SOIL SURVEY OF

Douglas County, Minnesota

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

Issued January 1975

Major fieldwork for this soil survey was done in the period 1963–69. Soil names and descriptions were approved in 1971. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1969. This survey was made cooperatively by the Soil Conservation Service and the Minnesota Agricultural Experiment Station. It is part of the technical assistance furnished to the Douglas County Soil and Water Conservation District.

Either enlarged or reduced copies of the soil map in this publication can be made by commercial photographers, or they can be purchased on individual order from the Cartographic Division, Soil Conservation Service, United States Department of Agriculture, Washington, D.C. 20250.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms 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 Douglas 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 "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in alphabetic order by map symbol and gives the capability classification of each. It also shows the page where each soil is described and the page for the woodland suitability group in which the soil has been placed.

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 and woodland suitability groups.

Foresters and others can refer to the section "Woodland and Windbreaks," where the soils of the county are grouped according to their suitability for trees.

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

Engineers and builders can find, under "Engineering Uses of the Soils," 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 the Soils."

Newcomers in Douglas County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the section "General Nature of the County."

Cover: **Contour stripcropping on a Waukon loam. Strips of alfalfa-bromegrass alternate with small grains and corn, and a grassed waterway intersects the small grains.**

Contents

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UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE MINNESOTA AGRICULTURAL EXPERIMENT STATION

DOUGLAS COUNTY is in the west-central part of Minnesota (fig. 1). The county seat is located at Alexandria. Douglas County is rectangular in shape, 30 miles long and 24 miles wide. The total land area is 407,680 acres. A total of 358,331 acres is in farms. Douglas County has 20 townships, and approximately one-tenth of the county is covered by lakes. Corn, soybeans, small grains, and hay are the principal crops. Dairy cattle, hogs, and feeder cattle are the principal kinds of livestock.

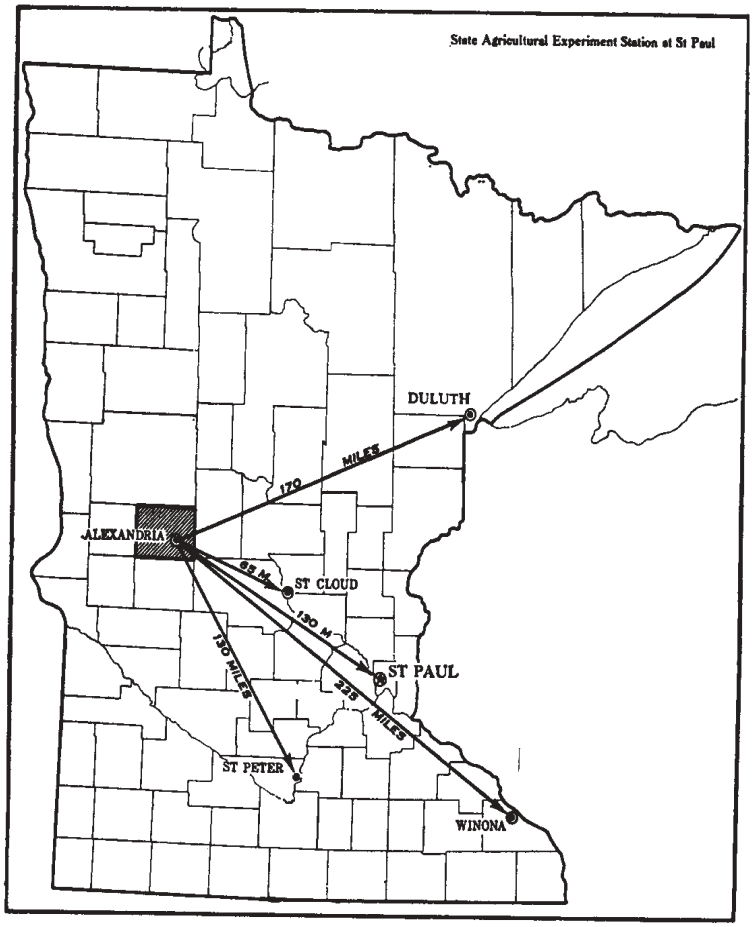

Figure 1.—Location of Douglas County in Minnesota.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Douglas County, where they are located, and how they can be used. The soil 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 (*5*).[1] 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. Barnes and Waukon, 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 in the undisturbed landscape.

Soils of one series can differ in texture of the surface soil 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, Nebish sandy loam, 2 to 6 percent slopes, is one of several phases within the Nebish 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 in the back of this publication was prepared from the aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a

[1] Italic numerals in parentheses refer to Literature Cited, page 111.

map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. One such mapping unit shown on the soil map of Douglas County is the soil complex.

A soil complex consists of areas of two or more soils, so intermingled 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. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Barnes-Langhei loams, 2 to 6 percent slopes, eroded, is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, or so severly eroded that it cannot be classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Alluvial land is a land type in Douglas County.

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

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way as to be readily useful to different groups of users, among them farmers, managers of woodland, and engineers.

On the basis of yield and practice tables and other data, the soil scientists set up trial groups. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others. Then they adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Douglas County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed, a wooded tract, or a wildlife area, or in planning engineering works, recreational facilities, and community developments. It is not a suitable map for planning the management of a farm or field or for selecting the exact location of a road, building, or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

Soil associations on the general soil map in this soil survey do not fully agree with those of the general soil maps in adjacent counties published at a different date. Differences in the maps are the result of improvements in the classification of soils, particularly in the modifications or refinements in soil series concepts.

The soil associations in Douglas County are discussed in the following pages.

1. Barnes-Langhei association

Well-drained and somewhat excessively drained, undulating to very steep soils formed in loamy glacial till

This association is undulating to very steep (fig. 2). Most slopes are 50 to 200 feet long and are irregular. Hills are irregular in size and shape and rise 20 to 70 feet above the swales. Many small lakes occur in this association. Small potholes, 5 to 15 acres or less in size, are numerous. In the two smaller areas in Brandon, Ida, and Leaf Valley Townships, the soils are gently sloping to moderately steep and the slopes are more uniform than in the western part. It occupies about 20 percent of the county.

Barnes soils make up about 35 percent of the association; Langhei soils, about 25 percent; and Flom, Quam, Aastad, Vallers, and other minor soils, the remaining 40 percent.

Barnes soils are well drained and have a surface layer of black loam. The subsoil typically is dark-brown loam. These soils occur on the side slopes below the Langhei soils and on the more nearly level parts of the ridgetops. Langhei soils are somewhat excessively drained and have a surface layer of very dark grayish-brown, calcareous loam that is light gray when dry. The underlying material is light olive-brown loam. These soils occur on the narrow ridgetops, on knolls and knobs, and at the top of the side slopes.

Flom, Quam, Aastad, Vallers, and other soils make up part of this association. The Flom soils are poorly drained and occur in the waterways and shallow depressions. The Quam soils are very poorly drained and occur in sloughs and potholes. The Aastad soils are nearly level to gently sloping and are moderately well drained. They occur on small upland flats and in areas adjacent to waterways. The Vallers soils are poorly drained, are calcareous, and occur as rims around and between potholes.

Most of this association is used for crops and pasture. Corn, soybeans, small grains, and hay are the main crops. Undrained marshes provide cover and habitat for wild game. Dairying is the main farm enterprise. Trees grow around lakes and along streams but are not abundant. Runoff, erosion, and wetness are the main limitations that affect use and management of these soils.

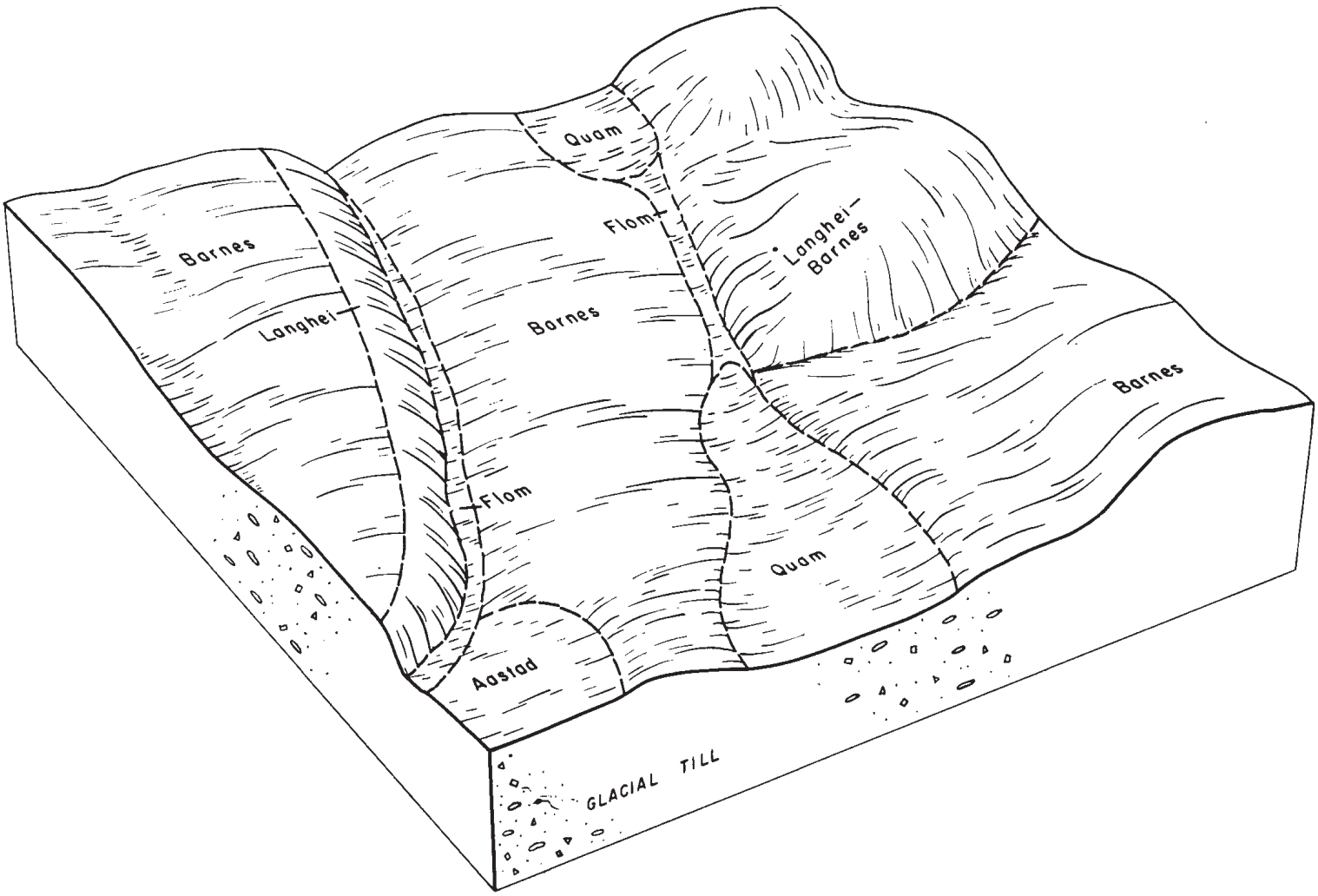

Figure 2.—**Relationship of soils in the Barnes-Langhei association to topography and underlying material.**

2. *Waukon-Flom association*

Well-drained and poorly drained, nearly level to steep soils formed in loamy glacial till

This association ranges from nearly level to steep (fig. 3). Most slopes are 50 to 200 feet long, are irregularly shaped, and rise 20 to 70 feet above the depressions. The hills are variable in size and shape. Many lakes, small and large, occur throughout the association. Many small potholes occur throughout the association. It occupies about 31 percent of the county.

Waukon soils make up about 40 percent of the association; Flom soils, about 15 percent; and, Langhei, Gonvick, Quam, organic soils, and other minor soils, the remaining 45 percent.

Waukon soils are well drained and have a surface layer of black loam and a subsoil of brown sandy loam to clay loam. These soils are undulating to steep. Flom soils are poorly drained and have a surface layer of black silty clay loam and a subsoil of dark grayish-brown clay loam. These soils occur in drainageways and in slightly depressed areas.

Langhei, Gonvick, Quam, and organic soils, and other minor soils make up part of this association. The Langhei soils are somewhat excessively drained and occur on the most exposed knobs, knolls, and ridges. The Gonvick soils are moderately well drained and occur in nearly level areas. The Quam soils are very poorly drained and occur in depressions. The organic soils occur in depressions and drainageways and along streams.

Most of this association is used for crops, pasture, or trees. Corn, soybeans, small grains, and hay are the main crops. The marshes provide food and cover for wildlife. Wooded areas vary in size and are scattered throughout the association. The principal trees are aspen, ash, oak, maple, basswood, and poplar. Dairying and hog raising are the main farm enterprises. Runoff, erosion, and wetness are the main limitations that affect use and management of these soils.

3. *Sinai-Fulda association*

Moderately well drained and poorly drained, nearly level to undulating soils formed in clayey glacial till or clayey lacustrine deposits

This association occurs as two small areas and is nearly level to undulating. Most slopes are 80 to 300 feet long. The hills are fairly uniform and rise 20 to 70 feet above the swales. There are few lakes in this association. Small potholes occur throughout the association. It occupies about 4 percent of the county.

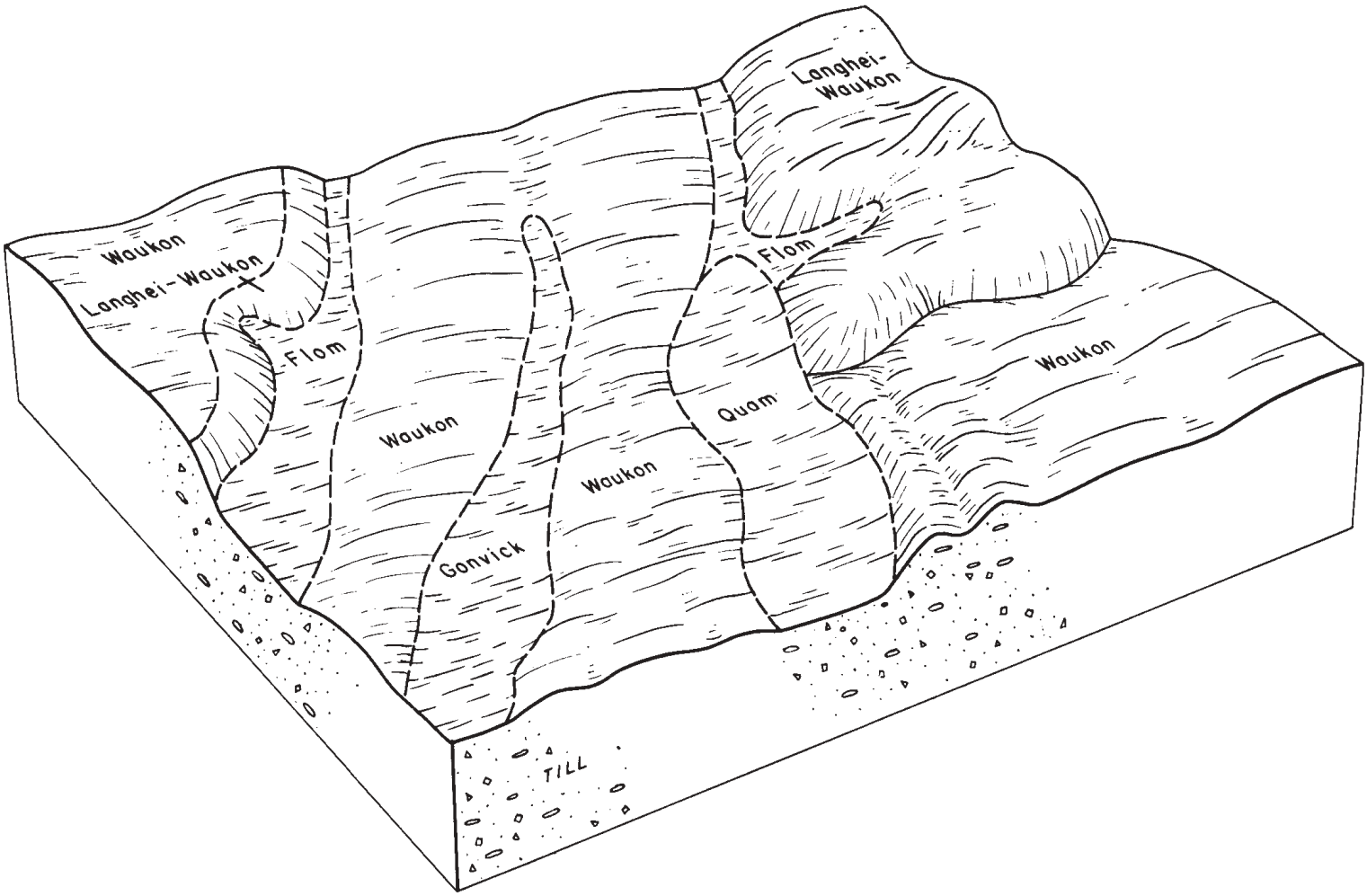

Figure 3.—**Relationship of soils in the Waukon-Flom association to topography and underlying material.**

Sinai soils make up about 40 percent of the association; Fulda soils, about 15 percent; and Dovray soils, organic soils, and other minor soils, the remaining 45 percent.

Sinai soils are moderately well drained and have a surface layer of black clay and a subsoil of dark grayish-brown clay. These soils are nearly level to undulating and occur next to and surrounding areas of the Fulda soil. Fulda soils are poorly drained and have a surface layer of black silty clay. These soils occur in the draws, drainageways, and shallow potholes.

Dovray soils, organic soils, and other minor soils make up part of this association. The Dovray and organic soils are very poorly drained and occur in potholes and sloughs.

Most of this association is used for crops and pasture. Corn, soybeans, small grains, and hay are the main crops. Undrained marshes provide cover and habitat for wild game. Dairying is the main farm enterprise. Trees grow along the lakes but are not abundant. Runoff, erosion, wetness, and clay content of the soil are the main limitations that affect use and management.

4. Nebish-Beltrami association

Well drained and moderately well drained, nearly level to steep soils formed in loamy glacial till

This association is nearly level to steep. The soils are undulating to hilly, but in the small area in Spruce Hill Township, they are nearly level to gently sloping. Most slopes are 50 to 200 feet long, are irregularly shaped, and rise 5 to 70 feet above the swales. In places the soils in Carlos and Miltona Townships are very stony and in spots are mixed with gravel. Small potholes, 5 to 15 acres or less in size, are numerous. This association occupies about 5 percent of the county.

Nebish soils make up about 60 percent of the association; Beltrami soils, about 5 percent; and Shooker, Sioux, organic soils, and other minor soils, the remaining 35 percent.

Nebish soils are well drained and have a surface layer of very dark gray loam, a subsurface layer of grayish-brown sandy loam, and a subsoil of brown to dark yellowish-brown sandy clay loam. These soils are undulating to steep. Beltrami soils are moderately well drained and have a surface layer of very dark gray loam, a subsurface layer of grayish-brown sandy loam, and a subsoil of mottled brown sandy clay and clay loam. The soils are nearly level.

Shooker and Sioux soils, organic soils, and other minor soils make up part of this association. The Shooker soils are poorly drained and occur in drainageways and slight depressions. The organic soils are very poorly drained and occur in deep depressions. The Sioux soils are excessively drained soils and are underlain by gravelly coarse sand.

Most of this association is used for crops, pasture, and woodland. Corn, soybeans, small grains, and hay are the main crops. Undrained marshes provide cover and habitat for wild game. Wooded areas vary in size and are scattered throughout the association. The principal trees are ash, maple, oak, aspen, and elm. Dairying is the main farm enterprise. Runoff, erosion, and wetness are the main limitations that affect use and management of these soils. Maintenance of soil tilth is a management problem.

5. *Arvilla-Sverdrup association*

Somewhat excessively drained, nearly level to rolling soils formed in dominantly loamy material over sand and gravel

Most of this association is nearly level to rolling, but in a few areas it is rolling to steep (fig. 4). The slopes are 50 to 200 feet long and rise 5 to 40 feet above the depressions. The hills are irregular in size and shape. Some of the large lakes in the country occur in or next to this association. Small potholes, 4 to 15 acres in size, occur throughout the association and are most common in the rolling to steep areas. This association occupies about 15 percent of the county.

Arvilla soils make up about 30 percent of the association; Sverdrup soils, about 13 percent; and Sioux, Osakis, Clontarf, Forada, and other minor soils, the remaining 57 percent.

Arvilla soils are somewhat excessively drained and have a surface layer of black sandy loam. The subsoil is brown and dark-brown loam underlain by sand and gravel. Sverdrup soils are somewhat excessively drained and have a surface layer of black sandy loam. They are nearly level to rolling and are underlain by sand.

Sioux, Osakis, Clontarf, Forada, and other minor soils make up part of this association. The Sioux soils are excessively drained, coarse-textured soils that are underlain by gravelly coarse sand. The Osakis soils are moderately well drained and are underlain by gravelly coarse sand. The Clontarf soils are moderately well drained and are underlain by sand. The Forada soils are poorly drained and are underlain by coarse sand and gravel.

Most of this association is used for crops or pasture. A few areas are wooded. Corn, soybeans, small grains, and hay are the main crops. The undrained marshes provide cover and habitat for wildlife. Dairying and hog raising are the main farm enterprises. Soil blowing, water erosion, wetness, droughtiness, and runoff are the main limitations in use and management of these soils. Maintenance of fertility is a management problem. The nearly level to gently sloping soils are suited to irrigation. A good water supply can be obtained in most places through use

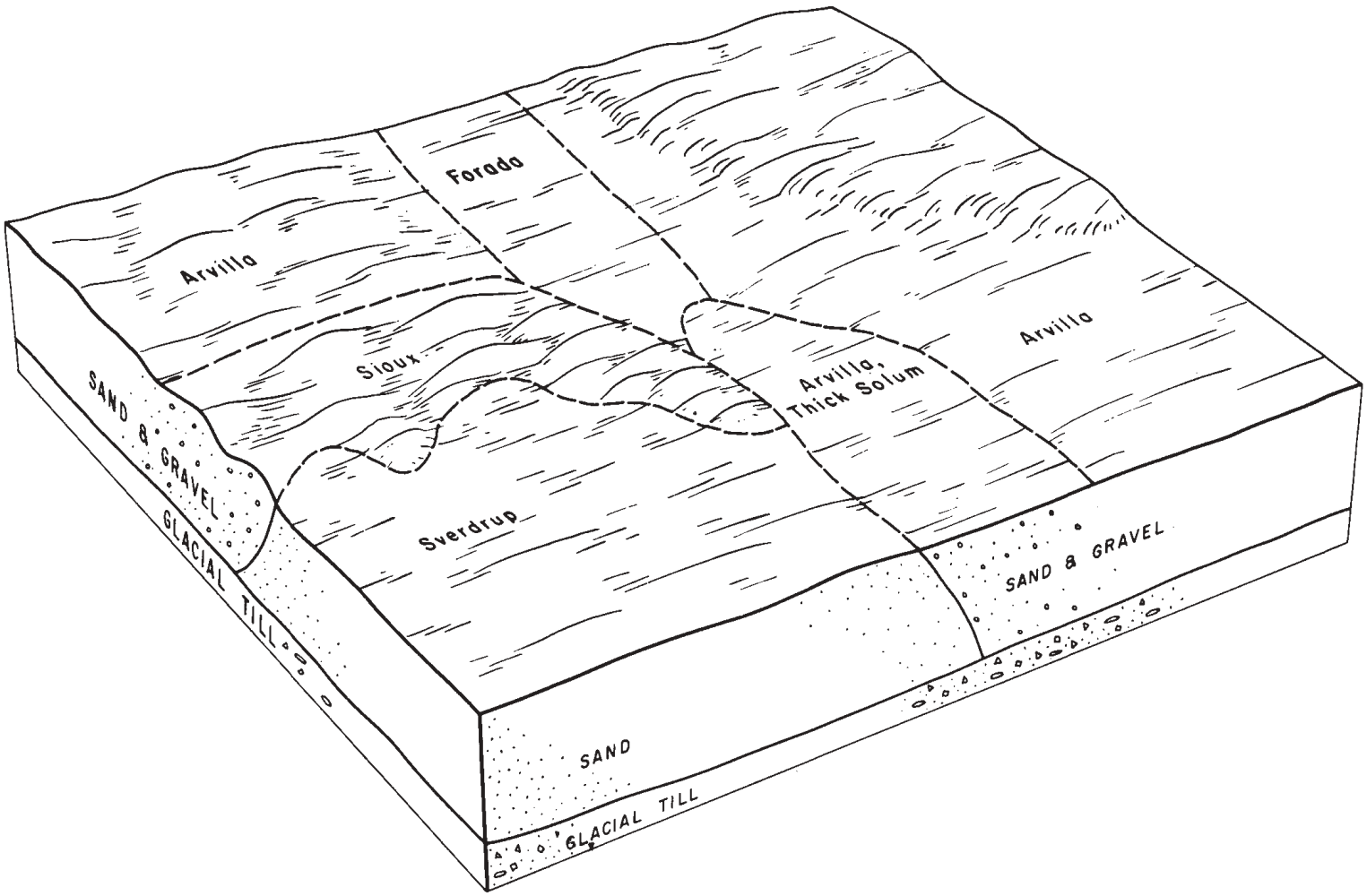

Figure 4.—**Relationship of soils in the Arvilla-Sverdrup association to topography and underlying material.**

of drilled wells. This association provides most of the sand and gravel used throughout the county.

6. *Forada-Arveson association*

Poorly drained, nearly level soils formed in loamy material over sand and gravel

This association is mainly nearly level, but there are some depressions and some small areas that rise 5 to 10 feet above the surrounding areas. This association occupies about 2 percent of the county.

Forada soils make up about 50 percent of the association; Arveson soils, about 15 percent; and Dassel, Clontarf, Hantho, Colvin, and other minor soils, the remaining 35 percent.

Forada soils are poorly drained and have a surface layer of black sandy loam underlain by coarse sand. Arveson soils are highly calcareous and poorly drained. They have a surface layer of black sandy clay loam and very dark gray fine sandy loam and are underlain by sand.

Dassell, Clontarf, Hantho, Colvin, and other minor soils make up part of this association. The Dassel soils are poorly drained and are underlain by sand. The Clontarf soils are moderately well drained and are underlain by sand. The Hantho soils are moderately well drained, silty soils. The Colvin soils are highly calcareous, poorly drained, silty soils.

Most of this association is used for crops and pasture. Corn, soybeans, small grains, and hay are the main crops. Undrained marshes provide food and cover for wild game. Soil blowing and wetness are the main limitations that affect use and management of these soils. Maintenance of fertility is a management problem.

7. *Waukon-Gonvick association*

Well drained and moderately well drained, nearly level to hilly soils formed in loamy glacial till

This association is nearly level to hilly (fig. 5). Most slopes are 50 to 200 feet long, are complex and irregularly shaped, and rise 5 to 30 feet above the depressions. Most soil areas are mainly variable in size and shape, but a few are uniform. Only a few lakes occur in this association. Many potholes and marshes occur throughout the association. This association occupies about 12 percent of the county.

Waukon soils make up about 35 percent of the association; Gonvick soils, about 25 percent; and Flom, Vallers, Quam, Urness, and other minor soils, the remaining 40 percent.

Waukon soils are well drained and have a surface layer of black loam and a subsoil of brown sandy loam to clay loam. These soils are undulating to hilly. Gonvick soils are moderately well drained and have a surface layer of

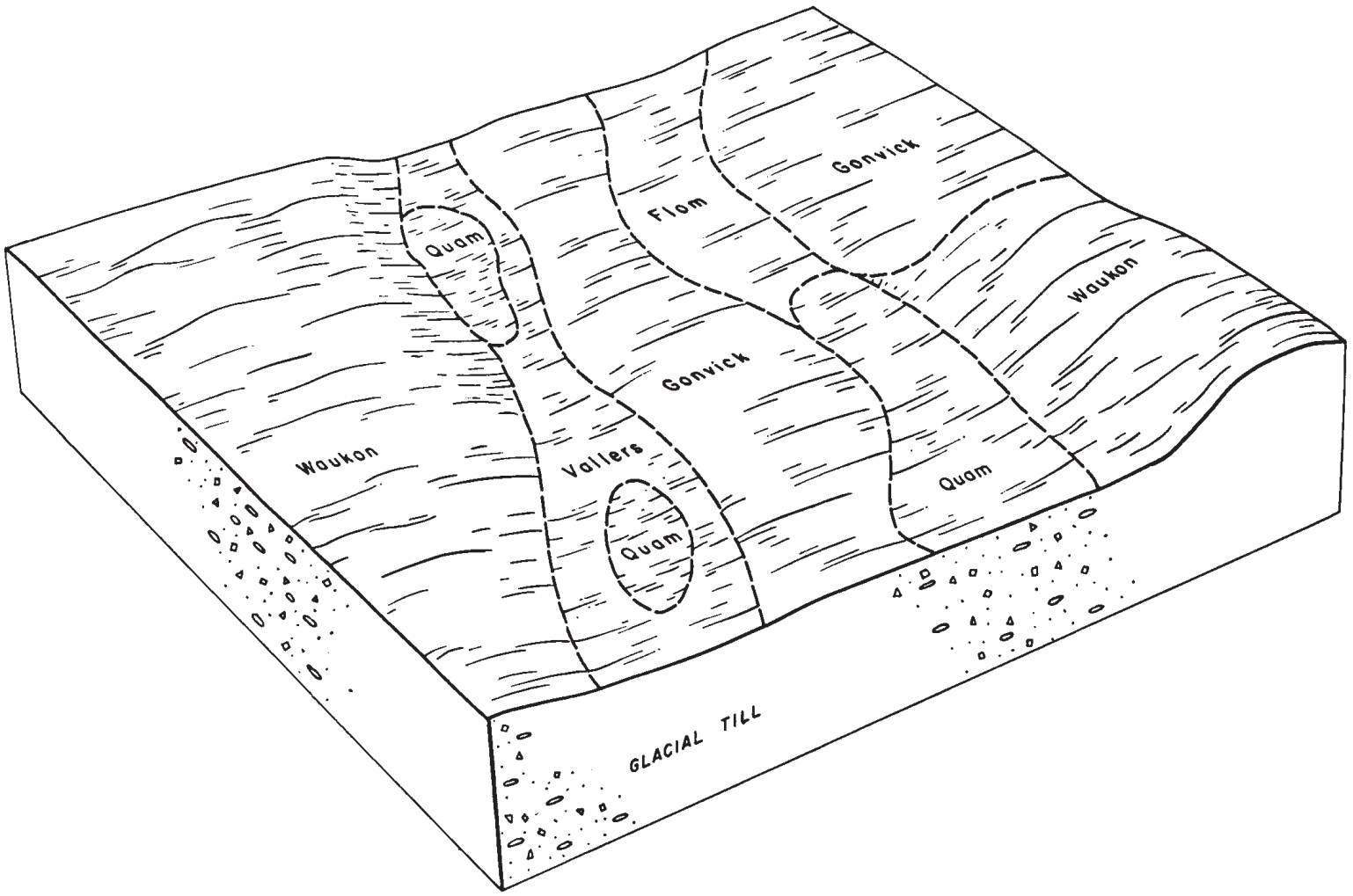

***Figure 5.*—Relationship of soils in the Waukon-Gonvick association to topography and underlying material.**

black loam and a subsoil of mottled dark grayish-brown clay loam. These nearly level soils occur on slight rises and flats of the upland till plain.

Flom, Vallers, Tonka, Quam, Urness, and other minor soils make up part of this association. The Flom and Tonka soils are poorly drained and occur in drainageways, slight depressions, and level areas. The Vallers soils are highly calcareous, poorly drained soils that occur around sloughs and potholes. The Quam soils are very poorly drained and occur in sloughs and potholes. The Urness soils are very poorly drained, calcareous soils that occur in sloughs and potholes.

Most of this association is used for crops, pasture, and woodland. Corn, soybeans, small grains, and hay are the main crops. Undrained marshes provide cover and habitat for wild game. Wooded areas vary in size and are scattered throughout the association. Dairying and hog raising are the main farm enterprises. Runoff, erosion, and wetness are the main limitations in use and management of these soils.

8. *Clarion-Flom association*

Well-drained and poorly drained, nearly level to rolling soils formed in loamy glacial till

This association is nearly level to rolling (fig. 6). Most slopes are 50 to 200 feet long and are irregular in size and shape. The areas are also variable in size and shape. The hills rise 10 to 25 feet above the surrounding swales. A few lakes occur in this association. This association occupies 4 percent of the county.

Clarion soils make up about 30 percent of the association; Flom soils, about 20 percent; and Nicollet, Quam, Vallers, and other minor soils, the remaining 50 percent.

Clarion soils are well drained and have a surface layer of black loam and a subsoil of brown loam. These undulating to rolling soils occur on side slopes. Flom soils are poorly drained and have a surface layer of black silty clay loam. The subsoil typically is dark grayish-brown clay loam that has light olive-brown mottles. These soils occur in drainageways and shallow depressions.

Nicollet, Quam, Vallers, and other minor soils make up part of this association. The Nicollet soils are moderately well drained. They are nearly level on hilltops and rises and gently sloping on side slopes. The Quam soils are very poorly drained and occur in sloughs and potholes. The Vallers soils are poorly drained, are highly calcareous, and occur around and between sloughs and potholes.

Most of this association is used for crops and pasture. Corn, soybeans, small grains, and hay are the main crops. The undrained marshes provide cover and habitat for wild game. Dairying is the main farm enterprise.

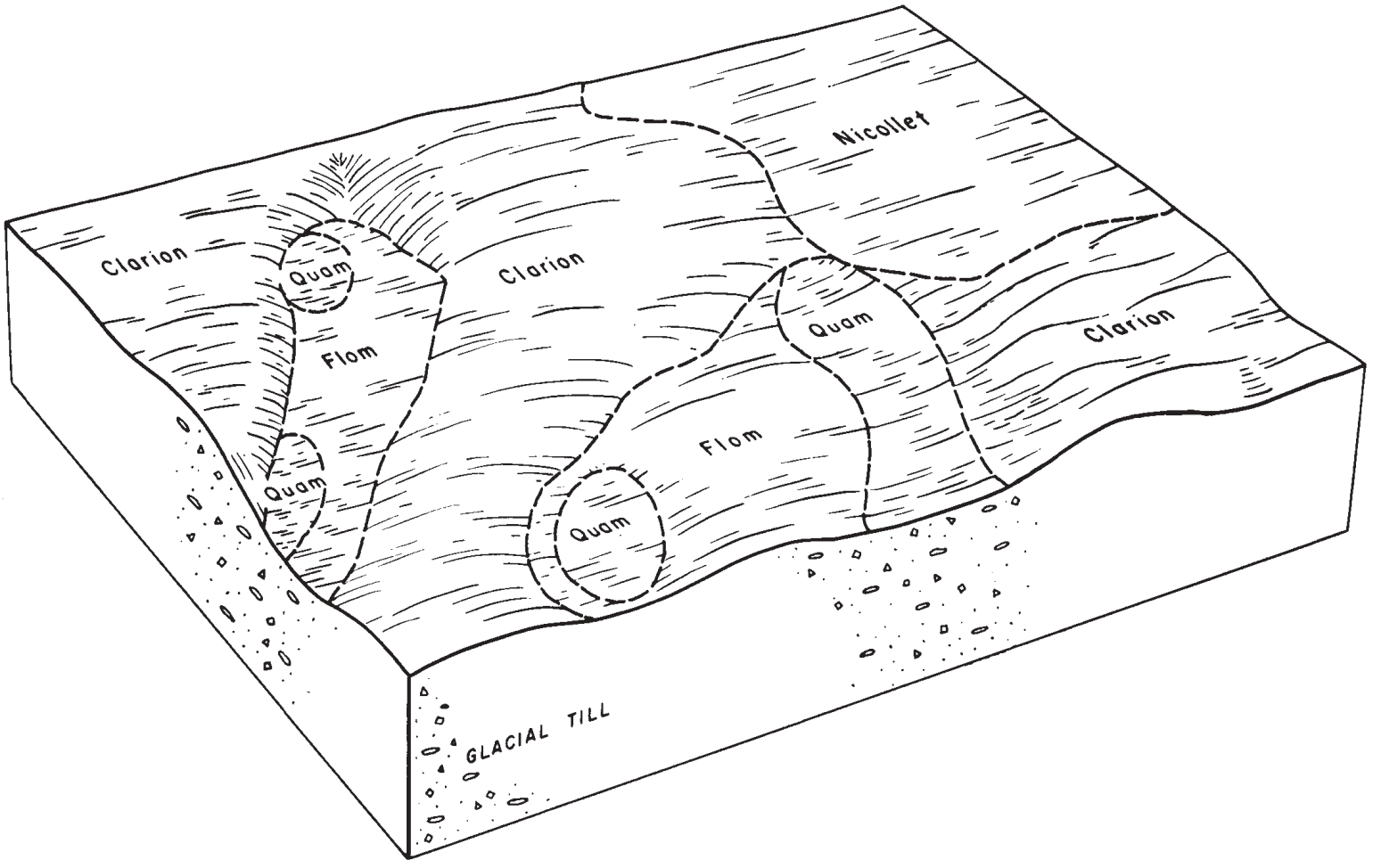

Figure 6.—**Relationship of soils in the Clarion-Flom association to topography and underlying material.**

Trees occur along lakes and streams but are not abundant. Runoff, erosion, and wetness are the main limitations that affect the use and management of these soils.

9. Dorset-Sioux association

Well-drained to excessively drained, nearly level to very steep soils formed in loamy material and in sand and gravel

This association is nearly level to very steep (fig. 7). Most slopes are 40 to 240 feet long, are irregularly shaped, and rise 5 to 40 feet above the surrounding swales. The hills are variable in size and shape. A few lakes occur throughout the association. Many small potholes also occur. This association occupies about 7 percent of the county.

Dorset soils make up about 40 percent of the association; Sioux soils, about 20 percent; and Forada and Marysland soils, organic soils, and other minor soils, the remaining 40 percent.

Dorset soils are somewhat excessively drained to well drained and have a surface layer of black sandy loam. The sandy loam is dark gray when dry. The subsoil is dark-brown sandy loam to gravelly coarse sand. These soils occur on the broad flats and in undulating to rolling areas. Sioux soils are excessively drained and have a surface layer of very dark brown loamy coarse sand. These soils occur on knolls, knobs, ridges, and side slopes where depth to gravel is 6 to 14 inches.

Forada and Marysland soils, organic soils, and other minor soils make up part of this association. The Forada soils are poorly drained, have a black surface layer, and occur in drainageways, on nearly level flats, and in slight depressions. The Marysland soils are calcareous, are poorly drained, and occur on nearly level flats and in slight depressions. The organic soils are very poorly drained.

Most of this association is used for crops, pasture, and woodland. Corn, soybeans, small grains, and hay are the main crops. Wooded areas vary in size and are scattered throughout the association. The principal trees are aspen, ash, oak, maple, and birch. The marshes provide food and cover for wild game. Dairying is the main farm enterprise. Soil blowing, runoff, water erosion, droughtiness, and wetness are the main limitations in use and management of these soils. Maintenance of fertility is a management problem. These soils are a source of sand and gravel.

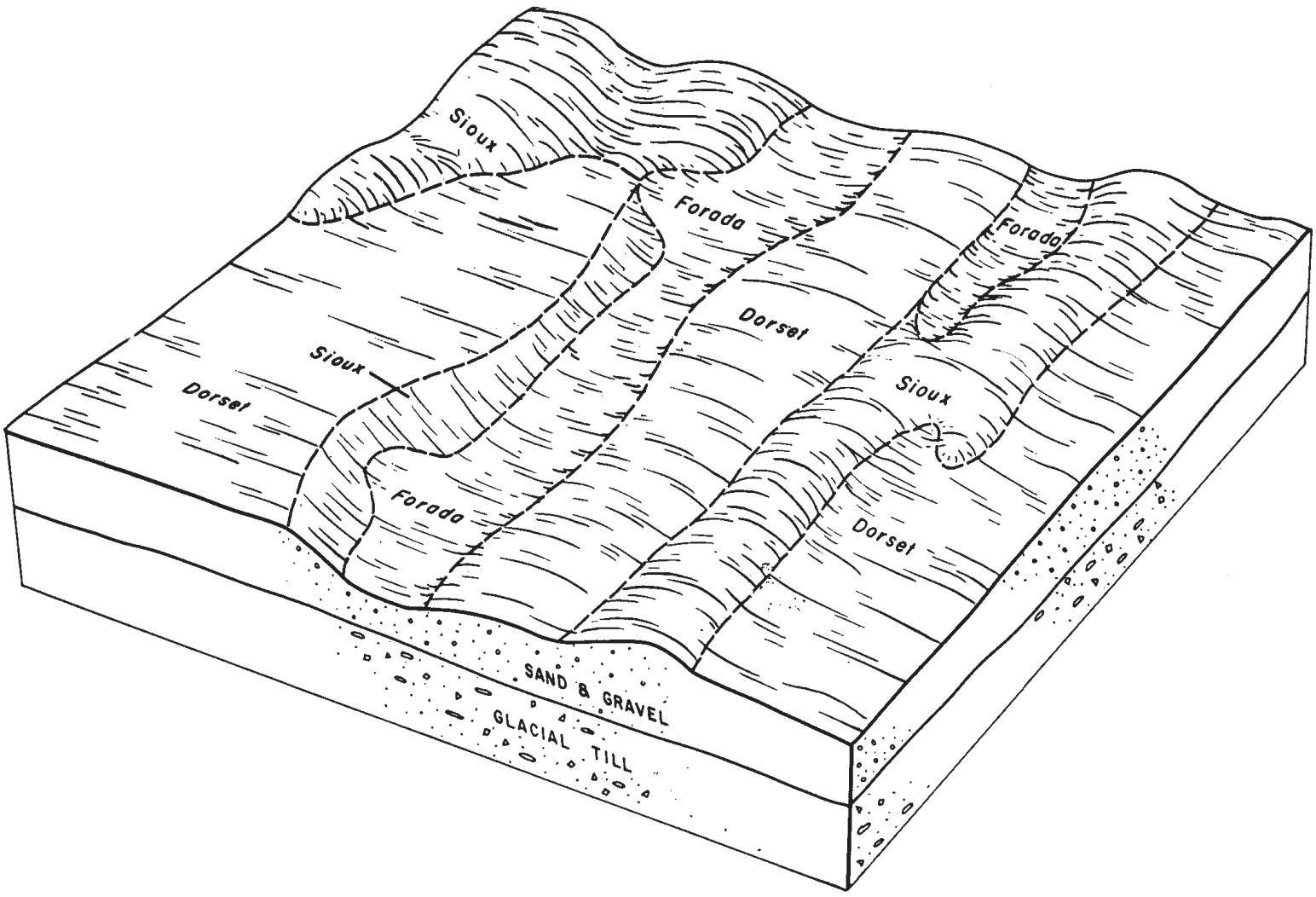

Figure 7.—**Relationship of soils in the Dorset-Sioux association to topography and underlying material.**

Descriptions of the Soils

In this section the soil series and mapping units represented in this county are described. The approximate acreage and proportionate extent of each mapping unit are given in table 1.

The soils of each series are first described as a group. Important features common to all the soils of the series are listed, and the position of the soils on the landscape is given. Each series description has a short narrative description of a representative profile and a much more detailed description of the same profile, from which highly technical interpretations can be made. Following the profile is a brief statement of the range of characteristics of the soils in the series as mapped in this county. Comparisons are made with other soils that are nearby or are generally similar to the soils of the series being described.

Each soil, or mapping unit, in the series is next described. Soils are the areas delineated on the map and identified by soil symbols. Generally, these descriptions tell how the profile of the soil differs from that described as representative of the series. They also tell about the use and suitability of the soil described and something about management needs.

For full information about any one mapping unit, it is necessary to read the description of the soil series as well as the description of the mapping unit. General information about the broad patterns of soils in the county is given in the section "General Soil Map." Unless otherwise indicated, the color names and color symbols given are for a moist soil.

The names, description, and soil areas shown on maps in this survey do not agree with or fully match areas of the same soils shown on the soil maps of adjoining counties published earlier. These differences have been brought about by modifications and refinements that are the result of continuing modification in soil series concepts. In addition, the correlation of a recognized soil is based upon the acreage of that soil and its dissimilarity to adjacent soils within the survey area. In many places, it is more feasible to include a small acreage of soils with other similar soils than to map them separately if the management and their response to management is similar.

Aastad Series

The Aastad series consists of deep, moderately well drained, nearly level to gently sloping soils on uplands. These soils formed under grasses in calcareous loam glacial till.

In a representative profile, the surface layer is clay loam that is black in the upper part and very dark gray in the lower part and is about 16 inches thick. The subsoil is dark grayish-brown and olive-brown clay loam about 8 inches thick. The underlying material is light brownish-gray and light olive-brown, mottled, calcareous loam.

The natural fertility and content of organic matter are high. The available water capacity is high, and permeability is moderate. The reaction of the surface layer is neutral.

Aastad soils are good farm soils. They are suited to all crops commonly grown in the county.

Representative profile of Aastad clay loam, 1 to 3 percent slopes, in a cultivated field, 455 feet west of the southeast corner of SW¼ sec. 9, T. 128 N., R. 40 W.

Ap—0 to 9 inches, black (10YR 2/1) clay loam; weak, fine, granular structure; friable; many roots; about 2 percent coarse fragments; neutral; abrupt, smooth boundary.

A1—9 to 11 inches, black (10YR 2/1) clay loam; weak, fine, granular structure; friable; many roots; about 2 percent coarse fragments; neutral; abrupt, wavy boundary.

A3—11 to 16 inches, very dark gray (10YR 3/1) clay loam; a few tongues of black (10YR 2/1); weak, fine, granular structure; friable; many roots; about 2 percent coarse fragments; neutral; abrupt, wavy boundary.

B21—16 to 18 inches, dark grayish-brown (2.5Y 4/2) clay loam, very dark grayish brown (2.5Y 3/2) when crushed; weak, medium, prismatic structure parting to weak, fine and medium, subangular blocky; friable; common roots; about 4 percent coarse fragments; mildly alkaline; clear, wavy boundary.

B22—18 to 24 inches, olive-brown (2.5Y 4/3) clay loam; few, fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, fine and medium, subangular blocky structure; friable; common roots; about 4 percent coarse fragments; mildly alkaline; gradual, wavy boundary.

C1ca—24 to 35 inches, light brownish-gray (2.5Y 6/2) loam; few, fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, very fine, subangular blocky structure; about 4 percent coarse fragments; friable; mildly alkaline; violently effervescent; gradual, wavy boundary.

C2—35 to 60 inches, light olive-brown (2.5Y 5/4) loam; few, fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, very fine, subangular blocky structure; friable; common, fine, white (10YR 8/1) segregations of lime; about 4 percent coarse fragments; mildly alkaline; strongly effervescent.

The solum ranges from 18 to 30 inches in thickness. The A horizon ranges from 10 to 20 inches in thickness. The B21 horizon has weak or moderate, prismatic or subangular blocky structure.

Aastad soils are associated with Langhei, Barnes, Flom, and Quam soils. Aastad soils have a thicker A horizon and have grayer colors below the A horizon than Langhei and Barnes soils. They are better drained than Flom and Quam soils, but they lack the mottled B horizon that is characteristic of Flom soils and they have a thinner A horizon than Quam soils.

Aastad clay loam, 1 to 3 percent slopes (AaA).—This soil has straight or slightly concave slopes and occurs in irregular patterns on till plains and in morainic areas.

Included in mapping were small areas of Barnes, Flom, and Darnen soils. Also included were some small areas of steeper soils and some areas where the surface layer is calcareous. In a few places the black surface layer is thicker than normal, and in some areas the surface layer is loam.

This soil has few limitations. It is suited to all the crops commonly grown in the county.

The main management need is maintenance of fertility and tilth. (Capability unit I–1; woodland suitability group 1)

Alluvial Land

Alluvial land (0 to 2 percent slopes) (Ad) consists of dark-colored soil material recently deposited by rivers and streams. It is nearly level and occurs in areas adjacent to streams and rivers. It is frequently flooded dur-

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Soil	Acres	Percent
Aastad clay loam, 1 to 3 percent slopes	4,040	1.0
Alluvial land	500	.1
Arveson sandy clay loam	1,520	.4
Arvilla sandy loam, 0 to 2 percent slopes	2,055	.5
Arvilla sandy loam, 2 to 6 percent slopes	11,875	2.9
Arvilla sandy loam, 6 to 12 percent slopes	3,105	.8
Arvilla sandy loam, thick solum, 0 to 3 percent slopes	2,580	.6
Barnes loam, 2 to 6 percent slopes, eroded	23,710	5.8
Barnes loam, 6 to 12 percent slopes, eroded	6,100	1.5
Barnes-Langhei loams, 2 to 6 percent slopes, eroded	4,825	1.2
Barnes-Langhei loams, 6 to 12 percent slopes, eroded	12,545	3.1
Beltrami loam, 1 to 3 percent slopes	1,110	.3
Brophy peat	540	.1
Carlos muck	1,015	.2
Cathro muck	9,030	2.2
Cathro muck, sandy subsoil variant	1,235	.3
Clarion loam, 2 to 6 percent slopes, eroded	4,610	1.1
Clarion loam, 6 to 12 percent slopes, eroded	1,085	.3
Clontarf sandy loam, 0 to 2 percent slopes	3,480	.9
Colvin silt loam	755	.2
Colvin silt loam, depressional	365	.1
Darnen loam, 1 to 4 percent slopes	390	.1
Dassel sandy loam	1,740	.4
Dassel sandy loam, depressional	1,300	.3
Dorset sandy loam, 0 to 2 percent slopes	1,990	.5
Dorset sandy loam, 2 to 6 percent slopes	6,085	1.5
Dorset sandy loam, 6 to 12 percent slopes	645	.2
Dorset sandy loam, thick solum, 0 to 2 percent slopes	1,300	.3
Dorset sandy loam, thick solum, 2 to 6 percent slopes	1,795	.4
Dorset sandy loam, thick solum, 6 to 12 percent slopes	1,245	.3
Dovray mucky silty clay	1,375	.3
Flom silty clay loam	25,915	6.3
Forada sandy loam	3,890	1.0
Forada loam, depressional	3,240	.8
Forada sandy loam, sandy subsoil	935	.2
Forman clay loam, 6 to 12 percent slopes, eroded	2,320	.6
Forman-Aastad clay loams, 1 to 5 percent slopes	3,535	.9
Fulda silty clay	3,360	.8
Gonvick loam, 1 to 3 percent slopes	14,995	3.7
Hangaard sandy loam	1,275	.3
Hantho silt loam, 1 to 3 percent slopes	1,110	.3
Lake beaches, sandy	2,660	.7
Lake beaches, loamy	1,115	.3
Langhei loam, 18 to 40 percent slopes	2,775	.7
Langhei-Barnes loams, 12 to 18 percent slopes, eroded	5,440	1.3
Langhei-Waukon loams, 12 to 18 percent slopes, eroded	3,190	.8
Langhei-Waukon loams, 18 to 24 percent slopes	825	.2
Langhei-Waukon-Sioux complex, 12 to 25 percent slopes	800	.2
Maddock fine sand, 0 to 2 percent slopes	810	.2
Maddock fine sand, 2 to 6 percent slopes	2,190	.5
Maddock fine sand, 6 to 12 percent slopes	1,020	.3
Marsh	27,965	6.9
Marysland loam	1,390	.3
Marysland loam, depressional	720	0.2
Millerville mucky peat	410	.1
Nebish sandy loam, 2 to 6 percent slopes	2,455	.6
Nebish sandy loam, 6 to 12 percent slopes	1,695	.4
Nebish sandy loam, 12 to 18 percent slopes	550	.1
Nebish loam, 2 to 6 percent slopes	3,090	.8
Nebish loam, 2 to 6 percent slopes, eroded	1,690	.4
Nebish loam, 6 to 12 percent slopes	1,685	.4
Nebish loam, 6 to 12 percent slopes, eroded	1,535	.4
Nebish loam, 12 to 18 percent slopes	1,295	.3
Nebish loam, 18 to 24 percent slopes	470	.1
Nebish-Dorset complex, 2 to 6 percent slopes	1,175	.3
Nebish-Dorset complex, 6 to 12 percent slopes	800	.2
Nicollet clay loam, 1 to 4 percent slopes	3,035	.7
Nymore loamy sand, 2 to 6 percent slopes	630	.2
Nymore loamy sand, 6 to 18 percent slopes	460	.1
Osakis loam, 0 to 3 percent slopes	3,270	.8
Quam mucky silty clay loam	18,080	4.4
Rifle mucky peat	3,180	.8
Rothsay silt loam, 2 to 6 percent slopes	1,155	.3
Seelyeville muck	1,030	.3
Shooker loam	1,055	.3
Sinai clay, 0 to 2 percent slopes	920	.2
Sinai clay, 2 to 6 percent slopes	8,135	2.0
Sioux loamy coarse sand, 0 to 6 percent slopes	3,755	.9
Sioux loamy coarse sand, 6 to 12 percent slopes	5,160	1.3
Sioux gravelly loamy coarse sand, 2 to 12 percent slopes	735	.2
Sioux gravelly loamy coarse sand, 12 to 35 percent slopes	4,325	1.1
Sverdrup sandy loam, 0 to 2 percent slopes	3,400	.8
Sverdrup sandy loam, 2 to 6 percent slopes	3,030	.7
Sverdrup sandy loam, 6 to 12 percent slopes	630	.2
Sverdrup loam, thick solum, 0 to 3 percent slopes	1,395	.3
Tonka loam	1,685	.4
Urness mucky silty clay loam	6,680	1.6
Urness mucky silt loam, peaty subsoil variant	770	.2
Vallers clay loam, 0 to 3 percent slopes	10,450	2.6
Waukon loam, 2 to 6 percent slopes	19,720	4.8
Waukon loam, 2 to 6 percent slopes, eroded	17,660	4.3
Waukon loam, 6 to 12 percent slopes	9,380	2.3
Waukon loam, 6 to 12 percent slopes, eroded	11,070	2.7
Waukon loam, 12 to 18 percent slopes	4,255	1.0
Waukon loam, 12 to 18 percent slopes, eroded	1,570	.4
Waukon loam, 18 to 24 percent slopes	845	.2
Waukon clay loam, 2 to 6 percent slopes	1,625	.4
Waukon clay loam, 6 to 12 percent slopes, eroded	955	.2
Waukon-Langhei loams, 2 to 6 percent slopes, eroded	875	.2
Waukon-Langhei loams, 6 to 12 percent slopes, eroded	6,045	1.5
Waukon-Langhei-Sioux complex, 2 to 6 percent slopes, eroded	1,180	.3
Waukon-Langhei-Sioux complex, 6 to 12 percent slopes, eroded	1,300	.3
Zell-Rothsay silt loams, 6 to 12 percent slopes, eroded	715	.2
Gravel pit	460	.1
Sewage lagoon	75	(1)
Water not meandered	4,715	1.2
Total	407,680	100.0

[1] Less than 0.05 percent.

ing spring and occasionally during periods of excessive rainfall. The soil material ranges from coarse sand to silty clay loam, but in most places it is sandy to loamy and is stratified. The color and reaction vary.

Most areas are poorly drained, but some included areas are very poorly drained or moderately well drained. The deposits are so recent that a profile has not formed, although the material is mottled in some places. Because of the low-lying position, the water table is at a depth of 1 to 5 feet during most of the growing season.

This land type is suited to pasture, woodland, or wildlife habitat. Many pastured areas are hummocky. (Capability unit VIw-1; woodland suitability group 8)

Arveson Series

The Arveson series consists of deep, poorly drained, calcareous, nearly level soils. These soils formed under grasses in calcareous, loamy material over calcareous sand. They are on outwash plains.

In a representative profile, the surface layer is about 23 inches thick. The upper 9 inches is black sandy clay loam, and the next 14 inches is very dark gray fine sandy loam. The underlying material is mottled, dark grayish-brown loamy fine sand and grayish-brown fine sand.

Arveson soils have high organic-matter content, medium natural fertility, and low to medium available water capacity. Permeability is moderately rapid in the surface layer and rapid in fine sand. Reaction is mildly alkaline in the surface layer.

If these soils are adequately drained, all the crops common in the county can be grown.

Representative profile of Arveson sandy clay loam, in a cultivated field where the slope is nearly level, in SE¼NE¼ sec. 18, T. 127 N., R. 36 W.

Ap—0 to 9 inches, black (10YR 2/1) sandy clay loam; weak, fine, granular structure; very friable; common bleached sand grains; mildly alkaline; strongly effervescent; abrupt, smooth boundary.

A1ca—9 to 16 inches, very dark gray (10YR 3/1) fine sandy loam, gray (10YR 6/1) when dry; weak, very fine, granular structure; few tongues of black (10YR 2/1); very friable; common bleached sand grains; mildly alkaline; violently effervescent; abrupt, wavy boundary.

A3ca—16 to 23 inches, very dark gray (10YR 3/1) fine sandy loam; weak, very fine, granular structure; very friable; mildly alkaline; violently effervescent; abrupt, wavy boundary.

IIC1g—23 to 25 inches, dark grayish-brown (2.5Y 4/2) loamy fine sand; many, fine, prominent, dark-brown (7.5YR 3/2) mottles; single grain; loose; mildly alkaline; strongly effervescent; gradual, wavy boundary.

IIIC2g—25 to 60 inches, grayish-brown (2.5Y 5/2) fine sand; common, fine and medium, distinct, yellowish-brown (10YR 5/6) mottles; single grain; mildly alkaline; strongly effervescent.

The A horizon is 12 to 24 inches thick. Its texture is fine sandy loam, loam, or sandy clay loam. Depth to the horizon of maximum lime accumulation, the Aca horizon, ranges from 6 to 16 inches. The color of this horizon is very dark gray, dark gray, or gray. Both the IIC1g and IIC2g horizons range from loamy fine sand to sand or fine sand in texture.

Arveson soils are associated with Clontarf, Dassel, and Marysland soils. Arveson soils lack the browner colored, noncalcareous B horizon that is typical of the Clontarf soils. They have a calcareous A horizon instead of the noncalcareous A horizon that is typical of Dassel soils. Arveson soils have more fine sand in their IIC horizon than Marysland soils.

Arveson sandy clay loam (Ao).—This soil is nearly level. The areas are irregularly shaped. Most areas are more than 40 acres in size.

Included in mapping were small areas of Dassel and Clontarf soils. Also included were a few areas of soil that is similar to the Arveson soils, except that it has a surface layer that is as much as 30 inches thick in places. Also included were about 250 acres of a soil that has a surface layer and subsoil of silt loam underlain by fine sand.

Additional drainage is needed, and most areas have been drained by surface ditches. Nearly all of this soil is used for cultivated crops, but some areas are used for pasture or for wildlife habitat. This soil is suited to all crops commonly grown in the county. Soil blowing is a hazard on fields left bare during winter and spring.

The main management needs are controlling erosion, improving and maintaining the drainage system, improving fertility, and conserving moisture. (Capability unit IIIw-2; woodland suitability group 5)

Arvilla Series

The Arvilla series consists of somewhat excessively drained, nearly level to rolling soils. These soils formed under grasses in loamy material. They are shallow to calcareous sand and gravel. They occur on outwash plains and stream terraces.

In a representative profile, the surface layer is black sandy loam about 7 inches thick. The upper part of the subsoil is brown loam about 7 inches thick. The lower part is dark-brown gravelly loamy coarse sand about 4 inches thick. The underlying material is dark yellowish-brown, light brownish-gray, and brown, stratified, calcareous gravelly coarse sand.

Arvilla soils have low to medium available water capacity, medium natural fertility, and medium to high organic-matter content. Reaction is neutral in the surface layer. The rooting zone is shallow. Permeability is moderately rapid in the surface layer and subsoil and rapid in the gravelly coarse sand.

Gravel pits have been opened on these soils and are a good source of gravel. These soils are droughty, and as a result crops do not grow well in most years.

Representative profile of Arvilla sandy loam, 2 to 6 percent slopes, in a wildlife area in NW¼NW¼NE¼ sec. 12, T. 130 N., R. 39 W.

Ap—0 to 7 inches, black (10YR 2/1) sandy loam; weak, very fine, granular structure; very friable; common bleached sand grains; common roots; neutral; abrupt, smooth boundary.

B21—7 to 10 inches, brown (7.5YR 4/3) loam; faces of peds are dark brown (7.5YR 3/2); weak, medium, sub-

angular blocky structure; very friable; common roots; neutral; gradual, wavy boundary.

B22—10 to 14 inches, brown (7.5YR 4/3) loam; faces of peds are brown (7.5YR 4/2); weak, medium, prismatic structure parting to weak, medium, subangular blocky; very friable; common roots; neutral; abrupt, wavy boundary.

IIB3—14 to 18 inches, dark-brown (7.5YR 4/4) gravelly loamy coarse sand; massive; very friable; few roots; neutral; abrupt, smooth boundary.

IIC1—18 to 23 inches, dark yellowish-brown (10YR 3/4) gravelly coarse sand; single grain; loose; few roots; mildly alkaline; slightly effervescent; abrupt, wavy boundary.

IIC2—23 to 60 inches, multicolored gravelly coarse sand that is dark yellowish brown (10YR 4/4), brown (10YR 4/3), and light brownish gray (10YR 6/2); single grain; loose; mildly alkaline; strongly effervescent.

The A1 or Ap horizon ranges from black in most places to dark gray or very dark brown in eroded places. It is 5 to 12 inches thick. The B horizon is 4 to 12 inches thick, and its texture is sandy loam in some places. It is most commonly dark yellowish brown, dark brown, brown, very dark grayish brown, or very dark brown. The proportions of sand and gravel in the underlying material are extremely variable, and the content of gravel ranges from about 10 to 50 percent.

Arvilla sandy loam, thick solum, has a B horizon that is as much as 20 inches thick in places, and the depth to the IIC horizon ranges from 22 to 36 inches. These features are beyond the defined range for the series, but the difference does not alter the usefulness and behavior of these soils.

Arvilla soils are associated wtih Sioux, Sverdrup, and Osakis soils. Arvilla soils have a thicker solum than Sioux soils. They differ from Sverdrup soils in being underlain by gravelly coarse sand rather than by sand. They have a browner colored B horizon than Osakis soils, and their B horizon lacks the mottles that are characteristic of Osakis soils.

Arvilla sandy loam, 0 to 2 percent slopes (AsA).—This soil is in outwash areas and on stream terraces. Areas are broad and are irregular in shape. This soil is closely associated with Sioux and Osakis soils, and Arvilla sandy loam, thick solum. The profile differs from the one described as representative for the series in being deeper to gravelly coarse sand.

Included in mapping were small areas of excessively drained Sioux soils, moderately well drained Osakis soils, and the well drained Arvilla sandy loam, thick solum. Also included were small areas of more strongly sloping soil, spots of eroded soils, and poorly drained or very poorly drained soils in depressions and draws. In some places the surface layer is loam.

Nearly all of this soil is used for cultivated crops. A few areas are used for pasture. This soil is suited to all crops commonly grown in the county, but it is better suited to early maturing crops because of the drought hazard. This soil is suited to irrigation, and field crops and vegetables can be irrigated. If the soil is left unprotected, soil blowing is a hazard in winter and early in spring.

The main management needs are practices that control erosion, improve fertility, and conserve moisture. (Capability unit IIIe–3; woodland suitability group 6)

Arvilla sandy loam, 2 to 6 percent slopes (AsB).—This soil is gently sloping and undulating. It is in outwash areas and on uplands. The areas are variable in size and shape. Slopes are 50 to 250 feet long. There are many narrow drainageways and small depressions scattered throughout the areas. This soil has the profile described as representative for the series.

Included in mapping were a few small areas of excessively drained Sioux soils, moderately well drained Osakis soils, and poorly drained Forada soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, spots of eroded soils, and areas where the surface layer is loam. Some areas are moderately eroded.

Nearly all this soil is used for cultivated crops. A few areas are used for pasture. This soil is suited to all crops commonly grown in the county, but it is better suited to early maturing crops because of the drought hazard. This soil is suited to irrigation, and field crops and vegetables can be irrigated. Water runs off at a medium rate. The hazard of further erosion is moderate.

The main management needs are practices that control erosion, improve fertility, and conserve moisture. (Capability unit IIIe–3; woodland suitability group 6)

Arvilla sandy loam, 6 to 12 percent slopes (AsC).—This sloping to rolling soil is in outwash areas and on uplands. The areas lie parallel to waterways or around sloughs. Slopes are irregularly shaped and are 50 to 200 feet long. The profile differs from the one described as representative for the series in being more shallow to gravelly coarse sand.

Included in mapping were small areas of excessively drained Sioux soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, eroded spots, and areas where the surface layer is loam.

Nearly all of this soil is used for cultivated crops. A few areas are used for pasture. This soil is suited to all crops commonly grown in the county. Droughtiness is a serious limitation. Water runs off this soil at a medium to rapid rate. The hazard of further erosion is moderately severe.

The main management needs are practices that control erosion, improve fertility, and conserve moisture. (Capability unit IVe–2; woodland suitability group 6)

Arvilla sandy loam, thick solum, 0 to 3 percent slopes (AtA).—This soil occurs in outwash areas of the county. It is nearly level to slightly depressed. The areas are variable in size and shape, but some areas are quite large. The profile differs from the one described as representative for the series in having a 22- to 36-inch combined surface layer and subsoil over the underlying gravelly coarse sand.

Included in mapping were small areas of well drained Arvilla soils, moderately well drained Osakis soils, and poorly drained Forada soils. In some places the depth to gravel is less than 22 inches. In a few places mottles are present in the lower part of the subsoil and some places have small areas of steeper soils. Some areas have a surface layer of loam.

Nearly all of this soil is used for cultivated crops. A few areas are used for pasture. This soil is suited to all crops commonly grown in the county. This soil has a slight drought hazard. Soil blowing is a hazard on bare fields in winter and spring. This soil is suited to irrigation, and field crops and vegetables can be irrigated.

The main management needs are practices that control erosion, conserve moisture, and maintain fertility. (Capability unit IIe–4; woodland suitability group 6)

Barnes Series

The Barnes series consists of deep, well-drained, undulating to hilly soils. These soils formed under grasses in calcareous loam glacial till.

In a representative profile, the surface layer is black loam about 8 inches thick. The subsoil is about 10 inches thick. The upper part is dark-brown loam, and the lower part is brown loam. The underlying material is light olive-brown loam.

Barnes soils have high natural fertility, high available water capacity, and high organic-matter content. Permeability is moderate. Reaction in the surface layer is neutral.

If adequate amounts of fertilizer are used and if erosion control measures are applied, Barnes soils are well suited to crops commonly grown in the county.

Representative profile of Barnes loam, 2 to 6 percent slopes, eroded, in a cultivated field where the slope is 4 percent, 337 feet east and 69 feet north of the southwest corner, SE¼SW¼ sec. 28, T. 127 N., R. 40 W.

Ap—0 to 8 inches, black (10YR 2/1) loam; cloddy, but parts to weak, fine, subangular blocky and granular structure; friable; common roots; few spots of dark brown; about 4 percent coarse fragments; neutral; abrupt, smooth boundary.

B21—8 to 13 inches, dark-brown (10YR 3/3) loam; weak, medium, prismatic structure parting to weak, medium and coarse, subangular blocky; friable; plentiful roots; few black (10YR 2/1) fillings in root channels; about 4 percent coarse fragments; neutral; gradual, wavy boundary.

B22—13 to 18 inches, brown (10YR 4/3) loam; weak, medium, prismatic structure parting to weak, medium, subangular blocky; friable; few thin clay films on faces of peds; few roots; about 4 percent coarse fragments; neutral; gradual, wavy boundary.

C1—18 to 26 inches, light olive-brown (2.5Y 5/6) loam; weak, very fine and fine, subangular blocky structure; friable; few, fine, distinct, light-gray (10YR 7/1) lime spots; few roots; about 4 percent coarse fragments; mildly alkaline; strongly effervescent; gradual, wavy boundary.

C2—26 to 60 inches, light olive-brown (2.5Y 5/4) loam; few, fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, fine, subangular blocky structure; friable; few, fine, distinct, light-gray (10YR 7/1) limy streaks and threads; few manganese concretions; about 4 percent coarse fragments; mildly alkaline; strongly effervescent.

The A horizon is very dark brown in places. It ranges from 5 to 10 inches in thickness and from loam to clay loam in texture. The B horizon ranges from dark grayish brown to dark yellowish brown or yellowish brown in color and from loam to clay loam in texture. The primary structure ranges from weak to moderate, prismatic. Some profiles have a thin, light olive-brown, calcareous B3 horizon.

Barnes soils are associated with Langhei, Aastad, Flom, and Quam soils. Barnes soils have a thicker, darker colored surface layer than Langhei soils. They are better drained than Aastad, Flom, and Quam soils and have a thinner A horizon and a browner B horizon than Aastad and Flom soils.

Barnes loam, 2 to 6 percent slopes, eroded (BaB2).—This is an undulating soil that occurs on side slopes. The areas vary in size and shape. This soil has complex slopes that are 50 to 200 feet long and are concave and convex. In a few areas the slopes are more uniform than is normal. This soil has the profile described as representative for the series. The present surface layer consists of the original surface layer mixed with moderate amounts of material from the subsoil as a result of erosion.

Included in mapping were small areas of somewhat excessively drained Langhei soils and moderately well drained Aastad and Darnen soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, areas of gravelly soils, spots where stones are on the surface, and a few areas that have a surface layer of sandy loam. Other inclusions were areas of Barnes soils that are adjacent to areas of Sinai soils and that have a surface layer of silty clay loam. In addition, areas of Barnes soils that are slightly eroded were included.

Nearly all of this soil is used for cultivated crops. A few small areas are in pasture. This soil is suited to all crops commonly grown in the county. Water runs off this soil at a medium rate, and the hazard of erosion is moderate.

The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IIe–1; woodland suitability group 1)

Barnes loam, 6 to 12 percent slopes, eroded (BaC2).—This is a rolling soil that occurs along the sides and around the heads of drainageways and around depressions. The slopes are complex and are 50 to 250 feet long. Along some of the drainageways and around some of the sloughs, slopes are more uniform. The profile differs from the one described as representative for the series in being thinner in most places. This soil has a plow layer that consists of the original surface layer mixed with some material from the subsoil because it is eroded.

Included in mapping were small areas of somewhat excessively drained Langhei soils and moderately well drained Aastad and Darnen soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, areas of gravelly soils, areas of uneroded soils, and spots where there are stones on the surface. Other inclusions were areas of Barnes soils that are adjacent to areas of Sinai soils and that have a surface layer of silty clay loam. In addition, a few other areas that have a surface layer of sandy loam were included.

Nearly all of this soil is used for cultivated crops. A few areas are in pasture. This soil is suited to all crops commonly grown in the county. Water runs off this soil at a medium to rapid rate. The hazard of erosion is moderately severe.

The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IIIe–1; woodland suitability group 1)

Barnes-Langhei loams, 2 to 6 percent slopes, eroded (BlB2).—These soils are undulating. The areas vary in size and shape, have convex and concave relief, and are 50 to 200 feet long. Barnes soil makes up 60 to 80 percent of the areas where the slopes are more uniform. Langhei soil makes up 20 to 40 percent of the areas where the slopes are convex and more exposed. The surface layer of the Langhei soils is light gray when dry. The Barnes and Langhei soils occur in such an intricate pattern that it is not practical to map them separately. This unit is

moderately eroded, and the soils have a surface layer that consists of the original surface layer mixed with moderate amounts of material from the subsoil.

Included in mapping were small areas of moderately well drained Aastad and Darnen soils and of poorly drained Flom and Vallers soils. Also included were small areas of steeper soils, gravelly soils, and severely or slightly eroded soils. In addition, some areas where stones are scattered on the surface were included.

Nearly all the acreage is used for cultivated crops. A few areas are used for pasture. These soils are suited to all crops commonly grown in the county. Langhei soil is less suited to crops than Barnes soil because of the nutrient imbalance caused by the high content of lime. Surface runoff is medium, and the hazard of erosion is moderate.

The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IIe–1; Barnes part in woodland suitability group 1; Langhei part in woodland suitability group 2)

Barnes-Langhei loams, 6 to 12 percent slopes, eroded (BlC2).—These soils are rolling. The areas vary in size and shape and have complex topography. Slopes are 75 to 250 feet long. Barnes soil makes up 50 to 70 percent of the area, and Langhei soil, 30 to 50 percent. Barnes soil occurs on the more uniform parts of the side slopes, and Langhei soil is on the exposed knobs, ridges, and knolls (fig. 8). This unit has been moderately eroded, and the surface layer is a mixture of the original surface layer and moderate amounts of material from the subsoil. This gives the surface layer of the Barnes soil a dark-brownish color and the Langhei soil a grayish color when dry. The Barnes and Langhei soils in this unit occur in such an intricate pattern that it is not practical to map them separately.

Included in mapping were small areas of the moderately well drained Aastad and Darnen soils and the poorly drained Flom and Vallers soils. Also included were small areas of more strongly sloping soils, small areas of less sloping soils, areas of gravelly soils, areas of severely or slightly eroded soils, and areas where stones are scattered on the surface.

Nearly all the acreage is used for cultivated crops. A few areas are used for pasture. These soils are suited to all crops commonly grown in the county. The Langhei soil is less well suited to crops than the Barnes soil because of the nutrient imbalance caused by the high content of lime. Surface runoff is medium to rapid, and the hazard of erosion is moderately severe.

The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IIIe–1; Barnes part in woodland suitability group 1; Langhei part in woodland suitability group 2)

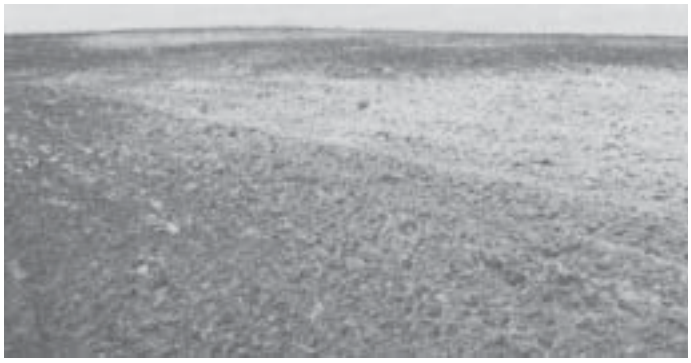

Figure 8.—**Barnes-Langhei loams, 6 to 12 percent slopes, eroded. Langhei soils are the lighter colored areas.**

Beltrami Series

The Beltrami series consists of deep, moderately well drained, nearly level soils. These soils formed under deciduous hardwood forest in calcareous loam glacial till.

In a representative profile, the surface layer is very dark gray loam about 6 inches thick. The subsurface layer is grayish-brown sandy loam about 5 inches thick. The subsoil is about 23 inches thick. The upper part is brown sandy clay loam, the middle part is mottled, olive-brown clay loam, and the lower part is mottled, light olive-brown sandy clay loam. The underlying material is calcareous, light olive-brown loam.

The Beltrami soils have medium natural fertility, high available water capacity, and medium organic-matter content. Permeability is moderate. Reaction in the surface layer is neutral.

Beltrami soils are well suited to the crops commonly grown in the county. Some of the areas are wooded.

Representative profile of Beltrami loam, 1 to 3 percent slopes, in a cultivated field where the slope is 1 percent, 165 feet east and 37 feet north of the southwest corner of sec. 7, T. 129 N., R. 37 W.

Ap—0 to 6 inches, very dark gray (10YR 3/1) loam; weak, fine, granular structure; friable; common roots; about 5 percent coarse fragments; neutral; abrupt, smooth boundary.

A2—6 to 11 inches, grayish-brown (10YR 5/2) sandy loam; weak, thin, platy structure parting to weak, fine, subangular blocky; friable; common roots; about 5 percent coarse fragments; neutral; clear, irregular boundary.

B21t—11 to 18 inches, brown (10YR 4/3) sandy clay loam; moderate, medium, subangular blocky structure; friable; many, medium, grayish-brown (10YR 5/2), porous coatings on faces of peds; few, thin, dark grayish-brown (10YR 4/2) clay films on faces of peds; common roots; slightly acid; about 5 percent coarse fragments; abrupt, wavy boundary.

B22t—18 to 25 inches, olive-brown (2.5Y 4/4) clay loam; few, fine, distinct, yellowish-brown (10YR 5/6) and light brownish-gray (10YR 6/2) mottles; strong, medium and coarse, subangular blocky structure; firm, sticky; many, thick, very dark grayish-brown (10YR 3/2) clay films on faces of peds; common roots; about 5 percent coarse fragments; slightly acid; gradual, wavy boundary.

B3t—25 to 34 inches, light olive-brown (2.5Y 5/4) sandy clay loam; common, fine, distinct, yellowish-brown (10YR 5/6) and grayish-brown (2.5Y 5/2) mottles; weak, medium, subangular blocky structure; friable, sticky; common very dark brown (10YR 2/2) clay films along old root channels; neutral; abrupt, wavy boundary.

C—34 to 60 inches, light olive-brown (2.5Y 5/4) loam; few, fine, faint, light olive-brown (2.5Y 5/6) mottles; weak, fine, subangular blocky structure; few black concretions; friable; mildly alkaline; strongly effervescent.

The A1 or Ap horizon is very dark gray or dark gray in color. Its texture typically is loam but is silt loam or sandy loam in some areas. The A2 horizon is 4 to 8 inches thick. Its

color ranges from dark grayish brown to light brownish gray. The B horizon ranges from loam or sandy clay loam to clay loam in texture. Content of clay ranges from 20 to 35 percent, and the B22t horizon commonly has the most clay. The color of the interiors of peds ranges from brown to yellowish brown or light olive brown. Clay films are thin to thick and few to many. The C horizon is sandy loam or loam.

Beltrami soils are associated with Nebish and Shooker soils. Beltrami soils are more poorly drained than Nebish soils and are better drained than Shooker soils. They contain mottles in the B horizon, but Nebish soils lack mottles in that horizon. They have browner colors in the B horizon than Shooker soils.

Beltrami loam, 1 to 3 percent slopes (BmA).—This soil is nearly level. It is in areas that are irregularly shaped and variable in size. The areas are on till plains and morainic uplands. Some of the areas are 40 acres or more in size.

Included in mapping were small areas of well-drained Nebish soils or poorly drained Shooker soils. In some places there are small, shallow, wet depressions. A surface layer of sandy loam occurs in some areas and there are stones on the surface in some places.

This soil is used for cultivated crops, pasture, and trees. It is well suited to all crops commonly grown in the county and to production of timber. Most wooded areas are grazed or are used as unmanaged woodland. There are few limitations to use of this soil. If the organic-matter content, fertility, and tilth are maintained and if erosion is controlled, this soil can be cropped intensively. (Capability unit I–1; woodland suitability group 1)

Brophy Series

The Brophy series consists of very poorly drained, organic soils. These soils are in undrained marshes. They formed in dead plant tissues derived from hypnum mosses and herbaceous plants.

In a representative profile, the surface layer is black and dark-gray peat about 6 inches thick. The middle layer is dark-brown peat about 32 inches thick. The underlying layer is very dark grayish-brown mucky peat.

Brophy soils have low natural fertility, very high available water capacity, and variable permeability. Reaction of the surface layer is neutral.

Brophy soils are used for wildlife habitat, pasture, and wild hay.

Representative profile of Brophy peat, 200 feet north and 310 feet west of the southeast corner, SE¼ sec. 1, T. 130 N., R. 38 W.

Oe1—0 to 6 inches, layered black (10YR 2/1, broken face) and dark-gray (10YR 4/1, broken face) hemic material, very dark gray (10YR 3/1) to dark grayish brown (10YR 4/2, rubbed); about 50 percent fiber, about 20 percent rubbed; massive; nonsticky; mixed herbaceous and hypnum fibers; trace of snail shells in lower part; about 70 percent mineral material; violently effervescent; neutral; clear, smooth boundary.

Oi—6 to 38 inches, dark-brown (7.5YR 3/2 and 10YR 3/3, broken face) fibric material, dark yellowish brown (10YR 3/4, rubbed and pressed); about 80 percent fiber, about 50 percent rubbed; massive; nonsticky; about 70 percent hypnum moss fibers, but some minor strata contain as little as 30 percent to as much as 90 percent hypnum moss fibers; the remainder are herbaceous; few, minor, more decomposed and less decomposed strata; few snail shells in parts; about 40 percent mineral material, but some minor strata contain as little as 15 percent to as much as 50 percent; slightly effervescent in some parts to strongly effervescent in other parts; neutral; clear, smooth boundary.

Oe2—38 to 57 inches, very dark grayish-brown (10YR 3/2, broken face) hemic material, dark brown (10YR 3/3, rubbed and pressed); about 50 percent fiber, about 35 percent rubbed; massive; nonsticky; mostly herbaceous fibers, remainder are hypnum moss; trace of snail shells; about 40 percent mineral material; slightly effervescent; neutral; clear, smooth boundary.

Oe3—57 to 112 inches, hemic material that has very dark grayish-brown (10YR 3/2) fibers and black (10YR 2/1) matrix, black (10YR 2/1) to very dark brown (10YR 2/2, rubbed); about 60 percent fiber, about 40 percent rubbed; massive; nonsticky; mostly herbaceous fibers; remainder are hypnum moss; trace of snail shells; about 15 percent mineral material; slightly effervescent; neutral.

The organic soil material is more than 51 inches thick and is commonly underlain by limnic sediment at a depth of 10 feet or less. A mineral substratum, variable in texture, underlies the limnic sediment commonly at a depth of less than 25 feet. Not more than the upper 12 inches consists of either hemic or fibric material or a combination of the two. The fibric material (Oi horizon) extends to a depth ranging from 25 to 40 inches. This material terminates in hemic material. Reaction in the organic material ranges from neutral to mildly alkaline.

Brophy soils differ from the Carlos and Millerville soils in having fibric material more than 13 inches thick at a depth between 12 and 35 inches.

Brophy peat (Bp).—This soil is nearly level. It occurs in large, wet drainageways and depressions that were formerly lakes.

Included in mapping were small areas that are noncalcareous.

This soil is undrained and is covered with bog birch, reeds, sedges, rushes, and in some small areas, tamaracks. It provides some food and cover for furbearers and upland game. A few small areas are used for production of wild hay. (Capability unit IVw–2; woodland suitability group 8)

Carlos Series

The Carlos series consists of very poorly drained, organic soils. These soils formed mainly in dead plant tissue derived from sedges, rushes, cattails, and grasses intermingled with layers of marl. They are in sloughs, potholes, drainageways, and flats.

In a representative profile, the surface layer is very dark gray muck about 6 inches thick. The next layer is gray and grayish-brown marl about 6 inches thick. The underlying layer is very dark grayish-brown, strongly effervescent mucky peat.

Carlos soils have low natural fertility, very high available water capacity, and high organic-matter content. Reaction of the surface layer is neutral.

Most areas of Carlos soils are undrained and are used for pasture and wildlife habitat.

Representative profile of Carlos muck, in a marsh 210 feet east and 120 feet north of the southwest corner, SW¼ sec. 31, T. 130 N., R. 36 W.

Oa—0 to 6 inches, very dark gray (10YR 3/1, broken face and rubbed) sapric material; about 15 percent fiber, 5 percent rubbed; massive; nonsticky; herbaceous fibers; few snail shells; about 50 percent mineral material; violently effervescent; neutral; clear, smooth boundary.

Lca—6 to 12 inches, gray (10YR 5/1) and grayish-brown (10YR 5/2, broken face and rubbed) marl; massive; nonsticky; about 70 percent mineral material; few thin sapric layers in lower part; few snail shells; about 10 percent plant detritus; violently effervescent; neutral; clear, smooth boundary.

Oe—12 to 60 inches, very dark grayish-brown (10YR 3/2, broken face and rubbed) hemic material; about 40 percent fibers, about 15 percent mineral material; trace of snail shells; strongly effervescent; neutral.

The thickness of the organic deposits is more than 51 inches. Reaction is neutral to mildly alkaline. The color of the surface layer is variable, depending on the stage of decomposition and the amount of marl. It ranges from black to dark gray. The color of the hemic material (Oe horizon) ranges from very dark grayish brown or dark brown to grayish brown or brown. Some soils have layers of fibric (Oi horizon) or sapric (Oa horizon) material at depths between 12 and 51 inches, but neither material has an aggregate thickness of more than 10 inches. Layers of marl make up 2 to 24 inches of the total thickness of the soil at depths above 51 inches.

Carlos soils differ from Millerville soils in that they have a marl layer and are calcareous. They differ from the similar Brophy soils in that they have hemic material more than 13 inches thick at depths between 21 and 35 inches.

Carlos muck (Ca).—This soil is nearly level. It is in large, wet, flat drainageways and large potholes.

Included in mapping were small areas that are noncalcareous.

Most of this soil is undrained and is covered with reeds, sedges, rushes, willows, and small areas of tamarack. This soil provides some food and cover for furbearers and upland game. Parts of a few areas are used for production of wild hay. (Capability unit IVw–2; woodland suitability group 8)

Cathro Series

The Cathro series consists of very poorly drained, organic soils. These soils formed in dead plant tissue derived from sedges, rushes, cattails, and grasses over a loamy mineral substratum that begins at a depth of 16 to 51 inches. They are in sloughs and depressions.

In a representative profile, the surface layer is black muck about 9 inches thick. The next layer is muck about 32 inches thick. The upper part is very dark brown, and the lower part is black. The underlying material is black mucky silt loam and dark-gray silt loam.

Cathro soils have low natural fertility and very high available water capacity. Reaction of the surface layer is neutral.

Cathro soils are used for hay, pasture, and crops.

Representative profile of Cathro muck, 1,312 feet south and 408 feet east of the northwest corner, NW¼ sec. 24, T. 127 N., R. 36 W.

Oa1—0 to 9 inches, black (10YR 2/1, rubbed) sapric material; less than 5 percent fiber rubbed; weak, very fine, granular structure; nonsticky; neutral; clear, smooth boundary.

Oa2—9 to 16 inches, very dark brown (10YR 2/2, rubbed) sapric material; 5 to 10 percent fiber; massive; nonsticky; few thin hemic layers; neutral; clear, smooth boundary.

Oa3—16 to 41 inches, black (10YR 2/1, rubbed) sapric material; less than 5 percent fiber; massive; nonsticky; neutral; abrupt, smooth boundary.

IIA1b—41 to 48 inches, black (10YR 2/1) mucky silt loam; about 85 percent mineral material; massive; friable; neutral; diffuse, wavy boundary.

IICg—48 to 60 inches, dark-gray (5Y 4/1) silt loam; massive; friable; mildly alkaline; strongly effervescent.

Depth to the underlying mineral material ranges from 16 to 51 inches. The sapric material typically is black in color but ranges to very dark gray, very dark brown, or very dark grayish brown. Some places contain layers of hemic material, but the total thickness of this material is less than 10 inches. The underlying mineral material is loam, silt loam, sandy loam, clay loam, or light silty clay loam. Reaction in this material ranges from neutral to mildly alkaline.

Cathro soils differ from the similar Seelyeville soils in being underlain by loamy material within a depth of 51 inches. They differ from Cathro muck, sandy subsoil variant, in being underlain by loamy material rather than by gravelly sand. They differ from the similar Rifle series in being shallower to a mineral substratum.

Cathro muck (Cc).—This soil is nearly level. It occupies depressions, potholes, and drainageways. The areas vary in size and shape. All soil areas are flooded in spring, and most areas are flooded or wet throughout the year.

Included in mapping were small areas of the Seelyeville soils and Cathro muck, sandy subsoil variant. Also included were small areas that are calcareous and a few areas where the organic material is less decomposed than typical.

Most areas of this soil are undrained and are covered with marsh vegetation that consists of sedges, rushes, reeds, and, in some areas, willows. These areas are well suited to wildlife habitat. They provide some food and cover for furbearers and upland game. If drained, this soil is used for hay or pasture, and a few areas are cropped. If adequately drained, this soil is suited to all crops commonly grown in the county, but small grains often lodge and corn and soybeans may not reach maturity. Soil blowing is a hazard on bare fields. (Capability unit IVw–2; woodland suitability group 8)

Cathro Series, Sandy Subsoil Variant

The Cathro series, sandy subsoil variant, consists of dark-colored, very poorly drained, nearly level, organic soils. These soils formed in dead plant tissue derived from sedges, rushes, cattails, and grasses over a loamy and sandy mineral substratum that begins at a depth of 16 to 51 inches. They are in sloughs and potholes.

In a representative profile, the surface layer is black muck about 20 inches thick. This is underlain by the mineral substratum. The upper part is dark-gray, strongly effervescent silty clay loam. The lower part, beginning at a depth of about 46 inches, is olive and olive-brown, strongly effervescent gravelly sand.

Cathro soils, sandy subsoil variant, have low natural fertility, high available water capacity, and high organic-matter content. Reaction of the surface layer is neutral.

Cathro soils, sandy subsoil variant, are used for hay, pasture, and crops.

Representative profile of Cathro muck, sandy subsoil variant, 2,700 feet north and 95 feet east of the southwest corner, SW¼ sec. 9, T. 129 N., R. 36 W.

Oa1—0 to 8 inches, black (10YR 2/1, broken face and rubbed) sapric material; 10 percent fiber, 2 percent rubbed; weak, very fine, granular structure; nonsticky; primarily herbaceous fiber; neutral; abrupt, smooth boundary.

Oa2—8 to 20 inches, black (N 2/0, broken face and rubbed) sapric material; less than 5 percent rubbed fiber; few, medium, distinct, dark-brown (7.5YR 3/2) mottles; weak, fine, granular structure; nonsticky; primarily herbaceous fiber; neutral; clear, smooth boundary.

IIA1b—20 to 22 inches, black (N 2/0) silt loam; few, medium, distinct, dark-brown (7.5YR 3/2) mottles; massive; friable; strongly effervescent; mildly alkaline; abrupt, smooth boundary.

IIC1g—22 to 46 inches, dark-gray (5Y 4/1) silty clay loam; few, fine, distinct, light olive-brown (2.5Y 5/6) mottles; massive; friable; strongly effervescent; mildly alkaline; abrupt, smooth boundary.

IIIC2—46 to 60 inches, olive (5Y 5/4) and olive-brown (2.5Y 4/4) gravelly coarse sand; single grain; loose; mildly alkaline; strongly effervescent.

Depth to the underlying sandy or gravelly material ranges from 16 to 51 inches. There is a finer textured layer, 6 to 30 inches thick, between the organic soil material and the sandy or gravelly material. The sapric material is black, very dark gray, very dark brown, very dark grayish brown, or dark brown. It has weak, granular structure or is massive. There are thin layers of hemic material in some places, but their total thickness is less than 10 inches. The IIC1g horizon is sandy loam, loam, silt loam, clay loam, or silty clay loam. The IIIC2 horizon is sand, coarse sand, or gravelly coarse sand.

Cathro soils, sandy subsoil variant, differ from the similar Cathro and Seelyeville soils in having a coarse-textured IIIC horizon beginning at a depth above 51 inches.

Cathro muck, sandy subsoil variant (Ch).—This soil occupies depressions, potholes, and drainageways. The areas vary in size and shape. All soil areas are flooded in spring, and most areas are flooded or wet throughout the year.

Included in mapping were small areas of Cathro and Seelyeville soils. Also included were small areas that are calcareous.

Most areas of this soil are undrained and are covered with marsh vegetation that consists of sedges, rushes, reeds, and, in some areas, willows. These areas are well suited as wildlife habitat. They provide some food and cover for furbearers and upland game. If drained, this soil is used for hay or pasture, and a few areas are cropped. If adequately drained, this soil is suited to all crops commonly grown in the county, but small grains often lodge and corn and soybeans may not reach maturity. Soil blowing is a hazard on bare fields. (Capability unit IVw–2; woodland suitability group 8)

Clarion Series

The Clarion series consists of deep, well-drained soils on uplands. These soils are undulating to rolling. They formed under grasses in calcareous glacial till.

In a representative profile, the surface layer is black loam about 8 inches thick. The subsoil is friable, brown loam about 14 inches thick. The underlying material is strongly effervescent, light olive-brown loam.

Clarion soils have high natural fertility, high available water capacity, and high organic-matter content. Permeability is moderate. Reaction of the surface layer is neutral.

If adequate amounts of fertilizer are used and if erosion control measures are applied, Clarion soils are well suited to all crops commonly grown in the county.

Representative profile of Clarion loam, 2 to 6 percent slopes, eroded, in a wildlife area where the slope is 4 percent, 1,120 feet north and 84 feet west of the southeast corner of sec. 9, T. 127 N., R. 36 W.

Ap—0 to 8 inches, black (10YR 2/1) loam; weak, fine, granular structure; friable; few bleached sand grains; common roots; about 5 percent coarse fragments; neutral; abrupt, smooth boundary.

B21—8 to 14 inches, brown (10YR 4/3) loam; faces of peds are dark grayish brown (10YR 4/2); weak, medium, prismatic structure parting to weak, medium and coarse, subangular blocky; friable; few roots; about 5 percent coarse fragments; neutral; gradual, wavy boundary.

B22—14 to 22 inches, brown (10YR 4/3) loam; weak, medium, prismatic structure parting to weak, medium, subangular blocky; friable; few dark-colored concretions; about 5 percent coarse fragments; neutral; clear, wavy boundary.

C—22 to 60 inches, light olive-brown (2.5Y 5/4) loam; weak, fine, subangular blocky structure; friable; few dark-colored concretions; common, fine, light-gray (10YR 7/1) limy segregations; about 5 percent coarse fragments; mildly alkaline; strongly effervescent.

The A horizon is black or very dark brown and ranges from 6 to 10 inches in thickness. It is typically loam, but in places it is clay loam or sandy loam. The interiors of the peds in the B horizon range from brown through dark yellowish brown and dark brown in color. The texture typically is loam, but in places it is clay loam. The B horizon ranges from 8 to 16 inches in thickness and from weak to moderate in grade of structure.

The average annual temperature of these soils is a few degrees cooler than the defined range for the series, but this difference does not appreciably alter their usefulness and behavior.

Clarion soils are associated with Flom, Nicollet, and Quam soils. Clarion soils are better drained and have browner colors in all horizons than those associated soils. In contrast to Clarion soils, Flom and Quam soils occur in draws and depressions.

Clarion loam, 2 to 6 percent slopes, eroded (ClB2).—This undulating soil occurs on the till plains in upland areas. The soil areas vary in size and shape. Slopes range in length from 50 to 250 feet and are mainly convex in shape. This soil has the profile described as representative for the series. This soil is moderately eroded and has a plow layer that consists of the original surface layer mixed with some material from the subsoil.

Included in mapping were small areas of Flom, Nicollet, and Waukon soils. Also included were areas of Quam soils in small depressions, small areas that have a surface layer of sandy loam, areas of less sloping soils, and areas of more strongly sloping soils. Other inclusions were areas that are only slightly eroded.

This soil is suited to all crops commonly grown in the county. A few small areas are used for pasture. Water runs off this soil at a medium rate, and the hazard of further erosion is moderate.

The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IIe–1; woodland suitability group 1)

Clarion loam, 6 to 12 percent slopes, eroded (ClC2).—This soil is rolling. It occurs on the till plains in upland areas. The soil areas vary in size and shape. The slopes are complex, are mainly convex in shape, and are 50 to 250 feet long. In places along some of the drainageways and around some of the sloughs, slopes are more uniform. In most places the profile differs from the one described as representative for the series in being shallower. This soil is moderately eroded and has a plow layer that consists of the original surface layer mixed with some material from the subsoil.

Included in mapping were small areas of somewhat excessively drained Langhei soils, moderately well

drained Nicollet soils, and poorly drained Flom soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, and areas of gravelly soils. Other inclusions were a few slightly eroded areas.

Nearly all of this soil is used for cultivated crops. A few areas are in pasture. This soil is suited to all crops commonly grown in the county. Water runs off this soil at a medium to rapid rate, and the hazard of erosion is moderate.

The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IIIe–1; woodland suitability group 1)

Clontarf Series

The Clontarf series consists of very deep, moderately well drained, nearly level soils. These soils formed under grasses in calcareous sand. They are on outwash plains and terraces.

In a representative profile, the surface layer is black sandy loam about 11 inches thick. The subsoil is very friable and loose and about 11 inches thick. The upper part is very dark grayish-brown light sandy loam, and the lower part is dark-brown loamy sand. The underlying material is yellowish-brown, dark yellowish-brown, dark grayish-brown, dark-brown, and very dark grayish-brown sand.

Clontarf soils have medium natural fertility and organic-matter content and low available water capacity. Reaction in the surface layer is slightly acid. Permeability is moderately rapid above the sand and rapid in the sand. These soils are droughty.

All crops can be grown, but small grains that mature early and have a low requirement for water are better suited.

Representative profile of Clontarf sandy loam, 0 to 2 percent slopes, in a cultivated field where the slope is 1 percent, 424 feet north and 195 feet west of the southeast corner, NE¼NE¼ sec. 11, T. 127 N., R. 37 W.

Ap—0 to 7 inches, black (10YR 2/1) sandy loam; weak, fine, granular structure; very friable; few bleached sand grains; slightly acid; clear, smooth boundary.

A1—7 to 11 inches, black (10YR 2/1) sandy loam; weak, fine, granular structure; very friable; few bleached sand grains; slightly acid; gradual, smooth boundary.

B21—11 to 17 inches, very dark grayish-brown (10YR 3/2) light sandy loam; few, faint, dark yellowish-brown (10YR 3/4) mottles; weak, fine and medium, subangular blocky structure parting to weak, fine, granular; very friable; few bleached sand grains; slightly acid; gradual, smooth boundary.

B22—17 to 22 inches, dark-brown (10YR 3/3) loamy sand; few, fine, faint, dark-brown (7.5YR 3/3) mottles; very weak, fine and medium, subangular blocky structure; loose; neutral; clear, smooth boundary.

IIC1—22 to 35 inches, mixed very dark grayish-brown (10YR 3/2), dark grayish-brown (10YR 4/2), and dark-brown (10YR 3/3) sand; single grain; loose; neutral; gradual, smooth boundary.

IIC2—35 to 42 inches, dark yellowish-brown (10YR 4/4) and yellowish-brown (10YR 5/4) sand; single grain; loose; neutral; gradual, smooth boundary.

IIC3—42 to 60 inches, yellowish-brown (10YR 5/4) sand; many, medium and coarse, distinct, dark reddish-brown (2.5YR 3/4) mottles; single grain; loose, mildly alkaline.

The A horizon is black or very dark brown loam or sandy loam. It ranges from 8 to 12 inches thick. Reaction is neutral to slightly acid. The B horizon is very dark grayish brown to grayish brown or olive brown to light olive brown or dark brown in color. The B21 horizon is sandy loam or loam, and the B22 horizon is loamy sand or sandy loam. The C horizon is fine sand or sand.

Clontarf soils are associated with Arveson, Dassel, and Sverdrup soils. Clontarf soils are more poorly drained and have a thicker A horizon than Sverdrup soils. They are better drained and have browner colors below the A horizon than Arveson and Dassel soils.

Clontarf sandy loam, 0 to 2 percent slopes (CmA).—This soil occurs in outwash areas. The areas vary in size and shape. Some are large, and some are narrow and elongated.

Included in mapping were small areas of Sverdrup soils and Dassel soils. Also included were a few moderately eroded areas and a few areas that have a surface layer and subsoil of loamy sand and are shallower to sand than is typical.

Nearly all of this soil is used for cultivated crops. A few areas are used for pasture. This soil is suited to all crops commonly grown in the county, but is better suited to early maturing crops because of the drought hazard. Soil blowing is a hazard on unprotected fields during winter and spring. This soil is suited to irrigation, and field crops and vegetables can be irrigated.

The main management needs are practices that control erosion, improve fertility, and conserve moisture. (Capability unit IIIe–4; woodland suitability group 6)

Colvin Series

The Colvin series consists of poorly drained, nearly level soils. These soils formed under grasses in calcareous, silty material.

In a representative profile, the surface layer is silt loam about 18 inches thick. The upper 12 inches is black, and the lower 6 inches is very dark gray. The underlying material is mottled silt loam. The upper part is dark gray, the middle part is gray, and the lower part is olive gray.

Colvin soils have medium natural fertility, very high available water capacity, and high organic-matter content. Reaction in the surface layer is mildly alkaline. Permeability is moderate to moderately slow.

If they receive good management, corrective fertilization, and adequate drainage, these soils are suited to all crops commonly grown in the county.

Representative profile of Colvin silt loam, in a cultivated field where the slope is nearly level, 1,075 feet south and 102 feet east of the northwest corner of sec. 33, T. 127 N., R. 36 W.

Ap—0 to 7 inches, black (10YR 2/1) silt loam; weak, very fine, granular structure; friable; many roots; strongly effervescent; mildly alkaline; abrupt, smooth boundary.

A1—7 to 12 inches, black (10YR 2/1) silt loam; few inclusions of very dark gray (10YR 3/1); weak, very fine, granular structure; friable; common roots; strongly effervescent; mildly alkaline; abrupt, irregular boundary.

A3ca—12 to 18 inches, very dark gray (10YR 3/1) silt loam; weak, very fine, granular structure; friable; common roots; strongly effervescent; mildly alkaline; gradual, wavy boundary.

C1cag—18 to 23 inches, dark-gray (2.5Y 4/1) silt loam; few, fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, very fine, subangular blocky structure; friable; few roots, strongly effervescent; mildly alkaline; clear, wavy boundary.

C2g—23 to 30 inches, gray (5Y 5/1) silt loam; weak, very fine, subangular blocky structure; friable; few roots; strongly effervescent; mildly alkaline; clear, wavy boundary.

C3g—30 to 36 inches, olive-gray (5Y 5/2) silt loam; few, fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, very fine, subangular blocky structure; friable; few, fine, light-gray (10YR 7/1) limy segregations; few roots; strongly effervescent; mildly alkaline; gradual, wavy boundary.

C4g—36 to 60 inches, olive-gray (5Y 5/2) silt loam; many, medium, prominent, brown (7.5YR 4/4) mottles; weak, very fine, subangular blocky structure; friable; common, medium, distinct, light-gray (10YR 7/1) limy segregations; strongly effervescent; mildly alkaline.

The A horizon is black or very dark gray. It is silt loam or silty clay loam in texture and ranges from 10 to 20 inches in thickness. The C horizon is silt loam or silty clay loam.

Colvin soils are associated with Hantho soils. They are more poorly drained than Hantho soils and contain lime in the A horizon.

Colvin silt loam (Co).—This soil is nearly level. The areas are irregular in size and shape. Some areas are broad flats, and some are elongated waterways. This soil has the profile described as representative for the series.

Included in mapping were small areas of Colvin silt loam, depressional, and of Hantho soils. Also included were areas where there are pebbles and stones on the surface and glacial till or sand is at a depth of less than 40 inches.

This poorly drained soil requires additional drainage. The water table fluctuates between a depth of 2 and 5 feet. This soil can be drained by open ditches or tile. If adequately drained, this soil is suited to all the crops commonly grown in the county.

The main management needs are improving drainage, controlling soil blowing, and improving fertility and tilth. (Capability unit IIw–3; woodland suitability group 5)

Colvin silt loam, depressional (Cp).—This nearly level soil occupies depressions and drainageways in the lacustrine areas of the county. It is flooded in spring and often throughout the year. The profile differs from the profile described as representative for the series in having a thicker dark-colored surface layer and in being very poorly drained.

Included in mapping were small areas of Colvin soils. Some areas differ in having a mucky surface layer.

If undrained, the soil is covered with marsh vegetation consisting of sedges, reeds, rushes, or willows. The undrained areas are well suited as wildlife habitat. They provide food, cover, and nesting for waterfowl, furbearers, and upland game. Many of these areas can be improved for wildlife by exposing open water or by creating additional open water.

If drained, this soil is used for crops, pasture, and hay, depending on the kind of drainage system installed. If adequately drained, this soil is suited to all crops commonly grown in the county. Small grains tend to lodge, and corn and soybeans may not reach maturity every year. This soil may be drained by open ditches or tile.

The main management needs are drainage and maintenance of fertility and tilth. (Capability unit IIIw–1, woodland suitability group 5)

Darnen Series

The Darnen series consists of deep, nearly level to gently sloping, moderately well drained to well drained soils. These soils formed under grasses in colluvial material at the bottoms of steep slopes and on fans at the ends of drainageways.

In a representative profile, the surface layer is black loam about 30 inches thick. The subsoil is loam about 16 inches thick. The upper part is black mixed with dark yellowish brown, and the lower part is very dark grayish brown and dark grayish brown. The underlying material is olive-brown and light olive-brown loam.

Darnen soils have high natural fertility, high organic-matter content, and high to very high available water capacity. Reaction of the surface layer is neutral. Permeability is moderate.

Darnen soils are free of stones, are easy to work, and are well suited to crops.

Representative profile of Darnen loam, 1 to 4 percent slopes, in a pasture where the slope is 2 percent, 1,340 feet east and 60 feet north of the southwest corner of sec. 7, T. 127 N., R. 40 W.

A11—0 to 8 inches, black (10YR 2/1) loam; weak, very fine and fine, granular structure; very friable; common roots; few bleached sand grains; neutral; abrupt, smooth boundary.

A12—8 to 19 inches, black (10YR 2/1) loam; weak, very fine, granular structure; very friable; few bleached sand grains; neutral; gradual, smooth boundary.

A13—19 to 30 inches, black (10YR 2/1) loam; few spots of dark yellowish brown (10YR 4/4); weak, fine, granular structure; very friable; few bleached sand grains; neutral; clear, smooth boundary.

B21—30 to 42 inches, loam that is black (10YR 2/1) mixed with dark yellowish-brown (10YR 4/4); weak, fine and medium, granular structure; friable; few bleached sand grains; neutral; clear, smooth boundary.

B22—42 to 46 inches, very dark grayish-brown (10YR 3/2) and dark grayish-brown (10YR 4/2) loam; weak, fine, subangular blocky structure parting to weak, fine, granular; friable; slightly effervescent; mildly alkaline; clear, smooth boundary.

C1—46 to 55 inches, olive-brown (2.5Y 4/4) loam; massive; friable; strongly effervescent; mildly alkaline; gradual, smooth boundary.

C2—55 to 68 inches, light olive-brown (2.5Y 5/6) loam; massive; friable; few, small, prominent limy segregations; strongly effervescent; mildly alkaline.

The A horizon is 18 to 48 inches thick and is loam or silt loam. The B horizon is loam, silt loam, or light clay loam and ranges from 10 to 20 inches in thickness. The structure is weak, granular or subangular blocky.

Darnen soils are associated with Barnes and Waukon soils. They differ from these soils in having a thicker A horizon.

Darnen loam, 1 to 4 percent slopes (DaA).—This soil occurs as long, narrow strips along the base of the stronger slopes. In places it is delta-shaped at the mouth of waterways in the morainic upland areas.

Included in mapping were small areas of Barnes, Aastad, and Flom soils. In some places the black surface layer is thicker than normal, and in others it is silt loam.

Most areas of this soil are in permanent pasture, because this soil is associated with more strongly sloping soils. Most of the areas are small and are farmed along with the adjacent soils. This soil is suited to all the crops commonly grown in the county.

The main management need is control of erosion in the larger areas. (Capability unit I–1; woodland suitability group 1)

Dassel Series

The Dassel series consists of nearly level, poorly drained and very poorly drained soils underlain by calcareous sand. These soils occur in shallow potholes and drainageways. They formed under grasses and scattered clumps of willows and brush on outwash plains and in upland areas of the county.

In a representative profile, the surface layer is black sandy loam about 8 inches thick. The subsoil is about 17 inches thick. The upper part is mottled, dark grayish-brown sandy loam, the middle part is mottled, grayish-brown loamy sand; and the lower part is mottled, olive-gray loam. The underlying material is mottled, grayish-brown, brown, and light brownish-gray sand.

Dassel soils have low natural fertility, low available water capacity, and medium organic-matter content. Reaction of the surface layer is slightly acid. Permeability is moderately rapid above the sand and rapid in the sand.

If adequately drained, this soil is suited to all crops commonly grown in the county.

Representative profile of Dassel sandy loam, 120 feet south and 1,340 feet east of the northwest corner, NW¼ sec. 12, T. 127 N., R. 37 W.

Ap—0 to 8 inches, black (10YR 2/1) sandy loam; weak, very fine and fine, granular structure; very friable; slightly acid; abrupt, smooth boundary.

B21—8 to 19 inches, dark grayish-brown (2.5Y 4/2) sandy loam; common, fine and medium, prominent, dark-brown (7.5YR 3/2) and brown 7.5YR 4/4) mottles; weak, fine and medium, subangular blocky structure; very friable; few black concretions; slightly acid; gradual, wavy boundary.

B22—19 to 23 inches, grayish-brown (2.5Y 5/2) loamy sand; common, fine, prominent, brown (7.5YR 4/4) mottles; massive; very friable; slightly acid; clear, wavy boundary.

IIB23—23 to 25 inches, olive-gray (5Y 5/2) loam; common, fine, prominent, brown (7.5YR 4/4) mottles; massive; friable; medium acid; abrupt, wavy boundary.

IIIC1—25 to 28 inches, grayish-brown (2.5Y 5/2) and brown (7.5YR 4/4) sand; single grain; loose; neutral; gradual, wavy boundary.

IIIC2—28 to 50 inches, grayish-brown (2.5Y 5/2) sand; few, fine, distinct, yellowish-brown (10YR 5/6) mottles; single grain; loose; neutral; abrupt, wavy boundary.

IIIC3—50 to 60 inches, light brownish-gray (2.5Y 6/2) sand; single grain; loose; slightly effervescent; mildly alkaline.

The A horizon is loam or sandy loam 6 to 12 inches thick. The B horizon ranges from olive to olive gray, from dark grayish brown to light brownish gray, or from olive brown to light olive brown. It is stratified, and the finer textured parts are loam, sandy loam, or sandy clay loam. The IIIC horizon is mostly sand, but there are strata of fine sand in some areas. Depth to free carbonates ranges from 40 to 60 inches.

The annual temperature of these soils is a few degrees cooler than the defined range for the series, but this difference does not alter their usefulness and behavior.

Dassel soils are associated with Sverdrup, Arveson, and Clontarf soils. They are more poorly drained and have a grayer B horizon than Clontarf and Sverdrup soils. Dassel soils lack free carbonates in the A horizon, but Arveson soils contain free carbonates in that horizon.

Dassel sandy loam (Dd).—This soil is nearly level. It is in drainageways and other areas on the outwash plains. Some areas are fairly large and are variable in shape, but the drainageways are generally 50 to 200 feet wide. This soil has the profile described as representative for the series.

Included in mapping were small bodies of Arveson and Clontarf soils. Also included were small calcareous spots, areas where loam till occurs within a depth of 40 inches, and a few places where the surface layer is loam.

Depth to the water table ranges from 3 to 4 feet. Soil blowing is a hazard on unprotected fields during winter and spring.

Some areas of this soil have been drained by open ditches. If adequately drained, this soil is used for all the crops commonly grown in the county. Some areas are used for pasture. This soil is less suited to crops during dry spells that cause drought.

The main management needs are drainage, control of erosion, and maintenance of fertility. (Capability unit IVw–1; woodland suitability group 3)

Dassel sandy loam, depressional (De).—This soil is nearly level. It occurs in enclosed circular depressions on outwash plains. This soil differs from the one described as representative for the series in being very poorly drained.

Included in mapping were small areas of Dassel sandy loam and some areas where the surface layer is calcareous.

If undrained, this soil is generally covered with vegetation consisting of reeds, sedges, and rushes. These undrained areas are well suited as wildlife habitat. They provide nesting, mating, and escape cover for waterfowl, furbearers, and upland game. If drained, this soil is used for hay, pasture, or crops. If adequately drained, it is suited to all crops commonly grown in the county.

The main management needs are drainage and maintenance of fertility. (Capability unit IVw–1; woodland suitability group 3)

Dorset Series

The Dorset series consists of somewhat excessively drained and well-drained, nearly level to rolling soils. These soils formed under grasses that were succeeded by deciduous trees. They formed in loamy material and are shallow and moderately deep to calcareous sand and gravel.

In a representative profile, the surface layer is black sandy loam about 8 inches thick. The subsoil is dark brown and about 17 inches thick. The upper part is sandy loam, the middle part is gravelly loamy coarse sand; and the lower part is gravelly coarse sand. The underlying material is brown gravelly coarse sand.

Dorset soils have low to medium natural fertility, low available water capacity, and low to medium organic-matter content in the surface layer. Reaction of the surface layer is slightly acid. Permeability is moderately rapid in the sandy loam material and rapid below.

Gravel pits have been opened on these soils and are a good source of gravel. These soils are droughty and not well suited to crops in most years.

Representative profile of Dorset sandy loam, 0 to 2 percent slopes, in a cultivated field where the slope is 1 percent, 680 feet south and 780 feet west of the northeast corner, SE¼ sec. 27, T. 130 N., R. 36 W.

Ap—0 to 8 inches, black (10YR 2/1) sandy loam, dark gray (10YR 4/1) when dry; weak, fine and medium, granular structure; friable; slightly acid; abrupt, smooth boundary.

B2t—8 to 16 inches, dark-brown (7.5YR 3/4) sandy loam; weak, fine and medium, subangular blocky structure parting to weak, very fine and fine, granular structure; friable; common, thin, porous, grayish coats on faces of peds; few, thin, dark-brown (7.5YR 3/2) clay films on faces of peds in lower part; neutral; clear, wavy boundary.

IIB31t—16 to 19 inches, dark-brown (7.5YR 3/2) gravelly loamy coarse sand; weak, coarse, subangular blocky structure parting to weak, very fine, granular; very friable; few thin clay films on faces of peds and common clay bridges between sand grains; about 35 percent gravel; neutral; clear, wavy boundary.

IIB32t—19 to 25 inches, dark-brown (7.5YR 3/3) gravelly coarse sand; single grain; loose; few thin clay films on sand grains; about 40 percent gravel; neutral; clear, wavy boundary.

IIC—25 to 60 inches, brown (7.5YR 4/2) gravelly coarse sand; single grain; loose; mildly alkaline; strongly effervescent.

The A horizon is black or very dark gray sandy loam or light loam. In some profiles there is a thin, discontinuous A2 horizon that is 1 to 2 inches thick. The B2t horizon is loam or sandy loam 6 to 18 inches thick. Depth to loamy sand or coarser textures ranges from 12 to 26 inches. Depth to the IIC horizon ranges from 18 to 34 inches.

Dorset soils are associated with Sioux soils. They have a thicker solum than Sioux soils. They have a B horizon that has an accumulation of clay, but the Arvilla soils, which are similar, lack that feature.

Dorset sandy loam, 0 to 2 percent slopes (DoA).—This soil is nearly level. It is in outwash areas. The areas are variable in size and shape. This soil has the profile described as representative for the series.

Included in mapping were small areas of Sioux, Osakis, and Forada soils. Also included were small areas of more strongly sloping soils and areas of eroded soils. Also included were a few areas that are underlain by loam till within a depth of 40 inches.

This soil is used for crops, pasture, and woodland. All the crops common in the county can be grown. Early maturing crops are better suited to this soil, since they can make better use of the limited amount of moisture available. Soil blowing is a hazard on fields left unprotected during winter and spring. This soil is suited to irrigation, and field crops and vegetables can be irrigated.

Main management needs are controlling erosion, conserving moisture, and maintaining fertility. (Capability unit IIIe–3; woodland suitability group 6)

Dorset sandy loam, 2 to 6 percent slopes (DoB).—This soil is gently sloping and undulating. It occupies rises in the outwash areas and on uplands. The areas are variable in size and irregular in shape. The slopes are short, ranging from 50 to 200 feet long. There are many narrow drainageways and small depressions scattered throughout the areas. The profile differs from the one described as representative for the series in being thinner.

Included in mapping were a few areas of Sioux, Osakis, and Forada soils. Also included were areas of less sloping soils, areas of more strongly sloping soils, eroded areas, and areas where the surface layer is loam. Also included were a few areas that are underlain by loam till within a depth of 40 inches.

Most areas of this soil are used for crops, but a few are used for pasture or woodland. All the crops common in the county can be grown. Early maturing crops are better suited because of the drought hazard. This soil is suited to irrigation, and field crops and vegetables can be irrigated. Water runs off this soil at a medium rate. The hazard of further erosion is moderate.

The main management needs are controlling erosion, conserving moisture, and maintaining fertility. (Capability unit IIIe–3; woodland suitability group 6)

Dorset sandy loam, 6 to 12 percent slopes (DoC).—This sloping and rolling soil occurs in outwash areas and on uplands parallel to waterways or around sloughs. Slopes are irregular and range from 50 to 200 feet in length. The profile differs from the one described as representative for the series in being more shallow to gravel.

Included in mapping were areas of Sioux soils, areas where the surface layer is loamy sand, and areas that are darker in color. Also included were small areas of less sloping soils, areas of more strongly sloping soils, and some eroded areas.

This soil is used for crops, woodland, and pasture. All the crops common in the county can be grown. Droughtiness is a serious limitation. Water runs off this soil at a medium to rapid rate. The hazard of further erosion is moderately severe.

The main management needs are controlling erosion, conserving moisture, and improving fertility. (Capability unit IVe–2; woodland suitability group 6)

Dorset sandy loam, thick solum, 0 to 2 percent slopes (DpA).—This soil is nearly level. It is in outwash areas. A few of the areas are quite large. The profile of this soil differs from the one described as representative for the series in having a thicker medium-textured subsoil. In addition, the depth to gravelly coarse sand ranges from 22 to 36 inches.

Included in mapping were small areas of more strongly sloping soils and areas of eroded soil. A few areas are underlain by sand. Also included were a few areas that have a loam surface layer and are 32 to 48 inches deep to sand.

Most areas are used for crops. A few areas are used for pasture or woodland. This soil is suited to all the crops commonly grown in the county. This soil has a drought hazard during prolonged dry seasons. Soil blowing is a hazard on unprotected fields during winter and spring.

The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IIe–4; woodland suitability group 6)

Dorset sandy loam, thick solum, 2 to 6 percent slopes (DpB).—This soil is gently sloping. It is in outwash areas. The areas are variable in size and shape. The profile differs from the one described as representative for the series in having a thicker medium-textured subsoil. In addition, the depth to gravelly coarse sand ranges from 22 to 36 inches.

Included in mapping were small areas of less sloping soils and small areas of more strongly sloping soils. A few areas are underlain by sand, and a few are eroded. Also included were a few areas that have a loam surface layer and subsoil and are 32 to 48 inches deep to sand.

Most areas are used for crops. A few areas are used for pasture or woodland. This soil is suited to all crops commonly grown in the county. This soil has a drought hazard during prolonged dry periods. Water runs off at a medium rate, and the hazard of erosion is moderate.

The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IIe–4; woodland suitability group 6)

Dorset sandy loam, thick solum, 6 to 12 percent slopes (DpC).—This soil is rolling and sloping. It is in outwash areas around sloughs and drainageways. The areas are variable in size and shape. The profile differs from the one described as representative for the series in having a thicker, medium-textured subsoil and a depth to gravelly coarse sand of 22 to 36 inches.

Included in mapping were some areas that are eroded, a few small areas of less sloping soils, and a few small areas of more strongly sloping soils. Also included were a few areas that have a loam surface layer and subsoil and are 32 to 48 inches deep to sand.

Most areas are used for crops. A few areas are in pasture or woodland. All crops common in the area can be grown. This soil has a drought hazard during prolonged dry seasons. Water runs off this soil at a medium to rapid rate. The hazard of further erosion is moderately severe.

The main management needs are controlling erosion, conserving moisture, and maintaining fertility and tilth. (Capability unit IIIe–3; woodland suitability group 6)

Dovray Series

The Dovray series consists of very poorly drained, nearly level soils that formed in calcareous silty clay or clay till or lacustrine material. These soils occur in sloughs and potholes and formed under vegetation consisting of marsh grass and cattails.

In a representative profile, the surface layer is black and about 44 inches thick. The upper 7 inches is mucky silty clay, and the lower 37 inches is silty clay. The underlying material is dark-gray to gray, calcareous silty clay that has yellowish-brown and brown mottles.

Dovray soils have medium available water capacity, high natural fertility, and high organic-matter content. Reaction of the surface layer is slightly acid. Permeability is very slow.

Dovray soils have a high content of clay, and proper management is needed to keep them productive and easy to work.

Representative profile of Dovray mucky silty clay, in a drained depression, 650 feet south and 130 feet west of the northeast corner of sec. 25, T. 129 N., R. 40 W.

Ap—0 to 7 inches, black (10YR 2/1) mucky silty clay; moderate, fine, granular structure; friable; many roots; slightly acid; abrupt, smooth boundary.

A11—7 to 15 inches, black (N 2/0) silty clay; weak, thin, platy structure parting to weak, very fine, subangular blocky; slightly sticky; many roots; neutral; gradual, wavy boundary.

A12—15 to 23 inches, black (N 2/0) silty clay; moderate, very fine and fine, subangular blocky structure; sticky; few roots; neutral; gradual, wavy boundary.

A13—23 to 44 inches, black (5Y 2/1) silty clay; few, fine, distinct, light olive-brown (2.5Y 5/6) mottles; moderate, very fine, subangular blocky structure; sticky; few reddish stains along root channels; neutral; clear, wavy boundary.

C1—44 to 48 inches, gray (5Y 5/1) silty clay; common, medium, distinct, yellowish-brown (10YR 5/6) mottles; moderate, very fine, subangular blocky structure; sticky; mildly alkaline; strongly effervescent; clear, wavy boundary.

C2—48 to 60 inches, dark-gray (5Y 4/1) silty clay; many, medium, prominent, brown (7.5YR 4/4) mottles; weak, very fine, subangular blocky structure; sticky; mildly alkaline; strongly effervescent.

The Ap horizon or, if the Ap horizon is lacking, the A11 horizon is commonly mucky silty clay or mucky clay, but in places it is silty clay, clay, or silty clay loam. The rest of the A horizon is silty clay or clay. The A horizon is 24 to 50 inches thick. The C horizon is silty clay or clay, and its color ranges from very dark gray to gray or from dark olive gray to olive gray. Depth to lime ranges from 20 to 50 inches.

Dovray soils are associated with Fulda and Sinai soils. Dovray soils differ from Fulda and Sinai soils in being more poorly drained and in having a thicker A horizon.

Dovray mucky silty clay (Dv).—This soil is nearly level. It is in depressions and potholes. It is flooded in spring and often throughout the entire year.

Included in mapping were some small areas of Fulda and Cathro soils. Also included were some areas of Dovray soil that does not have a mucky surface layer and some areas where the soil is black to a depth of more than 60 inches.

If undrained, this soil is covered with marsh vegetation consisting of reeds, sedges, and rushes. These undrained areas provide excellent food and cover for wildlife. Many of these areas can be improved by digging or blasting level ditches or trenches to provide additional open water.

If drained, this soil is suited to all crops common in the county. It is better suited to corn and soybeans than to small grains, because small grains have a tendency to lodge.

The main management needs are practices that improve drainage and maintain fertility and tilth. (Capability unit IIIw–1; woodland suitability group 4)

Flom Series

The Flom series consists of poorly drained, nearly level soils in shallow depressions, drainageways, swales, and flats. These soils formed under vegetation consisting of prairie and marsh grasses.

In a representative profile, the surface layer is about 17 inches thick (fig. 9). The upper part is black silty clay loam, and the lower part is very dark gray clay loam. The subsoil is dark grayish-brown clay loam about 7 inches thick that has light olive-brown mottles. The underlying material is light olive-gray loam.

Flom soils have a high available water capacity, high natural fertility, and in the surface layer, high organic-matter content. Reaction in the surface layer is neutral. Permeability is moderate.

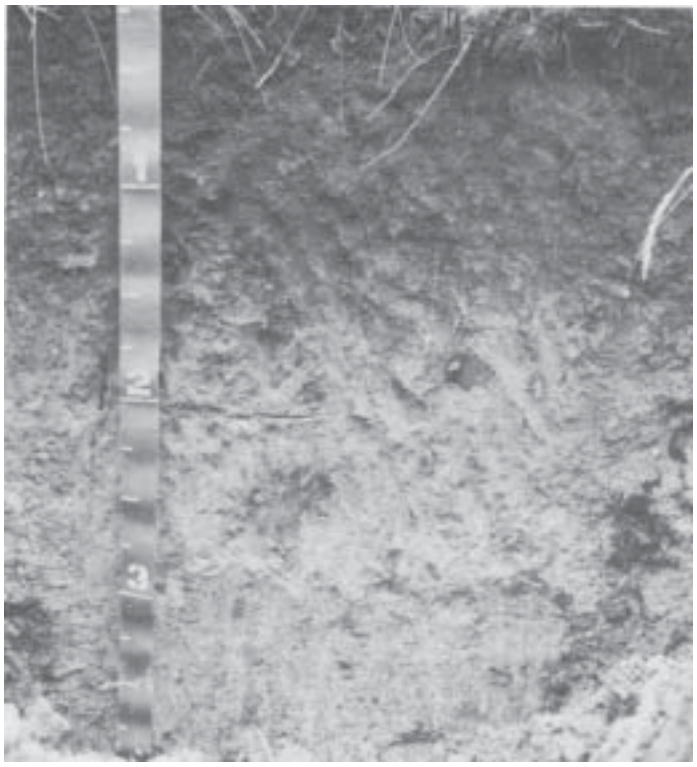

Figure 9.—Typical profile of Flom silty clay loam. The upper 17 inches is the dark-colored surface layer.

If adequately drained, fertilized, and managed, Flom soils are well suited to the crops commonly grown in the county.

Representative profile of Flom silty clay loam, in a wildlife area where the slope is 1 percent, 410 feet east and 55 feet south of the northwest corner, NE¼ sec. 29, T. 129 N., R. 40 W.

Ap—0 to 7 inches, black (N 2/0) silty clay loam that is at the high end of the range in content of sand; cloddy, but parts to weak, medium and coarse, granular structure; friable; neutral; abrupt, smooth boundary.

A1—7 to 13 inches, black (N 2/0) silty clay loam that is at the high end of the range in content of sand; weak, medium and coarse, granular structure; friable; neutral; abrupt, wavy boundary.

A3—13 to 17 inches, very dark gray (10YR 3/1) clay loam; weak, fine, subangular blocky structure; friable; about 4 percent coarse fragments; mildly alkaline; clear, wavy boundary.

B2g—17 to 24 inches, dark grayish-brown (2.5Y 4/2) clay loam; few, fine, distinct, light olive-brown (2.5Y 5/6) mottles; weak, medium, subangular blocky structure; friable; about 4 percent coarse fragments; mildly alkaline; abrupt, wavy boundary.

C1g—24 to 37 inches, light olive-gray (5Y 6/2) loam; few, fine, distinct, light olive-brown (2.5Y 5/6) mottles; weak, fine, subangular blocky structure; friable; about 4 percent coarse fragments; strongly effervescent; mildly alkaline; gradual, wavy boundary.

C2g—37 to 60 inches, light olive-gray (5Y 6/2) loam; many, medium, distinct, light olive-brown (2.5Y 5/6) mottles; weak, fine, subangular blocky structure; friable; about 4 percent coarse fragments; few light-gray (10YR 7/1) lime threads; strongly effervescent; mildy alkaline.

Texture in all of the horizons ranges from loam to silty clay loam. The number, size, color, and distinctness of the mottles are variable and depend on depth to the water table and position of the soil on the landscape. The B horizon ranges from very dark grayish brown to grayish brown. The C horizon is mainly grayish brown, olive gray, light olive gray, and gray. Depth to free lime is variable, ranging from 16 to 36 inches.

Flom soils are associated with Aastad, Barnes, Quam, and Vallers soils. Flom soils are in lower positions than Barnes and Aastad soils, and they have a grayer B horizon than those soils. They differ from the Vallers soils in that their A horizon is not limy. They have a thinner A horizon than Quam soils.

Flom silty clay loam (0 to 3 percent slopes) (Fa).—This soil is in shallow, circular or oblong depressions and in swales and drainageways on the till plains and in morainic upland areas. It is wet after spring runoff or after rain in summer.

Included in mapping were small areas of Vallers, Darnen, and Aastad soils. Also included were areas where the surface layer is thicker than normal and some areas where the surface layer is limy.

This soil is not suited to cultivation unless drained. If adequately drained, it is suited to all the crops commonly grown in the county. Open ditches provide adequate drainage in most years, but a tile system is needed for complete drainage.

The main management needs are drainage and maintenance of fertility and tilth. (Capability unit IIw–1; woodland suitability group 4)

Forada Series

The Forada series consists of nearly level, poorly drained and very poorly drained soils that formed in loamy material underlain by calcareous sand and gravel at a depth of 22 to 40 inches. These soils formed under grass vegetation on nearly level topography in outwash plains and upland areas.

In a representative profile, the surface layer is sandy loam about 16 inches thick. The upper 9 inches is black, and the lower part is very dark gray. The subsoil is about 12 inches thick. The upper part is mottled, dark grayish-brown sandy loam. The lower part is mottled, grayish-brown loam. The underlying material is light brownish-gray and dark grayish-brown coarse sand.

Forada soils have high natural fertility, low to medium available water capacity, and high organic-matter content. Permeability is moderately rapid in the sandy loam material and rapid in the coarse sand.

These soils have a high water table during spring and in wet periods at other times of the year. If this soil is adequately drained, all the common crops can be grown.

Representative profile of Forada sandy loam, in a cultivated field where the slope is 1 percent, 185 feet north of the southwest corner, NE¼ sec. 25, T. 127 N., R. 37 W.

Ap—0 to 9 inches, black (10YR 2/1) sandy loam; weak, very fine. granular structure; friable; neutral; few bleached sand grains; abrupt, smooth boundary.

A3—9 to 16 inches, very dark gray (10YR 3/1) sandy loam; weak, medium, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B1g—16 to 20 inches, dark grayish-brown (2.5Y 4/2) sandy loam; few, fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, fine, subangular blocky structure; friable; neutral; clear, wavy boundary.

B2—20 to 28 inches, grayish-brown (2.5Y 5/2) loam; few, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; weak, fine, subangular blocky structure; friable; slightly acid; abrupt, wavy boundary.

IIC1—28 to 33 inches, light brownish-gray (2.5Y 6/2) coarse sand; many, medium, distinct, yellowish-brown (10YR 5/6) mottles; single grain; loose; few dark-colored concretions; about 5 percent gravel; mildly alkaline; strongly effervescent; clear, wavy boundary.

IIC2—33 to 60 inches, dark grayish-brown (2.5Y 4/2) coarse sand; single grain; loose; slightly effervescent; mildly alkaline.

The A horizon is loam, silt loam, or sandy loam and ranges from 10 to 24 inches in thickness. It is neutral to mildly alkaline. The B horizon is sandy loam or loam, 12 to 20 inches thick, and slightly acid to mildly alkaline. Depth to the IIC1 horizon ranges from 22 to 40 inches. The IIC horizon typically is coarse sand, gravelly coarse sand, or stratified coarse sand and gravel. This horizon is sand in the soil mapped as Forada sandy loam, sandy subsoil.

Forada soils are associated with Arvilla, Osakis, and Dorset soils. They are more poorly drained than those soils, are in lower lying positions, and have a grayer B horizon.

Forada sandy loam (Fd).—This soil is nearly level. It is in outwash areas. The soil areas are irregular in shape and variable in size. Some of the areas are more than 60 acres in size. This soil has the profile described as representative for the series.

Included in mapping were small areas of Forada loam, depressional, and of Osakis soils. Also included were small areas that are more than 40 inches deep to gravel and some that contain sand in the underlying material. In a few areas the surface layer is calcareous.

Drainage is needed before this soil can be cropped successfully each year. It is difficult to maintain a drainage system because the underlying coarse sand tends to cave in. Nearly all of this soil is used for cultivated crops, but the undrained or inadequately drained areas are used for pasture. This soil is suited to all crops commonly grown in the county.

The main management needs are practices that improve drainage, fertility, and tilth. (Capability unit IIw–2; woodland suitability group 3)

Forada loam, depressional (Fe).—This soil occupies depressions and drainageways in outwash areas. The areas generally are circular or oblong in shape. This soil is flooded in spring and often throughout the entire year. The profile differs from the one described as representative for the series in commonly having a black loam surface layer 16 to 24 inches thick. In addition, this soil is very poorly drained.

Included in mapping were small areas of Forada sandy loam and of Marysland loam, depressional. Also included were areas where the surface layer is clay loam, silt loam, or silty clay loam.

If undrained, this soil is generally covered with marsh vegetation consisting of reeds, sedges, rushes, and, in some areas, willows. These undrained areas are well suited to wildlife habitat. They provide nesting, mating, and escape cover for wildlife.

If drained, this soil is used for crops, hay, and pasture. If adequately drained, this soil is suited to all crops commonly grown in the county.

The main management needs are practices that improve drainage, fertility, and tilth. (Capability unit IIIw–2; woodland suitability group 3)

Forada sandy loam, sandy subsoil (Ff).—This soil is nearly level. It occurs in upland drainageways and on outwash plains. The drainageways are 50 to 200 feet wide, and the areas on outwash plains vary in size and shape. The profile differs from the one described as representative for the series in being underlain by sand at a depth of 22 to 40 inches.

Included in mapping were small areas of Dassel, Forada, and Arveson soils and areas where the surface layer is loam.

This soil is used for crops and pasture. It has a fluctuating water table and needs additional drainage. If adequately drained, all crops common in the county can be grown. Soil blowing is a hazard on bare fields during winter and spring.

The main management needs are drainage, control of erosion, and maintenance of fertility. (Capability unit IIw–2; woodland suitability group 3)

Forman Series

The Forman series consists of deep, well-drained, gently sloping to rolling soils that formed in calcareous clay loam glacial till.

In a representative profile, the surface layer is black clay loam about 11 inches thick. The subsoil is dark grayish-brown clay loam about 8 inches thick. The underlying material is olive-gray clay loam.

Forman soils have high natural fertility, medium to high available water capacity, and high organic-matter content. Reaction of the surface layer is neutral. Permeability is moderately slow.

Forman soils are well suited to all crops commonly grown in the county.

Representative profile of Forman clay loam, 6 to 12 percent slopes, eroded, where the slope is 10 percent, 1,290 feet west and 1,040 feet south of the northeast corner, SE¼ sec. 30, T. 129 N., R. 39 W.

Ap—0 to 8 inches, black (10YR 2/1) clay loam; moderate, medium and coarse, granular structure; friable; about 2 percent coarse fragments; neutral; abrupt, smooth boundary.

A1—8 to 11 inches, black (10YR 2/1) clay loam; moderate, fine and medium, granular structure; friable; about 2 percent coarse fragments; neutral; clear, irregular boundary.

B21—11 to 15 inches, dark grayish-brown (10YR 4/2) clay loam; moderate, medium, subangular blocky structure; firm; few black (10YR 2/1) tongues; about 2 percent coarse fragments; neutral; clear, wavy boundary.

B22—15 to 19 inches, dark grayish-brown (2.5Y 4/2) clay loam; moderate, medium, subangular blocky structure; about 2 percent coarse fragments; neutral; abrupt, wavy boundary.

C1—19 to 27 inches, olive-gray (5Y 4/2) clay loam; weak, fine, subangular blocky structure; firm, about 2 percent coarse fragments; strongly effervescent; mildly alkaline; clear, wavy boundary.

C2—27 to 60 inches, olive-gray (5Y 5/2) clay loam; weak, fine, subangular blocky structure; about 2 percent coarse fragments; strongly effervescent; mildly alkaline.

The A horizon is 8 to 14 inches thick. The B horizon is dark grayish brown, grayish brown, brown, or olive brown in color. In some areas it has weak or moderate, prismatic structure that parts to subangular blocky. The B horizon is 6 to 14 inches thick. In some areas there are a few thin clay films on faces of peds.

Forman soils in this county do not have much evidence of translocated clay in their B horizon, and, thus, they are outside the defined range of the series. This difference does not alter their usefulness and behavior.

Forman soils are associated with Barnes and Aastad soils. They are better drained and have a thinner A horizon than Aastad soils. They have a finer textured solum than the similar Barnes soils.

Forman clay loam, 6 to 12 percent slopes, eroded (FmC2).—This soil is sloping and rolling. The slopes are fairly uniform and 100 to 300 feet long. This soil occurs along waterways and drainageways and around sloughs. It is moderately eroded, and tillage has mixed material from the subsoil with the original surface layer. As a result, the surface layer is less friable. This soil has the profile described as representative for the series.

Included in mapping were small areas of Flom and Quam soils and of lighter colored soils that are calcareous. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, and areas that are slightly eroded.

Nearly all of this soil is used for cultivated crops. A few areas are in pasture. This soil is suited to all crops commonly grown in the county. It is sticky when wet. Water runs off this soil at a medium to rapid rate, and the hazard of erosion is moderately severe.

The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IIIe-1; woodland suitability group 1)

Forman-Aastad clay loams, 1 to 5 percent slopes (FoB).—The soils of this complex occur on the till plains and morainic uplands. The areas vary in size and shape. Forman soils make up about 40 to 80 percent of the area, and Aastad soils, 20 to 60 percent. Forman soils occur on the rises, but Aastad soils have smooth, nearly level slopes. The Forman and Aastad soils in this unit occur in a pattern too complex to separate.

Included in mapping were small areas of poorly drained Flom soils and calcareous Vallers soils.

The soils in this unit are used for cultivated crops and pasture. They are suited to all crops commonly grown in the county.

The main management needs are practices that improve fertility and tilth. (Capability unit IIe-1; woodland suitability group 1)

Fulda Series

The Fulda series consists of nearly level, poorly drained soils. These soils formed under marsh grasses in calcareous silty clay to clay glacial material.

In a representative profile, the surface layer is black silty clay about 22 inches thick. The subsoil is olive-gray and dark-gray silty clay and silty loam about 20 inches thick. The underlying material is olive-gray silty clay loam.

Fulda soils have medium to high available water capacity and high natural fertility and organic-matter content. Reaction of the surface layer is neutral. Permeability is slow to very slow.

Fulda soils have a high content of clay, and proper management is needed to keep them suited to crops and easy to work.

Representative profile of Fulda silty clay, where the slope is 1 percent, 1,515 feet west and 254 feet south of the northeast corner, SE¼ sec. 30, T. 129 N., R. 39 W.

Ap—0 to 7 inches, black (N 2/0) silty clay; moderate, coarse, granular structure; loose, sticky; many roots; neutral; abrupt, smooth boundary.

A11—7 to 17 inches, black (N 2/0) silty clay; weak, very fine, granular structure; firm, sticky; few roots; neutral; gradual, wavy boundary.

A12—17 to 22 inches, black (5Y 2/1) silty clay; moderate, fine, subangular blocky structure; sticky; few roots; neutral; clear, wavy boundary.

B21g—22 to 29 inches, dark-gray (5Y 4/1) silty clay; weak, coarse, prismatic structure parting to moderate, fine, subangular blocky; sticky; few roots; few tongues of black (5Y 2/1) in upper part; neutral; gradual, wavy boundary.

B22g—29 to 36 inches, olive-gray (5Y 4/2) silty clay; few, fine, distinct, light olive-brown (2.5Y 5/6) mottles; moderate, fine, subangular blocky structure; sticky; neutral; clear, wavy boundary.

B3g—36 to 42 inches, olive-gray (5Y 5/2) silty clay loam; common, fine, distinct. light olive-brown (2.5Y 5/6) mottles; moderate, fine, subangular blocky structure; sticky; mildly alkaline; slightly effervescent; clear, wavy boundary.

Cg—42 to 60 inches, olive-gray (5Y 5/2) silty clay loam; common, fine, distinct, light olive-brown (2.5 5/6) mottles; we ak, fine, subangular blocky structure; sticky; strongly effervescent; mildly alkaline.

The A horizon is silty clay, clay, or heavy silty clay loam and ranges from 16 to 24 inches in thickness. The B2 horizon is silty clay or clay and ranges from dark gray to gray or olive gray in color. The structure ranges from moderate to strong, prismatic and blocky. The C horizon is calcareous silty clay loam, silty clay, or clay glacial till or lacustrine material. The depth to lime ranges from 20 to 42 inches.

Fulda soils are associated with Sinai and Dovray soils. They differ from Sinai soils in being more poorly drained and in having a grayer B horizon. They differ from Dovray soils in having a thinner A horizon.

Fulda silty clay (0 to 2 percent slopes) (Fu).—This soil is slightly depressed to nearly level. It is in swales and drainageways. The areas are variable in size and shape and are commonly surrounded by more strongly sloping soils.

Included in mapping were small areas of Sinai and Dovray soils. In some areas the surface layer is calcareous. In some areas there is clay loam till within a depth of 42 inches.

This soil is not well suited to cultivation unless it is drained. If adequately drained, it is suited to all crops commonly grown in the county. Some areas are used for pasture or wildlife habitat. Open ditches provide adequate drainage in most years.

The main management needs are practices that improve drainage and maintain fertility and tilth. (Capability unit IIw-1; woodland suitability group 4)

Gonvick Series

The Gonvick series consists of deep, moderately well drained, moderately permeable, nearly level soils. These soils formed under grasses that were succeeded by deciduous trees, in calcareous loam glacial till.

In a representative profile, the surface layer is black loam about 10 inches thick. The subsoil is clay loam about 19 inches thick. The upper part is brown, the middle part is olive brown, and the lower part is mottled dark grayish

brown. The underlying material is light olive-brown loam glacial till.

Gonvick soils have high natural fertility, available water capacity, and organic-matter content. Reaction of the surface layer is neutral. Permeability is moderate.

Gonvick soils are well suited to all crops commonly grown in the county.

Representative profile of Gonvick loam, 1 to 3 percent slopes, in a cultivated field where the slope is 2 percent, 410 feet west and 101 feet south of the northwest corner, NE¼NE¼ sec. 2, T. 129 N., R. 36 W.

Ap—0 to 7 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; weak, very fine, granular structure; friable; about 5 percent coarse fragments; neutral; abrupt, smooth boundary.

A1—7 to 10 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; weak, fine, granular structure; friable; about 5 percent coarse fragments; neutral; clear, wavy boundary.

B21t—10 to 16 inches, brown (10YR 4/3) clay loam; weak, medium, subangular blocky structure; friable; few, thin, very dark grayish-brown (10YR 3/2) clay films on faces of peds; few, thin, porous, grayish coatings on faces of peds; about 5 percent coarse fragments; neutral; gradual, wavy boundary.

B22t—16 to 23 inches, olive-brown (2.5Y 4/4) clay loam; moderate, fine and medium, subangular blocky structure; friable; many, thin and medium, very dark gray (10YR 3/1) clay films on faces of peds; about 5 percent coarse fragments; neutral; gradual, wavy boundary.

B3t—23 to 29 inches, dark grayish-brown (2.5Y 4/2) clay loam; few, fine, distinct, light olive-brown (2.5Y 5/6) and dark-gray (5Y 4/1) mottles; weak, medium, subangular blocky structure; friable; few, thin to thick, black (10YR 2/1) clay films on faces of peds and in old root channels; about 5 percent coarse fragments; neutral; abrupt, wavy boundary.

C—29 to 60 inches, light olive-brown (2.5Y 5/4) loam; common, fine, prominent, yellowish-brown (10YR 5/6) and gray (10YR 5/1) mottles; weak, fine and very fine, subangular blocky structure; friable; few lime segregations; strongly effervescent; mildly alkaline.

The A horizon is black or very dark gray and ranges from 7 to 12 inches in thickness. The texture is loam or light clay loam. The B2 horizon ranges from dark grayish brown or brown to olive brown. The clay films range from few to many and thin to thick in the B2 horizon. In some areas there is a thin, discontinuous A2 horizon.

Gonvick soils are associated with Flom, Quam, and Waukon soils. They have a thicker surface layer than Waukon soils. They are better drained and have browner colors below the A horizon than Flom and Quam soils.

Gonvick loam, 1 to 3 percent slopes (GoA).—This soil is nearly level. It is on the till plains and morainic uplands. The areas vary in size and shape. This soil occurs in close association with Waukon, Flom, and Quam soils. It is on slightly convey positions downslope from Waukon soils or upslope from Flom and Quam soils.

Included in mapping were small areas of well-drained Waukon, poorly drained Flom, and very poorly drained Quam soils. Also included were small calcareous areas and areas that are more strongly sloping. Other inclusions were areas where the surface layer is lighter colored and areas where the surface layer and subsoil are finer textured.

This soil is well suited to crops and there are few limitations to its use. Most areas are used for crops, but a few are used for woodland or pasture. All crops common in the county can be grown.

The main management need is maintenance of fertility and tilth. (Capability unit I–1; woodland suitability group 1)

Hangaard Series

The Hangaard series consists of poorly drained, nearly level soils that formed in medium-textured to coarse-textured material that overlies calcareous sand and gravel. These soils formed under a vegetation that consists of grasses and sedges, in the outwash areas of the county.

In a representative profile, the surface layer is black sandy loam about 11 inches thick. The subsoil is about 6 inches thick. The upper part is mottled, dark grayish-brown sandy loam, and the lower part is mottled, olive-brown loamy coarse sand. The underlying material is light olive-brown, olive-gray, and grayish-brown gravelly coarse sand.

Hangaard soils have high natural fertility, low available water capacity, and high organic-matter content in the surface layer. Permeability is moderately rapid above the gravelly coarse sand and rapid in the gravelly coarse sand. Reaction of the surface layer is mildly alkaline.

Hangaard soils are poorly drained, wet soils that are shallow to gravelly coarse sand. They are used for hay, pasture, and crops.

Representative profile of Hangaard sandy loam, where the slope is 1 percent, 600 feet west and 210 feet north of the southeast corner, NE¼SE¼ sec. 14, T. 129 N., R. 36 W.

Ap—0 to 8 inches, black (10YR 2/1) sandy loam; weak, very fine, granular structure; friable; common bleached sand grains; many roots; mildly alkaline; abrupt, smooth boundary.

A1—8 to 11 inches, black (10YR 2/1) sandy loam; weak, very fine, granular structure; friable; few bleached sand grains; few roots; mildly alkaline; clear, wavy boundary.

B21g—11 to 13 inches, dark grayish-brown (2.5Y 4/2) sandy loam; few, fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, very fine, subangular blocky structure; friable; few roots; mildly alkaline; clear, wavy boundary.

IIB22g—13 to 17 inches, olive-brown (2.5Y 4/4) loamy coarse sand; common, fine, distinct, yellowish-brown (10YR 5/6) mottles and few, medium, distinct, grayish-brown (2.5Y 5/2) mottles; single grain; loose; few roots; mildly alkaline; abrupt, wavy boundary.

IIC1—17 to 25 inches, light olive-brown (2.5Y 5/4) gravelly coarse sand; common, medium, distinct, yellowish-brown (10YR 5/6) mottles; single grain; loose; mildly alkaline; abrupt, wavy boundary.

IIC2—25 to 36 inches, olive-gray (5Y 5/2) gravelly coarse sand; single grain; loose; strongly effervescent; mildly alkaline; abrupt, wavy boundary.

IIC3—36 to 60 inches, grayish-brown (2.5Y 5/2) gravelly coarse sand; single grain; loose; strongly effervescent; mildly alkaline.

The A horizon is sandy loam or loam and 8 to 14 inches thick. The B horizon is 4 to 6 inches thick and has colors of dark grayish brown, grayish brown, olive brown, olive gray, and olive. The texture is loam or sandy loam in the B21g horizon and loamy sand or loamy coarse sand in the IIB22g horizon.

Hangaard soils are associated with Arvilla and Osakis soils. They are more poorly drained than those soils and have more olive colors in the B horizon. They differ from the similar Forada soils in having a thinner solum.

Hangaard sandy loam (0 to 2 percent) (Ha).—This soil is nearly level. It occurs on the outwash plains. The areas are irregular in shape and vary in size.

Included in mapping were small areas of Osakis and Forada soils. Also included were areas where the soil is calcareous and areas where the surface layer is loam. Other inclusions were areas where depth to gravel is more than 24 inches.

This soil is used for crops, pasture, and hay. All crops common in the county can be grown. This soil has a fluctuating water table and needs additional drainage. Soil blowing is a hazard on bare fields during winter and spring.

The main management needs are practices that improve drainage, control soil blowing, and maintain fertility. (Capability unit IVw–1; woodland suitability group 3)

Hantho Series

The Hantho series consists of deep, moderately well drained, nearly level soils that formed under grasses in calcareous, silty lacustrine material.

In a representative profile, the surface layer is silt loam about 16 inches thick. The upper 12 inches is black, and the lower 4 inches is very dark brown. The subsoil is dark grayish-brown, brown, and olive-brown silt loam about 21 inches thick. The underlying material is light olive-brown silt loam.

Hantho soils have high natural fertility, very high available water capacity, and high organic-matter content. Permeability is moderate. Reaction of the surface layer is neutral.

Hantho soils are silty and are free of stones. All crops grow well on them.

Representative profile of Hantho silt loam, 1 to 3 percent slopes, where the slope is 1 percent, 810 feet west and 980 feet south of the northeast corner, NW¼ sec. 35, T. 127 N., R. 36 W.

Ap—0 to 8 inches, black (10YR 2/1) silt loam; weak, fine, granular structure; friable; common roots; few bleached sand grains; neutral; abrupt, smooth boundary.

A1—8 to 12 inches, black (10YR 2/1) silt loam; weak, fine, granular structure; friable; common roots; few bleached sand grains; neutral; abrupt, smooth boundary.

A3—12 to 16 inches, very dark brown (10YR 2/2) silt loam; weak, fine, granular structure; friable; common roots; few bleached sand grains; neutral; clear, wavy boundary.

B21—16 to 21 inches, dark grayish-brown (10YR 4/2) silt loam; weak, fine, subangular blocky structure; friable; common roots; neutral; gradual, wavy boundary.

B22—21 to 30 inches, brown (10YR 4/3) silt loam; weak, medium, subangular blocky structure; friable, common roots; gradual, wavy boundary.

B3—30 to 37 inches, olive-brown (2.5Y 4/4) silt loam; few, fine, faint, yellowish-brown (10YR 5/6) mottles and common, fine, distinct, gray (5Y 5/1) mottles; weak, fine, subangular blocky structure; friable; common roots; neutral; abrupt, wavy boundary.

C—37 to 60 inches, light olive-brown (2.5Y 5/4) silt loam; common, medium, distinct, yellowish-brown (10YR 5/6) mottles and common, medium, distinct, light-gray (5Y 6/1) mottles; massive; friable; strongly effervescent; mildly alkaline.

The A horizon is black, very dark gray, or very dark brown and ranges from 10 to 20 inches in thickness. Among the colors in the B horizon are very dark grayish brown, dark grayish brown, dark brown, brown, and olive brown. The texture is silt loam or light silty clay loam. Faint to distinct mottles occur in the lower part of the horizon. Depth to the C horizon ranges from 30 to 44 inches.

Most of the Hantho soils in this county have a solum that is a few inches thicker than the defined range of the series, but this difference does not alter their usefulness and behavior.

Hantho soils are associated with the Rothsay and Zell soils. They have a thicker A horizon and are more poorly drained than Rothsay and Zell soils.

Hantho silt loam, 1 to 3 percent slopes (HhA).—This is a nearly level, deep, silty soil. The areas are variable in size and shape.

Included in mapping were small areas of Rothsay and Flom soils. Also included were areas where depth to loam till is less than 40 inches, areas that contain sandy bands, and areas that have silty clay loam throughout the profile.

Most areas are used for crops. A few areas are used for pasture or wildlife habitat. This soil is suited to all the crops commonly grown in the county. Soil blowing is a hazard on unprotected fields during winter and spring.

The main management needs are control of erosion and maintenance of fertility and tilth. (Capability unit I–1; woodland suitability group 1)

Lake Beaches

Lake Beaches is a miscellaneous land type that occurs along the rims of present or former lakes. Slopes range from 0 to 6 percent. Drainage is poor in the level and nearly level areas and good to excessive in sloping areas.

Lake beaches, sandy (La).—This land type occurs as rims along the edge of present or former lakes. The surface texture includes sand, sandy loam, and loamy sand. Most of these areas are nearly level and have a water table near the surface. They generally have a vegetative cover that consists of grass and willows and other trees. In some areas this soil has slopes of 3 to 6 percent. These areas are droughty and were formed as the ice expanded and pushed the beach material into ridges and as the lake level lowered. On most lakes these areas are being used for homes, cabins, and campsites.

Drainage is poor in the level to nearly level areas and excessive in the sloping areas. The fertility and available water capacity are low. Some of these areas that are on small lakes or that were former lakes are farmed or are used for pasture. (Capability unit VIw–1; woodland suitability group 3)

Lake beaches, loamy (Lb).—This land type is along the edge of present lakes and the borders of former lakes. The soil material lacks distinct layers. The surface texture is generally loam but in places sandy loam. The soil generally is deep, black loam or sandy loam.

Most areas are nearly level, but because of gradual lowering of the level of the lakes during the time when the material was deposited there are some areas where the slopes are as much as 3 to 5 percent.

This soil is poorly drained in the level areas to well drained in the sloping areas. The natural fertility is moderate, and the available water capacity is medium.

This land generally is too wet to be cropped. Most of this soil is used for pasture, wildlife habitat, or woodland. The higher lying areas are used for cabins and campsites. (Capability unit IIIw–2; woodland suitability group 3)

Langhei Series

The Langhei series consists of deep, undulating to very steep, somewhat excessively drained, moderately permeable soils. These soils formed under grasses in calcareous loam or clay loam glacial till.

In a representative profile, the surface layer is dark grayish-brown loam about 7 inches thick. The underlying material is calcareous, light yellowish-brown and light olive-brown loam.

Langhei soils have medium natural fertility, high available water capacity, and medium organic-matter content. Permeability is moderate. Reaction in the surface layer is mildly alkaline.

If fertilized and if erosion control practices are used, Langhei soils are suited to the crops commonly grown in the county.

Representative profile of Langhei loam, in an area of Langhei-Barnes loams, 12 to 18 percent slopes, eroded, 120 feet south and 280 feet east of the northwest corner, SW¼ sec. 22, T. 128 N., R. 40 W.

Ap—0 to 7 inches, dark grayish-brown (2.5Y 4/2) loam, light gray (10YR 7/1) when dry; weak, fine, granular structure; friable; many roots; about 4 percent coarse fragments; strongly effervescent; mildly alkaline; abrupt, smooth boundary.

C1ca—7 to 28 inches, light yellowish-brown (2.5Y 6/4) loam; weak, fine, subangular blocky structure; friable; few dark-colored concretions; few, light-gray (10YR 7/1), limy threads; about 4 percent coarse fragments; strongly effervescent; mildly alkaline; gradual, smooth boundary.

C2—28 to 60 inches, light olive-brown (2.5Y 5/4) loam; weak, fine, subangular blocky structure; friable; few, light-gray (10YR 7/1), limy spots; about 4 percent coarse fragments; strongly effervescent; mildly alkaline.

The A horizon is loam or light clay loam. The Ap horizon includes dark gray, dark grayish brown, and grayish brown. In some uncultivated areas there is an A1 horizon, up to 4 inches thick, that is black or very dark gray. The A horizon is slightly effervescent to strongly effervescent.

Langhei soils are associated with Aastad, Barnes, and Waukon soils. They differ from those soils in having a thinner A horizon, in having a lighter colored Ap horizon, and in being better drained. They differ from the similar Zell soils in containing more sand in the A and C horizons.

Langhei loam, 18 to 40 percent slopes (LeF).—This soil is adjacent to streams, waterways, sloughs, or lakes on the till plains and in morainic upland areas. Waterways dissect the area and make the cross slopes irregular. Slope ranges from 100 to 300 feet in length. The profile differs from the one described as representative for the series in being thinner.

Included in mapping were small areas of Barnes, Darnen, and Flom soils. Also included were small areas of less sloping soils and areas of gravelly soils. Also included were areas that are moderately eroded.

Most of this soil is under grass vegetation. A few areas are cultivated. The soil is well suited to grassland. Water runs off very rapidly.

The main management needs are practices that control erosion and conserve moisture. (Capability unit VIIe–1; woodland suitability group 2)

Langhei-Barnes loams, 12 to 18 percent slopes, eroded (lgD2).—These soils are hilly. The areas vary in size and shape and have complex topography. Slopes are 75 to 250 feet long. Langhei soils make up 60 to 80 percent of the area, and Barnes soils, 20 to 40 percent. The Langhei soil has the profile described as representative for the series. The Barnes soil, in most places has a profile that differs from the one described as representative for the Barnes series in being thinner. Barnes soils are on the more uniform parts of the slope, and Langhei soils are on the exposed knobs, ridges, and knolls. The soils in this unit have been moderately eroded, and the surface layer is a mixture of the original surface layer and moderate amounts of material from the subsoil. This mixing gives the surface layer of the Barnes soils a dark brownish color and the Langhei soils a grayish color when dry. The Barnes and Langhei soils in this unit occur in such an intricate pattern that it is not practical to map them separately.

Included in mapping were small areas of the moderately well drained Aastad and Darnen soils and the poorly drained Flom and Vallers soils. Also included were small areas of soils that are more strongly sloping, small areas that are less sloping, areas of gravelly soils, areas of severely eroded soils, and areas that are stony on the surface. Also included were some areas that are only slightly eroded.

These soils are used for cultivated crops and pasture and are suited to all crops commonly grown in the county. The Langhei soils are less suited to crops than the Barnes soils because of the nutrient imbalance caused by the high content of lime. Surface runoff is rapid, and the hazard of erosion is severe.

The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IVe–1; Langhei part in woodland suitability group 2; Barnes part in woodland suitability group 1)

Langhei-Waukon loams, 12 to 18 percent slopes, eroded (lkD2).—The soils of this complex are hilly. The areas are interspersed with many draws, potholes, drainageways, and lakes. The areas vary in size and shape and have complex topography. Slopes are 75 to 250 feet long. Langhei soils make up 50 to 70 percent of the area, and Waukon soils, 30 to 50 percent. Langhei soils are dark grayish brown in color when moist and are light gray in color when dry. They occur on the knobs, knolls, and ridges. Waukon soils occur on the less exposed parts of the slope. The Langhei and Waukon soils in this unit occur in such an intricate pattern that it is not practical to map them separately.

Included in mapping were small areas of the moderately well drained Gonvick soils and the poorly drained Flom and Vallers soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, areas of scattered stones and areas that are slightly eroded.

These soils are used for cultivated crops, pasture, and woodland. They are suited to all crops commonly grown in the county. Water runs off at a rapid rate, and the hazard of erosion is severe.

The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IVe–1; Langhei part in woodland suitability group 2; Waukon part in woodland suitability group 1)

Langhei-Waukon loams, 18 to 24 percent slopes (lkE).—The soils in this complex are generally adjacent to streams, waterways, sloughs, or lakes. Waterways dissect the area, making the cross slope very irregular. Langhei soils make up 60 to 80 percent of the area, and Waukon soils, 20 to 40 percent. The Langhei soils are dark grayish brown in color when moist and light gray when dry. They occur on the knobs, knolls, and ridges. The Waukon soils occur on the less exposed parts of the slope. The Langhei and Waukon soils of this mapping unit occur in such an intricate pattern that it is not practical to map them separately.

Included in mapping were small areas of the moderately well drained Gonvick soils and poorly drained Flom soils.

These soils are generally used for pasture or woodland, but a few areas are cultivated. They should be kept in permanent vegetation. The hazard of erosion is very severe. (Capability unit VIe–1; Langhei part in woodland suitability group 2; Waukon part in woodland suitability group 1)

Langhei-Waukon-Sioux complex, 12 to 25 percent slopes (lwD).—The soils in this complex are steep and hilly. They are generally adjacent to streams, waterways, sloughs, or lakes. Langhei loam makes up 40 to 60 percent of the area; Waukon loam, 20 to 30 percent; and Sioux gravelly loamy coarse sand, 20 to 30 percent. The Langhei soils are grayish when dry. They occur on the knolls, knobs, and ridges. The Waukon soils are in the less exposed areas, and the Sioux soils are in the gravelly areas. The profiles of these soils are similar to those described as representative for their respective series, except that they are generally thinner.

Included in mapping were small areas of the moderately well drained Gonvick and Darnen soils. Also included were small sandy areas.

This unit is used for cultivated crops, pasture, and woodland. The areas are suited to permanent vegetation. Water runs off at a rapid to very rapid rate. The hazard of erosion is very severe.

The main management needs are practices that control erosion and conserve moisture. (Capability unit VIe–1; Langhei part in woodland suitability group 2; Waukon part in woodland suitability group 1; Sioux part in woodland suitability group 7)

Maddock Series

The Maddock series consists of very deep, well-drained, nearly level to rolling soils. These soils formed under grasses in sandy outwash material.

In a representative profile, the surface layer is very dark brown and very dark grayish-brown fine sand about 14 inches thick. The subsoil is dark yellowish-brown fine sand about 16 inches thick. The underlying material is yellowish-brown and pale-brown fine sand.

Maddock soils have low natural fertility, low available water capacity, and medium organic-matter content. Permeability is rapid. Reaction of the surface layer is slightly acid.

Maddock soils are droughty. Soil blowing is a hazard on unprotected fields.

Representative profile of Maddock fine sand, 2 to 6 percent slopes, in a cultivated field where the slope is 4 percent, 363 feet west and 192 feet south of the northeast corner, NE¼ sec. 17, T. 127 N., R. 36 W.

Ap—0 to 9 inches, very dark brown (10YR 2/2) fine sand; single grain; loose; slightly acid; abrupt, smooth boundary.

A3—9 to 14 inches, very dark grayish-brown (10YR 3/2) fine sand; single grain; loose; slightly acid; abrupt, wavy boundary.

B2—14 to 30 inches, dark yellowish-brown (10YR 4/4) fine sand; single grain; loose; slightly acid; gradual, wavy boundary.

C1—30 to 46 inches, yellowish-brown (10YR 5/6) fine sand; single grain; loose; slightly acid; gradual, wavy boundary.

C2—46 to 60 inches, pale-brown (10YR 6/3) and yellowish-brown (10YR 5/6) fine sand; single grain; loose; slightly acid.

The A horizon is very dark brown, black, or very dark grayish brown. Its texture is fine sand or loamy fine sand. Reaction ranges from slightly acid to neutral. The B horizon is fine sand or loamy fine sand that is dark brown, brown, dark yellowish brown, or yellowish brown. Reaction ranges from medium acid to neutral. Depth to free lime ranges from 6 to 8 feet.

These soils have a slightly acid solum, and depth to carbonates is greater than the defined range for the series. This difference does not alter their usefulness and behavior.

Maddock soils are associated with Sverdrup soils and differ from them in being coarser textured and having a thinner solum over the sand. They differ from the similar Nymore soils in having a thicker A horizon and containing more fine sand throughout.

Maddock fine sand, 0 to 2 percent slopes (MaA).—This soil is on outwash plains. The areas vary in size and shape. The profile differs from the one described as representative for the series in having a thicker surface layer.

Included in mapping were small areas of well drained Sverdrup soils and moderately well drained Clontarf soils. Also included were small areas of more strongly sloping soils and a few areas that are moderately eroded.

Nearly all of the acreage is used for cultivated crops. This soil is suited to all crops commonly grown in the county. Soil blowing is a serious hazard on unprotected fields during winter and spring. Droughtiness is a serious limitation; it affects the crops in most years. The main management needs are controlling erosion, conserving moisture, and maintaining fertility. (Capability unit IVs–1; woodland suitability group 7)

Maddock fine sand, 2 to 6 percent slopes (MaB).—This soil is gently sloping. It occurs in outwash areas and on uplands. The areas are irregular in shape. Slopes are 50 to 200 feet long. This soil has the profile described as representative for the series.

Included in mapping were small areas of well drained Sverdrup soils and moderately well drained Clontarf soils. Also included were small areas of more strongly sloping soils, small areas of less sloping soils, and a few areas that are moderately eroded.

Nearly all of the acreage is used for cultivated crops. This soil is suited to all crops commonly grown in the county. Soil blowing is a hazard on fields left unpro-

tected during winter and spring. Droughtiness is a serious limitation; it affects the crops in most years. The main management needs are controlling erosion, conserving moisture, and maintaining fertility. (Capability unit IVs–1; woodland suitability group 7)

Maddock fine sand, 6 to 12 percent slopes (MaC).—This soil is rolling and sloping. It is on outwash areas and in upland areas. The areas vary in size and shape. Slopes are 50 to 200 feet long. The most uniform areas are along the waterways and around potholes. The profile of this soil differs from the one described as representative for the series in having a thinner surface layer.

Included in mapping were small areas of well-drained Sverdrup soils. Also included were small areas where slopes are lesser or steeper and a few areas that are eroded. A few areas differ in being underlain by medium sand.

Nearly all of the acreage is used for cultivated crops. This soil is suited to all crops commonly grown in the county. Soil blowing is a hazard on unprotected fields during winter and spring. Water runs off at a medium to rapid rate, and the hazard of erosion is moderately severe. Droughtiness is a serious limitation; it affects the crops in most years. The main management needs are controlling erosion, conserving moisture, and maintaining fertility. (Capability unit VIs–1; woodland suitability group 7)

Marsh

Marsh (0 to 1 perent slopes) (Mh) is a land type that occurs in shallow ponds and sloughs and in depressions that contain water throughout most of the year. Some of these areas go dry late in summer or during periods of drought, but most areas are wet all year. The vegetation consists of cattails, rushes, sedges, and other water-tolerant plants. The soil in these areas consists of mineral material, calcareous mucky lake sediments, or organic soil material.

Marsh is excellent for wildlife habitat. It provides nesting, mating, and escape areas for waterfowl, furbearers, and upland game. Most of these areas can be improved for wildlife production by controlling the water level, by increasing nesting and courting areas for ducks, and by fencing out livestock.

Many of these areas are impracticable to drain because of nearby streams or lakes. (Capability unit VIIIw–1; woodland suitability group 8)

Marysland Series

The Marysland series consists of poorly drained and very poorly drained, nearly level soils. These soils formed under grasses in calcareous material and are moderately deep over calcareous sand.

In a representative profile, the surface layer is black and very dark gray loam about 15 inches thick. Below this is dark grayish-brown, grayish-brown, and light brownish-gray loam and sandy loam about 17 inches thick. Below this is gray and light brownish-gray loamy fine sand about 8 inches thick. The underlying material is light olive-brown, yellowish-brown, and strong-brown gravelly coarse sand.

Marysland soils have high natural fertility and organic-matter content and medium available water capacity. Permeability is moderate above the sand and gravel and rapid in the sand and gravel. Reaction of the surface layer is mildly alkaline.

Marysland soils are used for pasture and crops. Wetness is a major limitation.

Representative profile of a nearly level Marysland loam, 280 feet north and 1,020 feet west of the southeast corner, NE¼ sec. 26, T. 130 N., R. 36 W.

A1—0 to 12 inches, black (10YR 2/1) loam; weak, fine, subangular blocky structure; friable; strongly effervescent; mildly alkaline; gradual, wavy boundary.

A3ca—12 to 15 inches, very dark gray (10YR 3/1) loam; weak, fine, subangular blocky structure; friable; strongly effervescent; mildly alkaline; gradual, wavy boundary.

C1ca—15 to 17 inches, dark grayish-brown (2.5Y 4/2) loam; few, fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, fine, subangular blocky structure; friable; strongly effervescent; mildly alkaline; clear, wavy boundary.

C2—17 to 20 inches, grayish-brown (2.5Y 5/2) sandy loam; common, medium, prominent, yellowish-brown (10YR 5/8) mottles; weak, fine, subangular blocky structure; friable; strongly effervescent; mildly alkaline; clear, wavy boundary.

C3—20 to 32 inches, light brownish-gray (2.5Y 6/2) loam; massive; friable; strongly effervescent; mildly alkaline; abrupt, wavy boundary.

IIC4—32 to 36 inches, light brownish-gray (2.5Y 6/2) loamy fine sand; single grain; loose; slightly effervescent; mildly alkaline; abrupt, wavy boundary.

IIC5—36 to 40 inches, gray (2.5Y 6/1) loamy fine sand; single grain; loose; sightly effervescent; mildly alkaline; abrupt, wavy boundary.

IIC6—40 to 60 inches, mixed light olive-brown (2.5Y 5/4), yellowish-brown (10YR 5/6), and strong-brown (7.5YR 5/6) gravelly coarse sand; single grain; loose; slightly effervescent; mildly alkaline.

The A horizon ranges from loam or sandy loam to light clay loam or sandy clay loam in texture. Its structure is very fine or fine granular or subangular blocky. The C1ca, C2, and C3 horizons range from sandy loam to loam or clay loam in texture. The depth to the coarse-textured IIC horizon ranges from 20 to 40 inches. The IIC horizon is variable in texture. The IIC4 and IIC5 horizons are loamy sand, loamy fine sand, fine sand, or sand. These horizons are lacking in some profiles. The IIC6 horizon is coarse sand, gravelly coarse sand, or stratified gravel and sand.

Some of these soils have slightly coarser texture in the upper part, some lack a calcic horizon, and in some the depth to the calcic horizon is more than 16 inches. These differences do not alter the usefulness and behavior of these soils.

Marysland soils are associated with Forada and Arveson soils. They differ from Forada soils in that they are calcareous throughout the solum. They differ from Arveson soils principally because they have a gravelly coarse sand substratum rather than a sandy substratum.

Marysland loam (0 to 2 percent slopes) (Mm).—This soil is nearly level or slightly depressed. The areas generally are broad, irregular in shape, and variable in size. A few areas are waterways. This soil has the profile described as representative for the series.

Included in mapping were small areas of Arveson, Forada, and Osakis soils. Also included were a few areas where the soil is deeper over sand and gravel than in the representative profile.

This soil is used for cultivated crops and pasture. It is not well suited to cultivation unless drained. If adequately drained, this soil is suited to all crops common

in the county. Soil blowing is a limitation on fields that are left bare in winter and spring.

The main management needs are practices that improve drainage, control erosion, and improve fertility and tilth. (Capability unit IIw–2; woodland suitability group 5)

Marysland loam, depressional (0 to 1 percent slopes) (Mo).—This soil is nearly level and very poorly drained. It is on the outwash plains in deep depressions or circular potholes, or in elongated waterways. The profile differs from the one described as representative for the series in having a thicker surface layer.

Included in mapping were small areas of other Marysland soils and of Cathro muck, sandy subsoil variant.

If undrained, this Marysland soil is generally covered with marsh vegetation that consists of reeds, sedges, rushes, and, in some places, willows. The undrained areas are well suited to wildlife habitat. They provide food, cover, and nesting for waterfowl, furbearers, and upland game.

If drained, this soil is used for cropland and pasture. Adequately drained areas can be used for all crops commonly grown in the county.

The main management needs are practices that improve drainage, fertility, and tilth. (Capability unit IIIw–2; woodland suitability group 5)

Millerville Series

The Millerville series consists of very poorly drained, nearly level, organic soils. These soils formed under vegetation consisting of sedges, rushes, cattails, and marsh grass. They are in sloughs, potholes, and drainageways.

In a representative profile, the surface layer is dark-brown mucky peat about 9 inches thick. The next layer is dark reddish-brown mucky peat about 10 inches thick. Below this is dark-brown and very dark brown mucky peat about 5 inches thick. The underlying material is very dark grayish-brown and very dark gray silt loam.

Millerville soils have low natural fertility and very high available water capacity.

Millerville soils are used for crops, pasture, and wildlife habitat. If drained, they are suited to all crops commonly grown in the county.

Representative profile of Millerville mucky peat, 110 feet west and 78 feet north of the southeast corner, SW¼ SE¼ sec. 3, T. 129 N., R. 39 W.

Oep—0 to 9 inches, dark-brown (7.5YR 3/2, broken face and rubbed) hemic material; about 75 percent fiber, about 35 percent rubbed; massive; nonsticky; common inclusions of black sapric material; herbaceous fibers; about 35 percent mineral material; slightly acid; abrupt, smooth boundary.

Oe2—9 to 19 inches, dark reddish-brown (5YR 3/2, broken face and rubbed) hemic material; about 60 percent fiber, about 25 percent rubbed; weak, thick, platy structure; nonsticky; herbaceous fibers; about 15 percent mineral material; slightly acid; clear, smooth boundary.

Oe3—19 to 24 inches, hemic material that has dark-brown (7.5YR 3/2) fiber and very dark brown (10YR 2/2) matrix, very dark grayish brown (10YR 3/2, rubbed); about 35 percent fiber, about 10 percent rubbed; weak, medium, platy structure; nonsticky; herbaceous fibers; about 15 percent mineral material; slightly acid; abrupt, smooth boundary.

Lco1—24 to 42 inches, very dark grayish-brown (10YR 3/2) coprogenous earth, very dark gray (10YR 3/2, rubbed); about 15 percent plant and detritus; massive; nonsticky; about 20 percent mineral material; slightly acid; gradual, smooth boundary.

Lco2—42 to 78 inches, very dark gray (10YR 3/1, broken face and rubbed) coprogenous earth; massive; nonsticky; about 5 percent plant detritus; about 15 percent snail shells; about 70 percent mineral material; strongly effervescent; neutral.

Depth to the underlying coprogenous earth (Lco1 horizon) ranges from 16 to 51 inches. The organic soil material is brown, dark brown, very dark brown, dark reddish brown, or reddish brown. Its reaction is slightly acid to mildly alkaline. Some areas contain layers of sapric or fibric material, but the total thickness of each of these materials is less than 10 inches. The Lco horizon has colors of very dark grayish brown, dark grayish brown, very dark gray, dark gray, and olive gray.

Millerville soils are similar to Carlos and Brophy soils. They differ from both of those soils in being underlain by coprogenous earth material within a depth of 51 inches.

Millerville mucky peat (0 to 1 percent slopes) (Mp).—This soil is nearly level. It is in depressions, potholes, small lake basins, and drainageways that vary in size and shape. All soil areas are flooded in spring, and most areas are flooded or wet throughout the year.

Included in mapping were small areas of Cathro and Rifle soils. Also included were small areas that are calcareous.

Most of the areas are undrained and are covered with marsh vegetation that consists of sedges, rushes, reeds, marsh grass, and, in some areas, willows. These areas are moderately well suited as wildlife habitat. They provide food and cover for waterfowl, furbearers, and upland game. If drained, this soil is used for hay or pasture, and a few areas are used for crops. If adequately drained, this soil is suited to all crops commonly grown in the county, but small grains often lodge and corn and soybeans may not reach maturity. Soil blowing can be a hazard on bare fields. (Capability unit IVw–2; woodland suitability group 8)

Nebish Series

The Nebish series consists of deep, well-drained, undulating to steep soils. These soils formed under hardwood forests in calcareous loam glacial till.

In a representative profile, the surface layer is very dark gray loam about 3 inches thick. The subsurface layer is grayish-brown sandy loam about 6 inches thick. The subsoil is about 24 inches thick. The upper part is dark yellowish-brown sandy clay loam, and the lower part is olive-brown sandy clay loam. The underlying material is light olive-brown loam.

Nebish soils have medium natural fertility, low to medium organic-matter content, and medium to high available water capacity. Permeability is moderate. Reaction of the surface layer is neutral.

Nebish soils are well suited to all crops commonly grown in the county. Some of the areas are wooded.

Representative profile of Nebish loam, 2 to 6 percent slopes, where the slope is 4 percent, 120 feet east and 320 feet north of the southwest corner of sec. 9, T. 128 N., R. 38 W.

A1—0 to 3 inches, very dark gray (10YR 3/1) loam; weak, very fine, granular structure; very friable; many

roots; about 5 percent coarse fragments; slightly acid; abrupt, smooth boundary.

A2—3 to 9 inches, grayish-brown (10YR 5/2) sandy loam; weak, very thin, platy structure; very friable; about 5 percent coarse fragments; slightly acid; abrupt, wavy boundary.

B21t—9 to 17 inches, dark yellowish-brown (10YR 4/4) sandy clay loam; strong, fine and medium, subangular blocky structure; firm; common, medium, very dark grayish-brown (10YR 3/2) clay films on faces of peds; many, thin, light-gray (10YR 7/2, dry) porous coatings on faces of peds; about 5 percent coarse fragments; many roots; slightly acid; gradual, wavy boundary.

B22t—17 to 29 inches, dark yellowish-brown (10YR 4/4) sandy clay loam; moderate, medium and coarse, subangular blocky structure; firm; many, medium, very dark grayish-brown (10YR 3/2) clay films on faces of peds; about 5 percent coarse fragments, few roots; medium acid; gradual, wavy boundary.

B3t—29 to 33 inches, olive-brown (2.5Y 4/4) sandy clay loam; weak, medium and coarse, subangular blocky structure; firm; common, thin and medium, very dark grayish-brown (10YR 3/2) clay films on faces of peds; about 5 percent coarse fragments; few roots; neutral; clear, wavy boundary.

C—33 to 60 inches, light olive-brown (2.5Y 5/4) loam; weak, thin, platy structure parting to weak, fine, subangular blocky; friable; few roots; few white (10YR 8/2) lime threads; strongly effervescent; mildly alkaline.

The A1 horizon ranges from 2 to 5 inches in thickness in uncultivated areas. The color is black or very dark gray. In cultivated areas, the Ap horizon is dark gray or dark grayish brown. The structure is weak to moderate, fine and very fine, granular. The A2 horizon is 4 to 10 inches thick. Its color ranges from dark grayish brown to grayish brown. It has weak, thin, platy structure or weak, fine and medium, subangular blocky. The A horizon ranges from sandy loam to loam in texture. About 50 percent of the areas have an AB horizon or BA horizon up to 4 inches thick. The B horizon is clay loam, sandy clay loam, or heavy loam in texture. The B2 horizon ranges from dark brown or brown to dark yellowish brown or yellowish brown. Clay films range from thin to thick and from common to many. The C horizon is loam or sandy loam that is olive brown or light olive brown.

Nebish soils are associated with Beltrami and Shooker soils. They are better drained than Beltrami soils, and they lack mottles in the B horizon. They are better drained than Shooker soils and have a browner B horizon. Nebish soils differ from the similar Waukon soils in having a thinner A1 horizon and a thicker A2 horizon.

Nebish sandy loam, 2 to 6 percent slopes (NbB).—This soil is undulating. It is on morainic uplands. The areas vary in size and shape. Slopes are complex and choppy. They are 50 to 200 feet long. The profile differs from the one described as representative for the series in having a coarser textured surface layer and subsoil.

Included in mapping were small areas of Beltrami and Shooker soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, eroded areas, gravelly spots, and areas that have many surface stones.

This soil is used for crops, woodland, and pasture. It is suited to all crops commonly grown in the county. Water runs off this soil at a medium rate. The hazard of erosion is moderate. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IIe–2; woodland suitability group 1)

Nebish sandy loam, 6 to 12 percent slopes (NbC).—This soil is rolling. It is on morainic uplands. The areas vary in size and shape. Slopes are short and complex and are 80 to 250 feet long. The profile differs from the one described as representative for the series in having a coarser textured surface layer and subsoil.

Included in mapping were small areas of Beltrami and Shooker soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, eroded areas, gravelly spots, and areas that have many surface stones.

This soil is used for crops, woodland, and pasture. It is suited to all crops commonly grown in the county. Water runs off this soil at a medium to rapid rate. The hazard of erosion is moderately severe. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IIIe–2; woodland suitability group 1)

Nebish sandy loam, 12 to 18 percent slopes (NbD).—This soil is hilly. It is on morainic uplands. The areas vary in size and shape. Slopes are short, complex, and 100 to 300 feet long. The profile differs from the one described as representative for the series in having a coarser textured surface layer and subsoil.

Included in mapping were small areas of Beltrami and Shooker soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, eroded areas, gravelly areas, and areas that have surface stones.

This soil is used for crops, woodland, and pasture. It is suited to all crops commonly grown in the county. Water runs off this soil at a rapid rate. The hazard of erosion is severe. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IVe–1; woodland suitability group 1)

Nebish loam, 2 to 6 percent slopes (NeB).—This soil is undulating. It is on morainic uplands. The areas vary in size and shape. Slopes are complex and choppy and are 80 to 200 feet long. This soil has the profile described as representative for the series.

Included in mapping were small areas of Beltrami and Shooker soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, eroded areas, and gravelly spots.

This soil is used for crops, pasture, and woodland. It is suited to all crops commonly grown in the county. Water runs off this soil at a medium rate. The hazard of erosion is moderate. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IIe–2; woodland suitability group 1)

Nebish loam, 2 to 6 percent slopes, eroded (NeB2).—This soil is undulating. It occurs on the morainic uplands. The areas vary in size and shape. Slopes are complex and choppy and 80 to 200 feet long. The moderate erosion, deep tillage, and the removal of trees have caused material from the subsoil to be mixed with the original surface layer. As a result, the present plow layer is more brownish and less friable than the slightly eroded Nebish soils. The profile differs from the one described as representative for the series in having a very dark grayish-brown surface layer.

Included in mapping were small areas of Beltrami and Shooker soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, uneroded areas, and gravelly areas.

This soil is used for crops, woodland, and pasture. It is suited to all crops commonly grown in the county. Water runs off this soil at a medium rate. The hazard of erosion is moderate. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IIe–2; woodland suitability group 1)

Nebish loam, 6 to 12 percent slopes (NeC).—This soil is rolling. It is on morainic uplands. The areas vary in size and shape. Slopes are short, complex, and 80 to 250 feet long. The profile differs from the one described as representative for the Nebish series in being thinner.

Included in mapping were small areas of Beltrami and Shooker soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, eroded areas, and gravelly spots.

This soil is used for crops, pasture, and woodland. It is suited to all crops commonly grown in the county. Water runs off this soil at a medium to rapid rate. The hazard of erosion is moderately severe. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IIIe–2; woodland suitability group 1)

Nebish loam, 6 to 12 percent slopes, eroded (NeC2).—This soil is rolling. It is on morainic uplands. The areas vary in size and shape. Slopes are complex and 75 to 250 feet long. Moderate erosion, deep tillage, and the removal of trees have caused material from the subsoil to be mixed with the original surface layer. As a result, the present plow layer has a more brownish color and is less friable than the slightly eroded Nebish soils. The profile differs from the one described as representative for the series in being thinner and having a dark grayish-brown surface layer.

Included in mapping were small areas of Beltrami and Shooker soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, uneroded areas, and gravelly areas.

This soil is used for crops, woodland, and pasture. It is suited to all crops commonly grown in the county. Water runs off this soil at a medium to rapid rate. The hazard of erosion is moderately severe. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IIIe–2; woodland suitability group 1)

Nebish loam, 12 to 18 percent slopes (NeD).—This soil is hilly. It occurs on the morainic uplands. The areas vary in size and shape. Slopes are short and complex and 100 to 300 feet long. The profile differs from the one described as representative for the series in being thinner.

Included in mapping were small areas of Beltrami, Shooker, and Langhei soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, gravelly areas, and moderately eroded areas.

This soil is used for crops, woodland, and pasture. It is suited to all crops commonly grown in the county. Water runs off this soil at a rapid rate. The hazard of erosion is severe. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IVe–1; woodland suitability group 1)

Nebish loam, 18 to 24 percent slopes (NeE).—This soil is steep. It occurs on the morainic uplands mainly in areas along waterways and drainageways or surrounding sloughs and lakes. The areas vary in size and shape. Slopes are 100 to 300 feet long . The profile differs from the one described as representative for the series in being thinner.

Included in mapping were small areas of Langhei soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, eroded areas, and gravelly areas.

This soil is used for woodland and pasture. It is suited to permanent vegetation. Water runs off very rapidly. The hazard of erosion is very severe. The main management needs are practices that control erosion. (Capability unit VIe–1; woodland suitability group 1)

Nebish-Dorset complex, 2 to 6 percent slopes (NhB).—These soils are undulating. They occur on the morainic uplands. The areas vary in size and shape. Slopes are irregular, complex, and 75 to 250 feet long. Nebish soils make up about 60 to 80 percent of the areas, and Dorset soils, about 20 to 40 percent. Nebish soils are the very dark gray areas, and Dorset soils are the black to dark-gray areas, which are underlain by gravel. The Nebish and Dorset soils occur in such an intricate pattern that it is not practical to map them separately.

Included in mapping were small areas of Beltrami and Shooker soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, eroded spots, and areas that have many stones.

The soils in this complex are used for crops, woodland, and pasture. They are suited to all crops commonly grown in the county. Dorset soils are less well suited to crops than Nebish soils because of lower fertility and a drought hazard. Water runs off these soils at a medium rate. The hazard of erosion is moderate. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IIIe–3; Nebish part in woodland suitability group 1; Dorset part in woodland suitability group 6)

Nebish-Dorset complex, 6 to 12 percent slopes (NhC).—These soils are rolling. They occur on the morainic uplands. The areas vary in size and shape. Slopes are complex and 75 to 250 feet long. Nebish soils make up about 60 to 80 percent of the area, and Dorset soils, about 20 to 40 percent. Nebish soils are the very dark gray areas, and Dorset soils are the black to dark-gray areas that are underlain by gravel. The Nebish and Dorset soils occur in such an intricate pattern that it is not practical to map them separately.

Included in mapping were small areas of Beltrami and Shooker soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, eroded spots, and areas that have many stones.

These soils are used for crops, woodland, and pasture. They are suited to all crops commonly grown in the county. The Dorset soils are less well suited to crops than Nebish soils because of lower fertility and a drought hazard. Water runs off these soils at a medium to rapid rate. The hazard of erosion is moderately severe. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IVe–1; Nebish part in woodland suitability group 1; Dorset part in woodland suitability group 6)

Nicollet Series

The Nicollet series consists of deep, moderately well drained, nearly level to gently sloping soils. These soils formed under grasses in calcareous loam glacial till.

In a representative profile, the surface layer is clay loam, about 14 inches thick, that is black in the upper part and very dark gray in the lower part. The subsoil is dark grayish-brown clay loam about 14 inches thick. The underlying material is olive-brown and light olive-brown loam.

Nicollet soils have high natural fertility, available water capacity, and organic-matter content. Permeability is moderate. Reaction of the surface layer is neutral.

Nicollet soils are good farm soils. They are suited to all crops commonly grown in the county.

Representative profile of Nicollet clay loam, 1 to 4 percent slopes, in a cultivated field where the slope is 2 percent, 436 feet north and 230 feet east of the southwest corner, NW¼ sec. 15, T. 127 N., R. 36 W.

Ap—0 to 9 inches, black (10YR 2/1) clay loam; weak, medium and coarse, granular structure; friable; about 3 percent coarse fragments; neutral; abrupt, smooth boundary.

A3—9 to 14 inches, very dark gray (10YR 3/1) clay loam; black (10YR 2/1) coatings on faces of peds; weak, very fine, granular structure; friable; about 3 percent coarse fragments; neutral; clear, wavy boundary.

B21—14 to 23 inches, dark grayish-brown (2.5Y 4/2) clay loam; weak, coarse, subangular blocky structure parting to weak, fine and medium, subangular blocky; friable; few, thin, patchy clay films on faces of peds; common bleached sand grains; few black concretions; about 4 percent coarse fragments; neutral; gradual, smooth boundary.

B22—23 to 28 inches, dark grayish-brown (2.5Y 4/2) clay loam; common, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; weak, medium, subangular blocky structure; friable; few manganese concretions; about 4 percent coarse fragments; neutral; abrupt, wavy boundary.

C1—28 to 38 inches, olive-brown (2.5Y 4/4) loam; common, fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, fine, subangular blocky structure; friable; common, medium, distinct, light-gray (2.5Y 7/2) lime segregations and threads; about 4 percent coarse fragments; strongly effervescent; mildly alkaline; gradual, wavy boundary.

C2—38 to 60 inches, light olive-brown (2.5Y 5/4) loam; common, medium, distinct, strong-brown (7.5YR 5/6) mottles; weak, fine, subangular blocky structure; friable; common, medium, distinct, light-gray (2.5Y 7/2) lime segregations and threads; few black concretions; about 4 percent coarse fragments; strongly effervescent; mildly alkaline.

The A horizon is 10 to 16 inches thick. Its texture is loam or clay loam. The most common colors in the B horizon are dark grayish brown, grayish brown, olive brown, and light olive brown. The B horizon ranges from loam to clay loam in texture. The B22 horizon contains faint to distinct mottles. Depth to lime ranges from 22 to 34 inches.

The annual temperature of these soils is a few degrees cooler than the defined range for the series, but this difference does not alter their usefulness and behavior.

Nicollet soils are associated with Clarion, Flom, and Quam soils. They have a thicker A horizon and more olive colors in the B horizon than Clarion soils. They are better drained than Flom and Quam soils. They lack mottles in the upper part of the B horizon, which are characteristic of Flom soils.

Nicollet clay loam, 1 to 4 percent slopes (NlA).—The areas of this soil vary in size and shape. They have slightly convex slopes. This soil is in lower positions than Clarion soils and in slightly higher positions than Flom soils.

Included in mapping were small areas of Clarion, Flom, and Vallers soils. Also included were areas of a calcareous soil in some places on slight rises and, in some areas, spots of more strongly sloping soils and sandy spots.

This soil is well suited to crops, and there are few limitations to its use. All suited crops in the county can be grown. The main management needs are practices that maintain fertility and tilth. (Capability unit I–1; woodland suitability group 1)

Nymore Series

The Nymore series consists of deep, sandy, well-drained, undulating to rolling soils. These soils formed under grasses and trees in outwash sand.

In a representative profile, the surface layer is very dark brown loamy sand about 6 inches thick. The subsoil is about 20 inches thick. It is dark reddish-brown loamy sand in the upper 6 inches and dark-brown and yellowish-brown sand in the lower part. The underlying material is brown sand.

Nymore soils have low available water capacity, natural fertility, and organic-matter content. Permeability is rapid. Reaction of the surface layer is slightly acid.

The Nymore soils are droughty. Soil blowing is a hazard on unprotected fields. Some areas are wooded.

Representative profile of Nymore loamy sand, 2 to 6 percent slopes, where the slope is 2 percent, 700 feet south and 125 feet west of the northeast corner, NW¼ NE¼ sec. 17, T. 130 N., R. 36 W.

Ap—0 to 6 inches, very dark brown (10YR 2/2) loamy sand; massive; friable; slightly acid; abrupt, smooth boundary.

B21—6 to 12 inches, dark reddish-brown (5YR 3/4) loamy sand; massive; friable; slightly acid; clear, wavy boundary.

B22—12 to 18 inches, dark-brown (7.5YR 4/4) sand; single grain; loose; slightly acid; clear, wavy boundary.

B3—18 to 26 inches, yellowish-brown (10YR 5/4) sand; single grain; loose; medium acid; clear, wavy boundary.

C—26 to 60 inches, brown (10YR 5/3) sand; single grain; loose; neutral.

The A horizon is 3 to 7 inches thick. The most common colors in the B horizon are brown, dark brown, dark reddish brown, reddish brown, and yellowish brown. Depth to sand ranges from 10 to 20 inches.

Nymore soils are similar to Maddock and Sioux soils. They differ from Maddock soils in having a thinner A horizon and containing more medium and coarse sand throughout. They differ from Sioux soils in either lacking gravel or containing less gravel throughout.

Nymore loamy sand, 2 to 6 percent slopes (NyB).—This soil is undulating. It occurs in outwash areas and on uplands. The areas vary in size and shape. Slopes generally are complex and 50 to 200 feet long. This soil has the profile described as representative for the series.

Included in mapping were small areas of Maddock or Sioux soils. Also included were small areas of more strongly sloping soils, small areas of less sloping soils, and eroded areas.

This soil is used for cultivated crops, pasture, and woodland. Drought and low fertility are hazards. Soil blowing is a hazard on fields left unprotected during win-

ter and spring. The main management needs are practices that control erosion, improve fertility, and conserve moisture. (Capability unit IVs–1; woodland suitability group 7)

Nymore loamy sand, 6 to 18 percent slopes (NyC).—This soil is rolling. It occurs in outwash areas and on uplands. These areas vary in size and shape. Slopes are complex and 50 to 200 feet long. The profile differs from the one described as representative for the series in being thinner.

Included in mapping were small areas of Maddock and Sioux soils. Also included were small areas of less sloping soils and small areas of more strongly sloping soils.

This soil is used for cultivated crops, pasture, and woodland. If this soil is used for crops, drought is a hazard. There is also a severe hazard of soil blowing and water erosion on fields left unprotected during winter and spring. This soil is better suited to permanent vegetation. The main management needs are practices that control erosion, improve fertility, and conserve moisture. (Capability unit VIs–1; woodland suitability group 7)

Osakis Series

The Osakis series consists of moderately well drained, nearly level soils. These soils formed under grasses in loamy material. They are shallow to calcareous sand and gravel.

In a representative profile, the surface layer is black loam about 7 inches thick. The subsoil is about 11 inches thick. The upper part is very dark grayish-brown and dark-brown loam. The lower part is dark-brown gravelly loamy sand. The underlying material is dark grayish-brown, grayish-brown, dark brownish-gray, brown, and yellowish-brown gravelly coarse sand.

Osakis soils have low natural fertility and available water capacity and medium organic-matter content. Permeability is moderate above the coarse sand and gravel and rapid in the coarse sand and gravel. Reaction of the surface layer is slightly acid.

Osakis soils are suited to all crops common in the county, but crop growth is often reduced by drought.

Representative profile of Osakis loam, 0 to 3 percent slopes, in a cultivated field where the slope is 1 percent, 802 feet south and 83 feet east of the northwest corner, NE¼ sec. 28, T. 127 N., R. 37 W.

Ap—0 to 7 inches, black (10YR 2/1) loam; weak, fine, granular structure; friable; few bleached sand grains; slightly acid; abrupt, smooth boundary.

B2—7 to 14 inches, very dark grayish-brown (10YR 3/2) and dark-brown (10YR 3/3) loam; few, fine, faint, dark yellowish-brown (10YR 4/4) mottles and few, fine, distinct, dark reddish-brown (5YR 3/3) mottles; moderate, medium and coarse, subangular blocky structure; friable; few black tongues; slightly acid; abrupt, wavy boundary.

IIB3—14 to 18 inches, dark-brown (10YR 3/3) gravelly loamy sand; common, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; weak, medium, subangular blocky structure; very friable; few, soft, black concretions; neutral; abrupt, wavy boundary.

IIC1—18 to 23 inches, dark grayish-brown (2.5Y 4/2), grayish-brown (2.5Y 5/2), brown (7.5YR 4/4), and yellowish-brown (10YR 5/8) gravelly coarse sand; single grain; loose; few coatings of lime on pebbles; strongly effervescent; mildly alkaline; gradual, wavy boundary.

IIC2—23 to 60 inches, dark brownish-gray (2.5Y 4/2), grayish-brown (2.5Y 5/2), brown (7.5YR 4/4), and yellowish-brown (10YR 5/8) gravelly coarse sand; single grain; loose; strongly effervescent; mildly alkaline.

The A horizon is loam or sandy loam that ranges from 6 to 14 inches thick. The B2 horizon is loam or sandy loam, and the IIB3 horizon is gravelly loamy sand or gravelly sandy loam. The B horizon is commonly very dark grayish brown, dark grayish brown, dark brown, or olive brown. Depth to the IIC1 horizon ranges from 14 to 22 inches.

Osakis soils are associated with Arvilla, Forada, and Hangaard soils. They differ from Arvilla soils in having mottles in the B horizon. They are better drained than Forada and Hangaard soils and are browner in most of the B horizon.

Osakis loam, 0 to 3 percent slopes (OsA).—This soil occurs on the outwash plains of the county. Areas are variable in size and shape. This soil generally occurs next to areas of Arvilla soils.

Included in mapping were small areas of Arvilla and Forada soils. Also included were small areas of more strongly sloping soils, areas where depth to gravel is more than 22 inches, and areas that are underlain by sand.

Nearly all of this soil is used for cultivated crops. A few small areas are used for pasture. This soil is suited to all crops commonly grown in the county, but it is better suited to early maturing crops because of the drought hazard. Soil blowing is a hazard on fields left unprotected in winter and spring. This soil is suited to irrigation, and field crops and vegetables can be irrigated. The main management needs are practices that control erosion, conserve moisture, and maintain fertility. (Capability unit IIIe–3; woodland suitability group 6)

Quam Series

The Quam series consists of deep, very poorly drained, nearly level soils that are in sloughs, potholes, and depressions. These soils formed under marsh grasses and cattails in water-sorted sediments derived from local drift.

In a representative profile, the surface layer is black and about 36 inches thick. The upper 8 inches is mucky silty clay loam, and the rest is silty clay loam. The underlying material is olive-gray silty clay loam and clay loam glacial till.

Quam soils have high natural fertility, organic-matter content, and available water capacity. Permeability is moderately slow. Reaction of the surface layer is neutral.

Drainage is needed before these soils can be used for crops. Undrained areas are marshy.

Representative profile of Quam mucky silty clay loam, in an undrained depression, 910 feet north and 85 feet east of the southwest corner, NW¼ sec. 15, T. 128 N., R. 40 W.

A11—0 to 8 inches, black (N 2/0) mucky silty clay loam; weak, very fine, granular structure; nonsticky; many roots; neutral; abrupt, smooth boundary.

A12—8 to 12 inches, black (N 2/0) silty clay loam; weak, very fine, granular structure; slightly sticky; common roots; neutral; abrupt, smooth boundary.

A13—12 to 18 inches, black (N 2/0) silty clay loam; weak, fine, subangular blocky structure; sticky; neutral; gradual, wavy boundary.

A14—18 to 36 inches, black (10YR 2/1) silty clay loam; few, medium, faint, very dark brown (10YR 2/2) mottles; moderate, fine and medium, subangular blocky structure; sticky; neutral; gradual, irregular boundary.

C1g—36 to 38 inches, olive-gray (5Y 5/2) silty clay loam; common, medium, prominent, strong-brown (7.5YR 5/6) and olive (5Y 5/3) mottles; massive; slightly sticky; neutral; abrupt, wavy boundary.

IIC2g—38 to 60 inches, olive-gray (5Y 5/2) clay loam; common, fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, fine, subangular blocky structure; slightly sticky; few light-gray (10YR 7/1) lime threads; about 5 percent coarse fragments; strongly effervescent; mildly alkaline.

The A11 horizon is mucky silt loam or mucky silty clay loam. The rest of the A horizon is silt loam or silty clay loam. The A horizon ranges from 24 to 50 inches in thickness. Depth to lime ranges from 30 to 65 inches. Some areas have a layer of peat up to 6 inches thick on the surface. The C horizon ranges from loam or clay loam to silt loam or silty clay loam.

Quam soils are associated with Barnes, Flom, and Waukon soils. They are more poorly drained and have a thicker A horizon than any of those soils.

Quam mucky silty clay loam (0 to 2 percent slopes) (Qu).—This soil occupies circular or oblong depressions and potholes that are variable in size. All soil areas are flooded in spring, and most areas are flooded throughout the entire year.

Included in mapping were small areas of Vallers, Urness, and Cathro soils, areas where the soil does not have a mucky surface layer, and areas where the black soil material is more than 48 inches thick. A few areas that are calcareous throughout the profile are shown on the map by spot symbols.

If undrained, this soil is covered with marsh vegetation that consists of sedges, reeds, rushes, or willows. The undrained areas are well suited as wildlife habitat. They provide food, cover, and nesting for waterfowl, furbearers, and upland game. Many of these areas can be improved for wildlife habitat by exposing or creating additional areas of open water. If drained, this soil is used for crops, pasture, and hay, depending on the kind of drainage system installed. If adequately drained, this soil is suited to all crops commonly grown in the county. Small grains tend to lodge, and corn and soybeans may not reach maturity every year. This soil may be drained by open ditches or tile. The main management needs are drainage and maintenance of fertility and tilth. (Capability unit IIIw–1; woodland suitability group 4)

Rifle Series

The Rifle series consists of very poorly drained, organic soils. These soils formed in dead-plant tissue derived from sedges, rushes, cattails, and marsh grass. They are in sloughs, potholes, and drainageways.

In a representative profile, the surface layer is black muck about 3 inches thick. The underlying material is very dark grayish-brown and dark yellowish-brown mucky peat.

Rifle soils have low natural fertility and very high available water capacity. Reaction of the surface layer is neutral.

Rifle soils are used for crops, pasture, and wildlife habitat. If these soils are drained, they are suited to all crops commonly grown in the county.

Representative profile of Rifle mucky peat, 310 feet south and 105 feet east of the northwest corner, SW¼ sec. 1, T. 130 N., R. 38 W.

Oa—0 to 3 inches, black (10YR 2/1, rubbed) sapric material; 10 percent fiber, 5 percent rubbed; weak, fine, granular structure; nonsticky; slightly effervescent; neutral; clear, smooth boundary.

Oe—3 to 68 inches, hemic material that has a very dark grayish-brown (10YR 3/2) matrix and dark yellowish-brown (10YR 4/4) fibers; about 65 percent fiber, about 35 percent rubbed; massive, nonsticky; neutral.

The organic material is more than 51 inches thick, but a mineral substratum commonly occurs within a depth of 12 feet. The organic material is derived primarily from herbaceous plants. The upper 12 inches is sapric material, hemic material, or a mixture of the two. Hemic material is dominant at depths between 12 and 51 inches, but in some areas there are thin layers of sapric or fibric material at that depth. The total thickness of each of these layers, whether sapric or fibric material, is less than 10 inches. In some areas, there are layers that consist mostly of hypnum moss at that depth. The hemic material ranges from very dark grayish brown or dark grayish brown to brown, dark brown, or dark yellowish brown in color. Reaction typically is neutral but ranges to slightly acid or mildly alkaline.

Rifle soils are similar to Seelyeville and Cathro soils. They differ from Seelyeville soils in having formed in hemic material rather than sapric material. They differ from Cathro soils in having organic soil material to a depth of more than 51 inches.

Rifle mucky peat (Rm).—This soil is nearly level. It occupies depressions, potholes, and drainageways that vary in size and shape. All soil areas are flooded in spring, and most areas are flooded or wet throughout the year.

Included in mapping were small areas of Cathro soils and the sandy subsoil variant of Cathro soils. Also included were small areas that are calcareous.

Most areas are undrained and are covered with marsh vegetation that consists of sedges, rushes, reeds, and, in some areas, willows. These areas are well suited as wildlife habitat. They provide food and cover for furbearers and upland game. If drained, this soil is used for hay or pasture, and, in a few areas, for crops. If adequately drained, it is suited to all the crops commonly grown in the county, but small grains often lodge and corn and soybeans may not reach maturity. Soil blowing is a hazard. (Capability unit IVw–2; woodland suitability group 8)

Rothsay Series

The Rothsay series consists of deep, undulating, well-drained, silty soils. These soils formed under grasses in calcareous, silty material. They are free from stones.

In a representative profile, the surface layer is black silt loam about 7 inches thick. The subsoil is silt loam about 15 inches thick. The upper part is very dark brown and dark grayish brown, the middle part is dark yellowish brown, and the lower part is olive brown. The underlying material is light olive-brown and olive-brown silt loam.

Rothsay soils have high natural fertility and organic-matter content and very high available water capacity. Permeability is moderate. Reaction of the surface layer is neutral.

These soils can be worked easily and are suited to all crops commonly grown in the county.

Representative profile of Rothsay silt loam, 2 to 6 percent slopes, in a cultivated field where the slope is 4

percent, 975 feet east and 30 feet north of the southwest corner of sec. 18, T. 130 N., R. 40 W.

Ap—0 to 7 inches, black (10YR 2/1) silt loam; weak, fine, granular structure; friable; neutral; abrupt, smooth boundary.
B21—7 to 11 inches, very dark brown (10YR 2/2) silt loam grading with depth to dark grayish brown (10YR 4/2); weak, coarse, prismatic structure parting to weak, medium, subangular blocky; friable; neutral; gradual, smooth boundary.
B22—11 to 18 inches, dark yellowish-brown (10YR 4/4) silt loam; weak, coarse, subangular blocky structure; very friable; neutral; abrupt, smooth boundary.
B3—18 to 22 inches, olive-brown (2.5Y 4/4) silt loam; massive; friable; slightly effervescent; neutral; gradual, smooth boundary.
C1—22 to 30 inches, light olive-brown (2.5Y 5/4) silt loam; massive; friable; strongly effervescent; mildly alkaline; gradual, smooth boundary.
C2—30 to 36 inches, olive-brown (2.5Y 4/4) silt loam; massive; friable; few light brownish-gray (2.5Y 6/2) limy strata; strongly effervescent; mildly alkaline; gradual, smooth boundary.
C3—36 to 60 inches, olive-brown (2.5Y 4/4) and light olive-brown (2.5Y 5/6) silt loam; massive; friable; few light brownish-gray (2.5Y 6/2) limy strata; strongly effervescent; mildly alkaline.

The A horizon is 5 to 12 inches thick. The B horizon commonly is very dark brown, very dark grayish brown, dark grayish brown, dark brown, brown, dark yellowish brown, olive brown, and light olive brown. Depth to the C horizon range from 15 to 30 inches.

Rothsay soils are associated with Zell and Hantho soils. They differ from Zell soils in having a thicker solum. They differ from Hantho soils in being better drained and from the similar Barnes soils in containing less sand throughout.

Rothsay silt loam, 2 to 6 percent slopes (RoB).—This soil is gently sloping and undulating. The areas are variable in size and shape. Slopes are 50 to 200 feet long.

Included in mapping were small areas of Zell and Hantho soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, and areas that are moderately eroded.

Nearly all the acreage is used for cultivated crops. A few small areas are in pasture. This soil is suited to all crops commonly grown in the county. Water runs off this soil at a medium rate. The hazard of erosion is moderate. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IIe–1; woodland suitability group 1)

Seelyeville Series

The Seelyeville series consists of very poorly drained, organic soils. These soils formed in plant tissue derived from sedges, rushes, cattails, and marsh grass. They are in sloughs and potholes.

In a representative profile, the surface layer is black muck about 7 inches thick. Below this, to a depth of 60 inches, is black muck that contains very dark grayish-brown fibers.

Seelyeville soils have low natural fertility and very high available water capacity. Reaction of the surface layer is neutral.

Seelyeville soils are used for crops, pasture, and wildlife habitat. If these soils are drained, they are suited to all crops commonly grown in the county.

Representative profile of Seelyeville muck, 810 feet east and 100 feet north of the southeast corner, SW¼ sec. 25, T. 130 N., R. 37 W.

Oa1—0 to 7 inches, black (10YR 2/1, broken face and rubbed) sapric material; less than 3 percent fiber, rubbed; massive; nonsticky; neutral; gradual, wavy boundary.
Oa2—7 to 60 inches, black (10YR 2/1, rubbed) sapric material; very dark grayish-brown (10YR 3/2) fibers; about 30 percent fiber, about 10 percent rubbed; herbaceous fiber; massive; nonsticky; neutral.

The organic deposits are more than 51 inches thick. Depth to the mineral substratum is commonly less than 10 feet. Sapric material is dominant to a depth of at least 51 inches, but some areas contain a layer or layers of hemic material that has a total thickness of less than 10 inches. Reaction is neutral to mildly alkaline. The organic soil material typically either is massive or has weak platy structure, but in some areas the upper 16 inches or less has weak granular structure.

Seelyeville soils are similar to Rifle and Cathro soils. They differ from Rifle soils in having formed in sapric material rather than hemic material. They differ from Cathro soils in having organic soil material that extends to a depth of more than 51 inches.

Seelyeville muck (0 to 1 percent slopes) (Se).—This nearly level soil occupies depressions, potholes, and drainageways that vary in size and shape, All soil areas are flooded in spring, and most areas are flooded or wet throughout the year.

Included in mapping were small areas of Cathro and Rifle soils. Also included were small areas that are calcareous.

Most areas are undrained and are covered with marsh vegetation that consists of sedges, rushes, reeds, and, in some areas, willows. These areas are well suited as wildlife habitat. They provide food and cover for furbearers and upland game. If drained, this soil is used for hay and pasture and a few areas are used for crops. If adequately drained, this soil is suited to all crops commonly grown in the county, but small grains often lodge and corn and soybeans may not reach maturity. Soil blowing is a hazard on bare fields. (Capability unit IVw–2; woodland suitability group 8)

Shooker Series

The Shooker series consists of poorly drained, nearly level soils. These soils formed under deciduous forest in calcareous loam glacial till.

In a representative profile, the surface layer is black loam about 3 inches thick. The subsurface layer is loam about 9 inches thick. The upper part is dark grayish brown, and the lower part is grayish brown. The subsoil is about 24 inches thick. The upper part is olive-brown loam, and the middle part is grayish-brown sandy clay loam, and the lower part is grayish-brown heavy fine sandy loam. The underlying material is light olive-brown heavy fine sandy loam.

Shooker soils have medium natural fertility and organic-matter content and medium to high available water capacity. Permeability is moderate. Reaction of the surface layer is slightly acid.

If adequately drained, fertilized, and managed, Shooker soils are suited to all crops commonly grown in the county. Some of the areas are wooded.

Representative profile of Shooker loam, where the slope is 1 percent, 100 feet north and 300 feet east of the southwest corner, sec. 7, T. 129 N., R. 37 W.

O—1 inch to 0, duff and litter.
A1—0 to 3 inches, black (10YR 2/1) loam; weak, fine, granular structure; friable; common roots; about 5 percent coarse fragments; medium acid; abrupt, smooth boundary.
A21—3 to 8 inches, dark grayish-brown (10YR 4/2) loam; few, fine, distinct, dark-brown (7.5YR 4/4) mottles; weak, thin and medium, platy structure; friable; common roots; about 5 percent coarse fragments; medium acid; clear, irregular boundary.
A22—8 to 12 inches, grayish-brown (2.5Y 5/2) loam; few, fine, distinct, dark-brown (7.5YR 4/4) mottles; weak, fine, subangular blocky structure; friable; about 5 percent fragments; medium acid; few roots; gradual, wavy boundary.
B21t—12 to 16 inches, olive-brown (2.5Y 4/3) loam; common, fine, distinct, dark-brown (7.5YR 4/4) mottles and few, fine, distinct, yellowish-brown (10YR 5/6) mottles; moderate, fine and medium, subangular blocky structure; firm; many, thin, very dark grayish-brown (2.5Y 3/2) clay films and common, thin, porous, dark grayish-brown (2.5Y 4/2) coatings on faces of peds; about 5 percent coarse fragments; medium acid; clear, wavy boundary.
B22tg—16 to 24 inches, grayish-brown (2.5Y 5/2) sandy clay loam; common, fine, distinct, yellowish-brown (10YR 5/6) mottles; moderate, fine and medium, subangular blocky structure; firm; sticky; many, thin and medium, very dark grayish-brown (2.5Y 3/2) and dark grayish-brown (2.5Y 4/2) clay films on faces of peds; few, fine, dark-colored concretions; about 5 percent coarse fragments; medium acid; gradual, wavy boundary.
B3tg—24 to 36 inches, grayish-brown (2.5Y 5/2) heavy fine sandy loam; common, medium, distinct, yellowish-brown (10YR 5/6) mottles; weak, fine and medium, subangular blocky structure; friable; few, thin, very dark grayish-brown (2.5Y 3/2) clay films on faces of peds; about 5 percent coarse fragments; slightly acid; abrupt, wavy boundary.
C—36 to 60 inches, light olive-brown (2.5Y 5/4) heavy fine sandy loam; many, medium, distinct, yellowish-brown (10YR 5/6) mottles; massive; friable; many lime threads; strongly effervescent; mildly alkaline.

The A1 horizon is black or very dark gray and 1 to 4 inches thick. The A2 horizon is 4 to 11 inches thick and is gray or grayish brown to dark grayish brown or dark gray in color. The A horizon is loam, sandy loam, fine sandy loam, or silt loam. The B horizon is loam, heavy sandy loam, heavy fine sandy loam, clay loam, or sandy clay loam and typically has colors of dark grayish brown, grayish brown, olive brown, and olive. Depth to lime in the C horizon ranges from 20 to 44 inches but typically is 28 to 40 inches.

Shooker soils are associated with Nebish and Beltrami soils. They differ from those soils in being more poorly drained and in having grayer colors in most of the B horizon. They differ from the similar Tonka soils in having a thinner A1 horizon and less clay in the B horizon.

Shooker loam (0 to 1 percent slopes) (Sh).—This soil occurs on the till plains and morainic uplands in shallow draws and on level flats. It is among areas of well drained Nebish soils and moderately well drained Beltrami soils.

Included in mapping were small areas of Beltrami soils. Also included were areas of soils that have a sandy loam surface layer.

This poorly drained soil requires additional drainage. Open ditches provide adequate drainage in most years. This soil is suited to all crops commonly grown in the county. The main management needs are drainage and maintenance of fertility and tilth. (Capability unit IIw–1; woodland suitability group 4)

Sinai Series

The Sinai series consists of deep, moderately well drained, nearly level to undulating soils. These soils formed under grasses in calcareous, silty clay or clay glacial lacustrine material.

In a representative profile, the surface layer is black clay about 22 inches thick. The subsoil is dark grayish-brown clay about 4 inches thick. The underlying material is olive-gray clay.

Sinai soils have high natural fertility and organic-matter content. The available water capacity is low to medium. Permeability is very slow. Reaction of the surface layer is neutral.

Unless a high level of organic matter is maintained and good management is used to prevent excessive compaction, Sinai soils are difficult to work.

Representative profile of Sinai clay, 2 to 6 percent slopes, in a cultivated field where the slope is 4 percent, 580 feet west and 20 feet north of the northeast corner, SE¼ sec. 32, T. 129 N., R. 39 W.

Ap—0 to 6 inches, black (N 2/0) clay; moderate; very fine, granular structure; sticky; few roots; neutral; abrupt, smooth boundary.
A11—6 to 14 inches, black (N 2/0) clay; moderate, very fine, granular structure; sticky; few roots; neutral; clear, wavy boundary.
A12—14 to 22 inches, black (5Y 2/1) clay; strong, fine and medium, subangular blocky structure; sticky; neutral; gradual, wavy boundary.
B2—22 to 26 inches, dark grayish-brown (2.5Y 4/2) clay; strong, fine and medium, subangular blocky structure; sticky; mildly alkaline; clear, wavy boundary.
C—26 to 60 inches, olive-gray (5Y 5/2) clay; moderate, fine, subangular blocky structure; sticky; strongly effervescent; mildly alkaline.

The A horizon is silty clay, clay, or silty clay loam. It ranges from 16 to 24 inches in thickness. The B horizon is silty clay, silty clay loam, or clay. It is typically very dark grayish brown, dark grayish brown, olive brown, or light olive brown. The structure is moderate to strong, prismatic or subangular blocky. Tongues of material from the A horizon extend into the B horizon in some areas. Depth to the C horizon is 18 to 32 inches. The C horizon is calcareous silty clay or clay.

Sinai soils are associated with Fulda and Dovray soils. They are better drained than Dovray and Fulda soils, which occur in draws and potholes, and they are browner below the A horizon. They have a thinner A horizon than Dovray soils.

Sinai clay, 0 to 2 percent slopes (SlA).—This soil is nearly level. It occurs in scattered areas throughout the county adjacent to drainageways and flat hilltops. The profile differs from the one described as representative for the series in being thicker.

Included in mapping were small areas of Dovray and Fulda soils. Also included were small areas of more strongly sloping soils.

Nearly all the acreage is used for cultivated crops. A few areas are in pasture. This soil is suited to all crops commonly grown in the county. This soil is sticky when wet and hard when dry. Soil blowing is a hazard on unprotected fields during winter and spring. The main management needs are practices that control erosion and improve fertility and tilth. (Capability unit IIe–3; woodland suitability group 1)

Sinai clay, 2 to 6 percent slopes (SlB).—This soil is gently sloping and undulating. It has slopes that are fairly uniform and 100 to 350 feet long. It lies in areas

that break away from nearly level Sinai soils and in sloping areas that break away from Fulda or Dovray soils. This soil has the profile described as representative for the series.

Included in mapping were small areas of Dovray and Fulda soils and soils that are lighter colored and are calcareous to the surface. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, and areas that are moderately eroded.

Nearly all the acreage is used for cultivated crops. A few areas are in pasture. This soil is suited to all crops commonly grown in the county. This soil is sticky when wet and hard when dry. Water runs off at a moderate rate. The hazard of erosion is moderate. The main management needs are practices that control erosion and improve fertility and tilth. (Capability unit IIe–3; woodland suitability group 1)

Sioux Series

The Sioux series consists of excessively drained, nearly level to very steep, sandy soils. These soils formed under grasses in areas of stream and glacial outwash. They are very shallow to calcareous sand and gravel. They are droughty.

In a representative profile, the surface layer is about 11 inches thick. The upper 9 inches is very dark brown loamy coarse sand, and the lower 2 inches is very dark grayish-brown gravelly loamy coarse sand. The underlying material is yellowish-brown gravelly coarse sand.

Sioux soils have low organic-matter content, very low natural fertility, and very low to low available water capacity. Permeability is very rapid. Reaction of the surface layer is neutral.

These soils are a good source of gravel.

Representative profile of Sioux loamy coarse sand, 0 to 6 percent slopes, in a wildlife area where the slope is 5 percent, NE¼NW¼NE¼ sec. 12, T. 130 N., R. 39 W.

Ap—0 to 9 inches, very dark brown (10YR 2/2) loamy coarse sand; weak, fine, granular structure; very friable; plentiful roots; neutral; abrupt, smooth boundary.

AC—9 to 11 inches, very dark grayish-brown (10YR 3/2) gravelly loamy coarse sand; single grain; loose; many roots; slightly effervescent; neutral; clear, smooth boundary.

IIC—11 to 60 inches, yellowish-brown (10YR 5/6) gravelly coarse sand; single grain; loose; strongly effervescent; mildly alkaline.

The A horizon has a texture of loamy coarse sand or gravelly loamy coarse sand. Its thickness ranges from 4 to 12 inches. It is black, very dark brown, very dark grayish brown, or very dark gray and neutral to mildly alkaline. The content of gravel in the IIC horizon ranges from about 35 to 60 percent.

Sioux soils are associated with Arvilla and Dorset soils. They differ from these soils in having a thinner solum.

Sioux loamy coarse sand, 0 to 6 percent slopes (SmB).—This soil is nearly level to undulating. It occurs in outwash areas and on uplands. The areas are variable in size and shape. Slopes are 50 to 200 feet long. This soil has the profile described as representative for the series.

Included in mapping were small areas of Arvilla soils and Sioux gravelly loamy coarse sand. Also included were small areas of more strongly sloping soils.

This soil is used for cultivated crops, pasture, and woodland. It is poorly suited to crops commonly grown in the county because the hazard of drought is severe. There is a hazard of soil blowing on unprotected fields. The main management needs are practices that control erosion, improve fertility, and conserve moisture. (Capability unit IVs–2; woodland suitability group 7)

Sioux loamy coarse sand, 6 to 12 percent slopes (SmC).—This soil is rolling. It occurs in outwash areas and on uplands. The areas are variable in size and shape. Slopes are 50 to 200 feet long. The profile differs from the one described as representative for the series in being more shallow to gravel.

Included in mapping were small areas of Arvilla soils and Sioux gravelly loamy coarse sand. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, and areas that are stony on the surface.

This soil is used for cultivated crops, pasture, and woodland. It is poorly suited to crops commonly grown in the county because the hazard of drought is severe. Soil blowing and water erosion are hazards on unprotected fields. The main management needs are practices that control erosion, improve fertility, and conserve moisture. (Capability unit IVs–2; woodland suitability group 7)

Sioux gravelly loamy coarse sand, 2 to 12 percent slopes (SoC).—This soil is gently sloping to rolling. It occurs in outwash areas and on uplands. The areas are variable in size and shape. Slopes are 50 to 200 feet long. The profile differs from the one described as representative for the series in having a surface layer of gravelly loamy coarse sand.

Included in mapping were small areas of Arvilla soils and Sioux loamy coarse sand. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, and areas that are stony on the surface.

This soil is used for pasture and woodland. Some areas are cropped along with other soils, because these areas are too small to manage separately. This soil is suited to permanent vegetation. The hazard of drought is severe. Soil blowing and water erosion are hazards on unprotected fields. The main management needs are practices that control erosion, improve fertility, and conserve moisture. (Capability unit VIs–1; woodland suitability group 7)

Sioux gravelly loamy coarse sand, 12 to 35 percent slopes (SoE).—This soil is hilly to very steep. It occurs in outwash and morainic upland areas. The areas are irregular in size and shape. They are cut up by many drainageways. Slopes are 80 to 250 feet long. The profile differs from the one described as representative for the series in having a surface layer of gravelly loamy coarse sand.

Included in mapping were small areas of Sioux loamy coarse sand and areas where there are many surface stones.

Most areas are in permanent vegetation. Plants do not grow well, because of very low available water capacity. The hazards of soil blowing and water erosion are severe. The main management needs are practices that control erosion and conserve moisture. (Capability unit VIIs–1; woodland suitability group 7)

Sverdrup Series

The Sverdrup series consists of deep, somewhat excessively drained, nearly level to rolling soils. These soils formed under grass vegetation.

In a representative profile, the surface layer is black sandy loam about 8 inches thick. The subsoil is about 12 inches thick. The upper 6 inches is brown sandy loam, and the lower 6 inches is dark yellowish-brown loamy coarse sand. The underlying material is brown, yellowish-brown, and pale-brown sand.

Sverdrup soils have low to medium available water capacity, medium to high natural fertility, and medium to high organic-matter content. Permeability is moderately rapid in the sandy loam and rapid in the sand. Reaction of the surface layer is neutral.

Sverdrup soils are droughy and consequently are better suited to crops that mature early and have low moisture requirements than to other crops.

Representative profile of Sverdrup sandy loam, 0 to 2 percent slopes, where the slope is 1 percent, 840 feet east and 180 feet south of the northwest corner, NE¼ sec. 14, T. 127 N., R. 37 W.

Ap—0 to 8 inches, black (10YR 2/1) sandy loam; weak, very fine, granular structure; very friable; few roots; few bleached sand grains; neutral; abrupt, smooth boundary.

B21—8 to 14 inches, brown (10YR 4/3) sandy loam; weak, medium, subangular blocky structure; very friable; very few roots; neutral; clear, wavy boundary.

B22—14 to 20 inches, dark yellowish-brown (10YR 3/4) loamy coarse sand; weak, medium, subangular blocky structure; very friable; very few roots; neutral; clear, wavy boundary.

IIC1—20 to 25 inches, brown (10YR 4/3) sand; single grain; loose; neutral; abrupt, wavy boundary.

IIC2—25 to 31 inches, yellowish-brown (10YR 5/4) sand; single grain; loose; slightly effervescent; mildly alkaline; gradual, wavy boundary.

IIC3—31 to 60 inches, pale-brown (10YR 6/3) sand; single grain; loose; strongly effervescent; mildly alkaline.

The A horizon is black or very dark brown and 8 to 14 inches thick. The B horizon is dark brown, brown, or dark yellowish brown. It ranges from sandy loam or loam in the upper part to loamy fine sand, loamy sand, or loamy coarse sand in the lower part. It is neutral to slightly acid. Depth to the IIC horizon ranges from 16 to 22 inches. Depth to lime ranges from 20 to 40 inches.

Sverdrup sandy loam, thick solum, has a thicker sandy loam or loam B horizon and has the IIC horizon at a depth of 22 to 36 inches. This soil is outside the defined range of the series because of these features, but these differences do not alter its usefulness or behavior.

Sverdrup soils are associated with Clontarf, Dassel, Maddock, and Arvilla soils. They differ from Clontarf and Dassel soils in being better drained and in having a browner B horizon and from Arvilla soils in being underlain by sand instead of by sand and gravel. They differ from Maddock soils in containing more clay in the B horizon.

Sverdrup sandy loam, 0 to 2 percent slopes (SpA).—Areas of this soil vary in size and shape. Some of the areas are extensive and occur on broad outwash plains. This soil has the profile described as representative for the series.

Included in mapping were small areas of Maddock, Clontarf, Arvilla, and Dassel soils. Also included were small areas of more strongly sloping soils, eroded areas, and sandy areas.

Nearly all this soil is used for cultivated crops. A few areas are in pasture. This soil is suited to all crops commonly grown in the county. It is better suited to early maturing crops than to other crops because of the drought hazard. Soil blowing is a hazard on fields left unprotected during winter and spring. This soil is suited to irrigation, and field crops and vegetables can be irrigated. The main management needs are practices that control erosion, conserve moisture, and maintain fertility. (Capability unit IIIe–4; woodland suitability group 6)

Sverdrup sandy loam, 2 to 6 percent slopes (SpB).—This soil is on the outwash plains along waterways and surrounding depressions. The areas vary in size and shape. Slopes are fairly uniform and 50 to 150 feet long. The profile differs from the one described as representative for the series in being more shallow to sand.

Included in mapping were small areas of Arvilla, Clontarf, and Maddock soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, and eroded areas. Other inclusions were areas where the surface layer is loam and areas where the depth to sand is more than 22 inches.

Nearly all this soil is used for cultivated crops. A few areas are in pasture. All crops common in the county can be grown. This soil is better suited to early maturing crops than to other crops because of the drought hazard. Soil blowing is a hazard on unprotected fields during winter and spring. Water erosion is also a hazard. This soil is suited to irrigation, and field crops and vegetables can be irrigated. The main management needs are practices that control erosion, conserve moisture, and maintain fertility. (Capability unit IIIe–4; woodland suitability group 6)

Sverdrup sandy loam, 6 to 12 percent slopes (SpC).—This soil is sloping and rolling. It occurs on outwash plains and uplands. The areas vary in size and shape; some are fairly uniform along waterways and drainageways and surrounding the sloughs. The profile differs from the one described as representative for the series in being more shallow to sand.

Included in mapping were small areas of Arvilla, Clontarf, and Maddock soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, and areas that are moderately eroded.

Nearly all the acreage is used for cultivated crops. A few areas are in pasture. All crops common in the county can be grown. This soil is better suited to early maturing crops than to other crops because of the severe drought hazard. Water runs off this soil at a medium to rapid rate, and the hazard of erosion is moderately severe. There is also a hazard of soil blowing on unprotected fields. The main management needs are practices that control erosion, improve fertility, and conserve moisture. (Capability unit IVe–2; woodland suitability group 6)

Sverdrup loam, thick solum, 0 to 3 percent slopes (SvA).—This soil is on outwash plains. The areas are variable in size and shape, and a few areas are quite large. The profile differs from the one described as representative for the series in being 22 to 36 inches deep to sand.

Included in mapping were small areas of well drained Sverdrup soils, moderately well drained Clontarf soils, and poorly drained Dassel soils. Also included were small areas of more strongly sloping soils.

Nearly all the acreage is used for cultivated crops. A few small areas are in pasture. Drought is a hazard during prolonged dry periods. Soil blowing is also a hazard on bare fields during winter and spring. This soil is suited to irrigation, and field crops and vegetables can be irrigated. The main management needs are practices that control erosion, improve fertility, and conserve moisture. (Capability unit IIe–4; woodland suitability group 6)

Tonka Series

The Tonka series consists of deep, poorly drained, nearly level soils that occur in shallow depressions, drainageways, and swales. These soils formed under grass vegetation in calcareous loam glacial till.

In a representative profile, the surface layer is black loam about 13 inches thick. The subsurface layer is grayish-brown loam about 3 inches thick. The subsoil is olive-gray clay loam about 21 inches thick. The underlying material is olive-gray loam.

Tonka soils have medium natural fertility and high organic-matter content and high available water capacity. Permeability is moderate. Reaction of the surface layer is slightly acid. If adequately drained, fertilized, and managed, Tonka soils are suited to all crops commonly grown in the county. Most of the areas are too small and too irregular to be farmed separately.

Representative profile of Tonka loam, in a nearly level cultivated field, 410 feet south and 186 feet west of the northeast corner, NW¼ sec. 11, T. 128 N., R. 37 W.

Ap—0 to 8 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; weak, fine, granular structure; very friable; common roots; slightly acid; abrupt, smooth boundary.

A1—8 to 13 inches, black (10YR 2/1) loam; weak, medium, granular structure; very friable; few bleached sand grains; few spots of grayish-brown (2.5Y 5/2) material; common roots; slightly acid; abrupt, wavy boundary.

A2—13 to 16 inches, grayish-brown (2.5Y 5/2) loam, white (10YR 8/1) when dry; few, fine, distinct, light olive-brown (2.5Y 5/6) mottles; weak, thick, platy structure; friable; common roots; slightly acid; clear, wavy boundary.

B21t—16 to 23 inches, olive-gray (5Y 4/2) heavy clay loam; common, fine, prominent, reddish-brown (5YR 4/4) mottles; moderate, fine and medium, subangular blocky structure; friable; few thin clay films and grayish porous coatings on faces of peds; about 2 percent coarse fragments; common roots; neutral; gradual, wavy boundary.

B22tg—23 to 30 inches, olive-gray (5Y 5/2) clay loam; common, fine, prominent, dark reddish-brown (5YR 3/4) mottles; moderate, fine and medium, subangular blocky structure; friable; many, medium, very dark brown (10YR 2/2) clay films on faces of peds; about 4 percent coarse fragments; few roots; neutral; gradual, wavy boundary.

B23tg—30 to 37 inches, olive-gray (5Y 5/2) clay loam; common, fine, distinct, dark-brown (7.5YR 3/2) mottles; moderate, medium, subangular blocky structure; firm; common, thin, gray (5Y 5/1) clay films and few thin porous coatings on faces of peds; about 4 percent coarse fragments; few roots; neutral; gradual, wavy boundary.

Cg—37 to 60 inches, olive-gray (5Y 5/2) loam; many, fine, prominent, dark reddish-brown (5YR 3/4) mottles; weak, fine, subangular blocky structure; friable; few roots; neutral.

The Ap and A1 horizons are black or very dark gray loam or silt loam. They range from 6 to 14 inches in thickness. The A2 horizon is 1 to 5 inches thick. It is very dark gray, dark gray, dark grayish brown, and grayish brown loam or silt loam. The B horizon is 15 to 30 inches thick. It is olive, olive gray, dark olive, olive brown, or dark grayish brown heavy clay loam, clay loam, or silty clay loam. Clay films are thin to thick and patchy to continuous.

The Tonka soils have a thinner A2 horizon and, in some areas, higher color values in the Bt horizon than the range defined for the series, but these differences do not alter the usefulness and behavior of these soils.

Tonka soils are associated with Waukon and Gonvick soils. They differ from those soils in being more poorly drained and in having a grayer B horizon. They have a thicker A1 horizon and more clay in the B horizon than the similar Shooker soils.

Tonka loam (0 to 1 percent slopes) (To).—This soil is in shallow depressions, swales, and drainageways. Most of the areas are small in size and irregular in shape. Some of the areas hold water for a short time in spring and after heavy rains.

Included in mapping were small areas of Quam and Flom soils. Also included were areas of soils that have a thicker, darker colored surface layer and some areas of soils that are very poorly drained and occur in depressions.

Most areas are used for crops, but a few are in pasture. If this soil is adequately drained, all crops commonly grown in the county can be grown. Shallow surface ditches have been used to drain many areas. The main management needs are drainage and maintenance or improvement of fertility and tilth. (Capability unit IIIw–1; woodland suitability group 4)

Urness Series

The Urness series consists of very poorly drained, calcareous, nearly level soils. These soils occur in areas that were old lake basins and in circular or oblong sloughs. They have a mucky surface layer. They formed in calcareous, silty, postglacial lake sediments. The original vegetation consisted of reeds, sedges, cattails, and marsh grass. Many areas are still covered by water throughout most of the year.

In a representative profile, the upper 32 inches is black and very dark gray mucky silty clay loam. Below this is black silty clay loam.

Urness soils have medium natural fertility, high to very high available water capacity, and high organic-matter content. Permeability is moderately slow. Reaction of the surface layer is moderately alkaline.

If partly drained, Urness soils are used for pasture and hay. If they are adequately drained, all crops common in the county are raised.

Representative profile of Urness mucky silty clay loam, in a depression, 856 feet east and 97 feet north of the southwest corner, SE¼NE¼ sec. 11, T. 127 N., R. 40 W.

Lcop—0 to 9 inches, black (10YR 2/1) coprogenous earth (mucky silty clay loam); many, fine, distinct, dark-brown (7.5YR 3/2) stains along root channels; weak, very fine, granular structure; loose; many roots; about 5 percent snail shells and fragments of snail shells; strongly effervescent; moderately alkaline; abrupt, smooth boundary.

Lco2—9 to 16 inches, very dark gray (10YR 3/1) coprogenous earth (mucky silty clay loam); many, fine, distinct,

dark-brown (7.5YR 3/2) stains along root channels; weak, very fine, granular structure; loose; common roots; about 20 percent snail shells; strongly effervescent; moderately alkaline; clear, wavy boundary.

Lco3—16 to 26 inches, black (5Y 2/1) coprogenous earth (mucky silty clay loam); many, fine, distinct, dark-brown (7.5YR 3/2) stains along root channels; weak, very fine, granular structure; loose; common roots; about 5 percent snail shells; strongly effervescent; moderately alkaline; abrupt, wavy boundary.

Lco4—26 to 32 inches, black (N 2/0) coprogenous earth (mucky silty clay loam); many, fine, distinct, dark-brown (7.5YR 3/2) stains along root channels; massive; slightly sticky; few roots; about 15 percent snail shells; strongly effervescent; moderately alkaline; gradual, wavy boundary.

Lco5—32 to 46 inches, black (N 2/0) coprogenous earth (silty clay loam); massive; slightly sticky; few roots; weakly effervescent; moderately alkaline; gradual, wavy boundary.

Lco6—46 to 60 inches, black (5Y 2/1) coprogenous earth (silty clay loam); massive; slightly sticky; about 10 percent snail shells; strongly effervescent; moderately alkaline.

Depth to the underlying mineral substratum is more than 30 inches but is commonly less than 12 feet. The coprogenous earth (Lco horizon) is mucky silt loam or mucky silty clay loam in the upper 4 feet or less and silt loam or silty clay loam below that depth. The color of the coprogenous earth is commonly black, but very dark gray, dark olive gray, and very dark grayish brown are in the color range. The underlying mineral substratum is commonly loam glacial till or silt loam or silty clay loam lacustrine sediment. A thin layer of sapric or hemic material up to 14 inches thick is on the surface in some areas.

Urness soils are associated with Flom and Quam soils. They differ from Flom soils in being more poorly drained. They differ from both Flom and Quam soils in having a higher content of organic matter, in containing free lime throughout, and in containing numerous fragments of snail shells throughout the solum. They differ from the similar Urness peaty subsoil variant soils in lacking organic soil material under the coprogenous earth.

Urness mucky silty clay loam (0 to 2 percent slopes) (Up).—This soil is in shallow lake basins and potholes. Included in mapping were small areas of Vallers and Quam soils along the edges of the soil areas.

This soil is flooded in spring and often throughout the entire year. The undrained areas are well suited as wildlife habitat. They provide nesting, mating, and escape cover for waterfowl, furbearers, and upland game. If drained, this soil is used for crops, pasture, and hay. Open ditches or tile are used for drainage. If adequately drained, it is suited to all crops commonly grown in the county. Small grains tend to lodge, and corn and soybeans often do not reach maturity. This soil is well suited to silage corn. The main management needs are maintaining the drainage system, controlling soil blowing, and maintaining fertility. (Capability unit IIIw–1; woodland suitability group 8)

Urness Series, Peaty Subsoil Variant

The Urness series, peaty subsoil variant, consists of very poorly drained soils that formed in a layer of postglacial lake sediment (coprogenous earth) over a layer of organic soil material. These soils occur in old lakebeds. The vegetation consists of reeds, sedges, and marsh grass.

In a representative profile, the surface layer is dark grayish-brown mucky silt loam about 5 inches thick. The subsoil is black, very dark gray, very dark brown, olive, and olive-gray mucky silt loam about 37 inches thick. The underlying material is black and very dark gray mucky peat.

These soils have low natural fertility, very high available water capacity, and high organic-matter content. Permeability is moderate above the organic material. Reaction of the surface layer is moderately alkaline.

This soil is used for wildlife habitat.

Representative profile of Urness mucky silt loam, peaty subsoil variant, in the NE¼SE¼NW¼ sec. 22, T. 127 N., R. 37 W.

Lco1—0 to 5 inches, dark grayish-brown (10YR 4/2) coprogenous earth (mucky silt loam); common, fine, distinct, olive (5Y 4/4) mottles; weak, fine and very fine, granular structure; slightly sticky; strongly effervescent; moderately alkaline; abrupt, smooth boundary.

Lco2—5 to 7 inches, black (10YR 2/1) coprogenous earth (mucky silt loam); few, fine, distinct, dark-brown (7.5YR 4/4) mottles; weak, very fine and fine, granular structure; slightly sticky; strongly effervescent; moderately alkaline; abrupt, smooth boundary.

Lco3—7 to 9 inches, olive-gray (5Y 4/2) coprogenous earth (mucky silt loam), very dark grayish brown (10YR 3/2) when rubbed; weak, fine and very fine, granular structure; slightly sticky; strongly effervescent; moderately alkaline; abrupt, smooth boundary.

Lco4—9 to 12 inches, very dark gray (10YR 3/1) coprogenous earth (mucky silt loam); weak, fine and very fine, granular structure; slightly sticky; strongly effervescent; moderately alkaline; abrupt, smooth boundary.

Lco5—12 to 15 inches, very dark brown (10YR 3/2) coprogenous earth (mucky silt loam); massive; slightly sticky; strongly effervescent; moderately alkaline; clear, smooth boundary.

Lco6—15 to 26 inches, very dark gray (10YR 3/1) coprogenous earth (mucky silt loam), very dark grayish brown (2.5Y 3/2) when rubbed; massive; slightly sticky; few snail shells and iron coatings; strongly effervescent; moderately alkaline; clear, smooth boundary.

Lco7—26 to 30 inches, very dark gray (10YR 3/1) coprogenous earth (mucky silt loam); common, medium, distinct, olive (5Y 4/3) mottles; massive; slightly sticky; few snail shells; strongly effervescent; moderately alkaline; clear, smooth boundary.

Lco8—30 to 34 inches, olive (5Y 4/4) and dark olive-gray (5Y 3/2) coprogenous earth (mucky silt loam); few, fine, distinct, gray (5Y 5/1) mottles; massive; slightly sticky; few snail shells; strongly effervescent; moderately alkaline; clear, smooth boundary.

Lco9—34 to 42 inches, very dark gray (10YR 3/1) coprogenous earth (mucky silt loam); common, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; massive; slightly sticky; slightly effervescent in places; mildly alkaline; clear, smooth boundary.

Oe1—42 to 52 inches, very dark gray (10YR 3/1, broken face) hemic material, black (10YR 2/1) when rubbed; about 35 percent fiber, about 20 percent rubbed; massive; nonsticky herbaceous fiber; strongly effervescent; mildly alkaline; clear, smooth boundary.

Oe2—52 to 74 inches, black (10YR 2/1) hemic material, dark-brown (7.5YR 3/2) fibers; about 40 percent fiber, about 15 percent rubbed; neutral.

The coprogenous earth material ranges from 24 to 50 inches in thickness. The underlying organic soil material is typically hemic, but in some profiles it is fibric or sapric or consists of strata of those three kinds of organic soil material. A mineral substratum typically is within a depth of 20 feet.

Soils of the Urness series, peaty subsoil variant, differ from other Urness soils in being underlain by organic material.

Urness mucky silt loam, peaty subsoil variant (0 to 1 percent slopes) (Us).—This soil occurs in a large, wet lake basin. It has been partly drained. Included in mapping were a few small, noncalcareous areas and a few areas that have a surface layer of muck or mucky peat.

This bog is covered with reeds, grasses, sedges, and, in a few spots, trees and willows. It provides some food and cover for furbearers and upland game. (Capability unit IVw–2; woodland suitability group 8)

Vallers Series

The Vallers series consists of calcareous, poorly drained, nearly level soils. These soils formed under grasses in loam glacial till.

In a representative profile, the surface layer is moderately alkaline clay loam about 11 inches thick. The upper part is black, and the lower part is very dark gray. The underlying material is dark-gray clay loam in the upper 5 inches and gray, light olive-gray, and olive-gray loam below.

Vallers soils have high available water capacity and organic-matter content and medium natural fertility. Permeability is moderate. Reaction of the surface layer is moderately alkaline.

If the soils receive good management, corrective fertilization, and adequate drainage, all crops that are common in the county grow well.

Representative profile of Vallers clay loam, 0 to 3 percent slopes, in a wildlife area where the slope is nearly level, 308 feet west and 11 feet north of the southeast corner, SW¼SE¼ sec. 25, T. 127 N., R. 40 W.

Ap—0 to 6 inches, black (10YR 2/1) clay loam; weak, fine, granular structure; friable; about 4 percent coarse fragments; strongly effervescent; moderately alkaline; abrupt, smootn boundary.

A3ca—6 to 11 inches, very dark gray (10YR 3/1) clay loam; weak, fine. granular structure; friable; about 4 percent coarse fragments; strongly effervescent; moderately alkaline; clear, wavy boundary.

C1cag—11 to 16 inches, dark-gray (2.5Y 4/1) clay loam; weak, fine, subangular blocky structure; friable; about 4 percent coarse fragments; strongly effervescent; moderately alkaline; clear, wavy boundary.

C2cag—16 to 20 inches, gray (5Y 5/1) loam; few, fine, faint, olive (5Y 5/6) mottles; weak, fine, subangular blocky structure; friable; about 4 percent coarse fragments; strongly effervescent; moderately alkaline; clear, wavy boundary.

C3g—20 to 32 inches, light olive-gray (5Y 6/2) loam; common, fine, distinct, light olive-brown (2.5Y 5/6) mottles; weak, fine, subangular blocky structure; friable; about 4 percent coarse fragments; strongly effervescent; moderately alkaline; gradual, wavy boundary.

C4g—32 to 60 inches, olive-gray (5Y 5/2) loam; many, medium, prominent, yellowish-brown (10YR 5/6) mottles; weak, fine, subangular blocky structure; friable; about 4 percent coarse fragments; strongly effervescent; moderately alkaline.

The A horizon is loam, clay loam, silt loam, or silty clay loam. The Cca horizon is dark gray, gray, olive gray, and light olive gray and ranges from clay loam or loam to light silty clay loam in texture.

Vallers soils are associated with Aastad, Barnes, Flom, and Quam soils. They differ from those soils in having a calcareous A horizon. They are more poorly drained than Barnes and Aastad soils.

Vallers clay loam, 0 to 3 percent slopes (VaA).—This soil occurs around the edges of depressions and in drainageways on the till plains and morainic uplands. The areas are variable in size and shape.

Included in mapping were small areas of Flom and Quam soils, a few areas in which the profile contains gravel bands, and areas of more strongly sloping soils. Also included were areas where the soil profile has less mottling and a few areas of soil that lacks a distinct horizon of lime accumulation.

If this soil is adequately drained, it is suited to all crops commonly grown in the county. Drainage can be improved with open ditches or tile. The nutrient imbalance can be improved by proper fertilization. The main management needs are practices that improve the drainage and improve tilth and fertility. (Capability unit IIw–3; woodland suitability group 5)

Waukon Series

The Waukon series consists of deep, well-drained, undulating to steep soils. These soils formed under mixed grasses and trees in calcareous, loam glacial till.

In a representative profile, the surface layer is black loam about 6 inches thick (fig. 10). The subsurface layer is discontinuous, very dark gray loam about 3 inches thick. The subsoil is brown and light olive-brown sandy loam and sandy clay loam about 15 inches thick. The underlying material is light olive-brown sandy loam.

Waukon soils have high natural fertility, available water capacity, and organic-matter content. Permeability is moderate. Reaction of the surface layer is neutral.

Waukon soils are used for crops, pasture, and woodland.

Representative profile of Waukon loam, 2 to 6 percent slopes, in an area where the slope is 4 percent, 782 feet west and 97 feet south of northeast corner, sec. 14, T. 130 N., R. 37 W.

A1—0 to 6 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; weak, very fine, granular structure; friable; about 5 percent coarse fragments; neutral; abrupt, wavy boundary.

Figure 10.—**Profile of Waukon loam, 2 to 6 percent slopes, eroded, showing the thin, dark-colored surface layer. The darker area at a depth of 2 feet is the lower limit of the subsoil, showing a wavy boundary.**

A2—6 to 9 inches, discontinuous horizon of very dark gray (10YR 3/1) loam, gray (10YR 6/1) when dry; weak, fine and very fine, granular structure; friable; about 5 percent coarse fragments; neutral; abrupt, wavy boundary.

B1—9 to 14 inches, brown (10YR 4/3) sandy loam; moderate, fine and medium, subangular blocky structure; friable; many, medium, porous coatings on faces of peds; about 5 percent coarse fragments; neutral; clear, wavy boundary.

B2t—14 to 21 inches, brown (10YR 4/3) sandy clay loam; moderate, fine and medium, subangular blocky structure; friable; many, thick, very dark grayish-brown (10YR 3/2) clay films on faces of peds; about 5 percent coarse fragments; mildly alkaline; clear, wavy boundary.

B3t—21 to 24 inches, light olive-brown (2.5Y 5/4) and brown (10YR 4/3) sandy loam; weak, fine and medium, subangular blocky structure; friable; few very dark brown (10YR 2/2) clay films in old root channels; about 5 percent coarse fragments; slightly effervescent; mildly alkaline; clear, wavy boundary.

C—24 to 60 inches, light olive-brown (2.5Y 5/4) sandy loam; weak, fine and medium, subangular blocky structure; friable; few light-gray (10YR 7/1) lime segregations; about 5 percent coarse fragments; strongly effervescent; moderately alkaline.

The A horizon is 4 to 10 inches thick and is black, very dark gray, or very dark brown. The texture typically is loam but includes silt loam, sandy loam, and clay loam. The A2 horizon is commonly lacking in cultivated areas. The B1 and B2 horizons range from sandy loam or sandy clay loam to clay loam or loam in texture and from brown or dark brown to dark yellowish brown in color. The B3 horizon is olive brown, light olive brown, or dark yellowish brown and is typically loam or sandy loam, but clay loam and sandy clay loam are in the range. The B horizon ranges from weak to strong, subangular blocky structure. In a few areas the primary structure is prismatic, and the secondary structure is subangular blocky. The clay films range from thin to thick and from few to many. Depth to the C horizon ranges from 18 to 40 inches. The C horizon is loam or sandy loam.

Waukon soils are associated with Flom, Gonvick, and Quam soils. They are better drained and have brighter colors below the A horizon than these soils.

Waukon loam, 2 to 6 percent slopes (WaB).—This undulating soil occurs on the till plains and morainic uplands. The areas vary in size and shape. The slopes are irregular and complex and 80 to 200 feet long. This soil has the profile described as representative for the series.

Included in mapping were small areas of Gonvick, Flom, and Quam soils. Also included were small areas of more strongly sloping soils, small areas of less sloping soils, and eroded areas.

This soil is used for cultivated crops, woodland, and pasture. This soil is suited to all crops commonly grown in the county. Water runs off at a medium rate. The hazard of erosion is moderate. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IIe–1; woodland suitability group 1)

Waukon loam, 2 to 6 percent slopes, eroded (WaB2).—This soil is undulating and moderately eroded. The areas vary in size and shape. Slopes are irregular and complex and 80 to 200 feet long. The profile differs from the one described as representative for the series in being more shallow. Tillage and the removal of trees have mixed material from the subsoil with the original surface layer. As a result, the surface layer is browner and less friable and contains less organic matter.

Included in mapping were small areas of Langhei, Gonvick, Flom, and Quam soils. Also included were small areas of less sloping soils, of more strongly sloping soils, and of gravel.

This soil is used for crops, and a few small areas are in pasture. This soil is suited to all crops commonly grown in the county. Water runs off at a medium rate. The hazard of erosion is moderate. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IIe–1; woodland suitability group 1)

Waukon loam, 6 to 12 percent slopes (WaC).—This rolling soil occurs on the till plains and morainic uplands. Areas vary in size and shape. Slopes are irregular and complex and 80 to 200 feet long. The profile differs from the one described as representative for the series in being more shallow.

Included in mapping were small areas of Langhei, Gonvick, Flom, and Quam soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, eroded areas, and gravelly areas.

This soil is used for cultivated crops, woodland, and pasture. It is suited to all crops commonly grown in the county. Water runs off at a medium to rapid rate. The hazard of erosion is moderately severe. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IIIe–1; woodland suitability group 1)

Waukon loam, 6 to 12 percent slopes, eroded (WaC2).—This rolling soil occurs in areas that vary in size and shape. Slopes are irregular and complex and are 80 to 200 feet long. This soil is moderately eroded. Its profile differs from the one described as representative for the series in being thinner. Tillage and the removal of trees have mixed material from the subsoil with the original surface layer. As a result, the present surface layer is browner and less friable and contains less organic matter.

Included in mapping were small areas of Langhei, Gonvick, Flom, and Quam soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, and areas where there are surface stones.

This soil is used for crops, and a few areas are in pasture. It is suited to all crops commonly grown in the county. Water runs off at a medium to rapid rate. The hazard of erosion is moderately severe. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IIIe–1; woodland suitability group 1)

Waukon loam, 12 to 18 percent slopes (WaD).—This soil is hilly. It occurs on the till plains and morainic uplands. The areas vary in size and shape. Slopes are irregular and complex and 80 to 250 feet long. This soil occurs along drainageways and around sloughs. The profile differs from the one described as representative for the series in being thinner.

Included in mapping were small areas of Langhei, Gonvick, Flom, and Quam soils. Also included were small areas of more strongly sloping soils, small areas of less sloping soils, eroded areas, and areas where there are surface stones.

This soil is used for cultivated crops, woodland, and pasture. It is suited to all crops commonly grown in the

county. Water runs off at a rapid rate. The hazard of erosion is severe. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IVe–1; woodland suitability group 1)

Waukon loam, 12 to 18 percent slopes, eroded (WaD2).—This soil is hilly and moderately eroded. The areas vary in size and shape. The slopes are irregular and complex and 80 to 200 feet long. This soil occurs along drainageways and waterways and around sloughs. The profile differs from the one described as representative for the series in being thinner. Tillage and the removal of trees have mixed material from the subsoil with the original surface layer. As a result, the present surface layer is browner and less friable and contains less organic matter.

Included in mapping were small areas of Langhei, Gonvick, and Darnen soils. Also included were small areas of less sloping soils, small areas of strongly sloping soils, and areas where there are surface stones.

This soil is used for crops, and a few areas are used for pasture. This soil is suited to all crops commonly grown in the county. Water runs off at a rapid rate. The hazard of erosion is severe. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IVe–1; woodland suitability group 1)

Waukon loam, 18 to 24 percent slopes (WaE).—This soil occurs along draws and waterways and around sloughs or lakes on morainic uplands. The areas vary in size and shape. Slopes are irregular, commonly cut up by draws, and 100 to 250 feet long. The profile differs from the one described as representative for the series in being thinner.

Included in mapping were small areas of Langhei, Gonvick, and Darnen soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, eroded areas, and areas where there are surface stones.

This soil is used for woodland and pasture. A few areas are used for crops. Water runs off very rapidly. The hazard of erosion is very severe. The main management needs are practices that control erosion and conserve moisture. (Capability unit VIe–1; woodland suitability group 1)

Waukon clay loam, 2 to 6 percent slopes (WcB).—This soil is undulating. It occurs on the morainic uplands. The areas vary in size and shape. Slopes are irregular and complex and 80 to 200 feet long. The profile differs from the one described as representative for the series in having a clay loam surface layer and subsoil.

Included in mapping were small areas of Gonvick, Flom, and Quam soils. Also included were small areas of more strongly sloping soils, small areas of less sloping soils, and moderately eroded areas.

This soil is used for crops, woodland, and pasture. It is suited to all crops commonly grown in the county. Water runs off at a medium rate. The hazard of erosion is moderate. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IIe–1; woodland suitability group 1)

Waukon clay loam, 6 to 12 percent slopes, eroded (WcC2).—This soil is rolling. It occurs on the morainic uplands. The areas vary in size and shape. Slopes are irregular and complex and 80 to 200 feet long. The profile differs from the one described as representative for the series in having a clay loam surface layer and subsoil.

Included in mapping were small areas of Gonvick, Flom, and Quam soils. Also included were small areas of more strongly sloping soils, small areas of less sloping soils, and moderately eroded areas of Waukon soil.

This soil is used for crops, woodland, and pasture. This soil is suited to all crops commonly grown in the county. Water runs off at a medium rate. The hazard of erosion is moderate. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IIIe–1; woodland suitability group 1)

Waukon-Langhei loams, 2 to 6 percent slopes, eroded (WlB2).—The soils in this complex are undulating. The areas vary in size and shape. Slopes are complex, may be concave or convex, and are 50 to 200 feet long. Waukon soil makes up 70 to 80 percent of each area and is on the more uniform parts of the side slopes. Langhei soil makes up 20 to 30 percent of each area and is on the more exposed knobs, knolls, and ridges. The surface layer of the Langhei soil is lighter colored than that of the Waukon soil. These soils occur in such an intricate pattern that it is not practical to map them separately. They are moderately eroded, and the present surface layer is a mixture of the original surface layer and moderate amounts of material from the subsoil.

Included in mapping were small areas of Gonvick, Flom, and Vallers soils. Also included were small areas of more strongly sloping soils, small areas of less sloping soils, some gravelly areas, and areas where there are surface stones. Also included were some areas that are only slightly eroded.

This complex is used for cultivated crops, pasture, and woodland. It is suited to all crops commonly grown in the county. The Langhei soil is less well suited to crops than the Waukon soil because of a nutrient imbalance caused by their high content of lime. Surface runoff is medium. The hazard of erosion is moderate. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IIe–1; Waukon part in woodland suitability group 1; Langhei part in woodland suitability group 2)

Waukon-Langhei loams, 6 to 12 percent slopes, eroded (WlC2).—The soils in this complex are rolling. The areas vary in size and shape. Slopes are complex, may be concave or convex, and are 50 to 200 feet long. Waukon soil makes up 50 to 70 percent of each area and is on the more uniform parts of the side slopes. Langhei soil makes up 30 to 50 percent of each area and is on the more exposed knobs, knolls, and ridges. The Langhei soil has a lighter colored surface layer than the Waukon soil. The soils in this complex are moderately eroded, and the present surface layer is a mixture of the original surface layer with moderate amounts of material from the subsoil. These soils occur in such an intricate pattern that it is not practical to map them separately.

Included in mapping were small areas of Gonvick,

Darnen, Flom, and Vallers soils. Also included were small areas of more strongly sloping soils, small areas of less sloping soils, gravelly areas, and areas where there are surface stones. Also included were areas that are only slightly eroded.

These soils are used for cultivated crops, pasture, and woodland. They are suited to all crops commonly grown in the county. The Langhei soil is less well suited to crops than the Waukon soil because of a nutrient imbalance caused by the high content of lime. Surface runoff is medium to rapid. The hazard of erosion is moderately severe. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IIIe–1; Waukon part in woodland suitability group 1; Langhei part in woodland suitability group 2)

Waukon-Langhei-Sioux complex, 2 to 6 percent slopes, eroded (WsB2).—The soils in this complex are undulating. The areas vary in size and shape. Slopes are irregular and complex and 75 to 250 feet long. Waukon loam makes up 40 to 60 percent of each area; Langhei loam, 20 to 30 percent; and Sioux loamy coarse sand, 20 to 30 percent. The Sioux soil makes up the gravelly areas, the Langhei soil makes up the light-gray areas on the exposed knobs and knolls, and the Waukon soil makes up the dark-gray to black areas on the smooth parts of the side slopes. The soils in this complex are moderately eroded, and the present surface layer is a mixture of the original surface layer with moderate amounts of material from the subsoil. These soils occur in such an intricate pattern that it is not practical to map them separately.

Included in mapping were small areas of Gonvick, Flom, and Quam soils. Also included were small areas of less sloping soils and small areas of more strongly sloping soils. Also included were areas that are only slightly eroded, and areas where there are many surface stones.

These soils are used for crops, woodland, and pasture. They are suited to all crops commonly grown in the county. The Sioux soil is less well suited to crops than the Waukon soil because of drought and lower fertility, and the Langhei soil is less well suited because of lower fertility. Water runs off at a medium rate. The hazard of erosion is moderate. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IIIe–1; Waukon part in woodland suitability group 1; Langhei part in woodland suitability group 2; Sioux part in woodland suitability group 7)

Waukon-Langhei-Sioux complex, 6 to 12 percent slopes, eroded (WsC2).—The soils in this complex are rolling. The areas vary in size and shape. Slopes are irregular and complex and 75 to 250 feet long. Waukon loam makes up 40 to 60 percent of each area; Langhei loam, 30 to 40 percent; and Sioux loamy coarse sand, 20 to 30 percent. The Sioux soil makes up the gravelly areas, the Langhei soil makes up the light-gray areas on the exposed knobs and knolls, and the Waukon soil makes up the dark-gray to black areas on the smooth parts of the side slopes. The soils in this complex are moderately eroded, and the present surface layer is a mixture of the original surface layer with moderate amounts of material from the subsoil. These soils occur in such an intricate pattern that it is not practical to map them separately.

Included in mapping were small areas of Gonvick, Flom, and Quam soils. Also included were areas that are only slightly eroded and areas where there are many surface stones. Also included were small areas of less sloping soils and small areas of more strongly sloping soils.

These soils are used for crops, woodland, and pasture. They are suited to all crops commonly grown in the county. The Sioux soil is less well suited to crops than the Waukon soil because of drought and lower fertility and the Langhei soil is less well suited because of lower fertility. Water runs off at a medium to rapid rate. The hazard of erosion is moderately severe. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IVe–1; Waukon part in woodland suitability group 1; Langhei part in woodland suitability group 2; Sioux part in woodland suitability group 7)

Zell Series

The Zell series consists of deep, well-drained, rolling soils. These soils formed under grasses in calcareous, silty material. They are free from stones.

In a representative profile, the surface is black silt loam about 7 inches thick. The underlying material is light olive-brown and light yellowish-brown silt loam.

Zell soils have medium natural fertility and organic-matter content and very high available water capacity. Permeability is moderate. Reaction of the surface layer is mildly alkaline.

These soils can be worked easily and are suited to all crops commonly grown in the county.

Representative profile of a Zell silt loam, in an area where the slope is 9 percent, 970 feet east and 30 feet north of the southwest corner, SW¼ sec. 18, T. 130 N., R. 40 W.

Ap—0 to 7 inches, black (10YR 2/1) silt loam; few inclusions of light olive brown (2.5Y 5/4); weak, fine, granular structure; friable; slightly effervescent; mildly alkaline; abrupt, smooth boundary.

C1ca—7 to 18 inches, light olive-brown (2.5Y 5/4) silt loam; massive; very friable; strongly effervescent; mildly alkaline; gradual, smooth boundary.

C2—18 to 24 inches, light olive-brown (2.5Y 5/4) silt loam; massive; very friable; strongly effervescent; mildly alkaline; gradual, smooth boundary.

C3—24 to 28 inches, light yellowish-brown (2.5Y 6/4) silt loam; few, fine, faint, light olive-brown (2.5Y 5/6) mottles; massive; very friable; few, medium, distinct lime segregations; strongly effervescent; mildly alkaline; gradual, smooth boundary.

C4—28 to 60 inches, light olive-brown (2.5Y 5/4) silt loam; common, medium, prominent, yellowish-brown (10YR 5/6) mottles; massive; very friable; strongly effervescent; mildly alkaline.

The A horizon is black or very dark gray and ranges from 4 to 8 inches in thickness. The C1ca horizon ranges from dark grayish brown to light olive brown.

Zell soils are associated with Rothsay and Hantho soils. They differ from these soils in lacking a B horizon. They are better drained than Hantho soils. They differ from the similar Langhei soils in having A and C horizons that contain less sand.

Zell-Rothsay silt loams, 6 to 12 percent slopes, eroded (ZoC2).—The soils in this complex are rolling. The areas vary in size and shape. Topography is complex, and the slopes are 50 to 250 feet long. Zell soils make up 50 to 70 percent of each area, and Rothsay soils, 30 to 50 percent. The Zell soils are on the knobs, knolls, and ridges. The Rothsay soils are on the more uniform parts of the side slopes. The soils in this complex are moderately eroded, and the present surface layer is a mixture of the original surface layer and moderate amounts of material from the subsoil. These soils occur in such an intricate pattern that it is not practical to map them separately.

Included in mapping were small areas of more strongly sloping soils and small areas of less sloping soils. Also included were some areas that are only slightly eroded.

Nearly all the acreage is used for cultivated crops. A few areas are used for pasture. These soils are suited to all crops commonly grown in the county. The Zell soil is less well suited to crops than the Rothsay soil because of the nutrient imbalance caused by the high content of lime. Surface runoff is medium to rapid. The hazard of erosion is moderately severe. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture. (Capability unit IIIe–1; Zell part in woodland suitability group 2; Rothsay part in woodland suitability group 1)

Use and Management of the Soils

This section discusses management of soils used for crops. The capability groupings are explained, and the soils of the county are grouped according to their suitability for crops and pasture. Yield predictions are given for the common crops. This section also discusses use of the soils for woodland and windbreaks, for wildlife, and for recreation. Engineering uses are also discussed.

Management of the Soils for Crops

Douglas County is primarily a dairy area. Many farmers raise feeder pigs, and a few raise cattle for beef. Corn, soybeans, oats, and alfalfa are the principal crops. Small acreages of wheat, barley, flax, and sunflowers are also grown. About 64 percent of the county is used for crops, and 20 percent is used for pasture.

Water erosion is a hazard on the sloping soils. To control water erosion, it is necessary to reduce runoff and increase water intake. Among the measures that help to accomplish this are terracing, contour farming, minimum tillage, mulch tillage, rough tillage, grassed waterways, and proper use of crop residue. A high content of organic matter and a high level of fertility increase the infiltration of water and enable the soil to support crops that improve soil structure.

Soil blowing occurs throughout the county but is less serious than the water erosion. It is more serious on the sandy soils in the north-central and eastern parts of the county than on other soils. Soil blowing in these sandy areas can be controlled by stripcropping, rough tillage, maintaining a cover of plants or crop residue, wind stripcropping, and the use of field windbreaks to protect exposed areas. Most of the soil blowing occurs during winter and spring on bare fields. Fall plowing should be left rough, and the crop residue should be exposed to protect the soil.

Wetness is a hazard in most of the level and depressional areas, which make up about 30 percent of the county. Many farmers have installed open ditches to remove surface water. Root development is good in soils that are adequately drained, because the movement of air and water is not restricted. Soils that are adequately drained generally warm up earlier in spring.

Frequent tilling or tilling when the soils are too wet or too dry damages the structure of the soils. Frequent tillage also makes the surface layer powdery, so that water is not absorbed readily. Tilling when the soil does not contain the proper amount of moisture also makes the surface layer cloddy and unsuitable as a seedbed. The soils should be tilled only enough to prepare a good seedbed and to control the growth of weeds. Fall plowing is a common practice. Plowing should be left rough to reduce erosion.

Fertilizer applications are beneficial on most of the soils in Douglas County and should be based on the results of soil tests. They also depend upon the kind of soil, past management, and the needs of the crop to be grown.

Capability grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of farming. The soils are grouped according to their limitations when used for field crops, the risk of damage when they are farmed, 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.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for forest trees or for engineering.

In the capability system, the kinds of soil are grouped at three levels: the capability class, the subclass, and the unit. These are discussed in the following paragraphs. The capability classification of any soil in the county can be learned by referring to the "Guide to Mapping Units."

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, 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, require special conservation practices, or both.

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

Class V soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, woodland, or wildlife habitat. (There are no class V soils in Douglas County.)

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture, woodland, or wildlife habitat.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture, woodland, or wildlife habitat.

Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife habitat, water supply, or esthetic purposes.

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 can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, woodland, wildlife habitat, or recreation.

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 and other responses to management. 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–1 or IIIe–3. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

In the following pages the capability units in Douglas County are described and suggestions for the use and management of the soils are given.

CAPABILITY UNIT I–1

This unit consists of moderately well drained to well drained, deep, nearly level to gently sloping, medium-textured and moderately fine textured soils. These soils are in the Aastad, Beltrami, Darnen, Gonvick, Hantho, and Nicollet series.

These soils have medium to high natural fertility, high to very high available water capacity, and medium to high organic-matter content. The root zone is deep, and permeability and infiltration are moderate.

In fields where these soils are dominant, row crops or small grains can be grown most of the time. All crops common in the county can be grown. Corn, soybeans, oats, and alfalfa are the main crops, but a small acreage is used for wheat, barley, and flax. Because of their location, some soils in this unit are used for pasture or trees.

In areas where these soils are used mainly for row crops, special practices are needed to maintain optimum infiltration and permeability. Among such practices are keeping tillage to a minimum, tilling the soils only when they contain the proper amount of moisture, and management of all crop residue. Pastures can be improved by fertilizing them properly and by seeding suitable grasses and legumes.

CAPABILITY UNIT IIe–1

This unit consists of deep, well-drained to somewhat excessively drained, undulating soils of the Aastad, Barnes, Clarion, Forman, Langhei, Rothsay, and Waukon series. These soils are medium textured to moderately fine textured. They are on uplands.

These soils have medium to high natural fertility; Langhei soils have medium natural fertility because of the high content of lime, which causes an imbalance of plant nutrients. The available water capacity is high to very high and organic-matter content is medium to high. The root zone is deep. Permeability and infiltration are moderate to moderately slow. All the soils are slightly to moderately eroded. Unless they are properly managed, they are subject to further erosion. Erosion is most likely to occur late in spring, when the soil is not protected from rain. Soil blowing may occur on unprotected fields during winter and spring.

All suited crops in the county can be grown on these soils. Corn, soybeans, oats, and alfalfa are the main crops, but small acreages of wheat, barley, and flax are also grown. Most areas are cultivated. A few areas are in grass and trees. Crop growth varies because of the differing surface texture and the varying thickness of the surface layer.

Among the practices that help control runoff and erosion are contour tillage, contour stripcropping, and the use of terraces, waterways, minimum tillage, and stubble mulching. In areas where contour stripcropping or terracing is impractical, the use of rough tillage, minimum tillage, and stubble mulching helps to control erosion. Management of crop residue, proper fertilization, and adding manure help to maintain organic-matter content and tilth. If these fields are fall-plowed, they should be left rough, as this helps to control erosion and to catch

snow in winter. Under a high level of management, these soils can be farmed more intensively to row crops.

CAPABILITY UNIT IIe-2

This unit consists of deep, well-drained, undulating soils of the Nebish series. These soils are on uplands.

These soils have medium natural fertility, medium to high available water capacity, and low to medium organic-matter content. The root zone is deep, and permeability and infiltration are moderate. These soils are slightly to moderately eroded. Nebish sandy loam, 2 to 6 percent slopes, is more susceptible to drought than the other Nebish soils because its surface layer and the upper part of its subsoil are more sandy. All the soils in this capability unit are subject to further erosion, unless they are properly managed.

All crops common in the county can be grown. Corn, soybeans, oats, and alfalfa are the main crops. Crop growth varies because of the differing surface texture and the varying thickness of the surface layer. Many areas are in woodland.

Erosion is the principal hazard. Many areas have complex or irregular slopes. In such areas, the cropping system should consist largely of close-growing crops. Among the practices that help control runoff and erosion are contour tillage, contour stripcropping, and the use of terraces, waterways, minimum tillage, and stubble mulching. Management of crop residue, proper fertilization, and adding manure help to maintain organic-matter content and tilth. If these fields are fall-plowed, they should be left rough, as this helps to control erosion and to catch snow in winter. If management is intensive, row crops can be grown for more years and meadow for fewer years than when management is less intensive. Some areas support fairly dense, unmanaged stands of hardwoods. Few areas are protected from grazing or fire.

CAPABILITY UNIT IIe-3

This unit consists of moderately well drained, nearly level, gently sloping or undulating, deep, fine-textured soils of the Sinai series. They occur on uplands.

These soils have high natural fertility, low to medium available water capacity, and high organic-matter content. The root zone is deep, and permeability and infiltration are very slow. Some areas are slightly eroded. All the soils in this capability unit are subject to erosion unless they are properly managed.

All crops common in the county can be grown. Corn, oats, soybeans, and alfalfa are the main crops, but small acreages of wheat, barley, and flax are also grown. A few areas are used for pasture. The pastures should be properly fertilized and seeded to suitable grasses and legumes. These clayey soils are sticky when wet and hard when dry and consequently are difficult to till. Because the soils are sticky, the period of time is short when the moisture content is right for preparing a good seedbed. These soils should be fall-plowed and left rough. If the soils are unprotected, the surface will break into fine granules that blow early in spring.

The hazard of further erosion is moderate. Among the practices that help control runoff are contour tillage, contour stripcropping, and the use of terraces, waterways, minimum tillage, and stubble mulching. Management of crop residue and adding manure help to maintain organic-matter content and tilth. If management is intensive, row crops can be grown for more years and meadow for fewer years than when management is less intensive.

CAPABILITY UNIT IIe-4

This unit consists of nearly level to undulating, well-drained soils of the Arvilla, Dorset, and Sverdrup series. All these soils are mapped as thick solum phases. They have a medium-textured to moderately coarse textured surface layer and subsoil underlain by sand or gravelly coarse sand at a depth of 22 to 36 inches.

These soils have medium to high natural fertility, low to medium available water capacity, and medium to high organic-matter content. Permeability and infiltration are moderate to moderately rapid above the sand and gravelly coarse sand and rapid in the sand and gravelly coarse sand. The hazard of erosion is moderate. Soil blowing is a hazard on fields left unprotected in winter and spring. Droughtiness occurs during prolonged dry seasons.

These soils warm up early in spring, and crops respond well to use of irrigation and fertilizer. If adequate moisture is available throughout the growing season, these soils are suited to all crops commonly grown in the county. Corn, soybeans, oats, and alfalfa are the main crops. Some areas are used for pasture and trees. These soils are suited to pasture early in the season, but it dries up or does not grow in summer. All the soils in this capability unit are suited to trees, but most of the wooded areas are not managed for woodland production.

These soils need to be managed to control erosion and conserve moisture. Practices that can be used where slopes are suitable are contour farming, contour stripcropping, grassed waterways, and terraces. In the nearly level areas, a suitable cropping system, minimum tillage, stubble mulching, field shelterbelts, and proper fertilization are needed. During the period between crops the surface should either be kept rough or be kept under cover crops. All crop residue should be returned to the soil. All these practices improve the available water capacity and control erosion.

CAPABILITY UNIT IIw-1

This unit consists of poorly drained, nearly level, medium-textured, moderately fine textured, and fine textured soils of the Flom, Fulda, and Shooker series. They occur in shallow depressions and drainageways throughout the county.

These soils have medium to high natural fertility, medium to high available water capacity, and medium to high organic-matter content. Permeability and infiltration are moderate, except in the Fulda soil where permeability is slow to very slow. The seasonal water table is fairly high.

If these soils are adequately drained and well managed,

they are suited to all crops commonly grown in the county. Corn, soybeans, oats, and hay are the main crops. Many areas are used for permanent pasture. The soils are especially well suited to pasture because they hold moisture throughout the growing season.

If these soils are adequately drained and fertilized and all crop residue returned, row crops can be grown extensively. Under a high level of management, row crops can be grown continuously on these soils. Practices that increase movement of air and water into and through the soil and that return large amounts of crop residue are needed. Such practices include minimum tillage, timely field operations, and management of crop residue. In addition, applying manure, growing legumes and grasses, and fertilizing properly are ways of maintaining tilth and fertility. Keeping the soils in good tilth is important to the maintenance of drainage systems. These soils should be fall-plowed to insure a good seedbed in spring. If these soils are plowed when they are too wet, clods form that are difficult to break, and compaction is likely.

Pasture can be improved if the soils are drained and a suitable grass-legume mixture is seeded. Many sites are suitable for stock-watering ponds.

CAPABILITY UNIT IIw–2

This unit consists of poorly drained, moderately coarse textured to medium-textured soils of the Forada and Marysland series. These soils occur in shallow depressions and drainageways and on level to slightly depressional flats. They are underlain by coarse sand and gravelly coarse sand at a depth of 22 to 40 inches.

These soils have high natural fertility, low to medium available water capacity, and high organic-matter content. Permeability and infiltration are moderate to moderately rapid in the upper part and rapid in the coarse sand and gravelly coarse sand. The seasonal water table determines the depth of the root zone.

If these soils are adequately drained, all crops common in the county can be grown. Corn, soybeans, oats, and hay are the main crops. Many areas of these soils are used for permanent pasture.

If these soils are drained and fertilized and if all crop residue is returned, row crops or small grains can be grown continuously. Practices that increase movement of air and water into and through the soil and that return large amounts of crop residue are needed. Such practices include minimum tillage, timely field operations, and management of all crop residue. In addition, applying manure, growing grasses and legumes, and fertilizing properly are ways of maintaining tilth and fertility and improving drainage. Many areas of these soils have been drained by surface ditches. Tile drainage is difficult because of the coarse-textured substratum. Plugging with sand is a hazard after the tile has been installed. These soils are generally fall-plowed. Leaving the surface rough and crop residue exposed, stubble mulching, and field windbreaks control soil blowing. Pasture can be improved if the soils are drained and a suitable grass-legume mixture is seeded.

CAPABILITY UNIT IIw–3

This unit consists of poorly drained, highly calcareous soils of the Colvin and Vallers series. The Colvin soil is silt loam, and the Vallers soil is clay loam.

These soils have medium natural fertility, high to very high available water capacity, and high organic-matter content. The root zone is limited by depth to the water table. Permeability and infiltration are moderate. These soils are very high in content of lime, which causes a nutrient imbalance.

If these soils are properly drained and well managed, they are well suited to most crops commonly grown in the county. Corn, oats, soybeans, and hay are the main crops grown, but small acreages of wheat, barley, and flax are also grown. Many areas are used for permanent pasture.

If these soils are adequately drained and fertilized and if all crop residue is returned, row crops can be grown extensively. Practices that increase movement of air and water into and through the soil and that return large amounts of crop residue are needed. Such practices include minimum tillage, timely field operations, and management of all crop residue. In addition, applying manure, growing legumes and grasses, and fertilizing properly are ways of maintaining tilth and fertility and improving drainage. Drainage through open ditches removes surface water early and permits cropping of the soil. Tile is needed to provide optimum drainage, lower the water table, and thus provide an adequate root zone. These soils should be fall-plowed to insure a good seedbed in spring. Pasture can be improved if the soils are drained and seeded to a proper grass-legume mixture.

CAPABILITY UNIT IIIe–1

This unit consists of well-drained to somewhat excessively drained, undulating to rolling, slightly eroded to moderately eroded soils of the Barnes, Clarion, Forman, Langhei, Rothsay, Sioux, Waukon, and Zell series. These soils are medium textured to moderately fine textured. The small areas of droughty Sioux soils were included because they occur in complex with Waukon and Langhei soils. These areas are not large enough to warrant a separate discussion.

These soils have medium to high natural fertility, medium to very high available water capacity, and medium to high organic-matter content. The root zone is deep, and permeability and infiltration are moderate, except in the Forman soil, where permeability and infiltration are moderately slow. These soils are slightly eroded to moderately eroded. The hazard of additional erosion is moderately severe. Erosion is most likely late in spring and early in summer, when the soils are not protected from rain.

All crops common in the county can be grown. Corn, oats, soybeans, and alfalfa are the main crops, but small acreages of flax, barley, and wheat are also grown. Some areas are used for permanent pasture or woodland.

To protect these soils from runoff and erosion, the cropping system should include a large proportion of grasses and legumes. Contour stripcropping (fig. 11) in many places, terraces, contour tillage, waterways, minimum tillage, and stubble mulching can be used to control erosion. On soils not terraced or stripcropped, row crops can also be plow planted. Returning crop residue, fertilizing properly, and adding manure help to maintain organic-matter content and tilth. Pasture can be improved by applying fertilizer and by seeding desirable

Figure 11.—**Contour stripcropping on Barnes loam, 6 to 12 percent slopes, eroded.**

forage plants. The wooded areas are generally not managed, and stands are poor. Crop growth varies because of the differing surface texture and the varying thickness of the surface layer.

CAPABILITY UNIT IIIe–2

This unit consists of deep, well-drained, slightly to moderately eroded, rolling soils of the Nebish series.

These soils have medium natural fertility, medium to high available water capacity, and low to medium organic-matter content. The root zone is deep, and permeability and infiltration are moderate. Nebish sandy loam is more susceptible to drought than the other Nebish soils because its surface layer and the upper part of its subsoil are more sandy. All the soils in this capability unit are subject to further erosion unless they are properly managed.

All crops common in the county can be grown. Corn, soybeans, oats, and alfalfa are the main crops. Crop growth varies because of the differing surface texture and the varying thickness of the surface layer. Many areas are in woodland.

Erosion is the principal hazard. Many areas have complex or irregular slopes. In such areas, the cropping system should consist largely of close-growing crops. Among the practices that help control runoff and erosion are contour tillage, contour stripcropping, and the use of terraces, waterways, minimum tillage, and stubble mulching. Management of crop residue, proper fertilization, and adding manure help to maintain organic-matter content and tilth. If these fields are fall-plowed, they should be left rough, as this helps to control erosion and to catch snow in winter. If management is intensive, soils in this unit can be used for row crops for more years and as meadow for fewer years than when management is less intensive.

CAPABILITY UNIT IIIe–3

This unit consists of nearly level to rolling, moderately well drained to somewhat excessively drained soils of the Arvilla, Dorset, Nebish, and Osakis series. Most soils of this capability unit have a medium-textured or moderately coarse textured surface layer and subsoil underlain by gravelly coarse sand at a depth of 12 to 22 inches, but the Nebish soil is underlain by loam.

In most areas, these soils have low to medium natural fertility, low available water capacity, and low to medium organic-matter content. Permeability and infiltration are moderately rapid above the gravelly coarse sand and rapid in the gravelly coarse sand. The hazard of erosion is moderate. These soils warm up early in spring. They are easy to till, but most areas are droughty and are subject to erosion.

These soils are suited to all crops grown in the county, but early maturing crops make better use of the limited moisture content than other crops. Some areas are used for pasture or woodland. These soils are suited to pasture early in the season, but the pasture dries up or does not grow in summer. All the soils in this capability unit are suited to trees, but most of the wooded areas are not managed for woodland production.

These soils need to be managed to control erosion and conserve moisture. Practices that can be used if the slope is suitable are contour farming, contour stripcropping, grassed waterways, and terraces. Managing all crop residue and adding manure help to maintain organic-matter content, fertility, and tilth and control erosion. Plowing in spring, minimum tillage, stubble mulching, and wheel track planting are desirable practices that help to control erosion. Crops respond well to the use of irrigation and fertilizer.

CAPABILITY UNIT IIIe–4

This unit consists of moderately well drained to somewhat excessively drained, nearly level to gently sloping soils of the Clontarf and Sverdrup series. These soils have a sandy loam surface layer and a sandy loam and loamy sand subsoil. They are underlain by sand at a depth of 12 to 22 inches.

These soils have medium natural fertility, low available water capacity, and medium organic-matter content. The root zone is deep, and permeability and infiltration are moderately rapid in the upper part of the profile and rapid beneath. The hazard of erosion is moderate. These soils warm up early in spring. They are easy to till, but are droughty.

These soils are suited to all crops grown in the county, but early maturing crops make better use of the limited moisture content than other crops. Corn, soybeans, oats, and alfalfa are the main crops. Some areas are used for pasture or woodland. These soils are suited to pasture early in the season, but pasture dries up or does not grow in late summer. Most of the wooded areas are not managed for woodland production.

Crops respond well to irrigation. These soils need to be managed to control erosion and conserve moisture. The surface layer erodes easily, and plowing therefore should be done in spring. A suitable cropping system, minimum tillage (fig. 12), stubble mulching, and proper fertilization are needed. During the period between crops the surface should either be kept rough or be kept under cover crops, and all crop residue should be returned to the soil. All these practices improve the supply of moisture and control erosion. Contour stripcropping and field shelterbelts also help to control erosion and to conserve moisture.

Figure 12.—**Minimum tillage on Sverdrup sandy loam, 0 to 2 percent slopes. Soil has been planted and crop residue left on the surface.**

CAPABILITY UNIT IIIw–1

This unit consists of poorly drained and very poorly drained soils of the Colvin, Dovray, Quam, Tonka, and Urness series. These soils occur in depressions and drainageways.

These soils have medium to high natural fertility, medium to very high available water capacity, and high organic-matter content. The root zone is determined by the depth to the water table. Permeability and infiltration are moderate in Tonka and Colvin soils, moderately slow in Quam and Urness soils, and very slow in Dovray soils.

If these soils are adequately drained and fertilized, corn, soybeans, and hay can be grown. Small grains can be grown, but lodging is generally a serious problem. These soils generally are not suited to alfalfa, but if they are adequately drained, red clover, alsike clover, ladino clover, bromegrass, and timothy can be grown. Some areas are in permanent pasture. Undrained areas provide excellent habitat for wild game.

Excess water severely limits the use of these soils. Drainage is necessary before these soils can be used for crops. In areas where large amounts of water must be removed, open ditches generally are used to provide drainage. These soils generally are farmed along with the surrounding soils in the field. If the areas are large enough and are farmed separately, row crops can be grown continuously. Tillage must be kept to a minimum and must be done only within a narrow range of moisture content. All crop residue should be returned to the soil. This practice, along with proper fertilization, helps to maintain organic-matter content and tilth. Undrained areas generally are marshy and are seasonally ponded. They can be improved for wildlife habitat by use of shallow pits and ditches. All of the soils in this capability unit are good sites for stock-watering ponds (fig. 13).

CAPABILITY UNIT IIIw–2

This unit consists of poorly drained and very poorly drained soils of the Arveson, Forada, and Marysland series and Lake beaches, loamy. The soils occur in drainageways, shallow depressions, and potholes, and lake beaches, loamy, occurs along lakes. They are underlain by fine sand to gravelly coarse sand at a depth of 22 to 40 inches.

These soils have medium to high natural fertility, low to medium available water capacity, and high organic-matter content. Arveson and Marysland soils are high in content of lime. Permeability and infiltration are moderate to moderately rapid in the upper part of the profile and rapid in the sand. The depth to the seasonal water table determines the depth of the root zone. Water is commonly ponded on Forada and Marysland soils in spring and occasionally ponded throughout the year.

Excess water limits the use of these soils. Some of the areas have been drained by surface ditches. Tile drainage is difficult because of the coarse-textured underlying material. Plugging with sand is a hazard after the tile has been installed.

If these soils are adequately drained, all crops common in the county can be grown. Corn, soybeans, oats, and hay are the main crops. Generally, undrained areas of these soils are marshy and seasonally ponded. Many areas of these soils are used for permanent pasture. Pasture can be improved if the soils are drained and a proper grass-legume mixture is seeded. These soils are generally farmed along with the surrounding soils in the field. Tillage should be kept to a minimum and should be done only within a narrow range of moisture content. Crop residue should be returned to the soil. This practice, along with proper fertilization, helps to maintain the organic-matter content and the tilth.

CAPABILITY UNIT IVe–1

This unit consists of deep, well-drained to somewhat excessively drained, hilly soils of the Barnes, Dorset, Langhei, Nebish, Sioux, and Waukon series. Small areas of droughty Dorset and Sioux soils were included because they occur in complexes with other soils in this capability unit. These areas are not large enough to warrant a separate discussion.

These soils have medium to high natural fertility, medium to high available water capacity, and low to high organic-matter content. Langhei soils have medium natural fertility because their high content of lime causes an imbalance of plant nutrients. The root zone is deep, and permeability and infiltration are moderate. These soils are slightly eroded to moderately eroded. All the

Figure 13.—**Stock watering pit on Quam mucky silty clay loam.**

soils in this capability unit are subject to further erosion unless they are properly managed. If these soils are cultivated, the hazard of further erosion is severe.

If proper management practices are used, these soils are suited to occasional cultivation. Corn can be grown if erosion is controlled. These soils are better suited to livestock raising than to other farm uses. The raising of livestock requires a large amount of forage. Among the practices that help control runoff and erosion are contour tillage, contour stripcropping, waterways, minimum tillage, and mulch tillage. Managing crop residue, fertilizing properly, and adding manure help to maintain the organic-matter content and the tilth. 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 soil from erosion, and row crops should not be grown.

Many areas are in permanent pasture or are wooded. These soils provide good pasture if they are fertilized properly and if proper legumes and grasses, such as bromegrass and alfalfa, are grown.

CAPABILITY UNIT IVe–2

This unit consists of sloping or rolling, somewhat excessively drained soils of the Arvilla, Dorset, and Sverdrup series. The soils of this capability unit have a medium-textured to moderately coarse textured surface layer and subsoil. They are underlain by sand and gravelly coarse sand at a depth of 12 to 22 inches, except for Sverdrup soils, which are underlain by sand.

These soils have low to medium natural fertility, low available water capacity, and low to medium organic-matter content. The root zone is shallow to deep, and permeability and infiltration are moderately rapid to the sand and gravelly coarse sand and rapid in the sand and gravelly coarse sand. The hazard of erosion is severe. These soils warm up early in spring and are easy to till.

Use of these soils is severely restricted because they are droughty and are subject to erosion. Soils in this unit can be cultivated occasionally, but practices that control further erosion are needed.

These soils should be managed to control erosion and conserve moisture. They should be plowed in spring. Managing crop residue and applying manure improve fertility, increase the supply of moisture, and control erosion. Minimum tillage, stubble mulching, wheel track planting, contour farming, and contour stripcropping help to control erosion and conserve moisture. In many places the soils have slopes that are too uneven or too irregular for the growing of row crops and for the use of practices that protect soils from erosion.

Some areas are used for pasture and woodland. Pasture on these soils is fairly good early in spring, but the soils are droughty and little forage is produced in summer. Some areas of the Dorset soil are poorly suited because they are partly wooded or brushy.

CAPABILITY UNIT IVs–1

This unit consists of well-drained, nearly level, gently sloping and undulating soils of the Maddock and Nymore series. These soils have a surface layer and subsoil of loamy sand or fine sand and are underlain by sand at a depth of 6 to 20 inches.

These soils have low natural fertility, low available water capacity, and low to medium organic-matter content. Permeability and infiltration are rapid.

These soils warm up early in spring and are easy to till. The hazard of drought is very severe, and the hazard of erosion is severe. The supply of nutrients is low.

Soils in this capability unit are better suited to small grains, hay, and early-maturing crops than to other crops.

They need to be managed to control erosion and conserve moisture. All tillage should be done in spring. Any cropping system used on these soils should provide year-round cover. Managing crop residue and applying manure improve fertility and the supply of moisture and control erosion. Minimum tillage, wind stripcropping, field shelterbelts, stubble mulching, wheel-track planting, and contour stripcropping help to control erosion and conserve moisture. Terracing is not suitable on these sandy soils. Gullies should be shaped and seeded to grass that is suitable for use in waterways.

These soils make poor permanent pasture because it is difficult to maintain a good sod on them. More forage is produced on pastures that consist of alfalfa and bromegrass than on pastures that consist of bluegrass.

CAPABILITY UNIT IVs–2

This unit consists of excessively drained, nearly level, undulating or rolling soils of the Sioux series. These soils have less than 12 inches of loamy coarse sand over the gravelly coarse sand underlying material.

These soils have very low natural fertility, very low to low available water capacity, and low organic-matter content. The root zone is very shallow, and permeability and infiltration are very rapid. Some of the areas are moderately eroded. These soils warm up early in spring and are easy to till. In some areas surface stones interfere with tillage operations. The hazard of drought is very severe, and the hazard of erosion is severe. The supply of nutrients is very low.

Soils in this capability unit are better suited to small grains, hay, and early maturing crops than to other crops.

These soils need to be managed to control erosion and conserve moisture. All tillage should be done in spring. Any cropping system used on these soils should provide year-round cover. Managing crop residue and applying manure improve fertility and the supply of moisture and control erosion. Minimum tillage, wind stripcropping, field shelterbelts, stubble mulching, wheel track planting, and contour stripcropping help to control erosion and conserve moisture. These soils are generally shallow over gravelly coarse sand and terracing is not suitable.

These soils make poor permanent pasture because a good sod is difficult to maintain on them. More forage is produced on pastures that consist of alfalfa and bromegrass than on pastures that consist of bluegrass.

CAPABILITY UNIT IVw–1

This unit consists of poorly drained and very poorly drained, nearly level to depressional soils of the Dassel and Hangaard series. They are underlain by sand or gravelly coarse sand at a depth of 12 to 24 inches.

These soils have low to high natural fertility, low available water capacity, and medium to high organic-

matter content. Permeability and infiltration are moderately rapid in the upper part and rapid in the sand. Depth to the seasonal water table determines depth of the root zone.

Many areas have been drained by surface ditches. If adequately drained and fertilized, these soils can be used to grow corn, oats, soybeans, and hay. If undrained, these soils generally are covered with water in spring. They are generally covered with aquatic grasses, sedges, reeds, and willows.

Many areas are used for permanent pasture. Pasture can be improved if these soils are drained and seeded to a suitable grass-legume mixture.

CAPABILITY UNIT IVw-2

This unit consists of very poorly drained, organic soils of the Brophy, Carlos, Cathro, Millerville, Rifle, and Seelyeville series and the Cathro series, sandy subsoil variant, and the Urness series, peaty subsoil variant. These soils occur in small and large potholes, shallow lakes, and drainageways throughout the county. These soils formed in an accumulation of reeds, sedges, cattails, and mosses.

The organic material in the Cathro soil and the sandy subsoil variant of Cathro soils is 16 to 51 inches thick. In the Brophy, Carlos, Millerville, Rifle, and Seelyeville soils it is 16 to more than 120 inches thick. The sandy subsoil variant of Cathro soils is underlain by gravelly sand within a depth of 51 inches, and the Cathro soil is underlain by medium-textured or moderately fine textured material within a depth of 51 inches. The peaty subsoil variant of Urness soil consists of silt loam underlain by organic material at a depth of 24 to 48 inches.

Natural fertility varies but generally is low, and the available water capacity is high to very high. The soils are subject to soil blowing. Erosion is more severe in the large areas than in the other areas.

These soils are used for hay, pasture, crops, and wildlife habitat. If drained, they are suited to corn grown for silage, oats, and suitable forage mixtures for hay and pasture. A large acreage is in hay and pasture. Undrained areas provide habitat for wild game.

The major limitations are poor drainage and low fertility. These soils are also susceptible to fire and frost. They are subject to soil blowing. The pasture can be improved by working the soil when it is dry and then fertilizing and seeding the areas to proper grasses. Topdressing with fertilizer improves the quality and palatability of the grass. Many areas can be improved for waterfowl and other wild game by constructing shallow pits or ditches (fig. 14) that provide open water.

CAPABILITY UNIT VIe-1

This unit consists of deep, somewhat excessively drained and well-drained, hilly and steep soils of the Langhei, Nebish, Sioux, and Waukon soils. Small areas of droughty Sioux soils were included because they were mapped in a complex with Langhei and Waukon soils, but these areas are too small to warrant a separate discussion.

These soils have medium to high natural fertility, high available water capacity, and medium to high organic-matter content. The root zone is deep, and permeability

Figure 14.—**Wildlife improvements made by blasting Seelyeville muck with ammonium nitrate.**

and infiltration are moderate. These soils are slightly eroded to moderately eroded.

These soils are not suitable for crops because of the steepness of slope and the very severe hazard of erosion. They are better suited to hay, pasture, woodland, or wildlife habitat than to other uses. Some of the soils have been cultivated.

Areas now in permanent pasture or woodland should be maintained, and areas now in crops should be put into permanent vegetation. Pasture or hay meadows can be improved by renovating and reseeding them. This can be done by digging, disking, or otherwise killing the plants in the old sod, but a cover of residue must be left on the surface. Gullies should be shaped and seeded to grass that is suitable for use in waterways.

CAPABILITY UNIT VIs-1

This unit consists of well-drained and excessively drained, undulating to rolling soils of the Maddock, Nymore, and Sioux series.

These soils have low to very low natural fertility and available water capacity and low to medium organic-matter content. The root zone is very deep in the soils that are underlain by sand and very shallow in the soils that are underlain by gravelly coarse sand. Permeability and infiltration are rapid to very rapid.

These soils are suitable for hay, pasture, woodland, and wildlife habitat. They are too droughty and erodible for cultivated crops. In some places soils that are farmed should be put into permanent vegetation.

If these soils are used for pasture or hay, good management is needed to maintain the sod. These soils can provide fair pasture early in spring and late in fall. Pastures can be renovated when necessary by plowing or digging in spring, then fertilizing and seeding to a nurse crop and suitable grasses and legumes. Gullies should be shaped and seeded to grass that is suitable for use in waterways.

CAPABILITY UNIT VIw-1

This unit consists of Alluvial land and Lake beaches, sandy. These land types are poorly drained. Alluvial land is variable in texture, but generally it is loamy and has sand layers in the profile. It is commonly cut up by

stream meanders, and in places there are small sandy areas. Lake beaches, sandy, are sandy throughout.

These land types are not suited to crops, because most areas are too wet or are subject to flooding. They are suited to permanent vegetation. If they are used for pasture, it is important to control the weeds and brush.

CAPABILITY UNIT VIIe–1

This unit consists of Langhei loam, 18 to 40 percent slopes. It is a deep, somewhat excessively drained, medium-textured, steep and very steep soil on uplands.

This soil has medium natural fertility, high available water capacity, and medium organic-matter content. Permeability and infiltration are moderate, but because runoff is very rapid, the amount of water that enters the soil is much reduced. The hazard of erosion is very severe.

This soil is not suited to cultivated crops, and areas now in crops should be put into permanent vegetation. If this soil is used for pasture, a good cover of plants should be maintained for control of erosion. Care should be taken to prevent overgrazing, which creates an erosion hazard. This soil is suited to trees and to use as wildlife habitat. Areas now in permanent pasture or woodland should be maintained. Gullies should be shaped and seeded to grass for use as waterways. Trees can be planted to improve woodland or to reforest areas that have been pastured.

CAPABILITY UNIT VIIs–1

This unit consists of Sioux gravelly loamy coarse sand, 12 to 35 percent slopes. It is an excessively drained, hilly to very steep soil. The surface layer generally is gravelly loamy coarse sand underlain by gravelly coarse sand within a depth of 12 inches.

This soil has very low natural fertility, very low available water capacity, and low organic-matter content. In some places there are large stones and boulders. Drought and the hazard of erosion severely limit the use of the soil.

This soil is too droughty for crops, and maintaining a good vegetative cover is difficult if the soil is used for pasture or hay (fig. 15). The areas are suited to woodland or wildlife habitat.

Figure 15.—Unmanaged permanent pasture on Sioux gravelly loamy coarse sand, 12 to 35 percent slopes. Stones and sparse vegetation in background.

CAPABILITY UNIT VIIIw–1

This capability unit consists of Marsh. This land type occurs along the edges of some lakes, ponds, and streams, and in depressions. The water level fluctuates, depending on the season. The vegetation consists of cattails, rushes, sedges, willows, and other water-tolerant plants. Because the areas are wet, the soil material has not been identified. In places during prolonged dry spells, the edges of the marsh can be cut for wild hay.

Areas of Marsh are unsuited to crops and pasture, but provide good habitat for waterfowl, muskrat, mink, and upland game (fig. 16, top). The areas can be improved for wildlife habitat by providing level ditches, made by blasting or digging, to control the level of the water (fig. 16, bottom).

Predicted yields

In table 2 are predicted yields per acre of the principal crops grown in Douglas County under two levels of management. This table provides guidelines to crop-yield potentials of the various soils in relation to the way in which the soils are managed. These yields are based on records and observations of the Soil Conservation Service, the Extension Service, and the University of Minnesota, and on interviews with farmers of the county.

Figure 16.—At top is an area of Marsh that provides waterfowl cover; at bottom is an aerial view of an area of Marsh that has been improved for wildlife.

TABLE 2.—*Predicted yields per acre of the*

[Figures in columns A indicate yields under average management. Figures in columns B indicate yields under

Soil	Corn for grain		Corn for silage		Soybeans	
	A	B	A	B	A	B
	Bu.	*Bu.*	*Tons*	*Tons*	*Bu.*	*Bu.*
Aastad clay loam, 1 to 3 percent slopes	55	75	11	15	20	30
Alluvial land						
Arveson sandy clay loam	30	55	6	11	14	20
Arvilla sandy loam, 0 to 2 percent slopes	30	50	6	10	12	18
Arvilla sandy loam, 2 to 6 percent slopes	25	50	5	10	10	16
Arvilla sandy loam, 6 to 12 percent slopes	20	40	4	8	8	14
Arvilla sandy loam, thick solum, 0 to 3 percent slopes	35	55	7	11	16	22
Barnes loam, 2 to 6 percent slopes, eroded	50	70	10	14	20	28
Barnes loam, 6 to 12 percent slopes, eroded	35	60	7	12	15	22
Barnes-Langhei loams, 2 to 6 percent slopes, eroded	40	60	8	12	18	26
Barnes-Langhei loams, 6 to 12 percent slopes, eroded	30	55	6	11	13	20
Beltrami loam, 1 to 3 percent slopes	45	65	9	13	15	20
Brophy peat						
Carlos muck						
Cathro muck			10	15		
Cathro muck, sandy subsoil variant			10	15		
Clarion loam, 2 to 6 percent slopes, eroded	55	75	11	15	20	30
Clarion loam, 6 to 12 percent slopes, eroded	40	70	8	14	20	30
Clontarf sandy loam, 0 to 2 percent slopes	35	50	7	10	15	20
Colvin silt loam	40	70	8	14	18	26
Colvin silt loam, depressional	30	60	6	12	15	26
Darnen loam, 1 to 4 percent slopes	50	75	10	15	25	35
Dassel sandy loam	20	35	4	7	10	15
Dassel sandy loam, depressional	20	35	4	8	8	13
Dorset sandy loam, 0 to 2 percent slopes	30	50	6	10	12	18
Dorset sandy loam, 2 to 6 percent slopes	25	45	5	10	10	16
Dorset sandy loam, 6 to 12 percent slopes	20	40	4	8	8	14
Dorset sandy loam, thick solum, 0 to 2 percent slopes	35	55	7	11	15	21
Dorset sandy loam, thick solum, 2 to 6 percent slopes	30	50	6	10	13	20
Dorset sandy loam, thick solum, 6 to 12 percent slopes	20	40	4	7	12	18
Dovray mucky silty clay	40	70	8	14	16	28
Flom silty clay loam	50	80	10	16	20	30
Forada sandy loam	25	45	5	9	12	15
Forada loam, depressional	20	45	4	9	10	15
Forada sandy loam, sandy subsoil	25	45	5	9	12	15
Forman clay loam, 6 to 12 percent slopes, eroded	35	55	7	11	13	21
Forman-Aasted clay loams, 1 to 5 percent slopes	50	70	10	14	20	30
Fulda silty clay	40	70	8	14	18	28
Gonvick loam, 1 to 3 percent slopes	45	65	9	13	18	28
Hangaard sandy loam	20	30	5	8	10	15
Hantho silt loam, 1 to 3 percent slopes	50	70	10	14	20	30
Lake beaches, sandy						
Lake beaches, loamy						
Langhei loam, 18 to 40 percent slopes						
Langhei-Barnes loams, 12 to 18 percent slopes, eroded	25	40	5	8	5	12
Langhei-Waukon loams, 12 to 18 percent slopes, eroded	25	40	5	8	5	15
Langhei-Waukon loams, 18 to 24 percent slopes						
Langhei-Waukon-Sioux complex, 12 to 25 percent slopes						
Maddock fine sand, 0 to 2 percent slopes	15	25	3	5	8	12
Maddock fine sand, 2 to 6 percent slopes	15	25	3	5	8	12
Maddock fine sand, 6 to 12 percent slopes						
Marsh						
Marysland loam	30	50	6	10	12	15
Marysland loam, depressional	20	45	4	9	10	15
Millerville mucky peat			10	15		
Nebish sandy loam, 2 to 6 percent slopes	25	45	5	9	13	16
Nebish sandy loam, 6 to 12 percent slopes	20	35	4	7	10	14
Nebish sandy loam, 12 to 18 percent slopes	20	35	4	7	8	12
Nebish loam, 2 to 6 percent slopes	35	60	7	12	18	22
Nebish loam, 2 to 6 percent slopes, eroded	30	50	6	10	16	20
Nebish loam, 6 to 12 percent slopes	30	50	6	10	16	20
Nebish loam, 6 to 12 percent slopes, eroded	25	45	5	9	12	16
Nebish loam, 12 to 18 percent slopes	20	35	4	7	8	12
Nebish loam, 18 to 24 percent slopes						
Nebish-Dorset complex, 2 to 6 percent slopes	35	50	7	10	14	20
Nebish-Dorset complex, 6 to 12 percent slopes	25	45	5	9	10	16
Nicollet clay loam, 1 to 4 percent slopes	55	80	11	16	25	35
Nymore loamy sand, 2 to 6 percent slopes	15	25	3	5	(3)	(3)

See footnotes at end of table.

principal crops under two levels of management

improved management. Absence of figures indicates the crop is not suited to or is not commonly grown on the soil specified]

Oats		Wheat		Barley		Rotation hay[1]		Rotation pasture		Permanent pasture	
A	B	A	B	A	B	A	B	A	B	A	B
Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Animal-unit-days*[2]	*Animal-unit-days*[2]	*Animal-unit-days*[2]	*Animal-unit-days*[2]
60	80	25	35	35	50	2. 5	4. 0	125	200	50	100
										60	100
30	55	20	30	25	35	2. 0	3. 0	100	150	40	80
30	50	15	20	18	28	1. 5	2. 5	75	125	25	55
25	50	15	20	18	28	1. 5	2. 5	75	125	25	50
20	40	10	15	15	25	1. 0	2. 0	50	100	20	40
40	55	20	25	20	30	2. 0	3. 5	100	175	30	60
50	70	25	35	30	50	2. 5	4. 0	125	200	50	100
45	65	20	30	25	40	2. 0	3. 5	100	175	45	100
45	65	25	30	25	40	2. 5	3. 5	125	175	45	100
40	60	20	25	20	35	2. 0	3. 5	100	175	40	95
50	75	(3)	(3)	(3)	(3)	3. 0	4. 5	150	225	55	115
										40	100
										40	110
20	40					1. 5	2. 5	75	125	40	110
20	40					1. 0	2. 0	50	100	40	110
50	80	25	35	35	50	2. 5	4. 5	125	225	50	110
35	70	20	30	30	45	2. 0	4. 0	100	200	45	90
40	50	16	26	20	35	1. 5	2. 5	75	125	30	65
45	70	25	35	30	45	2. 5	4. 0	125	200	50	105
35	60	15	30	20	40	2. 0	3. 0	100	150	40	105
55	75	25	40	40	55	2. 5	4. 5	125	225	55	105
30	40	(3)	(3)	(3)	(3)	1. 0	3. 0	50	150	30	75
20	40	(3)	(3)	(3)	(3)	1. 0	3. 0	50	150	20	70
35	55	(3)	(3)	(3)	(3)	1. 5	2. 5	75	125	35	70
35	55	(3)	(3)	(3)	(3)	1. 5	2. 5	75	125	35	70
20	40	(3)	(3)	(3)	(3)	1. 0	2. 0	50	100	30	60
35	55	(3)	(3)	(3)	(3)	2. 0	3. 0	100	150	40	80
30	50	(3)	(3)	(3)	(3)	1. 5	2. 5	75	125	30	60
20	40	(3)	(3)	(3)	(3)	1. 5	3. 0	75	150	20	40
40	70	25	35	30	50	2. 0	4. 0	100	200	35	100
50	70	30	40	35	55	2. 0	4. 0	100	200	40	100
30	45	15	20	20	30	2. 0	3. 0	100	150	40	80
25	45	10	20	15	30	1. 0	3. 0	50	150	20	80
30	45	15	20	20	30	1. 5	3. 0	75	150	40	80
40	60	15	30	20	40	2. 0	3. 0	100	175	40	90
50	70	30	45	35	55	2. 5	4. 0	125	200	50	110
40	70	20	30	30	50	2. 0	3. 5	100	175	40	100
60	80	25	40	30	50	2. 5	4. 0	125	200	50	105
25	40	12	18	15	25	1. 5	2. 0	75	100	30	65
60	80	25	40	30	50	2. 5	4. 0	125	200	50	110
										35	60
										40	65
								75	125	35	80
25	45	10	25	15	30	2. 0	3. 0	100	150	40	90
25	45	10	25	15	30	2. 0	3. 0	100	150	40	90
								100	150	35	80
								75	125	30	70
20	35	(3)	(3)	(3)	(3)	1. 0	2. 0	50	100	20	40
20	35	(3)	(3)	(3)	(3)	1. 0	2. 0	50	100	20	40
								40	80	15	30
30	45	15	22	20	35	2. 0	3. 5	100	175	40	80
20	45	10	15	15	30	1. 0	3. 0	50	150	20	80
25	50					1. 5	2. 5	75	125	40	110
40	55	(3)	(3)	(3)	(3)	1. 9	3. 0	95	150	35	75
30	45	(3)	(3)	(3)	(3)	1. 5	2. 5	75	125	30	65
25	40	(3)	(3)	(3)	(3)	1. 5	2. 5	75	125	30	80
50	70	(3)	(3)	(3)	(3)	2. 5	4. 0	125	200	50	100
40	60	(3)	(3)	(3)	(3)	2. 5	4. 0	125	200	50	100
40	60	(3)	(3)	(3)	(3)	2. 0	3. 5	100	175	40	90
35	55	(3)	(3)	(3)	(3)	2. 0	3. 5	100	175	40	90
30	50	(3)	(3)	(3)	(3)	1. 5	3. 0	150	150	30	80
								100	150	25	70
40	60	(3)	(3)	(3)	(3)	2. 5	3. 5	125	175	40	90
30	50	(3)	(3)	(3)	(3)	2. 0	3. 0	100	150	35	80
60	80	25	35	30	50	3. 0	4. 0	150	200	50	100
25	40	(3)	(3)	(3)	(3)	1. 0	1. 0	50	100	20	40

TABLE 2.—*Predicted yields per acre of the*

Soil	Corn for grain		Corn for silage		Soybeans	
	A	B	A	B	A	B
	Bu.	*Bu.*	*Tons*	*Tons*	*Bu.*	*Bu.*
Nymore loamy sand, 6 to 18 percent slopes						
Osakis loam, 0 to 3 percent slopes	35	50	7	10	15	20
Quam mucky silty clay loam	40	80	8	16	20	30
Rifle mucky peat			10	15		
Rothsay silt loam, 2 to 6 percent slopes	50	70	10	14	20	28
Seelyeville muck			10	15		
Shooker loam	40	60	8	12	15	20
Sinai clay, 0 to 2 percent slopes	45	60	9	12	18	26
Sinai clay, 2 to 6 percent slopes	40	60	8	12	16	24
Sioux loamy coarse sand, 0 to 6 percent slopes	20	30	4	6	10	12
Sioux loamy coarse sand, 6 to 12 percent slopes	10	20	2	4	8	10
Sioux gravelly loamy coarse sand, 2 to 12 percent slopes						
Sioux gravelly loamy coarse sand, 12 to 35 percent slopes						
Sverdrup sandy loam, 0 to 2 percent slopes	30	40	6	8	10	15
Sverdrup sandy loam, 2 to 6 percent slopes	25	40	5	8	10	15
Sverdrup sandy loam, 6 to 12 percent slopes	20	30	4	6	7	12
Sverdrup loam, thick solum, 0 to 3 percent slopes	35	45	7	9	12	18
Tonka loam	40	60	8	12	15	20
Urness mucky silty clay loam	45	70	9	14	20	25
Urness mucky silt loam, peaty subsoil variant						
Vallers clay loam, 0 to 3 percent slopes	50	80	10	16	20	30
Waukon loam, 2 to 6 percent slopes	45	70	9	14	20	26
Waukon loam, 2 to 6 percent slopes, eroded	40	60	8	12	15	21
Waukon loam, 6 to 12 percent slopes	40	60	8	12	15	21
Waukon loam, 6 to 12 percent slopes, eroded	35	55	7	11	12	18
Waukon loam, 12 to 18 percent slopes	35	50	7	10	8	16
Waukon loam, 12 to 18 percent slopes, eroded	30	45	6	9	6	14
Waukon loam, 18 to 24 percent slopes						
Waukon clay loam, 2 to 6 percent slopes	40	60	8	12	15	21
Waukon clay loam, 6 to 12 percent slopes, eroded	35	55	7	11	12	18
Waukon-Langhei loams, 2 to 6 percent slopes, eroded	40	60	8	12	18	26
Waukon-Langhei loams, 6 to 12 percent slopes, eroded	35	60	7	12	13	20
Waukon-Langhei-Sioux complex, 2 to 6 percent slopes, eroded	30	50	6	10	15	20
Waukon-Langhei-Sioux complex, 6 to 12 percent slopes, eroded	20	40	4	8	12	17
Zell-Rothsay silt loams, 6 to 12 percent slopes, eroded	35	60	7	12	13	20

[1] Estimates are for alfalfa-brome mixtures. Yields of mixtures of timothy and either red clover or alsike clover are 10 to 25 percent less.

[2] Animal-unit-days is a term used to express the carrying capacity of pasture. It is the number of animal units carried per acre multiplied by the number of days the pasture can be grazed during a single grazing season without injury to the sod. An acre of pasture that

principal crops under two levels of management—Continued

Oats		Wheat		Barley		Rotation hay[1]		Rotation pasture		Permanent pasture	
A	B	A	B	A	B	A	B	A	B	A	B
Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Animal-unit-days*[2]	*Animal-unit-days*[2]	*Animal-unit-days*[2]	*Animal-unit-days*[2]
								40	80	15	35
35	50	15	20	18	28	1. 5	2. 5	75	125	25	55
40	70	20	30	25	35	2. 0	4. 0	100	200	50	105
30	50					1. 5	2. 5	75	125	40	110
50	70	30	45	35	55	2. 5	4. 0	125	200	50	110
20	40					1. 5	2. 5	75	125	40	110
45	70	[3]	[3]	[3]	[3]	2. 0	4. 0	100	200	45	100
45	65	25	35	30	45	2. 5	3. 5	125	175	50	100
45	65	25	35	30	45	2. 5	3. 5	125	175	50	100
20	30					1. 5	2. 0	75	100	20	40
10	20					1. 0	1. 5	50	75	15	30
										20	40
										15	30
30	45	15	20	20	30	1. 5	2. 5	75	125	30	50
30	40	15	20	20	30	1. 5	2. 5	75	125	25	50
25	35	10	15	15	25	1. 0	2. 0	50	100	20	40
35	45	[3]	[3]	[3]	[3]	2. 0	3. 0	100	150	30	60
45	70	25	35	30	50	2. 0	4. 0	100	200	45	100
40	60					1. 0	3. 0	50	150	30	115
50	70	25	35	30	45	2. 5	4. 0	125	200	45	95
50	70	25	40	30	50	2. 5	4. 0	125	200	50	100
45	65	20	35	25	45	2. 0	3. 5	100	175	45	90
45	65	20	35	25	45	2. 0	3. 5	100	175	45	90
40	60	15	30	20	40	2. 0	3. 0	100	150	40	85
35	50	15	30	20	35	2. 0	3. 0	100	150	35	80
30	45	10	25	15	30	1. 5	2. 5	75	125	35	80
						1. 5	2. 5	75	125	30	70
45	65	20	35	25	45	2. 0	3. 5	100	175	45	90
40	60	15	30	20	40	1. 5	3. 0	75	150	40	80
45	65	25	40	30	45	2. 5	3. 5	125	175	45	100
40	60	20	30	25	40	2. 0	3. 0	100	150	35	80
35	55	18	33	20	35	2. 0	3. 0	100	150	40	80
25	45	15	25	15	25	1. 5	2. 5	75	125	30	60
40	60	20	30	25	40	2. 0	3. 0	100	150	40	80

provides 30 days of grazing for 2 cows has a carrying capacity of 60 animal-unit-days.

[3] Limited acreage grown.

Yields are not given for crops that are not considered suitable for a particular soil. The major crops can be grown on such soils, but they are not likely to be successful because the soils are droughty, steep, severely eroded, or poorly drained.

The yield figures represent an average to be expected over a period of 10 years. They do not take into account past management on a particular farm. Considered in making the estimates were the climate, characteristics of the soils, and the influence of different kinds of management on the soil. Yields from the same soil vary, depending on variations in management, weather, crop varieties, and plant diseases.

Crops.—In columns A are yields to be expected under average management. The management used to obtain these average yields consists of using a planned conservation cropping system that is generally followed. Surface drainage and internal drainage are improved, but they are not adequate. Moderate amounts of fertilizer are used on corn and hay. Seedbed preparation is sometimes inadequate and sometimes excessive. Weed competition and insects are not adequately controlled. Practices are used to control erosion.

Yields in columns B are those expected under improved management. The requirements of good management vary according to the soil, but under this level of management, crops suited to the soil are grown in a suitable cropping system. Surface and internal drainage provide optimum growing conditions. Commercial fertilizers, lime, and manure are applied; proper tillage methods are used; and all organic matter is returned to the soil. Weeds, insects, and plant diseases are adequately controlled. The productivity and workability of the soil are maintained or improved; soil blowing and erosion are adequately controlled; and the soil, plant nutrients, and moisture are conserved.

Pasture.—Under pasture management it is assumed that rotation pasture consists of suitable legumes and grasses. Permanent pasture, under average management, consists principally of native grass. Under improved management, in which permanent pasture is renovated at intervals, a mixture of suitable grasses and legumes is the principal cover.

In columns A are yields to be expected under average management. Under the management used to obtain these yields, weeds and brush are partly controlled. Fertilizer is not used or is used at infrequent intervals. Grazing is delayed in spring, but pastures are frequently overgrazed later in the year. Drainage is inadequate.

Yields given in columns B are those expected under improved management. The management used to obtain these yields includes fertilizing according to soil tests and the needs of the forage crop. Pastures are properly managed, weeds and brush are adequately controlled, and drainage is adequate for the forage species being grown.

The yields given in table 2 are those obtainable using present farming practices and varieties of crops. Increased yields per acre can be expected as agricultural technology advances. It is also possible that plant diseases and pests could cause average yields to be less than those predicted here.

Woodland and Windbreaks [2]

This section gives general facts about trees and shrubs that are suggested for use in field windbreaks, farmstead windbreaks, and woodland plantings. It shows the principal trees and discusses the soil properties that affect the growth of trees.

The woodlands of Douglas County are interspersed with crops and pasture. Figure 17 shows the distribution of the original vegetation in the county. In 1964, according to the U.S. Bureau of the Census, 46,000 acres were woodland. This acreage is about 11 percent of the land now in farms. The woodlands are scattered throughout the county and are around lakes and hilly moraines and in the northern part of the county. The native species are mainly soft maple, hard maple, white oak, red oak, bur oak, ironwood, white birch, ash, elm, poplar, basswood, and spruce. Only small areas of woodland have been managed for timber production in the county, but plantings, mainly of conifers, have been made.

Woodland suitability grouping

The soils of Douglas County have been placed into woodland suitability groups for woodland or windbreak use. Each group is made up of soils that are suited to the same kinds of trees and shrubs and need similar management. Species to plant or to favor in existing stands, seedling mortality, plant competition, erosion hazard, and equipment limitations are other factors used in grouping the soils.

Seedling mortality refers to the expected loss of naturally occurring or planted seedlings as a result of unfavorable soil characteristics. Mortality is slight if the expected loss is less than 25 percent; moderate if the expected loss is between 25 and 50 percent; and severe if the expected loss is more than 50 percent.

Plant competition refers to the difficulty in establishing desirable tree species and shrubs because of encroachment of undesirable vegetation. Competition is slight if competing vegetation does not cause the seedlings to die or restrict their growth; moderate if the plant invaders delay but do not prevent the establishment of a normal, fully stocked stand; and severe if grass, brush, or undesirable trees prevent adequate natural regeneration. In areas where plant competition is severe, intensive site preparation and maintenance are needed.

The equipment limitations are slight if there are no restrictions on the type of equipment or on the time of year that the equipment can be used. They are moderate if the use of equipment is restricted by slope or by wetness of soils for no more than 3 months, or if the use of equipment damages tree roots to some extent. They are severe if normal equipment cannot be used more than 3 months a year.

The erosion hazard is the degree of potential loss of soil by blowing or through the action of water. Vegetative cover, slope, and soil properties are important factors. The hazard is slight if erosion is no problem. It is moderate if normal measures are needed to prevent

[2] Prepared with the assistance of JOHN HULTGREN, woodland conservationist, Soil Conservation Service.

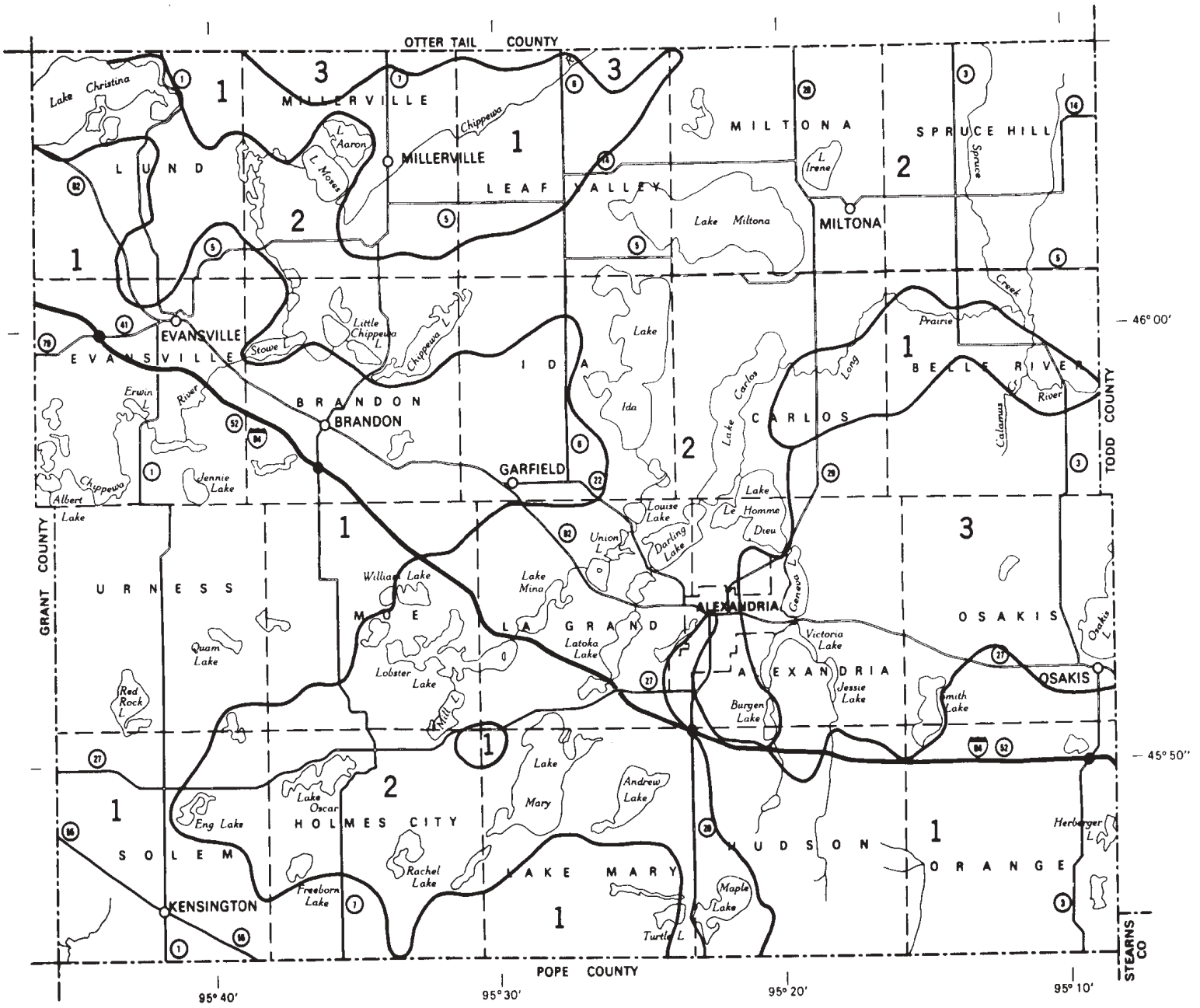

Figure 17.—Original vegetation of Douglas County. Number 1 identifies prairies, marshes, sloughs, and other grasslands where the vegetation consisted of big bluestem, little bluestem, prairie cordgrass, tall dropseed, indiangrass, switchgrass, side-oats grama, hairy grama, blue grama, leadplant, marshgrass, sedges, reeds, and scattered stands of woodland. Number 2 identifies oak groves and oak openings where the vegetation consisted of oaks and some poplar, basswood, hard maple, soft maple, cottonwood, tamarack, and spruce. In Spruce Hill Township there were also black spruce, balsam fir, white pine, and beaked hazelnut. Number 3 identifies areas of northern hardwoods where the vegetation consisted mainly of hard maple, white oak, bur oak, ironwood, birch, ash, elm, and basswood.

unnecessary loss of soil. It is severe if special care and methods are needed to minimize loss and deterioration of the soil.

WOODLAND SUITABILITY GROUP 1

This group consists of soils of the Aastad, Barnes, Beltrami, Clarion, Darnen, Forman, Gonvick, Hantho, Nebish, Nicollet, Rothsay, Sinai, and Waukon series. These are deep, medium-textured to fine-textured, moderately well drained to well drained soils. The slopes are 1 to 24 percent.

Natural fertility is medium to high, and the organic-matter content is low to high. Reaction is neutral in the surface layer and mildly alkaline in the underlying material. The available water capacity is medium to very high, and permeability is moderate to very slow.

The Beltrami, Gonvick, Nebish, and Waukon soils were originally in woodland that consisted mainly of hardwoods. In native stands basswood and red oak should be favored for woodland production. These soils are well suited to woodland plantings of pine and white spruce. An annual yield of 200 to 300 board feet per acre can be expected.

Plant competition is moderate to severe. Site preparation and weeding are needed to insure success of

plantings. Seedling mortality is slight. The equipment limitations and hazard of erosion are slight to severe, depending on the slope. Precautions are needed to keep equipment from tipping on the steeper soils. Steeper soils should be planted by hand.

WOODLAND SUITABILITY GROUP 2

This group consists of soils of the Langhei and Zell series. These soils are deep, medium-textured, well-drained and somewhat excessively drained, high-lime soils. Slopes are 2 to 40 percent.

Natural fertility is medium, and the organic-matter content is medium. Reaction is mildly alkaline. The available water capacity is high to very high. Permeability is moderate.

The soils in this group have a restricted root zone caused by the high content of lime. This excess lime affects the growth of trees and shrubs by interfering with the uptake of plant nutrients. These soils are poorly suited to timber production. The original vegetation was native grasses. Woody plantings can be made for windbreaks, wildlife habitat, and watershed protection.

On the steep soils the hazard of erosion is severe. Competition from other plants is moderate to severe. Seedling mortality is moderate to severe. The equipment limitations are slight to severe, depending on the slope. Steeper soils should be planted by hand. Work can be done on these soils throughout most of the year, except after a heavy rain and in spring during and following a thaw.

WOODLAND SUITABILITY GROUP 3

This group consists of soils of the Dassel, Forada, and Hangaard series and Lake beaches, loamy, and Lake beaches, sandy. These soils are moderately coarse textured and are 12 to 40 inches deep to sand and gravel or sand. They occur in nearly level to depressional areas and are poorly drained and very poorly drained.

Natural fertility is low to high, and the organic-matter content is medium to high. The available water capacity is low to medium. Permeability is rapid in the underlying material. Reaction is slightly acid to neutral.

The root zone of these soils is restricted by the coarse-textured underlying material and by depth to the water table. Drainage reduces ponding and lowers the water table so that trees and shrubs develop a deeper and better root system. The native vegetation consisted mainly of grasses, sedges, and reeds.

If these soils are adequately drained, the annual yield of timber should be 100 to 300 board feet per acre. Cottonwood, silver maple, and white pine should be planted for woodland production. Plant competition from weeds and grasses is severe. Seedling mortality is moderate, and equipment limitations are moderate. The hazard of erosion is slight.

WOODLAND SUITABILITY GROUP 4

This group consists of soils of the Dovray, Flom, Fulda, Quam, Shooker, and Tonka series. These are poorly drained and very poorly drained, medium-textured to fine-textured soils. They occur in depressions, draws, waterways, and potholes.

Natural fertility and the organic-matter content are medium to high. The available water capacity is medium to high. Permeability is moderate to very slow. Reaction is slightly acid to neutral in the surface layer and mildly alkaline in the underlying material.

The root zone of these soils is limited by depth to the water table. If these soils are undrained, the water table is at the surface or within 5 feet of the surface in spring. Undrained areas or areas that are not protected from flooding are covered with water for long periods and are too wet to be suitable for trees.

Cottonwood and silver maple should be planted for woodland production. The plant competition from weeds and grasses is severe, and seedling mortality is moderate to severe. Equipment limitations are moderate to severe. The hazard of erosion is slight.

WOODLAND SUITABILITY GROUP 5

This group consists of soils of the Arveson, Colvin, Marysland, and Vallers series. These are calcareous, poorly drained and very poorly drained soils that have a moderately coarse textured to moderately fine textured surface layer. The Marysland and Arveson soils are underlain by sand or sand and gravel at a depth of 22 to 40 inches. These soils are nearly level and depressional in areas throughout the county.

The available water capacity is low to medium in the Arveson soils, medium in the Marysland soils, and high to very high in the Colvin and Vallers soils. Permeability is moderately slow to rapid. The organic-matter content is high, and natural fertility is medium to high. Reaction is mildly alkaline to moderately alkaline.

The water table is high. Undrained areas are too wet to be suitable for trees. If adequately drained, these soils are suited to cottonwoods, and an annual yield of 150 to 300 board feet per acre can be expected.

Seedling mortality is moderate to severe. The excessive amount of lime affects the growth of trees and shrubs. Plant competition from weeds and grasses is severe. Equipment limitations are moderate, and the hazard of erosion is slight.

WOODLAND SUITABILITY GROUP 6

This group consists of soils of the Arvilla, Clontarf, Dorset, Osakis, and Sverdrup series. These are moderately well drained to somewhat excessively drained soils. They are moderately droughty to droughty and have a sandy or gravelly substratum at a depth of 12 to 36 inches. Slopes range from 0 to 12 percent.

Natural fertility and the organic-matter content are low to high. The available water capacity is low to medium. Permeability is rapid in the sand and gravel. Reaction is slightly acid to neutral.

Some areas of the Dorset soils are in woodland that consists of oaks, maple, ash, poplar, and native pine. These soils are better suited to red pine and jack pine, and an annual yield of 100 to 200 board feet per acre can be expected.

Seedling mortality is slight to moderate. Plant competition from weeds and grasses is moderate. Equipment limitations and hazard of erosion are slight to moderate, depending on the slope. Work can generally be done throughout the year, except after a heavy rain and in spring during and following snowmelt.

WOODLAND SUITABILITY GROUP 7

This group consists of soils of the Maddock, Nymore, and Sioux series. These are droughty soils that have a gravelly or sandy substratum within a depth of 6 to 20 inches. Slopes are 0 to 35 percent.

Natural fertility is very low to low, and the organic-matter content is low to medium. The available water capacity is low to very low. Permeability is rapid to very rapid. Reaction is slightly acid to mildly alkaline.

In the northeastern part of the county, mainly in Spruce Hill and Miltona Townships, some of the Sioux and Nymore soils are in woodland that consists of oak, ash, birch, and pine. Red pine and jack pine are the most desirable conifer species for woodland production, and annual yields of 50 to 100 board feet per acre can be expected.

Seedling mortality ranges from moderate to severe, depending on the moisture available. More than 75 percent of the planted stock is likely to be lost if a dry season follows planting. Pocket gophers may be a problem in planted areas. Plant competition from weeds and grasses is slight. The equipment limitations are slight to severe, depending on the slope. The hazards of soil blowing and water erosion are severe.

WOODLAND SUITABILITY GROUP 8

This group consists of soils of the Brophy, Carlos, Cathro, Millerville, Rifle, Seelyeville, and Urness series and Cathro series, sandy subsoil variant, Urness series, peaty subsoil variant, Alluvial land, and Marsh.

The seasonal water table is very high. Undrained areas, areas that are not protected from flooding, or areas that are covered with water for long periods are generally not suited to trees or shrubs. Onsite investigations should be made to determine suitability of the soils in this woodland suitability group for tree and shrub plantings.

Windbreaks

Trees and shrubs are planted extensively for windbreaks in Douglas County. Field windbreaks are necessary to retard soil blowing, to distribute and control snow, and to reduce crop damage and moisture loss.

Windbreaks are established to reduce soil erosion, block out severe winds, improve human comfort, protect livestock, control snow drifting, and provide food and cover for wildlife. The esthetic value is improved, dust and wind damage is reduced, and outdoor activity is more enjoyable.

Suitable trees and shrubs for windbreaks are listed in table 3. Each is given one of the following ratings: Preferred species are those that are vigorous and healthy, have good survival, and are easily managed. Suitable species are those that lack certain qualities required for a rating of preferred. Unsuitable species are those that normally will not survive without special care or treatment.

Texture, drainage, depth, reaction, stoniness, steepness, and aspect are important characteristics that affect survival and growth of trees and shrubs. The ratings are based largely on the experience and judgment of local soil scientists, district conservationists, and foresters.

Wildlife [3]

The soils of Douglas County have the potential to provide excellent habitat for various species of wildlife. Table 4 shows that different soils have different potentials for producing various wildlife habitat components. In addition, there is a distinct interrelationship between different kinds of plants on various soils and the animals associated with these plants. For example, the Barnes-Langhei soils have a medium potential to produce habitat elements that the ring-necked pheasant requires. Barnes soils can produce high-quality grasses and legumes for nesting cover and escape cover. It also can produce high-quality food plants as well as woody plants for winter cover and escape cover.

Undrained Quam soils can produce cattails, sedges, and water-tolerant grasses that provide escape cover, nesting cover, and winter cover. If drained, Quam soils produce quality crops of corn, soybeans, and small grain, which are excellent food for pheasant. As a result, each of these soils can furnish important habitat components for the pheasant. This statement is also true for other soils as they relate to various kinds of wildlife.

The wildlife of Douglas County are discussed by soil associations. The Barnes-Langhei, Waukon-Flom, Sinai-Fulda, and Waukon-Gonvick associations consist of deep, poorly drained to somewhat excessively drained, nearly level to steep soils that have numerous potholes, sloughs, and lakes. These areas are well suited to wildlife. The lakes and sloughs provide habitat for waterfowl, furbearers, and other wildlife species. The pheasant population varies from year to year, depending on the hardness of the winter, the cover available, and the success of nesting. The diverse crops grown in the various areas, including sloughs and potholes, provide good cover and nesting for the birds. Deer are quite numerous throughout these associations but the largest population is in the Waukon-Gonvick association. Deer hunters and archers are more successful in wooded areas along creeks and around lakes than in other areas. Muskrats, along with mink and other furbearers, are common in the wet marshy areas. Leased hunting and hunter services could be developed to provide supplemental income to farmers during the hunting season. The poorly drained and very poorly drained soils are well suited to the building of farm ponds or the digging of pits that supply water for wildlife.

The Nebish-Beltrami association consists of deep, well-drained and moderately well drained, nearly level to steep soils that have many sloughs, potholes, and lakes. This association is well suited to wildlife. The sloughs and potholes provide good habitat for waterfowl, furbearers, and other kinds of wildlife. Pheasant hunting is fair. Deer hunting is good; the woods and marshes provide food and cover. Muskrats are fairly common in the wet marshy areas. Mink and other furbearers are also present.

The Arvilla-Sverdrup association consists of somewhat excessively drained, nearly level to rolling, droughty soils. These soils are deep and shallow to sand and there are many small areas of marshland.

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[3] Prepared with the assistance of JOHN W. BEDISH, biologist, Soil Conservation Service.

TABLE 3.—*Trees and shrubs rated for*

[Woodland suitability group 8 generally not suited

Species	Woodland suitability group			
	Group 1	Group 2	Group 3	
			Drained	Undrained
Conifers:				
Black Hills spruce	Suitable	Unsuitable	Suitable	Unsuitable
Colorado spruce	Preferred	Suitable	Suitable	Unsuitable
Eastern redcedar	Preferred	Preferred	Suitable	Unsuitable
Jack pine	Suitable	Unsuitable	Unsuitable	Unsuitable
Northern white-cedar	Preferred	Unsuitable	Preferred	Suitable
Ponderosa pine	Preferred	Suitable	Preferred	Unsuitable
Red pine	Suitable	Unsuitable	Unsuitable	Unsuitable
White pine	Suitable	Unsuitable	Unsuitable	Unsuitable
White spruce	Suitable	Unsuitable	Suitable	Unsuitable
Deciduous trees:				
American elm	Suitable	Suitable	Suitable	Suitable
Green ash	Preferred	Preferred	Preferred	Suitable
Hackberry	Suitable	Suitable	Suitable	Unsuitable
Laurel leaf willow	Suitable	Unsuitable	Preferred	Preferred
Poplar (all varieties)	Preferred	Preferred	Preferred	Preferred
Siberian elm	Suitable	Preferred	Preferred	Suitable
Soft maple	Preferred	Suitable	Preferred	Suitable
White willow	Suitable	Unsuitable	Preferred	Preferred
Small trees and shrubs:				
American plum	Preferred	Preferred	Preferred	Preferred
Buffaloberry	Preferred	Preferred	Preferred	Suitable
Caragana	Preferred	Suitable	Suitable	Unsuitable
Crabapple	Preferred	Preferred	Preferred	Suitable
Dogwood	Preferred	Suitable	Preferred	Suitable
Ginnala maple	Preferred	Preferred	Suitable	Unsuitable
Honeysuckle	Preferred	Preferred	Preferred	Suitable
Lilac	Preferred	Preferred	Preferred	Suitable
Purple-osier willow	Suitable	Unsuitable	Preferred	Preferred
Russian-olive	Suitable	Preferred	Suitable	Unsuitable

windbreaks by woodland suitability group

to windbreaks; onsite investigation required]

Woodland suitability group—Continued				Group 6	Group 7
Group 4		Group 5			
Drained	Undrained	Drained	Undrained		
Suitable	Unsuitable	Unsuitable	Unsuitable	Suitable	Unsuitable.
Preferred	Unsuitable	Suitable	Unsuitable	Suitable	Unsuitable.
Suitable	Unsuitable	Suitable	Unsuitable	Preferred	Preferred.
Suitable	Unsuitable	Unsuitable	Unsuitable	Preferred	Suitable.
Preferred	Suitable	Unsuitable	Unsuitable	Suitable	Suitable.
Preferred	Unsuitable	Unsuitable	Unsuitable	Preferred	Suitable.
Suitable	Unsuitable	Unsuitable	Unsuitable	Preferred	Preferred.
Suitable	Unsuitable	Unsuitable	Unsuitable	Suitable	Unsuitable.
Suitable	Unsuitable	Unsuitable	Unsuitable	Suitable	Unsuitable.
Suitable	Suitable	Suitable	Unsuitable	Unsuitable	Unsuitable.
Preferred	Suitable	Preferred	Suitable	Suitable	Unsuitable.
Suitable	Unsuitable	Suitable	Unsuitable	Unsuitable	Unsuitable.
Preferred	Preferred	Preferred	Preferred	Unsuitable	Unsuitable.
Preferred	Preferred	Preferred	Suitable	Suitable	Suitable.
Preferred	Suitable	Preferred	Suitable	Preferred	Preferred.
Preferred	Suitable	Suitable	Unsuitable	Suitable	Unsuitable.
Preferred	Preferred	Preferred	Preferred	Unsuitable	Unsuitable.
Preferred	Suitable	Suitable	Suitable	Preferred	Suitable.
Preferred	Suitable	Suitable	Unsuitable	Preferred	Preferred.
Suitable	Unsuitable	Suitable	Unsuitable	Suitable	Suitable.
Suitable	Unsuitable	Suitable	Unsuitable	Preferred	Preferred.
Preferred	Suitable	Preferred	Suitable	Unsuitable	Unsuitable.
Preferred	Suitable	Suitable	Unsuitable	Suitable	Unsuitable.
Preferred	Suitable	Preferred	Suitable	Preferred	Suitable.
Preferred	Unsuitable	Preferred	Suitable	Suitable	Suitable.
Preferred	Suitable	Preferred	Suitable	Unsuitable	Unsuitable.
Suitable	Unsuitable	Preferred	Suitable	Suitable	Suitable.

TABLE 4.—*Wildlife habitat potential of the soil associations*

Soil association	Potential habitat for—				
	Upland game (pheasants)	Small game (squirrels and rabbits)	Waterfowl and furbearers (ducks, mink, and muskrats)	Big game (deer)	Song birds
1. Barnes-Langhei association	Medium	Medium to high	High	Medium	High.
2. Waukon-Flom association	Medium	Medium to high	High	Medium	High.
3. Sinai-Fulda association	Medium	Medium to high	High	Medium	High.
4. Nebish-Beltrami association	Low	High	Low [1]	Medium	High.
5. Arvilla-Sverdrup association	Low to medium	High	Low [1]	Medium	High.
6. Forada-Arveson association	Low	Medium	Medium [1]	Medium	Medium.
7. Waukon-Gonvick association	Medium	Medium to high	High	Medium	High.
8. Clarion-Flom association	Medium	Medium	High	Low	High.
9. Dorset-Sioux association	Low	Low to medium	Low [1]	Medium	High.

[1] Undrained, poorly drained, and very poorly drained soils and undrained marshes have a high potential for wetland development.

Most of this association is subject to drought. Duck hunting is fair to good, but it is limited to the large sloughs and lakes. Pheasant hunting is fair. Deer hunting is good in the wooded areas along the lakes and streams. Lake Christina provides food and habitat for waterfowl, and in fall, it is used as a stopover by migrating canvasbacks.

The Forada-Arveson association consists of poorly drained, nearly level soils that formed in loamy materials that are moderately deep and deep to sand and gravel. This association is moderately well suited to wildlife. It has a few depressions that provide habitat for waterfowl (fig. 18). Some of the sloughs and depressions can be improved for wildlife habitat. Resident duck populations are lower than in other areas. Pheasant populations generally are low, and hunting is fair. Shrubs and trees in some areas provide cover for upland game and deer. Deer hunting is fair.

The Clarion-Flom association consists of deep, well-drained and poorly drained, nearly level to rolling soils. It has many sloughs and a few small lakes. It is well suited to wildlife. The numerous lakes and sloughs provide good wildlife habitat. The pheasant population varies from year to year, depending on the hardness of winter, cover available, and nesting success. The varied cropping of the land and the numerous areas of marsh provide good cover and nesting areas for the birds. Deer hunting is fair. The soils in this association are well suited to the building of pits and ponds for wildlife habitat.

The Dorset-Sioux association consists of well-drained to excessively drained, nearly level to very steep, droughty soils that are moderately deep to very shallow to gravelly coarse sand. Most of this association is subject to drought. Duck hunting is fair and is limited to the larger sloughs. Pheasant hunting is poor because of the low population. Deer are quite numerous, and deer hunting is good. The wooded areas scattered throughout the association provide ample food and cover. They also provide food and cover for grouse, but grouse hunting is poor. Muskrats are common in the wet marshy areas, and there are also mink, beaver, and other furbearers.

Figure 18.—Wildlife wetland development with a loafing island. The soil is Forada loam, depressional.

Recreational Uses of the Soils

The many lakes and streams, the wooded hills, and the scenery in Douglas County provide ample opportunity for recreational development. The usual kinds of fish, including northern pike, walleye, largemouth bass, crappie, sunfish, bullhead, and carp, are in the lakes. City dwellers in increasing numbers are turning to outdoor activities for recreation. Consequently, owners of farms, woodlands, and lakeshore have an opportunity to develop new and potentially profitable enterprises, such as facilities for camping, picnicking, fishing, hunting, golfing, and other forms of outdoor recreation.

This section can be used to help determine the suitability for recreational purposes of the various soils in their natural condition. Intensive drainage, effective diking, and other practices can greatly alter natural soil limitations and should be considered during onsite evaluation.

In table 5 the degree of limitation is given for each

soil in the county for selected recreational purposes, and some of the soil features that affect these uses are given. The degree of limitation is based on soil features, but such items as land value, location, and esthetic value that may be important in selecting an area have not been considered. Slight means that the soil has few or no limitations or that the limitations can be easily overcome; moderate indicates that the soil limitations can be overcome with good management and careful design; severe indicates that the soil has limitations that are difficult to overcome and its development for the specified purpose is questionable.

TABLE 5.—*Limitations of soils for recreational uses*

Soil	Intensive play areas	Intensive picnic areas	Buildings for recreational use	Paths and trails	Intensive camping areas
Aastad clay loam, 1 to 3 percent slopes.	Slight	Slight	Slight	Moderately sticky when wet.	Slight.
Alluvial land	Severe: flooding hazard; water table 1 to 5 feet below surface.	Severe: flooding hazard; water table 1 to 5 feet below surface.	Severe: flooding hazard; water table 1 to 5 feet below surface.	Severe: flooding hazard; water table 1 to 5 feet below surface.	Severe: flooding hazard; water table 1 to 5 feet below surface.
Arveson sandy clay loam	Severe: poorly drained; water table 1 to 4 feet below surface.	Severe: poorly drained; water table 1 to 4 feet below surface.	Severe: poorly drained; water table 1 to 4 feet below surface.	Severe: poorly drained; water table 1 to 4 feet below surface.	Severe: poorly drained; water table 1 to 4 feet below surface.
Arvilla sandy loam, 0 to 2 percent slopes.	Slight	Slight	Slight	Slight	Slight.
Arvilla sandy loam, 2 to 6 percent slopes.	Moderate: slope	Slight	Slight	Slight	Slight.
Arvilla sandy loam, 6 to 12 percent slopes.	Severe: slope	Moderate: slope	Moderate: slope	Slight	Moderate: slope.
Arvilla sandy loam, thick solum, 0 to 3 percent slopes.	Slight	Slight	Slight	Slight	Slight.
Barnes loam, 2 to 6 percent slopes, eroded.	Moderate: slope	Slight	Slight	Slight	Slight.
Barnes loam, 6 to 12 percent slopes, eroded.	Severe: slope	Moderate: slope	Moderate: slope	Slight	Moderate: slope.
Barnes-Langhei loams, 2 to 6 percent slopes, eroded.	Moderate: slope	Slight	Slight	Slight	Slight.
Barnes-Langhei loams, 6 to 12 percent slopes, eroded.	Severe: slope	Moderate: slope	Moderate: slope	Slight	Moderate: slope.
Beltrami loam, 1 to 3 percent slopes.	Slight	Slight	Slight	Slight	Slight.
Brophy peat	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.
Carlos muck	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.
Cathro muck	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.

TABLE 5.—*Limitations of soils for recreational uses*—Continued

Soil	Intensive play areas	Intensive picnic areas	Buildings for recreational use	Paths and trails	Intensive camping areas
Cathro muck, sandy subsoil variant.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.
Clarion loam, 2 to 6 percent slopes, eroded.	Moderate: slope	Slight	Slight	Slight	Slight.
Clarion loam, 6 to 12 percent slopes, eroded.	Severe: slope	Moderate: slope	Moderate: slope	Slight	Moderate: slope.
Clontarf sandy loam, 0 to 2 percent slopes.	Slight	Slight	Slight	Slight	Slight.
Colvin silt loam	Severe: poorly drained; water table 2 to 5 feet below surface.	Severe: poorly drained; water table 2 to 5 feet below surface.	Moderate: poorly drained; water table 2 to 5 feet below surface.	Severe: poorly drained; slippery and sticky when wet; water table 2 to 5 feet below surface.	Severe: poorly drained; water table 2 to 5 feet below surface.
Colvin silt loam, depressional	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained; slippery and sticky when wet.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained; slippery and sticky when wet.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained; slippery and sticky when wet.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained; slippery and sticky when wet.
Darnen loam, 1 to 4 percent slopes.	Slight	Slight	Slight	Slight	Slight.
Dassel sandy loam	Severe: poorly drained; water table 2 to 4 feet below surface.	Severe: poorly drained; water table 2 to 4 feet below surface.	Moderate: water table 2 to 4 feet below surface.	Severe: poorly drained; water table 2 to 4 feet below surface.	Severe: poorly drained; water table 2 to 4 feet below surface.
Dassel sandy loam, depressional	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.
Dorset sandy loam, 0 to 2 percent slopes.	Slight	Slight	Slight	Slight	Slight.
Dorset sandy loam, 2 to 6 percent slopes.	Moderate: slope	Slight	Slight	Slight	Slight.
Dorset sandy loam, 6 to 12 percent slopes.	Severe: slope	Moderate: slope	Moderate: slope	Slight	Moderate: slope.
Dorset sandy loam, thick solum, 0 to 2 percent slopes.	Slight	Slight	Slight	Slight	Slight.
Dorset sandy loam, thick solum, 2 to 6 percent slopes.	Moderate: slope	Slight	Slight	Slight	Slight.
Dorset sandy loam, thick solum, 6 to 12 percent slopes.	Severe: slope	Moderate: slope	Moderate: slope	Slight	Moderate: slope.

TABLE 5.—*Limitations of soils for recreational uses*—Continued

Soil	Intensive play areas	Intensive picnic areas	Buildings for recreational use	Paths and trails	Intensive camping areas
Dovray mucky silty clay	Severe: very poorly drained: seasonally ponded; slippery and sticky when wet; very slow permeability; water table 0 to 2 feet below surface.	Severe: very poorly drained; seasonally ponded; slippery and sticky when wet; very slow permeability; water table 0 to 2 feet below surface.	Severe: very poorly drained; seasonally ponded; very slow permeability; water table 0 to 2 feet below surface.	Severe: very poorly drained; seasonally ponded; slippery and sticky when wet; very slow permeability; water table 0 to 2 feet below surface.	Severe: very poorly drained; seasonally ponded; slippery and sticky when wet; very slow permeability; water table 0 to 2 feet below surface.
Flom silty clay loam	Severe: poorly drained; slippery and sticky when wet; water table 2 to 5 feet below surface.	Severe: poorly drained; slippery and sticky when wet; water table 2 to 5 feet below surface.	Moderate: water table 2 to 5 feet below surface.	Severe: poorly drained; slippery and sticky when wet; water table 2 to 5 feet below surface.	Severe: poorly drained; slippery and sticky when wet; water table 2 to 5 feet below surface.
Forada sandy loam	Severe: poorly drained; water table 2 to 4 feet below surface.	Severe: poorly drained; water table 2 to 4 feet below surface.	Moderate: poorly drained; water table 2 to 4 feet below surface.	Severe: poorly drained; occasionally ponded; water table 2 to 4 feet below surface.	Severe: poorly drained; occasionally ponded; water table 2 to 4 feet below surface.
Forada loam, depressional	Severe: very poorly drained; water table 0 to 2 feet below surface; seasonally ponded; sticky and slippery when wet.	Severe: very poorly drained; water table 0 to 2 feet below surface; seasonally ponded; sticky and slippery when wet.	Severe: very poorly drained; water table 0 to 2 feet below surface; seasonally ponded.	Severe: very poorly drained; water table 0 to 2 feet below surface; seasonally ponded; sticky and slippery when wet.	Severe: very poorly drained; water table 0 to 2 feet below surface; seasonally ponded; sticky and slippery when wet.
Forada sandy loam, sandy subsoil.	Severe: poorly drained; water table 2 to 4 feet below surface.	Severe: poorly drained; water table 2 to 4 feet below surface.	Moderate: poorly drained; water table 2 to 4 feet below surface.	Severe: poorly drained; water table 2 to 4 feet below surface.	Severe: poorly drained; sticky when wet; water table 2 to 4 feet below surface.
Forman clay loam, 6 to 12 percent slopes, eroded.	Severe: slope; slippery and sticky when wet.	Moderate: slope; slippery and sticky when wet.	Moderate: slope	Moderate: slippery and sticky when wet.	Moderate: slope; slippery and sticky when wet.
Forman-Aastad clay loams, 1 to 5 percent slopes.	Moderate: slope	Slight	Slight	Moderate: sticky when wet.	Slight.
Fulda silty clay	Severe: poorly drained; slippery and sticky when wet; water table 1 to 4 feet below surface.	Severe: poorly drained; slippery and sticky when wet; water table 1 to 4 feet below surface.	Moderate: water table 1 to 4 feet below surface; poorly drained.	Severe: poorly drained; slippery and sticky when wet; water table 1 to 4 feet below surface.	Severe: poorly drained; slippery and sticky when wet; water table 1 to 4 feet below surface.
Gonvick loam, 1 to 3 percent slopes.	Slight	Slight	Slight	Slight	Slight.
Hangaard sandy loam	Severe: poorly drained; water table 1 to 4 feet below surface.	Severe: poorly drained; water table 1 to 4 feet below surface.	Moderate: poorly drained; water table 1 to 4 feet below surface.	Severe: poorly drained; sticky when wet; water table 1 to 4 feet below surface.	Severe: poorly drained; sticky when wet; water table 1 to 4 feet below surface.
Hantho silt loam, 1 to 3 percent slopes.	Moderate: slippery when wet.	Moderate: slippery when wet.	Slight	Moderate: slippery when wet.	Moderate: slippery when wet.

TABLE 5.—*Limitations of soils for recreational uses*—Continued

Soil	Intensive play areas	Intensive picnic areas	Buildings for recreational use	Paths and trails	Intensive camping areas
Lake beaches, sandy	Severe: poorly drained; high water table; flooding hazard.	Severe: poorly drained; high water table; flooding hazard.	Severe: poorly drained; high water table; flooding hazard.	Severe: poorly drained; high water table; flooding hazard.	Severe: poorly drained; high water table; flooding hazard.
Lake beaches, loamy	Severe: poorly drained; high water table; flooding hazard.	Severe: poorly drained; high water table; flooding hazard.	Severe: poorly drained; high water table; flooding hazard.	Severe: poorly drained; high water table; flooding hazard.	Severe: poorly drained; high water table; flooding hazard.
Langhei loam, 18 to 40 percent slopes.	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
Langhei-Barnes loams, 12 to 18 percent slopes, eroded.	Severe: slope	Severe: slope	Severe: slope	Moderate: slope	Severe: slope.
Langhei-Waukon loams, 12 to 18 percent slopes, eroded.	Severe: slope	Severe: slope	Severe: slope	Moderate: slope	Severe: slope.
Langhei-Waukon loams, 18 to 24 percent slopes.	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
Langhei-Waukon-Sioux complex, 12 to 25 percent slopes.	Severe: slope	Severe: slope	Severe: slope	Moderate: slope	Severe: slope.
Maddock fine sand, 0 to 2 percent slopes.	Moderate: loose soil subject to blowing; difficult to vegetate.	Moderate: loose soil subject to blowing; difficult to vegetate.	Slight	Moderate: loose soil subject to blowing.	Moderate: loose soil subject to blowing; difficult to vegetate.
Maddock fine sand, 2 to 6 percent slopes.	Moderate: slope; loose soil subject to blowing; difficult to vegetate.	Moderate: loose soil subject to blowing; difficult to vegetate.	Slight	Moderate: loose soil subject to blowing.	Moderate: loose soil subject to blowing; difficult to vegetate.
Maddock fine sand, 6 to 12 percent slopes.	Severe: slope; subject to blowing; difficult to vegetate.	Severe: subject to blowing; difficult to vegetate.	Moderate: slope	Moderate: loose, sandy soil subject to blowing.	Moderate: slope; loose, sandy soil subject to blowing; difficult to vegetate.
Marsh	Severe: very poorly drained; high water table; ponded.	Severe: very poorly drained; high water table; ponded.	Severe: very poorly drained; high water table; ponded.	Severe: very poorly drained; high water table; ponded.	Severe: very poorly drained; high water table; ponded.
Marysland loam	Severe: poorly drained; water table 2 to 4 feet below surface; sticky when wet.	Severe: poorly drained; water table 2 to 4 feet below surface.	Moderate: poorly drained; water table 2 to 4 feet below surface.	Severe: poorly drained; sticky when wet; water table 2 to 4 feet below surface.	Severe: poorly drained; sticky when wet; water table 2 to 4 feet below surface.
Marysland loam, depressional	Severe: very poorly drained; water table 0 to 2 feet below surface; seasonally ponded; sticky and slippery when wet.	Severe: very poorly drained; water table 0 to 2 feet below surface; seasonally ponded; sticky and slippery when wet.	Severe: very poorly drained; water table 0 to 2 feet below surface; seasonally ponded.	Severe: very poorly drained; water table 0 to 2 feet below surface; seasonally ponded; sticky and slippery when wet.	Severe: very poorly drained; water table 0 to 2 feet below surface; seasonally ponded; sticky and slippery when wet.
Millerville mucky peat	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.

TABLE 5.—*Limitations of soils for recreational uses*—Continued

Soil	Intensive play areas	Intensive picnic areas	Buildings for recreational use	Paths and trails	Intensive camping areas
Nebish sandy loam, 2 to 6 percent slopes.	Moderate: slope	Slight	Slight	Slight	Slight.
Nebish sandy loam, 6 to 12 percent slopes.	Severe: slope	Moderate: slope	Moderate: slope	Slight	Moderate: slope.
Nebish sandy loam, 12 to 18 percent slopes.	Severe: slope	Severe: slope	Severe: slope	Moderate: slope	Severe: slope.
Nebish loam, 2 to 6 percent slopes.	Moderate: slope	Slight	Slight	Slight	Slight.
Nebish loam, 2 to 6 percent slopes, eroded.	Moderate: slope	Slight	Slight	Slight	Slight.
Nebish loam, 6 to 12 percent slopes.	Severe: slope	Moderate: slope	Moderate: slope	Slight	Moderate: slope.
Nebish loam, 6 to 12 percent slopes, eroded.	Severe: slope	Moderate: slope	Moderate: slope	Slight	Moderate: slope.
Nebish loam, 12 to 18 percent slopes.	Severe: slope	Severe: slope	Severe: slope	Moderate: slope	Severe: slope.
Nebish loam, 18 to 24 percent slopes.	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
Nebish-Dorset complex, 2 to 6 percent slopes.	Moderate: slope	Slight	Slight	Slight	Slight.
Nebish-Dorset complex, 6 to 12 percent slopes.	Severe: slope	Moderate: slope	Moderate: slope	Slight	Moderate: slope.
Nicollet clay loam, 1 to 4 percent slopes.	Slight	Slight	Slight	Moderate: sticky when wet.	Slight.
Nymore loamy sand, 2 to 6 percent slopes.	Moderate: slope; loose soil subject to blowing; difficult to vegetate.	Moderate: loose soil subject to blowing; difficult to vegetate.	Slight	Moderate: loose soil subject to blowing.	Moderate: loose soil subject to blowing; difficult to vegetate.
Nymore loamy sand, 6 to 18 percent slopes.	Severe: slope; subject to blowing; difficult to vegetate.	Severe: subject to blowing; difficult to vegetate.	Moderate: slope	Moderate: loose sandy soil, subject to blowing.	Moderate: slope; loose sandy soil, subject to blowing; difficult to vegetate.
Osakis loam, 0 to 3 percent slopes.	Slight	Slight	Slight	Slight	Slight.
Quam mucky silty clay loam	Severe: very poorly drained; water table 0 to 2 feet below surface; seasonally ponded; sticky and slippery when wet.	Severe: very poorly drained; water table 0 to 2 feet below surface; seasonally ponded; sticky and slippery when wet.	Severe: very poorly drained; water table 0 to 2 feet below surface; seasonally ponded.	Severe: very poorly drained; water table 0 to 2 feet below surface; seasonally ponded; sticky and slippery when wet.	Severe: very poorly drained; water table 0 to 2 feet below surface; seasonally ponded; sticky and slippery when wet.
Rifle mucky peat	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.
Rothsay silt loam, 2 to 6 percent slopes.	Moderate: slope; slippery when wet.	Moderate: slippery when wet.	Slight	Moderate: slippery when wet.	Moderate: slippery when wet.

TABLE 5.—*Limitations of soils for recreational uses*—Continued

Soil	Intensive play areas	Intensive picnic areas	Buildings for recreational use	Paths and trails	Intensive camping areas
Seelyeville muck	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.
Shooker loam	Severe: poorly drained; sticky and slippery when wet; water table 2 to 5 feet below surface.	Severe: poorly drained; sticky and slippery when wet; water table 2 to 5 feet below surface.	Severe: poorly drained; water table 2 to 5 feet below surface.	Severe: poorly drained; slippery and sticky when wet; water table 2 to 5 feet below surface.	Severe: poorly drained; slippery and sticky when wet; water table 2 to 5 feet below surface.
Sinai clay, 0 to 2 percent slopes	Severe: slippery and sticky when wet; very slow permeability.	Severe: slippery and sticky when wet; very slow permeability.	Moderate: clayey texture.	Severe: slippery and sticky when wet; very slow permeability.	Severe: slippery and sticky when wet; very slow permeability.
Sinai clay, 2 to 6 percent slopes	Severe: slippery and sticky when wet; very slow permeability.	Severe: slippery and sticky when wet; very slow permeability.	Moderate: clayey texture and slope.	Severe: slippery and sticky when wet; very slow permeability.	Severe: slippery and sticky when wet; very slow permeability.
Sioux loamy coarse sand, 0 to 6 percent slopes.	Moderate: loose soil; difficult to vegetate.	Moderate: loose soil; difficult to vegetate.	Slight	Slight	Moderate: loose soil; difficult to vegetate.
Sioux loamy coarse sand, 6 to 12 percent slopes.	Severe: slope; loose soil; difficult to vegetate.	Moderate: slope; difficult to vegetate.	Moderate: slope	Slight	Moderate: slope; difficult to vegetate; loose soil.
Sioux gravelly loamy coarse sand, 2 to 12 percent slopes.	Severe: slope; loose soil; difficult to vegetate.	Severe: slope; difficult to vegetate; texture of surface layer.	Moderate: slope	Severe: texture of surface layer.	Severe: slope; difficult to vegetate; loose soil.
Sioux gravelly loamy coarse sand, 12 to 35 percent slopes.	Severe: slope; difficult to vegetate.	Severe: slope	Severe: slope	Severe: slope	Severe: slope; difficult to vegetate.
Sverdrup sandy loam, 0 to 2 percent slopes.	Slight	Slight	Slight	Slight	Slight.
Sverdrup sandy loam, 2 to 6 percent slopes.	Moderate: slope	Slight	Slight	Slight	Slight.
Sverdrup sandy loam, 6 to 12 percent slopes.	Severe: slope	Moderate: slope	Moderate: slope	Slight	Moderate: slope.
Sverdrup loam, thick solum, 0 to 3 percent slopes.	Slight	Slight	Slight	Slight	Slight.
Tonka loam	Severe: poorly drained; sticky and slippery when wet; water table 2 to 5 feet below surface.	Severe: poorly drained; sticky and slippery when wet; water table 2 to 5 feet below surface.	Severe: poorly drained; water table 2 to 5 feet below surface.	Severe: poorly drained; slippery and sticky when wet; water table 2 to 5 feet below surface.	Severe: poorly drained; slippery and sticky when wet; water table 2 to 5 feet below surface.
Urness mucky silty clay loam	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained; slippery and sticky when wet.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained; slippery and sticky when wet.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained; slippery and sticky when wet.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained; slippery and sticky when wet.

TABLE 5.—*Limitations of soils for recreational uses*—Continued

Soil	Intensive play areas	Intensive picnic areas	Buildings for recreational use	Paths and trails	Intensive camping areas
Urness mucky silt loam, peaty subsoil variant.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.	Severe: seasonally ponded; water table 0 to 2 feet below surface; very poorly drained.
Vallers clay loam, 0 to 3 percent slopes.	Severe: poorly drained; water table 2 to 5 feet below surface; slippery and sticky when wet.	Severe: poorly drained; water table 2 to 5 feet below surface; slippery and sticky when wet.	Moderate: poorly drained; water table 2 to 5 feet below surface.	Severe: poorly drained; slippery and sticky when wet; water table 2 to 5 feet below surface.	Severe: poorly drained; slippery and sticky when wet; water table 2 to 5 feet below surface.
Waukon loam, 2 to 6 percent slopes.	Moderate: slope	Slight	Slight	Slight	Slight.
Waukon loam, 2 to 6 percent slopes, eroded.	Moderate: slope	Slight	Slight	Slight	Slight.
Waukon loam, 6 to 12 percent slopes.	Severe: slope	Moderate: slope	Moderate: slope	Slight	Moderate: slope
Waukon loam, 6 to 12 percent slopes, eroded.	Severe: slope	Moderate: slope	Moderate: slope	Slight	Moderate: slope.
Waukon loam, 12 to 18 percent slopes.	Severe: slope	Severe: slope	Severe: slope	Moderate: slope	Severe: slope.
Waukon loam, 12 to 18 percent slopes, eroded.	Severe: slope	Severe: slope	Severe: slope	Moderate: slope	Severe: slope.
Waukon loam, 18 to 24 percent slopes.	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
Waukon clay loam, 2 to 6 percent slopes.	Moderate: slope	Slight	Slight	Moderate: sticky when wet.	Slight.
Waukon clay loam, 6 to 12 percent slopes, eroded.	Severe: slope	Moderate: slope	Moderate: slope	Moderate: sticky when wet.	Moderate: slope.
Waukon-Langhei loams, 2 to 6 percent slopes, eroded.	Moderate: slope	Slight	Slight	Slight	Slight.
Waukon-Langhei loams, 6 to 12 percent slopes, eroded.	Severe: slope	Moderate: slope	Moderate: slope	Slight	Moderate: slope.
Waukon-Langhei-Sioux complex, 2 to 6 percent slopes, eroded.	Moderate: slope	Slight	Slight	Slight	Slight.
Waukon-Langhei-Sioux complex, 6 to 12 percent slopes, eroded.	Severe: slope	Moderate: slope	Moderate: slope	Slight	Moderate: slope.
Zell-Rothsay silt loams, 6 to 12 percent slopes, eroded.	Severe: slope	Moderate: slope	Moderate: slope	Slight	Moderate: slope.

INTENSIVE PLAY AREAS.—Table 5 shows that the soils have a wide range in limitations for use as intensive play areas. These areas are to be developed for playing baseball, football, badminton, and similar organized games. They are subject to intensive foot traffic. The more desirable areas are nearly level, have good drainage, have soil texture and consistence that give a firm surface, and are free from flooding.

INTENSIVE PICNIC AREAS.—Picnicking accommodations should be uncrowded and should have suitable areas for parking cars. The degree of limitation is based on soil features only. Other factors that may affect the desirability of the site, such as trees, lakes, fishing, swimming, or hiking are not considered. Soils selected for intensive picnic areas generally have good drainage, are nearly level to gently sloping, provide good footage, and are safe from flooding.

BUILDINGS FOR RECREATIONAL USE.—Detailed onsite investigations are generally required for the selection of a specific building site. The soil limitations apply to seasonal and year-round use of cottages, washrooms, bathhouses, picnic shelters, and service buildings. The suitability of the soils for septic tanks and filter fields has not been considered. Extreme care should be taken to prevent the pollution of lakes and streams. In areas adjacent to the lakes where the soils are sandy or gravelly, the hazard of pollution is very great. In Douglas County most of the lakes in the eastern half of the county are surrounded by sand or gravelly coarse sand. On the lakes that are surrounded by loam glacial till the hazard of pollution is not so great, because the effluent cannot move so rapidly through the soil. Soils that are most suitable for building sites in recreational areas have good drainage, are nearly level to gently sloping, and are not subject to flooding.

PATHS AND TRAILS.—In table 5, the limitations are shown for use of soils for trails, local and cross-country hiking, bridle paths, and other nonintensive uses that allow for movement of people in many directions. Areas that have slight limitations for paths and trails have good drainage, are not subject to flooding, are nearly level to rolling, and have surface texture that provides good footing. Soils that have severe limitations have poor drainage, are subject to flooding, are steep, and do not provide good footing.

INTENSIVE CAMPING AREAS.—Intensive camping areas are used as campsites for tents and trailers and for the accompanying activities of outdoor living. Such areas are used frequently during the camping season. They ought to require little site preparation, other than shaping and leveling to make the unpaved surface suitable for parking of cars and as sites for tents and trailers. The soils should be suitable for heavy traffic by people and for limited traffic by motor vehicles. The more suitable sites have good drainage, are not subject to flooding, are nearly level to gently sloping, are not subject to soil blowing, and provide good footing in all kinds of weather.

Engineering Uses of the Soils [4]

This section provides information of special interest to engineers, contractors, farmers, and others who use soil as structural material or as foundation material upon which structures are built. Information contained in this section is valuable to planning commissions, town and country planners, town and city managers, sanitarians, land developers, architects, and realtors who are concerned with soils and their limitations in land-use planning and development. In this section are those properties of the soils that affect construction and maintenance of roads, airports, pipelines, building foundations, water storage facilities, erosion control structures, drainage systems, and sewage disposal systems. Among the soil properties most important in engineering are permeability, shear strength, density, shrink-swell potential, water-holding capacity, grain-size distribution, plasticity, and reaction.

Information concerning these and related soil properties is furnished in tables 6, 7, and 8. The estimates and interpretations of soil properties in these tables can be used in:

1. Selecting potential residential, industrial, commercial, and recreational areas. Among those factors which should be considered in selecting locations are depth to bedrock, seasonal high water table, frequency of flooding, and permeability of the soil.
2. Selecting potential locations for highways, airports, pipelines, and underground cables. Among the factors that should be considered in selecting locations are depth to bedrock, depth to water table, soil permeability, frequency of flooding, and susceptibility to sliding.
3. Locating probable sources of sand, gravel, or road fill suitable for use as construction material. Among the factors that should be considered in selecting locations are depth to water table, presence of stones and boulders, thickness of the deposits, shrink-swell potential, susceptibility to frost action, and moisture content.
4. Planning and designing of agricultural drainage systems, farm ponds, irrigation systems, diversion terraces, and other structures for controlling water and conserving soil. Among the factors that may be important are permeability and seepage rate; depth to water table; slope; water-holding capacity; depth to layers that influence the rate of water movement such as a fragipan, a claypan, bedrock, and sand; and flooding or stream overflow.

The engineering interpretations reported here do not eliminate the need for sampling and testing at the site of specific engineering works that involve heavy loads and where the excavations are deeper than the depths of layers reported in this soil survey. Even in these situa-

[4] Prepared with the assistance of CARROLL M. HENNING, agricultural engineer, Soil Conservation Service.

tions, however, the soil map is useful in planning more detailed field investigations and in indicating the kinds of problems that may be expected.

Some terms used by soil scientists have different meanings in soil science than they have in engineering. Among the terms that have special meaning in soil science are sand, silt, and clay. Many such terms are defined in the Glossary,

Engineering classification of soils

The two systems most commonly used in classifying soils for engineering (*2*) are the AASHO system adopted by the American Association of State Highway Officials (*1*) and the Unified system (*7*) used by the Soil Conservation Service, the Department of Defense, and other agencies.

The AASHO system is used to classify soils according to those properties that affect use in highway construction. In this system, a soil is placed in one of seven basic groups that range from A–1 through A–7 on the basis of grain-size distribution, liquid limit, and plasticity index. In group A–1 are gravelly soils of high bearing strength, or the best soils for road fill; at the other extreme are clay soils that have low strength when wet. The best soils for road fill are therefore classified A–1; the next best A–2, and so on to the poorest, which are classified A–7. If laboratory data are available, the A–1, A–2, and A–7 groups are subdivided as follows: A–1–a, A–1–b; A–2–4, A–2–5, A–2–6, A–2–7; and A–7–5, A–7–6. If soil material is near a classification boundary, it is given a symbol showing both classes; for example, A–2 or A–4. Within each group, the relative engineering value of a soil material can be indicated by a group index number. Group indexes range from 0 for the best material to 20 for the poorest. The AASHO classification for tested soils, with index numbers in parentheses, for example A–7–6(10), is shown in table 8; the estimated classifications for all soils mapped in the survey area is given in table 6.

In the Unified system, soils are classified according to particle-size distribution, plasticity, liquid limit, and organic-matter content. Soils are grouped in 15 classes. There are 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 are designated by symbols for both classes; for example SP–SM.

Estimated engineering properties

Table 6 provides estimates of soil properties important in engineering. The estimates are based on field classification and descriptions, on physical and chemical tests of selected representative samples, on test data from comparable soils in adjacent areas, and on detailed experience with the kinds of soil in the survey area.

Depth to water table, as shown in table 6, is based on field observations. Depth to bedrock is not given, because soils in the survey area are deep enough that bedrock does not affect their use.

USDA texture is determined by the relative proportions of sand, silt, and clay in soil material that is less than 2.0 millimeters in diameter.

Permeability, as used in table 6, relates only to movement of water downward through undisturbed and uncompacted soil. It does not include lateral seepage. The estimates are based on structure and porosity of the soil. Plowpans, surface crusts, and other properties that result from use of the soils are not considered.

Available water capacity is the capacity of soils to store water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

Reaction is the degree of acidity or alkalinity of a soil, expressed as a pH value. The relative terms used to describe soil reaction are given in the Glossary.

Shrink-swell potential is an indication of the volume change to be expected of the soil material with changes in moisture content. Shrinking and swelling of soils cause much damage to building foundations, roads, and other structures. A high shrink-swell potential indicates hazards to the maintenance of structures built in, on, or with such materials.

Engineering interpretations

Table 7 contains selected information useful to engineers and others who plan to use soil material in construction of highways, farm facilities, buildings, and sewage disposal systems. Detrimental or undesirable features are emphasized, but very important desirable features may also be listed. The ratings and interpretations in this table are based on estimated engineering properties of the soils in table 6; on available test data, including those in table 8; and on field experience. The information applies strictly only to the depths indicated in table 6, but it is reasonably reliable to a depth of about 5 or 6 feet. In the columns headed "Soil limitations for," the degree of limitation and principal reasons for assigning a moderate or severe degree of limitation are given.

Septic tank filter fields are affected mainly by permeability, location of water table, and susceptibility to flooding.

Sewage lagoons are influenced chiefly by permeability, location of water table, and slope.

Dwellings with basements are affected chiefly by features of the undisturbed soil that affect its capacity to support loads and resist settlement under loads and those that affect ease of excavation. Buildings of more than three stories and other buildings for which foundation loads would be in excess of those for three-story dwellings are not considered.

Topsoil is a term used to designate a fertile soil or soil material, ordinarily rich in organic matter, used as a topdressing for lawns, gardens, roadbanks, and the like. The ratings indicate the suitability for such use.

TABLE 6.—*Estimated soil properties*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. Because these in the first column. Absence of data indicates the determination was not made.

Soil series and map symbols	Depth to water table	Depth from surface	Classification		
			USDA texture	Unified	AASHO
	Feet	*Inches*			
Aastad: AaA	6–10	0–16	Clay loam	OL or CL	A–7
		16–24	Clay loam	CL	A–6
		24–60	Loam	CL	A–6
Alluvial land: Ad. Properties are too variable to be classified.					
Arveson: Ao	1–4	0–9	Sandy clay loam	SC	A–6
		9–25	Fine sandy loam	SM	A–2
		25–60	Fine sand	SP–SM	A–3
Arvilla: AsA, AsB, AsC, AtA	>10	0–7	Sandy loam	SM	A–2
		7–18	Loam	ML	A–4
		18–60	Gravelly coarse sand	GP, GW, SM, or SP	A–1
*Barnes: BaB2, BaC2, BlB2, BlC2— For properties of Langhei soils in BlB2, and BlC2, see the Langhei series.	>10	0–8	Loam	ML or OL	A–6 or A–7
		8–18	Loam	CL	A–6 or A–7
		18–60	Loam	CL	A–6
Beltrami: BmA	4–8	0–6	Loam	ML	A–4
		6–11	Sandy loam	SM	A–4
		11–34	Sandy clay loam or clay loam	SC or CL	A–6
		34–60	Loam	CL	A–6
Brophy: Bp	0–2	0–60	Peat (fibric material)	Pt	----------
Carlos: Ca	0–2	0–6	Mucky (sapric material)	Pt	----------
		6–12	Marl (limnic)	Pt	----------
		12–60	Mucky peat (hemic material)	Pt	----------
Cathro: Cc	0–2	0–41	Muck (sapric material)	Pt	----------
		41–60	Silt loam	ML	A–4
Cathro, sandy subsoil variant: Ch	0–2	0–20	Muck (sapric material)	Pt	----------
		20–46	Silty clay loam	CL	A–6
		46–60	Gravelly sand	SP or GP	A–2
Clarion: ClB2, ClC2	>10	0–8	Loam	ML or OL	A–6
		8–22	Loam	CL	A–6
		22–60	Loam	CL	A–6
Clontarf: CmA	4–8	0–11	Sandy loam	SM	A–2
		11–22	Sandy loam and loamy sand	SM	A–2
		22–60	Sand	SP	A–2
Colvin: Co	2–5	0–18	Silt loam	OL	A–4
		18–60	Silt loam	ML	A–4
Cp	0–2	0–28	Silt loam	OL	A–7
		28–36	Silt loam	ML	A–7
		36–60	Silty clay loam	CL	A–6
Darnen: DaA	>10	0–30	Loam	OL	A–4
		30–46	Loam	ML	A–4
		46–60	Loam	CL	A–6

See footnote at end of table.

significant to engineering

soils may have different properties and limitations, it is necessary to follow carefully the instructions for referring to other series that appear The sign > means more than, and the sign < means less than.]

Percentage passing sieve—				Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)				
				Inches per hour	*Inches per inch of soil*	*pH value*	
95–100	90–100	90–100	65–80	0. 6–2. 0	0. 17–0. 19	6. 6–7. 3	Moderate.
95–100	90–100	90–100	65–80	0. 6–2. 0	0. 15–0. 19	7. 4–7. 8	Moderate.
95–100	90–100	85–95	60–75	0. 6–2. 0	0. 17–0. 19	7. 4–7. 8	Moderate.
95–100	90–100	80–90	36–50	0. 6–2. 0	0. 18–0. 20	7. 4–7. 8	Moderate.
95–100	90–100	70–85	20–35	2. 0–6. 0	0. 15–0. 17	7. 4–7. 8	Low.
95–100	90–100	65–80	5–10	>6. 0	0. 05–0. 07	7. 4–7. 8	Low.
95–100	85–100	60–70	25–35	2. 0–6. 0	0. 13–0. 15	6. 6–7. 3	Low.
95–100	85–100	85–95	50–80	2. 0–6. 0	0. 17–0. 19	6. 6–7. 3	Low.
40–60	25–40	10–20	2–12	>6. 0	0. 02–0. 04	7. 4–7. 8	Low.
95–100	90–100	85–95	50–80	0. 6–2. 0	0. 20–0. 22	6. 6–7. 3	Moderate.
95–100	90–100	85–95	50–80	0. 6–2. 0	0. 17–0. 19	6. 6–7. 3	Moderate.
95–100	90–100	85–95	50–80	0. 6–2. 0	0. 17–0. 19	7. 4–7. 8	Moderate.
95–100	90–100	85–95	50–80	0. 6–2. 0	0. 20–0. 22	6. 6–7. 3	Moderate.
95–100	90–100	60–70	36–50	2. 0–6. 0	0. 13–0. 15	6. 6–7. 3	Moderate.
95–100	90–100	80–100	40–85	0. 6–2. 0	0. 15–0. 19	6. 1–7. 3	Moderate.
95–100	90–100	85–95	50–80	0. 6–2. 0	0. 17–0. 19	7. 4–7. 8	Moderate.
---	---	---	---	(1)	0. 25	6. 6–7. 3	Low.
---	---	---	---	(1)	0. 25	6. 6–7. 3	Low.
---	---	---	---	(1)	0. 25	6. 6–7. 3	Low.
---	---	---	---	(1)	0. 25	6. 6–7. 3	Low.
95–100	95–100	90–100	80–90	0. 6–2. 0	0. 20–0. 22	6. 6–7. 8	Low.
---	---	---	---	(1)	0. 25	6. 6–7. 3	Low.
95–100	90–100	95–100	70–85	0. 2–0. 6	0. 18–0. 20	7. 4–7. 8	High.
30–60	20–35	10–20	2–5	>6. 0	0. 02–0. 04	7. 4–7. 8	Low.
95–100	90–100	85–95	50–80	0. 6–2. 0	0. 20–0. 22	6. 6–7. 3	Moderate.
95–100	90–100	85–95	50–80	0. 6–2. 0	0. 17–0. 19	6. 6–7. 3	Moderate.
95–100	90–100	85–95	50–80	0. 6–2. 0	0. 17–0. 19	7. 4–7. 8	Moderate.
95–100	90–100	60–70	10–35	2. 0–6. 0	0. 13–0. 15	6. 1–6. 5	Low.
95–100	90–100	60–70	20–35	2. 0–6. 0	0. 09–0. 14	6. 1–7. 3	Low.
85–100	80–90	51–70	2–5	>6. 0	0. 05–0. 07	6. 6–7. 8	Low.
95–100	95–100	90–100	80–90	0. 6–2. 0	0. 22–0. 24	7. 4–7. 8	Moderate.
95–100	95–100	90–100	80–90	0. 6–2. 0	0. 20–0. 22	7. 4–7. 8	Moderate.
95–100	90–100	95–100	80–90	0. 6–2. 0	0. 22–0. 24	7. 4–7. 8	Moderate.
95–100	90–100	90–100	80–90	0. 6–2. 0	0. 20–0. 22	7. 4–7. 8	Moderate.
95–100	90–100	95–100	85–95	0. 2–0. 6	0. 18–0. 20	7. 4–7. 8	High.
95–100	90–100	85–95	80–90	0. 6–2. 0	0. 20–0. 22	6. 6–7. 3	Low.
95–100	90–100	85–95	60–80	0. 6–2. 0	0. 17–0. 19	6. 6–7. 8	Moderate.
95–100	90–100	85–95	50–80	0. 6–2. 0	0. 17–0. 19	7. 4–7. 8	Moderate.

TABLE 6.—*Estimated soil properties*

Soil series and map symbols	Depth to water table	Depth from surface	Classification		
			USDA texture	Unified	AASHO
	Feet	*Inches*			
Dassel:					
Dd	2–4	0–8	Sandy loam	SM	A–2
		8–25	Sandy loam and loamy sand	SM	A–2
		25–60	Sand	SP–SM	A–3
De	0–2	0–10	Sandy loam	SM	A–2
		10–18	Sandy clay loam	SC	A–2
		18–60	Sand	SP–SM	A–3
Dorset: DoA, DoB, DoC, DpA, DpB, DpC.	>10	0–8	Sandy loam	SM	A–2
		8–19	Sandy loam	SM	A–2
		19–60	Gravelly coarse sand	SP, SM, GP, or GW	A–1
Dovray: Dv	0–2	0–7	Mucky silty clay	OH	A–7
		7–44	Silty clay	CH	A–7
		44–60	Silty clay	CH	A–7
Flom: Fa	2–5	0–13	Silty clay loam	CL or OL	A–7
		13–24	Clay loam	CL	A–6
		24–60	Loam	CL or ML	A–6 or A–7
Forada:					
Fd, Ff	2–4	0–20	Sandy loam	SM	A–2
		20–28	Loam	ML	A–4
		28–60	Coarse sand and gravel	SP or GP	A–1
Fe	0–2	0–28	Loam	ML or OL	A–4
		28–60	Coarse sand and gravel	SP or GP	A–1
*Forman: FmC2, FoB. For properties of Aastad soils in FoB, see Aastad series.	>10	0–11	Clay loam	CL or OL	A–6
		11–19	Clay loam	CL	A–6
		19–60	Clay loam	CL	A–6
Fulda: Fu	1–4	0–7	Silty clay	MH or OH	A–7
		7–36	Silty clay	CH	A–7
		36–60	Silty clay loam	CL	A–7
Gonvick: GoA	3–8	0–10	Loam	ML	A–4
		10–29	Clay loam	CL	A–6
		29–60	Loam	CL	A–6
Hangaard: Ha	1–4	0–13	Sandy loam	SM	A–2
		13–17	Loamy coarse sand	SM	A–2
		17–60	Gravelly coarse sand	SP or GP	A–1
Hantho: HhA	3–8	0–16	Silt loam	OL	A–4
		16–37	Silt loam	ML	A–4
		37–60	Silt loam	ML	A–4
Lake beaches: La, Lb. Properties are too variable to be classified.					
*Langhei: LeF, LgD2, LkD2, LkE, LwD. For properties of Barnes soils in LgD2; for properties of Waukon soils in LkD2, LkE, and LwD; for properties of Sioux soils in LwD, see their respective series.	>10	0–60	Loam	CL	A–6
Maddock: MaA, MaB, MaC	>10	0–60	Fine sand	SP–SM	A–3
Marsh: Mh. No classification possible; onsite investigation needed.					

See footnote at end of table.

significant to engineering—Continued

Percentage passing sieve—				Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	*Inches per hour*	*Inches per inch of soil*	*pH value*	
95–100	90–100	60–70	20–35	2. 0–6. 0	0. 13–0. 15	6. 1–6. 5	Low.
95–100	90–100	50–70	20–35	2. 0–6. 0	0. 09–0. 14	5. 6–6. 5	Low.
95–100	90–100	51–70	5–10	>6. 0	0. 05–0. 07	6. 6–7. 8	Low.
95–100	90–100	60–70	20–35	2. 0–6. 0	0. 13–0. 15	6. 1–6. 5	Low.
95–100	90–100	80–90	20–35	2. 0–6. 0	0. 16–0. 18	6. 6–7. 3	Low.
95–100	90–100	51–70	5–10	>6. 0	0. 05–0. 07	7. 4–7. 8	Low.
90–100	85–100	60–70	20–35	2. 0–6. 0	0. 13–0. 15	6. 1–6. 5	Low.
90–100	85–100	60–70	20–35	2. 0–6. 0	0. 12–0. 14	6. 6–7. 3	Low.
30–60	25–40	10–20	2–12	>6. 0	0. 02–0. 04	7. 4–7. 8	Low.
98–100	98–100	95–100	90–100	<0. 06	0. 12–0. 14	6. 1–6. 5	High.
98–100	98–100	95–100	90–100	<0. 06	0. 11–0. 13	6. 6–7. 3	High.
98–100	98–100	95–100	90–100	<0. 06	0. 10–0. 12	7. 4–7. 8	High.
95–100	90–100	95–100	70–90	0. 2–0. 6	0. 21–0. 23	6. 6–7. 3	High.
95–100	90–100	90–100	60–80	0. 6–2. 0	0. 15–0. 19	6. 6–7. 3	Moderate.
95–100	90–100	85–95	60–80	0. 6–2. 0	0. 17–0. 19	7. 4–7. 8	Moderate.
95–100	90–100	60–70	25–35	2. 0–6. 0	0. 13–0. 15	6. 6–7. 3	Low.
95–100	90–100	85–95	50–80	2. 0–6. 0	0. 17–0. 19	6. 1–6. 5	Low.
30–60	25–40	10–20	2–5	>6. 0	0. 02–0. 04	7. 4–7. 8	Low.
95–100	90–100	85–95	50–80	2. 0–6. 0	0. 20–0. 22	6. 6–7. 3	Moderate.
30–60	25–40	10–20	2–5	>6. 0	0. 02–0. 04	7. 4–7. 8	Low.
90–100	85–100	90–100	60–80	0. 2–0. 6	0. 17–0. 19	6. 6–7. 3	High.
90–100	85–100	90–100	60–80	0. 2–0. 6	0. 15–0. 19	6. 6–7. 3	High.
90–100	85–100	90–100	50–80	0. 2–0. 6	0. 14–0. 16	7. 4–7. 8	High.
98–100	95–100	95–100	90–100	0. 2–0. 6	0. 12–0. 14	6. 6–7. 3	High.
98–100	95–100	95–100	90–100	<0. 6	0. 11–0. 13	6. 6–7. 3	High.
98–100	95–100	95–100	80–100	<0. 2–0. 6	0. 18–0. 20	7. 4–7. 8	High.
95–100	90–100	85–95	50–80	0. 6–2. 0	0. 20–0. 22	6. 6–7. 3	Moderate.
90–100	85–100	85–95	50–80	0. 6–2. 0	0. 15–0. 19	6. 6–7. 3	Moderate.
95–100	90–100	85–95	50–80	0. 6–2. 0	0. 17–0. 19	7. 4–7. 8	Moderate.
95–100	90–100	60–70	20–35	2. 0–6. 0	0. 13–0. 15	7. 4–7. 8	Low.
95–100	85–100	15–35	20–35	>6. 0	0. 09–0. 11	7. 4–7. 8	Low.
30–60	25–40	10–20	2–5	>6. 0	0. 02–0. 04	7. 4–7. 8	Low.
95–100	90–100	90–100	60–90	0. 6–2. 0	0. 22–0. 24	6. 6–7. 3	Low.
95–100	90–100	90–100	60–90	0. 6–2. 0	0. 20–0. 22	6. 6–7. 3	Low.
95–100	90–100	90–100	60–90	0. 6–2. 0	0. 20–0. 22	7. 4–7. 8	Low.
90–100	85–100	85–95	50–80	0. 6–2. 0	0. 17–0. 19	7. 4–7. 8	Moderate.
95–100	95–100	65–80	5–10	>6. 0	0. 06–0. 09	6. 1–6. 5	Low.

TABLE 6.—*Estimated soil properties*

Soil series and map symbols	Depth to water table	Depth from surface	Classification		
			USDA texture	Unified	AASHO
	Feet	*Inches*			
Marysland:					
Mm	2–4	0–15	Loam	OL	A–4
		15–32	Loam	ML	A–4
		32–40	Loamy fine sand	SM	A–2
		40–60	Gravelly coarse sand	SP or GP	A–1
Mo	0–2	0–20	Loam	OL	A–6
		20–38	Silty clay loam	CL	A–6
		38–60	Gravelly coarse sand	SP or GP	A–1
Millerville: Mp	0–2	0–24	Mucky peat (hemic material)	Pt	----------
		24–42	Mucky silt loam	OL	A–4
		42–60	Silt loam	ML	A–4
*Nebish: NbB, NbC, NbD, NeB, NeB2, NeC, NeC2, NeD, NeE, NhB, NhC. For properties of Dorset soils in NhB and NhC, see Dorset series.	>10	0–3	Loam	ML or SM	A–4
		3–9	Sandy loam	SM	A–4
		9–33	Sandy clay loam	SC or CL	A–6
		33–60	Loam	CL	A–6 or A–4
Nicollet: NlA	4–8	0–14	Clay loam	OL	A–6
		14–28	Clay loam	CL	A–6
		28–60	Loam	CL	A–6
Nymore: NyB, NyC	>10	0–12	Loamy sand	SM	A–2
		12–60	Sand	SP–SM	A–3
Osakis: OsA	4–8	0–14	Loam	ML	A–4
		14–18	Gravelly loamy sand	SM	A–2
		18–60	Gravelly coarse sand	GP, GW, SP, or SM	A–1
Quam: Qu	0–2	0–8	Mucky silty clay loam	OL	A–7
		8–38	Silty clay loam	CH	A–7
		38–60	Clay loam	CL	A–6
Rifle: Rm	0–2	0–60	Mucky peat (hemic material)	Pt	----------
Rothsay: RoB	>10	0–7	Silt loam	OL	A–4
		7–22	Silt loam	ML	A–4
		22–60	Silt loam	ML	A–4
Seelyeville: Se	0–2	0–60	Muck (sapric material)	Pt	----------
Shooker: Sh	2–5	0–16	Loam	ML	A–4
		16–24	Sandy clay loam	SC	A–6
		24–60	Sandy loam	SM	A–4
Sinai: SlA, SlB	8–15	0–22	Clay	CH	A–7
		22–60	Clay	CH	A–7
Sioux: SmB, SmC, SoC, SoE	>10	0–9	Loamy coarse sand	SM	A–2
		9–60	Gravelly coarse sand	GP, GW, SP, or SW	A–1
Sverdrup: SpA, SpB, SpC, SvA	>10	0–14	Sandy loam	SM	A–2
		14–20	Loamy sand	SM	A–2
		20–60	Sand	SP	A–2
Tonka: To	2–5	0–16	Loam	ML	A–4
		16–37	Clay loam	CL	A–6
		37–60	Loam	CL	A–6
Urness: Up	0–2	0–26	Mucky silty clay loam	OL	A–7
		26–60	Silty clay loam	CH	A–7

See footnote at end of table.

significant to engineering—Continued

Percentage passing sieve—				Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	*Inches per hour*	*Inches per inch of soil*	*pH value*	
95–100	90–100	85–95	50–80	0. 6–2. 0	0. 20–0. 22	7. 4–7. 8	Low.
95–100	90–100	85–95	50–80	0. 6–2. 0	0. 17–0. 19	7. 4–7. 8	Low.
95–100	90–100	90–95	15–25	>6. 0	0. 09–0. 11	7. 4–7. 8	Low.
40–60	25–50	10–20	2–5	>6. 0	0. 02–0. 04	7. 4–7. 8	Low.
95–100	90–100	85–95	50–80	0. 6–2. 0	0. 20–0. 22	7. 4–7. 8	Low.
95–100	90–100	95–100	70–85	0. 6–2. 0	0. 18–0. 20	7. 4–7. 8	Moderate.
40–60	25–50	10–20	2–5	>6. 0	0. 02–0. 04	7. 4–7. 8	Low.
				(1)	0. 25	6. 1–6. 5	Low.
95–100	95–100	90–100	80–90	0. 6–2. 0	0. 20–0. 22	6. 1–6. 5	Low.
95–100	95–100	90–100	80–90	0. 6–2. 0	0. 20–0. 22	6. 6–7. 3	Low.
95–100	90–100	85–95	40–70	0. 6–2. 0	0. 20–0. 22	6. 6–7. 3	Low.
95–100	90–100	60–70	36–50	2. 0–6. 0	0. 13–0. 15	6. 6–7. 3	Low.
95–100	90–100	80–90	36–75	0. 6–2. 0	0. 16–0. 18	5. 6–6. 5	Moderate.
95–100	90–100	85–95	50–75	0. 6–2. 0	0. 17–0. 19	7. 4–7. 8	Moderate.
95–100	90–100	90–100	65–80	0. 6–2. 0	0. 17–0. 19	6. 6–7. 3	Moderate.
95–100	90–100	90–100	65–80	0. 6–2. 0	0. 15–0. 19	6. 6–7. 3	Moderate.
95–100	90–100	85–95	60–75	0. 6–2. 0	0. 17–0. 19	7. 4–7. 8	Moderate.
95–100	90–100	50–75	10–20	>6. 0	0. 10–0. 12	6. 1–6. 5	Low.
95–100	90–100	51–70	5–10	>6. 0	0. 05–0. 07	5. 6–7. 3	Low.
90–100	80–95	85–95	50–80	0. 6–2. 0	0. 20–0. 22	6. 1–6. 5	Low.
60–80	40–60	20–30	15–25	>6. 0	0. 03–0. 05	6. 6–7. 3	Low.
25–50	20–40	10–20	2–12	>6. 0	0. 02–0. 04	7. 4–7. 8	Low.
95–100	90–100	95–100	80–90	0. 2–0. 6	0. 21–0. 23	6. 6–7. 3	High.
95–100	90–100	95–100	80–90	0. 2–0. 6	0. 18–0. 20	6. 6–7. 3	High.
95–100	90–100	90–100	60–90	0. 2–0. 6	0. 14–0. 16	7. 4–7. 8	High.
				(1)	0. 25	6. 6–7. 8	Low.
95–100	90–100	90–100	60–90	0. 6–2. 0	0. 22–0. 24	6. 6–7. 3	Low.
95–100	90–100	90–100	60–90	0. 6–2. 0	0. 20–0. 22	6. 6–7. 3	Low.
95–100	90–100	90–100	60–90	0. 6–2. 0	0. 20–0. 22	7. 4–7. 8	Low.
				(1)	0. 25	6. 6–7. 3	Low.
95–100	90–100	85–95	50–80	0. 6–2. 0	0. 20–0. 22	6. 1–7. 3	Low.
95–100	90–100	80–90	35–50	0. 6–2. 0	0. 16–0. 18	6. 6–7. 3	Moderate.
95–100	90–100	60–70	35–50	0. 6–6. 0	0. 11–0. 13	6. 6–7. 8	Moderate.
95–100	95–100	90–100	90–100	<0. 06	0. 11–0. 13	6. 6–7. 3	High.
95–100	95–100	90–100	90–100	<0. 06	0. 08–0. 10	7. 4–7. 8	High.
80–90	60–80	20–30	12–20	>6. 0	0. 10–0. 12	6. 6–7. 3	Low.
35–50	20–40	10–20	2–12	>6. 0	0. 02–0. 04	7. 4–7. 8	Low.
90–100	85–100	60–70	20–35	2. 0–6. 0	0. 13–0. 15	6. 6–7. 3	Low.
90–100	85–100	51–75	15–25	>6. 0	0. 09–0. 11	6. 6–7. 3	Low.
85–100	80–90	51–70	2–5	>6. 0	0. 05–0. 07	7. 4–7. 8	Low.
95–100	90–100	85–95	50–80	0. 6–2. 0	0. 20–0. 22	6. 1–6. 5	Moderate.
95–100	90–100	90–100	60–80	0. 6–2. 0	0. 15–0. 19	6. 6–7. 3	High.
95–100	90–100	85–95	50–80	0. 6–2. 0	0. 17–0. 19	6. 6–7. 3	Moderate.
95–100	90–100	95–100	80–90	0. 2–0. 6	0. 21–0. 23	7. 9–8. 4	High.
95–100	90–100	95–100	80–90	0. 2–0. 6	0. 18–0. 20	7. 9–8. 4	High.

TABLE 6.—*Estimated soil properties*

Soil series and map symbols	Depth to water table	Depth from surface	Classification		
			USDA texture	Unified	AASHO
	Feet	*Inches*			
Urness, peaty subsoil variant: Us	0–2	0–42	Silt loam	OL	A–4
		42–74	Mucky peat (hemic material)	Pt	
Vallers: VaA	2–5	0–16	Clay loam	CL	A–6
		16–60	Loam	CL	A–6
*Waukon: WaB, WaB2, WaC, WaC2, WaD, WaD2, WaE, WcB, WcC2, WlB2, WlC2, WsB2, WsC2. For properties of Langhei soils in WlB2, WlC2, WsB2, and WsC2; for properties of Sioux soils in WsB2 and WsC2, see their respective series.	>10	0–9	Loam	ML or OH	A–4 or A–7
		9–24	Sandy loam and sandy clay loam.	SC or SM	A–6
		24–60	Sandy loam	SM	A–6
*Zell: ZoC2. For properties of Rothsay soils, see Rothsay series.	>10	0–7	Silt loam	ML	A–4
		7–60	Silt loam	ML	A–4

[1] Variable.

TABLE 7.—*Interpretations*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. Because these in the first column. Absence of data

Soil series and map symbols	Soil limitations for—			Suitability as a source of—	
	Septic tank filter fields	Sewage lagoons	Dwellings with basements	Topsoil [1]	Sand and gravel
Aastad: AaA	Moderate: moderately well drained; moderate permeability.	Slight	Moderate: moderately well drained; moderate shrink-swell potential.	Fair: clay loam.	Not suitable
Alluvial land: Ad	Severe: flooding hazard; high water table.	Variable: check each site.	Severe: flooding hazard; high water table.	Poor: poorly drained.	Not suitable
Arveson: Ao	Severe: water table 1 to 4 feet below surface; poorly drained; pollution hazard.	Severe: rapid permeability.	Severe: poorly drained; water table 1 to 4 feet below surface.	Poor: poorly drained.	Fair: source of sand; water table 1 to 4 feet below surface.

See footnotes at end of table.

significant to engineering—Continued

Percentage passing sieve—				Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)				
				Inches per hour	*Inches per inch of soil*	*pH value*	
95–100	90–100	90–100	80–90	0. 6–2. 0	0. 20–0. 22	7. 9–8. 4	High.
				(1)	0. 25	6. 6–7. 8	Low.
90–100	90–100	90–100	60–80	0. 6–2. 0	0. 17–0. 19	7. 9–8. 4	High.
90–100	90–100	85–95	50–80	0. 6–2. 0	0. 17–0. 19	7. 4–7. 8	Moderate.
95–100	90–100	80–95	50–80	0. 6–2. 0	0. 20–0. 22	6. 6–7. 3	Moderate.
95–100	85–100	70–90	36–50	0. 6–2. 0	0. 15–0. 19	6. 6–7. 8	Moderate.
95–100	90–100	85–95	36–50	0. 6–2. 0	0. 15–0. 17	7. 9–8. 4	Moderate.
95–100	90–100	90–100	60–90	0. 6–2. 0	0. 22–0. 24	7. 4–7. 8	Low.
95–100	90–100	90–100	60–90	0. 6–2. 0	0. 20–0. 22	7. 4–7. 8	Low.

of engineering properties

soils may have different properties and limitations, it is necessary to follow carefully the instructions for referring to other series that appear
indicates the determination was not made]

Suitability as a source of—Con.	Soil features affecting—					
Road fill [2]	Farm pond reservoir areas	Embankments, dikes, and levees	Agricultural drainage	Irrigation sprinklers	Terraces and diversions	Waterways
Fair: moderate shrink-swell potential; moderate susceptibility to frost action; moderately well drained.	Moderate permeability; impervious when compacted.	Fair stability; fair compaction characteristics; low permeability when compacted; good resistance to piping.	Not needed; moderately well drained.	Soil features favorable.	Soil features favorable.	Soil features favorable.
Poor: high water table; flooding hazard; check each site.	High water table; flooding hazard; suitable for dugout pits.	Flooding hazard; high water table; variable material; check each site.	Frequent flooding; outlets difficult to obtain; water table 1 to 5 feet below surface.	Poorly drained.	Not needed; nearly level.	Poorly drained.
Poor: water table 1 to 4 feet below surface; poorly drained.	Water table 1 to 4 feet below surface; normally suited to dugout pits; rapid permeability; poor resistance to piping.	Fair stability; high permeability when compacted; poor resistance to piping; water table 1 to 4 feet below surface.	Sand subsoil at depth of less than 2 feet; water table 1 to 4 feet below surface.	Poorly drained.	Not needed; nearly level.	Poorly drained; shallow to sand.

TABLE 7.—*Interpretations*

Soil series and map symbols	Soil limitations for—			Suitability as a source of—	
	Septic tank filter fields	Sewage lagoons	Dwellings with basements	Topsoil [1]	Sand and gravel
Arvilla: AsA, AsB, AsC, AtA,	Slight: pollution hazard.	Severe: rapid permeability.	Slight where slopes are less than 8 percent. Moderate where slopes are more than 8 percent.	Poor: thin surface layer.	Good, but sand and gravel are mixed.
*Barnes: BaB2, BaC2, BlB2, BlC2. For properties of Langhei soils in BlB2, and BlC2, see Langhei series.	Slight where slopes are less than 6 percent. Moderate where slopes are 6 to 12 percent. Severe where slopes are more than 12 percent.	Moderate where slopes are 2 to 6 percent. Severe where slopes are more than 6 percent.	Slight where slopes are less than 8 percent. Moderate where slopes are more than 15 percent: moderate shrink-swell potential.	Fair to poor, depending on the slope and the thickness of surface layer.	Not suitable
Beltrami: BmA	Moderate: moderately well drained; moderate permeability.	Slight	Moderate: moderately well drained; moderate shrink-swell potential.	Fair: responsive to fertilizer; medium fertility; surface layer is thin.	Not suitable
Brophy: Bp	Severe: water table 0 to 2 feet below surface.	Severe: organic soil.	Severe: organic soil; water table 0 to 2 feet below surface.	Poor: organic soil; very poorly drained.	Not suitable
Carlos: Ca	Severe: water table 0 to 2 feet below surface.	Severe: organic soil.	Severe: organic soil; water table 0 to 2 feet below surface.	Poor: organic soil; very poorly drained.	Not suitable
Cathro: Cc	Severe: water table 0 to 2 feet below surface.	Severe: organic soil.	Severe: organic soil; water table 0 to 2 feet below surface.	Poor: organic soil; very poorly drained.	Not suitable

See footnotes at end of table.

of engineering properties—Continued

Suitability as a source of—Con.	Soil features affecting—					
Road fill [2]	Farm pond reservoir areas	Embankments, dikes, and levees	Agricultural drainage	Irrigation sprinklers	Terraces and diversions	Waterways
Good	Porous material; rapid permeability.	Upper layers have fair stability and moderate permeability when compacted; sand and gravel in deeper layers have fair stability and high permeability when compacted.	Not needed; somewhat excessively drained.	Features favorable; rapid intake rate; rapid permeability; low water-holding capacity.	Shallow or 1 to 2 feet to sand and gravel; difficult to vegetate; droughty.	Shallow to sand and gravel; droughty; erodible; difficult to vegetate.
Fair: moderate shrink-swell potential; moderate susceptibility to frost action.	Moderate permeability; impervious when compacted.	Fair stability; fair compaction characteristics; low permeability when compacted; good resistance to piping.	Not needed; well drained.	Features favorable; moderate permeability.	Irregular slopes; features favorable where slopes are less than 12 percent.	Steep in places.
Fair: moderate shrink-swell potential; moderate susceptibility to frost action; moderately well drained.	Moderate permeability; impervious when compacted.	Fair stability; fair compaction characteristics; low permeability when compacted; good resistance to piping.	Not needed; moderately well drained.	Features favorable; generally not irrigated.	Terraces and diversions generally not used; moderately well drained.	Soil features favorable.
Poor: organic soil; water table 0 to 2 feet below surface; very poorly drained.	Organic soil; water table 0 to 2 feet below surface; good for dug-out pits.	Organic soil; features unfavorable; water table 0 to 2 feet below surface.	Water table 0 to 2 feet below surface; drainage of surface and subsurface layers needed.	Very poorly drained.	Not needed; very poorly drained.	Very poorly drained.
Poor: organic soil; water table 0 to 2 feet below surface; very poorly drained.	Organic soil; water table 0 to 2 feet below surface.	Organic soil; features unfavorable; water table 0 to 2 feet below surface.	Water table 0 to 2 feet below surface; drainage of surface and subsurface layers needed.	Very poorly drained.	Not needed; very poorly drained.	Very poorly drained.
Poor: organic soil; water table 0 to 2 feet below surface; very poorly drained.	Organic soil; water table 0 to 2 feet below surface.	18 to 51 inches of organic soil not suitable for embankments; deeper material fair stability and compaction characteristics when drained; water table 0 to 2 feet below surface.	Water table 0 to 2 feet below surface; drainage of surface and subsurface layers needed.	Very poorly drained.	Not needed; very poorly drained.	Very poorly drained.

TABLE 7.—*Interpretations*

Soil series and map symbols	Soil limitations for—			Suitability as a source of—	
	Septic tank filter fields	Sewage lagoons	Dwellings with basements	Topsoil [1]	Sand and gravel
Cathro, sandy subsoil variant: Ch.	Severe: water table 0 to 2 feet below surface.	Severe: organic soil.	Severe: organic soil; water table 0 to 2 feet below surface.	Poor: organic soil; very poorly drained	Not suitable
Clarion: ClB2, ClC2	Slight where slopes are less than 6 percent. Moderate where slopes are 6 to 12 percent.	Moderate where slopes are 2 to 6 percent. Severe where slopes are more than 6 percent.	Slight where slopes are less than 8 percent. Moderate where slopes are 8 to 15 percent: moderate shrink-swell potential.	Good to fair, depending on slope; surface layer is thin in some places.	Not suitable
Clontarf: CmA	Moderate: water table 4 to 8 feet below surface; pollution hazard; moderately well drained.	Severe: rapid permeability in the sand.	Moderate: moderately well drained.	Fair: medium fertility; sandy loam surface layer.	Good source of sand.
Colvin: Co	Severe: water table 2 to 5 feet below surface; poorly drained.	Moderate: moderate permeability; ML material.	Severe: poorly drained; water table 2 to 5 feet below surface; moderate shrink-swell potential.	Poor: poorly drained.	Not suitable.
Cp	Severe: water table 0 to 2 feet below surface; frequently ponded.	Slight	Severe: very poorly drained; water table 0 to 2 feet below surface; high shrink-swell potential.	Poor: very poorly drained.	Not suitable.
Darnen: DaA	Slight	Slight	Slight	Good: thick surface layer.	Not suitable.

See footnotes at end of table.

of engineering properties—Continued

Suitability as a source of—Con.	Soil features affecting—					
Road fill [2]	Farm pond reservoir areas	Embankments, dikes, and levees	Agricultural drainage	Irrigation sprinklers	Terraces and diversions	Waterways
Poor: organic soil; water table 0 to 2 feet below surface; very poorly drained.	Organic soil; water table 0 to 2 feet below surface.	18 to 51 inches of organic soil not suitable for embankments; deeper material fair stability and compaction characteristics when drained; water table 0 to 2 feet below surface.	Water table 0 to 2 feet below surface; drainage of surface and subsurface layers needed.	Very poorly drained.	Not needed; very poorly drained.	Very poorly drained.
Fair: moderate shrink-swell potential; moderate susceptibility to frost action.	Moderate permeability; impervious when compacted.	Fair stability; fair compaction characteristics; slow permeability when compacted; good resistance to piping.	Not needed; well drained.	Features favorable; moderate permeability.	Irregular slopes; features favorable where slopes are less than 12 percent.	Steep in places.
Good if confined--	Porous material; rapid permeability.	Fair stability; high permeability when compacted; poor resistance to piping.	Not needed; moderately well drained.	Features favorable; low water-holding capacity; rapid intake rate; moderately rapid permeability.	Shallow to sand, which is 1 to 2 feet below surface; moderately well drained; droughty; erodible; difficult to vegetate.	Shallow to sand, which is 1 to 2 feet below surface; droughty; erodible; difficult to vegetate.
Poor: poorly drained; high susceptibility to frost action.	Suitable for dug-out pits; water table 2 to 5 feet below surface; moderate permeability.	Poor stability; fair compaction characteristics; low permeability when compacted; poor resistance to piping; water table 2 to 5 feet below surface.	Moderate permeability; water table 2 to 5 feet below surface; drainage of surface and subsurface layers needed.	Poorly drained--	Not needed; poorly drained.	Poorly drained; drainage needed before construction is begun.
Poor: very poorly drained; high susceptibility to frost action.	Water table 0 to 2 feet below surface; suitable for dug-out pits; moderately slow permeability.	Poor stability; fair compaction characteristics; moderate permeability when compacted; poor resistance to piping; water table 0 to 2 feet below surface.	Moderately slow permeability; water table 0 to 2 feet below surface; drainage of surface and subsurface layers needed; frequently ponded.	Very poorly drained.	Not needed; very poorly drained.	Very poorly drained; drainage needed before construction is begun.
Fair: moderate susceptibility to frost action; moderate shrink-swell potential.	Moderate permeability; impervious when compacted.	Thick surface layer has high organic-matter content and high compressibility.	Not needed; moderately well drained to well drained.	Soil features favorable.	Soil features favorable.	Soil features favorable.

TABLE 7.—*Interpretations*

Soil series and map symbols	Soil limitations for—			Suitability as a source of—	
	Septic tank filter fields	Sewage lagoons	Dwellings with basements	Topsoil [1]	Sand and gravel
Dassel: Dd	Severe: water table 2 to 4 feet below surface; pollution hazard; poorly drained.	Severe: rapid permeability.	Severe: poorly drained; water table 2 to 4 feet below surface.	Poor: poorly drained.	Fair source of sand; water table 2 to 4 feet below surface.
De	Severe: water table 0 to 2 feet below surface; pollution hazard.	Severe: rapid permeability.	Severe: very poorly drained; water table 0 to 2 feet below surface.	Poor: very poorly drained.	Fair source of sand; water table 0 to 2 feet below surface.
Dorset: DoA, DoB, DoC, DpA, DpB, DpC.	Slight: pollution hazard.	Severe: rapid permeability.	Slight where slopes are less than 8 percent. Moderate where slopes are 8 to 15 percent.	Poor: low fertility; responsive to fertilizer; thin surface layer.	Good: mixed sand and gravel.
Dovray: Dv	Severe: water table 0 to 2 feet below surface; very slow permeability.	Slight	Severe: water table 0 to 2 feet below surface; high shrink-swell potential; very poorly drained.	Poor: clayey soil; very poorly drained.	Not suitable
Flom: Fa	Severe: water table 2 to 5 feet below surface; poorly drained.	Slight	Severe: poorly drained; water table 2 to 5 feet below surface; moderate shrink-swell potential.	Poor: water table 2 to 5 feet below surface; poorly drained.	Not suitable

See footnotes at end of table.

of engineering properties—Continued

Suitability as a source of—Con.	Soil features affecting—					
Road fill [2]	Farm pond reservoir areas	Embankments, dikes, and levees	Agricultural drainage	Irrigation sprinklers	Terraces and diversions	Waterways
Fair: poorly drained.	Rapid permeability; water table 2 to 4 feet below surface; generally suited to dug-out pits; poor resistance to piping.	Fair stability; high permeability when compacted; poor resistance to piping; water table 2 to 4 feet below surface.	Sand subsoil at depth of less than 2 feet; water table 2 to 4 feet below surface.	Poorly drained	Not needed; poorly drained.	Poorly drained; sand at depth of 1 to 2 feet.
Poor: very poorly drained.	Rapid permeability; water table 0 to 2 feet below surface; generally suited to dug-out pits; poor resistance to piping.	Fair stability; high permeability when compacted; water table 0 to 2 feet below surface; poor resistance to piping.	Sand subsoil at depth of less than 2 feet; water table 0 to 2 feet below surface; frequently ponded.	Very poorly drained.	Not needed; very poorly drained.	Very poorly drained; sand at depth of 1 to 2 feet.
Good	Porous material; rapid permeability.	Upper layers have fair stability and moderate permeability when compacted; sand and gravel in deeper layers have fair stability and high permeability when compacted.	Not needed; somewhat excessively drained.	Features favorable; rapid intake rate; rapid permeability; low water-holding capacity.	Shallow to sand and gravel, which are at depth of 1 to 2 feet; difficult to vegetate; droughty.	Shallow to sand and gravel; droughty; erodible; difficult to vegetate.
Poor: very poorly drained; high shrink-swell potential; high susceptibility to frost action.	Very slow permeability.	Poor stability; poor compaction characteristics; very low permeability when compacted; high shrink-swell potential; water table 0 to 2 feet below surface.	Very slow permeability; drainage of surface and subsurface layers needed; water table 0 to 2 feet below surface; frequently ponded.	Very poorly drained.	Not needed; very poorly drained.	Very poorly drained; drainage needed before construction is begun.
Poor: poorly drained; moderate shrink-swell potential; high susceptibility to frost action.	Moderate permeability; water table 2 to 5 feet below surface.	Fair stability; low permeability when compacted; good resistance to piping; water table 2 to 5 feet below surface.	Drainage of surface and subsurface layers needed; water table 2 to 5 feet below surface; moderate permeability.	Poorly drained	Not needed; poorly drained.	Poorly drained; drainage needed before construction is begun.

TABLE 7.—*Interpretations*

Soil series and map symbols	Soil limitations for—			Suitability as a source of—	
	Septic tank filter fields	Sewage lagoons	Dwellings with basements	Topsoil [1]	Sand and gravel
Forada: Fd, Ff	Severe: water table 2 to 4 feet below surface; poorly drained; pollution hazard.	Severe: rapid permeability.	Severe: poorly drained; water table 2 to 4 feet below surface.	Poor: water table 2 to 4 feet below surface; poorly drained.	Good: sand and fine gravel; water table 2 to 4 feet below surface.
Fe	Severe: water table 0 to 2 feet below surface; pollution hazard.	Severe: rapid permeability.	Severe: water table 0 to 2 feet below surface; very poorly drained.	Poor: water table 0 to 2 feet below surface; very poorly drained.	Good: sand and gravel; water table 0 to 2 feet below surface.
*Forman: FmC2, FoB. For properties of Aastad soil in FoB; see Aastad series.	Moderate where slopes are 2 to 12 percent; moderately slow permeability.	Moderate where slopes are 2 to 6 percent. Severe where slopes are more than 6 percent.	Severe: high shrink-swell potential.	Fair where slopes are 6 to 12 percent; clay loam surface layer; surface layer is thin in some places.	Not suitable.
Fulda: Fu	Severe: poorly drained; water table 1 to 4 feet below surface; slow to very slow permeability.	Slight	Severe: water table 1 to 4 feet below surface; high shrink-swell potential; poorly drained.	Poor: water table 1 to 4 feet below surface; poorly drained.	Not suitable
Gonvick: GoA	Moderate: moderately well drained; moderate permeability.	Slight	Moderate: moderately well drained; moderate shrink-swell potential.	Fair to poor, depending on thickness of surface layer.	Not suitable

See footnotes at end of table.

of engineering properties—Continued

Suitability as a source of—Con.	Soil features affecting—					
Road fill [2]	Farm pond reservoir areas	Embankments, dikes, and levees	Agricultural drainage	Irrigation sprinklers	Terraces and diversions	Waterways
Poor: poorly drained.	Rapid permeability; water table 2 to 4 feet below surface; generally suited to dug-out ponds.	Upper 2 to 3 feet has fair stability and moderate permeability when compacted; sand and gravel below this depth has high permeability when compacted; water table 2 to 4 feet below surface.	Sand and gravel subsoil 2 to 3 feet below surface; water table 2 to 4 feet below surface.	Poorly drained.	Not needed; poorly drained.	Poorly drained; drainage needed before construction is begun.
Poor: very poorly drained.	Rapid permeability; water table 0 to 2 feet below surface; generally suited to dug-out pits.	Upper 2 to 3 feet has fair stability and moderate permeability when compacted; sand and gravel below this depth has high permeability when compacted; water table 0 to 2 feet below surface.	Sand and gravel subsoil 2 to 3 feet below surface; water table 0 to 2 feet below surface; frequently ponded.	Poorly drained.	Not needed; poorly drained.	Very poorly drained; needs drainage before construction is begun.
Fair: moderate shrink-swell potential; moderate susceptibility to frost action.	Moderately slow permeability; impervious when compacted.	Fair stability and compaction characteristics; low permeability when compacted; good resistance to piping.	Not needed; well drained.	Suitability doubtful; moderately slow permeability.	Irregular slopes; features favorable where slopes are less than 12 percent.	Steep in places.
Poor: poorly drained; high shrink-swell potential; high susceptibility to frost action.	Very slow to slow permeability; water table 1 to 4 feet below surface.	Poor stability; poor compaction characteristics; low permeability when compacted; high shrink-swell potential; water table 1 to 4 feet below surface.	Slow to very slow permeability; water table 1 to 4 feet below surface; drainage of surface and subsurface layers needed.	Poorly drained.	Not needed; poorly drained.	Poorly drained; drainage needed before construction is begun.
Fair: moderate shrink-swell potential; moderate susceptibility to frost action.	Moderate permeability; impervious when compacted.	Fair stability and compaction characteristics; low permeability when compacted; good resistance to piping.	Not needed; moderately well drained.	Features favorable; generally not irrigated.	Terraces and diversions generally not used; moderately well drained.	Soil features favorable.

TABLE 7.—*Interpretations*

Soil series and map symbols	Soil limitations for—			Suitability as a source of—	
	Septic tank filter fields	Sewage lagoons	Dwellings with basements	Topsoil [1]	Sand and gravel
Hangaard: Ha	Severe: poorly drained; water table 1 to 4 feet below surface; pollution hazard.	Severe: rapid permeability.	Severe: water table 1 to 4 feet below surface; poorly drained.	Poor: water table 1 to 4 feet below surface; poorly drained.	Good: stratified sand and gravel; high water table 1 to 4 feet below surface.
Hantho: HhA	Moderate: moderately well drained; moderate permeability.	Moderate: moderate permeability.	Slight	Good: fertile soil; silt loam texture.	Not suitable
Lake beaches:					
La	Severe: pollution hazard; check each site.	Severe: rapid permeability.	Severe: high water table; check each site.	Poor: sandy texture.	Poor: gravel and sand mixed; high water table.
Lb	Severe: high water table; check each site.	Severe: rapid permeability.	Severe: high water table; check each site.	Poor: high water table.	Not suitable
*Langhei: LeF, LgD2, LkD2, LkE, LwD. For properties of Barnes soils in LgD2, for properties of Waukon soils in LkD2, LkE, and LwD; for properties of Sioux soils in LwD, see their respective series.	Slight where slopes are less than 6 percent. Moderate where slopes are 6 to 12 percent. Severe where slopes are more than 12 percent.	Moderate where slopes are 2 to 6 percent. Severe where slopes are more than 6 percent.	Slight where slopes are less than 8 percent. Moderate where slopes are 8 to 15 percent. Severe where slopes are more than 15 percent: moderate shrink-swell potential.	Poor: thin surface layer; slopes up to 40 percent.	Not suitable
Maddock: MaA, MaB, MaC	Moderate: fine sand; pollution hazard.	Severe: rapid permeability.	Slight where slopes are less than 8 percent. Moderate where slopes are more than 8 percent.	Poor: sandy texture.	Fair source of fine sand.
Marsh: Mh. Properties too variable to classify.					

See footnotes at end of table.

of engineering properties—Continued

Suitability as a source of—Con.	Soil features affecting—					
Road fill [2]	Farm pond reservoir areas	Embankments, dikes, and levees	Agricultural drainage	Irrigation sprinklers	Terraces and diversions	Waterways
Poor: poorly drained.	Rapid permeability; water table 1 to 4 feet below surface; generally suited to dugout pits.	Fair stability; high permeability when compacted; water table 1 to 4 feet below surface; fair resistance to piping.	Sand and gravel at depth of less than 2 feet; water table 1 to 4 feet below surface.	Poorly drained	Not needed; poorly drained.	Poorly drained; unfavorable soil material at depth of less than 2 feet.
Poor: high susceptibility to frost action.	Moderate permeability; poor resistance to piping.	Poor stability; fair compaction characteristics; moderate permeability when compacted; poor resistance to piping.	Not needed; moderately well drained.	Soil features favorable.	Soil features favorable.	Soil features favorable.
Poor to fair: check each site.	Rapid permeability; check each site.	High permeability when compacted; fair stability; check each site.	Needed in some areas; generally no suitable outlets.	Check each site; suitability doubtful.	Not needed	Check each site.
Poor to fair: check each site.	High water table; moderate to rapid permeability; check each site.	High water table; fair stability; check each site.	Needed in some areas; generally no suitable outlets.	Chck each site; suitability doubtful.	Not needed	Check each site.
Fair to poor depending on slope; moderate shrink-swell potential; moderate susceptibility to frost action.	Moderate permeability; impervious when compacted.	Fair stability and compaction; low permeability when compacted; good resistance to piping.	Not needed; somewhat excessively drained.	Steep in places	Irregular slopes; medium fertility; features favorable where slopes are less than 12 percent.	Steep in places.
Good if confined	Rapid permeability; porous substratum; poor resistance to piping.	Fair stability; high permeability when compacted; poor resistance to piping.	Not needed; well drained.	Very droughty; rapid intake rate; very low water-holding capacity; frequent application of water needed.	Difficult to vegetate; erodible; sandy substratum; very droughty.	Very droughty; difficult to vegetate; erodible.

TABLE 7.—*Interpretations*

Soil series and map symbols	Soil limitations for—			Suitability as a source of—	
	Septic tank filter fields	Sewage lagoons	Dwellings with basements	Topsoil [1]	Sand and gravel
Marysland: Mm	Severe: water table 2 to 4 feet below surface; pollution hazard; poorly drained.	Severe: rapid permeability.	Severe: poorly drained; water table 2 to 4 feet below surface.	Poor: poorly drained; water table 2 to 4 feet below surface.	Good: stratified sand and gravel; water table 2 to 4 feet below surface.
Mo	Severe: water table 0 to 2 feet below surface; pollution hazard.	Severe: rapid permeability.	Severe: very poorly drained; water table 0 to 2 feet below surface.	Poor: water table 0 to 2 feet below surface; very poorly drained.	Good: stratified sand and gravel; water table 0 to 2 feet below surface.
Millerville: Mp	Severe: water table 0 to 2 feet below surface.	Severe: organic soil.	Severe: organic soil; water table 0 to 2 feet below surface; very poorly drained.	Poor: organic soil.	Not suitable
*Nebish: NbB, NbC, NbD, NeB, NeB2, NeC, NeC2, NeD, NeE, NhB, NhC. For properties of Dorset soils in NhB and NhC, see Dorset series.	Slight where slopes are less than 6 percent. Moderate where slopes are 6 to 12 percent. Severe where slopes are more than 12 percent.	Moderate where slopes are 2 to 6 percent. Severe where slopes are more than 6 percent.	Slight where slopes are 0 to 8 percent. Moderate where slopes are 8 to 15 percent. Severe where slopes are more than 15 percent: moderate shrink-swell potential.	Poor: thin surface layer; slopes up to 24 percent.	Not suitable
Nicollet: NlA	Moderate: moderately well drained; moderate permeability.	Slight	Moderate: moderately well drained; moderate shrink-swell potential.	Fair: surface layer 8 to 16 inches thick.	Not suitable

See footnotes at end of table.

of engineering properties—Continued

Suitability as a source of—Con.	Soil features affecting—					
Road fill [2]	Farm pond reservoir areas	Embankments, dikes, and levees	Agricultural drainage	Irrigation sprinklers	Terraces and diversions	Waterways
Poor: poorly drained.	Water table 2 to 4 feet below surface; rapid permeability; generally suited to dug-out pits.	Upper 2 to 3 feet has fair stability and moderate permeability when compacted; coarse sand and gravel below 2 to 3 feet has high permeability when compacted; water table 2 to 4 feet below surface.	Sand and gravel 2 to 3 feet below surface; water table 2 to 4 feet below surface.	Poorly drained.	Not needed; nearly level.	Poorly drained; sand and gravel 2 to 3 feet below surface.
Poor: very poorly drained.	Water table 0 to 2 feet below surface; rapid permeability; generally suited to dug-out pits.	Upper 2 to 3 feet has fair stability and moderate permeability when compacted; coarse sand and gravel below 2 to 3 feet has high permeability when compacted; water table 0 to 2 feet below surface.	Sand and gravel 2 to 3 feet below surface; water table 0 to 2 feet below surface.	Very poorly drained.	Not needed; very poorly drained.	Very poorly drained; sand and gravel 2 to 3 feet below surface.
Poor: organic soil; very poorly drained.	Organic soil; water table at depth of less than 2 feet.	18 to 51 inches of organic soil not suitable for embankments; deeper material has fair stability and compaction characteristics when drained; water table 0 to 2 feet below surface.	Water table 0 to 2 feet below surface; surface and subsurface drainage needed.	Very poorly drained.	Not needed; very poorly drained.	Very poorly drained.
Fair to poor, depending on slope; moderate susceptibility to frost action.	Moderate permeability; impervious when compacted.	Fair stability and compaction characteristics; low permeability when compacted; good resistance to piping.	Not needed; well drained.	Well drained.	Irregular slopes; features favorable where slopes are less than 12 percent.	Steep in places.
Fair: moderate shrink-swell potential; susceptibility to frost action; moderately well drained.	Moderate permeability; impervious when compacted.	Fair stability and compaction characteristics; low permeability when compacted; good resistance to piping.	Not needed; moderately well drained.	Soil features favorable.	Soil features favorable.	Soil features favorable.

TABLE 7.—*Interpretations*

Soil series and map symbols	Soil limitations for—			Suitability as a source of—	
	Septic tank filter fields	Sewage lagoons	Dwellings with basements	Topsoil [1]	Sand and gravel
Nymore: NyB, NyC	Moderate: sand substratum; pollution hazard.	Severe: rapid permeability.	Slight where slopes are less than 8 percent. Moderate where slopes are more than 8 percent.	Poor: sandy texture.	Fair source of sand.
Osakis: OsA	Moderate: moderately well drained pollution hazard.	Severe: rapid permeability.	Moderate: moderately well drained.	Poor: low fertility; thin surface layer.	Good, but sand is mixed with gravel.
Quam: Qu	Severe: water table 0 to 2 feet below surface; moderately slow permeability.	Slight	Severe: water table 0 to 2 feet below surface; high shrink-swell potential; very poorly drained.	Poor: water table 0 to 2 feet below surface; very poorly drained.	Not suitable
Rifle: Rm	Severe: water table 0 to 2 feet below surface.	Severe: organic soil.	Severe: organic soil; water table 0 to 2 feet below surface; very poorly drained.	Poor: organic soil.	Not suitable
Rothsay: RoB	Slight where slopes are less than 6 percent. Moderate where slopes are 6 to 12 percent.	Moderate: moderate permeability; ML material; 2 to 6 percent slopes.	Slight	Fair: surface layer may be thin in some places.	Not suitable
Seelyeville: Se	Severe: water table 0 to 2 feet below surface.	Severe: organic soil.	Severe: organic soil; water table 0 to 2 feet below surface; very poorly drained.	Poor: organic soil.	Not suitable

See footnotes at end of table.

of engineering properties—Continued

Suitability as a source of—Con.	Soil features affecting—					
Road fill [2]	Farm pond reservoir areas	Embankments, dikes, and levees	Agricultural drainage	Irrigation sprinklers	Terraces and diversions	Waterways
Good if confined	Rapid permeability; porous substratum; poor resistance to piping.	Fair stability; high permeability when compacted; poor resistance to piping.	Not needed; well drained.	Very droughty; rapid intake rate; very low water-holding capacity; steep.	Sandy substratum; erodible; difficult to vegetate.	Very droughty; difficult to vegetate; erodible; sand substratum.
Good	Rapid permeability; porous material; good resistance to piping.	Upper layers have fair stability and moderate permeability when compacted; sand and gravel in deeper layers have fair stability and high permeability when compacted.	Not needed; moderately well drained	Features favorable; rapid intake rate; rapid permeability; low water-holding capacity.	Shallow or 1 to 2 feet to sand and gravel; difficult to vegetate; moderately well drained.	Shallow or 1 to 2 feet to sand and gravel; difficult to vegetate; erodible.
Poor: very poorly drained; high susceptibility to frost action; high shrink-swell potential.	Water table 0 to 2 feet below surface; moderately slow permeability; generally suited to dug-out pits.	Fair stability; low permeability when compacted; good resistance to piping; water table 0 to 2 feet below surface.	Moderately slow permeability; water table 0 to 2 feet below surface; drainage of surface and subsurface layers needed.	Very poorly drained.	Not needed; very poorly drained.	Very poorly drained; drainage needed before construction is begun.
Poor: organic soil; very poorly drained.	Organic soil; water table 0 to 2 below surface.	Organic soil; features unfavorable; water table 0 to 2 feet below surface.	Water table 0 to 2 feet below surface; drainage of surface and subsurface layers needed.	Very poorly drained.	Not needed; very poorly drained.	Very poorly drained.
Poor: high susceptibility to frost action.	Moderate permeability; poor resistance to piping.	Poor stability; fair compaction characteristics; moderate permeability when compacted; poor resistance to piping.	Not needed; well drained.	Soil features favorable.	Irregular slopes; features favorable where slopes are less than 12 percent.	Steep in places.
Poor: organic soil; very poorly drained.	Organic soil; water table 0 to 2 feet below surface.	Organic soil; features unfavorable; water table 0 to 2 feet below surface.	Water table 0 to 2 feet below surface; drainage of surface and subsurface layers needed.	Very poorly drained.	Not needed; very poorly drained.	Very poorly drained.

TABLE 7.—*Interpretations*

Soil series and map symbols	Soil limitations for—			Suitability as a source of—	
	Septic tank filter fields	Sewage lagoons	Dwellings with basements	Topsoil [1]	Sand and gravel
Shooker: Sh	Severe: poorly drained; water table 2 to 5 feet below surface.	Slight	Severe: poorly drained; water table 2 to 5 feet below surface; moderate shrink-swell potential.	Poor: water table 2 to 5 feet below surface; poorly drained.	Not suitable
Sinai: SlA, SlB	Severe: very slow permeability; moderately well drained.	Slight	Severe: high shrink-swell potential; moderately well drained.	Poor: clayey soil.	Not suitable
Sioux: SmB, SmC, SoC, SoE.	Slight where slopes are less than 6 percent. Moderate where slopes are 6 to 12 percent. Severe where slopes are more than 12 percent: pollution hazard.	Severe: very rapid permeability.	Slight where slopes are less than 8 percent. Moderate where slopes are 8 to 15 percent. Severe where slopes are more than 15 percent.	Poor: shallow and coarse textured.	Good, but sand is mixed with gravel.
Sverdrup: SpA, SpB, SpC, SvA.	Slight where slopes are less than 6 percent. Moderate where slopes are 6 to 12 percent: pollution hazard.	Severe: rapid permeability.	Slight where slopes are less than 8 percent. Moderate where slopes are more than 8 percent.	Poor: medium fertility; slopes up to 12 percent; thin surface layer.	Good source of sand; some fine gravel.
Tonka: To	Severe: poorly drained; water table 2 to 5 feet below surface.	Slight	Severe: poorly drained; water table 2 to 5 feet below surface; moderate shrink-swell potential.	Poor: water table 2 to 5 feet below surface; poorly drained.	Not suitable
Urness: Up	Severe: water table 0 to 2 feet below surface; moderately slow permeability.	Slight below a depth of 24 to 60 inches.	Severe: water table 0 to 2 feet below surface; high shrink-swell potential.	Poor: water table 0 to 2 feet below surface; very poorly drained.	Not suitable

See footnotes at end of table.

of engineering properties—Continued

Suitability as a source of—Con.	Soil features affecting—					
Road fill [2]	Farm pond reservoir areas	Embankments, dikes, and levees	Agricultural drainage	Irrigation sprinklers	Terraces and diversions	Waterways
Poor: poorly drained; moderate shrink-swell potential; moderate susceptibility to frost action.	Moderate permeability; water table 2 to 5 feet below surface.	Fair stability and compaction characteristics; low permeability when compacted; good resistance to piping; water table 2 to 5 feet below surface.	Drainage of surface and subsurface layers needed; water table 2 to 5 feet below surface; moderate permeability.	Poorly drained	Not needed; poorly drained.	Poorly drained; drainage needed before construction is begun.
Poor: high shrink-swell potential; high susceptibility to frost action.	Very slow permeability.	Poor stability; poor compaction characteristics; very low permeability when compacted; high shrink-swell potential.	Not needed; moderately well drained.	Deep soil; slow intake rate.	Moderately well drained; clayey compact subsoil; poor workability.	Clayey compact subsoil; poor workability.
Good	Very rapid permeability; porous material.	Good stability; high permeability when compacted.	Not needed; excessively drained.	Very low water-holding capacity; rapid intake rate; steep in places; gravelly coarse sand substratum at depth of less than 1 foot.	Very shallow to sand and gravel; droughty.	Very shallow to sand and gravel; erodible; difficult to vegetate; droughty.
Good if confined	Rapid permeability; porous substratum; poor resistance to piping.	Fair stability; high permeability when compacted; poor resistance to piping.	Not needed; somewhat excessively drained.	Low water-holding capacity; rapid intake rate; rapid permeability.	Sand 1 to 2 feet below surface; erodible; difficult to vegetate; droughty.	Sand 1 to 2 feet below surface; erodible; difficult to vegetate; droughty.
Poor: poorly drained; moderate susceptibility to frost action; moderate shrink-swell potential.	Moderate permeability; water table 2 to 5 feet below surface.	Fair stability; low permeability when compacted; good resistance to piping; water table 2 to 5 feet below surface.	Drainage of surface and subsurface layers needed; water table 2 to 5 feet below surface; moderate permeability.	Poorly drained	Not needed; poorly drained.	Poorly drained; drainage needed before construction is begun.
Poor: very poorly drained; high shrink-swell potential; high susceptibility to frost action.	Moderately slow permeability; water table 0 to 2 feet below surface.	Upper 2 to 5 feet not suitable; high organic-matter content; deeper material has fair stability and low permeability when compacted; water table 0 to 2 feet below surface.	Drainage of surface and subsurface layers needed; moderately slow permeability; water table at depth of less than 2 feet.	Very poorly drained.	Not needed; very poorly drained.	Very poorly drained; drainage needed before construction is begun.

TABLE 7.—*Interpretations*

Soil series and map symbols	Soil limitations for—			Suitability as a source of—	
	Septic tank filter fields	Sewage lagoons	Dwellings with basements	Topsoil [1]	Sand and gravel
Urness, peaty subsoil variant: Us.	Severe: water table 0 to 2 feet below surface.	Severe: organic material 2 to 4 feet below surface.	Severe: water table 0 to 2 feet below surface; organic material 2 to 4 feet below surface.	Poor: water table 0 to 2 feet below surface.	Not suitable
Vallers: VaA	Severe: poorly drained; water table 2 to 5 feet below surface.	Slight	Severe: poorly drained; water table 2 to 5 feet below surface; moderate shrink-swell potential.	Poor: water table 2 to 5 feet below surface; poorly drained.	Not suitable
*Waukon: WaB, WaB2, WaC, WaC2, WaD, WaD2, WaE, WcB, WcC2, WlB2, WlC2, WsB2, WsC2. For properties of Langhei soils in WlB2, WlC2, WsB2, and WsC2; for properties of Sioux soils in WsB2 and WsC2, see their respective series.	Slight where slopes are less than 6 percent. Moderate where slopes are 6 to 12 percent. Severe where slopes are more than 12 percent.	Moderate where slopes are 2 to 6 percent. Severe where slopes are more than 6 percent.	Slight where slopes are less than 8 percent. Moderate where slopes are 8 to 15 percent. Severe where slopes are more than 15 percent: moderate shrink-swell potential.	Poor: thin surface layer; slopes to 24 percent.	Not suitable
*Zell: ZoC2 For properties of Rothsay soil in ZoC2, see Rothsay series.	Moderate where slopes are 6 to 12 percent.	Severe where slopes are more than 6 percent.	Moderate where slopes are 6 to 12 percent.	Poor: thin surface layer.	Not suitable

[1] Refers to surface layer only.

of engineering properties—Continued

Suitability as a source of—Con.	Soil features affecting—					
Road fill [2]	Farm pond reservoir areas	Embankments, dikes, and levees	Agricultural drainage	Irrigation sprinklers	Terraces and diversions	Waterways
Poor: very poorly drained; organic subsoil.	Organic material 2 to 4 feet below surface.	Features unfavorable; organic material 2 to 4 feet below surface; water table 0 to 2 feet below surface.	Organic material 2 to 4 feet below surface; water table at depth of less than 2 feet.	Very poorly drained.	Not needed; very poorly drained.	Very poorly drained; drainage needed before construction is begun.
Poor: poorly drained; moderate shrink-swell potential; high susceptibility to frost action.	Moderate permeability; water table 2 to 5 feet below surface.	Fair stability; low permeability when compacted; good resistance to piping; water table 2 to 5 feet below surface.	Drainage of surface and subsurface layers needed; water table 2 to 5 feet below surface; moderate permeability.	Poorly drained	Not needed; poorly drained.	Poorly drained; drainage needed before construction is begun.
Fair: moderate shrink-swell potential; moderate susceptibility to frost action.	Moderate permeability; impervious when compacted.	Fair stability and compaction characteristics; low permeability when compacted; good resistance to piping.	Not needed; well drained.	Moderate permeability; steep in places.	Irregular slopes; features favorable where slopes are less than 12 percent.	Steep in places.
Poor: high susceptibility to frost action.	Moderate permeability; poor resistance to piping.	Poor stability; fair compaction characteristics; moderate permeability when compacted; poor resistance to piping.	Not needed; well drained.	Moderate permeability; steep in places.	Irregular slopes	Steep in places.

[2] Refers to substratum or till unless a particular layer is specified.

TABLE 8.—*Engineering*

[Tests performed by Minnesota Department of Highways in accordance with standard

Soil name and location	Parent material	Minnesota report No. SS68	Depth from surface	Moisture-density data [1]		Mechanical analysis [2]	
				Maximum dry density	Optimum moisture	Percentage passing sieve—	
						⅜ in.	No. 4 (4.7 mm.)
			Inches	*Lb. per cu. ft.*	*Percent*		
Barnes loam:							
NW¼SE¼ sec. 22, T. 128 N., R. 40 W.	Glacial till of Mankato age.	649	0–7	92	23	100	99
		650	13–17	102	18	100	99
		651	32–60	108	17	[3] 97	96
Fulda silty clay:							
NW¼SE¼ sec. 30, T. 129 N., R. 39 W. (Modal)	Lacustrine deposits or glacial till.	640	0–7	79	34	----------	----------
		641	22–29	96	24	----------	----------
		642	42–60	103	21	----------	----------
Nebish loam:							
SW¼SW¼SW¼ sec. 9, T. 128 N., R. 38 W. (Modal)	Glacial till of Mankato age.	634	3–9	116	12	98	97
		635	9–17	108	16	100	99
		636	33–60	110	15	99	97
Waukon loam:							
NE¼NE¼ sec. 14, T. 130 N., R. 37 W. (Modal)	Glacial till of Mankato age.	643	0–6	75	37	100	99
		644	14–21	113	15	[4] 92	90
		645	24–48	116	14	100	98

[1] Based on AASHO Designation: T 99–57, Method C(*1*).

[2] Mechanical analysis according to AASHO Designation: T 88–57 (*1*). Results by this procedure differ somewhat from results obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method, and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method, and the material coarser than

The ratings for sand and gravel are based on the probability that mapped areas of the soil contain deposits of sand and gravel. They do not indicate quality or size of the deposits.

Road fill is the material used as an embankment to support the subbase and base course or surface course. The ratings indicate performance of soil material that has been moved from its source and used as borrow material for these purposes.

Farm pond reservoir areas are affected mainly by the loss of water through seepage. The soil features listed are those that influence such seepage through undisturbed soils in impoundment areas.

Embankments, dikes, and levees are structures designed to impound or divert water and serve as dams. The soil features of both subsoil and substratum are those important to the use of soils for constructing embankments, dikes, and levees.

Engineering test data

Table 8 gives the results of engineering tests performed by the Minnesota Department of Highways on samples of important soils in Douglas County. The table shows the four locations where samples were taken, the depth to which sampling was done, and the results of tests to determine particle-size distribution and other properties significant in soil engineering.

Maximum dry density is the maximum unit dry weight of the soil when it has been compacted with optimum moisture by the prescribed method of compaction. The moisture content that gives the highest dry unit weight is called the optimum moisture content for the specific method of compaction.

Mechanical analyses show the percentages, by weight, of soil particles that pass sieves of specified sizes. Sand and coarser materials do not pass the No. 200 sieve. Silt and clay particles pass the No. 200 sieve. Percentage fractions smaller than openings in the No. 200 sieve were determined by the hydrometer method, rather than by the pipette method used by most soil scientists to determine the clay content of soil samples.

Liquid limit and plasticity index indicate the effect of water on the strength and consistence of soil material. As the moisture content of a clayey soil is increased from a dry state, the material changes from a solid to a plastic state. If the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material passes from solid to plastic. The liquid limit is the moisture content at which the material changes from plastic to liquid. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is plastic.

test data

procedures of the American Association of State Highway Officials (AASHO)]

Mechanical analysis [2]—Continued							Liquid limit	Plasticity index	Classification	
Percentage passing sieve—Con.			Percentage smaller than—						AASHO	Unified
No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.				
							Percent			
98	91	67	58	43	28	20	45	16	A–7–6(10)	ML
98	91	66	64	50	37	27	42	21	A–7–6(10)	CL
94	88	67	62	54	32	20	32	13	A–6(7)	CL
100	98	91	82	60	39	26	66	28	A–7–5(19)	MH
100	99	97	94	81	68	56	68	47	A–7–6(20)	CH
100	99	84	78	56	42	35	43	26	A–7–6(15)	CL
95	85	45	40	24	11	5	17	0	A–4(2)	SM
97	87	50	45	36	27	24	32	15	A–6(5)	SC
94	83	52	47	33	22	14	26	8	A–4(3)	CL
95	80	55	52	34	17	9	62	12	A–7–5(7)	OH
86	70	42	39	31	23	18	33	18	A–6(5)	SM
95	76	49	45	33	22	18	29	13	A–6(4)	SM

2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analysis data used in this table are not suitable for naming textural classes for soils.

[3] 100 percent passes the 1-inch sieve, and 99 percent passes the 3/4-inch sieve.

[4] 95 percent passes the ¾-inch sieve, 96 percent passes the 1-inch sieve, 98 percent passes the 1½-inch sieve, and 100 percent passes the 2-inch sieve.

Formation and Classification of the Soils

This section consists of two main parts. The first part tells how the factors of soil formation have affected the development of soils in Douglas County. The second explains the system of soil classification and places each soil series represented in Douglas County in the classes of that system.

Factors of Soil Formation

Soil is produced by the action of soil-forming processes on materials deposited or accumulated by geologic forces. The characteristics of the soil at any given point are determined by (1) the composition of the parent material, (2) the climate under which the soil material has accumulated, (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 that 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 bring about the development of genetically related horizons. Relief modifies the effect of climate and plant and animal life. 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 the development of distinct horizons.

The factors of soil formation are so closely interrelated in their effect on the soil that few generalizations can be made about any one factor unless conditions are specified for the other four. Many of the processes of soil formation are unknown.

Parent material

Douglas County is in a glaciated region characterized by till plains, moraines, lakes, and outwash plains. Glacial till and glacial outwash make up much of the parent material of soils in this county (fig. 19).

GLACIAL TILL.—Most of Douglas County is covered by glacial drift, generally 200 to 300 feet thick, but ranging from about 125 to 475 feet in thickness (*3*). The entire county is underlain by Precambrian granite, gneiss, and schist of unknown thickness. There are some indications that Cretaceous sediments in the form of white sand and blue shale were deposited over the granite in places in the western part of the county. The elevation of the bedrock is about 1,125 feet at Alexandria and about 1,220 feet near Osakis. The general slope seems to be westward.

Parts of the continental Nebraskan, Kansan, and

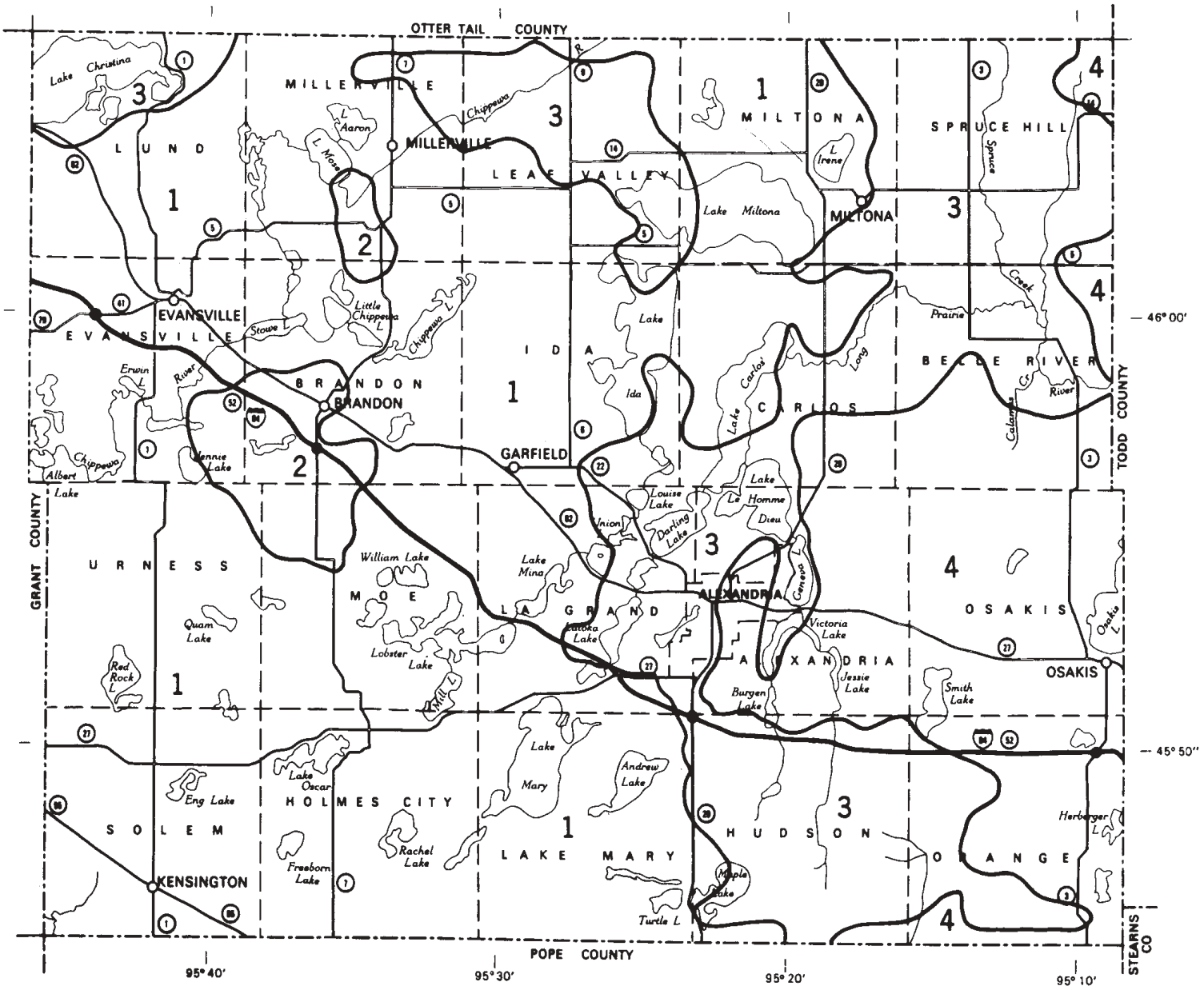

Figure 19.—**Surface geology map of Douglas County. Number 1 indicates morainic till areas. Number 2 indicates clayey areas. Number 3 indicates sand and gravel outwash areas. Number 4 indicates till plain areas.**

Wisconsin Glaciers covered Douglas County at various times. The most recent was the Wisconsin Glaciation, which terminated about 10,000 to 12,000 years ago. Material deposited by the earlier ice masses is buried deep under the deposits of the Wisconsin Glacier and in places is at a depth of 50 to 200 feet.

The Mankato substage of the Wisconsin Glacier is believed to have covered all of Douglas County. The till deposited is light olive-brown or olive-brown loam to clay loam that has yellowish-brown and light-gray mottles. The material has a high content (15 to 25 percent) of calcium carbonate, and it effervesces strongly when dilute hydrochloric acid is applied. It is made up mostly of material derived from limestone and calcareous shale, but it contains enough material to provide an abundance of minerals and a favorable range in soil texture. The principal soils formed in till of Mankato age are of the Barnes, Waukon, Clarion, and Langhei series.

The soils in the southwestern part of Brandon Township, the southeastern part of Evansville Township, the northwestern part of Moe Township, and the south-central part of Millerville Township formed in silty clay to clay glacial material. The principal soils formed in this till are of the Fulda and Sinai series.

OUTWASH SEDIMENTS.—Deposits of glacial outwash were originally carried by the glaciers, but the material was swept out and deposited beyond the front of the glacier by streams of melt water. In most of the areas the soils are nearly level to undulating, but in some areas in the northeastern part of the county, they are rolling to steep. Most of the outwash material is stratified and well sorted, but in many areas near the glacial till it is poorly sorted. It consists of sand and gravel or well-sorted sand.

The largest area of glacial outwash occurs in the eastern part of Douglas County. It covers most of Hudson Township, part of Orange Township, and then extends northward to cover part of Alexandria, Carlos, and Belle River Townships and most of Spruce Hill Township.

Other smaller areas occur in Millerville, Leaf Valley, and Lund Townships around Lake Christina.

Because the kinds of material in the glacial outwash vary greatly, many different soils formed in this parent material. The soils that formed in the outwash have textures that range from loamy sand to clay loam in the upper part and generally have sand and gravel within 4 feet of the surface. Depth to the sand and gravel varies. Large stones are mixed with the outwash in some places. The Arvilla, Sioux, Sverdrup, and Dorset series are some of the major soils of the county that formed in glacial outwash.

ORGANIC MATERIAL.—Soils consisting of organic material occur in many sloughs and potholes and along some stream channels throughout the county. The water table is high in these areas, which are always wet. The environment in and adjacent to such areas has encouraged the growth of many plants, such as cattails, sedges, reeds, and other grasses and shrubs. These plants thrive, die, sink down, and are covered by the water in which they grow. The water shuts out the air, and decomposition is reduced; thus organic material accumulates more rapidly than it decomposes. Plant remains in various stages of decomposition are the parent material of peat and muck soils. Some of the major soils of the county that formed in organic material are of the Brophy, Carlos, Cathro, and Rifle series.

ALLUVIUM AND COLLUVIUM.—Colluvium has accumulated in drainageways, on alluvial fans, and near the base of steeper areas. This material is similar to alluvium, but it is not limy. The Darnen soils formed in colluvium. Alluvium was deposited along the streams in the county. These sediments, in most places, are dark colored and limy. Alluvial land is the principal soil formed in the alluvium.

Climate

Climate affects the weathering of parent material directly through rainfall and temperature. Water from rainfall and melting snow dissolves minerals, supports biological activity, and transports mineral and organic residue through the soil profile. Temperature influences what kinds of organisms grow as well as their rate of growth. Alternate freezing and thawing hasten mechanical disintegration of parent material. Summer heat and humidity speed chemical weathering.

Climate affects the soils indirectly through its influence on vegetation and the kinds of animal life that can be sustained. The primary source of the organic matter in a soil is vegetation. Animals that live in the soil help to convert dead leaves, stems, roots, and other plant remains to usable organic matter.

Douglas County has a cool, subhumid, continental climate marked by wide extremes of temperature from summer to winter. In winter, soil-forming processes are largely dormant. Generally, the soils are frozen to a depth of 3 to 5 feet for 4 to 5 months of the year. The depth to which frost penetrates depends on the amount of snow that accumulates from the snowfall late in fall or early in winter.

The climate is essentially uniform throughout the county, but differences in vegetation, soil material, and relief can cause variations in the microclimate. Soils on the prairie are exposed to greater variation in temperature than those in the forest. Sinai and other fine-textured soils warm up more slowly in spring than Arvilla, Dorset, and other coarse-textured soils because they contain more moisture. Soils on south- and west-facing slopes receive more sunlight and generally are drier and warmer than soils on north- and east-facing slopes. The interaction of all these factors affects the development of soils. More information about the climate of Douglas County is given in the section "General Nature of the County."

Plant and animal life

Plants and animals are active in the soil-forming processes. They help to decompose plant residue. They also affect the chemistry of the soil and hasten soil development. Micro-organisms are an important link in the transformation of undecomposed organic matter into humus. The action of bacteria and various kinds of fungi causes the decay of dead leaves and other organic matter. Earthworms and small burrowing animals help to mix humus with the soil. The presence of decayed organic matter gradually changes the physical and chemical composition of the surface soil.

Two types of vegetation, forest and prairie, have strongly influenced the development of soils in this county. Douglas County is on the southern edge of the hardwood forest area. At the time the county was settled, about one-half of the county was forested and one-half was tall prairie grass. Some of the county has been covered part of the time by prairie and part of the time by forest. The prairie vegetation encroached on the forest, or forest vegetation came into the prairie either because the climate changed or possibly because of fire.

In soils that formed under similar conditions of relief, drainage, parent material, and time, the surface layer is thicker and darker colored in soils that formed under prairie than in soils that formed under forest. The tall prairie grasses affected the development of soils of the Barnes, Aastad, Clarion, Nicollet, Arvilla, and Flom series.

The surface layer of the soils formed under a combination of prairie and forest is intermediate in thickness between that of the soils formed under prairie and that of soils formed under forest because of the influence of grass. The subsurface layer, if present, generally resembles the gray, leached, platy horizon typical of forest soils. This horizon varies in distinctness and in places is lacking. The subsoil has an increased content of clay and a large accumulation of organic matter. Soils of the Waukon, Gonvick, and Dorset series are typical of such soils.

The surface layer of the soils formed under forest is thin. The subsurface layer is a thick, leached, platy, and gray. It has marked increase in content of clay and a large accumulation of organic matter. Soils of the Nebish and Beltrami series are typical of such soils.

Relief

Relief is an important factor in the formation of soils because of its effect upon drainage, aeration, and erosion.

The relief of Douglas County is variable, with three major kinds present. These are: (1) the irregular morainic areas, mainly in the western half of the county; (2)

the smooth glacial outwash areas; (3) the gently sloping till plains in the eastern and southeastern parts of the county. The morainic areas make up about one-half of the county; the glacial till plains, about one-fourth; and the outwash plains, the remainder. The elevation of the morainic areas is 1,400 to 1,500 feet above sea level, of the till plains in the eastern and southeastern areas 1,300 to 1,400 feet, and of the outwash areas about the same as the till plains.

Douglas County lies within the Minnesota River and Mississippi River drainage basins. The eastern part of the county is drained to the east and northeast by the Long Prairie River toward the Mississippi River. The western part is drained to the south and southwest by the Chippewa River into the Minnesota River (fig. 20). Stream development since the glacial period has been slight.

Lakes and marshes are common throughout the county. Approximately one-tenth of the county is covered by lakes.

Differences in relief can account for differences in soils that develop in the same kind of parent material. Relief influences the surface drainage, which in turn influences the kind of vegetation.

The soils on the knolls and steep soils, such as Langhei soils, receive less water for percolation through the profile because more water runs off. This makes the profile thinner. The gently sloping soils have more water percolating through the soil, and in many places are thicker than the steeper soils because less water runs off. The low-lying soils receive much more water than can percolate through the soil profile. This causes them to be wet during a large part of the growing season. Swales are frequently leached of salt to a depth of 3 to 6 feet or

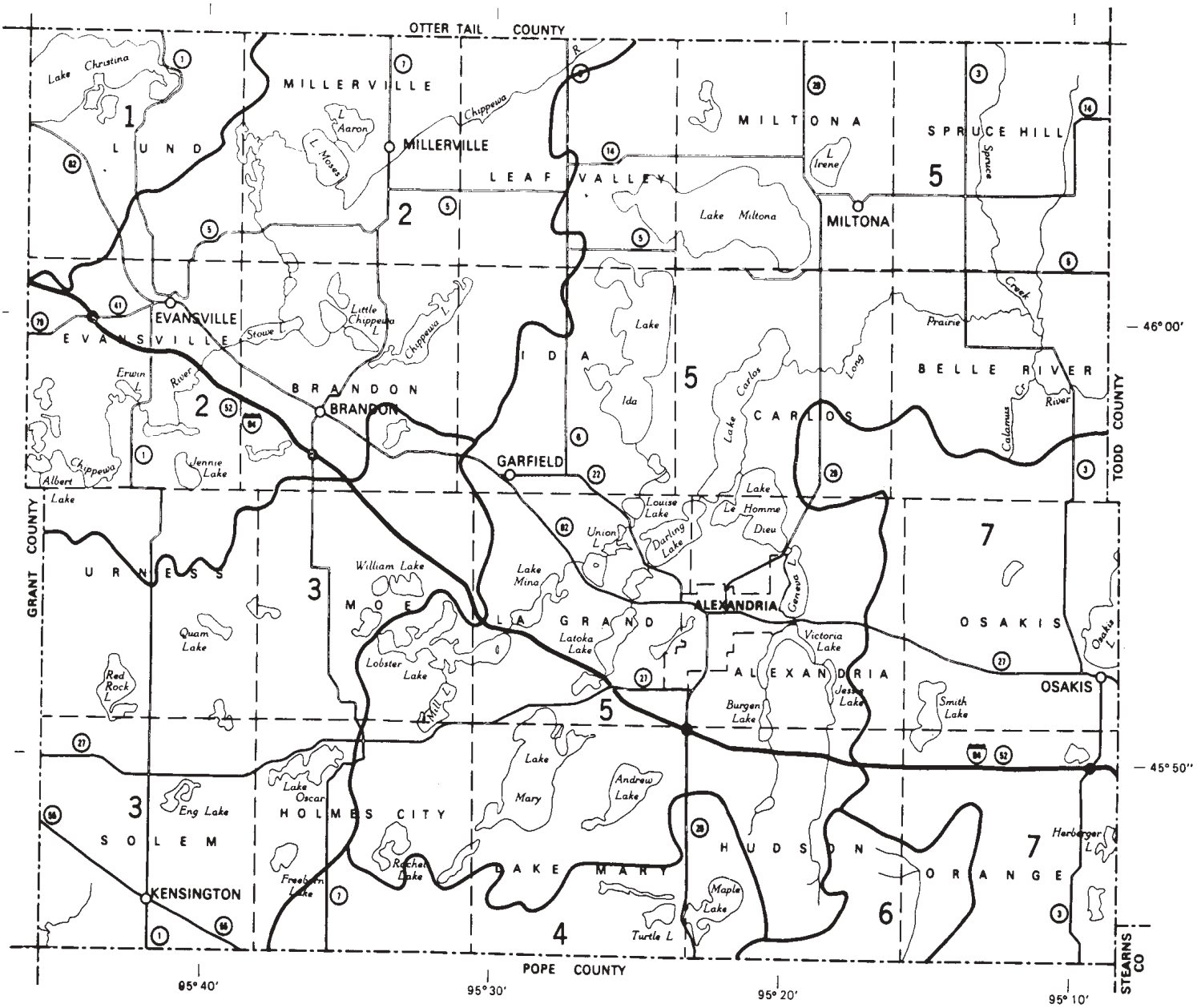

Figure 20.—Watershed map of Douglas County. Number 1 is Upper Pomme de Terre River. Number 2 is Upper West Branch Chippewa River. Number 3 is Middle West Branch Chippewa River. Number 4 is Little Chippewa River. Number 5 is Upper Long Prairie River. Number 6 is Upper East Branch Chippewa River. Number is Upper Sauk River.

more. Examples are soils of the Flom and Quam series, which have a thick surface layer.

Time

After the glacier receded, about 10,000 to 12,000 years ago, the glacial drift had a calcareous surface but no soil profile. It probably could not support the vegetation or crops that are now grown or that were growing before the settlement of the county. The plants that were able to grow in the cold climate on the fresh parent material contributed to the development of the soils. In time, the resulting soil changes permitted other kinds of plants to grow. The succession of plants and of soils, with time, were ultimately controlled by the climate. The equilibrium of soil, climate, and vegetation was changed or disturbed in Douglas County by man when he started plowing and clearing the land about one hundred twenty years ago.

Although the parent material has been in place for many hundreds of years, many of the soils are not more than a few hundred or a few thousand years old. The Barnes, Waukon, and similar soils were exposed to a more intense influence of the five factors of soil formation than were the other soils in the county. As a result, they have moderately distinct layers, or horizons. The Langhei soils, which have gentle to steep slopes, are continuously eroded and show little horizon development. The Flom soils occur in areas where a fluctuating water table modifies the normal effect of time. Soils formed in the alluvium adjacent to the major drainageways have little or no profile development.

Classification of the Soils

Classification consists of an orderly grouping of soils according to a system designed to make it easier to remember soil characteristics and interrelationships. Classification is useful in organizing and applying the results of experience and research. Soils are placed in narrow classes for discussion in detailed soil surveys and for application of knowledge within farms and fields. The many thousands of narrow classes are then grouped into progressively fewer and broader classes in successively higher categories, so that information can be applied to large geographic areas.

The system of classifying soils currently used by the National Cooperative Soil Survey was developed in the early sixties (*4*) and was adopted in 1965 (*6*). It is under continual study.

The current system of classification has six categories. Beginning with the most inclusive, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. The criteria for classification are soil properties that are observable or measurable, but the properties are selected so that soils of similar genesis are grouped together. The placement of some soil series in the current system of classification, particularly in families, may change as more precise information becomes available.

Table 9 shows the classification of each soil series of Douglas County by family, subgroup, and order, according to the current system. Some of the soils in this county do not fit in a series that has been recognized in the classification system, but recognition of a separate series would not serve a useful purpose. Such soils are named for series they strongly resemble because they differ from those series in ways too small to be of consequence in interpreting their usefulness or behavior. Soil scientists designate such soils as taxadjuncts to the series for which they are named. In this survey, soils of the Arvilla, Clarion, Dassel, Forman, Hantho, Maddock, Marysland, Nicollet, Sverdrup, and Tonka series are taxadjuncts to those series.

ORDER.—Ten soils orders are recognized. They are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate these 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 kinds of climate. Table 9 shows that the four soil orders represented in Douglas County are Entisols, Mollisols, Alfisols, and Histosols.

Entisols are light-colored soils that do not have natural genetic horizons or that have only very weakly expressed beginnings of such horizons. These soils do not have traits that reflect soil mixing caused by shrinking and swelling.

Mollisols formed under grass and have a thick, dark-colored surface layer that contains colloids dominated by bivalent cations. The soil material in these soils has not been mixed by shrinking and swelling.

Alfisols are mineral soils that contain horizons of clay accumulation. Unlike the Mollisols, they lack the thick, dark-colored surface layer that contains colloids dominated by bivalent cations. However, the base saturation of the lower horizons is not extremely low.

Histosols formed in wet areas under marsh grass vegetation and are muck or peat of varying thickness.

SUBORDER.—Each order has been divided into suborders, primarily on the basis of those soil characteristics that seem to produce classes that have 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 waterlogging or soil differences that result from the climate or vegetation.

GREAT GROUPS.—Suborders are 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 has accumulated or those that contain a pan that interferes with the growth of roots or movement of water. The features used are the self-mulching properties of clay, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), and the like. The great group is not shown separately in table 9, because its name is the same as the last word in the name of the subgroup.

SUBGROUP.—Great groups are divided into subgroups, one that represents the central (typic) segment of the group and others, called intergrades, that have properties of one group and also 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 great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group.

TABLE 9.—*Classification of soil series of Douglas County*

Series	Family	Subgroup	Order
Aastad	Fine-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Arveson	Coarse-loamy, mixed, frigid	Typic Calciaquolls	Mollisols.
Arvilla [1]	Sandy, mixed	Udic Haploborolls	Mollisols.
Barnes	Fine-loamy, mixed	Udic Haploborolls	Mollisols.
Beltrami	Fine-loamy, mixed	Aquic Eutroboralfs	Alfisols.
Brophy	Euic	Hemic Borofibrists	Histosols.
Carlos	Marly, euic	Limnic Borohemists	Histosols.
Cathro	Loamy, euic	Terric Borosaprists	Histosols.
Cathro, sandy subsoil variant.	Loamy, euic	Terric Borosaprists	Histosols.
Clarion [2]	Fine-loamy, mixed, mesic	Typic Hapludolls	Mollisols.
Clontarf	Coarse-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Colvin	Fine-silty, mixed, frigid	Typic Calciaquolls	Mollisols.
Darnen	Fine-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Dassel [2]	Coarse-loamy, mixed, noncalcareous, mesic	Typic Haplaquolls	Mollisols.
Dorset	Coarse-loamy, mixed	Mollic Eutroboralfs	Alfisols.
Dovray	Fine, montmorillonitic, noncalcareous, frigid	Cumulic Haplaquolls	Mollisols.
Flom	Fine-loamy, mixed, noncalcareous, frigid	Typic Haplaquolls	Mollisols.
Forada	Coarse-loamy, mixed, noncalcareous, frigid	Typic Haplaquolls	Mollisols.
Forman [3]	Fine-loamy, mixed	Udic Argiborolls	Mollisols.
Fulda	Fine, montmorillonitic, noncalcareous, frigid	Typic Haplaquolls	Mollisols.
Gonvick	Fine-loamy, mixed	Aquic Argiborolls	Mollisols.
Hangaard	Sandy, mixed, noncalcareous, frigid	Typic Haplaquolls	Mollisols.
Hantho [4]	Coarse-silty, mixed	Pachic Udic Haploborolls	Mollisols.
Langhei	Fine-loamy, mixed, calcareous, frigid	Typic Udorthents	Entisols.
Maddock [5]	Sandy, mixed	Udorthentic Haploborolls	Mollisols.
Marysland [6]	Fine-loamy over sandy or sandy-skeletal, mixed frigid	Typic Calciaquolls	Mollisols.
Millerville	Coprogenous, euic	Limnic Borohemists	Histosols.
Nebish	Fine-loamy, mixed	Typic Eutroboralfs	Alfisols.
Nicollet [2]	Fine-loamy, mixed, mesic	Aquic Hapludolls	Mollisols.
Nymore	Mixed, frigid	Typic Udipsamments	Entisols.
Osakis	Sandy, mixed	Aquic Haploborolls	Mollisols.
Quam	Fine-silty, mixed, noncalcareous, frigid	Cumulic Haplaquolls	Mollisols.
Rifle	Euic	Typic Borohemists	Histosols.
Rothsay	Coarse-silty, mixed, frigid	Udic Haploborolls	Mollisols.
Seelyeville	Euic	Typic Borosaprists	Histosols.
Shooker	Fine-loamy, mixed, frigid	Aeric Ochraqualfs	Alfisols.
Sinai	Fine, montmorillonitic	Pachic Udic Haploborolls	Mollisols.
Sioux	Sandy-skeletal, mixed	Udorthentic Haploborolls	Mollisols.
Sverdrup [7]	Sandy, mixed	Udic Haploborolls	Mollisols.
Tonka [8]	Fine, montmorillonitic, frigid	Argiaquic Argialbolls	Mollisols.
Urness	Fine-silty, mixed, calcareous, frigid	Mollic Fluvaquents	Entisols.
Urness, peaty subsoil variant.	Fine-silty, carbonatic, calcareous, frigid	Thapto-Histic Fluvaquents	Entisols.
Vallers	Fine-loamy, mixed, frigid	Typic Calciaquolls	Mollisols.
Waukon	Fine-loamy, mixed	Mollic Eutroboralfs	Alfisols.
Zell	Coarse-silty, mixed	Udorthentic Haploborolls	Mollisols.

[1] The Arvilla soils, thick solum, are taxadjuncts to the series because they have a thicker B horizon than typical, ranging to 20 inches, and the IIC horizon is at a greater depth, 22 to 36 inches.

[2] These soils are taxadjuncts to the respective series because they have a lower mean annual temperature than is typical for the series.

[3] This soil is a taxadjunct to the Forman series because it lacks an argillic horizon.

[4] The Hantho soils are taxadjuncts to the series because they have a thicker solum than is typical for the series.

[5] This soil is a taxadjunct to the Maddock series because of the slightly acid solum and greater depth to carbonates than is typical for the series.

[6] This soil is a taxadjunct to the Marysland series because of slightly coarser textures in the upper sediment than is typical for the series, and because some profiles lack a calcic horizon and some have a calcic horizon at a depth of more than 16 inches.

[7] The Sverdrup, thick solum, soils are taxadjuncts to the series because they have a thicker sandy loam or loam-textured B horizon than is typical for the series, and because the IIC horizon is at a greater depth, 22 to 36 inches.

[8] This soil is a taxadjunct to the Tonka series because the A2 horizon is thinner than is typical for the series and in some places the Bt horizon is higher in color value.

FAMILY.—Families are separated within a subgroup primarily on the basis of properties important to growth of plants or behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizon, and consistence.

SERIES.—The series consists of a group of soils that formed from a particular kind of parent material and that have genetic horizons that are similar in differentiating characteristics and arrangement in the profile. Among these characteristics are color, structure, reaction, consistence, and mineralogical and chemical composition.

General Nature of the County

No permanent settlements were made in the area that is now Douglas County until 1858. On the shore of Lake Agnes, the site of the town of Alexandria, Douglas County was formed. In 1859 a government road was built to the town, and Fort Alexandria was constructed. Immigration into the county began in earnest in the late 1860's. The population of the county was 17,964 but had increased to 22,892 by 1970. In 1970, Alexandria had a population of 6,973.

Douglas County is served by two railroads, the Great Northern and the Soo line. A municipal airport is located at Alexandria. Public highways have been well maintained. Among them are Interstate Highway 94, which runs diagonally through the county, Minnesota State Highways No. 27, 29, 55, 70, and 114, and several black-topped county roads. Good gravelled roads maintained by the county or township serve most of the farms.

Trading centers are located throughout the county. Marketing facilities are good. Milk is usually marketed as whole milk. There are creameries throughout the county, a processing plant for dairy products at Alexandria, and a number of grain elevators throughout the county.

Relief and Drainage

Douglas County is in an area through which several ice sheets advanced and retreated during the glacial period. The relief is typical of glaciated areas. The county has three kinds of relief: the irregular morainic areas, most of which occur in the western half of the county; the smooth to rolling glacial outwash areas; and the gently sloping till plains in the eastern part of the county.

Douglas County lies within the Minnesota and Mississippi River drainage basins. The eastern part of the county is drained to the east and northeast by the Long Prairie River, which drains into the Mississippi River. The western part is drained to the south and southwest by the Chippewa River, which drains into the Minnesota River.

Lakes and marshes are common throughout the county. A number of lakes cover several square miles. Among these are Ida, Miltona, Christina, Carlos, Le Homme Dieu, Mary, and Osakis Lakes.

Farming

Douglas County is largely rural. In 1969 there were 1,543 farms in the county, and the average size was 219 acres. Most of these farms were owner operated.

When Douglas County was first settled, farm products were grown mainly for home use. Wheat and oats were the principal cereal crops. Potatoes, beets, turnips, and onions were important vegetable crops. Only a few head of cattle were raised. Wheat was the most important cash crop, with 63,653 acres raised in 1909. After that date the production of wheat declined, but dairying and diversified farming gained importance.

In 1969 dairying continued to be a significant enterprise, but small dairy farms were fewer and large ones were more numerous. In 1969, there were 22,100 milk cows and 60,800 cattle and calves, and 27,000 hogs, the raising of which was of minor importance. There were also a few small flocks of sheep, totaling 3,400. Chickens and other kinds of poultry continue to decline in importance.

Corn was grown on only a small acreage in the early days of farming, and most of the early varieties of corn were not suited to the climate. The improvement in varieties has encouraged a shift to the growing of this crop. In 1969, 42,200 acres were planted, and 20,500 of these acres were harvested for silage. The growing of hay crops for forage is of major importance, and 53,100 acres were grown in 1969. The growing of oats for grain is also important, and 63,300 acres were planted in 1969. The acreage of soybeans has continued to increase, also because of the improvement in varieties. In 1969, about 12,600 acres were planted. The acreage of wheat has continued to decline, but 12,000 acres were planted in 1969.

Modern tractors are the main source of power on the farms. Combines, cornpickers, and balers are common equipment. There are also a few threshing machines, formerly used for harvesting grain, but the grain is generally combined instead of shocked.

Climate [5]

Douglas County is near the center of the North American continent. This is the chief factor in determining its climate. The county has warm summers because of the heating under a sun that shines for long hours at a high altitude. The largest amount of rain falls in summer, when southerly winds bring warm moist air from the Gulf of Mexico. In sharp contrast, the county has cold winters because of the rapid cooling under a sun that shines during short days and is low on the horizon. The

[2] By EARL L. KUEHNAST, State climatologist for Minnesota, U.S. Department of Commerce.

smallest amount of precipitation is received in winter, when northerly winds cause additional cooling of relatively dry air masses. As the county has no sharply marked differences in topography, the climate is quite uniform.

Approximately 72 percent, or almost 16.5 inches, of annual precipitation occurs during the period of April through September. Measurable precipitation of 0.01 inch can be expected on about 85 days per year and 1 inch or more on 4 of those days. Rainfall intensities of about 1 inch an hour can be expected once in 2 years. Table 10 lists the highest and lowest precipitation that can be expected 1 year in 10 for each of the 12 months. Annual precipitation has ranged from a low of 10.46 inches in 1936 to a high of 36.76 inches in 1941. The most precipitation at Alexandria in any month was 16.52 inches in August 1900. The annual average precipitation was 16.16 inches during the dry period 1931 to 1936. On the average about 40 thunderstorms occur each year, and some are accompanied by hail and damaging winds. Tornadoes occur only rarely in Douglas County; six were reported during the period 1916 through 1969.

Drought occurs whenever the supply of water for crops, either in the form of rainfall or of soil moisture, becomes inadequate. Each day that moisture is inadequate in the root zone is defined as a drought-day. Severe droughts occurred three times between 1931 and 1963. The length of drought periods ranged from 1 to 42 months.

The first measurable snowfall in fall occurs late in October in 1 year in 5 and the last in spring usually occurs in April. Annual snowfall has ranged from 12.9 inches in 1903 to 83.7 inches in 1951.

In winter the average temperature in the period December through February is 13.5° F, but it was only 0.3° for this period in the winter of 1935–1936, which was one of the colder winters. In most winters there are 1 or 2 days when the temperature is 20° below zero or more. The lowest recorded temperature was 44° below zero on February 10, 1888.

In summer the average temperature in the period June through August is 69.4°, and daily high temperatures range from the middle seventies to the low eighties. A temperature of 100° or more occurs about 50 times during a normal 30-year period. The highest recorded temperature in Douglas County was 105° on September 10, 1931, on July 22, 1934, and on July 10, 1936.

The wide range of temperatures to be expected is shown in table 10 and the probability of low temperatures in spring and fall is shown in table 11. For example, in 5 years out of 10, or 50 percent of the time, a temperature of 32° or lower can be expected after May 11 in spring or before September 29 in fall. The freeze-free period is long enough that the staple crops of the county reach maturity without much danger from frost.

Long-term records of humidity, cloudiness, and winds are not available for Douglas County but are available only from First Order Weather Bureau Airport Stations. The following information is based on these records and is representative of Douglas County. The wind blows at an average speed of nearly 12 miles per hour and is northwesterly in winter and southerly in summer. Noontime humidity averages close to 55 percent in summer and 72 percent in winter. On the average there will be 98 clear days, 116 partly cloudy days, and 151 cloudy days.

TABLE 10.—*Temperature and precipitation*

[All data recorded at Alexandria. Temperature data for the period 1931–1960; precipitation data for the period 1898–1968; snowfall data for the period 1930–1969]

Month	Temperature				Precipitation				
	Normal daily maximum	Normal daily minimum	Normal monthly extreme maximum	Normal monthly extreme minimum	Normal monthly total	One year in 10 will have—		Days with snow cover of 1.0 inch or more	Average depth of snow on days with snow cover
						Less than—	More than—		
	°F.	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*	*Number*	*Inches*
January	18	−1	38	−24	0.51	0.08	1.24	26	7
February	22	2	40	−22	.50	.05	1.21	24	9
March	34	14	54	−8	.87	.16	1.85	19	8
April	52	31	74	15	2.36	.59	3.42	4	2
May	66	44	85	28	3.19	1.00	5.53	0	----------
June	75	54	90	40	4.27	1.54	6.41	0	----------
July	82	60	95	49	2.96	1.32	5.98	0	----------
August	79	58	93	45	3.71	1.38	5.81	0	----------
September	69	48	89	32	1.89	.62	3.85	0	----------
October	57	36	75	20	1.40	.14	2.90	[1]	1
November	36	20	58	−1	.88	.08	1.74	7	3
December	24	4	40	−16	.48	.07	1.19	19	4
Year	----------	----------	[2] 97	[3] −27	22.80	17.78	29.43	100	5

[1] Less than one-half day.
[2] Average annual highest temperature.
[3] Average annual lowest temperature.

TABLE 11.—*Probabilities of low temperatures in spring and fall*

[All data from Alexandria, as published in the University of Minnesota Agricultural Experiment Station Technical Bulletin 243]

Probability	Dates for given probabilities 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 14	April 23	May 3	May 12	May 26
2 years in 10 later than	April 10	April 18	April 28	May 8	May 21
5 years in 10 later than	April 7	April 8	April 19	May 1	May 11
Fall:					
1 year in 10 earlier than	October 27	October 14	October 8	September 22	September 18
2 years in 10 earlier than	November 1	October 20	October 14	September 28	September 22
5 years in 10 earlier than	November 9	October 31	October 25	October 8	September 29

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Glossary

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Available water capacity (also termed 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 capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Clay film. A thin coating of clay on the surface of a soil aggregate. Synonyms: clay coating.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

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.

Coprogenous. Designating the influence of animal excrement, as of the earthworm, in forming soil, especially humus.

Drainage class (natural). Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, 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 different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low available water capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and have mottling in the lower B and the C horizons.

Somewhat poorly drained soils are wet for significant periods but not all the time, and some soils commonly have mottling at a depth below 6 to 16 inches.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Fertility, soil. The quality of a soil that enables it to provide compounds, in adequate amounts and in proper balance, for the growth of specified plants, when other growth factors such as light, moisture, temperature, and the physical condition of the soil are favorable.

Fibric. Slightly decomposed organic material; peat.

Green manure (agronomy). A crop grown for the purpose of being turned under in an early stage of maturity or soon after maturity for soil improvement.

Hemic. Moderately decomposed organic material; mucky peat.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

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 some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

L layer.—A layer that includes both organic and inorganic materials either (a) deposited in water through the action of aquatic organisms, such as algae or diatoms, or (b) derived from underwater and floating aquatic plants subsequently modified by aquatic animals.

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Infiltration. The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Limnic layer. See L layer, under Horizon, soil.

Mottling, soil. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of 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 these: *fine*, less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium*, ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse*, more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Muck. An organic soil consisting of fairly well decomposed organic material that is relatively high in mineral content, finely divided, and dark in color.

Organic soil. A general term applied to a soil or to a soil horizon that consists primarily of organic matter, such as peat soils, muck soils, and peaty soil layers. In chemistry, organic refers to the compounds of carbon.

Parent material. Disintegrated and partly weathered rock from which soil has formed.

Peat. Unconsolidated soil material, largely undecomposed organic matter, that has accumulated where there has been excess moisture.

Permeability. The quality that enables the soil to transmit water or air. Terms used to describe permeability are as follows: *very slow*, *slow*, *moderately slow*, *moderate*, *moderately rapid*, *rapid*, and *very rapid*.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Mildly alkaline	7.4 to 7.8
Very strongly acid	4.5 to 5.0	Moderately alkaline	7.9 to 8.4
Strongly acid	5.1 to 5.5	Strongly alkaline	8.5 to 9.0
Medium acid	5.6 to 6.0	Very strongly alkaline	9.1 and higher
Slightly acid	6.1 to 6.5		
Neutral	6.6 to 7.3		

Relief. The elevations or inequalities of a land surface, considered collectively.

Runoff (hydraulics). The part of the precipitation upon a drainage area that is discharged from the area in stream channels. The water that flows off the land surface without sinking in is called surface runoff; that which enters the ground before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Sapric. Highly decomposed organic material; muck.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes 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 characteristic of the soil are largely confined to the solum.

Terrace (geological). An old alluvial plain, ordinarily flat or undulating, bordering a river, lake, or the sea. Stream terraces are frequently called second bottoms, as contrasted to flood plains, and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand*, *loamy sand*, *sandy loam*, *loam*, *silt loam*, *silt*, *sandy clay loam*, *clay loam*, *silty clay loam*, *sandy clay*, *silty clay*, and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Texture classes. Soils are classified as coarse-textured (sand and loamy sand), moderately coarse textured (sandy loam and fine sandy loam), medium textured (very fine sandy loam, loam, silt loam, and silt), moderately fine textured (clay loam, sandy clay loam, and silty clay loam), and fine textured (sandy clay, silty clay, and clay).

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Topsoil. A presumed 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 suggest establishing a new soil series, but a soil of such limited known area that creation of a new series is not believed to be justified.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

Wheel-track planting. Planting a crop on plowed fields in the tractor wheel tracks.

GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and the description of the soil series to which the mapping unit belongs. In referring to a capability unit or woodland group, read the introduction to the section it is in for general information about its management. Other information is given in tables as follows:

Acreage and extent, table 1, page 10.
Predicted yields, table 2, page 56.
Recreational uses of the soils, table 5, page 67.
Engineering uses of the soils, tables 6, 7, and 8, pages 76 through 103.

Map symbol	Mapping unit	De-scribed on page	Capability unit		Woodland suitability group	
			Symbol	Page	Number	Page
AaA	Aastad clay loam, 1 to 3 percent slopes	9	I-1	48	1	61
Ad	Alluvial land	9	VIw-1	54	8	63
Ao	Arveson sandy clay loam	11	IIIw-2	52	5	62
AsA	Arvilla sandy loam, 0 to 2 percent slopes	12	IIIe-3	51	6	62
AsB	Arvilla sandy loam, 2 to 6 percent slopes	12	IIIe-3	51	6	62
AsC	Arvilla sandy loam, 6 to 12 percent slopes	12	IVe-2	53	6	62
AtA	Arvilla sandy loam, thick solum, 0 to 3 percent slopes	12	IIe-4	49	6	62
BaB2	Barnes loam, 2 to 6 percent slopes, eroded	13	IIe-1	48	1	61
BaC2	Barnes loam, 6 to 12 percent slopes, eroded	13	IIIe-1	50	1	61
BlB2	Barnes-Langhei loams, 2 to 6 percent slopes, eroded	13				
	Barnes part	--	IIe-1	48	1	61
	Langhei part	--	IIe-1	48	2	62
BlC2	Barnes-Langhei loams, 6 to 12 percent slopes, eroded	14				
	Barnes part	--	IIIe-1	50	1	61
	Langhei part	--	IIIe-1	50	2	62
BmA	Beltrami loam, 1 to 3 percent slopes	15	I-1	48	1	61
Bp	Brophy peat	15	IVw-2	54	8	63
Ca	Carlos muck	16	IVw-2	54	8	63
Cc	Cathro muck	16	IVw-2	54	8	63
Ch	Cathro muck, sandy subsoil variant	17	IVw-2	54	8	63
ClB2	Clarion loam, 2 to 6 percent slopes, eroded	17	IIe-1	48	1	61
ClC2	Clarion loam, 6 to 12 percent slopes, eroded	17	IIIe-1	50	1	61
CmA	Clontarf sandy loam, 0 to 2 percent slopes	18	IIIe-4	51	6	62
Co	Colvin silt loam	19	IIw-3	50	5	62
Cp	Colvin silt loam, depressional	19	IIIw-1	52	5	62
DaA	Darnen loam, 1 to 4 percent slopes	19	I-1	48	1	61
Dd	Dassel sandy loam	20	IVw-1	53	3	62
De	Dassel sandy loam, depressional	20	IVw-1	53	3	62
DoA	Dorset sandy loam, 0 to 2 percent slopes	21	IIIe-3	51	6	62
DoB	Dorset sandy loam, 2 to 6 percent slopes	21	IIIe-3	51	6	62
DoC	Dorset sandy loam, 6 to 12 percent slopes	21	IVe-2	53	6	62
DpA	Dorset sandy loam, thick solum, 0 to 2 percent slopes	21	IIe-4	49	6	62
DpB	Dorset sandy loam, thick solum, 2 to 6 percent slopes	21	IIe-4	49	6	62
DpC	Dorset sandy loam, thick solum, 6 to 12 percent slopes	22	IIIe-3	51	6	62
Dv	Dovray mucky silty clay	22	IIIw-1	52	4	62
Fa	Flom silty clay loam	23	IIw-1	49	4	62
Fd	Forada sandy loam	24	IIw-2	50	3	62
Fe	Forada loam, depressional	24	IIIw-2	52	3	62
Ff	Forada sandy loam, sandy subsoil	24	IIw-2	50	3	62
FmC2	Forman clay loam, 6 to 12 percent slopes, eroded	25	IIIe-1	50	1	61
FoB	Forman-Aastad clay loams, 1 to 5 percent slopes	25	IIe-1	48	1	61
Fu	Fulda silty clay	25	IIw-1	49	4	62
GoA	Gonvick loam, 1 to 3 percent slopes	26	I-1	48	1	61
Ha	Hangaard sandy loam	27	IVw-1	53	3	62
HhA	Hantho silt loam, 1 to 3 percent slopes	27	I-1	48	1	61
La	Lake beaches, sandy	27	VIw-1	54	3	62
Lb	Lake beaches, loamy	27	IIIw-2	52	3	62
LeF	Langhei loam, 18 to 40 percent slopes	28	VIIe-1	55	2	62
LgD2	Langhei-Barnes loams, 12 to 18 percent slopes, eroded	28				
	Langhei part	--	IVe-1	52	2	62
	Barnes part	--	IVe-1	52	1	61
LkD2	Langhei-Waukon loams, 12 to 18 percent slopes, eroded	28				
	Langhei part	--	IVe-1	52	2	62
	Waukon part	--	IVe-1	52	1	61

Map symbol	Mapping unit	Described on page	Capability unit		Woodland suitability group	
			Symbol	Page	Number	Page
LkE	Langhei-Waukon loams, 18 to 24 percent slopes	29				
	Langhei part	--	VIe-1	54	2	62
	Waukon part	--	VIe-1	54	1	61
LwD	Langhei-Waukon-Sioux complex, 12 to 25 percent slopes	29				
	Langhei part	--	VIe-1	54	2	62
	Waukon part	--	VIe-1	54	1	61
	Sioux part	--	VIe-1	54	7	63
MaA	Maddock fine sand, 0 to 2 percent slopes	29	IVs-1	53	7	63
MaB	Maddock fine sand, 2 to 6 percent slopes	29	IVs-1	53	7	63
MaC	Maddock fine sand, 6 to 12 percent slopes	30	VIs-1	54	7	63
Mh	Marsh	30	VIIIw-1	55	8	63
Mm	Marysland loam	30	IIw-2	50	5	62
Mo	Marysland loam, depressional	31	IIIw-2	52	5	62
Mp	Millerville mucky peat	31	IVw-2	54	8	63
NbB	Nebish sandy loam, 2 to 6 percent slopes	32	IIe-2	49	1	61
NbC	Nebish sandy loam, 6 to 12 percent slopes	32	IIIe-2	51	1	61
NbD	Nebish sandy loam, 12 to 18 percent slopes	32	IVe-1	52	1	61
NeB	Nebish loam, 2 to 6 percent slopes	32	IIe-2	49	1	61
NeB2	Nebish loam, 2 to 6 percent slopes, eroded	32	IIe-2	49	1	61
NeC	Nebish loam, 6 to 12 percent slopes	33	IIIe-2	51	1	61
NeC2	Nebish loam, 6 to 12 percent slopes, eroded	33	IIIe-2	51	1	61
NeD	Nebish loam, 12 to 18 percent slopes	33	IVe-1	52	1	61
NeE	Nebish loam, 18 to 24 percent slopes	33	VIe-1	54	1	61
NhB	Nebish-Dorset complex, 2 to 6 percent slopes	33				
	Nebish part	--	IIIe-3	51	1	61
	Dorset part	--	IIIe-3	51	6	62
NhC	Nebish-Dorset complex, 6 to 12 percent slopes	33				
	Nebish part	--	IVe-1	52	1	61
	Dorset part	--	IVe-1	52	6	62
NlA	Nicollet clay loam, 1 to 4 percent slopes	34	I-1	48	1	61
NyB	Nymore loamy sand, 2 to 6 percent slopes	34	IVs-1	53	7	63
NyC	Nymore loamy sand, 6 to 18 percent slopes	35	VIs-1	54	7	63
OsA	Osakis loam, 0 to 3 percent slopes	35	IIIe-3	51	6	62
Qu	Quam mucky silty clay loam	36	IIIw-1	52	4	62
Rm	Rifle mucky peat	36	IVw-2	54	8	63
RoB	Rothsay silt loam, 2 to 6 percent slopes	37	IIe-1	48	1	61
Se	Seelyeville muck	37	IVw-2	54	8	63
Sh	Shooker loam	38	IIw-1	49	4	62
SlA	Sinai clay, 0 to 2 percent slopes	38	IIe-3	49	1	61
SlB	Sinai clay, 2 to 6 percent slopes	38	IIe-3	49	1	61
SmB	Sioux loamy coarse sand, 0 to 6 percent slopes	39	IVs-2	53	7	63
SmC	Sioux loamy coarse sand, 6 to 12 percent slopes	39	IVs-2	53	7	63
SoC	Sioux gravelly loamy coarse sand, 2 to 12 percent slopes	39	VIs-1	54	7	63
SoE	Sioux gravelly loamy coarse sand, 12 to 35 percent slopes	39	VIIs-1	55	7	63
SpA	Sverdrup sandy loam, 0 to 2 percent slopes	40	IIIe-4	51	6	62
SpB	Sverdrup sandy loam, 2 to 6 percent slopes	40	IIIe-4	51	6	62
SpC	Sverdrup sandy loam, 6 to 12 percent slopes	40	IVe-2	53	6	62
SvA	Sverdrup loam, thick solum, 0 to 3 percent slopes	40	IIe-4	49	6	62
To	Tonka loam	41	IIIw-1	52	4	62
Up	Urness mucky silty clay loam	42	IIIw-1	52	8	63
Us	Urness mucky silt loam, peaty subsoil variant	43	IVw-2	54	8	63
VaA	Vallers clay loam, 0 to 3 percent slopes	43	IIw-3	50	5	62
WaB	Waukon loam, 2 to 6 percent slopes	44	IIe-1	48	1	61
WaB2	Waukon loam, 2 to 6 percent slopes, eroded	44	IIe-1	48	1	61
WaC	Waukon loam, 6 to 12 percent slopes	44	IIIe-1	50	1	61
WaC2	Waukon loam, 6 to 12 percent slopes, eroded	44	IIIe-1	50	1	61
WaD	Waukon loam, 12 to 18 percent slopes	44	IVe-1	52	1	61
WaD2	Waukon loam, 12 to 18 percent slopes, eroded	45	IVe-1	52	1	61
WaE	Waukon loam, 18 to 24 percent slopes	45	VIe-1	54	1	61
WcB	Waukon clay loam, 2 to 6 percent slopes	45	IIe-1	48	1	61
WcC2	Waukon clay loam, 6 to 12 percent slopes, eroded	45	IIIe-1	50	1	61
WlB2	Waukon-Langhei loams, 2 to 6 percent slopes, eroded	45				
	Waukon part	--	IIe-1	48	1	61
	Langhei part	--	IIe-1	48	2	62

Map symbol	Mapping unit	Described on page	Capability unit		Woodland suitability group	
			Symbol	Page	Number	Page
W1C2	Waukon-Langhei loams, 6 to 12 percent slopes, eroded	45				
	Waukon part	--	IIIe-1	50	1	61
	Langhei part	--	IIIe-1	50	2	62
WsB2	Waukon-Langhei-Sioux complex, 2 to 6 percent slopes, eroded	46				
	Waukon part	--	IIIe-1	50	1	61
	Langhei part	--	IIIe-1	50	2	62
	Sioux part	--	IIIe-1	50	7	63
WsC2	Waukon-Langhei-Sioux complex, 6 to 12 percent slopes, eroded	46				
	Waukon part	--	IVe-1	52	1	61
	Langhei part	--	IVe-1	52	2	62
	Sioux part	--	IVe-1	52	7	63
ZoC2	Zell-Rothsay silt loams, 6 to 12 percent slopes, eroded	47				
	Zell part	--	IIIe-1	50	2	62
	Rothsay part	--	IIIe-1	50	1	61

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