SOIL SURVEY OF

Blue Earth County, Minnesota

United States Department of Agriculture
Soil Conservation Service
in cooperation with
Minnesota Agricultural Experiment Station

This is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and agencies of the States, usually the Agricultural Experiment Stations. In some surveys, other Federal and local agencies also contribute. The Soil Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey. In line with Department of Agriculture policies, benefits of this program are available to all, regardless of race, color, national origin, sex, religion, marital status, or age.

Major fieldwork for this soil survey was completed in the period 1959–73. Soil names and descriptions were approved in 1975. Unless otherwise indicated, statements in the publication refer to conditions in the survey area in 1973. This survey was made cooperatively by the Soil Conservation Service and the University of Minnesota Agricultural Experiment Station. It is part of the technical assistance furnished to the Blue Earth Soil and Water Conservation District, and was partially funded by Blue Earth County.

HOW TO USE THIS SOIL SURVEY

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

Locating Soils

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

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

Finding and Using Information

The "Index to Map Units" on page ii lists all of the soils in the county by map symbol and shows the page where each soil is described. The capability unit to which each soil has been assigned is specified at the end of the soil description.

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

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

Foresters and others can refer to the section "Windbreaks and environmental plantings" where the soils of the county are evaluated according to their suitability for trees and shrubs.

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

Community planners and others can read about soil properties that affect the choice of sites for dwellings, industrial buildings, and for recreation areas in the sections, "Engineering" and "Recreation."

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

Scientists and others can read about how the soils formed and how they are classified in the section "Formation and classification of soils."

Newcomers in Blue Earth County may be especially interested in the section "General soil map for broad land use planning," where broad patterns of soils are described. They may also be interested in the information about the county given in the section "General nature of the county."

Cover: **Contour stripcropping on smooth, sloping and moderately steep, nearly level-topped circular hills in the Cordova-Lester-Caron map unit. Wita Lake in background.**

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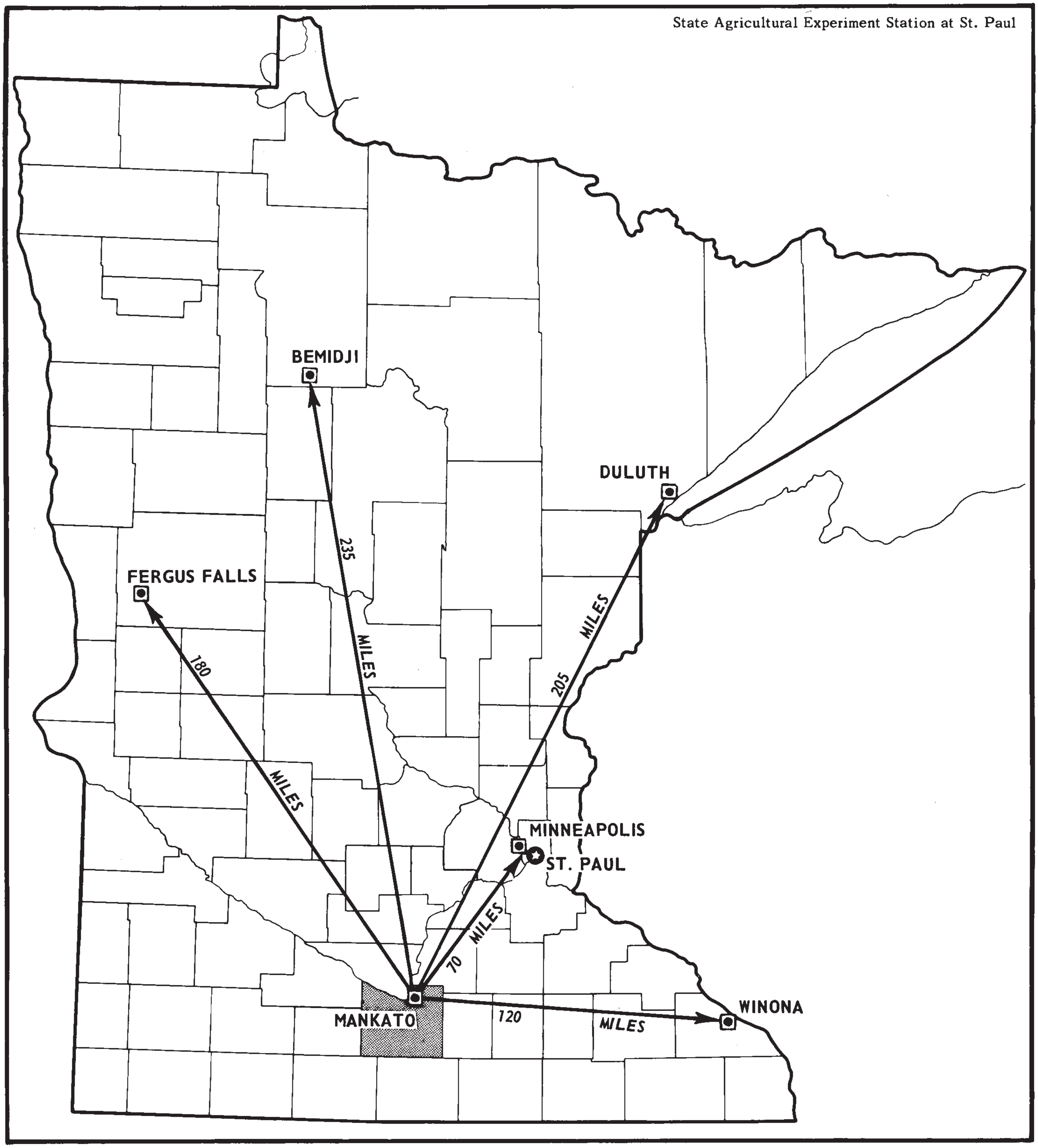

Location of Blue Earth County in Minnesota.

SOIL SURVEY OF BLUE EARTH COUNTY, MINNESOTA

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

BLUE EARTH COUNTY is in the south-central part of Minnesota (see facing page). Mankato, the county seat, is about 80 miles southwest of Minneapolis and St. Paul. It has a population of about 30,895. The total area is 481,920 acres. About 90 percent of this acreage is farmland. In 1969 approximately 85 percent of the land area in farms was used for crops, mainly corn, soybeans, and alfalfa. Beef and hogs are the principal livestock enterprises.

How This Survey Was Made

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

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

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

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

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

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

Some map units are made up of soils of different series, or of different phases within one series. One such kind of map unit is shown on the soil map of Blue Earth County, soil complexes.

A soil complex consists of areas of two or more soils, so intricately mixed or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. Generally, the name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Canisteo-Fieldon loams is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, so severely eroded, or so variable that it has not been classified by soil series. These places are shown on the soil map and are described in the survey, but they are called miscellaneous areas and are given descriptive names. Alluvial land, occasionally flooded, is an example.

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

Scientists observe how soils behave when used as a growing place for native and cultivated plants, and as material for structures, foundations for structures, or covering for structures. They relate this behavior to properties of the soils. For example, they observe that filter fields for onsite disposal of sewage fail on a given kind of soil, and they relate this to the slow permeability of the soil or its high water table. They see that streets, road pavements, and foundations for houses are cracked on a named kind of soil and they relate this failure to the high shrink-swell potential of the soil material. Thus, they use observation and knowledge of soil properties, together with available research data, to predict limitations or suitability of soils for present and potential uses.

But only part of a soil survey is done when the soils have been named, described, interpreted, and delineated on aerial photographs and when the laboratory data and other data have been assembled. The mass of detailed information then needs to be organized to be readily useful to different groups of users, among them farmers, managers of rangeland and woodland, engineers, planners, developers and builders, homebuyers, and those seeking recreation. Presenting the detailed information in an organized, understandable manner is the purpose of this publication.

General Soil Map For Broad Land Use Planning

The general soil map at the back of this publication shows, in color, map units that have a distinct pattern of soils and of relief and drainage. Each map unit is a unique natural landscape. Typically, a map unit consists of one or more major soils and some minor soils. It is named for the major soils. The soils making up one unit can occur in other units but in a different pattern.

The general soil map provides a broad perspective of the soils and landscapes in the survey area. It provides a basis for comparing the potential of large areas for general kinds of land use. Areas that are, for the most part, suited to certain kinds of farming or to other land uses can be identified on the map. Likewise, areas of soils having properties that are distinctly unfavorable for certain land uses can be located.

Because of its small scale, the map does not show the kind of soil at a specific site. Thus, it 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 kinds of soil in any one map unit differ from place to place in slope, depth, stoniness, drainage, or other characteristics that affect their management.

The 14 map units in Blue Earth County are described on the pages that follow.

Alluvial Terraces and Steep Land Adjacent to Rivers

These nearly level to very steep, poorly drained to somewhat excessively drained soils formed in medium textured and moderately coarse textured alluvial outwash and glacial till under mixed deciduous trees and prairie grasses. They are in the deeply entrenched river valleys.

Only two map units in Blue Earth County are in this group. They have high esthetic scenic value as well as value for recreation and wildlife.

1. Alluvial land-Copaston-Chaska

Nearly level and gently undulating, poorly drained to well drained soils formed in medium textured alluvium stratified with moderately coarse and coarse textured material; some are underlain by limestone bedrock

This map unit is on the Minnesota River flood plain and the higher terraces. The terraces typically have sharp escarpments on the side facing the river.

This unit, mainly along the Minnesota River, makes up about 4 percent of the county. It is about 30 percent Alluvial land, 15 percent Copaston soils, 5 percent Chaska soils, and 50 percent minor soils.

Alluvial land, gently sloping, is on alluvial fans at the mouth of ravines in the valleys. It is subject to flash flooding and seepage. Alluvial land, frequently flooded, and alluvial land, occasionally flooded, are on the flood plain. They consist of moderately well drained to poorly drained alluvial soils. They are variable in texture and stratified. They are subject to change caused by stream overflow, scouring, and channel changes.

Copaston soils are well drained, medium textured and moderately coarse textured, and nearly level. They are no more than 20 inches deep over limestone bedrock. The surface layer typically is black and very dark grayish brown loam about 10 inches thick. The subsoil is dark brown sandy loam about 9 inches thick. It is underlain by fractured limestone bedrock.

Chaska soils are deep, poorly drained, nearly level, and limy throughout. They formed in medium textured alluvial deposits stratified with moderately coarse and coarse textured material. They are on the flood plain and are occasionally flooded. The water table rises and falls with the water level in the river. The surface layer typically is very dark gray loam about 8 inches thick. It is underlain by mottled, variable colored, stratified loamy and sandy material.

Minor in this map unit are Caron, Joliet, Oshawa, Tilfer, and Lasa soils. The very poorly drained Caron mucky peat and Joliet soils are in seep areas along the base of the bedrock escarpments and steep slopes. The somewhat excessively drained Lasa, rock substratum, is on the higher bedrock terraces. The very poorly drained Oshawa soil is in the recently abandoned river channels. The poorly drained and very poorly drained Tilfer soil is on the bedrock controlled terraces in old river channels.

About 40 percent of this map unit is used for residential and commercial uses, 15 percent for recreation, for example, Minneopa State Park, and 45 percent for farming.

The flood hazard on the flood plain is a problem not only for farming but also for residential and commercial development. The bedrock controlled terraces provide a solid foundation for all commercial and residential development. The cost of installing water lines and sewer lines, however, is high. The contami-

Figure 1.—The Blue Earth River Valley. The LeSueur River enters the valley in the foreground.

nation of ground water by individual sewage disposal systems is a hazard.

The droughtiness of the medium textured and moderately coarse textured soils that are shallow over bedrock limits the productive potential of those soils for farm crops. Drainage is needed to increase the productive potential. Bedrock, however, increases the cost of installing a drainage system and draining old stream channels that are near the base of the steep river bluffs. Soils on the flood plain should be protected by dikes if they are farmed or used for commercial or residential purposes.

The limestone bedrock is quarried. It provides building stone. It is also crushed for agriculture lime and the aggregate used in construction.

2. *Storden-Comfrey-Lomax*

Nearly level to very steep, well drained and poorly drained soils formed in moderately coarse to moderately fine textured alluvium and medium textured glacial till

This map unit is on valley walls adjacent to the deeply entrenched rivers and on the different terraces. The terraces occur within the river valleys (fig. 1).

This unit makes up about 9 percent of the county. It is about 30 percent Storden soils, 20 percent Comfrey soils, 10 percent Lomax soils, and 40 percent minor soils.

Storden soils are steep and very steep, well drained, and limy. They formed in medium textured material on valley walls. The surface layer typically is very dark grayish brown loam about 8 inches thick. It is underlain by dark grayish brown and light olive brown loam.

Comfrey soils are deep and poorly drained. They formed in moderately fine textured alluvial deposits. They are on flood plains and in side valleys. They are subject to variable flood frequency. The surface layer typically is black clay loam and loam about 34 inches thick. It is underlain by mottled dark grayish brown and olive loam.

Lomax soils are deep, well drained, and dark colored. They formed in medium textured and moderately coarse textured material. They are on high terraces above the present flood plain. The surface layer typically is black and very dark gray loam about 19 inches thick. The subsoil is very dark grayish brown, dark grayish brown, and dark brown loam.

Minor in this map unit are Alluvial land and Estherville, Lester, Minneopa, Terril, and Wadena soils. Alluvial land is on the present flood plain. The somewhat excessively drained Estherville and Minneopa soils and the well drained Wadena soil are on high river terraces. The well drained Lester soil occurs in complex with the Storden soil. The moderately well drained Terril soil is on concave foot slopes.

The steep and very steep slopes of this map unit are used mainly for recreation, wildlife management, woodland management and, in some areas, for residential use. The fields of the river terraces and flood plains are isolated and provide an excellent opportunity for specialty farm crops, such as research plots for the development of new seed corn hybrids. This map unit has high potential for the development of recreational enterprises, wildlife management, and woodland management. It also adds a special esthetic quality to the landscape.

This map unit provides most of the source of sand and gravel used for construction in Blue Earth County and the Mankato vicinity. Some of these gravel pits are buried and are being excavated out of the river bed or excavated from beneath the glacial drift material from the side of the river valleys.

A large amount of sediment is carried annually in these rivers as they erode and cut into the banks and the very steep slopes nearby. Many stretches along the deeply entrenched river valleys are actively eroding; some are as much as three-quarters of a mile long.

New gullies form in many wooded ravines as water runs off from the nearly level uplands, thus eroding more soil material. Many other ravines are presently stable but should be protected from housing and recreation developments and from intensive farm uses.

Low, Nearly Circular Hills Having Nearly Level to Gently Undulating Tops and Smooth Sides

These nearly level to moderately steep, very poorly drained to well drained upland soils formed mostly in medium and moderately fine textured, friable glacial till and fine and moderately fine textured material 2 to 4 feet thick over medium textured glacial till. They formed under prairie grasses or mixed deciduous trees and prairie grasses. Some are used for farming. Some provide wildlife habitat. Others are in residential areas.

Four map units in Blue Earth County are in this group. The potential is intensive management for both farm and wildlife uses, which are compatible in this landscape.

3. *Nicollet-Webster-Clarion*

Nearly level and gently undulating, moderately well drained, poorly drained, and well drained soils formed in medium textured and moderately fine textured glacial till

The soils in this map unit formed under prairie grasses. They occupy the nearly level tops and smooth sides of nearly circular hills. The elevations between the hilltops and the swales between the hills differ by about 5 to 15 feet.

This unit makes up about 2 percent of the county. It is about 36 percent Nicollet soils, 23 percent Webster soils, 20 percent Clarion soils, and 21 percent minor soils.

Nicollet soils are deep, nearly level, and moderately well drained. They formed in medium textured and moderately fine textured material. They are on smooth sides of the nearly circular hills and on low convex rises in low areas between the hills. The surface layer typically is black and very dark grayish brown loam about 21 inches thick. The subsoil is dark grayish brown to light olive brown clay loam about 23 inches thick. It is underlain by mottled, light olive brown loam.

Webster soils are deep, nearly level, and poorly drained. They formed in medium textured and moderately fine textured material. They are on the tops of the circular hills and in the low areas between the hills. The surface layer typically is black silty clay loam and clay loam about 20 inches thick. The subsoil is mottled very dark gray and dark gray clay loam about 10 inches thick. It is underlain by mottled olive gray loam.

Clarion soils are deep, well drained, and gently undulating. They formed in medium textured material. They are on smooth sides of the nearly circular hills. The surface layer typically is black and very dark gray loam about 14 inches thick. The subsoil is brown and dark brown heavy loam about 20 inches thick. It is underlain by yellowish brown loam.

Minor in this map unit are Canisteo and Glencoe soils. The poorly drained Canisteo soil occupies the limy rims around the depressions and the flats between some of the nearly circular hills. The very poorly drained Glencoe soil occurs in the depressions.

This map unit is prime agricultural land and is well suited to farm crop production. The organic-matter content, natural fertility, and available water capacity are high. The very poorly drained and poorly drained soils need to be drained for efficient crop production. Adequate drainage can be provided by tile lines at 100-foot intervals. The soils in this unit have about 10 percent less sand than similar soils in the Webster-Nicollet-Canisteo map unit.

4. *Cordova-Lester-Caron*

Nearly level and moderately steep, very poorly drained, poorly drained, and well drained soils formed in medium textured and moderately fine textured glacial till and organic material

This map unit is on the hilltops and smooth sides and in broad, low swales between the nearly level-topped circular hills (see cover photo). The soils formed under mixed deciduous trees and prairie grasses.

This unit makes up about 6 percent of the county. It is about 48 percent Cordova soils, 15 percent Lester soils, 6 percent Caron soils, and 31 percent minor soils.

Cordova soils are deep, poorly drained, and nearly level. They formed in medium textured and moderately fine textured material. They are in large areas on the tops of circular hills. The surface layer typically is black clay loam about 13 inches thick. The subsoil is clay loam. It is very dark gray in the upper part and mottled olive gray in the lower part. It is underlain by mottled olive gray and olive brown loam.

Lester soils are deep, well drained, and sloping to moderately steep. They are on smooth sides of the nearly level-topped circular hills. The surface layer typically is very dark gray and very dark grayish brown loam about 15 inches thick. The subsoil is dark brown, dark yellowish brown, and yellowish brown clay loam about 33 inches thick. It is underlain by limy, light olive brown loam.

Caron soils are very poorly drained. They formed in moderately decomposed organic material about 3 feet thick over limnic lake sediments. They are in broad depressions between nearly level-topped circular hills. The surface layer typically is black muck about 8 inches thick. The next layer is very dark gray peaty muck about 17 inches thick and black muck about 10 inches thick. It is underlain by limy, black limnic sediments.

Minor in this map unit are Glencoe, Le Sueur, Muskego, and Rolfe soils. The very poorly drained Glencoe soil is in deeper depressions on the flat-topped hills at the edge of the organic soil areas. The moderately well drained Le Sueur soil occupies low convex knolls. The very poorly drained Muskego soil is in broad swales between the flat-topped hills. The very poorly drained Rolfe soil occupies shallow depressions in the hills.

This map unit is well suited to farm crop production. The organic-matter content, available water capacity, and natural fertility are high. Drainage can be provided by tile lines at 100-foot intervals. Lime is needed for maximum efficient use of these soils for crop production. Crops in low swales between the circular hills are more susceptible to frost late in spring and early in fall. Shorter season crops or varieties are better suited to these areas. The wooded slopes around the lakes and adjacent to streams are suited to wildlife, recreation, or residential development. Many undrained soils in swales between the circular, flat-topped hills have high potential for intensive wildlife development. The management of these swales for wildlife is compatible with the intensive management of farm lands on the nearly level, flat-topped hills.

5. *Minnetonka-Kilkenny-Caron*

Nearly level and moderately steep, very poorly drained, poorly drained, and well drained soils formed in moderately fine and fine textured material over glacial till or in organic material

This map unit is on the flat tops and smooth sides of circular hills and in swales between the hills. The soils formed under mixed deciduous trees and prairie grasses.

This unit makes up about 5 percent of the county. It is about 45 percent Minnetonka soils, 15 percent Kilkenny soils, 6 percent Caron soils, and 34 percent minor soils.

Minnetonka soils are poorly drained and nearly level. They formed in about 40 inches of moderately fine textured and fine textured material over medium textured material. They are on the nearly level tops of circular hills. The surface layer typically is black and very dark grayish brown silty clay loam about 19 inches thick. The subsoil is mottled dark grayish brown and olive gray silty clay and clay. It is underlain by limy, mottled olive gray loam.

Kilkenny soils are well drained and moderately steep. They formed in moderately fine textured to medium textured material. They are on smooth sides of the nearly level-topped circular hills. The surface layer typically is black clay loam about 7 inches thick. The subsoil is olive brown and dark yellowish brown clay loam about 38 inches thick. It is underlain by limy, light olive brown loam.

Caron soils are very poorly drained. They formed in moderately decomposed organic material about 3 feet thick over limnic lake sediments. They are in broad depressions between the nearly level-topped circular hills. The surface layer typically is black muck about 8 inches thick. The next layer is very dark gray mucky peat about 17 inches thick and black muck about 10 inches thick. It is underlain by limy, black limnic sediments.

Minor in this map unit are Barbert, Lester, Le Sueur, and Shorewood soils. The very poorly drained Barbert soil is in shallow depressions. The well drained Lester soil is on some of the smooth side slopes. The moderately well drained Le Sueur and Shorewood soils are on slightly elevated rises.

This map unit is well suited to farm crop production. The available water capacity, natural fertility, and organic-matter content are high. Lime and drainage on the nearly level hill tops and in swales between the tops of the circular hills are needed for efficient crop production. Tile lines at 75- to 80-feet intervals are needed because of the high clay content. The gridiron tile system can be used according to the contour of the land, as opposed to the random system needed around the gently undulating knolls in map unit 6, the Kilkenny-Minnetonka-Lerdal unit. Crops in the low swales are more susceptible to frost late in spring or early in fall. Shorter season crops or varieties are better suited to these areas.

In wooded areas, the moderately steep, smooth side slopes are conducive to management for wildlife, residential areas, and small tracts of woodlots. The poorly drained swales between the nearly level, circular hills provide an excellent opportunity for intensive wildlife management, which would be compatible with intensive farming on the higher land. Many of these lower swales are dead lakes and bays off the present lakes.

6. *Kilkenny-Minnetonka-Lerdal*

Nearly level to moderately steep, poorly drained, somewhat poorly drained, and well drained soils formed in moderately fine and fine textured material over glacial till

This map unit is on the tops and smooth sides of circular hills. The soils formed under mixed deciduous trees and prairie grasses.

This unit makes up about 2 percent of the county. It is about 35 percent Kilkenny soils, 20 percent Minnetonka soils, 15 percent Lerdal soils, and 30 percent minor soils.

Kilkenny soils are well drained and gently sloping to moderately steep. They formed in moderately fine textured material, which has a high shale content, over medium textured material. They are on the tops and smooth complex sides of circular hills. The surface layer typically is black clay loam about 7 inches thick. The subsoil is olive brown clay loam about 38 inches thick. It is underlain by limy, light olive brown loam.

Minnetonka soils are poorly drained. They formed in 40 inches of moderately fine textured and fine textured material over medium textured material. They are on the tops of circular hills. The surface layer typically is black and very dark grayish brown silty clay loam about 19 inches thick. The subsoil is mottled dark grayish brown, very dark grayish brown, and olive gray silty clay and clay. It is underlain by limy, mottled olive gray loam.

Lerdal soils are somewhat poorly drained to moderately well drained and are gently sloping. They formed in moderately fine textured material, which has a high shale content, over medium textured material. They are on the tops of circular hills and the smooth side slopes where side hill seeps are common. The surface layer typically is black silty clay loam about 7 inches thick. The subsurface layer is dark grayish brown silty clay about 5 inches thick. The subsoil is dark grayish brown silty clay about 22 inches thick with mottles in the lower part. It is underlain by limy, light olive brown clay loam.

Minor in this map unit are Caron, Cordova, Lester, and Le Sueur soils. The very poorly drained Caron soil is in swales between the nearly circular hills. The poorly drained, nearly level, medium textured Cordova soil is on hilltops. The well drained, gently sloping to moderately steep and steep, medium textured Lester soil is on smooth and complex side slopes. The moderately well drained, medium textured Le Sueur soil is on low convex rises.

This map unit is well suited to farm crop production. The available water capacity and natural fertility are high. The organic-matter content is moderate. Lime and drainage of the poorly drained and very poorly drained soils on the tops of circular hills, in drainageways, and in swales are needed for efficient crop production. Tile lines at 75- to 80-foot intervals are effective. Typically, a random tile drainage system is used to fit the more complex topography. Care is needed to prevent water erosion, which occurs in the drainageways unless they are kept in sod. Crops in the swales are more susceptible to frost late in spring or early in fall. Shorter season crops or varieties are better suited to these areas. The wooded slopes around the perimeter of many circular hills, along streams, and near lakes are excellent areas for wildlife and intensive management of small tracts of timber. The swales and wet depressions between circular hills provide an excellent opportunity for intensive wildlife management, which would be compatible with the intensive farm use on the higher uplands.

Gently Undulating to Steep, Irregularly Sloping Ground and End Moraines

These nearly level to steep, poorly drained to somewhat excessively drained, upland soils formed in medium textured and moderately coarse textured, friable glacial drift. They formed under prairie grasses. Slopes are complex.

Two map units in Blue Earth County are in this group. The dominant and potential use is intensive farming.

7. Webster-Nicollet-Canisteo

Nearly level and gently undulating, poorly drained and moderately well drained soils formed in medium textured and moderately fine textured glacial till

This map unit is on ground moraines. Slopes are irregular and only about 75 to 125 feet long. The difference in relief is 5 to 15 feet or less.

This unit makes up about 14 percent of the county. It is about 23 percent Webster soils, 15 percent Nicollet soils, 15 percent Canisteo soils, and 47 percent minor soils.

Webster soils are neutral, poorly drained, and nearly level. They formed in medium textured and moderately fine textured material. They are in broad areas and drainageways. The surface layer is typically black and very dark gray silty clay loam and clay loam about 20 inches thick. The subsoil is mottled dark gray clay loam about 10 inches thick. It is underlain by mottled olive gray loam.

Nicollet soils are neutral, moderately well drained, and gently undulating. They formed in medium textured and moderately fine textured material. The surface layer typically is black and very dark grayish brown loam about 21 inches thick. The subsoil is dark grayish brown, light olive brown, and olive brown clay loam about 23 inches thick. It is underlain by mottled light olive brown loam.

Canisteo soils are poorly drained and limy. They formed in medium textured and moderately fine textured material. They are in broad areas or on rims around very poorly drained depressions. The surface layer typically is black and very dark gray, limy silty clay loam about 14 inches thick. The subsoil is mottled dark gray and gray, limy clay loam about 13 inches thick. It is underlain by mottled olive gray and light olive gray loam.

Minor in this map unit are Clarion, Glencoe, and Palms soils. The well drained Clarion soil is on convex slopes. The very poorly drained Glencoe and Palms soils are in depressions.

This map unit is well suited to farm crop production. The organic-matter content, available water capacity, and natural fertility are high. Most soils in the unit need drainage for efficient crop production. Adequate drainage can be provided by tile lines at 100-foot intervals. Improvement of outlets for further tile drainage is also needed. Some of the deeper depressions have alternative wildlife and recreational uses. Limy soils have special management needs in fertility, herbicides, and varieties of crops. Higher rates of potassium and varieties of alkaline-tolerant crops are needed.

8. Clarion-Storden-Estherville

Rolling to steep, well drained and somewhat excessively drained soils formed in medium textured glacial till and moderately coarse textured glacial outwash

This map unit is at the highest elevation in the county. The soil pattern is complex with short, rolling to steep slopes around numerous closed depressions.

Difference in relief between the low areas and the high areas is 15 to 30 feet or more.

This unit makes up about 2 percent of the county. It is about 50 percent Clarion soils, 15 percent Storden soils, 10 percent Estherville soils, and 25 percent minor soils.

Clarion soils are well drained and are rolling to moderately steep. They formed in medium textured material. Slopes are complex, irregular, and convex. The surface layer typically is black and very dark gray loam about 14 inches thick. The subsoil is brown and dark brown heavy loam about 20 inches thick. It is underlain by yellowish brown loam.

Storden soils are well drained, moderately steep and steep, and limy. They formed in medium textured material. Slopes are irregular and convex. The surface layer typically is very dark grayish brown loam about 8 inches thick. It is underlain by dark grayish brown and light olive brown loam.

Estherville soils are rolling to steep and somewhat excessively drained. They formed in moderately coarse textured material over coarse textured material. Slopes are complex and irregular. The surface layer typically is black and very dark gray sandy loam about 14 inches thick. The subsoil is very dark grayish brown sandy loam, about 8 inches thick, grading toward dark brown loamy coarse sand in the lower part. It is underlain by dark brown coarse sand and gravel.

Minor in this map unit are Ocheyedan, Lester, Wadena, Webster, and Glencoe soils. The well drained Ocheyedan, Lester, and Wadena soils are intermingled with the major soils in the same landscape. The poorly drained Webster soil is in drainageways and on broader flats. The very poorly drained Glencoe soil is in depressions.

The moderately steep and steep soils are poorly suited to farming. The rolling areas are moderately suited. This unit is better suited to small grain and hay. Intensive farming on the steeper slopes increases the risk of localized erosion and decreases the efficiency of larger farming operations. This unit contributes the least amount of soil as sediment to lakes and streams. Most of the soil washed off the barren slope is deposited on the concave toe slopes. The rest is carried out into the enclosed depression and settles out of the water. This unit has good potential for recreation, upland wildlife, and wetland wildlife.

Clayey Mantled Ground Moraine

These nearly level to gently undulating, very poorly drained to moderately well drained upland soils formed in 2 to 4 feet of moderately fine textured and fine textured lacustrine material and the underlying medium textured glacial till. They formed under prairie grasses or mixed deciduous trees and prairie grasses.

Two map units in Blue Earth County are in this group. The dominant and potential use is intensive farming. The few scattered areas of broad deeper depressions can be managed for upland and wetland wildlife without seriously restricting the development of prime farm land.

9. Minnetonka-Shorewood-Lura

Nearly level and gently sloping, very poorly drained, poorly drained, and moderately well drained soils formed under timber and grasses in moderately fine and fine textured lacustrine material and the underlying glacial till

The soils in this map unit formed under mixed deciduous trees and prairie grasses. The very poorly drained and poorly drained soils are nearly level. The moderately well drained, gently sloping soils are on 1- to 20-acre, low, convex knolls.

This unit makes up about 6 percent of the county. It is about 40 percent Minnetonka soils, 15 percent Shorewood soils, 10 percent Lura soils, and 35 percent minor soils.

Minnetonka soils are poorly drained and nearly level. They formed in about 40 inches of moderately fine textured and fine textured material over medium textured material. The surface layer typically is black and very dark grayish brown silty clay loam about 19 inches thick. The subsoil is mottled dark grayish brown, very dark grayish brown, and olive gray silty clay and clay about 21 inches thick. It is underlain by mottled olive gray clay loam and loam.

Shorewood soils are moderately well drained and nearly level to gently sloping. They formed in about 39 inches of moderately fine textured and fine textured material over medium textured material. They are on the low convex knolls. The surface layer typically is black silty clay loam about 11 inches thick. The next layer is very dark gray and very dark grayish brown silty clay loam about 6 inches thick. The subsoil is dark grayish brown and grayish brown silty clay and clay, about 22 inches thick, that has mottles in the lower part. It is underlain by mottled grayish brown clay loam and loam.

Lura soils are very poorly drained. They formed in fine textured material. They are in broad depressions and broad, low gradient drainageways. The surface layer typically is black and very dark gray silty clay and clay about 58 inches thick. It is underlain by mottled gray and olive gray silty clay.

Minor in this map unit are Barbert, Cordova, and Le Sueur soils. The very poorly drained Barbert soil is in shallow depressions. The poorly drained Cordova soil is nearly level. The moderately well drained Le Sueur soil is on low convex rises.

This map unit is prime farmland and is well suited to crops. The available water capacity, organic-matter content, and natural fertility are high. Lime and drainage are needed to insure efficient crop production. Tile lines, at 75- to 80-foot intervals, should be considered for the most efficient removal of excess water. Surface inlets are needed in the depressions because of the slow infiltration rate and slow permeability of Lura and Barbert soils. Because of the high clay content in the soils, timely tillage is needed to reduce soil compaction and loss of structure when the soils are wet.

10. Marna-Guckeen-Lura

Nearly level and gently undulating, very poorly drained, poorly drained, and moderately well drained soils formed under prairie grasses in moderately fine and fine textured lacustrine material and the underlying glacial till

This ground moraine is dotted with many shallow wet depressions and low convex knolls. Slopes are nearly level to gently undulating.

This unit makes up about 16 percent of the county. It is about 45 percent Marna soils, 20 percent Guckeen soils, 10 percent Lura soils, and 25 percent minor soils.

Marna soils are poorly drained and nearly level. They formed in moderately fine textured and fine textured material over medium textured material. They occupy broad areas on the ground moraine and in some drainageways. The surface layer typically is black and very dark gray silty clay loam and silty clay about 20 inches thick. The subsoil is mottled dark grayish brown, dark olive gray, olive gray, and olive clay and heavy clay loam about 21 inches thick. It is underlain by mottled olive gray and gray limy clay loam and loam.

Guckeen soils are moderately well drained and nearly level to gently undulating. They formed in moderately fine textured and fine textured material over medium textured material. They are on low convex knolls. The surface layer typically is black and very dark grayish brown silty clay loam and silty clay about 22 inches thick. The subsoil, about 17 inches thick, is dark grayish brown silty clay. It is mottled olive brown clay loam in the lower part. It is underlain by mottled grayish brown and light olive brown clay loam and loam.

Lura soils are very poorly drained. They formed in fine textured material. They are in broad depressions or in low gradient drainageways. The surface layer typically is black and very dark gray silty clay and clay about 58 inches thick. It is underlain by mottled gray and olive gray silty clay.

Minor in this map unit are Barbert, Nicollet, and Webster soils. The very poorly drained Barbert soil is in shallow depressions. The moderately well drained Nicollet soil is on low convex knolls. The poorly drained, nearly level Webster soil is in drainageways and on broader flats.

This map unit is prime farm land and is well suited to crops. The available water capacity, natural fertility, and organic-matter content are high. The soils require artificial drainage for efficient crop production. Tile lines, at 75- to 80-foot intervals, should be considered for the most efficient removal of excess soil water. Surface inlets are needed in the Barbert and Lura depressions to remove surface water. Timely tillage is needed to reduce compaction and loss of structure when the soils are wet.

Clayey Lake Plain

These nearly level, very poorly drained to moderately well drained soils formed in moderately fine textured and fine textured lacustrine material ranging from 4 to more than 25 feet in thickness. They are on lake plains. They formed under prairie grasses or mixed deciduous trees and prairie grasses.

Two map units in Blue Earth County are in this group. The dominant and potential use is intensive farming. The few scattered areas of broad, deeper depressions can be managed for wetland and upland wildlife without seriously restricting the development of the prime farm land.

11. Waldorf-Collinwood-Lura

Nearly level, very poorly drained, poorly drained, and moderately well drained soils formed in moderately fine and fine textured lacustrine material underlain in some areas by stratified, medium textured material

This map unit is on a glacial lake plain. The moderately well drained soils are on low, convex, 1- to 30-acre knolls. The unit makes up about 8 percent of the county. It is about 35 percent Waldorf soils (fig. 2), 18 percent Collinwood soils, 11 percent Lura soils, and 36 percent minor soils. The clay content of these soils is 35 to 60 percent.

Waldorf soils are nearly level and poorly drained. They formed in moderately fine and fine textured material overlying medium textured, stratified material. The surface layer typically is black silty clay loam and silty clay about 20 inches thick. The subsoil is mottled olive gray silty clay about 30 inches thick. It is underlain by mottled olive gray silty clay loam.

Collinwood soils are moderately well drained and nearly level to gently sloping. They formed on low convex knolls in moderately fine and fine textured material overlying medium textured, stratified material. The surface layer typically is black and very dark grayish brown silty clay loam about 17 inches thick. The subsoil, about 28 inches thick, is dark grayish brown silty clay and is mottled with dark brown, dark grayish brown, and grayish brown in the lower part. It is underlain by limy, mottled light olive brown silt loam.

Lura soils are very poorly drained. They formed in fine textured material in depressions or low gradient drainageways. The surface layer typically is black and very dark gray silty clay and clay about 58 inches thick. It is underlain by mottled gray and olive gray silty clay.

Minor in this map unit are Barbert, Minnetonka, Palms, and Shorewood soils. The very poorly drained Barbert soil is in shallow depressions and shallow, low gradient drainageways. The poorly drained, nearly level Minnetonka silty substratum soil is on broad flats. The moderately well drained, moderately fine textured Shorewood silty substratum soil is on low convex knolls. The very poorly drained Palms soil is in depressions.

This map unit is well suited to farm crops. Natural fertility, organic-matter content, and available water capacity are high. Artificial drainage is needed for efficient crop production. Tile lines every 75 to 80 feet are the most efficient in removing excess soil water. Surface outlets are needed to provide adequate drainage in the depressional Barbert and Lura soils. The high clay content and fine silt content of all soils in this unit increase the hazard of compaction and loss of soil structure if the soils are tilled at high moisture content. Frost heave and shrink-swell are major problems for roads and building foundations.

12. Beauford-Lura-Shorewood

Nearly level, very poorly drained, poorly drained, and moderately well drained soils formed in fine textured lacustrine material

This map unit is on low convex knolls within the lake plain. It makes up about 9 percent of the county. It is about 60 percent Beauford soils, 10 percent Lura

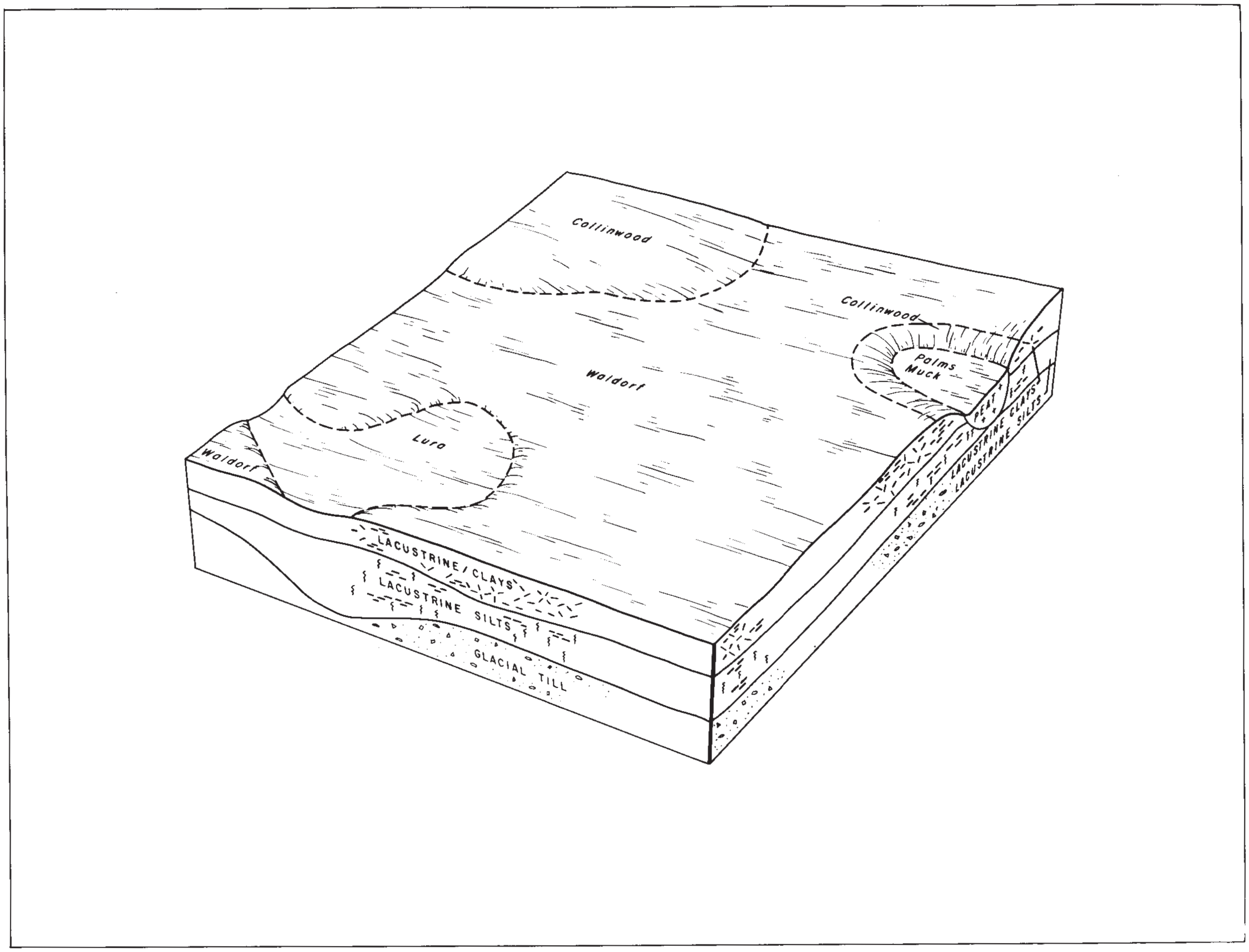

Figure 2.—**Typical pattern in Waldorf-Collinwood-Lura.**

soils, 10 percent Shorewood soils, and 20 percent minor soils. The lacustrine material in which these soils formed is more than 60 percent clay.

Beauford soils are poorly drained and nearly level. They formed under prairie grasses in fine textured material. The surface layer typically is black and very dark gray clay about 20 inches thick. The subsoil is mottled olive gray clay about 26 inches thick. It is underlain by mottled grayish brown and olive clay.

Lura soils are very poorly drained. They formed under prairie grasses in fine textured material. They are in depressions and low gradient drainageways. The surface layer typically is black and very dark gray silty clay and clay about 58 inches thick. It is underlain by mottled gray and olive gray silty clay.

Shorewood soils are moderately well drained. They formed under timber in fine textured material over medium textured material. They are on low convex knolls. The surface layer is black and very dark gray silty clay about 17 inches thick. The subsoil is dark grayish brown and grayish brown silty clay and clay about 33 inches thick. It is underlain by mottled grayish brown loam and clay loam.

Minor in this map unit are Barbert, Marna, and Waldorf soils. The very poorly drained Barbert soil is in shallow depressions and drainageways. The poorly drained Marna and Waldorf soils are on broad flats.

This map unit is moderately well suited to farm crop production. The organic-matter content and natural fertility are high. The available water capacity is moderate to high. Because of the very high clay content, special management is needed. Tile lines at 50-foot intervals are needed for efficient removal of excess water. Timely tillage is essential because of the risk of soil compaction and loss of soil structure. Shrink-swell is a major problem for roads and building foundations.

Silty Lake Plain

These nearly level to gently sloping, poorly drained to moderately well drained soils formed in moderately fine textured and medium textured lacustrine material

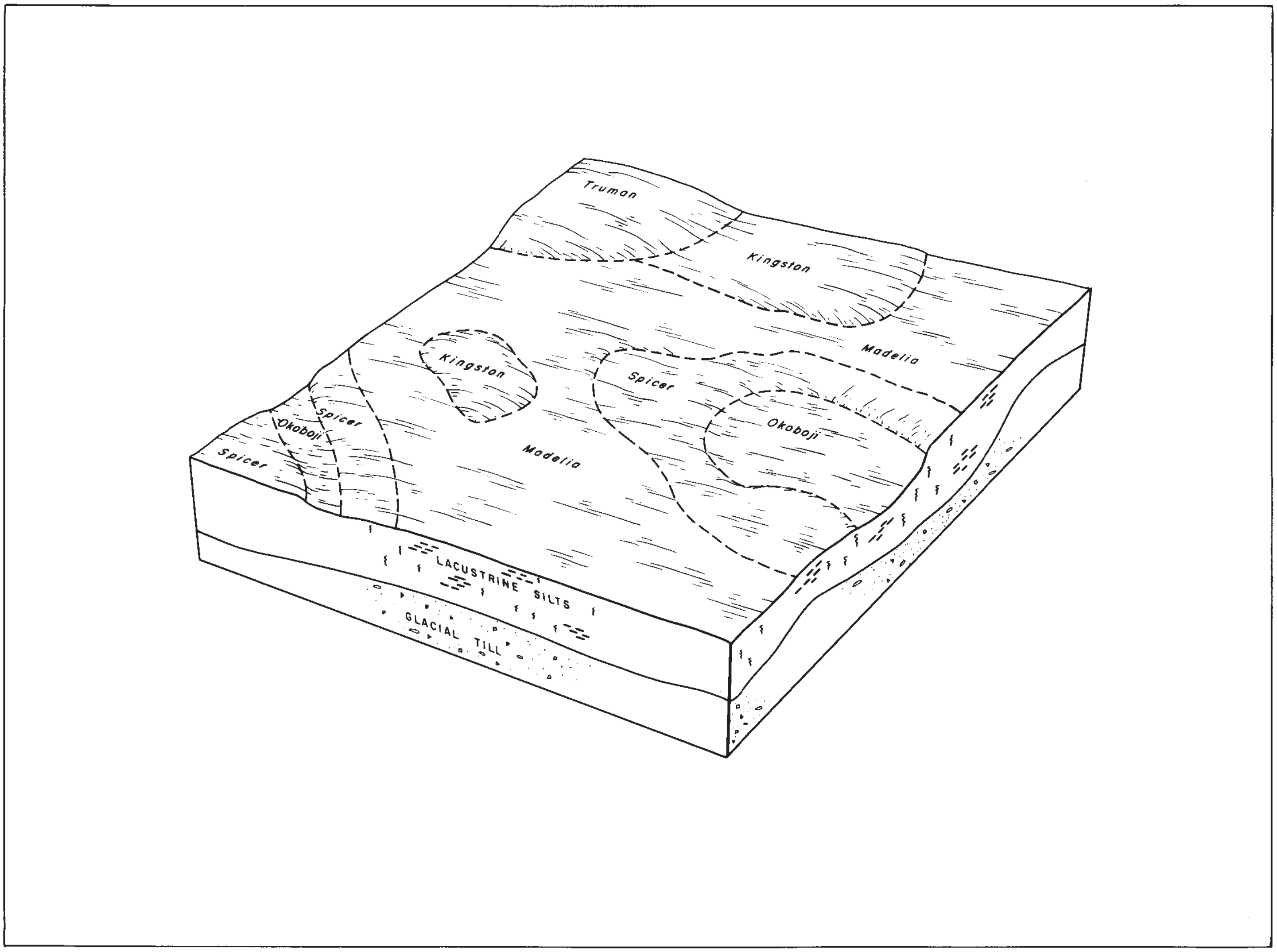

***Figure 3.*—Typical pattern in Madelia-Kingston-Spicer.**

4 to more than 25 feet thick. They are on lake plains. They formed under prairie grasses.

Only one map unit in Blue Earth County is in this group. The dominant and potential use is intensive farming. The few scattered areas of deeper, broad depressions can be managed for wetland and upland wildlife without seriously restricting the development of prime farm land.

13. Madelia-Kingston-Spicer

Nearly level and gently sloping, poorly drained and moderately well drained soils formed in moderately fine textured and medium textured lacustrine material

This map unit is on low convex knolls and on side slopes. It makes up about 9 percent of the county. It is 32 percent Madelia soils (fig. 3), 25 percent Kingston soils, 5 percent Spicer soils, and 38 percent minor soils. The lacustrine material in which these soils formed is less than 35 percent clay.

Madelia soils are poorly drained and nearly level. They formed in moderately fine textured material. The surface layer typically is black and very dark gray silty clay loam about 19 inches thick. The subsoil is mottled olive gray silty clay loam about 8 inches thick. It is underlain by mottled olive gray and olive silty loam and silty clay loam.

Kingston soils are moderately well drained and nearly level to gently undulating. They formed in moderately fine textured and medium textured material. They are on low convex knolls. The surface layer typically is black and very dark grayish brown silty clay loam about 17 inches thick. The subsoil is dark grayish brown silty clay loam and silt loam about 14 inches thick. It is underlain by mottled light olive brown and yellowish brown silt loam.

Spicer soils are poorly drained, nearly level, and limy. They formed in moderately fine textured and medium textured material. They are on broad flats and rims around wet depressions. The surface layer typically is limy, black and very dark gray silty clay loam about 16 inches thick. The subsoil is limy, mottled dark

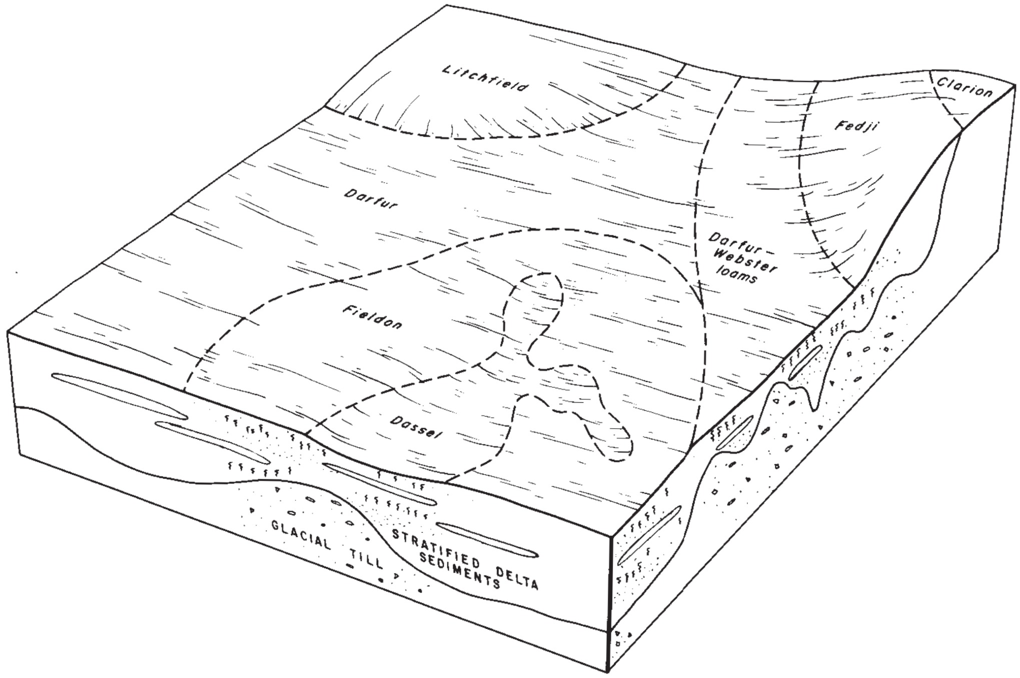

***Figure 4.*—Typical pattern in Darfur-Dassel-Fieldon.**

gray, olive, and olive gray silt loam about 24 inches thick. It is underlain by limy, mottled light olive gray silt loam.

Minor in this map unit are the Barrington, Grays, Okoboji, and Truman soils. The moderately well drained Grays and Truman soils are on low convex knolls and side slopes. The very poorly drained Okoboji soil is in depressions and low gradient drainageways.

This map unit is well suited to farm crops. The available water capacity, organic-matter content, and natural fertility are high. The poorly drained soils require artificial drainage for efficient crop production. Tile lines, at 100-foot intervals, should be considered for efficient and effective removal of excess water. The high content of fine silt increases the compaction hazard. Frost heave is a major problem for construction of roads and foundations of buildings.

Delta Sediments on Ground Moraine

These nearly level to gently undulating, very poorly drained to moderately well drained soils formed in medium textured and moderately coarse textured material ranging from 2 to more than 15 feet thick. They are on a deltaic plain.

One map unit in Blue Earth County is in this group. The dominant and potential use is intensive farming.

14. Darfur-Dassel-Fieldon

Nearly level, very poorly drained and poorly drained soils formed in moderately coarse textured and medium textured, stratified delta sediments

This map unit is on a deltaic plain. It makes up about 8 percent of the county. It is about 15 percent Darfur soils (fig. 4), 11 percent Dassel soils, 10 percent Fieldon soils, and 64 percent minor soils.

Darfur soils are poorly drained and nearly level. They formed in medium textured material over stratified coarse textured and moderately coarse textured material. The surface layer typically is black, very dark gray, and very dark grayish brown loam about 19 inches thick. The subsoil is mottled grayish brown and dark grayish brown fine sandy loam about 12 inches thick. It is underlain by mottled light olive gray and olive gray, stratified sand and loam.

Dassel soils are very poorly drained. They formed in medium textured material over stratified coarse textured material. They are in depressions and low gradient drainageways. The surface layer typically is black and very dark gray loam about 24 inches thick. The subsoil, about 14 inches thick, is mottled light olive gray loam and has mottled gray and olive gray fine sand in the lower part. It is underlain by mottled olive gray fine sand.

Fieldon soils are very poorly drained, nearly level, and limy. They formed in medium textured and moderately coarse textured material over stratified coarse textured material. They are in broad areas on the delta and on rims around very poorly drained depressions. The surface layer typically is limy, black and very dark gray loam about 19 inches thick. The subsoil is limy, mottled dark grayish brown, dark gray, and light olive brown very fine sandy loam about 18 inches thick. It is underlain by limy, mottled light olive brown and light olive gray stratified fine sand.

Minor in this map unit are the Fedji, Grogan, Lasa, and Litchfield soils. The somewhat excessively drained Fedji soil is on slightly elevated convex knolls. The well drained Lasa soil is on low convex knolls. The moderately well drained Litchfield soil is on low convex knolls and rises. The Fedji, Lasa, and well drained Grogan soils are gently undulating.

This map unit is moderately well suited to farm crop production. The soils have moderate available water capacity, high organic-matter content, and medium to high natural fertility. Good drainage outlets are needed to fully develop this area for farming. The fine sand is a critical problem in construction of ditches and installation of tile lines. Ditch banks cave and fill the ditch bottoms. Tile lines become clogged with sand unless filtering material is used to cover the tile. Soil blowing is a serious problem on bare soils in spring. Minimum tillage or mulch tillage is needed to reduce erosion. Irrigation is used on droughty soils to supplement the low rainfall during July and August. The limy soils have special management needs in fertility, herbicides, and varieties of crops. Higher rates of potassium and varieties of alkaline-tolerant crops are needed.

Descriptions of the Soils

This section describes the soil series and map units in Blue Earth County. Each soil series is described in detail, and then, briefly, each map unit in that series. Unless it is specifically mentioned otherwise, it is to be assumed that what is stated about the soil series holds true for the map units in that series. Thus, to get full information about any one map unit, it is necessary to read both the description of the map unit and the description of the soil series to which it belongs.

An important part of the description of each soil series is the soil profile, that is, the sequence of layers from the surface downward to rock of other underlying material. Each series contains two descriptions of this profile. The first is brief and in terms familiar to the layman. The second is much more detailed and is for those who need to make thorough and precise studies of soils. Color terms are for moist soil unless otherwise stated. The profile described in the series is representative of units in that series. If the profile of a given map unit is different from the one described for the series, these differences are stated in describing the map unit, or they are differences that are apparent in the name of the map unit.

As mentioned in the section "How this survey was made," not all map units are members of a soil series. Alluvial land, occasionally flooded, for example, does not belong to a soil series, but nevertheless, is listed in alphabetic order with the soil series.

The names, descriptions, and areas of soils in this soil survey do not always agree or join fully with soil maps of adjoining counties published at an earlier date. Differences are brought about by better knowledge about soils or modification and refinements in soil series concepts. In addition, the correlation of a recognized soil is based upon the acreage of that soil and the dissimilarity to adjacent soils within the survey area. Frequently, it is more feasible to include soils, small in extent, with similar soils, where management and response is much the same, rather than set them apart as individuals. The soil descriptions reflect these combinations. Other differences are brought about by the predominance of different soils in taxonomic units made up by two or three series. Still another difference may be caused by the range in slope allowed within the map unit for each survey.

Preceding the name of each map unit is a symbol which identifies the map unit on the detailed soil map. Listed at the end of each description of a map unit is the capability unit in which the map unit has been placed.

The acreage and proportionate extent of each map unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary at the end of this survey, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (*15*).[1]

Alluvial Land

Alluvial land consists of areas of unconsolidated alluvium that is generally stratified and varies widely in texture. This material was recently deposited by streams and is subject to frequent changes resulting from stream overflow.

1002—Alluvial land, frequently flooded. This area consists of moderately well drained to poorly drained soils that formed in recent alluvium. The soils are nearly level and occupy 3- to 40-acre areas on stream bottom lands that are subject to frequent flooding. Slopes are 0 to 2 percent. The soil material is commonly 10 feet or more thick. Texture is variable, but is mainly loam or silt loam. Strata of coarse texture, however, are common. These soils vary in color, drainage, and reaction and are subject to frequent changes resulting from stream overflow, scouring, and channel changes.

[1] Italic numbers in parentheses refer to References, p. 210.

TABLE 1.—*Acreage and proportionate extent of the soils*

Map symbol	Soil name	Acres	Percent	Map symbol	Soil name	Acres	Percent
17	Minneopa sandy loam, 0 to 3 percent slopes	3,694	0.8	134	Okoboji silty clay loam	1,326	0.3
18	Comfrey clay loam	5,683	1.2	136	Madelia silty clay loam	12,924	2.7
27	Dickinson fine sandy loam, 0 to 2 percent slopes	805	0.2	138B2	Lerdal silty clay loam, 2 to 6 percent slopes, eroded	995	0.2
27B	Dickinson fine sandy loam, 2 to 6 percent slopes	1,752	0.4	138C2	Lerdal silty clay loam, 6 to 15 percent slopes, eroded	237	*
35	Blue Earth mucky silt loam	1,941	0.4	140	Spicer silty clay loam	2,510	0.5
39	Wadena loam, 0 to 2 percent slopes	1,089	0.2	160	Fieldon loam	3,552	0.7
39B	Wadena loam, 2 to 6 percent slopes	852	0.2	178	Granby fine sandy loam	1,421	0.3
41	Estherville sandy loam, 0 to 2 percent slopes	379	0.1	181	Litchfield loamy fine sand, 1 to 3 percent slopes	2,984	0.6
41B	Estherville sandy loam, 2 to 6 percent slopes	758	0.2	183	Dassel loam	4,026	0.8
41C	Estherville sandy loam, 6 to 18 percent slopes	663	0.1	196	Joliet silty clay loam	379	0.1
62	Barrington silt loam, 1 to 3 percent slopes	1,468	0.3	197	Kingston silty clay loam, 1 to 3 percent slopes	11,623	2.4
69	Fedji loamy fine sand, 1 to 3 percent slopes	284	0.1	211	Lura silty clay	20,307	4.2
69B	Fedji loamy fine sand, 3 to 8 percent slopes	1,184	0.2	219	Rolfe silt loam	900	0.2
84	Brownton silty clay loam	1,184	0.2	222B	Lasa fine sand, 2 to 8 percent slopes	1,989	0.4
85	Calco silty clay loam	852	0.2	229	Waldorf silty clay loam	13,350	2.8
86	Canisteo silty clay loam	10,060	2.1	230	Guckeen silty clay loam, 1 to 4 percent slopes	16,899	3.5
94	Terril loam, 0 to 2 percent slopes	521	0.1	238B	Kilkenny clay loam, 2 to 6 percent slopes	4,547	0.9
94B	Terril loam, 2 to 6 percent slopes	2,036	0.4	238C	Kilkenny clay loam, 6 to 12 percent slopes	2,747	0.6
94C	Terril loam, 6 to 15 percent slopes	521	0.1	238D	Kilkenny clay loam, 12 to 18 percent slopes	426	0.1
96	Collinwood silty clay loam, 1 to 3 percent slopes	5,257	1.1	239	Le Sueur clay loam, 1 to 3 percent slopes	12,692	2.6
96B	Collinwood silty clay loam, 2 to 6 percent slopes	474	0.1	248	Lomax loam, 1 to 3 percent slopes	3,220	0.7
96C	Collinwood silty clay loam, 6 to 12 percent slopes	616	0.1	259B	Grays silt loam, 2 to 8 percent slopes	1,231	0.3
96D	Collinwood silty clay loam, 12 to 18 percent slopes	426	0.1	275B	Ocheyedan loam, 2 to 8 percent slopes	568	0.1
100	Copaston loam, 1 to 4 percent slopes	568	0.1	281	Darfur loam	4,783	1.0
101B	Truman silt loam, 2 to 6 percent slopes	5,210	1.1	286	Shorewood silty clay loam, 1 to 6 percent slopes	12,829	2.7
101C	Truman silt loam, 6 to 12 percent slopes	947	0.2	287	Minnetonka silty clay loam	18,741	3.9
102B	Clarion loam, 2 to 6 percent slopes	13,782	2.9	310	Beauford clay	28,164	5.8
102C	Clarion loam, 6 to 12 percent slopes	2,984	0.6	311	Shorewood silty clay, 1 to 6 percent slopes	5,068	1.1
102D	Clarion loam, 12 to 18 percent slopes	332	0.1	316	Baroda silty clay loam	4,404	0.9
105B	Kamrar silty clay, 2 to 6 percent slopes	1,847	0.4	317	Oshawa silt loam	237	*
105C	Kamrar silty clay, 6 to 12 percent slopes	1,468	0.3	319	Barbert silt loam	3,552	0.7
105D	Kamrar silty clay, 12 to 18 percent slopes	189	*	321	Tilfer silty clay loam	853	0.2
106B	Lester loam, 2 to 6 percent slopes	9,567	2.0	329	Chaska loam	947	0.2
106C	Lester loam, 6 to 12 percent slopes	4,925	1.0	349	Calco silty clay loam, very wet	995	0.2
106D	Lester loam, 12 to 18 percent slopes	1,042	0.2	353	Comfrey clay loam, frequently flooded	3,315	0.7
106E	Lester loam, 18 to 24 percent slopes	284	0.1	354	Dorchester loam, occasionally flooded	284	0.1
109	Cordova clay loam	13,640	2.8	360B	Lasa loamy fine sand, rock substratum, 1 to 6 percent slopes	758	0.2
110	Marna silty clay loam	34,037	7.1	360E	Lasa loamy fine sand, rock substratum, 12 to 35 percent slopes	95	*
113	Webster silty clay loam	16,708	3.5	363	Minneopa loamy fine sand, occasionally flooded, 0 to 3 percent slopes	2,084	0.4
114	Glencoe silty clay loam	11,576	2.4	364	Minnetonka silty clay loam, silty substratum	4,452	0.9
128	Grogan silt loam, 1 to 3 percent slopes	1,563	0.3	414	Hamel clay loam, 1 to 4 percent slopes	2,273	0.5
128B	Grogan silt loam, 3 to 6 percent slopes	1,279	0.3	440	Copaston loam, very shallow, 1 to 4 percent slopes	758	0.2
130	Nicollet clay loam, 1 to 3 percent slopes	15,409	3.2	448	Shorewood silty clay loam, silty substratum, 1 to 3 percent slopes	1,516	0.3
				451	Dorchester loam, 1 to 3 percent slopes	1,373	0.3
				524	Caron muck	2,700	0.6
				525	Muskego muck	3,741	0.8
				539	Palms muck	5,541	1.1

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

Map symbol	Soil name	Acres	Percent	Map symbol	Soil name	Acres	Percent
548	Palms muck, sandy substratum	663	0.1	941	Kingston-Nicollet complex, 1 to 3 percent slopes	1,279	0.3
851	Chaska-Urban land complex	95	*	946	Litchfield-Nicollet complex, 1 to 3 percent slopes	1,752	0.4
852	Copaston-Urban land complex, 1 to 4 percent slopes	332	0.1	947	Madelia-Webster silty clay loams	663	0.1
853	Copaston-Urban land bouldery complex, 1 to 4 percent slopes	237	*	960E	Storden-Clarion loams, 18 to 24 percent slopes	379	0.1
854	Cordova-Urban land complex, 0 to 3 percent slopes	1,184	0.2	961	Storden complex, very steep	13,019	2.7
855	Dorchester-Urban land complex, 1 to 3 percent slopes	142	*	961F	Storden complex, 24 to 45 percent slopes	2,226	0.5
856B	Terril-Urban land complex, 2 to 6 percent slopes	95	*	968	Webster-Darfur-Granby complex	758	0.2
856C	Terril-Urban land complex, 6 to 15 percent slopes	142	*	978	Cordova-Rolfe complex	616	0.1
909C	Bold-Truman silt loams, 6 to 12 percent slopes	189	*	992	Rock outcrop-Copaston complex, very steep	805	0.2
909D	Bold-Truman silt loams, 12 to 18 percent slopes	379	0.1	996	Beauford-Barbert complex	1,373	0.3
919	Canisteo-Fieldon loams	616	0.1	997	Marna-Barbert complex	2,463	0.5
920B	Clarion-Estherville complex, 2 to 6 percent slopes	568	0.1	998	Minnetonka-Barbert complex	2,368	0.5
920C	Clarion-Estherville complex, 6 to 12 percent slopes	616	0.1	1001	Alluvial land, occasionally flooded	3,741	0.8
920D	Clarion-Estherville complex, 12 to 20 percent slopes	474	0.1	1002	Alluvial land, frequently flooded	8,714	1.8
921C	Clarion-Storden loams, 6 to 12 percent slopes	1,089	0.2	1004	Alluvial land, gently sloping	426	0.1
921D	Clarion-Storden loams, 12 to 18 percent slopes	1,137	0.2	1007	Alluvial-Urban land complex	474	0.1
923	Copaston-Rock outcrop complex, 1 to 4 percent slopes	1,563	0.3	1032	Lake beaches	1,752	0.4
926	Darfur-Webster loams	1,468	0.3	1039	Urban land, 0 to 2 percent slopes	200	*
929	Fieldon-Canisteo loams	1,989	0.4	1053	Marsh	2,700	0.6
932	Glencoe-Dassel loams	284	0.1	1800	Caron mucky peat	200	*
				1801B	Grogan loamy fine sand, 2 to 6 percent slopes	1,373	0.3
					Made land	795	0.2
					Quarry	142	*
					Gravel pit	568	0.1
					Water	9,700	2.0
					Total	481,920	100.0

* Less than 0.1 percent.

Natural fertility and organic-matter content are variable. The seasonal high water table depends on stream flow and the water level of adjacent streams and drainageways. Some areas are ponded throughout the year.

These soils are generally unsuited to crops unless protected from flooding. They are generally used for undeveloped pasture and wildlife habitat. The hazard of flooding severely limits the potential for building site development, sanitary facilities, and recreational development. Capability unit VIw–1.

1004—Alluvial land, gently sloping. This area consists of moderately well drained soils that formed in recent mixed alluvium from side valley intermittent streams and ravines. The soils occupy 2- to 30-acre alluvial fans at the base of ravines. Slopes are 2 to 6 percent and 200 to 800 feet long.

Soil characteristics are variable. The seasonal high water table is maintained by seepage along the coarse textured layers. The soil is commonly more sandy than Alluvial land, occasionally flooded. Reaction is neutral to mildly alkaline. Available water capacity, natural fertility, and organic-matter content are variable. Permeability is moderate to moderately rapid. Flood frequency is related to high intensity rain. This area will flash flood and the water will recede in a few hours. Flooding is very local or general, depending on the size of the storm.

These soils are used mainly for row crops and pasture and have fair potential production. Flooding can damage crops in some years. Trees and shrubs grow in this area, but onsite investigation helps select the most adapted species. The soils have severe limitations for building site development and sanitary facilities and moderate limitations for recreational development because of the flood hazard. They have fair potential for and are well adapted to openland and woodland wildlife habitat. Capability unit IIw–6.

1001—Alluvial land, occasionally flooded. This area consists of poorly drained, somewhat poorly drained, and moderately well drained soils that formed in stratified, recent mixed alluvium. The soils occupy 2- to 30-acre areas on nearly level stream bottom lands that are subject to occasional flooding and scouring. Slopes are 0 to 2 percent.

Soil characteristics are variable. The soils have a deep rooting zone when the water level of the river is down. Texture is variable but is mainly loam and silt loam. Strata of coarser textures, however, are common. Reaction is neutral to mildly alkaline. The available water capacity, natural fertility, and organic-matter content are variable. The water table fluctuates with the rise and fall of the water level in the nearby stream. Permeability is moderate to moderately rapid.

These soils are used mainly for row crops and have fair potential production. The main concern of management is flooding, which delays planting in spring. Trees and shrubs grow in this area, but onsite investigation helps select the most adapted species. The soils have severe limitation for building site development and sanitary facilities and moderate limitations for recreational development because of the flood hazard. They have fair potential for and are well adapted to all kinds of wildlife habitat. Capability unit IIw–6.

1007—Alluvial-Urban land complex. This map unit consists of Urban land and nearly level, poorly drained, somewhat poorly drained, and moderately well drained soils that formed in recent stratified, mixed alluvium. The soils are on stream bottom lands that are protected from flooding and scouring by dikes along the Minnesota River and on alluvial fans at the mouth of ravines. Slopes are 0 to 2 percent.

Characteristics are variable. Texture is mainly loam or silt loam, but strata of sand and loamy sand are common. Reaction is neutral to mildly alkaline. The available water capacity is variable, and a seasonal high water table fluctuates with the rise and fall of the river. Natural fertility and organic-matter content are also variable. Permeability is moderate or moderately rapid. In areas of Urban land the soil has been excavated for foundations, basements, or roads and spread on the ground's surface or used to fill in the depressions.

The variable seasonal high water table is the limitation of this map unit for most urban use. Seepage along sandy layers is common on the alluvial fans. Artificial drainage, especially around the footings of basement walls, helps to control wetness. Runoff is high from roofs, roads, and other paved surfaces which cover much of this unit. Most areas of this map unit have been committed to urban use. Onsite investigation is needed for each area. There are only slight limitations for recreational development. Not assigned to a capability group.

Barbert Series

The Barbert series consists of very poorly drained soils formed in fine textured and moderately fine textured glacial lacustrine sediment. These soils occupy slight depressions and long, partially closed swales. Native vegetation was mostly a wet site community of tall grass prairie.

In a representative profile the surface layer is very dark gray silt loam about 7 inches thick. The subsurface layer is dark gray silt loam about 10 inches thick. The subsoil is about 26 inches thick. The upper part is mottled black clay and the lower part is mottled olive gray clay. The underlying material is limy, mottled olive silty clay loam.

Runoff is slow to ponded. The depth to the seasonal high water table is less than 1 foot, or near tile depth. Permeability is very slow. Available water capacity is high. Organic-matter content is moderate, and natural fertility is medium.

Barbert soils are well suited to farming if adequate drainage is provided. Undrained areas are used mainly for wild hay and pasture. These areas offer good cover for wildlife. Most of the acreage is used for row crops, mainly corn and soybeans. Some areas are in hay and pasture.

Representative profile of Barbert silt loam in cultivated area 1,120 feet east and 260 feet south of northwest corner sec. 4, T. 106 N., R. 26 W.

Ap—0 to 7 inches, very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) dry; weak very thin platy structure; very friable; medium acid; abrupt smooth boundary.

A21—7 to 10 inches, dark gray (10YR 4/1) silt loam, light gray (10YR 6/1) dry; common fine distinct light olive brown (2.5Y 5/4) mottles; moderate thin and medium platy structure; very friable; medium acid; clear smooth boundary.

A22—10 to 17 inches, dark gray (10YR 4/1) heavy silt loam with common masses of very dark gray (10YR 3/1), gray (10YR 5/1) dry; strong medium platy structure; friable; medium acid; clear smooth boundary.

B21tg—17 to 23 inches, black (10YR 2/1) clay; few fine faint olive gray (5Y 5/2) and few fine distinct light olive brown (2.5Y 5/4) mottles; strong medium and coarse prismatic structure parting to strong fine and very fine angular blocky; very firm; thick continuous clay films on ped faces; medium acid; clear wavy boundary.

B22tg—23 to 31 inches, olive gray (5Y 4/2) clay; few thin tongues of dark olive gray (5Y 3/2); few fine faint light olive brown (2.5Y 5/4) and few fine and medium faint olive gray (5Y 5/2) mottles; moderate medium prismatic structure parting to strong fine and very fine angular blocky; very firm; thick continuous clay films on ped faces and in old root channels; slightly acid; clear wavy boundary.

B23tg—31 to 43 inches, olive gray (5Y 5/2) clay; common fine prominent strong brown (7.5YR 5/6) mottles; weak fine and medium prismatic structure parting to moderate fine angular blocky; very firm; few black clayey fillings in old root channels; few clean sand particles on faces of prisms; slightly acid; clear wavy boundary.

Cg—43 to 60 inches, olive (5Y 5/3) heavy silty clay loam; many medium prominent yellowish brown (10YR 5/8) mottles; weak platy structure of variable thickness; firm; common dark colored concretions; strongly effervescent, mildly alkaline.

Solum thickness and depth to free carbonates range from 35 to 60 inches.

The A1 horizon is black or very dark gray. The A2 horizon is very dark gray or dark gray and dries to gray or light gray. Texture of the A horizon typically is silt loam, but the range includes light silty clay loam. The A horizon is strongly acid to slightly acid.

The B horizon ranges from black to very dark gray in the upper part to olive gray and olive in the lower part. The texture typically is clay, but the range includes silty clay. Sand content is less than 10 percent, and clay content ranges from 45 to 60 percent. The B horizon is strongly acid to medium acid in the upper part and medium acid to neutral in the lower part.

Texture of the C horizon typically is silty clay loam, but the range includes silty clay or silt loam. Thin strata of these textures are common. The C horizon is slightly acid to mildly alkaline.

The Barbert soils that are associated with Beauford and Baroda soils contain more clay in the Btg horizon than is defined as the range for the series. This difference does not alter use and management.

Barbert soils are also associated with Waldorf and Marna soils. Unlike Beauford, Waldorf, and Marna soils they have a B horizon with an accumulation of clay. Barbert soils are very poorly drained, but Baroda, Beauford, Marna, and Waldorf soils are poorly drained.

319—Barbert silt loam. This soil occupies 3- to 20-acre depressions and swales in the glacial uplands within areas of Beauford, Marna, Waldorf, and Minnetonka soils. It has the profile described for the series. It is nearly level. Slopes are 0 to 2 percent and plane to slightly concave.

Included with this soil in mapping are small areas of Waldorf, Lura, Okoboji, and Minnetonka soils. Waldorf and Minnetonka soils are nearly level and poorly drained. Lura and Okoboji soils are very poorly drained and are more permeable than this Barbert soil. Also included are a few areas underlain by loamy material within a depth of 4 feet. Where this soil is mapped in association with Beauford soils, it has more clay.

This soil is used mostly for row crops, mainly corn and soybeans. The seasonal high water table severely limits its potential for intensive farming unless artificial drainage is provided. Undrained areas are used mainly for wild hay and pasture.

Tillage at optimum moisture content is important. If worked when wet, the surface layer puddles easily, tilth is destroyed, aeration is reduced, and the soil becomes hard and cloddy when dry.

The seasonal high water table, hazard of ponding, high shrink-swell potential, low strength, and slow permeability limit the potential of this soil for most urban and recreation use. When left in its natural condition, this soil offers good cover for wildlife. Capability unit IIIw-2.

Baroda Series

The Baroda series consists of deep, nearly level, poorly drained soils on broad flats and low rises and in shallow depressions on the glacial lake plain. The soils formed on a ground moraine in fine textured and moderately textured glacial lacustrine sediment 2 to 20 feet thick over medium textured and moderately fine textured glacial till. Native vegetation was mixed deciduous trees and tall grass prairie.

In a representative profile the surface layer is black silty clay loam about 14 inches thick. The subsoil is mottled olive gray clay in the upper 24 inches and mottled grayish brown silty clay loam in the lower 8 inches. The underlying material is limy, mottled grayish brown clay loam and loam.

Permeability is very slow. Runoff is slow. Available water capacity, organic-matter content, and natural fertility are high. The depth to the seasonal high water table ranges from 1 to 3 feet.

Most of the acreage is used for corn and soybeans. The soils are suited to most crops if adequately drained and limed.

Representative profile of Baroda silty clay loam in cultivated field about 100 feet south and 1,200 feet east of northwest corner sec. 10, T. 105 N., R. 27 W.

Ap—0 to 9 inches, black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; weak fine subangular blocky structure; friable; common roots; medium acid; abrupt smooth boundary.

A3—9 to 14 inches, black (10YR 2/1) silty clay loam; few channels of very dark gray (10YR 3/1); weak very fine and fine subangular blocky structure; friable; common roots; strongly acid; clear smooth boundary.

B21tg—14 to 19 inches, olive gray (10YR 4/2) clay; many fine distinct strong brown (7.5YR 5/6) mottles; strong very fine and fine angular blocky structure; very firm; many thin black (10YR 2/1) and very dark gray (10YR 3/1) clay films on faces of peds; few thin porous grayish coatings on faces of peds in upper part; few roots; strongly acid; clear smooth boundary.

B22tg—19 to 22 inches, olive gray (5Y 4/2) clay; many fine distinct, yellowish brown (10YR 5/6) mottles; strong fine angular blocky structure; very firm; many thin and medium dark gray (5Y 4/1) clay films on faces of peds; very strongly acid; clear smooth boundary.

B23tg—22 to 27 inches, olive gray (5Y 4/2) clay; many fine distinct yellowish brown (10YR 5/6) mottles; strong fine angular blocky structure; very firm; many thin and medium black (10YR 2/1) clay films on faces of peds and in pores; strongly acid; clear smooth boundary.

B31tg—27 to 38 inches, olive gray (5Y 5/2) clay; many medium prominent yellowish brown (10YR 5/6) mottles; weak and moderate coarse prismatic structure; firm; common black (10YR 2/1) clay films in pores and root channels; neutral; clear smooth boundary.

B32tg—38 to 46 inches, grayish brown (2.5YR 5/2) silty clay loam; many fine faint light olive brown (2.5YR 5/4) mottles; weak medium and thick platy structure; friable; common black (10YR 2/1) clay films in pores and root channels; neutral; clear smooth boundary.

IIC1g—46 to 54 inches, grayish brown (2.5Y 5/2) clay loam; many fine faint light olive brown (2.5Y 5/4) mottles; weak medium and thick platy structure; friable; few dark clay films in pores; few soft lime masses; moderately alkaline; strong effervescence; clear smooth boundary.

IIC2g—54 to 60 inches, grayish brown (2.5Y 5/2) loam; many fine faint light olive brown (2.5Y 5/4) mottles; weak fine subangular blocky structure; friable; few soft lime masses; moderately alkaline; strong effervescence.

Solum thickness commonly ranges from 34 to 60 inches. The A horizon is typically silty clay loam but ranges to silty clay. It is 7 to 16 inches thick. The Btg horizon is mostly clay but in places the lower part is silty clay or silty clay loam. Clay films and pressure faces occur as shiny black exteriors in the Btg horizon and as clay films and fillings near the B and C boundary. They range from thick to thin and continuous to patchy. Reaction ranges from medium acid to very strongly acid in the upper part and neutral to medium acid in the lower part. The texture of the C horizon ranges widely from clay to loam and silt loam but is typically silty clay loam and clay loam.

Baroda soils are associated with Beauford, Lura, Shorewood, and Collinwood soils. They have an accumulation of clay in the B horizon which Beauford soils lack. They have a thinner A horizon than the Lura soil. They are wetter than Shorewood and Collinwood soils.

316—Baroda silty clay loam. This soil occupies 5- to 100-acre broad flats, shallow drainageways, and slight rises in the uplands. Slopes are 0 to 2 percent.

Included with this soil in mapping are a few small areas of Shorewood or Collinwood soils where slopes are more than 2 percent. Also included are Lura and Barbert soils in small, shallow depressions and drainageways, which are identified by a spot symbol on the soil map. Some soils that contain a considerable amount of shale and less clay in the subsoil than Baroda soils, and areas that have a silt loam substratum where this soil is mapped adjacent to Beauford and Minnetonka, silty substratum, soils are also included.

This soil is used mostly for corn and soybeans. The high seasonal water table limits the yield potential and drainage is required for the best growth.

This soil has a narrow range of optimum moisture for proper tillage. If worked when wet, the surface layer compacts easily, tilth is destroyed, aeration is reduced, and the soil becomes hard and cloddy when dry. The root zone is restricted by the clayey, acid subsoil. Fertilization and lime are needed.

This soil is poorly suited to most urban and recreational use because of the seasonal high water table and high clay content. Capability unit IIw–2.

Barrington Series

The Barrington series consists of moderately well drained, nearly level silty soils on the glacial lake plain. These soils formed in deep, medium textured glacial lacustrine sediments. Native vegetation was mixed tall grass prairie and deciduous trees.

In a representative profile the surface layer is black and very dark gray silt loam about 15 inches thick. The subsoil is friable silt loam about 18 inches thick. The upper part is dark brown and the lower part is mottled olive brown. The underlying material is friable, limy grayish brown silt loam.

Permeability is moderate. Available water capacity, organic-matter content, and natural fertility are high. The depth to the seasonal high water table ranges from 3 to 5 feet.

Barrington soils are well suited to farming.

Representative profile of Barrington silt loam, 1 to 3 percent slopes, in wooded area 2,400 feet north and 1,000 feet east of southwest corner sec. 2, T. 107 N., R. 27 W.

A1—0 to 10 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) dry; weak very fine subangular blocky structure; friable; frequent roots; neutral; clear smooth boundary.

A3—10 to 15 inches, very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) dry; weak very fine subangular blocky structure; friable; frequent roots; neutral; clear, smooth boundary.

B21t—15 to 20 inches, dark brown (10YR 3/3) silt loam, very dark grayish brown (10YR 3/2) coatings on faces of peds; weak very fine and fine subangular blocky structure; friable; frequent roots; few thin black (10YR 2/1) clay films on faces of peds; slightly acid; clear smooth boundary.

B22t—20 to 25 inches, olive brown (2.5Y 4/4) silt loam, dark gray (10YR 4/1) coatings on faces of peds; weak and moderate fine subangular blocky structure; friable; few thin clay films on faces of peds; slightly acid; clear smooth boundary.

B3t—25 to 33 inches, olive brown (2.5Y 4/4) silt loam, dark grayish brown (2.5Y 4/2) coatings on faces of peds; few fine faint light olive brown (2.5Y 5/6) mottles; weak very fine and fine subangular blocky structure; friable; many thin clay films on faces of peds and in root channels; neutral; clear smooth boundary.

C—33 to 60 inches, grayish brown (2.5Y 5/2) silt loam; few medium faint, light yellowish brown (2.5Y 6/4) mottles; massive; few thin black clay films on faces of peds and in root channels in upper part; few thin loamy very fine sand layers; few soft white lime masses in lower part; slightly effervescent, mildly alkaline.

Thickness of the solum and depth to carbonates range from 24 to 50 inches. The solum has neutral to medium acid reaction and friable consistence. The A horizon typically is silt loam, but the range includes light silty clay loam. The B horizon typically is silt loam, but the range includes light silty clay loam. Clay films are thin and patchy. The C horizon typically is silt loam, but the range includes light silty clay loam. This horizon is limy and in some places is stratified with very fine sandy loam or loamy very fine sand.

This soil has yellower hue in the lower part of the B horizon and in the C horizon than is defined as the range for the series. This difference, however, does not alter its use and management.

Barrington soils are associated with Grays, Lester, Madelia, and Webster soils. Barrington and Grays soils formed in similar material, but Barrington soils are wetter and occupy adjacent less sloping knolls and side slopes. Barrington soils formed in silty lacustrine material, whereas Lester and Webster soils formed in glacial till. They occupy higher, better drained areas than the poorly drained Madelia soils, which are on flats and in drainageways.

62—Barrington silt loam, 1 to 3 percent slopes. This soil occupies 2- to 15-acre nearly level flats within areas of Grays or Lester soils and slight rises within areas of Madelia or Waldorf soils. Slopes in most areas are slightly convex.

Included with this soil in mapping are small areas of Lester and Grays soils on the higher convex rises and areas of the poorly drained Madelia and Webster soils on flats and in drainageways. Also included are a few areas where slopes are slightly steeper than 3 percent.

The erosion hazard is slight in cultivated areas. It can be easily controlled if the soil is well managed.

Except for slight seasonal wetness, this soil has few limitations for intensive use as cropland. Most of the acreage is in corn and soybeans. The slight hazard of wetness, the potential frost action, and the low strength are features that limit urban and recreational uses. Capability unit I–1.

Beauford Series

The Beauford series consists of deep, poorly drained clayey soils on flats and in shallow depressions. These soils formed in fine textured glacial lacustrine sediments. Native vegetation was the wet site community of tall grass prairie.

In a representative profile the surface layer is black and very dark gray clay about 20 inches thick. The subsoil is mottled olive gray clay about 26 inches thick. The underlying material is limy, mottled grayish brown clay.

Beauford soils have moderate available water capacity and slow permeability. Organic-matter content and natural fertility are high. The depth to the seasonal high water table ranges from 1 to 3 feet, or near tile depth.

Beauford soils are well suited to farming if excess water is removed. They have fair potential for wildlife. Most areas have some degree of artificial drainage and are used for row crops.

Representative profile of Beauford clay in cultivated area 1,390 feet west and 430 feet south of northeast corner sec. 36, T. 105 N., R. 26 W.

Ap—0 to 8 inches, black (N 2/0) clay; cloddy structure parting to moderate fine subangular blocky; firm; neutral; abrupt smooth boundary.

A12—8 to 14 inches, black (10YR 2/1) clay; moderate very fine angular blocky structure; firm; neutral; clear wavy boundary.

A3—14 to 20 inches, very dark gray (10YR 3/1) clay; moderate very fine subangular blocky structure; very firm; few channel fillings of black (10YR 2/1) and dark gray (10YR 4/1); neutral; gradual wavy boundary.

B21g—20 to 29 inches, olive gray (5Y 4/2) clay; moderate very fine angular blocky structure; very firm; few narrow very dark gray (10YR 3/1) tongues; very few small pebbles; few thin black (10YR 2/1) and very dark gray (10YR 3/1) coatings on faces of peds; neutral; clear wavy boundary.

B22g—29 to 38 inches, olive gray (5Y 5/2) clay; few fine distinct light olive brown (2.5Y 5/4) mottles; moderate medium prismatic structure parting to moderate very fine angular blocky; very firm; few very dark gray (10YR 3/1) worm casts; neutral; clear wavy boundary.

B3g—38 to 46 inches, olive gray (5Y 4/2) clay; many fine distinct light olive brown (2.5Y 5/6) mottles; moderate medium prismatic structure; firm; neutral; abrupt wavy boundary.

Cg—46 to 62 inches, grayish brown (2.5Y 5/2) clay; many fine and medium distinct light olive brown (2.5Y 5/6) mottles; massive; firm; slightly effervescent; mildly alkaline.

Thickness of the solum and depth to lime carbonates range from 28 to 54 inches. Clay content of the solum typically ranges from 60 to 80 percent. The A horizon commonly ranges from 16 to 24 inches in thickness. It is typically clay but the range includes silty clay. The B horizon ranges from 10 to 35 inches in thickness. It is typically clay but the range includes silty clay. The C horizon is typically clay but the range includes silty clay loam or silty clay. Reaction ranges from slightly acid to neutral in the solum and neutral to mildly alkaline in the C horizon.

Beauford soils are associated with Marna, Lura, Barbert, Guckeen, and Shorewood soils. Beauford soils have more clay than the Marna soil. They are better drained than Barbert and Lura soils, and they are wetter than Guckeen and Shorewood soils.

310—Beauford clay. This soil occupies 5- to 300-acre, broad, level areas and slight depressions in the lake plain. It has the profile described for the series. Slopes are 0 to 2 percent.

Included with this soil in mapping are small areas of Marna, Waldorf, Guckeen, Lura, and Barbert soils. Barbert and Lura soils are in depressions and drainageways and are identified by spot symbols on the soil map. Marna and Waldorf soils have less clay in the solum. The Guckeen soil is better drained and has less clay in the solum. Also included are areas of Brownton soils on rims of depressions and a few small areas that are high in gypsum.

The main concerns of management are removal of excess water and maintenance of good tilth. If this soil is adequately drained and managed, it is well suited to crops. Most areas presently have some degree of artificial drainage and are used mostly for farming. If worked when wet, the surface layer compacts easily, tilth is destroyed, and the soil becomes hard and cloddy when dry. Undrained areas are used for hay and pasture but are also suitable for wildlife. This soil is poorly suited to most urban and recreational developments because of the seasonal high water table, high shrink-swell potential, medium to low shear strength, and slow permeability. Capability unit IIw–2.

996—Beauford-Barbert complex. This nearly level map unit occupies 5- to 80-acre flats and slight depressions. It consists of Beauford clay and Barbert silt loam. These soils are intermingled in such an intricate pattern that mapping them separately is not practical. This unit is about 60 percent Beauford soil, 35 percent Barbert soil, and 5 percent other soils. These soils have profiles similar to those described as representative of their respective series. Slopes are 0 to 2 percent. They are concave and convex. The Barbert soil occupies depressions and elongated closed basins within areas of Beauford soil.

Included with the unit in mapping are small areas of Marna, Lura, and Waldorf soils. The Lura soil is in depressions. The Marna and Waldorf soils have less clay in the solum than Beauford and Barbert soils.

These soils have a severe wetness hazard unless they are drained. Organic-matter content is high in the Beauford soil and moderate in the Barbert soil. The main concerns of management are removal of excess water and maintenance of good tilth.

These soils are used mainly for row crops. The seasonal high water table limits the potential for intensive farm use unless artificial drainage is provided. Tillage at optimum moisture content is important. If worked when wet, the surface layer puddles easily, tilth is destroyed, and the soil becomes hard and cloddy when dry. Undrained areas are used mainly for hay and pasture but are suitable for wildlife habitat. These soils are poorly suited to most urban and recreational uses because of the seasonal high water table, high shrink-swell potential, low strength, and slow permeability. Beauford silty clay, capability unit IIw–2; Barbert silt loam, capability unit IIIw–2.

Blue Earth Series

The Blue Earth series consists of deep, very poorly drained, limy soils high in organic-matter content. These soils formed in silty post glacial lake sediments (limnic material). They are in old lake bottoms and formerly ponded areas.

In a representative profile the surface layer is black and very dark gray mucky silt loam about 48 inches thick. The deep underlying material is mottled dark olive gray clay loam. The profile is limy throughout and contains many snail shells.

The available water capacity is high, and permeability is moderate. The organic-matter content is high, and natural fertility is medium. Depth to the seasonal high water table is less than 1 foot, or near tile depth.

If adequately drained and well-managed, these soils are well suited to crops. Drainage and fertility are the major problems.

Representative profile of Blue Earth mucky silt loam, 1,700 feet east and 400 feet north of southwest corner sec. 20, T. 109 N., R. 26 W.

Lco1—0 to 19 inches; very dark gray (10YR 3/1) mucky silt loam; dark gray (10YR 4/1) dry; weak fine subangular blocky structure; very friable; many snail shells; strongly effervescent; mildly alkaline; clear smooth boundary.

Lco2—19 to 29 inches; very dark gray (2.5Y 3/1) mucky silt loam; weak fine subangular blocky structure; very friable; many snail shells; strongly effervescent; mildly alkaline; clear smooth boundary.

Lco3—29 to 48 inches; black (10YR 2/1) mucky silt loam; weak fine granular structure; very friable; many snail shells; strongly effervescent; mildly alkaline; clear smooth boundary.

IICg—48 to 60 inches; dark olive gray (5Y 3/2) clay loam; common fine distinct dark brown (7.5YR 3/2) mottles; massive; few snail shells; strongly effervescent; strongly alkaline.

The limnic material ranges from black to dark gray. The texture typically is mucky silt loam, but the range includes mucky silty clay loam. In many areas, a shallow layer of muck is at the surface. In places the limnic material is as much as 20 percent coarse fragments, which consist entirely of snail or clam shells and shell fragments. The depth to the IICg horizon ranges from 28 to 60 inches or more. The IICg horizon is typically clay loam, but the range includes silty clay loam or loam.

Blue Earth soils are associated with Muskego, Caron, and Palms soils. In contrast with those soils, they are mineral soil material, contain clam and snail shells and shell fragments, and are limy throughout.

35—Blue Earth mucky silt loam. This soil is in flat and concave old lake basins. Areas are generally round and range from small to large. Slopes are 0 to 2 percent.

Included with this soil in mapping are small areas of Canisteo and Glencoe soils, which occur along the edges of mapped areas. Many lake basins have a sandy rim of beach material and have steep escarpments at the edges. The layer of muck at the surface of this soil is thickest near the middle of the lakebed and is thinner near the edges.

Wetness is the main limitation. Soil blowing is a hazard on bare soil in large open areas. The response to fertilizer and other chemicals is modified by the high lime content.

If tile drained, this soil can be cropped intensively. It is productive if adequately drained and fertilized and well managed. Most of the acreage is in corn, soybeans, hay, or pasture. Undrained areas are covered with reeds, sedges, and rushes and provide good wetland wildlife habitat. Because of the wetness and low strength, the soil is poorly suited to most urban and recreational uses. Capability unit IIIw–4.

Bold Series

The Bold series consists of deep, well drained, rolling to moderately steep, limy, silty soils. These soils formed in medium textured glacial lacustrine sediments on the uplands. Native vegetation was tall grass prairie.

In a representative profile the surface layer is dark grayish brown friable silt loam about 7 inches thick. The underlying material is light olive brown and brownish yellow, very friable silt loam. The profile is limy throughout. Stratification begins at a depth of about 20 inches.

Permeability is moderate. Runoff is medium to very rapid. The seasonal high water table is below a depth of 6 feet. Available water capacity is high. Organic-matter content is moderate, and natural fertility is medium.

Most areas of Bold soils are in cropland. The hazard of erosion is severe. Special fertility programs are beneficial for most crops because of the high lime content.

Representative profile of Bold silt loam, in an area of Bold-Truman silt loams, 6 to 12 percent slopes, in cultivated area 1,600 feet east and 1,300 feet south of northwest corner sec. 30, T. 107 N., R. 27 W.

Ap—0 to 7 inches, dark grayish brown (10YR 4/2) silt loam, brown (10YR 5/3) crushed; weak very fine subangular blocky structure; very friable; slightly effervescent; neutral; abrupt smooth boundary.

C1—7 to 12 inches, light olive brown (2.5Y 5/6) silt loam; weak fine and medium subangular blocky structure; very friable; common tubular pores; stratified with loamy very fine sand; strongly effervescent; mildly alkaline; clear smooth boundary.

C2—12 to 20 inches, light olive brown (2.5Y 5/6) silt loam; few fine distinct yellowish brown (10YR 5/4) and light brownish gray (10YR 6/2) mottles; very weak medium subangular blocky structure; very friable; common tubular pores; stratified with loamy very fine sand; strongly effervescent; mildly alkaline; clear smooth boundary.

C3—20 to 60 inches, brownish yellow (10YR 6/6) silt loam; weak fine platy structure; very friable; stratified with loamy very fine sand; strongly effervescent; mildly alkaline.

The Ap or A1 horizon is typically dark grayish brown but the range includes brown, dark brown, or yellowish brown. The C horizon commonly is light olive brown but the range includes yellowish brown, light gray, or brownish yellow.

These soils are outside the defined range for the series because they formed in stratified glacial lacustrine sediments rather than in loess. This difference, however, does not alter their use or management.

Bold soils occur on the landscape with Truman and Grays soils. In contrast with those soils, Bold soils are limy throughout.

909C—Bold-Truman silt loams, 6 to 12 percent slopes. This sloping map unit is in areas in the lake plain and lacustrine-mantled ground moraine in the central and southwestern part of the county. The areas are 5 to 20 acres in size and irregular in shape. The unit is about 55 percent Bold silt loam, 40 percent Truman silt loam, and 5 percent other soils. The Bold soil is on convex slopes and is lighter in color than the Truman soil. The Bold soil has the profile described for the series; the Truman soil has a profile similar to the one described for the series, but the surface layer is thinner.

Included with this unit in mapping are a few areas of soils that have a silty clay loam surface layer. Also included are small areas of moderately well drained Kingston and Barrington soils and well drained Grays soil. The Kingston and Barrington soils are on less steep slopes. The Grays and Barrington soils formed under deciduous hardwoods near the river valleys.

Runoff is medium. The main concerns of management are controlling erosion and maintaining fertility.

Most of the acreage is used for corn and soybeans. The soils are well suited to cultivated crops if protective measures are used. Most urban and recreational developments are limited by slope, frost action, and low strength. Capability unit IIIe–1.

909D—Bold-Truman silt loams, 12 to 18 percent slopes. This moderately steep map unit occurs on side slopes that border streams and in lake plains. The areas are 5 to 15 acres in size and irregular in shape. This unit is about 65 percent Bold silt loam, 30 percent Truman silt loam, and 5 percent other soils. The Bold soil is on convex slopes and is lighter colored than the Truman soil. The Truman soil has a profile similar to the one described for the series, but the surface layer is thinner.

Included with this soil in mapping are a few areas of soils that have a silty clay loam surface layer. Also included are a few areas of well drained Clarion and Grays soils. Clarion soils occur where glacial till crops out at the surface. Grays soils formed under deciduous hardwoods near the river valleys.

Runoff is rapid. The main concerns of management are controlling erosion and maintaining fertility.

Much of the acreage is in corn and soybeans. Some areas are pasture and woodland. The soils are well suited to small grain, pasture, and hay. If row crops are grown, protective measures should be taken to control erosion. Slope is the dominant limitation for urban and recreational developments. Capability unit IVe–1.

Brownton Series

The Brownton series consists of deep, poorly drained, limy soils on flats and slightly elevated rims of depressions. These soils formed in moderately fine textured and fine textured, water-deposited sediments over medium textured and moderately fine textured glacial till. Native vegetation was a wet site community of tall grass prairie.

In a representative profile the surface layer is black and very dark gray silty clay loam about 22 inches thick. The subsoil is firm silty clay about 16 inches thick. It is mottled dark gray and olive gray. The underlying material is mottled olive gray clay loam. The profile is limy throughout.

Permeability is slow. Available water capacity is high. Organic-matter content is high, and natural fertility is medium. The depth to the seasonal high water table ranges from 1 to 3 feet, or near tile depth.

Brownton soils are well suited to farming if adequately drained. They have good potential for wetland wildlife. Areas that have been drained are used for crops.

Representative profile of Brownton silty clay loam in cultivated area 1,980 feet north and 925 feet east of southwest corner sec. 23, T. 105 N., R. 28 W.

Ap—0 to 7 inches, black (10YR 2/1) silty clay loam; weak fine subangular blocky structure; friable; slightly effervescent; mildly alkaline; abrupt smooth boundary.

A12—7 to 15 inches, black (10YR 2/1) silty clay loam; weak fine and very fine subangular blocky structure; friable; slightly effervescent; mildly alkaline; clear wavy boundary.

A3g—15 to 22 inches, very dark gray (10YR 3/1) silty clay loam; moderate fine subangular blocky structure; friable; numerous worm casts; few tongues of olive gray (5Y 5/2); slightly effervescent; mildly alkaline; gradual smooth boundary.

B2g—22 to 38 inches, dark gray (5Y 4/1) and olive gray (5Y 5/2) silty clay; few fine distinct olive (5Y 5/4) mottles; moderate fine and very fine subangular blocky structure; firm; few channels of very dark gray (10YR 3/1); slightly effervescent; mildly alkaline; clear wavy boundary.

IIC1g—38 to 44 inches, olive gray (5Y 5/2) clay loam; few fine distinct olive (5Y 5/4) mottles; moderate fine and very fine subangular blocky structure; about 5 percent coarse fragments, firm; strongly effervescent; mildly alkaline; clear wavy boundary.

IIC2g—44 to 60 inches, olive gray (5Y 5/2) clay loam; common medium distinct light olive brown (2.5Y 5/6) mottles; massive; friable; common soft 2- to 10-millimeter lime masses; about 5 percent coarse fragments; strongly effervcescent; mildly alkaline.

The A horizon is 16 to 24 inches thick and is heavy silty clay loam or silty clay. The B horizon is 10 to 20 inches thick. It has few to many mottles. It is typically silty clay, but the range includes clay or silty clay loam. In places the lower part is heavy clay loam, light clay loam, silty clay loam, silty clay, clay, or heavy loam. The C horizon is mottled grayish brown, olive gray, and olive brown. It typically is clay loam, but the range includes loam, silty clay loam, clay, or silty clay. It is till or lacustrine sediments. Depth to loam or clay loam glacial till is commonly within 48 inches but ranges from 30 to 60 inches.

Brownton soils formed in material similar to Guckeen, Marna, and Lura soils. They have a thicker, darker colored A horizon and are wetter than the moderately well drained to somewhat poorly drained Guckeen soils. Brownton soils have lime in all horizons, whereas the poorly drained Marna soils and the very poorly drained Lura soils contain no lime.

84—Brownton silty clay loam. This nearly level soil is on rims of depressions on level lake plains or lacustrine-mantled end and ground moraines. Areas typically are 2 to 10 acres in size, but may range to as much as 40 acres. Slopes are 0 to 2 percent.

Included with this soil in mapping are small areas of poorly drained Marna soils, Lura soils in depressions, sloping Guckeen and Kamrar soils, and small areas of Beauford soils. In small areas where this Brownton soil is associated with Waldorf soils, the underlying material is silt loam.

Runoff is slow. The main concerns of management are maintenance of soil tilth and removal of excess water. This soil responds efficiently to properly designed and installed drainage systems. Response to fertilizer and other chemicals is modified by the high lime content.

If this soil is adequately drained and managed, it is well suited to farming. It is poorly suited to most recreational and urban uses because of the seasonal high water table, high shrink-swell potential, low bearing values, and low strength. Capability unit IIw-3.

Calco Series

The Calco series consists of deep, nearly level, poorly drained, limy soils formed in silty recent alluvium. These soils are on bottom lands and abandoned stream channels of the Minnesota River and its tributaries. Native vegetation was water-tolerant grasses, shrub willow, and sedges.

In a representative profile the surface layer is limy, black and very dark gray silty clay loam about 48 inches thick. Snail shells are common throughout. The underlying material is a limy, mottled olive gray silty clay loam.

Permeability is moderately slow. Runoff is slow to ponded. The depth to the seasonal high water table is 0 to 3 feet, or near tile depth. Available water capacity, organic-matter content, and natural fertility are high.

These soils are used for row crops or pasture, but some areas lack drainage outlets and remain in their natural condition.

Representative profile of Calco silty clay loam, 2,245 feet east and 2,600 feet north of southwest corner sec. 29, T. 109 N., R. 26 W.

Ap—0 to 10 inches, black (10YR 2/1) silty clay loam; weak fine granular structure; friable; strongly effervescent; mildly alkaline; gradual wavy boundary.

A12—10 to 35 inches, very dark gray (10YR 3/1) silty clay loam; weak fine granular structure; friable; common shell fragments, strongly effervescent; mildly alkaline; gradual wavy boundary.

A13—35 to 48 inches, very dark gray (10YR 3/1) silty clay loam; common dark gray (10YR 4/1) tongues; weak fine granular structure; friable; common shell fragments; strongly effervescent; mildly alkaline; gradual wavy boundary.

Cg—48 to 60 inches, olive gray (5Y 4/2) silty clay loam; many common fine distinct olive (5Y 5/3) mottles; weak fine subangular blocky structure; friable; strongly effervescent; mildly alkaline.

The Ap or A11 horizon is typically silty clay loam, but the range includes heavy silt loam. It is 14 to 24 inches thick. The A12 and A13 horizons are typically silty clay loam, but the range includes heavy silt loam. They are 15 to 38 inches thick. In places there is a Bg horizon. It is mottled olive gray, dark olive gray, olive or dark gray, or gray silty clay loam, silt loam, or loam that is high in silt. Reaction is mildly alkaline or neutral. The Cg horizon is olive gray, dark greenish gray, or dark gray. It is commonly silty clay loam, but the range includes silt loam and loam or clay loam.

Calco soils are associated with Comfrey, Joliet, and Tilfer soils. They have more silt and less sand in the solum than Comfrey soils and are limy throughout.

Calco soils are deeper over bedrock than Joliet soils. They are in positions similar to those of Tilfer soils, but they are deeper over bedrock.

85—Calco silty clay loam. This soil occupies stream bottom lands and abandoned stream channels. It is occasionally flooded. It has the profile described for the series. Slopes are 0 to 2 percent.

Included with this soil in mapping are small areas of Alluvial land; Alluvial land, frequently flooded; and Comfrey soils. The Alluvial land areas are coarser textured than this Calco soil, and the Comfrey soils are not limy.

This is a wet soil. The depth to the water table is controlled by stream flow or seepage from valleysides. Flooding occurs principally during snow melt in spring and occasionally during periods of high or extended rainfall in May, June, and early in July. Some areas are tiled. Tile functions satisfactorily except when streams are at or near flood flow.

Most of the acreage is cropland. This soil has poor potential for urban use because of the hazard of flooding. Capability unit IIw–6.

349—Calco silty clay loam, very wet. This nearly level soil occupies stream bottom lands and abandoned stream channels. It is subject to a constant high water table and to frequent flooding. The surface is generally "hummocky." There are many, small, 2- to 4-inch high black mounds because active crayfish burrow down into the soil creating a "churning" effect. Slopes are 0 to 2 percent.

Extensive outlet development or installation of pumps and dikes is needed if this soil is to be dependable cropland. Most areas are idle or are used as native pasture. The soil has poor potential for cropland and for urban and recreational uses because of wetness. Capability unit VIw–1.

Canisteo Series

The Canisteo series consists of nearly level, poorly drained, limy soils formed in medium textured and moderately fine textured glacial till. These soils occupy broad, upland tracts and rims of depressions and drainageways. Native vegetation was a wet site community of tall grass prairie.

In a representative profile the surface layer is limy, black and very dark gray silty clay loam about 14 inches thick. The subsoil, about 13 inches thick, is limy, mottled dark gray and gray, friable clay loam. The underlying material is limy, mottled olive gray and light olive gray, friable loam or clay.

Permeability is moderate. Runoff is slow. The seasonal high water table ranges from 1 to 3 feet, or near tile depth. Available water capacity and organic-matter content are high, and natural fertility is medium.

These soils, in their natural state, are moderately well suited to poorly suited to crops. If adequately drained, they are well suited. Most areas are used for crops.

Representative profile of Canisteo silty clay loam in cultivated area 660 feet east and 2,580 feet north of southwest corner sec. 9, T. 108 N., R. 28 W.

Ap—0 to 8 inches, black (10YR 2/1) silty clay loam; weak very fine subangular blocky structure; friable; few fine shell fragments; strongly effervescent; mildly alkaline; abrupt smooth boundary.

A12—8 to 11 inches, very dark gray (10YR 3/1) silty clay loam; weak fine and very fine subangular blocky structure; friable; strongly effervescent; mildly alkaline; clear smooth boundary.

A3—11 to 14 inches, very dark gray (10YR 3/1) silty clay loam; weak fine and very fine subangular blocky structure; friable; strongly effervescent; mildly alkaline; clear smooth boundary.

B21g—14 to 21 inches, dark gray (5Y 4/1) clay loam; few fine faint olive (5Y 5/3) mottles; weak fine and very fine subangular blocky structure; friable; few very dark gray (5Y 3/1) and dark olive gray (5Y 3/2) krotovina; about 5 percent coarse fragments; strongly effervescent; mildly alkaline; clear smooth boundary.

B22g—21 to 27 inches, gray (5Y 5/1) clay loam; common fine distinct olive (5Y 5/3 and 5/4) mottles; weak fine and very fine subangular blocky structure; few very dark gray (5Y 3/1) and black (5Y 2/1) krotovina; about 5 percent coarse fragments, strongly effervescent; mildly alkaline; clear smooth boundary.

C1g—27 to 38 inches, olive gray (5Y 5/2) clay loam; few fine distinct olive yellow (5Y 6/6) mottles; weak fine subangular blocky structure; friable; few light olive gray (5Y 6/2) feathered lime masses; about 5 percent coarse fragments with few shale fragments and lime pebbles; strongly effervescent; mildly alkaline; clear smooth boundary.

C2g—38 to 60 inches, light olive gray (5Y 6/2) loam; many fine distinct olive yellow (5Y 6/6), pale olive (5Y 6/3), and olive (5Y 5/4) mottles; weak fine subangular and angular blocky structure; friable; few light gray (5Y 7/2) feathered lime masses; about 5 percent coarse fragments with few fine shale fragments and few lime pebbles; few reddish orange iron oxide stains; strongly effervescent; mildly alkaline.

Solum thickness ranges from 20 to 36 inches. The A horizon is typically silty clay loam, but the range includes loam or clay loam. The B horizon is typically clay loam, but the range includes loam. It is mildly alkaline, but in places the lower part is neutral. The C horizon is loam or clay loam. Typically the soil is about 5 percent, by volume, of coarse fragments of mixed lithology. In places the upper 20 to 30 inches lacks coarse fragments.

Canisteo soils are on the same landscape with Webster, Glencoe, Nicollet, Clarion, Cordova, Le Sueur, and Lester soils. Unlike Webster and Cordova soils, Canisteo soils are limy throughout. Canisteo soils are not so well drained as Nicollet, Clarion, Le Sueur, and Lester soils. They are better drained than the depressional Glencoe soils.

86—Canisteo silty clay loam. This nearly level soil occupies 10- to 100-acre tracts in broad, upland flats and rims of depressions and drainageways. It has the profile described for the series. Slopes are 0 to 2 percent.

Included with this soil in mapping are small areas of Webster soils. Also included are small areas of the moderately well drained Nicollet and Le Sueur soils on low convex knolls, and small areas of soils in the northwestern part of the county that have a higher lime content than this Canisteo soil.

Drainage is needed if this soil is to be dependable cropland. Tile drainage effectively controls the water table. This soil is limy throughout. Lime is more concentrated on rims of depressions and is less concentrated on the broad, nearly level areas. High application rates of potash and phosphate are generally needed to offset the high lime condition.

If this soil is adequately drained and managed, it is very good for crops. Most of the acreage is used for crops. The soil is poorly suited to most nonfarm uses because of the seasonal high water table, low strength, and frost action. Capability unit IIw–3.

919—Canisteo-Fieldon loams. This map unit consists of limy, poorly drained, nearly level soils on upland flats and rims of depressions and drainageways. It occupies irregularly shaped 5- to 30-acre tracts. It is about 65 percent Canisteo loam, 30 percent Fieldon loam, and 5 percent minor soils. The profile of the Canisteo soil differs from the one described for the series in having a loam surface layer. The profile of the Fieldon soil differs from the one described for the series in having loamy material at a depth of about 48 to 72 inches.

Included with this unit in mapping are small areas which contain sandy material. Also included are small areas of poorly drained Webster and Darfur soils, moderately well drained Nicollet and Litchfield soils on low convex knolls, and very poorly drained depressional Glencoe soils.

All crops commonly grown in the county are grown on this unit. Wetness and high concentrations of lime carbonates are limitations. Drainage is needed to provide a deep root zone for most crops. High application rates of potash and phosphate are generally needed to offset the high lime condition. Soil blowing is a hazard in places if fields are left bare in winter and spring.

The soils are poorly suited to most nonfarm uses because of the seasonal high water table, low strength, and frost action. Canisteo loam, capability unit IIw–3; Fieldon loam, capability unit IIw–5.

Caron Series

The Caron series consists of deep, very poorly drained organic soils formed mostly in moderately decomposed reed and sedge vegetation over limnic material. These soils are in bogs, which formerly were lakes and bays of existing lakes.

In sequence downward a representative profile is about 8 inches of black muck, or sapric material; 17 inches of very dark grayish brown mucky peat, or hemic material; 10 inches of black muck, or sapric material; and several feet of lake sediments of black, limy limnic material.

Caron soils are high in nitrogen and low in phosphorus and potassium. Organic-matter content is very high. Permeability is moderately rapid. The seasonal high water table is within a depth of 1 foot, or near tile depth. Available water capacity is very high.

Unless drained, these soils are poorly suited to most crops. If adequately drained, they are suited to early maturing field crops and truck garden crops. The frost hazard, the wetness, and the fertility are the major limitations. Only the smaller areas are cropped.

Representative profile of Caron muck in cultivated field 660 feet east and 350 feet north of southwest corner sec. 1, T. 106 N., R. 26 W.

Oap—0 to 8 inches, black (N 2/0) broken face sapric material, black (10YR 2/1) rubbed; about 20 percent fibers, about 5 percent rubbed; weak very fine subangular blocky structure; friable; herbaceous fibers; about 40 percent mineral; slightly acid; abrupt smooth boundary.

Oe1—8 to 20 inches, very dark grayish brown (10YR 3/2) broken face hemic material, black (10YR 2/1) rubbed; about 50 percent fibers, about 25 percent rubbed; many dark brown (10YR 4/3) fibers; weak medium platy structure; friable; herbaceous fibers; sodium, pyrophosphate color test of 10YR 6/2; about 15 percent mineral; slightly acid; clear smooth boundary.

Oe2—20 to 25 inches, very dark grayish brown (10YR 3/2) broken face and rubbed hemic material; about 40 percent fibers, about 25 percent rubbed; many dark brown (10YR 4/3) fibers; weak medium and coarse, subangular blocky structure; friable; herbaceous fibers; sodium pyrophosphate test of 10YR 6/2; about 15 percent mineral; slightly acid; clear smooth boundary.

Oa2—25 to 35 inches, black (N 2/0) broken face sapric material, black (10YR 2/1) rubbed; about 35 percent fibers, about 10 percent rubbed; weak medium and coarse, subangular blocky structure; friable; herbaceous fibers; sodium pyrophosphate test of 10YR 5/2; about 45 percent mineral; neutral; clear smooth boundary.

Lco—35 to 60 inches; black (10YR 2/1), very dark gray (10YR 3/1) rubbed, coprogenous earth; about 15 percent plant tissue, trace rubbed; about 55 percent mineral; slightly effervescent, mildly alkaline.

The depth to coprogenous earth ranges from 16 to 51 inches. The Oa1 horizon is 0 to 12 inches thick. The Oe horizon is 16 to 51 inches thick. It is very dark grayish brown, very dark gray, or very dark brown. The Oa2 horizon does not occur in some profiles. The Lco horizon ranges from 30 to 50 inches or more in thickness. It is neutral or mildly alkaline and is black, very dark brown, very dark grayish brown, or dark grayish brown. Snail shells are common. Depth to a IIC horizon of silty clay loam, sandy clay loam, clay loam or loam ranges from 51 to 120 inches or more.

The Caron mucky peat soils are outside the defined range for the series because they have a thicker layer of hemic material, are mildly alkaline, and have no Lco horizon within 51 inches.

Caron soils are associated with Palms and Muskego soils. They differ from Palms soils in having mineral material at a depth of more than 51 inches. They have a layer of hemic material, which is lacking or very thin in the Muskego soil.

524—Caron muck. This soil is in bogs of 200 acres or more. It has the profile described for the series. Slopes are 0 to 2 percent. The largest areas are in the northeastern part of the county.

Included with this soil in mapping are small, discontinuous strips of sandy or gravelly material near the edge of the larger bogs and small areas where the mineral material is within a depth of 51 inches. In a few places the surface layer is limy. Also included are small areas of peaty material in boggy bays near lakes.

Runoff is slow or ponded. Improving the drainage and fertility are the major management needs if this soil is to be used for crops. In some places dikes are needed to control flooding.

Some areas are cropland. Some are pasture. Some are used for production of reed canarygrass seed. The soil is very poorly suited to most urban and recreational uses because of wetness and low strength. Several of the larger bogs are in their natural environment. Capability unit IIIw–4.

1800—Caron mucky peat. This soil occupies 10- to 150-acre seep areas below scarp slopes mainly in the Minnesota River Valley. The profile differs from the one described for the series because it is slightly limy, it is mucky peat to a depth of 51 inches or more, and it contains no limnic material. Slopes are 0 to 3 percent.

Included with this soil in mapping are small areas where mineral material is within a depth of 51 inches. At the edges of some bogs are narrow, discontinuous strips of mucky peat that is underlain by bedrock. In a few areas the surface layer is not limy.

This soil has potential for development of wetland wildlife habitat and trout ponds. It is very poorly suited to most urban and recreational uses because of wetness, constant seepage, and low strength. The entire acreage has been left in its natural condition. Capability unit VIIIw–1.

Chaska Series

The Chaska series consists of deep, nearly level, poorly drained, limy soils formed in recent loamy alluvial sediments on flood plains of the Minnesota River. These soils are on broad flats along this river. Native vegetation was wetland grasses and sedges.

In a representative profile the surface layer is very dark gray loam about 8 inches thick. The underlying material is mottled and stratified very dark gray to olive loam, loamy fine sand, and very fine sandy loam. The profile is limy throughout.

Permeability is moderate. Available water capacity, organic-matter content, and natural fertility are high. The depth to the seasonal high water table ranges from 1 to 3 feet and fluctuates with the rise and fall of the river level. These soils are subject to frequent flooding early in spring and after periods of heavy rainfall.

Most areas of Chaska soils are used for crops. The soils are well suited to all crops grown in the county. The major limitation is the hazard of flooding.

Representative profile of Chaska loam in cultivated field about 1,320 feet south and 20 feet west of northeast corner sec. 22, T. 109 N., R. 29 W.

Ap—0 to 8 inches, very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) dry; weak fine and medium subangular blocky structure; friable; few fine fragments of snail shells; slightly effervescent; mildly alkaline; abrupt smooth boundary.

C1—8 to 38 inches, stratified very dark grayish brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) loamy fine sand, very dark gray (10YR 3/1) loam, and very dark grayish brown (2.5Y 3/2) and dark grayish brown (2.5Y 4/2) very fine sandy loam; few fine distinct yellowish brown (10YR 5/4), dark yellowish brown (10YR 3/4), and olive brown (2.5Y 4/4) mottles; weak medium platy structure in some parts and weak variable-sized subangular blocky structure in other parts; friable; silt loam is dominant; few fine fragments of snail shells; slightly effervescent; mildly alkaline; gradual smooth boundary.

C2—38 to 60 inches, stratified dark grayish brown (2.5Y 4/2) and olive (5Y 5/3) fine sandy loam and grayish brown (2.5Y 5/2) loamy fine sand; common fine distinct dark yellowish brown (10YR 4/4) mottles; weak coarse platy structure; friable; few fine fragments of snail shells; slightly effervescent; mildly alkaline.

The entire profile is typically slightly alkaline or moderately alkaline. The A horizon is typically loam or silt loam but ranges to clay loam and silty clay loam. It is very dark gray but is dark gray or gray when dry. It has weak or moderate, granular or subangular blocky structure. It ranges from neutral to moderately alkaline. The Ap horizon is 6 to 9 inches thick. The C horizon has stratified colors and stratified textures. It is dominantly silt loam, loam, and very fine sandy loam, but the range includes fine sand, loamy fine sand, fine sandy loam, sandy clay loam, silty clay loam, and clay loam. The C horizon has weakly developed structure or is massive. Fragments of snail shells are lacking in some pedons. The content of organic matter in the C horizon decreases irregularly with increasing depth.

Chaska soils are associated with Dorchester and Oshawa soils. They are wetter than the Dorchester soils, which are on the gentle rises within the flood plain or on the higher bottom lands adjoining stream terraces. They are drier than the Oshawa soils, which are in abandoned river channels and oxbows of the flood plain.

329—Chaska loam. This nearly level soil is in areas of the flood plain along the Minnesota River. The areas are large in size and irregular in shape. This soil has the profile described for the series. Slopes are 0 to 2 percent.

Included with this soil in mapping are small areas of moderately well drained Dorchester soils. Some areas are dissected by meandering old stream channels and contain small areas of Oshawa soils. Also included are small areas of Alluvial land.

Runoff is slow, and the hazard of erosion is slight. The main concern of management is flooding, which occurs frequently for short periods early in spring and during periods of heavy, prolonged rainfall. The water table fluctuates with the rise and fall of the river level.

Most areas of this soil are well suited to crops commonly grown in the county, especially corn and soybeans, if the soil is adequately protected from flooding. Potential for urban and recreational uses is limited by flooding and wetness. Capability unit IIw–6.

851—Chaska-Urban land complex. This nearly level map unit is in areas of the flood plain along the Minnesota River that are protected from flooding and scouring by dikes. The areas are large in size and irregular in shape. Urban land is where the Chaska soil has been excavated for foundations, basements, or roads and spread on the ground's surface or used to fill in the depressions. Slopes are 0 to 2 percent.

Included with this unit in mapping are small areas of moderately well drained Dorchester soils and Alluvial land. Also included are small areas of very poorly drained Oshawa soils, which are in old meandering stream channels. These areas are being filled.

This is a wet soil. The seasonal high water table fluctuates with the rise and fall of the river level. It commonly is at depths ranging from 1 to 3 feet in undrained areas, and it limits most urban and recreational uses. Artificial drainage is needed to overcome wetness, especially around the footings of basement walls. Runoff is high from roofs, roads, and other paved surfaces that cover much of this complex. Not assigned to a capability group.

Clarion Series

The Clarion series consists of deep, gently undulating to steep, well drained soils formed in medium textured and moderately fine textured glacial till. These soils are in uplands on knolls and hillsides. Native vegetation was tall grass prairie.

In a representative profile the surface layer is black and very dark gray loam about 14 inches thick. The subsoil is dark brown and brown friable loam about 20 inches thick. The underlying material is limy, yellowish brown friable loam.

Permeability is moderate. The seasonal high water table is below a depth of 6 feet. Available water capacity, organic-matter content, and natural fertility are high.

Most areas of Clarion soils are cropland and are well suited to this use. A few areas are in woodland or permanent pasture. The hazard of erosion is the major limitation.

Representative profile of Clarion loam, 2 to 6 percent slopes, in cultivated area 2,350 feet south and 1,350 feet west of northeast corner sec. 9, T. 108 N., R. 28 W.

Ap—0 to 8 inches, black (10YR 2/1) loam; weak very fine subangular blocky structure; friable; about 2 percent coarse fragments; neutral; abrupt smooth boundary.

A12—8 to 11 inches, black (10YR 2/1) loam; moderate very fine subangular blocky structure; friable; about 2 percent coarse fragments; slightly acid; clear smooth boundary.

A3—11 to 14 inches, very dark gray (10YR 3/1) loam; moderate very fine subangular blocky structure; friable; about 2 percent coarse fragments; slightly acid; clear smooth boundary.

B21—14 to 19 inches, dark brown (10YR 3/3) loam, very dark grayish brown (10YR 3/2) coatings on faces of peds; weak and moderate very fine subangular blocky structure; friable; about 2 percent coarse fragments; slightly acid; clear smooth boundary.

B22—19 to 25 inches, brown (10YR 4/3) loam, dark brown (10YR 3/3) coatings on faces of peds; weak very fine and fine subangular blocky structure; friable; about 2 percent coarse fragments; medium acid; clear smooth boundary.

B23—25 to 34 inches, brown (10YR 4/3) loam; weak very fine subangular blocky structure; friable; about 2 percent coarse fragments; slightly acid; clear smooth boundary.

C1—34 to 40 inches, yellowish brown (10YR 5/4) loam; weak very fine and fine subangular blocky structure; friable; about 2 percent coarse fragments; slightly effervescent; mildly alkaline; clear smooth boundary.

C2—40 to 60 inches, yellowish brown (10YR 5/4) loam; weak fine subangular blocky structure; about 2 percent coarse fragments; few segregated lime masses; strongly effervescent; mildly alkaline.

Solum thickness and depth to lime carbonates range from 18 to 44 inches. Content of coarse fragments in the solum and C horizon ranges from 2 to 8 percent. The A horizon is typically 12 to 18 inches, but in some eroded areas it is less than 10 inches. It is typically black, but the range includes very dark gray, very dark grayish brown, and very dark brown. Texture is typically loam, but the range includes clay loam. Reaction is medium acid to neutral. The B horizon typically is dark brown, dark yellowish brown, and yellowish brown and ranges from about 10 to 30 inches in thickness. It is loam or light clay loam. Reaction is neutral to medium acid. The C horizon is light olive brown or yellowish brown. Mottles are present in this horizon in some pedons.

Clarion soils are associated on the landscape with Nicollet, Storden, and Webster soils. They occupy steeper slopes than the moderately well drained Nicollet soil. Clarion soils are better drained than Webster soils, which occupy upper drainageways and broad flats. In contrast with Storden soils, Clarion soils have a nonlimy solum, a well developed subsoil, and a thicker, dark colored surface layer.

102B—Clarion loam, 2 to 6 percent slopes. This gently undulating soil occupies 5- to 30-acre knolls, hilltops, and rises. Slopes are convex and concave and 45 to 150 feet long. This soil has the profile described for the series.

Included with this soil in mapping are areas that are moderately eroded and have a few very short 6 to 12 percent slopes. Also included are small areas of Nicollet soils on slightly concave slopes and areas of Webster and Glencoe soils, which are on concave slopes and are identified by spot symbols on the soil map.

The erosion hazard is moderate in cultivated areas. Runoff is medium. The soil is used mainly for corn and soybeans. It is well suited to farming if erosion is controlled. It has fair to good potential for most recreational and nonfarm uses. Capability unit IIe–2.

102C—Clarion loam, 6 to 12 percent slopes. This rolling soil occupies 5- to 20-acre knolls and side slopes. Slopes are convex and concave and range from 45 to 150 feet in length. This soil has a profile similar to the one described for the series, but it has a thinner surface layer and subsoil.

Included with this soil in mapping are areas that are moderately eroded. Also included are a few areas where slopes are less than 6 percent and more than 12 percent and small areas of Storden soils on the steeper convex slopes. Also included, and identified by spot symbols on the soil map, are small areas of gravelly soils and areas of Webster, Nicollet, and Glencoe soils on concave slopes.

If this soil is cultivated, the hazard of erosion is severe. Runoff is medium to rapid. Erosion control is needed if cultivated crops are grown.

This soil is used mainly for corn and soybeans. It has fair potential for most urban and recreational uses. Slope is the main limitation. Capability unit IIIe–1.

102D—Clarion loam, 12 to 18 percent slopes. This hilly soil occupies 5- to 20-acre knolls and side slopes. Slopes are 75 to 150 feet long. This soil has a profile similar to the one described for the series, but it has thinner layers.

Included with this soil in mapping are small moderately eroded or severely eroded areas, a few areas where slopes are less than 12 percent and more than 18 percent, and small areas of Storden soils on the steeper convex slopes. Also included, and identified by spot symbols on the soil map, are small areas of gravelly soils and areas of Nicollet, Webster, and Glencoe soils on concave slopes. Long, narrow areas of Terril soils commonly occur in concave positions at the base of steeper slopes.

If this soil is cultivated, the hazard of erosion is very severe. Runoff is rapid. Organic-matter content is medium. Conservation practices to reduce the erosion hazard are needed if cultivated crops are grown.

This soil is used mainly for corn, soybeans, and hay and pasture. Most urban and recreational uses are limited because of slope. Capability unit IVe–1.

920B—Clarion-Estherville complex, 2 to 6 percent slopes. This gently undulating map unit is one of Clarion, Estherville, and several other well drained soils on end moraines. These soils are so intermixed on the landscape that mapping them separately is not practical. The unit varies, but it is commonly about 55 percent Clarion soil, 20 percent Estherville soil, and 25 percent other soils, mostly Storden, Wadena, and Dickinson soils.

This unit occupies 2- to 25-acre knolls and side slopes adjacent to Clarion, Nicollet, Terril, and Webster soils. Slopes are convex and concave and are 80 to 150 feet long.

Included with this unit in mapping are a few areas where slopes are very short and more than 12 percent and areas of Grays and Nicollet soils. Also included, on concave slopes, are a few wet areas of Webster and Glencoe soils which are identified by spot symbols on the soil map. In some areas this unit is underlain by silty material at a depth of 40 to 60 inches.

The hazard of erosion is moderate to severe in cultivated areas. Organic-matter content is high in most of the soils, but it is low in the Storden soil. The main concerns of management are erosion control, conservation of moisture, and maintenance of fertility.

This unit is used mainly for row crops. Irregular topography limits the application of some of the common erosion control practices. The sandy soils are droughty in years of average or below average rainfall. This soil has good potential for most urban and recreational uses. Clarion loam in capability unit IIe–2, Estherville sandy loam in capability unit IIIs–1.

920C—Clarion-Estherville complex, 6 to 12 percent slopes. This rolling map unit is one of Clarion, Estherville, and several other well drained soils on end moraines. These soils are so intermixed on the landscape that mapping them separately is not practical. Composition of the unit varies, but it is commonly 50 percent Clarion soil, 25 percent Estherville soil, and 25 percent other soils, mostly Storden, Wadena, and Dickinson soils.

This unit occupies 2- to 25-acre knolls and side slopes adjacent to mapping units of Clarion, Nicollet, Terril, and Webster soils. Slopes are convex and concave and are 80 to 150 feet long.

Included with this unit in mapping are a few areas where slopes are very short and more than 12 percent and areas of Grays and Nicollet soils. Also included, on concave slopes, are a few wet areas of Webster and Glencoe soils, which are identified by spot symbols on the soil map. In some areas this unit is underlain by silty material at a depth of 40 to 60 inches.

The hazard of erosion is moderate to severe in cultivated areas. Organic-matter content is high in most of the soils, but it is low in the Storden soil. The main concerns of management are erosion control, conservation of moisture, and maintenance of fertility.

This unit is used mainly for row crops. Irregular topography limits the application of some of the common erosion control practices. The sandy soils are droughty in years of average or below average rainfall. This soil has fair potential for most urban and recreational uses. Slope is the main limitation. Clarion loam in capability unit IIIe–1, Estherville sandy loam in capability unit VIs–1.

920D—Clarion-Estherville complex, 12 to 20 percent slopes. This hilly map unit is one of Clarion, Estherville, and several other well drained soils on an end moraine. The soils are intermixed in such a pattern on the landscape that mapping them separately is not practical. The unit commonly is about 45 percent Clarion soil, 25 percent Estherville soil, and 30 percent other soils, mostly Storden, Dickinson, and Wadena soils.

This unit occupies 2- to 30-acre knolls and side slopes.

Slopes are 70 to 160 feet long and are convex and concave.

Included with this unit in mapping are some areas where slopes are short and less than 12 percent or more than 20 percent and areas of Grays and Nicollet soils. Also included, on concave slopes, are a few areas of Webster and Glencoe soils which are identified by spot symbols on the soil map. Some areas are underlain by silty material at a depth of 40 to 60 inches. Areas of Terril soils at the base of some slopes are also included.

This unit has a very severe hazard of erosion if cultivated. Organic-matter content is high in most soils, but it is low in the Storden soil. The main concerns of management are erosion control, conservation of moisture, and maintenance of fertility.

This unit is used mainly for row crops, but some areas are in pasture and brush. Erosion control practices are generally needed if cultivated crops are grown, but they are limited by the irregular topography. The sandy soils are droughty during years of average or below average rainfall. Most urban and recreational uses are limited by slope. Clarion loam in capability unit IVe–1, Estherville sandy loam in capability unit VIs–1.

921C—Clarion-Storden loams, 6 to 12 percent slopes. This rolling map unit is one of Clarion and Storden loams. These soils are intermixed in such an intricate pattern that mapping them separately is not practical. The unit is 60 percent Clairon soil, 35 percent Storden soil, and 5 percent other soils.

This unit occupies 2- to 40-acre knolls, rises, and side slopes adjacent to Clarion, Nicollet, and Webster soils. Slopes are convex and concave. The Storden soil is on more convex slopes. The Clarion soil is on less convex slopes. Slopes are 60 to 150 feet long.

The profiles of the soils in this unit are similar to those described for the respective series, but some areas of Clarion soil are thinner and have a very dark brown surface layer.

Included with the unit in mapping are a few areas where slopes are less than 6 percent or more than 12 percent and some moderately eroded areas of Clarion soils. Also included, and identified on the soil map by spot symbols, are small areas of Estherville soils and a few wet areas of Webster and Glencoe soils on concave slopes. In places Clarion and Storden soils are underlain by silty material at a depth of 40 to 60 inches. Areas of Terril soils at the base of some slopes are also included.

The hazard of erosion is severe in cultivated areas. On sharp, convex knobs on the landscape the Storden soil has a root zone that is affected by the high content of lime. It is also somewhat droughty because of rapid runoff.

This unit is used mainly for row crops. Runoff is medium to rapid. Erosion control practices are needed if cultivated crops are grown. In areas of Storden soil the commonly grown crops require special fertility treatments because of the high concentration of lime carbonates. This unit has fair potential for most urban and recreational uses. Slope is the main limitation. Capability unit IIIe–1.

921D—Clarion-Storden loams, 12 to 18 percent slopes. This hilly map unit is one of Clarion and Storden loams. These soils are intermixed in such an intricate pattern on the landscape that mapping them separately is not practical. This unit is about 55 percent Clarion soil, 40 percent Storden soil, and 5 percent other soils. Slopes are convex and concave.

This unit occupies 3- to 30-acre knolls and side slopes adjacent to other Clarion, Nicollet, and Webster soils. The Storden soil is on convex knolls above areas of Clarion soils, which are generally on less convex side slopes. Slopes are 75 to 150 feet long. The Storden soil has the profile described for the series. The Clarion soil differs from the one described for the series in having a thinner profile and a very dark brown surface layer.

Included with this unit in mapping are a few areas where slopes are less than 12 percent or more than 18 percent and an eroded area of Clarion soil. Also included, and identified by spot symbols on the soil map, are areas of Estherville soils and areas of Webster and Glencoe soils on concave slopes. In places this unit is underlain by silty material at a depth of 40 to 60 inches. Areas of Terril soils at the base of some slopes are also included.

The hazard of erosion is very severe in cultivated areas. The Storden soil's root zone is affected by the high content of lime. On sharp, convex knobs on the landscape the Storden soil is also somewhat droughty because of rapid runoff.

This unit is used for row crops, hay, and pasture. Runoff is rapid. Erosion control practices are needed if cultivated crops are grown. In areas of Storden soil the commonly grown crops require special fertility treatments because of the high concentration of lime carbonates. This unit is limited for most urban uses because of steep slopes. Capability unit IVe–1.

Collinwood Series

The Collinwood series consists of nearly level to moderately steep, moderately well drained and well drained soils. These soils formed in moderately fine textured and fine textured glacial lacustrine sediments 4 to 20 feet thick. They occupy plane to convex slopes. Native vegetation was tall grass prairie.

In a representative profile the surface layer is black and very dark grayish brown friable silty clay loam about 17 inches thick. The subsoil, about 28 inches thick, is dark grayish brown silty clay in the upper 7 inches and mottled dark brown, dark grayish brown, and grayish brown silty clay in the lower 21 inches. The underlying material is limy, mottled light olive brown silt loam.

Permeability is moderately slow. A seasonal high water table ranges from a depth of 2 to 5 feet. Available water capacity, organic-matter content, and natural fertility are high.

Most areas of Collinwood soils are used for corn and soybeans. They are suited to most crops if well managed.

Representative profile of Collinwood silty clay loam, 1 to 3 percent slopes in cultivated area 990 feet north and 225 feet east of southwest corner sec. 27, T. 106 N., R. 29 W.

Ap—0 to 9 inches, black (10YR 2/1) silty clay loam; weak very fine subangular blocky structure; friable; slightly acid; abrupt smooth boundary.

A12—9 to 13 inches, black (10YR 2/1) silty clay loam; weak and moderate very fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

A3—13 to 17 inches, very dark grayish brown (10YR 3/2) silty clay loam, very dark gray (10YR 3/1) coatings on faces of peds; weak and moderate very fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

B21—17 to 24 inches, dark grayish brown (10YR 4/2) light silty clay, very dark gray (10YR 3/1) and very dark grayish brown (10YR 3/2) coatings on faces of peds; moderate very fine subangular blocky structure; firm; slightly acid; clear smooth boundary.

B22—24 to 32 inches, dark brown (10YR 4/3) silty clay, dark grayish brown (10YR 4/2) coatings on faces of peds; common fine faint olive brown (2.5Y 4/4) and light olive brown (2.5Y 5/4) mottles; moderate and strong fine and very fine subangular blocky structure; firm; neutral; clear smooth boundary.

B23—32 to 45 inches, dark grayish brown (2.5Y 4/2) and grayish brown (2.5Y 5/2) silty clay; many fine distinct light olive brown (2.5Y 5/4 and 5/6) mottles; weak and moderate fine subangular and angular blocky structure; firm; neutral; clear irregular boundary.

C—45 to 60 inches, light olive brown (2.5Y 5/4) silt loam; many fine faint grayish brown (2.5Y 5/2) mottles; weak thin to thick platy structure; friable; slightly effervescent; moderately alkaline.

Solum thickness and depth to free lime range from 24 to 40 inches. Clay content in the solum is typically 45 to 55 percent but ranges from 35 to 60 percent. The solum is neutral to medium acid.

The A horizon ranges from 14 to 24 inches in thickness. It is friable to firm and is black to very dark gray. Texture is typically silty clay loam, but the range includes silty clay.

The B horizon is firm to very firm and is very dark grayish brown to dark brown. Mottles are common in the lower part. Texture is typically silty clay, but the range includes silty clay or clay.

The C horizon is light brownish gray, grayish brown, or light olive brown silty clay, silty clay loam, or silt loam.

The Collinwood soils that have slopes of 2 to 6 percent, 6 to 12 percent, and 12 to 18 percent have higher chroma in the B horizon. They are well drained and have a seasonal high water table below a depth of 6 feet. They are therefore outside the range of the series. This difference, however, does not alter the use or management of the soils.

Collinwood soils are associated with Waldorf, Lura, and Guckeen soils. They are better drained than Waldorf soils. They have a thinner A horizon and are better drained than Lura soils. They are underlain by lacustrine sediments, whereas Guckeen soils are underlain by glacial till.

96—Collinwood silty clay loam, 1 to 3 percent slopes. This moderately well drained soil occupies 2- to 14-acre low, convex slopes and knolls. Slopes are 60 to 200 feet long. They are convex in the upper part and concave in the lower part. This soil has the profile described for the series.

Included with the soil in mapping are areas of Lura or Barbert soils in shallow drainageways and small depressions that are identified on the soil map by spot symbols. Also included are small, level areas of Waldorf and Beauford soils. A few areas where slopes are more than 3 percent are also included.

Erosion is seldom a hazard. The high content of fine silt and clay narrows the range of moisture content at which the soil can be tilled. Seasonal wetness can be a problem. Drainage is needed for maximum yields.

Most areas of this soil are used for corn and soybeans. A seasonal high water table, high clay content, and shrink-swell potential are the major limitations for urban and recreational development. Capability unit IIs–2.

96B—Collinwood silty clay loam, 2 to 6 percent slopes. This gently sloping, well drained soil occupies 5- to 20-acre knolls and hillsides. Slopes are 70 to 150 feet long. This soil has a profile similar to the one described for the series, but it has a brighter colored subsoil.

Included with this soil in mapping are areas where slopes are less than 2 percent or more than 6 percent and small areas where slopes are 6 to 12 percent. Also included are Waldorf soils in concave areas and in down slope drainageways. Small areas that have a thicker surface layer at the base of the slope and small eroded areas are also included.

Erosion is a hazard if this soil is used for row crops. Runoff is medium; it is concentrated in drainageways and not over the entire face of slopes. The hazard of erosion is greatest on the upper part of slopes, in adjacent areas of ravines, and on complex slopes.

Most areas of this soil are used for corn and soybeans. Urban and recreational uses are limited mainly by the high clay content and shrink-swell potential. Capability unit IIe–3.

96C—Collinwood silty clay loam, 6 to 12 percent slopes. This sloping, well drained soil occupies 5- to 20-acre knolls and side slopes. Slopes are 70 to 200 feet long. This soil has a profile similar to the one described for the series, but it has a brighter colored subsoil and thinner layers.

Included with this soil in mapping are areas where slopes are less than 6 percent or more than 12 percent. Also included are areas of Waldorf soils on concave slopes and down slope drainageways; these areas are too small to be mapped separately. Small areas of soils that have a thicker surface layer are at the base of the slope.

Runoff is medium; it is concentrated in drainageways and not over the entire face of slopes. Conservation practices are needed to reduce the hazard of erosion if the soil is used for row crops. The hazard of erosion is greatest on the upper part of slopes in nearby adjacent areas of drainageways, and on convex knolls.

Most areas of this soil are used for corn and soybeans. Urban and recreational uses are limited by the slope, high clay content, and shrink-swell potential. Capability unit IIIe–1.

96D—Collinwood silty clay loam, 12 to 18 percent slopes. This moderately steep, well drained soil occupies 5- to 20-acre knolls and side slopes. Slopes are convex and concave and are about 75 to 250 feet long. This soil has a profile similar to the one described for the series, but it has a brighter colored subsoil and thinner layers.

Included with this soil in mapping are areas where slopes are less than 12 percent or more than 18 percent and some moderately eroded areas. Also included are areas of Truman and Bold soils on steeper, convex slopes; these areas are too small to be mapped separately. Small areas of soils that have a thicker surface layer are at the base of the slope.

Runoff is rapid. It is concentrated in drainageways and not over the entire face of slopes. The hazard of erosion is greatest on the upper part of slopes, in nearby adjacent areas of drainageways, and on convex knolls. Conservation practices are needed to reduce the hazard of erosion if this soil is used for row crops.

Most areas of this soil are cropped. Some are used for pasture. Slope is the main limitation for most urban and recreational uses. Capability unit IVe–1.

Comfrey Series

The Comfrey series consists of deep, poorly drained, nearly level soils. These soils formed in recent medium textured and moderately fine textured alluvium on nearly level stream flood plains. Native vegetation was aquatic grasses, sedges, and willow trees.

In a representative profile the surface layer is black friable clay loam and loam about 34 inches thick. The underlying material is mottled dark grayish brown, very dark gray, and olive friable loam.

Permeability is moderate. Available water capacity, natural fertility, and organic-matter content are high. Runoff is slow. The depth to the seasonal high water table ranges from 1 to 3 feet, or near tile depth. The soils are subject to flooding.

Comfrey soils are suited to all crops commonly grown in the county if they are protected from flooding and are adequately drained. Areas that are frequently flooded are used mainly for pasture and wild hay.

Representative profile of Comfrey clay loam in cultivated field 1,980 feet east and 1,050 feet south of northwest corner sec. 14, T. 105 N., R. 27 W.

Ap—0 to 9 inches, black (10YR 2/1) light clay loam, dark gray (10YR 4/1) dry; weak very fine subangular blocky structure; friable; few clean sand grains; neutral; abrupt smooth boundary.

A12—9 to 16 inches, black (10YR 2/1) light clay loam, very dark gray (10YR 3/1) dry; moderate fine and medium subangular blocky structure; friable; few clean sand grains; neutral; clear smooth boundary.

A13—16 to 26 inches, black (10YR 2/1) loam, very dark gray (10YR 3/1) crushed; moderate medium and coarse subangular blocky structure breaking to moderate fine subangular blocky; friable; few clean sand grains; neutral; clear smooth boundary.

A14—26 to 34 inches, black (10YR 2/1) with common inclusions of very dark grayish brown (2.5Y 3/2) loam; moderate medium and coarse subangular blocky structure breaking to moderate fine subangular blocky; friable; neutral; gradual smooth boundary.

C1g—34 to 39 inches, dark grayish brown (2.5Y 4/2) with common inclusions of very dark gray (5Y 3/1) loam; few fine distinct light olive brown (2.5Y 5/6) mottles; weak very fine and fine subangular blocky structure; friable; neutral; clear smooth boundary.

C2g—39 to 60 inches, olive (5Y 5/3) loam; common medium distinct dark yellowish brown (10YR 4/4) mottles; weak very fine and fine subangular blocky structure; friable; slightly effervescent; mildly alkaline.

The solum is neutral to mildly alkaline throughout. The A horizon is typically clay loam but ranges to silty clay loam or loam. It is black, very dark gray, or dark gray and ranges from 24 to 36 inches in thickness. The C horizon typically is loam, but the range includes clay loam, silty clay loam, or silt loam that is high in content of sand. Depth to light olive brown mottles and lime carbonates commonly is 39 inches but ranges from 18 to 46 inches. Sandy layers are common in the underlying material.

Comfrey soils are commonly associated with Calco, Oshawa, Chaska, and Dorchester soils because they formed on the same landscape of stream bottom land that is subject to flooding. Comfrey soils are better drained than Oshawa soils and they lack lime in the solum. They are in positions similar to those of Chaska soils, but they differ in having a clay loam surface layer and little or no stratification in the profile, and they lack lime in the solum. Comfrey soils are wetter than the Dorchester soil. They are nonlimy and have less silt and more sand than the Calco soil.

18—Comfrey clay loam. This nearly level soil is mainly on flood plains. Some areas are in abandoned stream channels on the higher river terraces and are subject to flooding by runoff from nearby uplands. Most areas flood early in spring and after heavy rains. Generally this soil occurs in long, narrow, meandering strips which once were stream channels. This soil has the profile described for the series. Slopes are 0 to 2 percent.

Included with the soil in mapping are small areas of Calco and Chaska soils. Alkaline spots and seep or marshy areas are common and are identified by spot symbols on the soil map. Also included is a large area of Comfrey soil which is not subject to flooding. This area is on a high river terrace near St. Clair in sections 6, 7, and 8.

If protected from flooding and adequately drained, this soil is suited to all row crops commonly grown in the county. It has poor potential for recreational and urban developments because of flooding and wetness. Capability unit IIw–6.

353—Comfrey clay loam, frequently flooded. This nearly level soil is on flood plains which are subject to frequent flooding. The water table is constantly at a depth of less than 2 feet, and the surface is generally "boggy." Slopes are 0 to 2 percent.

Included with this soil in mapping are small areas of Chaska, Caron, Oshawa, and Calco soils. Marsh is common in this area and is identified by spot symbols on the soil map.

Most areas of this soil are idle or used as native pasture or wild hay. This soil has very poor potential for urban and recreational uses because of the flood hazard. Capability unit VIw–1.

Copaston Series

The Copaston series consists of nearly level to gently undulating, well drained soils that formed in 8 to 20 inches of medium textured sediments over limestone bedrock. These soils occupy broad flats having closed, braided stream patterns on the bedrock terraces and escarpments. Native vegetation was mixed tall grass prairie and deciduous trees.

In a representative profile the surface layer is black and very dark grayish brown friable loam about 10 inches thick. The subsoil is dark brown friable sandy loam about 9 inches thick. A thin layer of gravelly sandy loam commonly lies above the bedrock. The underlying material is fractured limestone bedrock.

Permeability is moderate. Available water capacity is low to very low. Organic-matter content is moderate, and natural fertility is medium.

Some areas of Copaston soils are cropland, some areas remain woodland or permanent pasture, and a few are used for urban development. All uses are limited by bedrock at shallow depths.

Representative profile of Copaston loam, 1 to 4 percent slopes, in cultivated area about 2,600 feet north and 100 feet east of southwest corner sec. 2, T. 108 N., R. 28 W.

A1—0 to 8 inches, black (10YR 2/1) loam; weak very fine and fine subangular blocky structure; friable; about 2 percent coarse fragments; neutral; clear smooth boundary.

A3—8 to 10 inches, very dark grayish brown (10YR 3/2) loam; weak very fine and fine subangular blocky structure; friable; about 2 percent coarse fragments; medium acid; clear wavy boundary.

B2—10 to 17 inches, dark brown (10YR 3/3) sandy loam, very dark grayish brown (10YR 3/2) coatings on peds; weak fine subangular blocky structure; friable; about 10 percent coarse fragments; slightly acid; abrupt wavy boundary.

B3—17 to 19 inches, dark brown (10YR 3/3) gravelly sandy loam; weak medium subangular blocky structure; friable; about 25 percent coarse fragments; neutral; calcareous in spots; abrupt smooth boundary.

R—19 inches plus, fractured limestone bedrock.

Depth to the R horizon ranges from 8 to 20 inches. Thickness of the Ap and A1 horizons ranges from 7 to 14 inches. Reaction is neutral or slightly acid to medium acid. The A3 horizon is very dark grayish brown or dark brown and is 0 to 6 inches thick. Reaction is slightly acid or medium acid. Thickness of the B2 horizon is 3 to 15 inches. A few thin clay films are on faces of peds in the B2 horizon in places. Reaction is slightly acid or medium acid. A B3 horizon, as much as 10 inches thick, is in some profiles. The R horizon is level bedded limestone that has been irregularly eroded by glacial melt waters. This irregularity causes wide variations in solum thickness within short lateral distances.

Copaston soils are mapped in association with Tilfer and Joliet soils. They contain more sand in the solum and are better drained than Joliet soils. They are better drained and shallower over bedrock than Tilfer soils. Copaston soils are similar to Wadena soils but are underlain at shallow depths by limestone bedrock rather than by sand and gravel.

100—Copaston loam, 1 to 4 percent slopes. This nearly level to gently undulating soil occupies areas on rock terraces along the Minnesota River near Judson and Mankato. It has the profile described for the series. Relief consists of irregular convex and concave slopes of an undeveloped braided stream pattern.

Included with this soil in mapping are a few areas where limestone bedrock outcrops. These areas are identified by spot symbols on the soil map. Moderately well drained soils in swales that are similar to Copaston soils are also included. Also, some areas of Joliet soil in small swales and depressions are included. In places variable-sized boulders and stones are on the surface. In a few places the surface layer is light sandy loam or loamy sand.

This is a moderately droughty soil. Runoff is medium. There is a slight hazard of soil blowing.

Some areas of this soil are in crops, but the thin soil layer and the rock outcrops interfere with tillage. Other areas are in pasture or woods. This soil is poorly suited to urban use because of the difficulty in excavating areas that are shallow to rock. It is well suited to recreational use. Capability unit IIIs–2.

440—Copaston loam, very shallow, 1 to 4 percent slopes. This nearly level to gently undulating soil is in broad areas of bedrock-controlled terraces along the Minnesota River. The profile differs from the one described for the series because it is 8 to 12 inches deep over fractured limestone bedrock. The underlying bedrock is nearly level to gently undulating. Occasional boulders of granite are present.

Included with this soil in mapping are small areas of the very poorly drained Joliet soil in swales or draws. Also included are small areas of the deeper Copaston soil, which is in areas where the surface of the underlying bedrock is concave, and limestone outcrops which occupy as much as 10 percent of the soil in places. Limestone outcrops mainly occur where the undulating bedrock has a low, convex slope.

This is a very droughty soil. Runoff is medium into the closed swales. The fractured limestone drains most of the swales quickly.

Some areas of this soil are in crops, but the thin surface layer and rock outcrops interfere with tillage. Other areas are in pasture and woods. This soil is poorly suited to urban use because of the difficulty in

***Figure 5.*—Typical example of Copaston-Rock outcrop complex.**

excavating areas that are shallow to rock. It is moderately suited to recreational use. Capability unit IVs–2.

923—Copaston-Rock outcrop complex, 1 to 4 percent slopes. This nearly level to gently undulating map unit is in broad areas of bedrock-controlled terraces along the Minnesota River. The underlying bedrock is nearly level to gently undulating. The unit is about 55 percent Copaston loam, 35 percent Rock outcrop, and 10 percent other soils. The Copaston soil is in areas where the underlying bedrock is concave. Rock outcrop is in areas where the underlying bedrock is convex. Granite boulders 2 to 4 feet in diameter are common.

Included with this unit in mapping are areas of soils that are thicker than 20 inches. Also included are chimney-shaped outcrops of bedrock formed by erosion of overlying layers of limestone and sandstone bedrock (fig. 5). These chimney-shaped outcrops are in sections 19 and 30 of Lime Township, locally called "Valley of the Gods."

This unit is very droughty and is not suited to crops. Boulders and bedrock outcrops limit the normal tillage to very light machinery or hand tools. Runoff is medium into the closed swales and depressions. The fractured limestone drains most of the swales very quickly.

This unit is used mainly for pasture. It has special esthetic value for parks and recreation. It is poorly suited to urban and recreational uses because of the difficulty in excavating areas that are shallow to rock. Copaston loam in capability unit IIIs–2.

853—Copaston-Urban land bouldery complex, 1 to 4 percent slopes. This nearly level to gently undulating map unit is in broad areas of bedrock-controlled terraces along the Minnesota River. The dominant relief is a closed, braided, stream pattern with swales and depressions. Boulders as much as 4 feet in diameter occur in the Copaston soil and on the surface layer. The Urban land is where the soil material and rock have been excavated for foundations, basements, or roads and back-filled with other soil material.

Included with this unit in mapping are soils that are deeper than 20 inches to fractured limestone bedrock. Also included are small areas of the poorly drained Joliet soil in wet swales and depressions.

This unit is droughty. Runoff is medium into the closed swales and depressions. Limestone bedrock, which is fractured horizontally and vertically, drains most of them quickly.

This unit is used for urban and industrial development. It is limited, however, because of the difficulty in excavating and installing community services such as water and sewers in areas that are shallow to bedrock. Runoff is high from roofs, roads, and other paved surfaces covering much of this unit. Not assigned to a capability group.

852—Copaston-Urban land complex, 1 to 4 percent slopes. This map unit is on the bedrock-controlled terraces along the Minnesota River. The dominant relief is a closed, braided, stream pattern with the very poorly drained Joliet soil in some swales and the deeper Copaston soils in others. The profile of the Copaston soil differs from the one described for the series because it is only 8 to 12 inches deep to fractured limestone bedrock. The Urban land is where the soil material and rock have been excavated for foundations, basements, or roads and back-filled with other soil material.

This unit is droughty. Runoff is medium into the closed swales. Limestone rock, which is fractured horizontally and vertically, drains most of the swales quickly.

This unit is used for urban and industrial development. It is very severely limited because of the difficulty in excavating the rock for installing community services such as water and sewers in areas that are shallow to bedrock.

Runoff is high from roofs, roads, and other paved surfaces covering much of this unit. Not assigned to a capability group.

Cordova Series

The Cordova series consists of nearly level, poorly drained soils that formed in medium textured glacial till. These soils occupy flats and drainageways on uplands. Native vegetation was a mixed wet site community of tall grass prairie and deciduous trees.

In a representative profile the surface layer is black clay loam about 13 inches thick. The subsoil is firm clay loam about 19 inches thick. The upper part of the subsoil is very dark gray and the middle and lower parts are mottled olive gray. The underlying material is limy, mottled olive gray and olive brown friable loam.

Permeability is moderately slow. The seasonal high water table is at a depth of 1 to 3 feet, or near tile depth. Available water capacity, organic-matter content, and natural fertility are high.

Most areas of Cordova soils are cropland. In their natural state, the soils are only moderately well suited to poorly suited to most crops. If adequately drained, they are well suited to most crops.

Representative profile of Cordova clay loam in forested area, 100 feet west and 1,850 feet south of northeast corner sec. 9, T. 108 N., R. 26 W.

A1—0 to 9 inches, black (N 2/0) clay loam; moderate very fine subangular blocky structure; friable; common roots; neutral; clear smooth boundary.

A3—9 to 13 inches, black (N 2/0) clay loam; moderate and strong very fine subangular and angular blocky structure; friable; common roots; neutral; clear smooth boundary.

B21t—13 to 20 inches, very dark gray (10YR 3/1) clay loam; weak and moderate fine and medium prismatic structure parting to moderate and strong fine and very fine subangular and angular blocky; firm; many thin black (10YR 2/1) clay films on faces of peds; few thin patchy coatings of clean sand and silt particles on faces of peds; neutral; clear smooth boundary.

B22tg—20 to 27 inches, olive gray (5YR 4/2) clay loam; few fine faint very dark grayish brown (2.5Y 3/2) mottles; weak and moderate fine and medium prismatic structure parting to moderate and strong subangular and angular blocky; firm; many thin and medium very dark gray (10YR 3/1) and black (10YR 2/1) clay films on faces of peds; about 5 percent coarse fragments; neutral; clear smooth boundary.

B3tg—27 to 32 inches, olive gray (5Y 5/2) clay loam; common fine distinct light olive brown (2.5Y 5/4) mottles; weak fine and medium prismatic structure parting to weak fine and medium subangular blocky; friable; few thin very dark gray (10YR 3/1) clay films on faces of peds and few thick clay films in pores and root channels; few soft lime masses; about 5 percent coarse fragments; neutral; clear smooth boundary.

C1g—32 to 40 inches, olive gray (5Y 4/2) loam; common fine distinct light olive brown (2.5Y 5/6 and 5/4) and common fine distinct yellowish brown (10YR 5/6) mottles; weak coarse prismatic structure parting to weak fine subangular and angular blocky; friable; few black (10YR 2/1) clay films in old root channels; about 5 percent coarse fragments; about 5 percent soft lime masses; slightly effervescent; moderately alkaline; clear smooth boundary.

C2g—40 to 60 inches, olive brown (2.5Y 4/4) and light olive brown (2.5Y 5/4) loam; common fine and medium distinct dark gray (5Y 4/1) mottles; weak fine angular and subangular blocky structure; friable; yellowish orange iron stains; common fine seams of gray (5Y 6/1) segregated lime; about 5 percent coarse fragments; about 5 percent soft lime masses; strongly effervescent; moderately alkaline.

Solum thickness and depth to carbonate range from 24 to 48 inches.

The A horizon is commonly 10 to 16 inches thick, but it ranges from 10 to 24 inches. Typically it is clay loam, but the range includes silty clay loam, and some profiles are silt loam or loam. Reaction ranges from neutral to slightly acid. Some profiles have a thin, discontinuous A2 horizon.

The upper part of the B horizon is typically clay loam that is 30 to 40 percent clay, but the range includes silty clay loam. The lower part is clay loam or loam that is 20 to 32 percent clay. Distinct or prominent mottles are few or common throughout the B horizon. Clay films are present throughout this horizon and range from thin to thick and patchy to continuous.

The C horizon is heavy loam or light clay loam and is 22 to 30 percent clay. Distinct mottles are common to many. Black fillings in old root channels are in places. This horizon is 2 to 10 percent coarse fragments of mixed lithology. Reaction is mildly alkaline to moderately alkaline.

Cordova soils occupy topographic positions similar to those of Webster, Cannisteo, and Marna soils. Cordova, Canisteo, and Webster soils formed in similar material, but Cordova soils lack the limy profile characteristic of Canisteo soils, and they have more clay in the subsoil than Webster soils. Cordova soils are not so fine textured throughout as Marna soils.

109—Cordova clay loam. This nearly level soil occupies 3- to 60-acre broad flats on tops of circular hills that have smooth side slopes, or it is in upper drainageways within areas of Lester and Le Sueur soils. In a few places, this soil is associated with Kilkenny and Lerdal soils. This soil has the profile described for the series. Slopes are 0 to 2 percent.

Included with this soil in mapping are small areas of Glencoe and Rolfe soils in depressions and drainageways which are identified by spot symbols on the soil map. Also included are small areas of Canisteo soils on the rims of depressions or low gradient drainageways and some soils that have a silt loam surface layer.

This soil is wet. Runoff is slow. Drainage is needed for dependable cropland. Lime is needed to correct acidity and to help crops make the best use of fertilizers applied to the soil.

Most areas of this soil are cropland. This soil is poorly suited to most urban and recreational uses because of the seasonal high water table. Capability unit IIw–1.

854—Cordova-Urban land complex, 0 to 3 percent slopes. This nearly level map unit is on broad flats on tops of rounded, smooth sided hills or upper drainageways within areas of Lester and Le Sueur soils. The Urban land is where the Cordova soil has been excavated for foundations, basements, or roads and used for leveling or to fill depressions.

Included with this unit in mapping are small areas of Glencoe and Rolfe soils in depressions and drainageways. Some small areas of Canisteo soils are on the rims of drainageways and small areas of Le Sueur soils are on small, low convex knolls.

The depth to the seasonal high water table ranges from 1 to 3 feet in undrained areas. Wetness severely limits this unit for most urban and recreational uses. Artificial drainage is needed to overcome wetness, especially around the footings of basement walls. Runoff is high from roofs, roads, and other paved surfaces covering much of the unit. Not assigned to a capability group.

978—Cordova-Rolfe complex. This nearly level map unit is one of Cordova clay loam and Rolfe silt loam in 5- to 40-acre, nearly level areas and gentle rises. These soils are intermixed in such an intricate pattern that mapping them separately is not practical. The unit is 60 percent Cordova soil, 35 percent Rolfe soil, and 5 percent other soils. The Rolfe soil is in depressions and drainageways within areas of the Cordova soil. Slopes are 0 to 2 percent and are convex, plane, and concave.

Included with this unit in mapping within areas of Rolfe soil are small areas of Minnetonka, Cordova, and Glencoe soils and some areas of undrained soils that have a thin organic surface layer. Small areas of Webster and Le Sueur soils are within areas of Cordova soil.

Permeability is moderately slow in the Cordova soil and slow in the Rolfe soil. Runoff is slow on the Cordova soil and ponded on the Rolfe soil. Water table control and maintenance of tilth and high levels of fertility are the major management needs.

Drained areas of this unit are used mostly as cropland; undrained areas are used mostly for hay and permanent pasture. Drainage is needed for dependable production of present crops. French drains, surface tile inlets, or shallow surface ditches are needed to effectively drain the Rolfe soil in this unit. Lime to correct acidity is needed to help crops make best use of the fertilizer applied to the soil. The Rolfe part of the unit has a narrow range of optimum moisture for tillage. If worked when wet, it puddles easily, tilth is destroyed, aeration is reduced, and the soil becomes hard and cloddy when dry.

This unit is poorly suited to most urban and recreational uses because of the seasonal high water table. Cordova clay loam, capability unit IIw–1; Rolfe silt loam, capability unit IIIw–2.

Darfur Series

The Darfur series consists of nearly level, poorly drained soils on glacial lake plain deltas and outwash plains. These soils formed in loamy and sandy lacustrine or outwash sediments that are dominated by fine and very fine sand and are commonly stratified. Native vegetation was a wet site community of the tall grass prairie.

In a representative profile the surface layer is black, very dark gray, and very dark grayish brown loam about 19 inches thick. The subsoil is mottled dark grayish brown and grayish brown, very friable fine sandy loam about 12 inches thick. The underlying material is light olive gray and olive gray stratified loam and sand.

Runoff is slow. The depth to the seasonal high water table is 1 to 3 feet, or near tile depth. Permeability is moderate in the upper part and moderately rapid in the underlying loam and sand. The available water capacity is moderate. Organic-matter content and natural fertility are high.

If Darfur soils are adequately drained and managed, they are suited to crops. Most areas are used for this purpose.

Representative profile of Darfur loam 1,400 feet west and 500 feet south of northeast corner sec. 21, T. 107 N., R. 28 W.

Ap—0 to 9 inches, black (10YR 2/1) loam; weak very fine subangular blocky structure; friable; neutral; abrupt smooth boundary.

A12—9 to 14 inches, very dark gray (10YR 3/1) loam; weak very fine subangular blocky structure; friable; few channels of very dark grayish brown (10YR 3/2); neutral; clear irregular boundary.

A3—14 to 19 inches, very dark grayish brown

(10YR 3/2) loam; weak very fine subangular blocky structure; friable; few very dark gray (10YR 3/1) strata and tongues; neutral; clear irregular boundary.

B21g—19 to 22 inches, dark grayish brown (2.5Y 4/2) fine sandy loam; many fine faint grayish brown (2.5Y 5/2) and few fine distinct dark brown (7.5YR 3/2) mottles; weak very fine subangular blocky structure; very friable; few dark colored concretions, neutral; clear wavy boundary.

B22g—22 to 27 inches, grayish brown (2.5Y 5/2) fine sandy loam; many fine faint dark grayish brown (2.5Y 4/2) and a few fine distinct dark brown (7.5YR 3/2) mottles; weak very fine subangular blocky structure; very friable; few dark colored concretions, neutral; clear wavy boundary.

B23g—27 to 31 inches, grayish brown (2.5Y 5/2) fine sandy loam; many fine faint dark grayish brown (2.5Y 4/2), many medium distinct pale brown (10YR 6/3), and light brownish gray (10YR 6/2) mottles; weak very fine subangular blocky structure; very friable; few dark colored concretions; neutral; clear wavy boundary.

Cg—31 to 60 inches, light olive gray (5Y 6/2) with some olive gray (5Y 5/2) stratified fine sand, loamy fine sand, and fine sandy loam; common medium prominent brown (7.5YR 4/4) mottles, mostly in lower part; single grained; very friable and loose; few dark colored concretions; neutral.

Thickness of the solum ranges from 20 to 40 inches. Depth to free carbonates ranges from 20 to 70 inches. The A horizon is 14 to 24 inches thick. It is typically loam, but the range includes fine sandy loam, very fine sandy loam, or sandy clay loam. The B horizon is typically fine sandy loam, but the range includes loam, sandy clay loam, and loamy fine sand. The C horizon is typically stratified loam and sand. In places, a IIC horizon of loamy glacial till is as shallow as 40 inches. Mottles are present in the B and C horizons. The profile is slightly acid to mildly alkaline throughout. These soils lack coarse fragments.

Darfur soils are associated with Dassel, Fieldon, and Litchfield soils. They are less wet than Dassel soils but are wetter than Litchfield soils. In contrast with Fieldon soils, Darfur soils do not have free lime in the solum.

281—Darfur loam. This nearly level soil occupies 3- to 30-acre flats and few shallow drainageways on glacial lake plain deltas and in outwash areas. It has the profile described for the series. Slopes are 0 to 2 percent.

Included with this soil in mapping are a few, small depressional areas of Dassel soils and an area underlain by gravel on a stream terrace along Perch Creek in sections 7 and 18 in Pleasant Mound Township. Also included are areas of Granby and Fieldon soils which are identified by spot symbols on the soil map; areas of soils that have in the underlying sandy material small pockets or thin strata of acid fine sand that is stained or cemented by iron oxides; and some slopes that are more than 2 percent. Some areas of finer textured soils and soils that have a surface layer more than 24 inches thick are also included.

This is a naturally wet soil and tile drainage is needed for crops. During prolonged periods of dryness, this soil becomes droughty. The sandy substratum causes caving of ditch banks and filling of tile lines. Blinding the tile before backfilling tile trenches or using plastic tile reduces the movement of sand into the tile lines. Acid-resistant clay tile or plastic tile must be used where acid, iron oxide stained, or iron cemented sands are observed. Soil blowing is a hazard in areas left bare during winter and spring.

Most of these areas are used for corn and soybeans. This soil is poorly suited to most urban and recreational uses because of wetness. Capability unit IIw–4.

926—Darfur-Webster loams. This nearly level map unit is one of poorly drained soils on upland flats and drainageways. It occupies irregularly shaped 5- to 20-acre tracts. It is about 70 percent Darfur loam, 25 percent Webster silty clay loam, and 5 percent other soils. The profile of Darfur soils differs from the one described for the series in having loamy material between depths of 40 and 72 inches, and that of the Webster soils differs from the one described for the series in having a higher sand content in the surface layer. Slopes are 0 to 2 percent.

Included with this unit in mapping are small areas that have sandy material more than 72 inches thick or less than 40 inches thick. Also included are small areas of moderately well drained Litchfield and Nicollet soils on the low convex slopes, and areas of poorly drained Canisteo soils and very poorly drained depressional Dassel and Glencoe soils.

All the crops commonly grown in the county are grown on the soils of this unit. Wetness is a limitation, and drainage is needed to provide a deep root zone for most crops. Soil blowing is a hazard on bare fields in winter and spring. Management is needed to maintain organic-matter content and fertility. This unit is poorly suited to most urban and recreational uses because of wetness. Darfur loam, capability unit IIw–4; Webster loam, capability unit IIw–1.

Dassel Series

The Dassel series consists of very poorly drained soils in depressions on glacial lake plain deltas and outwash plains. The slopes are typically concave and have gradients less than 1 percent. The soils formed on a gently rolling ground moraine in stratified outwash material typically more than 60 inches thick over glacial till. Native vegetation was reeds, sedges, and pussy willows.

In a representative profile the surface layer is black and very dark gray friable loam about 24 inches thick. The subsoil is about 14 inches thick. The upper part is light olive gray friable loam 7 inches thick. The lower part is gray and olive gray fine sand with a thin stratum of loam. The underlying material is olive gray fine sand. The subsoil and underlying material are limy.

The seasonal high water table is at a depth of less than 1 foot, or near tile depth. Permeability is moderate in the upper part and moderately rapid in the lower part. The available water capacity is moderate. Organic-matter content and natural fertility are high.

If Dassel soils are adequately drained, they are suited to crops.

Representative profile of Dassel loam 2,450 feet west and 250 feet north of southeast corner sec. 23, T. 107 N., R. 29 W.

Ap—0 to 9 inches, black (N 2/0) loam that is high in content of organic matter; moderate very fine subangular blocky structure; friable; neutral; abrupt smooth boundary.

A12—9 to 19 inches, black (N 2/0) loam; moderate very fine subangular blocky structure; friable; neutral; clear irregular boundary.

A3—19 to 24 inches, very dark gray (10YR 3/1) loam; few fine distinct dark brown (7.5YR 4/4) mottles and coatings along root channels; weak very fine and fine subangular blocky structure; friable; few dark concretions; few gray (10YR 6/1) and light brownish gray (10YR 6/2) krotovinas; slightly effervescent; mildly alkaline; clear irregular boundary.

B21g—24 to 31 inches, light olive gray (5Y 6/2) loam; many coarse prominent yellowish brown (10YR 5/4) mottles; weak fine and very fine subangular blocky structure; friable; many soft secondary lime masses; slightly effervescent; mildly alkaline; clear wavy boundary.

B22g—31 to 36 inches, gray (5Y 5/1) and olive gray (5Y 5/2) fine sand; common coarse distinct light olive brown (2.5Y 5/4) mottles; single grained; loose; slightly effervescent; mildly alkaline; abrupt smooth boundary.

IIIB23g—36 to 38 inches, gray (5Y 5/1) loam; moderate fine and medium subangular blocky structure; friable; slightly effervescent; mildly alkaline; abrupt smooth boundary.

IVC—38 to 60 inches, olive gray (5Y 5/2) fine sand; common fine distinct yellowish brown (10YR 5/8) mottles and yellowish red (5YR 5/6) iron pipes; single grained; loose; strongly effervescent; mildly alkaline.

Thickness of the solum and depth to lime range from 22 to 44 inches. The A horizon is 16 to 24 inches thick. It is typically loam, but the range includes fine sandy loam or sandy loam. Chroma ranges from 0 to 2. The B horizon is stratified. It is mostly loam, fine sandy loam, or sandy loam in the upper part and fine sand, loamy fine sand, fine sandy loam, and loam in the lower part. The C horizon typically is fine sand, but it commonly is stratified with sand and loam.

Dassel soils are associated with Darfur and Fieldon soils. They are wetter and occupy lower positions on the landscape than those soils.

183—Dassel loam. This very poorly drained soil occupies 3- to 15-acre depressions and swales on glacial lake plain deltas and in outwash areas. It has the profile described for the series.

Included with this soil in mapping are a few areas of the better drained Darfur soils and the limy Fieldon soils. Also included are some areas which lack stratification in the subsoil or underlying material and a few areas of soils that have in the underlying sandy material pockets or strata of acid fine sand that is stained or cemented by iron oxide. A few limy areas are identified by spot symbols on the soil map.

This is a naturally wet soil. Tile drainage is needed for crops. The sandy underlying material causes caving of ditch banks and filling of tile lines. Blinding the tile before backfilling tile trenches or using plastic tile reduces the movement of sand into the tile lines. Acid-resistant clay tile or plastic tile must be used where acid, iron oxide stained, or iron cemented sands are observed. During prolonged periods of dryness, this soil becomes droughty.

Most areas of this soil are in crops. The soil is poorly suited to most urban and recreational uses because of wetness. Capability unit IIIw-3.

Dickinson Series

The Dickinson series consists of well drained, nearly level to gently sloping soils on lake plains and stream deltas and in outwash areas. These soils formed in glacial outwash consisting of a 24- to 42-inch thick medium textured mantle over coarse textured sediments. Native vegetation was tall grass prairie.

In a representative profile the surface layer is very dark brown fine sandy loam about 11 inches thick. The subsoil is very dark grayish brown, dark yellowish brown, and dark brown fine sandy loam and loamy fine sand about 24 inches thick. The underlying material is light yellowish brown fine sand.

Dickinson soils have moderate available water capacity. Organic-matter content is moderate. Natural fertility is medium. Permeability is moderately rapid. The seasonal high water table is at a depth below 6 feet.

Most areas of Dickinson soils are used for crops. The moderate available water capacity and hazard of soil blowing are the major limitations for farming.

Representative profile of Dickinson fine sandy loam, 2 to 6 percent slopes, in cultivated area 2,440 feet west and 2,050 feet south of northeast corner sec. 23, T. 107 N., R. 28 W.

Ap—0 to 11 inches, very dark brown (10YR 2/2) fine sandy loam; weak fine and very fine subangular blocky structure; very friable; medium acid; abrupt smooth boundary.

B1—11 to 18 inches, very dark grayish brown (10YR 3/2) fine sandy loam; weak fine and very fine subangular blocky structure; very friable; medium acid; clear smooth boundary.

B21—18 to 24 inches, dark yellowish brown (10YR 3/4) fine sandy loam, very dark grayish brown (10YR 3/2) coatings on faces of peds; weak medium and coarse subangular blocky structure; very friable; slightly acid; clear smooth boundary.

B22—24 to 35 inches, dark brown (10YR 4/3) loamy fine sand, dark yellowish brown (10YR 3/4) coatings on faces of peds; moderate fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

C—35 to 60 inches, light yellowish brown (10YR 6/4) fine sand; single grained; loose; slightly acid.

The A horizon ranges from very dark brown to very dark gray and very dark grayish brown. It is typically fine sandy loam, but the range includes sandy loam or loam. Thickness ranges from 10 to 20 inches. Reaction is medium acid to neutral. The B horizon ranges from dark brown and brown to yellowish brown. It is sandy loam to fine sandy loam in the upper part and fine sandy loam to loamy fine sand in the lower part. Thickness ranges from 10 to 30 inches. Reaction is medium acid or slightly acid. The C horizon ranges from brown and yellowish brown to light yellowish brown. It is typically fine sand or sand. Reaction is medium acid to slightly acid.

Dickinson soils are associated with Estherville, Wadena, Litchfield, and Darfur soils. They are similar to Estherville soils, but they have more and finer sand in the solum and lack gravel. They lack the finer textured subsoil, contain less coarse sand in the underlying material, and are more deeply leached of carbonates than the Wadena soils. Dickinson soils are better drained than the moderately well drained Litchfield soils. They are better drained than the poorly drained Darfur soils, which are in drainageways and depressions.

27—Dickinson fine sandy loam, 0 to 2 percent slopes. This nearly level soil occupies 10- to 50-acre areas in the glacial lake delta and on high river terraces. Slopes are mostly slightly convex. The profile is similar to the one described for the series, but it has a thicker surface layer.

Included with this soil in mapping are areas of soils that are similar to the Dickinson soils, except they are underlain by loamy till at a depth of 45 to 60 inches. Also included are small areas of Wadena, Litchfield, and Darfur soils; eroded areas; small areas of soils that have a loam surface layer and 2 to 6 percent slopes; and soils which have more clay in the subsoil than this Dickinson soil. Rodent burrowings are common in the surface layer.

This soil has a moderate hazard of soil blowing if it is unprotected in spring. Organic-matter content is moderate. Runoff is slow. Droughtiness, medium fertility, and erosion control are the main management concerns.

This soil is used mainly for row crops, although a few areas are in hay. It is better suited to early-maturing crops because of the limited amount of available moisture. This soil is well suited to most urban and recreational uses. There is a severe danger of contamination of ground water sources if the soil is used as a septic tank filter field. Capability unit IIs–1.

27B—Dickinson fine sandy loam, 2 to 6 percent slopes. This gently sloping soil occupies 10- to 50-acre circular hilltops, knolls, and river terraces. Slopes are mostly convex. This soil has the profile described for the series.

Included with this soil in mapping are areas of soils that are similar to the Dickinson soils, except they are underlain by loamy till at a depth of 45 to 60 inches. Also included are small areas of Wadena, Litchfield, and Darfur soils; eroded areas; and small areas of soils that have a loam surface layer and 0 to 2 percent slopes. Slopes more than 6 percent are identified by spot symbols on the soil map. Also included are soils that have a thinner dark surface layer and more clay in the subsoil than this Dickinson soil. Rodent burrowings are common in the surface layer.

This soil has a moderate hazard of erosion if it is cultivated and a moderate hazard of soil blowing if it is unprotected in spring. Organic-matter content is moderate. Runoff is medium. Droughtiness, medium fertility, and erosion control are the main management concerns.

This soil is used mostly for row crops, although a few areas are in hay. It is better suited to early-maturing crops because of the limited amount of available moisture. If cultivated crops are grown, erosion control is needed. This soil is well suited to most urban and recreational uses. There is a severe danger of contamination of ground water sources if septic tank filter fields are placed in this soil. Capability unit IIe–4.

Dorchester Series

The Dorchester series consists of deep, nearly level, moderately well drained soils formed in medium textured recent alluvium. These soils are on flood plains of the Minnesota River and the Blue Earth River and its tributaries, on slight rises on the flood plain, and on the lower terraces in the river valleys. Native vegetation was tall grass prairie and bottom land deciduous trees.

In a representative profile the surface layer is black loam about 10 inches thick. The underlying material is limy, very dark grayish brown and grayish brown loam and silt loam. The buried surface layer of another soil is black and very dark grayish brown silt loam, loam, and silty clay loam and occurs at a depth of about 36 to 87 inches.

Permeability is moderate. The available water capacity, natural fertility, and organic-matter content are high. The seasonal high water table is at a depth of 3 to 5 feet. These soils are subject to rare to occasional flooding.

Most areas of Dorchester soils are used for crops and are well suited to corn or soybeans. A few areas are developed for urban use. The major limitation for use of this soil is the hazard of flooding.

Representative profile of Dorchester loam, 1 to 3 percent slopes in cultivated area 325 feet north and 50 feet west of southeast corner sec. 23, T. 108 N., R. 27 W.

Ap—0 to 10 inches, black (10YR 2/1) loam; weak fine subangular blocky structure; friable; slightly effervescent; mildly alkaline; clear smooth boundary.

C1—10 to 24 inches, stratified grayish brown (10YR 5/2) and very dark grayish brown (10YR 3/2) loam; weak fine platy structure; friable; stratified with loamy fine sand; slightly effervescent; mildly alkaline; clear smooth boundary.

C2—24 to 36 inches, stratified grayish brown (10YR 5/2) and very dark grayish brown (10YR 3/2) silt loam; weak fine platy structure; friable; stratified with loamy fine sand; slightly effervescent; mildly alkaline; clear smooth boundary.

A1b—36 to 46 inches, black (10YR 2/1) silt loam; weak fine granular structure; friable; mildly alkaline; clear smooth boundary.

A12b—46 to 61 inches, black (10YR 2/1) loam; moderate medium subangular blocky structure; friable; neutral; clear smooth boundary.

A13b—61 to 76 inches, very dark grayish brown (10YR 3/2) silty clay loam, dark yellowish brown (10YR 3/4) rubbed; weak fine subangular blocky structure; firm; neutral; clear smooth boundary.

A14b—76 to 87 inches, very dark grayish brown (10YR 3/2) loam; few fine faint dark yellowish brown (10YR 3/4) mottles; weak fine subangular blocky structure; friable; neutral.

The A horizon is typically loam, but the range includes silt loam. It is black to very dark grayish brown and is 8 to 14 inches thick. The C horizon is very dark grayish brown, dark grayish brown, and grayish brown. The A and C horizons are slightly alkaline to moderately alkaline. The buried A horizon is black, very dark grayish brown, and dark yellowish brown. It is neutral to mildly alkaline and begins at a depth of 30 to 45 inches.

These soils have more sand and less silt than the defined range for the series, but this difference does not alter the use and management of the soils.

Dorchester soils are associated with Comfrey, Chaska, Lomax, and Oshawa soils. Dorchester, Oshawa, and Chaska soils formed in similar material. Dorchester soils are better drained and are at higher elevations than the very poorly drained Oshawa soils and the poorly drained Chaska and Comfrey soils. They are not so well drained as Lomax soils and are on lower flood plains or terraces than those soils.

451—Dorchester loam, 1 to 3 percent slopes. This nearly level soil is on flood plains and the lower stream terraces along the Minnesota River and the Blue Earth River and its tributaries. The areas are 3 to 100 acres in size and irregular in shape. This soil has the profile described for the series.

Included with this soil in mapping are small areas of Comfrey and Lomax soils. The Comfrey soil is in poorly drained, old stream channels or nearly level bottom lands; the Lomax soil is on well drained remnants of older flood plains. Also included are small areas of sandy alluvium and areas that are dissected by old stream channels.

Runoff is slow. The hazard of erosion is slight. The main concerns of management are the slight hazard of rare, but brief, flooding in spring and the high levels of free lime which affect the efficient use of fertilizer.

This soil is well suited to crops commonly grown in the county. Because of the hazard of rare flooding, this soil is well suited to recreational development but poorly suited to urban development unless it is protected by dikes. Capability unit I–1.

354—Dorchester loam, occasionally flooded. This nearly level soil is on rises of flood plains along the Minnesota River. It is occasionally flooded. These areas are 5 to 40 acres in size and irregular in shape. Slopes are 1 to 3 percent.

Included with this soil in mapping are small areas of poorly drained Chaska and Comfrey soils. Also included are small areas of sandy alluvium and areas that are dissected by old stream channels.

Runoff is slow. The hazard of erosion is slight. The main concern of management is occasional flooding early in spring and periods of heavy, prolonged rainfall.

Most areas of this soil are well suited to crops commonly grown in the county, especially corn or soybeans. The hazard of flooding is the main limitation for most recreational and urban developments. Capability unit IIw–6.

855—Dorchester-Urban land complex, 1 to 3 percent slopes. This nearly level map unit is on rises of flood plains along the Minnesota River which are protected by dikes from flooding and scouring. The Urban land is where the Dorchester soil has been excavated for foundations, basements, or roads and spread on the ground's surface or used to fill in the depressions.

Included with this unit in mapping are small areas of Comfrey soils in the old stream channels and Lomax soils on the higher ground. Also included are small areas of Alluvial land.

This unit is used for urban and industrial development. Runoff is high from roofs, roads, and other paved surfaces which cover much of the surface area of this unit. If the soils are protected from flooding, they have fair potential for most urban uses. Low strength and potential frost action are the main limitations. Not assigned to a capability group.

Estherville Series

The Estherville series consists of somewhat excessively drained, nearly level to moderately steep soils that formed in glacial outwash consisting of a moderately coarse textured mantle over sandy and gravelly sediments. These soils are on outwash plains and stream terraces. Native vegetation was tall grass prairie.

In a representative profile the surface layer is black and very dark gray sandy loam about 14 inches thick. The subsoil, about 8 inches thick, is very dark grayish brown sandy loam that grades to dark brown loamy coarse sand in the lower part. The upper part of the underlying material is dark brown coarse sand and gravel about 6 inches thick. The lower part is limy, grayish brown and brown coarse sand and gravel.

Estherville soils have low available water capacity. Natural fertility is low, and organic-matter content is moderate. Permeability is moderately rapid in the upper layers and rapid in the coarse substratum. The seasonal high water table is at a depth below 6 feet.

Estherville soils are generally suited to small-grain farming and early-maturing row crops. If irrigated, they are suited to late-maturing crops. Droughtiness, fertility, and soil blowing are the main management concerns.

Representative profile of Estherville sandy loam, 0 to 2 percent slopes, in a gravel pit 600 feet east and 1,450 feet north of southwest corner sec. 22, T. 109 N., R. 29 W.

Ap—0 to 7 inches, black (10YR 2/1) sandy loam; weak fine and medium subangular blocky structure; friable; slightly acid; clear smooth boundary.

A12—7 to 10 inches, black (10YR 2/1) sandy loam; weak fine and medium subangular blocky structure; friable; slightly acid; clear smooth boundary.

A3—10 to 14 inches, very dark gray (10YR 3/1) sandy loam; weak fine and medium subangular blocky structure; slightly acid; clear smooth boundary.

B2—14 to 20 inches, very dark grayish brown (10YR 3/2) sandy loam; weak fine subangular blocky structure; friable; medium acid; clear smooth boundary.

B3—20 to 22 inches, dark brown (10YR 3/3) loamy coarse sand; weak fine subangular blocky structure; very friable; medium acid; clear smooth boundary.

IIC1—22 to 28 inches, dark brown (10YR 4/3) gravelly coarse sand and gravel; single grained; loose; mildly alkaline; slightly effervescent; clear smooth boundary.

IIC2—28 to 60 inches, grayish brown (10YR 5/2) and brown (10YR 5/3) gravelly coarse sand and gravel; single grained; loose; mildly alkaline; slightly effervescent to strongly effervescent.

Solum thickness and depth to sand and gravel range from 15 to 24 inches. The A horizon is sandy loam to loam but typically is sandy loam. Reaction ranges from strongly acid to slightly acid. The B horizon is 8 to 20 inches thick. It ranges from sandy loam to coarse sandy loam in the upper part and loamy coarse sand or loamy sand in the lower part. Reaction is slightly acid to medium acid. The IIC horizon is loamy coarse sand, gravelly coarse sand, or stratified coarse sand and gravel. The upper few inches of this horizon is leached of carbonates in some profiles.

Estherville soils occur on the landscape with Dickinson and Wadena soils. They contain more gravel in the C horizon than Dickinson soils. They contain less clay and more sand in the solum than Wadena soils.

41—Estherville sandy loam, 0 to 2 percent slopes. This nearly level soil occupies 5- to 100-acre flats adjacent to other Estherville, Wadena, and Dickinson soils. Slopes are mostly convex or plane. This soil has the profile described for the series.

Included with this soil in mapping are small areas of Wadena and Dickinson soils which typically have 24 to 36 inches of loamy material over gravel and sand. Also included are a few areas where slopes are more than 2 percent; areas of a soil that has a thinner, dark surface layer; and areas that have accumulations of clay in the subsoil. Rodent burrowings are common in the surface layer.

Runoff is slow. The hazard of erosion is slight in cultivated areas. In spring there is a moderate hazard of soil blowing. Organic-matter content is moderate. Droughtiness, low natural fertility, and erosion control are the main management concerns.

This soil is used mainly for row crops and hay. If cultivated crops are grown, erosion control practices are needed. This soil is generally a fair to good source of sand and gravel, and some areas have been used for that purpose. Potential is good for most urban uses. There is a severe danger of contaminating ground water sources if septic tank filter fields are placed in this soil. Capability unit IIIs–1.

41B—Estherville sandy loam, 2 to 6 percent slopes. This gently sloping soil occupies 5- to 100-acre flats, circular hilltops, and knolls adjacent to other Estherville, Wadena, and Dickinson soils. Slopes are mostly convex. The profile is similar to the one described for the series, but the surface layer is thinner.

Included with this soil in mapping are small areas of Wadena and Dickinson soils which typically have 24 to 36 inches of loamy material over sand and gravel. Also included are a few areas where slopes are less than 2 percent or more than 6 percent. Areas of a soil that has a thin solum are identified by spot symbols on the soil map. Rodent burrowings are common in the surface layer.

Runoff is medium. The hazard of erosion is moderate in cultivated areas. In spring there is a moderate hazard of soil blowing. Organic-matter content is moderate. Droughtiness, low natural fertility, and erosion control are the main management concerns.

This soil is used mainly for row crops and hay. If cultivated crops are grown, erosion control practices are needed. This soil is generally a fair to good source of sand and gravel, and some areas have been used for that purpose. Potential is good for most urban and recreational uses. There is a severe danger of contaminating ground water sources if septic tank filter fields are placed in this soil. Capability unit IIIs–1.

41C—Estherville sandy loam, 6 to 18 percent slopes. This sloping to moderately steep soil occupies 3- to 30-acre circular hills, knolls, and side slopes adjacent to other Estherville, Wadena, and Dickinson soils. Slopes are mostly convex. The profile is similar to the one described for the series, but it is thinner.

Included with this soil in mapping are small areas of Wadena and Dickinson soils which typically have 24 to 36 inches of loamy material over sand and gravel. Also included are a few areas where slopes are less than 6 percent or more than 18 percent. Areas of a soil that has a thin solum are identified by a spot symbol on the soil map. Rodent burrowings are common in the surface layer.

Runoff is medium to rapid. The hazard of erosion is severe in cultivated areas. Organic-matter content is moderate. Droughtiness, low natural fertility, and erosion control are the main management concerns.

This soil is used mainly for row crops and hay. Erosion control practices are needed if row crops are grown. The soil is generally a fair to good source of sand and gravel, and some areas have been used for that purpose. This soil is well suited to most urban and recreational uses except for steepness. There is a severe danger of contaminating ground water sources if septic tank filter fields are placed in this soil. Capability unit VIs–1.

Fedji Series

The Fedji series consists of nearly level to gently sloping, somewhat excessively drained soils on ground moraines and on islands of ground moraines within outwash, valley trains, and deltas. These soils formed in a 20- to 40-inch thick mantle of sandy glacial outwash and underlying loamy glacial till. Slopes are concave and convex. The native vegetation was tall grass prairie.

In a representative profile the surface layer is very dark gray loamy fine sand about 10 inches thick. The upper part of the subsoil is dark brown and dark yellowish brown loamy fine sand about 14 inches thick. The lower part is dark yellowish brown loam 15 inches thick. The underlying material is limy, light olive brown loam.

These soils have moderate available water capacity. Organic-matter content is moderately low, and natural fertility is low. Permeability is moderate. The seasonal high water table is at a depth below 6 feet.

Fedji soils are used mainly for row crops. They are generally suited to all farm crops, but are better suited to early-maturing small grains.

Representative profile of Fedji loamy fine sand, 3 to 8 percent slopes, in cultivated field 720 feet east and 2,180 feet south of northwest corner sec. 31, T. 107 N., R. 28 W.

Ap—0 to 10 inches, very dark gray (10YR 3/1) loamy fine sand; weak fine granular structure; very friable; slightly acid; abrupt smooth boundary.

B1—10 to 15 inches, dark brown (10YR 3/3) loamy fine sand; weak fine granular structure; very friable; slightly acid; clear smooth boundary.

B21—15 to 21 inches, dark yellowish brown (10YR 4/4) loamy fine sand; weak fine granular structure; very friable; slightly acid; clear smooth boundary.

B22—21 to 24 inches, dark yellowish brown (10YR 4/4) loamy fine sand; weak fine subangular blocky structure; friable; about 5 percent coarse fragments; slightly acid; clear smooth boundary.

IIB3—24 to 39 inches, dark yellowish brown (10YR 4/4) loam; weak medium prismatic structure parting to weak fine subangular blocky; friable; about 5 percent coarse fragments; slightly acid; clear wavy boundary.

IIC—39 to 60 inches, light olive brown (2.5Y 5/4) loam; few fine prominent reddish brown (5YR 4/4) and many medium faint grayish brown (2.5Y 5/2) mottles; massive; friable; about 5 percent coarse fragments; mildly alkaline; strongly effervescent.

The thickness of the sandy mantle over loamy glacial till or silty lacustrine sediments ranges from 20 to 40 inches. The A horizon is 8 to 20 inches thick. It is typically loamy fine sand, but the range includes fine sandy loam and loamy sand. It is black, very dark brown to very dark gray, and very dark grayish brown. The B horizon is 10 to 30 inches thick. It is typically loamy fine sand, but the range includes sand, loamy sand, or fine sand. It is dark brown to dark yellowish brown. The IIB horizon is typically loam, but is silty clay loam or silt loam in a few places. The IIC horizon is typically loam, but the range includes silt loam or silty clay loam. It is olive gray to light olive brown. In most places this horizon contains few to many, faint to prominent mottles.

Fedji soils are associated with Clarion, Truman, Lasa, and Darfur soils. They have a sandy mantle, whereas Clarion and Truman soils are loamy throughout. Darfur soils are poorly drained soils in the surrounding flats and drainageways. Fedji soils are similar to Lasa soils but are underlain by loamy till rather than by stratified sandy sediments.

69—Fedji loamy fine sand, 1 to 3 percent slopes. This nearly level soil is in 2- to 40-acre tracts on outwash plains and stream deltas. The profile is similar to the one described for the series, but the surface layer is thicker.

Included with this soil in mapping are small areas that have short slopes of more than 3 percent. Also included are small areas of moderately well drained Litchfield soils. Small areas of Darfur soils are identified by spot symbols on the soil map. Rodent burrowings are common in the surface layer.

Runoff is slow. The main concerns of management are maintaining organic-matter content, conserving moisture, and controlling erosion.

This soil is used mainly for cultivated crops. However, the moderate available water capacity limits crop growth because of the lack of moisture during prolonged periods of dryness. This soil is susceptible to soil blowing in spring. It has good potential for most urban and recreational uses. Capability unit IIIs–1.

69B—Fedji loamy fine sand, 3 to 8 percent slopes. This gently sloping soil occupies 2- to 40-acre tracts on knolls and hilltops. Slopes are concave and convex. This soil has the profile described for the series.

Included with this soil in mapping are areas where slopes are less than 3 percent or more than 8 percent, which are identified by spot symbols on the soil map. Also included are small areas of moderately well drained Litchfield soils and deep, sandy Dickinson soils.

Runoff is slow to medium. Maintaining organic-matter content, conserving moisture, and controlling erosion are the major management concerns.

This soil is used mainly for cultivated crops. Crop growth is limited by the lack of moisture during prolonged periods of dryness because of the moderate available water capacity. This soil is susceptible to erosion and soil blowing in spring. Conservation practices are needed to reduce soil losses. The soil has good potential for most urban and recreational uses. Capability unit IVs–1.

Fieldon Series

The Fieldon series consists of nearly level, poorly drained, loamy soils on glacial lake plain deltas and outwash plains. These soils formed in loamy and sandy lacustrine or outwash sediments that are dominated by fine and very fine sand and are commonly stratified.

Native vegetation was a wet site community of the tall grass prairie.

In a representative profile the surface layer is black and very dark gray loam about 19 inches thick. The subsoil is mottled dark grayish brown, dark gray, and light olive brown friable very fine sandy loam about 18 inches thick. The underlying material is light olive brown and light olive gray stratified fine sand. The profile is limy throughout.

Permeability is moderate in the upper part and moderately rapid in the underlying stratified sandy material. The seasonal high water table is at a depth of 1 to 3 feet, or near tile depth. The available water capacity is moderate. Organic-matter content is high, and natural fertility is medium.

If Fieldon soils are adequately drained, they are suited to crops.

Representative profile of Fieldon loam in cultivated field 2,530 feet east and 1,030 feet north of southwest corner sec. 25, T. 107 N., R. 29 W.

Ap—0 to 9 inches, black (N 2/0) loam, very dark gray (10YR 3/1) dry; weak fine and medium subangular blocky structure; friable; few fine fragments of snail shells; strongly effervescent; mildly alkaline; abrupt smooth boundary.

A12—9 to 13 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) dry; few channel fillings of very dark gray (10YR 3/1); weak very fine and fine subangular blocky structure; friable; few fine fragments of snail shells; strongly effervescent; mildly alkaline; clear wavy boundary.

A3—13 to 19 inches, very dark gray (10YR 3/1) loam, gray (10YR 5/1) dry; weak medium subangular blocky structure; friable; few root and worm channel fillings of dark grayish brown (2.5Y 4/2); strongly effervescent; mildly alkaline; gradual wavy boundary.

B1g—19 to 23 inches, dark grayish brown (2.5Y 4/2) and dark gray (10YR 4/1) very fine sandy loam, gray (10YR 6/1) dry; common fine distinct light olive brown (2.5Y 5/4) mottles; weak medium subangular blocky structure; friable; few root and worm channels; strongly effervescent; mildly alkaline; clear wavy boundary.

B21g—23 to 33 inches, light olive brown (2.5Y 5/4) fine sandy loam, olive brown (2.5Y 4/4) rubbed; common fine faint light olive brown (2.5Y 5/6) and distinct fine yellowish brown (10YR 5/6) mottles; weak medium platy structure parting to weak medium subangular blocky; friable; strongly effervescent; mildly alkaline; clear wavy boundary.

B22g—33 to 37 inches, light olive brown (2.5Y 5/4) very fine sandy loam; common medium distinct strong brown (7.5YR 5/6) and few fine prominent black (5YR 2/1) mottles; weak medium platy structure parting to weak medium subangular blocky; friable; few 1- to 2-millimeter wide soft threads of lime, strongly effervescent; mildly alkaline; clear smooth boundary.

C1g—37 to 47 inches, light olive brown (2.5Y 5/4) fine sand; many medium prominent strong brown (7.5YR 5/6) and light brownish gray (2.5Y 6/2) and few fine prominent dark brown (7.5YR 4/2) mottles; very weak thick platy structure; loose; stratified with loamy fine sand; weakly effervescent; mildly alkaline; clear wavy boundary.

C2g—47 to 60 inches, light olive gray (5Y 6/2) fine sand; common medium prominent yellowish brown (10YR 5/6) and black (5YR 2/1) mottles; very weak thick platy structure; loose; stratified with loamy fine sand; weakly effervescent; mildly alkaline.

Thickness of the solum ranges from 20 to 40 inches. The A horizon is 14 to 24 inches thick. It is typically loam, but the range includes fine sandy loam, very fine sandy loam, or sandy clay loam. The B horizon is fine sandy loam, sandy clay loam, loamy fine sand, or loam. The C horizon is typically stratified with fine sand, loamy fine sand, and very fine sandy loam. Loamy glacial till is as shallow as 40 inches in some profiles. These soils lack coarse fragments.

Fieldon soils are associated with Darfur and Dassel soils. They are high in lime carbonates in the solum, whereas Darfur and Dassel soils are nonlimy.

160—Fieldon loam. This nearly level soil occupies 3- to 30-acre flats and slightly elevated rims of depressions on outwash plains and stream deltas. This soil has the profile described for the series. Slopes are 0 to 2 percent.

Included with this soil in mapping are a few small depressional areas of Dassel soils, which are identified by spot symbols on the soil map, and areas of nonlimy Darfur soils. Also included in the underlying sandy material are pockets or strata of acid fine sand that is stained or cemented by iron oxide. Some slopes are more than 2 percent.

This is a naturally wet soil and tile drainage is needed for use of this soil as cropland. During prolonged periods of dryness, this soil can become droughty. The sandy underlying material causes caving of ditch banks and filling of tile lines. Blinding of tile before backfilling the tile trenches or using plastic tile reduces movement of sand into the tile. Acid-resistant clay tile or plastic tile must be used where acid, iron oxide stained, or iron cemented sands are observed. Special fertility treatments are needed to offset the high lime conditions. Soil blowing is a hazard in areas that are left bare in winter and in spring.

Most of the acreage is in corn and soybeans. This soil is poorly suited to most urban and recreational uses because of wetness. Capability unit IIw–5.

929—Fieldon-Canisteo loams. This nearly level map unit is one of poorly drained, calcareous soils on upland flats and rims of depressions and drainageways. It occupies irregularly shaped, 5- to 35-acre tracts. It is about 70 percent Fieldon loam, 25 percent Canisteo loam, and 5 percent other soils. The profile of the Fieldon soil differs from the one described for the series in having loam till at a depth of 40 to 72 inches, and that of the Canisteo soil differs from the one described for the series in having a loam surface layer. Slopes are 0 to 2 percent.

Included with this unit in mapping are small sandy areas. Also included are small areas of moderately well drained Litchfield and Nicollet soils on the low relief convex slopes, areas of poorly drained Webster and Darfur soils, and areas of very poorly drained depressional Dassel and Glencoe soils.

All crops commonly grown in the county are grown on the soils of this unit. Wetness and high concentrations of lime are limitations of these soils. Drainage is needed to provide a deep root zone for most crops. High application rates of potash and phosphate are generally needed to offset the high lime conditions. Soil blowing is a hazard in areas that are left bare in winter and spring. This unit is poorly suited to most urban and recreational uses because of wetness. Fieldon loam, capability unit IIw-5; Canisteo loam, capability unit IIw-3.

Glencoe Series

The Glencoe series consists of depressional and nearly level, very poorly drained moderately fine textured soils formed in glacial till. These soils occupy depressions in the uplands. Native vegetation was the wet site community of the tall grass prairie.

In a representative profile the surface layer is black silty clay loam about 26 inches thick. The lower part is mottled. The subsoil is mottled very dark gray and dark gray silty clay loam about 12 inches thick. The underlying material is mottled gray, limy silty clay loam.

Glencoe soils have moderately slow permeability. Natural fertility, organic-matter content, and available water capacity are high. Runoff is very slow. The seasonal high water table is within a depth of 1 foot, or near tile depth.

Glencoe soils are well suited to farming if excess water is removed. In undrained areas they are used mainly for wild hay and pasture. They support very good cover for wetland wildlife. They are generally poorly suited to woodland. Presently they are used mainly for row crops.

Representative profile of Glencoe silty clay loam in cultivated area 2,600 feet north and 1,975 feet west of southeast corner sec. 9, T. 108 N., R. 28 W.

Ap—0 to 7 inches, black (N 2/0) silty clay loam, high in content of sand; weak very fine and fine subangular blocky structure; friable; frequent roots; neutral; abrupt smooth boundary.

A12—7 to 16 inches, black (N 2/0) silty clay loam, high in content of sand; weak very fine and fine subangular blocky structure; friable; few roots; neutral; clear smooth boundary.

A13—16 to 22 inches, black (5Y 2/1) silty clay loam, high in content of sand; weak very fine and fine subangular blocky structure; friable; few roots; neutral; clear smooth boundary.

A3—22 to 26 inches, black (5Y 2/1) silty clay loam, high in content of sand; fine faint dark olive gray (5Y 3/2) mottles; weak very fine subangular blocky structure; friable; neutral; clear smooth boundary.

B21g—26 to 32 inches, very dark gray (5Y 3/1) silty clay loam, high in content of sand; fine faint dark olive gray (5Y 3/2) mottles; weak very fine subangular blocky structure; friable; neutral; clear smooth boundary.

B22g—32 to 38 inches, dark gray (5Y 4/1) silty clay loam, high in content of sand; common fine prominent olive (5Y 4/3 and 4/4) and common fine distinct olive gray (5Y 4/2) mottles; weak very fine subangular blocky structure; friable; black (5Y 2/1) and olive (5Y 4/3) iron stains; neutral; clear smooth boundary.

Cg—38 to 60 inches, gray (5Y 5/1) silty clay loam, high in content of sand; common fine prominent olive (5Y 5/4) and olive gray (5Y 5/2) mottles; weak very fine subangular blocky structure; friable; black (5Y 2/1) and very dark gray (5Y 3/1) krotovina; common fine distinct reddish brown (5YR 4/3) iron stains; few lime pebbles; slightly to strongly effervescent, mildly alkaline.

The upper part of the A horizon is typically silty clay loam, but the range includes clay loam or loam. The silty clay loam is 10 to 20 percent total sand. The lower part of the A horizon and the B horizon are silty clay loam, clay loam, or loam. The weighted average sand content coarser than very fine sand exceeds 15 percent. The reaction of the A and B horizons is typically neutral but ranges to mildly alkaline. The C horizon is gray or grayish brown silty clay loam, loam, or clay loam.

Glencoe soils are typically associated with Cordova, Canisteo, and Webster soils. Glencoe soils are similar to Cordova and Webster soils but have a thicker A horizon and typically are lower in the landscape. They have a thicker A horizon than Canisteo soils and are not limy throughout.

114—Glencoe silty clay loam. This soil occupies 2- to 4-acre depressions and 5- to 40-acre long, winding, low gradient drainageways within or below areas of Webster, Nicollet, Clarion, Lester, and Le Sueur soils. It has the profile described for the series. Slopes are 0 to 2 percent.

Included with this soil in mapping are small areas of Webster and Canisteo soils on rims of the depressions. Also included are a few areas where a thin layer of muck has formed, generally near the deeper part of the depressions. In some areas there are thin strata of sandy loam, sand, or gravel in the substratum.

Poor tilth, a high water table, ponding and poor aeration are the main problems of management. Runoff is slow to ponded. Drainage is essential for the commonly grown crops. If worked wet, the surface layer puddles readily, tilth is destroyed, and the soil becomes hard and cloddy.

This soil is being used mostly for row crops. Because of the seasonal high water table and hazard of flooding, it is poorly suited to most urban and recreational uses. Capability unit IIIw–1.

932—Glencoe-Dassel loams. This nearly level, very poorly drained map unit is in depressions in upland flats and drainageways. It occupies irregularly shaped 2- to 30-acre tracts. It is about 65 percent Glencoe loam, 30 percent Dassel loam, and 5 percent other soils. Slopes are 0 to 2 percent. The profile of the Glencoe soil differs from the one described for the series in having a clay loam or loam surface layer and subsoil. The profile of the Dassel soil differs in having loamy material at depths of 40 to 72 inches.

Included with this unit in mapping are small areas of poorly drained Webster, Darfur, and limy Fieldon soils on rims and flat areas around the depressions.

All crops commonly grown in the county are grown on this unit. Wetness is a limitation. Drainage is needed to provide a deep root zone for most crops. Management is needed to maintain organic-matter content and fertility. Tillage should be restricted when the soil is wet. This unit is poorly suited to most urban and recreational uses because it is wet. Glencoe loam, capability unit IIIw–1; Dassel loam, capability unit IIIw–3.

Granby Series

The Granby series consists of nearly level, poorly drained soils formed in coarse textured and moderately coarse textured sediments on glacial lake plains, deltas, moraines, or outwash plains. Native vegetation was a wet site community of tall grass prairie.

In a representative profile the surface layer is black and very dark gray fine sandy loam about 18 inches thick. The subsoil is mottled dark grayish brown, very friable, loamy fine sand about 24 inches thick. The underlying material is gray and olive gray sand.

Runoff is slow. Permeability is rapid. The available water capacity is low to moderate. Organic-matter content is high, and natural fertility is medium. The seasonal high water table is at a depth of 1 to 3 feet, or near tile depth.

If Granby soils are well managed, they are suited to crops.

Representative profile of Granby fine sandy loam 2,600 feet east and 2,140 feet south of northwest corner sec. 26, T. 107 N., R. 29 W.

Ap—0 to 12 inches, black (10YR 2/1) fine sandy loam; weak fine granular structure; friable; slightly acid; abrupt smooth boundary.

A3—12 to 18 inches, very dark gray (10YR 3/1) fine sandy loam; weak fine granular structure; very friable; slightly acid; clear irregular boundary.

B2g—18 to 31 inches, dark grayish brown (2.5Y 4/2) loamy fine sand; few fine distinct dark brown (7.5YR 3/2) mottles in lower part; weak very fine granular structure; very friable; few dark gray (10YR 4/1) and very dark gray (10YR 3/1) tongues and krotovina; slightly acid; clear wavy boundary.

C1g—31 to 42 inches, light olive gray (5Y 6/2) and pale olive (5Y 6/3) loamy fine sand; common fine distinct dark brown (7.5YR 3/2) mottles; weak fine granular structure; very friable; neutral; clear wavy boundary.

C2g—42 to 60 inches, gray (5Y 5/1) and olive gray (5Y 5/2) sand; single grained; loose; neutral.

The solum ranges from 24 to 50 inches in thickness. Depth to lime ranges from 30 to 72 inches. Reaction is medium acid to neutral. The A horizon is typically fine sandy loam, but the range includes sandy loam, loamy sand, or loamy fine sand. The B horizon is typically loamy fine sand, but the range includes loamy sand, sand, or fine sand. The C horizon is typically sand or fine sand, but the range includes loamy sand or loamy fine sand. Strata of loam or sand are in the lower part of the B or C horizon in places.

Granby soils are associated with Dassel, Fieldon, and Darfur soils. They occupy broad flats, whereas the wetter Dassel soils are in depressions. Granby soils lack lime in the solum, whereas Fieldon soils are limy throughout. They contain more sand and less clay in the solum than Darfur soils.

178—Granby fine sandy loam. This nearly level soil occupies 3- to 30-acre flats and shallow swales on lake plain deltas and outwash plains. Slopes are 0 to 2 percent.

Included with this soil in mapping are a few areas of Darfur, Dassel, and Fieldon soils. The Dassel soils are very poorly drained soils in depressions and are generally identified by spot symbols on the soil map. The Darfur and Fieldon soils are poorly drained and have a loam surface layer and subsoil. Also included are a few small areas of soils that have loamy layers in the subsoil or underlying material.

This soil is naturally wet and needs drainage for best production. If tiled, it is susceptible to drought because of the sandy solum. The sandy underlying material causes caving of ditch banks and filling of tile lines. Blinding of tile before backfilling the tile trenches or using plastic tile reduces movement of sand into the tile. Shallow surface ditches provide adequate drainage. This soil is very susceptible to soil blowing in spring and in winter.

Most of the acreage is in corn and soybeans. This soil is poorly suited to most urban and recreational uses because of wetness. Capability unit IIIw–5.

Grays Series

The Grays series consists of deep, gently sloping, well drained, medium textured soils. These soils formed in friable, limy, glacial lacustrine sediments and occupy uplands along major rivers. Native vegetation was mixed tall grass prairie and deciduous trees.

In a representative profile the surface layer is very dark gray silt loam about 8 inches thick. The subsurface layer is dark grayish brown silt loam about 6 inches thick. The subsoil is about 26 inches thick. The upper part is dark brown and brown, friable silty clay loam and the lower part is yellowish brown, friable silt loam. At a depth of 35 to 40 inches there are very pronounced dark organic stainings. The deep underlying material is limy, light olive brown, friable silt loam stratified with thin seams of loamy very fine sand.

Permeability is moderate. Available water capacity, natural fertility, and organic-matter content are high. The depth to the seasonal high water table is more than 6 feet. Runoff is medium. The more sloping soils are subject to erosion.

If Grays soils are well managed and protected from erosion, they are suitable for all crops commonly grown in the county, and most areas are used for this purpose.

Representative profile of Grays silt loam, 2 to 8 percent slopes, 2,600 feet east and 100 feet north of southwest corner sec. 32, T. 108 N., R. 27 W.

Ap—0 to 8 inches, very dark gray (10YR 3/1) silt loam, very dark grayish brown (10YR 3/2) crushed; moderate very fine and fine subangular blocky structure; friable; common roots; slightly acid; clear smooth boundary.

A2—8 to 14 inches, dark grayish brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) coatings on faces of peds; weak and moderate very fine and fine subangular blocky structure; friable; common roots; slightly acid; clear smooth boundary.

B21t—14 to 18 inches, dark brown (10YR 4/3) silty clay loam, very dark grayish brown (10YR 3/2) coatings on faces of peds; moderate very fine and fine subangular blocky structure; friable; few thin black clay films on faces of peds; common roots; neutral; clear smooth boundary.

B22t—18 to 23 inches, dark yellowish brown (10YR 4/4) silty clay loam, brown (10YR 4/3) coatings on faces of peds; moderate fine subangular blocky structure; friable; few black clay films on faces of peds; few roots; few clean sand and silt particles on faces of peds; neutral; clear smooth boundary.

B23t—23 to 35 inches, yellowish brown (10YR 5/4) silt loam, dark yellowish brown (10YR 4/4) crushed; weak fine subangular blocky structure; friable; dark yellowish brown (10YR 3/4) fillings in old root channels; few roots; few black patchy clay films on faces of peds; neutral; clear smooth boundary.

B3t—35 to 40 inches, yellowish brown (10YR 5/4) silt loam; massive; friable; few black clayey fillings in root channels; neutral; clear smooth boundary.

C—40 to 60 inches, light olive brown (2.5Y 5/4) silt loam; laminated; friable; common strong brown (7.5YR 5/6) stains and concretions; stratified with loamy very fine sand; strongly effervescent; mildly alkaline.

The thickness of the solum and depth to free carbonates range from 20 to 45 inches. Reaction is slightly acid, neutral, or medium acid. The A horizon is typically silt loam, but the range includes silty clay loam. It is black, very dark gray, or dark grayish brown. The A2 horizon is absent in places. The B horizon is typically silt loam, but the range includes silty clay loam. The clay films on faces of peds are thin and patchy to moderately thick and continuous. The C horizon is silt loam, very fine sandy loam, or light silty clay loam stratified with loamy very fine sand or very fine sand.

Grays soils are associated with Barrington, Truman, Lester, and Le Sueur soils. They are better drained than the Barrington soils. They have an argillic horizon, whereas the Truman soils have a cambic horizon. In contrast with Lester and Le Sueur soils, which formed in loamy glacial till, Grays soils formed in silty glacial lacustrine sediments.

259B—Grays silt loam, 2 to 8 percent slopes. This gently sloping soil occupies 3- to 25-acre knolls, hilltops, and side slopes adjacent to Clarion, Lester, Barrington, Madelia, and Webster soils. Slopes are convex and concave and are about 80 to 150 feet long. This soil occurs mainly on uplands along rivers and wooded areas of the county.

Included with this soil in mapping are areas that are moderately eroded and a few areas that have very short slopes of less than 2 percent or more than 8 percent, which are identified by spot symbols on the soil map. Also included, on concave slopes, are Madelia and Webster soils which are generally identified by spot symbols; and small areas of Barrington soils on slightly concave slopes. A few areas of Lester soils are also included where the underlying glacial till is exposed.

This soil has a moderate hazard of erosion if cultivated. Runoff is medium. Organic-matter content is high.

Most areas of this soil are used for corn and soybeans. If cultivated crops are grown, erosion control practices are needed. This soil has fair potential for most urban and recreational uses. Low strength and potential frost action are the main limitations. Capability unit IIe–2.

Grogan Series

The Grogan series consists of nearly level to gently undulating, well drained and moderately well drained silty soils on lake plains and stream deltas. These soils formed in glacial lacustrine sediments. Native vegetation was tall grass prairie.

In a representative profile the surface layer is very dark brown and dark brown silt loam and loam about 13 inches thick. The subsoil is about 18 inches thick. The upper part is brown loam, the middle part is dark yellowish brown silt loam, and the lower part is yellowish brown loam. The underlying material is limy, light olive brown and light yellowish brown very fine sandy loam with strata of loamy very fine sand.

Permeability is moderately rapid. Runoff is slow to medium. Available water capacity, organic-matter content, and natural fertility are moderate to high. The seasonal high water table is at a depth of 3 to 6 feet or more.

Grogan soils are suitable for all farm crops commonly grown in the county.

Representative profile of Grogan silt loam, 3 to 6 percent slopes, in cultivated area 800 feet south and 2,440 feet west of northeast corner sec. 21, T. 107 N., R. 28 W.

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

A3—10 to 13 inches, dark brown (10YR 3/3) loam, very dark grayish brown (10YR 3/2) coatings on faces of peds; weak very fine subangular blocky structure; very friable; slightly acid; abrupt irregular boundary.

B21—13 to 16 inches, brown (10YR 4/3) loam, very dark grayish brown (10YR 3/2) coatings on faces of peds; weak very fine subangular blocky structure; very friable; slightly acid; clear smooth boundary.

B22—16 to 22 inches, dark yellowish brown (10YR 4/4) silt loam; weak very fine subangular blocky structure; very friable; slightly acid; clear wavy boundary.

B3—22 to 31 inches, yellowish brown (10YR 5/4) loam; weak very fine and fine subangular blocky structure; very friable; neutral; abrupt wavy boundary.

C1—31 to 36 inches, light olive brown (2.5Y 5/4) very fine sandy loam; weak fine and medium subangular blocky structure; very friable; few fine distinct gray (10YR 6/1) and common fine faint grayish brown (2.5Y 5/2) mottles; strongly effervescent; mildly alkaline; gradual wavy boundary.

C2—36 to 60 inches, light yellowish brown (10YR 6/4) and brownish yellow (10YR 6/6) stratified very fine sandy loam and loamy very fine sand; many coarse prominent gray (10YR 6/1) mottles; weak thin to coarse platy structure; loose; few strong brown (7.5YR 5/8) iron oxide "pipes;" strongly effervescent; mildly alkaline.

Thickness of the solum and depth to free carbonates range from 20 to 40 inches. These soils lack coarse fragments. They appear to be stratified. The content of the various sizes of particles changes with increasing depth. The A horizon is 10 to 18 inches thick. It is silt loam or loam and is high in content of very fine sand. It is friable or very friable and slightly acid to neutral. The B horizon typically is mostly loam or silt loam, but subhorizons in some pedons are very fine sandy loam or loamy very fine sand. Consistence is friable or very friable. Reaction is slightly acid to neutral in the upper part and neutral to mildly alkaline in the lower part. The C horizon is mostly very fine sandy loam or loamy very fine sand, but strata of silt loam or coarser textures are in places. Reaction is mildly alkaline or moderately alkaline. Depth to the IIC horizon of glacial till is as little as 50 inches in places.

Grogan loamy fine sand is outside the defined range of the series because it has less clay and more fine and very fine sand. This difference, however, does not significantly affect use and management.

Grogan soils are associated with Dickinson, Lomax, and Fedji soils. They have more very fine sand and silt than Dickinson and Lomax soils. They have a silty or sandy C horizon, but the Fedji soils have a IIC horizon of loamy glacial till within a depth of 40 inches.

1801B—Grogan loamy fine sand, 2 to 6 percent slopes. This gently undulating, well drained soil occupies 5- to 40-acre areas on lake plains and stream deltas. Slopes are plane to convex. The profile is similar to the one described for the series, but it has loamy fine sand, fine sand, and loamy very fine sand throughout.

Included with this soil in mapping are small areas of Dassel soils in depressions and drainageways, which are identified by spot symbols on the soil map. Also included are some areas underlain by loam till below a depth of 40 inches, areas where slopes are more than 6 percent, and areas of soils that have finer textured strata in the subsoil and substratum.

Runoff is medium. Available water capacity and organic-matter content are moderate, and natural fertility is medium. The main concerns of management are maintenance of fertility and slight droughtiness.

This soil is well suited to early-maturing small grain because of the slight droughtiness. It is susceptible to soil blowing. It has good potential for most urban and recreational uses. Capability unit IIe-4.

128—Grogan silt loam, 1 to 3 percent slopes. This nearly level, moderately well drained soil occupies 2- to 20-acre areas which are irregular in shape. It has a profile simlar to the one described for the series, but mottles occur at a depth of 3 to 5 feet.

Included with this soil in mapping are small areas of Litchfield and Nicollet soils. The Litchfield soil is identified by a spot symbol on the soil map and the Nicollet soil is where the underlying glacial till outcrops at the surface. Also included are small areas of steeper slopes; small, poorly drained Madelia and Darfur soils; and very poorly drained Okoboji soils in depressions that are also identified by spot symbols.

Runoff is slow. The hazard of erosion is slight. The seasonal high water table is at a depth of 3 to 5 feet. It is fairly high and helps to replenish soil moisture. Good management and adequate fertilization are needed to maintain organic matter, tilth, and high yields.

Most of this soil is used as cropland. It is suited to all crops commonly grown in the county. It is well suited to recreational uses, but is limited for urban development mainly by potential frost action. Capability unit I-1.

128B—Grogan silt loam, 3 to 6 percent slopes. This gently undulating, well drained soil occupies 3- to 40-acre areas on lake plains. Relief is mainly convex. This soil has the profile described for the series.

Included with this soil in mapping are small areas of Lasa soils and small areas of nearly level Grogan soils at the base of some slopes. Small areas of sandy soils are identified by a spot symbol on the soil map. Also included are some areas where slopes are more than 6 percent.

Permeability is moderately rapid. Organic-matter content and natural fertility are high. The seasonal high water table is at a depth of more than 6 feet. Available water capacity is higher than normal for a soil of this texture because of the influence of bands in the underlying material.

Most of this soil is cropland. The main concern of management is controlling erosion and soil blowing with conservation practices. This soil has fair to good potential for most urban and recreational uses. Potential frost action is the main limitation. Capability unit IIe-2.

Guckeen Series

The Guckeen series consists of deep, moderately well drained, nearly level to gently undulating soils on ground moraines and lake plains. These soils formed in a mantle of moderately fine textured to fine textured glacial lacustrine sediments and the underlying friable, limy, loamy glacial till. Native vegetation was tall grass prairie.

In a representative profile the surface layer is about 22 inches thick. It is black silty clay loam in the upper part and black and very dark grayish brown silty clay in the lower part. The subsoil is about 17 inches thick. It is dark grayish brown silty clay in the upper part and mottled olive brown clay loam in the lower part. The underlying material is mottled grayish brown and light olive brown clay loam and loam that contain free lime carbonates.

The available water capacity, natural fertility, and organic-matter content are high. Runoff is slow to medium, depending on slopes. Permeability is moderately slow. The depth to the seasonal high water table is 3 to 5 feet. The more sloping areas are subject to erosion.

If Guckeen soils are well managed, they are very productive. They are well suited to all crops commonly grown in the county.

Representative profile of Guckeen silty clay loam, 1 to 4 percent slopes, in cultivated field 2,400 feet north and 2,240 feet east of southwest corner sec. 23, T. 105 N., R. 28 W.

Ap—0 to 8 inches, black (10YR 2/1) silty clay loam; weak very fine subangular blocky structure; friable; medium acid; abrupt smooth boundary.

A12—8 to 13 inches, black (10YR 2/1) silty clay, very dark gray (10YR 3/1) crushed; moderate fine and very fine angular and subangular blocky structure; friable; medium acid; abrupt smooth boundary.

A13—13 to 22 inches, very dark grayish brown (10YR 3/2) silty clay, black (10YR 2/1) coatings on faces of peds; moderate fine and very fine angular and subangular blocky structure; friable; medium acid; clear smooth boundary.

B1—22 to 31 inches, dark grayish brown (2.5Y 4/2) silty clay, very dark grayish brown (10YR 3/2) coatings on faces of peds; moderate fine and medium prismatic structure; friable; few black (10YR 2/1) and very dark gray (10YR 3/1) worm casts; slightly acid; clear smooth boundary.

IIB2—31 to 39 inches, olive brown (2.5Y 4/4) clay loam; common fine faint grayish brown (2.5Y 5/2) and light olive brown (2.5Y 5/4) mottles; weak and moderate fine and medium prismatic structure; friable; about 3 percent coarse fragments; neutral; clear smooth boundary.

IIC1—39 to 50 inches, grayish brown (2.5Y 5/2) clay loam; many medium distinct light olive brown (2.5Y 5/4) mottles; weak fine and medium subangular blocky structure; friable; few white (2.5Y 8/1) lime masses; about 5 percent coarse fragments; strongly effervescent; mildly alkaline; clear smooth boundary.

IIC2—50 to 60 inches, light olive brown (2.5Y 5/4) loam; many coarse distinct gray (5Y 6/1) and light olive gray (5Y 6/2) mottles; massive; friable; about 5 percent coarse fragments; strongly effervescent; mildly alkaline.

Thickness of the solum and depth to carbonates range from 26 to 44 inches. Consistence of the upper part of the solum is friable and firm. The Ap horizon is typically silty clay loam, but the range includes silty clay. The A12 and A13 horizons are typically silty clay, but the range includes silty clay loam. The upper part of the B horizon is typically silty clay, but clay is in the range. The IIB horizon is typically clay loam, but the range includes loam and silty clay loam. The IIC horizon is typically clay loam, but the range includes loam.

Guckeen soils are closely associated with Marna, Kamrar, and Lura soils. They occupy slightly higher positions and are better drained than the poorly drained Marna soils and very poorly drained Lura soils. They are wetter than the well drained Kamrar soils.

230—Guckeen silty clay loam, 1 to 4 percent slopes. This nearly level to gently sloping soil occupies slightly convex areas on ground moraines and lake plains. Areas are 5 to 50 acres in size and irregular in shape.

Included with this soil in mapping are small areas of Marna soils in swales and drainageways. Small areas of Kamrar soils are included on some of the steeper convex slopes.

This soil is well suited to farming. The optimum range of moisture for proper tillage in this soil is narrow, and maintenance of surface tilth is a continuing concern. The hazard of erosion is slight.

Most of the acreage is used for corn and soybeans. Tile drainage is not generally needed for crops, but it is needed to protect basements and foundations from ground water seepage. Moderate shrink-swell potential and high susceptibility to frost action are the main limitations for most urban and recreational uses. Capability unit IIs-2.

Hamel Series

The Hamel series consists of nearly level to gently sloping, poorly drained, medium textured and moderately fine textured soils. These soils formed in a mantle of colluvium and water-deposited sediments from glacial drift over medium textured and moderately fine textured glacial till. They occupy concave positions in upper drainageways and depressions on glacial uplands. Native vegetation was a wet site community of the tall grass prairie or mixed tall grass prairie and deciduous trees.

In a representative profile the surface layer is black and very dark gray clay loam about 28 inches thick. The subsoil, about 6 inches thick, is mottled dark olive gray and olive gray clay loam. The underlying material is limy, mottled olive loam.

Runoff is slow to moderate, and permeability is moderately slow. The depth to the seasonal high water table is 1 to 3 feet, or near tile depth. Organic-matter content and natural fertility are high.

Tile drainage is essential for crops. If adequately drained, these soils are well suited to farming. Most areas are cropland.

Representative profile of Hamel clay loam, 1 to 4 percent slopes, in cultivated area 130 feet east and 360 feet south of northwest corner sec. 21, T. 109 N., R. 25 W.

Ap—0 to 9 inches, black (10YR 2/1) clay loam, very dark gray (10YR 3/1) dry; weak fine subangular blocky structure; friable; slightly acid; abrupt smooth boundary.

A12—9 to 18 inches, black (10YR 2/1) clay loam; moderate very fine and fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

A13—18 to 28 inches, black (10YR 2/1) clay loam; many fine inclusions of very dark gray (5Y 3/1); moderate very fine and fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

B2tg—28 to 34 inches, dark olive gray (5Y 3/2) and olive gray (5Y 4/2) clay loam; few fine faint dark grayish brown (2.5Y 4/2) mottles; moderate fine and medium subangular blocky structure; friable; few thin clay films on faces of peds; about 3 percent coarse fragments; slightly acid; clear smooth boundary.

C1g—34 to 54 inches, olive (5Y 5/3) loam; common medium distinct yellowish brown (10YR 5/8) mottles; massive; friable; about 4 percent coarse fragments; neutral; gradual smooth boundary.

C2g—54 to 60 inches, olive (5Y 5/3) loam, olive gray (5Y 5/2) rubbed; common medium distinct yellowish brown (10YR 5/6) mottles; massive; friable; about 4 percent coarse fragments; manganese concretions; slightly effervescent; mildly alkaline.

The thickness of the solum and depth to free carbonates range from 30 to 60 inches. The Ap and A1 horizons are typically black clay loam, but range to heavy loam. They range from 24 to 40 inches in thickness. The B2 horizon is very dark gray, dark gray, olive gray, and dark olive gray. It is typically clay loam, but ranges to loam and silty clay loam. It is 5 to 20 inches thick. The C horizon is typically loam, but includes clay loam in places.

Hamel soils are associated with Clarion, Lester, Cordova, and Glencoe soils. They are wetter and have a grayer B horizon than Lester and Clarion soils. They are slightly higher on the landscape and are better drained than Glencoe soils. They have a thicker A horizon than Cordova soils.

414—Hamel clay loam, 1 to 4 percent slopes. This level to gently sloping soil occupies 2- to 10-acre tracts in the upper part of drainageways and on toe slopes adjacent to depressions of uplands.

Included with this soil in mapping are small areas of the very poorly drained Glencoe soils. Some of these areas are identified by spot symbols on the soil map. Also included are small areas of soils that are similar to this Hamel soil except they have less clay in the subsoil, and small areas that are underlain by heavy silty clay loam or silty clay.

Maintenance of good tilth and adequate drainage are essential for maintaining good crop yields. Most areas of this soil are used for crops. If worked when wet, the surface layer puddles easily and the soil becomes hard and cloddy upon drying. This soil is poorly suited to most urban and recreational uses because of the seasonal high water table, moderate shrink-swell potential, and high susceptibility to frost action. Capability unit IIw–1.

Joliet Series

The Joliet series consists of poorly drained loamy soils that formed in a 10- to 20-inch thick mantle of glacial sediments over limestone bedrock. The soils occupy flats and slight depressions on outwash plains and bedrock-cored terraces. Native vegetation was a wet site community of tall grass prairie.

In a representative profile the surface layer is black and very dark gray friable silty clay loam about 13 inches thick. The subsoil, about 4 inches thick, is dark olive gray silty clay loam. The underlying material, at a depth of 17 inches, is limestone bedrock.

Permeability is moderate. These soils have low available water capacity, high organic-matter content, and medium natural fertility. The depth to the seasonal high water table is 0 to 2 feet.

Wetness, rock outcrops, and scattered large stones severely limit use in some areas. These soils are not well suited to row crops because of the shallow depth to bedrock. They are best suited to pasture or hay.

Representative profile of Joliet silty clay loam, 1,320 feet south and 75 feet east of northwest corner sec. 3, T. 108 N., R. 28 W.

Ap—0 to 8 inches, black (10YR 2/1) light silty clay loam; weak very fine subangular blocky structure; friable; slightly effervescent; mildly alkaline; abrupt smooth boundary.

A12—8 to 11 inches, black (10YR 2/1) light silty clay loam; weak and moderate very fine subangular blocky structure; friable; slightly effervescent; mildly alkaline; clear smooth boundary.

A3—11 to 13 inches, very dark gray (5Y 3/1) silty clay loam; common fine faint dark olive gray (5Y 3/2) mottles; weak fine subangular blocky structure; friable; slightly effervescent; mildly alkaline; clear smooth boundary.

B29—13 to 17 inches, dark olive gray (5Y 3/2) silty clay loam; common faint prominent olive (5Y 5/3) mottles; weak very fine subangular blocky structure; friable; slightly effervescent; mildly alkaline; clear smooth boundary.

R—17 inches plus, pale brown (10YR 6/3) and light yellowish brown (10YR 6/4) limestone bedrock.

Depth to bedrock is 10 to 20 inches. The A horizon is black, very dark gray, or very dark grayish brown. It is typically silty clay loam, but the range includes silt loam and loam. The B horizon is very dark gray, dark gray, dark grayish brown, and gray. It is typically silty clay loam, but the range includes silt loam and loam. A few places have a thin C horizon.

This soil is limy throughout and is therefore outside the range of the series. This difference, however, does not alter use or management.

Joliet soils are associated with Tilfer and Copaston soils. They are similar to Tilfer soils, but they are shallower to bedrock. The Joliet soils are more poorly drained, are limy throughout, and are finer textured in the solum than Copaston soils.

196—Joliet silty clay loam. This nearly level soil occupies 3- to 40-acre flats and slight depressions on outwash plains and bedrock-cored terraces. It is mainly in the Minnesota River Valley. Slopes are 0 to 2 percent.

Included with this soil in mapping are small areas of Tilfer soils. Small areas of bedrock outcrops and small areas that have stones and boulders on the surface are also included and are identified by spot symbols on the soil map. Also included are areas that are subject to flooding by runoff from the uplands.

Runoff is slow. The main concerns of management are removal of excess water and maintenance of fertility.

This soil is very difficult to till because of the shallow depth over bedrock. Some areas are cropland, but the soil is better suited to permanent pasture and hay than to row crops. Wetness limits the use of this soil, and in places rock outcrops and stones and boulders on the surface are also limitations. This soil has poor potential for urban and recreational use. Capability unit VIw-2.

Kamrar Series

The Kamrar series consists of deep, moderately well drained, gently sloping to moderately steep soils on convex rises and side slopes on uplands. These soils formed in a mantle of fine textured and moderately fine textured glacial lacustrine sediments and medium textured and moderately fine textured glacial till. Native vegetation was tall grass prairie.

In a representative profile the surface layer is black, dark gray, and very dark gray silty clay about 16 inches thick. The subsoil is about 22 inches thick. The upper part is brown firm silty clay, the middle part is yellowish brown firm clay, and the lower part is mottled grayish brown friable clay loam. The underlying material is limy, mottled grayish brown friable loam.

Permeability is moderately slow. The available water capacity, organic-matter content, and natural fertility are high. The seasonal high water table is below a depth of 6 feet.

Control of erosion and maintenance of tilth are the main concerns of management. If these soils are well managed and protected from erosion, they are suitable for all crops commonly grown in the county. The steeper soils are better suited to hay or pasture.

Representative profile of Kamrar silty clay, 2 to 6 percent slopes in cultivated field 2,340 feet north and 2,080 feet east of southwest corner sec. 23, T. 105 N., R. 28 W.

Ap—0 to 8 inches, black (10YR 2/1) silty clay; weak fine subangular blocky structure; friable; medium acid; abrupt smooth boundary.

A12—8 to 11 inches, dark gray (10YR 4/1) silty clay; moderate fine subangular blocky structure; friable; medium acid; abrupt smooth boundary.

A3—11 to 16 inches, very dark gray (10YR 3/1) silty clay, very dark grayish brown (10YR 3/2) crushed; moderate fine and very fine subangular blocky structure; friable; dark yellowish brown (10YR 3/4) worm channels; slightly acid; clear smooth boundary.

B21—16 to 22 inches, brown (10YR 4/3) silty clay, dark grayish brown (10YR 4/2) coatings on faces of peds; moderate fine and medium subangular blocky structure; firm; slightly acid; clear smooth boundary.

B22—22 to 31 inches, yellowish brown (10YR 5/4) clay, brown (10YR 4/3) coatings on faces of peds; few fine faint yellowish brown (10YR 5/6) mottles; weak and moderate fine and medium prismatic structure; firm; slightly acid; clear smooth boundary.

IIB3—31 to 38 inches, grayish brown (2.5Y 5/2) clay loam, dark grayish brown (2.5Y 4/2) coatings on faces of peds; common fine distinct light olive brown (2.5Y 5/4 and 5/6) mottles; weak and moderate fine and medium prismatic structure; friable; 2 percent coarse fragments; slightly acid; clear smooth boundary.

IIC—38 to 60 inches, grayish brown (2.5Y 5/2) loam; common fine distinct light olive brown (2.5Y 5/4 and 5/6) mottles; massive; friable; few white (2.5Y 8/1) lime masses; 5 percent coarse fragments; strongly effervescent; mildly alkaline.

Thickness of the solum and depth to carbonates range from 30 to 60 inches. The thickness of the clayey mantle ranges from 24 to 40 inches. The upper part of the A horizon is 8 to 14 inches thick. The A horizon is typically silty clay, but the range includes clay loam, silty clay loam, and clay. The A and B horizons have about 10 to 15 percent more clay than the IIB and IIC horizons. The B horizon typically is silty clay and clay, but the range includes silty clay loam and clay loam. Clay content of the IIB and IIC horizons ranges from 20 to 35 percent. The IIB horizon is typically clay loam, but the range includes loam. The IIC horizon is typically loam, but the range includes clay loam.

Kamrar soils are associated with Guckeen, Marna, and Lura soils. They are better drained and are on higher lying or more sloping positions than those soils.

105B—Kamrar silty clay, 2 to 6 percent slopes. This gently sloping soil is on small convex rises on uplands. The areas range from 5 to 20 acres in size. This soil has the profile described for the series.

Included with this soil in mapping are small areas of moderately well drained Guckeen soils and poorly drained Marna soils in swales and drainageways. Also included are areas where slopes are less than 2 percent or more than 6 percent, which are identified by spot symbols on the soil map.

Runoff is medium. Control of erosion and maintenance of tilth are the main concerns of management. The optimum range of moisture for tilling this soil is narrow.

Most of the acreage is used for corn and soybeans. Some areas are woodland. This soil is well suited to farming if erosion is controlled and tilth is maintained. It has only fair potential for most urban and recreational uses because of the shrink-swell potential and the clay content. Capability unit IIe–3.

105C—Kamrar silty clay, 6 to 12 percent slopes. This sloping soil is on knolls and hillsides on uplands. The areas range from 5 to 20 acres in size. This soil has a profile similar to the one described for the series, but the surface layer is a few inches thinner.

Included with this soil in mapping, and identified by spot symbols on the soil map, are small areas of Marna soils in swales and drainageways. Also included are small areas of medium textured Clarion soils and moderately well drained Guckeen soils, small areas of moderately eroded soils, and small areas of severely eroded soils. Areas where slopes are less than 6 percent or more than 12 percent are also identified by spot symbols on the soil map.

Runoff is moderately rapid. Control of erosion and maintenance of tilth are the main concerns of management. The optimum range of moisture for tilling this soil is narrow.

Most of the acreage is used for corn and soybeans. Some areas are woodland or pasture. This soil is well suited to farming if erosion is controlled and tilth is maintained. It has only fair potential for most urban and recreational uses because of slope, the shrink-swell potential, and the clay content. Capability unit IIIe–1.

105D—Kamrar silty clay, 12 to 18 percent slopes. This moderately steep soil occurs on the convex part of hillsides. The areas range from 5 to 15 acres in size. This soil has a profile similar to the one described for the series, but the surface layer is lighter colored and the solum is thinner.

Included with this soil in mapping are small areas of Storden soils on the upper parts of convex slopes. Also included are strips of Terril loam at the base of slopes, some areas of moderately eroded soils, and some areas of severely eroded soils. Areas where slopes are less than 12 percent or more than 18 percent are identified by spot symbols on the soil map.

Runoff is rapid. Erosion is the main hazard. The optimum range of moisture for tilling this soil is narrow.

Most of the acreage is in corn, soybeans, or pasture. This soil is best suited to small grain or pasture. Row crops can be grown if erosion is controlled. This soil has poor potential for most urban and recreational uses because of slope. Capability unit IVe–1.

Kilkenny Series

The Kilkenny series consists of gently sloping to moderately steep, well drained, moderately fine textured soils. These soils formed in a shaly, clay loam mantle 3 to 10 feet thick over loamy glacial till. They occupy convex positions on knolls and side slopes. Slopes are simple and are about 75 to 200 feet long. Native vegetation was mixed deciduous forest and tall grass prairie.

In a representative profile the surface layer is black friable clay loam about 7 inches thick. The subsoil is olive brown, dark yellowish brown, and light olive brown firm clay loam about 38 inches thick. The underlying material is limy, light olive brown friable loam.

Permeability is moderately slow. Runoff is medium to rapid. The seasonal high water table is below a depth of 6 feet. Available water capacity, organic-matter content, and natural fertility are high.

Most areas of Kilkenny soils are cropped; some areas are woodland or pasture. The soils are suited to most crops if well managed. Maintenance of tilth, erosion control, and liming are the main management needs.

Representative profile of Kilkenny clay loam, 6 to 12 percent slopes in cultivated field 2,400 feet north and 1,970 feet east of southwest corner sec. 2, T. 108 N., R. 25 W.

Ap—0 to 7 inches, black (10YR 2/1) light clay loam; moderate medium subangular blocky structure; friable; about 3 percent coarse fragments, mainly shale; neutral; abrupt smooth boundary.

B21t—7 to 18 inches, olive brown (2.5Y 4/4) clay loam; moderate medium subangular blocky structure; firm; very dark gray (10YR 3/1) clay films on faces of peds; about 3 percent coarse fragments, mainly shale; neutral; clear smooth boundary.

B22t—18 to 28 inches, dark yellowish brown (10YR 4/4) clay loam; few common prominent strong brown (7.5YR 4/8) mottles along root channels; strong medium subangular blocky structure; firm; very dark grayish brown (10YR 3/2) clay films on faces of peds; about 4 percent coarse fragments, mainly shale; medium acid; clear smooth boundary.

B23t—28 to 34 inches, olive brown (2.5Y 4/4) clay loam; few common prominent strong brown (7.5Y 5/8) mottles in root channels; moderate medium prismatic structure; firm; very dark grayish brown (10YR 3/2) clay films on faces of peds; about 4 percent coarse fragments, mainly shale; medium acid; clear smooth boundary.

B24t—34 to 41 inches, olive brown (2.5Y 4/4) clay loam; moderate medium prismatic structure; firm; very dark grayish brown

(10YR 3/2) clay films on faces of peds; about 4 percent coarse fragments, mainly shale; medium acid; clear smooth boundary.

B3t—41 to 45 inches, light olive brown (2.5Y 5/4) clay loam; moderate medium prismatic structure; friable; black (10YR 2/1) clay films on faces of peds and in root channels; about 4 percent coarse fragments, mainly shale; slightly acid; clear smooth boundary.

IIC1—45 to 49 inches, light olive brown (2.5Y 5/4) loam; massive structure; friable; few black (10YR 2/1) clay films on faces of peds and in root channels; about 4 percent coarse fragments, mainly shale; neutral; clear smooth boundary.

IIC2—49 to 60 inches, light olive brown (2.5Y 5/4) loam; massive structure; friable; few black (10YR 2/1) clay films in root channels in upper part; about 4 percent coarse fragments, mainly shale; strongly effervescent; moderately alkaline.

Thickness of the solum and depth to free lime range from 36 to 64 inches. The A horizon is typically clay loam but the range includes silty clay. It is about 5 to 10 inches thick. Reaction is neutral to medium acid. An A2 horizon of loam, clay loam, or silty clay loam as much as 4 inches thick is in places. Part of this horizon is incorporated into the Ap horizon in some profiles. Reaction is slightly acid to medium acid. The B horizon is 28 to 45 inches thick. The B2t horizon is typically clay loam, but ranges to silty clay loam, silty clay, or clay. It is medium acid to very strongly acid. The B3t horizon is medium acid to neutral.

Kilkenny soils are associated with Lester and Lerdal soils. They have more clay in the B2 horizon than Lester soils. They have brighter colors in the B horizon and are better drained than Lerdal soils.

238B—Kilkenny clay loam, 2 to 6 percent slopes. This gently sloping soil occupies 5- to 20-acre knolls. Slopes are concave and convex and are 80 to 150 feet long. This soil has a profile similar to the one described for the series, but it is thicker.

Included with this soil in mapping are a few areas of somewhat poorly drained Lerdal soils, moderately well drained Shorewood soils, and medium textured Lester soils. These areas are too small to be mapped separately. Also included, and identified on the soil map by spot symbols, are areas of Hamel and Cordova soils on toe slopes, in shallow draws, and in drainageways, and areas where slopes are less than 2 percent or more than 6 percent.

Runoff is medium. The hazard of erosion is moderate. Erosion is more serious on this soil because of the increase in clay in the subsoil. The hazard is greatest in areas adjacent to ravines, in draws, and on convex slopes.

Most of the acreage is used for cultivated crops, but a few areas remain in woodland. Low strength, moderately slow permeability, and potential frost action are limitations for most urban and recreational uses. Capability unit IIe–3.

238C—Kilkenny clay loam, 6 to 12 percent slopes. This sloping soil occupies 5- to 20-acre knolls that have concave and convex slopes and smooth hillsides. Slopes are 80 to 150 feet long. This soil has the profile described for the series.

Included with this soil in mapping are a few areas where slopes are less than 6 percent or more than 12 percent, which are identified by spot symbols on the soil map. Erosion, tree removal, and deep tillage have mixed part of the brownish subsoil with the surface layer in some areas. This mixed layer is browner, has less organic matter, and is less friable than is typical. A few narrow swales of Cordova and Hamel soils in drainageways are also identified by spot symbols on the soil map. Also included in mapping are small areas of somewhat poorly drained Lerdal soils, moderately well drained Shorewood soils, and medium textured Lester soils. Terril soils occur in narrow areas at the base of slopes.

Runoff is medium to rapid. The hazard of erosion is severe. It is greatest in areas adjacent to ravines and draws and on convex slopes.

A few areas remain in woodland, but much of the acreage of this soil is used for cultivated crops. Low strength, moderately slow permeability, potential frost action, and slope are limitations for most urban and recreational uses. Capability unit IIIe–1.

238D—Kilkenny clay loam, 12 to 18 percent slopes. A few areas of this moderately steep soil occupy 5- to 20-acre irregular knolls, but most areas are on 3- to 20-acre hillsides that are frequently crossed by narrow draws and occasionally crossed by deep ravines. Slopes are 80 to 150 feet long. This soil has a profile similar to the one described for the series, but the surface layer is thinner.

Included with this soil in mapping are a few areas where slopes are less than 12 percent or more than 18 percent, which are identified by spot symbols on the soil map. Erosion, tree removal, and deep tillage have mixed part of the brownish subsoil with the surface layer in some areas. This mixed layer is browner, has less organic matter, and is less friable than is typical. Small areas of medium textured Storden and Lester soils are included on the convex slopes. The shallow, narrow drainageways are occupied by Lerdal, Hamel, and Cordova soils and are identified by spot symbols. Terril soils occur in narrow areas at the base of many slopes.

Runoff is rapid. The hazard of erosion is severe. Erosion is more serious on this soil because of the abrupt increase in clay in the subsoil. The hazard is greatest in areas adjacent to ravines and draws and on convex slopes. Good tilth is difficult to maintain without special management.

This soil is used as cropland, woodland, or woodland pasture. It is poorly suited to most urban and recreational uses because of slope. Capability unit IVe–1.

Kingston Series

The Kingston series consists of deep, moderately well drained, nearly level, moderately fine textured and medium textured soils on convex rises on the glacial lake plain. These soils formed in silty glacial lacustrine sediments. Native vegetation was tall grass prairie.

In a representative profile the surface layer is black and very dark grayish brown, friable silty clay loam about 17 inches thick. The subsoil, about 14 inches thick, is dark grayish brown, friable light silty clay loam and silt loam. The underlying material is limy, mottled light olive brown and yellowish brown, very friable silt loam.

Permeability is moderate. The available water capacity, organic-matter content, and natural fertility are high. The depth to the seasonal high water table is 3 to 5 feet.

If Kingston soils are well managed to maintain tilth and fertility, they are among the most productive soils in the county. They are well suited to all general farm crops.

Representative profile of Kingston silty clay loam, 1 to 3 percent slopes, in cultivated area 1,540 feet south and 750 feet east of northwest corner sec. 30, T. 107 N., R. 27 W.

- Ap—0 to 11 inches, black (10YR 2/1) silty clay loam; weak very fine subangular blocky structure; friable; slightly acid; abrupt smooth boundary.
- A3—11 to 17 inches, very dark grayish brown (10YR 3/2) silty clay loam, very dark gray (10YR 3/1) coatings on faces of peds; weak very fine subangular blocky structure; friable; slightly acid; clear smooth boundary.
- B21—17 to 25 inches, dark grayish brown (10YR 4/2) silty clay loam, very dark brown (10YR 2/2) coatings on faces of peds; weak very fine and fine subangular blocky structures; friable; neutral; clear smooth boundary.
- B22—25 to 31 inches, dark grayish brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) coatings on faces of peds; weak very fine and fine subangular blocky structure; friable; neutral; clear smooth boundary.
- C1—31 to 43 inches, light olive brown (2.5Y 5/4) silt loam; medium fine distinct yellowish brown (10YR 5/4) and light brownish gray (10YR 6/2) mottles; weak very fine subangular blocky structure; very friable; strongly effervescent; mildly alkaline; gradual smooth boundary.
- C2—43 to 60 inches, yellowish brown (10YR 5/4) silt loam; medium fine distinct light brownish gray (10YR 6/2) mottles; laminated; very friable; few reddish pipes and concretions; strongly effervescent; mildly alkaline.

Thickness of the solum and depth to free carbonates range from 20 to 40 inches. Reaction is slightly acid to neutral. The A horizon ranges from 12 to 24 inches in thickness. It is typically silty clay loam, but the range includes silt loam. In some profiles the texture is silty clay loam throughout the B and C horizons, but silt loam is included. The C horizon is mildly alkaline or moderately alkaline.

Kingston soils are associated with Truman, Madelia, and Spicer soils. These soils formed in similar material, but Kingston soils are not as wet as Madelia and Spicer soils and are wetter than Truman soils.

197—Kingston silty clay loam, 1 to 3 percent slopes. This nearly level soil is on low convex rises and elevated flats on the lacustrine-mantled ground moraines. The areas are irregular in shape and are 5 to 70 acres in size. This soil has the profile described for the series.

Included with this soil in mapping are small areas of well drained Truman soils on the highest part of the slope and poorly drained Madelia soils in swales and around the base of slopes. Also included are a few areas of Nicollet soil.

The hazard of erosion is slight. Maintenance of tilth and fertility are the main management needs.

Most of the acreage is used for corn and soybeans. This soil is well suited to all crops grown in the county. It is fairly to poorly suited to most urban and recreational uses because of frost action potential and low strength. Capability unit I–1.

941—Kingston-Nicollet complex, 1 to 3 percent slopes. This nearly level map unit occurs on low convex slopes. It is about 60 percent Kingston silty clay loam, 30 percent Nicollet clay loam, and 10 percent other soils. The profiles of the Kingston and Nicollet soils differ from the ones described for their respective series in having a higher content of very fine and fine sand.

Included with this unit in mapping are areas which have a silt loam or fine sandy loam surface layer. Small areas of Madelia silty clay loam and Webster silty clay loam on wetter, nearly level and concave slopes are also included. Small areas where slopes are more than 3 percent are identified by spot symbols on the soil map.

All crops commonly grown in the county are grown on these soils. Management is needed to maintain good tilth and fertility. This soil is fairly to poorly suited to most urban and recreational uses because of frost action potential and low strength. Capability unit I–1.

Lake Beaches

1032—Lake beaches. This area consists of moderately well drained to poorly drained, narrow, sandy and loamy beaches that border lakes, marshes, and larger peat bogs. It occupies 2- to 100-acre, nearly level to gently sloping areas. Slopes are 1 to 3 percent and are mostly convex. Native vegetation was mainly water-tolerant grasses. The materials are so intermingled and variable that they cannot be classified as a soil series.

Texture is variable. Small stones and pockets of gravel occur on the surface layer. Reaction is neutral to mildly alkaline. The areas may be wet or droughty, depending on lake levels and drainage development. Most areas have a water table at a depth of 1 to 4 feet that is controlled by the water level of the adjacent lake or marsh. The water table is lower where the lake beaches border peat bogs that have been artificially drained.

Included in mapping are beaches of the Jackson lakebed, east of Amboy, which are predominantly sandy loam. The beach is 200 to 800 feet wide on the perimeter of the lakebed. About 30 feet from the shore it is sandy, but the rest has 10 to 20 inches of sandy loam over calcareous, mottled silt loam. This was perhaps caused by wave action of the water which carried the sandy beach material farther out into the lake.

Water table control, flooding, droughtiness, and soil blowing are the main management concerns. Land use of these areas is variable. Some areas are left idle and provide food and cover for wildlife. Some are used as pasture. Other areas, adjacent to drained peat bogs, are used as cropland. Onsite investigation is needed to determine which species of trees and shrubs will grow.

The seasonal high water table severely limits the use of these areas for building site development, recreational development, and sanitary facilities. There is a high hazard of polluting adjacent lakes if septic tank absorption fields are installed. Capability unit IVw–1.

Lasa Series

The Lasa series consists of gently undulating, somewhat excessively drained, sandy soils that formed in glacial lacustrine or outwash sediments. These soils are on sandy outwash plains and in stream delta areas. The rock substratum phases are gently sloping to very steep and are on rock terraces and escarpments. Native vegetation was tall grass prairie.

In a representative profile the surface layer is very dark gray and very dark grayish brown fine sand about 15 inches thick. The subsoil is about 30 inches thick. The upper part is 21 inches of dark brown and yellowish brown fine sand and the lower part is 9 inches of dark yellowish brown loamy fine sand. The underlying material is light brownish gray fine sand.

Permeability is moderately rapid, but varies depending on the texture and thickness of the underlying bands and depth to bedrock. Organic-matter content is moderately low. Available water capacity and natural fertility are low. The seasonal high water table is at a depth below 6 feet. There is a hazard of soil blowing.

Most Lasa soils are cultivated. Because of droughtiness, however, these soils are best suited to early-maturing row crops and small grain.

Representative profile of Lasa fine sand, 2 to 8 percent slopes in cultivated field 1,515 feet west and 2,570 feet south of northeast corner sec. 21, T. 107 N., R. 28 W.

Ap—0 to 10 inches, very dark gray (10YR 3/1) fine sand; weak fine granular structure; very friable; slightly acid; abrupt smooth boundary.

A3—10 to 15 inches, very dark grayish brown (10YR 3/2) fine sand with common inclusions of very dark gray (10YR 3/1) loamy fine sand; weak fine granular structure; very friable; slightly acid; clear smooth boundary.

B21—15 to 23 inches, dark brown (10YR 3/3) fine sand; weak medium granular structure; very friable; slightly acid; clear smooth boundary.

B22—23 to 36 inches, yellowish brown (10YR 5/4) fine sand; weak medium granular structure; very friable; slightly acid; abrupt smooth boundary.

B3—36 to 45 inches, dark yellowish brown (10YR 4/4) loamy fine sand; weak very fine and fine subangular blocky structure; friable; slightly acid; abrupt smooth boundary.

C—45 to 60 inches, light brownish gray (10YR 6/2) fine sand; single grained; loose; slightly acid.

Thickness of the solum ranges from 40 to 70 inches. Depth to free carbonates ranges from 60 to 80 inches. The A horizon is typically fine sand but ranges to loamy fine sand. It is very friable or loose. Reaction is medium acid to slightly acid. The B horizon is dominantly fine sand, but it also contains one or more layers of loamy fine sand at a depth of 24 to 50 inches. Consistence ranges from loose to friable. Reaction is slightly acid to neutral. In places, mottles are in the lower part of the B horizon. The C horizon is mostly fine sand, but in places it is stratified with loamy fine sand. Mottles are in this horizon in some pedons.

Lasa loamy fine sand, rock substratum, is outside the defined range of the series because it has fractured limestone bedrock at depths between 40 and 80 inches.

Lasa soils are associated with Fedji and Litchfield soils. They have a sandy C horizon, whereas the Fedji soils have a loamy IIC horizon beginning within a depth of 40 inches. Lasa and Litchfield soils formed in similar material, but Lasa soils are better drained.

222B—Lasa fine sand, 2 to 8 percent slopes. This gently undulating soil occupies 5- to 40-acre areas on sandy outwash plains and stream deltas. Slopes are plane to convex. This soil has the profile described for the series.

Included with this soil in mapping are areas of very poorly drained Dassel soil in depressions and low gradient drainageways, and small areas where slopes are more than 6 percent. These included areas are identified by spot symbols on the soil map.

Runoff is slow to medium. The main concerns of management are slight droughtiness and maintenance of fertility. There is also a hazard of erosion.

Most areas of this soil are cultivated. The soil is best suited to early-maturing varieties of row crops and small grain because of its slight droughtiness. It has good potential for most urban and recreational uses. If septic tank filter fields are installed, there is a hazard of contaminating nearby lakes, streams, and wells. Capability unit IIIs–1.

360B—Lasa loamy fine sand, rock substratum, 1 to 6 percent slopes. This gently sloping soil occupies 3- to 160-acre areas on rock terraces of the Minnesota River. This soil has a profile similar to the one described for the series, but it has a loamy fine sand surface layer and is underlain by limestone bedrock at a depth of 40 to 80 inches.

Included with this soil in mapping are small areas where bedrock is at a depth of less than 40 inches or more than 80 inches. Also included and identified by spot symbols on the soil map are areas where slopes are more than 6 percent, a few areas where bedrock is exposed at the surface, small areas of Tilfer or Joliet soils in drainageways and depressions, and small areas of gravel.

Runoff is slow to medium. The main concerns of management are droughtiness and erosion control. This soil is subject to soil blowing in spring and in winter if there is little or no snow cover.

This soil is best suited to early-maturing varieties of row crops and small grain. Many areas are permanent pasture or woodland. The soil has fair potential for most urban and recreational uses but is limited by slope and depth to bedrock. Capability unit IVs–1.

360E—Lasa loamy fine sand, rock substratum, 12 to 35 percent slopes. This soil occupies 4- to 30-acre narrow scarp slopes of rock terraces of the Minnesota River. It has a profile similar to the one described for the series, but it is thinner, has a loamy fine sand surface layer, and is underlain by limestone bedrock at a depth of 40 to 80 inches.

Included with this soil in mapping are small areas where bedrock is at a depth of less than 40 inches or more than 80 inches. Small areas of Terril soils are included at the base of some slopes.

Runoff is medium to rapid. The hazard of erosion is severe. Droughtiness and steep slopes severely limit the use of this soil for any crops. The soil is well suited to woodland or permanent pasture. It is poorly suited to most urban and recreational uses because of the slope. Capability unit VIIs–1.

Lerdal Series

The Lerdal series consists of deep, gently sloping to sloping, somewhat poorly drained to moderately well drained soils. These soils formed in a limy, shale-rich, fine textured and moderately fine textured mantle 3 to 10 feet thick over medium textured and moderately fine textured glacial till. They occur on concave, plane, and convex slopes on upland till plains. Slopes are simple and complex and are 75 to 150 feet long. Native vegetation was mixed deciduous trees and tall grass prairie.

In a representative profile the surface layer is very dark gray silty clay loam about 7 inches thick. The subsurface layer is dark grayish brown silty clay loam about 5 inches thick. The subsoil is dark grayish brown silty clay in the upper 17 inches and mottled dark grayish brown silty clay loam in the lower 16 inches. Most ped surfaces have very dark grayish brown coatings of clay films. The underlying material is limy, grayish brown and light olive brown clay loam.

Permeability is slow. The available water capacity and natural fertility are high. Organic-matter content is moderate. The seasonal high water table is at a depth of 2 to 5 feet, or near tile depth.

Most areas of Lerdal soils are used as cropland. Some are woodland. Erosion is a problem on some slopes. Maintenance of good tilth, erosion control, and water control are management needs.

Representative profile of Lerdal silty clay loam, 2 to 6 percent slopes, eroded, taken in an uneroded area, in cultivated area 1,500 feet east and 100 feet south of northwest corner sec. 13, T. 106 N., R. 26 W.

Ap—0 to 7 inches, very dark gray (10YR 3/1) silty clay loam, gray (10YR 5/1) dry; weak very fine subangular blocky structure; friable; slightly acid; abrupt smooth boundary.

A2—7 to 12 inches, dark grayish brown (2.5Y 4/2) silty clay loam; weak very fine subangular blocky structure; friable to firm; slightly acid; clear wavy boundary.

B21t—12 to 21 inches, dark grayish brown (2.5Y 4/2) silty clay; many fine faint olive brown (2.5Y 4/4) mottles; moderate fine angular blocky structure; common thin very dark grayish brown (2.5Y 3/2) clay films on faces of peds; few sand-sized shale particles; strongly acid; clear wavy boundary.

B22tg—21 to 29 inches, dark grayish brown (2.5Y 4/2) silty clay; common fine distinct light olive brown (2.5Y 5/4 and 5/6) mottles; moderate fine and medium prismatic structure parting to moderate fine and medium subangular blocky and angular blocky; firm; many thin very dark grayish brown (2.5Y 3/2) clay films on faces of peds; about 4 percent coarse fragments, mostly shale; very strongly acid; clear wavy boundary.

B23tg—29 to 45 inches, dark grayish brown (2.5Y 4/2) silty clay loam; many fine distinct grayish brown (2.5Y 5/2) and light olive brown (2.5Y 5/4) mottles; moderate medium and coarse prismatic structure; firm; many thin dark grayish brown (2.5Y 4/2) clay films on faces of peds; about 4 percent coarse fragments, mostly shale; strongly acid; clear wavy boundary.

C—45 to 60 inches, grayish (2.5Y 5/2) clay loam; many fine faint light olive brown (2.5Y 5/4 and 5/6) mottles; massive; firm; common thin dark grayish brown (2.5Y 4/2) clay films in root channels; about 5 percent coarse fragments, mostly shale; slightly effervescent; neutral.

Thickness of the solum and depth to free lime range from 30 to 60 inches. The Ap horizon is black or very dark gray. The A horizon is typically silty clay loam, but the range includes silt loam or clay loam. It is slightly acid or medium acid. In places the A2 horizon is incorporated into the Ap horizon. The B2 horizon is typically silty clay that is high in sand, but the range includes clay loam, clay, or silty clay loam. Shale fragments are few to common. Few to many, prominent to distinct mottles are in most parts. Consistence is firm or very firm. Reaction is strongly acid to very strongly acid. Ped coatings of clean sand and silt particles are in the upper part of the B horizon in places. Deposits of iron around old root channels are in the lower part of the B horizon of some places. The sand fraction is mostly shale. Clay films range from thin to thick and are common to many. The C horizon is typically clay loam, but the range includes loam and gritty silty clay loam. Consistence is friable or firm. In places a few soft masses of lime are in the upper part of this horizon.

Lerdal soils occur on the landscape with Kilkenny, Lester, Shorewood, Minnetonka, and Le Sueur soils. They have more clay and less sand and silt than Le Sueur soils. They are wetter and grayer in the B horizon than Kilkenny and Lester soils. They have more sand and less silt in the solum than Shorewood and Minnetonka soils.

138B2—Lerdal silty clay loam, 2 to 6 percent slopes, eroded. This gently sloping soil occupies 3- to 30-acre knolls, gentle rises, and flat hilltops. Slopes are about 75 to 150 feet long. They are concave and convex. This soil has the profile described for the series.

Included with this soil in mapping are a few small areas of the better drained Kilkenny and Shorewood soils. Small, wet areas of Minnetonka, Marna, Glencoe, Lura, and Rolfe soils are also included and are identified by spot symbols on the soil map. A few uneroded areas and areas where slopes are less than 2 percent or more than 6 percent are also included. Lime occurs within a depth of 20 inches in a few areas of this soil.

Wetness is a problem on this soil. Runoff is medium. The hazard of erosion is moderate because of saturation from the perched water table. It is greatest in areas adjacent to ravines and draws and on convex slopes. Maintaining good tilth and high fertility and applying lime are management needs. Plowing when wet often results in a hard and cloddy surface layer. Bulk density values of surface layers are much lower in the woodland areas.

Most of the acreage is cropland, but a few areas are woodland or pasture. Low strength, moderately slow permeability, and potential frost action are limitations for most urban and recreational uses. Capability unit IIe–1.

138C2—Lerdal silty clay loam, 6 to 15 percent slopes, eroded. This sloping soil occupies 3- to 20-acre knolls and side slopes. Slopes are concave and convex and are about 75 to 150 feet long. This soil has a profile similar to that described for the series, but the soil layers are thinner.

Included with this soil in mapping are a few small areas of better drained Kilkenny, Lester, and Shorewood soils. Small, wet areas of Minnetonka, Marna, Glencoe, Lura, and Rolfe soils are also included and are identified by spot symbols on the soil map. Areas where slopes are less than 6 percent or more than 15 percent and some severely eroded areas are also included. The surface layer is thinnest on the convex slopes, and it is lower in organic matter and less friable in these areas. Lime occurs at depths of 20 inches in a few areas.

Wetness is a problem on this soil. Runoff is medium to rapid. The hazard of erosion is moderate to severe because of saturation from the perched water table. It is greatest in areas adjacent to ravines and draws and on convex slopes. Hillside seeps are a problem but can be corrected with tiles at the seep area. Maintaining good tilth and high fertility and applying lime are management needs. Plowing when wet often results in a hard and cloddy surface layer.

Most of the acreage is cropland. A few areas are woodland and pasture. Low strength, moderately slow permeability, potential frost action, and slope are limitations for most urban and recreational uses. Capability unit IIIe–2.

Lester Series

The Lester series consists of gently undulating to steep, well drained soils formed in moderately fine textured and medium textured glacial till. These soils occupy irregular hilltops and knolls and smooth side slopes. Slopes are convex and plane. Native vegetation was mixed deciduous trees and tall grass prairie.

In a representative profile the surface layer is very dark gray loam about 10 inches thick. The next 5 inches is very dark grayish brown friable loam. The subsoil is about 33 inches thick. The upper part is 6 inches of dark brown friable clay loam, and the lower part is dark yellowish brown, yellowish brown, and light olive brown friable clay loam and loam. The underlying material is limy, light olive brown friable loam.

Permeability is moderate. The seasonal high water table is below a depth of 6 feet. The available water capacity, organic-matter content, and natural fertility are high.

Most areas of the less sloping Lester soils are used as cropland. The steeper areas are woodland or permanent pasture. The hazard of erosion is the major limitation to use of these soils for crops. Maintenance of tilth is a special management need.

Representative profile of Lester loam, 2 to 6 percent slopes in cultivated field 1,655 feet north and 50 feet west of southeast corner sec. 13, T. 107 N., R. 25 W.

Ap—0 to 10 inches, very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) dry; weak fine and medium subangular blocky structure; friable; neutral; abrupt smooth boundary.

A3—10 to 15 inches, very dark grayish brown (10YR 3/2) loam; moderate fine and medium subangular blocky structure; friable; common clean sand and silt particles on faces of peds; slightly acid; clear wavy boundary.

B1—15 to 21 inches, dark brown (10YR 4/3) clay loam; moderate medium subangular blocky structure; friable; common clean sand grains on faces of peds; about 4 percent coarse fragments; slightly acid; clear wavy boundary.

B21t—21 to 30 inches, dark yellowish brown (10YR 4/4) clay loam; moderate medium subangular blocky structure; friable; dark brown (10YR 4/3) and very dark grayish brown (10YR 3/2) clay films on faces of peds; common clean sand grains on faces of peds and in tubular pores; about 4 percent coarse fragments; slightly acid; clear wavy boundary.

B22t—30 to 41 inches, yellowish brown (10YR 5/4) clay loam; moderate medium prismatic structure parting to moderate medium subangular blocky; friable; many moderately thick very dark grayish brown (10YR 3/2) and dark brown (10YR 4/3) clay films on faces of peds and in pores; about 4 percent coarse fragments; slightly acid; clear wavy boundary.

B3t—41 to 48 inches, light olive brown (2.5Y 5/4) loam; moderate coarse prismatic structure parting to weak coarse subangular blocky; friable; many thick black (10YR 2/1) and dark brown (10YR 3/3) clay films on faces of peds; about 5 percent coarse fragments; neutral; clear wavy boundary.

C—48 to 60 inches, light olive brown (2.5Y 5/4) loam; common medium distinct yellowish brown (10YR 5/6) mottles; massive; friable; soft lime masses; about 5 percent coarse fragments; strongly effervescent; mildly alkaline.

Thickness of the solum and depth of lime range from 20 to 54 inches. Coarse fragments of mixed lithology make up 2 to 8 percent of the solum and C horizon. The Ap or A1 horizon is typically black, very dark gray, or very dark brown loam, but the range includes clay loam. Some profiles have an A2 horizon as thick as 4 inches. It is very dark gray, dark gray, or dark grayish brown. The A horizon is slightly acid to medium acid. The B1 horizon is very dark grayish brown or dark grayish brown and is slightly acid or medium acid. The B2 horizon is slightly acid to strongly acid and it is 9 to 22 inches thick. The B3 horizon is slightly acid or neutral.

These soils have a thicker, darker colored A horizon than that defined for the series, but this difference does not alter the use or management of the soils.

Lester soils are associated with Kilkenny, Le Sueur, and Cordova soils. They are better drained and have brighter colors in the B horizon than Le Sueur and Cordova soils. They contain less clay and more sand and silt in the solum than Kilkenny soils.

106B—Lester loam, 2 to 6 percent slopes. This gently undulating soil occupies 5- to 30-acre knolls, hilltops, and rises. Slopes are about 80 to 150 feet long. This soil is above the more sloping Lester soils on the landscape. It has the profile described for the series. The soil layers are thinner where slopes are more convex.

Included with this soil in mapping are moderately eroded areas on the convex slopes. A few areas where slopes are more than 6 percent are also included. The concave slopes are occupied by small areas of Cordova, Le Sueur, or Webster soils and are identified by spot symbols on the soil map. In a few areas the surface layer and the upper part of the subsoil are sandy loam.

Runoff is medium. The hazard of erosion is moderate in cultivated areas. Good tilth is difficult to maintain without special management practices.

Most areas of this soil are used as cropland. A few are wooded. This soil has fair to good potential for most urban uses. Capability unit IIe–2.

106C—Lester loam, 6 to 12 percent slopes. This rolling soil occupies 5- to 20-acre, irregularly shaped knolls and hillsides. Slope segments are 80 to 150 feet long. This soil has a profile similar to that described for the series, but the soil layers are thinner on the more convex slopes.

Included with this soil in mapping are a few areas where slopes are less than 6 percent or more than 12 percent. Erosion, tree removal, and deep tillage have mixed part of the brownish subsoil with the surface layer in some areas. This mixed layer has browner colors, has less organic matter, and is less friable than is typical. The concave slopes are occupied by small areas of Cordova, Le Sueur, or Hamel soils and are identified by spot symbols on the soil map. Small areas of Storden and Estherville soils occur on convex slopes and are also identified by spot symbols.

Runoff is medium. Erosion control and maintenance of fertility are the major management needs.

Areas of this soil are woodland or cropland. The soil is well suited to most crops grown in the county. It has fair potential for most urban and recreational uses. Capability unit IIIe–1.

106D—Lester loam, 12 to 18 percent slopes. This moderately steep soil occupies 5- to 20-acre knolls and side slopes. Relief is convex and concave. Slopes are about 80 to 150 feet long. This soil has a profile similar to that described for the series, but the layers are thinner.

Included with this soil in mapping are a few areas where slopes are less than 12 percent or more than 18 percent. Erosion, tree removal, and deep tillage have mixed part of the brownish subsoil with the surface layer in some areas. This mixed layer has browner colors, has less organic-matter content, and is less friable than is typical. Drainageways and depressions on the concave slopes are occupied by Cordova, Hamel, or Le Sueur soils. In a few areas the surface layer and the upper part of the subsoil are sandy loam. At the base of many slopes is a soil that has a thick surface layer.

Runoff is rapid. Erosion control and maintenance of fertility are the major management needs.

This soil is used mainly for row crops. A few areas are pasture or woodland. Slope is the main limitation for urban and recreational uses. Capability unit IVe–1.

106E—Lester loam, 18 to 24 percent slopes. This steep soil occupies wooded and pastured slopes along the major rivers and their tributaries. Slopes are 80 to 150 feet long. They are convex and concave. This soil is dissected at frequent intervals by shallow down slope drains and occasional abrupt, deep, narrow ravines. It has a profile similar to that described for the series, but the layers are thinner.

Included with this soil in mapping are a few small areas of Storden soils on the convex slopes. A few areas have Estherville soils mixed with Storden soils, and in some areas there is a thin sandy loam mantle. Erosion, tree removal, and deep tillage have mixed part of the brownish subsoil with the surface layer in some areas. This mixed layer has browner colors, has less organic matter, and is less friable. Small areas of Hamel and Terril soils that have a thick surface layer are included at the base of some slopes.

Most of the acreage is woodland; a few areas are used as permanent pasture. The steep, wooded slopes commonly limit this soil to esthetic enhancement of the natural environment. Capability unit VIe–1.

Le Sueur Series

The Le Sueur series consists of moderately well drained, nearly level soils on slight convex rises on the ground moraine. These soils formed in limy, moderately fine textured and medium textured glacial till. Native vegetation was tall grass prairie and mixed deciduous trees.

In a representative profile (fig. 6) the surface layer is black clay loam about 13 inches thick. The subsoil, about 28 inches thick, is dark grayish brown, olive brown, and grayish brown clay loam with dark colored clay films. The underlying material is mottled olive brown loam.

Permeability is moderate. Available water capacity, organic-matter content, and natural fertility are high.

Figure 6.—**Profile of Le Sueur clay loam.**

The seasonal high water table is at a depth of 3 to 5 feet.

Most areas of Le Sueur soils are cropland, but some remain in trees. The soils are well suited to all general farm crops. They respond well to fertilizers and chemicals.

Representative profile of Le Sueur clay loam, 1 to 3 percent slopes in cultivated area 1,980 feet north and 100 feet west of southeast corner sec. 13, T. 107 N., R. 25 W.

Ap—0 to 9 inches, black (10YR 2/1) clay loam, gray (10YR 5/1) dry; weak very fine and fine subangular blocky structure; friable; neutral; abrupt smooth boundary.

A12—9 to 13 inches, black (10YR 2/1) clay loam; moderate fine subangular blocky structure; friable; very dark gray (10YR 3/1) coatings on faces of peds; neutral; clear wavy boundary.

B21t—13 to 16 inches, dark grayish brown (2.5Y 4/2) clay loam; moderate fine and medium subangular blocky structure; friable; few thin very dark gray (10YR 3/1) and dark grayish brown (10YR 4/2) clay films on faces of peds; about 3 percent coarse fragments; neutral; clear wavy boundary.

B22t—16 to 25 inches, grayish brown (2.5Y 5/2) clay loam; moderate medium prismatic structure parting to moderate medium subangular blocky; friable; many thin very dark grayish brown (2.5Y 3/2) and very dark gray (10YR 3/1) clay films on faces of peds; about 3 percent coarse fragments; medium acid; clear smooth boundary.

B23t—25 to 36 inches, olive brown (2.5Y 4/4) clay loam; common medium distinct strong brown (7.5YR 5/6) mottles; moderate medium prismatic structure parting to moderate medium and coarse subangular blocky; friable; common moderately thick very dark gray (10YR 3/1) and very dark grayish brown (10YR 3/2) clay films on faces of peds and in pores; about 3 percent coarse fragments; medium acid; clear wavy boundary.

B3t—36 to 41 inches, grayish brown (2.5Y 5/2) clay loam; common medium distinct strong brown (7.5YR 5/6) mottles; moderate coarse prismatic structure parting to weak coarse subangular blocky; friable; many thick black (10YR 2/1) and olive brown (2.5Y 4/4) clay films on faces of peds and in pores; about 4 percent coarse fragments; neutral; clear wavy boundary.

C—41 to 60 inches, olive brown (2.5Y 4/4) loam; common medium distinct light brownish gray (2.5Y 6/2) and yellowish brown (10YR 5/6) mottles; friable; black (10YR 2/1) clay films on some pores in upper part; about 4 percent coarse fragments; slightly effervescent; mildly alkaline.

Thickness of the solum and depth to lime range from 30 to 55 inches. The A1p and A12 horizons typically are clay loam, but the range includes silty clay loam, loam, and silt loam. They are black to very dark gray. Some profiles have a dark gray or dark grayish brown A2 horizon as much as 5 inches thick. The A horizon ranges from neutral to medium acid but is generally medium acid. The B horizon is 15 to 34 inches thick. In places the lower part is loam. The B horizon ranges from slightly acid to very strongly acid but is generally medium acid. The C horizon is dark grayish brown to grayish brown. It is mildly alkaline to moderately alkaline and is slightly effervescent to strongly effervescent.

Le Sueur, Lester, Cordova, and Glencoe soils formed in similar materials. Le Sueur soils have a grayer solum and are wetter than Lester soils. They are better drained than Cordova and Glencoe soils.

239—Le Sueur clay loam, 1 to 3 percent slopes. This nearly level soil occupies 3- to 40-acre, irregularly shaped, low gradient rises or hilltops. Slopes are concave and convex.

Included with this soil in mapping are some areas of Lester soils that have 3 to 6 percent slopes. Small areas that are similar to Shorewood soils are included within large mapped areas. Small, wet areas of Cordova and Webster soils on concave slopes are included and are identified by spot symbols on the soil map. Included in urban areas are places where Le Sueur soil has been excavated for foundations, basements, or roads and spread on the ground's surface or used to fill in depressions.

There is very little or no erosion, and the hazard of erosion is slight because of the low gradient short slopes. This soil is used mainly for row crops, though some areas still remain in woodland. Other than slight seasonal wetness, this soil has few limitations for farming. If worked when wet, the surface layer compacts easily, tilth is destroyed, and the soil becomes hard and cloddy.

In urban areas runoff is high from roofs, roads, and other paved surfaces which cover as much as 50 percent of the surface layer. This soil has fair to poor potential for most urban uses because of the moderate shrink-swell potential, low strength, and seasonal wetness. Capability unit I–1.

Litchfield Series

The Litchfield series consists of nearly level, somewhat poorly drained to moderately well drained, coarse textured soils formed in glacial outwash or lacustrine sediments. These soils occupy broad flats and slight rises on outwash plains and deltas. Slopes are plane to slightly convex. Native vegetation was tall grass prairie.

In a representative profile the surface layer is very dark gray loamy fine sand about 16 inches thick. The subsoil, about 36 inches thick, is mottled very dark grayish brown, dark grayish brown, and light olive brown loamy fine sand in the upper part and mottled olive gray fine sandy loam in the lower part. The underlying material is mottled light brownish gray, loose fine sand.

Runoff is slow. Permeability is moderately rapid. The seasonal high water table is at a depth of 3 to 5 feet. Available water capacity and natural fertility are low. Organic-matter content is moderate.

Drought is a problem. These soils respond well to applications of fertilizer if adequate moisture is available. Most areas of Litchfield soils are used for corn and soybeans.

Representative profile of Litchfield loamy fine sand, 1 to 3 percent slopes 2,540 feet south and 1,450 feet west of northeast corner sec. 26, T. 107 N., R. 29 W.

Ap—0 to 8 inches, very dark gray (10YR 3/1) loamy fine sand; weak fine granular structure; friable; neutral; abrupt smooth boundary.

A12—8 to 16 inches, very dark gray (10YR 3/1) loamy fine sand; weak fine granular structure; very friable; neutral; clear smooth boundary.

B1—16 to 24 inches, very dark grayish brown (10YR 3/2) loamy fine sand; few fine faint dark brown (10YR 3/3) mottles; weak medium subangular blocky structure; very friable; medium acid; clear smooth boundary.

B21—24 to 39 inches, dark grayish brown (10YR 4/2) fine sand; common fine faint very dark grayish brown (10YR 3/2) mottles; single grained; loose; medium acid; clear smooth boundary.

B22—39 to 48 inches, light olive brown (2.5Y 5/4) loamy fine sand; few fine distinct light olive brown (2.5Y 5/6) mottles; single grained; loose; medium acid; clear smooth boundary.

B23—48 to 52 inches, olive gray (5Y 5/2) fine sandy loam; many coarse prominent yellowish brown (10YR 5/6) mottles; moderate fine angular blocky structure; friable; medium acid; clear smooth boundary.

C—52 to 60 inches, light brownish gray (2.5Y 6/2) fine sand; common coarse prominent yellowish brown (10YR 5/6) mottles; single grained; loose; slightly acid.

Solum thickness ranges from 36 to 65 inches. Depth to lime is 50 to 100 inches. The A horizon is 10 to 24 inches thick. It is typically loamy fine sand, but the range includes fine sandy loam. The upper part of the B horizon is fine sand or loamy fine sand. Some parts of the B horizon have finer textures including sandy loam, fine sandy loam, or loam. Mottles are few to common. The C horizon is mostly fine sand or sand, but can include thin, discontinuous, medium textured or moderately coarse textured strata. In places loam till or silty lacustrine sediments are below a depth of 40 inches.

Litchfield soils occur on the landscape with Lasa, Fieldon, Darfur, and Dassel soils. They are wetter than the Lasa soils and better drained than the Darfur, Fieldon, and Dassel soils.

181—Litchfield loamy fine sand, 1 to 3 percent slopes. This nearly level soil occupies 5- to 20-acre broad flats within areas of Dickinson, Estherville, and Darfur soils. Slopes are plane to slightly convex. This soil has the profile described for the series.

Included with this soil in mapping are small areas of Dickinson and poorly drained Darfur soils and sandy soils which lack the finer textured bands. Also included are some areas of soils that have an alkaline surface layer and some that have a silty substratum at a depth of 40 to 60 inches. Soils that have finer textured bands of silt loam are also included.

This soil has a severe hazard of soil blowing in unprotected areas in winter and spring. It is used mainly for row crops. Droughtiness, low natural fertility, and slight seasonal wetness limit its effectiveness for farm use unless irrigation and fertilization are provided.

This soil has only fair potential for most urban and recreational uses because of the seasonal high water table. There is a high hazard of contamination of ground water sources if septic tanks are placed in this soil. Capability unit IIIs–1.

946—Litchfield-Nicollet complex, 1 to 3 percent slopes. This nearly level to gently undulating map unit is one of moderately well drained soils on convex slopes. The irregular slopes are 75 to 125 feet long. Areas range from 3 to 25 acres in size. This unit is about 60 percent Litchfield loamy fine sand, 30 percent Nicollet clay loam, and 10 percent other soils. The profile of Litchfield soils differs from that described for the series in having loamy glacial till at depths of 40 to 72 inches. The profile of Nicollet soil differs in having a higher sand content in the surface layer.

Included with this unit in mapping are small sandy areas. Small areas where the subsoil is fine sandy loam or very fine sandy loam to a depth of 20 to 36 inches are also included. In places the underlying material is silt loam. Small areas of the poorly drained Granby, Darfur, and Webster soils which are on the nearly level, concave slopes adjacent to the Litchfield-Nicollet complex are also included.

All crops commonly grown in the county are grown on these soils. The soils are moderately well suited to crops, depending upon the amount of rainfall. Droughtiness is a limitation. Soil blowing is a hazard on bare fields in winter and spring. Management is needed to control erosion and to maintain high levels of organic matter and plant nutrients. The seasonal high water table is the main limitation for urban and recreational uses. Litchfield loamy fine sand, capability unit IIIs–1; Nicollet clay loam, capability unit I–1.

Lomax Series

The Lomax series consists of deep, well drained, medium textured soils formed in moderately coarse textured, older alluvium. These soils occupy relatively high positions on the flood plain where the river has degraded to a lower level. They are not subject to present day flooding. Native vegetation was mixed deciduous forest and tall grass prairie.

In a representative profile the surface layer is black and very dark gray loam about 19 inches thick. The subsoil is very dark grayish brown, dark grayish brown, and dark brown loam and fine sandy loam about 41 inches thick.

Permeability is moderately rapid, and the available water capacity is moderate to high. Organic-matter content and natural fertility are high. Runoff is slow. The seasonal high water table is below a depth of 6 feet.

Lomax soils are used as cropland. They are well suited to most row crops, although they may be slightly droughty during prolonged dry periods. They warm up early in spring and are easy to till. They respond well to good management.

Representative profile of Lomax loam, 1 to 3 percent slopes 2,375 feet east and 2,045 feet south of northwest corner sec. 18, T. 106 N., R. 27 W.

Ap—0 to 9 inches, black (10YR 2/1) loam; weak very fine and fine subangular blocky structure; friable; slightly acid; abrupt smooth boundary.

A12—9 to 14 inches, black (10YR 2/1) loam; weak very fine and fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

A3—14 to 19 inches, very dark gray (10YR 3/1) loam; weak very fine and fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

B2—19 to 26 inches, very dark grayish brown (10YR 3/2) loam; weak very fine and fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

B31—26 to 32 inches, dark grayish brown (10YR 4/2) fine sandy loam; weak very fine and fine subangular blocky structure; very friable; slightly acid; clear smooth boundary.

B32—32 to 60 inches, dark brown (10YR 4/3) fine sandy loam; weak very fine and fine subangular blocky structure; very friable; slightly acid.

Thickness of the solum ranges from 40 to 70 inches. The depth to lime is 60 inches or more. The A horizon is 24 to 42 inches thick. It generally is loam, but in places it is fine sandy loam. The B horizon ranges from loam or sandy loam to fine sandy loam, and a few places have thin, intermittent strata of finer textures. The A and B horizons are slightly acid to neutral. The C horizon is sand or loamy sand or stratified sandy material. It ranges from neutral to medium acid.

The Lomax soil is outside the defined range of the series because it has lower chroma in the B horizon. This difference, however, does not alter the use or management.

Lomax soils formed in landscape positions similar to those of Minneopa and Dorchester soils. They have more silt and clay and less sand than Minneopa soils. In contrast with Dorchester soils, they have more sand throughout the profile, are more permeable, have a thicker, dark colored A horizon, and are well drained.

248—Lomax loam, 1 to 3 percent slopes. This nearly level soil occupies high terraces that are 30 to 50 feet above present stream flood stages. Areas are 5 to 60 acres in size. This soil commonly has a sharp escarpment slope toward the river and an abandoned stream channel toward the uplands.

Included with this soil in mapping are small areas of moderately well drained Dorchester soils and sandier Minneopa soils. Also included are areas that have a seasonal high water table at a depth of 3 to 5 feet, small areas of soils that have a sandy and gravelly layer, and areas where slopes are more than 3 percent.

Runoff is slow. The main concern of management is slight droughtiness. Most areas of this soil are used for crops, although some are still in woodland. This soil has good potential for most urban and recreational uses. Capability unit I–1.

Lura Series

The Lura series consists of deep, very poorly drained soils formed in fine textured glacial lacustrine sediments over glacial till. These soils occupy depressions in the lake plain. Native vegetation was marsh grass, reeds, and sedges.

In a representative profile the surface layer is black and very dark gray silty clay and clay about 58 inches thick. The underlying material is mottled gray and olive gray silty clay.

Runoff is very slow, and permeability is slow. Available water capacity, organic-matter content, and natural fertility are high. Depth to the seasonal high water table is less than 1 foot, or near tile depth.

These soils are well suited to farm crops if they are adequately drained and managed. Most areas of Lura soils have been drained and are used for row crops. Undrained areas are used mainly for wild hay and pasture. They offer good cover for wildlife.

Representative profile of Lura silty clay in cultivated area 560 feet north and 2,250 feet east of southwest corner sec. 26, T. 105 N., R. 27 W.

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

A12—10 to 20 inches, black (5Y 2/1) silty clay; weak and moderate very fine angular blocky structure; friable; neutral; clear smooth boundary.

A13—20 to 26 inches, black (5Y 2/1) clay; few fine distinct olive (5Y 5/4) mottles; weak coarse prismatic structure parting to moderate very fine angular blocky; very dark gray (5Y 3/1) coarse blotches; neutral; clear smooth boundary.

A14—26 to 46 inches, black (5Y 2/1) clay; moderate very fine angular blocky structure; firm; slightly acid; clear smooth boundary.

A15—46 to 58 inches, very dark gray (5Y 3/1) silty clay; common fine distinct dark gray (5Y 4/1) and olive gray (5Y 4/2) mottles; weak and moderate very fine angular blocky structure; friable; slightly acid; clear smooth boundary.

C—58 to 60 inches, gray (5Y 5/1) and olive gray (5Y 5/2) silty clay; common fine distinct olive (5Y 5/4) mottles; weak very fine angular structure; friable; slightly acid.

Thickness of the solum and depth to free carbonates range from 40 to 80 inches. The depth to the underlying loamy till commonly ranges from 48 to 80 inches. The A horizon typically is silty clay but ranges from silty clay loam to clay. It is slightly acid to neutral. The C horizon is typically silty clay, but the range includes silty clay loam, clay loam, and in places, clay. The C horizon is neutral to mildly alkaline.

Lura soils are associated with Barbert, Beauford, Marna, Waldorf, and Minnetonka soils. They are wetter than the Beauford, Marna, Waldorf, and Minnetonka soils. Lura soils have more clay in the A horizon, are less acid, and lack the argillic horizon of the Barbert soil.

211—Lura silty clay. This nearly level soil occupies 3- to 15-acre depressions and swales and 5- to 40-acre long winding, low gradient drainageways. Slopes are 0 to 2 percent. They are plane to slightly concave.

Included with this soil in mapping are a few areas where slopes are 2 to 4 percent. Also included are small areas of Barbert soil and better drained Marna, Minnetonka, Waldorf, and Beauford soils on adjacent nearly level land. Some soils that have a thin organic mat in the deepest part of depressions are also included.

This soil has a severe hazard of wetness unless it is drained. The main concerns of management are removal of excess water and maintenance of good tilth.

This soil is used mainly for row crops. Undrained areas are used mainly for wild hay and pasture. Runoff is slow to ponded, and drainage is essential for the crops commonly grown in the county. The soil can be tilled properly only within a narrow range of soil moisture content. If worked when wet, it puddles easily, tilth is destroyed, aeration is reduced, and the soil becomes hard and cloddy when dry.

The seasonal high water table, slow percolation rates, high shrink-swell potential, and low strength severely limit this soil for most urban and recreational uses. Capability unit IIIw-1.

Madelia Series

The Madelia series consists of deep, nearly level, poorly drained, medium textured and moderately fine textured soils formed in friable glacial lacustrine sediments. These soils occupy flats and drainageways on the silt-mantled till plain. Native vegetation was a wet site community of the tall grass prairie.

In a representative profile the surface layer is black and very dark gray silty clay loam about 19 inches thick. The subsoil is mottled olive gray friable silty clay loam about 8 inches thick. The underlying material is limy, mottled olive gray and olive silt loam and silty clay loam.

Permeability is moderate. Available water capacity, organic-matter content, and natural fertility are high. Runoff is slow. Depth to the seasonal high water table is 1 to 3 feet, or near tile depth. Removal of excess water and maintenance of tilth are management needs.

If Madelia soils are adequately drained and well managed, they are excellent cropland, and most areas are used for this purpose. Limitations for many urban uses are moderate to severe.

Representative profile of Madelia silty clay loam 1,680 feet south and 220 feet east of northwest corner sec. 30, T. 107 N., R. 27 W.

Ap—0 to 9 inches, black (10YR 2/1) silty clay loam; weak very fine subangular blocky structure; friable; neutral; abrupt smooth boundary.

A12—9 to 14 inches, black (10YR 2/1) silty clay loam; weak fine subangular blocky structure; friable; neutral; gradual wavy boundary.

A3g—14 to 19 inches, very dark gray (10YR 3/1) silty clay loam; weak fine subangular blocky structure; friable; few thin grayish brown (2.5Y 5/2) channel fillings; many fine tubular pores; neutral; gradual irregular boundary.

B2g—19 to 27 inches, olive gray (5Y 5/2) silty clay loam; few medium distinct light olive brown (2.5Y 5/6) mottles; moderate fine subangular blocky structure; friable; many fine tubular pores; few dark colored tongues and krotovinas; neutral; abrupt wavy boundary.

C1g—27 to 37 inches, olive gray (5Y 5/2) and olive (5Y 5/3) silty clay loam; many medium prominent yellowish brown

(10YR 5/8) mottles; weak fine subangular blocky structure; friable; few dark colored krotovinas; many fine rounded black concretions; many fine tubular pores; slightly effervescent; mildly alkaline; abrupt wavy boundary.

C2g—37 to 60 inches, pale olive (5Y 6/3) and olive gray (5Y 5/2) silt loam; many fine prominent yellowish brown (10YR 5/8) mottles; laminated; friable; strongly effervescent; mildly alkaline.

Thickness of the solum and depth to free lime range from 25 to 40 inches. The solum is slightly acid or neutral throughout. The A horizon is black or very dark gray and is 16 to 24 inches thick. It is typically silty clay loam but the range includes silt loam. The B horizon is typically silty clay loam, but the range includes silt loam. The C horizon is silt loam, silty clay loam, or stratified silt loam and loam high in content of very fine sand.

Madelia soils are associated with Kingston, Truman, Spicer, and Okoboji soils. Madelia, Truman, and Kingston soils formed in similar material, but Madelia soils are more poorly drained and lie lower on the landscape. Madelia soils are similar to Spicer soils, but they lack the free lime carbonates throughout the profile. They have a thinner A horizon than Okoboji soils.

136—Madelia silty clay loam. This nearly level soil is on broad flats and drainageways in the lake plain and lacustrine-mantled till plain. Areas are small to large. This soil has the profile described for the series. Slopes are 0 to 2 percent and plane to concave.

Included with this soil in mapping are small areas of better drained Kingston soils on slight convex rises. Also included are small areas of poorly drained, finer textured Marna and Waldorf soils. Areas of Okoboji soils in small depressions and small areas of limy Spicer soils on rims of depressions and drainageways are identified by spot symbols on the soil map.

The main concern of management is the removal of excess water. Tile drainage is needed. If this soil is tilled when too wet, the surface layer becomes cloddy.

Most areas of this soil are used for corn and soybeans. This soil is well suited to crops if excess water is removed and tilth is maintained. A few undrained areas are in hay or pasture. This soil is poorly suited to most urban and recreational uses because of wetness and low strength. Capability unit IIw–1.

947—Madelia-Webster silty clay loams. This nearly level map unit is one of poorly drained soils on upland flats and in drainageways. It occupies irregular 3- to 25-acre tracts. It is about 60 percent Madelia silty clay loam, 35 percent Webster silty clay loam, and 5 percent other soils. The profile of Madelia soils differs from that described for the series in having glacial till at depths of 48 to 72 inches. Slopes are 0 to 2 percent.

Included with this unit in mapping are small areas of Glencoe and Okoboji soils in depressions and small areas of moderately well drained Kingston soils on low, convex slopes.

All crops commonly grown in the county are grown on the soils of this unit. Wetness is a limitation, and tile drainage is needed. Tillage practices should be restricted when these soils are wet. This unit is poorly suited to most urban and recreational uses because of wetness and low strength. Capability unit IIw–1.

Marna Series

The Marna series consists of deep, poorly drained soils on nearly level, smooth slopes. These soils formed in a mantle of fine textured and moderately fine textured lacustrine sediments and underlying medium textured and moderately fine textured glacial till. Native vegetation was a wet site community of the tall grass prairie.

In a representative profile the surface layer is black and very dark gray silty clay loam and silty clay about 20 inches thick. The upper part of the subsoil is mottled dark grayish brown, olive gray, and olive clay 12 inches thick. The lower part is mottled dark olive gray and olive gray clay loam about 9 inches thick. The underlying material is limy, mottled olive gray and gray clay loam and loam.

Permeability is slow. Available water capacity, organic-matter content, and natural fertility are high. The depth to the seasonal high water table is 1 to 3 feet, or near tile depth.

Marna soils are well suited to row crops if they are well managed. The main management needs are adequate tile drainage and maintenance of good surface tilth. Most of the acreage is used for row crops.

Representative profile of Marna silty clay loam in cultivated area 10 feet east and 5 feet north of southwest corner sec. 23, T. 105 N., R. 28 W.

Ap—0 to 9 inches, black (N 2/0) silty clay loam; moderate fine subangular blocky structure; firm; many root channels and worm casts; few coarse fragments; slightly acid; gradual smooth boundary.

A12—9 to 15 inches, black (N 2/0) silty clay; moderate fine subangular blocky structure; very firm; abundant roots and worm casts; few coarse fragments; slightly acid; clear wavy boundary.

A3g—15 to 20 inches, very dark gray (10YR 3/1) silty clay; moderate fine subangular blocky structure; very firm; common worm casts; few tongues of dark gray (10YR 4/1); few coarse fragments; slightly acid; gradual smooth boundary.

B21g—20 to 26 inches, dark grayish brown (2.5Y 4/2) clay, very dark grayish brown (2.5Y 3/2) coatings on faces of peds; few fine distinct olive (5Y 5/6) mottles; moderate fine subangular blocky structure; very firm; common rounded sand-sized shale particles; few coarse fragments; slightly acid; gradual smooth boundary.

B22g—26 to 32 inches, olive gray (5Y 5/2) and olive (5Y 5/3) clay, olive gray (5Y 4/2) coatings on faces of peds; many fine distinct light olive brown (2.5Y 5/4) mottles; moderate medium prismatic structure parting to moderate medium subangular blocky; firm; common shale pebbles; few coarse fragments; neutral; gradual smooth boundary.

IIB3g—32 to 41 inches, dark olive gray (5Y 3/2) and olive gray (5Y 4/2) heavy clay loam; many fine distinct light olive brown (2.5Y 5/6) mottles; moderate medium prismatic structure parting to moderate fine subangular blocky; firm; 5 percent coarse fragments, mostly shale and dolomite; few very dark gray (10YR 3/1) old root channel fillings; neutral; abrupt wavy boundary.

IIC1g—41 to 48 inches, olive gray (5Y 4/2 and 5/2) clay loam; many fine prominent light olive brown (2.5Y 5/6) mottles; massive; friable; 5 percent coarse fragments, mostly limestone pebbles; few soft lime masses; strongly effervescent; mildly alkaline; clear smooth boundary.

IIC2g—48 to 60 inches, gray (5Y 5/1) loam; common fine prominent olive (5Y 4/4) mottles; weak fine and medium subangular blocky structure; friable; 5 percent coarse fragments; few soft lime masses; strongly effervescent; mildly alkaline.

Thickness of the solum and depth to lime range from 36 to 48 inches. The Ap horizon is typically silty clay loam, but the range includes clay or silty clay. The A1 and A3 horizons are typically silty clay, but the range includes silty clay loam and clay. They are 15 to 24 inches thick. The B horizon is typically clay, but the range includes silty clay loam and silty clay. The IIB horizon is typically clay loam, but the range includes loam. The B horizon ranges from very dark grayish brown or dark gray to olive gray. Light olive brown to olive mottles are distinct to prominent in the lower part of the B horizon and in the C horizon. The IIC horizon is loam or clay loam.

Marna soils occur on the same landscape as Lura, Kamrar, Guckeen, and Brownton soils. They have a thinner A horizon than the wetter Lura soil. Marna soils lack lime in the solum, whereas the Brownton soil is limy throughout. They are wetter than the Kamrar and Guckeen soils.

110—Marna silty clay loam. This nearly level soil occupies 5- to 80-acre broad flats and upper drainageways within or below areas of Guckeen and Kamrar soils. This soil has the profile described for the series. Slopes are 0 to 2 percent.

Included with this soil in mapping are areas where slopes are more than 2 percent. Also included, and identified by spot symbols on the soil map, are small areas of the Lura soil, small depressional areas of Barbert soil that have a grayish colored surface when dry, and small areas of limy Brownton soil adjacent to small depressions and drainageways.

This soil has a severe hazard of wetness. Runoff is slow, and tile drainage is necessary for profitable yields of the crops commonly grown in the county. This soil can be worked only within a narrow range of moisture content. If worked when wet, it puddles easily, tilth is destroyed, aeration is reduced, and the soil becomes hard and cloddy upon drying.

Most of the acreage of this soil is cropland. The soil has poor potential for most urban and recreational uses because of the high water table, high shrink-swell potential, and low strength. Capability unit IIw–2.

997—Marna-Barbert complex. This nearly level map unit is one of Marna silty clay loam and Barbert silt loam. It occupies 5- to 40-acre, nearly level areas and gentle rises. The soils are intermixed in such an intricate pattern that mapping them separately is not practical. This unit is 60 percent Marna soil, 35 percent Barbert soil, and 5 percent other soils. The Barbert soil occupies depressions and elongated, closed basins within areas of the Marna soil. Slopes are 0 to 2 percent and convex and concave.

Included with this unit in mapping are small areas of depressional Lura soils. Also included are a few areas that are underlain by loamy material within a depth of 4 feet.

The hazard of wetness is severe unless the soils are drained. Organic-matter content is moderate in the Barbert soil and high in the Marna soil. The main management needs are adequate tile drainage and maintenance of good soil tilth. Runoff is slow, and artificial drainage is necessary for profitable yields of the crops commonly grown in the county. These soils can be worked within only a narrow range of moisture content. If worked when wet, they puddle easily, tilth is destroyed, aeration is reduced, and the soil becomes hard and cloddy upon drying.

This unit is used mostly for row crops, mainly corn and soybeans. Because of the high seasonal water table, high shrink-swell potential, and low strength, this unit has poor potential for most urban and recreational uses. Marna silty clay loam, capability unit IIw–2; Barbert silt loam, capability unit IIIw–2.

Marsh

1053—Marsh occupies undrained depressions, shallow lakes or ponds, shallow bays, and fringes of the larger lakes that are under water most of the year. It is covered with a dense growth of reeds, sedges, and rushes. Some areas are open water. Some areas are dry if precipitation is below normal. The underlying material has not been identified, but it is generally muck and coprogenous earth material. Slopes are 0 to 2 percent.

A few areas have been developed for cropland. If drained, Marsh can be managed similar to Palms, Muskego, Caron, Glencoe, and Lura soils. Generally, however, it is not suited to crops and trees and shrubs.

The potential is good for wetland wildlife habitat but is very poor for openland and woodland wildlife habitat. Limitations are very severe for building site development, sanitary facilities, and recreational development because of the wetness. Capability unit VIIIw–1.

Minneopa Series

The Minneopa series consists of moderately well drained, nearly level to gently sloping, moderately coarse textured and coarse textured soils. These soils formed in sandy alluvial deposits of old rivers. They occupy high terraces within the valleys. The native vegetation was mixed tall grass prairie and deciduous trees.

In a representative profile the surface layer is black and very dark gray, very friable sandy loam about 15 inches thick. The subsoil is dark grayish brown sandy loam and loamy sand about 17 inches thick. The underlying material is limy, dark grayish brown loamy sand.

Permeability is moderately rapid, and available water capacity is low to moderate. Natural fertility is medium, and organic-matter content is moderate. Runoff is slow. The depth to the seasonal high water table is 3 to 5 feet.

Minneopa soils are suitable for all farm crops generally grown in the county. They are droughty, however, during prolonged periods of dryness. Some areas are subject to sidehill seepage from adjacent higher areas. A few areas remain wooded and are well suited to most types of outdoor recreational uses.

Representative profile of Minneopa sandy loam, 0 to 3 percent slopes, in cultivated field 1,700 feet north and 2,500 feet west of southeast corner sec. 27, T. 108 N., R. 26 W.

Ap—0 to 7 inches, black (10YR 2/1) sandy loam; weak fine granular structure; very friable; slightly acid; abrupt smooth boundary.

A12—7 to 11 inches, black (10YR 2/1) sandy loam; weak fine granular structure; very friable; slightly acid; clear wavy boundary.

A3—11 to 15 inches, very dark gray (10YR 3/1) sandy loam; weak fine granular structure; very friable; slightly acid; clear wavy boundary.

B2—15 to 20 inches, dark grayish brown (10YR 4/2) light sandy loam; weak fine granular structure; very friable; few very dark gray (10YR 3/1) channel fillings; common bleached sand grains on faces of peds; slightly acid; clear wavy boundary.

B3—20 to 32 inches, dark grayish brown (10YR 4/2) loamy sand; weak coarse subangular blocky structure; very friable; few bleached sand grains on faces of peds; neutral; clear wavy boundary.

C—32 to 60 inches, dark grayish brown (10YR 4/2) loamy sand; single grained; loose; few snail shells; mildly alkaline; strongly effervescent.

Thickness of solum and depth to free carbonates range from 28 to 50 inches. The A horizon typically is sandy loam but the range includes fine sandy loam, loamy sand, or loamy fine sand. This horizon is medium acid to neutral. The B horizon is sandy loam or loamy sand in the upper part and loamy sand or sand in the lower part. It is slightly acid to neutral. Mottles are in the lower part of this horizon in some profiles. The C horizon is sand or loamy sand and is mildly or moderately alkaline.

Minneopa loamy fine sand, occasionally flooded, is outside the defined range of the series. It is mildly alkaline throughout and is subject to flooding.

Minneopa soils are associated with Dorchester and Lomax soils. They have thinner A horizons than Lomax soils. They are sandier than Dorchester soils.

363—Minneopa loamy fine sand, occasionally flooded, 0 to 3 percent slopes. This nearly level soil occupies 5- to 50-acre broad flats on stream terraces adjacent to Alluvial land and Minneopa, Lomax, Comfrey, and Dorchester soils. This soil has a profile similar to that described for the series, but is is more sandy, is subject to occasional flooding, and is mildly alkaline throughout.

Included with this soil in mapping are some areas where bands or lenses of either coarser or finer textured material are in the subsoil. Small gravel spots are included and are identified by spot symbols on the soil map. Also included are areas where there is a buried surface layer from an earlier flood plain level, small areas where the surface layer is sandy loam, and small areas of Alluvial land and another Minneopa soil.

This soil is used extensively for breeding and for producing seed corn. It is droughty during prolonged dry periods. It responds well to fertilization, is easy to till, and warms up early in spring. The hazard of flooding limits most urban and recreational uses. If the soil is used as a septic tank filter field, there is a hazard of pollution to nearby streams and wells. Capability unit IIIw–7.

17—Minneopa sandy loam, 0 to 3 percent slopes. This nearly level to gently sloping soil occupies 5- to 100-acre broad flats on stream terraces adjacent to Alluvial land and Comfrey, Lomax, Dorchester, and Storden soils. It is above the level of most or all flooding. It has the profile described for the series.

Included with this soil in mapping are areas where bands or lenses of either coarser or finer textured material are in the subsoil. Small areas of Minneopa loamy fine sand, Lomax, and Dorchester soils are also included. Rodent burrowings are common in the surface layer. Seep areas and gravel spots, which are common in this soil, are identified by spot symbols on the soil map.

This soil warms up fairly early in spring, is easy to till, and responds well to fertilization. Droughtiness during prolonged dry periods is a limitation. Most areas are planted to specialty crops used in seed corn research. This soil has fair potential for most urban uses. Each potential home site or housing development on this soil should be critically examined to be sure it is above the level of known flood elevations. There is a hazard of ground water pollution from septic tank filter fields. Capability unit IIIs–1.

Minnetonka Series

The Minnetonka series consists of nearly level, poorly drained soils formed in a mantle of fine textured and moderately fine textured lacustrine sediments over loamy glacial till. These soils occupy broad level tracts, slight rises, and shallow draws in the uplands. Native vegetation was mixed deciduous trees and a wet plant community of the tall grass prairie.

In a representative profile the surface layer is black and very dark grayish brown silty clay loam about 19 inches thick. The subsoil is mottled dark grayish brown and very dark grayish brown silty clay in the upper 12 inches. The middle part is mottled olive gray clay 9 inches thick. The lower part is mottled olive gray and olive clay loam about 8 inches thick. The underlying material is limy, mottled olive gray loam.

Permeability is slow. Runoff is slow. The depth to the seasonal high water table is 1 to 3 feet, or near tile depth. Available water capacity, organic-matter content, and natural fertility are high.

Most of the acreage of Minnetonka soils is in corn and soybeans. The soils are suited to most crops if properly drained.

Representative profile of Minnetonka silty clay loam in cultivated area 200 feet north and 2,540 feet east of southwest corner sec. 34, T. 108 N., R. 26 W.

Ap—0 to 9 inches, black (10YR 2/1) silty clay loam; moderate very fine subangular blocky structure; friable; common roots; slightly acid; abrupt smooth boundary.

A12—9 to 13 inches, black (10YR 2/1) silty clay loam; moderate very fine subangular blocky structure with some horizontal cleavage; friable; common roots; very dark gray (10YR 3/1) coatings on faces of peds; slightly acid; abrupt smooth boundary.

A13—13 to 19 inches, very dark grayish brown (10YR 3/2) silty clay loam; moderate and strong very fine subangular blocky structure; friable; very dark gray (10YR 3/1) coatings on faces of peds; slightly acid; clear smooth boundary.

B21tg—19 to 24 inches, dark grayish brown (2.5Y 4/2) silty clay; common fine distinct light olive brown (2.5Y 5/4) mottles; strong fine and very fine subangular and angular blocky structure; firm; common thin black (10YR 2/1) and very dark brown (10YR 2/2) clay films on faces of peds; about 2 percent coarse fragments, mostly shale; medium acid; clear smooth boundary.

B22tg—24 to 31 inches, dark grayish brown (2.5Y 4/2) and very dark grayish brown (2.5Y 3/2) silty clay; common fine distinct dark olive gray (5Y 3/2) and olive (5Y 4/4) mottles; moderate and strong fine and very fine subangular and angular blocky structure; firm; many medium black (10YR 2/1) and very dark brown (10YR 2/2) clay films on faces of peds; few thin porous grayish coatings on faces of peds; about 2 percent coarse fragments, mostly shale; medium acid; clear smooth boundary.

B23tg—31 to 40 inches, olive gray (5Y 4/2) and 5/2) clay; few fine distinct light olive brown (2.5Y 5/4) mottles; moderate fine and medium angular blocky structure; firm; many medium black (10YR 2/1) and very dark gray (10YR 3/1) clay films on faces of peds and in root channels; few thin porous grayish coatings on faces of peds; about 2 percent coarse fragments, mostly shale; medium acid; clear smooth boundary.

IIB3tg—40 to 48 inches, olive gray (5Y 5/2) and olive (5Y 5/4) heavy clay loam; common fine faint light olive brown (2.5Y 5/4) mottles; weak coarse prismatic structure; firm; few thin and medium very dark gray (10YR 3/1) and black (10YR 2/1) clay films on faces of peds; few thin black (10YR 2/1) clay fillings in root channels; about 5 percent coarse fragments, mostly shale; slightly acid; clear smooth boundary.

IIC1—48 to 54 inches, olive gray (5Y 5/2) loam; many fine distinct olive (5Y 5/3, 5/4, and 5/6) mottles; massive; friable; few thick black (10YR 2/1) clay fillings in old root channels; about 5 percent coarse fragments, mostly shale; slightly effervescent; mildly alkaline; clear smooth boundary.

IIC2—54 to 60 inches, olive gray (5Y 5/2) loam; many fine distinct olive (5Y 5/3, 5/4, and 5/6) mottles; massive; friable; few thick black (10YR 2/1) clay fillings in old root channels; about 5 percent coarse fragments, mostly shale; common fine soft lime masses; slightly effervescent; mildly alkaline.

Solum thickness ranges from 28 to 52 inches. This soil is typically free of coarse fragments, but can be as much as 6 percent, by volume. Fragments are mostly shale. The A horizon is typically 10 to 14 inches thick but can extend to 20 inches. It is typically silty clay loam, but the range includes silty clay. Reaction is slightly acid to medium acid. In places there is a thin A2 horizon. The B2 horizon is typically silty clay and clay, but the range includes silty clay loam. This horizon is 35 to 60 percent clay. Reaction ranges from medium acid to very strongly acid. The IIC horizon is typically loam, but the range includes clay loam or silt loam.

Minnetonka soils are commonly associated with Shorewood, Lura, Marna, and Waldorf soils. They are more acid and have more clay in the solum than Marna and Waldorf soils. Minnetonka soils are better drained and have a thinner A horizon than the Lura soil. They are wetter than the Shorewood soils.

364—Minnetonka silty clay loam, silty substratum. This nearly level soil occupies 5- to 200-acre broad flats and low convex knolls on lake plains. The profile differs from that described for the series in having about 8 feet of stratified silt loam material between the subsoil and the medium textured glacial till below. The silt loam material, which is high in coarse silts stratified with loamy very fine sand, is 1 to 18 feet thick. Slopes can be as much as 2 percent but are typically less than 1 percent.

Included with this soil in mapping are small areas of Shorewood, silty substratum; and Lura, Collinwood, and Barbert soils. The Shorewood, silty substratum, and Collinwood soils are on convex knolls and are identified by spot symbols on the soil map. Lura and Barbert soils are in depressions and low gradient drainageways and are also identified on the soil map.

Most of the acreage is used for corn and soybeans. Tile drainage is required for dependable crop production and maximum yields. Maintaining good surface tilth and a high fertility level is also a management problem. This soil can be worked within only a narrow range of moisture content because of the high clay and fine silt content and the very low sand content. Tilling when wet results in a hard, cloddy soil. The underlying silt loam material has high frost action potential, is very erosive when exposed in road ditches and other new construction near the river valleys, has moderately rapid permeability, and has poor stability when saturated. Because of the seasonal high water table and low strength, this soil has poor potential for most urban uses. Capability unit IIw–2.

287—Minnetonka silty clay loam. This nearly level soil occupies 5- to 100-acre broad flats, shallow drainageways, and low convex knolls on uplands. It has the profile described for the series. Slopes are 0 to 2 percent.

Included with this soil in mapping are small areas of Shorewood, Guckeen, Marna, Barbert, and Lura soils. These soils are identified by spot symbols on the soil map. The Shorewood and Guckeen soils are on convex knolls, the Marna soils are on broad flats, and the Lura and Barbert soils are in depressions and low gradient drainageways.

Most of the acreage is used for corn and soybeans. Tile drainage is required for dependable crop production and maximum yields. Maintaining good surface tilth and a high fertility level is also a management problem. This soil can be worked within only a narrow range of moisture content. Tilling the soil when wet destroys tilth, reduces aeration, and causes the soil to become hard and cloddy when dry. Because of the seasonal high water table, low strength, and high shrink-swell potential, this soil has poor potential for most urban uses. Capability unit IIw–2.

998—Minnetonka-Barbert complex. This map unit occupies 10- to 200-acre tracts in nearly level areas of the lake plain and in numerous, shallow depressions. It is about 60 percent Minnetonka silty clay loam, 35 percent Barbert silt loam, and 5 percent other soils. The Minnetonka soil is in nearly level areas, and the Barbert soil is in shallow depressions. Slopes are 0 to 2 percent.

Included with this soil in mapping are small areas of Marna, Shorewood, and Lura soils. The Shorewood soils are on convex knolls, the Marna soils are on broad flats, and the Lura soils are in depressions and low gradient drainageways. Shorewood and Lura soils are identified by spot symbols on the soil map.

Most of the acreage is used for corn and soybeans. Artificial drainage is required for dependable crop production. Maintaining good surface tilth and a high fertility level is also a management problem. The surface of the Barbert soil puddles easily and becomes nearly impervious if tilled when wet. This unit has poor potential for most urban and recreational uses. Minnetonka silty clay loam, capability unit IIw–2; Barbert silt loam, capability unit IIIw–2.

Muskego Series

The Muskego series consists of a nearly level, very poorly drained, organic soil formed mostly in a mantle of decomposed reed and sedge vegetation over post-glacial lake sediments. This soil is in bogs that formerly were ponds and lakes.

In a representative profile the surface layer is black muck 32 inches thick. The underlying material is limy, very dark grayish brown, very dark gray, and gray coprogenous earth and marl.

Permeability is moderate. Runoff is slow to ponded. The seasonal high water table is within a depth of 1 foot, or near tile depth. Available water capacity is very high. Organic matter-content is very high. The soil is high in nitrogen and low in phosphate and potassium.

Many areas of Muskego soils are cropland. In their natural state, these soils are poorly suited to most crops. If adequately drained and fertilized, they are suited to early maturing field crops and truck crops. The frost hazard and low fertility are also limitations for crop production.

Representative profile of Muskego muck, 50 feet east and 50 feet south of northwest corner sec. 16, T. 108 N., R. 25 W.

Oa1—0 to 19 inches, black (10YR 2/1) broken face sapric material, very dark brown (10YR 2/2) rubbed; few strong brown (7.5YR 5/8) fibers; about 15 percent fibers, less than 5 percent rubbed; weak very fine granular structure; herbaceous fibers; about 25 percent mineral material; neutral; abrupt smooth boundary.

Oa2—19 to 32 inches, black (10YR 2/1) broken face and rubbed, sapric material; about 10 percent fibers, less than 5 percent rubbed; herbaceous fibers; about 50 percent mineral material; neutral; clear wavy boundary.

Lco1—32 to 65 inches, very dark grayish brown (2.5Y 3/2) with thin strata of light gray (10YR 7/1) and white (10YR 8/1) coprogenous earth; about 10 percent plant detritus; laminated; common snail shells; about 60 percent mineral material; strongly effervescent; mildly alkaline; clear wavy boundary.

Lco2—65 to 76 inches, very dark gray (10YR 3/1) with thin strata of light gray (10YR 7/1) and white (10YR 8/1) coprogenous earth; laminated; common snail shells; about 80 percent mineral material; strongly effervescent to violently effervescent; mildly alkaline; clear wavy boundary.

Lca3—76 to 84 inches, gray (5Y 5/1) with thin strata of light gray (10YR 7/1) and white (10YR 8/1) marl; laminated; snail shells; about 80 percent mineral material; violently effervescent; mildly alkaline; clear wavy boundary.

The thickness of sapric material over coprogenous earth ranges from 16 to 51 inches. The Oa horizon is black or very dark gray and is a trace to 30 percent fibers. The Lco horizon ranges from 30 to 60 inches or more in thickness. It is black, very dark gray, or very dark grayish brown. The Lca horizon is lacking in some profiles. The underlying mineral material is mucky silt loam, loam, sandy clay loam, or sandy loam. The depth to this material ranges from 51 inches to 10 feet or more.

Muskego soils are commonly associated with Caron and Palms soils. They lack the mineral substratum above a depth of 51 inches that is typical in Palms soils at depths ranging from 16 to 51 inches. Muskego soils are mostly sapric material over limnic material, whereas the similar Caron soils are mostly hemic material over limnic material.

525—Muskego muck. This soil occupies small depressions and several large bogs. The muck layer is less than 51 inches thick and is underlain by several feet of silty, postglacial lake sediments. These sediments are 10 feet or more thick in the larger bogs. The edges of the larger bogs often have a narrow, discontinuous strip of sandy or gravelly underlying material. Slopes are 0 to 2 percent.

Included with this soil in mapping are a few small sand bars. Small areas where the soil is less than 51 inches to silt loam, sandy loam, or sandy clay loam are included because of the irregular surface of the underlying substratum. In a few areas the surface layer is limy.

Most of the smaller areas of this soil are cropland. Some of the larger areas are also used for crops. Some areas are in pasture. Several of the larger bogs, which are in the northeastern part of the county, are used for growing reed canarygrass seed. Drainage and maintaining fertility are the major management needs. Because of wetness and low strength, this soil has very poor potential for most urban uses. It has good potential for wetland wildlife development. Capability unit IIIw–4.

Nicollet Series

The Nicollet series consists of deep, nearly level to gently undulating, moderately well drained soils that formed in medium textured and moderately fine textured glacial till. These soils are on uplands. Native vegetation was tall grass prairie.

In a representative profile the surface layer is black and very dark grayish brown clay loam about 21 inches thick. The subsoil is mottled dark grayish brown to light olive brown clay loam about 23 inches thick. The underlying material is limy, mottled light olive brown loam.

Nicollet soils have high natural fertility, high organic-matter content, high available water capacity, and moderate permeability. Runoff is slow to medium. The depth to the seasonal high water table is 3 to 5 feet.

These soils are well suited to all general farm crops if they are well managed to maintain tilth and fertility. They respond well to applications of fertilizer and other agricultural chemicals. Most areas are used for crops.

Representative profile of Nicollet clay loam, 1 to 3 percent slopes, in cultivated field 30 feet south and 30 feet west of northeast corner sec. 3, T. 107 N., R. 29 W.

Ap—0 to 8 inches, black (10YR 2/1) clay loam, dark gray (10YR 4/1) dry; weak very fine subangular blocky structure; friable; neutral; abrupt smooth boundary.

A12—8 to 13 inches, black (10YR 2/1) clay loam; moderate medium very fine and fine subangular blocky structure; friable; very dark grayish brown (10YR 3/2) worm casts; neutral; clear smooth boundary.

A3—13 to 21 inches, black (10YR 2/1) clay loam with common inclusions of very dark grayish brown (10YR 3/2); moderate fine and medium subangular blocky structure; friable; about 2 percent coarse fragments; neutral; clear wavy boundary.

B21—21 to 28 inches, dark grayish brown to olive brown (2.5Y 4/3) clay loam, dark grayish brown (10YR 4/2) coatings on faces of peds; moderate medium subangular blocky structure; friable; about 3 percent coarse fragments; neutral; clear smooth boundary.

B22—28 to 44 inches, light olive brown (2.5Y 5/4) clay loam, olive brown (2.5Y 4/4) coatings on faces of peds; few fine distinct strong brown (7.5YR 5/6) mottles; moderate fine and medium subangular blocky structure; friable; about 3 percent coarse fragments; neutral; clear wavy boundary.

C—44 to 60 inches, light olive brown (2.5Y 5/4) loam; common medium distinct strong brown (7.5YR 5/6) mottles; weak coarse platy structure; friable; light gray (2.5Y 7/2) threads of lime; about 4 percent coarse fragments; strongly effervescent; mildly alkaline.

Thickness of the solum and depth to lime range from 20 to 40 inches. The A horizon is 12 to 22 inches thick and is black to very dark gray. Reaction is medium acid to neutral. Texture is mainly clay loam, but the range includes loam. The B horizon is typically dark grayish brown and olive brown but can range to grayish brown and light olive brown. Reaction is medium acid to slightly acid in the upper part and slightly acid to neutral in the lower part.

Nicollet soil occurs on the same landscape as Clarion, Glencoe, Storden, and Webster soils. It is more poorly drained and occupies lower positions on the landscape than Storden and Clarion soils. It is better drained than Webster and Glencoe soils.

130—Nicollet clay loam, 1 to 3 percent slopes. This nearly level to gently undulating soil occupies 5- to 30-acre rises within or above areas of Clarion, Webster, and Glencoe soils. Slopes are convex and concave. This soil has the profile described for the series.

Included with this soil in mapping are small areas of soils that are moderately eroded, convex rises of well drained Clarion soils, and a few small areas of Le Sueur and Barrington soils. Small wet areas of Webster soils on concave slopes are included, and some are identified by spot symbols on the soil map.

There is little or no erosion and little hazard because of the low gradient short slopes. Maintaining tilth and a high level of fertility is the main management problem.

This soil is used mainly for row crops. Except for slight seasonal wetness, it has few limitations for farm use. If worked when wet, this soil compacts easily, tilth is destroyed, and the soil becomes hard and cloddy when dry. The potential is only fair for most urban and recreational uses because of wetness and low strength. Capability unit I–1.

Ocheyedan Series

The Ocheyedan series consists of deep, gently undulating to rolling, well drained soils on the lake plain. These soils formed in a mantle of loamy glacial and silty lacustrine sediments. They occupy slight convex rises and steep slopes. Native vegetation was tall grass prairie.

In a representative profile the surface layer is black and very dark brown loam about 15 inches thick. The subsoil is about 30 inches thick. The upper 19 inches is very dark grayish brown, dark brown, and dark yellowish brown, friable loam. The lower 11 inches is yellowish brown, very friable silt loam. The underlying material is limy, very friable, mottled light olive brown silt loam.

Permeability is moderate. The available water capacity, organic-matter content, and natural fertility are high. The seasonal water table is below 6 feet. Erosion is the main problem on this soil.

Most areas are cultivated. Ocheyedan soils are well suited to crops if properly managed.

Representative profile of Ocheyedan loam, 2 to 8 percent slopes 1,350 feet south and 1,200 feet west of northeast corner sec. 28, T. 105 N., R. 27 W.

Ap—0 to 9 inches, black (10YR 2/1) loam; weak fine granular structure; friable; slightly acid; clear smooth boundary.

A3—9 to 15 inches, very dark brown (10YR 2/2) loam; weak and moderate very fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

B21—15 to 20 inches, very dark grayish brown (10YR 3/2) loam, dark brown (10YR 3/3) crushed; weak and moderate very fine and fine subangular blocky structure; friable; medium acid; clear smooth boundary.

B22—20 to 28 inches, dark brown (10YR 4/3) loam; few fine faint mottles; moderate very fine and fine subangular blocky structure; friable; few fine shale fragments; medium acid; clear smooth boundary.

B23—28 to 34 inches, dark yellowish brown (10YR 4/4) loam; weak fine subangular blocky structure; friable; few fine shale fragments; few manganese or iron concretions; medium acid; clear smooth boundary.

IIB3—34 to 45 inches, yellowish brown (10YR 5/4) silt loam; massive; very friable; neutral; clear smooth boundary.

IIC—45 to 60 inches, light olive brown (2.5Y 5/4) silt loam; massive; very friable; common fine distinct yellowish brown (10YR 5/6) mottles; strongly effervescent; slightly alkaline.

The solum and depth to carbonates range from 24 to 50 inches. The A horizon typically is loam, but the range includes sandy clay loam. The upper part of the B horizon typically is loam, but the range includes sandy clay loam. The solum ranges from medium acid to neutral. In places there is a thin, sandy or gravelly transitional layer above the silty IIC horizon.

Ocheyedan soils are associated with Clarion, Nicollet, and Collinwood soils. They have a silty IIC horizon, whereas Clarion soils have a C horizon of glacial till. They are similar to Collinwood soils but have less clay in the solum. They occupy higher positions and have a brighter colored B horizon than Nicollet soils.

275B—Ocheyedan loam, 2 to 8 percent slopes. This gently sloping to rolling soil is in 5- to 50-acre areas that are irregular in shape.

Included with this soil in mapping are small areas of Clarion soils and areas of Nicollet and Webster soils in drainageways and at the base of slopes. Included areas where slopes are more than 8 percent and a few small areas of sandy Dickinson soils are identified by spot symbols on the soil map. Some areas of soils that are moderately eroded are also included.

Runoff is medium. Erosion is a hazard on some of the steeper slopes. Crops are well suited to this soil, but management is needed to control erosion and maintain high levels of organic matter and plant nutrients.

Most of the acreage is used for corn and soybeans. The potential is fair to good for most urban and recreational uses. Capability unit IIe–2.

Okoboji Series

The Okoboji series consists of deep, very poorly drained soils formed in glacial lacustrine sediments on the glacial lake plain. These soils are in closed depressions. Native vegetation was reeds and sedges.

In a representative profile the surface layer is black and very dark gray silty clay loam about 32 inches thick. The upper 18 inches of the subsoil is mottled very dark grayish brown, friable silty clay loam. The lower 5 inches is mottled olive gray, very friable silt loam. The underlying material is limy, olive gray silt loam.

Permeability is moderately slow. Available water capacity, organic-matter content, and natural fertility are high. Runoff is slow to ponded. The seasonal high water table is within a depth of 1 foot, or near tile depth.

Okoboji soils are well suited to farming if excess water is removed. Most of the acreage is cropland. Maintaining tilth and adequate drainage are the main concerns of management for cropland.

Representative profile of Okoboji silty clay loam 2,000 feet east and 100 feet south of northwest corner sec. 10, T. 106 N., R. 28 W.

Ap—0 to 8 inches, black (N 2/0) silty clay loam; weak fine and medium subangular blocky structure; friable; neutral; abrupt smooth boundary.

A12—8 to 18 inches, black (N 2/0) silty clay loam; moderate fine and very fine subangular blocky structure; friable; neutral; clear wavy boundary.

A13—18 to 26 inches, black (10YR 2/1) silty clay loam; moderate fine and very fine subangular blocky structure; friable; neutral; clear irregular boundary.

A3—26 to 32 inches, very dark gray (5Y 3/1) silty clay loam; few fine faint mottles; moderate fine and very fine subangular blocky structure; friable; tongue of black (5Y 2/1); clear irregular boundary.

B21g—32 to 40 inches, very dark grayish brown (2.5Y 3/2) silty clay loam; few fine olive gray (5Y 4/2) mottles and tongues; weak fine subangular blocky structure; friable; neutral; clear irregular boundary.

B22g—40 to 45 inches, olive gray (5Y 4/2) silt loam; few fine distinct olive brown (2.5Y 4/4) and common fine prominent strong brown (7.5Y 5/8) mottles; weak fine and very fine subangular blocky structure; very friable; neutral; clear wavy boundary.

Cg—45 to 60 inches, olive gray (5Y 5/2) silt loam; common fine faint pale olive (5Y 6/3) mottles; massive; very friable; few dark gray (5Y 4/1) krotovina and yellowish red (5YR 4/6) channels; iron concretions and stains; strongly effervescent; mildly alkaline.

The A horizon is 24 to 40 inches thick. It is typically silty clay loam, but the range includes silt loam. Solum thickness and depth to carbonates typically are 30 to 50 inches, but in places carbonates occur near 20 inches. The B horizon is silty clay loam or silt loam. It is mottled throughout. The C horizon is typically silt loam, but the range includes silty clay loam. In some places loam till occurs at depths as shallow as 40 inches.

This soil has less clay in the solum than the defined range for the series, but this difference does not alter the use or behavior of this soil.

Okoboji soils are associated with Spicer and Madelia soils. They formed in similar material but lack the limy solum of the Spicer soil. They are wetter and have a thicker A horizon than Madelia soils.

134—Okoboji silty clay loam. This nearly level soil predominantly occupies 3- to 10-acre depressions and a few low gradient drainageways within the glacial lake plain and lacustrine-mantled ground moraine. Slopes are 0 to 2 percent and are concave to plane.

Included with this soil in mapping are small areas of the better drained Madelia soils and the finer textured Lura soil. Also included are a few areas of soils that have a thin surface layer of muck.

Wetness is the main hazard. If this soil is tilled when wet, the surface layer becomes cloddy. If tile drainage is provided, the soil is well suited to cropland. Most areas are used for corn and soybeans. A few undrained areas are idle and provide food and cover for wildlife. Because of wetness and low strength, this soil has poor potential for most urban and recreational uses. Capability unit IIIw-1.

Oshawa Series

The Oshawa series consists of very poorly drained soils formed in medium textured, recent alluvium on flood plains, in shallow depressions, and in abondoned channels of the Minnesota River. These soils are subject to frequent flooding.

In a representative profile the surface layer is very dark gray and black silt loam about 28 inches thick. The underlying material is mottled gray, grayish brown, and olive gray stratified loam, silt loam, sandy loam, and loamy sand. The profile is limy throughout.

Permeability is moderately slow. The available water capacity and organic-matter content are high. The seasonal high water table is within a depth of 1 foot. The soil is ponded from frequent flooding.

Most of the acreage is used for pasture, hay, or wildlife. The major limitation is the hazard of frequent flooding.

Representative profile of Oshawa silt loam 1,500 feet east and 1,350 feet south of northwest corner sec. 31, T. 109 N., R. 26 W.

A1g—0 to 11 inches, very dark gray (10YR 3/1) silt loam; common medium prominent brown and dark brown (7.5YR 4/4) mottles; weak very fine subangular blocky structure; friable; many roots; few fine shells; slightly effervescent; mildly alkaline; clear smooth boundary.

A12—11 to 21 inches, black (10YR 2/1) silt loam; common medium prominent brown and dark brown (7.5YR 4/4) mottles; moderate very fine subangular blocky structure; friable; few fine shells; slightly effervescent; mildly alkaline; clear smooth boundary.

A13—21 to 28 inches, very dark gray (10YR 3/1) loam; common medium prominent brown and dark brown (7.5YR 4/4) mottles; weak very fine subangular blocky structure; friable; very dark gray (10YR 3/1) root channels; few fine shells; slightly effervescent; mildly alkaline; clear smooth boundary.

Cg—28 to 60 inches, gray (5Y 5/1), grayish brown (2.5Y 5/2), and olive gray (5Y 5/2) stratified loam, silt loam, sandy loam, and loamy sand; many medium prominent dark brown (7.5YR 3/4) mottles in upper part; weak thin to thick platy structure parting to weak very fine subangular blocky; friable; slightly effervescent; mildly alkaline.

The profile is slightly alkaline or moderately alkaline throughout. The A horizon is typically silt loam but ranges to silty clay loam. It is 24 to 48 inches thick. It has common or many, distinct or prominent mottles. The C horizon commonly is stratified with loam and sand, but in some profiles it is loamy throughout.

Oshawa soils formed in material similar to that of Dorchester and Chaska soils. They are wetter and occupy lower lying areas than those soils.

317—Oshawa silt loam. This nearly level soil is in slight depressions and abandoned channels along the Minnesota River. Areas are 10 to 80 acres and irregular in shape. Slopes are 0 to 2 percent.

Included with this soil in mapping are small areas of Chaska and Palms soils and Marsh. The Chaska soil is better drained and subject to less frequent flooding. Marsh has mixed open water and reed and cattail vegetation in the old stream channels. Palms is an organic soil.

Because this soil is in slight depressions and abandoned river channels and is ponded most of the year, it is well suited to pasture or wetland wildlife. The water table fluctuates with the water level of the river. The soil is unsuitable as cropland unless adequately drained and protected from flooding. It is unsuitable for most urban and recreational uses because of wetness and flooding. Capability unit VIw–1.

Palms Series

The Palms series consists of nearly level, very poorly drained organic soils formed in decomposed reed and sedge vegetation. These soils are at the edges of bogs. The bogs were formerly ponds, lakes, and large marshes.

In a representative profile the surface layer is very dark brown and dark brown muck about 18 inches thick. The next layer is very dark gray and black muck about 32 inches thick. The underlying material is black silt loam.

Permeability is moderately rapid. Runoff is slow to ponded. The seasonal high water table is within a depth of 1 foot, or near tile depth. Available water capacity is very high. Organic-matter content is very high. The soil is high in nitrogen and low in phosphorus and potassium.

If adequately drained, Palms soils are in cropland. They are suited to early maturing crops and vegetables. Wetness is the major limitation. Frost hazard is a limitation for crop production. Some of the larger areas that do not have a vegetative cover are subject to severe soil blowing.

Representative profile of Palms muck 1,600 feet west and 2,600 feet north of southeast corner sec. 23, T. 109 N., R. 26 W.

Oa1—0 to 18 inches, very dark brown (10YR 2/2) and dark brown (10YR 4/3) broken face sapric material, black (10YR 2/1) rubbed; about 20 percent fiber, less than 10 percent rubbed; weak fine subangular blocky structure; herbaceous fibers; about 15 percent mineral material; slightly acid; abrupt smooth boundary.

Oa2—18 to 36 inches, very dark gray (10YR 3/1) broken face sapric material, black 10YR 2/1) rubbed; about 20 percent fiber, less than 10 percent rubbed; weak fine subangular blocky structure; herbaceous fibers; about 15 percent mineral material; slightly acid; gradual wavy boundary.

Oa3—36 to 50 inches, black (10YR 2/1) broken face sapric material, black (10YR 2/1) rubbed; less than 10 percent fibers; weak fine subangular blocky structure; herbaceous fibers; about 30 percent mineral material; slightly acid; gradual smooth boundary.

IIcg—50 to 60 inches, black (10YR 2/1) silt loam; massive; friable; neutral.

Thickness of the muck is commonly 16 to 40 inches but ranges from 12 to 51 inches. Reaction ranges from slightly acid to mildly alkaline. The underlying mineral material is mostly silt loam, silty clay loam, clay loam, or loam, but in places sandy horizons underlie the IICg horizon.

Palms soils are associated with Caron and Muskego soils. They have a mineral substratum between depths of 12 to 51 inches, whereas Caron and Muskego soils lack a mineral substratum above 51 inches.

539—Palms muck. This soil occupies 3- to 200-acre depressions, the rims of depressions, and the larger bogs. It has the profile described for the series. Slopes are 0 to 2 percent.

Included with this soil in mapping are areas where the mucky surface layer is thinner than 12 inches and the organic-matter content is less than 30 percent. A few areas where the surface layer is limy are identified by spot symbols on the soil map. In some areas slightly to moderately decomposed peaty layers are just below the surface layer. At the edge of many of the larger bogs is a narrow, discontinuous strip of sandy or gravelly underlying material. In a few spots a thin, sandy layer separates the muck from the fine textured underlying material.

Most of the acreage is cropland. The smaller areas are commonly cropped the same as the surrounding mineral soils. Some bogs are in pasture. Dikes and pumps are needed to prevent ponding in some areas. Drainage, protection from soil blowing, and maintenance of fertility are the major management needs. This soil has very poor potential for most urban and recreational uses because of wetness and low strength. Capability unit IIIw–4.

548—Palms muck, sandy substratum. This soil occupies 3- to 100-acre depressions, the rims of depressions, and the larger bogs. The profile differs from the one described for the series because the mineral soil beneath the organic layer is about 15 inches of loamy material over sandy material. Slopes are 0 to 2 percent.

Included with this soil in mapping are areas where the surface layer is mucky and is less than 12 inches thick. A few areas where the surface layer is limy are identified by spot symbols on the soil map. Also included in the underlying sandy material are pockets or strata of acid fine sand stained or cemented by iron oxide. In some areas this soil has only sandy material below the muck layer.

Drainage is difficult. The sandy substratum causes caving of ditch banks and filling of tile lines. Blinding the tile before backfilling tile trenches or using plastic tile reduces the movement of sand into the tile line. Acid-resistant clay tile or plastic tile must be used where acid, iron oxide stained, or iron cemented sands occur.

Most of the acreage is cropland and is commonly cropped the same as the surrounding mineral soils. Some bogs are in pasture. Others have been left in their natural state for use as wetland wildlife habitat. Drainage, protection from soil blowing, and fertility maintenance are the major management needs. This soil has very poor potential for most urban and recreational uses because of wetness and low strength. Capability unit IIIw–4.

Rock Outcrop

992—Rock outcrop-Copaston complex, very steep. This unit is about 60 percent Rock outcrop, 30 percent Copaston soils, and 10 percent other soils. It occupies 2- to 200-acre side slopes, escarpments, and ravines adjacent to the major streams and drainageways. Slopes are more than 45 percent, are 75 to 150 feet long, and are highly irregular.

The soil material is shallow over bedrock, and in many places bedrock is exposed. There is very little topsoil.

Included with this unit in mapping are small areas where slopes are less than 45 percent. Also included are small areas of Terril soils and areas of sand and gravel are common in small drainageways.

Runoff is very rapid, and permeability is moderate. The hazard of erosion is very severe. Sloughing and slumping are common.

This unit is too steep and rocky for any type of farm, urban, or recreational use. It is moderately limited for wildlife. Copaston soils, capability unit VIIs-2; Rock outcrop, capability unit VIIIs-1.

Rolfe Series

The Rolfe series consists of nearly level, very poorly drained soils formed in moderately fine textured and medium textured glacial till. These soils occupy slight depressions and drainageways. Native vegetation was marsh grasses and sedges.

In a representative profile the surface layer is black silt loam about 10 inches thick. The subsurface layer, about 4 inches thick, is very dark gray loam. The subsoil is about 31 inches thick. The upper part is very dark grayish brown clay that has black coatings on the peds, the middle part is olive gray clay loam that has black and very dark gray coatings, and the lower part is olive gray clay loam that have very dark gray and dark olive gray coatings. The underlying material is limy, mottled olive gray clay loam.

Runoff is very slow to ponded. Permeability is slow. Available water capacity is high. Organic-matter content and natural fertility are high. The seasonal high water table is within a depth of 1 foot, or near tile depth.

Wetness limits the use of Rolfe soils. If adequately drained, however, the soils are suited to most crops grown in the county. Major management needs are maintenance of tilth and fertility and liming. Undrained areas are used mainly for wild hay and pasture. They offer good cover for wildlife.

Representative profile of Rolfe silt loam in cultivated area 10 feet east and 1,620 feet north of southwest corner sec. 1, T. 108 N., R. 25 W.

Ap—0 to 10 inches, black (10YR 2/1) silt loam; weak fine and medium subangular blocky structure; friable; neutral; abrupt smooth boundary.

A2—10 to 14 inches, very dark gray (10YR 3/1) loam, gray (10YR 6/1) dry; moderate medium and thin platy structure; friable; slightly acid; clear smooth boundary.

B21tg—14 to 22 inches, very dark grayish brown (2.5Y 3/2) clay; few fine distinct strong brown (7.5YR 5/8) mottles; strong very fine angular blocky structure; firm; many thin black (10YR 2/1) clay films on faces of peds; slightly acid; clear smooth boundary.

B22tg—22 to 30 inches, olive gray (5Y 4/2) heavy clay loam; many fine distinct light olive brown (2.5Y 5/4) mottles; moderate medium prismatic structure parting to moderate medium angular blocky; firm; many medium black (5Y 2/1) and very dark gray (5Y 3/1) clay films on faces of peds; about 2 percent coarse fragments; slightly acid; clear smooth boundary.

B3g—30 to 45 inches, olive gray (5Y 5/2) clay loam; many fine distinct light olive brown (2.5Y 5/6) mottles; weak coarse prismatic structure; firm; many medium very dark gray (5Y 3/1) and dark olive gray (5Y 3/2) clay films on faces of peds and in root channels; about 5 percent coarse fragments; slightly acid; clear smooth boundary.

Cg—45 to 60 inches, olive gray (5Y 5/2) clay loam; many medium prominent strong brown (7.5YR 5/6) mottles; massive; friable; about 5 percent coarse fragments; few soft lime masses; neutral to mildly alkaline.

Solum thickness and depth to lime range from 40 to 55 inches. The Ap horizon is typically silt loam, but the range includes loam or silty clay loam. Reaction ranges from slightly acid to mildly alkaline. The A2 horizon is 3 to 8 inches thick. Reaction ranges from slightly acid to strongly acid. In some profiles the lower part of the A horizon and upper part of the B horizon have coatings of clean sand and silt particles on ped faces. The B2 horizon is clay or silty clay in the upper part and clay or clay loam in the lower part. Reaction ranges from very strongly acid to medium acid. The C horizon is clay loam or loam.

Rolfe soils are mapped in association with Cordova, Webster, Glencoe, Le Sueur, and Nicollet soils. They are similar to the Barbert soil. They occupy a lower position on the landscape and are wetter than Cordova, Webster, Le Sueur, and Nicollet soils. In contrast with Glencoe soils, Rolfe soils have an argillic horizon. In contrast with the Barbert soils, which formed in glacial lacustrine sediments, Rolfe soils formed at least partly in glacial till.

219—Rolfe silt loam. This soil occupies small depressions, short side slope draws, and 5- to 20-acre, long, winding, low gradient drainageways. Slopes are 0 to 2 percent. Included with this soil in mapping are areas of the better drained Minnetonka, Cordova, Webster, and Glencoe soils in depressions.

This is a wet soil. Drainage is needed for dependable cropland. The soil can be tilled within only a narrow range of moisture content. If worked when wet, it puddles easily, tilth is destroyed, and aeration is reduced. Also the soil becomes hard and cloddy when dry.

Most areas are used for cropland. Because of high shrink-swell potential, a high seasonal water table, and low strength, this soil has low potential for most urban and recreational uses. Capability unit IIIw-2.

Shorewood Series

The Shorewood series consists of nearly level to gently sloping, moderately well drained soils formed in a mantle of fine textured and moderately fine textured glacial lacustrine sediments over friable, limy, loamy glacial till. These soils are on flats, convex rises, and gentle slopes on the lake plain. Native vegetation was mixed tall grass prairie and deciduous trees.

In a representative profile the surface layer is black, friable silty clay loam about 11 inches thick. The next layer, about 6 inches thick, is very dark gray and very dark grayish brown silty clay loam. The subsoil is about 22 inches thick. The upper part is dark grayish brown firm silty clay, the middle part is mottled dark grayish brown clay, and the lower part is mottled grayish brown, friable silty clay with pronounced dark colored clay films. The underlying material is limy, mottled grayish brown and dark grayish brown friable clay loam and loam till.

Available water capacity is moderate to high, natural fertility and organic-matter content are high, and permeability is moderately slow to slow. The depth to the seasonal high water table is 3 to 5 feet.

If Shorewood soils are well managed, they are very productive. They are well suited to all general farm crops.

Representative profile of Shorewood silty clay loam, 1 to 6 percent slopes, 2,300 feet east and 100 feet north of southwest corner sec. 34, T. 108 N., R. 26 W.

Ap—0 to 8 inches, black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; weak very fine and fine subangular blocky structure; friable; many roots; neutral; abrupt smooth boundary.

A12—8 to 11 inches, black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; weak and moderate very fine and fine subangular blocky structure; friable; many roots; neutral; clear smooth boundary.

A3—11 to 17 inches, very dark gray (10YR 3/1) grading to very dark grayish brown (10YR 3/2) in lower part, silty clay loam, dark gray (10YR 4/1) dry; moderate very fine and fine subangular and angular blocky structure and weak thin platy structure; friable; many thin gray (10YR 5/1) coatings of clean silt and sand particles on faces of peds; few roots; slightly acid; clear smooth boundary.

B21t—17 to 24 inches, dark grayish brown (10YR 4/2) silty clay; weak and moderate fine and medium prismatic structure; firm; many thin very dark grayish brown (10YR 3/2) clay films on faces of peds; few thin light gray (10YR 6/1) coatings of clean sand and silt particles on faces of peds; strongly acid; clear smooth boundary.

B22tg—24 to 33 inches, dark grayish brown (2.5Y 4/2) clay; common fine distinct olive brown (2.5Y 4/4) mottles; weak and moderate medium and coarse prismatic structure; firm; many thin very dark grayish brown (2.5Y 3/2) and black (10YR 2/1) clay films on faces of peds and in root channels; strongly acid; clear smooth boundary.

B3tg—33 to 39 inches, grayish brown (2.5Y 5/2) silty clay; common fine distinct light olive brown (2.5Y 5/4 and 5/6) mottles; weak coarse prismatic structure; friable; many thin black (10YR 2/1) clay fillings in root channels; slightly effervescent; neutral; clear smooth boundary.

IIC1g—39 to 45 inches, grayish brown (2.5Y 5/2) clay loam; common fine distinct olive brown (2.5Y 4/4), light olive brown (2.5Y 5/4), and gray (2.5Y 5/1) mottles; weak fine subangular blocky structure; friable; few thin dark grayish brown (2.5Y 4/2) and black (10YR 2/1) clay films; about 3 percent coarse fragments; strongly effervescent; mildly alkaline; clear smooth boundary.

IIC2g—45 to 60 inches, grayish brown (2.5Y 5/2) loam; common fine distinct light olive brown (2.5Y 5/4 and 5/6) mottles; massive with some horizontal cleavages; about 5 percent coarse fragments; strongly effervescent; mildly alkaline.

Solum thickness and depth to free carbonates range from 28 to 50 inches. Depth to horizons in glacial till ranges from 30 to more than 60 inches. The A horizon is 10 to 22 inches thick. It typically is silty clay loam, but the range includes silty clay. It is medium acid to neutral. Eluviation is expressed by coatings of clean silt and sand particles on faces of peds in the lower part of the A horizon or upper part of the B horizon, or both. The upper part of the B horizon ranges from heavy silty clay loam to silty clay. The lower part ranges from loam, clay loam, silt loam, silty clay loam, clay, or silty clay. The upper 20 inches of the B horizon is very strongly acid in the upper part and medium acid to neutral in the lower part. The IIC horizon is loam, silt loam, clay loam, silty clay loam, silty clay, or clay.

Shorewood soils are associated with Kilkenny, Lerdal, Minnetonka, Beauford, and Baroda soils. They are similar in clay content but contain less sand and shale fragments than Kilkenny and Lerdal soils. They are better drained and brighter colored than Baroda, Minnetonka, and Beauford soils.

286—Shorewood silty clay loam, 1 to 6 percent slopes. This nearly level to gently sloping soil occupies 5- to 40-acre areas on smooth knolls and hilltops. Slopes are typically convex and are 75 to 300 feet long. This soil has the profile described for the series.

Included with this soil in mapping are small areas of Minnetonka, Kilkenny, Lerdal, and Guckeen soils. Minnetonka soils are in nearly level areas and at the base of some slopes. Kilkenny and Lerdal soils are between the fine textured, lacustrine-mantled ground moraine and the fine textured, flat hilltops with smooth side slopes. Also included are areas where slopes are steeper than 6 percent.

Most of the acreage is used for corn and soybeans. A few areas are in pasture and woodland. Maintaining good surface tilth and a high fertility level and liming are management problems. Runoff is slow to medium. Available water capacity is high, and permeability is moderately slow. If properly managed, this soil is well suited to cropland. Because of shrink-swell and low strength, it is fairly to poorly suited to most urban and recreational uses. Capability unit IIs–2.

448—Shorewood silty clay loam, silty substratum, 1 to 3 percent slopes. This nearly level soil occupies 3- to 100-acre areas on low convex knolls and ridges on the lake plain. The profile differs from the one described for the series in having about 8 feet of stratified silt loam material at depths of 30 to 60 inches. This soil overlies loamy glacial till. The silt loam material, which is high in coarse silt stratified with loamy very fine sand, ranges from 1 to 18 feet in thickness.

Included with this soil in mapping are small areas of Collinwood, Minnetonka, silty substratum, Lura, and Barbert soils. Minnetonka soils are at the base of slopes and on nearly level landscapes. Lura and Barbert soils, in depressions, are identified by spot symbols on the soil map. Collinwood soils occur closely with the Shorewood, silty substratum, soils. Also included are better drained soils on steeper slopes and some areas where glacial till is shallower than 60 inches.

Most of the acreage is used for corn and soybeans. Maintaining good surface tilth and a high fertility level and liming are the main management problems. Runoff is slow. Available water capacity is high, and permeability is moderately slow. This soil can be worked within only a narrow range of moisture content because of the clay and high fine silt content and the very low sand content. Tilling when wet results in hard, cloddy soils. Because of the moderately high seasonal water table, shrink-swell, and low strength, this soil is poorly suited to most urban and recreational uses. The underlying silt loam has high frost action potential, is very erosive when exposed in road ditches and other new construction near the river valleys, has moderately rapid permeability, and has poor stability when saturated. Capability unit IIs–2.

311—Shorewood silty clay, 1 to 6 percent slopes. This nearly level and gently sloping soil occupies 5- to 30-acre areas on convex rises in the lake plain. The profile differs from the one described for the series because it is thicker, is more acid throughout, and has about 20 percent more clay and a higher content of fine silt. It also has slow permeability and moderate to high available water capacity.

Included with this soil in mapping are small areas of Beauford, Minnetonka, Marna, Lura, and Barbert soils. Beauford, Minnetonka, and Marna soils are nearly level or are in swales. Lura and Barbert soils are in depressions and low gradient drainageways and are identified by spot symbols on the soil map. Also included are some areas where slopes are more than 6 percent and some moderately eroded areas.

Most of the acreage is in corn and soybeans. If tilth is maintained, this soil is suited to cropland. Runoff is slow to medium. The soil becames hard and cloddy if tilled when wet because of the high content of clay and fine silt. Liming offsets acidity in the surface layer.

This soil is poorly suited to most urban and recreational uses because of the high content of clay and shrink-swell potential. Capability unit IIs–2.

Spicer Series

The Spicer series consists of deep, nearly level, poorly drained medium textured and moderately fine textured soils. These soils formed in silty glacial lacustrine sediments. They are in broad areas or on rims around potholes in the silt-mantled till plain. Native vegetation was a wet site community of the tall grass prairie.

In a representative profile the surface layer is black and very dark gray silty clay loam about 16 inches thick. The subsoil, about 24 inches thick, is mottled dark gray, olive gray, and olive, friable silt loam. The deep underlying material is mottled light olive gray, friable silt loam. The profile is limy throughout.

Permeability is moderate, and natural fertility is medium. Runoff is slow. Available water capacity and organic-mater content are high. The depth to the seasonal high water table is 2 to 3 feet, or near tile depth.

Spicer soils are well suited to farming if excess water is removed and applications of potash and phosphate are added to offset the high lime content in the soil. Most of the acreage is used for cropland.

Representative profile of Spicer silty clay loam in cultivated area 2,540 feet south and 920 feet west of northeast sec. 25, T. 107 N., R. 28 W.

Ap—0 to 12 inches, black (10YR 2/1) silty clay loam; weak fine subangular blocky structure; friable; strongly effervescent; mildly alkaline; abrupt smooth boundary.

A3—12 to 16 inches, very dark gray (10YR 3/1) silty clay loam; moderate fine subangular blocky structure; friable; few channel fillings of black (10YR 2/1) and dark gray (10YR 4/1); strongly effervescent; mildly alkaline; gradual irregular boundary.

B1g—16 to 24 inches, dark gray (5Y 4/1) heavy silt loam; common fine faint dark grayish brown (2.5Y 4/2) mottles; weak fine subangular blocky structure; friable; few olive gray (5Y 5/2) channel fillings; strongly effervescent; mildly alkaline; clear wavy boundary.

B2g—24 to 30 inches, olive gray (5Y 5/2) heavy silt loam; common medium distinct yellowish brown (10YR 5/8) mottles; weak fine subangular blocky structure; friable; strongly effervescent; mildly alkaline; clear wavy boundary.

B3g—30 to 40 inches, olive (5Y 5/3) and olive gray (5Y 5/2) heavy silt loam; many fine distinct yellowish brown (10YR 5/8) mottles; weak very fine subangular blocky structure; friable; strongly effervescent; mildly alkaline; abrupt wavy boundary.

Cg—40 to 60 inches, light olive gray (5Y 6/2) silt loam; many coarse distinct yellowish brown (10YR 5/8) mottles; weak thin to thick platy structure; friable; common fine dark colored stains and concretions; strongly effervescent; mildly alkaline.

The A horizon is 12 to 24 inches thick. It is black or very dark gray. It is typically silty clay loam, but silt loam and loam high in content of very fine sand are included. The B horizon is typically silt loam but ranges to silty clay loam. It is mottled throughout. The C horizon is silt, silt loam, or silty clay loam. Thin strata of loamy very fine sand occur in some areas.

Spicer soils occur on the same landscape as Truman, Kingston, Madelia, and Okoboji soils and formed in similar materials. In contrast with those soils, they have lime throughout the solum. They occupy lower positions on the landscape than the moderately well drained Kingston soils and the well drained Truman soils.

140—Spicer silty clay loam. This nearly level soil is in broad areas on the rims of depressions. Slopes are 0 to 2 percent.

Included with this soil in mapping are small areas of the nonlimy Madelia soils and the Okoboji soils in depressions. Also included are some areas where the surface layer is nonlimy. A few areas are very high in content of lime.

This soil is wet. Properly designed tile drainage is needed to adequately remove excess water. Maintaining tilth and the fertility level is the main management need. If this soil is tilled when wet, the surface layer becomes cloddy. Most areas are used for corn and soybeans. If excess water is removed and the high lime condition is offset by applications of fertilizer, this soil is well suited to cropland. It is poorly suited to most urban and recreational uses because of wetness. Capability unit IIw–3.

Storden Series

The Storden series consists of deep, rolling to very steep, well drained, medium textured soils. These soils formed in limy, loamy glacial till. They are on knolls and convex slopes in the uplands. They are closely associated with and mapped with Clarion, Lester, and Estherville soils. They are so intricately mixed on the landscape that they are not mapped separately in this county. The native vegetation was a sparse growth of tall grass prairie or mixed prairie and deciduous trees.

In a representative profile the surface layer is limy, very dark grayish brown loam about 8 inches thick. The underlying material is limy, dark grayish brown and light olive brown, friable loam.

Permeability is moderate. The concentration of lime carbonates reduces the rates of infiltration and permeability. The seasonal high water table is below 6 feet. Available water capacity is high. The soil is seldom fully saturated, however, because runoff is rapid on the convex slopes. Organic-matter content is low, and natural fertility is medium.

Most areas of Storden soils are farmed along with the associated soils in the field. The hazard of erosion is severe. Special fertility programs are beneficial for most crops because of the high content of lime. Most areas are used for crops. The steeper slopes are in permanent pasture or woodland.

Representative profile of Storden loam in cultivated field in area of Clarion-Storden loams, 12 to 18 percent slopes, 2,540 feet west and 760 feet south of northeast corner sec. 20, T. 106 N., R. 29 W.

Ap—0 to 8 inches, very dark grayish brown (10YR 4/2) loam; weak fine and medium subangular blocky structure; very friable; about 8 percent coarse fragments; slightly effervescent, mildly alkaline; abrupt, smooth boundary.

C1—8 to 11 inches, dark grayish brown (10YR 4/2) loam; weak fine and medium subangular blocky structure; very friable; about 5 percent coarse fragments; strongly effervescent, mildly alkaline; clear, smooth boundary.

C2—11 to 60 inches, light olive brown (2.5Y 5/4) loam; massive; very friable; about 5 percent coarse fragments; few small lime masses; strongly effervescent, moderately alkaline.

Solum thickness is commonly the same as that of the A horizon, about 4 to 10 inches. These soils are 2 to 10 percent coarse fragments of mixed lithology. Some have a B horizon as much as 4 inches thick. Texture is loam or light clay loam in all horizons. Reaction is typically mildly or moderately alkaline, but in a few places it is neutral in the A horizon.

In contrast with Clarion and Lester soils, Storden soils are limy in the solum and commonly have steeper, more convex slopes. In contrast with Estherville soils, they are limy in the solum and contain less sand and fewer coarse fragments.

961F—Storden complex, 24 to 45 percent slopes. This very steep map unit is one of Storden, Lester, Clarion, and other well drained loamy and sandy soils. The soils are so intermixed on the landscape that mapping them separately is not practical. The unit is 60 percent Storden loam, 30 percent Lester or Clarion soil, and 10 percent other loamy and sandy soils.

This unit is on 5- to 30-acre knolls and side slopes adjacent to Clarion, Nicollet, Lester, and Le Sueur soils and on side slopes and ravines adjacent to the major streams and drainageways. The Storden soil is on convex knolls above the Clarion or Lester soil which is on slightly concave side slopes. Slopes are 75 to 150 feet long and are highly irregular.

The profiles of the Clarion and Lester soils differ from those described for the respective series in having thinner surface and subsoil layers.

Included with this unit in mapping are small areas where slopes are either less than 24 percent or greater than 45 percent. Small areas of Estherville, Dickinson, and Terril soils are also included. Severely eroded areas are common.

Runoff is rapid. The hazard of erosion is severe. High concentrations of lime carbonates are common near the surface.

Because of the very steep, irregular slopes and the severe hazard of erosion, this unit is used only for pasture or woodland. Wildlife suitability is slightly to moderately limited. Urban and recreational development are severely limited by the excessive slopes. Capability unit VIIe–1.

961—Storden complex, very steep. This map unit is one of Storden, Lester, Clarion, and other excessively drained to well drained loamy and sandy soils. The soils are so intermixed on the landscape that mapping them separately is not practical. The unit varies, but it is commonly 60 percent Storden loam, 25 percent Lester or Clarion soils, and 15 percent sandy soils or other loamy soils. Less extensive are Bold, Truman, Estherville, Terril, Grays, and Copaston soils.

This unit occupies 2- to 500-acre side slopes, escarpments, and ravines adjacent to the major streams and drainageways. Slopes are more than 45 percent, are 75 to 150 feet long, and are highly irregular. Vertical scarps along the rivers are identified by spot symbols on the soil map.

The profiles of the Clarion and Lester soils differ from those described for the respective series in having thinner surface and subsoil layers.

Included with this unit in mapping are small areas where slopes are less than 45 percent. Small areas of rock outcrop, sand, and gravel are also common.

Runoff is very rapid. The hazard of erosion is very severe. Sloughing and slumping are common. High concentrations of lime carbonates near the surface are common.

This unit is used only for woodland and wildlife habitat. Some slopes provide sparse grazing. Capability unit VIIe–1.

960E—Storden-Clarion loams, 18 to 24 percent slopes. This steep map unit occupies 3- to 30-acre knolls and side slopes adjacent to Nicollet and Webster soils and other Clarion soils. It is about 55 percent Storden soil and 45 percent Clarion soil. Slopes are both convex and concave. The Storden soil is on the convex knolls above the Clarion soil, which is typically on plane or slightly concave side slopes. Slopes are 75 to 150 feet long. The Storden soil has a profile that is similar to the one described for the series, but thinner. Coarse fragments range from 2 to 10 percent by volume.

Included with this unit in mapping are a few areas where slopes are either less than 18 percent or more than 24 percent and areas of Terril soils at the concave base of slopes. A few wet areas of Webster and Glencoe soils on concave slopes are identified by spot symbols on the soil map.

Runoff is rapid. Organic-matter content is high in the Clarion soil and low in the Storden soil.

Because this unit is steep and subject to erosion, it is generally poorly suited to cultivated crops. The Storden soil has a high concentration of lime carbonates. It is used mostly for pasture and hay. A few areas are cropland, and others are idle. The steep slope severely limits most urban uses. Capability unit VIe–1.

Terril Series

The Terril series consists of nearly level to sloping, moderately well drained, medium textured soils. These soils formed in more than 40 inches of loamy alluvium and glacial sediments. They occupy accumulating positions between the slope above and the valley floor below, typically the long, narrow, slightly concave toe slopes below more rolling soils. Native vegetation was tall grass prairie or mixed prairie and deciduous trees.

In a representative profile the surface layer is black and very dark brown friable loam about 36 inches thick. The subsoil is very dark grayish brown and olive brown loam about 13 inches thick. The underlying material is light olive brown loam.

Permeability is moderate. The depth to the seasonal high water table is typically below 6 feet. Available water capacity, organic-matter content, and natural fertility are high.

Terril soils are well suited to cultivation. Many areas occur as narrow, irregular strips and are farmed with the adjacent steeper soils.

Representative profile of Terril loam, 2 to 6 percent slopes, in cultivated field 1,050 feet south and 1,500 feet east of northwest corner sec. 24, T. 107 N., R. 28 W.

Ap—0 to 7 inches, black (10YR 2/1) loam; weak fine subangular blocky structure; friable; about 3 percent coarse fragments; slightly acid; abrupt smooth boundary.

A12—7 to 21 inches, black (10YR 2/1) loam; weak and moderate fine and medium subangular blocky structure; friable; about 3 percent coarse fragments; slightly acid; clear wavy boundary.

A3—21 to 36 inches, very dark brown (10YR 2/2) loam; weak and moderate fine and medium subangular blocky structure; friable; about 3 percent coarse fragments; slightly acid; clear wavy boundary.

B2—36 to 45 inches, very dark grayish brown (10YR 3/2) loam; weak and moderate fine and medium subangular blocky structure; friable; about 3 percent fragments; slightly acid; clear wavy boundary.

B3—45 to 49 inches, olive brown (2.5Y 4/4) loam; weak and moderate fine and medium subangular blocky structure; friable; about 3 percent coarse fragments; slightly acid; clear wavy boundary.

C—49 to 60 inches, light olive brown (2.5Y 5/4) loam; massive; friable; about 3 percent coarse fragments; neutral.

Solum thickness ranges from 36 to 60 inches. The A horizon is black, very dark brown, or very dark gray. It is typically loam, but the range includes clay loam. It is 18 to 36 inches thick. The B horizon is very dark grayish brown, olive brown, brown, or dark yellowish brown. It is loam, clay loam, or sandy clay loam. The C horizon is loam to sandy loam.

Terril soils are associated with Clarion, Lester, and Storden soils. They are not so brightly colored as those soils, and they have a thicker surface layer.

94—Terril loam, 0 to 2 percent slopes. This nearly level soil occupies 3- to 18-acre concave toe slopes below areas of Clarion, Storden, Lester, Dickinson, and Estherville soils. Slopes are 60 to 100 feet long. The profile is similar to the one described for the series, but the surface layer is thicker.

Included with this soil in mapping are a few areas where slopes are more than 2 percent. Also included are areas of Hamel, Webster, Le Sueur, Nicollet, Clarion, and Lester soils, a few small seep areas, and areas of soils, below Estherville and Dickinson soils, that have a sandy loam surface layer.

Most of the acreage is used for cultivated crops and has few limitations for this use. Runoff is slow. Tile drainage is needed to remove excess water in seeps and to protect building foundations. Low strength, moderate percolation rates, and shrink-swell potential limit this soil for most urban uses. Many areas are subject to sidehill seepage. Capability unit I–1.

94B—Terril loam, 2 to 6 percent slopes. This gently sloping soil occupies 3- to 30-acre concave toe slopes below areas of Clarion, Lester, Storden, Dickinson, and Estherville soils. Slopes are about 60 to 150 feet long. This soil has the profile described for the series.

Included with this soil in mapping are a few areas where slopes are less than 2 percent or more than 6 percent. Also included are small areas of Hamel, Webster, Le Sueur, Nicollet, Clarion, Lester, and Storden soils, small seep areas, and a few areas of soils, below Dickinson and Estherville soils, that have a sandy loam surface layer.

The erosion hazard is slight in cultivated areas. Runoff is medium. Tile has been installed in some areas to remove water from seeps. Most of the acreage is used for crops and has few limitations for this use. Low strength and a moderate percolation rate limit this soil for most urban and recreational uses. Many areas are subject to sidehill seepage. A little system is needed to protect building foundations. Capability unit IIe–2.

94C—Terril loam, 6 to 15 percent slopes. This sloping soil occupies 5- to 20-acre concave toe slopes below areas of Storden, Clarion, and Lester soils. Slopes are about 60 to 150 feet long. The profile is similar to the one described for the series, but the surface layer is thinner.

Included with this soil in mapping are a few areas where slopes are less than 6 percent or more than 15 percent. Also included are a few areas of soils that have a sandy loam or clay loam surface layer, small seep areas, and a few areas of Clarion, Nicollet, Lester, Storden, Le Sueur, Hamel, and Webster soils.

Most of the acreage is used for cropland. Runoff is medium to rapid. The erosion hazard is moderate, and control practices are needed. Tile has been installed in some areas to remove water from seeps. Low strength and a moderate percolation rate limit this soil for most urban uses. Many areas are subject to sidehill seepage. A tile system is needed to protect building foundations. Capability unit IIIe–1.

856B—Terril-Urban land complex, 2 to 6 percent slopes. This gently sloping map unit is one of moderately well drained soils on concave toe slopes at the base of steep or very steep slopes. Slopes are 60 to 500 feet long. In the Urban land part, the soil has been exacavated for foundations, basements, or roads and used in leveling or as fill in the depressions.

Included with this unit in mapping are a few areas where slopes are less than 2 percent or more than 6 percent. Also included are small areas of the Hamel soil in drainageways and areas of Le Sueur and Lester soils.

This unit is used for urban development. It is limited by low strength, moderate permeability, and potential for sidehill seepage. A tile system is needed to protect building foundations and basements from wetness. The hazard of erosion from runoff is moderate. Runoff is high from roofs, roads, and other paved surfaces covering much of this unit. Not assigned to a capability group.

856C—Terril-Urban land complex, 6 to 15 percent slopes. This sloping map unit is one of moderately well drained soils on concave toe slopes at the base of steep and very steep slopes. Slopes are 60 to 300 feet long. In the Urban land part, the soil has been excavated for foundations, basements, or roads and used in leveling or as fill in depressions.

Included with this soil in mapping are a few areas where slopes are less than 6 percent or more than 15 percent. Also included are small areas of the Hamel soil in drainageways and areas of Le Sueur and Lester soils.

This unit is used for urban development. It is limited primarily by slope, low strength, moderate permeability, and potential for sidehill seepage. Walkout basements and retaining walls help the homeowner develop his lot for a suitable home site. A tile system is needed to protect building foundations and basements from wetness. Runoff is high from roofs, roads, and other paved surfaces covering much of this unit. Not assigned to a capability group.

Tilfer Series

The Tilfer series consists of nearly level, poorly drained to very poorly drained soils. These soils formed in 2 to 3 feet of moderately fine textured sediments over bedrock. They occupy depressions and sluggish drainageways. Native vegetation was principally water-tolerant grasses and sedges.

In a representative profile the surface layer is black silty clay loam about 11 inches thick. The subsoil is very dark gray and dark gray, friable silty clay loam about 20 inches thick. The underlying material is fractured limestone bedrock.

Permeability is moderate in the upper part of the soil and rapid in the disintegrated limestone fragments at a depth of 31 to 33 inches. Runoff is slow to ponded. The depth to the seasonal high water table ranges from 0 to 3 feet, or near tile depth. Available water capacity is low to moderate. Organic-matter content is high, and natural fertility is medium.

Part of the acreage is cropland. If properly drained, the soils are suited to most crops. Water table control is the principal management need. The limestone bedrock limits drainage in some areas.

Representative profile of Tilfer silty clay loam 2,000 feet north and 600 feet east of southwest corner sec. 3, T. 108 N., R. 28 W.

Ap—0 to 8 inches, black (10YR 2/1) light silty clay loam; weak very fine subangular blocky structure; friable; few roots; strongly effervescent; mildly alkaline; abrupt smooth boundary.

A12—8 to 11 inches, black (10YR 2/1) light silty clay loam; moderate very fine subangular blocky structure; friable; few roots; strongly effervescent; mildly alkaline; clear smooth boundary.

B1g—11 to 22 inches, very dark gray (5Y 3/1) light silty clay loam; moderate very fine subangular blocky structure; friable; strongly effervescent; mildly alkaline; clear smooth boundary.

B2g—22 to 31 inches, dark gray (5Y 4/1) silty clay loam; many fine distinct dark grayish brown (2.5Y 4/2) mottles; moderate very fine subangular blocky structure; friable; strongly effervescent; mildly alkaline; clear smooth boundary.

C—31 to 33 inches, olive gray (5Y 5/2) and olive (5Y 5/3) disintegrated limestone fragments; light brownish gray (10YR 6/2) streaks; single grained; loose; strongly effervescent; mildly alkaline; gradual irregular boundary.

R—33 inches plus, pale brown (10YR 6/3) and very pale brown (10YR 7/3) limestone bedrock; strongly effervescent; mildly alkaline.

Depth to bedrock ranges from 20 to 40 inches. The entire profile is weakly to strongly effervescent. In places snail shells are common. The A horizon is typically silty clay loam, but the range includes loam, sandy clay loam, or clay loam. It is 10 to 24 inches thick. The B horizon is typically silty clay loam, but the range includes loam or clay loam. It is about 10 to 24 inches thick. The R horizon is typically limestone bedrock. In places it is limy sandstone.

Tilfer soils are associated with Copaston and Joliet soils. They are poorly drained to very poorly drained and have a darker colored B horizon than Copaston soils. They are similar to the Joliet soil but are deeper to bedrock.

321—Tilfer silty clay loam. This nearly level soil occupies 3- to 20-acre swales and flats on bedrock-controlled benches. It formed in a silty mantle of limy, glacial alluvium in the Minnesota River Valley. Limestone bedrock is within 20 to 40 inches. Slopes are 0 to 2 percent.

Included with this soil in mapping are small, nonlimy areas and areas of shallow Joliet soil. Also included are small areas in old river channels next to steep river bluffs where the soil is more than 40 inches deep to bedrock. These areas are in section 32 of Lime Township and sections 5 and 6 of Mankato Township. Areas that are subject to flooding from upland runoff as it leaves the ravines and small creeks and moves toward the Minnesota River are also included. Many of these inclusions are subject to flash flooding, which occurs following 5- to 100-year frequency storms.

This is a wet soil. Seepage is common along the rock contact. Runoff is slow to ponded. Drainage is needed for dependable crops, but bedrock limits installation of adequate drainage systems in some places. The water table is lowered significantly in some places when an outlet ditch is installed nearby.

Most of the acreage is cropland. High application rates of phosphorus and potassium are needed to offset the high lime content. This soil has poor potential for most urban and recreational uses because of wetness and underlying rock. Capability unit IIIw–6.

Truman Series

The Truman series consists of deep, gently sloping to sloping, well drained, medium textured soils formed in silty lacustrine sediments. These soils are on convex slopes on the silt mantled till plain. Native vegetation was tall grass prairie.

In a representative profile the surface layer is very dark brown and dark brown silt loam about 14 inches thick. The very friable silt loam subsoil is about 22 inches thick. The upper part is dark yellowish brown, and the lower part is yellowish brown. The underlying material is limy, mottled brownish yellow and light yellowish brown silt loam. Iron and manganese concretions are present in the C horizon.

Permeability is moderate. Runoff is medium to rapid. The available water capacity, organic-matter content, and natural fertility are high. The depth to the seasonal high water table is below 6 feet.

Erosion is the main hazard on the steeper slopes. If Truman soils are protected from erosion and well managed, they are suitable for all crops grown in the county.

Representative profile of Truman silt loam, 2 to 6 percent slopes, 2,250 feet south and 1,720 feet east of northwest corner sec. 4, T. 107 N., R. 27 W.

Ap—0 to 10 inches, very dark brown (10YR 2/2) silt loam; very fine subangular blocky structure; friable; neutral; clear smooth boundary.

A3—10 to 14 inches, dark brown (10YR 3/3) silt loam, very dark grayish brown (10YR 3/2) coatings on faces of peds; few tongues of very dark brown (10YR 2/2); weak fine subangular blocky structure; very friable; neutral; clear smooth boundary.

B1—14 to 20 inches, dark yellowish brown (10YR 3/4) silt loam, dark brown coatings on faces of peds; weak fine subangular blocky structure; very friable; many fine tubular pores; slightly acid; clear smooth boundary.

B2—20 to 30 inches, yellowish brown (10YR 5/4) silt loam, dark yellowish brown (10YR 4/4) coatings on faces of peds; weak medium prismatic structure parting to weak fine and very fine subangular blocky; very friable; many fine tubular pores; slightly acid; clear smooth boundary.

B3—30 to 36 inches, yellowish brown (10YR 5/4) silt loam; weak moderate prismatic structure; very friable; many fine tubular pores; neutral; clear smooth boundary.

C1—36 to 42 inches, brownish yellow (10YR 6/6) silt loam; few fine distinct light brownish gray (10YR 6/2) mottles; weak medium and thick platy structure; very friable; strongly effervescent; mildly alkaline; clear smooth boundary.

C2—42 to 60 inches, light yellowish brown (10YR 6/4) silt loam; many medium faint light brownish gray (10YR 6/2) and common yellowish brown (10YR 5/8) mottles; weak medium and thick platy structure; very friable; thin strata of very fine sandy loam; strongly effervescent; mildly alkaline.

Thickness of the solum and depth to lime range from 24 to 56 inches. The A horizon is 8 to 16 inches thick. It is typically silt loam, but the range includes light silty clay loam. Reaction ranges from neutral to slightly acid. The B horizon is 20 to 40 inches thick. It is typically silt loam, but the range includes loam and light silty clay loam. The B1 and B3 horizons are not in all pedons. Reaction ranges from slightly acid to neutral in the B1 and B2 horizons and neutral to mildly alkaline in the B3 horizon. The C horizon is typically silt loam, but included in the range are stratifications of very fine sandy loam and loam. The IIC horizon of glacial till begins at depths as shallow as 48 inches in a few profiles.

Truman soils are associated with Kingston, Madelia, and Spicer soils. They are better drained and have brighter colored subsoils than these associated soils.

101B—Truman silt loam, 2 to 6 percent slopes. This gently sloping soil is on convex rises on the lake plain. Areas are small to large and are irregular in shape. This soil has the profile described for the series.

Included with this soil in mapping are small areas of moderately well drained Kingston soils, typically in small swales in the midst or at the edge of the soil delineation. Also included are small areas of Clarion soils where the silt mantle is thin and some areas of Grogan soils. Included slopes steeper than 6 percent are identified by spot symbols on the soil map.

Most of the acreage is used for corn and soybeans. The soil is well suited to crops, but erosion control is needed. Runoff is medium. This soil is fairly well suited to most urban uses and is well suited to most recreational uses. Capability unit IIe–2.

101C—Truman silt loam, 6 to 12 percent slopes. This sloping soil is on short, irregular slopes adjacent to areas of Kingston and Madelia soils and areas of less sloping Truman soils. The profile is similar to the one described for the series, but the surface layer is lighter colored and thinner.

Included with this soil in mapping are a few small areas of Bold soils on the steepest part of the convex slopes. Also included are some areas that are moderately eroded to severely eroded, small areas of Grogan soils, and small areas where slopes are less than 6 percent or steeper than 12 percent.

Erosion is the main hazard. Under proper management corn, soybeans, and small grains are well suited. Runoff is medium to rapid. This soil has fair potential for most urban and recreational uses. Slope is the main limitation. Capability unit IIIe–1.

Urban Land

1039—Urban land, 0 to 2 percent slopes. This area typically consists of poorly drained and very poorly drained soils that are commonly covered with several feet of fill material. This fill material is typically loamy glacial till but includes debris from old buildings and old street surfaces.

Included with Urban land in mapping are areas where soil material has been removed for fill or where the surface layer has been removed during leveling operations. Characteristics are too variable to be rated for urban development. Each area should be checked before urban and industrial developments or other uses are considered. Not assigned to a capability group.

Wadena Series

The Wadena series consists of nearly level to gently sloping, well drained, medium textured soils. These soils formed in glacial outwash consisting of a loamy mantle 24 to 42 inches thick over limy sand and gravel. They are on the glacial outwash plains and stream terraces. Native vegetation was tall grass prairie.

In a representative profile the surface layer is black and very dark brown loam about 14 inches thick. The subsoil is about 22 inches thick. The upper part is very dark grayish brown and dark brown loam, the middle part is brown sandy loam, and the lower part brown loamy coarse sand. The underlying material is limy, grayish brown and brown gravelly coarse sand.

Permeability is moderately rapid in the upper part and rapid in the underlying material at a depth of about 36 inches. The seasonal high water table is below 6 feet. Available water capacity is moderate. Organic-matter content is moderate, and natural fertility is medium.

Most of the acreage is cropland, to which the soils are moderately well suited. The moderate available water capacity and the hazard of soil blowing and water erosion are the major limitations for crop production.

Representative profile of Wadena loam, 0 to 2 percent slopes, 2,110 feet east and 2,210 feet south of northwest corner sec. 14, T. 106 N., R. 29 W.

A11—0 to 7 inches, black (10YR 2/1) loam; weak fine subangular blocky structure; friable; medium acid; abrupt smooth boundary.

A12—7 to 11 inches, black (10YR 2/1) loam; weak fine subangular blocky structure; friable; medium acid; clear smooth boundary.

A3—11 to 14 inches, very dark brown (10YR 2/2) loam; weak fine subangular blocky structure; friable; medium acid; clear smooth boundary.

B21—14 to 19 inches, very dark grayish brown (10YR 3/2) loam; weak fine subangular blocky structure; friable; medium acid; clear smooth boundary.

B22—19 to 24 inches, dark brown (10YR 4/3) loam; weak fine subangular blocky structure; friable; medium acid; clear smooth boundary.

B23—24 to 33 inches, brown (10YR 4/3) sandy loam; weak fine subangular blocky structure; friable; medium acid; clear smooth boundary.

IIB3—33 to 36 inches, brown (10YR 4/3) loamy coarse sand; single grained; very friable; medium acid; clear smooth boundary.

IIC—36 to 60 inches, grayish brown (10YR 5/2) and brown (10YR 5/3) gravelly coarse sand; single grained; loose; mildly alkaline; slightly effervescent to strongly effervescent.

The depth to loamy sand or coarser and free carbonates ranges from 24 to 40 inches. The A horizon is slightly acid to medium acid and 10 to 18 inches thick. The B horizon is slightly acid to medium acid in the upper part and slightly acid to neutral in the lower part. It ranges from 14 to 28 inches in thickness. The IIC horizon is typically coarse sand and fine gravel, but in some places it is interbedded with seams and pockets of fine sand.

Wadena soils occur on the same landscape as Estherville and Dickinson soils. They have a thicker solum and contain more clay that Estherville soils. They contain less sand and are not leached so deep as Dickinson soils.

39—Wadena loam, 0 to 2 percent slopes. This nearly level soil occupies 3- to 50-acre tracts. The smaller tracts are commonly scattered within the loamy uplands, and the larger tracts are on terraces along the Minnesota River and its tributaries. This soil has the profile described for the series.

Included with this soil in mapping are small areas where slopes are more than 2 percent. The broader areas are often crossed by drainageways of a poorly developed drainage net. Also included are small areas, on the upper terraces of the Minnesota River, where the solum is silty and small areas of Estherville and Dickinson soils.

This soil warms up early in spring and is easy to till, but it is moderately droughty. Runoff is slow. Soil blowing is a hazard on the larger tracts, especially in spring.

Most of the acreage is used for cultivated crops. Management is needed to conserve moisture and provide a high content of plant nutrients. The potential is good for most urban and recreational uses. Because of the high percolation rate, there is a hazard of pollution of nearby streams and wells if this soil is used for septic tank filter fields. Capability unit IIs–1.

39B—Wadena loam, 2 to 6 percent slopes. This gently sloping soil occupies 2- to 50-acre tracts. It is on irregular hills within the loamy uplands or on side slopes below the less sloping Wadena soils. Slopes are 50 to 125 feet long. This soil has a profile similar to the one described for the series, but the surface layer is thinner.

Included with this soil in mapping are a few small areas of Estherville soils and small areas, on the upper terraces of the Minnesota River, where the solum is silty. Small areas where the surface layer is gravelly are identified by spot symbols on the soil map. Also included are a few areas where slopes are less than 2 percent or more than 6 percent and a few small eroded areas where part of the brownish subsoil has been mixed with the surface layer.

This is a moderately droughty soil. Runoff is medium. The hazard of soil blowing and water erosion is moderate. Most of the acreage is used for cultivated crops. Management is needed to provide a high content of plant nutrients, especially nitrogen and phosphorus. This soil has good potential for most urban and recreational uses. If it is used as a septic tank filter field, however, there is a hazard of contamination of local water supplies. Capability unit IIe–4.

Waldorf Series

The Waldorf series consists of level to nearly level, poorly drained, fine textured and moderately fine textured soils formed in glacial lacustrine sediments. These soils occupy broad flats, very shallow depressions and drainageways, and slightly convex positions on the upland landscape. Native vegetation was a wet site community of tall grass prairie.

In a representative profile the surface layer is black, friable silty clay loam about 15 inches thick. The subsoil, about 30 inches thick, is mottled black and olive gray silty clay and silty clay loam. The underlying material is limy, mottled olive gray silty clay loam.

Permeability is moderately slow. Runoff is slow. The depth to the seasonal high water table ranges from 1 to 3 feet, or near tile depth. Available water capacity, organic-matter content, and natural fertility are high.

Most of the acreage is in corn and soybeans. The soils are suited to most crops if properly drained. Maintaining good tilth and a high fertility level is a major management need.

Representative profile of Waldorf silty clay loam in cultivated field 100 feet north and 300 feet east of southwest corner sec. 27, T. 106 N., R. 29 W.

Ap—0 to 9 inches, black (N 2/0) heavy silty clay loam; moderate very fine subangular blocky structure; friable; common roots; neutral; abrupt smooth boundary.

A12—9 to 15 inches, black (N 2/0) heavy silty clay loam; moderate medium and coarse angular blocky structure; friable; common roots; neutral; clear smooth boundary.

A3—15 to 20 inches, black (5Y 2/1) silty clay; few fine faint dark olive gray (5Y 3/2) mottles; weak fine and medium prismatic structure parting to moderate and strong very fine subangular blocky; firm; few roots; neutral; clear smooth boundary.

B21g—20 to 28 inches, olive gray (5Y 4/2) silty clay, very dark gray (5Y 3/1) coatings on faces of peds; many fine faint dark olive gray (5Y 3/2) mottles; moderate and strong very fine angular blocky structure; firm; neutral; clear smooth boundary.

B22g—28 to 35 inches, olive gray (5Y 4/2) silty clay, dark gray (5Y 4/1) coatings on faces of peds; many fine faint olive (5Y 4/3 and 5/3) mottles; weak and moderate very fine angular blocky structure; firm; neutral; clear smooth boundary.

B3g—35 to 45 inches, olive gray (5Y 5/2) heavy silty clay loam, gray (5Y 5/1) coatings on faces of peds; common fine distinct olive (5Y 5/4 and 5/6) mottles; weak very fine angular blocky structure; friable; neutral; clear smooth boundary.

Cg—45 to 62 inches, olive gray (5Y 5/2) silty clay loam, few gray (5Y 5/1) coatings on faces of peds in the upper part; many fine distinct olive (5Y 5/3 and 5/6) mottles in upper part and many fine prominent strong brown (7.5YR 5/6) mottles in lower part; weak thick platy structure parting to weak medium prismatic; friable; neutral in upper part becoming slightly effervescent and mildly alkaline below 53 inches.

Thickness of the solum ranges from 26 to 48 inches. The depth to free lime ranges from 26 to 55 inches. The A horizon is 16 to 24 inches thick. The solum and the C horizon have no coarse fragments. Concretions occur in some profiles.

The A horizon is black or very dark gray. It is typically silty clay loam, but the range includes silty clay. The B horizon is gray, dark gray, or olive gray. It is typically silty clay, but the range includes silty clay loam and clay. The C horizon is mottled gray to olive gray. It typically is silty clay loam, but the range includes silt loam, silty clay, or clay. In places the C horizon is stratified with these textures to a depth of 60 inches. Below 60 inches it is commonly silt loam high in coarse silts stratified with very fine sandy loam and loamy very fine sand. The stratified silt loam is typically 8 feet thick, but ranges from 1 to 17 feet. In a few places a IIC horizon of loam or clay loam glacial till begins at a depth of 48 inches.

Waldorf soils are associated with Collinwood, Lura, and Beauford soils. They are wetter than Collinwood soils and drier than Lura soils. They have less clay in the solum than Beauford soils.

229—Waldorf silty clay loam. This nearly level soil occupies 5- to 200-acre broad flats, very shallow drainageways and depressions, and slightly convex positions on the upland landscape. It is a large part of the lacustrine landform that developed under glacial lake water. Slopes are 0 to 2 percent.

Included with this soil in mapping are areas of the better drained Collinwood, Guckeen, and Kingston soils, all of which are identified by spot symbols on the soil map. Also included are small areas of the Minnetonka silty substratum soil near the river valleys, lakes, or peat bogs and small areas of Lura or Barbert soils. The Lura soil occurs in low gradient drainageways and depressions. The Barbert soil is in shallow depressions. All are identified by spot symbols.

Most of the acreage is used for corn and soybeans. Runoff is slow. Drainage is needed for dependable crop production and maximum yields. Maintaining good tilth and a high fertility level is a major need. The soil can be tilled within only a narrow range of moisture content. Because of the high shrink-swell potential, high seasonal water table, low strength, and slow percolation rates, it is poorly suited to most urban and recreational uses. Capability unit IIw–2.

Webster Series

The Webster series consists of nearly level, poorly drained, moderately fine textured soils formed in limy, loamy glacial till. These soils are intermingled with more sloping soils on broad upland flats and in drainageways. The native vegetation was a wet site community of tall grass prairie.

In a representative profile (fig. 7) the surface layer is black silty clay loam about 15 inches thick. It is mottled in the lower part. The subsoil is mottled very dark gray and dark gray loam about 15 inches thick. The underlying material is limy, mottled olive gray loam.

Permeability is moderate. The depth to the seasonal high water table ranges from 1 to 4 feet, or near tile depth. Available water capacity is high. Organic-matter content and natural fertility are high.

Unless drained, these soils are moderately well suited to poorly suited to crops. If adequately drained, they are well suited. Controlling the water table and maintaining tilth and a high level of fertility are the major management needs. Most areas are in crops.

Representative profile of Webster silty clay loam in cultivated field 130 feet east and 2,580 feet north of southwest corner sec. 9, T. 108 N., R. 23 W.

Ap—0 to 8 inches, black (N 2/0) silty clay loam; weak very fine subangular blocky structure; friable; few roots, neutral; abrupt smooth boundary.

A12—8 to 12 inches, black (10YR 2/1) silty clay loam; weak very fine subangular blocky structure; friable; few roots; neutral; clear smooth boundary.

A13—12 to 15 inches, black (5Y 2/1) silty clay loam; few fine faint mottles; weak very fine subangular blocky structure; friable; about 2 percent coarse fragments; few roots; neutral; clear smooth boundary.

B1g—15 to 20 inches, very dark gray (5Y 3/1) clay loam; common fine faint olive gray (5Y 4/2) and olive (5Y 4/3) mottles; weak very fine subangular blocky structure; friable; about 2 percent coarse fragments; few roots; neutral; clear smooth boundary.

B21g—20 to 24 inches, dark gray (5Y 4/1) clay loam; common fine distinct olive (5Y 5/3, 4/3) mottles; weak very fine subangular blocky structure; friable; about 4 percent coarse fragments; few roots; neutral; clear smooth boundary.

B22g—24 to 30 inches, dark gray (5Y 4/1) clay loam; common fine distinct olive gray (5Y 5/2) and olive (5Y 5/3, 5/4) mottles; weak very fine subangular blocky structure; friable; about 4 percent coarse

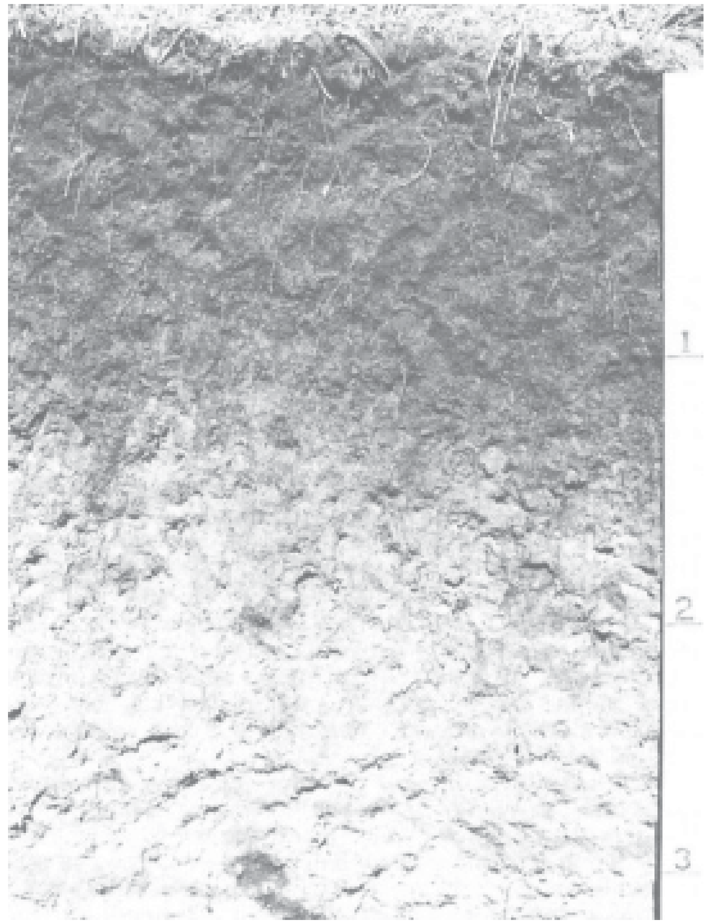

Figure 7.—**Profile of Webster silty clay loam.**

fragments; neutral; clear smooth boundary.

Cg—30 to 60 inches, olive gray (5Y 5/2) loam; common fine distinct olive (5Y 5/3, 5/4) mottles; weak very fine subangular blocky structure; friable; about 6 percent coarse fragments; few lime pebbles; strongly effervescent; mildly alkaline.

The thickness of the solum and the depth to lime carbonates range from 24 to 50 inches. The soil, by volume, is about 2 to 8 percent coarse fragments. The A horizon is typically silty clay loam but ranges to clay loam. It is 10 to 24 inches thick. The B horizon is typically clay loam but ranges to silty clay loam. It is neutral to mildly alkaline. The C horizon is clay loam or loam. In some areas there is a thin discontinuous coarse textured stratum between the B and C horizons.

Webster soils are associated with Glencoe, Nicollet, and Clarion soils. They have a thinner A horizon than Glencoe soils. They are more poorly drained, occupy lower positions on the landscape, and have more gray in the subsoil than Nicollet and Clarion soils.

113—Webster silty clay loam. This nearly level soil occupies 5- to 300-acre broad flats and upper drainageways within or below areas of Nicollet and Clarion soils. Slopes are 0 to 2 percent and are slightly concave to slightly convex. This soil has the profile described for the series.

Included with this soil in mapping are a few small areas of Rolfe soils in depressions near the crests of the drainage divides. A few small areas of limy Canisteo soils on rims of depressions and drainageways and a few areas of Cordova soils are also included.

This soil is wet. Runoff is slow to ponded. If this soil is tilled when wet, it puddles easily, tilth is destroyed, and it becomes hard and cloddy when dry. Removing excess water and maintaining good tilth are the main management concerns.

Drainage is essential for all commonly grown crops. Most of the acreage is used for crops. Because of the seasonal high water table, the moderate shrink-swell potential, and the high susceptibility to frost action, the soil is poorly suited to most urban and recreational developments. Capability unit IIw–1.

968—Webster-Darfur-Granby complex. This nearly level map unit is one of poorly drained soils in irregularly shaped areas ranging from 5 to 50 acres. It is 60 percent Webster silty clay loam, 20 percent Darfur loam, 10 percent Granby fine sandy loam, and 10 percent other soils. Slopes are 0 to 2 percent.

The profile of the Webster soil differs from the one described for the series in having a higher content of sand in the surface layer. The profiles of the Darfur and Granby soils differ from those described for the respective series in having loamy material at a depth of 48 to 72 inches.

Included with this unit in mapping are small sandy areas. Also included are small areas of moderately well drained Litchfield and Nicollet soils on nearly level convex slopes and areas of very poorly drained Dassel and Glencoe soils in depressions.

Soil blowing is a hazard in the sandy areas if fields are bare in winter and spring.

All crops commonly grown in the county are grown on this unit. Wetness is a limitation. Depth to the seasonal high water table is commonly 1 to 3 feet in undrained areas. Drainage is needed to provide a deep root zone for most crops. Management is needed to maintain high levels of organic matter and plant nutrients. This unit is poorly suited to most urban and recreational uses because it is wet. Webster silty clay loam, capability unit IIw–1; Darfur loam, capability unit IIw–4; Granby fine sandy loam, capability unit IIw–5.

Planning the Use and Management of the Soils

The soil survey is a detailed analysis and evaluation of the most basic resource of the survey area—the soil. It may be used to fit the use of the land, including urbanization, to the limitations and potentials of the natural resources and the environment and to help avoid soil-related failures in uses of the land.

During a soil survey scientists, conservationists, engineers, and others keep extensive notes, not only about the nature of the soils but also about unique aspects of behavior of these soils in the field and at construction sites. These notes include observations of erosion, drought damage to specific crops, yield estimates, flooding, the functioning of septic systems, and other factors relating the kinds of soil and their productivity, potentials, and limitations under various uses and management. In this way field experience, incorporated with measured data on soil properties and performance, is used as a basis for predicting soil behavior.

Information in this section is useful in applying basic facts about the soils to plans and decisions for use and management of soils for crops and pasture, woodland, and many nonfarm uses, including building sites, highways and other transportation systems, sanitary facilities, parks and other recreational developments, and wildlife habitat. From the data presented, the potential of each soil for specified land uses can be determined, soil limitations to these land uses can be identified, and costly failures in homes and other structures, because of unfavorable soil properties, can be avoided. A site can be selected where the soil properties are favorable, or practices can be planned that will overcome the limitations.

Planners and others using the soil survey can evaluate the impact of specific land uses on the overall productivity of the survey area or other broad planning area, and on the environment. Both of these factors are closely related to the nature of the soil. Plans can be made to maintain or create a land use pattern in harmony with the natural soil.

Contractors can find information useful in locating sources of sand and gravel, roadfill, and topsoil. Other information indicates the presence of bedrock, wetness, or very firm soil horizons that cause difficulty in excavation.

Health officials, highway officials, engineers, and many other specialists can find useful information in this soil survey. The safe disposal of wastes, for example, is closely related to properties of the soil. Pavements, sidewalks, campsites, playgrounds, lawns, trees and shrubs, and most other uses of land are influenced by the nature of the soil.

Crops

This section explains the capability classification used by the Soil Conservation Service and describes the capability units to which the soils of the county are assigned. Table 2 lists estimates of yields for the arable soils.

Most of the farmland in the county is used for corn, seed corn, soybeans, oats, wheat, barley, sweet corn, and peas. The potential is excellent for sugar beets in the stonefree, lacustrine soils. Productivity is marginal to high.

Artificial drainage is needed if wet, level, or depressional areas are farmed. Much of Blue Earth County is nearly level. There are few large developed streams and natural drainageways. Thus, open ditches are commonly used to remove surface water from low areas and closed depressions and to provide outlets for tile drainage systems. Tile drainage can be installed in most of the soils. Soils affect the design and types of drainage systems used. For example, fine textured soils require surface inlets and closer spacings between tile lines as compared to the medium textured soils. Also, some soils on the flood plains of rivers in Blue Earth County require dikes to protect them from frequent flooding.

Soil blowing occurs throughout the county but is severe on the sandy river terraces along the Minnesota River and the sandy outwash in Lincoln and Garden City townships. Stripcropping, field shelterbelts, crop residue management, minimum tillage, and stubble mulch help to control soil blowing. Most of the erosion occurs when the fields are left bare in winter and spring; therefore, fields that are fall-plowed should be left rough so that crop residue is exposed and the soil is protected.

Fall plowing is better than spring plowing on the fine textured and moderately fine textured soils. Freezing and thawing during winter mellow the surface soil and make it easier to work in spring. In spring the soils are wet. Spring plowing destroys soil structure and compacts the soil. Compaction affects root development of plants, infiltration of surface water, and soil temperature. If good tilth is maintained, plant nutrients are used more efficiently and the soils are easier to work.

The sloping soils in the county are subject to water erosion. Because slopes are short, the eroded material is seldom carried beyond the concave positions at the base of the slopes. Minimum tillage, contour farming, stripcropping, grassed waterways, and terraces reduce runoff and help to control erosion. A year before terraces are built, waterways should be constructed and seeded to grass to provide outlets for the terraces. If waterways are properly designed and kept in grass, they prevent gullying. Terraces on sloping, fine textured soils create a serious wetness problem in terrace channels. Gully control structures are necessary to prevent the gullies from further developing into the uplands and ruining good farm land. Returning crop residue increases the infiltration rate, which increases the amount of water available for plant growth.

Crops grown on most soils in the survey area respond to fertilization. The soils are generally low in phosphorus and medium to high in potassium. Soils that formed under woodland and mixed trees and prairie grasses contain acid and require lime. The need for fertilizer depends on the kind of soil, on past and present management, and on the crop that is grown. Soil tests provide part of the information that is needed to choose the best kinds and amounts of fertilizer. Cold soils have lower available plant food because of slow action by soil bacteria on soil and organic material. Early spring planting requires a starter application of fertilizer with phosphorus and potash to counteract the cold soil temperature. This should be done even though soil tests read high.

Moisture deficiencies occur in most years on the well drained and excessively drained soils of Blue Earth County. Irrigation is used on the somewhat excessively drained soils. It is anticipated that it will be used more in the future in Lincoln township and the Minnesota River terrace areas. Irrigation in these areas will make it practicable to grow a greater variety of crops, especially on soils that have low available water capacity and otherwise are well suited to early maturing crops. Crop yields can be stabilized on the deep, well drained soils by use of irrigation during the dry periods that occur in most years.

Pasture and Hay

The Conservation Needs Inventory of land use shows that Blue Earth County had about 28,691 acres of pasture and hay in 1958 and 20,015 acres in 1967, a decrease of about 35 percent. This reflects a change of land use from mixed cash grain and livestock to intensive cash grain farming. Table 2 gives estimates of expected yields of hay and pasture.

Most well drained soils, such as those in capability unit IIe–2, are suited to crops and well suited to pasture and hay. These soils have the potential for high levels of production from pasture and hay under good management, including proper fertilization, rotation grazing, optimum time of harvest, and weed control. Normally, the hay is alfalfa or an alfalfa-grass mixture. Pasture is mainly grass, such as brome or timothy, or a mixture of grasses and legumes.

On wet soils, such as those in capability unit IIw–1 where wetness or flooding is a hazard, hay or pasture is an alternative land use because of greater tolerance to these hazards. Under good management, such as proper fertilization, optimum time of harvest, rotation grazing, and proper stocking, high levels of production can be obtained. On such soils, it is essential to select species of grasses and legumes tolerant of wet conditions.

On droughty soils, such as those in capability unit IIIs–1, or on soils that have a severe hazard of erosion, such as those in capability unit VIe–1, hay or pasture is an alternative land use. Moisture is the limitation on these soils, and careful management is essential. Fertilization must be related to the productive potential of the site. Grazing is limited to the active growth period of the grasses and legumes in use, and weeds are controlled to obtain maximum production of forage for hay or grazing.

TABLE 2.—*Yields per acre of crops and pasture*

[All yields were estimated for a high level of management in 1974. Absence of a yield figure indicates the crop is seldom grown or is not suited]

Soil name and map symbol	Corn	Soybeans	Oats	Grass-legume hay	Bromegrass-alfalfa	Kentucky bluegrass	Reed canarygrass
	Bu	*Bu*	*Bu*	*Ton*	*AUM* *	*AUM* *	*AUM* *
17 Minneopa	75	26	60	3.0	4.0	2.0	
18 Comfrey	85	34	75	3.5			7.5
27 Dickinson	83	32	62	3.0		2.7	
27B Dickinson	81	31	60	3.0		2.7	
35 Blue Earth	75	35		3.0	4.5		6.0
39 Wadena	75	28	60	3.5	5.2	3.6	
39B Wadena	70	26	55	3.2	4.8	3.4	
41 Estherville	50	17	40	2.0	3.0	2.0	
41B Estherville	45	15	35	2.0	3.0	2.0	
41C Estherville	30	10	30	1.5	2.5	1.5	
62 Barrington	113	38	77	4.9	8.1		
69 Fedji	68	25	55	3.0	4.0	2.6	
69B Fedji	60	25	45	3.0	4.0	2.0	
84 Brownton	110	36	75	4.0		3.0	
85 Calco	99	38	84	4.2		6.0	
86 Canisteo	110	36	75	3.5	5.2	3.0	
94 Terril	120	46	95	5.0		4.2	
94B Terril	118	45	94	5.0		4.2	
94C Terril	113	43	91	4.8		4.2	
96 Collinwood	115	35	80	4.0	6.0	3.5	
96B Collinwood	115	35	80	4.0	6.0	3.5	
96C Collinwood	100	30	75	3.8	5.5	3.2	
96D Collinwood	90	27	65	3.5	5.0	3.0	

TABLE 2.—*Yields per acre of crops and pasture*—Continued

Soil name and map symbol	Corn	Soybeans	Oats	Grass-legume hay	Bromegrass-alfalfa	Kentucky bluegrass	Reed canarygrass
	Bu	*Bu*	*Bu*	*Ton*	*AUM* *	*AUM* *	*AUM* *
100 Copaston	55	22	45	2.7	4.0	2.0	------------
101B Truman	110	36	75	4.5	------------	4.0	------------
101C Truman	100	33	70	4.0	------------	3.5	------------
102B Clarion	110	42	80	4.6	------------	4.2	------------
102C Clarion	105	40	70	4.0	------------	3.8	------------
102D Clarion	81	31	65	3.4	------------	3.3	------------
105B Kamrar	96	36	77	4.0	------------	3.7	------------
105C Kamrar	91	35	73	3.8	------------	3.7	------------
105D Kamrar	80	30	65	3.5	------------	3.0	------------
106B Lester	105	35	80	4.5	6.5	3.5	------------
106C Lester	95	33	75	4.5	6.5	3.5	------------
106D Lester	75	25	65	4.0	6.0	3.0	------------
106E Lester	------------	------------	------------	3.0	4.5	3.0	------------
109 Cordova	110	36	75	4.0	6.0	3.0	------------
110 Marna	120	36	75	4.0	6.0	3.0	------------
113 Webster	120	36	88	4.4	6.0	4.2	------------
114 Glencoe	95	34	75	3.5	5.2	------------	5.5
128 Grogan	110	38	75	4.5	6.0	3.2	------------
128B Grogan	110	30	65	4.0	6.0	2.8	------------
130 Nicollet	120	40	80	4.5	6.5	3.5	------------
134 Okoboji	94	32	67	3.4	------------	3.3	5.5
136 Madelia	120	36	80	4.0	6.0	3.0	5.5
138B2 Lerdal	90	35	70	4.5	6.7	3.7	------------
138C2 Lerdal	80	33	65	4.0	6.0	3.5	------------

TABLE 2.—*Yields per acre of crops and pasture*—Continued

Soil name and map symbol	Corn	Soybeans	Oats	Grass-legume hay	Bromegrass-alfalfa	Kentucky bluegrass	Reed canarygrass
	Bu	*Bu*	*Bu*	*Ton*	*AUM **	*AUM **	*AUM **
140 Spicer	110	36	75	4.0	6.0	-----	5.5
160 Fieldon	70	25	65	3.5	5.0	3.0	-----
178 Granby	75	25	55	3.3	5.0	3.0	-----
181 Litchfield	68	25	55	3.0	4.5	2.6	-----
183 Dassel	80	25	70	3.5	5.2	-----	5.5
196 Joliet	-----	-----	-----	-----	-----	-----	5.0
197 Kingston	120	38	80	4.5	6.7	3.5	-----
211 Lura	80	32	65	3.5	5.2	-----	5.5
219 Rolfe	90	30	65	3.0	-----	3.3	4.5
222B Lasa	45	16	40	2.5	3.7	2.6	-----
229 Waldorf	120	40	85	4.0	6.0	-----	5.5
230 Guckeen	105	38	78	4.5	6.7	4.7	-----
238B Kilkenny	90	34	75	4.5	6.7	4.7	-----
238C Kilkenny	80	30	65	4.0	6.0	4.2	-----
238D Kilkenny	70	28	55	3.5	5.2	3.6	-----
239 Le Sueur	120	38	80	4.5	6.7	4.7	-----
248 Lomax	105	37	66	4.3	6.7	-----	-----
259B Grays	106	36	70	4.5	7.0	-----	-----
275B Ocheyedan	105	40	80	3.5	6.5	3.3	-----
281 Darfur	85	30	60	3.5	5.2	3.6	-----
286 Shorewood	90	36	75	4.5	6.7	4.7	-----
287 Minnetonka	110	36	75	4.0	6.0	-----	5.5
310 Beauford	100	36	80	5.0	-----	4.5	-----
311 Shorewood	85	33	70	4.5	6.7	4.7	-----

TABLE 2.—*Yields per acre of crops and pasture*—Continued

Soil name and map symbol	Corn	Soybeans	Oats	Grass-legume hay	Bromegrass-alfalfa	Kentucky bluegrass	Reed canarygrass
	Bu	*Bu*	*Bu*	*Ton*	*AUM* *	*AUM* *	*AUM* *
316 Baroda	100	36	75	5.0	—	3.5	—
317 Oshawa	—	—	—	—	—	5.3	7.5
319 Barbert	90	30	65	3.0	—	—	4.5
321 Tilfer	85	32	68	3.6	5.6	3.4	—
329. Chaska							
349 Calco	—	—	—	—	—	—	—
353 Comfrey	—	—	—	—	—	—	7.0
354 Dorchester	95	38	80	4.4	7.3	4.0	—
360B Lasa	40	16	55	2.0	3.0	2.1	—
360E Lasa	—	—	—	1.5	2.2	1.6	—
363 Minneopa	75	26	60	3.0	4.0	2.0	—
364 Minnetonka	110	36	75	4.0	6.0	—	5.5
414 Hamel	105	36	80	4.0	6.0	—	5.2
440 Copaston	—	—	—	—	3.7	1.6	—
448 Shorewood	100	38	75	4.5	6.7	4.7	—
451 Dorchester	104	40	83	4.4	7.3	4.0	—
524 Caron	75	35	—	—	—	—	6.0
525 Muskego	80	35	—	—	—	—	6.0
539 Palms	105	42	—	—	—	—	6.0
548 Palms	80	35	—	—	—	—	6.0
851.** Chaska-Urban land							
852.** Copaston-Urban land							
853.** Copaston-Urban land							
854.** Cordova-Urban land							

TABLE 2.—*Yields per acre of crops and pasture*—Continued

Soil name and map symbol	Corn	Soybeans	Oats	Grass-legume hay	Bromegrass-alfalfa	Kentucky bluegrass	Reed canarygrass
	Bu	*Bu*	*Bu*	*Ton*	*AUM* *	*AUM* *	*AUM* *
855.** Dorchester-Urban land							
856B.** Terril-Urban land							
856C.** Terril-Urban land							
909C* Bold-Truman	80	28	59	3.5	4.5	3.0	---
909D** Bold-Truman	69	23	48	3.2	4.0	3.0	---
919** Canisteo-Fieldon	98	33	73	3.6	5.1	3.0	---
920B** Clarion-Estherville	91	34	73	3.8	5.0	3.5	---
920C** Clarion-Estherville	75	27	57	3.0	4.5	2.7	---
920D** Clarion-Estherville	50	15	37	2.0	3.0	2.5	---
921C** Clarion-Storden	100	35	65	3.6	6.0	3.5	---
921D** Clarion-Storden	70	24	55	3.0	5.5	3.2	---
923** Copaston-Rock outcrop	---	---	---	---	---	---	---
926** Darfur-Webster	93	34	68	3.8	5.2	3.8	---
929** Fieldon-Canisteo	82	29	69	3.6	5.1	3.0	---
932** Glencoe-Dassel	84	32	74	3.6	5.2	---	6.0
941** Kingston-Nicollet	120	39	80	4.5	6.6	3.5	---
946** Litchfield-Nicollet	89	31	65	3.6	5.3	3.0	---
947** Madelia-Webster	116	39	83	4.5	6.0	3.0	---
960E** Storden-Clarion	---	---	---	3.0	4.0	2.5	---
961 Storden	---	---	---	---	---	---	---
961F Storden	---	---	---	---	---	1.5	---
968** Webster-Darfur-Granby	98	38	76	4.0	5.8	---	---
978** Cordova-Rolfe	100	35	73	3.6	---	---	5.1

TABLE 2.—*Yields per acre of crops and pasture*—Continued

Soil name and map symbol	Corn	Soybeans	Oats	Grass-legume hay	Bromegrass-alfalfa	Kentucky bluegrass	Reed canarygrass
	Bu	*Bu*	*Bu*	*Ton*	*AUM* *	*AUM* *	*AUM* *
992** Rock outcrop-Copaston	---	---	---	---	---	---	---
996** Beauford-Barbert	96	36	78	4.3	---	---	5.1
997** Marna-Barbert	108	36	75	3.6	---	---	5.1
998** Minnetonka-Barbert	108	36	75	3.6	---	---	5.1
1001**, 1002**, 1004** Alluvial land							
1007.** Alluvial-Urban land							
1032.** Lake beaches							
1039.** Urban land							
1053.** Marsh							
1800. Caron							
1801B Grogan	75	30	65	4.0	6.0	2.8	---

* 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 a period of 30 days.

** See map unit description for the composition and behavior of the map unit.

Capability classes and subclasses

Capability classes and subclasses show, in a general way, the suitability of soils for most kinds of field crops. The soils are classed according to their limitations when they are used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops that require special management. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for rangeland, for forest trees, or for engineering purposes.

In the capability system, all kinds of soil are grouped at three levels: capability class, subclass, and unit. These levels are defined in the following paragraphs. A survey area may not have soils of all classes.

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 landforms have limitations that nearly preclude their use for commercial crop production.

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter, *e, w, s,* or *c,* to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c,* used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too 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, though they have other limitations that restrict their use to pasture, rangeland, woodland, wildlife habitat, or recreation.

The capability unit is identified in the description of each soil mapping unit in the section "Descriptions of the Soils." Capability units are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe–4 or IIIe–6.

CAPABILITY UNIT I–1

This unit consists of well drained and moderately well drained, medium textured to moderately fine textured soils in the upland and on high river terraces. These are loams, silt loams, silty clay loams, or clay loams that are more than 60 inches deep and have an unrestricted root zone. Slopes are 0 to 3 percent. They are 50 to 150 feet long.

These soils are easily tilled and are permeable to roots, air, and water. The organic-matter content and nutrient-supplying capacity are high. Available water capacity is high or moderate to high.

These soils are among the most productive in the county. They are used intensively for corn and soybeans but are well suited to all crops commonly grown.

Keeping tillage to a minimum and tilling the soils only when they contain the proper amount of moisture maintains optimum infiltration and permeability. Returning crop residue and leaving the fall plowing rough help in retaining good tilth as well as protecting the soils from erosion caused by wind. If rough plowed in fall, soils dry out and warm up faster in spring than if tilled smooth or left untilled.

Crops respond to application of nitrogen and phosphorus. The response to lime varies.

CAPABILITY UNIT IIe–1

The one soil in this unit, Lerdal silty clay loam, 2 to 6 percent slopes, eroded, is moderately well drained to somewhat poorly drained, moderately fine textured, and gently sloping. The surface layer is friable. Slopes are 75 to 150 feet long. In spring the water table is within 2 to 5 feet of the surface.

The organic-matter content is moderate. Nutrient-supplying capacity and available water capacity are high. Permeability is slow. The subsoil is strongly to very strongly acid.

This soil is suitable for intensive farming. Corn and soybeans are the main crops. Small grain, legumes, grasses, and trees are also suitable.

Because the water table is high in spring, tile drainage is usually needed. Other management concerns are the fertility level, soil reaction, organic-matter content, tilth, and erosion.

Row crops can be grown intensively under a high level of management. Return of crop residue helps to maintain the organic-matter content and keeps the soil in good tilth. The soil is often plowed in fall. When the plowing is left rough, the furrows help to control the erosion caused by water and wind. They also catch snow in winter. Runoff can be reduced by keeping the plow layer in good tilth. Minimum tillage and stubble mulching help to keep the soil permeable to water. Contour tillage and sodded waterways should be considered in areas where slopes are suitable. The hazard of erosion is moderate to severe. The content of clay in the upper part of the subsoil increases the hazard of erosion. Care is needed in constructing terraces. If the grade is too nearly level, wetness may develop in and below the channel. The terrace channel may need to be tiled. Tilth deteriorates if this soil is tilled when wet.

Because this soil is slow to warm up in spring, starter applications of phosphorus and potassium are needed to provide available plant nutrients. Crops respond to applications of fertilizer and lime.

CAPABILITY UNIT IIe–2

This unit consists of well drained and moderately well drained, medium textured, gently undulating and gently sloping soils in the uplands. These are loams and silt loams that are more than 60 inches deep and have unrestricted root depth. Slopes are 75 to about 150 feet long.

These soils are easily tilled and readily permeable to roots, air, and water. All have high organic-matter content and nutrient-supplying capacity. Available water capacity is high.

These soils are farmed intensively. Corn and soybeans are the main crops. Small grain, legumes, grasses, trees, and other plantings for wildlife habitat are also well suited. The main limitation is erosion. It generally occurs when the soils are not protected by a plant cover.

Row crops can be grown intensively under a high level of management. Return of crop residue maintains the organic-matter content and keeps the soil in good tilth. The soil is often plowed in fall. When the plowing is left rough, the furrows help to control soil erosion by water and wind. They also catch snow in winter. Runoff can be reduced by keeping the plow layer in good tilth. Minimum tillage and stubble mulching keep the soil permeable to water and reduce the risk of erosion by water. Terracing, contour tillage, and sodded waterways should be considered in areas where slopes are suitable.

Crops respond to applications of nitrogen, phosphorus, and potassium. Lime is needed on the more acid soils.

CAPABILITY UNIT IIe-3

This unit consists of well drained, fine textured and moderately fine textured, gently sloping soils in the uplands. These are clay loams, silty clay loams, and silty clays that are more than 60 inches deep and have an unrestricted root zone. The slopes are 75 to about 200 feet long.

The higher clay content of these soils makes them less easily tilled than those in capability unit IIe-2. The soils have high organic-matter content, available water capacity, and nutrient-supplying capacity. Permeability of the subsoil is moderately slow. These soils warm up more slowly in spring than those in capability unit IIe-2. Tilth deteriorates if they are tilled when wet. The content of clay in the upper part of the subsoil, immediately below the dark colored surface layer, increases the hazard of erosion.

These soils are farmed intensively. Corn and soybeans are the main crops. The soils are also well suited to small grain, legumes, grasses, and trees and other plantings for wildlife habitat. Row crops can be grown intensively under a high level of management. Returning crop residue helps to maintain the organic-matter content and to keep the soil in good tilth. These soils are often plowed in fall. When plowing is left rough, the furrows help to control the erosion caused by wind and water. They also catch snow in winter. Soil and water losses because of runoff are reduced by keeping good tilth in the plow layer. Minimum tillage and stubble mulching help to keep the soil permeable to water. Terraces, contour tillage, and sodded waterways should be considered where slopes are suitable.

Crops respond to applications of nitrogen, phosphorus, potassium, and lime when needed.

CAPABILITY UNIT IIe-4

This unit consists of well drained, medium textured and moderately coarse textured, gently undulating, gently sloping soils in the uplands. These soils are underlain by sand or sand and gravel at about 36 inches, or they are loamy fine sand and fine sand throughout.

These soils warm up early in spring, are easily tilled, and are readily permeable to roots, air, and water. They are slightly droughty and subject to erosion. They have moderate available water capacity, moderate organic-matter content, medium natural fertility, and medium runoff. Permeability is moderate in the solum and moderately rapid or rapid in the underlying material.

If the supply of moisture is adequate and these soils are well managed, they are well suited to corn and soybeans. They are also suited to small grain, legumes, grasses, and trees.

Because of the hazard of water erosion, these soils should be farmed on the contour or across the slope whenever possible. Contour tillage, contour stripcropping, mulch tillage, minimum tillage, and terraces are suitable practices for controlling erosion and conserving moisture. Terracing controls erosion more effectively than other practices and permits more intensive use. For soils in this unit, uniformity of depth to the substratum should be checked before constructing terraces. In areas where slopes are very uneven, contour farming is not feasible. In such areas, mulch tillage and legumes and grasses generally provide protection from erosion and maintain tilth. These soils should be tilled in spring to reduce the amount of time that bare soil is exposed to winds in winter and spring.

Stubble mulching, minimum tillage, and field windbreaks reduce erosion caused by wind. Droughtiness can occur during prolonged dry periods, and the soil cannot supply enough water to keep the crops growing. These soils, however, are well suited to irrigation to supplement the soil water needed by crops.

Soils in this unit are fairly good for pasture, but supplemental pasture generally is needed during prolonged dry periods.

CAPABILITY UNIT IIw-1

This unit consists of poorly drained, moderately fine textured, nearly level soils in the uplands. These are silty clay loams and clay loams that are more than 60 inches deep. The depth of the root zone is determined by the depth to the water table. The water table is often within 1 to 3 feet of the surface in spring.

Both internal and surface drainage are restricted. Permeability is moderate and moderately slow. Organic-matter content, available water capacity, and nutrient-supplying capacity are high.

These soils are farmed intensively. Corn and soybeans are the main crops. Small grain and legumes are also suited. If adequately drained and fertilized and all crop residue is returned, these soils can be farmed to row crops year after year. They are also suited to trees and other plantings for wildlife habitat.

Wetness is the main limitation. Sometimes the soils are ponded for a few days because of the moderate and moderately slow permeability. In most areas they have been tile drained. Tile spaced every 90 to 100 feet is needed for adequate drainage. Drainage lowers the water table and provides an optimum root zone. Water from the surrounding sloping areas often collects and runs across these soils in drainageways. Consequently, the drainageways should be shaped, sodded, and tiled to prevent the formation of gullies. If tilled when wet, the soils become puddled and less permeable to roots and moisture.

Erosion caused by wind is a problem on fields left bare in winter and spring. These soils generally are plowed in fall. Fall plowing makes it unnecessary to work the fields when they are too wet in spring and allows the cloddy soil to mellow from freezing and thawing in winter. Leaving the plowing rough so that crop residue is exposed helps to control the erosion caused by wind. Minimum tillage and proper timing of fieldwork help to prevent soil compaction. Growing a green-manure crop or, occasionally, a deep rooted legume helps to keep the soil in good tilth and to maintain subsoil permeability.

Crops respond well to applications of nitrogen and phosphorus. It is important that starter fertilizer is applied. These soils are slow to warm up in spring, and plant nutrients are not always available to young plants because of cool soil temperature.

CAPABILITY UNIT IIw-2

This unit consists of poorly drained, fine textured and moderately fine textured, nearly level soils in the uplands. They are silty clay loams and clays that are more than 60 inches deep. The depth of the root zone is determined by the depth to the water table. The water table is often within 1 to 3 feet of the surface in spring.

Both internal and surface drainage are restricted. Infiltration of water into the soil at the surface is moderate to slow. Permeability is slow and moderately slow. Organic-matter content and available water capacity are high. These soils release water more slowly than the medium textured soils in capability unit IIw–1.

Wetness and the fine texture of the surface layer are the main limitations. If these soils are adequately drained and well managed, they are among the most productive soils in the county. They are well suited to intensive row cropping of corn and soybeans. If drained, they are suited to all crops grown in the county.

Practices that promote movement of air and water into and through the soil and that return large amounts of crop residue are needed. These practices include rough plowing in fall to reduce the erosion caused by wind, allow the soil to mellow and become friable with freezing and thawing, and help the soil to dry and warm up faster in spring. Tile spaced every 50 to 80 feet is needed for adequate drainage. Surface inlets should also be used to offset slow infiltration and slow permeability. Tillage must be kept to a minimum and done when the moisture content of the soils is favorable. Keeping the soil in good tilth is important in the maintenance of drainage systems and the efficient use of plant nutrients.

Yields are good if the optimum number of plants per acre is seeded and large amounts of fertilizer are applied. Crops respond well to applications of nitrogen and phosphorus. Some soils require application of lime to correct acidity. Starter fertilizer with phosphorus and potassium is needed. These soils are slow to warm up in spring, and plant nutrients are not always available to young plants because of the cool soil temperature.

CAPABILITY UNIT IIw–3

This unit consists of poorly drained, moderately fine textured, nearly level soils. These are silty clay loams that are more than 60 inches deep. The entire profile is limy. Depth of the root zone is limited by depth to the water table. In spring the water table is within 3 feet of the surface.

The organic-matter content and available water capacity are high. The nutrient-supplying capacity is medium because of the high lime content. Both internal and surface drainage are slow. Permeability ranges from moderate to slow.

If adequately drained, these soils are farmed intensively. Corn and soybeans are the main crops. Small grain and legumes are also suitable. These soils are also well suited to grasses and trees, and other plantings for wildlife habitat. If the soils are under a high level of management, including proper fertilization, returning crop residue, and minimum tillage, they can be farmed to row crops year after year.

Wetness and a high lime condition are the main limitations. Water is often ponded for several days in spring and following heavy rains. If tilled when wet, these soils become compacted and more impermeable to roots, air, and water. Tile spaced every 80 to 100 feet is needed to provide optimum soil drainage, to lower the water table, and to provide an adequate root zone. Minimum tillage and proper timing of fieldwork are important in preventing soil compaction. Growing an occasional green-manure crop or a deep rooted legume helps to keep the soil in good tilth and the subsoil permeable.

These soils generally are plowed in fall, because they are too wet in spring. Fall plowing allows the cloddy soil to mellow from the freezing and thawing that take place in winter. Leaving the plowing rough, with much crop residue on the surface, helps to reduce the erosion caused by wind. Stubble mulching and field windbreaks also help to reduce erosion. Drainageways should be sodded where there is a hazard of gullying.

These soils have high lime content. Special attention should be given to the level of available phosphorus and potassium. The high lime content keeps the availability of these nutrients at a low level. Application of phosphorus and, particularly, potassium should be made on the high lime areas in addition to the normal application of fertilizers on the other soils. Crops also respond well to application of nitrogen.

CAPABILITY UNIT IIw–4

The one soil in this unit, Darfur loam, is poorly drained and medium textured. It is underlain by sand within 24 to 42 inches. This soil occupies flats and slight depressions on outwash plains and deltas. Depth of the root zone is limited by depth to the water table. In spring the water table is often within 1 to 3 feet of the surface.

The organic-matter content is high. Nutrient-supplying capacity is medium, and permeability is moderate. The available water capacity is moderate. Occasional pockets or strata of acid, iron oxide stained, or iron cemented fine sands are in the underlying sandy material.

If this soil is adequately drained, it is farmed intensively. Corn and soybeans are the main crops. This soil is also well suited to small grain, legumes, and grasses.

Wetness is the main limitation. In most areas this soil has been drained. Tile drainage is somewhat difficult because of the sandy underlying material. Sloughing and caving of tile trenches are constant hazards during installation of tile, and plugging with sand is a hazard after tile has been installed. Using plastic tile, which has smaller holes, or backfilling, or blinding, over the tile with finer textured material will stop most of the sand from filling the tile holes. Acid-resistant clay tile or plastic tile must be used where acid, iron oxide stained, or iron cemented sands are observed. If water from the surrounding slopes runs across this soil, the waterways should be shaped and sodded to prevent water from cutting into the coarse textured underlying material.

These soils generally are plowed in fall. Fall plowing eliminates working the field when it is too wet in spring. Leaving the fall plowed surface rough so that crop residue is exposed helps to reduce the erosion caused by wind. Returning crop residue is needed to keep the soil in good tilth. Minimum tillage and proper timing of fieldwork help in preventing soil compaction.

Special attention should be given to the phosphorus content of this soil. Crops respond well to application of nitrogen and phosphorus.

CAPABILITY UNIT IIw-5

The one soil in this unit, Fieldon loam, is poorly drained, medium textured, nearly level, and limy. It is underlain by sand within 24 to 42 inches. Depth of the root zone is limited by depth to the water table. In spring the water table is within 3 feet of the surface.

Runoff is slow, and permeability is moderate to moderately rapid. Organic-matter content is high. The nutrient-supplying capacity is medium because of the restricted root zone and the high lime content. The available water capacity is moderate. Occasional pockets or strata of acid, iron oxide stained, or iron cemented fine sands are in the underlying material.

If adequately drained, this soil is farmed intensively. Corn and soybeans are the main crops. This soil is also well suited to small grain, legumes, and grasses.

Wetness and high lime conditions are the main limitations. In most areas, this soil has been drained. Tile drainage is somewhat difficult because the underlying material is sandy. Sloughing and plugging with sand is a hazard after tile has been installed. Using plastic tile, which has smaller holes, or backfilling, or blinding, over the tile with finer textured material will stop most of the sand from filling the tile lines. Acid-resistant clay tile or plastic tile must be used where acid, iron oxide stained, or iron cemented sands are observed. If water from the surrounding slopes runs across this soil, the waterways should be shaped and sodded to prevent water from cutting into the coarse textured substratum.

This soil is generally plowed in fall. Fall plowing eliminates working the fields when they are too wet in spring and allows the cloddy soil to mellow from freezing and thawing in winter. Leaving the fall plowed surface rough so that crop residue is exposed helps reduce the erosion caused by wind. Return of crop residue helps to keep the soil in good tilth. Minimum tillage and proper timing of fieldwork help to prevent soil compaction.

Special attention should be given to the phosphorus and potassium levels of this soil. The high lime content keeps the availability of these nutrients at a low level. Application of phosphorus and potassium should be made on the high lime areas in addition to the normal application of fertilizers on the other soils. Crops also respond well to applications of nitrogen.

CAPABILITY UNIT IIw-6

This unit consists of moderately well drained and poorly drained, medium textured and moderately fine textured soils on stream bottom lands subject to occasional flooding. Some of these soils are on broad, nearly level bottom lands adjacent to major streams and drainageways, and some are on gently sloping deltas at the outlet of deep ravines which bring water from the uplands down to the river bottoms. All are subject to quick floods of short duration.

If these soils are dominant in a field, row crops can be grown most of the time. Because of their location, some areas are in permanent pasture. If these soils are drained, the root zone is deep. Wetness and occasional overflow are the major limitations. Some areas can be diked to protect them from overflow. Except for Dorchester loam, adequate tile drainage is also required for satisfactory yields. If tile outlets can be located in a suitable place, pumps can be installed to facilitate drainage. A crop rotation in which grasses or legumes are grown keeps the soil in good tilth if the proper kinds and amounts of fertilizer are added. Forage yields can be increased if these soils are fertilized and grazing is controlled.

Soil tests are needed to determine the need for fertilizer. Lime is generally not needed. One soil has a high lime condition in addition to the flood hazard. The high lime content keeps the availability of nutrients at a low level. Additional applications of phosphorus and potassium should be made on this soil to provide more available food to the plants.

CAPABILITY UNIT IIs-1

This unit consists of well drained, medium textured and moderately coarse textured, nearly level soils. These soils are underlain by sand or sand and gravel at a depth of 24 to 40 inches.

These soils are easily tilled and are readily permeable to roots, air, and water. The organic-matter content is medium, the natural fertility is moderate, and available water capacity is moderate. Erosion caused by wind is the major hazard.

These soils are farmed intensively. Corn and soybeans are the main crops. Small grain, legumes, and grasses are also well suited.

Erosion caused by wind can be a problem on fields left bare in winter and spring. These soils should be plowed in spring. Fields that are plowed in fall after the spring grain crop has been harvested generally are left rough to help control the erosion caused by wind in winter and the following spring. Stubble mulching and field windbreaks help in erosion control. Droughtiness can occur during prolonged dry periods, and the amount of moisture that the soil can hold is not adequate for good crop growth. These soils are well suited to irrigation. Waterways crossing these soils should be sodded to prevent the water from cutting into the coarse textured substratum.

Crops grown on these soils respond well to application of nitrogen, phosphorus, and potash.

CAPABILITY UNIT IIs-2

This unit consists of moderately well drained to somewhat poorly drained, fine textured and moderately fine textured, nearly level to gently sloping soils. These are silty clay loams and silty clays.

Permeability is moderately slow to slow. Available water capacity is moderate to high, but the rate at which the soil releases water to plants is slow. The organic-matter content and the nutrient-supplying capacity are high. Depth of the root zone is unrestricted, although the water table is often within 3 to 5 feet of the surface, especially in spring.

These soils are well suited to all crops commonly grown in the county and can be farmed intensively to row crops. Corn and soybeans are the main crops. The soils are also suited to small grain, legumes, grasses, and trees, and other plantings for wildlife habitat. In many places where they are intermingled with other soils or are in odd shaped areas, the cropping system should be the same as that used on the adjacent soils.

Tile drainage is not usually needed for crops. Maintenance of tilth is a continuing problem, and the more sloping soils are subject to erosion. In most areas, erosion can be controlled if a grass-legume crop is included in the rotation and if practices are used that maintain fertility and the content of organic matter. Returning all crop residue to the soil helps to improve tilth and to maintain the content of organic matter. If row crops are grown, wheel-track planting and minimum tillage help to reduce erosion and soil compaction. Fall plowing gives the soils a chance to mellow through action of freezing and thawing. The plowing should be left rough and residue left on the surface to reduce the erosion caused by wind.

Contour stripcropping and terracing generally are not suitable for these soils because slopes are short and internal drainage is restricted. If such practices are used, the strips and terraces should be built on a grade to allow movement of water.

Crops respond to applications of nitrogen, phosphorus, and potash.

CAPABILITY UNIT IIIe-1

This unit consists of well drained and moderately well drained, medium textured to fine textured, sloping and undulating soils in uplands. These are loams, silt loams, silty clay loams, and silty clays that are more than 60 inches deep. Slopes are 75 to 200 feet long.

The organic-matter content, nutrient-supplying capacity, and available water capacity are high. Permeability is moderate to moderately slow. Runoff is medium to rapid.

These soils are farmed intensively and are productive if well managed. They are suited to row crops, such as corn and soybeans. They are well suited to small grain, legumes, and grasses. The lighter colored soils are less productive because of the high lime content of the surface layer, the lower infiltration rate, and the lower organic-matter content.

The main limitation is erosion from runoff. A cropping system that provides frequent use of legumes and grasses is needed. Mulch tillage and rough tillage are needed to conserve moisture and control erosion. All crop residue should be utilized to maintain good tilth and infiltration. Contour stripcropping, contour tillage, and terraces can be used where slopes are long and smooth. Tillage across the slope can be used in areas where slopes are short and irregular. The sides of all waterways and gullies should be shaped, seeded with grass, and then kept in grass or other permanent vegetation.

Grassed waterways should be constructed a year before terraces are built to provide a protected outlet for water. Terraces built on moderately fine and fine textured soils should be carefully constructed to avoid wetness in the terrace channel and below the terrace. The wetness is caused by moderately slow infiltration and permeability. Water will remain in the terrace channel if the terrace is too level.

Crops on these soils respond well to applications of nitrogen, phosphorus and potassium. Some need lime. Crop response varies.

CAPABILITY UNIT IIIe-2

The one soil in this unit, Lerdal silty clay loam, 6 to 12 percent slopes, eroded, is moderately well drained and moderately fine textured. It is in the uplands. Slopes are 75 to 200 feet long.

This soil has high available water capacity. It also has high natural fertility, but because of acidity it responds well to lime and fertilizer. The organic-matter content is moderate. Permeability is slow. Erosion and runoff are major hazards. The silty clay in the upper part of the subsoil, just below the dark colored surface layer, causes a severe hazard of erosion. Water is perched above the subsoil, saturating the surface layer. The surface layer is unstable and highly susceptible to erosion.

This soil is well suited to alfalfa and other plants grown for hay or pasture. It is only fair for row crops, such as corn and soybeans. Management is needed to control erosion and runoff, maintain fertility, and improve and maintain tilth in the surface layer. Contour stripcropping can be used in many places to help control erosion. Contour tillage or tillage across the slope is effective if slopes are too short or irregular for contour stripcropping or for terraces. If waterways are properly designed and kept in grass or other permanent vegetation, they remove water safely and prevent erosion. Tile drainage of seep or wet areas on the slope and in drainageways is needed to increase the potential for crops.

Terraces should be constructed carefully. Building the terraces on a grade to allow water to run out as it is intercepted should be considered. Tile should be placed in the upslope part of the channel to intercept the sidehill seepage and keep the terraces dry. Outlets should be constructed and seeded a year before the terraces are built. Then, the water can be removed without forming gullies.

Because of the moderate organic-matter content, all crop residue should be plowed into the soil. Applying large amounts of manure and keeping the soils in grasses and legumes help to restore tilth and fertility and to protect the soils from erosion.

CAPABILITY UNIT IIIw-1

This unit consists of very poorly drained, fine textured and moderately fine textured soils in depressions and drainageways in the uplands. These are silty clay loams or silty clays that are more than 60 inches deep. Depth of the root zone is determined by the depth to water table, which is generally near the surface.

Available water capacity is high. Permeability is moderately slow to slow. Both internal and surface drainage are restricted. Nutrient-supplying capacity and organic-matter content are high.

These soils are poorly suited to farming in their natural state. If adequately drained, they are farmed intensively. Corn and soybeans are well suited to these soils, but early maturing varieties should be planted because of the hazard of frost damage. Small grain can be grown, but lodging generally is a serious problem. These soils are generally not suited to alfalfa, but they are suited to clover, timothy, and bluegrass.

The major management needs are removing excess water and improving and maintaining tilth. In most areas, the soils are drained by open ditches, which remove surface water and provide outlets for tile drainage. Tile drainage, which is necessary to provide adequate internal drainage, lowers the water table, provides an optimum root zone, and allows the soils to warm up earlier in spring.

If these soils are tilled when wet, they become compacted and less permeable to roots and moisture. Minimum tillage and proper timing of fieldwork help to prevent compaction. Growing a green-manure crop or occasionally a deep-rooted legume helps to improve tilth and maintain permeability. Fall plowing helps to improve tilth by making it unnecessary to work the soils in spring, when they are usually too wet, and allows the cloddy soil to mellow from freezing and thawing in winter. If fall plowing is left rough, the soils warm up and dry out faster in spring. They are also less subject to erosion caused by wind.

These soils are slow to warm up in spring, and nutrients are not always available to the young plants. Therefore, a starter fertilizer is helpful in initiating plant growth.

CAPABILITY UNIT IIIw-2

This unit consists of very poorly drained, medium textured, nearly level soils in shallow depressions in the uplands. These are silt loams that are more than 60 inches deep. Depth of the root zone is determined by the depth to the water table.

Permeability is slow and very slow, and available water capacity is high. The organic-matter content generally is moderate to high, and nutrient-supplying capacity is medium to high. Infiltration and internal drainage are restricted by a clayey subsoil, resulting in a perched water table at a depth within 1 foot. The structure of the surface layer is easily destroyed. This layer tends to puddle.

If adequately drained, these soils are well suited to all crops grown in the county and are used intensively for row crops, such as corn and soybeans. The main management concerns are removal of excess water and improvement and maintenance of good surface tilth. Because tile drainage is limited by the slow permeability of the subsoil, surface inlets, French drains, or shallow surface ditches generally are needed to improve drainage. If tile is used, a cropping system that includes deep-rooted legumes and grasses helps to increase the efficiency of the drainage system. All crop residue can be returned to the soil and large amounts of manure applied to increase the content of organic matter and to maintain fertility. If these soils are tilled when wet, they become compacted and poorly aerated. They also become hard and cloddy when dry. Minimum tillage and proper timing of fieldwork are needed. Fall plowing is desirable. Otherwise, the soils have to be worked in spring when they are wet.

These soils are slow to warm up in spring, and nutrients are not always readily available. Because of the low acidity, nutrients are held by the soil. Crops grown on these soils respond well to additions of lime and fertilizer.

CAPABILITY UNIT IIIw-3

The only soil in this unit, Dassel loam, is very poorly drained and medium textured. It is in depressions in the uplands. Depth of the root zone is determined by the depth to the water table.

This soil has moderate permeability and moderate to high available water capacity. It has high organic-matter content and high nutrient-supplying capacity. Occasional pockets or strata of acid, iron oxide stained, or iron cemented fine sands are in the underlying sandy material. Because of the seasonal high water table, this soil is wet unless adequately drained.

If adequately drained, this soil is well suited to corn, soybeans, and small grain. It is generally too wet for alfalfa, but clover, bromegrass, timothy, and similar legumes and grasses that tolerate wetness can be grown. Drainage is needed for successful yields of crops. If adequately drained, this soil may be slightly droughty during prolonged dry periods. Drainage can be improved by shallow surface ditches or grassed waterways. Tile drainage requires special precautions because the fine sand may fill the tile lines. This plugging with sand can be prevented by using plastic tile, which has small holes, or by backfilling, or blinding, over the tile with finer textured material. Acid-resistant clay tile or plastic tile must be used where acid, iron stained, or iron cemented sands are observed. This soil puddles easily if tilled when wet and is less permeable to roots and water. Minimum tillage and proper timing of fieldwork should be considered. Fall plowing helps by making it unnecessary to work this soil in spring when it is wet.

This soil is generally high in nutrient-supplying capacity, but a cold, wet spring reduces bacterial and chemical action within the soil and makes nutrients unavailable to plants. The high pH in the limy soils limits the availability of nutrients. Crops grown on this soil respond well to fertilizer. A starter fertilizer is helpful in initiating plant growth.

CAPABILITY UNIT IIIw-4

This unit consists of very poorly drained organic soils in depressions and old lakes in the glacial plain and in seep areas along the rivers. They are mucky silt loams and mucks.

All the soils are low in phosphorus and potassium but high in potential nitrogen. Available water capacity is very high to high, and organic-matter content is very high. Wetness severely limits the use of these soils. In undrained areas, the water table is at or near the surface.

If adequately drained, these soils are cropped intensively. They are slow to warm up in spring. Late and early frost are also annual problems. Corn and soybeans are the main crops. Field corn is occasionally grown but does not always mature. Corn for silage usually grows well. Small grain is grown and is well suited, but lodging is serious and makes harvesting difficult. Potatoes, onions, and other garden vegetables are also suited. Grasses are well suited and provide excellent pasture in drained areas. Some areas are used for the production of reed canarygrass seed.

The major management concerns are removal of excess water, maintenance of fertility, fire hazard, and frost hazard. Wetness is the main concern. Ponding commonly occurs for several weeks late in spring and early in summer. Most of the soils have not been drained and are under a cover of marshgrass. Such areas are generally wet throughout the year. Some areas have been drained by surface ditches, which remove enough water to make them suitable for cropping. Lateral lines of tile may be installed to provide better drainage. Care is needed in installing tile deep enough to compensate for the subsidence that takes place when these soils are drained. The drainage system needs controls that keep the soils from becoming too dry, because the risk of damage by fire to dry organic soils is serious.

These soils are highly susceptible to erosion caused by wind because they are light and fine textured. The hazard can be controlled by the use of cover crops, rough tillage, and field windbreaks.

Crops respond well to application of a balanced fertilizer. As previously mentioned, the soils contain an adequate supply of nitrogen but are low in phosphorus and potassium. Most of the soils are noncalcareous, but some are calcareous throughout.

CAPABILITY UNIT IIIw-5

The one soil in this unit, Granby fine sandy loam, is nearly level, poorly drained, and moderately coarse textured. It is on lake plain deltas or outwash plains. The subsoil is loamy fine sand and fine sand. Depth of the root zone is determined by depth to the water table.

This soil is high in organic-matter content. Permeability is moderately rapid. Available water capacity is low to moderate. The water table is at a depth of 1 to 3 feet. Natural fertility is medium.

This soil is moderately well suited to corn, soybeans, and small grain. Because of the sandy underlying material, it becomes droughty during prolonged dry periods, thus affecting crop yields.

Wetness and erosion caused by wind are the main hazards. Management is needed to maintain the organic-matter content and fertility, improve drainage, and control erosion. Tile drainage is somewhat difficult because of the sandy underlying material. Sloughing and caving of tile trenches are constant hazards during installation of tile. Plugging with sand, which is a hazard after tile has been installed, can be prevented by using plastic tile, which has smaller holes, or by backfilling, or blinding, over the tile with finer textured material. Minimum tillage, mulch tillage, utilizing all crop residue, and stripcropping help to control erosion. Tillage needed to prepare a seedbed should be done in spring to reduce the erosion caused by wind in winter and early in spring.

Crops grown on this soil respond well to the application of nitrogen, phosphorus, and potassium. Excess nitrogen will be leached downward into the soil and the tile line. The organic-matter content and nutrient-supplying capacity can be improved by applying large amounts of manure and by including legumes and grasses in the cropping system.

CAPABILITY UNIT IIIw-6

The one soil in this unit, Tilfer silty clay loam, is poorly drained to very poorly drained, moderately fine textured, and nearly level. It is a slightly depressional soil on terraces along the Minnesota River. It is underlain by limestone bedrock at depths ranging from 20 to 40 inches.

Because of shallowness, this soil has low to moderate available water capacity. Permeability is moderate. The organic-matter content is high, and natural fertility is medium. This soil has a seasonal high water table at 0 to 3 feet and frequently is kept wet by seepage. Some areas are subject to occasional flooding from upland runoff.

Drainage is needed for dependable crops, but depth to bedrock limits installation of an adequate drainage system in some places. Shallow ditches can improve drainage. If adequately drained, this soil is used for corn and soybeans. If left undrained, it is well suited to wild hay or pasture.

Most of the acreage is limy. High applications of phosphorus and potassium are needed to offset the high lime effects on crops and to improve the fertility. The included areas of nonlimy soil have medium nutrient-supplying capacity. Crops commonly grown respond to applications of fertilizers.

CAPABILITY UNIT IIIw-7

The one soil in this unit, Minneopa loamy fine sand, occasionally flooded, 0 to 3 percent slopes, is nearly level to gently sloping, moderately well drained, and coarse textured. It is on the lower river terraces.

This soil is easily tilled and is readily permeable to roots, air, and water. It has moderately low organic-matter content, low natural fertility, low available water capacity, and moderately rapid permeability. The main hazards are drought and flooding.

This soil is farmed intensively. Seed corn is the main crop, but corn, soybeans, and small grain are also well suited. Erosion caused by wind is not normally a problem because this soil is in the deep river valleys. Droughtiness does occur during dry periods, and the available moisture capacity is not adequate for good crop growth. The soil is well suited to irrigation. Occasional flooding from spring runoff temporarily delays tillage and planting. An occasional, prolonged heavy rain can cause temporary flooding during the growing season.

Crops grown on this soil respond well to the application of nitrogen, phosphorus, and potash.

CAPABILITY UNIT IIIs-1

This unit consists of somewhat poorly drained to somewhat excessively drained, moderately coarse textured and coarse textured, nearly level and gently undulating soils. These soils are loamy fine sands, fine sands, and sandy loams. They are on terraces along the larger rivers and small outwash areas in the uplands. The water table is below 5 feet in most soils but is between 3 and 5 feet in some.

Permeability is moderately rapid in most soils but is only moderate in some. Available water capacity is moderate to low. These soils are droughty during dry periods and are subject to erosion. They have moderate to low organic-matter content. Nutrient-supplying capacity is medium to low. Crops respond well if fertilizer is added. The soils warm up early in spring and are easy to till.

If rainfall is adequate throughout the growing season and if fertilizer is added and other good management is used, these soils are suitable for all crops grown in the county. Normally they are slightly droughty and are best suited to early maturing small grain unless irrigation is used. They are moderately suited to pasture.

These soils are highly susceptible to erosion caused by wind. Plowing and other tillage needed to prepare seedbeds should be done in spring to reduce the erosion hazard. Using a suitable cropping system, stubble mulching, keeping the surface rough between crops or growing cover crops, and returning all crop residue to the soils reduce the risk of erosion and increase the supply of moisture.

The organic-matter content and nutrient-supplying capacity can be improved by applying large amounts of manure and by including legumes and grasses in the cropping system. Crops grown on these soils respond well to the application of nitrogen, phosphorus, and potassium. Excess nitrogen will be easily leached downward and lost. Because of the slight to medium acidic nature of these soils crops respond well to applications of lime. They also respond well to irrigation if an adequate supply of water is available.

CAPABILITY UNIT IIIs-2

The one soil in this unit, Copaston loam, 1 to 4 percent slopes, is well drained and medium textured. It formed over bedrock. It occupies broad flats along the Minnesota River.

Permeability is moderate. Available water capacity is low. The soil is droughty during dry periods. It has moderate organic-matter content and medium nutrient-supplying capacity. It warms up early in spring. The major management concerns are droughtiness and maintenance of fertility.

With adequate moisture and good management, this soil is suitable for all crops grown in the county. The most suitable crop is early maturing small grain. The soil is too droughty for corn in most years. Areas where stones and rock outcrop interfere with cultivation are left in permanent pasture. Where cultivation is possible, a cropping system that includes legumes and grasses is best because they improve fertility and the supply of moisture. Pasture on this soil is productive mainly in spring and early in summer.

Because of the moderate organic-matter content and medium fertility, green-manure crops, large amounts of manure, and legumes and grasses in the cropping system are needed. Crops grown on this soil also respond well to applications of lime and fertilizer.

CAPABILITY UNIT IVe-1

This unit consists of well drained and moderately well drained, medium textured to fine textured, moderately steep and hilly soils. These soils are on knolls and side slopes in the uplands and in moderately steep areas adjacent to streams. They are silt loams, loams, clay loams, silty clay loams, and silty clays. Slopes are 12 to 18 percent and 75 to 250 feet long.

Permeability ranges from slow to moderate. Available water capacity is high. Nutrient-supplying capacity is medium and high. These soils are dominantly moderate and high in organic-matter content. The surface layer varies in thickness. It is thinnest on the convex slopes and on the upper part of the slope and is thickest on the concave slopes and at the base of slopes.

These soils are best suited to small grain and to hay and pasture crops. If row crops are grown, erosion control is needed. In many places slopes are short and irregular and contour stripcropping or contour farming is impractical. In these places it is difficult to protect the soils from erosion, and row crops should not be grown.

Erosion and runoff are the major hazards. Much of the rain that falls runs off. The soils, therefore, are seldom fully charged with water, and plants lack sufficient moisture. Droughtiness is often a problem in mid-July and August, especially on the south and west-facing slopes, which are exposed to direct sunlight.

Management is needed to maintain the organic-matter content and fertility, improve and maintain good tilth, and control erosion. Minimum tillage, contour farming, stripcropping, terraces and grassed waterways help to control erosion and runoff. Farming should be across the slope. Wherever needed, waterways should be established and maintained. Gullies should be shaped and seeded to grass for use as waterways. In places engineering structures are needed to stabilize gullies before grass can be established. In severely eroded areas, large amounts of fertilizer and manure are needed to improve tilth and fertility.

Utilization of crop residue and fertilization will help to improve and maintain the organic-matter content, fertility, and tilth.

CAPABILITY UNIT IVw-1

This unit consists of moderately well drained to poorly drained Lake beaches consisting of mixed coarse, moderately coarse, and medium textured material over medium textured material at the edges of lakes and larger bogs. Many stones are on the surface. Depth of the root zone is determined by the depth to the water table.

Available water capacity, nutrient-supplying capacity, permeability, and infiltration are variable. A seasonal water table is at a depth of 1 to 4 feet.

Many areas are used for pasture. Those around the lakes and undrained ponds provide beaches for recreational use. They also provide good habitat for wildlife. Some could be developed further for those uses.

If drained, lake beaches are too sandy and droughty for good growth of crops. Areas are too narrow to be farmed separately. If the adjoining soils are drained, Lake beaches can generally be farmed with those soils.

CAPABILITY UNIT IVs-1

This unit consists of excessively drained, coarse textured soils on outwash plains and river terraces. These soils are predominantly nearly level to gently sloping but range from sloping to moderately steep. Slopes are 75 to 150 feet long. The root zone is deep.

These soils are low in nutrient-supplying capacity, organic-matter content, and available water capacity. Permeability is rapid. The water table is below 5 feet. The rock substratum affects the use of these soils in some areas. The soils warm up early in spring and have few wet spots that would delay tillage.

These soils are poorly suited to corn, soybeans, and small grain. They are better suited to grasses and legumes than to other crops. Alfalfa and bromegrass is a better mixture than native bluegrass because it is more resistant to drought. Early maturing small grain is better suited than corn and soybeans.

Droughtiness and erosion caused by wind are the main hazards. The soils are generally deficient in moisture by mid-July. Field stripcropping, stubble mulch tillage, and tree windbreaks help to control erosion. Returning all crop residue and available manure to the soils also helps to control erosion and to increase the supply of moisture. Fields generally are plowed in spring to protect them from erosion caused by wind in winter and early in spring.

Crops grown on these soils respond well to the application of nitrogen, phosphorus, and potassium if the needed moisture is available. Excess nitrogen will be easily leached downward into the soil and lost to the plants. These soils have good potential for irrigation if adequate water is available. The infiltration rate is good.

CAPABILITY UNIT IVs-2

The one soil in this unit, Copaston loam, very shallow, 1 to 4 percent slopes, is well drained and gently undulating to nearly level. It is on rock terraces along the Minnesota River. It formed in 12 to 20 inches of loamy sediments over bedrock. The root zone is limited by depth to the bedrock.

This soil is moderate in organic-matter content and medium in nutrient-supplying capacity. The available water capacity is very low. Permeability is moderate.

This soil is droughty and is poorly suited to corn, soybeans, and small grain. It is better suited to pasture. Early maturing crops make the best use of the limited moisture supply. Alfalfa and bromegrass is a better mixture than native bluegrass because it is more resistant to drought. Some areas are in cropland, but the thin surface layer and boulder outcrops interfere with tillage.

Crops and pasture can be improved by the application of nitrogen, phosphorus, and potassium.

CAPABILITY UNIT VIe-1

This unit consists of well drained, medium textured, steep soils in the glacial uplands. These soils have a loam surface layer and a loam or clay loam subsoil. Slopes are 75 to 200 feet long. The root zone is deep.

Permeability is moderate. Available water capacity is high. The organic-matter content is high in most soils but is low in the Storden soil. The nutrient-supplying capacity is medium to high. Erosion and runoff are the major hazards. The surface layer varies in thickness. It is thinnest on the convex slopes and on the upper part of the slopes, and thickest on the concave slopes and at the base of slopes.

These soils are generally poorly suited to crops because of the severe hazard of erosion. They are better suited to hay and pasture or to use as woodland or wildlife habitat. Areas now in permanent pasture or woodland should not be cleared, and areas that may now be in cropland should be in permanent vegetation. Most of these soils have free lime carbonates within a depth of 36 inches and are therefore well suited to alfalfa and other legumes.

The major management needs are those designed to control erosion. A good plant cover is needed in all cleared areas. Grazing must be controlled to prevent erosion. Late in summer the soils become dry, and grasses become dormant. This is most apparent on south- and west-facing slopes, which are exposed to direct sunlight. All gullies should be shaped and seeded to grass. In some, engineering structures are needed to stabilize the banks enough so that grass can be established.

Permanent pasture can be improved by weed control, rotational and restricted grazing, and the application of fertilizers.

CAPABILITY UNIT VIw-1

This unit consists of moderately well drained to very poorly drained, moderately fine textured to medium textured soils and miscellaneous areas on stream bottom lands and side valley deltas that are subject to frequent flooding. In many places, the soils are cut by abandoned stream channels.

The flood hazard severely restricts the use of these soils. The soils are subject to flooding early in spring and after heavy summer rains. Areas in side valleys are subject to flooding from upper drainageways and from sidehill seepage. Permeability is moderate to moderately slow. Available water capacity, organic-matter content, and nutrient-supplying capacity are high.

These soils and miscellaneous areas are not suitable for crops because of wetness and flood hazard. Row crops can be grown occasionally in some of the drier areas. At present, it is too costly to provide flood control structures that are needed to protect most areas and make them suitable for crops. Drainage is not feasible as long as the flood hazard exists. A few areas have been diked to protect the cropland from damages caused by frequent minor floods. Areas where major improvement is made in the stream channels can be used as cropland.

The better drained soils provide good pasture if they are cleared and well managed. Varieties of grasses and legumes that tolerate flooding can be seeded.

CAPABILITY UNIT VIw-2

The one soil in this unit, Joliet silty clay loam, is nearly level or depressional, poorly drained, and moderately fine textured. It is on terraces along the Minnesota River. It is underlain within 20 inches by limestone bedrock.

Because it is shallow, this soil has low available water capacity. Permeability is moderate. The organic-matter content is high, and natural fertility is medium. This soil has a seasonal high water table at a depth of 1 to 2 feet and frequently stays wet from seepage. Some areas are subject to occasional flooding from upland runoff.

This soil generally is not suited to row crops. Because it is shallow over bedrock, tile drainage should not be considered. Shallow ditches may improve drainage. In some areas where adequate drainage has been provided, this soil can be used for corn and soybeans. Areas where bedrock crops out and areas where stones and boulders are on the surface are unsuitable for cropland. The entire undrained acreage is well suited to wild hay or pasture.

This soil is limy. High applications of phosphorus and potassium are needed to offset the high lime effects on crops and to improve the fertility. The included nonlimy soil has a medium nutrient-supplying capacity. Crops respond to applications of fertilizers.

CAPABILITY UNIT VIs-1

The one soil in this unit is Estherville sandy loam, 6 to 18 percent slopes. It is a moderately coarse textured, sloping to moderately steep soil on outwash plains, stream terraces, and uplands. It has a shallow root zone. Sand and gravel is within a depth of 24 inches. Slopes are 75 to 150 feet long.

Permeability is moderately rapid in the solum and rapid below. Available water capacity and natural fertility are low. Organic-matter content is moderate. The major hazards are drought and water erosion.

Unless irrigated, this soil is generally poorly suited to most crops. Special management is needed to control erosion in areas used for row crops. The soil is better suited to hay and pasture, woodland, and wildlife habitat than to row crops. Cover crops should be maintained in all cleared areas. Areas now in permanent pasture or woodland should not be cleared.

Because this soil is droughty, it is subject to severe erosion. It is poorly suited to irrigation because of the slope. Cover crops and contour farming are needed to control erosion, conserve moisture, and maintain fertility and the organic-matter content. Gullies should be shaped, seeded to grass, and kept in permanent vegetation. In some, engineering structures are needed to stabilize the sides enough so that grass can be established.

Permanent pasture can be improved by controlling weeds, by rotational and restricted grazing, and by applying fertilizer. Late in summer, however, the soil becomes dry and grasses become dormant. This fact is most apparent on south- and west-facing slopes exposed to direct sunlight.

CAPABILITY UNIT VIIe-1

This unit consists of well drained, medium textured, very steep soils. These soils are in the uplands and on side slopes of the deeply entrenched river valleys and ravines. They are dominantly loams that are more than 60 inches deep and have an unrestricted root zone. Slopes are 24 percent to more than 45 percent. They are 100 to 250 feet long.

Permeability is moderate. Nutrient-supplying capacity and available water capacity are high. The organic-matter content is low on the convex slopes and moderate on the concave slopes. The soils along the deeply entrenched river valleys and ravines are generally calcareous at or near the surface.

These soils are so steep that they should be kept in permanent vegetation, preferably trees. They are sometimes used for pasture, but care is needed to prevent overgrazing and creating an erosion hazard. Pasture can be improved by restricted grazing, control of weeds and brush, and application of fertilizer. Trees and shrubs should be planted in open areas and left as wildlife habitat or managed as a tree farm. On slopes facing south and west, only the drought- and heat-resistant tree species should be selected for planting.

Water erosion is the most serious hazard. Because slopes are very steep and most of the rain runs off, the soils never reach their available water capacity. They are therefore somewhat droughty. Gullies should be shaped and seeded to grass. Some have to be stabilized with engineering structures and the seeps tiled before grass can be established.

CAPABILITY UNIT VIIs-1

The one soil in this unit, Lasa loamy fine sand, rock substratum, 12 to 35 percent slopes, is somewhat excessively drained, coarse textured, and moderately steep to very steep. It is on bedrock-controlled terraces along the Minnesota River. It is underlain by fine sand within 12 inches and bedrock within 40 to 80 inches. The surface layer, in some places, contains large stones and boulders.

This soil is loose and has moderately rapid permeability. Available water capacity, organic-matter content, and natural fertility are low.

This soil is too droughty for crops. It is well suited to woodland and recreational use, such as trails, and it provides food and shelter for wildlife. Maintaining a good cover of vegetation is difficult if the soil is used for pasture or hay.

Drought and erosion are the main hazards. This soil is generally deficient of moisture by mid-July. If it is used for pasture, rotational and restricted grazing are needed and weeds should be controlled. Care is needed to prevent overgrazing. Occasionally gullying is severe. Gullied areas should be shaped and then seeded to grass. In some, engineering structures are needed to stabilize them before grass can be established.

CAPABILITY UNIT VIIs-2

This unit consists of well drained and excessively drained, medium textured, nearly level to gently undulating and very steep soils. These soils are on bedrock-controlled terraces along streams. They have a loam surface layer. Bedrock is within a depth of 20 inches, and fractured limestone bedrock is exposed at the surface. Glacial boulders and chimneylike rock outcrops are common. The root zone is limited.

These soils have low to very low available water capacity, moderate organic-matter content, and medium nutrient-supplying capacity. Permeability is moderate.

These soils cannot be used as cropland because of the thin surface layer and the rock outcrop and glacial boulders. The nearly level to gently undulating areas are best suited to pasture, wildlife, or recreational uses, such as camping and trails. The very steep areas are suitable only as woodland and wildlife habitat.

Droughtiness and the rock outcrop and boulders are the main limitations. The soils are generally deficient of moisture by mid-July. If they are used for pasture, rotational and restricted grazing are needed. Weeds should be controlled and fertilizer applied to take advantage of the available moisture. Care is needed to prevent overgrazing.

CAPABILITY UNIT VIIIw-1

This unit consists of Marsh and very poorly drained soils at edges of some lakes, shallow basins, ponds, and undrained depressions. They also are along the seep areas in the Minnesota River Valley. Generally they are covered with marsh vegetation, including cattails, rushes, sedges, willows, and other plants that tolerate wetness.

Most areas of these soils and Marsh cannot be drained because they lack outlets or because ground water keeps the areas seepy. These areas provide very good cover for waterfowl, muskrat, and upland game. They should be improved as wildlife habitat.

Estimated yields

The average yields per acre that can be expected of the principal crops under a high level of management are listed in table 2. In any given year, yields may be higher or lower than those indicated in table 2 because of seasonal variations in rainfall and other climatic factors. Absence of a yield estimate indicates that the crop is not suited to or is not commonly grown on the soil or that the given crop is commonly not irrigated.

The estimated yields were based mainly on the experience and records of farmers, conservationists, and extension agents. Results of field trials and demonstrations and available yield data from nearby counties were also considered.

The latest soil and crop management practices used by many farmers in the county were assumed in estimating the yields. Hay and pasture yields were estimated for varieties of grasses and legumes suited to the soil. A few farmers may be using more advanced practices and are obtaining average yields higher than those shown in table 2.

The management needed to achieve the indicated yields of the various crops depends upon the kind of soil and the crop. Such management provides drainage, erosion control, and protection from flooding; the proper planting and seeding rates; suitable high-yielding crop varieties; appropriate tillage practices, including time of tillage and seedbed preparation and tilling when soil moisture is favorable; 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; harvesting crops with the smallest possible loss; and timeliness of all fieldwork.

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

Crops other than those shown in table 2 are grown in the survey area, but the acreage is small. The local offices of the Soil Conservation Service and the Cooperative Extension Service can provide additional information.

Windbreaks and Environmental Plantings

Windbreaks are established to protect livestock, buildings, and yards from wind and snow. Windbreaks also help protect fruit trees and gardens, and they furnish habitat for wildlife. Several rows of broad-leaved and coniferous species provide the most protection.

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

Environmental plantings help to beautify and screen homes and other buildings and to abate surrounding noise. The plants, mostly evergreen shrubs and trees, are closely spaced. Healthy planting stock of suitable species planted properly on a well prepared site and maintained in good condition can insure a high degree of plant survival.

Table 3 shows the height that locally adapted trees and shrubs are expected to reach on various kinds of soils in 20 years. The estimates in table 3, based on measurements and observation of established plantings that have been given adequate care, can be used as a guide in planning windbreaks and screens. Additional information about planning windbreaks and screens and the planting and care of trees can be obtained from the local office of the Soil Conservation Service, Extension Service, or local nurserymen.

The sloping to very steep soils in areas where slopes are 12 to 45 percent or more are poorly suited to field and farmstead windbreaks but are well suited to trees and shrubs. Most areas are wooded and should be managed as woodland. The soils have high available water capacity, medium to high natural fertility, moderate to high organic-matter content, and moderate to moderately slow permeability. The surface layer is dominantly neutral to medium acid, and the underlying material is limy. Two soils in the areas are limy throughout.

Wooded areas in Blue Earth County generally are interspersed with fields and pasture. They are largest and most common on stream bottoms, valley slopes, and uplands in the northeastern quarter of the county. Basswood, American elm, green ash, maple, bur oak, ironwood, black walnut, and cottonwood are the most common species. Both trees and shrubs are important in windbreak plantings in the county.

Weed competition is severe. Weeds have to be controlled. Controlling them by cultivation increases the erosion hazard. Chemicals can be used in areas that are too steep for cultivation. Because runoff is rapid, these soils have less favorable moisture conditions than other soils. Plantings are better suited to north- and east-facing slopes. Those on south- and west-facing slopes are exposed to direct sunlight and become hot and dry.

Wildlife Habitat [2]

The soils of Blue Earth County have the potential to provide excellent habitat for various species of wildlife. There is a distinct interrelationship between kinds of plants on various soils and the animals associated with these plants.

For example, the Webster-Nicollet-Canisteo and Nicollet-Webster-Clarion map units (see general soil map) have high potential as habitat for ring-necked pheasant. Clarion and Nicollet soils are well suited to the woody and herbaceous cover needed for nesting and security. They also produce the food needed by pheasants. Webster soils can produce nesting and escape cover, cattails and bulrushes, for example, which also are utilized as winter cover. If drained, Webster soils produce row crops, such as corn and soybeans, which are good food sources for the pheasant.

The landscape forms of some map units allow compatible development and use for both intensive farming and wildlife. The Cordova-Lester-Caron, Minnetonka-

[2] JOHN W. BEDISH, biologist, Soil Conservation Service, helped prepare this section.

TABLE 3.—*Windbreaks and environmental plantings*

[The symbol < means less than; the symbol > means greater than. Absence of an entry means the soil does not normally grow trees of this height class. Only soils that are suitable for growing trees or shrubs are rated]

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of—				
	<8	8–15	16–25	26–35	>35
17 Minneopa		Redosier dogwood, Tatarian honeysuckle.	Northern white-cedar, white spruce, Siberian crabapple, tall purple willow, Amur maple.	Eastern white pine, green ash, hackberry.	Eastern cottonwood, silver maple.
18 Comfrey		American plum, tall purple willow.	Russian-olive	Green ash	Eastern cottonwood, golden willow.
27, 27B Dickinson	American hazel, European privet.	Late lilac, Tatarian honeysuckle, American plum.	Eastern redcedar, Siberian crab-apple, northern white-cedar.	Green ash, Scotch pine, eastern white pine, ponderosa pine.	
35 Blue Earth				Black ash	Eastern cottonwood, laurel willow.
39, 39B Wadena		Tatarian honeysuckle, gray dogwood, lilac.	Eastern redcedar, northern white-cedar, white spruce, Siberian crabapple, bur oak.	Green ash, ponderosa pine, hackberry.	Eastern cottonwood, silver maple.
41, 41B, 41C Estherville		Eastern redcedar, Russian-olive, Siberian crab-apple, silver buffaloberry, Tatarian honeysuckle, Siberian peashrub.	Jack pine, ponderosa pine, Austrian pine, hackberry, bur oak.		
62 Barrington		Gray dogwood, Tatarian honeysuckle.	Amur maple, white spruce, Siberian crab-apple.	Ponderosa pine, eastern white pine, green ash.	Silver maple.
69, 69B Fedji		Siberian crab-apple, gray dogwood.	Eastern redcedar, hackberry, bur oak, white spruce, eastern white pine.	Green ash	
84 Brownton		Northern white-cedar, tall purple willow, redosier dog-wood, Tatarian honeysuckle, lilac.	White spruce, Amur maple.	White willow, green ash, silver maple.	Eastern cottonwood.
85 Calco		Lilac, northern white-cedar, tall purple willow, Tatarian honeysuckle.	Amur maple, white spruce.	Green ash, silver maple, golden willow, black ash.	Eastern cottonwood.

TABLE 3.—*Windbreaks and environmental plantings*—Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of—				
	<8	8–15	16–25	26–35	>35
86 Canisteo		Tall purple willow, redosier dogwood, Tatarian honeysuckle, Siberian peashrub.	Russian-olive, eastern redcedar, northern white-cedar.	Green ash, American elm.	Eastern cottonwood, golden willow, Siberian elm.
94, 94B, 94C Terril		Gray dogwood, lilac, Tatarian honeysuckle.	Blue spruce, white spruce, eastern redcedar, Douglas-fir.	Eastern white pine, green ash, Scotch pine, hackberry, ponderosa pine.	Silver maple.
96, 96B, 96C Collinwood		Gray dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, Siberian crabapple, Amur maple, eastern redcedar.	Eastern white pine, green ash, hackberry, ponderosa pine.	
100 Copaston		Eastern redcedar, Siberian crabapple, silver buffaloberry, Tatarian honeysuckle.	Ponderosa pine, hackberry, bur oak.		
101B, 101C Truman		Redosier dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, Siberian crabapple, Amur maple.	Eastern white pine, green ash, hackberry.	American elm, eastern cottonwood, silver maple.
102B, 102C Clarion		Redosier dogwood, Tatarian honeysuckle, lilac.	Blue spruce, Norway spruce, white spruce, eastern redcedar, Douglas-fir.	Eastern white pine, green ash, Scotch pine, European larch, hackberry, ponderosa pine.	Silver maple.
105B, 105C Kamrar		Tatarian honeysuckle, lilac.	Blue spruce, Siberian crabapple, eastern redcedar, Douglas-fir.	Eastern white pine, red pine, Scotch pine, hackberry, silver maple.	Green ash.
106B, 106C Lester		Gray dogwood, Tatarian honeysuckle, lilac.	Siberian crabapple, Amur maple.	Eastern white pine, green ash, hackberry.	Eastern cottonwood, American elm, silver maple.
109 Cordova		Northern white-cedar, lilac, Tatarian honeysuckle, tall purple willow.	White spruce, Amur maple.	Golden willow, black ash.	Eastern cottonwood, silver maple.
110 Marna		Northern white-cedar, Tatarian honeysuckle, lilac, tall purple willow.	White spruce, Amur maple.	Golden willow, green ash.	Eastern cottonwood.

TABLE 3.—*Windbreaks and environmental plantings*—Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of—				
	<8	8–15	16–25	26–35	>35
113 Webster	----------	Northern white-cedar, lilac, tall purple willow, Tatarian honeysuckle.	White spruce, Amur maple.	Green ash, silver maple, American sycamore, golden willow, black ash.	Eastern cottonwood.
128, 128B Grogan	----------	Gray dogwood, Tatarian honeysuckle, lilac.	White spruce, Siberian crab-apple, Amur maple, eastern redcedar, northern white-cedar.	Ponderosa pine, eastern white pine, green ash, hackberry.	Silver maple.
130 Nicollet	----------	Gray dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, Siberian crab-apple, Amur maple, eastern redcedar.	Ponderosa pine, eastern white pine, green ash, hackberry.	Silver maple.
136 Madelia	----------	Northern white-cedar, lilac, tall purple willow, Tatarian honeysuckle, Amur maple.	White spruce ----	Green ash, golden willow.	Eastern cottonwood.
138B2, 138C2 Lerdal	----------	Gray dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, Siberian crabapple, Amur maple, eastern redcedar.	Ponderosa pine, eastern white pine, green ash, hackberry.	Silver maple, eastern cottonwood.
140 Spicer	----------	Tall purple willow, Tatarian honeysuckle, Siberian peashrub, redosier dogwood.	Russian-olive ----	Green ash, American elm.	Eastern cottonwood, golden willow.
160 Fieldon	----------	Northern white-cedar, lilac, tall purple willow, American plum, Tatarian honeysuckle.	White spruce, Amur maple.	Green ash, black ash.	Eastern cottonwood, silver maple.
178 Granby	----------	Northern white-cedar, lilac, tall purple willow, American plum, Tatarian honeysuckle.	White spruce, Amur maple.	Green ash, black ash.	Eastern cottonwood, silver maple.

TABLE 3.—*Windbreaks and environmental plantings*—Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of—				
	<8	8–15	16–25	26–35	>35
181 Litchfield		Eastern redcedar, Russian-olive, Siberian crabapple, Tatarian honeysuckle, Siberian peashrub.	Jack pine, ponderosa pine, Austrian pine, hackberry, bur oak.		
197 Kingston		Lilac, gray dogwood, Tatarian honeysuckle.	Northern white-cedar, white spruce, Siberian crabapple, Amur maple, eastern redcedar.	Ponderosa pine, eastern white pine, green ash, hackberry.	
222B Lasa		Eastern redcedar, Russian-olive, Siberian crabapple, Tatarian honeysuckle.	Jack pine, ponderosa pine, Austrian pine, hackberry, bur oak.		
229 Waldorf		Northern white-cedar, lilac, tall purple willow, Tatarian honeysuckle.	White spruce, Amur maple.	Golden willow, silver maple, green ash, black ash.	Eastern cottonwood.
230 Guckeen		Gray dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, Siberian crabapple, Amur maple, eastern redcedar.	Ponderosa pine, green ash, hackberry, eastern white pine.	Silver maple, eastern cottonwood.
238B, 238C Kilkenny		Gray dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, Siberian crabapple, Amur maple, eastern redcedar.	Red pine, eastern white pine, green ash, hackberry.	
239 Le Sueur		Gray dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, Siberian crabapple, Amur maple, eastern redcedar.	Ponderosa pine, eastern white pine, green ash, hackberry.	Silver maple, eastern cottonwood.
248 Lomax		Amur honeysuckle, autumn-olive, late lilac, Tatarian honeysuckle, redosier dogwood.	Russian-olive, tall purple willow, white spruce.	Eastern white pine, green ash, ponderosa pine.	Silver maple, eastern cottonwood.
259B Grays		Silky dogwood, Amur maple, Amur honeysuckle.	Northern white-cedar, Russian-olive, Siberian crabapple.	Eastern white pine, ponderosa pine, Douglas-fir.	Silver maple.

TABLE 3.—*Windbreaks and environmental plantings*—Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of—				
	<8	8–15	16–25	26–35	>35
275B Ocheyedan		Gray dogwood, lilac.	Blue spruce, white spruce, northern white-cedar, Douglas-fir, Amur maple.	Eastern white pine, red pine, Scotch pine, hackberry, green ash.	Silver maple.
281 Darfur		Northern white-cedar, tall purple willow, redosier dogwood, Tatarian honeysuckle, lilac, eastern redcedar.	White spruce, Amur maple.	Golden willow, green ash, silver maple.	Eastern cottonwood.
286 Shorewood		Gray dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, Siberian crab-apple, Amur maple, eastern redcedar.	Ponderosa pine, eastern white pine, green ash, hackberry.	Silver maple.
287 Minnetonka		Northern white-cedar, Tatarian honeysuckle, lilac, tall purple willow.	White spruce, Amur maple.	Black ash, silver maple, green ash, golden willow.	Eastern cottonwood.
310 Beauford		Northern white-cedar, medium purple willow, Tatarian honeysuckle.	White spruce	Silver maple, green ash, black ash.	Eastern cottonwood.
311 Shorewood		Gray dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, Siberian crab-apple, Amur maple, eastern redcedar.	Ponderosa pine, eastern white pine, green ash, hackberry.	Silver maple.
316 Baroda		Northern white-cedar, tall purple willow, Tatarian honeysuckle, lilac.	White spruce, Amur maple.	Golden willow, green ash.	Eastern cottonwood.
354 Dorchester		Northern white-cedar, lilac, Tatarian honeysuckle.	Siberian crab-apple, white spruce.	Green ash, hackberry, eastern white pine.	Silver maple.
360B Lasa		Eastern redcedar, Russian-olive, Siberian crab-apple, Tatarian honeysuckle, Siberian peashrub.	Jack pine, ponderosa pine, Austrian pine, hackberry, bur oak.		
360E Lasa		Eastern redcedar, Russian-olive.	Hackberry, ponderosa pine.		

TABLE 3.—*Windbreaks and environmental plantings*—Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of—				
	<8	8–15	16–25	26–35	>35
363 Minneopa	---	Redosier dogwood, Tatarian honeysuckle.	Northern white-cedar, white spruce, Siberian crab-apple, tall purple willow, Amur maple.	Eastern white pine, green ash, hackberry.	Eastern cottonwood, silver maple.
364 Minnetonka	---	Northern white-cedar, Tatarian honeysuckle, lilac, tall purple willow.	White spruce, Amur maple.	Black ash, silver maple, green ash, golden willow.	Eastern cottonwood.
414 Hamel	---	Northern white-cedar, lilac, tall purple willow, Tatarian honeysuckle.	White spruce, Amur maple.	Black ash, golden willow, green ash.	Eastern cottonwood.
440 Copaston	---	Eastern redcedar, Siberian crab-apple, silver buffaloberry, Tatarian honeysuckle.	Ponderosa pine, hackberry, bur oak.	---	---
448 Shorewood	---	Lilac, gray dogwood, Tatarian honeysuckle.	Northern white-cedar, white spruce, Siberian crab-apple, Amur maple, eastern redcedar.	Hackberry, Scotch pine, green ash, eastern white pine.	Silver maple.
451 Dorchester	---	Tatarian honeysuckle, lilac, northern white-cedar.	Eastern redcedar.	Scotch pine, Austrian pine.	---
852*, 853* Copaston	---	Eastern redcedar, Siberian crab-apple, silver buffaloberry, Tatarian honeysuckle.	Red pine, hackberry, bur oak.	---	---
854* Cordova	---	Northern white-cedar, lilac, Tatarian honeysuckle, tall purple willow.	Amur maple, white spruce.	Golden willow, black ash.	Eastern cottonwood, silver maple.
855* Dorchester	---	Northern white-cedar, lilac, Tatarian honeysuckle.	Eastern redcedar.	Austrian pine, eastern white pine.	Eastern cottonwood, silver maple.
856B*, 856C* Terril	---	Gray dogwood, lilac, Tatarian honeysuckle.	Blue spruce, white spruce, eastern redcedar, Douglas-fir.	Eastern white pine, green ash, Scotch pine, hackberry, ponderosa pine.	Silver maple.

TABLE 3.—*Windbreaks and environmental plantings*—Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of—				
	<8	8–15	16–25	26–35	>35
909C*:					
Bold	---	Eastern redcedar, lilac, Siberian peashrub, Tatarian honeysuckle.	White spruce, ponderosa pine, Siberian crabapple.	Green ash, American elm, Russian-olive.	Siberian elm, silver maple.
Truman	---	Redosier dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, Siberian crabapple, Amur maple.	Eastern white pine, green ash, hackberry.	American elm, eastern cottonwood.
919*:					
Canisteo	---	Tall purple willow, redosier dogwood, Tatarian honeysuckle, Siberian peashrub.	Russian-olive, eastern redcedar, northern white-cedar.	Green ash, American elm.	Eastern cottonwood, golden willow, Siberian elm.
Fieldon	---	Northern white-cedar, lilac, tall purple willow, American plum, Tatarian honeysuckle.	White spruce, Amur maple.	Green ash, black ash.	Eastern cottonwood, silver maple.
920B*, 920C*:					
Clarion	---	Amur maple, Tatarian honeysuckle.	Blue spruce, Norway spruce, white spruce, eastern redcedar, Douglas-fir.	Eastern white pine, green ash, Scotch pine, European larch, hackberry, ponderosa pine.	Silver maple.
Estherville	---	Eastern redcedar, Russian-olive, Siberian crabapple, silver buffaloberry, Tatarian honeysuckle, Siberian peashrub.	Jack pine, ponderosa pine, Austrian pine, hackberry, bur oak.	---	---
921C*:					
Clarion	---	Amur maple, Tatarian honeysuckle, lilac.	Blue spruce, Norway spruce, white spruce, eastern redcedar, Douglas-fir.	Eastern white pine, green ash, Scotch pine, European larch, hackberry, ponderosa pine.	Silver maple.
Storden	---	Tall purple willow, Tatarian honeysuckle, Siberian peashrub, northern white-cedar.	Eastern redcedar, white spruce.	Green ash, Russian-olive.	Eastern cottonwood, Siberian elm.

TABLE 3.—*Windbreaks and environmental plantings*—Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of—				
	<8	8–15	16–25	26–35	>35
923* Copaston		Eastern redcedar, Siberian crab-apple, silver buffaloberry, Tatarian honeysuckle.	Ponderosa pine, hackberry, bur oak.		
926*: Darfur		Northern white-cedar, tall purple willow, redosier dog-wood, Tatarian honeysuckle, lilac, eastern redcedar.	White spruce, Amur maple.	Golden willow, green ash, silver maple.	Eastern cottonwood.
Webster		Northern white-cedar, lilac, tall purple willow, Tatarian honeysuckle.	White spruce, Amur maple.	Green ash, silver maple, American syca-more, golden willow, black ash.	Eastern cottonwood.
929*: Fieldon		Northern white-cedar, lilac, tall purple willow, American plum, Tatarian honeysuckle.	White spruce, Amur maple.	Green ash, black ash.	Eastern cottonwood, silver maple.
Canisteo		Tall purple willow, redosier dogwood, Tatarian honeysuckle, Siberian peashrub.	Russian-olive, eastern red-cedar, northern white-cedar.	Green ash, American elm.	Eastern cottonwood, golden willow, Siberian elm.
941*: Kingston		Lilac, gray dogwood, Tatarian honeysuckle.	Northern white-cedar, white spruce, Siberian crabapple, Amur maple, eastern redcedar.	Ponderosa pine, eastern white pine, green ash, hackberry.	Silver maple.
Nicollet		Gray dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, Siberian crab-apple, Amur maple, eastern redcedar.	Red pine, eastern white pine, green ash, hackberry.	
946*: Litchfield		Eastern redcedar, Russian-olive, Siberian crab-apple, silver buffaloberry, Tatarian honeysuckle, Siberian peashrub.	Jack pine, ponderosa pine, Austrian pine, hackberry, bur oak.		

TABLE 3.—*Windbreaks and environmental plantings*—Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of—				
	<8	8–15	16–25	26–35	>35
Nicollet	----------	Gray dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, Siberian crab-apple, Amur maple, eastern redcedar.	Ponderosa pine, eastern white pine, green ash, hackberry.	----------
947*:					
Madelia	----------	Northern white-cedar, tall purple willow, Tatarian honeysuckle, lilac.	White spruce, Amur maple.	Golden willow, green ash.	Eastern cottonwood.
Webster	----------	Northern white-cedar, lilac, tall purple willow, Tatarian honeysuckle.	White spruce, Amur maple.	Green ash, silver maple, American syca-more, golden willow, black ash.	Eastern cottonwood.
968*:					
Webster	----------	Northern white-cedar, lilac, tall purple willow, Tatarian honeysuckle.	White spruce, Amur maple.	Green ash, silver maple, American syca-more, golden willow, black ash.	Eastern cottonwood.
Darfur	----------	Northern white-cedar, tall purple willow, redosier dog-wood, Tatarian honeysuckle, lilac, eastern redcedar.	White spruce, Amur maple.	Golden willow, green ash, silver maple.	Eastern cottonwood.
Granby	----------	Northern white-cedar, tall purple willow, redosier dog-wood, lilac, Tatarian honeysuckle, eastern redcedar.	White spruce, Amur maple.	----------	----------
978*:					
Cordova	----------	Northern white-cedar, Tatarian honeysuckle, lilac, tall purple willow.	White spruce, Amur maple.	Green ash, golden willow, black ash, silver maple.	Eastern cottonwood.
996*:					
Beauford	----------	Northern white-cedar, medium purple willow, Tatarian honeysuckle.	White spruce, Amur maple.	Silver maple, green ash, black ash.	Eastern cottonwood.

TABLE 3.—*Windbreaks and environmental plantings*—Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of—				
	<8	8–15	16–25	26–35	>35
997*: Marna		Northern white-cedar, tall purple willow, Tatarian honeysuckle, lilac.	White spruce, Amur maple.	Golden willow, green ash.	Eastern cottonwood.
998*: Minnetonka		Northern white-cedar, Tatarian honeysuckle, lilac, tall purple willow.	White spruce, Amur maple.	Black ash, silver maple, green ash, golden willow.	Eastern cottonwood.
1801B Grogan		Gray dogwood, Tatarian honeysuckle, lilac.	White spruce, Siberian crab-apple, Amur maple, eastern redcedar, northern white-cedar.	Ponderosa pine, eastern white pine, green ash, hackberry.	

* See map unit description for the composition and behavior of the map unit.

Kilkenny-Caron, and Kilkenny-Minnetonka-Lerdal map units have broad, nearly level to gently undulating, flat topped hills and smooth side slopes and broad, wet depressions between the hills. Intensive farming, which includes tile drainage, would not conflict with maintaining and developing the lower wetlands as wildlife habitat.

Habitat alone does not assure the presence of wildlife population. Other factors such as native range and land use patterns have a significant effect. Some of the principal species of wildlife in the county include the ring-necked pheasant, Hungarian partridge, cottontail, white-tailed deer, gray squirrel, red squirrel, mink, muskrat, raccoon, and several species of waterfowl.

The white-tailed deer population is fairly low compared with that of the main herd in the northern part of Minnesota, but it is important locally. Deer are associated with the more wooded areas of the county. Habitat is provided on the Alluvial land-Copaston-Chaska, the Storden-Comfrey-Lomax, the Cordova-Lester-Caron, the Minnetonka-Kilkenny-Caron, the Kilkenny-Minnetonka-Lerdal, and the Minnetonka-Shorewood-Lura map units.

The present ring-necked pheasant population is more concentrated on the Webster-Nicollet-Canisteo, the Nicollet-Webster-Clarion, the Beauford-Lura-Shorewood, the Marna-Guckeen-Lura, and the Minnetonka-Kilkenny-Caron map units.

Significant populations of the Hungarian partridge are associated with the Webster-Nicollet-Canisteo, the Madelia-Kingston-Spicer, the Waldorf-Collinwood-Lura, the Beauford-Lura-Shorewood, and the Marna-Guckeen-Lura map units.

The waterfowl population is more common on the Cordova-Lester-Caron, the Minnetonka-Kilkenny-Caron, and the Beauford-Lura-Shorewood map units.

Raccoon, rabbits, and squirrels are common throughout the county. They are more commonly associated, however, with the wooded areas in the Alluvial land-Copaston-Chaska, the Storden-Comfrey-Lomax, the Cordova-Lester-Caron, the Minnetonka-Kilkenny-Caron, and the Kilkenny-Minnetonka-Lerdal map units.

Soils directly affect the kind and amount of vegetation that is available to wildlife as food and cover, and they affect the construction of water impoundments. The kind and abundance of wildlife that populate an area depend largely on the amount and distribution of food, cover, and water. If any one of these elements is missing, is inadequate, or is inaccessible, wildlife either are scarce or do not inhabit the area.

If the soils have the potential, wildlife habitat can be created or improved by planting appropriate vegetation, by maintaining the existing plant cover, or by helping the natural establishment of desirable plants.

In table 4, the soils in the survey area are rated according to their potential to support the main kinds of wildlife habitat in the area. This information can be used in planning for parks, wildlife refuges, nature study areas, and other developments for wildlife; selecting areas that are suitable for wildlife; selecting soils that are suitable for creating, improving, or maintaining specific elements of wildlife habitat; and 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* means that the element of wildlife habitat or the kind of habitat is easily created, improved, or maintained. Few or no limitations affect management, and satisfactory results can be expected if the soil is used for the designated purpose. A rating of *fair* means that the element of wildlife habitat or kind of habitat can be created, improved, or maintained in most places. Moderately intensive management is required for satisfactory results. A rating of *poor* means that limitations are severe for the designated element or kind of wildlife habitat. Habitat can be created, improved, or maintained in most places, but management is difficult and must be intensive. A rating of *very poor* means that restrictions for the element of wildlife habitat or kind of wildlife are very severe, and that unsatisfactory results can be expected. Wildlife habitat is impractical or even impossible to create, improve, or maintain on soils having such a rating.

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

Grain and seed crops are seed-producing annuals used by wildlife. The major soil properties that affect the growth of grain and seed crops are depth of the root zone, texture of the surface layer, available water capacity, wetness, slope, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations. Examples of grain and seed crops are corn, wheat, oats, and barley.

Grasses and legumes are domestic perennial grasses and herbaceous legumes that are planted for wildlife food and cover. Major soil properties that affect the growth of grasses and legumes are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, flood hazard, and slope. Soil temperature and soil moisture are also considerations. Examples of grasses and legumes are fescue, bromegrass, clover, and alfalfa.

Wild herbaceous plants are native or naturally established grasses and forbs, including weeds, that provide food and cover for wildlife. Major soil properties that affect the growth of these plants are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations. Examples of wild herbaceous plants are bluestem, indiangrass, goldenrod, partridgepea, wheatgrass, fescue, and grama.

Hardwood trees and the associated woody understory provide cover for wildlife and produce nuts or other fruit, buds, catkins, twigs, bark, or foliage that wildlife eat. Major soil properties that affect growth of hardwood trees and shrubs are depth of the root zone, available water capacity, and wetness. Examples of native plants are oak, poplar, hackberry, elm, sumac, apple, hazelnut, black walnut, grape, viburnum, and chokecherry. Examples of fruit-producing shrubs that are commercially available and suitable for planting on soils rated *good* are Russian-olive, autumn-olive, and crabapple.

Coniferous plants are cone-bearing trees, shrubs, or ground cover plants that furnish habitat or supply food in the form of browse, seeds, or fruitlike cones. Soil properties that have a major effect on the growth of coniferous plants 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, exclusive of submerged or floating aquatics. They produce food or cover for wildlife that use wetland as habitat. Major soil properties 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, and cordgrass and rushes, sedges, and reeds.

Shallow water areas are bodies of water that have an average depth of less than 5 feet and that are useful to wildlife. They can be naturally wet areas, or they can be created by dams or levees or by water-control structures in marshes or streams. Major soil properties affecting shallow water areas are depth to bedrock, wetness, surface stoniness, slope, and permeability. The availability of a dependable water supply is important if water areas are to be developed. Examples of shallow water areas are marshes, waterfowl feeding areas, and ponds.

The kinds of wildlife habitat are briefly described in the following paragraphs.

Openland habitat consists of cropland, pasture, meadows, and areas that are overgrown with grasses, herbs, shrubs, and vines. These areas produce grain and seed crops, grasses and legumes, and wild herbaceous plants. The kinds of wildlife attracted to these areas include Hungarian partridge, pheasant, meadowlark, field sparrow, killdeer, cottontail rabbit, red fox, and woodchuck.

Woodland habitat consists of areas of hardwoods or conifers, or a mixture of both, and associated grasses, legumes, and wild herbaceous plants. Wildlife attracted to these areas include woodcock, thrushes, vireos, woodpeckers, squirrels, gray fox, raccoon, and deer.

Wetland habitat consists of open, marshy or swamp, shallow water areas where water-tolerant plants grow. Some of the wildlife attracted to such areas are ducks, geese, herons, shore birds, rails, kingfishers, muskrat, mink, and beaver.

Recreation

The county has a long-range plan for developing its recreational resources. There are now several scattered parks throughout the county. Included in this plan is a program to preserve an environmental corridor along the entire length of the Blue Earth River in the county. Land acquisition and zoning would be needed to preserve and protect a unique area in south-central Minnesota.

Blue Earth County not only has some of the best farm land in the State, but also some of the more scenic areas, including "Minneopa Falls" and the "Garden of the Gods." The good farm land is crossed by several rivers, flowing through the deeply cut river valleys, that meet the Blue Earth River near Mankato and join the Minnesota River. The scenic overlooks and roads, by and through these valleys, provide opportunity for good hiking, hunting, snowmobiling, bird watching, mushroom hunting, and a variety of other outdoor activities. Canoeing is also very popular on the lower part of the Blue Earth and Le Sueur Rivers and on the Minnesota River. These activities are commonly associated with the Alluvial land-Copaston-Chaska and the Storden-Comfrey-Lomax map units (see general soil map).

Permanent lake homes, vacation lake homes, boating, and fishing are mostly on the Cordova-Lester-Caron, the Minnetonka-Kilkenny-Caron, and the Kilkenny-Minnetonka-Lerdal map units. These lakes are classified as warm water lakes. They are typically shallow. They

TABLE 4.—*Wildlife*

[See text for definitions of "good," "fair," "poor," and "very

Soil name and map symbol	Potential for habitat elements			
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees
17 Minneopa	Fair	Fair	Fair	Fair
18 Comfrey	Fair	Fair	Fair	Fair
27, 27B Dickinson	Fair	Fair	Fair	Fair
35 Blue Earth	Fair	Poor	Poor	Poor
39, 39B Wadena	Good	Good	Good	Good
41, 41B, 41C Estherville	Fair	Fair	Fair	Fair
62 Barrington	Good	Good	Good	Good
69, 69B Fedji	Fair	Fair	Fair	Fair
84 Brownton	Fair	Fair	Fair	Fair
85 Calco	Good	Fair	Good	Poor
86 Canisteo	Fair	Fair	Fair	Fair
94, 94B Terril	Good	Good	Good	Good
94C Terril	Fair	Good	Good	Good
96, 96B Collinwood	Fair	Fair	Fair	Good
96C, 96D Collinwood	Poor	Fair	Fair	Good
100 Copaston	Poor	Poor	Fair	Fair
101B, 101C Truman	Good	Good	Good	Good
102B Clarion	Good	Good	Good	Good
102C Clarion	Fair	Good	Good	Good
102D Clarion	Poor	Fair	Good	Good
105B Kamrar	Good	Good	Good	Good
105C, 105D Kamrar	Fair	Good	Good	Good
106B Lester	Good	Good	Good	Good

habitat potentials

poor." Absence of an entry indicates the soil was not rated]

Potential for habitat elements—Continued			Potential as habitat for—		
Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
Fair	Poor	Poor	Fair	Fair	Poor.
Fair	Good	Good	Fair	Fair	Good.
Fair	Very poor	Very poor	Fair	Fair	Very poor.
Poor	Good	Good	Poor	Poor	Good.
Good	Poor	Very poor	Good	Good	Very poor.
Fair	Very poor	Very poor	Fair	Fair	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Fair	Very poor	Very poor	Fair	Fair	Very poor.
Fair	Good	Good	Fair	Fair	Good.
Very poor	Good	Fair	Fair	Poor	Fair.
Fair	Good	Fair	Fair	Fair	Fair.
Good	Poor	Poor	Good	Good	Poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Poor	Fair	Fair	Good	Poor.
Good	Very poor	Very poor	Poor	Good	Very poor.
Fair	Very poor	Very poor	Poor	Fair	Very poor.
Fair	Poor	Very poor	Good	Good	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Fair	Good	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.

TABLE 4.—*Wildlife habitat*

Soil name and map symbol	Potential for habitat elements			
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees
106C, 106D Lester	Fair	Good	Good	Good
106E Lester	Poor	Fair	Good	Good
109 Cordova	Good	Good	Good	Fair
110 Marna	Fair	Fair	Fair	Fair
113 Webster	Good	Fair	Good	Fair
114 Glencoe	Fair	Fair	Fair	Fair
128, 128B Grogan	Good	Good	Good	Good
130 Nicollet	Good	Good	Good	Good
134 Okoboji	Fair	Fair	Fair	Poor
136 Madelia	Good	Good	Good	Fair
138B2 Lerdal	Good	Good	Good	Good
138C2 Lerdal	Fair	Good	Good	Good
140 Spicer	Fair	Fair	Fair	Poor
160 Fieldon	Fair	Fair	Fair	Fair
178 Granby	Fair	Poor	Poor	Poor
181 Litchfield	Fair	Good	Good	Good
183 Dassel	Fair	Fair	Poor	Poor
196 Joliet	Fair	Fair	Fair	Fair
197 Kingston	Good	Good	Good	Good
211 Lura	Fair	Fair	Poor	Poor
219 Rolfe	Fair	Fair	Fair	Fair
222B Lasa	Poor	Poor	Fair	Fair
229 Waldorf	Good	Fair	Fair	Fair

potentials—Continued

Potential for habitat elements—Continued			Potential as habitat for—		
Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Fair	Good	Very poor.
Fair	Good	Good	Good	Fair	Good.
Fair	Good	Good	Fair	Fair	Good.
Poor	Good	Good	Fair	Fair	Good.
Very poor	Fair	Good	Fair	Very poor	Fair.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Poor	Poor	Good	Good	Poor.
Very poor	Good	Good	Fair	Poor	Good.
Fair	Good	Good	Good	Fair	Good.
Good	Poor	Poor	Good	Good	Poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Poor	Good	Fair	Fair	Poor	Good.
Fair	Good	Good	Fair	Fair	Good.
Poor	Good	Good	Poor	Poor	Good.
Good	Fair	Poor	Good	Good	Poor.
Poor	Fair	Fair	Fair	Poor	Fair.
Poor	Good	Poor	Fair	Fair	Fair.
Good	Poor	Poor	Good	Good	Poor.
Poor	Poor	Good	Fair	Poor	Fair.
Poor	Good	Good	Fair	Fair	Good.
Fair	Very poor	Very poor	Poor	Fair	Very poor.
Fair	Good	Good	Fair	Fair	Good.

TABLE 4.—*Wildlife habitat*

Soil name and map symbol	Potential for habitat elements			
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees
230 Guckeen	Good	Good	Good	Good
238B Kilkenny	Good	Good	Good	Good
238C, 238D Kilkenny	Fair	Good	Good	Good
239 Le Sueur	Good	Good	Good	Good
248 Lomax	Good	Good	Good	Good
259B Grays	Good	Good	Good	Good
275B Ocheyedan	Good	Good	Good	Good
281 Darfur	Fair	Fair	Fair	Fair
286 Shorewood	Good	Good	Good	Good
287 Minnetonka	Good	Fair	Fair	Fair
310 Beauford	Fair	Fair	Fair	Fair
311 Shorewood	Fair	Fair	Fair	Good
316 Baroda	Fair	Fair	Fair	Fair
317 Oshawa	Poor	Poor	Poor	Poor
319 Barbert	Poor	Poor	Fair	Poor
321 Tilfer	Fair	Fair	Fair	Fair
329 Chaska	Good	Good	Good	Fair
349 Calco	Very poor	Poor	Poor	Very poor
353 Comfrey	Poor	Poor	Fair	Very poor
354 Dorchester	Fair		Fair	Fair
360B Lasa	Poor	Poor	Fair	Fair
360E Lasa	Very poor	Very poor	Fair	Fair
363 Minneopa	Fair	Fair	Fair	Fair

potentials—Continued

Potential for habitat elements—Continued			Potential as habitat for—		
Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
Good	Fair	Fair	Good	Good	Fair.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Fair	Good	Very poor.
Good	Poor	Poor	Good	Good	Poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Fair	Good	Good	Fair	Fair	Good.
Good	Poor	Poor	Good	Good	Poor.
Fair	Good	Good	Fair	Fair	Good.
Fair	Poor	Good	Fair	Fair	Fair.
Good	Poor	Poor	Fair	Good	Poor.
Fair	Good	Good	Fair	Fair	Good.
Poor	Good	Good	Poor	Poor	Good.
Poor	Good	Good	Poor	Poor	Good.
Poor	Good	Good	Fair	Fair	Good.
Fair	Good	Good	Good	Fair	Good.
Very poor	Good	Good	Very poor	Very poor	Good.
Very poor	Good	Good	Poor	Poor	Good.
Poor	Fair	Poor	Fair	Poor	Poor.
Fair	Very poor	Very poor	Fair	Fair	Very poor.
Fair	Very poor	Very poor	Poor	Fair	Very poor.
Fair	Poor	Poor	Fair	Fair	Poor.

TABLE 4.—*Wildlife habitat*

Soil name and map symbol	Potential for habitat elements			
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees
364 Minnetonka	Good	Fair	Fair	Fair
414 Hamel	Good	Fair	Fair	Fair
440 Copaston	Poor	Poor	Fair	Fair
448 Shorewood	Good	Good	Good	Good
451 Dorchester	Good	Good	Fair	Fair
524 Caron	Fair	Fair	Poor	Poor
525 Muskego	Fair	Fair	Poor	Poor
539 Palms	Fair	Fair	Poor	Poor
548 Palms	Fair	Fair	Poor	Poor
851* Chaska-Urban land	Good	Good	Good	Fair
852*, 853* Copaston-Urban land	Poor	Poor	Fair	Fair
854* Cordova-Urban land	Good	Good	Good	Fair
855* Dorchester-Urban land	Fair	Fair	Fair	Fair
856B* Terril-Urban land	Good	Good	Good	Good
856C* Terril-Urban land	Fair	Good	Good	Good
909C*:				
Bold	Fair	Good	Good	Poor
Truman	Good	Good	Good	Good
909D*:				
Bold	Fair	Good	Good	Poor
Truman	Fair	Good	Good	Good
919*:				
Canisteo	Fair	Fair	Fair	Fair
Fieldon	Fair	Fair	Fair	Fair
920B*:				
Clarion	Good	Good	Good	Good
Estherville	Fair	Fair	Fair	Fair
920C*:				
Clarion	Fair	Good	Good	Good
Estherville	Fair	Fair	Fair	Fair

potentials—Continued

Potential for habitat elements—Continued			Potential as habitat for—		
Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
Fair	Good	Good	Fair	Fair	Good.
Fair	Good	Good	Fair	Fair	Good.
Fair	Very poor	Very poor	Poor	Fair	Very poor.
Good	Poor	Poor	Good	Good	Poor.
Fair	Poor	Poor	Good	Fair	Poor.
Poor	Good	Good	Fair	Poor	Good.
Poor	Good	Good	Fair	Poor	Good.
Poor	Good	Good	Fair	Poor	Good.
Poor	Good	Good	Fair	Poor	Good.
Fair	Good	Good	Good	Fair	Good.
Fair	Very poor	Very poor	Poor	Fair	Very poor.
Fair	Good	Good	Good	Fair	Good.
Poor	Fair	Poor	Fair	Poor	Poor.
Good	Poor	Poor	Good	Good	Poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Poor	Very poor	Very poor	Good	Fair	Very poor.
Fair	Poor	Very poor	Good	Good	Very poor.
Poor	Very poor	Very poor	Fair	Fair	Very poor.
Fair	Very poor	Very poor	Fair	Good	Very poor.
Fair	Good	Fair	Fair	Fair	Fair.
Fair	Good	Good	Fair	Fair	Good.
Good	Poor	Very poor	Good	Good	Very poor.
Fair	Very poor	Very poor	Fair	Fair	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Fair	Very poor	Very poor	Fair	Fair	Very poor.

TABLE 4.—*Wildlife habitat*

Soil name and map symbol	Potential for habitat elements			
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees
920D*:				
Clarion	Poor	Fair	Good	Good
Estherville	Poor	Fair	Fair	Fair
921C*, 921D*:				
Clarion	Fair	Good	Good	Good
Storden	Fair	Good	Good	Fair
923* Copaston-Rock outcrop	Poor	Poor	Fair	Fair
926*:				
Darfur	Fair	Fair	Fair	Fair
Webster	Good	Fair	Good	Fair
929*:				
Fieldon	Fair	Fair	Fair	Fair
Canisteo	Fair	Fair	Fair	Fair
932*:				
Glencoe	Fair	Fair	Fair	Fair
Dassel	Fair	Fair	Poor	Poor
941*:				
Kingston	Good	Good	Good	Good
Nicollet	Good	Good	Good	Good
946*:				
Litchfield	Fair	Good	Good	Good
Nicollet	Good	Good	Good	Good
947*:				
Madelia	Good	Fair	Fair	Fair
Webster	Good	Fair	Good	Fair
960E*:				
Storden	Poor	Fair	Good	Fair
Clarion.				
961*, 961F* Storden	Poor	Poor	Good	Fair
968*:				
Webster	Good	Fair	Good	Fair
Darfur	Fair	Fair	Fair	Fair
Granby	Fair	Poor	Poor	Poor
978*:				
Cordova	Good	Good	Good	Fair
Rolfe	Fair	Fair	Fair	Fair
992*:				
Rock outcrop.				
Copaston	Poor	Poor	Fair	Fair
996*:				
Beauford	Fair	Fair	Fair	Fair

potentials—Continued

Potential for habitat elements—Continued			Potential as habitat for—		
Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
Good	Very poor	Very poor	Fair	Good	Very poor.
Fair	Very poor	Very poor	Poor	Fair	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Poor	Very poor	Very poor	Fair	Fair	Very poor.
Fair	Very poor	Very poor	Poor	Fair	Very poor.
Fair	Good	Good	Fair	Fair	Good.
Poor	Good	Good	Fair	Fair	Good.
Fair	Good	Good	Fair	Fair	Good.
Fair	Good	Fair	Fair	Fair	Fair.
Very poor	Good	Good	Fair	Very poor	Good.
Poor	Fair	Fair	Fair	Poor	Fair.
Good	Poor	Poor	Good	Good	Poor.
Good	Poor	Poor	Good	Good	Poor.
Good	Fair	Poor	Good	Good	Poor.
Good	Poor	Poor	Good	Good	Poor.
Fair	Good	Good	Fair	Fair	Good.
Poor	Good	Good	Fair	Fair	Good.
Poor	Very poor	Very poor	Fair	Fair	Very poor.
Poor	Very poor	Very poor	Poor	Fair	Very poor.
Poor	Good	Good	Fair	Fair	Good.
Fair	Good	Good	Fair	Fair	Good.
Poor	Good	Good	Poor	Poor	Good.
Fair	Good	Good	Good	Fair	Good.
Poor	Good	Good	Fair	Fair	Good.
Fair	Very poor	Very poor	Poor	Fair	Very poor.
Fair	Poor	Good	Fair	Fair	Fair.

TABLE 4.—*Wildlife habitat*

Soil name and map symbol	Potential for habitat elements			
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees
Barbert	Poor	Poor	Fair	Poor
997*:				
Marna	Good	Fair	Fair	Fair
Barbert	Poor	Poor	Fair	Poor
998*:				
Minnetonka	Good	Fair	Fair	Fair
Barbert	Poor	Poor	Fair	Poor
1001*, 1002*, 1004*. Alluvial land				
1007*. Alluvial-Urban land				
1032*. Lake beaches				
1039*. Urban land				
1053*. Marsh				
1800 Caron	Very poor	Very poor	Poor	Very poor
1801B Grogan	Good	Good	Good	Good

* See map unit description for the composition and behavior of the map unit.

tend to freeze occasionally late in winter, and they have poor shorelines for bathing beaches. Sunfish, crappies, bass, and bullheads are the main fish. Walleyes are caught in spring and fall.

The soils of the survey area are rated in table 5 according to limitations that affect their suitability for recreation uses. The ratings are based on such restrictive soil features as flooding, wetness, slope, and texture of the surface layer. Not considered in these ratings, but important in evaluating a site, are location and accessibility of the area, size and shape of the area and its scenic quality, the ability of the soil to support vegetation, access to water, potential water impoundment sites available, and either access to public sewerlines or capacity of the soil to absorb septic tank effluent. Soils subject to flooding are limited, in varying degree, for recreation use by the duration and intensity of flooding and the season when flooding occurs. Onsite assessment of height, duration, intensity, and frequency of flooding is essential in planning recreation facilities.

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

The information in table 5 can be supplemented by information in other parts of this survey. Especially helpful are interpretations for septic tank absorption fields, given in table 7 and interpretations for dwellings without basements and for local roads and streets, given in table 6.

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

Picnic areas are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas. The best soils for use as 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

potentials—Continued

Potential for habitat elements—Continued			Potential as habitat for—		
Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
Poor	Good	Good	Poor	Poor	Good.
Fair	Good	Good	Fair	Fair	Good.
Poor	Good	Good	Poor	Poor	Good.
Fair	Good	Good	Fair	Fair	Good.
Poor	Good	Good	Poor	Poor	Good.
Very poor	Good	Good	Very poor	Very poor	Good.
Good	Very poor	Very poor	Good	Good	Very poor.

or stones or boulders that will increase the cost of shaping sites or of building access roads and parking areas.

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

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

Engineering

This section provides information about the use of soils for building sites, sanitary facilities, construction material, and water management. Among those who can benefit from this information are engineers, landowners, community planners, town and city managers, land developers, builders, contractors, and farmers and ranchers.

The ratings in the engineering tables are based on test data and estimated data in the "Soil properties" section. The ratings were determined jointly by soil scientists and engineers of the Soil Conservation Service using known relationships between the soil properties and the behavior of soils in various engineering uses.

Among the soil properties and site conditions identified by a soil survey and used in determining the ratings in this section were grain-size distribution, liquid limit, plasticity index, soil reaction, depth to bedrock, hardness of bedrock that is within 5 or 6 feet of the surface, soil wetness, depth to a seasonal high water table, slope, likelihood of flooding, natural soil structure or aggregation, in-place soil density, and geologic origin of the soil material. Where pertinent, data about kinds of clay minerals, mineralogy of the sand and silt fractions, and the kind of absorbed cations were also considered.

On the basis of information assembled about the soil properties, ranges of values can be estimated for erodibility, permeability, corrosivity, shrink-swell potential, available water capacity, shear strength, compressibility, slope stability, and other factors of

TABLE 5.—*Recreational development*

[Some of the terms used in this table to describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry means soil was not rated]

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
17 Minneopa	Slight	Slight	Slight	Slight.
18 Comfrey	Severe: wetness, floods.	Severe: wetness	Severe: wetness, floods.	Severe: wetness.
27 Dickinson	Slight	Slight	Slight	Slight.
27B Dickinson	Slight	Slight	Moderate: slope	Slight.
35 Blue Earth	Severe: wetness, floods.	Severe: wetness	Severe: wetness, floods.	Severe: wetness.
39 Wadena	Slight	Slight	Slight	Slight.
39B Wadena	Slight	Slight	Moderate: slope	Slight.
41 Estherville	Slight	Slight	Slight	Slight.
41B Estherville	Slight	Slight	Moderate: slope	Slight.
41C Estherville	Moderate: slope	Moderate: slope	Severe: slope	Slight.
62 Barrington	Slight	Slight	Slight	Slight.
69 Fedji	Moderate: too sandy	Moderate: too sandy	Moderate: too sandy	Moderate: too sandy.
69B Fedji	Moderate: too sandy	Moderate: too sandy	Moderate: too sandy, slope.	Moderate: too sandy.
84 Brownton	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
85 Calco	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness.
86 Canisteo	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
94 Terril	Slight	Slight	Slight	Slight.
94B Terril	Slight	Slight	Moderate: slope	Slight.
94C Terril	Slight	Slight	Severe: slope	Slight.
96 Collinwood	Moderate: too clayey	Moderate: too clayey	Moderate: too clayey	Moderate: too clayey.
96B Collinwood	Moderate: too clayey	Moderate: too clayey	Moderate: too clayey, slope.	Moderate: too clayey.
96C Collinwood	Moderate: too clayey, slope.	Moderate: too clayey, slope.	Severe: slope	Moderate: too clayey.
96D Collinwood	Severe: slope	Severe: slope	Severe: slope	Moderate: too clayey, slope.

TABLE 5.—*Recreational development*—Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
100 Copaston	Slight	Slight	Severe: depth to rock.	Slight.
101B Truman	Slight	Slight	Moderate: slope	Slight.
101C Truman	Moderate: slope	Moderate: slope	Severe: slope	Slight.
102B Clarion	Slight	Slight	Moderate: slope	Slight.
102C Clarion	Moderate: slope	Moderate: slope	Severe: slope	Slight.
102D Clarion	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
105B Kamrar	Severe: too clayey	Severe: too clayey	Severe: too clayey	Severe: too clayey.
105C, 105D Kamrar	Severe: too clayey	Severe: too clayey	Severe: too clayey, slope.	Severe: too clayey.
106B Lester	Slight	Slight	Moderate: slope	Slight.
106C Lester	Moderate: slope	Moderate: slope	Severe: slope	Slight.
106D, 106E Lester	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
109 Cordova	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
110 Marna	Severe: wetness, too clayey.	Severe: wetness, too clayey.	Severe: wetness, too clayey.	Severe: wetness, too clayey.
113 Webster	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
114 Glencoe	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.
128 Grogan	Slight	Slight	Slight	Slight.
128B Grogan	Slight	Slight	Moderate: slope	Slight.
130 Nicollet	Moderate: too clayey	Moderate: too clayey	Moderate: too clayey, wetness.	Moderate: too clayey.
134 Okoboji	Severe: wetness, floods.	Severe: wetness	Severe: wetness, floods.	Severe: wetness.
136 Madelia	Severe: wetness, floods.	Severe: wetness	Severe: wetness	Severe: wetness.
138B2 Lerdal	Moderate: percs slowly.	Moderate: too clayey	Moderate: percs slowly, slope.	Moderate: too clayey.
138C2 Lerdal	Moderate: slope	Moderate: too clayey, slope.	Severe: slope	Moderate: too clayey.
140 Spicer	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
160 Fieldon	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.

TABLE 5.—*Recreational development*—Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
178 Granby	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
181 Litchfield	Moderate: too sandy	Moderate: too sandy	Moderate: too sandy	Moderate: too sandy.
183 Dassel	Severe: wetness, floods.	Severe: wetness	Severe: wetness, floods.	Severe: wetness.
196 Joliet	Severe: wetness, floods.	Severe: wetness	Severe: wetness, depth to rock, floods.	Severe: wetness.
197 Kingston	Moderate: too clayey	Moderate: too clayey	Moderate: too clayey	Moderate: too clayey.
211 Lura	Severe: wetness, floods, percs slowly.	Severe: wetness, floods, too clayey.	Severe: wetness, floods, percs slowly.	Severe: floods, wetness, too clayey.
219 Rolfe	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness.
222B Lasa	Moderate: too sandy	Moderate: too sandy	Severe: too sandy	Severe: too sandy.
229 Waldorf	Severe: wetness, too clayey.	Severe: wetness, too clayey.	Severe: wetness, too clayey.	Severe: wetness, too clayey.
230 Guckeen	Moderate: wetness	Moderate: wetness	Moderate: wetness	Moderate: too clayey, wetness.
238B Kilkenny	Moderate: percs slowly.	Moderate: too clayey	Moderate: slope, percs slowly, too clayey.	Moderate: too clayey.
238C Kilkenny	Moderate: slope, percs slowly.	Moderate: slope, too clayey.	Severe: slope	Moderate: too clayey.
238D Kilkenny	Severe: slope	Severe: slope	Severe: slope	Moderate: slope, too clayey.
239 Le Sueur	Moderate: too clayey, wetness.	Moderate: too clayey, wetness.	Moderate: too clayey, wetness.	Moderate: too clayey.
248 Lomax	Slight	Slight	Slight	Slight.
259B Grays	Slight	Slight	Moderate: slope	Slight.
275B Ocheyedan	Slight	Slight	Moderate: slope	Slight.
281 Darfur	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
286 Shorewood	Moderate: too clayey	Moderate: too clayey	Moderate: too clayey, wetness.	Moderate: too clayey.
287 Minnetonka	Severe: wetness, percs slowly.	Severe: wetness	Severe: wetness, percs slowly.	Severe: wetness.
310 Beauford	Severe: too clayey, wetness.	Severe: too clayey, wetness.	Severe: too clayey, wetness.	Severe: too clayey, wetness.
311 Shorewood	Severe: too clayey	Severe: too clayey	Severe: too clayey	Severe: too clayey.
316 Baroda	Severe: wetness, percs slowly.	Severe: wetness	Severe: wetness, percs slowly.	Severe: wetness.
317 Oshawa	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.

TABLE 5.—*Recreational development*—Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
319 Barbert	Severe: percs slowly, floods, wetness.	Severe: floods, wetness.	Severe: percs slowly, wetness.	Severe: floods, wetness.
321 Tilfer	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
329 Chaska	Severe: wetness, floods.	Severe: wetness	Severe: wetness, floods.	Severe: wetness.
349 Calco	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness.
353 Comfrey	Severe: wetness, floods.	Severe: wetness	Severe: wetness, floods.	Severe: wetness.
354 Dorchester	Severe: floods	Moderate: floods	Moderate: floods	Slight.
360B Lasa	Moderate: too sandy	Moderate: too sandy	Severe: slope	Moderate: too sandy.
360E Lasa	Severe: slope	Severe: slope	Severe: slope	Moderate: slope, too sandy.
363 Minneopa	Slight	Slight	Slight	Slight.
364 Minnetonka	Severe: wetness, percs slowly.	Severe: wetness	Severe: wetness, percs slowly.	Severe: wetness.
414 Hamel	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
440 Copaston	Slight	Slight	Severe: depth to rock.	Slight.
448 Shorewood	Moderate: percs slowly, too clayey.	Moderate: too clayey	Moderate: slope, too clayey, percs slowly.	Moderate: too clayey.
451 Dorchester	Severe: floods	Slight	Moderate: floods	Slight.
524 Caron	Severe: excess humus, wetness.	Severe: excess humus, wetness.	Severe: excess humus, wetness.	Severe: excess humus, wetness.
525 Muskego	Severe: wetness, excess humus, floods.	Severe: wetness, excess humus.	Severe: wetness, excess humus, floods.	Severe: wetness, excess humus.
539, 548 Palms	Severe: wetness, floods, excess humus.	Severe: wetness, floods, excess humus.	Severe: wetness, floods, excess humus.	Severe: wetness, floods, excess humus.
851* Chaska-Urban land	Severe: wetness, floods.	Moderate: wetness	Severe: wetness	Moderate: wetness.
852* Copaston-Urban land	Slight	Slight	Severe: depth to rock.	Slight.
853* Copaston-Urban land	Moderate: large stones.	Slight	Severe: depth to rock.	Moderate: large stones.
854* Cordova-Urban land	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
855* Dorchester-Urban land	Severe: floods	Slight	Slight	Slight.
856B* Terril-Urban land	Slight	Slight	Moderate: slope	Slight.

TABLE 5.—*Recreational development*—Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
856C*: Terril-Urban land	Moderate: slope	Moderate: slope	Severe: slope	Slight.
909C*:				
Bold	Moderate: slope	Moderate: slope	Severe: slope	Slight.
Truman	Moderate: slope	Moderate: slope	Severe: slope	Slight.
909D*:				
Bold	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
Truman	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
919*:				
Canisteo	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Fieldon	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
920B*:				
Clarion	Slight	Slight	Moderate: slope	Slight.
Estherville	Slight	Slight	Moderate: slope	Slight.
920C*:				
Clarion	Moderate: slope	Moderate: slope	Severe: slope	Slight.
Estherville	Moderate: slope	Moderate: slope	Severe: slope	Slight.
920D*:				
Clarion	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
Estherville	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
921C*:				
Clarion	Moderate: slope	Moderate: slope	Severe: slope	Slight.
Storden	Moderate: slope	Moderate: slope	Severe: slope	Slight.
921D*:				
Clarion	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
Storden	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
923*: Copaston	Slight	Slight	Severe: depth to rock.	Slight.
926*:				
Darfur	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Webster	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
929*:				
Fieldon	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Canisteo	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
932*:				
Glencoe	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness.
Dassel	Severe: wetness, floods.	Severe: wetness	Severe: wetness, floods.	Severe: wetness.
941*:				
Kingston	Moderate: too clayey	Moderate: too clayey	Moderate: too clayey	Moderate: too clayey.
Nicollet	Moderate: too clayey	Moderate: too clayey	Moderate: too clayey, wetness.	Moderate: too clayey.

TABLE 5.—*Recreational development*—Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
946*:				
Litchfield	Moderate: too sandy	Moderate: too sandy	Moderate: too sandy	Moderate: too sandy.
Nicollet	Moderate: too clayey	Moderate: too clayey	Moderate: too clayey, wetness.	Moderate: too clayey.
947*:				
Madelia	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Webster	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
960E*:				
Storden	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
Clarion	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
961*, 961F* Storden	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
968*:				
Webster	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Darfur	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Granby	Severe: wetness, floods.	Severe: wetness	Severe: wetness, floods.	Severe: wetness.
978*:				
Cordova	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Rolfe	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness.
992*:				
Rock outcrop.				
Copaston	Severe: slope	Severe: slope	Severe: depth to rock, slope.	Severe: slope.
996*:				
Beauford	Severe: too clayey, wetness.	Severe: too clayey, wetness.	Severe: too clayey, wetness.	Severe: too clayey, wetness.
Barbert	Severe: percs slowly, floods, wetness.	Severe: wetness	Severe: percs slowly, wetness, floods.	Severe: wetness.
997*:				
Marna	Severe: wetness, too clayey.	Severe: wetness, too clayey.	Severe: wetness, too clayey.	Severe: wetness, too clayey.
Barbert	Severe: percs slowly, floods, wetness.	Severe: wetness	Severe: percs slowly, wetness, floods.	Severe: wetness.
998*:				
Minnetonka	Severe: wetness, percs slowly.	Severe: wetness	Severe: wetness, percs slowly.	Severe: wetness.
Barbert	Severe: percs slowly, floods, wetness.	Severe: wetness	Severe: percs slowly, wetness, floods.	Severe: wetness.
1001*, 1002*, 1004*. Alluvial land				
1007*. Alluvial-Urban land				
1032*. Lake beaches				
1039*. Urban land				
1053*. Marsh				

TABLE 5.—*Recreational development*—Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
1800 Caron	Severe: excess humus, wetness.	Severe: excess humus, wetness.	Severe: excess humus, wetness.	Severe: excess humus, wetness.
1801B Grogan	Slight	Slight	Moderate: slope	Slight.

*See map unit description for the composition and behavior of the map unit.

expected soil behavior in engineering uses. As appropriate, these values can be applied to each major horizon of each soil or to the entire profile.

These factors of soil behavior affect construction and maintenance of roads, airport runways, pipelines, foundations for small buildings, ponds and small dams, irrigation projects, drainage systems, sewage and refuse disposal systems, and other engineering works. The ranges of values can be used to (1) select potential residential, commercial, industrial, and recreational uses; (2) make preliminary estimates pertinent to construction in a particular area; (3) evaluate alternative routes for roads, streets, highways, pipelines, and underground cables; (4) evaluate alternative sites for location of sanitary landfills, onsite sewage disposal systems, and other waste disposal facilities; (5) plan detailed onsite investigations of soils and geology; (6) find sources of gravel, sand, clay, and topsoil; (7) plan farm drainage systems, irrigation systems, ponds, terraces, and other structures for soil and water conservation; (8) relate performance of structures already built to the properties of the kinds of soil on which they are built so that performance of similar structures on the same or a similar soil in other locations can be predicted; and (9) predict the trafficability of soils for cross-country movement of vehicles and construction equipment.

Data presented in this section are useful for land-use planning and for choosing alternative practices or general designs that will overcome unfavorable soil properties and minimize soil-related failures. Limitations to the use of these data, however, should be well understood. First, the data are generally not presented for soil material below a depth of 5 or 6 feet. Also, because of the scale of the detailed map in this soil survey, small areas of soils that differ from the dominant soil may be included in mapping. Thus, these data do not eliminate the need for onsite investigations, testing, and analysis by personnel having expertise in the specific use contemplated.

The information is presented mainly in tables. Table 6 shows, for each kind of soil, the degree and kind of limitations for building site development; table 7, for sanitary facilities; and table 9, for water management. Table 8 shows the suitability of each kind of soil as a source of construction materials.

The information in the tables, along with the soil map, the soil descriptions, and other data provided in this survey, can be used to make additional interpretations and to construct interpretive maps for specific uses of land.

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

Building site development

The degree and kind of soil limitations that affect shallow excavations, dwellings with and without basements, small commercial buildings, and local roads and streets are indicated in table 6. A *slight* limitation indicates that soil properties generally are favorable for the specified use; any limitation is minor and easily overcome. A *moderate* limitation indicates that soil properties and site features are unfavorable for the specified use, but the limitations can be overcome or minimized by special planning and design. A *severe* limitation indicates that one or more soil properties or site features are so unfavorable or difficult to overcome that a major increase in construction effort, special design, or intensive maintenance is required. For some soils rated severe, such costly measures may not be feasible.

Shallow excavations are made for pipelines, sewerlines, communications and power transmission lines, basements, and open ditches. Such digging or trenching is influenced by soil wetness caused by a seasonal high water table; the texture and consistence of soils; the tendency of soils to cave in or slough; and the presence of very firm, dense soil layers, bedrock, or large stones. In addition, excavations are affected by slope of the soil and the probability of flooding. Ratings do not apply to soil horizons below a depth of 6 feet unless otherwise noted.

In the soil series descriptions, the consistence of each soil horizon is given, and the presence of very firm or extremely firm horizons, usually difficult to excavate, is indicated.

Dwellings and *small commercial buildings* referred to in table 6 are built on undisturbed soil and have foundation loads of a dwelling no more than three stories high. Separate ratings are made for small commercial buildings without basements and for dwellings with and without basements. For such structures, soils should be sufficiently stable that cracking or subsidence of the structure from settling or shear failure of the foundation does not occur. These ratings were determined from estimates of the shear strength, compressibility, and shrink-swell potential of the soil. Soil texture, plasticity and in-place density, potential frost action, soil wetness, and depth to a seasonal high water table were also considered. Soil wetness and depth to a seasonal high water table indicate potential difficulty in providing adequate drainage for basements, lawns, and gardens. Depth to bedrock, slope, and large stones

TABLE 6.—*Building site development*

[Some of the terms used in this table to describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry means soil was not rated]

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
17 Minneopa	Severe: cutbanks cave.	Severe: floods	Severe: floods, wetness.	Severe: floods	Moderate: floods, frost action.
18 Comfrey	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods, frost action.
27, 27B Dickinson	Severe: cutbanks cave.	Slight	Slight	Slight	Slight.
35 Blue Earth	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods, frost action.
39 Wadena	Severe: cutbanks cave.	Slight	Slight	Slight	Slight.
39B Wadena	Severe: cutbanks cave.	Slight	Slight	Moderate: slope	Slight.
41 Estherville	Severe: cutbanks cave.	Slight	Slight	Slight	Slight.
41B Estherville	Severe: cutbanks cave.	Slight	Slight	Moderate: slope	Slight.
41C Estherville	Severe: cutbanks cave.	Moderate: slope	Moderate: slope	Severe: slope	Moderate: slope.
62 Barrington	Moderate: wetness.	Moderate: shrink-swell.	Moderate: shrink-swell, wetness.	Moderate: shrink-swell.	Severe: frost action, low strength.
69 Fedji	Slight	Slight	Slight	Slight	Slight.
69B Fedji	Slight	Slight	Slight	Moderate: slope	Slight.
84 Brownton	Severe: wetness	Severe: shrink-swell, wetness.	Severe: shrink-swell, wetness.	Severe: shrink-swell, wetness.	Severe: shrink-swell, wetness, frost action.
85 Calco	Severe: wetness, floods.	Severe: floods, low strength, shrink-swell.	Severe: floods, low strength, shrink-swell.	Severe: floods, low strength, shrink-swell.	Severe: floods, low strength, shrink-swell.
86 Canisteo	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness	Severe: frost action, wetness.
94, 94B Terril	Moderate: wetness.	Slight	Moderate: wetness.	Slight	Moderate: low strength, frost action.
94C Terril	Moderate: wetness, slope.	Moderate: slope	Moderate: wetness, slope.	Severe: slope	Moderate: low strength, frost action, slope.
96, 96B Collinwood	Severe: too clayey.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength, frost action.
96C Collinwood	Severe: too clayey.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength, slope.	Severe: shrink-swell, low strength, frost action.

TABLE 6.—*Building site development*—Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
96D Collinwood	Severe: too clayey, slope.	Severe: shrink-swell, low strength, slope.	Severe: shrink-swell, low strength, slope.	Severe: shrink-swell, low strength, slope.	Severe: shrink-swell, low strength, frost action.
100 Copaston	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.
101B Truman	Slight	Moderate: shrink-swell, low strength.	Moderate: shrink-swell, low strength.	Moderate: slope, shrink-swell, low strength.	Severe: frost action.
101C Truman	Moderate: slope	Moderate: slope, shrink-swell.	Moderate: slope	Severe: slope	Severe: frost action.
102B Clarion	Slight	Slight	Slight	Slight	Moderate: low strength, frost action.
102C Clarion	Moderate: slope	Moderate: slope	Moderate: slope	Severe: slope	Moderate: low strength, frost action, slope.
102D Clarion	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
105B Kamrar	Moderate: too clayey.	Moderate: low strength, shrink-swell.	Moderate: low strength, shrink-swell.	Moderate: low strength, shrink-swell.	Severe: low strength.
105C Kamrar	Moderate: too clayey, slope.	Moderate: low strength, shrink-swell, slope.	Moderate: low strength, shrink-swell, slope.	Severe: slope	Severe: low strength.
105D Kamrar	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: low strength.
106B Lester	Moderate: too clayey.	Moderate: shrink-swell, low strength.	Moderate: shrink-swell, low strength.	Moderate: slope, shrink-swell, low strength.	Severe: low strength.
106C Lester	Moderate: too clayey, slope.	Moderate: slope, shrink-swell.	Moderate: slope, shrink-swell, low strength.	Severe: slope	Severe: low strength.
106D, 106E Lester	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: low strength, slope.
109 Cordova	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness	Severe: frost action, wetness.
110 Marna	Severe: wetness, too clayey.	Severe: wetness, floods, shrink-swell.	Severe: wetness, floods, shrink-swell.	Severe: wetness, floods, shrink-swell.	Severe: wetness, frost action, shrink-swell.
113 Webster	Severe: wetness	Severe: low strength, shrink-swell, wetness.	Severe: low strength, shrink-swell, wetness.	Severe: low strength, shrink-swell, wetness.	Severe: low strength, shrink-swell, wetness.
114 Glencoe	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods, frost action.
128 Grogan	Slight	Moderate: low strength.	Moderate: low strength.	Moderate: low strength.	Severe: frost action.
128B Grogan	Slight	Moderate: low strength.	Moderate: low strength.	Moderate: low strength, slope.	Severe: frost action.
130 Nicollet	Moderate: wetness.	Moderate: shrink-swell.	Moderate: wetness, shrink-swell.	Moderate: shrink-swell.	Severe: frost action, low strength.

TABLE 6.—*Building site development*—Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
134 Okoboji	Severe: wetness	Severe: wetness, low strength, shrink-swell.	Severe: wetness, low strength, shrink-swell.	Severe: wetness, low strength, shrink-swell.	Severe: wetness, low strength, shrink-swell.
136 Madelia	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness, frost action.
138B2 Lerdal	Severe: wetness, too clayey.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: shrink-swell, wetness.	Severe: frost action, shrink-swell, low strength.
138C2 Lerdal	Severe: wetness, too clayey.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: shrink-swell, wetness, slope.	Severe: frost action, shrink-swell, low strength.
140 Spicer	Severe: wetness	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, frost action.
160 Fieldon	Severe: wetness, cutbanks cave.	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness, frost action.
178 Granby	Severe: wetness, cutbanks cave, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.
181 Litchfield	Severe: cutbanks cave.	Slight	Moderate: wetness.	Slight	Moderate: frost action, wetness.
183 Dassel	Severe: wetness, floods, cutbanks cave.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods, frost action.
196 Joliet	Severe: wetness, floods, depth to rock.	Severe: wetness, floods, depth to rock.	Severe: wetness, floods, depth to rock.	Severe: wetness, floods, depth to rock.	Severe: wetness, floods, depth to rock.
197 Kingston	Moderate: wetness.	Moderate: shrink-swell, low strength.	Moderate: low strength, wetness, shrink-swell.	Moderate: shrink-swell, low strength.	Severe: frost action, low strength.
211 Lura	Severe: wetness, floods, too clayey.	Severe: wetness, floods, shrink-swell.	Severe: wetness, floods, shrink-swell.	Severe: wetness, floods, shrink-swell.	Severe: wetness, floods, shrink-swell.
219 Rolfe	Severe: wetness, floods.	Severe: wetness, low strength, shrink-swell.	Severe: wetness, low strength, shrink-swell.	Severe: wetness, low strength, shrink-swell.	Severe: wetness, low strength, shrink-swell.
222B Lasa	Severe: cutbanks cave.	Slight	Slight	Moderate: slope	Slight.
229 Waldorf	Severe: wetness, too clayey.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, frost action, shrink-swell.
230 Guckeen	Moderate: wetness.	Moderate: shrink-swell, low strength.	Moderate: wetness, shrink-swell, low strength.	Moderate: shrink-swell, low strength.	Severe: frost action, low strength.
238B Kilkenny	Moderate: too clayey.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: slope, shrink-swell.	Severe: low strength.
238C Kilkenny	Moderate: too clayey, slope.	Moderate: shrink-swell, slope.	Moderate: slope, shrink-swell.	Severe: slope	Severe: low strength.
238D Kilkenny	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: low strength, slope.

TABLE 6.—*Building site development*—Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
239 Le Sueur	Moderate: wetness, too clayey.	Moderate: shrink-swell, low strength.	Moderate: shrink-swell, low strength, wetness.	Moderate: shrink-swell, low strength.	Severe: frost action, low strength.
248 Lomax	Slight	Slight	Slight	Slight	Moderate: frost action, low strength.
259B Grays	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: frost action, low strength.
275B Ocheyedan	Slight	Slight	Slight	Slight	Moderate: low strength, frost action.
281 Darfur	Severe: wetness, cutbanks cave.	Severe: wetness	Severe: wetness.	Severe: wetness	Severe: wetness, frost action.
286 Shorewood	Severe: too clayey.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.	Severe: frost action, shrink-swell, low strength.
287 Minnetonka	Severe: wetness, too clayey.	Severe: wetness, low strength, shrink-swell.	Severe: wetness, low strength, shrink-swell.	Severe: wetness, low strength, shrink-swell.	Severe: wetness, frost action, shrink-swell.
310 Beauford	Severe: wetness	Severe: shrink-swell, wetness.	Severe: shrink-swell, wetness.	Severe: wetness, corrosive, shrink-swell.	Severe: shrink-swell, wetness.
311 Shorewood	Severe: too clayey.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.	Severe: frost action, shrink-swell, low strength.
316 Baroda	Severe: wetness, too clayey.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.
317 Oshawa	Severe: wetness, floods.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, frost action, wetness.
319 Barbert	Severe: wetness, floods, too clayey.	Severe: shrink-swell, wetness, floods.	Severe: shrink-swell, wetness, floods.	Severe: wetness, shrink-swell, floods.	Severe: shrink-swell, wetness, floods.
321 Tilfer	Severe: depth to rock, wetness.	Severe: wetness, depth to rock, floods.	Severe: wetness, depth to rock, floods.	Severe: wetness, depth to rock, floods.	Severe: wetness, depth to rock, floods.
329 Chaska	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods, frost action.
349 Calco	Severe: wetness, floods.	Severe: floods, low strength, shrink-swell.	Severe: floods, low strength, shrink-swell.	Severe: floods, low strength, shrink-swell.	Severe: floods, low strength, shrink-swell.
353 Comfrey	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods, frost action.
354 Dorchester	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Severe: floods, low strength, frost action.
360B Lasa	Moderate: depth to rock.	Slight	Moderate: depth to rock.	Moderate: slope, depth to rock.	Slight.

TABLE 6.—*Building site development*—Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
360E Lasa	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
363 Minneopa	Severe: floods	Severe: floods	Severe: floods, wetness.	Severe: floods	Severe: floods.
364 Minnetonka	Severe: wetness, too clayey.	Severe: wetness, low strength, shrink-swell.	Severe: wetness, low strength, shrink-swell.	Severe: wetness, low strength, shrink-swell.	Severe: wetness, frost action, shrink-swell.
414 Hamel	Severe: wetness	Severe: wetness	Severe: wetness.	Severe: wetness	Severe: wetness, frost action, low strength.
440 Copaston	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.
448 Shorewood	Severe: too clayey.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.	Severe: frost action, low strength, shrink-swell.
451 Dorchester	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Severe: floods, low strength, frost action.
524 Caron	Severe: excess humus, wetness, floods.	Severe: excess humus, low strength, wetness.	Severe: excess humus, low strength, wetness.	Severe: excess humus, low strength, wetness.	Severe: excess humus, low strength, wetness.
525 Muskego	Severe: wetness, excess humus, floods.	Severe: wetness, low strength, floods.	Severe: wetness, low strength, floods.	Severe: wetness, low strength, floods.	Severe: wetness, low strength, floods.
539 Palms	Severe: wetness, excess humus, cutbanks cave.	Severe: wetness, frost action, excess humus.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, frost action, low strength.
548 Palms	Severe: wetness, excess humus, cutbanks cave.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods, excess humus.
851* Chaska	Severe: wetness	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, frost action.
852*, 853* Copaston	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.
854* Cordova	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness	Severe: frost action, wetness.
855* Dorchester	Moderate: wetness.	Severe: floods	Severe: floods	Severe: floods	Severe: low strength, frost action.
856B* Terril	Moderate: wetness.	Slight	Moderate: wetness.	Moderate: slope	Moderate: low strength, frost action.
856C* Terril	Moderate: wetness, slope.	Moderate: slope	Moderate: wetness, slope.	Severe: slope	Moderate: low strength, frost action, slope.
909C*:					
Bold	Moderate: slope	Moderate: slope	Moderate: slope	Severe: slope	Severe: frost action.
Truman	Moderate: slope	Moderate: slope, shrink-swell.	Moderate: slope	Severe: slope	Severe: frost action.

TABLE 6.—*Building site development*—Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
909D*:					
Bold	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: frost action.
Truman	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: frost action, slope.
919*:					
Canisteo	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness	Severe: frost action, wetness.
Fieldon	Severe: wetness, cutbanks cave.	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness, frost action.
920B*:					
Clarion	Slight	Slight	Slight	Moderate: slope	Moderate: low strength, frost action.
Estherville	Severe: cutbanks cave.	Slight	Slight	Moderate: slope	Slight.
920C*:					
Clarion	Moderate: slope	Moderate: slope	Moderate: slope	Severe: slope	Moderate: low strength, frost action.
Estherville	Severe: cutbanks cave.	Moderate: slope	Moderate: slope	Severe: slope	Moderate: slope.
920D*:					
Clarion	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
Estherville	Severe: cutbanks cave, slope.	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
921C*:					
Clarion	Moderate: slope	Moderate: slope	Moderate: slope	Severe: slope	Moderate: low strength, frost action, slope.
Storden	Moderate: slope	Moderate: slope	Moderate: slope	Severe: slope	Moderate: slope, frost action.
921D*:					
Clarion	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
Storden	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
923* Copaston	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.
926*:					
Darfur	Severe: wetness, cutbanks cave.	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness, frost action.
Webster	Severe: wetness	Severe: low strength, shrink-swell, wetness.	Severe: low strength, shrink-swell, wetness.	Severe: low strength, shrink-swell, wetness.	Severe: low strength, shrink-swell, wetness.
929*:					
Fieldon	Severe: wetness, cutbanks cave.	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness, frost action.
Canisteo	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness	Severe: frost action, wetness.
932*:					
Glencoe	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods, frost action.

TABLE 6.—*Building site development*—Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
Dassel	Severe: wetness, floods, cutbanks cave.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods, frost action.
941*:					
Kingston	Moderate: wetness.	Moderate: shrink-swell, low strength.	Moderate: low strength, wetness, shrink-swell.	Moderate: shrink-swell, low strength.	Severe: frost action, low strength.
Nicollet	Moderate: wetness.	Moderate: shrink-swell.	Moderate: wetness, shrink-swell.	Moderate: shrink-swell.	Severe: frost action, low strength.
946*:					
Litchfield	Severe: cutbanks cave.	Slight	Moderate: wetness.	Slight	Moderate: frost action, wetness.
Nicollet	Moderate: wetness.	Moderate: shrink-swell.	Moderate: wetness, shrink-swell.	Moderate: shrink-swell.	Severe: frost action, low strength.
947*:					
Madelia	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness, frost action.
Webster	Severe: wetness	Severe: low strength, shrink-swell, wetness.	Severe: low strength, shrink-swell, wetness.	Severe: low strength, shrink-swell, wetness.	Severe: low strength, shrink-swell, wetness.
960E*:					
Storden	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
Clarion	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
961*, 961F* Storden	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
968*:					
Webster	Severe: wetness	Severe: low strength, shrink-swell, wetness.	Severe: low strength, shrink-swell, wetness.	Severe: low strength, shrink-swell, wetness.	Severe: low strength, shrink-swell, wetness.
Darfur	Severe: wetness, cutbanks cave.	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness, frost action.
Granby	Severe: wetness, cutbanks cave, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.
978*:					
Cordova	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness	Severe: frost action, wetness.
Rolfe	Severe: wetness, floods.	Severe: wetness, low strength, shrink-swell.	Severe: wetness, low strength, shrink-swell.	Severe: wetness, low strength, shrink-swell.	Severe: wetness, low strength, shrink-swell.
992*:					
Rock outcrop.					
Copaston	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.
996*:					
Beauford	Severe: wetness, too clayey.	Severe: shrink-swell, wetness.	Severe: shrink-swell, wetness.	Severe: wetness, corrosive, shrink-swell.	Severe: shrink-swell, wetness.
Barbert	Severe: wetness, floods, too clayey.	Severe: shrink-swell, wetness, floods.	Severe: shrink-swell, wetness, floods.	Severe: wetness, shrink-swell, floods.	Severe: shrink-swell, wetness, floods.

TABLE 6.—*Building site development*—Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
997*:					
Marna	Severe: wetness, too clayey.	Severe: wetness, floods, shrink-swell.	Severe: wetness, floods, shrink-swell.	Severe: wetness, floods, shrink-swell.	Severe: wetness, frost action, shrink-swell.
Barbert	Severe: wetness, floods, too clayey.	Severe: shrink-swell, wetness, floods.	Severe: shrink-swell, wetness, floods.	Severe: wetness, shrink-swell, floods.	Severe: shrink-swell, wetness, floods.
998*:					
Minnetonka	Severe: wetness, too clayey.	Severe: wetness, low strength, shrink-swell.	Severe: wetness, low strength, shrink-swell.	Severe: wetness, low strength, shrink-swell.	Severe: wetness, frost action, shrink-swell.
Barbert	Severe: wetness, floods, too clayey.	Severe: shrink-swell, wetness, floods.	Severe: shrink-swell, wetness, floods.	Severe: wetness, shrink-swell, floods.	Severe: shrink-swell, wetness, floods.
1001*, 1002*, 1004*. Alluvial land					
1007*. Alluvial-Urban land					
1032*. Lake beaches					
1039* Urban land					
1053*. Marsh					
1800 Caron	Severe: excess humus, wetness.	Severe: excess humus, low strength, wetness.	Severe: excess humus, low strength, wetness.	Severe: excess humus, low strength, wetness.	Severe: excess humus, low strength, wetness.
1801B Grogan	Slight	Moderate: low strength.	Moderate: low strength.	Moderate: low strength, slope.	Severe: frost action.

* See map unit description for the composition and behavior of the map unit.

in or on the soil are also important considerations in the choice of sites for these structures and were considered in determining the ratings. Susceptibility to flooding is a serious hazard.

Local roads and streets referred to in table 6 have an all-weather surface that can carry light to medium traffic all year. They consist of a subgrade of the underlying soil material; a base of gravel, crushed rock fragments, or soil material stabilized with lime or cement; and a flexible or rigid surface, commonly asphalt or concrete. The roads are graded with soil material at hand, and most cuts and fills are less than 6 feet deep.

The load supporting capacity and the stability of the soil as well as the quantity and workability of fill material available are important in design and construction of roads and streets. The classifications of the soil and the soil texture, density, shrink-swell potential, and potential frost action are indicators of the traffic supporting capacity used in making the ratings. Soil wetness, flooding, slope, depth to hard rock or very compact layers, and content of large stones affect stability and ease of excavation.

Sanitary facilities

Favorable soil properties and site features are needed for proper functioning of septic tank absorption fields, sewage lagoons, and sanitary landfills. The nature of the soil is important in selecting sites for these facilities and in identifying limiting soil properties and site features to be considered in design and installation. Also, those soil properties that affect ease of excavation or installation of these facilities will be of interest to contractors and local officials. Table 7 shows the degree and kind of limitations of each soil for such uses and for use of the soil as daily cover for landfills. It is important to observe local ordinances and regulations.

If the degree of soil limitation is expressed as *slight*, soils are generally favorable for the specified use and limitations are minor and easily overcome; if *moderate*, soil properties or site features are unfavorable for the specified use, but limitations can be overcome by special

TABLE 7.—*Sanitary facilities*

[Some of the terms used in this table to describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," "good," "fair," and other terms used to rate soils. Absence of an entry means soil was not rated]

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
17 Minneopa	Severe: wetness	Severe: seepage	Severe: seepage, wetness.	Severe: seepage	Fair: thin layer.
18 Comfrey	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness.
27, 27B Dickinson	Slight	Severe: seepage	Severe: seepage	Severe: seepage	Fair: thin layer.
35 Blue Earth	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness.
39, 39B Wadena	Slight	Severe: seepage	Severe: seepage	Severe: seepage	Fair: thin layer.
41, 41B Estherville	Slight	Severe: seepage	Severe: too sandy, seepage.	Severe: seepage	Fair: thin layer, too sandy.
41C Estherville	Moderate: slope	Severe: seepage, slope.	Severe: too sandy, seepage.	Severe: seepage	Fair: thin layer, too sandy, slope.
62 Barrington	Moderate: wetness.	Severe: seepage	Severe: seepage, wetness.	Slight	Fair: too clayey.
69 Fedji	Moderate: percs slowly.	Moderate: seepage.	Slight	Slight	Fair: too sandy, thin layer.
69B Fedji	Moderate: percs slowly.	Moderate: slope, seepage.	Slight	Slight	Fair: too sandy, thin layer.
84 Brownton	Severe: percs slowly.	Moderate: excess humus.	Severe: wetness	Severe: wetness	Poor: wetness.
85 Calco	Severe: percs slowly, wetness, floods.	Severe: excess humus, wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness.
86 Canisteo	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness	Poor: wetness.
94, 94B Terril	Slight	Moderate: seepage, excess humus.	Slight	Slight	Good.
94C Terril	Moderate: slope	Severe: slope	Slight	Moderate: slope	Fair: slope.
96 Collinwood	Severe: percs slowly.	Slight	Severe: wetness, too clayey.	Moderate: wetness.	Poor: too clayey.
96B Collinwood	Severe: percs slowly.	Moderate: slope	Severe: wetness, too clayey.	Moderate: wetness.	Poor: too clayey.
96C Collinwood	Severe: percs slowly.	Severe: slope	Severe: wetness, too clayey.	Moderate: wetness, slope.	Poor: too clayey.
96D Collinwood	Severe: percs slowly, slope.	Severe: slope	Severe: wetness, too clayey.	Severe: slope	Poor: too clayey, slope.
100 Copaston	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Slight	Poor: thin layer.
101B Truman	Slight	Moderate: slope, seepage.	Slight	Slight	Good.
101C Truman	Moderate: slope	Severe: slope	Slight	Moderate: slope	Fair: slope.
102B Clarion	Slight	Moderate: slope, seepage.	Slight	Slight	Good.

TABLE 7.—*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
102C --------------- Clarion	Moderate: slope --	Severe: slope, seepage.	Slight ------------	Moderate: slope --	Fair: slope.
102D --------------- Clarion	Severe: slope ----	Severe: slope, seepage.	Moderate: slope --	Severe: slope ----	Poor: slope.
105B --------------- Kamrar	Severe: percs slowly.	Moderate: slope, seepage, excess humus.	Moderate: too clayey.	Slight ------------	Fair: too clayey.
105C --------------- Kamrar	Severe: percs slowly.	Severe: slope ----	Moderate: too clayey.	Slight ------------	Fair: too clayey.
105D --------------- Kamrar	Severe: percs slowly.	Severe: slope ----	Moderate: too clayey.	Moderate: slope --	Fair: too clayey, slope.
106B --------------- Lester	Moderate: percs slowly.	Moderate: slope, seepage.	Slight ------------	Slight ------------	Fair: too clayey.
106C --------------- Lester	Moderate: percs slowly, slope.	Severe: slope ----	Slight ------------	Moderate: slope --	Fair: slope, too clayey.
106D, 106E ---------- Lester	Severe: slope ----	Severe: slope ----	Moderate: slope --	Severe: slope ----	Poor: slope.
109 ---------------- Cordova	Severe: percs slowly, wetness.	Severe: wetness --	Severe: wetness --	Severe: wetness --	Poor: wetness.
110 ---------------- Marna	Severe: wetness, percs slowly.	Moderate: excess humus, wetness.	Severe: wetness, too clayey.	Severe: wetness --	Poor: wetness, too clayey.
113 ---------------- Webster	Severe: wetness --	Severe: excess humus, wetness.	Severe: wetness --	Severe: wetness --	Poor: wetness.
114 ---------------- Glencoe	Severe: wetness, floods, percs slowly.	Severe: wetness, excess humus, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness, excess humus.
128, 128B ----------- Grogan	Slight ------------	Severe: seepage --	Severe: seepage --	Severe: seepage --	Good.
130 ---------------- Nicollet	Severe: wetness --	Moderate: wetness.	Severe: wetness --	Moderate: wetness.	Fair: too clayey.
134 ---------------- Okoboji	Severe: percs slowly, wetness, floods.	Severe: excess humus.	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness.
136 ---------------- Madelia	Severe: wetness --	Severe: wetness --	Severe: wetness --	Severe: wetness --	Poor: wetness.
138B2 --------------- Lerdal	Severe: percs slowly.	Moderate: slope --	Severe: too clayey.	Severe: wetness --	Poor: too clayey.
138C2 --------------- Lerdal	Severe: percs slowly.	Severe: slope ----	Severe: too clayey.	Severe: wetness --	Poor: too clayey.
140 ---------------- Spicer	Severe: wetness --	Severe: wetness --	Severe: wetness --	Severe: wetness --	Poor: wetness.
160 ---------------- Fieldon	Severe: wetness --	Severe: seepage, wetness.	Severe: wetness, seepage.	Severe: seepage, wetness.	Poor: wetness.
178 ---------------- Granby	Severe: wetness, floods.	Severe: wetness, seepage.	Severe: wetness, seepage, floods.	Severe: wetness, seepage, floods.	Poor: wetness, too sandy.
181 ---------------- Litchfield	Moderate: wetness.	Severe: seepage --	Severe: seepage --	Severe: seepage --	Fair: too sandy.
183 ---------------- Dassel	Severe: wetness, floods.	Severe: wetness, seepage.	Severe: wetness, floods, seepage.	Severe: wetness, floods, seepage.	Poor: wetness.

TABLE 7.—*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
196 Joliet	Severe: depth to rock, wetness, floods.	Severe: depth to rock.	Severe: depth to rock, wetness, floods.	Severe: wetness, floods.	Poor: thin layer, wetness.
197 Kingston	Severe: wetness	Moderate: wetness, seepage.	Severe: wetness	Moderate: wetness.	Fair: too clayey.
211 Lura	Severe: wetness, percs slowly, floods.	Moderate: excess humus.	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness, too clayey.
219 Rolfe	Severe: floods, percs slowly, wetness.	Severe: wetness	Severe: floods, wetness, too clayey.	Severe: floods, wetness.	Poor: wetness.
222B Lasa	Slight	Severe: seepage	Severe: seepage	Severe: seepage	Poor: too sandy.
229 Waldorf	Severe: wetness, percs slowly.	Severe: wetness	Severe: wetness, too clayey.	Severe: wetness	Poor: wetness, too clayey.
230 Guckeen	Severe: percs slowly.	Moderate: excess humus.	Severe: wetness	Moderate: wetness.	Fair: too clayey.
238B Kilkenny	Severe: percs slowly.	Moderate: slope	Moderate: too clayey.	Slight	Fair: too clayey.
238C Kilkenny	Severe: percs slowly.	Severe: slope	Moderate: too clayey.	Moderate: slope	Fair: too clayey, slope.
238D Kilkenny	Severe: percs slowly, slope.	Severe: slope	Moderate: too clayey, slope.	Severe: slope	Poor: slope.
239 Le Sueur	Moderate: percs slowly.	Moderate: wetness.	Moderate: wetness.	Moderate: wetness.	Fair: too clayey.
248 Lomax	Slight	Severe: seepage	Severe: seepage	Severe: seepage	Good.
259B Grays	Slight	Moderate: slope, seepage.	Slight	Slight	Good.
275B Ocheyedan	Slight	Moderate: seepage, excess humus, slope.	Slight	Slight	Good.
281 Darfur	Severe: wetness	Severe: wetness, seepage.	Severe: wetness, seepage.	Severe: wetness, seepage.	Poor: wetness.
286 Shorewood	Severe: percs slowly.	Slight	Severe: wetness, too clayey.	Moderate: wetness.	Poor: too clayey.
287 Minnetonka	Severe: wetness, percs slowly.	Slight	Severe: wetness, too clayey.	Severe: wetness	Poor: wetness, too clayey.
310 Beauford	Severe: percs slowly, wetness.	Moderate: excess humus.	Severe: wetness	Severe: wetness	Poor: wetness, too clayey.
311 Shorewood	Severe: percs slowly.	Slight	Severe: wetness, too clayey.	Moderate: wetness.	Poor: too clayey.
316 Baroda	Severe: wetness, percs slowly.	Moderate: excess humus.	Severe: wetness	Severe: wetness	Poor: wetness, too clayey.
317 Oshawa	Severe: floods, percs slowly, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Poor: wetness.
319 Barbert	Severe: percs slowly, wetness.	Slight	Severe: floods, wetness.	Severe: floods, wetness.	Poor: wetness, too clayey.

TABLE 7.—*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
321 Tilfer	Severe: wetness, depth to rock.	Severe: wetness, depth to rock.	Severe: wetness, depth to rock.	Severe: wetness, depth to rock.	Poor: wetness, area reclaim.
329 Chaska	Severe: wetness, floods.	Severe: wetness, floods, seepage.	Severe: wetness, floods, seepage.	Severe: wetness, floods.	Poor: wetness.
349 Calco	Severe: percs slowly, wetness, floods.	Severe: excess humus, wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness.
353 Comfrey	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness.
354 Dorchester	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Good.
360B Lasa	Moderate: depth to rock.	Severe: seepage	Severe: seepage, depth to rock.	Severe: seepage	Poor: too sandy.
360E Lasa	Severe: slope	Severe: seepage, slope.	Severe: seepage, depth to rock.	Severe: seepage, slope.	Poor: too sandy, slope.
363 Minneopa	Severe: floods	Severe: seepage	Severe: seepage, floods.	Severe: seepage, floods.	Fair: thin layer.
364 Minnetonka	Severe: wetness, percs slowly.	Moderate: seepage, wetness.	Severe: wetness, too clayey.	Severe: wetness	Poor: wetness, too clayey.
414 Hamel	Severe: wetness, percs slowly.	Severe: wetness	Severe: wetness	Severe: wetness	Poor: wetness.
440 Copaston	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Slight	Poor: thin layer.
448 Shorewood	Severe: wetness, percs slowly.	Severe: wetness	Moderate: wetness.	Slight	Poor: thin layer.
451 Dorchester	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Good.
524 Caron	Severe: wetness, floods.	Severe: excess humus, wetness, floods.	Severe: excess humus, wetness, floods.	Severe: wetness, floods.	Poor: excess humus, wetness.
525 Muskego	Severe: wetness, floods.	Severe: wetness, floods, excess humus.	Severe: wetness, floods, excess humus.	Severe: wetness, floods.	Poor: wetness, hard to pack.
539, 548 Palms	Severe: wetness, flood.	Severe: wetness, excess humus, seepage.	Severe: wetness, floods, seepage.	Severe: wetness, floods, seepage.	Poor: excess humus, hard to pack.
851* Chaska	Severe: wetness	Severe: wetness, seepage.	Severe: wetness, seepage.	Severe: wetness	Poor: wetness.
852*, 853* Copaston	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Slight	Poor: thin layer.
854* Cordova	Severe: percs slowly, wetness.	Severe: wetness	Severe: wetness	Severe: wetness	Poor: wetness.
855* Dorchester	Severe: wetness	Severe: wetness	Severe: wetness	Moderate: wetness.	Good.
856B* Terril	Slight	Moderate: seepage, excess humus.	Slight	Slight	Good.
856C* Terril	Moderate: slope	Severe: slope	Moderate: slope	Slight	Fair: slope.

TABLE 7.—*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
909C*:					
Bold	Moderate: slope	Severe: slope	Slight	Moderate: slope	Fair: slope.
Truman	Moderate: slope	Severe: slope	Slight	Moderate: slope	Fair: slope.
909D*:					
Bold	Severe: slope	Severe: slope	Moderate: slope	Severe: slope	Poor: slope.
Truman	Severe: slope	Severe: slope	Moderate: slope	Severe: slope	Poor: slope.
919*:					
Canisteo	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness	Poor: wetness.
Fieldon	Severe: wetness	Severe: seepage, wetness.	Severe: wetness, seepage.	Severe: seepage, wetness.	Poor: wetness.
920B*:					
Clarion	Slight	Moderate: slope, seepage.	Slight	Slight	Good.
Estherville	Slight	Severe: seepage	Severe: too sandy, seepage.	Severe: seepage	Fair: thin layer, too sandy.
920C*:					
Clarion	Moderate: slope	Severe: slope, seepage.	Slight	Moderate: slope	Fair: slope.
Estherville	Moderate: slope	Severe: seepage, slope.	Severe: too sandy, seepage.	Severe: seepage	Fair: thin layer, too sandy, slope.
920D*:					
Clarion	Severe: slope	Severe: slope, seepage.	Moderate: slope	Severe: slope	Poor: slope.
Estherville	Severe: slope	Severe: seepage, slope.	Severe: too sandy, seepage.	Severe: seepage, slope.	Poor: slope.
921C*:					
Clarion	Moderate: slope	Severe: slope	Slight	Moderate: slope	Fair: slope.
Storden	Moderate: slope	Severe: slope	Slight	Moderate: slope	Fair: slope.
921D*:					
Clarion	Severe: slope	Severe: slope	Moderate: slope	Severe: slope	Poor: slope.
Storden	Severe: slope	Severe: slope	Moderate: slope	Severe: slope	Poor: slope.
923* Copaston	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Slight	Poor: thin layer.
926*:					
Darfur	Severe: wetness	Severe: wetness, seepage.	Severe: wetness, seepage.	Severe: wetness, seepage.	Poor: wetness.
Webster	Severe: wetness	Severe: excess humus, wetness.	Severe: wetness	Severe: wetness	Poor: wetness.
929*:					
Fieldon	Severe: wetness	Severe: seepage, wetness.	Severe: wetness, seepage.	Severe: seepage, wetness.	Poor: wetness.
Canisteo	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness	Poor: wetness.
932*:					
Glencoe	Severe: wetness, floods, percs slowly.	Severe: wetness, excess humus, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness, excess humus.
Dassel	Severe: wetness, floods.	Severe: wetness, floods, seepage.	Severe: wetness, floods, seepage.	Severe: wetness, floods, seepage.	Poor: wetness.

TABLE 7.—*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
941*:					
Kingston	Severe: wetness	Moderate: wetness, seepage.	Severe: wetness	Moderate: wetness.	Fair: too clayey.
Nicollet	Severe: wetness	Moderate: wetness, seepage.	Severe: wetness	Moderate: wetness.	Fair: too clayey.
946*:					
Litchfield	Moderate: wetness.	Severe: seepage	Severe: seepage	Severe: seepage	Fair: too sandy.
Nicollet	Severe: wetness	Moderate: wetness, seepage.	Severe: wetness	Moderate: wetness.	Fair: too clayey.
947*:					
Madelia	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness	Poor: wetness.
Webster	Severe: wetness	Severe: excess humus, wetness.	Severe: wetness	Severe: wetness	Poor: wetness.
960E*:					
Storden	Severe: slope	Severe: slope	Moderate: slope	Severe: slope	Poor: slope.
960E*:					
Clarion	Severe: slope	Severe: slope	Moderate: slope	Severe: slope	Poor: slope.
961*, 961F* Storden	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Poor: slope.
968*:					
Webster	Severe: wetness	Severe: excess humus, wetness.	Severe: wetness	Severe: wetness	Poor: wetness.
Darfur	Severe: wetness	Severe: wetness, seepage.	Severe: wetness, seepage.	Severe: wetness, seepage.	Poor: wetness.
Granby	Severe: wetness, floods.	Severe: wetness, seepage, floods.	Severe: wetness, seepage, floods.	Severe: wetness, seepage, floods.	Poor: wetness, too sandy.
978*:					
Cordova	Severe: percs slowly, wetness.	Severe: wetness	Severe: wetness	Severe: wetness	Poor: wetness.
Rolfe	Severe: floods, percs slowly, wetness.	Severe: wetness	Severe: floods, wetness, too clayey.	Severe: floods, wetness.	Poor: wetness.
992*:					
Rock outcrop.					
Copaston	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock.	Severe: slope	Poor: thin layer, slope.
996*:					
Beauford	Severe: percs slowly, wetness.	Moderate: excess humus.	Severe: wetness	Severe: wetness	Poor: wetness, too clayey.
Barbert	Severe: percs slowly, wetness.	Slight	Severe: floods, wetness.	Severe: floods, wetness.	Poor: wetness, too clayey.
997*:					
Marna	Severe: wetness, percs slowly.	Moderate: excess humus, wetness.	Severe: wetness, too clayey.	Severe: wetness	Poor: wetness, too clayey.
Barbert	Severe: percs slowly, wetness.	Slight	Severe: floods, wetness.	Severe: floods, wetness.	Poor: wetness, too clayey.
998*:					
Minnetonka	Severe: wetness, percs slowly.	Slight	Severe: wetness, too clayey.	Severe: wetness	Poor: wetness, too clayey.
Barbert	Severe: percs slowly, wetness.	Slight	Severe: floods, wetness.	Severe: floods, wetness.	Poor: wetness, too clayey.

TABLE 7.—*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
1001*, 1002*, 1004*. Alluvial land					
1007*. Alluvial-Urban land					
1032*. Lake beaches					
1039*. Urban land					
1053*. Marsh					
1800 Caron	Severe: wetness	Severe: excess humus, wetness.	Severe: excess humus, wetness.	Severe: wetness	Poor: excess humus, wetness.
1801B Grogan	Slight	Severe: seepage	Severe: seepage	Severe: seepage	Good.

* See map unit description for the composition and behavior of the map unit.

planning and design; and if *severe,* soil properties or site features are so unfavorable or difficult to overcome that major soil reclamation, special designs, or intensive maintenance is required. Soil suitability is rated by the terms *good, fair,* or *poor,* which, respectively, mean about the same as the terms *slight, moderate,* and *severe.*

Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into the natural soil. Only the soil horizons between depths of 18 and 72 inches are evaluated for this use. The soil properties and site features considered are those that affect the absorption of the effluent and those that affect the construction of the system.

Properties and features that affect absorption of the effluent are permeability, depth to seasonal high water table, depth to bedrock, and susceptibility to flooding. Stones, boulders, and shallowness to bedrock interfere with installation. Excessive slope can cause lateral seepage and surfacing of the effluent. Also, soil erosion and soil slippage are hazards if absorption fields are installed on sloping soils.

In some soils, loose sand and gravel or fractured bedrock is less than 4 feet below the tile lines. In these soils the absorption field does not adequately filter the effluent, and ground water in the area may be contaminated.

On many of the soils that have moderate or severe limitations for use as septic tank absorption fields, a system to lower the seasonal water table can be installed or the size of the absorption field can be increased so that performance is satisfactory.

Sewage lagoons are shallow ponds constructed to hold sewage while aerobic bacteria decompose the solid and liquid wastes. Lagoons have a nearly level floor and cut slopes or embankments of compacted soil material. Aerobic lagoons generally are designed to hold 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. Soils that are very high in content of organic matter and those that have cobbles, stones, or boulders are not suitable. Unless the soil has very slow permeability, contamination of ground water is a hazard where the seasonal high water table is above the level of the lagoon floor. In soils where the water table is seasonally high, seepage of ground water into the lagoon can seriously reduce the lagoon's capacity for liquid waste. Slope, depth to bedrock, and susceptibility to flooding also affect the suitability of sites for sewage lagoons or the cost of construction. Shear strength and permeability of compacted soil material affect the performance of embankments.

Sanitary landfill is a method of disposing of solid waste by placing refuse in successive layers either in excavated trenches or on the surface of the soil. The waste is spread, compacted, and covered daily with a thin layer of soil material. Landfill areas are subject to heavy vehicular traffic. Risk of polluting ground water and trafficability affect the suitability of a soil for this use. The best soils have a loamy or silty texture, have moderate to slow permeability, are deep to a seasonal water table, and are not subject to flooding. Clayey soils are likely to be sticky and difficult to spread. Sandy or gravelly soils generally have rapid permeability, which might allow noxious liquids to contaminate ground water. Soil wetness can be a limitation, because operating heavy equipment on a wet soil is difficult. Seepage into the refuse increases the risk of pollution of ground water.

Ease of excavation affects the suitability of a soil for the trench type of landfill. A suitable soil is deep to bedrock and free of large stones and boulders. If the seasonal water table is high, water will seep into trenches.

Unless otherwise stated, the limitations in table 7

TABLE 8.—*Construction materials*

[Some of the terms used in this table to describe restrictive soil features are defined in the Glossary. See text for definitions of "good," "fair," "poor," and "unsuited." Absence of an entry means soil was not rated]

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
17 Minneopa	Good	Poor: excess fines	Unsuited	Good.
18 Comfrey	Poor: wetness	Unsuited	Unsuited	Poor: wetness.
27, 27B Dickinson	Good	Fair: excess fines	Unsuited	Good.
35 Blue Earth	Poor: low strength	Unsuited	Unsuited	Poor: wetness.
39, 39B Wadena	Good	Good	Fair: excess fines	Poor: area reclaim.
41, 41B, 41C Estherville	Good	Good	Good	Poor: area reclaim.
62 Barrington	Poor: low strength	Unsuited	Unsuited	Fair: thin layer.
69, 69B Fedji	Fair: thin layer	Unsuited	Unsuited	Poor: too sandy.
84 Brownton	Poor: shrink-swell, wetness.	Unsuited	Unsuited	Poor: wetness, excess lime, too clayey.
85 Calco	Poor: wetness, shrink-swell, low strength.	Unsuited	Unsuited	Poor: wetness.
86 Canisteo	Poor: low strength	Unsuited	Unsuited	Poor: excess lime, wetness.
94, 94B, 94C Terril	Fair: low strength	Unsuited	Unsuited	Good.
96, 96B Collinwood	Poor: shrink-swell, low strength.	Unsuited	Unsuited	Fair: too clayey.
96C Collinwood	Poor: shrink-swell, low strength.	Unsuited	Unsuited	Fair: too clayey, slope.
96D Collinwood	Poor: shrink-swell, low strength.	Unsuited	Unsuited	Poor: slope.
100 Copaston	Poor: thin layer	Unsuited	Unsuited	Fair: thin layer, area reclaim.
101B Truman	Fair: low strength	Unsuited	Unsuited	Good.
101C Truman	Fair: low strength	Unsuited	Unsuited	Fair: slope.
102B, 102C Clarion	Fair: low strength	Unsuited	Unsuited	Good.
102D Clarion	Fair: low strength, slope.	Unsuited	Unsuited	Poor: slope.
105B, 105C, 105D Kamrar	Poor: low strength	Unsuited	Unsuited	Poor: too clayey.
106B Lester	Poor: low strength	Unsuited	Unsuited	Fair: too clayey.
106C Lester	Poor: low strength	Unsuited	Unsuited	Fair: slope, too clayey.

TABLE 8.—*Construction materials*—Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
106D, 106E Lester	Poor: low strength	Unsuited	Unsuited	Poor: slope.
109 Cordova	Poor: wetness	Unsuited	Unsuited	Poor: wetness.
110 Marna	Poor: shrink-swell, wetness.	Unsuited	Unsuited	Poor: too clayey, wetness.
113 Webster	Poor: wetness, shrink-swell, low strength.	Unsuited	Unsuited	Poor: wetness.
114 Glencoe	Poor: wetness, low strength.	Unsuited	Unsuited	Poor: wetness.
128, 128B Grogan	Good	Unsuited	Unsuited	Good.
130 Nicollet	Poor: low strength	Unsuited	Unsuited	Fair: too clayey.
134 Okoboji	Poor: wetness, low strength, shrink-swell.	Unsuited	Unsuited	Poor: wetness.
136 Madelia	Poor: wetness	Unsuited	Unsuited	Poor: wetness.
138B2 Lerdal	Poor: shrink-swell, low strength.	Unsuited	Unsuited	Fair: too clayey.
138C2 Lerdal	Poor: shrink-swell, low strength.	Unsuited	Unsuited	Fair: too clayey, slope.
140 Spicer	Poor: wetness, low strength.	Unsuited	Unsuited	Poor: wetness, excess lime.
160 Fieldon	Poor: wetness	Fair: excess fines	Unsuited	Poor: wetness.
178 Granby	Poor: wetness	Good	Unsuited	Poor: wetness.
181 Litchfield	Fair: wetness	Fair: excess fines	Poor: excess fines	Poor: too sandy.
183 Dassel	Poor: wetness	Poor: excess fines	Unsuited	Poor: wetness.
196 Joliet	Poor: wetness, thin layer.	Unsuited	Unsuited	Poor: wetness, area reclaim.
197 Kingston	Poor: low strength	Unsuited	Unsuited	Fair: too clayey.
211 Lura	Poor: shrink-swell, wetness.	Unsuited	Unsuited	Poor: wetness, too clayey.
219 Rolfe	Poor: low strength, shrink-swell, wetness.	Unsuited	Unsuited	Poor: wetness.
222B Lasa	Good	Poor: excess fines	Unsuited	Poor: too sandy.
229 Waldorf	Poor: wetness, shrink-swell.	Unsuited	Unsuited	Poor: wetness, too clayey.
230 Guckeen	Poor: low strength	Unsuited	Unsuited	Fair: too clayey.
238B Kilkenny	Poor: low strength	Unsuited	Unsuited	Fair: too clayey.

TABLE 8.—*Construction materials*—Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
238C Kilkenny	Poor: low strength	Unsuited	Unsuited	Fair: too clayey, slope.
238D Kilkenny	Poor: low strength	Unsuited	Unsuited	Poor: slope.
239 Le Sueur	Poor: low strength	Unsuited	Unsuited	Fair: too clayey.
248 Lomax	Fair: low strength	Good	Unsuited	Good.
259B Grays	Poor: low strength	Unsuited	Unsuited	Fair: thin layer.
275B Ocheyedan	Fair: low strength	Unsuited	Unsuited	Good.
281 Darfur	Poor: wetness	Poor: excess fines	Unsuited	Poor: wetness.
286 Shorewood	Poor: shrink-swell, low strength.	Unsuited	Unsuited	Fair: thin layer, too clayey.
287 Minnetonka	Poor: shrink-swell, wetness.	Unsuited	Unsuited	Poor: too clayey, wetness.
310 Beauford	Poor: shrink-swell, wetness.	Unsuited	Unsuited	Poor: too clayey, wetness.
311 Shorewood	Poor: shrink-swell, low strength.	Unsuited	Unsuited	Poor: too clayey.
316 Baroda	Poor: wetness, shrink-swell.	Unsuited	Unsuited	Poor: wetness, too clayey.
317 Oshawa	Poor: wetness	Unsuited	Unsuited	Poor: wetness.
319 Barbert	Poor: shrink-swell, wetness.	Unsuited	Unsuited	Poor: wetness.
321 Tilfer	Poor: wetness, area reclaim.	Unsuited	Unsuited	Poor: wetness, area reclaim.
329 Chaska	Poor: wetness	Unsuited	Unsuited	Poor: wetness, excess lime.
349 Calco	Poor: wetness, shrink-swell, low strength.	Unsuited	Unsuited	Poor: wetness.
353 Comfrey	Poor: wetness	Unsuited	Unsuited	Poor: wetness.
354 Dorchester	Poor: low strength	Unsuited	Unsuited	Fair: excess lime.
360B Lasa	Good	Poor: excess fines	Unsuited	Poor: too sandy.
360E Lasa	Fair: slope	Poor: excess fines	Unsuited	Poor: too sandy, slope.
363 Minneopa	Good	Poor: excess fines	Unsuited	Good.
364 Minnetonka	Poor: shrink-swell, wetness.	Unsuited	Unsuited	Poor: too clayey, wetness.
414 Hamel	Poor: wetness, low strength.	Unsuited	Unsuited	Poor: wetness.

TABLE 8.—*Construction materials*—Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
440 Copaston	Poor: thin layer	Unsuited	Unsuited	Fair: thin layer.
448 Shorewood	Poor: low strength, shrink-swell.	Unsuited	Unsuited	Fair: too clayey.
451 Dorchester	Poor: low strength	Unsuited	Unsuited	Fair: excess lime.
524 Caron	Poor: excess humus, wetness.	Unsuited	Unsuited	Poor: wetness.
525 Muskego	Poor: wetness, low strength.	Unsuited	Unsuited	Poor: wetness, excess humus.
539, 548 Palms	Poor: wetness, excess humus.	Unsuited	Unsuited	Poor: wetness.
851* Chaska	Poor: wetness	Unsuited	Unsuited	Poor: wetness, excess lime.
852* Copaston	Poor: thin layer	Unsuited	Unsuited	Fair: thin layer.
853* Copaston	Poor: thin layer	Unsuited	Unsuited	Poor: large stones.
854* Cordova	Poor: wetness	Unsuited	Unsuited	Poor: wetness.
855* Dorchester	Poor: low strength	Unsuited	Unsuited	Fair: excess lime.
856B*, 856C* Terril	Fair: low strength	Unsuited	Unsuited	Good.
909C*:				
Bold	Fair: low strength	Unsuited	Unsuited	Fair: slope.
Truman	Fair: low strength	Unsuited	Unsuited	Fair: slope.
909D*:				
Bold	Fair: low strength, slope.	Unsuited	Unsuited	Poor: slope.
Truman	Fair: low strength, slope.	Unsuited	Unsuited	Poor: slope.
919*:				
Canisteo	Poor: low strength	Unsuited	Unsuited	Poor: excess lime, wetness.
Fieldon	Poor: wetness	Fair: excess fines	Unsuited	Poor: wetness.
920B*, 920C*:				
Clarion	Fair: low strength	Unsuited	Unsuited	Good.
Estherville	Good	Good	Good	Poor: area reclaim.
920D*:				
Clarion	Fair: low strength	Unsuited	Unsuited	Fair: slope.
Estherville	Fair: slope	Good	Good	Poor: area reclaim, slope.
921C*:				
Clarion	Fair: low strength	Unsuited	Unsuited	Good.
Storden	Fair: low strength	Unsuited	Unsuited	Fair: slope, thin layer.

TABLE 8.—*Construction materials*—Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
921D*:				
Clarion	Fair: slope, low strength.	Unsuited	Unsuited	Fair: slope.
Storden	Fair: slope, low strength.	Unsuited	Unsuited	Poor: slope.
923* Copaston	Poor: thin layer	Unsuited	Unsuited	Fair: thin layer.
926*:				
Darfur	Poor: wetness	Poor: excess fines	Unsuited	Poor: wetness.
Webster	Poor: wetness, shrink-swell, low strength.	Unsuited	Unsuited	Poor: wetness.
929*:				
Fieldon	Poor: wetness	Fair: excess fines	Unsuited	Poor: wetness.
Canisteo	Poor: low strength	Unsuited	Unsuited	Poor: excess lime, wetness.
932*:				
Glencoe	Poor: wetness, low strength.	Unsuited	Unsuited	Poor: wetness.
Dassel	Poor: wetness	Poor: excess fines	Unsuited	Poor: wetness.
941*:				
Kingston	Poor: low strength	Unsuited	Unsuited	Fair: too clayey.
Nicollet	Poor: low strength	Unsuited	Unsuited	Fair: too clayey.
946*:				
Litchfield	Fair: wetness	Fair: excess fines	Poor: excess fines	Poor: too sandy.
Nicollet	Poor: low strength	Unsuited	Unsuited	Fair: too clayey.
947*:				
Madelia	Poor: wetness	Unsuited	Unsuited	Poor: wetness.
Webster	Poor: wetness, shrink-swell, low strength.	Unsuited	Unsuited	Poor: wetness.
960E*:				
Storden	Fair: slope, low strength.	Unsuited	Unsuited	Poor: slope.
Clarion	Fair: low strength, slope.	Unsuited	Unsuited	Poor: slope.
961*, 961F* Storden	Poor: slope	Unsuited	Unsuited	Poor: slope.
968*:				
Webster	Poor: wetness, shrink-swell, low strength.	Unsuited	Unsuited	Poor: wetness.
Darfur	Poor: wetness	Poor: excess fines	Unsuited	Poor: wetness.
Granby	Poor: wetness	Good	Unsuited	Poor: wetness.
978*:				
Cordova	Poor: frost action, wetness.	Unsuited	Unsuited	Poor: wetness.
Rolfe	Poor: low strength, shrink-swell, wetness.	Unsuited	Unsuited	Poor: wetness.

TABLE 8.—*Construction materials*—Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
992*: Rock outcrop.				
Copaston	Poor: thin layer	Unsuited	Unsuited	Poor: slope.
996*: Beauford	Poor: shrink-swell, wetness.	Unsuited	Unsuited	Poor: too clayey, wetness.
Barbert	Poor: shrink-swell	Unsuited	Unsuited	Poor: wetness.
997*: Marna	Poor: shrink-swell, wetness.	Unsuited	Unsuited	Poor: too clayey, wetness.
Barbert	Poor: shrink-swell	Unsuited	Unsuited	Poor: wetness.
998*: Minnetonka	Poor: shrink-swell, wetness.	Unsuited	Unsuited	Poor: too clayey, wetness.
Barbert	Poor: shrink-swell	Unsuited	Unsuited	Poor: wetness.
1001*, 1002*, 1004*. Alluvial land				
1007*. Alluvial-Urban land				
1032*. Lake beaches				
1039*. Urban land				
1053*. Marsh				
1800 Caron	Poor: excess humus, wetness.	Unsuited	Unsuited	Poor: wetness.
1801B Grogan	Good	Unsuited	Unsuited	Good.

*See map unit description for the composition and behavior of the map unit.

apply only to the soil material within a depth of about 6 feet. If the trench is deeper, a limitation of slight or moderate may not be valid. Site investigation is needed before a site is selected.

Daily cover for landfill should be soil that is easy to excavate and spread over the compacted fill in wet and dry periods. Soils that are loamy or silty and free of stones or boulders are better than other soils. Clayey soils may be sticky and difficult to spread; sandy soils may be subject to soil blowing.

The soils selected for final cover of landfills should be suitable for growing plants. Of all the horizons, the A horizon in most soils has the best workability, more organic matter, and the best potential for growing plants. Thus, for either the area- or trench-type landfill, stockpiling material from the A horizon for use as the surface layer of the final cover is desirable.

Where it is necessary to bring in soil material for daily or final cover, thickness of suitable soil material available and depth to a seasonal high water table in soils surrounding the sites should be evaluated. Other factors to be evaluated are those that affect reclamation of the borrow areas. These factors include slope, erodibility, and potential for plant growth.

Construction materials

The suitability of each soil as a source of roadfill, sand, gravel, and topsoil is indicated in table 8 by ratings of good, fair, or poor. The texture, thickness, and organic-matter content of each soil horizon are important factors in rating soils for use as construction materials. Each soil is evaluated to the depth observed, generally about 6 feet.

Roadfill is soil material used in embankments for roads. Soils are evaluated as a source of roadfill for low embankments, which generally are less than 6 feet high and less exacting in design than high embankments. The ratings reflect the ease of excavating and working the material and the expected performance of the material where it has been compacted and adequately drained. The performance of soil after it is stabilized with lime or cement is not considered in the ratings, but

TABLE 9.—*Water management*

[Some of the terms used in this table to describe restrictive soil features are defined in the Glossary. Absence of an entry means soil was not evaluated]

Soil name and map symbol	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
17 Minneopa	Seepage	Piping	Not needed	Fast intake, wetness, floods.	Not needed	Favorable.
18 Comfrey	Favorable	Compressible, low strength.	Wetness, floods.	Wetness, floods.	Not needed	Wetness.
27, 27B Dickinson	Seepage	Seepage, piping.	Not needed	Soil blowing, droughty, fast intake.	Too sandy, soil blowing, complex slope.	Droughty.
35 Blue Earth	Favorable	Low strength, compressible, excess humus.	Wetness, floods.	Wetness	Not needed	Wetness.
39, 39B Wadena	Seepage	Seepage	Not needed	Droughty, rooting depth.	Rooting depth	Rooting depth.
41, 41B Estherville	Seepage	Seepage, piping.	Not needed	Rooting depth, droughty.	Rooting depth, too sandy.	Rooting depth.
41C Estherville	Seepage	Seepage, piping.	Not needed	Complex slope, rooting depth, droughty.	Complex slope, rooting depth, too sandy.	Slope, rooting depth.
62 Barrington	Seepage	Low strength, piping.	Not needed	Favorable	Erodes easily	Erodes easily.
69, 69B Fedji	Seepage	Favorable	Not needed	Droughty, soil blowing.	Soil blowing, too sandy, slope.	Droughty, erodes easily, slope.
84 Brownton	Favorable	Compressible, low strength.	Percs slowly, wetness.	Slow intake, wetness.	Not needed	Percs slowly, wetness.
85 Calco	Favorable	Compressible, low strength, hard to pack.	Floods, wetness, frost action.	Floods, wetness.	Not needed	Wetness.
86 Canisteo	Favorable	Compressible, low strength.	Favorable	Wetness	Not needed	Wetness.
94, 94B, 94C Terril	Favorable	Low strength, compressible.	Not needed	Slope	Favorable	Favorable.
96, 96B Collinwood	Favorable	Compressible, low strength, shrink-swell.	Not needed	Percs slowly, slow intake.	Percs slowly	Percs slowly.
96C, 96D Collinwood	Slope	Compressible, low strength, shrink-swell.	Not needed	Percs slowly, slow intake, slope.	Percs slowly, slope.	Percs slowly, slope.
100 Copaston	Depth to rock	Thin layer	Not needed	Droughty, rooting depth.	Depth to rock	Rooting depth.
101B Truman	Seepage	Piping, low strength.	Not needed	Favorable	Favorable	Erodes easily, slope.
101C Truman	Seepage	Piping, low strength.	Not needed	Erodes easily, slope.	Slope, erodes easily.	Erodes easily, slope.
102B, 102C, 102D Clarion	Favorable	Low strength, piping.	Not needed	Complex slope, erodes easily.	Complex slope, erodes easily.	Erodes easily.
105B, 105C, 105D Kamrar	Favorable	Low strength, compressible, shrink-swell.	Not needed	Slow intake, percs slowly, slope.	Favorable	Percs slowly.

TABLE 9.—*Water management*—Continued

Soil name and map symbol	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
106B, 106C, 106D, 106E Lester	Favorable	Low strength	Not needed	Complex slope, erodes easily.	Complex slope, erodes easily.	Erodes easily, slope.
109 Cordova	Favorable	Low strength	Percs slowly, frost action.	Wetness	Not needed	Percs slowly, wetness.
110 Marna	Favorable	Shrink-swell, low strength, compressible.	Percs slowly, wetness, frost action.	Slow intake, wetness.	Not needed	Percs slowly, wetness.
113 Webster	Favorable	Compressible, low strength, hard to pack.	Wetness, frost action.	Wetness, slow intake.	Not needed	Wetness.
114 Glencoe	Favorable	Compressible, low strength.	Wetness, floods.	Wetness	Not needed	Wetness.
128, 128B Grogan	Seepage	Piping, low strength.	Not needed	Favorable	Favorable	Erodes easily, slope.
130 Nicollet	Favorable	Shrink-swell, low strength, piping.	Not needed	Wetness	Not needed	Favorable.
134 Okoboji	Favorable	Compressible, low strength, shrink-swell.	Percs slowly, poor outlets, wetness.	Wetness, percs slowly.	Not needed	Not needed.
136 Madelia	Favorable	Erodes easily, low strength, piping.	Wetness, frost action, floods.	Wetness	Not needed	Wetness.
138B2, 138C2 Lerdal	Favorable	Shrink-swell, erodes easily.	Complex slope, percs slowly, wetness.	Complex slope, percs slowly, wetness.	Complex slope, percs slowly, wetness.	Percs slowly, slope, wetness.
140 Spicer	Seepage	Low strength, piping, erodes easily.	Wetness, frost action.	Wetness	Not needed	Wetness.
160 Fieldon	Seepage	Piping, compressible.	Cutbanks cave, wetness.	Wetness	Wetness	Wetness.
178 Granby	Seepage	Seepage, piping.	Cutbanks cave, floods.	Wetness, fast intake, floods.	Not needed	Wetness.
181 Litchfield	Seepage	Piping	Not needed	Seepage, wetness.	Not needed	Rooting depth.
183 Dassel	Seepage	Piping	Wetness, floods, cutbanks cave.	Wetness	Not needed	Wetness.
196 Joliet	Depth to rock	Thin layer	Poor outlets	Wetness	Not needed	Not needed.
197 Kingston	Favorable	Low strength, piping, shrink-swell.	Not needed	Favorable	Not needed	Favorable.
211 Lura	Favorable	Shrink-swell, low strength.	Floods, wetness, percs slowly.	Wetness, slow intake.	Not needed	Percs slowly, wetness.
219 Rolfe	Favorable	Low strength, compressible, shrink-swell.	Floods, percs slowly, poor outlets.	Floods, percs slowly, wetness.	Not needed	Not needed.
222B Lasa	Seepage	Piping	Not needed	Seepage, fast intake.	Erodes easily	Erodes easily, slope, droughty.

TABLE 9.—*Water management*—Continued

Soil name and map symbol	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
229 Waldorf	Favorable	Shrink-swell, low strength.	Wetness, percs slowly, frost action.	Wetness, slow intake.	Not needed	Wetness, percs slowly.
230 Guckeen	Favorable	Low strength, compressible.	Not needed	Slow intake	Percs slowly	Percs slowly.
238B, 238C, 238D Kilkenny	Favorable	Hard to pack, shrink-swell.	Not needed	Slopes, erodes easily.	Erodes easily, percs slowly, slope.	Erodes easily, percs slowly, slope.
239 Le Sueur	Favorable	Shrink-swell, low strength.	Not needed	Slow intake	Not needed	Favorable.
248 Lomax	Seepage	Piping	Not needed	Favorable	Favorable	Favorable.
259B Grays	Seepage	Piping	Not needed	Slope, erodes easily.	Favorable	Slope, erodes easily.
275B Ocheyedan	Seepage	Low strength, piping.	Not needed	Erodes easily	Erodes easily	Erodes easily.
281 Darfur	Seepage	Piping, low strength.	Wetness, cutbanks cave.	Wetness	Not needed	Wetness.
286 Shorewood	Favorable	Shrink-swell, low strength.	Not needed	Slow intake	Not needed	Percs slowly, wetness.
287 Minnetonka	Favorable	Shrink-swell, piping.	Percs slowly, wetness, frost action.	Wetness, slow intake.	Not needed	Percs slowly, wetness.
310 Beauford	Favorable	Low strength, shrink-swell.	Percs slowly, wetness.	Percs slowly, wetness.	Not needed	Percs slowly, wetness.
311 Shorewood	Favorable	Shrink-swell, low strength.	Not needed	Slow intake	Not needed	Percs slowly, wetness.
316 Baroda	Favorable	Low strength, compressible.	Wetness, percs slowly.	Wetness, slow intake.	Not needed	Wetness, percs slowly.
317 Oshawa	Favorable	Compressible, low strength.	Floods, percs slowly.	Floods, wetness.	Not needed	Percs slowly, wetness.
319 Barbert	Favorable	Low strength, shrink-swell.	Percs slowly, poor outlets.	Percs slowly, wetness.	Not needed	Not needed.
321 Tilfer	Depth to rock	Thin layer, low strength.	Depth to rock, wetness.	Rooting depth, wetness.	Not needed	Not needed.
329 Chaska	Seepage	Compressible, low strength, piping.	Wetness, floods.	Wetness, excess lime.	Not needed	Wetness.
349 Calco	Favorable	Compressible, low strength, hard to pack.	Floods, wetness, frost action.	Floods, wetness.	Not needed	Wetness.
353 Comfrey	Favorable	Compressible, low strength.	Wetness, floods.	Wetness, floods.	Not needed	Wetness.
354 Dorchester	Seepage	Compressible, low strength, piping.	Floods	Floods	Favorable	Erodes easily.
360B, 360E Lasa	Depth to rock, seepage.	Piping, seepage.	Not needed	Droughty, seepage.	Depth to rock, erodes easily.	Droughty, erodes easily.
363 Minneopa	Seepage	Piping	Not needed	Floods, droughty.	Not needed	Favorable.

TABLE 9.—*Water management*—Continued

Soil name and map symbol	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
364 Minnetonka	Favorable	Shrink-swell, piping.	Percs slowly, wetness, frost action.	Wetness, slow intake.	Not needed	Percs slowly, wetness.
414 Hamel	Favorable	Shrink-swell, low strength, compressible.	Wetness, frost action.	Wetness	Not needed	Wetness.
440 Copaston	Depth to rock	Thin layer	Not needed	Droughty, rooting depth.	Depth to rock	Rooting depth.
448 Shorewood	Seepage	Shrink-swell, low strength, piping.	Not needed	Slow intake, percs slowly.	Favorable	Percs slowly.
451 Dorchester	Seepage	Compressible, low strength, piping.	Floods	Floods, excess lime.	Favorable	Erodes easily.
524 Caron	Seepage	Compressible, low strength, excess humus.	Cutbanks cave, floods, wetness.	Wetness, soil blowing, fast intake.	Not needed	Not needed.
525 Muskego	Seepage	Excess humus, unstable fill, hard to pack.	Wetness, floods.	Wetness, floods, soil blowing.	Not needed	Not needed.
539 Palms	Seepage	Compressible, hard to pack, low strength.	Wetness, floods, cutbanks cave.	Wetness, fast intake, soil blowing.	Not needed	Not needed.
548 Palms	Seepage	Compressible, hard to pack, low strength.	Floods, cutbanks cave, wetness.	Wetness, fast intake, soil blowing.	Not needed	Not needed.
851* Chaska	Seepage	Compressible, low strength, piping.	Wetness, floods.	Wetness, excess lime.	Not needed	Wetness.
852*, 853* Copaston	Depth to rock	Thin layer	Not needed	Droughty, rooting depth.	Depth to rock	Rooting depth.
854* Cordova	Favorable	Low strength	Percs slowly, frost action.	Wetness	Not needed	Percs slowly, wetness.
855* Dorchester	Seepage	Compressible, low strength, piping.	Not needed	Favorable	Favorable	Erodes easily.
856B*, 856C* Terril	Favorable	Low strength, compressible.	Not needed	Slope	Favorable	Favorable.
909C*, 909D*:						
Bold	Seepage, slope	Piping	Not needed	Slope, erodes easily.	Slope, erodes easily.	Erodes easily, slope.
Truman	Seepage	Piping, low strength.	Not needed	Erodes easily, slope.	Slope, erodes easily.	Erodes easily, slope.
919*:						
Canisteo	Favorable	Compressible, low strength.	Favorable	Wetness	Not needed	Wetness.
Fieldon	Seepage	Piping, compressible.	Cutbanks cave, wetness.	Wetness	Wetness	Wetness.
920B*:						
Clarion	Favorable	Low strength, piping.	Not needed	Complex slope, erodes easily.	Complex slope, erodes easily.	Erodes easily.
Estherville	Seepage	Seepage, piping.	Not needed	Rooting depth	Rooting depth, too sandy.	Rooting depth.

TABLE 9.—*Water management*—Continued

Soil name and map symbol	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
920C*, 920D*:						
Clarion	Favorable	Low strength, piping.	Not needed	Complex slope, erodes easily.	Complex slope, erodes easily.	Erodes easily.
Estherville	Seepage	Seepage, piping.	Not needed	Complex slope, rooting depth.	Complex slope, rooting depth, too sandy.	Slope, rooting depth.
921C*, 921D*:						
Clarion	Favorable	Low strength, piping.	Not needed	Complex slope, erodes easily.	Complex slope, erodes easily.	Erodes easily.
Storden	Seepage	Low strength	Not needed	Complex slope, erodes easily.	Complex slope, erodes easily.	Erodes easily.
923* Copaston	Depth to rock	Thin layer	Not needed	Droughty, rooting depth.	Depth to rock	Rooting depth.
926*:						
Darfur	Seepage	Piping, low strength.	Wetness, cut-banks cave.	Wetness	Not needed	Wetness.
Webster	Favorable	Compressible, low strength, hard to pack.	Wetness, frost action.	Wetness, slow intake.	Not needed	Wetness.
929*:						
Fieldon	Seepage	Piping, compressible.	Cutbanks cave, wetness.	Wetness	Wetness	Wetness.
Canisteo	Favorable	Compressible, low strength.	Favorable	Wetness	Not needed	Wetness.
932*:						
Glencoe	Favorable	Compressible, low strength.	Wetness, floods.	Wetness	Not needed	Wetness.
Dassel	Seepage	Piping	Wetness, floods, cutbanks cave.	Wetness	Not needed	Wetness.
941*:						
Kingston	Favorable	Low strength, piping, shrink-swell.	Not needed	Favorable	Not needed	Favorable.
Nicollet	Favorable	Shrink-swell, low strength, piping.	Not needed	Favorable	Not needed	Favorable.
946*:						
Litchfield	Seepage	Piping	Not needed	Seepage, wetness.	Not needed	Rooting depth.
Nicollet	Favorable	Shrink-swell, low strength, piping.	Not needed	Favorable	Not needed	Favorable.
947*:						
Madelia	Favorable	Erodes easily, low strength, piping.	Wetness, frost action, floods.	Wetness	Not needed	Wetness.
Webster	Favorable	Compressible, low strength, hard to pack.	Wetness, frost action.	Wetness, slow intake.	Not needed	Wetness.
960E*:						
Storden	Seepage	Low strength	Not needed	Complex slope, erodes easily.	Complex slope, erodes easily.	Erodes easily.
Clarion	Favorable	Low strength, piping.	Not needed	Complex slope, erodes easily.	Complex slope, erodes easily.	Erodes easily.
961*, 961F* Storden	Seepage	Low strength	Not needed	Complex slope, erodes easily.	Complex slope, erodes easily.	Erodes easily.

TABLE 9.—*Water management*—Continued

Soil name and map symbol	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
968*:						
Webster	Favorable	Compressible, low strength, hard to pack.	Wetness, frost action.	Wetness, slow intake.	Not needed	Wetness.
Darfur	Seepage	Piping, low strength.	Wetness, cutbanks cave.	Wetness	Not needed	Wetness.
Granby	Seepage	Seepage, piping.	Cutbanks cave, floods.	Wetness, fast intake, floods.	Not needed	Wetness.
978*:						
Cordova	Favorable	Low strength	Percs slowly, frost action.	Wetness	Not needed	Percs slowly, wetness.
Rolfe	Favorable	Low strength, compressible, shrink-swell.	Floods, percs slowly, poor outlets.	Floods, percs slowly, wetness.	Not needed	Not needed.
992*:						
Rock outcrop.						
Copaston	Depth to rock	Thin layer	Not needed	Droughty, rooting depth.	Depth to rock	Rooting depth.
996*:						
Beauford	Favorable	Low strength, shrink-swell.	Percs slowly, wetness.	Percs slowly, wetness.	Not needed	Percs slowly, wetness.
Barbert	Favorable	Low strength, shrink-swell.	Percs slowly, poor outlets.	Percs slowly, wetness.	Not needed	Not needed.
997*:						
Marna	Favorable	Shrink-swell, low strength, compressible.	Percs slowly, wetness, frost action.	Slow intake, wetness.	Not needed	Percs slowly, wetness.
Barbert	Favorable	Low strength, shrink-swell.	Percs slowly, poor outlets.	Percs slowly, wetness.	Not needed	Not needed.
998*:						
Minnetonka	Favorable	Shrink-swell, piping.	Percs slowly, wetness, frost action.	Wetness, slow intake.	Not needed	Percs slowly, wetness.
Barbert	Favorable	Low strength, shrink-swell.	Percs slowly, poor outlets.	Percs slowly, wetness.	Not needed	Not needed.
1001*, 1002*, 1004*. Alluvial land						
1007*. Alluvial-Urban land						
1032*. Lake beaches						
1039*. Urban land						
1053*. Marsh						
1800 Caron	Seepage	Compressible, low strength, excess humus.	Cutbanks cave, floods, wetness.	Wetness	Not needed	Not needed.
1801B Grogan	Seepage	Piping, low strength.	Not needed	Favorable	Favorable	Erodes easily, slope.

*See map unit description for the composition and behavior of the map unit.

information about some of the soil properties that influence such performance is given in the descriptions of the soil series.

The ratings apply to the soil material between the A horizon and a depth of 5 to 6 feet. It is assumed that soil horizons will be mixed during excavation and spreading. Many soils have horizons of contrasting suitability within their profile. The estimated engineering properties in table 10 provide specific information about the nature of each horizon. This information can help determine the suitability of each horizon for roadfill.

Soils rated *good* are coarse grained. They have low shrink-swell potential, low potential frost action, and few cobbles and stones. They are at least moderately well drained and have slopes of 15 percent or less. Soils rated *fair* have a plasticity index of less than 15 and have other limiting features, such as moderate shrink-swell potential, moderately steep slopes, wetness, or many stones. If the thickness of suitable material is less than 3 feet, the entire soil is rated *poor*.

Sand and *gravel* are used in great quantities in many kinds of construction. The ratings in table 8 provide guidance as to where to look for probable sources and are based on the probability that soils in a given area contain sizable quantities of sand or gravel. A soil rated *good* or *fair* has a layer of suitable material at least 3 feet thick, the top of which is within a depth of 6 feet. Coarse fragments of soft bedrock material, such as shale and siltstone, are not considered to be sand and gravel. Fine-grained soils are not suitable sources of sand and gravel.

The ratings do not take into account depth to the water table or other factors that affect excavation of the material. Descriptions of grain size, kinds of minerals, reaction, and stratification are given in the soil series descriptions and in table 13.

Topsoil is used in areas where vegetation is to be established and maintained. Suitability is affected mainly by the ease of working and spreading the soil material in preparing a seedbed and by the ability of the soil material to support plantlife. Also considered is the damage that can result at the area from which the topsoil is taken.

The ease of excavation is influenced by the thickness of suitable material, wetness, slope, and amount of stones. The ability of the soil to support plantlife is determined by texture, structure, and the amount of soluble salts or toxic substances. Organic matter in the A1 or Ap horizons greatly increases the absorption and retention of moisture and nutrients. Therefore, the soil material from these horizons should be carefully preserved for later use.

Soils rated *good* have at least 16 inches of friable loamy material at their surface. They are free of stones and cobbles, are low in content of gravel, and have gentle slopes. They are low in soluble salts that can limit or prevent plant growth. They are naturally fertile or respond well to fertilizer. They are not so wet that excavation is difficult during most of the year.

Soils rated *fair* are loose sandy soils or firm loamy or clayey soils in which the suitable material is only 8 to 16 inches thick or soils that have appreciable amounts of gravel, stones, or soluble salt.

Soils rated *poor* are very sandy soils and very firm clayey soils; soils with suitable layers less than 8 inches thick; soils having large amounts of gravel, stones, or soluble salt; steep soils; and poorly drained soils.

Although a rating of *good* is not based entirely on high content of organic matter, a surface horizon is generally preferred for topsoil because of its organic-matter content. This horizon is designated as A1 or Ap in the soil series descriptions. The absorption and retention of moisture and nutrients for plant growth are greatly increased by organic matter.

Water management

Many soil properties and site features that affect water management practices have been identified in this soil survey. In table 9 the soil and site features that affect use are indicated for each kind of soil. This information is significant in planning, installing, and maintaining water control structures.

Pond reservoir areas hold water behind a dam or embankment. Soils best suited to this use have a low seepage potential, which is determined by permeability and the depth to fractured or permeable bedrock or other permeable material.

Embankments, dikes, and levees require soil material that is resistant to seepage, erosion, and piping and has favorable stability, shrink-swell potential, shear strength, and compaction characteristics. Large stones and organic matter in a soil downgrade the suitability of a soil for use in embankments, dikes, or levees.

Drainage of soil is affected by such soil properties as permeability; texture; depth to bedrock, hardpan, or other layers that affect the rate of water movement; depth to the water table; slope; stability of ditch-banks; susceptibility to flooding; alkalinity; and availability of outlets for drainage.

Irrigation is affected by such features as slope, susceptibility to flooding, hazards of water erosion and soil blowing, texture, presence of salts and alkali, depth of root zone, rate of water intake at the surface, permeability of the soil below the surface layer, available water capacity, need for drainage, and depth to the water table.

Terraces and diversions are embankments or a combination of channels and ridges constructed across a slope to intercept runoff. They allow water to soak into the soil or flow slowly to an outlet. Features that affect suitability of a soil for terraces are uniformity and steepness of slope; depth to bedrock, hardpan, or other unfavorable material; large stones; permeability; ease of establishing vegetation; and resistance to water erosion, soil blowing, soil slipping, and piping.

Grassed waterways are constructed to channel runoff to outlets at a nonerosive velocity. Features that affect the use of soils for waterways are slope, permeability, erodibility, wetness, and suitability for permanent vegetation.

Soil Properties

Extensive data about soil properties are summarized on the following pages. The two main sources of these data are the many thousands of soil borings made during the course of the survey and the laboratory analyses of selected soil samples from typical profiles.

In making soil borings during field mapping, soil scientists can identify several important soil properties. They note the seasonal soil moisture condition or the presence of free water and its depth. For each horizon in the profile, they note the thickness and color of the soil material; the texture, or amount of clay, silt, sand, and gravel or other coarse fragments; the structure, or the natural pattern of cracks and pores in the undisturbed soil; and the consistence of the soil material in place under the existing soil moisture conditions. They record the depth of plant roots, determine the pH or reaction of the soil, and identify any free carbonates.

Samples of soil material are analyzed in the laboratory to verify the field estimates of soil properties and to determine all major properties of key soils, especially properties that cannot be estimated accurately by field observation. Laboratory analyses are not conducted for all soil series in the survey area, but laboratory data for many soil series not tested are available from nearby survey areas.

The available field and laboratory data are summarized in tables. The tables give the estimated range of engineering properties, the engineering classifications, and the physical and chemical properties of each major horizon of each soil in the survey area. They also present data about pertinent soil and water features, engineering test data, and data obtained from physical and chemical laboratory analyses of soils.

Engineering properties

Table 10 gives esimates of engineering properties and classifications for the major horizons of each soil in the survey area.

Most soils have, within the upper 5 or 6 feet, horizons of contrasting properties. Table 10 gives information for each of these contrasting horizons in a typical profile. *Depth* to the upper and lower boundaries of each horizon is indicated. More information about the range in depth and about other properties in each horizon is given for each soil series in the section "Soil series and morphology."

Texture is described in table 10 in the standard terms used by the U.S. Department of Agriculture (*15*). These terms are defined according to percentages of sand, silt, and clay in soil material that is less than 2 millimeters in diameter. "Loam," for example, is soil material that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If a soil contains gravel or other particles coarser than sand, an appropriate modifier is added, for example, "gravelly loam." Other texture terms are defined in the Glossary.

The two systems commonly used in classifying soils for engineering use are the Unified Soil Classification System (Unified) (*2*) and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO) (*1*). See also the PCA Soil Primer (*10*).

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, plasticity index, liquid limit, and organic-matter content. Soils are grouped into 15 classes—eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt. Soils on the borderline between two classes have a duel classification symbol, for example, CL–ML.

The *AASHTO* system classifies soils according to those properties that affect their use in highway construction and maintenance. In this system a mineral soil is classified in one of seven basic groups ranging 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. At the other extreme, in group A–7, are fine-grained soils. Highly organic soils are classified in group A–8 on the basis of visual inspection.

When laboratory data are available, the A–1, A–2 and A–7 groups are further classified as follows: A–1–a, A–1–b, A–2–4, A–2–5, A–2–6, A–2–7, A–7–5, and A–7–6. As an additional refinement, the desirability of soils as subgrade material can be indicated by a group index number. These numbers range from 0 for the best subgrade material to 20 or higher for the poorest. The AASHTO classification for soils tested in the survey area, with group index numbers in parentheses, is given in table 13. The estimated classification, without group index numbers, is given in table 10. Also in table 10 the percentage, by weight, of rock fragments more than 3 inches in diameter is estimated for each major horizon. These estimates are determined mainly by observing volume percentage in the field and then converting that, by formula, to weight percentage.

Percentage of the soil material less than 3 inches in diameter that passes each of four sieves (U.S. standard) is estimated for each major horizon. The estimates are based on tests of soils that were sampled in the survey area and in nearby areas and on field estimates from many borings made during the survey.

Liquid limit and *plasticity index* indicate the effect of water on the strength and consistence of soil. These indexes are used in both the Unified and AASHTO soil classification systems. They are also used as indicators in making general predictions of soil behavior. Range in liquid limit and plasticity index are estimated on the basis of test data from the survey area or from nearby areas and on observations of the many soil borings made during the survey.

Physical and chemical properties

Table 11 shows estimated values for several soil characteristics and features that affect behavior of soils in engineering uses. These estimates are given for each major horizon, at the depths indicated, in the typical pedon of each soil. The estimates are based on field observations and on test data for these and similar soils.

Permeability is estimated on the basis of known relationships among the soil characteristics observed in the field—particularly soil structure, porosity, and gradation or texture—that influence the downward movement of water in the soil. The estimates are for vertical water movement when the soil is saturated. Not considered in the estimates is lateral seepage or such transient soil features as plowpans and surface crusts. Permeability of the soil is an important factor to be considered in planning and designing drainage systems, in evaluating the potential of soils for septic tank systems and other waste disposal systems, and in many other aspects of land use and management.

TABLE 10.—*Engineering properties*

[The symbol < means less than; > means greater than.

Soil name and map symbol	Depth	USDA texture	Classification	
			Unified	AASHTO
	In			
17 Minneopa	0–15	Sandy loam	SM	A–2, A–4
	15–20	Sandy loam	SM	A–2
	20–60	Loamy sand, sand	SM, SP–SM	A–2, A–3
18 Comfrey	0–34	Clay loam, loam	OL, OH, MH, ML	A–7
	34–60	Clay loam, loam	CL	A–7, A–6
27, 27B Dickinson	0–11	Fine sandy loam	SM, SC, SM–SC	A–4, A–2
	11–35	Fine sandy loam	SM, SC, SM–SC	A–4
	35–60	Fine sand	SM, SP–SM, SM–SC	A–2, A–3
35 Blue Earth	0–48	Mucky silt loam	OL	A–5
	48–60	Clay loam, loam, silty clay loam	CL, ML	A–6, A–7
39, 39B Wadena	0–14	Loam	ML, CL, CL–ML	A–4
	14–33	Loam, sandy loam, sandy clay loam	SM, ML, CL, SC	A–4, A–6
	33–60	Sand and gravel	SP, SP–SM	A–1, A–3
41, 41B, 41C Estherville	0–14	Sandy loam	SM, SM–SC, SC	A–2, A–4
	14–22	Sandy loam, loamy sand	SM, SM–SC, SC	A–2, A–4
	22–60	Coarse sand, gravelly coarse sand	SP, SP–SM, SM	A–1, A–2
62 Barrington	0–15	Silt loam	CL, ML	A–4, A–6
	15–33	Silty clay loam, silt loam	CL	A–6, A–7
	33–60	Stratified silt loam to fine sand	CL, SM–SC, SC, CL–ML	A–4, A–6
69, 69B Fedji	0–24	Loamy fine sand	SM	A–2
	24–39	Loam	CL	A–6
	39–60	Loam	CL, CL–ML	A–6, A–4
84 Brownton	0–22	Silty clay loam	OH, MH, CH	A–7
	22–38	Silty clay	MH, CH	A–7
	38–60	Clay loam, loam	CL	A–6, A–7
85 Calco	0–48	Silty clay loam	ML, MH, CH, CL	A–7
	48–60	Silty clay loam	CH, CL	A–7
86 Canisteo	0–14	Silty clay loam	OL, CL	A–7
	14–27	Clay loam, loam	CL	A–7, A–6
	27–60	Clay loam, loam	CL	A–6
94, 94B, 94C Terril	0–45	Loam	OL, CL	A–4, A–6
	45–60	Loam, clay loam	CL	A–4, A–6
96, 96B, 96C, 96D Collinwood	0–17	Silty clay loam	CL, CH, MH	A–7
	17–45	Silty clay, clay, silty clay loam	MH, CH	A–7
	45–60	Silty clay, silt loam, silty clay loam	MH, CH, ML, CL	A–7
100 Copaston	0–10	Loam	SM, ML	A–4
	10–19	Sandy loam	SM	A–2
	19	Unweathered bedrock.	---	---

and classifications

Absence of an entry means data were not estimated]

Fragments >3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
	4	10	40	200		
Pct					*Pct*	
0	100	90–100	60–70	30–40	-----	NP
0	100	90–100	60–70	15–30	-----	NP
0	100	90–100	50–75	5–15	-----	NP
0	100	100	85–98	65–85	45–60	12–20
0	100	100	80–98	60–85	35–50	12–25
0	100	100	85–95	30–50	15–30	NP–10
0	100	100	85–95	35–50	15–30	NP–10
0	100	100	80–95	5–20	10–20	NP–5
0	95–100	95–100	85–95	80–95	41–50	2–8
0	95–100	90–100	80–100	70–95	35–50	11–20
0	95–100	85–100	80–95	50–65	25–40	2–10
0	95–100	85–100	80–95	40–60	25–40	5–12
0	80–95	70–95	40–80	2–10	-----	NP
0–10	90–100	80–95	50–75	25–50	20–30	2–10
0	85–100	70–95	40–75	15–45	20–30	2–8
0–10	60–90	40–80	10–40	2–25	-----	NP
0	100	95–100	90–100	80–95	30–40	8–18
0	100	100	95–100	80–95	35–50	11–25
0	100	95–100	75–100	36–90	25–40	5–15
0	95–100	95–100	50–75	15–30	-----	NP
0	95–100	90–100	80–95	60–75	20–40	10–20
0–5	95–100	90–100	80–95	60–75	20–40	5–20
0	100	98–100	90–98	85–95	50–65	20–35
0	100	98–100	90–98	85–95	50–80	25–40
0	95–100	90–98	75–90	60–75	30–50	15–25
0	100	100	95–100	85–100	41–60	15–30
0	100	100	90–100	80–100	40–55	15–30
0	98–100	95–100	85–98	60–90	40–50	15–20
0	98–100	90–100	85–95	65–85	38–50	25–35
0–5	95–100	90–98	80–95	60–75	30–40	12–20
0–5	100	95–100	70–90	60–80	25–40	8–15
0–5	100	90–100	70–90	60–80	25–40	8–15
0	100	100	95–100	90–95	40–55	15–25
0	100	100	95–100	90–95	50–65	20–35
0	100	100	95–100	90–98	35–60	5–30
0	95–100	90–100	65–80	45–60	30–40	NP–10
0–5	90–100	85–100	50–70	20–35	-----	NP
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TABLE 10.—*Engineering properties*

Soil name and map symbol	Depth	USDA texture	Classification	
			Unified	AASHTO
	In			
101B, 101C Truman	0–14	Silt loam	ML	A–4
	14–36	Silt loam	ML, CL, CL–ML	A–4, A–6, A–7
	36–60	Silt loam	CL, CL–ML	A–4, A–6
102B, 102C, 102D Clarion	0–14	Loam	CL, CL–ML	A–4, A–6
	14–34	Loam, clay loam	CL, CL–ML	A–4, A–6
	34–60	Loam, sandy loam	CL, CL–ML	A–4, A–6
105B, 105C, 105D Kamrar	0–16	Silty clay	CL, CH	A–7
	16–31	Clay loam, clay, silty clay	CL, CH, MH	A–7
	31–60	Clay loam, loam	CL	A–6, A–7
106B, 106C, 106D, 106E Lester	0–15	Loam	ML	A–6, A–4, A–7
	15–48	Clay loam	CL	A–7, A–6
	48–60	Loam, clay loam	CL, CL–ML	A–6, A–4
109 Cordova	0–13	Clay loam	OL, ML, MH	A–6, A–7
	13–32	Silty clay loam, clay loam	CL	A–7, A–6
	32–60	Clay loam, loam	CL	A–6
110 Marna	0–20	Silty clay loam	MH, ML	A–7
	20–32	Clay, silty clay	CH, MH	A–7
	32–60	Clay loam, loam	CL	A–7, A–6
113 Webster	0–15	Silty clay loam	ML, MH, CL, CH	A–7, A–6
	15–30	Clay loam, silty clay loam	CL	A–6, A–7
	30–60	Loam, clay loam	CL, ML	A–6, A–7
114 Glencoe	0–26	Silty clay loam	OL, OH, MH, ML	A–7
	26–38	Loam, clay loam, silty clay loam	CL	A–7, A–6
	38–60	Loam, clay loam, silty clay loam	CL	A–6, A–7
128, 128B Grogan	0–13	Silt loam	ML, CL, CL–ML	A–4
	13–31	Loam, silt loam	ML, CL, CL–ML	A–4
	31–60	Stratified very fine sandy loam to loamy very fine sand.	ML, CL–ML	A–4
130 Nicollet	0–21	Clay loam	OL, ML, CL	A–6, A–7, A–4
	21–44	Clay loam, loam	CL	A–6, A–7
	44–60	Loam	CL, ML	A–6, A–4
134 Okoboji	0–32	Silty clay loam	MH, CH	A–7
	32–60	Silty clay loam, silt loam	CH, MH, CL	A–7
136 Madelia	0–19	Silty clay loam	ML, CL	A–7
	19–37	Silty clay loam, silt loam	ML, CL	A–7, A–6
	37–60	Silt loam	ML, CL	A–6, A–4, A–7
138B2, 138C2 Lerdal	0–12	Silty clay loam	CL, ML	A–6, A–7
	12–34	Silty clay	MH, CH	A–7
	34–60	Clay loam	CL	A–7
140 Spicer	0–16	Silty clay loam	OL, ML	A–7, A–6
	16–40	Silt loam, silty clay loam	ML	A–7, A–6
	40–60	Silt loam, silty clay loam	ML	A–4, A–6
160 Fieldon	0–19	Loam	CL–ML, CL, ML	A–4
	19–37	Fine sandy loam, very fine sandy loam, loam	ML, SM	A–4
	37–60	Fine sand, loamy fine sand	SM, SP–SM	A–2, A–3
178 Granby	0–18	Fine sandy loam	SM	A–2
	18–60	Sand	SP, SP–SM	A–3, A–2–4
181 Litchfield	0–16	Loamy fine sand	SM	A–2
	16–48	Loamy fine sand, fine sand, very fine sandy loam.	SP–SM, SM	A–2, A–3
	48–60	Loamy fine sand	SM	A–2

and classifications—Continued

Fragments >3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
	4	10	40	200		
Pct					*Pct*	
0	100	100	95–100	80–98	30–40	5–10
0	100	100	95–100	75–100	30–45	5–20
0	100	100	95–100	75–95	25–40	4–15
0–5	95–100	95–100	75–90	50–75	25–40	5–15
0–5	90–100	85–100	75–90	50–75	25–40	5–15
0–5	90–100	85–100	75–90	50–75	25–40	5–15
0	95–100	90–100	70–100	60–90	40–55	15–30
0	90–100	90–100	70–100	60–90	40–60	15–30
0–5	90–100	85–100	60–95	50–80	35–50	15–30
0	95–100	90–100	80–95	50–70	30–45	5–15
0	95–100	90–100	80–95	55–75	35–45	15–25
0	95–100	90–100	75–90	50–70	20–40	5–20
0	98–100	98–100	90–98	70–85	38–60	12–25
0	90–100	90–100	85–95	65–80	38–50	20–30
0–5	90–100	90–100	80–95	55–70	30–40	10–20
0	98–100	98–100	90–100	85–95	45–65	15–30
0	98–100	98–100	90–100	85–95	50–80	20–45
0–5	95–100	90–98	75–95	60–75	35–50	15–25
0–5	100	95–100	85–95	70–90	35–60	15–30
0–5	95–100	95–100	85–95	60–80	35–50	15–30
0–5	95–100	90–100	75–85	50–75	35–50	10–25
0	100	95–100	85–98	75–90	45–60	10–20
0	100	95–100	85–98	75–90	35–50	15–25
0–5	98–100	92–98	80–98	70–85	35–50	15–25
0	100	100	95–100	70–90	20–40	NP–10
0	100	100	95–100	70–95	20–40	NP–10
0	100	100	90–100	65–95	20–30	NP–5
0	95–100	95–100	85–98	55–85	35–50	10–25
0	95–100	95–100	80–95	55–80	35–50	15–25
0–5	95–100	90–100	75–90	50–75	30–40	5–15
0	100	100	90–100	80–95	50–85	20–50
0–5	95–100	95–100	90–100	80–95	45–80	20–50
0	100	100	100	90–100	40–50	10–20
0	100	100	100	90–100	30–50	10–25
0	100	100	100	90–100	30–50	5–15
0	98–100	90–98	80–95	70–85	30–50	10–20
0	95–100	90–98	80–95	60–75	50–70	25–35
0–5	90–98	85–95	75–90	60–75	40–50	15–25
0	100	100	95–100	90–100	35–50	10–20
0	100	100	95–100	85–100	35–50	10–20
0	100	100	95–100	85–100	30–40	5–12
0	100	100	85–95	50–75	20–32	NP–10
0	100	100	70–90	35–60	<30	NP–5
0	100	100	75–85	5–35	----------	NP
0	100	100	60–70	20–35	----------	NP
0	100	95–100	50–70	0–5	----------	NP
0	100	100	80–95	15–35	<20	NP–4
0	100	100	70–95	5–30	<20	NP–4
0	100	100	80–95	20–35	<20	NP–4

TABLE 10.—*Engineering properties*

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO
	In			
183 Dassel	0–24	Loam	OL, ML	A-4
	24–38	Stratified loamy fine sand to fine sandy loam	SM	A-4, A-2
	38–60	Stratified loamy sand to fine sand	SM, SP-SM	A-2
196 Joliet	0–17	Silty clay loam	CL, OL	A-7, A-6
	17	Unweathered bedrock.	---	---
197 Kingston	0–17	Silty clay loam	ML, OL, CL-ML, CL	A-4, A-6, A-7
	17–31	Silty clay loam	CL, ML	A-6, A-7
	31–60	Silt loam, silty clay loam	CL-ML, CL	A-4, A-6, A-7
211 Lura	0–58	Silty clay, clay	OH, MH, CH	A-7
	58–60	Silty clay	CL, CH	A-7
219 Rolfe	0–14	Silt loam	OL, CL, ML, CL-ML	A-6, A-4
	14–30	Clay, silty clay, clay loam	CH, MH	A-7
	30–60	Clay loam, loam	CL	A-7, A-6
222B Lasa	0–15	Fine sand	SM, SP-SM	A-2
	15–45	Fine sand, loamy fine sand	SM	A-2
	45–60	Fine sand	SP	A-3
229 Waldorf	0–20	Silty clay loam	ML, MH	A-7
	20–45	Silty clay, silty clay loam	MH	A-7
	45–60	Silty clay loam, silty clay	MH, CL, ML	A-7, A-6
230 Guckeen	0–22	Silty clay loam	MH, ML	A-7
	22–31	Silty clay	MH, ML	A-7
	31–60	Clay loam	CL	A-6, A-7
238B, 238C Kilkenny	0–7	Clay loam	ML, MH	A-7
	7–34	Clay loam	MH, CH	A-7
	34–60	Clay loam	CL	A-7
238D Kilkenny	0–7	Clay loam	ML, MH	A-7
	7–31	Clay loam	MH, CH	A-7
	31–60	Clay loam	CL	A-7
239 Le Sueur	0–13	Clay loam	CL	A-6
	13–41	Clay loam	CL, CH	A-6, A-7
	41–60	Loam	CL-ML, CL	A-6, A-4
248 Lomax	0–19	Loam	CL, CL-ML	A-4, A-6
	19–26	Sandy loam, loam	SM, SC, CL-ML, ML	A-4, A-6, A-2
	26–60	Stratified sandy loam to sand	SP-SM, SP, SM	A-3, A-2
259B Grays	0–14	Silt loam	CL	A-4, A-6
	14–40	Silty clay loam	CL	A-6, A-7
	40–60	Stratified silt loam to very fine sand	ML, CL, SM, SC	A-4, A-2, A-6
275B Ocheyedan	0–15	Loam	CL, CL-ML	A-4, A-6
	15–34	Sandy clay loam, fine sandy loam, loam	SC, CL, SM-SC, CL-ML	A-4, A-6
	34–60	Silt loam, sandy loam, sandy clay loam	CL-ML, CL	A-4, A-6
281 Darfur	0–19	Loam	OL, ML	A-4
	19–31	Fine sandy loam	SM, SM-SC	A-4
	31–60	Stratified fine sand to fine sandy loam	SM	A-2, A-4
286 Shorewood	0–17	Silty clay loam	CL, ML	A-6, A-7
	17–39	Silty clay, clay	MH	A-7
	39–60	Clay loam, silty clay loam, silty clay	CL, ML	A-6, A-7

and classifications—Continued

Fragments >3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
	4	10	40	200		
Pct					*Pct*	
0	100	100	70–85	50–65	<30	NP–5
0	100	100	60–75	30–40	<30	NP–5
0	100	90–100	50–80	10–35		NP
0–15	90–100	90–100	80–100	60–90	35–50	10–22
0	100	100	95–100	85–98	25–45	5–15
0	100	100	95–100	85–98	35–45	12–20
0	100	100	95–100	85–98	25–45	5–15
0	100	100	95–100	90–98	50–75	15–40
0	100	100	95–100	90–98	40–55	20–30
0	100	95–100	90–100	80–95	30–40	5–15
0	100	95–100	90–100	75–95	50–70	15–35
0–5	95–100	90–100	80–90	55–75	30–50	10–25
0	100	100	80–95	10–20		NP
0	100	100	80–95	15–30		NP
0	100	100	75–90	0–5		NP
0	100	100	95–100	90–100	44–55	14–25
0	100	100	95–100	95–100	50–70	20–30
0	100	100	95–100	95–100	35–65	11–30
0	100	95–100	95–100	80–95	40–60	15–25
0	100	95–100	95–100	80–95	40–65	15–30
0–5	90–100	90–98	85–95	60–75	30–50	10–25
0	95–100	95–100	80–95	70–85	40–60	10–25
0	95–100	90–98	80–95	65–80	50–70	25–35
0–5	95–100	90–98	75–90	60–75	40–50	18–25
0	95–100	95–100	80–95	70–85	40–60	10–25
0	95–100	90–98	80–95	65–80	50–70	25–35
0–5	95–100	90–98	75–90	60–75	40–50	18–25
0	95–100	95–100	90–98	70–85	25–40	10–20
0	95–100	95–100	85–98	60–80	35–60	12–30
0	95–100	90–100	80–95	55–75	20–40	5–20
0	100	80–95	80–95	50–75	25–35	5–15
0	100	80–95	80–95	30–60	20–30	3–13
0–5	100	70–90	70–90	3–20	<20	NP
0	100	95–100	90–100	80–95	25–40	8–20
0	100	95–100	90–100	60–90	30–45	15–25
0	90–100	80–100	70–100	30–70	15–40	NP–20
0	100	95–100	75–90	65–80	25–40	5–15
0	100	95–100	60–80	35–55	25–40	5–15
0	100	95–100	85–95	75–90	25–40	5–15
0	100	100	100	60–80	25–40	NP–10
0	100	100	40–100	35–50	20–30	NP–5
0	100	100	40–100	15–40		
0	100	100	90–98	85–98	35–50	12–20
0	100	100	90–100	85–98	55–75	20–40
0–5	98–100	95–100	85–100	80–95	35–50	10–20

TABLE 10.—*Engineering properties*

Soil name and map symbol	Depth	USDA texture	Classification	
			Unified	AASHTO
	In			
287 Minnetonka	0–19	Silty clay loam	MH, ML	A–5, A–7
	19–40	Silty clay, silty clay loam	MH, CH, CL, ML	A–7
	40–60	Clay loam, loam	CL, ML	A–7, A–4, A–6
310 Beauford	0–20	Clay	CH	A–7
	20–46	Clay	CH	A–7
	46–60	Clay	CH	A–7
311 Shorewood	0–17	Silty clay	MH	A–7
	17–45	Silty clay, clay	MH	A–7
	45–60	Clay loam, silty clay loam, silty clay	CL, ML	A–6, A–7
316 Baroda	0–14	Silty clay loam	OL, ML, CL	A–6, A–7
	14–46	Clay	MH, CH	A–7
	46–60	Clay loam	CL	A–6, A–7
317 Oshawa	0–21	Silt loam	OL, ML, CL	A–4, A–6
	21–60	Loam	CL	A–6
319 Barbert	0–17	Silt loam	ML, OL	A–4, A–7
	17–43	Clay	CH, MH	A–7
	43–60	Silty clay loam	CH, CL, ML, MH	A–7
321 Tilfer	0–11	Silty clay loam	MH, OL, ML	A–7
	11–31	Loam, clay loam, silty clay loam	SC, CL, SM, ML	A–6, A–7
	31	Unweathered bedrock.	---	---
329 Chaska	0–8	Loam	OL, CL, ML	A–4, A–6
	8–38	Stratified silt loam to loamy fine sand	CL, CL–ML, ML	A–4, A–6
	38–60	Stratified silt loam to fine sand	SM, ML	A–4, A–2
349 Calco	0–48	Silty clay loam	ML, MH, CH, CL	A–7
	48–60	Silty clay loam	CH, CL	A–7
353 Comfrey	0–34	Clay loam	OL, OH, MH, ML	A–7
	34–60	Clay loam, loam	CL	A–7, A–6
354 Dorchester	0–36	Silt loam	ML, CL–ML, CL	A–4
	36–61	Silt loam	OL, ML, CL	A–6, A–7
360B, 360E Lasa	0–22	Loamy fine sand	SM	A–2
	22–48	Loamy fine sand, fine sand, fine sandy loam	SM, SP–SM	A–2
	48	Unweathered bedrock.	---	---
363 Minneopa	0–15	Sandy loam	SM	A–2, A–4
	15–20	Sandy loam	SM	A–2
	20–60	Loamy sand, sand	SM, SP–SM	A–2, A–3
364 Minnetonka	0–16	Silty clay loam	MH, ML	A–5, A–7
	16–35	Silty clay, silty clay loam	MH, CH, CL, ML	A–7
	35–60	Silty clay loam, silt loam	MH, ML	A–7, A–4, A–6
414 Hamel	0–28	Clay loam	MH, ML, OL, CL	A–6, A–7
	28–34	Clay loam, loam	CH, CL	A–7
	34–60	Loam	CL	A–6
440 Copaston	0–8	Loam	SM, ML	A–4
	8–12	Sandy loam	SM	A–2
	12	Unweathered bedrock.	---	---
448 Shorewood	0–15	Silty clay loam	CL, ML	A–6, A–7
	15–33	Silty clay	MH, CH	A–7
	33–60	Silt loam	ML	A–4
451 Dorchester	0–36	Silt loam	ML, CL–ML, CL	A–4
	36–61	Silt loam	OL, ML, CL	A–6, A–7

and classifications—Continued

Fragments >3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
	4	10	40	200		
Pct					*Pct*	
0	95–100	95–100	90–98	85–95	40–55	6–20
0	95–100	95–100	90–98	85–95	40–65	12–35
0–5	90–100	85–100	75–90	60–85	30–50	5–25
0	100	100	98–100	90–100	50–70	30–45
0	100	100	98–100	90–100	65–80	35–50
0	100	100	98–100	90–100	60–75	35–50
0	100	100	90–100	85–98	50–70	15–25
0	100	100	90–100	85–98	55–75	20–40
0–5	98–100	95–100	85–100	80–95	35–50	10–20
0	100	100	95–100	85–95	30–50	11–20
0	100	100	95–100	85–95	50–70	20–40
0–5	100	100	90–100	70–80	30–50	11–30
0	100	100	90–100	85–95	30–40	5–15
0	95–100	95–100	90–100	85–95	30–40	10–13
0	100	100	90–100	90–100	35–50	5–20
0	100	100	90–100	90–100	50–80	20–50
0	100	100	95–100	65–100	40–60	15–35
0	95–100	95–100	80–90	70–85	45–55	15–25
2–5	90–95	85–90	60–70	45–70	35–45	11–20
0	100	100	90–100	70–80	30–40	5–15
0	100	100	85–95	60–75	20–40	5–15
0	100	100	85–95	35–75	15–35	NP–10
0	100	100	95–100	85–100	41–60	15–30
0	100	100	90–100	80–100	40–55	15–30
0	100	100	85–98	65–85	45–60	12–20
0	100	100	80–98	60–85	35–50	12–25
0	100	100	95–100	90–95	25–35	5–10
0	100	100	95–100	90–95	35–45	10–20
0	100	100	80–95	15–30	---	NP
0	100	100	80–95	10–30	---	NP
0	100	90–100	60–70	30–40	---	NP
0	100	90–100	60–70	15–30	---	NP
0	100	90–100	50–75	5–15	---	NP
0	95–100	95–100	90–98	85–95	40–55	6–20
0	95–100	95–100	90–98	85–95	40–65	12–35
0	95–100	90–100	80–100	75–95	30–55	5–25
0	100	97–100	85–98	70–85	30–60	10–25
0	98–100	95–100	85–95	65–80	40–55	25–35
0–5	98–100	95–100	80–95	60–80	30–40	15–25
0	95–100	90–100	65–80	45–60	30–40	NP–10
0–5	90–100	85–100	50–70	20–35	---	NP
0	100	100	100	85–95	35–50	12–20
0	100	100	100	85–95	50–75	20–45
0	100	100	100	90–95	30–35	5–10
0	100	100	95–100	90–95	25–35	5–10
0	100	100	95–100	90–95	35–45	10–20

TABLE 10.—*Engineering properties*

Soil name and map symbol	Depth	USDA texture	Classification	
			Unified	AASHTO
	In			
524 Caron	0–8	Sapric material	Pt	---
	8–35	Hemic material	Pt	A–5
	35–60	Coprogenous earth	OL	A–5
525 Muskego	0–32	Sapric material	Pt	A–8
	32–84	Coprogenous earth	OH	A–8
539 Palms	0–50	Sapric material	Pt	---
	50–60	Clay loam, loam, silty clay loam, silt loam	CL–ML, CL	A–4, A–6
548 Palms	0–30	Sapric material	Pt	A–8
	30–45	Clay loam, silt loam	CL–ML, CL	A–4, A–6
	45–60	Fine sand, loamy fine sand	SM	A–2
851* Chaska	0–8	Loam	OL, CL, ML	A–4, A–6
	8–38	Stratified silt loam to loamy fine sand	CL, CL–ML, ML	A–4, A–6
	38–60	Stratified silt loam to fine sand	SM, ML	A–4, A–2
852* Copaston	0–8	Loam	SM, ML	A–4
	8–12	Sandy loam	SM	A–2
	12	Unweathered bedrock.	---	---
853* Copaston	0–10	Bouldery loam	SM, ML	A–4
	10–19	Sandy loam	SM	A–2
	19	Unweathered bedrock.	---	---
854* Cordova	0–13	Clay loam	OL, ML, MH	A–6, A–7
	13–32	Silty clay loam, clay loam	CL	A–7, A–6
	32–60	Clay loam	CL	A–6
855* Dorchester	0–36	Silt loam	ML, CL–ML, CL	A–4
	36–61	Silt loam	OL, ML, CL	A–6, A–7
856B*, 856C* Terril	0–45	Loam	OL, CL	A–4, A–6
	45–60	Loam, clay loam	CL	A–4, A–6
909C*, 909D*:				
Bold	0–60	Silt loam	ML, CL, CL–ML	A–4, A–6
Truman	0–14	Silt loam	ML	A–4
	14–36	Silt loam	ML, CL, CL–ML	A–4, A–6, A–7
	36–60	Silt loam	CL, CL–ML	A–4, A–6
919*:				
Canisteo	0–14	Loam	OL, CL	A–7
	14–27	Clay loam, loam	CL	A–7, A–6
	27–60	Clay loam, loam	CL	A–6
Fieldon	0–19	Loam	CL–ML, CL, ML	A–4
	19–37	Fine sandy loam, very fine sandy loam, loam	ML, SM	A–4
	37–60	Fine sand, loamy fine sand	SM, SP–SM	A–2, A–3
920B*, 920C*, 920D*:				
Clarion	0–14	Loam	CL, CL–ML	A–4, A–6
	14–34	Loam, clay loam	CL, CL–ML	A–4, A–6
	34–60	Loam, sandy loam	CL, CL–ML	A–4, A–6
Estherville	0–14	Sandy loam	SM, SM–SC, SC	A–2, A–4
	14–22	Sandy loam, loamy sand	SM, SM–SC, SC	A–2, A–4
	22–60	Coarse sand, gravelly coarse sand	SP, SP–SM, SM	A–1, A–2
921C*, 921D*:				
Clarion	0–14	Loam	CL, CL–ML	A–4, A–6
	14–34	Loam, clay loam	CL, CL–ML	A–4, A–6
	34–60	Loam, sandy loam	CL, CL–ML	A–4, A–6
Storden	0–8	Loam	ML, CL, CL–ML	A–4, A–6
	8–60	Loam	CL–ML, CL	A–4, A–6

and classifications—Continued

Fragments >3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
	4	10	40	200		
Pct					*Pct*	
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0	100	95–100	90–95	70–90	40–50	5–10
0	100	95–100	90–95	70–90	40–50	5–10
0	---	---	---	---	---	---
0	---	---	---	---	---	---
---	---	---	---	---	---	---
0	85–100	80–100	70–95	50–90	25–40	5–20
0	---	---	---	---	---	---
0	100	100	95–100	65–80	20–35	5–15
0	100	100	95–100	15–40	---	NP
0	100	100	90–100	70–80	30–40	5–15
0	100	100	85–95	60–75	20–40	5–15
0	100	100	85–95	35–75	15–35	NP–10
0	95–100	90–100	65–80	45–60	30–40	NP–10
0–5	90–100	85–100	50–70	20–35	---	NP
---	---	---	---	---	---	---
1–5	90–100	85–95	65–80	45–60	30–40	NP–10
0–5	90–100	85–100	50–70	20–35	---	NP
---	---	---	---	---	---	---
0	98–100	98–100	90–98	70–85	38–60	12–25
0	90–100	90–100	85–95	65–80	38–50	20–30
0	90–100	90–100	80–95	55–70	30–40	10–20
0	100	100	95–100	90–95	25–35	5–10
0	100	100	95–100	90–95	35–45	10–20
0–5	100	95–100	70–90	60–80	25–40	8–15
0–5	100	90–100	70–90	60–80	25–40	8–15
0	100	100	100	90–100	20–35	3–15
0	100	100	95–100	80–98	30–40	5–10
0	100	100	95–100	80–98	30–45	5–20
0	100	100	95–100	75–100	25–40	4–15
0	98–100	95–100	85–98	60–90	40–50	15–20
0	98–100	90–100	85–95	65–85	38–50	25–35
0–5	95–100	90–98	80–95	60–75	30–40	12–20
0	100	100	85–95	50–75	20–32	NP–10
0	100	100	70–90	35–60	<30	NP–5
0	100	100	75–85	5–35	---	NP
0–5	95–100	95–100	75–90	50–75	25–40	5–15
0–5	90–100	85–100	75–90	50–75	25–40	5–15
0–5	90–100	85–100	75–90	50–75	25–40	5–15
0	90–100	80–95	50–75	25–50	20–30	2–10
0	85–100	70–95	40–75	15–45	20–30	2–8
0–10	60–90	40–80	10–40	2–25	---	NP
0–5	95–100	95–100	75–90	50–75	25–40	5–15
0–5	90–100	85–100	75–90	50–75	25–40	5–15
0–5	90–100	85–100	75–90	50–75	25–40	5–15
0–5	95–100	95–100	70–85	55–70	30–40	5–15
0–5	95–100	85–97	70–85	55–70	20–40	5–15

TABLE 10.—*Engineering properties*

Soil name and map symbol	Depth	USDA texture	Classification	
			Unified	AASHTO
	In			
923* Copaston	0–10	Loam	SM, ML	A-4
	10–19	Sandy loam	SM	A-2
	19	Unweathered bedrock.		
926*: Darfur	0–19	Loam	OL, ML	A-4
	19–31	Fine sandy loam	SM, SM-SC	A-4
	31–60	Stratified fine sand to fine sandy loam	SM	A-2, A-4
Webster	0–20	Loam	ML, MH, CL, CH	A-7, A-6
	20–30	Clay loam, silty clay loam	CL	A-6, A-7
	30–60	Loam, sandy loam, clay loam	CL, ML	A-6, A-7
929*: Fieldon	0–19	Loam	CL-ML, CL, ML	A-4
	19–37	Fine sandy loam, very fine sandy loam, loam	ML, SM	A-4
	37–60	Fine sandy loam, loamy fine sand	SM, SP-SM	A-2, A-3
Canisteo	0–14	Loam	OL, CL	A-7
	14–27	Clay loam, loam	CL	A-7, A-6
	27–60	Clay loam, loam	CL	A-6
932*: Glencoe	0–26	Loam	OL, OH, MH, ML	A-7
	26–38	Loam, clay loam, silty clay loam	CL	A-7, A-6
	38–60	Loam, clay loam	CL	A-6, A-7
Dassel	0–24	Loam	OL, ML	A-4
	24–38	Stratified loamy fine sand to fine sandy loam	SM	A-4, A-2
	38–60	Stratified loamy sand to fine sand	SM, SP-SM	A-2
941*: Kingston	0–17	Silty clay loam	ML, OL, CL-ML, CL	A-4, A-6, A-7
	17–31	Silty clay loam	CL, ML	A-6, A-7
	31–60	Silt loam, silty clay loam	CL-ML, CL	A-4, A-6
Nicollet	0–21	Clay loam	OL, ML, CL	A-6, A-7, A-4
	21–44	Clay loam, loam	CL	A-6, A-7
	44–60	Loam	CL, ML	A-6, A-4
946*: Litchfield	0–16	Loamy fine sand	SM	A-2
	16–48	Loamy fine sand, fine sand, very fine sandy loam.	SP-SM, SM	A-2, A-3
	48–60	Loamy fine sand	SM	A-2
Nicollet	0–21	Clay loam	OL, ML, CL	A-6, A-7, A-4
	21–44	Clay loam, loam	CL	A-6, A-7
	44–60	Loam	CL, ML	A-6, A-4
947*: Madelia	0–19	Silty clay loam	ML, CL	A-7
	19–37	Silty clay loam, silt loam	ML	A-7, A-6
	37–60	Silt loam	ML	A-6, A-4
Webster	0–20	Silty clay loam	ML, MH, CL, CH	A-7, A-6
	20–30	Clay loam, silty clay loam	CL	A-6, A-7
	30–60	Loam, clay loam	CL, ML	A-6, A-7
960E*: Storden	0–8	Loam	ML, CL, CL-ML	A-4, A-6
	8–60	Loam	CL-ML, CL	A-4, A-6
Clarion	0–14	Loam	CL, CL-ML	A-4, A-6
	14–22	Loam, clay loam	CL, CL-ML	A-4, A-6
	22–60	Loam, sandy loam	CL, CL-ML	A-4, A-6

and classifications—Continued

Fragments >3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
	4	10	40	200		
Pct					*Pct*	
0	95–100	90–100	65–80	45–60	30–40	NP–10
0–5	90–100	85–100	50–70	20–35	---	NP
---	---	---	---	---	---	---
0	100	100	100	60–80	25–40	NP–10
0	100	100	40–100	35–50	20–30	NP–5
0	100	100	40–100	15–40	---	---
0–5	100	95–100	85–95	70–90	35–60	15–30
0–5	95–100	95–100	85–95	60–80	35–50	15–30
0–5	95–100	90–100	75–85	50–75	35–50	10–25
0	100	100	85–95	50–75	20–32	NP–10
0	100	100	70–90	35–60	<30	NP–5
0	100	100	75–85	5–35	---	NP
0	98–100	95–100	85–98	60–90	40–50	15–20
0	98–100	90–100	85–95	65–85	38–50	25–35
0	95–100	90–98	80–95	60–75	30–40	12–20
0	100	95–100	85–98	75–90	45–60	10–20
0	100	95–100	85–98	75–90	35–50	15–25
0–5	98–100	92–98	80–98	70–85	35–50	15–25
0	100	100	70–85	50–65	<30	NP–5
0	100	100	60–75	30–40	<30	NP–5
0	100	90–100	50–80	10–35	---	NP
0	100	100	95–100	85–98	25–45	5–15
0	100	100	95–100	85–98	35–45	12–20
0	100	100	95–100	85–98	25–45	5–15
0	95–100	95–100	85–98	55–85	35–50	10–25
0	95–100	95–100	80–95	55–80	35–50	15–25
0–5	95–100	90–100	75–90	50–75	30–40	5–15
0	100	100	80–95	15–35	<20	NP–4
0	100	100	70–95	5–30	<20	NP–4
0	100	100	80–95	20–35	<20	NP–4
0	95–100	95–100	85–98	55–85	35–50	10–25
0	95–100	95–100	80–95	55–80	35–50	15–25
0–5	95–100	90–100	75–90	50–75	30–40	5–15
0	100	100	100	90–100	40–50	10–15
0	100	100	100	90–100	30–50	10–20
0	100	100	100	90–100	30–40	5–15
0–5	100	95–100	85–95	70–90	35–60	15–30
0–5	95–100	95–100	85–95	60–80	35–50	15–30
0–5	95–100	90–100	75–85	50–75	35–50	10–25
0–5	95–100	95–100	70–85	55–70	30–40	5–15
0–5	95–100	85–97	70–85	55–70	20–40	5–15
0–5	95–100	95–100	75–90	50–75	25–40	5–15
0–5	90–100	85–100	75–90	50–75	25–40	5–15
0–5	90–100	85–100	75–90	50–75	25–40	5–15

TABLE 10.—*Engineering properties*

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO
	In			
961*, 961F*: Storden	0-8	Loam	ML, CL, CL-ML	A-4, A-6
	8-60	Loam	CL-ML, CL	A-4, A-6
968*: Webster	0-20	Loam	ML, MH, CL, CH	A-7, A-6
	20-30	Clay loam, silty clay loam	CL	A-6, A-7
	30-60	Loam, sandy loam, clay loam	CL, ML	A-6, A-7
Darfur	0-19	Loam	OL, ML	A-4
	19-31	Fine sandy loam	SM, SM-SC	A-4
	31-60	Stratified fine sand to fine sandy loam	SM	A-2, A-4
Granby	0-18	Fine sandy loam	SM	A-2
	18-60	Sand	SP, SP-SM	A-3, A-2-4
978*: Cordova	0-13	Clay loam	OL, ML, MH	A-6, A-7
	13-32	Silty clay loam, clay loam	CL	A-7, A-6
	32-60	Clay loam	CL	A-6
978*: Rolfe	0-14	Silt loam	OL, CL, ML, CL-ML	A-6, A-4
	14-45	Clay, silty clay, clay loam	CH, MH	A-7
	45-60	Clay loam, loam	CL	A-7, A-6
992*: Rock outcrop.				
Copaston	0-7	Loam	SM, ML	A-4
	7-12	Sandy loam	SM	A-2
	12	Unweathered bedrock.	---	---
996*: Beauford	0-18	Clay	CH	A-7
	18-40	Clay	CH	A-7
	40-60	Clay	CH	A-7
Barbert	0-17	Silt loam	ML, OL	A-4, A-7
	17-43	Clay	CH, MH	A-7
	43-60	Silty clay loam	CH, CL, ML, MH	A-7
997*: Marna	0-20	Silty clay loam	MH, ML	A-7
	20-32	Clay, silty clay	CH	A-7
	32-60	Clay loam, loam	CL	A-7, A-6
Barbert	0-17	Silt loam	ML, OL	A-4, A-7
	17-43	Clay	CH, MH	A-7
	43-60	Silty clay loam	CH, CL, ML, MH	A-7
998*: Minnetonka	0-19	Silty clay loam	MH, ML	A-5, A-7
	19-40	Silty clay, silty clay loam	MH, CH, CL, ML	A-7
	40-60	Clay loam, loam	CL, ML	A-7, A-4, A-6
Barbert	0-17	Silt loam	ML, OL	A-4, A-7
	17-43	Clay	CH, MH	A-7
	43-60	Silty clay loam	CH, CL, ML, MH	A-7
1001*, 1002*, 1004*. Alluvial land				
1007*. Alluvial-Urban land				
1032*. Lake beaches				

and classifications—Continued

Fragments >3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
	4	10	40	200		
Pct					*Pct*	
0-5	95-100	95-100	70-85	55-70	30-40	5-15
0-5	95-100	85-97	70-85	55-70	20-40	5-15
0-5	100	95-100	85-95	70-90	35-60	15-30
0-5	95-100	95-100	85-95	60-80	35-50	15-30
0-5	95-100	90-100	75-85	50-75	35-50	10-25
0	100	100	100	60-80	25-40	NP-10
0	100	100	40-100	35-50	20-30	NP-5
0	100	100	40-100	15-40	---	---
0	100	100	60-70	20-35	---	NP
0	100	95-100	50-70	0-5	---	NP
0	98-100	98-100	90-98	70-85	38-60	12-25
0	90-100	90-100	85-95	65-80	38-50	20-30
0-5	90-100	90-100	80-95	55-70	30-40	10-20
0	100	95-100	90-100	80-95	30-40	5-15
0	100	95-100	90-100	75-95	50-70	15-35
0	95-100	90-100	80-90	55-75	30-50	10-25
0	95-100	90-100	65-80	45-60	30-40	NP-10
0-5	90-100	85-100	50-70	20-35	---	NP
---	---	---	---	---	---	---
0	100	100	98-100	90-100	50-70	30-45
0	100	100	98-100	90-100	65-80	35-50
0	100	100	98-100	90-100	60-75	35-50
0	100	100	90-100	90-100	35-50	5-20
0	100	100	90-100	90-100	50-80	20-50
0	100	100	95-100	66-100	40-60	15-35
0	98-100	98-100	90-98	85-95	45-65	15-30
0	98-100	98-100	90-98	85-95	60-80	35-45
0	95-100	90-98	75-90	60-75	35-50	15-25
0	100	100	90-100	90-100	35-50	5-20
0	100	100	90-100	90-100	50-80	20-50
0	100	100	95-100	65-100	40-60	15-35
0	95-100	95-100	90-98	85-95	40-55	6-20
0	95-100	95-100	90-98	85-95	40-65	12-35
0-5	90-100	85-100	75-90	60-85	30-50	5-25
0	100	100	90-100	90-100	35-50	5-20
0	100	100	90-100	90-100	50-80	20-50
0	100	100	95-100	65-100	40-60	15-35

TABLE 10.—*Engineering properties*

Soil name and map symbol	Depth	USDA texture	Classification	
			Unified	AASHTO
	In			
1039*. Urban land				
1053*. Marsh				
1800 Caron	0–60	Hemic material	Pt	---
1801B Grogan	0–13	Loamy fine sand	ML, SM	A–4
	13–60	Stratified loamy fine sand to fine sand, loamy very fine sand.	SM	A–2, A–4

* See map unit description for the composition and behavior of the map unit.

Available water capacity is rated on the basis of soil characteristics that influence the ability of the soil to hold water and make it available to plants. Important characteristics are content of organic matter, soil texture, and soil structure. Shallow-rooted plants are not likely to use the available water from the deeper soil horizons. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design of irrigation systems.

Soil reaction is expressed as a range in pH values. The range in pH of each major horizon is based on many field checks. For many soils, the values have been verified by laboratory analyses. Soil reaction is important in selecting the crops, ornamental plants, or other plants to be grown; in evaluating soil amendments for fertility and stabilization; and in evaluating the corrosivity of soils.

Shrink-swell potential depends mainly on the amount and kind of clay in the soil. Laboratory measurements of the swelling of undisturbed clods were made for many soils. For others the swelling was estimated on the basis of the kind and amount of clay in the soil and on measurements of similar soils. The size of the load and the magnitude of the change in soil moisture content also influence the swelling of soils. Shrinking and swelling of some soils can cause damage to building foundations, basement walls, roads, and other structures unless special designs are used. A high shrink-swell potential indicates that special design and added expense may be required if the planned use of the soil will not tolerate large volume changes.

Risk of corrosion pertains to potential soil-induced chemical action that dissolves or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to soil moisture, particle-size distribution, total acidity, and electrical conductivity of the soil material. The rate of corrosion of concrete is based mainly on the sulfate content, texture, and acidity of the soil. Protective measures for steel or more resistant concrete help to avoid or minimize damage resulting from the corrosion. Uncoated steel intersecting soil boundaries or soil horizons is more susceptible to corrosion than an installation that is entirely within one kind of soil or within one soil horizon.

Erosion factors are used to predict the erodibility of a soil and its tolerance to erosion in relation to specific kinds of land use and treatment. The soil erodibility factor (K) is a measure of the susceptibility of the soil to erosion by water. Soils having the highest K values are the most erodible. K values range from 0.10 to 0.64. To estimate annual soil loss per acre, the K value of a soil is modified by factors representing plant cover, grade and length of slope, management practices, and climate. The soil-loss tolerance factor (T) is the maximum rate of soil erosion, whether from rainfall or soil blowing, that can occur without reducing crop production or environmental quality. The rate is expressed in tons of soil loss per acre per year.

Wind erodibility groups are made up of soils that have similar properties that affect their resistance to soil blowing if cultivated. The groups are used to predict the susceptibility of soil to blowing and the amount of soil lost as a result of blowing. Soils are grouped according to the following distinctions:

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

Loamy sands, loamy fine sands, and loamy very fine sands. These soils are very highly erodible, but crops can be grown if intensive measures to control soil blowing are used.

Sandy loams, coarse sandy loams, fine sandy loams, and very fine sandy loams. These soils are highly erodible, but crops can be grown if intensive measures to control soil blowing are used.

Calcareous loamy soils that are less than 35 percent clay and more than 5 percent finely divided calcium carbonate. These soils are erodible, but crops can be grown if intensive measures to control soil blowing are used.

Clays, silty clays, clay loams, and silty clay loams

and classifications—Continued

Fragments >3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
	4	10	40	200		
Pct					*Pct*	
0	---	---	---	---	---	---
0	100	100	80–100	35–55	<25	NP
0	100	100	80–100	30–56	---	NP

that are more than 35 percent clay. These soils are moderately erodible, but crops can be grown if measures to control soil blowing are used.

Loamy soils that are less than 18 percent clay and less than 5 percent finely divided calcium carbonate and sandy clay loams and sandy clays that are less than 5 percent finely divided calcium carbonate. These soils are slightly erodible, but crops can be grown if measures to control soil blowing are used.

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

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

Stony or gravelly soils and other soils not subject to soil blowing.

Soil and water features

Table 12 contains information helpful in planning land uses and engineering projects that are likely to be affected by soil and water features.

Hydrologic soil groups are used to estimate runoff from precipitation. Soils not protected by vegetation are placed in one of four groups on the basis of the intake of water after the soils have been wetted and have received 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 chiefly of deep, well drained to excessively drained sands or gravels. 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 that have a layer that impedes the downward movement of water or soils that have 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 clay soils that have a high shrink-swell potential, soils that have a permanent high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Flooding is the temporary covering of soil with water from overflowing streams, with runoff from adjacent slopes, and by tides. Water standing for short periods after rains or after snow melts is not considered flooding, nor is water in swamps and marshes. Flooding is rated in general terms that describe the frequency and duration of flooding and the time of year when flooding is most likely. The ratings are based on evidence in the soil profile of the effects of flooding, namely thin strata of gravel, sand, silt, or, in places, clay deposited by floodwater; irregular decrease in organic-matter content with increasing depth; and absence of distinctive soil horizons that form in soils of the area that are not subject to flooding. The ratings are also based on local information about floodwater levels in the area and the extent of flooding; and on information that relates the position of each soil on the landscape to historic floods.

The generalized description of flood hazards is of value in land-use planning and provides a valid basis for land-use restrictions. The soil data are less specific, however, than those provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

High water table is the highest level of a saturated zone more than 6 inches thick for a continuous period of more than 2 weeks during most years. The depth to a seasonal high water table applies to undrained soils.

TABLE 11.—*Physical and chemical*

[The symbol < means less than; > means greater than. The erosion tolerance factor (T) is

Soil name and map symbol	Depth	Permeability	Available water capacity	Soil reaction
	In	*In/hr*	*In/in*	*pH*
17 Minneopa	0–15	2.0–6.0	0.13–0.15	6.1–7.3
	15–20	2.0–6.0	0.09–0.14	6.1–7.3
	20–60	6.0–20	0.08–0.10	6.1–7.3
18 Comfrey	0–34	0.6–2.0	0.18–0.22	6.6–7.8
	34–60	0.6–2.0	0.15–0.19	7.4–8.4
27, 27B Dickinson	0–11	2.0–6.0	0.12–0.15	5.6–6.5
	11–35	2.0–6.0	0.12–0.15	5.6–6.5
	35–60	6.0–20	0.08–0.10	5.6–6.5
35 Blue Earth	0–48	2.0–6.0	0.18–0.24	7.4–8.4
	48–60	0.2–2.0	0.14–0.16	7.4–8.4
39, 39B Wadena	0–14	2.0–6.0	0.20–0.22	6.1–7.3
	14–33	2.0–6.0	0.12–0.14	6.1–7.3
	33–60	>20	0.02–0.04	6.6–8.4
41, 41B, 41C Estherville	0–14	2.0–6.0	0.13–0.15	5.6–7.3
	14–22	2.0–6.0	0.09–0.14	5.6–7.3
	22–60	6.0–20	0.02–0.04	6.6–7.8
62 Barrington	0–15	0.6–2.0	0.22–0.24	5.6–7.3
	15–33	0.6–2.0	0.18–0.20	5.6–6.5
	33–60	0.6–6.0	0.07–0.11	6.6–8.4
69, 69B Fedji	0–24	6.0–20	0.10–0.12	6.1–6.5
	24–39	0.2–2.0	0.17–0.19	6.1–7.3
	39–60	0.2–2.0	0.17–0.19	7.4–8.4
84 Brownton	0–22	0.06–0.2	0.18–0.22	7.4–7.8
	22–38	0.06–0.2	0.13–0.16	7.4–7.8
	38–60	0.2–0.6	0.14–0.16	7.4–7.8
85 Calco	0–48	0.2–0.6	0.21–0.23	7.4–8.4
	48–60	0.2–0.6	0.18–0.20	7.4–8.4
86 Canisteo	0–14	0.6–2.0	0.18–0.22	7.4–8.4
	14–27	0.6–2.0	0.15–0.19	7.4–8.4
	27–60	0.6–2.0	0.14–0.16	7.4–8.4
94, 94B, 94C Terril	0–45	0.6–2.0	0.20–0.22	6.1–7.3
	45–60	0.6–2.0	0.16–0.18	6.1–7.3
96, 96B, 96C, 96D Collinwood	0–17	0.2–0.6	0.14–0.17	5.6–6.5
	17–45	0.06–0.6	0.13–0.16	5.6–7.3
	45–60	0.06–2.0	0.11–0.15	7.4–8.4
100 Copaston	0–10	0.6–2.0	0.20–0.22	6.1–7.3
	10–19	0.6–6.0	0.12–0.14	5.6–7.3
	19	----------	----------	----------
101B, 101C Truman	0–14	0.6–2.0	0.20–0.23	6.1–7.3
	14–36	0.6–2.0	0.18–0.21	6.1–7.8
	36–60	0.6–2.0	0.18–0.20	7.4–8.4
102B, 102C, 102D Clarion	0–14	0.6–2.0	0.20–0.22	6.1–7.3
	14–34	0.6–2.0	0.17–0.19	5.6–7.8
	34–60	0.6–2.0	0.17–0.19	7.9–8.4
105B, 105C, 105D Kamrar	0–16	0.2–0.6	0.15–0.19	5.6–7.3
	16–31	0.2–0.6	0.15–0.19	5.6–7.3
	31–60	0.6–2.0	0.14–0.16	7.4–8.4
106B, 106C, 106D, 106E Lester	0–15	0.6–2.0	0.20–0.22	5.6–6.5
	15–48	0.6–2.0	0.15–0.19	5.1–6.5
	48–60	0.6–2.0	0.14–0.19	6.6–7.8

properties of soils

for the entire profile. Absence of an entry means data were not available or were not estimated]

Shrink-swell potential	Risk of corrosion		Erosion factors		Wind erodibility group
	Uncoated steel	Concrete	K	T	
Low	Low	Low	0.20	5	3
Low	Low	Low	0.20		
Low	Low	Low	0.20		
Moderate	High	Low	0.24	5	6
Moderate	High	Low	0.37		
Low	Low	Moderate	0.20	4–3	3
Low	Low	Moderate	0.20		
Low	Low	Moderate	0.20		
Low	High	Low	0.28	5	8
Moderate	High	Low	0.37		
Low	Low	Low	0.24	4–3	5
Low	Low	Low	0.32		
Low	Low	Low	0.10		
Low	Low	Low	0.20	3–2	3
Low	Low	Low	0.20		
Low	Low	Low	0.10		
Low	Low	Moderate	0.28	5	6
Moderate	High	Moderate	0.43		
Low	Moderate	Low	0.43		
Low	Low	Low	0.17	5–4	2
Low	Low	Low	0.32		
Low	Low	Low	0.32		
High	High	Low	0.32	5	4
High	High	Low	0.32		
Moderate	High	Low	0.32		
High	High	Low	0.37	5	7
High	High	Low	0.37		
Moderate	High	Low	0.24	5	4L
Moderate	High	Low	0.32		
Moderate	High	Low	0.32		
Low	Moderate	Low	0.24	5	6
Low	Moderate	Low	0.32		
Moderate	High	Low	0.32	5	4
High	High	Low	0.32		
High	High	Low	0.32		
Low	Low	Low	0.28	2	5
Low	Low	Low	0.28		
Low	Low	Low	0.32	5–4	6
Moderate	Low	Low	0.43		
Low	Low	Low	0.43		
Low	Low	Low	0.28	5–4	6
Low	Low	Low	0.28		
Low	Low	Low	0.37		
Moderate	High	Low	0.28	5–4	4
Moderate	High	Low	0.28		
Moderate	High	Low	0.37		
Low	Low	Moderate	0.28	5–4	6
Moderate	Low	Moderate	0.28		
Low	Low	Low	0.37		

TABLE 11.—*Physical and chemical*

Soil name and map symbol	Depth	Permeability	Available water capacity	Soil reaction
	In	*In/hr*	*In/in*	*pH*
109 Cordova	0–13	0.2–0.6	0.18–0.22	6.1–7.3
	13–32	0.2–0.6	0.15–0.19	5.1–6.5
	32–60	0.6–2.0	0.14–0.16	7.4–8.4
110 Marna	0–20	0.06–0.2	0.18–0.22	6.1–7.3
	20–32	0.06–0.2	0.13–0.16	6.1–7.3
	32–60	0.2–2.0	0.14–0.19	6.6–7.8
113 Webster	0–15	0.6–2.0	0.19–0.21	6.6–7.3
	15–30	0.2–2.0	0.16–0.18	6.6–7.8
	30–60	0.6–2.0	0.17–0.19	7.9–8.4
114 Glencoe	0–26	0.2–2.0	0.18–0.22	6.6–7.3
	26–38	0.2–2.0	0.15–0.19	6.6–7.8
	38–60	0.2–2.0	0.15–0.19	7.4–7.8
128, 128B Grogan	0–13	2.0–6.0	0.22–0.24	5.6–7.3
	13–31	2.0–6.0	0.17–0.19	6.1–7.8
	31–60	2.0–6.0	0.17–0.19	7.4–8.4
130 Nicollet	0–21	0.6–2.0	0.17–0.22	6.1–7.3
	21–44	0.6–2.0	0.15–0.19	5.6–7.8
	44–60	0.6–2.0	0.14–0.19	7.4–7.8
134 Okoboji	0–32	0.2–0.6	0.21–0.23	7.4–7.8
	32–60	0.2–0.6	0.18–0.20	7.4–8.4
136 Madelia	0–19	0.6–2.0	0.18–0.24	6.1–7.3
	19–37	0.6–2.0	0.16–0.22	6.6–7.8
	37–60	0.6–2.0	0.16–0.22	7.4–7.8
138B2, 138C2 Lerdal	0–12	0.6–2.0	0.18–0.22	5.1–6.0
	12–34	0.06–0.2	0.13–0.19	4.5–6.0
	34–60	0.2–0.6	0.14–0.19	6.6–7.8
140 Spicer	0–16	0.6–2.0	0.18–0.24	7.4–7.8
	16–40	0.6–2.0	0.16–0.22	7.4–7.8
	40–60	0.6–2.0	0.16–0.22	7.4–7.8
160 Fieldon	0–19	0.6–2.0	0.18–0.20	7.4–7.8
	19–37	0.6–2.0	0.15–0.17	7.4–7.8
	37–60	6.0–20	0.05–0.07	7.4–7.8
178 Granby	0–18	6.0–20	0.16–0.18	5.6–7.3
	18–60	6.0–20	0.05–0.09	5.6–8.4
181 Litchfield	0–16	2.0–6.0	0.10–0.12	6.1–7.3
	16–48	2.0–6.0	0.07–0.16	5.6–6.5
	48–60	2.0–6.0	0.08–0.10	6.1–7.3
183 Dassel	0–24	2.0–6.0	0.18–0.20	6.1–6.5
	24–38	2.0–6.0	0.12–0.17	6.1–6.5
	38–60	6.0–20	0.08–0.10	6.6–7.8
196 Joliet	0–17	0.6–2.0	0.17–0.24	6.1–8.4
	17	----------	----------	----------
197 Kingston	0–17	0.6–2.0	0.18–0.24	6.1–7.3
	17–31	0.6–2.0	0.16–0.20	6.1–7.3
	31–60	0.6–2.0	0.16–0.20	7.4–7.8
211 Lura	0–58	0.06–0.2	0.14–0.17	6.1–7.3
	58–60	0.06–0.2	0.11–0.19	7.4–7.8
219 Rolfe	0–14	0.6–2.0	0.22–0.24	5.1–6.5
	14–30	0.06–0.2	0.11–0.13	6.1–7.3
	30–60	0.2–2.0	0.14–0.16	6.1–8.4

properties of soils—Continued

Shrink-swell potential	Risk of corrosion		Erosion factors		Wind erodibility group
	Uncoated steel	Concrete	K	T	
Moderate	High	Low	0.24	5	6
Moderate	High	Low	0.24		
Moderate	High	Low	0.37		
High	High	Low	0.37	5	4
High	High	Low	0.37		
Moderate	High	Low	0.37		
High	High	Low	0.24	5	6
High	High	Low	0.24		
Moderate	High	Low	0.37		
Moderate	High	Low	0.24	5	6
Moderate	High	Low	0.32		
Moderate	High	Low	0.32		
Low	Low	Low	0.32	5	5
Low	Low	Low	0.43		
Low	Low	Low	0.43		
Moderate	High	Low	0.24	5–4	6
Moderate	High	Low	0.24		
Low	High	Low	0.32		
High	High	Low	0.37	5	4
High	High	Low	0.37		
Moderate	High	Low	0.28	5	6
Moderate	High	Low	0.37		
Low	High	Low	0.37		
Moderate	High	High	0.37	3	6
High	High	High	0.37		
Moderate	High	High	0.37		
Moderate	High	Low	0.28	5	4L
Moderate	High	Low	0.37		
Low	High	Low	0.37		
Low	High	Low	0.20	5	4L
Low	High	Low	0.20		
Low	High	Low	0.15		
Low	High	Low	0.17	5	3
Low	High	Low	0.17		
Low	Low	Low	0.15	5	2
Low	Low	Low	0.15		
Low	Low	Low	0.15		
Low	High	Low	0.20	5	5
Low	High	Low	0.20		
Low	High	Low	0.20		
Moderate	High	Low	0.37	2	6
Low	High	Low	0.28	5	7
Moderate	High	Low	0.37		
Low	High	Low	0.37		
High	High	Low	0.32	5	8
High	High	Low	0.32		
Moderate	High	Moderate	0.37	5	6
High	High	Moderate	0.37		
Moderate	High	Low	0.37		

TABLE 11.—*Physical and chemical*

Soil name and map symbol	Depth	Permeability	Available water capacity	Soil reaction
	In	*In/hr*	*In/in*	*pH*
222B Lasa	0–15	2.0–6.0	0.08–0.10	5.6–6.5
	15–45	2.0–6.0	0.07–0.09	6.1–7.3
	45–60	6.0–20	0.06–0.08	6.1–7.3
229 Waldorf	0–20	0.2–2.0	0.18–0.25	6.6–7.8
	20–45	0.2–0.6	0.13–0.16	6.6–7.8
	45–60	0.2–2.0	0.20–0.22	7.4–8.4
230 Guckeen	0–22	0.2–0.6	0.16–0.19	5.6–6.5
	22–31	0.06–0.6	0.13–0.16	6.1–7.3
	31–60	0.2–0.6	0.15–0.17	7.4–7.8
238B, 238C Kilkenny	0–7	0.2–0.6	0.17–0.19	5.6–6.5
	7–34	0.2–0.6	0.15–0.19	4.5–6.5
	34–60	0.2–2.0	0.14–0.16	7.4–7.8
238D Kilkenny	0–7	0.2–0.6	0.17–0.19	5.6–6.5
	7–31	0.2–0.6	0.15–0.19	4.5–6.5
	31–60	0.2–2.0	0.14–0.16	7.4–7.8
239 Le Sueur	0–13	0.6–2.0	0.17–0.19	5.6–7.3
	13–41	0.6–2.0	0.15–0.19	5.6–7.3
	41–60	0.6–2.0	0.14–0.16	7.4–8.4
248 Lomax	0–19	2.0–6.0	0.13–0.22	5.1–6.5
	19–26	2.0–6.0	0.12–0.19	5.1–6.5
	26–60	2.0–6.0	0.05–0.11	5.1–7.3
259B Grays	0–14	0.6–2.0	0.22–0.24	5.6–6.5
	14–40	0.6–2.0	0.18–0.20	5.6–6.5
	40–60	0.6–6.0	0.14–0.22	7.4–8.4
275B Ocheyedan	0–15	0.6–2.0	0.20–0.22	5.1–7.3
	15–34	0.6–6.0	0.16–0.18	6.1–7.3
	34–60	0.6–2.0	0.19–0.21	7.9–8.4
281 Darfur	0–19	0.6–2.0	0.20–0.22	6.1–7.3
	19–31	2.0–6.0	0.15–0.17	6.6–7.8
	31–60	2.0–6.0	0.08–0.10	6.6–8.4
286 Shorewood	0–17	0.2–0.6	0.18–0.22	5.6–7.3
	17–39	0.06–0.6	0.13–0.16	5.1–6.5
	39–60	0.2–2.0	0.14–0.16	6.6–7.8
287 Minnetonka	0–19	0.2–0.6	0.18–0.22	5.6–7.3
	19–40	0.06–0.2	0.13–0.19	5.6–7.3
	40–60	0.2–2.0	0.16–0.21	6.6–7.8
310 Beauford	0–20	0.06–0.2	0.13–0.16	6.6–7.3
	20–46	0.06–0.2	0.10–0.14	6.6–7.3
	46–60	0.06–0.2	0.09–0.13	7.4–7.8
311 Shorewood	0–17	0.2–0.6	0.14–0.17	5.6–7.3
	17–45	0.06–0.6	0.13–0.16	5.1–6.5
	45–60	0.2–2.0	0.14–0.16	6.6–7.8
316 Baroda	0–14	0.6–2.0	0.18–0.22	5.1–7.3
	14–46	<0.06	0.13–0.16	4.5–6.0
	46–60	0.6–2.0	0.14–0.16	7.9–8.4
317 Oshawa	0–21	0.6–2.0	0.20–0.22	7.4–7.8
	21–60	0.2–0.6	0.17–0.19	7.4–7.8
319 Barbert	0–17	0.6–2.0	0.22–0.24	5.1–6.5
	17–43	0.06–0.2	0.10–0.14	5.1–7.3
	43–60	0.2–0.6	0.16–0.19	7.4–7.8
321 Tilfer	0–11	0.6–2.0	0.20–0.22	7.4–8.4
	11–31	0.6–2.0	0.17–0.19	6.6–8.4
	31	-------------------	-------------------	-------------------

properties of soils—Continued

Shrink-swell potential	Risk of corrosion: Uncoated steel	Risk of corrosion: Concrete	Erosion factors: K	Erosion factors: T	Wind erodibility group
Low	Low	Moderate	0.15	5	1
Low	Low	Moderate	0.15		
Low	Low	Moderate	0.15		
Moderate	High	Low	0.28	5	4
High	High	Low	0.28		
Moderate	High	Low	0.28		
Moderate	High	Low	0.28	3	7
Moderate	High	Low	0.28		
Moderate	High	Low	0.37		
Moderate	Moderate	Moderate	0.28	5–4	6
Moderate	Moderate	Low	0.28		
Moderate	Moderate	Low	0.37		
Moderate	Moderate	Moderate	0.28	5–4	6
Moderate	Moderate	Low	0.28		
Moderate	Moderate	Low	0.37		
Moderate	High	Low	0.24	5–4	6
Moderate	High	Low	0.32		
Moderate	High	Low	0.32		
Low	Low	Moderate	0.28	5	5
Low	Low	Moderate	0.28		
Very low	Low	High	0.15		
Low	Moderate	Moderate	0.32	5–4	6
Moderate	Moderate	Moderate	0.43		
Low	Moderate	Low	0.43		
Low	Low	Low	0.24	5–4	6
Low	Low	Low	0.32		
Low	Low	Low	0.32		
Low	High	Low	0.20	5	5
Low	High	Low	0.20		
Low	High	Low	0.20		
Moderate	High	Moderate	0.37	3	7
High	High	Moderate	0.37		
Moderate	High	Low	0.37		
Moderate	High	Moderate	0.37	5	7
High	High	Moderate	0.37		
Moderate	High	Low	0.37		
High	High	Low	0.32	5	4
High	High	Low	0.32		
High	High	Low	0.32		
High	High	Moderate	0.37	3	4
High	High	Moderate	0.37		
Moderate	High	Low	0.37		
Moderate	High	Moderate	0.32	5	4
High	High	Moderate	0.32		
High	High	Low	0.32		
Low	High	Low	0.24	5	8
Low	High	Low	0.24		
Moderate	High	Moderate	0.32	3	6
High	High	Low	0.32		
High	High	Low	0.32		
Moderate	High	Low	0.24	4	6
Moderate	High	Low	0.32		

TABLE 11.—*Physical and chemical*

Soil name and map symbol	Depth	Permeability	Available water capacity	Soil reaction
	In	*In/hr*	*In/in*	*pH*
329 Chaska	0–8	0.6–2.0	0.20–0.22	6.6–7.8
	8–38	0.6–2.0	0.17–0.19	7.4–7.8
	38–60	2.0–6.0	0.07–0.16	7.4–8.4
349 Calco	0–48	0.2–0.6	0.21–0.23	7.4–8.4
	48–60	0.2–0.6	0.18–0.20	7.4–8.4
353 Comfrey	0–34	0.6–2.0	0.18–0.22	6.6–7.8
	34–60	0.6–2.0	0.15–0.19	7.4–8.4
354 Dorchester	0–36	0.6–2.0	0.20–0.22	7.9–8.4
	36–61	0.6–2.0	0.22–0.24	6.6–7.3
360B, 360E Lasa	0–22	2.0–6.0	0.10–0.12	5.6–6.5
	22–48	2.0–6.0	0.07–0.09	6.1–7.3
	48	----------	----------	----------
363 Minneopa	0–15	2.0–6.0	0.13–0.15	6.1–7.3
	15–20	2.0–6.0	0.09–0.14	6.1–7.3
	20–60	6.0–20	0.08–0.10	6.1–7.3
364 Minnetonka	0–16	0.2–0.6	0.18–0.22	5.6–7.3
	16–35	0.06–0.2	0.13–0.19	5.6–7.3
	35–60	0.2–2.0	0.16–0.21	6.6–7.8
414 Hamel	0–28	0.2–2.0	0.18–0.22	5.1–6.5
	28–34	0.2–0.6	0.16–0.19	5.6–7.3
	34–60	0.6–2.0	0.14–0.18	7.4–7.8
440 Copaston	0–8	0.6–2.0	0.20–0.22	6.1–7.3
	8–12	0.6–6.0	0.12–0.14	5.6–7.3
	12	----------	----------	----------
448 Shorewood	0–15	0.2–0.6	0.18–0.21	5.6–7.3
	15–33	0.06–0.2	0.13–0.19	5.6–7.3
	33–60	0.6–2.0	0.18–0.21	6.6–7.8
451 Dorchester	0–36	0.6–2.0	0.20–0.22	7.9–8.4
	36–61	0.6–2.0	0.22–0.24	6.6–7.3
524 Caron	0–8	2.0–6.0	0.30–0.40	5.6–7.8
	8–35	2.0–20	0.40–0.50	5.6–7.8
	35–60	0.2–0.6	0.20–0.22	6.1–7.8
525 Muskego	0–32	0.2–6.0	0.35–0.45	6.1–7.3
	32–84	0.06–0.2	----------	6.6–7.8
539 Palms	0–50	0.2–6.0	0.35–0.45	5.1–8.4
	50–60	0.2–2.0	0.05–0.19	6.1–8.4
548 Palms	0–30	0.2–6.0	0.35–0.45	5.1–6.5
	30–45	0.6–2.0	0.16–0.20	6.1–7.8
	45–60	2.0–6.0	0.08–0.10	7.4–7.8
851* Chaska	0–8	0.6–2.0	0.20–0.22	6.6–7.8
	8–38	0.6–2.0	0.17–0.19	7.4–7.8
	38–60	2.0–6.0	0.07–0.16	7.4–8.4
852* Copaston	0–8	0.6–2.0	0.20–0.22	6.1–7.3
	8–12	0.6–6.0	0.12–0.14	5.6–7.3
	12	----------	----------	----------
853* Copaston	0–10	0.6–2.0	0.20–0.22	6.1–7.3
	10–19	0.6–6.0	0.12–0.14	5.6–7.3
	19	----------	----------	----------
854* Cordova	0–13	0.2–0.6	0.18–0.22	6.1–7.3
	13–32	0.2–0.6	0.15–0.19	5.1–6.5
	32–60	0.6–2.0	0.14–0.16	7.4–8.4

properties of soils—Continued

Shrink-swell potential	Risk of corrosion		Erosion factors		Wind erodibility group
	Uncoated steel	Concrete	K	T	
Low	High	Low	0.24	5	4L
Low	High	Low	0.32		
Low	High	Low	0.32		
High	High	Low	0.37	5	7
High	High	Low	0.37		
Moderate	High	Low	0.24	5	6
Moderate	High	Low	0.37		
Low	High	Low	0.37	5	6
Moderate	High	Low	0.37		
Low	Low	Moderate	0.15	5	2
Low	Low	Moderate	0.15		
—	—	—	—		
Low	Low	Low	0.20	5	3
Low	Low	Low	0.20		
Low	Low	Low	0.20		
Moderate	High	Moderate	0.37	5	7
High	High	Moderate	0.37		
Moderate	High	Low	0.37		
Moderate	High	Low	0.24	5	6
Moderate	High	Low	0.32		
Moderate	High	Low	0.32		
Low	Low	Low	0.28	2	5
Low	Low	Low	0.28		
—	—	—	—		
Moderate	High	Moderate	0.37	3	7
High	High	Moderate	0.37		
Low	Moderate	Low	0.37		
Low	High	Low	0.37	5	6
Moderate	High	Low	0.37		
—	High	Moderate	0.10	5	3
High	High	Moderate	0.10		
High	High	Moderate	0.10		
—	Moderate	Moderate	0.10	5	3
—	Moderate	Moderate	0.10		
—	High	Moderate	0.10	5	3
Low	High	Low	0.10		
—	High	High	0.10	5	3
Moderate	High	Low	0.32		
Low	High	Low	0.15		
Low	High	Low	0.24	5	4L
Low	High	Low	0.32		
Low	High	Low	0.32		
Low	Low	Low	0.28	2	5
Low	Low	Low	0.28		
—	—	—	—		
Low	Low	Low	0.20	2	8
Low	Low	Low	0.28		
—	—	—	—		
Moderate	High	Low	0.24	5	6
Moderate	High	Low	0.24		
Moderate	High	Low	0.37		

TABLE 11.—*Physical and chemical*

Soil name and map symbol	Depth	Permeability	Available water capacity	Soil reaction
	In	*In/hr*	*In/in*	*pH*
855* Dorchester	0-36 36-61	0.6-2.0 0.6-2.0	0.20-0.22 0.22-0.24	7.9-8.4 6.6-7.3
856B*, 856C* Terril	0-45 45-60	0.6-2.0 0.6-2.0	0.20-0.22 0.16-0.18	6.1-7.3 6.1-7.3
909C*, 909D*: Bold	0-60	0.6-2.0	0.20-0.24	7.4-8.4
Truman	0-14 14-36 36-60	0.6-2.0 0.6-2.0 0.6-2.0	0.20-0.23 0.18-0.21 0.18-0.20	6.1-7.3 6.1-7.8 7.4-8.4
919*: Canisteo	0-14 14-27 27-60	0.6-2.0 0.6-2.0 0.6-2.0	0.18-0.22 0.15-0.19 0.14-0.16	7.4-8.4 7.4-8.4 7.4-8.4
Fieldon	0-19 19-37 37-60	0.6-2.0 0.6-2.0 6.0-20	0.18-0.20 0.15-0.17 0.05-0.07	7.4-7.8 7.4-7.8 7.4-7.8
920B*, 920C*, 920D*: Clarion	0-14 14-34 34-60	0.6-2.0 0.6-2.0 0.6-2.0	0.20-0.22 0.17-0.19 0.17-0.19	6.1-7.3 5.6-7.8 7.9-8.4
Estherville	0-14 14-22 22-60	2.0-6.0 2.0-6.0 6.0-20	0.13-0.15 0.09-0.14 0.02-0.04	5.6-7.3 5.6-7.3 6.6-7.8
921C*, 921D*: Clarion	0-14 14-34 34-60	0.6-2.0 0.6-2.0 0.6-2.0	0.20-0.22 0.17-0.19 0.17-0.19	6.1-7.3 5.6-7.8 7.9-8.4
Storden	0-8 8-60	0.6-2.0 0.6-2.0	0.20-0.22 0.17-0.19	7.4-8.4 7.4-8.4
923* Copaston	0-10 10-19 19	0.6-2.0 0.6-6.0 ---	0.20-0.22 0.12-0.14 ---	6.1-7.3 5.6-7.3 ---
926*: Darfur	0-19 19-31 31-60	0.6-2.0 2.0-6.0 2.0-6.0	0.20-0.22 0.15-0.17 0.08-0.10	6.1-7.3 6.6-7.8 6.6-8.4
Webster	0-20 20-30 30-60	0.6-2.0 0.2-2.0 0.6-2.0	0.19-0.21 0.16-0.18 0.17-0.19	6.6-7.3 6.6-7.8 7.9-8.4
929*: Fieldon	0-19 19-37 37-60	0.6-2.0 0.6-2.0 6.0-20	0.18-0.20 0.15-0.17 0.05-0.07	7.4-7.8 7.4-7.8 7.4-7.8
Canisteo	0-14 14-27 27-60	0.6-2.0 0.6-2.0 0.6-2.0	0.18-0.22 0.15-0.19 0.14-0.16	7.4-8.4 7.4-8.4 7.4-8.4
932*: Glencoe	0-26 26-38 38-60	0.2-2.0 0.2-2.0 0.2-2.0	0.18-0.22 0.15-0.19 0.15-0.19	6.6-7.3 6.6-7.8 7.4-7.8
Dassel	0-24 24-38 38-60	2.0-6.0 2.0-6.0 6.0-20	0.18-0.20 0.12-0.17 0.08-0.10	6.1-6.5 6.1-6.5 6.6-7.8

properties of soils—Continued

Shrink-swell potential	Risk of corrosion		Erosion factors		Wind erodibility group
	Uncoated steel	Concrete	K	T	
Low	High	Low	0.37	5	6
Moderate	High	Low	0.37		
Low	Moderate	Low	0.24	5	6
Low	Moderate	Low	0.32		
Low	Low	Low	0.43	5–4	4L
Low	Low	Low	0.32	5–4	6
Moderate	Low	Low	0.43		
Low	Low	Low	0.43		
Moderate	High	Low	0.24	5	4L
Moderate	High	Low	0.32		
Moderate	High	Low	0.32		
Low	High	Low	0.20	5	4L
Low	High	Low	0.20		
Low	High	Low	0.15		
Low	Low	Low	0.28	5–4	6
Low	Low	Low	0.28		
Low	Low	Low	0.37		
Low	Low	Low	0.20	3–2	3
Low	Low	Low	0.20		
Low	Low	Low	0.10		
Low	Low	Low	0.28	5–4	6
Low	Low	Low	0.28		
Low	Low	Low	0.37		
Low	Low	Low	0.28	5–4	4L
Low	Low	Low	0.37		
Low	Low	Low	0.28	2	5
Low	Low	Low	0.28		
---	---	---	---		
Low	High	Low	0.20	5	5
Low	High	Low	0.20		
Low	High	Low	0.20		
High	High	Low	0.24	5	6
High	High	Low	0.24		
Moderate	High	Low	0.37		
Low	High	Low	0.20	5	4L
Low	High	Low	0.20		
Low	High	Low	0.15		
Moderate	High	Low	0.24	5	4L
Moderate	High	Low	0.32		
Moderate	High	Low	0.32		
Moderate	High	Low	0.24	5	6
Moderate	High	Low	0.32		
Moderate	High	Low	0.32		
Low	High	Low	0.20	5	5
Low	High	Low	0.20		
Low	High	Low	0.20		

TABLE 11.—*Physical and chemical*

Soil name and map symbol	Depth	Permeability	Available water capacity	Soil reaction
	In	*In/hr*	*In/in*	*pH*
941*:				
Kingston	0-17	0.6-2.0	0.18-0.24	6.1-7.3
	17-31	0.6-2.0	0.16-0.20	6.1-7.3
	31-60	0.6-2.0	0.16-0.20	7.4-7.8
Nicollet	0-21	0.6-2.0	0.17-0.22	6.1-7.3
	21-44	0.6-2.0	0.15-0.19	5.6-7.8
	44-60	0.6-2.0	0.14-0.19	7.4-7.8
946*:				
Litchfield	0-16	2.0-6.0	0.10-0.12	6.1-7.3
	16-48	2.0-6.0	0.07-0.16	5.6-6.5
	48-60	2.0-6.0	0.08-0.10	6.1-7.3
Nicollet	0-21	0.6-2.0	0.17-0.22	6.1-7.3
	21-44	0.6-2.0	0.15-0.19	5.6-7.8
	44-60	0.6-2.0	0.14-0.19	7.4-7.8
947*:				
Madelia	0-19	0.6-2.0	0.18-0.24	6.1-7.3
	19-37	0.6-2.0	0.16-0.22	6.6-7.8
	37-60	0.6-2.0	0.16-0.22	7.4-7.8
Webster	0-20	0.6-2.0	0.19-0.21	6.6-7.3
	20-30	0.2-2.0	0.16-0.18	6.6-7.8
	30-60	0.6-2.0	0.17-0.19	7.9-8.4
960E*:				
Storden	0-8	0.6-2.0	0.20-0.22	7.4-8.4
	8-60	0.6-2.0	0.17-0.19	7.4-8.4
Clarion	0-14	0.6-2.0	0.20-0.22	6.1-7.3
	14-22	0.6-2.0	0.17-0.19	5.6-7.8
	22-60	0.6-2.0	0.17-0.19	7.9-8.4
961*, 961F* Storden	0-8	0.6-2.0	0.20-0.22	7.4-8.4
	8-60	0.6-2.0	0.17-0.19	7.4-8.4
968*:				
Webster	0-20	0.6-2.0	0.19-0.21	6.6-7.3
	20-30	0.2-2.0	0.16-0.18	6.6-7.8
	30-60	0.6-2.0	0.17-0.19	7.9-8.4
Darfur	0-19	0.6-2.0	0.20-0.22	6.1-7.3
	19-31	2.0-6.0	0.15-0.17	6.6-7.8
	31-60	2.0-6.0	0.08-0.10	6.6-8.4
Granby	0-18	6.0-20	0.16-0.18	5.6-7.3
	18-60	6.0-20	0.05-0.09	5.6-8.4
978*:				
Cordova	0-13	0.2-0.6	0.18-0.22	6.1-7.3
	13-32	0.2-0.6	0.15-0.19	5.1-6.5
	32-60	0.6-2.0	0.14-0.16	7.4-8.4
Rolfe	0-14	0.6-2.0	0.22-0.24	5.1-6.5
	14-45	0.06-0.2	0.11-0.13	6.1-7.3
	45-60	0.2-2.0	0.14-0.16	6.1-8.4
992*:				
Rock outcrop.				
Copaston	0-7	0.6-2.0	0.20-0.22	6.1-7.3
	7-12	0.6-6.0	0.12-0.14	5.6-7.3
	12	---	---	---

properties of soils—Continued

Shrink-swell potential	Risk of corrosion		Erosion factors		Wind erodibility group
	Uncoated steel	Concrete	K	T	
Low	High	Low	0.28	5	7
Moderate	High	Low	0.37		
Low	High	Low	0.37		
Moderate	High	Low	0.24	5–4	6
Moderate	High	Low	0.24		
Low	High	Low	0.32		
Low	Low	Low	0.15	5	2
Low	Low	Low	0.15		
Low	Low	Low	0.15		
Moderate	High	Low	0.24	5–4	6
Moderate	High	Low	0.24		
Low	High	Low	0.32		
Moderate	High	Low	0.28	5	6
Moderate	High	Low	0.37		
Low	High	Low	0.37		
High	High	Low	0.24	5	6
High	High	Low	0.24		
Moderate	High	Low	0.37		
Low	Low	Low	0.28	5–4	4L
Low	Low	Low	0.37		
Low	Low	Low	0.28	5–4	6
Low	Low	Low	0.28		
Low	Low	Low	0.37		
Low	Low	Low	0.28	5–4	4L
Low	Low	Low	0.37		
High	High	Low	0.24	5	6
High	High	Low	0.24		
Moderate	High	Low	0.37		
Low	High	Low	0.20	5	5
Low	High	Low	0.20		
Low	High	Low	0.20		
Low	High	Low	0.17	5	3
Low	High	Low	0.17		
Moderate	High	Low	0.24	5	6
Moderate	High	Low	0.24		
Moderate	High	Low	0.37		
Moderate	High	Moderate	0.37	5	6
High	High	Moderate	0.37		
Moderate	High	Low	0.37		
Low	Low	Low	0.28	2	5
Low	Low	Low	0.28		

TABLE 11.—*Physical and chemical*

Soil name and map symbol	Depth	Permeability	Available water capacity	Soil reaction
	In	*In/hr*	*In/in*	*pH*
996*:				
Beauford	0-18 18-40 40-60	0.06-0.2 0.06-0.2 0.06-0.2	0.13-0.16 0.10-0.14 0.09-0.13	6.6-7.3 6.6-7.3 7.4-7.8
Barbert	0-17 17-43 43-60	0.6-2.0 0.06-0.2 0.2-0.6	0.22-0.24 0.10-0.14 0.16-0.19	5.1-6.5 5.1-7.3 7.4-7.8
997*:				
Marna	0-20 20-32 32-60	0.06-0.2 0.06-0.2 0.2-2.0	0.18-0.22 0.13-0.16 0.14-0.19	6.1-7.3 6.1-7.3 6.6-7.8
Barbert	0-17 17-43 43-60	0.6-2.0 0.06-0.2 0.2-0.6	0.22-0.24 0.10-0.14 0.16-0.19	5.1-6.5 5.1-7.3 7.4-7.8
998*:				
Minnetonka	0-19 19-40 40-60	0.2-0.6 0.06-0.2 0.2-2.0	0.18-0.22 0.13-0.19 0.16-0.21	5.6-7.3 5.6-7.3 6.6-7.8
Barbert	0-17 17-43 43-60	0.6-2.0 0.06-0.2 0.2-0.6	0.22-0.24 0.10-0.14 0.16-0.19	5.1-6.5 5.1-7.3 7.4-7.8
1001*, 1002*, 1004*. Alluvial land				
1007*. Alluvial-Urban land				
1032*. Lake beaches				
1039*. Urban land				
1053*. Marsh				
1800 Caron	0-60	2.0-20	0.40-0.50	5.6-7.8
1801B Grogan	0-13 13-60	2.0-6.0 2.0-6.0	0.22-0.24 0.17-0.19	5.6-7.3 6.1-8.4

* See map unit description for the composition and behavior of the map unit.

Estimates are based mainly on the relationship between grayish colors or mottles in the soil and the depth to free water observed in many borings made during the course of the soil survey. Indicated in table 12 are the depth to the seasonal high water table; the kind of water table, that is, perched, artesian, or apparent; and the months of the year that the water table commonly is high. Only saturated zones above a depth of 5 or 6 feet are indicated.

Information about the seasonal high water table helps in assessing the need for specially designed foundations, the need for specific kinds of drainage systems, and the need for footing drains to insure dry basements. Such information is also needed to decided whether or not construction of basements is feasible and to determine how septic tank absorption fields and other underground installations will function. Also, a seasonal high water table affects ease of excavation.

Depth to bedrock is shown for all soils that are underlain by bedrock at a depth of 5 to 6 feet or less. For many soils, the limited depth to bedrock is a part of the definition of the soil series. The depths shown are based on measurements made in many soil borings and on other observations during the mapping of the soils. The kind of bedrock and its hardness as related to ease of excavation is also shown. Rippable bedrock

properties of soils—Continued

Shrink-swell potential	Risk of corrosion		Erosion factors		Wind erodibility group
	Uncoated steel	Concrete	K	T	
High High High	High High High	Low Low Low	0.32 0.32 0.32	5	4
Moderate High High	High High High	Moderate Low Low	0.32 0.32 0.32	3	6
High High Moderate	High High High	Low Low Low	0.37 0.37 0.37	5	4
Moderate High High	High High High	Moderate Low Low	0.32 0.32 0.32	3	6
Moderate High Moderate	High High High	Moderate Moderate Low	0.37 0.37 0.37	5	7
Moderate High High	High High High	Moderate Low Low	0.32 0.32 0.32	3	6
	High	Moderate	0.10	5	8
Low Low	Low Low	Low Low	0.32 0.43	5	5

can be excavated with a single-tooth ripping attachment on a 200-horsepower tractor, but hard bedrock generally requires blasting.

Potential frost action refers to the likelihood of damage to pavements and other structures by frost heaving and low soil strength after thawing. Frost action results from the movement of soil moisture into the freezing temperature zone in the soil, which causes ice lenses to form. Soil texture, temperature, moisture content, porosity, permeability, and content of organic matter are the most important soil properties that affect frost action. It is assumed that the soil is not covered by insulating vegetation or snow and is not artificially drained. Silty and clayey soils that have a high water table in winter are most susceptible to frost action. Well drained very gravelly or sandy soils are the least susceptible.

Soil test data

Table 13 contains engineering test data for some of the major soil series in Blue Earth County. These tests were made by the Minnesota Highway Department in St. Paul. They were made to help evaluate the soils for engineering purposes. The engineering classifications given are based on data obtained by mechanical analyses and by tests to determine liquid limits and

TABLE 12.—*Soil and*

[Absence of an entry indicates the feature is not a concern.

Soil name and map symbol	Hydrologic group	Flooding		
		Frequency	Duration	Months
17 Minneopa	B	Rare		
18 Comfrey	B/D	Occasional	Brief to long	Apr–Jul
27, 27B Dickinson	B	None		
35 Blue Earth	B/D	Common	Brief	Apr–Jun
39, 39B Wadena	B	None		
41, 41B, 41C Estherville	B	None		
62 Barrington	B	None		
69, 69B Fedji	A	None		
84 Brownton	C/D	None		
85 Calco	B/D	Common	Brief	Mar–Jun
86 Canisteo	C/D	None		
94, 94B, 94C Terril	B	None		
96, 96B, 96C, 96D Collinwood	C	None		
100 Copaston	D	None		
101B, 101C Truman	B	None		
102B, 102C, 102D Clarion	B	None		
105B, 105C, 105D Kamrar	B	None		
106B, 106C, 106D, 106E Lester	B	None		
109 Cordova	C/D	None		
110 Marna	D	None		
113 Webster	B/D	None		
114 Glencoe	B/D	Frequent	Brief to long	Apr–May

water features

The symbol > means greater than]

High water table			Bedrock		Potential frost action
Depth	Kind	Months	Depth	Hardness	
Ft			*In*		
3.0–5.0	Apparent	Apr–May	>60		Moderate.
1.0–3.0	Apparent	Nov–Jul	>60		High.
>6.0			>60		Moderate.
0–1.0	Apparent	Nov–Jun	>60		High.
>6.0			>60		Low.
>6.0			>60		Low.
3.0–5.0	Apparent	Mar–Jun	>60		High.
>6.0			>60		Low.
1.0–3.0	Apparent	Nov–Jun	>60		High.
1.0–3.0	Apparent	Nov–May	>60		High.
1.0–3.0	Apparent	Nov–Jun	>60		High.
>6.0			>60		Moderate.
2.0–5.0	Apparent	Nov–May	>60		High.
>6.0			12–20	Hard	Moderate.
>6.0			>60		High.
>6.0			>60		Moderate.
>6.0			>60		Moderate.
>6.0			>60		Moderate.
1.0–3.0	Apparent	Nov–May	>60		High.
1.0–3.0	Apparent	Nov–Jun	>60		High.
1.0–4.0	Apparent	Nov–May	>60		High.
0–1.0	Apparent	Oct–Jun	>60		High.

TABLE 12.—*Soil and*

Soil name and map symbol	Hydrologic group	Flooding		
		Frequency	Duration	Months
128, 128B Grogan	B	None	---	---
130 Nicollet	B	None	---	---
134 Okoboji	B/D	Common	Brief	Nov–Jun
136 Madelia	B/D	None	---	---
138B2, 138C2 Lerdal	C	None	---	---
140 Spicer	B/D	None	---	---
160 Fieldon	B/D	None	---	---
178 Granby	A/D	Occasional	Brief	Mar–Apr
181 Litchfield	A	None	---	---
183 Dassel	B/D	Common	Brief	Apr–May
196 Joliet	D	Frequent	Brief	Apr–Jun
197 Kingston	B	None	---	---
211 Lura	C/D	Frequent	Brief to long	Apr–May
219 Rolfe	C/D	Common	Brief	Mar–Jun
222B Lasa	A	None	---	---
229 Waldorf	C/D	None	---	---
230 Guckeen	C	None	---	---
238B, 238C, 238D Kilkenny	B	None	---	---
239 Le Sueur	B	None	---	---
248 Lomax	B	None	---	---
259B Grays	B	None	---	---
275B Ocheyedan	B	None	---	---
281 Darfur	B/D	None	---	---

water features—Continued

High water table			Bedrock		Potential frost action
Depth	Kind	Months	Depth	Hardness	
Ft			*In*		
3.0–6.0	Apparent	Mar–Jun	>60		High.
3.0–5.0	Apparent	Apr–May	>60		High.
0–1.0	Apparent	Nov–May	>60		High.
1.0–3.0	Apparent	Nov–May	>60		High.
1.0–3.0	Perched	Apr–May	>60		High.
1.0–3.0	Apparent	Nov–May	>60		High.
1.0–3.0	Apparent	Nov–Jun	>60		High.
1.0–3.0	Apparent	Nov–Jun	>60		Moderate.
3.0–5.0	Apparent	Apr–May	>60		Moderate.
0–1.0	Apparent	Oct–Jun	>60		High.
0–2.0	Perched	Nov–Jul	10–20	Hard	High.
3.0–5.0	Apparent	Apr–May	>60		High.
0–1.0	Apparent	Nov–May	>60		High.
0–3.0	Perched	Nov–Jun	>60		High.
>6.0			>60		Low.
1.0–3.0	Apparent	Nov–Jun	>60		High.
3.0–5.0	Apparent	Apr–May	>60		High.
>6.0			>60		Moderate.
2.0–5.0	Apparent	Apr–May	>60		High.
>6.0			>60		Moderate.
>4.0	Apparent	Feb–Mar	>60		High.
>6.0			>60		Moderate.
1.0–3.0	Apparent	Dec–May	>60		High.

TABLE 12.—*Soil and*

Soil name and map symbol	Hydrologic group	Flooding		
		Frequency	Duration	Months
286 Shorewood	C	None		
287 Minnetonka	D	None		
310 Beauford	D	None		
311 Shorewood	C	None		
316 Baroda	C/D	None		
317 Oshawa	D	Frequent	Long	Apr–Jul
319 Barbert	D	Common	Brief	Apr–May
321 Tilfer	B/D	Occasional	Brief	Mar–Jul
329 Chaska	B/D	Occasional	Brief	Apr–Jun
349 Calco	B/D	Common	Brief	Mar–Jun
353 Comfrey	B/D	Frequent	Brief to long	Apr–Jul
354 Dorchester	B	Occasional	Brief to long	Feb–Nov
360B, 360E Lasa	A	None		
363 Minneopa	B	Occasional	Brief	Apr–May
364 Minnetonka	D	None		
414 Hamel	C	None		
440 Copaston	D	None		
448 Shorewood	C	None		
451 Dorchester	B	Rare		
524 Caron	A/D	Frequent	Long	Apr–Jun
525 Muskego	A/D	Frequent	Long	Nov–May
539, 548 Palms	A/D	Frequent	Long	Nov–May
851* Chaska	B/D	Rare		

water features—Continued

High water table			Bedrock		Potential frost action
Depth	Kind	Months	Depth	Hardness	
Ft			*In*		
3.0–5.0	Perched	Apr–Jun	>60		High.
1.0–3.0	Perched	Apr–Jun	>60		High.
1.0–3.0	Apparent	Nov–Jun	>60		High.
3.0–5.0	Perched	Apr–Jun	>60		High.
1.0–3.0	Perched	Nov–Jun	>60		High.
0–1.0	Apparent	Nov–Jul	>60		High.
0–2.0	Perched	Nov–Jun	>60		High.
1.0–3.0	Apparent	Nov–Jun	20–40	Hard	High.
1.0–3.0	Apparent	Nov–Jun	>60		High.
1.0–3.0	Apparent	Nov–May	>60		High.
1.0–3.0	Apparent	Nov–Jul	>60		High.
3.0–6.0	Apparent	Mar–Jun	>60		High.
>6.0			>60		Low.
3.0–5.0	Apparent	Apr–May	>60		Moderate.
1.0–3.0	Perched	Apr–Jun	>60		High.
1.0–3.0	Apparent	Nov–May	>60		High.
>6.0			12–20	Hard	Moderate.
3.0–5.0	Perched	Apr–Jun	>60		High.
3.0–5.0	Apparent	Mar–Jun	>60		High.
0–1.0	Apparent	Nov–Jun	>60		High.
0–1.0	Apparent	Nov–Aug	>60		High.
0–1.0	Apparent	Nov–May	>60		High.
1.0–3.0	Apparent	Nov–Jun	>60		High.

TABLE 12.—*Soil and*

Soil name and map symbol	Hydrologic group	Flooding		
		Frequency	Duration	Months
852*, 853* Copaston	D	None	---	---
854* Cordova	C/D	None	---	---
855* Dorchester	B	Rare	---	---
856B*, 856C* Terril	B	None	---	---
909C*, 909D*:				
Bold	B	None	---	---
Truman	B	None	---	---
919*:				
Canisteo	C/D	None	---	---
Fieldon	B/D	None	---	---
920B*, 920C*, 920D*:				
Clarion	B	None	---	---
Estherville	B	None	---	---
921C*, 921D*:				
Clarion	B	None	---	---
Storden	B	None	---	---
923* Copaston	D	None	---	---
926*:				
Darfur	B/D	None	---	---
Webster	B/D	None	---	---
929*:				
Fieldon	B/D	None	---	---
Canisteo	C/D	None	---	---
932*:				
Glencoe	B/D	Frequent	Brief to long	Apr–May
Dassel	B/D	Common	Brief	Apr–May
941*:				
Kingston	B	None	---	---
Nicollet	B	None	---	---
946*:				
Litchfield	A	None	---	---
Nicollet	B	None	---	---
947*:				
Madelia	B/D	None	---	---
Webster	B/D	None	---	---
960E*:				
Storden	B	None	---	---

water features—Continued

High water table			Bedrock		Potential frost action
Depth	Kind	Months	Depth	Hardness	
Ft			*In*		
>6.0			12–20	Hard	Moderate.
1.0–3.0	Apparent	Nov–May	>60		High.
3.0–5.0	Apparent	Mar–Jun	>60		High.
>6.0			>60		Moderate.
>6.0			>60		High.
>6.0			>60		High.
1.0–3.0	Apparent	Nov–Jun	>60		High.
1.0–3.0	Apparent	Nov–Jun	>60		High.
>6.0			>60		Moderate.
>6.0			>60		Low.
>6.0			>60		Moderate.
>6.0			>60		Moderate.
>6.0			12–20	Hard	Moderate.
1.0–3.0	Apparent	Dec–May	>60		High.
1.0–3.0	Apparent	Nov–May	>60		High.
1.0–3.0	Apparent	Nov–Jun	>60		High.
1.0–3.0	Apparent	Nov–Jun	>60		High.
0–1.0	Apparent	Oct–Jun	>60		High.
0–1.0	Apparent	Oct–Jun	>60		High.
3.0–5.0	Apparent	Apr–May	>60		High.
3.0–5.0	Apparent	Apr–May	>60		High.
3.0–5.0	Apparent	Apr–May	>60		Moderate.
3.0–5.0	Apparent	Apr–May	>60		High.
1.0–3.0	Apparent	Nov–May	>60		High.
1.0–3.0	Apparent	Nov–May	>60		High.
>6.0			>60		Moderate.

TABLE 12.—*Soil and*

Soil name and map symbol	Hydrologic group	Flooding		
		Frequency	Duration	Months
960E*:				
Clarion	B	None	---	---
961*, 961F* Storden	B	None	---	---
968*:				
Webster	B/D	None	---	---
Darfur	B/D	None	---	---
Granby	A/D	Occasional	Brief	Mar–Apr
978*:				
Cordova	C/D	None	---	---
Rolfe	C	Common	Brief	Mar–Jun
992*:				
Rock outcrop.				
Copaston	D	None	---	---
996*:				
Beauford	D	None	---	---
Barbert	D	Common	Brief	Apr–May
997*:				
Marna	D	None	---	---
Barbert	D	Common	Brief	Apr–May
998*:				
Minnetonka	D	None	---	---
Barbert	D	Common	Brief	Apr–May
1001*, 1002*, 1004*. Alluvial land				
1007*. Alluvial-Urban land				
1032*. Lake beaches				
1039*. Urban land				
1053*. Marsh				
1800 Caron	D	None	---	---
1801B Grogan	B	None	---	---

* See map unit description for the composition and behavior of the map unit.

water features—Continued

High water table			Bedrock		Potential frost action
Depth	Kind	Months	Depth	Hardness	
Ft			*In*		
>6.0			>60		Moderate.
>6.0			>60		Moderate.
1.0–3.0	Apparent	Nov–May	>60		High.
1.0–3.0	Apparent	Dec–May	>60		High.
1.0–3.0	Apparent	Nov–Jun	>60		Moderate.
1.0–3.0	Apparent	Nov–May	>60		High.
0–3.0	Perched	Nov–Jun	>60		High.
>6.0			12–20	Hard	Moderate.
1.0–3.0	Apparent	Nov–Jun	>60		High.
0–2.0	Perched	Nov–Jun	>60		High.
1.0–3.0	Apparent	Nov–Jun	>60		High.
0–2.0	Perched	Nov–Jun	>60		High.
1.0–3.0	Perched	Apr–Jun	>60		High.
0–2.0	Perched	Nov–Jun	>60		High.
0–1.0	Perched	Jan–Dec	>60		High.
>6.0			>60		High.

TABLE 13.—*Engineering*

Soil name and location	Parent material	Minnesota report number SS–	Depth from surface	Mechanical analysis: Percentage less than 3 inches passing sieve— No. 4 (4.7 mm)	Mechanical analysis: Percentage less than 3 inches passing sieve— No. 10 (2.0 mm)
			In		
Barbert silt loam: NW¼NW¼ sec. 10, T. 105 N., R. 27 W., about 360 feet east and 100 feet south of NW section corner. (Marginal to very fine)	Lacustrine sediments.	7052	0–7	--------	100
		7053	21–41	--------	--------
		7054	51–75	97	95
Baroda silty clay loam: NW¼NW¼ sec. 10, T. 105 N., R. 27 W., 1,200 feet east and 100 feet south of NW section corner. (Marginal to Minnetonka series)	Lacustrine sediments.	7049	0–9	--------	100
		7050	14–27	--------	--------
		7051	38–54	100	99
Collinwood silty clay loam: SW¼SW¼ sec. 47, T. 107 N., R. 27 W., 1,000 feet north and 100 feet east of SW corner of section 27. (Modal profile)	Lacustrine sediments.	7066	0–13	--------	100
		7067	24–45	100	99
		7068	45–61	--------	--------
Cordova clay loam: SE¼NE¼ sec. 9, T. 108 N., R. 26 W., 800 feet north and 100 feet west of SE corner of NE¼ section 9. (Modal profile)	Glacial till.	7072	0–13	99	99
		7073	13–27	93	92
		7074	32–58	94	92
Grogan silt loam: NW¼NE¼ sec. 21, T. 107 N., R. 28 W., about 1,180 feet east and 2,100 feet south of NW section corner.	Lacustrine sediments deposited over sandy sediments with variable silty bands.	7087	0–10	--------	--------
		7088	16–31	--------	--------
		7089	36–50	--------	--------
SW¼NW¼ sec. 30, T. 107 N., R. 27 W., about 1,180 feet east and 2,100 feet south of NW section corner. (Marginal to Truman series)	Lacustrine sediments.	7084	0–10	99	99
		7085	14–31	--------	--------
		7086	31–46	--------	--------
Guckeen silty clay loam: SE¼SW¼ sec. 23, T. 105 N., R. 28 W., about 2,240 feet east and 2,400 feet north of SW section corner. (Modal profile)	Lacustrine sediments deposited over glacial till.	7045	0–8	--------	100
		7046	8–22	--------	100
		7047	22–39	100	99
		7048	39–60	99	98
Kamrar silty clay: NE¼SW¼ sec. 23, T. 105 N., R. 28 W., about 2,340 feet north and 2,080 feet east of the SW section corner. (Modal profile)	Fine textured material deposited over glacial till.	7078	0–8	--------	100
		7079	16–22	--------	100
		7080	38–48	100	98
Kingston silty clay loam: SW¼NW¼ sec. 30, T. 107 N., R. 27 W., about 385 feet east and 1.580 feet south of NW section corner. (Modal profile)	Lacustrine sediments.	7081	0–11	100	99
		7082	17–31	--------	100
		7083	31–43	--------	100
Lura silty clay loam: NE¼SW¼ sec. 26, T. 105 N., R. 27 W., about 800 feet south and 360 feet west of NE section corner. (Modal profile)	Lacustrine sediments.	7061	0–13	--------	100
		7062	20–46	--------	100
Madelia silty clay loam: SW¼NW¼ sec. 30, T. 107 N., R. 27 W., about 1,940 feet south and 500 feet east of NW section corner. (Taxadjunct to Madelia too deep to lime)	Lacustrine sediments.	7069	0–14	--------	100
		7070	14–33	--------	100
		7071	33–50	--------	100
Marna silty clay loam: SW¼SW¼ sec. 23, T. 105 N., R. 28 W., about 1,760 feet north and 300 feet east of SW section corner.	Lacustrine sediments over glacial till.	7042	0–9	--------	100
		7043	13–18	100	99
		7044	28–42	99	98

test data

Mechanical analysis—cont.						Liquid limit	Plasticity index	Classification	
Percentage less than 3 inches passing sieve—Cont.		Percentage smaller than—						AASHTO	Unified
No. 40 (0.42 mm)	No. 200 (0.074 mm)	0.05 mm	0.02 mm	0.005 mm	0.002 mm				
						Pct			
99	95.7	90	74	43	26	43	12	A-7-6(10)	ML
100	98.3	98	97	81	65	76	47	A-7-6(30)	CH
85	66.5	64	61	44	36	53	29	A-7-5(16)	CH
99	95.3	91	74	47	34	45	14	A-7-5(11)	ML
100	98.5	97	96	82	67	71	31	A-7-5(20)	MH
98	96.5	96	92	73	44	62	28	A-7-5(19)	MH
99	91.3	86	72	39	25	45	14	A-7-5(11)	ML
98	91.9	90	85	65	59	61	35	A-7-6(20)	CH
100	97.7	90	61	17	11	37	6	A-4(8)	ML
94	75.9	71	57	37	27	57	20	A-7-5(15)	MH
87	71.1	65	58	41	32	49	22	A-7-6(14)	CL
85	59.5	54	43	29	20	34	11	A-6(5)	CL
100	72.0	59	33	20	16	26	2	A-4(7)	ML
100	87.0	79	38	24	19	32	6	A-4(8)	ML
100	81.3	63	25	7	7	----------	----------	A-4(8)	CL
98	95.5	88	54	24	18	37	10	A-4(8)	ML
100	98.8	93	51	25	20	35	9	A-4(8)	ML
100	98.8	98	68	23	16	37	6	A-4(8)	ML
98	89.4	85	77	49	32	47	14	A-7-5(11)	ML
98	89.6	87	81	50	34	55	16	A-7-5(13)	MH
97	84.9	83	77	57	40	55	21	A-7-5(15)	MH
93	73.0	67	56	36	24	41	20	A-7-6(12)	CL
98	87.6	85	77	55	36	48	15	A-7-5(16)	MH
99	89.5	88	83	62	30	57	22	A-7-6(20)	CH
94	76.2	74	63	42	28	44	16	A-7-6(11)	ML
99	96.1	95	70	34	20	45	14	A-7-5(11)	ML
98	97.8	97	80	35	21	44	14	A-7-5(11)	ML
95	97.7	97	86	34	18	45	10	A-5(9)	ML
98	92.9	87	74	57	39	63	20	A-7-5(16)	MH
99	95.6	93	81	65	49	65	41	A-7-6(20)	CH
99	97.8	90	73	41	29	48	18	A-7-5(13)	MH
99	96.9	91	72	40	31	48	25	A-7-6(16)	CL
99	97.6	97	82	40	32	49	22	A-7-6(15)	CL
99	90.6	87	75	55	42	49	16	A-7-5(12)	ML
98	90.1	89	78	59	45	51	21	A-7-5(14)	MH
95	79.7	76	70	50	33	47	22	A-7-6(14)	CL

TABLE 13.—*Engineering*

Soil name and location	Parent material	Minnesota report number SS–	Depth from surface	Mechanical analysis — Percentage less than 3 inches passing sieve— No. 4 (4.7 mm)	No. 10 (2.0 mm)
			In		
Minnetonka silty clay loam: SE¼SW¼ sec. 34, T. 108 N., R. 28 W., about 200 feet north and 100 feet west of SE section corner. (Slightly higher sand content than range allows for Bt horizon)	Lacustrine sediments.	7075	0–13	99	99
		7076	24–48	99	99
		7077	48–66	99	98
Shorewood silty clay loam: NE¼SW¼ sec. 26, T. 105 N., R. 27 W., about 40 feet west and 40 feet south of NE corner of section 26. (Modal profile)	Lacustrine sediments.	7055	0–13	------------	100
		7056	17–37	------------	100
		7057	45–58	97	95
Waldorf silty clay loam: SW¼SW¼ sec. 27, T. 106 N., R. 29 W., about 300 feet east and 100 feet north of SW corner of section 27. (Modal profile)	Lacustrine sediments.	7063	0–15	------------	100
		7064	20–35	------------	100
		7065	53–62	------------	100

plastic limits. The mechanical analyses were made by combined sieve and hydrometer methods.

Tests to determine liquid limit and plastic limit measure the effect of water on the consistence of soil material, as has been explained for table 13.

Formation and Classification of Soils

The pages that follow explain how certain factors have affected the formation of soils in Blue Earth County. They also define the system of soil classification currently used and classify each soil series according to that system.

Factors of Soil Formation

The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent material, (2) the climate under which the soil material has accumulated and existed since accumulation, (3) the plant and animal life on and in the soil, (4) the relief, or lay of the land, and (5) the length of time the forces of soil formation have acted on the soil material.

Climate and plant and animal life, chiefly plants, are active factors of soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it to a natural body that has genetically related horizons. The effects of climate and plant and animal life are conditioned by relief. The parent material also affects the kind of soil profile that is formed and, in extreme cases, determines it almost entirely. Finally, time is needed for changing the parent material into a soil profile. It may be much or little, but some time is always required for differentiation of soil horizons. Usually, a long time is required for the development of distinct horizons.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four. Many of the processes of soil formation are unknown.

Parent material

Blue Earth County is covered by drift of the New Ulm phase of the late Wisconsin glaciation. This glacier receded from the county about 12,000 years ago (*17*, *18*). When it receded, a mantle of glacial till remained. Melt water from the glacier flowed out over much of the county depositing lacustrine, deltaic, and outwash sediments.

The soils in map units 3, 4, 7, and 8 (see general soil map) formed in calcareous loamy till. These are principally Clarion, Nicollet, Webster, Lester, Le Sueur, and Cordova soils.

The soils in map units 5 and 6 have 2 to 4 feet of clayey glacial till, which has a high shale content. They overlie the loamy glacial till. They are principally Kilkenny, Lerdal, Minnetonka, and Marna soils.

The soils in map units 9, 10, 11, 12, and 13 formed in silty and clayey lacustrine sediments. They are principally Marna, Waldorf, Madelia, and Beauford soils.

The soils in map unit 14 formed in loamy and sandy, *test data*—Continued

Mechanical analysis—cont.									
Percentage less than 3 inches passing sieve—Cont.		Percentage smaller than—				Liquid limit	Plasticity index	Classification	
No. 40 (0.42 mm)	No. 200 (0.074 mm)	0.05 mm	0.02 mm	0.005 mm	0.002 mm			AASHTO	Unified
						Pct			
95	81.6	73	56	33	23	42	7	A-5(8)	ML
95	80.3	78	47	52	42	49	22	A-7-6(15)	CL
90	64.7	58	68	35	27	44	20	A-7-6(11)	CL
99	94.6	87	73	57	37	51	15	A-7-5(12)	MH
99	96.1	93	84	72	54	72	36	A-7-5(30)	MH
89	73.5	71	61	50	38	58	28	A-7-5(19)	MH-CH
99	95.2	92	74	47	47	46	18	A-7-6(12)	CL
99	94.6	94	77	69	69	64	31	A-7-5(20)	MH
99	94.5	89	89	48	48	51	18	A-7-5(13)	MH

stratified materials deposited in the delta. They are principally Darfur, Dassel, Fieldon, and Litchfield soils.

The soils in map units 1 and 2 formed in loamy and sandy alluvial materials deposited by the rivers on bottom lands and terraces. They are principally Alluvial land and Minneopa, Lomax, Comfrey, and Chaska soils.

For additional information about the parent material of the soils in this county, see "Geology" under "Environmental Factors Affecting Soil Use."

Climate

Blue Earth County has a cool, humid, continental climate. Temperatures vary widely from summer to winter. In winter, soil-forming processes are largely dormant. Generally, the soils are frozen to a depth of 2 to 3 feet for 4 to 5 months of the year. The depth to which frost penetrates depends mostly on the amount of snowfall in November and December.

The climate is essentially uniform throughout the county. Differences in vegetation, soil material, and relief can cause variations in the microclimate. For example, soils in the prairie regions are exposed to a greater variation in temperature than those in the forest regions. Marna, Lura, and other fine textured soils warm up more slowly in spring than coarse textured soils, such as Estherville and Dickinson, because they contain more moisture. Dark colored soils, such as Clarion and Nicollet, absorb more heat from sunlight than light colored soils. Well drained soils also warm up faster than poorly drained soils. Soils on south- and west-facing slopes receive more sunlight and tend to be drier and warmer than soils on north- and east-facing slopes. The interaction of all these factors affects the formation of soils.

Plant and animal life

Before the county was settled, native vegetation was most important to the complex of living organisms that affect soil formation. The activities of animals were of minor importance. Earthworms performed an important function in the transformation and translocation of organic material.

Forest and prairie vegetation have strongly influenced the formation of soils in this county (fig. 8). Most of the county, especially the western part, has had prairie vegetation almost continuously since the glacier receded. The county extends along the northern margin of an extensive zone of ecological tension between prairie and forest regions. Throughout the centuries this margin advanced and retreated as shifts in the climate pattern affected temperature, relative humidity, wind velocity, and precipitation.

Most soils that formed under forest have recently been influenced by prairie and are transitional between the Alfisols and the Mollisols. The soils of the grasslands, such as Nicollet, show well developed characteristics of Mollisols. In some areas, however, the amount of translocated clay in the subsoil, in the Le Sueur soil, for example, suggests the influence of forest vegetation. The influence of forest on soils that are lower in carbonates has resulted in stronger horizon development within the profile. The rank growth of vegetation on the poorly drained prairie soils, such as Webster, Marna, and Glencoe, has caused the soils to have a thick surface layer and large amounts of organic matter.

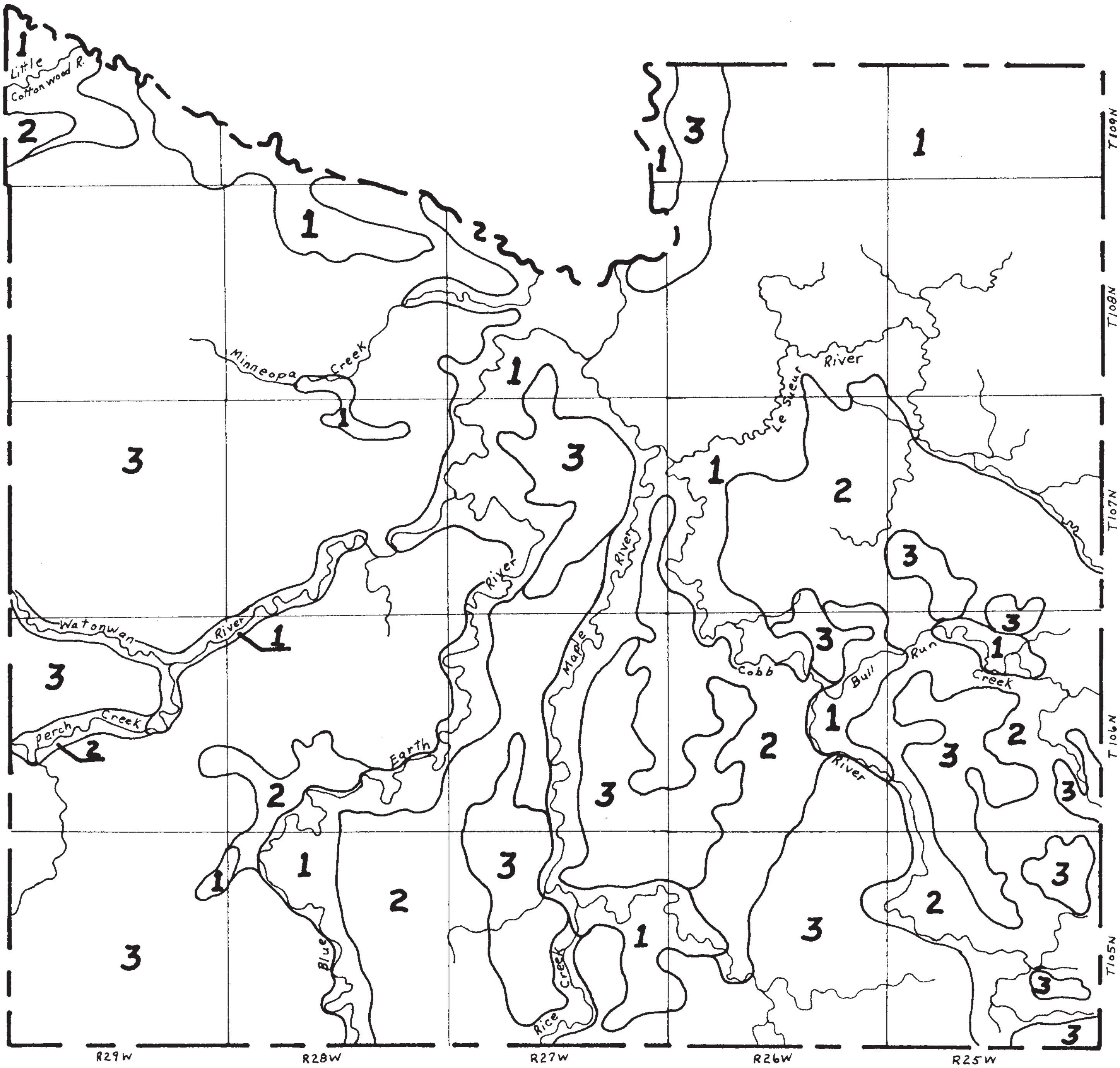

Figure 8.—**Native vegetation:**

1. **Solid-canopy deciduous trees, such as oak, elm, basswood, ash, maple, and aspen.**
2. **Dominantly groves of oak, elm, and aspen on the better drained soils and tall prairie grasses and sedges on the wet soils; a few areas of soil-canopy woods near lakes and streams.**
3. **Dominantly tall grass prairie; a few small groves of oak and aspen, and a few hazelnut thickets.**

For additional information about the vegetation of the county, see "Natural Vegetation" under "Environmental Factors Affecting Soil Use."

Relief

Relief, through its effect on drainage, aeration, and runoff, is an important factor in the formation of soils. Maximum profile development takes place in well drained or moderately well drained, gently sloping soils.

In Blue Earth County, the effect of relief is most evident in the rolling to hilly, morainic areas. Here the steep slopes and hilltops are occupied by soils that have a thin A horizon directly underlain by the calcareous parent material. Because these soils are so steep, vegetation has been sparse. The supply of moisture has been deficient because the rainfall is lost through runoff. For these reasons, no B horizon developed. Storden soils are an example.

On the lower slopes, where soil formation is more evident, the soils have a thick, black A horizon, a brownish B horizon, and a greater depth to lime. Clarion soils are an example.

Soils formed in depressional areas have a thick, dark surface layer that is high in content of organic matter. The color and mottling of these soils are affected by poor drainage. Webster and Glencoe soils are examples.

Some calcareous soils formed in nearly level to gently undulating areas have a water table within a few feet of the surface. They have a thin, black, calcareous surface layer underlain by a thick, grayish, strongly calcareous layer. While these soils were forming, moisture evaporated from the ground surface, and lime concentrated on the surface layer. Canisteo soils are an example.

Time

All the soils in Blue Earth County are young. The process of soil formation began about 12,000 years ago, when the glaciers receded. Most of the soil material deposited by the glacier consisted of reworked drift carried by earlier glaciers. The weathering of minerals had already begun at the time of deposition as is evident by the dominance of montmorillonite clay (*4*).

Most soils that formed in glacial drift have distinct A, B, and C horizons. Lester and similar soils that formed under forest vegetation have been exposed to greater intensities of the five factors of soil formation than have many other soils. The development of horizons is less distinct in the poorly drained soils, such as Webster, than in the well drained soils, such as Clarion, because a high or fluctuating water table has modified the effect of time. Soils on bottom land near rivers and small streams show little formation because the soil material is very young.

Processes in Soil Formation

Soil genesis (*11*) consists of two steps: the accumulation of parent material and the development of distinct properties and horizons in the profile. Soil properties develop through the interaction of the processes whereby additions, removals, transfers, and transformations of organic matter, silicate clays, silica, soluble salts, iron, aluminum oxides, and carbonates are made. The terms podzolization, calcification, gleization, and laterization stress the dominant processes in the development of soil properties. In this county the five factors of soil formation interact in such a way that three processes are dominant—podzolization, calcification, and gleization.

Podzolization (*14*) is the dominant soil-forming process in areas of high humidity and forest vegetation. In this county the factors of climate and vegetation are marginal in the podzolization process.

Podzolization is expressed in the formation of Alfisols that grade toward Mollisols, for example, in Grays, Kilkenny, and Lester soils. The partial removal of clay minerals, organic matter, iron, and aluminum oxides results in a concentration of resistant primary minerals, such as quartz and feldspar. This process causes a slight graying in the color of the subsurface layer, the development of an A2 horizon, or a reduction in the thickness of the A1 horizon.

The silicate clays and organic matter, which have been removed from the surface layer, accumulate in the B horizon as films along channels or on the faces of the structural aggregates. The accumulation of clay and organic matter, with some weathering of silicate minerals in places, causes a distinct increase in the content of clay in the subsoil. The increase in carbonates in the lower part of the B horizon causes the organic material and clay to precipitate. Prominent coatings form on the surface of the structural aggregates just above the calcareous till C horizon.

In this county the intensity of podzolization is influenced by the amount of carbonates in the parent material. The lower amount of carbonates is expressed in the stronger horizonation and thicker solum of the Kilkenny soils. Long-term variations in climate have restricted the normal influence of timber on the soils of this county.

Calcification (*14*) is a process normally restricted to regions of the temperate zone where rainfall is 25 inches or less and the dominant vegetation is grass or brush. By this process, which is marginal in this county, carbonates are redistributed in the profile but not entirely removed. The more than 24 inch rainfall in the county does not provide enough water to percolate through the profile and entirely remove the calcium carbonate that was originally in the parent material.

During calcification, calcium and magnesium carbonates accumulate at some point in the profile at about the same depth as that to which the surface water most frequently percolates. A secondary result of the process is that the soil material becomes somewhat granular. The granulation results from the action of the carbonates on the clay colloids in this soil material. Also, because the colloids are thus influenced, there is little downward movement of colloids in the profile. The calcification process therefore involves the accumulation of carbonates in the soil and the absorption of calcium and magnesium ions by clay colloids.

Vegetation contributes in the formation of soils influenced by calcification. Grasses and other plants that require a relatively large amount of bases, particularly calcium, carry these bases to the surface through their roots. When the plants decay, the calcium is returned to the surface layer. The loss through leaching is partly offset in this way. Soils formed through the process of calcification, therefore, seldom have a strongly acid surface layer. The large accumulation of decayed grasses on the surface and to a depth of 8 to 16 inches causes organic matter, nitrogen, phosphorus, and sulfur to accumulate on the surface layer.

In this county the Mollisols were influenced by the process of calcification. They formed under higher rainfall, however, than is characteristic for soils where the process of calcification has produced a horizon of accumulated lime in the profile. Because of the greater amount of rainfall, the average downward percolation of water in Mollisols under a good cover of prairie may be such that there is no zone in which calcium carbonate has accumulated. Yet these soils have a high degree of base saturation and are high in exchangeable calcium, even though no free lime is present. In some areas Mollisols show evidence of relic properties of Alfisols, for example, Barrington, Le Sueur, and Shorewood soils.

Generally, calcification causes soils to be fertile. Some of the soils whose formation has been influenced by calcification are among the most productive soils in the Corn Belt. The Clarion and Truman soils are typical examples.

Gleization (14) is a process that develops a horizon of light olive gray or gray material immediately below the dark colored surface layer. In this county this process occurs where a perched water table is at or slightly below the surface layer.

The gleization process is evident in Webster, Marna, and other poorly drained soils of Blue Earth County. These soils belong to the Haplaquoll and Argiaquoll great groups.

Some Haplaquolls in this county formed in areas where the relief produced a fluctuating water table, for example in Brownton, Canisteo, and Fieldon soils. In such soils percolation is offset by evaporation, resulting in the diffusion of free carbonates throughout the profile because of gleization and calcification.

Soils that formed in small, shallow depressions have a prominent A2 horizon and appreciable amounts of translocated clay in the B horizon. The characteristics are generally associated with areas where a low water table causes the removal of organic matter and silicate clays from the A1 horizon, the concentration of silica in the A2 horizon, and the accumulation of silicate clays and organic matter in the B horizon. A high water table causes gleization in the B horizon. Soils in depressions, such as Barbert and Rolfe soils, have properties of the Argialboll great group.

Caron, Muskego, and Palms soils, for example, which belong to the Histosol order, formed in sites where abundant water encourages the luxuriant growth of reeds, sedges, and mosses. The organic matter from these plants decays slowly in very poorly drained areas. Plant remains accumulate faster than they decay; and organic matter, known as peat, accumulates. Where drainage is improved, the peat decays and oxidizes to form muck or a mineral soil.

Classification of the Soils

Soils are classified so that we can easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationship to one another and to their environment, and to develop principles that help us to understand their behavior and response to manipulation. First through classification, and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

The narrow categories of classification, such as those used in detailed soil surveys, allow us to organize and apply knowledge about soils in managing farms, fields, and woodlands; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad classes to facilitate study and comparison in large areas, such as countries and continents.

The system of classification used by the National Cooperative Soil Survey (*16*) has six categories. Beginning with broadest, these categories are order, suborder, great group, subgroup, family, and series. In this system the criteria used as a bases for classification are soil properties that are observable and measurable. The properties are chosen, however, so that the soils of similar genesis, or mode of origin, are grouped. In table 14 the soil series of Blue Earth County are placed in four categories of the current system. Classes of the current system are briefly defined in the following paragraphs.

ORDER. Ten soil orders are recognized. The properties used to differentiate among soil orders are those that tend to give broad climatic groupings of soils. The two exceptions to this are the Entisols and Histosols, which occur in many different climates. Each order is identified by a word of three or four syllables ending in *sol*. An example is Mollisol.

SUBORDER. Each order is divided into suborders that are based primarily on those soil characteristics that seem to produce classes with the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of water-logging, or soil differences resulting from the climate or vegetation. Each suborder is identified by a word of two syllables. The last syllable indicates the order. An example is *Aquoll* (*Aqu*, meaning water or wet, and *oll*, from *Mollisol*).

GREAT GROUP. Each suborder is divided into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus have accumulated; those that have pans that interfere with growth of roots, movement of water, or both; and thick, dark colored surface layers. The features used are the self-mulching properties of clay; the temperature, the major differences in chemical composition mainly calcium, magnesium, sodium, and potassium; and the dark red and dark brown colors associated with basic rocks, and the like. The names of great groups have three or four syllables. A great group is identified by adding a prefix to the name of the suborder. An example is *Haplaquoll* (*Hapl*, meaning simple horizons, *aqu* for wetness or water, and *oll*, from Mollisols).

SUBGROUP. Each great group is divided into subgroups, representing the central (typic) segment of the group, and others called intergrades that have properties of the group and one or more properties of another great group, suborder, or order. Subgroups may also be made in those instances where soil properties intergrade outside of the range of any other great group, suborder, or order. Each subgroup is identified by the name of the great group preceded by one or more adjectives. An example is Typic Haplaquoll (a typical Haplaquoll).

FAMILY. Soil families are established within a subgroup primarily on the basis of properties important to the growth of plants or on the behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reactions, soil temperature, permeability, thickness of horizons, and consistence. A family name is the subgroup name preceded by a series of adjectives, the class names for

TABLE 14.—*Classification of the soils*

[An asterisk in the first column indicates a taxadjunct to the series. See text for a description of those characteristics of this taxadjunct that are outside the range of the series]

Soil name	Family or higher taxonomic class
Alluvial land	Udifluvents
*Barbert	Fine, montmorillonitic, mesic Typic Argialbolls
Baroda	Very-fine, montmorillonitic, mesic Typic Argiaquolls
*Barrington	Fine-silty, mixed, mesic Typic Argiudolls
Beauford	Very-fine, montmorillonitic, mesic Typic Haplaquolls
Blue Earth	Fine-silty, mixed (calcareous), mesic Mollic Fluvaquents
*Bold	Coarse-silty, mixed (calcareous), mesic Typic Udorthents
Brownton	Fine, montmorillonitic (calcareous), mesic Typic Haplaquolls
Calco	Fine-silty, mixed (calcareous), mesic Cumulic Haplaquolls
Canisteo	Fine-loamy, mixed (calcareous), mesic Typic Haplaquolls
*Caron	Coprogenous, euic Limnic Medihemists
Chaska	Fine-loamy, mixed (calcareous), mesic Mollic Fluvaquents
Clarion	Fine-loamy, mixed, mesic Typic Hapludolls
Collinwood	Fine, montmorillonitic, mesic Aquic Hapludolls
Comfrey	Fine-loamy, mixed, mesic Cumulic Haplaquolls
Copaston	Loamy, mixed, mesic Lithic Hapludolls
Cordova	Fine-loamy, mixed, mesic Typic Argiaquolls
Darfur	Coarse-loamy, mixed, mesic Typic Haplaquolls
Dassel	Coarse-loamy, mixed, mesic Typic Haplaquolls
Dickinson	Coarse-loamy, mixed, mesic Typic Hapludolls
*Dorchester	Fine-silty, mixed (calcareous), mesic Typic Udifluvents
Estherville	Coarse-loamy over sandy or sandy-skeletal, mixed, mesic Typic Hapludolls
Fedji	Sandy over loamy, mixed, mesic Typic Hapludolls
Fieldon	Coarse-loamy, mixed (calcareous), mesic Typic Haplaquolls
Glencoe	Fine-loamy, mixed, mesic Cumulic Haplaquolls
Granby	Sandy, mixed, mesic Typic Haplaquolls
Grays	Fine-silty, mixed, mesic Mollic Hapludalfs
*Grogan	Coarse-silty, mixed, mesic Typic Hapludolls
Guckeen	Fine, montmorillonitic, mesic Aquic Hapludolls
Hamel	Fine-loamy, mixed, mesic Typic Argiaquolls
*Joliet	Loamy, mixed, mesic Lithic Haplaquolls
Kamrar	Fine, montmorillonitic, mesic Typic Hapludolls
Kilkenny	Fine, montmorillonitic, mesic Mollic Hapludalfs
Kingston	Fine-silty, mixed, mesic Aquic Hapludolls
Lake beaches	Fluvaquents and Udifluvents
*Lasa	Sandy, mixed, mesic Entic Hapludolls
Le Sueur	Fine-loamy, mixed, mesic Aquic Argiudolls
Lerdal	Fine, montmorillonitic, mesic Udollic Ochraqualfs
*Lester	Fine, montmorillonitic, mesic Cumulic Haplaquolls
Litchfield	Sandy, mixed, mesic Aquic Hapludolls
*Lomax	Coarse-loamy, mixed, mesic Cumulic Hapludolls
Lura	Fine, montmorillonitic, mesic Cumulic Haplaquolls
Madelia	Fine-silty, mixed, mesic Typic Haplaquolls
Marna	Fine, montmorillonitic, mesic Typic Haplaquolls
Marsh	Aquents and Histosols
Minneopa	Sandy, mixed, mesic Aquic Hapludolls
Minnetonka	Fine, montmorillonitic, mesic Typic Argiaquolls
Muskego	Coprogenous, euic, mesic Limnic Medisaprists
Nicollet	Fine-loamy, mixed, mesic Aquic Hapludolls
Ocheyedan	Fine-loamy, mixed, mesic Typic Hapludolls
*Okoboji	Fine, montmorillonitic, mesic Cumulic Haplaquolls
Oshawa	Fine-loamy, mixed (calcareous), mesic Cumulic Haplaquolls
Palms	Loamy, mixed, euic, mesic Terric Medisaprists
Rolfe	Fine, montmorillonitic, mesic Typic Argialbolls
Shorewood	Fine, montmorillonitic, mesic Aquic Argiudolls
Spicer	Fine-silty, mixed (calcareous), mesic Typic Haplaquolls
Storden	Fine-loamy, mixed (calcareous), mesic Typic Udorthents
Terril	Fine-loamy, mixed, mesic Cumulic Hapludolls
Tilfer	Fine-loamy, mixed (calcareous), mesic Typic Haplaquolls
Truman	Fine-silty, mixed, 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

texture, and mineralogy, for example, that are used as family differentiae (see table). An example is the fine loamy, mixed, noncalcareous, mesic family of Typic Haplaquolls.

General Nature of the County

The Blue Earth River, for which the county is named, enters the county on the south, traverses its entire length, and joins the Minnesota River at its great south bend. The Minnesota River forms the northern boundary of the county. The Blue Earth region was first discovered by the French traveler M. Le Sueur, in October 1700, who ascended the stream for a short distance, claimed to have made valuable mineral discoveries, and established a French post, Fort L'Hillier, near the mouth of the Le Sueur River.

The city of Mankato was founded in 1852. Other early towns were South Bend, Garden City, Vernon Center, Shelbyville, and Winnebago Agency.

According to the 1970 census, Blue Earth County has a population of 52,322. Of this total, 21,427 lived in rural areas and 1,028 on farms. An influx from Mankato is increasing the rural population.

The county has 23 townships. The land area is 471,360 acres. There are 1,858 farms in the county. The total area in farmland is about 428,153 acres.

When the county was first settled, crops were grown mainly for home use. As the population increased, the sale of farm products increased. By 1873 the county had 1,981 farms and 90,515 acres under cultivation (*3*). Wheat and oats were the principal crops, but most farms were diversified. Dairy farming and raising hogs were the leading livestock enterprises.

About 54 percent of the county is wet and requires artificial drainage for crop production. Some drainage outlets were improved in the 1880's, and tile was being installed by 1910. Improved farm machinery, better crop varieties, and a larger acreage under cultivation increased the interest for complete drainage systems. A few areas still need better outlets, but the chief need is to improve the present drainage systems and reclaim odd areas.

Most of the drained areas have changed from pasture to corn and soybeans. This change has caused a shift from dairy and hog enterprises to beef and hog enterprises, which are in confined areas. Cash grain farming has increased in recent years. The farms in the southwestern three-fourths of the county are the largest. In 1970, about 165,200 acres was in soybeans; 11,500 acres in oats; 2,500 acres in wheat; and 12,500 acres in alfalfa.

Two railroads presently serve the cities of Mankato, Eagle Lake, Lake Crystal, Mapleton, Judson, Cambria, and St. Clair. Several miles of railroad track and beds have been abandoned. There is a commercial airport at Mankato and two bus lines. Several interstate truck lines also serve the county.

Mankato is the hub of several State and Federal highways from various directions. Approximately 717 miles is county roads, 573 miles township roads, and 167 miles State and Federal highways.

Industries in the Mankato area include tractor cab factories; seed firms specializing in research, production, and sales; a soybean processing plant; a flour mill; a feed mill; plastic industry; and quarries for building stone and agricultural lime. There are also numerous fertilizer blending plants in the county.

A wide variety of agricultural supplies and services are provided to farmers. The many modern retail stores have made Mankato a major trade center for an area that takes in much of the surrounding counties.

Environmental Factors Affecting Soil Use

This section describes the natural and cultural features of the county. The natural features are relief, water, climate, natural vegetation, and geology. Cultural features are transport facilities, manufacturing and business services of agriculture, and trends in soil use.

Relief

The relief of Blue Earth County is the product of a back–wasting continental glacier. The glacial drift that was deposited was of such thickness that the underlying rock strata have had little effect on the surface relief. Most of the county is nearly level to gently undulating. The relief, however, ranges from nearly level on the lake plain and on ground moraines to rolling where the end moraines form a complex pattern. In areas where there were scattered ice block depressions, a few large lakes formed. There are many small depressions.

The main drainage channels, such as the Blue Earth and Le Sueur Rivers, developed during the retreat of the glacier. They occur as abrupt gorges within the landscape (see fig. 1, p. 3). Secondary drainage was immature and needed extensive artificial development.

The larger streams have a series of terraces. At Mankato and northeast toward Lime Valley Township is such an area on a limestone bedrock-controlled terrace. Most of the downtown area of Mankato is on a low alluvial terrace. The lower part of the Le Sueur River has at least four distinct terraces. The northeast quarter of the county has distinctive, flat topped hills with smooth side slopes and broad, wet depressions between them. This area is part of a more extensive area in adjoining Le Sueur and Waseca Counties. There are some rolling to steep moraines in Pleasant Mound Hills and in the northeast corner of Jamestown Township.

Most of the plain is between 1,000 and 1,050 feet above sea level, but the Pleasant Mound Hills and the northeast corner of Jamestown Township are at an elevation of about 1,130 feet and 1,170 feet respectively. The elevation of the uplands near the bluffs of the Minnesota River Valley is about 975 feet and the river at Mankato is at 756 feet.

Water

Water supplies in Blue Earth County are directly related to the thickness of the mantle of glacial drift and to the kind of rock formation that underlies it (*5, 12, 13*).

Most of the county is covered by an unconsolidated mantle of glacial drift and lacustrine sediments. This mantle ranges from about 90 to more than 200 feet in thickness. It is thickest in the northwestern part of the county, but decreases toward the southeastern part, where it ranges from 90 to about 140 feet. In a narrow belt beginning in the Minnesota River Valley at Mankato and extending eastward to a point beyond Janesville in Waseca County, the drift is 50 to 100 feet thicker than on either side of the belt. This narrow zone could represent an interglacial or preglacial channel. The mantle yields little water.

Recent alluvium occurs along the streams. The thickness varies. These sediments are saturated with water, but the fine texture retards the water yield. Numerous terraces of late glacial gravel or buried glacial gravel beds are important local sources of water supply.

Bedrock is exposed along the Minnesota River and the steep bluffs along the lower parts of the Blue Earth, Le Sueur, and Maple Rivers (*5, 12*). The rocks directly beneath the glacial drift are of four geologic time periods (fig. 9). The oldest is the granitic type of rock of Precambrian age in area 1, in the northwestern part of the county. The second oldest is the St. Croixan group of Cambrian period in area 2. The rocks belonging to the Ordovician period are the Prairie du Chien Formation of area 3, St. Peter Sandstone of area 5, and the Platteville and Glenwood Formations of area 6. The youngest rock in the county is the Windrow Formation of the Cretaceous period in area 4. The rocks of the Cambrian, Ordovician, and Cretaceous periods dip toward the southeast at a slight angle. The top of the Jordan Sandstone near Judson is about 850 feet above sea level, but in the southeast corner near Minnesota Lake the same stratigraphic horizon is about 600 feet above sea level. Thus the water in the Jordan Sandstone is under artesian pressure in the southeast corner of the county.

For the stratigraphy of rocks at Mankato (*13*), see figure 10.

Precambrian Group. This group includes the granitic rocks, the red clastics, and the Hinckley Sandstone. The granitic rocks and red clastics are poor sources of water. The Hinckley Sandstone, which ranges from a few feet to nearly 200 feet thick, yields abundant water under artesian pressure. The water is much softer than that of the Paleozoic sediments.

St. Croixan Group. The whole group of upper Cambrian Sandstone, Shale, and Dolomite occurs under most of the area in Blue Earth County. Of these formations, the Dresbach and the Jordan are the best water producers.

Ordovician Group. This group includes the Shakopee-Oneota, St. Peter, Platteville, and Glenwood Formations. It begins near the central part of the county and continues to the southeast (fig. 9). Few wells end in either the Shakopee-Oneota or Platteville Limestone. These formations yield some water from joints, bedding planes, and solution passages, but no large supply of water can be expected. The St. Peter Sandstone occurs in about the southeastern quarter of the county. It generally contains abundant water, but is under little or no artesian pressure.

Climate

Blue Earth County is in the south-central till prairies of Minnesota. Elevation ranges from approximately 1,000 feet to 1,060 feet above mean sea level. Relief is mainly a few feet to 20 or 30 feet. The climate is continental with cold winters and warm summers. The location of the county in the interior of the great land mass of North America is the chief factor in determining its climate. Summers are warm. Southerly winds in summer bring warm, moist air from the Gulf of Mexico and provide the area with a large part of the precipitation during the growing season. Winters are cold. The prevailing north to northwest winds supply an abundance of frigid air. Because this cold air contains little moisture, winter preciptaton if light. The following paragraphs are based on data from the station at St. Peter 2 southwest, Minnesota, for the period 1941–70. St. Peter 2 southwest is not in Blue Earth County, but has similar topography and general climatic conditions. Temperature and precipitation data for the county are listed in table 15.

Average daily maximum temperatures in summer range from 80° to 85° F. Average daily minimums range from the high fifties to the low sixties. The average daily mean temperature during the summer is 71°. Hot days with maximum temperatures equal to or more than 100° have been recorded only six times during the last 30 years.

About 70 percent of the annual precipitation of 29 inches occurs during the growing season. Precipitation of 0.01 inch or more can be expected on 75 to 80 days a year, 6 of which will have an inch or more. Rainfall intensities of more than 1 inch per hour can be expected about once in 2 years. June is most likely to receive this type of precipitation. The greatest monthly precipitation recorded in the last 30 years was 11.46 inches in June, 1956. Annual precipitation has varied from 15.55 inches in 1958 to 41.16 inches in 1968. The heaviest rains occur as the result of thunderstorms, which average about 40 annually. Some thunderstorms are accompanied by hail and damaging winds.

Based on the Rochester records, the relative humidity at noon in summer averages about 60 percent and the prevailing wind direction is south. The windspeed averages about 10 miles per hour during the summer.

Daily maximum temperatures in winter average around 29°. The daily minimums average about 9°. The average daily mean temperature is 18°. Outbreaks of cold Canadian air decrease the temperature to zero or lower on about 33 days per year. The extreme cold temperature of the last 30 years was −38° on January 30, 1951, but a minimum temperature of −42° has been reported in the area.

The annual snowfall averages about 37 inches in amounts ranging from 2 inches in 1960 to 94 inches in 1951. The first snowfall of the season generally occurs in November and the last around mid April.

The average relative humidity at noon during the winter at Rochester is about 75 percent, and the prevailing wind is northwest at an average speed of about 13 miles per hour.

Spring and fall are transitional periods with fewer extremes than in winter and summer. Heavy fog is reported on an average of 35 days annually at Rochester with the greatest frequency between October and March.

The average length of the growing season in Blue Earth County is 156 days. The average date of the last freeze in spring is May 2, and the first in fall is October 5. Table 16 shows probabilities that are representative for the entire county of the last freezing temperature in spring and the first in fall.

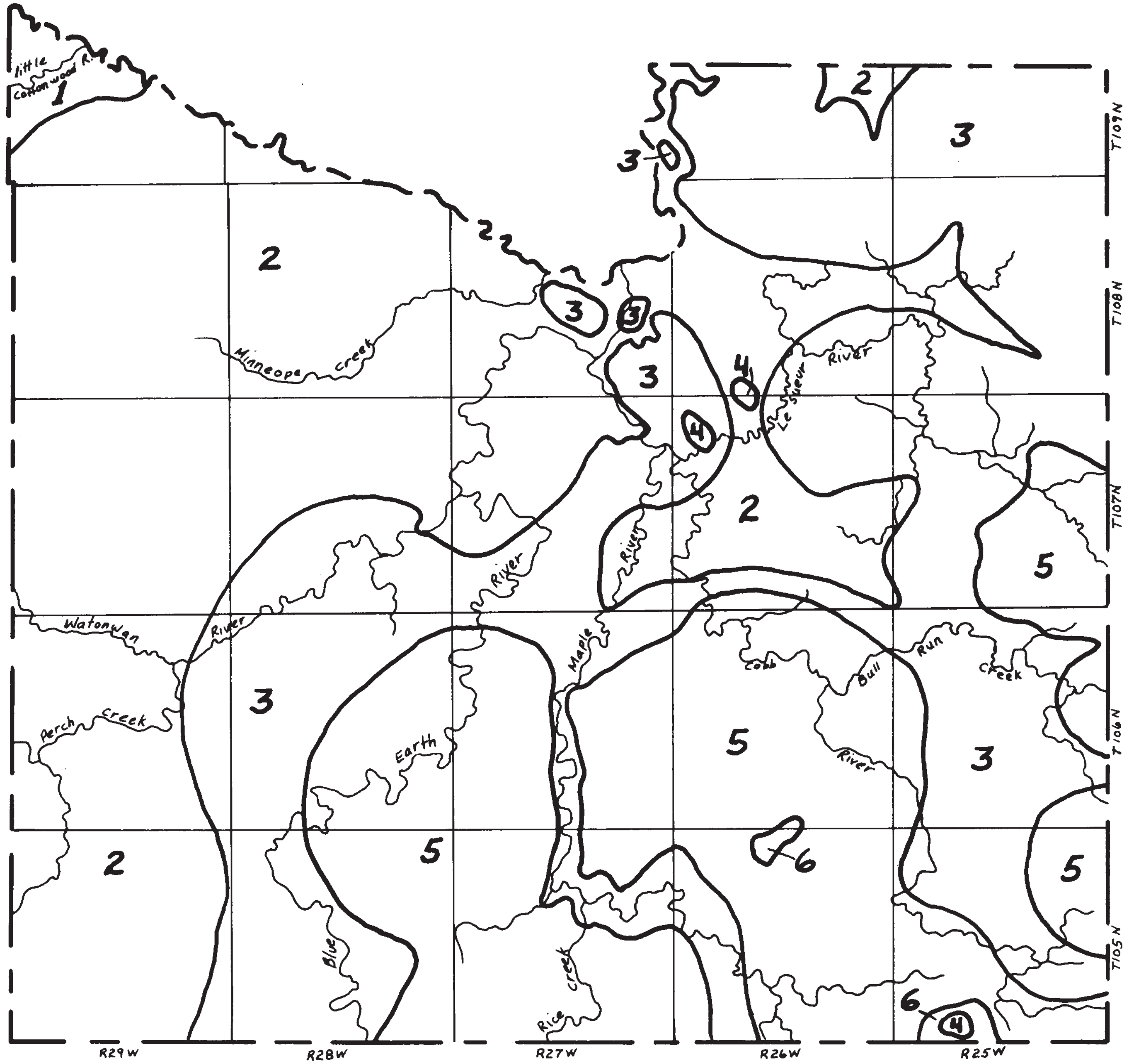

Figure 9.—**Geologic formations in Blue Earth County:**

1. **Granitic rocks, undivided, of Precambrian age.**
2. **St. Croixan group of Cambrian period: Jordan Sandstone, St. Lawrence Formation, Franconia Sandstone, and Dresbach Formation.**
3. **Prairie du Chien Formation of Ordovician period: Shakopee and Oneota Dolomite.**
4. **Windrow Formation of Cretaceous period.**
5. **St. Peter Sandstone of Ordovician period: sandstone and minor siltstone.**
6. **Platteville and Glenwood Formations of Ordovician period: Platteville Dolomite and Limestone, Glenwood Shale.**

Effect of climate on crops

Farming in this county is influenced by shifts from the modal climatic pattern. In some years, for example, warm air from the south encroaches for brief periods in winter and causes what are locally called January or February thaws. During these short periods, the snow cover melts and there are wide extremes between daytime and nighttime temperatures. Legumes, fruit trees, and other trees are sometimes injured.

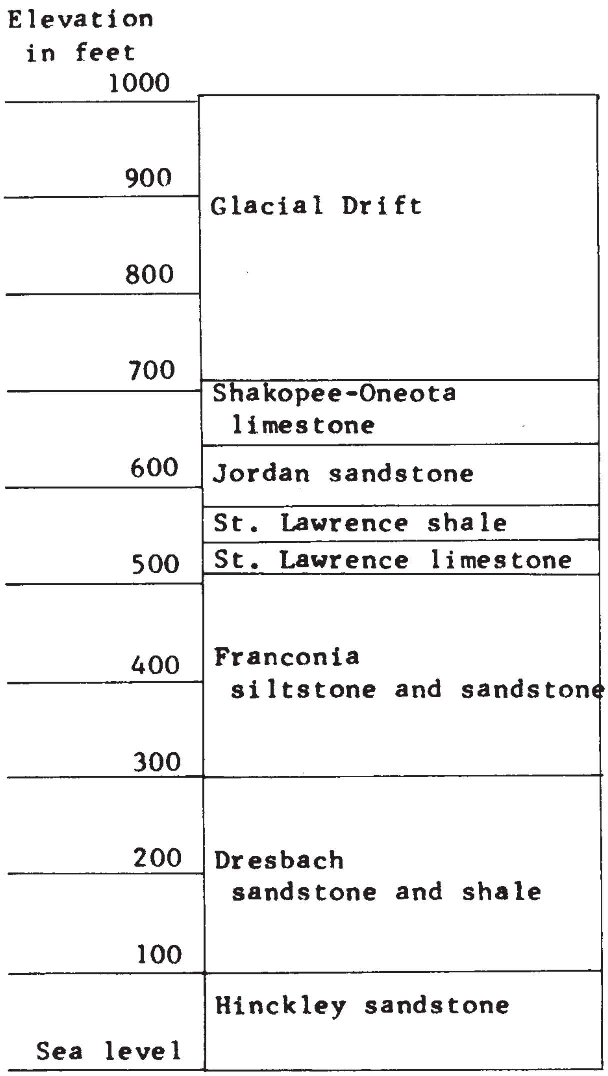

Figure 10.—**Geologic cross section at Mankato in Blue Earth County, Minnesota.**

Alternate freezing and thawing early in spring sometimes damages legumes on fine textured soils that have not been drained. Occasionally, a "late spring" affects the timeliness of fieldwork.

The pronounced increase in precipitation during May and June is characterized by high intensity rains. Then, erosion is likely to be especially severe on exposed soils where moisture is at or near field capacity. The crop cover and the usual lower supply of moisture in July and August reduce the damage caused by intense rains during that period. Occasionally, a prolonged rainy period in June delays spraying or the cultivation of corn and soybeans. It can also delay the harvesting of the first crop of hay.

In some seasons high temperatures and erratic rainfall during July and early in August reduce the bushel weight of small grain and adversely affect the pollination of corn. Sometimes persistent light rains in October and early in November hamper the harvesting of corn and soybeans. Frost occasionally occurs in the lower lying areas late in May and August and early in September. Infrequently, once in 20 years or more, climatic patterns that are typical of those in the Great Plains (*6, 7*) drift into the county, resulting in periods of drought. Drought occurs whenever the supply of moisture, either the supply from rainfall or that stored in the soil, becomes inadequate for crops. Each day when moisture is inadequate in the root zone is defined as a drought day.

Although adverse weather sometimes affects agriculture in this county, crop failure has never occurred. The usual weather pattern is one especially suited to the high production of corn, small grain, soybeans, and hay.

Natural Vegetation

Before this county was settled, the native vegetation was most important in the complex of living organisms that affect soil formation. Two types of vegetation, forest and prairie, have strongly influenced the formation of soils. The survey area is along the northern margin of a large area covered partly by prairie and partly by forest. Throughout the centuries, this margin advanced and retreated as shifts in climate pattern affected temperature, relative humidity, wind velocity, and the pattern of precipitation.

The Le Sueur River forms a general boundary between the area called the Big Woods to the north and east and the prairie. There are strips of the Big Woods along the river entering the county from the south and west. The Blue Earth River and the glacial lake plain in map unit 12 (see general soil map) generally form the southern and western boundary of the oak openings. The rest of the county is of the tall grass prairie. Pioneer settlers and many early scholars believed that the prairies in this area resulted from fire. This, undoubtedly, was a modifying factor at the edge of the forest, but generally the dominant vegetation is that best suited to the climate (*7*).

The soils influenced by timber in their formation occupy considerably larger areas on the north and east sides of the river valleys and lakes. They probably preserved remnants of the Big Woods until such time as the climate became favorable for the growth of these trees. The prevailing westerly and southwesterly winds probably carried the seeds of trees to the east and northeast. Also, the mature trees protected the young seedlings from the dry, searing, prevailing winds. The existing remains of groves in the oak openings and the areas of soils that are influenced by timber are typically on low convex rises on the nearly level landscape. The prairie soils occupy the nearly level, wetter sites.

But oak was the dominant tree on the better drained soils in the uplands. Many slopes along the river valleys had maple, butternut, and black walnut. Elm, basswood, and aspen were the dominant trees on the river bottoms and on wetter soils in the uplands. Shrubs that were common were the smooth sumac, prickly ash, smooth and prickly gooseberries, hazel, climbing bittersweet, and chokecherry.

Geology

To the geologist, amateur or professional, the land-

TABLE 15.—*Temperature and precipitation*

[All data from St. Peter, Minn., 1941–70]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Two years in 10 will have at least 4 days with— Maximum temperature equal to or higher than—	Two years in 10 will have at least 4 days with— Minimum temperature equal to or lower than—	Average total precipitation	One year in 10 will have— Less than—	One year in 10 will have— More than—	Days with snow cover	Average depth of snow on days with snow cover
	°F	°F	°F	°F	Inches	Inches	Inches		Inches
January	24.0	3.6	42	−20	0.76	0.14	1.78	24	6
February	29.0	7.5	45	−14	.89	.17	1.81	21	7
March	39.5	20.1	61	0	1.55	.59	2.78	17	7
April	57.8	35.6	79	24	2.32	.92	3.91	1	3
May	70.4	46.8	86	33	3.84	1.93	6.79	(1)	0
June	79.9	57.1	92	45	4.73	2.15	7.75	(1)	0
July	84.6	61.3	94	52	4.14	1.86	7.24	(1)	0
August	82.9	59.3	93	48	3.90	1.40	6.57	(1)	0
September	73.2	49.6	88	37	3.10	.87	5.51	(1)	0
October	63.7	39.2	81	26	1.77	.28	3.50	(1)	0
November	43.4	24.7	62	6	1.25	.23	2.41	5	3
December	29.2	11.1	47	−10	.98	.17	2.21	14	5
Year	56.5	34.7	[2] 97	[3] −24	29.55	24.55	35.97	82	6

[1] Less than 0.5 day.
[2] Average annual maximum.
[3] Average annual minimum.

scape of Blue Earth County suggests a history of recent glaciation (*17, 18*). The youthful glacial landscape is pock marked with water-filled depressions of all shapes and sizes, nearly level ground moraines with a poorly developed natural drainage network, and a few large entrenched streams. Although the county was covered by ice sheets several times during the glacial period, the landforms and surficial deposits record only the last glaciation, the Wisconsin.

The Quaternary deposits in Blue Earth County are glacial till, lacustrine, and outwash (*9*). Thick exposures along the Minnesota, Blue Earth, Le Sueur, Maple, and Cobb Rivers reveal a complicated stratigraphy characterized by different tills that are superimposed. They are sometimes separated by a variety of nonglacial sediments. The entire sequence is a long history of climatic fluctuations in the county.

Evidence of the Pleistocene glacial stages, which preceded the Wisconsin, are not readily seen in the county. Some iron oxide stained, shale-free gravel occurs along the Le Sueur River in section 34 of South Bend township. Glacial till of an older age occurs along the Minnesota River to the northwest and near the surface in some counties, such as Freeborn, to the

TABLE 16.—*Probabilities of last freezing temperatures in spring and first in fall*

[All data from St. Peter, Minn., 1941–70]

Probability	Dates for given probability and temperature				
	16° F or lower	20° F or lower	24° F or lower	28° F or lower	32° F or lower
Spring:					
1 year in 10 later than	April 3	April 16	April 29	May 10	May 19
2 years in 10 later than	April 1	April 11	April 22	May 3	May 12
5 years in 10 later than	March 22	March 29	April 9	April 23	May 2
Fall:					
1 year in 10 earlier than	October 30	October 25	October 12	September 30	September 22
2 years in 10 earlier than	November 7	October 31	October 17	October 5	September 27
5 years in 10 earlier than	November 16	November 9	October 27	October 13	October 5

south and east. Radiocarbon dates indicate that these glacial deposits are older than 40,000 years.

Four glacial advances and recessions, which can be attributed to the climatic fluctuations of the Wisconsin stage of glaciation, are recorded in the Quaternary deposits in the southern part of Minnesota. The earliest phase of ice activity was an advance into the area of a glacier from the north or northwest. The extent of this ice sheet is largely unknown. This sheet deposited a loam, calcareous, shale-free till that is exposed near Granite Falls northwest of Blue Earth County. It is thought to have reached this county, but no deposits attributed to this phase have been identified. The ice retreated and erosion took place, leaving lag deposits, or stone lines, on the slopes and filling in the depressions. Debris from plants were also seen in these depressions.

Before the development of a significant soil profile on this lowest calcareous till, a glacial advance, the Hawk Creek phase from the Lake Superior area, buried the landscape under a blanket of reddish brown sandy loam till. The history of the retreat of this glacial lobe is completely obscured by later glacial deposits. This till is evident in deep road cuts along U.S. Highway 169 near Le Sueur. It is also in distant pockets mixed in the next younger till along the Maple River in section 13 of Rapidan township.

Renewed ice activity in the north and northwest resulted in another glacial advance from the Wadena lobe, the Granite Falls phase. It left a thick layer of loam, calcareous, shale-free till, which ranges from 15 to about 50 feet below the surface in Blue Earth County. Outwash associated with this phase is exposed along the Minnesota, Le Sueur, Maple, and Cobb Rivers. This glacial event may have occurred about 34,000 radiocarbon years ago. The ice lobe retreated to an unknown northerly position. The landscape laid bare by the melted ice sheet was vulnerable to extensive erosion, leaving evidence of lag deposits, or stone lines, on the surface. The environment then may have been an arid climate because neither soils nor organic deposits formed.

The last glacier to advance across the area moved south from the Winnipeg lowland in Canada. The Des Moines lobe, New Ulm phase, moved along the Minnesota River lowland, covered all of Blue Earth County, and eventually reached as far south as Des Moines, Iowa. This lobe spread a broad sheet of distinctive shale-rich, calcareous till. It is not known when the ice moved through the county, but it had reached the central part of Iowa by 14,000 radiocarbon years before the present. By about 12,000 years ago, the melting of glacial ice had completely cleared the county of active ice. Much of the terrain, however, remained covered with buried dead ice. The boreal forest had moved into the county by about 12,650 years ago. Water and sediments ponded within unstable basins on the stagnant ice surface. This time of the rapid melting of the Des Moines lobe is represented by presence of melt water channels and lacustrine, deltaic, and other sediments.

As the Des Moines lobe melted back into the Red River basin, the water ponded and formed Glacial Lake Agassiz. This is the Lake Agassiz phase. During its early stage, Lake Agassiz had just one outlet, the Glacial River Warren, or the Minnesota River. The large volume of water carried by the River Warren entrenched itself into the landscape and continued to deepen and widen its valley as Lake Agassiz expanded. Eventually, the ice melted back to expose other outlets for Lake Agassiz, removing water from Glacial River Warren. Thus, the wide and deep channel now carries only a small fraction of its former volume of water, and the present day Minnesota River is a classic example of an underfit stream.

Most of the county has landscape features associated with dead ice left by the Des Moines lobe (*8*). Map units 3, 4, 5, and 6 (see general soil map) are associated with a dead ice moraine that had soil material on top of the dirty ice. The result is the various sizes of circular, flat topped hills, which have smooth side slopes and broad, wet areas between them (see cover photo). These soils have lower sand content and higher clay content than those in similar glacial till deposits, for example, map unit 7.

Most remaining areas of the county have a nearly level to gently undulating ground moraine associated with stagnant ice that had little, if any, soil material on the surface and some material incorporated within the ice. The lakes and depressions are typically broad and shallow. A typical example of this is in map unit 7.

Many areas in the ground moraine, however, have features changed by other events brought about by melting glacial ice. Map units 1 and 2 on the general soil map are deeply entrenched rivers that were cut by the large volume of water coming down from melting glaciers (fig. 1, p. 3). These rivers have several terraces which are related to geologic events, some of which are not understood as yet. For example, one of the terraces along the Le Sueur River was probably made when the mouth of the river changed from the Pleasant Street Slough area of Mankato to its present site in section 34 of South Bend Township. Map unit 1 along the Minnesota River is the broad valley cut by the Glacial River Warren, which at one time was the outlet of Glacial Lake Agassiz.

Map units 9, 10, 11, 12, and 13 on the general soil map are thought to have been part of what has been called Glacial Lake Minnesota. Units 9 and 10 have only about 2 to 4 feet of silty clay and silty clay loam material, which slightly smooths out the slopes in the gently undulating ground moraine. Units 11, (fig. 2, p. 9), 12 and 13 (fig. 3, p. 10) have about 4 to 25 feet or more of stratified silt loam or silty clay or clay over silt loam. The thicker, lacustrine deposits have masked the gently undulating slopes in the ground moraine, leaving a smooth, nearly level and gently sloping lake plain.

Map unit 14 on the general soil map (fig. 4. p. 11) is a delta formed by water carrying sediment from the melting ice to the west and north into the Minnesota Lake Plain. The deltaic sediments are stratified fine sand, medium sand, coarse sand, and some silt loam. The soil pattern is very complex, and the material is 2 to more than 15 feet thick.

Map unit 8 is a complex of loam and silt loam till and sand or gravel. These areas are end moraines or dump moraines near the outer edge of the glaciers where the material in the ice and that carried by the water from the melting ice was deposited and pushed up.

References

(1) American Association of State Highway [and Transportation] Officials. 1970. Standard specifications for highway materials and methods of sampling and testing. Ed. 10, 2 vol., illus.

(2) American Society for Testing and Materials. 1974. Method for classification of soils for engineering purposes. ASTM Stand. D 2487-69. *In* 1974 Annual Book of ASTM Standards, Part 19, 464 pp., illus.

(3) Andreas, Alfred T. 1874. Blue Earth County. An illustrated historical atlas of the State of Minnesota, pp. 73 and 240-241. illus.

(4) Arneman, Harold F., Azziz D. Khan, and P. R. Miller. 1958. Physical, chemical, and mineralogical properties of related Minnesota prairie soils. Univ. Minn. Agric. Exp. Stn. Tech. Bull. 227, 47 pp., illus.

(5) Austin, G. S., J. A. Grant, I. J. Ikola, and P. K. Sims. 1970. New Ulm Sheet, Geologic Map of Minnesota. Minnesota Geol. Surv., Univ. of Minn.

(6) Blake, G. R., E. R. Allred, C. H. M. Van Bavel, and F. D. Whisler. 1960. Agricultural drought and excesses in Minnesota. Univ. Minn. Agric. Exp. Stn. Tech. Bull. 235, 36 pp., illus.

(7) Borchart, John R. 1950. The Climate of the Central North American Grassland. Ann. of The Assoc. of Amer. Geog. 40(1), 39 pp., illus.

(8) Clayton, L. and T. Treers. 1967. Glacial geology of the Missouri Coteau and adjacent areas. North Dakota geological Survey, Misc. Ser. 30, 170 pp., illus.

(9) Matsch, C. L. 1972. Quaternary Geology of Southwestern Minnesota. Geology of Minnesota, a Centennial Volume, edited by P. K. Sims and G. B. Morey. Minnesota Geol. Surv., Chapt. VII, pp. 547-560.

(10) Portland Cement Association. 1973. PCA soil primer. 38 pp., illus.

(11) Simonson, Roy W. 1959. Outline of a generalized theory of soil genesis. Soil Sci. Soc. Am. Proc. 23:152-156, illus.

(12) Sloan, R. E., Austin, G. S. 1966. St. Paul Sheet, Geologic Map of Minnesota. Minnesota Geol. Surv., Univ. of Minnesota.

(13) Thiel, George A. 1956. Geology and underground waters of southern Minnesota. Minn. Geol. Surv. Bull. 31, 506 pp., illus.

(14) United States Department of Agriculture. 1938. Soils and men. U.S. Dep. Agric. Ybk. 1232 pp, illus.

(15) United States Department of Agriculture. 1951. Soil survey manual. U.S. Dep. Agric. Handb. 18, 503 pp., illus. [Supplements replacing pp. 173-188 issued May 1962]

(16) United States Department of Agriculture. 1975. Soil Taxonomy. A basic system of soil classification for making and interpreting soil surveys. Soil Conserv. Serv., U.S. Dep. Agric. Handb. 436, 754 pp., illus

(17) Wright, H. E., Jr. 1972. Cenozoic Quaternary History of Minnesota, a Centennial Volume, edited by P. K. Sims and G. B. Morey. Minn. Geol. Surv., Chapt. VII, pp. 515-547.

(18) Wright, H. E., Matsch, C. L., Cushing, E. S. 1973. Superior and Des Moines Lobe. Geol. Soc. Am. Mem. 136, pp. 153-185.

Glossary

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates, such as crumbs, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alluvial fan. A fan-shaped deposit of sand, gravel, and fine material dropped by a stream where its gradient lessens abruptly.

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as—

	Inches
Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	More than 9

Back-wasting glacier. An ice sheet where the principal melting or wasting occurs along the leading edge.

Buried soil. A developed soil, once exposed but now overlain by more recently formed soil.

Calcareous soil. A soil containing enough calcium carbonate (commonly with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid. A soil having measurable amounts of calcium carbonate or magnesium carbonate.

Calcification. The soil forming processes that keep enough calcium in the surface layer to saturate the soil colloids with exchangeable calcium to the extent that the colloids are rendered almost immobile and almost neutral in reaction.

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 coat, clay skin.

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.

Concave slope. An inwardly rounded slope.

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.

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 for 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, as for example in "hillpeats" and "climatic moors."

Erosion. The wearing away of the land surface by running water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (geologic). Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of the activities of man or other animals or of a catastrophe in nature, for example, fire, that exposes a bare surface.

Fine textured (heavy textured) soil. Sandy clay, silty clay, and clay.

Flood plain. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

French drains. A section of the tile trench above the tile that is fitted with stone, gravel, or crushed rock, or a combination of these materials.

Friability. Term for the ease with which soil crumbles. A friable soil is one that crumbles easily.

Glacial drift (geology). Pulverized and other rock material transported by glacial ice and then deposited. Also the assorted and unassorted material deposited by streams flowing from glaciers.

Glacial outwash (geology). Gravel, sand, and silt, commonly stratified, deposited by melt water as it flows from glacial ice.

Glacial till (geology). Unassorted, 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.

Gleization. The reduction, translocation, and segregation of soil compounds, notably of iron, usually in the lower horizons, as a result of waterlogging with poor aeration and drainage; expressed in the soil by mottled colors dominated by gray. The soil-forming processes leading to the development of a gley soil.

Ground moraine (geology). Glacial till accumulated beneath the advancing ice and deposited from it during its dissolution, rather than aggregated in a thickened belt at the ice edge; the deposit is relatively thin and characteristically forms an undulating plain with gently sloping swells, sags, and closed depressions.

Gypsum. Colorless translucent crystals of calcium sulfate that form in or below soil horizons in which calcium carbonate has accumulated.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. The major horizons of mineral soil are as follows:

O horizon.—An organic layer, fresh and decaying plant residue, at the surface of a mineral soil.

A horizon.—The mineral horizon, formed or forming at or near the surface, in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon most of which was originally part of a B horizon.

A2 horizon.—A mineral horizon, mainly a residual concentration of sand and silt high in content of resistant minerals as a result of the loss of silicate clay, iron, aluminum, or a combination of these.

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or a combination of these; (2) by prismatic or blocky structure; (3) by redder or browner colors than those in the A horizon; or (4) by a combination of these. The combined A and B horizons are generally called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the A or B horizon. The material of a C horizon may be either like or unlike that from which the solum is presumed to have formed. If the material is known to differ from that in the solum the Roman numeral II precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock commonly underlies a C horizon, but can be directly below an A or a B horizon.

Humus. The well decomposed, more or less stable part of the organic matter in mineral soils.

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.

Lacustrine deposit (geology). Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

Landslide. The rapid downhill movement of a mass of soil and loose rock generally when wet or saturated. The speed and distance of movement, as well as the amount of soil and rock material, vary greatly.

Leaching. The removal of soluble material from soil or other material by percolating water.

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 greater than that of organic soil.

Montmorillonite. A fine, platy, alumino-silicate clay material that expands and contracts with the absorption and loss of water. It has a high cation-exchange capacity and is plastic and sticky when moist.

Moraine (geology). An accumulation of earth, stones, and other debris deposited by a glacier. Types are terminal, lateral, medial, and ground.

Mottling, soil. Irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded drainage. Descriptive terms are as follows: abundance—few, common, and many; size—fine, medium, and coarse; and contrast—faint, distinct, and prominent. The size measurements are of the diameter along the greatest dimension. Fine indicates less than 5 millimeters (about 0.2 inch); medium, from 5 to 15 millimeters (about 0.2 to 0.6 inch); and coarse, more than 15 millimeters (about 0.6 inch).

Muck. Dark colored, finely divided, well decomposed organic soil material mixed with mineral soil material. The content of organic matter is more than 20 percent.

Munsell notation. A designation of color by degrees of the three single variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color of 10YR hue, value of 6, and chroma of 4.

Organic matter. A general term for plant and animal material, in or on the soil, in all stages of decomposition. Readily decomposed organic matter is often distinguished from the more stable forms that are past the stage of rapid decomposition.

Parent material. The great variety of unconsolidated organic and mineral material in which soil forms. Consolidated bedrock is not yet parent material by this concept.

Peat. Unconsolidated material, largely undecomposed organic matter, that has accumulated under excess moisture.

Ped. An individual natural soil aggregate, such as a granule, a prism, or a block.

Permeability. The quality that enables the soil to transmit water or air, measured as the number of inches per hour that water moves through the soil. Terms describing permeability are very slow (less than 0.06 inch), slow (0.06 to 0.20 inch), moderately slow (0.2 to 0.6 inch), moderate (0.6 to 2.0 inches), moderately rapid (2.0 to 6.0 inches), rapid (6.0 to 20 inches), and very rapid (more than 20 inches).

Phase, soil. A subdivision of a soil series or other unit in the soil classification system based on differences in the soil that affect its management. A soil series, for example, may be divided into phases on the bases of differences in slope, stoniness, thickness, or some other characteristic that affects management. These differences are too small to justify separate series.

Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degree of acidity or alkalinity is expressed as—

	pH		pH
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Relief. The elevations or inequalities of a land surface, considered collectively.

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.

Seepage. The rapid movement of water through the soil. Seepage adversely affects the specified use.

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.

Soil. A natural, three-dimensional body at the earth's surface that is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in mature soil consists of the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristics of the soil are largely confined to the solum.

Stratified. Arranged in strata, or layers. The term refers to geologic material. Layers in soils that result from the processes of soil formation are called horizons; those inherited from the parent material are called strata.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates that are separated from adjoining aggregates. The principal forms of soil structure are—platy (laminated), prismatic (vertical axis of aggregates longer than horizontal), columnar (prisms with rounded tops), blocky (angular or subangular), and granular. Structureless soils are either single grained (each grain by itself, as in dune sand) or massive (the particles adhering without any regular cleavage, as in many hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. The part of the soil below the solum.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that it can soak into the soil or flow slowly to a prepared outlet without harm. A terrace in a field is generally built so that the field can be farmed. A terrace intended mainly for drainage has a deep channel that is maintained in permanent sod.

Terrace (geologic). An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea. A stream terrace is frequently called a second bottom, in contrast with a flood plain, and is seldom subject to overflow. A marine terrace, generally wide, was deposited by 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, silt loam, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Till plain. An extensive flat to undulating area underlain by glacial till.

Topsoil (engineering). Presumably a fertile soil or soil material, or one that responds to fertilization, ordinarily rich in organic matter, used to topdress roadbanks, lawns, and gardens.

Variant, soil. A soil having properties sufficiently different from those of other known soils to justify a new series name, but the limited geographic soil area does not justify creation of a new series.

Water table. The upper limit of the soil or underlying rock material that is wholly saturated with water.

Water table, apparent. A thick zone of free water in the soil. An apparent water table is indicated by the level at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil.

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

Water table, perched. A water table standing above an unsaturated zone. In places an upper, or perched, water table is separated from a lower one by a dry zone.

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