slope.	Moderate: frost action.	Slight.
138D, 138D2-------- Clarion	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope, frost action.	Moderate: slope.
221---------------- Palms	Severe: excess humus, ponding.	Severe: subsides, ponding, low strength.	Severe: subsides, ponding.	Severe: subsides, ponding, low strength.	Severe: subsides, 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.	Slight---------	Moderate: shrink-swell, slope.	Severe: low strength.	Slight.
236D--------------- Lester	Moderate: slope.	Moderate: shrink-swell, slope.	Moderate: slope.	Severe: slope.	Severe: low strength.	Moderate: slope.
236F, 236G--------- 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, wetness, frost action.	Severe: wetness.

TABLE 11.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
354--------------- Aquolls	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.
384--------------- Collinwood	Severe: wetness.	Severe: shrink-swell.	Severe: wetness, shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell, low strength.	Slight.
390--------------- Waldorf	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: shrink-swell, low strength, wetness.	Severe: wetness.
485--------------- Spillville	Moderate: wetness, flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: low strength, flooding.	Moderate: flooding.
485B-------------- Spillville	Moderate: wetness.	Moderate: shrink-swell.	Moderate: wetness, shrink-swell.	Moderate: shrink-swell.	Severe: low strength.	Slight.
507--------------- Canisteo	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, wetness, frost action.	Severe: wetness.
508--------------- Calcousta	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: low strength, ponding, frost action.	Severe: ponding.
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.
511B-------------- Blue Earth	Severe: excess humus, wetness.	Severe: wetness, low strength.	Severe: wetness.	Severe: wetness, low strength.	Severe: wetness, frost action.	Severe: wetness.
524--------------- Linder	Severe: cutbanks cave, wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Severe: frost action.	Slight.
559--------------- Talcot	Severe: cutbanks cave, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
585B: Coland-----------	Severe: wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: low strength, flooding, frost action.	Moderate: wetness, flooding.
Spillville-------	Moderate: wetness.	Moderate: shrink-swell.	Moderate: wetness, shrink-swell.	Moderate: shrink-swell.	Severe: low strength.	Slight.
638B: Clarion----------	Moderate: wetness.	Slight---------	Moderate: wetness.	Slight---------	Moderate: frost action.	Slight.

TABLE 11.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
638B:						
Storden----------	Slight---------	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, low strength.	Slight.
638C2:						
Clarion----------	Moderate: wetness.	Slight---------	Moderate: wetness.	Moderate: slope.	Moderate: frost action.	Slight.
Storden----------	Slight---------	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Moderate: shrink-swell, low strength.	Slight.
638D2:						
Clarion----------	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope, frost action.	Moderate: slope.
Storden----------	Moderate: slope.	Moderate: shrink-swell, slope.	Moderate: slope, shrink-swell.	Severe: slope.	Moderate: shrink-swell, low strength, slope.	Moderate: slope.
638E2:						
Clarion----------	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
Storden----------	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
639D2:						
Storden----------	Moderate: slope.	Moderate: shrink-swell, slope.	Moderate: slope, shrink-swell.	Severe: slope.	Moderate: shrink-swell, low strength, slope.	Moderate: slope.
Salida-----------	Severe: cutbanks cave.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope.	Severe: droughty.
655--------------- Crippin	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Severe: low strength, frost action.	Slight.
707--------------- Delft	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
733--------------- Calco	Severe: wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: low strength, wetness, flooding.	Severe: wetness.
787B-------------- Vinje	Moderate: too clayey.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength.	Slight.
811--------------- Muskego	Severe: excess humus, ponding.	Severe: subsides, ponding.	Severe: subsides, ponding.	Severe: subsides, ponding.	Severe: subsides, ponding, frost action.	Severe: ponding, excess humus.
823--------------- Ridgeport	Severe: cutbanks cave.	Slight---------	Slight---------	Slight---------	Slight---------	Moderate: droughty.

TABLE 11.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
828B-------------- Zenor	Severe: cutbanks cave.	Slight---------	Slight---------	Slight---------	Slight---------	Moderate: droughty.
828C2------------- Zenor	Severe: cutbanks cave.	Slight---------	Slight---------	Moderate: slope.	Slight---------	Moderate: droughty.
879--------------- Fostoria	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Severe: low strength, frost action.	Slight.
956:						
Okoboji----------	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: shrink-swell, low strength, ponding.	Severe: ponding.
Harps------------	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, wetness, frost action.	Severe: wetness.
1133-------------- Colo	Severe: wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: low strength, wetness, flooding.	Severe: wetness, flooding.
1458-------------- Millington	Severe: ponding.	Severe: flooding, ponding.	Severe: flooding, ponding.	Severe: flooding, ponding.	Severe: low strength, ponding, flooding.	Severe: ponding, flooding.
1585:						
Coland-----------	Severe: wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: low strength, flooding, frost action.	Severe: flooding.
Spillville-------	Moderate: wetness, flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: low strength, flooding.	Severe: flooding.
1707B:						
Delft------------	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
Terril-----------	Slight---------	Slight---------	Slight---------	Slight---------	Severe: low strength.	Slight.
5010-------------- Pits	Severe: cutbanks cave.	Slight---------	Slight---------	Slight---------	Slight---------	Severe: droughty.
5040, 5043-------- Orthents	Slight---------	Slight---------	Slight---------	Moderate: slope.	Slight---------	Slight.

TABLE 12.--SANITARY FACILITIES

(Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "good," and other terms. Absence of an entry indicates that the soil was not rated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation)

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
6 Okoboji	Severe: ponding, percs slowly.	Severe: ponding.	Severe: ponding, too clayey.	Severe: ponding.	Poor: too clayey, hard to pack, ponding.
27 Terril	Slight	Moderate: seepage.	Moderate: too clayey.	Slight	Fair: too clayey.
27B, 27C Terril	Slight	Moderate: seepage, slope.	Moderate: too clayey.	Slight	Fair: too clayey.
28, 28B Dickman	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.
34 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.
55 Nicollet	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: too clayey, wetness.
62C2 Storden	Moderate: percs slowly.	Severe: slope.	Moderate: too clayey.	Slight	Fair: too clayey.
62D2, 62D3 Storden	Moderate: percs slowly, slope.	Severe: slope.	Moderate: slope, too clayey.	Moderate: slope.	Fair: too clayey, slope.
62E, 62E2, 62F, 62G Storden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
72, 72B Estherville	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
73B Salida	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
73C2, 73D2 Salida	Severe: poor filter.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.

TABLE 12.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
73G 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, too clayey.	Severe: ponding.	Poor: too clayey, 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.
108 Wadena	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
133 Colo	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Poor: hard to pack, wetness.
135 Coland	Severe: flooding, wetness.	Severe: seepage, flooding, wetness.	Severe: flooding, seepage, wetness.	Severe: flooding, wetness.	Poor: wetness.
138B Clarion	Slight	Moderate: seepage, slope, wetness.	Severe: wetness.	Moderate: wetness.	Good.
138C, 138C2 Clarion	Slight	Severe: slope.	Severe: wetness.	Moderate: wetness.	Good.
138D, 138D2 Clarion	Moderate: slope.	Severe: slope.	Severe: wetness.	Moderate: slope.	Fair: slope.
221 Palms	Severe: subsides, ponding, percs slowly.	Severe: seepage, excess humus, ponding.	Severe: ponding.	Severe: seepage, ponding.	Poor: ponding.
224 Linder	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, too sandy, small stones.
236B Lester	Moderate: percs slowly.	Moderate: seepage, slope.	Moderate: too clayey.	Slight	Fair: too clayey.
236C Lester	Moderate: percs slowly.	Severe: slope.	Moderate: too clayey.	Slight	Fair: too clayey.
236D Lester	Moderate: percs slowly, slope.	Severe: slope.	Moderate: slope, too clayey.	Moderate: slope.	Fair: too clayey, slope.

TABLE 12.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
236F, 236G---------- Lester	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
259----------------- Biscay	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness.	Severe: seepage, wetness.	Poor: seepage, too sandy, small stones.
354----------------- Aquolls	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: ponding.
384----------------- Collinwood	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack.
390----------------- Waldorf	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack, wetness.
485----------------- Spillville	Severe: flooding, wetness.	Severe: seepage, flooding, wetness.	Severe: flooding, seepage, wetness.	Severe: flooding, wetness.	Fair: wetness.
485B---------------- Spillville	Severe: wetness.	Severe: seepage, wetness.	Severe: seepage, wetness.	Severe: wetness.	Fair: wetness.
507----------------- Canisteo	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.
508----------------- Calcousta	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: ponding.
511----------------- Blue Earth	Severe: ponding.	Severe: ponding.	Severe: ponding, excess humus.	Severe: ponding.	Poor: hard to pack, ponding.
511B---------------- Blue Earth	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness, excess humus.	Severe: wetness.	Poor: hard to pack, wetness.
524----------------- Linder	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, too sandy, small stones.
559----------------- Talcot	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, too sandy, wetness.
585B:					
Coland--------------	Severe: flooding, wetness.	Severe: seepage, flooding, wetness.	Severe: flooding, seepage, wetness.	Severe: flooding, wetness.	Poor: wetness.
Spillville----------	Severe: wetness.	Severe: seepage, wetness.	Severe: seepage, wetness.	Severe: wetness.	Fair: wetness.

TABLE 12.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
638B:					
Clarion	Slight	Moderate: seepage, slope, wetness.	Severe: wetness.	Moderate: wetness.	Good.
Storden	Moderate: percs slowly.	Moderate: seepage, slope.	Moderate: too clayey.	Slight	Fair: too clayey.
638C2:					
Clarion	Slight	Severe: slope.	Severe: wetness.	Moderate: wetness.	Good.
Storden	Moderate: percs slowly.	Severe: slope.	Moderate: too clayey.	Slight	Fair: too clayey.
638D2:					
Clarion	Moderate: slope.	Severe: slope.	Severe: wetness.	Moderate: slope.	Fair: slope.
Storden	Moderate: percs slowly, slope.	Severe: slope.	Moderate: slope, too clayey.	Moderate: slope.	Fair: too clayey, slope.
638E2:					
Clarion	Severe: slope.	Severe: slope.	Severe: wetness.	Severe: slope.	Poor: slope.
Storden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
639D2:					
Storden	Moderate: percs slowly, slope.	Severe: slope.	Moderate: slope, too clayey.	Moderate: slope.	Fair: too clayey, slope.
Salida	Severe: poor filter.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
655 Crippin	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: wetness.
707 Delft	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.
733 Calco	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Poor: hard to pack, wetness.
787B Vinje	Severe: percs slowly.	Moderate: seepage, slope.	Severe: too clayey.	Slight	Poor: too clayey, hard to pack.
811 Muskego	Severe: subsides, ponding.	Severe: seepage, excess humus, ponding.	Severe: ponding, excess humus.	Severe: seepage, ponding.	Poor: hard to pack, ponding.

TABLE 12.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
823----------------- Ridgeport	Severe: poor filter.	Severe: seepage.	Severe: seepage.	Severe: seepage.	Poor: thin layer.
828B---------------- Zenor	Severe: poor filter.	Severe: seepage.	Slight-----------	Severe: seepage.	Poor: thin layer.
828C2--------------- Zenor	Severe: poor filter.	Severe: seepage, slope.	Severe: too sandy.	Severe: seepage.	Poor: seepage, too sandy.
879----------------- Fostoria	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: wetness.
956:					
Okoboji------------	Severe: ponding, percs slowly.	Severe: ponding.	Severe: ponding, too clayey.	Severe: ponding.	Poor: too clayey, hard to pack, ponding.
Harps--------------	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: hard to pack, wetness.
1133---------------- Colo	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Poor: hard to pack, wetness.
1458---------------- Millington	Severe: flooding, ponding.	Severe: flooding, ponding.	Severe: flooding, ponding.	Severe: flooding, ponding.	Poor: ponding.
1585:					
Coland-------------	Severe: flooding, wetness.	Severe: seepage, flooding, wetness.	Severe: flooding, seepage, wetness.	Severe: flooding, wetness.	Poor: wetness.
Spillville---------	Severe: flooding, wetness.	Severe: seepage, flooding, wetness.	Severe: flooding, seepage, wetness.	Severe: flooding, wetness.	Fair: wetness.
1707B:					
Delft--------------	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.
Terril-------------	Slight-----------	Moderate: seepage, slope.	Moderate: too clayey.	Slight-----------	Fair: too clayey.
5010---------------- Pits	Severe: poor filter.	Severe: seepage.	Severe: too sandy.	Severe: seepage.	Poor: seepage, too sandy.
5040, 5043---------- Orthents	Moderate: percs slowly.	Moderate: seepage, slope.	Slight-----------	Slight-----------	Good.

TABLE 13.--CONSTRUCTION MATERIALS

(Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "good," "fair," and other terms. Absence of an entry indicates that the soil was not rated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation)

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
6: Okoboji	Poor: shrink-swell, low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, wetness.
27, 27B, 27C: Terril	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
28, 28B: Dickman	Good	Probable	Improbable: too sandy.	Poor: too sandy.
34, 34C2: Estherville	Good	Probable	Probable	Poor: too sandy, small stones, area reclaim.
55: Nicollet	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
62C2: Storden	Fair: shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones.
62D2, 62D3: Storden	Fair: shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones, slope.
62E, 62E2, 62F: Storden	Fair: shrink-swell, low strength, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
62G: Storden	Poor: slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
72, 72B: Estherville	Good	Probable	Probable	Poor: too sandy, small stones, area reclaim.
73B, 73C2, 73D2: Salida	Good	Probable	Probable	Poor: too sandy, small stones, area reclaim.
73G: Salida	Poor: slope.	Probable	Probable	Poor: too sandy, small stones, area reclaim.
90: Okoboji	Poor: shrink-swell, low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, wetness.

TABLE 13.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
95: Harps	Poor: wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
107: Webster	Poor: wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
108: Wadena	Good	Probable	Probable	Poor: small stones, area reclaim.
133: Colo	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
135: Coland	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
138B, 138C: Clarion	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
138C2: Clarion	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones.
138D, 138D2: Clarion	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones.
221: Palms	Poor: wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: excess humus, wetness.
224: Linder	Fair: wetness.	Probable	Improbable: too sandy.	Poor: too sandy, small stones, area reclaim.
236B: Lester	Fair: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones.
236C: Lester	Fair: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones.
236D: Lester	Fair: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones, slope.
236F: Lester	Fair: low strength, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
236G: Lester	Poor: slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
259: Biscay	Poor: wetness.	Probable	Probable	Poor: area reclaim, wetness.
354: Aquolls	Poor: wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.

TABLE 13.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
384 Collinwood	Poor: shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
390 Waldorf	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
485, 485B Spillville	Good	Improbable: excess fines.	Improbable: excess fines.	Good.
507 Canisteo	Poor: wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
508 Calcousta	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
511 Blue Earth	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
511B Blue Earth	Poor: wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: small stones, wetness.
524 Linder	Fair: wetness.	Probable	Improbable: too sandy.	Poor: too sandy, small stones, area reclaim.
559 Talcot	Fair: wetness.	Probable	Probable	Fair: small stones, area reclaim, thin layer.
585B:				
Coland	Fair: wetness.	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.	Fair: small stones.
Storden	Fair: shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones.
638C2:				
Clarion	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones.
Storden	Fair: shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones.

TABLE 13.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
638D2:				
Clarion	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones, slope.
Storden	Fair: shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones, slope.
638E2:				
Clarion	Good	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
Storden	Fair: shrink-swell, low strength, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
639D2:				
Storden	Fair: shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones, slope.
Salida	Good	Probable	Probable	Poor: too sandy, small stones, area reclaim.
655 Crippin	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
707 Delft	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
733 Calco	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
787B Vinje	Fair: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
811 Muskego	Poor: wetness, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: excess humus, wetness.
823 Ridgeport	Good	Probable	Improbable: too sandy.	Fair: small stones, area reclaim, thin layer.
828B Zenor	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones, thin layer.
828C2 Zenor	Good	Improbable: thin layer.	Improbable: too sandy.	Fair: small stones, thin layer.
879 Fostoria	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.

TABLE 13.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
956:				
Okoboji	Poor: shrink-swell, low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, wetness.
Harps	Poor: wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
1133 Colo	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
1458 Millington	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
1585:				
Coland	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
Spillville	Good	Improbable: excess fines.	Improbable: excess fines.	Good.
1707B:				
Delft	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
Terril	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
5010 Pits	Good	Probable	Probable	Poor: too sandy.
5040, 5043 Orthents	Good	Improbable: excess fines.	Improbable: excess fines.	Good.

TABLE 14.--WATER MANAGEMENT

(Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not evaluated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation)

Soil name and map symbol	Limitations for--			Features affecting--		
	Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Drainage	Terraces and diversions	Grassed waterways
6 Okoboji	Slight	Severe: ponding.	Severe: slow refill.	Ponding, frost action.	Ponding	Wetness.
27 Terril	Moderate: seepage.	Severe: piping.	Severe: no water.	Deep to water	Favorable	Favorable.
27B, 27C Terril	Moderate: seepage, slope.	Severe: piping.	Severe: no water.	Deep to water	Favorable	Favorable.
28, 28B Dickman	Severe: seepage.	Severe: seepage.	Severe: no water.	Deep to water	Too sandy, soil blowing.	Droughty.
34, 34C2 Estherville	Severe: seepage.	Severe: seepage.	Severe: no water.	Deep to water	Too sandy, soil blowing.	Droughty.
55 Nicollet	Moderate: seepage.	Moderate: wetness.	Moderate: deep to water, slow refill.	Frost action	Wetness	Favorable.
62C2 Storden	Moderate: seepage, slope.	Severe: piping.	Severe: no water.	Deep to water	Erodes easily	Erodes easily.
62D2, 62D3, 62E, 62E2, 62F, 62G Storden	Severe: slope.	Severe: piping.	Severe: no water.	Deep to water	Slope, erodes easily.	Slope, erodes easily.
72, 72B Estherville	Severe: seepage.	Severe: seepage.	Severe: no water.	Deep to water	Too sandy	Droughty.
73B, 73C2 Salida	Severe: seepage.	Severe: seepage.	Severe: no water.	Deep to water	Too sandy	Droughty.
73D2, 73G Salida	Severe: seepage, slope.	Severe: seepage.	Severe: no water.	Deep to water	Slope, too sandy.	Slope, droughty.
90 Okoboji	Slight	Severe: ponding.	Severe: slow refill.	Ponding, frost action.	Ponding	Wetness.
95 Harps	Moderate: seepage.	Severe: wetness.	Moderate: slow refill.	Frost action	Wetness	Wetness.
107 Webster	Moderate: seepage.	Severe: piping, wetness.	Moderate: slow refill.	Frost action	Wetness	Wetness.
108 Wadena	Severe: seepage.	Severe: seepage, piping.	Severe: no water.	Deep to water	Too sandy	Favorable.
133 Colo	Moderate: seepage.	Severe: wetness.	Moderate: slow refill.	Flooding, frost action.	Wetness	Wetness.
135 Coland	Severe: seepage.	Severe: wetness.	Moderate: slow refill.	Flooding, frost action.	Wetness	Wetness.

TABLE 14.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Features affecting-- Drainage	Terraces and diversions	Grassed waterways
138B, 138C, 138C2-Clarion	Moderate: seepage, slope.	Severe: piping.	Moderate: deep to water, slow refill.	Deep to water	Erodes easily	Erodes easily.
138D, 138D2-------Clarion	Severe: slope.	Severe: piping.	Moderate: deep to water, slow refill.	Deep to water	Slope, erodes easily.	Slope, erodes easily.
221---------------Palms	Severe: seepage.	Severe: piping, ponding.	Severe: slow refill.	Ponding, subsides, frost action.	Erodes easily, ponding, soil blowing.	Wetness, erodes easily, rooting depth.
224---------------Linder	Severe: seepage.	Severe: seepage, piping.	Severe: cutbanks cave.	Frost action, cutbanks cave.	Wetness, too sandy.	Rooting depth.
236B--------------Lester	Moderate: seepage.	Severe: piping.	Severe: no water.	Deep to water	Erodes easily	Erodes easily, rooting depth.
236C--------------Lester	Moderate: seepage, slope.	Severe: piping.	Severe: no water.	Deep to water	Erodes easily	Erodes easily, rooting depth.
236D, 236F, 236G--Lester	Severe: slope.	Severe: piping.	Severe: no water.	Deep to water	Slope, erodes easily.	Slope, erodes easily, rooting depth.
259---------------Biscay	Severe: seepage.	Severe: seepage, piping, wetness.	Severe: cutbanks cave.	Frost action, cutbanks cave.	Wetness, too sandy.	Wetness.
354---------------Aquolls	Slight---------	Severe: ponding.	Slight---------	Ponding--------	Ponding--------	Wetness.
384---------------Collinwood	Slight---------	Moderate: hard to pack, wetness.	Severe: slow refill.	Percs slowly, frost action.	Wetness, percs slowly.	Percs slowly.
390---------------Waldorf	Slight---------	Severe: hard to pack, wetness.	Severe: slow refill.	Percs slowly, frost action.	Wetness, percs slowly.	Wetness, percs slowly.
485, 485B---------Spillville	Severe: seepage.	Moderate: thin layer, piping, wetness.	Moderate: deep to water, slow refill.	Deep to water	Favorable------	Favorable.
507---------------Canisteo	Moderate: seepage.	Severe: wetness.	Moderate: slow refill.	Frost action---	Wetness--------	Wetness.
508---------------Calcousta	Moderate: seepage.	Severe: piping, ponding.	Moderate: slow refill.	Ponding, frost action.	Erodes easily, ponding.	Wetness, erodes easily.
511---------------Blue Earth	Moderate: seepage.	Severe: piping, excess humus, ponding.	Severe: slow refill.	Ponding, frost action.	Ponding--------	Wetness.

TABLE 14.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Features affecting-- Drainage	Terraces and diversions	Grassed waterways
511B Blue Earth	Moderate: slope.	Severe: piping, excess humus, wetness.	Severe: slow refill.	Frost action, slope.	Wetness	Wetness.
524 Linder	Severe: seepage.	Severe: seepage, piping.	Severe: cutbanks cave.	Frost action, cutbanks cave.	Wetness, too sandy.	Rooting depth.
559 Talcot	Severe: seepage.	Severe: seepage, wetness.	Severe: cutbanks cave.	Frost action, cutbanks cave.	Wetness, too sandy.	Wetness.
585B:						
Coland	Severe: seepage.	Severe: wetness.	Moderate: slow refill.	Flooding, frost action, slope.	Wetness	Wetness.
Spillville	Severe: seepage.	Moderate: thin layer, piping, wetness.	Moderate: deep to water, slow refill.	Deep to water	Favorable	Favorable.
638B:						
Clarion	Moderate: seepage, slope.	Severe: piping.	Moderate: deep to water, slow refill.	Deep to water	Erodes easily	Erodes easily.
Storden	Moderate: seepage, slope.	Severe: piping.	Severe: no water.	Deep to water	Erodes easily	Erodes easily.
638C2:						
Clarion	Moderate: seepage, slope.	Severe: piping.	Moderate: deep to water, slow refill.	Deep to water	Erodes easily	Erodes easily.
Storden	Moderate: seepage, slope.	Severe: piping.	Severe: no water.	Deep to water	Erodes easily	Erodes easily.
638D2, 638E2:						
Clarion	Severe: slope.	Severe: piping.	Moderate: deep to water, slow refill.	Deep to water	Slope, erodes easily.	Slope, erodes easily.
Storden	Severe: slope.	Severe: piping.	Severe: no water.	Deep to water	Slope, erodes easily.	Slope, erodes easily.
639D2:						
Storden	Severe: slope.	Severe: piping.	Severe: no water.	Deep to water	Slope, erodes easily.	Slope, erodes easily.
Salida	Severe: seepage, slope.	Severe: seepage.	Severe: no water.	Deep to water	Slope, too sandy.	Slope, droughty.
655 Crippin	Moderate: seepage.	Severe: piping.	Moderate: deep to water, slow refill.	Frost action	Wetness	Rooting depth.

TABLE 14.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Features affecting-- Drainage	Terraces and diversions	Grassed waterways
707 Delft	Moderate: seepage.	Severe: thin layer, wetness.	Severe: slow refill.	Frost action	Wetness	Wetness.
733 Calco	Moderate: seepage.	Severe: wetness.	Moderate: slow refill.	Flooding, frost action.	Wetness	Wetness.
787B Vinje	Moderate: seepage, slope.	Moderate: hard to pack.	Severe: no water.	Deep to water	Favorable	Favorable.
811 Muskego	Severe: seepage.	Severe: excess humus, ponding.	Severe: slow refill.	Ponding, percs slowly.	Ponding, soil blowing, percs slowly.	Wetness, percs slowly.
823 Ridgeport	Severe: seepage.	Severe: piping.	Severe: no water.	Deep to water	Soil blowing	Droughty, rooting depth.
828B Zenor	Severe: seepage.	Severe: thin layer.	Severe: no water.	Deep to water	Soil blowing	Droughty, rooting depth.
828C2 Zenor	Severe: seepage.	Severe: seepage.	Severe: no water.	Deep to water	Too sandy, soil blowing.	Droughty, rooting depth.
879 Fostoria	Moderate: seepage.	Moderate: piping, wetness.	Moderate: deep to water, slow refill.	Frost action	Erodes easily, wetness.	Erodes easily, rooting depth.
956:						
Okoboji	Slight	Severe: ponding.	Severe: slow refill.	Ponding, frost action.	Ponding	Wetness.
Harps	Moderate: seepage.	Severe: wetness.	Moderate: slow refill.	Frost action	Wetness	Wetness.
1133 Colo	Moderate: seepage.	Severe: wetness.	Moderate: slow refill.	Flooding, frost action.	Wetness	Wetness.
1458 Millington	Moderate: seepage.	Severe: piping, ponding.	Moderate: slow refill.	Ponding, flooding, frost action.	Ponding	Wetness.
1585:						
Coland	Severe: seepage.	Severe: wetness.	Moderate: slow refill.	Flooding, frost action.	Wetness	Wetness.
Spillville	Severe: seepage.	Moderate: thin layer, piping, wetness.	Moderate: deep to water, slow refill.	Deep to water	Favorable	Favorable.
1707B:						
Delft	Moderate: seepage.	Severe: thin layer, wetness.	Severe: slow refill.	Frost action	Wetness	Wetness.
Terril	Moderate: seepage, slope.	Severe: piping.	Severe: no water.	Deep to water	Favorable	Favorable.

TABLE 14.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Features affecting-- Drainage	Terraces and diversions	Grassed waterways
5010 Pits	Severe: seepage.	Severe: seepage, piping.	Severe: no water.	Deep to water	Too sandy	Droughty.
5040, 5043 Orthents	Moderate: seepage, slope.	Slight	Severe: no water.	Deep to water	Soil blowing	Droughty.

TABLE 15.--ENGINEERING INDEX PROPERTIES

(The symbol < means less than; > means more than. Absence of an entry indicates that data were not estimated)

Soil name and map symbol	Depth	USDA texture	Classification		Fragments 3-10 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
6----------------- Okoboji	0-8	Silty clay loam	CH	A-7	0	100	100	90-100	80-95	50-60	30-35
	8-36	Silty clay loam, silty clay.	CH, CL	A-7	0	100	100	90-100	80-95	50-60	30-35
	36-48	Silty clay loam, silty clay.	CH, CL	A-7	0	95-100	95-100	90-100	80-95	50-60	30-35
	48-60	Stratified loam to silty clay loam.	CL, CH	A-7	0-5	95-100	90-100	90-100	75-90	45-55	20-30
27---------------- Terril	0-39	Loam--------------	CL	A-6	0-5	95-100	95-100	70-90	60-80	30-40	10-20
	39-55	Loam, clay loam	CL, CL-ML	A-6, A-7	0-5	95-100	90-100	70-90	60-80	30-45	10-25
	55-60	Clay loam, loam, sandy loam.	CL, SC, SC-SM, CL-ML	A-6, A-4	0-5	95-100	90-100	65-95	35-85	20-40	5-20
27B--------------- Terril	0-37	Loam--------------	CL	A-6	0-5	95-100	95-100	70-90	60-80	30-40	10-20
	37-52	Loam, clay loam	CL, CL-ML	A-6, A-7	0-5	95-100	90-100	70-90	60-80	30-45	10-25
	52-60	Clay loam, loam, sandy loam.	CL, SC, SC-SM, CL-ML	A-6, A-4	0-5	95-100	90-100	65-95	35-85	20-40	5-20
27C--------------- Terril	0-36	Loam--------------	CL	A-6	0-5	95-100	95-100	70-90	60-80	30-40	10-20
	36-50	Loam, clay loam	CL, CL-ML	A-6, A-7	0-5	95-100	90-100	70-90	60-80	30-45	10-25
	50-60	Clay loam, loam, sandy loam.	CL, SC, SC-SM, CL-ML	A-6, A-4	0-5	95-100	90-100	65-95	35-85	20-40	5-20
28---------------- Dickman	0-16	Sandy loam--------	SM, SC-SM, SC	A-2, A-4	0	95-100	95-100	55-95	25-40	20-30	2-8
	16-36	Sandy loam, fine sandy loam, loamy sand.	SM, SC-SM, SC	A-2, A-4	0	95-100	85-100	55-95	25-45	15-25	2-8
	36-60	Fine sand, coarse sand, sand.	SP-SM	A-3, A-2	0	95-100	75-100	50-80	5-10	0-14	NP
28B--------------- Dickman	0-14	Sandy loam--------	SM, SC-SM, SC	A-2, A-4	0	95-100	95-100	55-95	25-40	20-30	2-8
	14-32	Sandy loam, fine sandy loam, loamy sand.	SM, SC-SM, SC	A-2, A-4	0	95-100	85-100	55-95	25-45	15-25	2-8
	32-60	Fine sand, coarse sand, sand.	SP-SM	A-3, A-2	0	95-100	75-100	50-80	5-10	0-14	NP
34---------------- Estherville	0-15	Sandy loam--------	SM, SC-SM, SC	A-2, A-4	0-5	90-100	80-100	50-75	25-50	20-30	2-10
	15-20	Sandy loam, loam, coarse sandy loam.	SM, SC-SM, 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, loamy coarse sand, gravelly loamy sand.	SP, SP-SM, SM, GP	A-1	0-10	55-90	50-85	10-40	2-25	---	NP

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Frag- ments 3-10 inches	Percentage passing sieve number-- 4	10	40	200	Liquid limit	Plas- ticity index
	In				Pct					Pct	
34C2-------------- Estherville	0-8	Sandy loam-------	SM, SC-SM, SC	A-2, A-4	0-5	90-100	80-100	50-75	25-50	20-30	2-10
	8-12	Sandy loam, loam, coarse sandy loam.	SM, SC-SM, SC	A-2, A-4, A-1	0-5	85-100	80-95	40-75	15-45	20-30	2-8
	12-60	Coarse sand, gravelly coarse sand, loamy coarse sand, gravelly loamy sand.	SP, SP-SM, SM, GP	A-1	0-10	55-90	50-85	10-40	2-25	---	NP
55---------------- Nicollet	0-18	Loam-------------	ML, CL	A-6, A-7	0-5	95-100	90-100	85-100	55-85	30-45	10-25
	18-42	Clay loam, loam, silty clay loam.	CL	A-6, A-7	0-5	95-100	90-100	80-95	55-80	35-50	15-25
	42-60	Loam, clay loam	CL	A-6	0-5	95-100	90-100	75-90	50-75	30-40	15-25
62C2, 62D2, 62D3, 62E, 62E2, 62F, 62G------------- Storden	0-8	Loam-------------	CL	A-6	0-5	95-100	95-98	75-95	60-75	28-36	9-15
	8-60	Loam, clay loam	CL, ML	A-6	0-5	95-100	90-98	70-95	55-70	28-39	9-18
72---------------- Estherville	0-15	Loam-------------	CL-ML, CL	A-4, A-6	0-5	90-100	80-100	50-75	50-60	25-40	4-15
	15-22	Sandy loam, loam, coarse sandy loam.	SM, SC-SM, SC	A-2, A-4, A-1	0-5	85-100	80-95	40-75	15-45	20-30	2-8
	22-60	Coarse sand, gravelly coarse sand, loamy coarse sand, gravelly loamy sand.	SP, SP-SM, SM, GP	A-1	0-10	55-90	50-85	10-40	2-25	---	NP
72B-------------- Estherville	0-14	Loam-------------	CL-ML, CL	A-4, A-6	0-5	90-100	80-100	50-75	50-60	25-40	4-15
	14-18	Sandy loam, loam, coarse sandy loam.	SM, SC-SM, SC	A-2, A-4, A-1	0-5	85-100	80-95	40-75	15-45	20-30	2-8
	18-60	Coarse sand, gravelly coarse sand, loamy coarse sand, gravelly loamy sand.	SP, SP-SM, SM, GP	A-1	0-10	55-90	50-85	10-40	2-25	---	NP
73B-------------- Salida	0-8	Gravelly loamy sand.	SP-SM	A-1	0-5	80-95	50-75	20-40	5-10	---	NP
	8-16	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
	16-60	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

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Fragments 3-10 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
73C2, 73D2, 73G-- Salida	0-8	Gravelly loamy sand.	SP-SM	A-1	0-5	80-95	50-75	20-40	5-10	---	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	0-18	Mucky silt loam	MH	A-7	0	100	100	95-100	90-95	35-45	15-25
	18-36	Silty clay loam, silty clay.	CH, CL	A-7	0	100	100	90-100	80-95	50-60	30-35
	36-60	Silty clay loam, silty clay.	CH, CL	A-7	0	95-100	95-100	90-100	80-95	50-60	30-35
95--------------- Harps	0-21	Clay loam--------	CL, CH	A-6, A-7	0-5	95-100	95-100	80-90	65-80	35-55	15-35
	21-35	Loam, clay loam, sandy clay loam.	CL, CH	A-6, A-7	0-5	95-100	95-100	80-90	65-80	30-60	10-20
	35-60	Loam, sandy clay loam, sandy loam.	CL, CL-ML, SC	A-6, A-4	0-5	95-100	90-100	70-80	40-70	25-35	8-15
107-------------- Webster	0-23	Silty clay loam	CL, CH	A-7, A-6	0-5	95-100	95-100	85-95	80-90	35-45	15-25
	23-41	Clay loam, silty clay loam, loam.	CL	A-6, A-7	0-5	95-100	95-100	85-95	65-85	35-45	15-25
	41-60	Loam, sandy loam	CL, CL-ML, SC	A-6, A-4	0-5	95-100	90-100	75-90	40-70	25-35	8-15
108-------------- Wadena	0-14	Loam-------------	ML	A-4	0	95-100	90-100	75-95	50-65	25-40	2-10
	14-26	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
	26-60	Stratified sand to gravelly coarse sand.	SP, SP-SM, GP, GP-GM	A-1, A-3, A-2	0-5	45-100	35-100	10-80	2-10	---	NP
133-------------- Colo	0-30	Silty clay loam	CL, CH	A-7	0	100	100	90-100	90-100	40-60	15-30
	30-52	Silty clay loam	CL, CH	A-7	0	100	100	90-100	90-100	40-55	20-30
	52-60	Silty clay loam, clay loam, silt loam.	CL, CH	A-7	0	100	100	95-100	80-100	40-55	15-30
135-------------- Coland	0-9	Clay loam--------	CL	A-7, A-6	0	100	100	95-100	65-80	35-50	15-25
	9-52	Clay loam, silty clay loam.	CL	A-7, A-6	0	100	100	95-100	65-80	35-50	15-25
	52-60	Loam, sandy loam, sandy clay loam, clay loam.	CL, SC, CL-ML, SC-SM	A-4, A-6	0	100	90-100	60-70	40-60	20-40	5-15
138B------------- Clarion	0-19	Loam-------------	CL, CL-ML	A-4, A-6	0-5	95-100	95-100	75-90	50-75	25-40	5-15
	19-42	Loam, clay loam	CL, CL-ML	A-4, A-6	0-5	90-100	85-100	75-90	50-75	25-40	5-15
	42-60	Loam, sandy loam	CL, CL-ML, SC, SC-SM	A-4, A-6	0-5	90-100	85-100	75-90	45-70	25-40	5-15
138C------------- Clarion	0-18	Loam-------------	CL, CL-ML	A-4, A-6	0-5	95-100	95-100	75-90	50-75	25-40	5-15
	18-38	Loam, clay loam	CL, CL-ML	A-4, A-6	0-5	90-100	85-100	75-90	50-75	25-40	5-15
	38-60	Loam, sandy loam	CL, CL-ML, SC, SC-SM	A-4, A-6	0-5	90-100	85-100	75-90	45-70	25-40	5-15

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Fragments 3-10 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
138C2------------- Clarion	0-8	Loam-------------	CL, CL-ML	A-4, A-6	0-5	95-100	95-100	75-90	50-75	25-40	5-15
	8-24	Loam, clay loam	CL, CL-ML	A-4, A-6	0-5	90-100	85-100	75-90	50-75	25-40	5-15
	24-60	Loam, sandy loam	CL, CL-ML, SC, SC-SM	A-4, A-6	0-5	90-100	85-100	75-90	45-70	25-40	5-15
138D------------- Clarion	0-14	Loam-------------	CL, CL-ML	A-4, A-6	0-5	95-100	95-100	75-90	50-75	25-40	5-15
	14-30	Loam, clay loam	CL, CL-ML	A-4, A-6	0-5	90-100	85-100	75-90	50-75	25-40	5-15
	30-60	Loam, sandy loam	CL, CL-ML, SC, SC-SM	A-4, A-6	0-5	90-100	85-100	75-90	45-70	25-40	5-15
138D2------------ Clarion	0-8	Loam-------------	CL, CL-ML	A-4, A-6	0-5	95-100	95-100	75-90	50-75	25-40	5-15
	8-22	Loam, clay loam	CL, CL-ML	A-4, A-6	0-5	90-100	85-100	75-90	50-75	25-40	5-15
	22-60	Loam, sandy loam	CL, CL-ML, SC, SC-SM	A-4, A-6	0-5	90-100	85-100	75-90	45-70	25-40	5-15
221-------------- Palms	0-22	Muck-------------	PT	A-8	0	---	---	---	---	---	---
	22-29	Muck, mucky silty clay loam.	PT	A-8	0	---	---	---	---	---	---
	29-60	Clay loam, silty clay loam, gravelly sandy loam.	CL-ML, CL, SC, SC-SM	A-4, A-6, A-7, A-2	0	85-100	60-100	35-95	15-90	20-45	5-20
224-------------- Linder	0-16	Loam-------------	CL	A-4, A-6	0	100	95-100	80-95	50-80	25-40	8-15
	16-27	Sandy loam-------	SC, SC-SM	A-2, A-4	0	95-100	80-100	45-75	30-45	20-30	5-10
	27-60	Gravelly sand, gravelly loamy sand, loamy coarse sand.	SP, SP-SM	A-1	0-5	75-95	30-95	25-50	2-12	---	NP
236B------------- Lester	0-12	Loam-------------	ML, CL, CL-ML	A-6, A-4	0-5	95-100	90-100	80-95	50-85	30-40	11-15
	12-47	Clay loam, loam	CL	A-6	0-5	95-100	90-100	80-95	55-75	35-40	15-20
	47-60	Loam, clay loam	CL, CL-ML	A-6	0-5	95-100	90-100	75-90	50-70	32-39	13-18
236C------------- Lester	0-10	Loam-------------	ML, CL, CL-ML	A-6, A-4	0-5	95-100	90-100	80-95	50-85	30-40	11-15
	10-43	Clay loam, loam	CL	A-6	0-5	95-100	90-100	80-95	55-75	35-40	15-20
	43-60	Loam, clay loam	CL, CL-ML	A-6	0-5	95-100	90-100	75-90	50-70	32-39	13-18
236D------------- Lester	0-8	Loam-------------	ML, CL, CL-ML	A-6, A-4	0-5	95-100	90-100	80-95	50-85	30-40	11-15
	8-38	Clay loam, loam	CL	A-6	0-5	95-100	90-100	80-95	55-75	35-40	15-20
	38-60	Loam, clay loam	CL, CL-ML	A-6	0-5	95-100	90-100	75-90	50-70	32-39	13-18
236F------------- Lester	0-7	Loam-------------	ML, CL, CL-ML	A-6, A-4	0-5	95-100	90-100	80-95	50-85	30-40	11-15
	7-33	Clay loam, loam	CL	A-6	0-5	95-100	90-100	80-95	55-75	35-40	15-20
	33-60	Loam, clay loam	CL, CL-ML	A-6	0-5	95-100	90-100	75-90	50-70	32-39	13-18
236G------------- Lester	0-6	Loam-------------	ML, CL, CL-ML	A-6, A-4	0-5	95-100	90-100	80-95	50-85	30-40	11-15
	6-28	Clay loam, loam	CL	A-6	0-5	95-100	90-100	80-95	55-75	35-40	15-20
	28-60	Loam, clay loam	CL, CL-ML	A-6	0-5	95-100	90-100	75-90	50-70	32-39	13-18

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Frag- ments 3-10 inches	Percentage passing sieve number--				Liquid limit	Plas- ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
259: Biscay	0-19	Clay loam	CL, ML	A-7, A-6	0	95-100	95-100	70-95	50-80	35-50	10-25
	19-34	Loam, clay loam, sandy clay loam.	CL, ML	A-6, A-7	0	95-100	90-100	70-90	50-75	30-50	10-20
	34-38	Gravelly loam, sandy loam, gravelly sandy loam.	SM, SC-SM, SC	A-4	0-5	95-100	70-95	50-80	35-50	15-30	2-10
	38-60	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
354: Aquolls	0-60	Variable	---	---	---	---	---	---	---	---	---
384: Collinwood	0-23	Silty clay loam	CL, CH, ML, MH	A-7	0	100	100	95-100	90-95	40-55	15-25
	23-39	Silty clay, clay, silty clay loam.	MH, CH	A-7	0	100	100	95-100	90-95	50-65	20-35
	39-60	Silty clay, clay, silty clay loam.	CH, CL	A-7	0	100	100	95-100	90-95	40-60	15-30
390: Waldorf	0-20	Silty clay loam	ML, MH	A-7	0	100	100	95-100	90-100	45-65	14-30
	20-52	Silty clay, silty clay loam.	MH	A-7	0	100	100	95-100	95-100	50-70	20-35
	52-60	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: Spillville	0-37	Loam	CL	A-6	0	100	95-100	85-95	60-80	25-40	10-20
	37-60	Sandy clay loam, loam, sandy loam.	CL, CL-ML, SC-SM, SC	A-6, A-4	0	100	95-100	80-90	35-75	20-40	5-15
485B: Spillville	0-32	Loam	CL	A-6	0	100	95-100	85-95	60-80	25-40	10-20
	32-60	Sandy clay loam, loam, sandy loam.	CL, CL-ML, SC-SM, SC	A-6, A-4	0	100	95-100	80-90	35-75	20-40	5-15
507: Canisteo	0-20	Clay loam	OL, CL	A-7	0	95-100	95-100	85-100	60-100	40-50	15-20
	20-40	Clay loam, loam, silty clay loam.	CL	A-6, A-7	0	98-100	90-100	85-100	65-95	38-50	25-35
	40-48	Clay loam, loam	CL, ML	A-6	0-5	90-100	80-95	60-95	50-85	30-40	5-15
	48-60	Clay loam, loam	CL	A-6	0-5	95-100	90-98	80-95	50-75	30-40	12-20
508: Calcousta	0-13	Mucky silt loam	CH, CL	A-7	0	100	100	95-100	95-100	40-65	20-40
	13-48	Silty clay loam, silt loam.	CH, CL	A-7	0	100	100	90-100	90-100	40-60	20-35
	48-60	Silty clay loam, silt loam.	CL, ML	A-6, A-4	0-5	95-100	95-100	85-100	80-90	30-40	5-15
511: Blue Earth	0-9	Mucky silt loam	OL, ML	A-5	0	95-100	95-100	85-95	80-95	41-50	2-8
	9-60	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
511B: Blue Earth	0-8	Mucky silt loam	OL, ML	A-5, A-7	0	95-100	95-100	90-100	80-95	40-50	2-12
	8-60	Mucky clay loam, mucky silty clay loam, mucky silt loam.	OL, ML	A-5, A-7, A-4	0	95-100	60-100	60-100	55-95	35-50	2-12

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification Unified	Classification AASHTO	Frag- ments 3-10 inches	Percentage passing sieve number-- 4	10	40	200	Liquid limit	Plas- ticity index
	In				Pct					Pct	
524------------- Linder	0-13	Loam-------------	CL	A-4, A-6	0	100	95-100	80-95	50-80	25-40	8-15
	13-37	Sandy loam-------	SC, SC-SM	A-2, A-4	0	95-100	80-100	45-75	30-45	20-30	5-10
	37-60	Gravelly sand, gravelly loamy sand, loamy coarse sand.	SP, SP-SM	A-1	0-5	75-95	30-95	25-50	2-12	---	NP
559------------- Talcot	0-23	Clay loam--------	CL	A-7	0	100	100	80-90	60-85	40-50	15-25
	23-39	Clay loam, silty clay loam, loam.	CL	A-7	0	95-100	85-100	70-90	60-85	40-50	15-25
	39-60	Stratified loamy sand to gravelly coarse sand.	SP, SP-SM, SW	A-1	0	65-90	50-85	20-50	2-10	---	NP
585B:											
Coland----------	0-34	Clay loam--------	CL	A-7, A-6	0	100	100	95-100	65-80	35-50	15-25
	34-52	Clay loam, silty clay loam.	CL	A-7, A-6	0	100	100	95-100	65-80	35-50	15-25
	52-60	Loam, sandy loam, sandy clay loam, clay loam.	CL, SC, CL-ML, SC-SM	A-4, A-6	0	100	90-100	60-70	40-60	20-40	5-15
Spillville------	0-37	Loam-------------	CL	A-6	0	100	95-100	85-95	60-80	25-40	10-20
	37-60	Sandy clay loam, loam, sandy loam.	CL, CL-ML, SC-SM, SC	A-6, A-4	0	100	95-100	80-90	35-75	20-40	5-15
638B:											
Clarion---------	0-19	Loam-------------	CL, CL-ML	A-4, A-6	0-5	95-100	95-100	75-90	50-75	25-40	5-15
	19-42	Loam, clay loam	CL, CL-ML	A-4, A-6	0-5	90-100	85-100	75-90	50-75	25-40	5-15
	42-60	Loam, sandy loam	CL, CL-ML, SC, SC-SM	A-4, A-6	0-5	90-100	85-100	75-90	45-70	25-40	5-15
Storden---------	0-10	Loam-------------	CL	A-6	0-5	95-100	95-98	75-95	60-75	28-36	9-15
	10-60	Loam, clay loam	CL, ML	A-6	0-5	95-100	90-98	70-95	55-70	28-39	9-18
638C2:											
Clarion---------	0-8	Loam-------------	CL, CL-ML	A-4, A-6	0-5	95-100	95-100	75-90	50-75	25-40	5-15
	8-24	Loam, clay loam	CL, CL-ML	A-4, A-6	0-5	90-100	85-100	75-90	50-75	25-40	5-15
	24-60	Loam, sandy loam	CL, CL-ML, SC, SC-SM	A-4, A-6	0-5	90-100	85-100	75-90	45-70	25-40	5-15
Storden---------	0-8	Loam-------------	CL	A-6	0-5	95-100	95-98	75-95	60-75	28-36	9-15
	8-60	Loam, clay loam	CL, ML	A-6	0-5	95-100	90-98	70-95	55-70	28-39	9-18
638D2:											
Clarion---------	0-8	Loam-------------	CL, CL-ML	A-4, A-6	0-5	95-100	95-100	75-90	50-75	25-40	5-15
	8-22	Loam, clay loam	CL, CL-ML	A-4, A-6	0-5	90-100	85-100	75-90	50-75	25-40	5-15
	22-60	Loam, sandy loam	CL, CL-ML, SC, SC-SM	A-4, A-6	0-5	90-100	85-100	75-90	45-70	25-40	5-15
Storden---------	0-8	Loam-------------	CL	A-6	0-5	95-100	95-98	75-95	60-75	28-36	9-15
	8-60	Loam, clay loam	CL, ML	A-6	0-5	95-100	90-98	70-95	55-70	28-39	9-18
638E2:											
Clarion---------	0-8	Loam-------------	CL, CL-ML	A-4, A-6	0-5	95-100	95-100	75-90	50-75	25-40	5-15
	8-20	Loam, clay loam	CL, CL-ML	A-4, A-6	0-5	90-100	85-100	75-90	50-75	25-40	5-15
	20-60	Loam, sandy loam	CL, CL-ML, SC, SC-SM	A-4, A-6	0-5	90-100	85-100	75-90	45-70	25-40	5-15
Storden---------	0-8	Loam-------------	CL	A-6	0-5	95-100	95-98	75-95	60-75	28-36	9-15
	8-60	Loam, clay loam	CL, ML	A-6	0-5	95-100	90-98	70-95	55-70	28-39	9-18

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Frag- ments 3-10 inches	Percentage passing sieve number--				Liquid limit	Plas- ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
639D2:											
Storden	0-8	Loam	CL	A-6	0-5	95-100	95-98	75-95	60-75	28-36	9-15
	8-60	Loam, clay loam	CL, ML	A-6	0-5	95-100	90-98	70-95	55-70	28-39	9-18
Salida	0-8	Gravelly loamy sand.	SP-SM	A-1	0-5	80-95	50-75	20-40	5-10	---	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
655 Crippin	0-23	Loam	CL	A-6, A-7	0	95-100	95-100	80-90	60-80	30-45	10-20
	23-46	Loam, clay loam	CL	A-6	0-5	95-100	90-100	80-90	60-80	30-40	10-20
	46-60	Loam, sandy loam	CL, CL-ML, SC	A-6, A-4	2-5	90-100	85-100	75-90	40-70	25-35	8-15
707 Delft	0-18	Clay loam	CL, ML	A-6, A-7	0	95-100	90-100	75-90	60-80	30-45	10-20
	18-44	Loam, clay loam, silty clay loam.	CL, ML	A-6, A-7	0	95-100	90-100	75-90	60-80	30-45	10-20
	44-60	Loam, clay loam, silt loam.	CL, ML	A-6, A-4	0	95-100	90-100	70-90	50-75	25-40	7-15
733 Calco	0-22	Silty clay loam	CH, CL	A-7	0	100	100	95-100	85-100	40-60	15-30
	22-47	Silty clay loam	CL, CH	A-7	0	100	100	95-100	85-100	40-60	15-30
	47-60	Silty clay loam, loam, clay loam.	CL	A-7, A-6	0	100	100	90-100	80-100	30-45	10-20
787B Vinje	0-17	Silty clay loam	CL, CH, ML, MH	A-7	0	100	100	95-100	95-100	40-55	15-25
	17-36	Silty clay, silty clay loam.	CH, CL	A-7	0	100	100	95-100	95-100	40-60	15-30
	36-60	Clay loam, loam, silty clay loam.	CL, SC	A-6	0-5	90-100	85-95	75-90	45-70	25-40	10-20
811 Muskego	0-9	Muck	PT	A-8	0	---	---	---	---	---	---
	9-25	Sapric material, muck.	PT	A-8	0	---	---	---	---	---	---
	25-60	Coprogenous earth	OL	A-5	0	95-100	95-100	85-100	75-96	40-50	2-8
823 Ridgeport	0-12	Sandy loam	SM, SC, SC-SM	A-2, A-4	0	95-100	90-100	70-90	25-50	15-30	2-10
	12-36	Sandy loam, gravelly sandy loam.	SM, SC, SC-SM	A-2, A-4	0	95-100	85-100	65-85	20-45	15-30	2-10
	36-60	Gravelly loamy sand, gravelly sand, sand.	SW, SP, SW-SM, SP-SM	A-1	0-5	80-95	75-95	35-50	2-10	<25	NP-6
828B Zenor	0-13	Sandy loam	SC-SM, SC	A-2, A-4	0-5	85-95	80-95	60-70	25-40	<25	5-10
	13-30	Sandy loam, loam	SC-SM, SC	A-2, A-4	0-5	85-95	80-95	50-70	25-40	<25	5-10
	30-60	Gravelly loamy sand, gravelly sand, loamy sand.	SW, SP, SP-SM	A-1	0-5	85-95	80-90	20-40	3-12	<20	NP-5

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Fragments 3-10 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
828C2------------ Zenor	0-7	Sandy loam-------	SC-SM, SC	A-2, A-4	0-5	85-95	80-95	60-70	25-40	<25	5-10
	7-27	Sandy loam, loam	SC-SM, SC	A-2, A-4	0-5	85-95	80-95	50-70	25-40	<25	5-10
	27-60	Gravelly loamy sand, gravelly sand, loamy sand.	SW, SP, SP-SM	A-1	0-5	85-95	80-90	20-40	3-12	<20	NP-5
879-------------- Fostoria	0-7	Loam-------------	CL, CL-ML	A-4, A-6	0	100	100	95-100	80-95	25-40	5-15
	7-18	Loam, clay loam	CL	A-6	0-5	100	100	75-100	55-95	30-40	10-20
	18-60	Silt loam, loam, sandy loam.	CL	A-6	0-5	100	100	75-100	55-95	30-40	10-20
956: Okoboji---------	0-8	Silty clay loam	CH	A-7	0	100	100	90-100	80-95	50-60	30-35
	8-36	Silty clay loam, silty clay.	CH, CL	A-7	0	100	100	90-100	80-95	50-60	30-35
	36-48	Silty clay loam, silty clay.	CH, CL	A-7	0	95-100	95-100	90-100	80-95	50-60	30-35
	48-60	Stratified loam to silty clay loam.	CH, CL	A-7	0-5	95-100	90-100	90-100	75-90	45-55	20-30
Harps-----------	0-21	Clay loam--------	CL, CH	A-6, A-7	0-5	95-100	95-100	80-90	65-80	35-55	15-35
	21-35	Loam, clay loam, sandy clay loam.	CL, CH	A-6, A-7	0-5	95-100	95-100	80-90	65-80	30-60	10-20
	35-60	Loam, sandy clay loam, sandy loam.	CL, CL-ML, SC	A-6, A-4	0-5	95-100	90-100	70-80	40-70	25-35	8-15
1133------------- Colo	0-30	Silty clay loam	CL, CH	A-7	0	100	100	90-100	90-100	40-60	15-30
	30-45	Silty clay loam	CL, CH	A-7	0	100	100	90-100	90-100	40-55	20-30
	45-60	Silty clay loam, clay loam, silt loam.	CL, CH	A-7	0	100	100	95-100	80-100	40-55	15-30
1458------------- Millington	0-14	Silt loam--------	ML, CL, OL	A-6, A-7, A-4	0	90-100	90-100	80-100	70-95	30-45	8-17
	14-60	Loam, silty clay loam, clay loam.	CL	A-7, A-6	0	95-100	90-100	80-100	70-95	28-50	10-22
1585: Coland----------	0-34	Clay loam--------	CL	A-7, A-6	0	100	100	95-100	65-80	35-50	15-25
	34-52	Clay loam, silty clay loam.	CL	A-7, A-6	0	100	100	95-100	65-80	35-50	15-25
	52-60	Loam, sandy loam, sandy clay loam, clay loam.	CL, SC, CL-ML, SC-SM	A-4, A-6	0	100	90-100	60-70	40-60	20-40	5-15
Spillville------	0-37	Loam-------------	CL	A-6	0	100	95-100	85-95	60-80	25-40	10-20
	37-60	Sandy clay loam, loam, sandy loam.	CL, CL-ML, SC-SM, SC	A-6, A-4	0	100	95-100	80-90	35-75	20-40	5-15
1707B: Delft-----------	0-18	Clay loam--------	CL, ML	A-6, A-7	0	95-100	90-100	75-90	60-80	30-45	10-20
	18-44	Loam, clay loam, silty clay loam.	CL, ML	A-6, A-7	0	95-100	90-100	75-90	60-80	30-45	10-20
	44-60	Loam, clay loam, silt loam.	CL, ML	A-6, A-4	0	95-100	90-100	70-90	50-75	25-40	7-15

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Frag- ments 3-10 inches	Percentage passing sieve number--				Liquid limit	Plas- ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
1707B:											
Terril----------	0-36	Loam-------------	CL	A-6	0-5	95-100	95-100	70-90	60-80	30-40	10-20
	36-50	Loam, clay loam	CL, CL-ML	A-6, A-7	0-5	95-100	90-100	70-90	60-80	30-45	10-25
	50-60	Clay loam, loam, sandy loam.	CL, SC, SC-SM, CL-ML	A-6, A-4	0-5	95-100	90-100	65-95	35-85	20-40	5-20
5010------------- Pits	0-60	Sand and gravel	GP, SP, GP-GM, SP-SM	---	0-10	---	---	---	---	---	---
5040, 5043. Orthents											

TABLE 16.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS

(The symbol < means less than; > means more than. Entries under "Erosion factors--T" apply to the entire profile. Entries under "Wind erodibility group" 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
	In	Pct	g/cc	In/hr	In/in	pH				
6	0-8	35-40	1.30-1.40	0.2-0.6	0.21-0.23	6.1-7.8	High	0.32	5	4
Okoboji	8-36	35-45	1.30-1.40	0.2-0.6	0.18-0.20	6.6-7.8	High	0.32		
	36-48	25-35	1.35-1.40	0.2-0.6	0.18-0.20	6.6-8.4	High	0.32		
	48-60	20-30	1.40-1.50	0.6-2.0	0.18-0.20	7.4-8.4	Moderate	0.28		
27	0-39	18-26	1.35-1.40	0.6-2.0	0.20-0.22	6.1-7.3	Low	0.24	5	6
Terril	39-55	24-30	1.40-1.45	0.6-2.0	0.17-0.19	6.1-7.3	Low	0.28		
	55-60	15-30	1.45-1.70	0.6-2.0	0.16-0.18	6.1-7.8	Low	0.32		
27B	0-37	18-26	1.35-1.40	0.6-2.0	0.20-0.22	6.1-7.3	Low	0.24	5	6
Terril	37-52	24-30	1.40-1.45	0.6-2.0	0.17-0.19	6.1-7.3	Low	0.28		
	52-60	15-30	1.45-1.70	0.6-2.0	0.16-0.18	6.1-7.8	Low	0.32		
27C	0-36	18-26	1.35-1.40	0.6-2.0	0.20-0.22	6.1-7.3	Low	0.24	5	6
Terril	36-50	24-30	1.40-1.45	0.6-2.0	0.17-0.19	6.1-7.3	Low	0.28		
	50-60	15-30	1.45-1.70	0.6-2.0	0.16-0.18	6.1-7.8	Low	0.32		
28	0-16	6-18	1.30-1.40	2.0-6.0	0.13-0.15	5.6-6.5	Low	0.20	3	3
Dickman	16-36	6-18	1.35-1.50	2.0-6.0	0.12-0.14	5.6-7.3	Low	0.20		
	36-60	1-10	1.50-1.60	6.0-20	0.02-0.07	5.6-7.8	Low	0.15		
28B	0-14	6-18	1.30-1.40	2.0-6.0	0.13-0.15	5.6-6.5	Low	0.20	3	3
Dickman	14-32	6-18	1.35-1.50	2.0-6.0	0.12-0.14	5.6-7.3	Low	0.20		
	32-60	1-10	1.50-1.60	6.0-20	0.02-0.07	5.6-7.8	Low	0.15		
34	0-15	5-15	1.25-1.35	2.0-6.0	0.13-0.18	5.6-7.3	Low	0.20	3	3
Estherville	15-20	10-18	1.35-1.60	2.0-6.0	0.12-0.19	5.6-7.3	Low	0.20		
	20-60	0-8	1.50-1.65	>6.0	0.02-0.04	6.6-8.4	Low	0.10		
34C2	0-8	5-15	1.25-1.35	2.0-6.0	0.13-0.18	5.6-7.3	Low	0.20	3	3
Estherville	8-12	10-18	1.35-1.60	2.0-6.0	0.12-0.19	5.6-7.3	Low	0.20		
	12-60	0-8	1.50-1.65	6.0-20	0.02-0.04	6.6-8.4	Low	0.10		
55	0-18	25-27	1.15-1.25	0.6-2.0	0.17-0.22	5.6-7.3	Moderate	0.24	5	6
Nicollet	18-42	25-35	1.25-1.35	0.6-2.0	0.15-0.19	5.6-7.8	Moderate	0.32		
	42-60	22-30	1.35-1.55	0.6-2.0	0.14-0.19	7.4-8.4	Low	0.32		
62C2, 62D2, 62D3, 62E, 62E2, 62F, 62G	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
Storden	8-60	18-30	1.35-1.65	0.6-2.0	0.15-0.19	7.4-8.4	Moderate	0.37		
72	0-15	10-18	1.35-1.45	2.0-6.0	0.19-0.22	5.6-7.3	Low	0.28	3	5
Estherville	15-22	10-18	1.35-1.60	2.0-6.0	0.12-0.19	5.6-7.3	Low	0.20		
	22-60	0-8	1.50-1.65	>6.0	0.02-0.04	6.6-8.4	Low	0.10		
72B	0-14	10-18	1.35-1.45	2.0-6.0	0.19-0.22	5.6-7.3	Low	0.28	3	5
Estherville	14-18	10-18	1.35-1.60	2.0-6.0	0.12-0.19	5.6-7.3	Low	0.20		
	18-60	0-8	1.50-1.65	>6.0	0.02-0.04	6.6-8.4	Low	0.10		
73B	0-8	3-10	1.35-1.50	6.0-20	0.09-0.11	6.1-8.4	Low	0.10	5	8
Salida	8-16	2-8	1.50-1.65	>20	0.02-0.04	7.4-8.4	Low	0.10		
	16-60	0-5	1.50-1.65	>20	0.02-0.04	7.4-8.4	Low	0.10		
73C2, 73D2, 73G	0-8	3-10	1.35-1.50	6.0-20	0.09-0.11	6.1-8.4	Low	0.10	5	8
Salida	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		

TABLE 16.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodibility group
	In	Pct	g/cc	In/hr	In/in	pH				
90---------------- Okoboji	0-18	20-27	1.20-1.25	0.6-2.0	0.22-0.25	6.1-7.8	Moderate-----	0.32	5	6
	18-36	35-45	1.30-1.40	0.2-0.6	0.18-0.20	6.6-7.8	High---------	0.32		
	36-60	25-35	1.35-1.40	0.2-0.6	0.18-0.20	6.6-8.4	High---------	0.32		
95---------------- Harps	0-21	27-35	1.35-1.40	0.6-2.0	0.19-0.21	7.9-8.4	Moderate-----	0.24	5	4L
	21-35	18-32	1.40-1.50	0.6-2.0	0.17-0.19	7.9-8.4	Moderate-----	0.32		
	35-60	14-22	1.55-1.75	0.6-2.0	0.14-0.19	7.4-8.4	Low----------	0.32		
107--------------- Webster	0-23	27-35	1.35-1.40	0.6-2.0	0.19-0.21	6.6-7.3	Moderate-----	0.28	5	7
	23-41	25-35	1.40-1.50	0.6-2.0	0.16-0.18	6.6-7.8	Moderate-----	0.32		
	41-60	14-22	1.50-1.70	0.6-2.0	0.14-0.19	7.4-8.4	Moderate-----	0.32		
108--------------- Wadena	0-14	18-27	1.30-1.50	0.6-2.0	0.20-0.22	6.1-7.3	Low----------	0.24	4	6
	14-26	18-30	1.35-1.50	0.6-2.0	0.14-0.19	5.6-7.3	Low----------	0.32		
	26-60	1-5	1.55-1.65	>20	0.02-0.04	6.6-8.4	Low----------	0.10		
133--------------- Colo	0-30	27-36	1.28-1.32	0.6-2.0	0.21-0.23	5.6-7.3	Moderate-----	0.28	5	7
	30-52	30-35	1.25-1.35	0.6-2.0	0.18-0.20	5.6-7.3	Moderate-----	0.28		
	52-60	25-35	1.35-1.45	0.6-2.0	0.18-0.20	6.1-7.3	Moderate-----	0.32		
135--------------- Coland	0-9	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	Moderate-----	0.24	5	6
	9-52	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	Moderate-----	0.24		
	52-60	12-26	1.50-1.65	0.6-6.0	0.13-0.17	6.1-7.8	Low----------	0.28		
138B-------------- Clarion	0-19	18-26	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Low----------	0.24	5	6
	19-42	24-30	1.50-1.70	0.6-2.0	0.17-0.19	5.6-7.8	Low----------	0.37		
	42-60	12-22	1.50-1.70	0.6-2.0	0.17-0.19	7.4-8.4	Low----------	0.37		
138C-------------- Clarion	0-18	18-26	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Low----------	0.24	5	6
	18-38	24-30	1.50-1.70	0.6-2.0	0.17-0.19	5.6-7.8	Low----------	0.37		
	38-60	12-22	1.50-1.70	0.6-2.0	0.17-0.19	7.4-8.4	Low----------	0.37		
138C2------------- Clarion	0-8	18-26	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Low----------	0.28	5	6
	8-24	24-30	1.50-1.70	0.6-2.0	0.17-0.19	5.6-7.8	Low----------	0.37		
	24-60	12-22	1.50-1.70	0.6-2.0	0.17-0.19	7.4-8.4	Low----------	0.37		
138D-------------- Clarion	0-14	18-26	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Low----------	0.24	5	6
	14-30	24-30	1.50-1.70	0.6-2.0	0.17-0.19	5.6-7.8	Low----------	0.37		
	30-60	12-22	1.50-1.70	0.6-2.0	0.17-0.19	7.4-8.4	Low----------	0.37		
138D2------------- Clarion	0-8	18-26	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Low----------	0.28	5	6
	8-22	24-30	1.50-1.70	0.6-2.0	0.17-0.19	5.6-7.8	Low----------	0.37		
	22-60	12-22	1.50-1.70	0.6-2.0	0.17-0.19	7.4-8.4	Low----------	0.37		
221--------------- Palms	0-22	---	0.30-0.40	2.0-6.0	0.35-0.45	5.1-7.8	-------------	----	2	2
	22-29	---	0.15-0.30	2.0-6.0	0.35-0.45	5.1-7.8	-------------	----		
	29-60	7-35	1.45-1.75	0.6-2.0	0.14-0.22	6.1-8.4	Low----------	0.37		
224--------------- Linder	0-16	14-18	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.8	Low----------	0.24	4	5
	16-27	10-18	1.45-1.55	2.0-6.0	0.15-0.17	6.1-7.8	Low----------	0.24		
	27-60	2-8	1.55-1.75	>20	0.02-0.04	7.4-8.4	Low----------	0.10		
236B-------------- Lester	0-12	20-27	1.30-1.40	0.6-2.0	0.20-0.22	5.6-7.3	Low----------	0.28	5	6
	12-47	24-32	1.45-1.55	0.6-2.0	0.15-0.19	5.1-7.3	Moderate-----	0.28		
	47-60	22-30	1.55-1.75	0.6-2.0	0.14-0.19	7.4-8.4	Low----------	0.37		
236C-------------- Lester	0-10	20-27	1.30-1.40	0.6-2.0	0.20-0.22	5.6-7.3	Low----------	0.28	5	6
	10-43	24-32	1.45-1.55	0.6-2.0	0.15-0.19	5.1-7.3	Moderate-----	0.28		
	43-60	22-30	1.55-1.75	0.6-2.0	0.14-0.19	7.4-8.4	Low----------	0.37		
236D-------------- Lester	0-8	20-27	1.30-1.40	0.6-2.0	0.20-0.22	5.6-7.3	Low----------	0.28	5	6
	8-38	24-32	1.45-1.55	0.6-2.0	0.15-0.19	5.1-7.3	Moderate-----	0.28		
	38-60	22-30	1.55-1.75	0.6-2.0	0.14-0.19	7.4-8.4	Low----------	0.37		

TABLE 16.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodibility group
	In	Pct	g/cc	In/hr	In/in	pH				
236F------------- Lester	0-7	20-27	1.30-1.40	0.6-2.0	0.20-0.22	5.6-7.3	Low----------	0.28	5	6
	7-33	24-32	1.45-1.55	0.6-2.0	0.15-0.19	5.1-7.3	Moderate-----	0.28		
	33-60	22-30	1.55-1.75	0.6-2.0	0.14-0.19	7.4-8.4	Low----------	0.37		
236G------------- Lester	0-6	20-27	1.30-1.40	0.6-2.0	0.20-0.22	5.6-7.3	Low----------	0.28	5	6
	6-28	24-32	1.45-1.55	0.6-2.0	0.15-0.19	5.1-7.3	Moderate-----	0.28		
	28-60	22-30	1.55-1.75	0.6-2.0	0.14-0.19	7.4-8.4	Low----------	0.37		
259-------------- Biscay	0-19	27-30	1.20-1.30	0.6-2.0	0.20-0.22	6.1-7.8	Moderate-----	0.28	4	6
	19-34	18-30	1.25-1.35	0.6-2.0	0.17-0.19	6.6-7.8	Moderate-----	0.28		
	34-38	10-28	1.35-1.55	2.0-6.0	0.11-0.17	6.6-7.8	Low----------	0.28		
	38-60	1-6	1.55-1.65	6.0-20	0.02-0.04	7.4-8.4	Low----------	0.05		
354-------------- Aquolls	0-60	---	---	0.06-0.2	---	---	-------------	----	---	8
384-------------- Collinwood	0-23	35-40	1.20-1.30	0.2-0.6	0.14-0.17	5.6-7.3	Moderate-----	0.32	5	4
	23-39	35-60	1.25-1.35	0.06-0.6	0.13-0.16	5.6-7.3	High---------	0.32		
	39-60	35-45	1.25-1.40	0.06-0.6	0.11-0.15	7.4-8.4	High---------	0.32		
390-------------- Waldorf	0-20	35-40	1.20-1.30	0.2-0.6	0.18-0.25	6.1-7.3	High---------	0.28	5	4
	20-52	40-55	1.25-1.35	0.06-0.6	0.13-0.16	6.6-7.8	High---------	0.32		
	52-60	24-45	1.25-1.45	0.06-0.6	0.20-0.22	7.4-8.4	Moderate-----	0.32		
485-------------- Spillville	0-37	18-26	1.45-1.55	0.6-2.0	0.19-0.21	5.6-7.3	Moderate-----	0.24	5	6
	37-60	14-24	1.55-1.70	0.6-6.0	0.15-0.18	5.6-7.3	Low----------	0.28		
485B------------- Spillville	0-32	18-26	1.45-1.55	0.6-2.0	0.19-0.21	5.6-7.3	Moderate-----	0.24	5	6
	32-60	14-24	1.55-1.70	0.6-6.0	0.15-0.18	5.6-7.3	Low----------	0.28		
507-------------- Canisteo	0-20	27-35	1.25-1.35	0.6-2.0	0.18-0.22	7.4-8.4	Moderate-----	0.24	5	4L
	20-40	25-35	1.35-1.50	0.6-2.0	0.15-0.19	7.4-8.4	Moderate-----	0.32		
	40-48	25-35	1.30-1.50	0.6-2.0	0.12-0.18	7.4-8.4	Low----------	0.32		
	48-60	22-30	1.45-1.60	0.6-2.0	0.14-0.16	7.4-8.4	Low----------	0.32		
508-------------- Calcousta	0-13	27-35	1.25-1.30	0.6-2.0	0.21-0.23	7.4-8.4	High---------	0.28	5	4L
	13-48	24-32	1.30-1.40	0.6-2.0	0.18-0.20	7.4-8.4	High---------	0.43		
	48-60	22-30	1.30-1.40	0.6-2.0	0.20-0.22	7.4-8.4	Moderate-----	0.43		
511-------------- Blue Earth	0-9	18-32	0.20-0.80	0.6-2.0	0.18-0.24	7.4-8.4	Moderate-----	0.28	5	6
	9-60	18-32	0.20-0.80	0.6-2.0	0.18-0.24	7.4-8.4	Low----------	0.28		
511B------------- Blue Earth	0-8	27-35	0.60-1.30	0.2-0.6	0.18-0.24	7.4-8.4	Low----------	0.28	5	6
	8-60	18-35	0.60-1.30	0.2-0.6	0.18-0.24	7.4-8.4	Low----------	0.28		
524-------------- Linder	0-13	14-18	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.8	Low----------	0.24	4	5
	13-37	10-18	1.45-1.55	2.0-6.0	0.15-0.17	6.1-7.8	Low----------	0.24		
	37-60	2-8	1.55-1.75	>20	0.02-0.04	7.4-8.4	Low----------	0.10		
559-------------- Talcot	0-23	30-35	1.20-1.30	0.6-2.0	0.18-0.22	7.4-8.4	Moderate-----	0.28	4	4L
	23-39	30-35	1.25-1.35	0.6-2.0	0.17-0.20	7.4-8.4	Moderate-----	0.28		
	39-60	1-6	1.55-1.65	6.0-20	0.02-0.04	7.4-8.4	Low----------	0.15		
585B:										
Coland----------	0-34	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	Moderate-----	0.24	5	6
	34-52	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	Moderate-----	0.24		
	52-60	12-26	1.50-1.65	0.6-6.0	0.13-0.17	6.1-7.8	Low----------	0.28		
Spillville------	0-37	18-26	1.45-1.55	0.6-2.0	0.19-0.21	5.6-7.3	Moderate-----	0.24	5	6
	37-60	14-24	1.55-1.70	0.6-6.0	0.15-0.18	5.6-7.3	Low----------	0.28		

TABLE 16.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodi-bility group
	In	Pct	g/cc	In/hr	In/in	pH				
638B:										
Clarion----------	0-19	18-26	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Low-----------	0.24	5	6
	19-42	24-30	1.50-1.70	0.6-2.0	0.17-0.19	5.6-7.8	Low-----------	0.37		
	42-60	12-22	1.50-1.70	0.6-2.0	0.17-0.19	7.4-8.4	Low-----------	0.37		
Storden----------	0-10	18-27	1.35-1.45	0.6-2.0	0.20-0.22	7.4-8.4	Low-----------	0.28	5	4L
	10-60	18-30	1.35-1.65	0.6-2.0	0.15-0.19	7.4-8.4	Moderate------	0.37		
638C2:										
Clarion----------	0-8	18-26	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Low-----------	0.28	5	6
	8-24	24-30	1.50-1.70	0.6-2.0	0.17-0.19	5.6-7.8	Low-----------	0.37		
	24-60	12-22	1.50-1.70	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
	8-60	18-30	1.35-1.65	0.6-2.0	0.15-0.19	7.4-8.4	Moderate------	0.37		
638D2:										
Clarion----------	0-8	18-26	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Low-----------	0.28	5	6
	8-22	24-30	1.50-1.70	0.6-2.0	0.17-0.19	5.6-7.8	Low-----------	0.37		
	22-60	12-22	1.50-1.70	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
	8-60	18-30	1.35-1.65	0.6-2.0	0.15-0.19	7.4-8.4	Moderate------	0.37		
638E2:										
Clarion----------	0-8	18-26	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Low-----------	0.28	5	6
	8-20	24-30	1.50-1.70	0.6-2.0	0.17-0.19	5.6-7.8	Low-----------	0.37		
	20-60	12-22	1.50-1.70	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
	8-60	18-30	1.35-1.65	0.6-2.0	0.15-0.19	7.4-8.4	Moderate------	0.37		
639D2:										
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
	8-60	18-30	1.35-1.65	0.6-2.0	0.15-0.19	7.4-8.4	Moderate------	0.37		
Salida-----------	0-8	3-10	1.35-1.50	6.0-20	0.09-0.11	6.1-8.4	Low-----------	0.10	5	8
	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		
655--------------- Crippin	0-23	24-27	1.35-1.40	0.6-2.0	0.20-0.22	6.6-8.4	Low-----------	0.24	5	4L
	23-46	20-32	1.40-1.55	0.6-2.0	0.17-0.19	7.4-8.4	Low-----------	0.28		
	46-60	14-22	1.55-1.75	0.6-2.0	0.14-0.19	7.9-8.4	Low-----------	0.32		
707--------------- Delft	0-18	27-35	1.40-1.65	0.2-0.6	0.18-0.20	5.6-7.8	Moderate------	0.24	5	6
	18-44	18-35	1.40-1.55	0.2-2.0	0.19-0.22	5.6-7.8	Moderate------	0.24		
	44-60	18-32	1.30-1.40	0.6-2.0	0.19-0.22	6.6-7.8	Low-----------	0.32		
733--------------- Calco	0-22	28-33	1.25-1.30	0.6-2.0	0.21-0.23	7.4-8.4	Moderate------	0.28	5	4L
	22-47	30-35	1.25-1.30	0.6-2.0	0.21-0.23	7.4-8.4	Moderate------	0.28		
	47-60	22-32	1.30-1.45	0.6-2.0	0.18-0.20	7.4-8.4	Moderate------	0.32		
787B-------------- Vinje	0-17	32-40	1.25-1.30	0.2-0.6	0.21-0.23	5.6-7.3	Moderate------	0.32	5	4
	17-36	35-45	1.30-1.45	0.2-0.6	0.20-0.22	5.6-7.3	Moderate------	0.32		
	36-60	20-30	1.45-1.70	0.6-2.0	0.17-0.19	6.6-8.4	Low-----------	0.37		
811--------------- Muskego	0-9	---	0.10-0.21	0.6-6.0	0.35-0.45	5.6-7.3	--------------	0.10	1	2
	9-25	---	0.10-0.21	0.6-6.0	0.35-0.45	5.6-7.3	--------------	0.10		
	25-60	18-35	0.30-1.10	0.06-0.2	0.18-0.24	6.6-8.4	Moderate------	0.28		

TABLE 16.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodi-bility group
	In	Pct	g/cc	In/hr	In/in	pH				
823----------------- Ridgeport	0-12	10-18	1.50-1.55	2.0-6.0	0.10-0.12	5.6-7.3	Low-----------	0.20	4	3
	12-36	10-18	1.55-1.60	2.0-6.0	0.07-0.09	5.6-7.3	Low-----------	0.24		
	36-60	2-8	1.60-1.75	>20	0.01-0.03	7.4-8.4	Low-----------	0.10		
828B--------------- Zenor	0-13	10-15	1.50-1.55	2.0-6.0	0.10-0.12	5.6-7.3	Low-----------	0.20	4	3
	13-30	14-18	1.55-1.60	2.0-6.0	0.09-0.11	6.1-8.4	Low-----------	0.20		
	30-60	2-8	1.60-1.75	>20	0.01-0.03	7.4-8.4	Low-----------	0.10		
828C2-------------- Zenor	0-7	10-15	1.50-1.55	2.0-6.0	0.10-0.12	5.6-7.3	Low-----------	0.20	4	3
	7-27	14-18	1.55-1.60	2.0-6.0	0.09-0.11	6.1-8.4	Low-----------	0.20		
	27-60	2-8	1.60-1.75	>20	0.01-0.03	7.4-8.4	Low-----------	0.10		
879---------------- Fostoria	0-7	25-27	1.35-1.40	0.6-2.0	0.20-0.22	6.1-7.3	Low-----------	0.24	5	6
	7-18	25-30	1.35-1.40	0.6-2.0	0.20-0.22	6.1-7.3	Low-----------	0.24		
	18-60	16-26	1.40-1.75	0.6-2.0	0.20-0.22	7.4-8.4	Low-----------	0.43		
956:										
Okoboji-----------	0-8	35-40	1.30-1.40	0.2-0.6	0.21-0.23	6.1-7.8	High----------	0.32	5	4
	8-36	35-45	1.30-1.40	0.2-0.6	0.18-0.20	6.6-7.8	High----------	0.32		
	36-48	25-35	1.35-1.40	0.2-0.6	0.18-0.20	6.6-8.4	High----------	0.32		
	48-60	20-30	1.40-1.50	0.6-2.0	0.18-0.20	7.4-8.4	Moderate------	0.28		
Harps--------------	0-21	27-35	1.35-1.40	0.6-2.0	0.19-0.21	7.9-8.4	Moderate------	0.24	5	4L
	21-35	18-32	1.40-1.50	0.6-2.0	0.17-0.19	7.9-8.4	Moderate------	0.32		
	35-60	14-22	1.55-1.75	0.6-2.0	0.14-0.19	7.4-8.4	Low-----------	0.32		
1133--------------- Colo	0-30	27-36	1.28-1.32	0.6-2.0	0.21-0.23	5.6-7.3	Moderate------	0.28	5	7
	30-45	30-35	1.25-1.35	0.6-2.0	0.18-0.20	5.6-7.3	Moderate------	0.28		
	45-60	25-35	1.35-1.45	0.6-2.0	0.18-0.20	6.1-7.3	Moderate------	0.32		
1458--------------- Millington	0-14	20-27	1.40-1.60	0.6-2.0	0.20-0.24	7.4-8.4	Low-----------	0.28	5	4L
	14-60	18-35	1.40-1.60	0.6-2.0	0.17-0.20	7.4-8.4	Moderate------	0.28		
1585:										
Coland------------	0-34	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	Moderate------	0.24	5	6
	34-52	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	Moderate------	0.24		
	52-60	12-26	1.50-1.65	0.6-6.0	0.13-0.17	6.1-7.8	Low-----------	0.28		
Spillville--------	0-37	18-26	1.45-1.55	0.6-2.0	0.19-0.21	5.6-7.3	Moderate------	0.24	5	6
	37-60	14-24	1.55-1.70	0.6-6.0	0.15-0.18	5.6-7.3	Low-----------	0.28		
1707B:										
Delft-------------	0-18	27-35	1.40-1.65	0.2-0.6	0.18-0.20	5.6-7.8	Moderate------	0.24	5	6
	18-44	18-35	1.40-1.55	0.2-2.0	0.19-0.22	5.6-7.8	Moderate------	0.24		
	44-60	18-32	1.30-1.40	0.6-2.0	0.19-0.22	6.6-7.8	Low-----------	0.32		
Terril------------	0-36	18-26	1.35-1.40	0.6-2.0	0.20-0.22	6.1-7.3	Low-----------	0.24	5	6
	36-50	24-30	1.40-1.45	0.6-2.0	0.17-0.19	6.1-7.3	Low-----------	0.28		
	50-60	15-30	1.45-1.70	0.6-2.0	0.16-0.18	6.1-7.8	Low-----------	0.32		
5010--------------- Pits	0-60	0-2	---	6.0-20	0.02-0.07	---	--------------	----	---	---
5040, 5043. Orthents										

TABLE 17.--SOIL AND WATER FEATURES

("Flooding" and "water table" and terms such as "frequent," "brief," and "apparent" are explained in the text. The symbol < means less than; > means more than. Absence of an entry indicates that the feature is not a concern or that data were not estimated)

Soil name and map symbol	Hydro-logic group	Flooding			High water table			Bedrock		Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months	Depth	Hardness		Uncoated steel	Concrete
					Ft			In				
6----------------- Okoboji	B/D	None---------	---	---	+1-1.0	Apparent	Nov-Jul	>60	---	High-----	High-----	Low.
27, 27B, 27C------ Terril	B	None---------	---	---	>6.0	---	---	>60	---	Moderate	Moderate	Low.
28, 28B----------- Dickman	A	None---------	---	---	>6.0	---	---	>60	---	Low------	Low------	Moderate.
34, 34C2---------- Estherville	B	None---------	---	---	>6.0	---	---	>60	---	Low------	Low------	Low.
55---------------- Nicollet	B	None---------	---	---	2.0-3.5	Apparent	Nov-Jul	>60	---	High-----	High-----	Low.
62C2, 62D2, 62D3, 62E, 62E2, 62F, 62G-------------- Storden	B	None---------	---	---	>6.0	---	---	>60	---	Moderate	Low------	Low.
72, 72B----------- Estherville	B	None---------	---	---	>6.0	---	---	>60	---	Low------	Low------	Low.
73B, 73C2, 73D2, 73G-------------- Salida	A	None---------	---	---	>6.0	---	---	>60	---	Low------	Low------	Low.
90---------------- Okoboji	B/D	None---------	---	---	+1-1.0	Apparent	Nov-Jul	>60	---	High-----	High-----	Low.
95---------------- Harps	B/D	None---------	---	---	0-1.0	Apparent	Nov-Jul	>60	---	High-----	High-----	Low.
107--------------- Webster	B/D	None---------	---	---	0-1.0	Apparent	Nov-Jul	>60	---	High-----	High-----	Low.
108--------------- Wadena	B	None---------	---	---	>6.0	---	---	>60	---	Low------	Low------	Low.
133--------------- Colo	B/D	Occasional	Very brief to long.	Feb-Nov	0-1.0	Apparent	Nov-Jul	>60	---	High-----	High-----	Moderate.
135--------------- Coland	B/D	Occasional	Brief-----	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	>60	---	High-----	High-----	Low.

TABLE 17.--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	Bedrock: Depth	Bedrock: Hardness	Potential frost action	Risk of corrosion: Uncoated steel	Risk of corrosion: Concrete
					Ft			In				
138B, 138C-------- Clarion	B	None---------	---	---	4.0-6.0	Apparent	Nov-Jul	>60	---	Moderate	Low------	Low.
138C2------------- Clarion	B	None---------	---	---	4.0-6.0	---	Nov-Jul	>60	---	Moderate	Low------	Low.
138D-------------- Clarion	B	None---------	---	---	4.0-6.0	Apparent	Nov-Jul	>60	---	Moderate	Low------	Low.
138D2------------- Clarion	B	None---------	---	---	4.0-6.0	---	Nov-Jul	>60	---	Moderate	Low------	Low.
221--------------- Palms	A/D	None---------	---	---	+1-1.0	Apparent	Nov-Jul	>60	---	High-----	High-----	Moderate.
224--------------- Linder	B	None---------	---	---	2.0-4.0	Apparent	Nov-Jul	>60	---	High-----	Moderate	Low.
236B, 236C, 236D, 236F, 236G------- Lester	B	None---------	---	---	>6.0	---	---	>60	---	Moderate	Low------	Moderate.
259--------------- Biscay	B/D	None---------	---	---	0.5-1.5	Apparent	Nov-Jul	>60	---	High-----	Moderate	Low.
354--------------- Aquolls	---	None---------	---	---	+.5-2.0	Apparent	Jan-Dec	>60	---	---	---	---
384--------------- Collinwood	C	None---------	---	---	2.5-4.0	Apparent	Nov-Jul	>60	---	High-----	High-----	Low.
390--------------- Waldorf	C/D	None---------	---	---	0.5-1.5	Apparent	Nov-Jul	>60	---	High-----	High-----	Low.
485--------------- Spillville	B	Occasional	Very brief	Feb-Nov	3.0-5.0	Apparent	Nov-Jul	>60	---	Moderate	High-----	Moderate.
485B-------------- Spillville	B	None---------	---	---	3.0-5.0	Apparent	Nov-Jul	>60	---	Moderate	High-----	Moderate.
507--------------- Canisteo	B/D	None---------	---	---	0.5-1.5	Apparent	Nov-Jul	>60	---	High-----	High-----	Low.
508--------------- Calcousta	B/D	None---------	---	---	+1.-1.0	Apparent	Nov-Jul	>60	---	High-----	High-----	Low.
511--------------- Blue Earth	B/D	None---------	---	---	+1-0.5	Apparent	Nov-Jul	>60	---	High-----	High-----	Low.

TABLE 17.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydro-logic group	Flooding			High water table			Bedrock		Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months	Depth	Hardness		Uncoated steel	Concrete
					Ft			In				
511B--------------- Blue Earth	D	None----------	---	---	0-1.0	Apparent	Jan-Dec	>60	---	High-----	High-----	Low.
524---------------- Linder	B	None----------	---	---	2.0-4.0	Apparent	Nov-Jul	>60	---	High-----	Moderate	Low.
559---------------- Talcot	B/D	None----------	---	---	1.0-2.5	Apparent	Nov-Jul	>60	---	High-----	High-----	Low.
585B:												
Coland------------	B/D	Occasional	Brief-----	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	>60	---	High-----	High-----	Low.
Spillville--------	B	None----------	---	---	3.0-5.0	Apparent	Nov-Jul	>60	---	Moderate	High-----	Moderate.
638B:												
Clarion-----------	B	None----------	---	---	4.0-6.0	Apparent	Nov-Jul	>60	---	Moderate	Low------	Low.
Storden-----------	B	None----------	---	---	>6.0	---	---	>60	---	Moderate	Low------	Low.
638C2, 638D2, 638E2:												
Clarion----------	B	None----------	---	---	4.0-6.0	---	Nov-Jul	>60	---	Moderate	Low------	Low.
Storden----------	B	None----------	---	---	>6.0	---	---	>60	---	Moderate	Low------	Low.
639D2:												
Storden-----------	B	None----------	---	---	>6.0	---	---	>60	---	Moderate	Low------	Low.
Salida------------	A	None----------	---	---	>6.0	---	---	>60	---	Low------	Low------	Low.
655---------------- Crippin	B	None----------	---	---	2.0-4.0	Apparent	Nov-Jul	>60	---	High-----	High-----	Low.
707---------------- Delft	B/D	None----------	---	---	1.0-3.0	Apparent	Nov-Jul	>60	---	High-----	High-----	Low.
733---------------- Calco	B/D	Occasional	Brief-----	Feb-Nov	0-1.0	Apparent	Nov-Jul	>60	---	High-----	High-----	Low.
787B--------------- Vinje	B	None----------	---	---	>6.0	---	---	>60	---	Moderate	Moderate	Low.
811---------------- Muskego	A/D	None----------	---	---	+1-1.0	Apparent	Nov-Jul	>60	---	High-----	Moderate	Moderate.
823---------------- Ridgeport	B	None----------	---	---	>6.0	---	---	>60	---	Low------	Low------	Low.

TABLE 17.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydro-logic group	Flooding			High water table			Bedrock		Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months	Depth	Hardness		Uncoated steel	Concrete
					Ft			In				
828B, 828C2------- Zenor	B	None--------	---	---	>6.0	---	---	>60	---	Low------	Low------	Low.
879--------------- Fostoria	B	None--------	---	---	2.0-4.0	Apparent	Nov-Jul	>60	---	High-----	High-----	Low.
956:												
Okoboji----------	B/D	None--------	---	---	+1-1.0	Apparent	Nov-Jul	>60	---	High-----	High-----	Low.
Harps------------	B/D	None--------	---	---	0-1.0	Apparent	Nov-Jul	>60	---	High-----	High-----	Low.
1133-------------- Colo	B/D	Frequent----	Very brief to long.	Feb-Nov	0-1.0	Apparent	Nov-Jul	>60	---	High-----	High-----	Moderate.
1458-------------- Millington	B/D	Frequent----	Brief-----	Feb-Nov	+.5-2.0	Apparent	Mar-Jul	>60	---	High-----	High-----	Low.
1585:												
Coland-----------	B/D	Frequent----	Brief-----	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	>60	---	High-----	High-----	Low.
Spillville-------	B	Frequent----	Very brief	Feb-Nov	3.0-5.0	Apparent	Nov-Jul	>60	---	Moderate	High-----	Moderate.
1707B:												
Delft------------	B/D	None--------	---	---	1.0-3.0	Apparent	Nov-Jul	>60	---	High-----	High-----	Low.
Terril-----------	B	None--------	---	---	>6.0	---	---	>60	---	Moderate	Moderate	Low.
5010-------------- Pits	A	None--------	---	---	>6.0	---	---	>60	---	---	---	---
5040, 5043-------- Orthents	---	None--------	---	---	>6.0	---	---	>60	---	---	---	---

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	Loamy, mixed, mesic Haplaquolls
Biscay	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Typic Haplaquolls
Blue Earth	Fine-silty, mixed (calcareous), mesic Mollic Fluvaquents
Calco	Fine-silty, mixed (calcareous), mesic Cumulic Haplaquolls
Calcousta	Fine-silty, mixed (calcareous), mesic Typic Haplaquolls
Canisteo	Fine-loamy, mixed (calcareous), mesic Typic Haplaquolls
Clarion	Fine-loamy, mixed, mesic Typic Hapludolls
Coland	Fine-loamy, mixed, mesic Cumulic Haplaquolls
Collinwood	Fine, montmorillonitic, mesic Aquic Hapludolls
Colo	Fine-silty, mixed, mesic Cumulic Haplaquolls
Crippin	Fine-loamy, mixed, mesic Aquic Hapludolls
Delft	Fine-loamy, mixed, mesic Cumulic Haplaquolls
Dickman	Sandy, mixed, mesic Typic Hapludolls
Estherville	Sandy, mixed, mesic Typic Hapludolls
Fostoria	Fine-loamy, mixed, mesic Aquic Hapludolls
Harps	Fine-loamy, mesic Typic Calciaquolls
Lester	Fine-loamy, mixed, mesic Mollic Hapludalfs
Linder	Coarse-loamy, mixed, mesic Aquic Hapludolls
Millington	Fine-loamy, mixed (calcareous), mesic Cumulic Haplaquolls
Muskego	Coprogenous, euic, mesic Limnic Medisaprists
Nicollet	Fine-loamy, mixed, mesic Aquic Hapludolls
Okoboji	Fine, montmorillonitic, mesic Cumulic Vertic Haplaquolls
Orthents	Loamy, mixed, mesic Typic Udorthents
Palms	Loamy, mixed, euic, mesic Terric Medisaprists
Ridgeport	Coarse-loamy, mixed, mesic Typic Hapludolls
*Salida	Sandy-skeletal, mixed, mesic Entic Hapludolls
Spillville	Fine-loamy, mixed, mesic Cumulic Hapludolls
Storden	Fine-loamy, mixed (calcareous), mesic Typic Udorthents
Talcot	Fine-loamy over sandy or sandy-skeletal, mixed (calcareous), mesic Typic Haplaquolls
Terril	Fine-loamy, mixed, mesic Cumulic Hapludolls
Vinje	Fine, montmorillonitic, mesic Typic Hapludolls
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
Zenor	Coarse-loamy, mixed, mesic Typic Hapludolls

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