Issued June 1971

SOIL SURVEY

Stevens County, Minnesota

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with
UNIVERSITY OF MINNESOTA AGRICULTURAL EXPERIMENT STATION

Major fieldwork for this soil survey was done in the period 1958–63. Soil names and descriptions were approved in 1966. Unless otherwise indicated, statements in this publication refer to conditions in the county in 1963. This survey was made cooperatively by the Soil Conservation Service and the University of Minnesota Agricultural Experiment Station. It is part of the technical assistance furnished to the Stevens 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, USDA, 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 agriculture, industry, and recreation.

Locating Soils

All the soils of Stevens 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 windbreak 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 windbreak 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 and shrubs.

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, Morphology, and Classification of Soils."

Newcomers in the county will 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," which gives additional information about the county.

Cover: Contour strips of alfalfa and corn on rolling Barnes-Buse soils.

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SOIL SURVEY OF STEVENS COUNTY, MINNESOTA

BY ROYCE R. LEWIS, DONALD E. DeMARTELAERE, AND ERNEST L. MILLER, SOIL CONSERVATION SERVICE

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

STEVENS COUNTY is in the west-central part of Minnesota (fig. 1). It has a land area of about 570 square miles, or 364,800 acres. Morris, the county seat, is in the east-central part of the county.

All of the county has been glaciated. The soils are black and granular. About 75 percent of the county consists of nearly level soils, and about 50 percent are calcareous at the surface. Many of the soils in the western one-third of the county occupy areas that lack adequate drainage outlets and are wet.

Farming is the leading enterprise in the county, and about 95 percent of the land is in cultivated crops and rotation pasture. Most of the farm income comes from livestock and livestock products and from grain grown for cash. Corn, oats, soybeans, wheat, flax, barley, and alfalfa are the chief crops grown. The county is on the northern border of the Corn Belt. A short growing season and lack of moisture limit growth and quality of corn in many years. Growing varieties that mature early and use of driers and silos for wet corn have made corn the most important farm crop in the county.

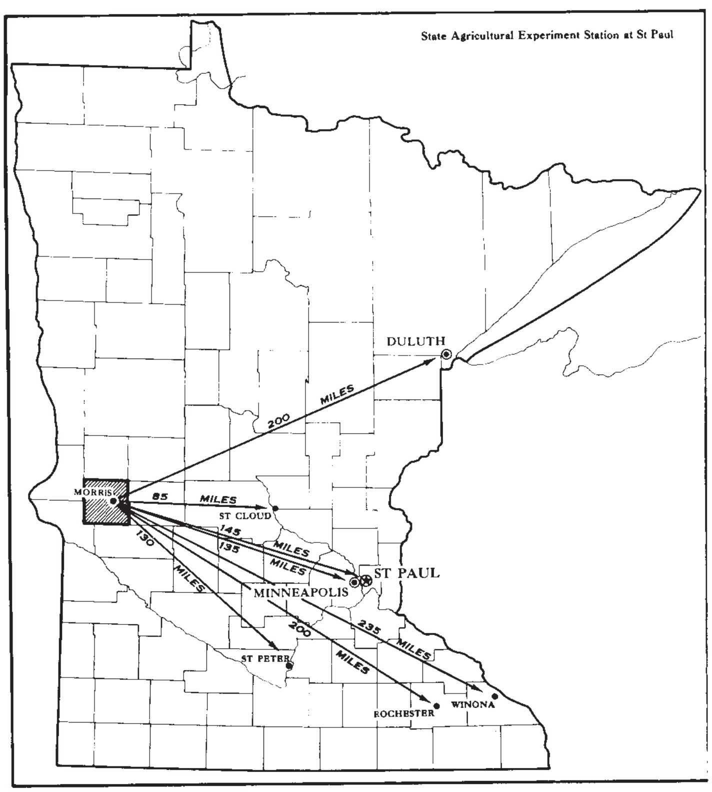

Figure 1.—**Location of Stevens County in Minnesota.**

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soils are in Stevens 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. As they traveled over the county, they observed the steepness, length, and shape of slopes, the size and speed of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

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

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Hamerly and Parnell, 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, Sioux gravelly sandy loam, 2 to 12 percent slopes, is one of several phases within the Sioux series.

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 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. Two such kinds of mapping units are shown on the soil map of Stevens County: complexes and undifferentiated groups.

A complex consists of areas of two or more soils, so intricately mixed or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a complex consists of the names of the dominant soils, joined by a hyphen. Barnes-Buse loams, 2 to 6 percent slopes, eroded, is an example.

An undifferentiated group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils, or of two or more. The name of an undifferentiated group consists of the names of the dominant soils, joined by "and." Parnell and Flom soils is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, or so severely 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. Marsh is a land type in Stevens County.

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

The soil scientists set up trial groups on the basis of yield and practice tables and other data they have collected. 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 Stevens 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.

Twelve soil associations are in Stevens County. Associations 1 through 5 are deep, loamy, moderately alkaline soils; associations 6 through 10 are deep, loamy, neutral to mildly alkaline soils; association 11 is made up of deep, clayey, neutral to mildly alkaline soils; and association 12 consists of soils that are shallow to sand and gravel and are neutral to mildly alkaline.

Deep, Loamy, Moderately Alkaline Soils

The soils that are deep, loamy, and moderately alkaline are nearly level, and many of them are wet. If the wet areas are drained, cultivated crops can be grown successfully on them. Nearly all areas are cultivated, and growth of corn, soybeans, small grains, and hay is good.

Five of the soil associations in Stevens County consist of deep, loamy, moderately alkaline soils.

1. Grimstad-Rockwell association

Nearly level, moderately well drained to poorly drained fine sandy loams underlain dominantly by silty clay loam to silty clay

This soil association is in the northwest corner of the county within the boundaries of old glacial Lake Agassiz. It is nearly level but contains some microrelief.

This association occupies less than 1 percent of the county. The closely intermingled Grimstad and Rockwell soils make up about 90 percent of the association, and minor soils make up the remaining 10 percent.

Grimstad soils are moderately well drained to somewhat poorly drained. The surface layer typically is black calcareous fine sandy loam that is about 9 inches thick. Below is a thin layer of very dark gray, strongly calcareous fine sandy loam underlain by dark-gray loamy fine sand. The substratum is dark grayish-brown to olive-brown fine sand in the upper part and dark grayish-brown silty clay loam to silty clay below. Depth to silty clay is about 30 inches.

Rockwell soils are somewhat poorly drained. Their surface layer typically is black, calcareous fine sandy loam about 8 inches thick. It is underlain by a thin layer of very dark gray, strongly calcareous fine sandy loam. Below is dark grayish-brown loamy fine sand, and as depth increases, mottled olive fine sand. Silty clay is at a depth of about 29 inches.

Small areas of the Malachy variant and of Vallers soils occur adjacent to Grimstad and Rockwell soils.

The soils in this association are used mainly for such cash crops as corn, soybeans, small grains, and hay, which grow fairly well. Most of the soils are so high in lime as to cause an imbalance of plant nutrients. Phosphorus, and in places iron or zinc, are needed to correct the imbalance. Drainage is needed to remove excess surface water and to prevent flooding.

2. *McIntosh-Winger association*

Nearly level, moderately well drained to poorly drained silt loams and silty clay loams underlain by loam and silt loam

This soil association occupies areas in the southeastern and northwestern parts of the county. It is mainly nearly level but includes many swales and swells that have differences in elevation that range from about 2 to 4 feet. Runoff collects in the swales.

The soils of this association formed in silty sediment laid down by wind and water. The deposits are shallow to moderately deep over glacial till.

This association occupies about 19 percent of the county. About 50 percent is made up of McIntosh soils, 20 percent of Winger soils, and 30 percent of minor soils.

McIntosh soils occupy slightly rounded swells and are moderately well drained to somewhat poorly drained. Their surface layer typically is black, calcareous silt loam about 7 inches thick. It is underlain by very dark gray, strongly calcareous silt loam. Below is grayish-brown silt loam underlain by light olive-brown to light yellowish-brown loam at a depth between 24 and 30 inches.

Winger soils occupy more nearly level to slightly concave areas and are somewhat poorly drained to poorly drained. Their surface layer typically is black, calcareous silty clay loam about 14 inches thick. Below is dark-gray, strongly calcareous silt loam that is underlain by gray to olive-gray, strongly calcareous silt loam and loam at a depth between 24 and 30 inches.

Minor soils in this association are the Hamerly, Hidewood, Parnell, and Tara. The Hidewood and Parnell soils are in swales and are somewhat poorly drained to very poorly drained. They are noncalcareous. The Hamerly and Tara soils are on slightly rounded swells and are moderately well drained to somewhat poorly drained.

Crops grow well on the soils of this association, and nearly all of the acreage is cultivated. Corn, soybeans, small grains, and hay are the chief crops grown. An imbalance of plant nutrients occurs in the soils that are calcareous or are moderately alkaline. The many wet swales in the association hinder planting, cultivating, and harvesting of crops. Drainage is needed for good growth of most cultivated crops. County ditches provide drainage in some parts of the association, but most of the northwestern part is inadequately drained because suitable outlets for surface drains are lacking.

Many of the farms in the southeastern part of the association have facilities for feeding large numbers of beef cattle (fig. 2). The main enterprises in the northwestern part of the association are dairying, the feeding of beef cattle, and the growing of cash crops. If drainage is improved and if adequate amounts of fertilizer are applied, the soils of this association have high potential for all cultivated crops commonly grown in the county.

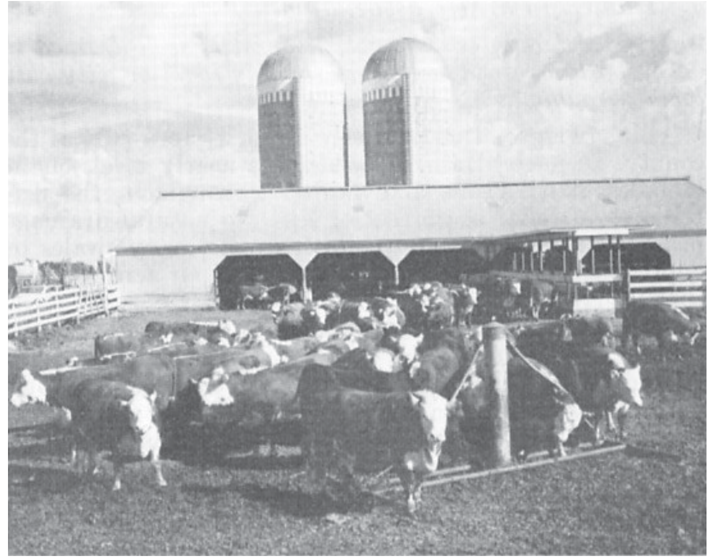

***Figure 2.*—Automatic feeding facilities for beef cattle on farm in the McIntosh-Winger soil association.**

3. *Bearden-Glyndon association*

Nearly level, moderately well drained and somewhat poorly drained silt loams underlain by silt loam or very fine sand

This soil association is in the northwestern part of the county. It consists of a nearly level lake plain that contains many shallow depressions and gently sloping beach ridges. On the average, differences in elevations are about 2 to 4 feet.

This association occupies about 3 percent of the county. About 60 percent is made up of Bearden soils, 30 percent of Glyndon soils, and 10 percent of minor soils.

Bearden soils are moderately well drained and somewhat poorly drained. They have a surface layer of black, friable, calcareous silt loam about 8 inches thick. This layer is underlain by black to very dark gray silt loam that is strongly calcareous. Below is strongly calcareous, grayish-brown and mottled olive-brown and light olive-brown, friable silt loam.

Glyndon soils occupy nearly level areas and are moderately well drained and somewhat poorly drained. They have a surface layer of black, calcareous silt loam about 9 inches thick that is underlain by dark-gray, strongly calcareous silt loam. Below is light olive-brown to olive-brown silt loam. At a depth of about 2½ feet is mottled light olive-brown very fine sand.

The minor soils are the Borup and Colvin. They occupy level to slightly concave areas and are wet and calcareous.

Nearly all of this association is used for such cash crops as corn, soybeans, small grains, and hay, which grow fairly well. The feeding of beef cattle is important on only a few farms.

The soils in this association are so high in lime that phosphorus, and possibly zinc and iron, are needed to correct the imbalance of plant nutrients. Improvement of drainage also is needed for removal of excess surface water.

4. Hamerly-Parnell association

Nearly level and depressional, moderately well drained to very poorly drained soils that are clay loam or silty clay loam throughout

This soil association is mostly in the western part of the county. In general, the association is nearly level, but it includes many swells and swales. Throughout, the differences in relief are 5 feet or less. No natural drainage pattern exists. All runoff collects in the many swales or depressions that range from about half an acre to more than 10 acres in size.

This association occupies about 16 percent of the county. About 70 percent is made up of Hamerly soils, 20 percent of Parnell soils, and 10 percent of minor soils.

Hamerly soils are moderately well drained and occupy swells in the association. The surface layer is black, calcareous clay loam about 6 to 12 inches thick. It is underlain by very dark gray to dark-gray, strongly calcareous clay loam.

Parnell soils occupy depressional areas and are poorly drained or very poorly drained. Their surface layer typically is black silty clay loam about 30 inches thick. Below is black to very dark gray silty clay loam to silty clay underlain by mottled gray to olive-gray silty clay loam and clay loam.

The minor soils are the Blue Earth, Oldham, Tonka, and Vallers. The Tonka and Vallers soils are poorly drained, and the Blue Earth and Oldham soils are very poorly drained. The Tonka soils are in shallow depressions and have a claypan; the calcareous Vallers soils are on flats and on rims around depressions; and the Blue Earth and Oldham soils are in large sloughs.

Growth of crops is moderate to good on the soils of this association, and most of the acreage is cultivated. Corn, soybeans, small grains, legumes, and grasses are the chief crops grown. An imbalance of plant nutrients occurs in the soils that are calcareous or are moderately alkaline. Additions of phosphorus, and possibly zinc or iron, therefore are needed. The many wet depressions throughout the area hinder planting, cultivating, and harvesting of crops. County ditches provide drainage in a few areas. Most of the association, however, is inadequately drained, because suitable outlets for surface drains are lacking.

A few farms have facilities for feeding large numbers of beef cattle. The main enterprises, however, are general farming and the growing of cash crops. If drainage is improved and if adequate amounts of fertilizer are applied, the soils of this association have high potential for all cultivated crops ordinarily grown in the county.

5. Malachy-Marysland association

Nearly level, moderately well drained to poorly drained sandy loams underlain by sand

This soil association is in the southeast corner of the county. The area is nearly level, and over much of it differences in elevation are less than 3 feet. In most of the association a natural drainage system is lacking, but a few shallow drainageways and small depressional areas are present.

The association occupies less than 1 percent of the county. About 90 percent is made up of Malachy and Marysland soils, in equal parts. The remaining 10 percent consists of minor soils.

Malachy soils are moderately well drained and occupy the slightly higher areas in this association. The surface layer typically is black, calcareous sandy loam about 14 inches thick. It is underlain by very dark gray sandy loam that is calcareous in the upper part and slightly calcareous in the lower part. Below is dark grayish-brown sandy loam and loam that is slightly calcareous in the upper part and calcareous in the lower part. Loose sand is at a depth of about 30 inches.

Marysland soils are poorly drained. They occupy slightly lower areas in the association. The surface layer typically is black, calcareous sandy loam about 10 inches thick. It is underlain by black to very dark gray sandy loam that is strongly calcareous. Below is dark-gray to olive-gray, strongly calcareous sandy loam to loam. Loose, calcareous sand is at a depth of about 32 inches.

The minor soils are the Biscay and Sverdrup. The depressional Biscay soils occupy shallow, wet, concave areas. Only areas that are considerably higher than the water table are occupied by the Sverdrup soils, which are somewhat excessively drained and are slightly droughty.

Soils in this association are used both for cash crops and the raising of livestock. The chief crops are corn, soybeans, small grains, hay, and pasture. Even though the available water capacity of the soils is low, growth of these crops is moderate to good because the water table is fairly high. These soils tend to blow readily. Fertility is low, but the response to fertilizer is good. The poorly drained soils need surface drainage for continuous growth of crops, but overdrainage is likely to make the surrounding soils droughty.

Deep, Loamy, Neutral to Mildly Alkaline Soils

The soils that are deep, loamy, and neutral to mildly alkaline are dominantly nearly level and gently sloping. Only a small acreage is hilly and steep. Nearly all areas are cultivated, and growth of corn, soybeans, small grains, and hay is good. Some of the soils are eroded and require practices for the control of erosion.

Five of the soil associations in Stevens County consist of deep, loamy, and neutral to mildly alkaline soils.

6. Forman-Aastad association

Nearly level to gently sloping, well-drained and moderately well drained soils that are clay loam throughout

This soil association is west of the Pomme de Terre River. It consists of an undulating ground moraine made up of swells and swales that have differences in elevation ranging from about 10 to 30 feet. Slopes are mostly nearly level and gently sloping. They are steeper, however, in a few places around the many large sloughs and potholes scattered throughout the association and along the few large drainageways. The gentle slopes generally are short.

This soil association occupies about 11 percent of the county. About 60 percent is made up of Forman soils, 20 percent of Aastad soils, and the remaining 20 percent of minor soils (fig. 3).

Forman soils, on slightly rounded swells, are nearly level to gently sloping and are well drained. The surface

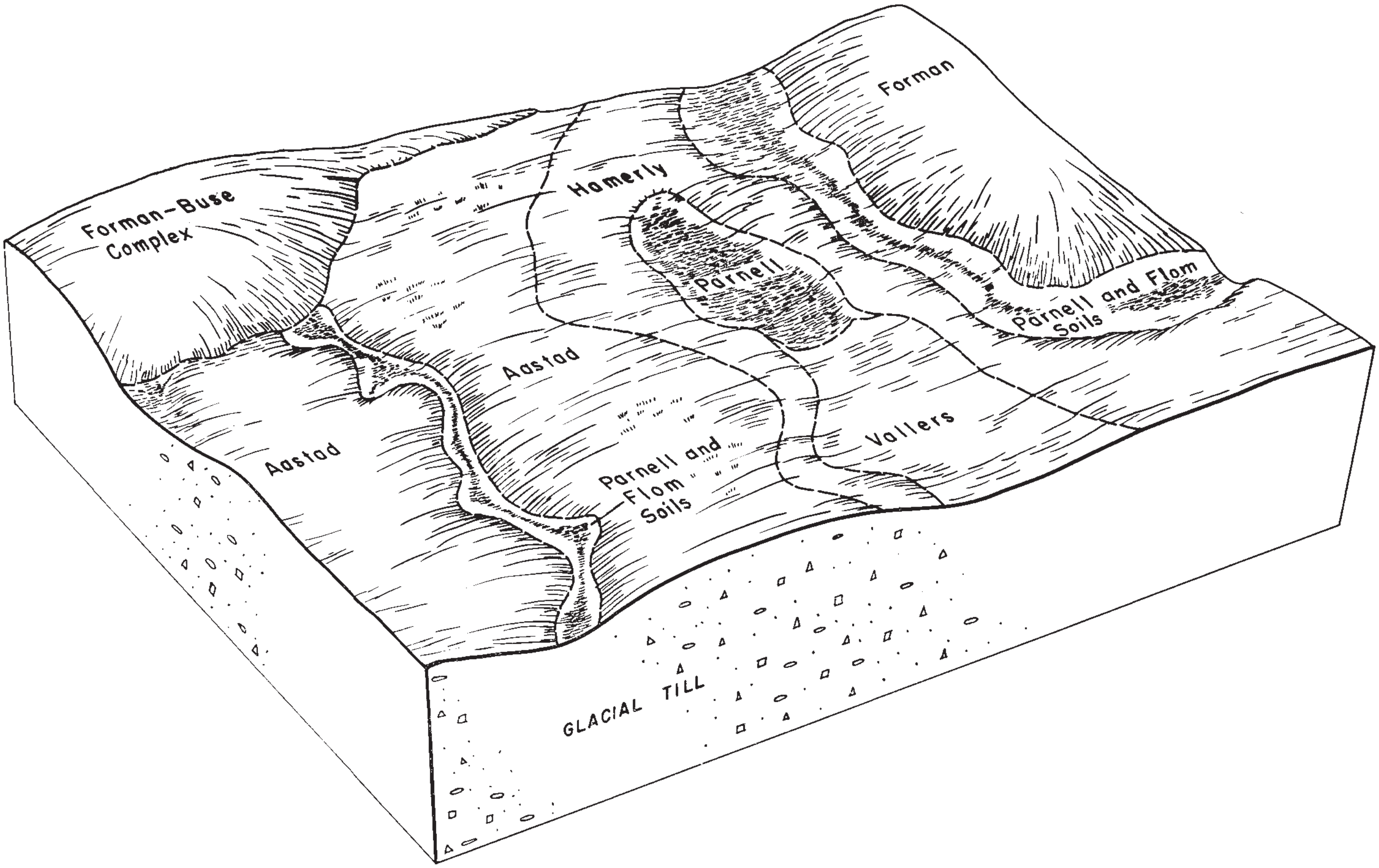

Figure 3.—**Cross section of soils in association 6 showing the topography, soils, and underlying material.**

layer typically is black clay loam about 8 inches thick. It is underlain by very dark grayish-brown to dark-brown and dark yellowish-brown clay loam. Olive-brown, strongly calcareous clay loam is at a depth of about 22 inches.

Aastad soils are nearly level to level and are moderately well drained. Their surface layer typically is black clay loam about 10 inches thick. Below is very dark brown to very dark grayish-brown clay loam underlain by olive-brown, strongly calcareous clay loam at a depth of about 23 inches.

The minor soils in this association are the Buse, Flom, Hamerly, Parnell, and Vallers.

The swales and low concave areas are occupied by the wet, noncalcareous Flom and Parnell soils. The rims around the wet soils are occupied by the nearly level, calcareous Hamerly and Vallers soils. Areas of the sloping, calcareous Buse soils are closely intermingled with areas of Forman soils.

Corn, soybeans, small grains, and hay grow well on the soils of this association. Fertility and content of organic matter are high in all of the soils, and the available water capacity also is high. The main concerns of management are control of water erosion, improvement of drainage, and maintaining tilth and fertility.

Nearly all of this association is used for cultivated crops, but a few steep areas and undrained, wet areas are used for permanent pasture and for wildlife. The main enterprises are the growing of cash crops, dairying, and the feeding of beef cattle. The soils have high potential for all cultivated crops commonly grown in the county.

7. Forman-Aastad-Parnell association

Nearly level and depressional, well-drained to very poorly drained clay loams and silty clay loams that have a subsoil of clay loam to silty clay

This soil association is mostly in the central and north-central parts of the county where the landscape is marked by swales and swells. Differences in elevation are less than 8 feet. No natural drainage pattern exists. Runoff collects in the many enclosed swales, which are a half to more than 10 acres in size.

The association occupies about 14 percent of the county. About 30 percent is made up of Forman soils, 20 percent each of the Aastad and Parnell soils, and the remaining 30 percent of minor soils.

Forman soils occupy high, slightly rounded swells and are well drained. Their surface layer typically is black clay loam about 8 inches thick. It is underlain by very dark grayish-brown to dark-brown and dark yellowish-brown clay loam. Olive-brown, strongly calcareous clay loam is at a depth of about 22 inches.

Aastad soils are nearly level to level and are moderately well drained. The surface layer typically is black clay loam about 10 inches thick. Below is very dark brown to very dark grayish-brown clay loam underlain by olive-brown, strongly calcareous clay loam at a depth of about 23 inches.

Parnell soils occupy depressional areas and are poorly drained or very poorly drained. Their surface layer typically is black silty clay loam about 30 inches thick. Below is black to very dark gray silty clay loam to silty clay underlain by mottled gray to olive-gray silty clay loam and clay loam.

The minor soils in this association are the Blue Earth, Oldham, Hamerly, Tonka, and Vallers. The calcareous Hamerly and Vallers soils occupy level to nearly level areas, and the poorly drained Tonka soils are in shallow depressions. The Blue Earth and Oldham soils are in the large sloughs.

Most areas in this association are used for such crops as corn, soybeans, small grains, and hay. Growth is good. The soils are fertile, are in good tilth, and are high in organic matter. The available water capacity also is high. The main concerns of management are improving drainage of the wet soils and maintaining and improving the supply of plant nutrients. The soils have high potential for all cultivated crops commonly grown in the county.

8. Buse-Barnes-Forman association

Gently sloping to hilly and steep, well-drained soils that are loam or clay loam throughout

This soil association occupies scattered areas throughout the eastern one-third of the county. It is mostly gently sloping, rolling, or hilly, though a few steep areas are along the rivers and creeks. The gentle slopes generally are short and complex and extend in several directions. The steep slopes are long and commonly slope in only one direction. Differences in elevation commonly range from 20 to 50 feet but are as much as 100 feet in a few areas.

This soil association occupies about 2 percent of the county. The Buse, Barnes, and Forman soils make up 90 percent of the association, in equal parts; and the minor soils, the remaining 10 percent.

Buse soils are steep and occur in a complex pattern with Barnes and Forman soils. The surface layer typically is black to very dark brown and very dark grayish-brown loam that is about 5 inches thick. It is underlain by light brownish-gray to light olive-brown loam glacial till. These soils are calcareous throughout.

Barnes soils are gently sloping and occur in a complex pattern with Buse soils in many areas east of the Pomme de Terre River. They typically have a surface layer of black loam that is about 8 inches thick. Below is dark yellowish-brown to dark-brown, friable loam underlain by calcareous loam glacial till.

Forman soils also are gently sloping. They occur with the Buse soils in a complex pattern in many areas west of the Pomme de Terre River. Forman soils typically have a surface layer of black clay loam that is about 8 inches thick. Below is very dark grayish-brown to dark-brown and dark yellowish-brown clay loam underlain by calcareous clay loam glacial till.

The minor soils in this association are the Darnen, Flom, and Parnell. The wet Flom and Parnell soils occupy the potholes or concave areas. The thick Darnen soils are at the foot of steep slopes.

Most of this association is used for such cultivated crops as corn, soybeans, small grains, and hay. The soils are poorly suited to moderately well suited to cultivated crops. The steep areas commonly are in permanent bluegrass pasture. Chief concerns of management are controlling erosion and maintaining fertility and tilth. Growing crops for cash, the feeding of beef cattle, and dairying are the main farm enterprises.

9. Barnes-Doland association

Dominantly nearly level to gently sloping, well-drained soils that are loam or silt loam throughout

Most of this soil association is east of the Pomme de Terre River, on a landscape marked by swales and swells. The soil material is loam glacial till that has a thin discontinuous cover of windblown silt. Some of the soils formed in silt, and others formed in the till. Much of the area is nearly level to gently sloping; differences in elevation range from about 10 to 30 feet. A few areas are rolling, and in these elevations range from about 30 to 50 feet. In the rolling areas slopes are short and irregular and extend in several directions.

This association occupies about 12 percent of the county. About 40 percent is made up of Barnes soils, 35 percent of Doland soils, and 25 percent of minor soils. Both the Barnes and Doland soils are well drained.

Barnes soils, on swells, are nearly level to gently sloping and rolling. They typically have a surface layer of black loam that is about 8 inches thick. Below is dark yellowish-brown to dark-brown, friable loam underlain by calcareous loam glacial till.

Doland soils, also on swells, are nearly level to gently sloping. They typically have a surface layer of black silt loam that is about 10 inches thick. Below is dark-brown and dark yellowish-brown silt loam underlain by olive-brown to light olive-brown, calcareous loam. The soils are friable throughout. Poorly sorted loam glacial till is at a depth of about 21 inches.

The minor soils in this association are the Flom, Hamerly, Hidewood, McIntosh, and Parnell. The wet Flom, Hidewood, and Parnell soils are in swales. The calcareous Hamerly and McIntosh soils are on rims around the swales.

Corn, soybeans, small grains, legumes, and grasses grow moderately well to well on the soils of this association. The soils are high in content of organic matter. Fertility also is high. Many of the wet areas have been drained and are now suitable for crops. The main concerns of management are maintaining fertility, controlling erosion, and improving drainage.

Most of this association is cultivated. Only a few steep or wet areas are used for permanent pasture. Growing crops for cash, dairying, and the feeding of beef cattle are the chief farm enterprises.

10. Tara-Doland association

Dominantly nearly level, well-drained and moderately well drained silt loams that have a subsoil of silt loam underlain by loam

This soil association is east of the Pomme de Terre River. Most of it is nearly level and contains many swales

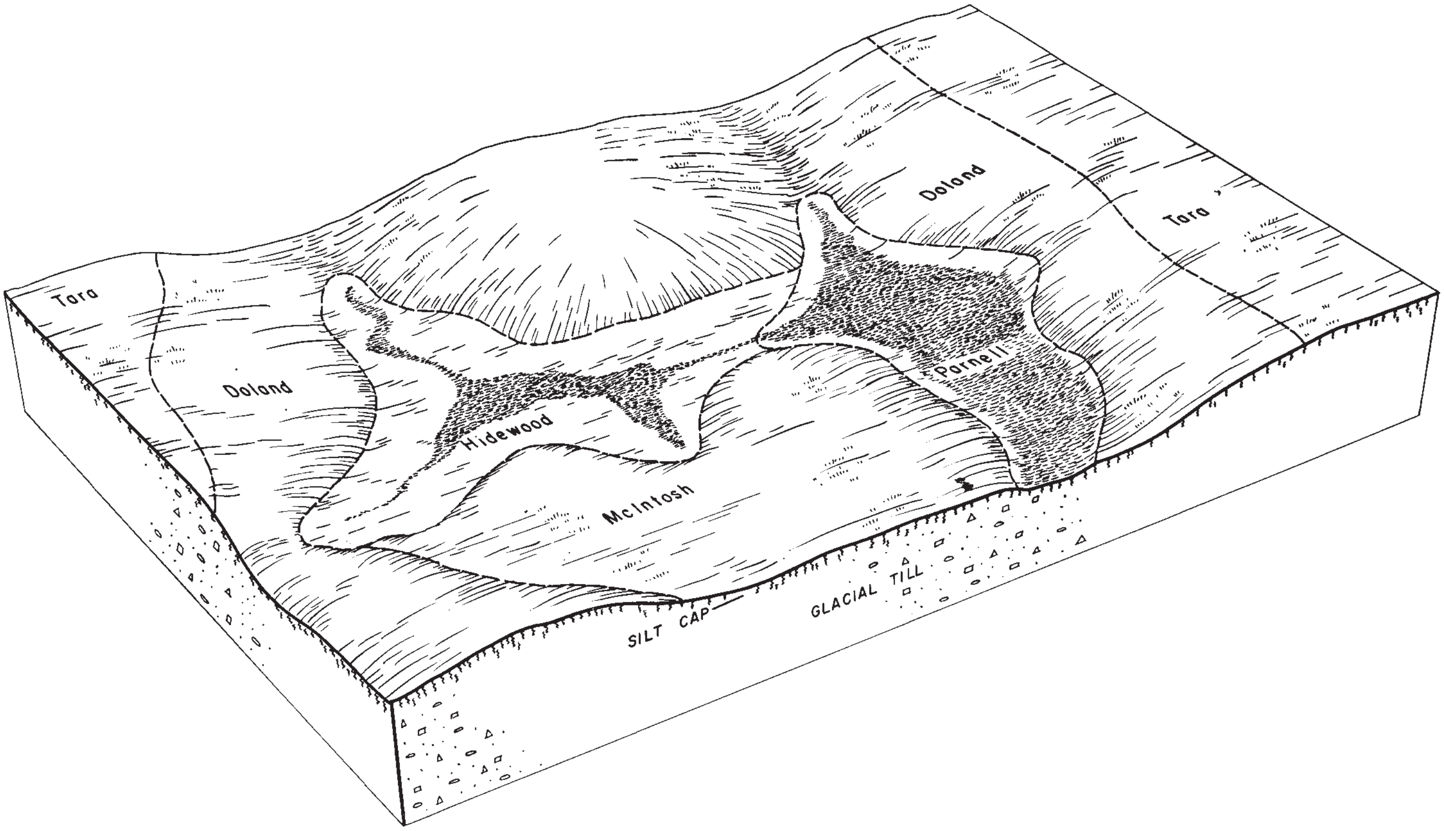

Figure 4.—**Cross section of soils in association 10 showing the topography, soils, and underlying material.**

and swells that have differences in elevation that range from less than 5 feet up to 10 feet. A few areas are gently undulating and have short slopes. A nearly continuous mantle of windblown silt covers the underlying loam glacial till.

This association occupies about 3 percent of the county. About 80 percent consists of Tara and Doland soils, in equal parts. The remaining 20 percent consists of minor soils (fig. 4).

Tara soils are nearly level and are moderately well drained. They typically have a surface layer of black silt loam, about 8 inches thick, underlain by black to very dark brown silt loam. Below is very dark grayish-brown to olive-brown silt loam. At a depth of about 32 inches is light olive-brown, calcareous, poorly sorted loam glacial till. The soils are friable throughout.

Doland soils, on slightly rounded swells, are nearly level and gently undulating. These well-drained soils are adjacent to the Tara soils. They typically have a surface layer of black silt loam that is about 10 inches thick. Below is dark-brown and dark yellowish-brown silt loam underlain by olive-brown to light olive-brown, calcareous loam. Poorly sorted loam glacial till is at a depth of about 21 inches.

The minor soils in this association are the Hidewood, Parnell, McIntosh, and Winger. The wet Hidewood and Parnell soils occupy the swales. The calcareous McIntosh and Winger soils occupy the rims around the swales and flat areas.

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Corn, soybeans, small grains, and hay grow moderately well to well on these soils. The soils are naturally highly fertile, but fertilizer is needed in some areas for best growth of plants. The chief concerns of management are maintaining tilth and fertility and improving drainage of the wet areas.

Most of this association is cultivated. The main farm enterprises are dairying and the feeding of beef cattle. The soils have high potential for the crops commonly grown in the county.

Deep, Clayey, Neutral to Mildly Alkaline Soils

The soils that are deep, clayey, and neutral to mildly alkaline are nearly level to steep. The high content of clay makes these soils more difficult to manage than most other soils in the county. All of the cultivated crops commonly grown in the county are suitable for the gently sloping soils, but pasture is most suitable for the steep soils. Nearly all areas are cultivated, and crops grow well in most years.

One soil association in Stevens County consists of deep, clayey, neutral to mildly alkaline soils.

11. Nutley-Hattie-Dovray association

Nearly level to hilly, moderately well drained to very poorly drained soils that are clay throughout

Most of this association is in the southwestern part of the county, but some areas are in the northeastern part.

About 50 percent of this association consists of clayey moraines that are mostly nearly level and contains swells and swales that have 3 to 4 feet of difference in elevation. About 40 percent of the association is nearly level to gently sloping or undulating and has differences in elevation of from about 10 to 30 feet. The remaining 10 percent of the association is rolling to hilly and has differences in elevation that range from about 30 to 50 feet. These steeper areas are mostly west of the city of Morris. Slopes in this association generally are among the longest and most uniform in the county.

This association occupies about 12 percent of the county. About 75 percent is made up of Nutley and Hattie soils, 20 percent of Dovray soils, and 5 percent of minor soils (fig. 5).

Nutley soils are moderately well drained and are nearly level and gently sloping. They typically have a surface layer of black, sticky clay that is about 7 inches thick. Below is very dark gray clay that has streaks of black, dark grayish brown, and very dark gray in the lower part. At a depth of about 17 inches is dark grayish-brown to olive-brown, calcareous clay.

Hattie soils are moderately well drained. They are mostly nearly level to gently sloping and occur in a complex pattern with Nutley soils, but some are steeper and are adjacent to Nutley soils. The steeper Hattie soils are thinner than the less sloping ones. Typically, Hattie soils have a surface layer of black, sticky clay about 7 inches thick. Below is olive-brown to dark grayish-brown clay. Hattie soils are calcareous throughout.

Dovray soils are poorly drained and very poorly drained. They are in depressions. Their surface layer is black, sticky clay about 34 inches thick. Below is black to very dark gray, mottled clay.

The minor soils in this association are the Hegne and Tonka. The Hegne soils are wet and calcareous and occupy level to slightly concave areas. The poorly drained Tonka soils are in concave areas or are in shallow depressions.

Corn, soybeans, small grains, and hay are grown on most of this association, but a small acreage of steep soils is in permanent pasture. Crops on these soils grow moderately well to well. The main concerns of management are improving drainage, controlling erosion, and increasing fertility. Also, the soils are clayey and are difficult to manage. The chief farm enterprises are the growing of crops for cash, the feeding of beef cattle, and general farming.

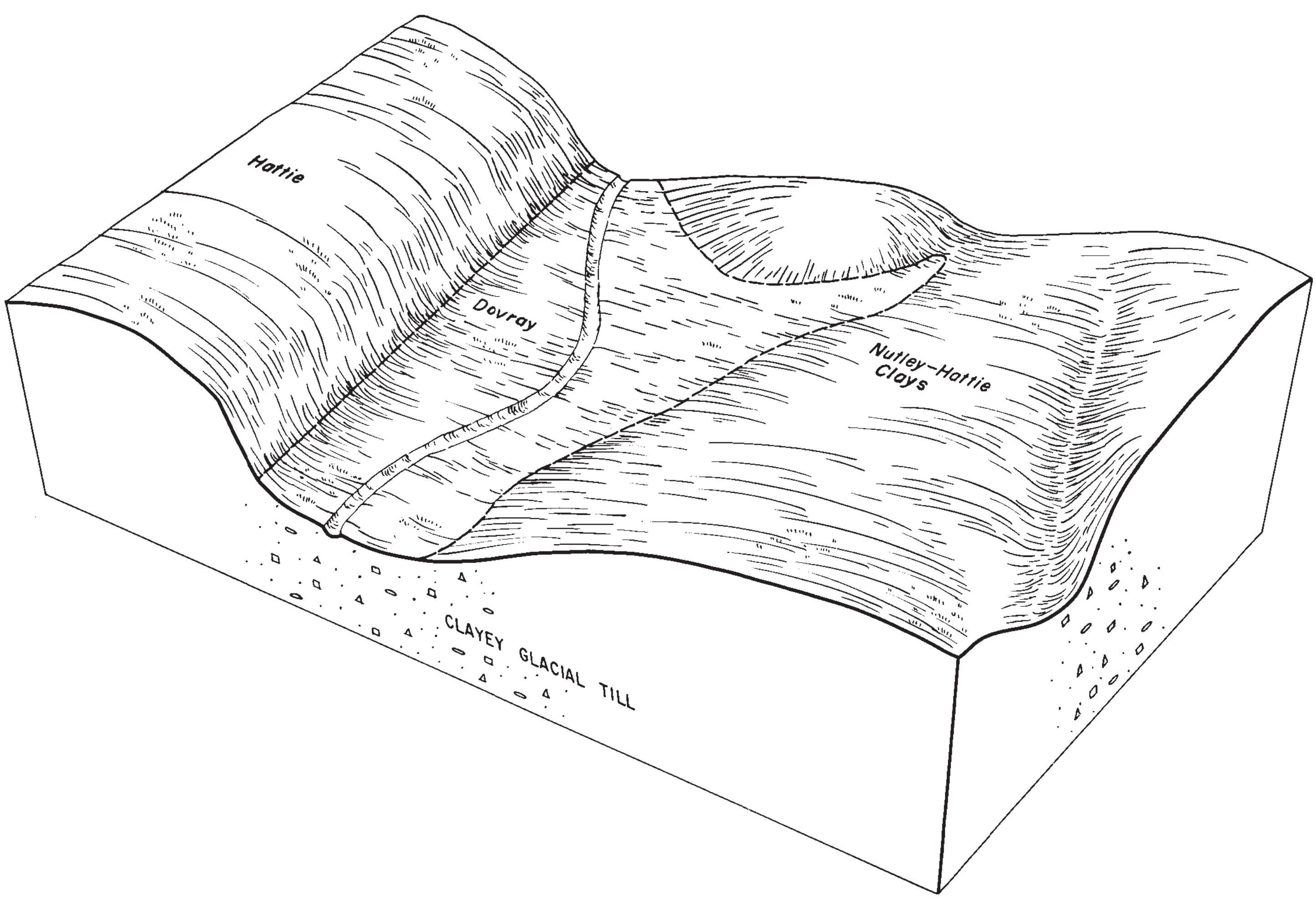

Figure 5.—**Cross section of soils in association 11 showing the topography, soils, and underlying material.**

Neutral to Mildly Alkaline Soils That Are Shallow to Sand and Gravel

The neutral to mildly alkaline soils that are shallow to sand and gravel are dominantly droughty. They generally are poorly suited to crops, though some areas are suited to crops if irrigated. Other areas are suited to limited use as pasture for livestock or for use as wildlife habitat.

One soil association in Stevens County consists of neutral to mildly alkaline soils that are shallow to sand and gravel.

12. Sioux-Renshaw association

Nearly level to gently sloping, excessively drained and somewhat excessively drained gravelly sandy loams and loams underlain by sand and gravel

Most of this soil association is in the valleys of the Pomme de Terre and Chippewa Rivers and south of Hancock. The valleys have steep walls and are 50 to 100 feet below the uplands. Their floors consist of stream terraces that are 10 to 15 feet above the present river channel. In many places these terraces are smooth or nearly level and contain a few, small, circular depressions. In other places the terraces are hummocky or undulating and differences in elevation range from about 5 to 10 feet. South of Hancock, the surface is hummocky next to the uplands, but it becomes smoother as the distance away from the uplands increases. Depth to sand and gravel is more uniform in the more smooth areas than in other areas.

This soil association occupies about 6 percent of the county. About 35 percent is made up of Sioux soils, 30 percent of Renshaw soils, and the remaining 35 percent of minor soils (fig. 6).

Sioux soils are gently undulating and are excessively drained. The surface layer typically is black gravelly sandy loam about 6 inches thick. It is underlain by calcareous, stratified sand and gravel that is many feet thick.

Renshaw soils are nearly level to gently sloping, are somewhat excessively drained, and are friable throughout. The surface layer typically is black loam about 7 inches thick. It is underlain by very dark brown to dark yellowish brown loam that is 13 inches thick. Dark grayish-brown, stratified, calcareous sand and gravel is at a depth of about 20 inches.

Minor soils in this association are the Biscay, Buse, Darnen, Fordville, Lamoure, and Rauville. Alluvial land also occurs in small areas.

Alluvial land and the wet, calcareous Lamoure and Rauville soils are adjacent to the rivers in the association. On the terraces, the shallow depressions and drainageways are occupied by the wet noncalcareous Biscay soils and the nearly level areas are occupied by the moderately deep, well-drained Fordville soils. The deep Darnen soils are on foot slopes of steep valley walls occupied by Buse soils.

Some soils in this association are unsuitable for crops because they are droughty or are wet. The wet soils adjacent to the rivers are subject to flooding and cannot be

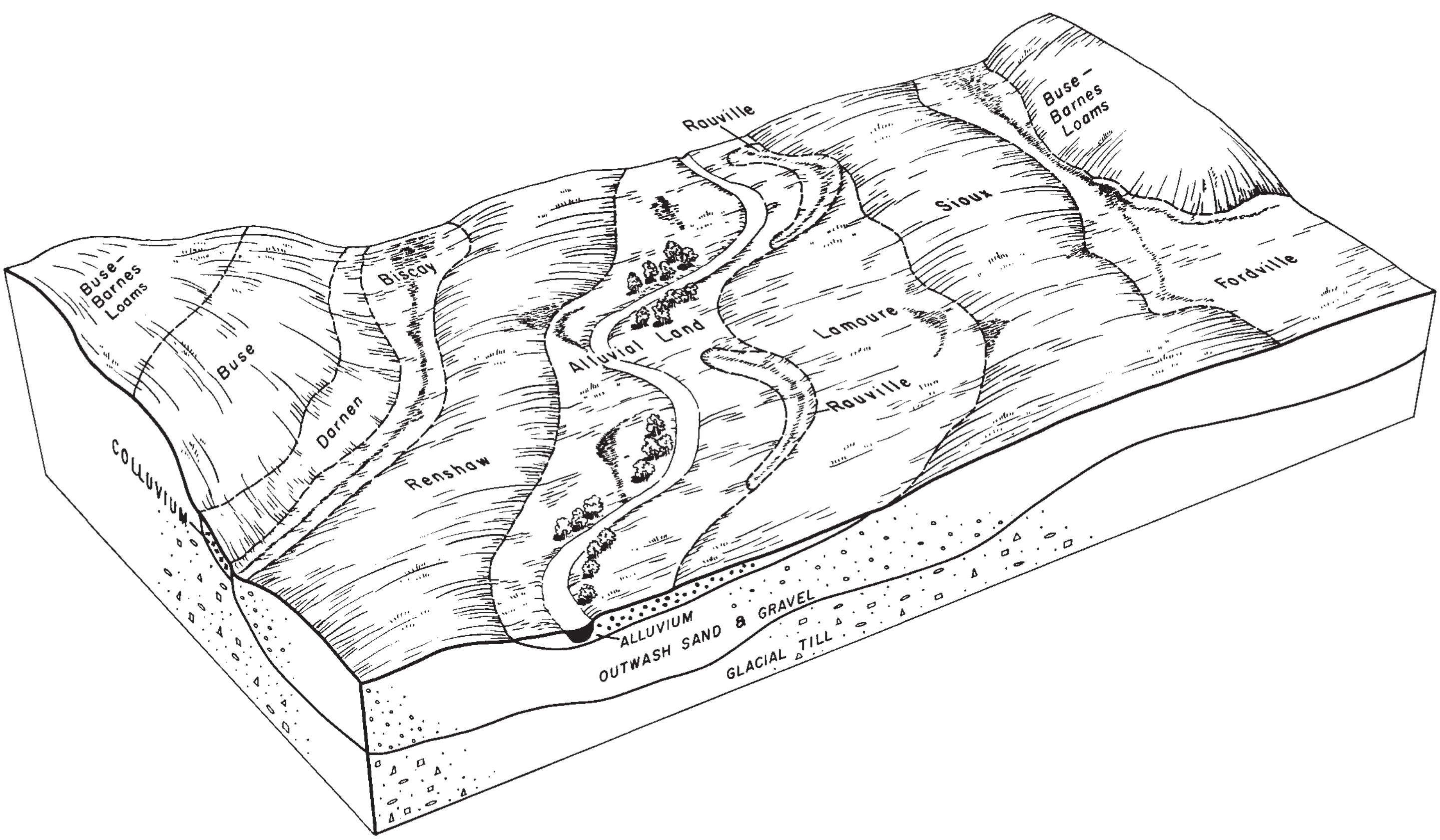

Figure 6.—**Cross section of soils in association 12 showing the topography, soils, and underlying material.**

drained, because they lack suitable outlets. Many of the soils on terraces in the association are either extremely droughty or are somewhat droughty. The extremely droughty soils are not suitable for crops, and growth of grasses and shrubs is poor. These areas provide limited pasture for livestock and some cover for wildlife.

Corn, wheat, oats, and barley are grown on the soils that are suited to cultivation. Growth is poor because the supply of moisture is low. Grain sorghum has potential as a crop for these soils. Most areas have an excellent supply of underground water that could be used for irrigating crops.

Many gravel pits are scattered through this association. Most of the gravel available to the county comes from these pits.

Descriptions of the Soils

This section describes the soil series and the mapping units of Stevens County in alphabetical order. The procedure is first to describe the soil series, and then the mapping units in that series. Thus to get full information on any one mapping unit, it is necessary to read the description of that unit and also the description of the series to which it belongs. The description of a soil series mentions features that apply to all the soils in a series. Differences among the soils of one series are pointed out in the description of the individual soils or are indicated in the soil name. As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Sandy lake beaches, for example, is a miscellaneous land type that does not belong to a soil series. It is listed, nevertheless, in alphabetic order along with the soil series.

Each series contains a short description of a typical soil profile and a much more detailed description of the same profile that scientists, engineers, and others can use in making highly technical interpretations. In the technical description, the color of each layer, or horizon, is given in words, such as yellowish brown, and is also indicated by symbols for hue, value, and chroma, such as 10YR 5/4. These symbols, called Munsell color notations, are used to evaluate the color of the soil precisely (*11*)[1]. Unless otherwise stated all color terms are for moist soil.

Many of the terms used to describe the soils are defined in the Glossary at the back of this soil survey. For more general information about the soils, the reader can refer to the section "General Soil Map," where broad patterns of the soils are described. The approximate acreage and proportionate extent of the soils are given in table 1, and their location and extent are shown on the detailed soil map at the back of this survey.

Aastad Series

The Aastad series consists of nearly level, moderately well drained soils that formed in glacial till. These soils are in the uplands, mainly west of the Pomme de Terre River.

In a typical profile the surface layer is black clay loam about 10 inches thick. The subsoil is very dark brown to very dark grayish-brown, firm clay loam about 13 inches thick. Below is strongly calcareous clay loam glacial till. The till is olive brown or light olive brown and is mottled.

The surface layer of these soils is fairly easy to work. Its content of organic matter is high. The surface layer and subsoil are neutral to mildly alkaline. They generally are low in available phosphorus and high in available potassium. Available water capacity is high. Downward movement of water is somewhat restricted and is moderate to moderately slow. Few boulders and stones are in these soils.

Aastad soils are used chiefly for cultivated crops.

Typical profile of Aastad clay loam, 0 to 2 percent slopes (SE¼SE¼SE¼ sec. 4, T. 123 N., R. 42 W.):

Ap—0 to 7 inches, black (10YR 2/1) clay loam; cloddy, but breaks to moderate, very fine, granular structure; friable when moist; neutral; abrupt, smooth boundary.

A1—7 to 10 inches, black (10YR 2/1) clay loam; moderate, very fine to fine, granular structure; friable when moist; neutral; clear, wavy boundary.

B1—10 to 14 inches, very dark brown (10YR 2/2) to very dark grayish-brown (2.5Y 3/2) clay loam, same color when crushed; moderate, medium, prismatic structure that breaks to moderate, fine, subangular blocky; firm when moist; neutral; abrupt, smooth boundary.

B2—14 to 23 inches, very dark grayish-brown (2.5Y 3/2) clay loam, very dark grayish brown (2.5Y 3/2) to olive brown (2.5Y 3/4) when crushed; moderate to strong, medium, prismatic structure that breaks to moderate, fine, subangular blocky; surfaces of peds shine; nearly continuous clay films; firm when moist; neutral; abrupt, smooth boundary.

C1ca—23 to 45 inches, olive-brown (2.5Y 4/4) clay loam; many, medium, prominent, gray (5Y 5/1) mottles; massive (structureless); firm when moist; strongly calcareous; threads and accretions of carbonates; gradual, wavy boundary.

C2—45 to 50 inches, light olive-brown (2.5Y 5/4) clay loam; many, medium, prominent, gray (5Y 5/1) mottles; massive (structureless); friable to firm when moist; calcareous, dispersed carbonates.

The Ap and A1 horizons have a combined thickness ranging from 8 to 10 inches, and the B2 horizon, a thickness of 6 to 14 inches. Reaction in this horizon is neutral to mildly alkaline. The B2 horizon ranges from moderate to strong in structure, and clay films and shiny surfaces are common on the peds. In places a few mottles occur in the lower part of the B horizon. The content of clay in the B horizon ranges from about 30 to 35 percent. Depth to free lime ranges from 16 to 26 inches. In areas where the profile contains nearly the maximum content of clay, tongues of dark-colored material extend from the A horizon into the B horizon in some places. In some places the B horizon is weakly calcareous in the lower part.

Aastad soils are better drained and have a browner subsoil than the Flom soils. They are slightly thicker and are not so well drained as the Forman soils. They contain more clay and have stronger structure than the Svea soils.

Aastad clay loam, 0 to 2 percent slopes (AaA).—This is the only Aastad soil mapped in the county. It is adjacent to the well-drained Forman soils and the moderately well drained, calcareous Hamerly soils. Runoff is medium to slow.

Included with this soil in mapping are small areas of Forman and Hamerly soils and a few gently sloping areas that have better surface drainage. Also included are small areas of poorly drained Flom soils. In a few other areas are soils that are thinner than this soil but have thick, noncalcareous surface and subsurface layers and a calcareous subsoil. In a few other areas near the Pomme de

[1] Italic numbers in parentheses refer to Literature Cited, p. 86.

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

Soil	Acres	Percent
Aastad clay loam, 0 to 2 percent slopes	4, 391	1. 2
Alluvial land, frequently flooded	1, 729	. 5
Arveson fine sandy loam	471	. 1
Barnes loam, 0 to 2 percent slopes	2, 853	. 8
Barnes loam, 2 to 6 percent slopes	6, 324	1. 7
Barnes-Buse loams, 2 to 6 percent slopes, eroded	6, 811	1. 9
Barnes-Buse loams, 6 to 12 percent slopes, eroded	7, 884	2. 2
Bearden silt loam, 0 to 2 percent slopes	11, 127	3. 0
Biscay silty clay loam	691	. 2
Biscay silty clay loam, depressional	140	[1]
Blue Earth silt loam	2, 575	. 7
Borup silt loam	937	. 3
Buse loam, 18 to 35 percent slopes	1, 153	. 3
Buse-Barnes loams, 12 to 18 percent slopes, eroded	3, 685	1. 0
Buse-Forman complex, 12 to 18 percent slopes	2, 347	. 6
Colvin silty clay loam	3, 310	. 9
Colvin silty clay loam, depressional	625	. 2
Colvin-Borup complex	995	. 3
Darnen loam, 0 to 4 percent slopes	1, 618	. 4
Doland silt loam, 0 to 2 percent slopes	11, 580	3. 2
Doland silt loam, 2 to 6 percent slopes	8, 035	2. 2
Dovray clay, poorly drained	4, 368	1. 2
Dovray clay, very poorly drained	3, 603	1. 0
Eckman very fine sandy loam, 1 to 4 percent slopes	216	. 1
Estelline silt loam, 0 to 2 percent slopes	598	. 2
Fordville loam, 0 to 2 percent slopes	737	. 2
Forman clay loam, 0 to 2 percent slopes	12, 785	3. 5
Forman clay loam, 2 to 6 percent slopes	6, 447	1. 8
Forman clay loam, 2 to 6 percent slopes, eroded	11, 489	3. 1
Forman-Buse complex, 2 to 6 percent slopes, eroded	3, 694	1. 0
Forman-Buse complex, 6 to 12 percent slopes, eroded	7, 052	1. 9
Glyndon silt loam, 0 to 2 percent slopes	4, 000	1. 1
Glyndon very fine sandy loam, 0 to 2 percent slopes	217	. 1
Glyndon-McIntosh complex, 0 to 2 percent slopes	4, 686	1. 3
Grimstad-Rockwell fine sandy loams	1, 096	. 3
Hamerly clay loam, 0 to 3 percent slopes	57, 649	16. 0
Hattie clay, 6 to 12 percent slopes, eroded	1, 951	. 5
Hattie clay, 12 to 18 percent slopes, eroded	778	. 2
Hattie-Nutley clays, 2 to 6 percent slopes	9, 679	2. 6
Hegne clay	1, 002	. 3
Hidewood silty clay loam	2, 114	. 6
Lamoure silty clay loam	1, 192	. 3
Lamoure silty clay loam, frequently flooded	810	. 2
La Prairie loam	228	. 1
Maddock sandy loam, 0 to 4 percent slopes	813	. 2
Malachy sandy loam, 0 to 2 percent slopes	1, 090	. 3
Malachy fine sandy loam, loamy subsoil variant	223	. 1
Marsh	5, 919	1. 6
Marysland sandy loam	1, 196	. 3
McIntosh silt loam, 0 to 3 percent slopes	35, 551	9. 7
Muck and peat, calcareous	426	. 1
Muck and peat, calcareous, flooded	130	[1]
Muck, shallow	978	. 3
Nutley-Hattie clays, 0 to 2 percent slopes	20, 421	5. 6
Nutley clay, silty substratum, 0 to 2 percent slopes	875	. 2
Oldham silty clay loam	3, 767	1. 0
Parnell silty clay loam	16, 374	4. 5
Parnell and Flom soils	15, 979	4. 4
Rauville silty clay loam	245	. 1
Renshaw loam, 0 to 2 percent slopes	4, 720	1. 3
Renshaw loam, 2 to 6 percent slopes	859	. 2
Rothsay silt loam, 0 to 2 percent slopes	145	[1]
Rothsay-Zell silt loams, 2 to 6 percent slopes	91	[1]
Sandy lake beaches	974	. 3
Sioux gravelly sandy loam, 2 to 12 percent slopes	1, 254	. 3
Sioux sandy loam, 0 to 2 percent slopes	3, 510	1. 0
Sioux sandy loam, 2 to 6 percent slopes	2, 075	. 6
Svea loam, 0 to 2 percent slopes	3, 721	1. 0
Sverdrup sandy loam, 0 to 2 percent slopes	508	. 1
Sverdrup sandy loam, 2 to 6 percent slopes	150	[1]
Tara silt loam, 0 to 2 percent slopes	8, 700	2. 4
Tonka loam	1, 814	. 5
Vallers silty clay loam	10, 906	3. 0
Winger silty clay loam	5, 714	1. 6
Total	364, 800	100. 0

[1] Less than 0.05 percent.

Terre River, the soil has a very thin surface layer of silt loam. In many other included areas the content of clay in the subsoil is about 35 to 38 percent. Still other included areas are somewhat poorly drained.

Aastad clay loam, 0 to 2 percent slopes, is well suited to all crops grown in the county. Capability unit I-1; windbreak group 1.

Alluvial Land, Frequently Flooded

Alluvial land, frequently flooded (0 to 1 percent slopes) (Af) is nearly level and occupies areas next to the Pomme de Terre and Chippewa Rivers. It is made up of calcareous material laid down recently by streams. The soil material is subject to change because the areas are flooded frequently. It has been in place long enough, however, for trees and other plants to grow. The deposits are too recent for a soil profile to have developed, but the material is mottled in some places.

The soil material is black to very dark gray in the upper part, but as depth increases it becomes gray or olive gray mottled with greenish gray. It is stratified and varies greatly in texture. In many areas snail shells occur throughout the soil material, and here the material is calcareous.

This land type occupies low-lying areas, and the water table usually is at a depth of 1 to 2 feet during much of the growing season. The areas generally are only about 3 feet above the stream channels. Drainage therefore is impractical. This land type is flooded during spring thaws and after heavy rains during the growing season. Turfy hummocks, formed by frost action, occur in some areas.

Because flooding is a hazard and drainage is impractical, Alluvial land, frequently flooded, is not suitable for cultivation. It is well suited to pasture, woodland, and wildlife. Capability unit VIw-1; windbreak group 7.

Arveson Series

Arveson soils are nearly level, poorly drained and very poorly drained, and calcareous. They occupy low areas in the northwestern part of the county.

In a typical profile the surface layer is black, calcareous fine sandy loam about 12 inches thick. Below is very dark gray, strongly calcareous fine sandy loam about 6 inches thick. This is underlain by light olive-brown to light yellowish-brown, mottled fine sandy loam. Pale-olive, calcareous, loose fine sand is at a depth of about 24 inches.

These soils have a high water table that restricts depth to which roots can penetrate. Available water capacity is low. The content of organic matter in the surface layer is high. Supplies of available phosphorus and potassium generally are low. The soils generally are free of cobblestones and other stones.

Because of the high water table, crops can be grown on these soils only in years when rainfall is less than normal for the area. Drainage is needed for continuous growth of crops. Many areas have been drained and are now used for cultivated crops. Undrained areas are used chiefly for pasture.

Typical profile of Arveson fine sandy loam (NE¼NE¼SE¼ sec. 27, T. 126 N., R. 44 W.):

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

A11—8 to 12 inches, black (10YR 2/1) fine sandy loam; weak, very fine, granular structure; friable when moist; calcareous; abrupt, smooth boundary.

A12ca—12 to 18 inches, very dark gray (10YR 3/1) fine sandy loam that contains a few spots of dark gray (10YR 4/1); weak, very fine, granular structure; very friable when moist; a few threads of lime; strongly calcareous; clear, smooth boundary.

C1ca—18 to 24 inches, light olive-brown (2.5Y 5/4) to light yellowish-brown (2.5Y 6/4) fine sandy loam; many, coarse, faint, grayish-brown (2.5Y 5/2) mottles; weak, very fine, granular structure; very friable when moist; strongly calcareous; gradual, smooth boundary.

IIC2—24 to 48 inches, pale-olive (5Y 6/3 to 6/4) fine sand; many, fine, faint, light olive-gray mottles and many, fine, distinct, light olive-brown mottles; single grain (structureless); loose when moist; calcareous.

The Ap and A11 horizons have a combined thickness ranging from 6 to 14 inches, and the A12ca horizon, a thickness of 4 to 12 inches. In some places the Ap horizon is loam, but as depth increases, it grades abruptly to sandy loam. Depth to underlying sand ranges from 20 to 36 inches. Arveson soils in Stevens County are not so strongly gleyed as in other areas.

The Arveson soils have more sand and less silt in the upper part of the profile than the Borup soils.

Arveson fine sandy loam (0 to 1 percent slopes) (Ar).—This is the only Arveson soil mapped in this county. It occupies slightly concave, low-lying flats adjacent to higher areas of moderately well drained Glyndon soils. The areas are irregular in shape and seldom are larger than 10 acres.

Included with this soil in mapping in the lowest part of some concave areas are small areas of soil that is leached of lime to a depth of about 40 inches. Also included are small areas of Borup soil. A few other areas have a surface layer of loamy fine sand. Still other included areas are somewhat poorly drained.

Water moves moderately rapidly through Arveson fine sandy loam. The water table generally is within a few inches of the surface early in spring, but by midsummer it is at a depth of 3 to 4 feet or more. The soil is easy to work. If it is drained, this soil is suited to all of the cultivated crops commonly grown in the county. In areas that are plowed in fall, soil blowing is a slight hazard in winter and early in spring. Excess lime in the surface and subsurface layers causes an imbalance of plant nutrients that can be corrected by adding phosphorus, potassium, and possibly iron or zinc. Capability unit IIIw-4; windbreak group 5.

Barnes Series

Deep, nearly level to rolling, well-drained soils are in the Barnes series. These soils are in the uplands on glacial till moraines. Most areas are in the eastern part of the county.

In a typical profile (fig. 7) the surface layer is black loam that is neutral in reaction and is about 8 inches thick. Below is dark yellowish-brown to dark-brown, friable loam that is neutral to mildly alkaline and is about 8 inches thick. The underlying material is light brownish-gray to light olive-brown, friable, strongly calcareous and calcareous loam. Small calcareous pebbles are in the upper part of the substratum.

Permeability is moderate in these soils, and available water capacity is high. Root penetration is deep. The supply of plant nutrients is favorable for growth of most crops, though additions of phosphorus and nitrogen are needed for best growth. The soils contain few stones and boulders and are in good tilth. They are friable and fertile and are easy to till.

Barnes soils are well suited to all crops commonly grown in the county. Most areas are cultivated.

Typical profile of a Barnes loam (NE¼SW¼SW¼ sec. 23, T. 125 N., R. 41 W.):

Ap—0 to 8 inches, black (10YR 2/1) loam; cloddy, but tends toward weak, fine and very fine, granular structure; friable when moist; contains a few spots of material from the B horizon that has been mixed with this layer by plowing; neutral; abrupt, smooth boundary.

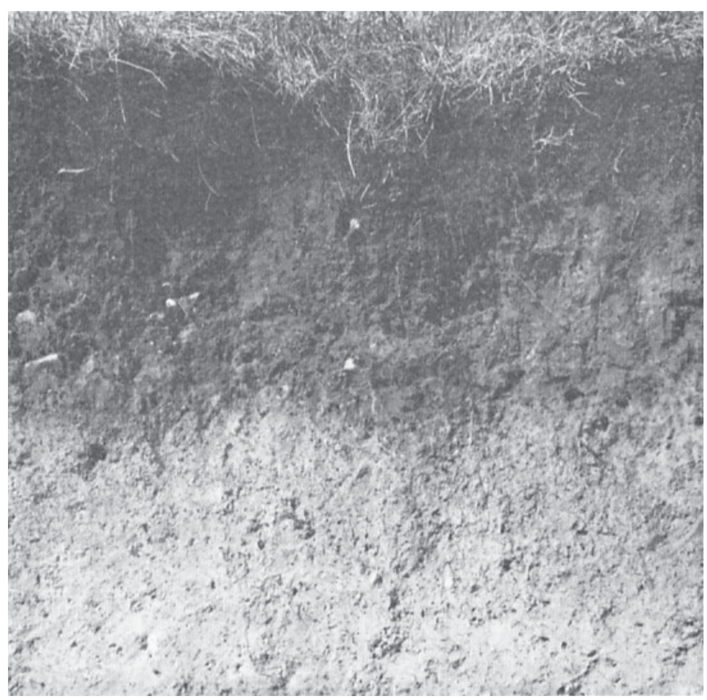

Figure 7.—Typical profile of a Barnes loam.

B2—8 to 16 inches, dark yellowish-brown (10YR 3/4) to dark-brown (10YR 3/3) loam that with increasing depth grades to dark yellowish brown (10YR 4/4 to 3/4); weak, medium and coarse, prismatic structure that breaks to weak, medium and fine, subangular blocky; friable when moist; neutral to mildly alkaline; abrupt, wavy boundary.

C1ca—16 to 31 inches, light brownish-gray (2.5Y 6/2) to light yellowish-brown (2.5Y 6/4) loam; massive (structureless); friable when moist; strongly calcareous; clear, wavy boundary.

C2—31 to 60 inches, light olive-brown (2.5Y 5/4 to 5/6) loam; common, fine, prominent, gray (10YR 5/1) and yellowish-brown (10YR 5/8) mottles; massive (structureless); friable when moist; calcareous.

The A horizon and the B2 horizon each ranges from 6 to 12 inches in thickness. Structure of the B horizon is weak to moderate, and in places the peds have a few, thin, patchy clay films on their surface. The amount of clay in the B horizon ranges from 18 to 26 percent. Depth to the C horizon or to free lime ranges from 12 to 24 inches. In most places the glacial till is mottled at a depth between 2½ and 4 feet.

Barnes soils have weaker structure than Forman soils and contain less clay but more sand.

Barnes loam, 0 to 2 percent slopes (BaA).—This soil is in slightly convex areas on ground moraines. The areas are irregular in shape and are mainly east of the Pomme de Terre River. Many of the areas adjoin nearly level, moderately well drained Hamerly and Svea soils. Other areas adjoin Doland soils, which formed in a thin capping of silt, and Barnes and Buse soils, which have stronger slopes. Runoff on this Barnes soil provides adequate surface drainage, but it is not so rapid as to cause erosion. In a few areas dark-brown to dark yellowish-brown material from the subsoil has been mixed with the surface layer by plowing. In these places the soil has a brownish cast, unlike the soil described as typical for the series, which appears black just after plowing.

Included with this soil in mapping are small areas of Doland and Svea soils. Other included areas consist of soil that is sandier in the lower part of the profile than this soil because it overlies glacial till that contains strata of coarser texture.

This Barnes soil is used mainly for such cultivated crops as corn and small grains. Growth of crops is somewhat restricted by lack of moisture, but crops grow moderately well to well. Practices that conserve moisture or make more effective use of the moisture available are needed. Soil blowing is a slight hazard in winter and early in spring, and protection from strong winds is needed. Capability unit I-1; windbreak group 1.

Barnes loam, 2 to 6 percent slopes (BaB).—This soil has the profile described as typical for the series. Slopes range from 50 to 200 feet in length. They are fairly uniform and slope in one direction in some places, but they are undulating and slope in several directions in other places. In the middle part of the slope, the soil profile is like that described as typical for the series, but near the top of the slope it is thinner in places. Near the bottom of the slope, the soil is thicker than typical and grades to wetter soils.

Included with this soil in mapping are small areas of Doland silt loams. Also included are small areas of nearly level and steep soils. Other small areas consist of soils that are sandier than this soil because they overlie glacial till that contains spots of coarser textured material.

Runoff is medium on this soil, and the hazard of erosion is moderate if the soil is left unprotected. Most areas are cultivated. The soil is well suited to all crops commonly grown in the county. Corn, soybeans, and small grains are among the chief crops. Maintaining and improving soil fertility and structure and controlling runoff are the chief concerns of management. Capability unit IIe-1; windbreak group 1.

Barnes-Buse loams, 2 to 6 percent slopes, eroded (BbB2).—Most areas of this complex are east of the Pomme de Terre River on a loamy ground moraine. Differences in elevation range from 20 to 40 feet. The soils are moderately eroded and have a lighter colored surface layer than that in the profile described as typical for their respective series. The darker colored, brownish areas on the least convex part of the slope are noncalcareous Barnes soil. The grayish areas on the most convex part of the slope are calcareous Buse soil, surrounded by Barnes soil. The Barnes soil makes up 60 to 70 percent of each mapped area. The remainder is mainly Buse soil. Most areas of this complex are undulating, and the slopes extend in several directions. A few areas have fairly uniform slopes that slope in only one direction. The uniform slopes generally are the longest; they range from 100 to 250 feet in length.

Many areas of this complex adjoin nearly level Doland and Tara soils that formed in a thin mantle of silty material. Other areas adjoin the nearly level, moderately well drained Hamerly and Svea soils. Small areas of all of these soils are included with this complex in mapping. Also included are small areas of more sloping soils and of nearly level soils.

Most areas of this complex are used for the cultivated crops that commonly are grown in the county. Crops generally grow better on the Barnes soil than on the Buse soil because the Buse soil is naturally lower in fertility. Runoff is medium on both soils. The hazard of further erosion is moderate, and especially if clean-tilled crops are grown. Practices are needed that improve fertility and soil structure and that control further erosion.

Most crops on these soils respond if fertilizer that contains nitrogen and phosphorus is added. Crops on the Buse soil may also need additions of minor plant nutrients. Capability unit IIe-1; windbreak group 1.

Barnes-Buse loams, 6 to 12 percent slopes, eroded (BbC2).—This complex occupies rolling uplands, chiefly in the eastern one-third of the county. The darker colored, brownish areas are noncalcareous Barnes soil, and the grayish areas on the upper part of the slope are calcareous Buse soil (fig. 8). Barnes soil makes up 40 to 50 percent of each mapped area. The remainder is mainly Buse soil. In many areas the soils of this complex have irregular slopes that extend in several directions. Slopes generally range from 150 to 250 feet in length. The top part of the slope generally adjoins nearly level or gently sloping Barnes soils. Near the foot of the slope the soils are near wet Flom, Parnell, and Vallers soils.

The Barnes soil adjacent to the Buse soil is thinner than that in the profile described as typical for the series. Much of the original surface layer of both of these soils has been washed away. The present surface layer consists of about equal parts of lighter colored material, formerly in the subsoil, that has been mixed with the darker colored remaining surface soil by plowing. The soils in

Figure 8.—**Typical landscape of Barnes-Buse loams, 6 to 12 percent slopes, eroded. The darker colored areas are Barnes soil, and the lighter colored areas are Buse soil.**

eroded areas on the upper part of the hillsides are thinner than those near the foot of the hills.

Included with this complex in mapping are a few small areas that are less eroded than this soil, and a few that are more eroded. Also included are small areas of soils that are sandier than this soil because they overlie coarser textured glacial till. A few other small areas have a silty surface layer and subsoil.

Corn, small grains, soybeans, grasses, and legumes are grown on nearly all areas of this complex. Crops generally grow better on the Barnes soil than on the Buse soil because the Buse soil is naturally lower in fertility. Runoff is rapid on both soils, and the soils are slightly more droughty than gently sloping Barnes and Buse soils. If these soils are used intensively, more careful management is needed than that used on surrounding nearly level to gently sloping soils. Particularly needed are practices that improve fertility and soil structure and that control further erosion.

Most crops on these soils respond if fertilizer that contains nitrogen and phosphorus is added. Capability unit IIIe-1; windbreak group 1.

Bearden Series

Bearden soils are nearly level, somewhat poorly drained, and calcareous. These soils formed on silty sediment more than 3½ feet thick. They are in the northwestern part of the county.

In a typical profile the surface layer is black, calcareous silt loam about 8 inches thick. Just below is black to very dark gray silt loam that is strongly calcareous and is about 6 inches thick. The underlying material is grayish-brown, strongly calcareous silt loam in the upper part. The lower part is mottled olive-brown to light olive-brown, calcareous silt loam.

Permeability of these soils is moderate. Available water capacity is high. The high content of lime in the upper part of the profile reduces the availability of phosphorus and some other plant nutrients. The content of organic matter in the surface layer generally is high. Bearden soils are friable and have good workability. They are free of stones or boulders that would interfere with tillage.

Nearly all areas of these soils are cultivated. The soils are well suited to all crops commonly grown. Small grains, however, generally grow better on these calcareous soils than soybeans or alfalfa.

Typical profile of Bearden silt loam, 0 to 2 percent slopes (SW¼SE¼SE¼ sec. 31, T. 126 N., R. 44 W.):

Ap—0 to 6 inches, black (10YR 2/1) silt loam; cloddy, but breaks to weak and moderate, very fine, granular structure; friable when moist; calcareous; abrupt, smooth boundary.

A11—6 to 8 inches, black (10YR 2/1) silt loam; weak and moderate, very fine and fine, granular structure; friable when moist; calcareous; clear, wavy boundary.

A12ca—8 to 14 inches, black (10YR 2/1) to very dark gray (10YR 3/1) silt loam that includes small gray (10YR 6/1) spots; weak, fine, granular structure; friable when moist; strongly calcareous; clear, irregular boundary.

C1ca—14 to 29 inches, grayish-brown (2.5Y 5/2) and light-gray (2.5Y 7/2) silt loam; massive (structureless), or weak, fine, granular structure; friable when moist; strongly calcareous; clear, wavy boundary.

C2—29 to 37 inches, olive-brown (2.5Y 4/4) to light olive-brown (2.5Y 5/4) silt loam; massive (structureless); very friable when moist; moderately calcareous to strongly calcareous; gradual, smooth boundary.

C3—37 to 50 inches, light olive-brown (2.5Y 5/4) silt loam; common, medium, faint, light brownish-gray (2.5Y 6/2) mottles and common, fine, prominent, yellowish-brown (10YR 5/8) mottles; massive (structureless); very friable when moist; calcareous.

The Ap and A11 horizons have a combined thickness ranging from 6 to 12 inches, and the A12ca horizon, a thickness of 3 to 9 inches. Many gypsum crystals are in the A12ca and C horizons. Texture of the A horizon ranges from silt loam to light silty clay loam but it is predominantly silt loam.

Bearden soils are silty throughout, unlike McIntosh soils that are underlain by loam glacial till at a depth between 24 and 30 inches. They lack the sandy substratum typical of the nearby Glyndon soils.

Bearden silt loam, 0 to 2 percent slopes (BdA).—This is the only Bearden soil mapped in the county. It occupies nearly level areas that contain many wet depressions. Runoff is medium to slow.

Included with this soil in mapping are small areas of Colvin and Hidewood soils in shallow depressions, and of very poorly drained Parnell soils in deeper depressions. These areas are shown on the detailed map by a spot symbol. Also included are small areas of Bearden soil in the southwest corner of Eldorado Township that have a texture of light silty clay loam. Along the creeks a few, small, narrow areas of this soil are noncalcareous to a depth between 18 and 24 inches. Also included are some areas that have a strongly calcareous layer near the surface and have a light-gray plow layer. A few other areas have gentle slopes.

Bearden silt loam, 0 to 2 percent slopes, is well suited to all crops commonly grown in the county. Available phosphorus generally is low to very low, but exchangeable potassium is medium to high. Tillage should be kept to a minimum. Soil blowing is a slight hazard in winter and early in spring if the soil is plowed in fall and all crop residues are turned under. Capability unit IIs-2; windbreak group 3.

Biscay Series

The Biscay series consists of nearly level, poorly drained and very poorly drained soils. These soils formed in loamy material underlain by stratified sand and gravel at a depth of less than 3½ feet. They are in shallow depressions, chiefly in river valleys and outwash areas in the southeast corner of the county.

In a typical profile the surface layer is black silt loam to silty clay loam about 20 inches thick. The subsoil is very dark gray silty clay loam in the upper part, but as depth increases it becomes olive-gray silt loam to loam. The surface layer and upper part of the subsoil are neutral in reaction. Loose, calcareous sand and gravel are at a depth of about 38 inches.

Runoff is slow to very slow on these soils. Permeability of the loamy material above the sand and gravel is moderately slow. Available water capacity is medium. Fertility generally is high. Water is within a few inches of the surface early in spring and after heavy rains early in summer. By midsummer, however, the water table generally is at a depth of more than 3½ feet. Unless the soils are drained, the depth to which roots can penetrate is limited and use of the soils is restricted. The soils generally are free of stones.

Biscay soils are well suited to all cultivated crops commonly grown in the county. Many areas have been drained and are used for cultivated crops. Undrained areas are used chiefly for pasture.

Typical profile of Biscay silty clay loam (SE¼SE¼SE¼ sec. 15, T. 123 N. R. 41 W.):

Ap—0 to 6 inches, black (N 2/0 to 10YR 2/1) silt loam to silty clay loam; cloddy, but breaks to moderate, very fine, granular structure; friable when moist; neutral; abrupt, smooth boundary.

A11—6 to 15 inches, black (N 2/0 to 10YR 2/1) silt loam to silty clay loam; moderate, very fine and fine, granular structure; friable to firm when moist; neutral; gradual, smooth boundary.

A12—15 to 20 inches, black (10YR 2/1) silt loam to silty clay loam; moderate to strong, fine, granular structure; friable to firm when moist; neutral; gradual, smooth boundary.

B2g—20 to 30 inches, very dark gray (10YR 3/1) silty clay loam; moderate and strong, fine, subangular blocky structure; firm when moist; nearly continuous clay films; neutral; clear, smooth boundary.

B3g—30 to 38 inches, olive-gray (5Y 5/2) silt loam to loam; weak, fine, subangular blocky structure; friable when moist; a few discontinuous clay films; many pores; neutral to mildly alkaline; abrupt, smooth boundary.

IIC—38 to 46 inches, multicolored, slightly calcareous sand and gravel.

The A horizon ranges from 15 to 24 inches in thickness. The soils feel gritty throughout, and in places the texture is loam or clay loam. The A and B horizons range from neutral to mildly alkaline. Depth to underlying sand and gravel ranges from about 30 to 42 inches. Biscay soils in Stevens County typically have a thicker A horizon than in other places.

The Biscay soils are wetter than the nearby Estelline and Fordville soils. They also have a thicker A horizon and a more olive colored B horizon.

Biscay silty clay loam (0 to 1 percent slopes) (Be).—This soil has the profile described for the series. It is poorly drained and occupies low areas. Water remains on the areas for about 2 weeks after spring runoff and after heavy rains in summer. The areas are chiefly on river terraces and on outwash adjacent to droughty Renshaw and Sioux soils and to well-drained Estelline and Fordville soils. A few areas are in the uplands adjacent to well-drained Barnes soils, which are on glacial till.

Included with this soil in mapping are a few areas that are more than 42 inches deep to sand and gravel. Also included are a few areas that have a slightly calcareous subsoil. In other areas the subsoil contains more clay than Biscay silty clay loam.

Many areas of this Biscay soil have been drained and are used for the crops commonly grown in the county. Undrained areas are used mainly for pasture. Crop growth on drained areas is considerably better than on the surrounding droughty soils. Removing excess water is the major problem in using this soil for crops. Installing tile drains and open drains is difficult because the underlying material tends to cave or slough. Capability unit IIw-3; windbreak group 2.

Biscay silty clay loam, depressional (0 to 1 percent slopes) (Bf).—This soil is very poorly drained. It occupies depressional areas in the southeast corner of the county adjacent to Malachy and Marysland soils. The areas range from 2 to 10 acres in size. This soil is wetter than the typical Biscay silty clay loam.

The surface and subsurface layers are black silt loam to silty clay loam 30 to 40 inches thick. They are neutral to mildly alkaline and commonly are very dark gray or dark greenish gray in the lower part. At a depth between 30 and 40 inches, the texture changes abruptly to gray, medium and coarse sand that generally is strongly calcareous.

Included with this soil in mapping are small areas that contain strata of loam or clay loam in the lower part of the profile. Also included are a few areas that are calcareous throughout.

The water table is within a few inches of the surface of this Biscay soil during the growing season. Consequently, depth to which roots can penetrate is limited. Available water capacity is medium. Water moves through the upper part of the profile at a fairly moderate rate and through the sandy substratum at a rapid rate. The content of organic matter in the surface layer is very high, and the supply of plant nutrients is high. The soils generally are free of cobblestones or of other stones that would interfere with tillage.

Wetness limits use of this soil. A few acres have been drained and are used for the crops commonly grown in the county. Undrained areas are used as pasture or as wildlife habitat. Capability unit IIIw-4; windbreak group 2.

Blue Earth Series

Blue Earth soils are nearly level, very poorly drained, and calcareous. These soils are in sloughs throughout most of the county. They formed in organic and mineral sediment in areas that once may have been shallow lakes. The vegetation consists chiefly of such plants as reeds, sedges, cattails, and marsh grasses.

In a typical profile the surface layer is black mucky silt loam about 17 inches thick. It is high in organic matter, is calcareous, and contains many snail shells. Below is black silty clay loam that contains less organic matter than the surface layer but has many snail shells.

Runoff water ponds on these soils. Permeability of the substratum is moderately slow, and available water capacity is high. The content of organic matter is high.

Many areas of Blue Earth soils are drained and are used for cultivated crops. Other areas are partly drained and provide excellent pasture. Areas undrained are not suitable for cultivated crops or for pasture.

Typical profile of Blue Earth silt loam (NW¼NE¼-NE¼ sec. 8, T. 124 N., R. 42 W.):

Ap—0 to 7 inches, black (N 2/0 to 10YR 2/1) mucky silt loam; cloddy; very friable when moist; many roots; slightly calcareous; abrupt, smooth boundary.

A11g—7 to 17 inches, black (N 2/0 to 2/1) mucky silt loam; many, fine, prominent, yellowish-red (5YR 4/8) mottles; weak, coarse, prismatic structure that breaks to weak, coarse, subangular blocky; very friable when moist; many roots; many small pockets of calcium sulfate and of calcium carbonate; calcareous; gradual, smooth boundary.

A12g—17 to 48 inches, black (N 2/0 to 10YR 2/1) silty clay loam; a few, fine, faint, olive mottles; weak, coarse, prismatic structure that breaks to moderate, fine and very fine, subangular blocky; friable when moist; a few roots; strongly calcareous; gradual, smooth boundary.

A13g—48 to 54 inches, black (N 2/0 to 10YR 2/1) silty clay loam; common, medium, prominent, olive (5Y 5/4) mottles; weak, fine and very fine, subangular blocky structure; calcareous; many snail shells occur throughout the profile.

The Ap and A11 horizons range from mucky silt loam to mucky silty clay loam in texture. They generally are 15 to 30 inches thick and are about 15 to 30 percent organic matter. The A12g and A13g horizons range from silty clay loam to silty clay in texture. The black color commonly changes gradually to very dark gray in the lower part. Conspicuous, reddish, iron oxide commonly occurs along root channels.

Blue Earth soils contain less organic material than the Muck and peat soils but more than Oldham and Parnell soils.

Blue Earth silt loam (0 to 1 percent slopes) (Bh).—This is the only Blue Earth soil mapped in the county. It is in large circular or oblong sloughs or old lakebeds scattered throughout most of the county.

Included with this soil in mapping, on the rims of areas of this soil, are small areas of wet, calcareous Oldham and Vallers soils. In some included areas the soil is clay in the lower part because it overlies clayey glacial till. In other included areas a mantle of silt overlies silt loam or light silty clay loam, and in still other areas the mucky layer is more than 40 inches thick.

Many areas of Blue Earth silt loam are undrained and have more than 1½ feet of water on them during the growing season, though in some years they are dry by midsummer. Such areas provide excellent cover for wildlife. Other areas have been drained by open ditches or tile and are used for crops or pasture. Drained areas are well suited to silage crops and to soybeans. They are not suitable for small grains for the first few years after draining, because of lodging.

Wetness is the chief factor limiting use of this soil. Soil blowing is a slight hazard in winter and early in spring if the soil is left bare. Frost comes earlier to the low areas occupied by this soil than to surrounding higher soils and damages corn and other crops that mature late. Capability unit IIIw-3; windbreak group 2.

Borup Series

Borup soils are nearly level, poorly drained, and calcareous. They formed in silty sediment underlain by very fine sand at a depth of about 1½ to 3½ feet. Most areas are in the northwestern part of the county.

In a typical profile the surface layer is black, calcareous silt loam about 12 inches thick. Just below is very dark gray, strongly calcareous and calcareous silt loam, about 9 inches thick. It is underlain by dark-gray and olive-gray, strongly calcareous silt loam that becomes mottled as depth increases. Light olive-brown, mottled loose very fine sand that is calcareous is at a depth of more than 31 inches.

These soils have so high a content of lime as to have an imbalance of plant nutrients. Permeability of the silty material is moderate, and that of the sandy substratum is moderately rapid. Available water capacity is medium. The soils generally are free of stones or boulders.

Many areas of Borup soils are drained and used for cultivated crops. Areas undrained are used mainly for pasture and hay.

Typical profile of Borup silt loam (NW¼NW¼SW¼ sec. 2, T. 125 N., R. 44 W):

Ap—0 to 6 inches, black (N 2/0 to 10YR 2/1) silt loam; cloddy, but breaks to weak, fine, granular structure; friable when moist; calcareous; abrupt, smooth boundary.

A11—6 to 12 inches, black (N 2/0 to 10YR 2/1) silt loam; weak, fine and medium, granular structure; friable when moist; calcareous; gradual, smooth boundary.

A12ca—12 to 17 inches, very dark gray (10YR 3/1) silt loam, dark gray when crushed (10YR 4/1); weak, fine and medium, granular structure; friable when moist; many pores; strongly calcareous; gradual, wavy boundary.

ACca—17 to 21 inches, very dark gray (10YR 3/1) to dark-gray (10YR 4/1) silt loam; weak, very fine, subangular blocky structure; friable when moist; many pores; calcareous; gradual, smooth boundary.

C1cag—21 to 25 inches, dark-gray (5Y 4/1) silt loam; weak, very fine, subangular blocky structure; friable when moist; many pores; strongly calcareous; gradual, smooth boundary.

C2cag—25 to 31 inches, olive-gray (5Y 5/2) silt loam that grades to olive (5Y 5/3 to 5/4) as depth increases; a few, fine, faint, olive-yellow mottles; weak, very fine, subangular blocky structure; friable when moist; many pores; strongly calcareous; gradual, smooth boundary.

IIC3—31 to 40 inches, light olive-brown (2.5 5/4 to 5/6) very fine sand; a few, fine, prominent, gray (10YR 6/2) and yellowish-red (5YR 4/8) mottles; single grain (structureless); loose when moist; calcareous; gradual, smooth boundary.

IIC4—40 to 55 inches, grayish-brown to light olive-brown (2.5Y 5/3) very fine sand; common, medium, prominent, gray (10YR 6/1) mottles and many, medium, yellowish-brown (10YR 5/3) mottles; single grain (structureless); loose when moist; calcareous.

The Ap and A11 horizons have a combined thickness of 6 to 12 inches, and the A12ca and ACca horizons, a thickness of 4 to 12 inches. In some places the A horizon is light silty clay loam. Depth to the sandy substratum ranges from 18 to 42 inches but generally is about 30 inches. Borup soils in Stevens County have a slightly thicker solum than in other places.

Borup soils have poorer drainage than Glyndon soils and have a darker colored subsurface. They contain more silt and clay than Arveson soils.

Borup silt loam (0 to 1 percent slopes) (Bm).—This is the only Borup soil mapped in the county. It occupies shallow depressions, chiefly in the northwestern part of the county. The areas generally are circular or oblong in shape. They generally are surrounded by moderately well drained Glyndon soils in higher areas.

Included with this soil in mapping are a few small areas of Glyndon soils, which have better surface drainage than this soil. Also included are some areas, in the lowest part of shallow depressions, that are leached of lime to a depth between 20 and 30 inches. A few other areas in Donnelly Township have surface and subsurface layers of heavy silty clay loam to light silty clay. In still other included areas, especially in the southeastern part of the county, the substratum consists of sand that is coarser than that in Borup silt loam. The soil in some included areas is somewhat poorly drained.

Borup silt loam remains wet for more than 2 weeks after spring runoff, and in summer it is likely to stay wet for a time after heavy rains. Drainage is needed for growing cultivated crops successfully year after year. Open ditches are preferred for draining this soil because in places the substratum flows when wet and is likely to plug tile drains. When the soil is adequately drained, it is well suited to corn, soybeans, and small grains. Capability unit IIw-3; windbreak group 5.

Buse Series

The Buse series consists of gently sloping to very steep, somewhat excessively drained soils. These soils are in the uplands on the most convex part of the slopes.

In a typical profile (fig. 9) the surface layer is black to very dark grayish-brown loam about 5 inches thick. Below is light brownish-gray to light olive-brown, loam glacial till. The profile is slightly calcareous to strongly calcareous throughout.

The available water capacity of these soils is high. Runoff is very rapid on the steep and very steep slopes, however, and makes the soil somewhat excessively drained. Permeability is moderate. Root penetration is deep. Fertility is low. In many places supplies of such plant nutrients as available phosphorus and nitrogen are low. These soils generally contain a few cobblestones and boulders.

Nearly all areas of Buse soils are used for cultivated crops. The very steep slopes generally are pastured.

Typical profile of a Buse loam (SW¼SW¼SE¼ sec. 4, T. 124 N., R. 41 W.):

***Figure 9.*—Profile of a typical Buse loam.**

A11—0 to 4 inches, black (10YR 2/1) to very dark brown (10YR 2/2) loam when moist, very dark brown (10YR 2/2) when dry; weak, fine, granular and subangular blocky structure; friable when moist; slightly calcareous; abrupt, wavy boundary.

A12—4 to 5 inches, very dark grayish-brown (10YR 3/2) loam when moist, very dark gray (10YR 3/1) when dry; weak, fine, granular and subangular blocky structure; friable when moist; calcareous; horizon is discontinuous; clear, wavy boundary.

C1ca—5 to 14 inches, light brownish-gray (10YR 6/2) to grayish-brown (10YR 5/2) loam when moist, light gray (2.5Y 7/2) when dry; massive (structureless); friable when moist; carbonates in threads and accretions; strongly calcareous; gradual, smooth boundary.

C2—14 to 24 inches, light olive-brown (2.5Y 5/4) to olive-brown (2.5Y 4/4) loam; massive (structureless); friable when moist; dispersed carbonates; calcareous; gradual, smooth boundary.

C3—24 to 42 inches, light olive-brown (2.5Y 5/4) loam; many, medium, distinct, gray (10YR 6/1) mottles; massive (structureless); friable when moist; a few, fine lenses of sandy loam in lower part; calcareous; gradual, smooth boundary.

C4—42 to 54 inches, light olive-brown (2.5Y 5/5) loam; massive (structureless); friable when moist; calcareous.

The A horizon ranges from 3 to 8 inches in thickness. The soil is nearly always calcareous throughout the profile, but in a few places it is leached to a depth of 5 inches or less. In many places in uneroded, cultivated fields, the plow layer is very dark gray because plowing has mixed some of the lighter colored underlying material with the surface soil.

Buse soils contain less clay than Hattie soils and have weaker structure. They are thinner than the nearby Barnes and Forman soils and are more alkaline. Buse soils contain less silt than Zell soils.

Buse loam, 18 to 35 percent slopes (BnE).—Most areas of this soil are along valley walls of the Pomme de Terre and Chippewa Rivers. Some areas are along deep, V-shaped natural drainageways, however, that extend back from those rivers. Differences in elevation range from 50 to 100 feet. Slopes range from 150 to 300 feet in length. In many places at the top of the slopes, the soils adjoin nearly level to gently sloping, well-drained Barnes and Forman soils. Colluvial areas occupied by moderately well drained Darnen soils are on the adjoining foot slopes.

This soil has a thinner profile than that described for the series. The soil also is more droughty because runoff is greater. On the uppermost convex part of the slope, the surface layer is only 1 to 3 inches thick.

Included with this soil in mapping are small areas of moderately well drained and poorly drained soils along the many short, narrow, incised drainageways that cut the areas. Also included are a few small areas that contain pockets of gravelly and sandy material.

Most of this Buse soil is in bluegrass pasture. Overgrazing must be avoided. Steep slopes make this soil unsuitable for cultivated crops. Keeping an adequate cover of grass on the areas and controlling erosion are the main concerns of management. Capability unit VIe-1; windbreak group 1.

Buse-Barnes loams, 12 to 18 percent slopes, eroded (BoD2).—This complex is on hilly areas in the uplands and along valley walls of rivers. The Buse soil, which is grayish in cultivated areas, is on the most convex part of the slopes and generally occupies 60 to 70 percent of the hillsides. The remainder is moderately eroded, brownish Barnes soil. The Barnes soil is thinner than the typical Barnes soil on the upper part of the slopes, and thicker in many places near the bottom of the slopes. Many areas in the uplands are along natural, prominent drainageways and around large sloughs.

Slopes range from 150 to 250 feet in length in many places. They are uniform in some places, but in other places they are cut by small, sharp drainageways. The slopes extend in only one direction in most places. In many places at the top of the slopes, this complex adjoins nearly level Barnes or Doland soils. Adjoining colluvial areas are occupied by moderately well drained Darnen soils or by wet Flom and Parnell soils.

Included with this complex in mapping are a few severely eroded areas and some areas that are slightly eroded. Also included are small areas of nearly level Barnes, Darnen, Doland, Flom, and Parnell soils. Other included small areas consist of pockets of sandy material.

Some areas of this complex are in permanent pasture, and others are in cultivated crops. Runoff is rapid on these hilly soils. As a result, the amount of moisture available for plant growth is reduced and the hazard of further erosion is severe if clean-tilled crops are grown. Corn and soybeans therefore are not so well suited to these soils as are other cultivated crops commonly grown in the county. Capability unit IVe-1; windbreak group 1.

Buse-Forman complex, 12 to 18 percent slopes (BuD).—This complex is on hilly areas in the uplands west of the Pomme de Terre River. The Buse soil, which is grayish in cultivated areas, is on the most complex part of the slopes. This soil contains more clay than the typical Buse soil. It generally occupies 60 to 70 percent of each area mapped and is surrounded by dark-colored Forman soil. The Forman soil is thinner than the typical Forman soil on the upper part of the slopes, but it is thicker on the bottom of the slopes. It occupies 30 to 40 percent of the area.

Many areas of this complex are around big sloughs and along prominent drainageways. Here slopes extend in only one direction. The slopes in the hilly areas, however, extend in several directions. Most of the hillsides have slopes that range from 150 to 250 feet in length. In many places the areas are between gently sloping and rolling areas of Buse and Forman soils. At the top of the slopes, however, the areas adjoin nearly level areas of Aastad and Forman soils in many places. Adjoining the bottom of the slopes in many places are wet Flom, Parnell, and Vallers soils.

Some areas of this complex are in bluegrass pasture. Other areas are in cultivated crops. Runoff is rapid on these hilly soils. The amount of water available for plants therefore is reduced. The hazard of erosion is severe if row crops are grown. Consequently, corn and soybeans generally are not suited to these soils. Capability unit IVe-1; windbreak group 1.

Colvin Series

In the Colvin series are nearly level, poorly drained, calcareous soils. These soils formed in silty sediment more than 3½ feet thick. They are in the northwestern part of the county.

In a typical profile the surface layer is black, calcareous silty clay loam about 10 inches thick. Just below is dark-gray, strongly calcareous silty clay loam about 13 inches thick. The underlying material consists of gray, strongly calcareous light silty clay loam over gray to light olive-brown silt loam that is mottled.

Permeability of these soils is moderately slow. The available water capacity is high. The content of organic matter in the surface layer also is high. These soils have so high a content of lime as to have an imbalance of plant nutrients. The supply of available phosphorus is low. Because of the poor drainage, the depth to which roots can penetrate is restricted. The soils generally are free of stones and boulders.

Many areas of these soils have been drained by use of tile or ditches and are used for cultivated crops. Areas undrained are used for pasture.

Typical profile of Colvin silty clay loam (SW¼NW¼NE¼ sec. 33, T. 126 N., R. 43 W.):

Ap—0 to 10 inches, black (10YR 2/1) silty clay loam; cloddy, but breaks to moderate, very fine, granular structure; friable to firm when moist; calcareous; abrupt, smooth boundary.

ACca—10 to 23 inches, dark-gray (10YR 4/1) silty clay loam that includes a few streaks of very dark gray (10YR 3/1) and spots of gray (10YR 5/1); weak to moderate, very fine to fine, granular and subangular blocky structure; friable to firm when moist; strongly calcareous; clear, irregular boundary.

C1ca—23 to 29 inches, gray (10YR 5/1) light silty clay loam; a few streaks of dark gray (10YR 4/1); weak, very fine, subangular blocky structure; friable when moist; strongly calcareous; clear, wavy boundary.

C2g—29 to 34 inches, gray (5Y 6/1) to light olive-gray (5Y 6/2) silt loam; many, fine, distinct, olive-yellow (2.5Y 6/5) mottles; massive (structureless); friable when moist; calcareous; gradual, smooth boundary.

C3g—34 to 48 inches, gray (5Y 6/1) silt loam; common, fine, distinct, light olive-brown (2.5Y 5/4) to olive-brown (2.5Y 4/6) mottles; massive (structureless); friable when moist; many pores; calcareous; gradual, smooth boundary.

C4—48 to 54 inches, light olive-brown (2.5Y 5/4) to olive-brown (2.5Y 4/4) silt loam; many, medium, distinct, gray (5Y 6/1) mottles and a few, medium, prominent, strong-brown (7.5YR 5/6) mottles; friable when moist; many pores; calcareous.

The Ap horizon and the A1 horizon, where present, have a thickness ranging from 8 to 12 inches, and the ACca horizon, a thickness of 6 to 14 inches. In some places the ACca horizon is silt loam, and in other places the profile is silty clay loam throughout. Many gypsum crystals occur in the ACca horizon in some places.

Colvin soils are wetter than Bearden soils and have a grayer subsurface. Their underlying material is more silty than that of Winger soils.

Colvin silty clay loam (0 to 1 percent slopes) (Co).—This soil has the profile described for the series. It occupies flat areas and shallow depressions adjacent to moderately well drained, higher lying Bearden soils. The flat areas are on rims around potholes of very poorly drained soils. The shallow depressions generally are a foot below surrounding higher areas. They are likely to retain water for about 2 weeks after spring runoff and after heavy rains in summer.

Included with this soil in mapping are small areas of Winger soils. Also included are areas in the lowest part of depressions that are leached of lime to a depth between 20 and 30 inches. Other included areas consist of somewhat poorly drained soils.

Wetness and the imbalance of plant nutrients are the chief factors limiting use of this soil. Many areas have been drained and are well suited to the crops commonly grown in the county. Many of the areas that are not drained lack suitable outlets. Such areas are used chiefly for pasture. Capability unit IIw-2; windbreak group 2.

Colvin silty clay loam, depressional (0 to 1 percent slopes) (Cp).—This soil is very poorly drained. It occupies oblong or circular depressional areas, chiefly in the northwestern part of the county. The depressions are deep and are about 2 to 3 feet below surrounding higher areas. Most of the depressions are 10 to 20 acres in size, but some are larger. Calcareous Colvin soils that are also poorly drained generally are on the rims of the depressions. After spring runoff or heavy rains, water does not remain as long on such areas as on other areas of these soils. Just beyond the rims, on slightly higher areas, are moderately well drained Bearden and Glyndon soils.

Included with this soil in mapping are some areas, in depressions where water remains the longest, that are noncalcareous and are leached to a depth of 30 inches or more. Also included are areas that are sandy at a depth below 30 inches. These areas generally are surrounded by areas of Glyndon-McIntosh complex, 0 to 2 percent slopes.

About 1½ feet of water is ponded on this Colvin soil during the early part of the growing season. In many years, however, the areas are dry by midsummer. Supplies of available phosphorus and other plant nutrients are low in this soil. Even when drained, this soil warms up and dries out more slowly than nearby moderately well drained soils.

Many areas of this soil have been drained and are used for all crops commonly grown in the county. Small areas generally are used and managed along with the soils that surround them. Big sloughs, lakebeds, and other large areas are used and managed separately from surrounding areas. Capability unit IIIw-3; windbreak group 2.

Colvin-Borup complex (0 to 1 percent slopes) (Cu).—This mapping unit is in Donnelly, Eldorado, and Everglade Townships. It consists of poorly drained, calcareous Colvin and Borup soils in level to slightly concave areas that are irregular in shape. The proportion of each of these soils varies from one place to another. Generally Colvin soil makes up 30 to 40 percent of each mapped area, and Borup soil, 20 to 30 percent. Most of the areas are 10 acres or less in size, but a few of them are larger. Adjoining, lower lying depressional areas are occupied by noncalcareous or leached soils, which occur in a recurring pattern with the calcareous soils.

Included with this soil in mapping are small areas of calcareous Winger soils. Also included are small areas of noncalcareous Flom and Hidewood soils. Other small areas consist of a soil that has a profile similar to that of Hidewood soils but is underlain by sand at a depth of about 36 inches. Small areas of calcareous Arveson and Rockwell soils also are included.

Runoff is very slow on areas of this complex, and water stands in ponds for a short time after heavy rains. Areas undrained generally are poorly suited to crops, though a few areas can be cropped successfully. If drainage is provided, the soils are suited to all of the crops commonly grown in the county.

The calcareous Colvin and Borup soils have so much lime near the surface as to cause a slight imbalance of plant nutrients. Fertility of the included noncalcareous soils is naturally higher. In addition to providing drainage, practices are needed that maintain or improve fertility and soil structure. Capability unit IIw-2; windbreak group 5.

Darnen Series

Darnen soils are deep, nearly level to gently sloping, and moderately well drained to well drained. These soils formed in material deposited at the foot of steep slopes. They occur chiefly along river valley walls, but some areas are in the uplands.

In a typical profile the surface layer is black loam that is about 24 inches thick and is neutral in reaction. Below is about 18 inches of black to very dark grayish-brown, friable loam that is neutral to moderately alkaline; about 7 inches of grayish-brown to light olive-brown loam that is moderately alkaline; and then a buried soil that has many features like those of the surface layer.

The surface layer is high in organic matter. It is moderately permeable and absorbs water readily. The surface layer and subsoil are neutral to mildly alkaline. They are naturally high in fertility, generally are free of stones and boulders, and are easy to work.

Darnen soils are well suited to all cultivated crops commonly grown in the county. They are used both for cultivated crops and for pasture.

Typical profile of Darnen loam, 0 to 4 percent slopes (NW¼NE¼NW¼ sec. 19, T. 125 N., R. 41 W.):

A1—0 to 24 inches, black (10YR 2/1) loam; weak, very fine, granular structure; friable when moist; neutral; gradual, smooth boundary.

B1—24 to 34 inches, black (10YR 2/1) and very dark brown (10YR 2/2) loam, (10YR 2/1 to 3/1) when crushed; weak, medium, prismatic structure that breaks to weak, very fine, subangular blocky; friable when moist; neutral; gradual, wavy boundary.

B2—34 to 42 inches, very dark grayish-brown (10YR 3/2) loam that as depth increases grades to dark grayish brown (10YR 4/2); weak, medium, prismatic structure that breaks to weak, very fine, subangular blocky; friable when moist; slightly calcareous; gradual, wavy boundary.

Cca—42 to 49 inches, grayish-brown (2.5Y 5/2) to light olive-brown (2.5Y 5/4) loam; massive to weak, very fine, subangular blocky structure; friable when moist; strongly calcareous; gradual, smooth boundary.

IIB21b—49 to 61 inches, very dark brown (10YR 2/2 to 2/3) heavy silt loam; weak, medium, prismatic structure that breaks to weak and moderate, fine, subangular blocky; patchy clay films; friable when moist; calcareous; clear, wavy boundary.

IIB22b—61 to 72 inches, very dark grayish-brown (10YR 3/2) to dark grayish-brown (10YR 4/2) silt loam; weak to moderate, fine, subangular blocky structure; friable when moist; calcareous; clear, smooth boundary.

IICca—72 to 80 inches, dark grayish-brown (2.5Y 4/2) to olive-brown (2.5Y 4/4) silt loam; massive (structureless); friable when moist; strongly calcareous.

The A horizon has a thickness ranging from about 15 to 30 inches, and the combined B1 and B2 horizons, a thickness of 12 to 24 inches. The A horizon ranges from silt loam to loam, and the underlying material, from loam to clay loam. Thin sandy lenses occur in some places. Lime is leached to a depth between 30 and 42 inches.

Darnen soils are thicker than Svea soils. They lack the gray and mottled subsoil typical of Flom soils.

Darnen loam, 0 to 4 percent slopes (DaB).—This is the only Darnen soil mapped in the county. It occupies long narrow areas. Slopes are short and concave. Along the river valley walls, the areas are below steep Buse soils and adjacent to droughty Renshaw and Sioux soils on low terraces. A few areas are in the uplands above poorly drained Flom, Parnell, and Vallers soils. At the outlets of upland drainageways on alluvial fans are small sandy areas that are considerably stratified in places.

Because of the shape of its slopes, this soil does not erode readily. Limitations in use are few. About half the acreage is in permanent pasture, because the areas are not readily accessible or are too small to cultivate separately. Larger areas or small areas that are surrounded by arable soils are used for the cultivated crops commonly grown in the county, to which they are well suited. Capability unit I-1; windbreak group 1.

Doland Series

In the Doland series are nearly level to gently sloping, well-drained soils. These soils formed in silt underlain by glacial till at a moderately shallow depth. They are in the eastern one-third of the county.

The surface layer in a typical profile is black to very dark brown silt loam about 10 inches thick. Below is about 11 inches of dark-brown and dark yellowish-brown silt loam; about 3 inches of olive-brown to light olive-brown loam; and then the grayish-brown to light yellowish-brown, moderately alkaline loam glacial till. The material is friable throughout.

These soils are neutral to mildly alkaline. They are moderately permeable to plant roots, air, and moisture. The content of organic matter in the surface layer is medium to high. Supplies of plant nutrients and available water are fairly high. The surface layer generally is free of cobblestones, though in places a few cobblestones occur in the profile. The soils are easy to work. Only minimum tillage is needed for preparing a good seedbed.

Nearly all areas of these soils are used for cultivated crops.

Typical profile of Doland silt loam, 0 to 2 percent slopes (SE¼SE¼NE¼ sec. 22, T. 123 N.. R. 42 W.):

Ap—0 to 10 inches, black (10YR 2/1) to very dark brown (10YR 2/2) silt loam; weak, very fine, granular structure; friable when moist; neutral; abrupt, smooth boundary.

B21—10 to 16 inches, dark-brown (10YR 3/3) silt loam; ped exteriors are very dark grayish brown (10YR 3/2) and interiors are dark brown (10YR 3/3) to dark yellowish brown (10YR 3/4); weak, medium, prismatic structure that breaks to weak, very fine, subangular blocky; friable when moist; neutral; gradual, wavy boundary.

B22—16 to 21 inches, dark yellowish-brown (10YR 4/4) silt loam; weak, medium, prismatic structure that breaks to moderate, very fine, subangular blocky; friable when moist; neutral; abrupt, smooth boundary.

IIB3ca—21 to 24 inches, olive-brown (2.5Y 4/4) to light olive-brown (2.5Y 5/4) loam; weak, very fine, subangular blocky structure; friable when moist; calcareous; abrupt, smooth boundary.

IIC1ca—24 to 28 inches, grayish-brown (2.5 5/2) heavy loam, light olive brown (2.5Y 5/2 to 5/4) when crushed; massive (structureless) to weak, very fine, subangular blocky structure; friable when moist; spots of lime accretions; strongly calcareous; diffuse, smooth boundary.

IIC2—28 to 54 inches, light olive-brown (2.5Y 5/4) to light yellowish-brown (2.5Y 6/4) heavy loam; a few, fine, prominent, reddish and grayish mottles; massive (structureless) to weak, very fine, subangular blocky structure; friable when moist; a few iron and manganese concretions; calcareous.

The A horizon and the B2 horizon each range from 6 to 12 inches in thickness. Thickness of the silty material varies considerably within a short distance because the surface of the underlying till is irregular. On the average the silt ranges from 16 to 30 inches in thickness, but pockets of thicker silt are common. Where the capping of silt is thin, part of the subsoil may have formed in loam glacial till. The surface layer generally contains more clay than the subsoil. The surface layer and subsoil generally are 55 to 65 percent silt. In many places a discontinuous band of pebbles occurs between the silt and the till. Depth to lime ranges from 18 to 28 inches.

Doland soils are better drained than Tara soils and have a browner subsoil. They have more silt in the surface soil and subsoil than Barnes soils.

Doland silt loam, 0 to 2 percent slopes (DlA).—This soil has the profile described for the series. It is on slightly rounded areas adjacent to level areas of moderately well drained McIntosh and Tara soils and sloping areas of Doland and Barnes soils. The areas are irregular in shape and are mostly east of the Pomme de Terre River. This soil absorbs moisture readily, and runoff is slight.

Included with this soil in mapping are small areas that have a very thin silt cap or lack a silt cap. Also included are pockets of silt that are more than 3½ feet deep. In other small areas, the subsoil is brown and is slightly calcareous. A few slightly eroded areas also are included.

This Doland soil is well suited to all cultivated crops commonly grown in the county, and nearly all areas are cultivated. Growth of crops is limited by lack of plant nutrients in some places, but it is limited by lack of moisture in most places. Practices are needed that conserve moisture or that make more effective use of the moisture available. The hazard of soil blowing is slight; it can be controlled by protecting the soils from strong winds in winter and early in spring. Capability unit I-1; windbreak group 1.

Doland silt loam, 2 to 6 percent slopes (DlB).—This soil occupies undulating areas. Slopes range from 100 to 200 feet in length. The areas adjoin nearly level Doland soils. In many places at the foot of the slopes, are low-lying swales of wet Hidewood soils. The profile of this soil is thinner than that of the profile described as typical for the Doland series in some places on the most convex part of the slopes. It is thicker, however, on the lower part of the slopes.

Included with this soil in mapping are small areas of Barnes and Buse loams that have a very thin capping of silt or lack a silt cap. Other included areas, on the lower part of the slopes, consist of less well-drained Tara soil.

Most areas of this Doland soil are used for the crops commonly grown in the county. Runoff is greater than on the nearly level Doland soil. It causes moderate erosion and reduces the amount of moisture available for crops. Practices are needed that control runoff and maintain fertility and soil structure. Capability unit IIe-1; windbreak group 1.

Dovray Series

The Dovray series consists of poorly drained and very poorly drained soils in deep sloughs or potholes and in shallow slightly depressional areas. These soils formed in clayey material that washed onto the areas from surrounding higher areas. Most areas are in the southwestern part of the county. The native vegetation was chiefly tall prairie grasses, marsh grasses, sedges, and cattails.

In a typical profile the surface and subsurface layers consist of black, neutral heavy silty clay to clay that is sticky when wet and about 34 inches thick. Below is black to very dark gray, mottled clay that also is sticky when wet. This layer is neutral to mildly alkaline.

Runoff is very slow to ponded on these neutral to mildly alkaline soils. Internal drainage is very slow. The available water capacity is high. Water moves very slowly through these clayey soils. The supply of plant nutrients is adequate, and the soils are fertile. Content of organic matter generally is high. Because of a high water table, the root zone is shallow unless drainage is provided. Even when drained, these soils generally are somewhat wetter and colder early in spring than naturally well-drained soils. Dovray soils are very sticky when wet. If they are plowed when wet, the surface becomes puddled. Then when they dry out, the clods become hard and are difficult to break. Consequently, preparing a seedbed in these soils is difficult.

Many areas of these soils are drained and used for cultivated crops. Areas undrained provide excellent cover for wildlife.

Typical profile of Dovray clay, very poorly drained (SE¼NE¼NE¼ sec. 14, T. 123 N., R. 43 W.):

Ap—0 to 7 inches, black (N 2/0) heavy silty clay to clay; cloddy; firm when moist; sticky when wet; neutral; abrupt, smooth boundary.

A11g—7 to 15 inches, black (N 2/0) clay; moderate, fine and very fine, subangular blocky structure; firm when moist, sticky when wet; neutral; gradual, smooth boundary.

A12g—15 to 34 inches, black (N 2/0 to 5Y 2/1) clay; strong, fine and very fine, subangular blocky structure; firm when moist, sticky when wet; neutral; gradual, smooth boundary.

A13g—34 to 66 inches, black (5Y 2/1) to very dark gray (5Y 3/1) clay; common, medium, faint, dark olive-gray (5Y 3/2) mottles; moderate, very fine, subangular blocky structure; sticky when wet; neutral to mildly alkaline.

A layer that contains accumulated lime that has been leached from the overlying layers generally is at a depth of about 50 inches. Depth to this layer varies from one pothole to another, but it commonly is between 42 and 60 inches. In some potholes the surface soil is mucky silty clay loam about 12 inches thick. The thickness of the black colored material generally is about 34 inches, but it ranges from 26 to 46 inches.

Dovray soils are more clayey than Parnell soils. They are leached of lime to a greater depth than Hegne soils.

Dovray clay, poorly drained (0 to 1 percent slopes) (Do).—This soil is in shallow depressions and nearly level areas. Nearby are nearly level to steep, moderately well drained, clayey Hattie and Nutley soils and poorly drained, calcareous Hegne soils. In the deeper potholes are very poorly drained, ponded Dovray soils. Runoff is very slow.

This soil has a somewhat thinner profile than that of the typical profile described for the series. The black and very dark gray layers have a combined thickness of 26 to 40 inches, but they generally are about 33 inches thick. Just below is olive-gray clay. The soil is leached of lime to a depth between 26 and 40 inches. The subsoil commonly has strong prismatic structure.

Included with this soil in mapping are small areas of Hegne and Tonka soils. Also included are a few areas, in the old lake basin around Drywood Lake in the southern part of Synnes Township, that are underlain by silty material at a depth between 30 and 42 inches. In other small areas, particularly in the southwestern part of Eldorado Township, the soil is thinner than this soil and is calcareous at a shallower depth. Still other included areas have a more clayey subsoil than this soil. The soil in these places is similar to Tonka soils but lacks a gray subsurface.

Water is likely to remain on this soil for 2 weeks after spring runoff and after heavy rains during the growing season. Drainage is needed for good growth of crops, and all crops commonly grown in the county are well suited if the soil is drained. Also needed are practices that maintain or improve soil fertility and tilth. Capability unit IIw-1; windbreak group 2.

Dovray clay, very poorly drained (0 to 1 percent slopes) (Dv).—This soil has the profile described for the series. It occupies sloughs or potholes that are circular or oblong in shape and are the lowest areas on the landscape.

Included with this soil in mapping are nearly level to steep, moderately well drained, clayey Hattie and Nutley soils, which occur in a complex pattern. Also included are small areas of poorly drained Dovray and Hegne soils in shallow depressions and on flats. Other small areas consist of Dovray soil, in an old lake basin in the southern part of Synnes Township, underlain by silty material at a depth between about 30 and 42 inches.

Dovray clay, very poorly drained, receives runoff from surrounding higher areas and has little or no surface drainage. As much as 1½ feet or more of water is ponded on the surface in the early part of the growing season, but by midsummer the areas may be dry. If this soil is left undrained, it can be cropped only during extremely dry years. Such areas, however, provide excellent food and cover for wildlife.

Drained areas of this soil generally are cropped the same as surrounding soils, particularly the small areas. Some of the larger areas are farmed separately to such crops as feed grains, grasses, and legumes. The soil is fertile, and small grains grown on it tend to lodge because of rank growth. Other than providing drainage, the main concerns of management are maintaining soil fertility and tilth. Capability unit IIIw-1; windbreak group 2.

Eckman Series

Eckman soils are nearly level to gently sloping and well drained. They are in the northwestern part of the county.

In a typical profile the surface layer is black, neutral very fine sandy loam about 11 inches thick. Below is about 4 inches of very dark brown very fine sandy loam. The subsoil is dark-brown to dark yellowish-brown, neutral to calcareous, very friable very fine sandy loam. Below is grayish-brown to brown, strongly calcareous to calcareous very fine sandy loam and loamy very fine sand.

Mottled olive-gray to light-gray, calcareous silty clay loam is at a depth of 52 inches.

Permeability is moderately rapid in the substratum, and available water capacity is low. The soils are friable and well aerated and are readily penetrated by plant roots. The content of organic matter generally is high to medium. Supplies of available phosphorus and potassium generally are medium to low. The soils can be cultivated within a wide range of moisture content.

Nearly all areas of Eckman soils are used for cultivated crops.

Typical profile of Eckman very fine sandy loam, 1 to 4 percent slopes (SW¼SW¼NW¼ sec. 8, T. 125 N., R. 44 W.):

Ap—0 to 7 inches, black (10YR 2/1) very fine sandy loam; cloddy, but breaks to weak, fine, granular and subangular blocky structure; friable when moist; abrupt, smooth boundary.

A1—7 to 11 inches, black (10YR 2/1) very fine sandy loam; weak, fine, granular structure; very friable when moist; gradual, smooth boundary.

A3—11 to 15 inches, very dark brown (10YR 2/2) very fine sandy loam; weak, coarse, prismatic structure that breaks to weak, medium, subangular blocky; very friable when moist; gradual, smooth boundary.

B2—15 to 22 inches, dark-brown (10YR 3/3) to dark yellowish-brown (10YR 3/4) very fine sandy loam; weak, coarse, prismatic structure that breaks to weak, medium, subangular blocky; very friable when moist; clear, smooth boundary.

B3ca—22 to 27 inches, dark yellowish-brown (10YR 4/4) to yellowish-brown (10YR 5/4) very fine sandy loam; weak, coarse, prismatic structure that breaks to weak, medium, subangular blocky; very friable when moist; calcareous; abrupt, smooth boundary.

C1ca—27 to 31 inches, grayish-brown (2.5Y 5/2) to light olive-brown (2.5Y 5/4) very fine sandy loam; massive (structureless); very friable when moist; strongly calcareous; clear, smooth boundary.

C2—31 to 46 inches, yellowish-brown (10YR 5/4) loamy very fine sand; single grain (structureless); loose; calcareous; clear, smooth boundary.

C3—46 to 52 inches, brown (10YR 5/3) loamy very fine sand; a few, fine, distinct, gray mottles; single grain (structureless); loose; calcareous; abrupt, smooth boundary.

IIC4—52 to 60 inches, light olive-gray (5Y 6/2) to light-gray (5Y 7/2) silty clay loam; many, medium, distinct, olive-brown (2.5Y 4/4) mottles; light olive brown (2.5Y 5/4) when crushed; massive (structureless); firm when moist; calcareous.

The Ap and A1 horizons have a combined thickness ranging from 6 to 12 inches, and the B2 horizon, a thickness of 6 to 12 inches. Depth to calcareous material ranges from 14 to 24 inches. The very fine sandy loam material ranges from 18 to 32 inches in thickness. The silty clay loam layer is lacking in places. The A and B horizons are neutral to mildly alkaline in reaction. Eckman soils in Stevens County contain more sand than Eckman soils in other places.

Eckman soils are not so silty as Glyndon soils and are leached of lime to a greater depth.

Eckman very fine sandy loam, 1 to 4 percent slopes (EcB).—This is the only Eckman soil mapped in the county. It is on ridgetops that are 8 to 10 feet higher than surrounding nearly level areas. Adjacent to the ridges are calcareous, moderately well drained Glyndon soils and poorly drained Borup soils. Runoff is slight.

Included with this soil in mapping are small areas that have a surface layer and subsoil of fine sandy loam. Also included are some areas that lack the finer textured layer of the soil described as typical for the series. Other small areas have a very dark gray surface layer like that of Zell soils and are calcareous throughout. Still other included areas are eroded. In these eroded areas the present surface layer is a mixture of the remaining dark-colored surface layer and of dark-brown or dark yellowish-brown material from the subsoil.

This Eckman soil is free of stones and readily absorbs much of the rain that falls. The soil blows readily, but water erosion is not a serious hazard.

Except for a few odd-shaped areas, all of this soil is cultivated. Low available water capacity is the chief factor limiting use. This soil warms up early in spring, is friable, and is easy to till. Practices are needed that maintain and improve fertility and that control soil blowing. Tillage should be kept to a minimum. Capability unit IIIs-1; windbreak group 4.

Estelline Series

In the Estelline series are nearly level, well-drained soils. These soils formed in silt loam material underlain by sand and gravel at a depth between 2 and 3½ feet. They are mainly along the Chippewa and Pomme de Terre Rivers and on outwash in the southeast corner of the county.

The surface layer in a typical profile is black silt loam about 10 inches thick. It is underlain by about 4 inches of very dark brown silt loam. Below is dark yellowish-brown, very friable silt loam. Dark yellowish-brown and dark grayish-brown, stratified sand and gravel are at a depth of about 32 inches.

The surface layer and subsoil are neutral to mildly alkaline. Estelline soils are high in fertility and in content of organic matter. They readily absorb water and air. The soils are in good tilth, and preparing a seedbed is easy. The available water capacity of the soils is medium, and timely precipitation is needed for good growth of crops.

Nearly all areas of Estelline soils are used for cultivated crops.

Typical profile of Estelline silt loam, 0 to 2 percent slopes (SW¼NE¼SE¼ sec. 28, T. 123 N., R. 41 W.):

Ap—0 to 7 inches, black (10YR 2/1) silt loam; cloddy, but breaks to weak, fine, granular and subangular blocky structure; very friable when moist; neutral; clear, smooth boundary.

A1—7 to 10 inches, black (10YR 2/1) silt loam; weak, fine, granular and subangular blocky structure; very friable when moist; neutral; clear, smooth boundary.

AB—10 to 14 inches, very dark brown (10YR 2/2 to 2/3) silt loam; weak, medium, prismatic structure that breaks to weak, very fine to fine, subangular blocky; very friable when moist; neutral; clear, smooth boundary.

B1—14 to 23 inches, dark yellowish-brown (10YR 3/4) silt loam; weak, medium, prismatic structure that breaks to weak, fine, subangular blocky; very friable when moist; neutral; clear, smooth boundary.

B2—23 to 32 inches, dark yellowish-brown (10YR 4/4) to brown (10YR 4/3) silt loam; weak, medium, prismatic structure that breaks to weak, fine, subangular blocky; very friable when moist; neutral; abrupt, smooth boundary.

IICca—32 to 42 inches, dark yellowish-brown (10YR 4/4) and dark grayish-brown (10YR 4/2), stratified sand and gravel; strongly calcareous.

The A horizon has a thickness ranging from 8 to 16 inches, and the B horizon, a thickness of 16 to 24 inches. In some places a thin layer of loam or sandy loam occurs just above the sand and gravel. Thickness of the silt cap over the underlying sand and gravel generally is about 30 inches, but it ranges from 24 to 42 inches.

Estelline soils contain more silt and less sand than Fordville soils.

Estelline silt loam, 0 to 2 percent slopes (EsA).—This is the only Estelline soil mapped in the county. It is on river terraces and on outwash areas. Some of the areas are adjacent to droughty Renshaw and Sioux soils, and others are near well-drained Fordville soils.

Included with this soil in mapping are small areas of Fordville, Renshaw, and Sioux soils. Also included are some small areas that have thicker surface and subsurface layers than this Estelline soil. These areas are close to steep slopes that separate the river terraces and outwash areas from the uplands. In other included areas the soil is moderately well drained and the subsoil has a duller color than that of this Estelline soil. Also its acreage is about half the size of that soil. A few small included areas are gently sloping.

Sand and gravel are at a depth between 2 and 3½ feet in this Estelline soil. Available water capacity is medium, and the soil is moderately droughty.

This soil is well suited to all cultivated crops commonly grown in the county, and most areas are under cultivation. The soil warms up early in spring. A good seedbed can be prepared easily by plowing just before planting. In this way tillage is kept to a minimum and moisture is conserved. Also needed are practices that maintain or improve fertility. Capability unit IIs-1; windbreak group 1.

Flom Series

The Flom series consists of poorly drained and somewhat poorly drained soils. These soils are in the uplands. Most areas are in shallow depressions or swales, but a few areas are in narrow drainageways.

In a typical profile the surface layer is black silty clay loam about 10 inches thick. Below is about 7 inches of very dark gray silty clay loam to clay loam; about 8 inches of olive-gray, friable to firm clay loam; and then light-gray to light olive-gray, friable to firm, strongly calcareous clay loam.

The content of organic matter in the surface layer is high. The surface layer and subsoil are neutral to moderately alkaline. Fertility is high. The water table is high for significant periods during the growing season. Consequently, unless the soils are drained, root penetration is limited. Permeability is moderately slow, and available water capacity is high. These wet soils warm up later in spring than surrounding better drained soils.

In this county Flom soils are mapped only in a complex with Parnell soils. A description of Parnell soils is given under the Parnell series.

Typical profile of Flom silty clay loam (SE¼SW¼SW¼ sec. 23, T. 124 N., R. 43 W.):

A1—0 to 10 inches, black (N 2/0 to 10YR 2/1) silty clay loam; cloddy, but breaks to moderate, fine, granular and subangular blocky structure; firm when moist; mildly alkaline; clear, smooth boundary.

A3g—10 to 17 inches, very dark gray (10YR 3/1) silty clay loam to clay loam; weak, medium, prismatic structure that breaks to weak and moderate, fine, subangular blocky; firm when moist; mildly alkaline; gradual, smooth boundary.

B2g—17 to 25 inches, olive-gray (5Y 5/2) clay loam; a few, fine, distinct, olive-brown mottles; weak, medium, prismatic structure that breaks to weak and moderate, fine, subangular blocky; friable to firm when moist; mildly alkaline; abrupt, smooth boundary.

C1cag—25 to 31 inches, light-gray (5Y 7/2) clay loam; a few, fine, distinct, light olive-brown mottles; massive; friable to firm when moist; gypsum crystals present; strongly calcareous; gradual, smooth boundary.

C2cag—31 to 42 inches, light olive-gray (5Y 6/2) clay loam; common, fine, distinct, light olive-brown mottles; massive (structureless); friable to firm when moist; strongly calcareous; gradual, smooth boundary.

C3cag—42 to 54 inches, light olive-gray (5Y 6/2) clay loam; common, fine, distinct, olive-brown mottles; massive (structureless); friable to firm when moist; calcareous.

The A1 horizon has a thickness ranging from 10 to 16 inches, and the B2 horizon, a thickness of 6 to 16 inches. The silty clay loam material, which is derived from local sorting, generally ranges from 10 to 30 inches in thickness, but in places it is thicker. The B2g horizon is indistinct and ranges from weak to moderate in structure. It generally is gray, but in somewhat poorly drained areas it is olive brown and is strongly mottled in the upper part. Depth to strongly calcareous material typically is about 18 to 36 inches. In places, however, both the surface and subsurface layers are slightly calcareous.

Flom soils have less silt in the surface soil and subsoil than Hidewood soils. They are thinner and have weaker structure than Parnell soils, and their subsoil contains less clay.

Fordville Series

The Fordville series consists of nearly level, well-drained soils. These soils formed in loamy material underlain by sand and gravel at a depth between 2 and 3½ feet. They are mainly in river valleys.

In a typical profile the surface layer is black to very dark brown loam about 15 inches thick. The subsoil is dark-brown to brown, friable to very friable loam and sandy loam about 21 inches thick. Below is several feet of yellowish-brown, strongly calcareous, stratified sand and gravel.

The surface layer and subsoil are neutral to mildly alkaline and are moderately permeable. The substratum is very rapidly permeable. These soils are free of stones and are easy to cultivate. The soils warm up early in spring. A good seedbed can be prepared easily by plowing just before planting.

Nearly all areas of Fordville soils are used for cultivated crops.

Typical profile of Fordville loam, 0 to 2 percent slopes (SW¼SW¼NW¼ sec. 24, T. 124 N., R. 42 W.):

Ap—0 to 8 inches, black (10YR 2/1) loam; cloddy, but breaks to weak, very fine, granular structure; friable when moist; neutral; abrupt, smooth boundary.

A1—8 to 15 inches, black (10YR 2/1) to very dark brown (10YR 2/2) loam; moderate, very fine to fine, granular and subangular blocky structure; friable when moist; neutral; gradual, smooth boundary.

B1—15 to 25 inches, dark-brown (10YR 3/3) heavy loam on surface of peds, dark yellowish brown (10YR 3/4) in ped interiors; weak to moderate, medium, prismatic structure that breaks to weak and moderate, fine, subangular blocky; friable when moist, sticky when wet; neutral; clear, smooth boundary.

B2—25 to 30 inches, dark-brown (10YR 3/3 to 4/3) heavy loam; weak, medium, prismatic structure that breaks to weak, fine, subangular blocky; friable when moist, sticky when wet; neutral; abrupt, smooth boundary.

B3—30 to 36 inches, dark-brown to brown (10YR 4/3) sandy loam; weak, fine, subangular blocky structure; very friable when moist; mildly alkaline; abrupt, wavy boundary.

IIC1ca—36 to 40 inches, yellowish-brown (10YR 5/4) and light yellowish-brown (10YR 6/4) stratified sand and gravel; strongly calcareous.

The A horizon has a thickness ranging from 8 to 16 inches, and the B horizon, a thickness of 16 to 24 inches. Depth to sand and gravel ranges from 24 to 42 inches. In many places just above the sand and gravel, thin layers of sandy material occur. In some places thin, patchy clay films are on peds in the B horizon. Fordville soils in Stevens County have a thicker, darker A horizon than in other places.

Fordville soils contain more sand and less silt than Estelline soils. They have a thicker surface layer and subsoil than nearby, droughty Renshaw soils.

Fordville loam, 0 to 2 percent slopes (FdA).—This is the only Fordville soil mapped in the county. Most areas are on terraces in valleys of the Pomme de Terre and Chippewa Rivers and on outwash plains in the southeastern part of the county. A few small areas are in the uplands. On the terraces and outwash plains, the areas adjoin droughty Renshaw and Sioux soils. In the uplands the soil adjoins areas of deep Barnes and Forman soils.

Included with this soil in mapping are small areas of Barnes, Forman, Renshaw, and Sioux soils. Also included are some areas that are more than 42 inches deep to sand and gravel. In a few small areas, in nearly level sags, the soil is moderately well drained. A few other included areas have a clay loam subsoil that has thick clay films on the surfaces of peds. Still other small areas have very short gentle slopes and are somewhat better drained than this soil.

This Fordville soil is suited to all of the cultivated crops commonly grown in the county, and most areas are cultivated. The soil is well suited to small grains that mature by midsummer. Fertilizer that contains nitrogen and phosphorus is needed for some crops. Use of the soils is moderately limited because the soils have medium available water capacity and are slightly droughty. Capability unit IIs-1; windbreak group 1.

Forman Series

The Forman series consists of nearly level to rolling, well-drained soils that formed in glacial till. These soils are on moraines in the uplands. They are mainly west of the Pomme de Terre River.

In a typical profile the surface layer is black clay loam about 8 inches thick. Below is very dark grayish-brown to dark-brown, firm clay loam, about 12 inches thick; about 2 inches of dark yellowish-brown and dark grayish-brown, calcareous clay loam; and then the olive-brown to light olive-brown, calcareous, firm clay loam glacial till.

The surface layer and subsoil are neutral to mildly alkaline. Supplies of phosphorus and nitrogen generally are low. Permeability of these soils is moderately slow, and available water capacity is high. Penetration of roots generally is not restricted. The soils generally contain a few stones and boulders. They are slightly sticky, and they therefore are somewhat more difficult to cultivate than some other soils in the county.

Forman soils are well suited to all of the crops commonly grown in the county, and most areas are cultivated.

Typical profile of a Forman clay loam (NE¼NE¼NW¼ sec. 4, T. 123 N., R. 42 W.):

A—0 to 8 inches, black (10YR 2/1) clay loam; cloddy, but breaks to moderate, fine and very fine, granular structure; friable when moist; some mixing of material from the B horizon; neutral; abrupt, smooth boundary.

B21—8 to 16 inches, very dark grayish-brown (10YR 3/2) clay loam, dark brown (10YR 4/3) when crushed; moderate to strong, medium and coarse, prismatic structure that breaks to moderate and strong, fine and medium, subangular blocky; clay films on horizontal and vertical surfaces of peds; firm when moist; neutral; clear, wavy boundary.

B22—16 to 20 inches, dark grayish-brown (10YR 3/2) clay loam on outside of peds and dark brown (10YR 3/3) in ped interiors, brown (10YR 4/3) to dark yellowish brown (10YR 4/4) when crushed; moderate to strong, medium and coarse, prismatic structure that breaks to moderate and strong, fine and medium, subangular blocky; clay films on horizontal and vertical surfaces of peds; firm when moist; neutral; clear, wavy boundary.

B3ca—20 to 22 inches, dark yellowish-brown (10YR 4/4) and dark grayish-brown (10YR 4/2) clay loam; weak, fine and medium, prismatic structure that breaks to moderate, fine and medium, subangular blocky; clay films on vertical surfaces of peds; firm when moist; calcareous; abrupt, wavy boundary.

C1ca—22 to 37 inches, olive-brown (2.5Y 3/4) and olive-gray (5Y 5/2) clay loam; weak, fine, angular blocky and weak, fine, subangular blocky structure; segregated calcium carbonate; firm when moist; strongly calcareous; gradual, wavy boundary.

C2—37 to 48 inches, light olive-brown (2.5Y 5/4) to olive-brown (2.5Y 4/4) clay loam; a few, fine, prominent gray (10YR 6/1) and yellowish-brown (10YR 5/6) mottles; massive (structureless); firm when moist; a few iron and manganese concretions; calcareous.

The Ap horizon and the B2 horizon each range from 6 to 12 inches in thickness. In places the A horizon is heavy loam. Lime is leached to a depth between 12 and 24 inches. The content of clay in the B2 horizon commonly ranges from 30 to 35 percent. Clay films are common on vertical and horizontal surfaces of peds, though in some profiles they occur only on the vertical surfaces of the peds. Structure ranges from moderate to strong.

Forman soils have more clay and less sand in the surface layer and subsoil than Barnes soils. They are better drained than Aastad soils and have a browner subsoil.

Forman clay loam, 0 to 2 percent slopes (FmA).—This soil is west of the Pomme de Terre River. The areas are slightly rounded and are slightly higher than the areas that surround them. They generally are small and irregular in shape. In many places this soil adjoins sloping areas of Forman and Buse soils. Other low areas adjoin moderately well drained soils, chiefly Aastad and Hamerly soils.

Included with this soil in mapping are some soils that have a thinner profile than this soil and that have some features of the nearby calcareous Buse soils. Also included are a few areas near the Pomme de Terre River that have a surface layer of silt loam and small areas of Aastad soils. Still other included small areas are about 35 to 38 percent clay.

This Forman soil is deep and fertile. Runoff is so slow that little erosion occurs when clean-cultivated crops are grown. Free water stays on the surface for only short periods.

All crops commonly grown in the county are well suited to this soil. Fertilizer is needed in some places for best growth of crops, and practices that conserve moisture also are needed. If the soil is not protected from strong wind, soil blowing is a slight hazard in winter and early in spring. Capability unit I-1; windbreak group 1.

Forman clay loam, 2 to 6 percent slopes (FmB).—This soil has slopes that range from 50 to 200 feet in length. In some places the slopes are fairly uniform and slope in one direction, but in other places they are undulating and slope in many directions. At the middle of a long slope, the soil profile is like that described as typical for the series. Near the top of the slope, however, the soil is thinner than typical in some places, and on the lower part, it is thicker.

Included with this soil in mapping, near the top of the slope, are a few small areas of grayish Buse soil. Also included are small areas of moderately well drained Aastad and Darnen soils near the bottom of the slope. In many areas the underlying glacial till contains strata of coarse-textured material and the soil profile is sandier than typical.

This Forman soil is deep and fertile. Runoff is medium, and the supply of moisture available for crops thus is reduced. The hazard of erosion is moderate.

All of the crops commonly grown in the county are well suited to this soil. Corn, soybeans, and small grains are among the chief crops grown. If cultivated crops are grown, the main concerns of management are controlling erosion and maintaining and improving fertility and structure. Capability unit IIe-1; windbreak group 1.

Forman clay loam, 2 to 6 percent slopes, eroded (FmB2).—This soil occupies areas similar to those occupied by Forman clay loam, 2 to 6 percent slopes. Much of the original surface layer has been washed away, and plowing has mixed dark-brown or dark yellowish-brown material from the subsoil with the remaining surface soil. As a result, the present surface layer is brownish and is predominantly lighter colored than that in the typical profile. Also tilth, fertility, and moisture capacity are reduced.

Included with this soil in mapping are spots of grayish Buse soils. Also included, on the lower part of the slopes and along small natural waterways and reaching up the slopes, are soils that have a thicker, darker colored surface layer than this soil.

This Forman soil is suited to all of the crops commonly grown in the county. Corn and small grains are the chief crops. When cultivated crops are grown, the main concerns of management are maintaining fertility, improving tilth, and controlling runoff. In this way erosion is controlled and the supply of moisture held available for crops is increased. Capability unit IIe-1; windbreak group 1.

Forman-Buse complex, 2 to 6 percent slopes, eroded (FuB2).—This complex is west of the Pomme de Terre River on clay loam glacial till. The darker colored, brownish areas are Forman soil. The grayish areas on the most convex part of the slopes are Buse soil. This soil makes up 30 to 40 percent of each mapped area and contains more clay than the typical Buse soil. The remainder is mainly Forman soil. Some areas are undulating and have slopes that extend in several directions. Other areas have fairly uniform slopes that slope in only one direction. The uniform slopes generally are the longest; they range from 100 to 250 feet in length.

Included with this complex in mapping are small areas of Aastad, Barnes, Flom, and Hamerly soils. Also included are small areas of steeper soils and of less sloping soils. Other included small areas are only slightly eroded.

Most of this complex is used for the cultivated crops that commonly are grown in the county. Much of the original surface layer of the soils has been washed away. Thus fertility is lower than formerly, and tilth is poorer. Crops generally grow better on the Forman soil than on the Buse soil, because the calcareous Buse soil is naturally lower in fertility. Runoff is medium on both soils. The hazard of further erosion is moderate when row crops are grown. Practices are needed that conserve moisture, that maintain or improve fertility and soil structure, and that control further erosion. Capability unit IIe-1; windbreak group 1.

Forman-Buse complex, 6 to 12 percent slopes, eroded (FuC2).—This complex is on uplands west of the Pomme de Terre River. The darker colored, brownish areas are Forman soil. The grayish areas on the uppermost, convex part of the slopes are Buse soil. This soil makes up 40 to 50 percent of each mapped area and contains more clay than the typical Buse soil. The remainder is mainly Forman soil. In many places the slopes are irregular and extend in several directions. Slopes generally range from 150 to 200 feet in length. The more uniformly sloping areas generally adjoin areas of nearly level Aastad and Forman soils. In many places on foot slopes, the areas are near Flom, Parnell, and Vallers soils. The Forman soil adjacent to the Buse soil on the upper part of the slopes generally is thinner and has a lighter colored surface layer than that nearer the bottom of the slopes.

Included with these soils in mapping are small areas that have gentler slopes than these soils, or that have steeper slopes. Also included are small areas that are only slightly eroded. In these areas the proportion of Buse soil is smaller than that in this complex.

Most of this complex is used for growing feed grains, grasses, and legumes that commonly are grown in the county. Crops generally grow better on the Forman soil than on the Buse soil because the Buse soil is calcareous and is naturally lower in fertility. Runoff is rapid on both soils. The hazard of further erosion is severe when row crops are grown. Practices are needed that prevent further erosion and that maintain and improve fertility and soil structure. Capability unit IIIe-1; windbreak group 1.

Glyndon Series

The Glyndon series consists of nearly level, moderately well drained, calcareous soils. These soils formed in silty sediment about 1½ to 3 feet thick over very fine and fine sand. They are in the northwestern part of the county.

In a typical profile the surface layer is black, calcareous silt loam about 9 inches thick. Below is about 6 inches of dark-gray and gray, friable, strongly calcareous silt loam; about 15 inches of light olive-brown and olive-brown, friable and very friable, strongly calcareous to calcareous silt loam; and then loose, mottled light olive-brown, calcareous very fine sand.

The surface layer of these soils generally is high in content of organic matter. Fertility of the soils commonly is medium. The upper part of the profile has so high a content of lime as to reduce the availability of some of the plant nutrients. Available water capacity is medium. Cobblestones and boulders generally are not present in these soils.

Nearly all areas of Glyndon soils are used for cultivated crops.

Typical profile of Glyndon silt loam, 0 to 2 percent slopes (SE¼SE¼SW¼ sec. 3, T. 125 N., R. 44 W.):

Ap—0 to 9 inches, black (10YR 2/1) silt loam; weak to moderate, very fine, granular structure; friable when moist; calcareous; clear, wavy boundary.

ACca—9 to 15 inches, dark-gray (10YR 4/1) mixed with gray (10YR 5/1) silt loam; weak, very fine, granular structure; friable when moist; strongly calcareous; clear, wavy boundary.

C1ca—15 to 21 inches, light olive-brown (2.5 5/4) to grayish-brown (2.5Y 5/2) silt loam; single grain (structureless); friable when moist; many pores; strongly calcareous; clear, wavy boundary.

C2—21 to 30 inches, olive-brown (2.5Y 4/4) to light olive-brown (2.5Y 5/4) silt loam to very fine sandy loam; a few, fine, prominent, gray (5Y 6/1) mottles; single grain (structureless); very friable when moist; calcareous; gradual, wavy boundary.

IIC3—30 to 60 inches, light olive-brown (2.5Y 5/4) very fine sand; common, medium, prominent, gray (5Y 5/1) mottles and a few, medium, prominent, dark reddish-brown (5YR 3/4) mottles; single grain (structureless); a few cylindrical iron and manganese concretions; calcareous.

The Ap horizon has a thickness ranging from 8 to 12 inches, and the ACca horizon, a thickness of 3 to 9 inches. These horizons range from silt loam to very fine sandy loam in texture. Depth to the underlying sand ranges from 18 to 36 inches but generally is about 30 inches. In some places the overlying silty material changes abruptly to fine sand.

Glyndon soils are better drained than Borup soils. They lack the silty substratum typical of Bearden soils.

Glyndon silt loam, 0 to 2 percent slopes (GdA).—This soil has the profile described for the series. Some areas are adjacent to low-lying, wet Borup soil. Other areas adjoin nearly level, moderately well drained Bearden soils. Runoff is medium to slow.

In some areas a strongly calcareous layer is at the surface. In a few places clay loam glacial till is at a depth between 40 and 48 inches. The substratum in other areas contains more coarse silt than that of the profile described as typical for the series.

Included with this soil in mapping are some gently sloping areas that have slopes less than 100 feet long. A few small areas of Bearden soil also are included.

This Glyndon soil is well suited to all cultivated crops commonly grown in the county, and it is used chiefly for cultivated crops. The soil is friable and has good workability. The chief concern of management is improving the balance of plant nutrients. Capability unit IIs-2; windbreak group 6.

Glyndon very fine sandy loam, 0 to 2 percent slopes (GlA).—This soil is adjacent to Glyndon silt loam, 0 to 2 percent slopes, and to poorly drained Arveson and Borup soils. The surface and subsurface layers are very fine sandy loam. Depth to sand generally is about 30 inches but ranges from 18 to 36 inches.

In some places the black surface layer and dark grayish-brown subsoil are slightly calcareous. In some other areas the sand is slightly coarser and is nearer the surface than in the soil described as typical for the series.

Nearly all areas of this soil are used for the cultivated crops commonly grown in the county. The available water capacity is lower than in some other soils in the county, and plant growth is poorer. Excess lime in the upper part of the profile makes fertility about medium. If these soils are plowed in fall and all crop residues turned under, soil blowing is a hazard in winter and early in spring. Capability unit IIIs-3; windbreak group 6.

Glyndon-McIntosh complex, 0 to 2 percent slopes (GmA).—This complex is in the northwestern part of the county adjacent to the Colvin-Borup complex. In most places Glyndon and McIntosh soils, in equal parts, make up 50 percent of each mapped area. About 25 percent of the remaining acreage is Hamerly soils, and the remaining 25 percent is Bearden and Grimstad soils. The proportion of each soil varies from place to place, and the component soils occur in no particular pattern, size, or shape.

Most soils of this complex formed in silty and sandy lake sediment laid down on loamy glacial till. The till occupied a landscape made up of swells and swales occurring in an irregular pattern. Sand was deposited first, and then the finer textured silt. All but the highest glacial swells received a thick mantle of material. The Glyndon soils formed in silty material underlain by deep deposits of sandy material. Hamerly soils occur 50 feet or less from Glyndon soils and formed directly on glacial till.

This complex is used for all cultivated crops commonly grown in the county. All of the soils are calcareous. Fertilizer that contains phosphorus and other plant nutrients is needed to correct the imbalance of plant nutrients. If these soils are plowed in fall and worked smooth, soil blowing is a hazard in winter and early in spring. Capability unit IIs-2; windbreak group 6.

Grimstad Series

Grimstad soils are nearly level, moderately well drained, and calcareous. They formed in loamy material underlain by sandy and clayey material. These soils occur only in the northwest corner of the county.

In a typical profile the surface layer is black fine sandy loam about 9 inches thick. Below is about 4 inches of very dark gray fine sandy loam, and then about 6 inches of dark-gray, strongly calcareous loamy fine sand. The underlying material is loose, dark grayish-brown to olive-brown, strongly calcareous fine sand in the upper 5 inches. Just below is mottled dark grayish-brown to gray, firm, calcareous silty clay loam to silty clay that contains a few pebbles.

These soils have high available water capacity. Fertility generally is medium. The upper part of the profile has so high a content of lime that availability of such plant nutrients as phosphorus, and possibly iron or zinc, is low. After heavy rains water is likely to remain perched above the silty, fine-textured layer and hinder penetration of plant roots. The surface and subsurface layers generally are free of stones.

In this county Grimstad soils are mapped only in a complex with Rockwell soils. A description of the Rockwell soils is given under the Rockwell series.

Typical profile of Grimstad fine sandy loam (SW¼SW¼NW¼ sec. 7, T. 126 N., R. 44 W.):

Ap—0 to 9 inches, black (10YR 2/1) fine sandy loam that contains clods of very dark gray (10YR 3/1), black (10YR 2/1) to very dark gray (10YR 3/1) when crushed; cloddy, but breaks to very fine and fine, granular structure; very friable when moist; moderately calcareous to strongly calcareous; abrupt, smooth boundary.

A1ca—9 to 13 inches, very dark gray (10YR 3/1) fine sandy loam; weak, fine, subangular blocky structure; very friable when moist; strongly calcareous; clear, wavy boundary.

ACca—13 to 19 inches, dark-gray (10YR 4/1) loamy fine sand; single grain (structureless); very friable when moist; strongly calcareous; abrupt, smooth boundary.

C1ca—19 to 24 inches, dark grayish-brown (2.5Y 4/2) to olive-brown (2.5Y 4/4) fine sand; single grain (structureless); loose when moist; strongly calcareous; abrupt, smooth boundary.

IIC2—24 to 39 inches, dark grayish-brown (2.5Y 4/3) to grayish-brown (2.5Y 5/3) silty clay loam to silty clay; a few, fine, distinct, gray and strong-brown mottles; moderate, fine, subangular blocky structure; firm when moist; a few nests of gypsum crystals; pebbles of limestone, shale, and granite; calcareous; gradual, smooth boundary.

IIC3—39 to 45 inches, gray (5Y 6/1) and olive-brown (2.5Y 4/4) to light olive-brown (2.5Y 5/4) silty clay; moderate, fine, subangular blocky structure; firm when moist; a few nests of gypsum crystals; pebbles of limestone, shale, and granite; calcareous.

The Ap horizon has a thickness ranging from 6 to 10 inches, and the A1ca and ACca horizons, a combined thickness of 6 to 10 inches. In a few places the Ap horizon is loam. In areas outside of the basin of Lake Agassiz, the underlying material is clay loam. Depth to the finer textured material generally ranges from 20 to 30 inches.

Grimstad soils are better drained than Rockwell soils and have a browner subsurface. They have more lime near the surface than the loamy subsoil variants from the Malachy series.

Grimstad-Rockwell fine sandy loams (0 to 2 percent slopes) (Gr).—This complex is on a level or nearly level lake plain in the northwest corner of the county. The Grimstad soil, which makes up about 60 percent of each mapped area, is on irregular rims a few inches above the Rockwell soil. The poorly drained Rockwell soil occupies flat to slightly concave areas and makes up about 40 percent of the complex. Permeability is moderately rapid in the sandy loam surface layer of these soils, rapid in the sandy subsurface, and slow in the loamy subsoil. Runoff ranges from slow to very slow, and internal drainage, from medium to slow.

Included with this soil in mapping are small areas of a noncalcareous, poorly drained soil and of the slightly calcareous Malachy, loamy subsoil variant. These soils are similar to Grimstad and Rockwell soils in texture but occupy somewhat deeper depressional areas. Also included are some small areas in which depth to underlying, finer textured material is more than 42 inches. Other small areas are somewhat poorly drained.

Grimstad-Rockwell fine sandy loams is used for all cultivated crops commonly grown in the county. When drainage is provided, the response to fertilizer is good. Soil blowing is a serious hazard in winter and early in spring if the soils are plowed in fall and worked smooth. Because of their favorable structure, these friable soils are easier to cultivate than many other soils in the county. Capability unit IIw-2; windbreak group 6.

Hamerly Series

The Hamerly series consists of nearly level, moderately well drained, calcareous soils. These soils are on loam and clay loam ground moraines, mainly west of the Pomme de Terre River.

In a typical profile the surface layer is black, calcareous clay loam about 7 inches thick. The subsurface is very dark gray clay loam in the upper part and dark-gray clay loam in the lower part. It is strongly calcareous and is about 11 inches thick. The underlying till is light olive-brown and olive-brown, firm clay loam. It is strongly calcareous in the upper part and calcareous in the lower part. The till contains many gypsum crystals and is mottled at a depth of about 38 inches.

Permeability is moderately slow in these soils. Available water capacity is high, and internal drainage is medium. The content of organic matter in the surface layer generally is high. Near the surface layer the content of lime is so high as to cause an imbalance of plant nutrients. Consequently supplies of phosphorus, and possibly iron and zinc, are low. The soils generally contain some stones and boulders.

Nearly all areas of Hamerly soils are used for cultivated crops.

Typical profile of Hamerly clay loam, 0 to 3 percent slopes (NW¼SW¼SW¼ sec. 35, T. 125 N., R. 44 W.):

Ap—0 to 7 inches, black (10YR 2/1) clay loam; cloddy, breaks to weak and moderate, very fine to fine granular structure; friable when moist; calcareous; abrupt, smooth boundary.

A1ca—7 to 18 inches, very dark gray (10YR 3/1) clay loam that grades to dark gray (10YR 4/1) as depth increases; weak, very fine to fine, granular and subangular blocky structure; friable when moist; strongly calcareous; clear, wavy boundary.

C1ca—18 to 28 inches, light olive-brown (2.5Y 5/4) clay loam, light olive brown (2.5Y 5/4) to light yellowish brown (2.5 6/4) when crushed; massive (structureless); friable when moist; strongly calcareous; gradual, smooth boundary.

C2—28 to 38 inches, olive-brown (2.5Y 4/4) clay loam; massive (structureless); many nests of gypsum crystals; firm when moist; calcareous; gradual, smooth boundary.

C3—38 to 50 inches, light olive-brown (2.5Y 5/4) to olive-brown (2.5Y 4/4) clay loam; many, medium, gray (5Y 5/1) to light-gray (5Y 6/1) mottles; massive (structureless); many nests of gypsum crystals; firm when moist; calcareous.

The Ap horizon has a thickness ranging from 6 to 10 inches, and the A1ca horizon, a thickness of 4 to 12 inches. Texture throughout the profile ranges from loam to clay loam. The cobblestones and other stones in the subsurface generally have a thick accumulation of calcium carbonate on the bottom.

Hamerly soils are better drained than Vallers soils and have browner underlying material.

Hamerly clay loam, 0 to 3 percent slopes (HaA).—This is the only Hamerly soil mapped in the county. It occupies swells and rises in areas that contain many depressions. Differences in elevation are slight. Many areas near silty McIntosh soils have a silty surface layer. In some places the surface layer is noncalcareous to a depth between 8 and 10 inches. On the crest of higher swells, the surface layer is thinner than in other areas and the grayish, strongly calcareous layer just below also is thinner. The texture is loam east of the Pomme de Terre River, and it generally is clay loam west of the river. Many grayish spots occur where the strongly calcareous layer is near the surface.

Included with this soil in mapping are many depressions occupied by such wet soils as Flom, Parnell, and Vallers. These depressions range from 1/10 to 1 acre in size and are shown on the detailed soil map by a spot symbol. They may hold water or be too wet to bear machinery for 2 or 3 weeks after a heavy rain. Use therefore is limited because tillage and time of planting are delayed. Small areas of Aastad and Svea soils also are included. Other small included areas are somewhat poorly drained.

Most areas of this Hamerly soil are used for the crops commonly grown in the county. Excess lime near the surface causes a nutrient imbalance that can be corrected by adding phosphorus, and possibly iron or zinc. Soil blowing is a slight hazard in winter and early in spring if this soil is plowed in fall and left bare and smooth. Capability unit IIs-2; windbreak group 3.

Hattie Series

Hattie soils are nearly level to steep, well drained to moderately well drained, and calcareous. These soils formed in clayey material. They are in the uplands west of the Pomme de Terre River.

In a typical profile the surface layer is black, calcareous clay that is sticky when wet and is about 6 inches thick. The material below is olive-brown to dark grayish-brown clay that also is sticky when wet. It is strongly calcareous and contains many black tongues of material to a depth of about 20 inches.

The available water capacity of these soils is high. Except in eroded areas, the content of organic matter in the surface soil is high. The soils are plastic and sticky. They puddle readily if plowed when wet. Supplies of plant nutrients generally are good. The calcareous layer near the surface contains so much lime, however, that availability of phosphorus and some other plant nutrients is reduced. Cracks form in these soils as they dry and hasten initial absorption of water. As the soils become moist, the clay swells, the cracks close, and permeability to water slows. A few cobblestones and other stones are in these soils, but they are not numerous enough to hinder tillage.

Hattie soils are used for cultivated crops and for pasture.

Typical profile of a Hattie clay (NW¼SW¼NW¼ sec. 22, T. 123 N., R. 43 W.):

Ap—0 to 6 inches, black (10YR 2/1) clay that contains a few peds of grayish brown (2.5Y 5/2); cloddy, but breaks to strong, fine and very fine, granular structure; very firm when moist, sticky when wet; mildly alkaline and slightly calcareous; abrupt, smooth boundary.

C1ca—6 to 24 inches, olive-brown (2.5 4/4) clay that grades to dark grayish brown (2.5Y 4/2); black tongues of material ¼ to ¾ inch wide extend to a depth of 20 inches; moderate, fine and medium, prismatic structure that breaks to strong, fine and very fine, subangular blocky; very firm when moist, sticky when wet; moderately alkaline and strongly calcareous; gradual, smooth boundary.

C2—24 to 46 inches, dark grayish-brown (2.5Y 4/2) to olive-brown (2.5Y 4/4) clay; common, medium, distinct, olive (5Y 5/3) mottles; moderate, medium, fine and very fine, subangular blocky structure; very firm when moist, sticky when wet; moderately alkaline and calcareous; gradual, smooth boundary.

The Ap horizon ranges in thickness from 5 to 10 inches. It is mildly alkaline to moderately alkaline, and the C horizon is moderately alkaline. These soils are about 50 to 65 percent clay.

Hattie soils contain more clay than Buse soils. They are calcareous nearer the surface than Nutley soils.

Hattie clay, 6 to 12 percent slopes, eroded (HcC2).—This soil has fairly long, uniform, rolling slopes, many of which slope in only one direction. Slopes range from 100 to 250 feet in length. In many places the top of the slope adjoins Nutley-Hattie clays, 0 to 2 percent slopes. Areas on foot slopes adjoin wet Dovray and Hegne soils.

Much of the original dark-colored surface layer of this soil has been washed away, and plowing has mixed lighter colored underlying material with the remaining surface layer. As a result, on the upper convex part of the slope, the present surface layer is grayish. Drainage is better than that of the nearly level, gently sloping Hattie soils.

Included with this soil in mapping, near the bottom half of the slope, are areas of Nutley soils that are thinner than typical. Also included are some slightly eroded soils. Still other soils have gentler slopes than this soil or steeper ones.

Many areas of this Hattie soil are used for feed grains, grasses, and legumes that commonly are grown in the county. Available phosphorus is low. Runoff is rapid, and the hazard of further erosion is severe if row crops are grown. The areas generally are used and managed differently than surrounding nearly level to gently sloping soils. Practices are needed that control further erosion and that improve and maintain fertility. Capability unit IIIe-1; windbreak group 1.

Hattie clay, 12 to 18 percent slopes, eroded (HcD2).—This soil occupies hilly areas. Many of the areas are around big sloughs and along prominent drainageways and slope in one direction. Most slopes, however, extend in several directions and range from 250 to 300 feet in length. In places this soil occurs between gently sloping and rolling Hattie and Nutley soils.

The surface layer of this soil is thinner than typical in many places. It is grayish, particularly on the upper part of the slope. Near the bottom of the slope, the surface layer is thicker and darker colored than typical. Drainage is better than in nearly level and gently sloping Hattie soils.

Included with this soil in mapping are small patchy areas, on foot slopes, of noncalcareous Nutley soil that is thinner than typical. Also included are some areas that are slightly eroded and some areas that are slightly steeper than 18 percent.

Runoff is very rapid on this hilly soil. The amount of water available for plant growth therefore is reduced. If cultivated crops are grown, the hazard of further erosion is very severe. Available phosphorus generally is low.

Some areas of this soil are in bluegrass pasture; other areas are in cultivated crops. The soil is better suited to grasses, legumes, and small grains than to row crops. Controlling further erosion and improving fertility and tilth are the main concerns of management. Capability unit IVe-1; windbreak group 1.

Hattie-Nutley clays, 2 to 6 percent slopes (HnB).—This complex consists of clayey Hattie and Nutley soils that occur together in a fine pattern. The calcareous Hattie soil generally is on the upper convex part of the slopes and makes up about 50 percent of each mapped area. The remainder is chiefly Nutley soil. Slopes range from about 100 to 250 feet in length. They generally are uniform and slope in one direction. At the top of the slopes, the areas adjoin Nutley-Hattie clays, 0 to 2 percent slopes. Areas on foot slopes adjoin low-lying areas of wet Dovray and Hegne soils.

Included with this complex in mapping are small areas of soils that are nearly level or that are steeper than this soil. Also included are some slightly eroded to moderately eroded soils.

Soils in this complex are well suited to all crops commonly grown in the county. Stones occur in a few places. Runoff is medium, and the hazard of erosion is moderate if row crops are grown. Because the soils contain much clay, they are sticky and are difficult to work. Timely tillage is needed for preparing a good seedbed. Capability unit IIe-1; windbreak group 1.

Hegne Series

The Hegne series consists of deep, nearly level, poorly drained soils. These soils formed in clayey material. They occur chiefly in the southwestern part of the county in Stevens and Synnes Townships.

In a typical profile the surface layer is black, calcareous clay that is about 7 inches thick. Below is dark-gray to olive-gray clay that is strongly calcareous in the upper part and calcareous in the lower part. Mottles are at a depth of about 33 inches. The material is plastic to very plastic when wet.

The content of organic matter in the surface layer of these soils generally is high. Excessive lime near the surface causes an imbalance of plant nutrients, and additions of phosphorus and some other plant nutrients are needed to correct the imbalance. Available water capacity is high. Internal drainage is slow, and water moves very slowly through these tight, clayey soils. As the soils become dry, many cracks ½ to 1½ inches wide form. The clayey texture makes tillage difficult. Early in spring the water table generally is near the surface and restricts the depth to which roots can penetrate. Cobblestones and other stones occur in places, but they seldom are numerous enough to hinder tillage.

Nearly all areas of these soils are used for cultivated crops. Only a few undrained areas are used primarily for pasture.

Typical profile of Hegne clay (NE¼SE¼NE¼ sec. 25, T. 123 N., R. 43 W.):

Ap—0 to 7 inches, black (10YR 2/1) clay; cloddy, but breaks to strong, very fine, granular structure; firm when moist, very plastic and sticky when wet; calcareous; abrupt, smooth boundary.

C1cag—7 to 33 inches, dark-gray (5Y 4/1) to olive-gray (5Y 4/2) clay that has spots of light gray (5Y 6/1) to light olive gray (5Y 6/2); strong, very fine, subangular blocky structure; firm when moist, very plastic and sticky when wet; many black tongues of material less than half an inch wide to a depth of 18 inches; strongly calcareous; gradual, smooth boundary.

C2g—33 to 41 inches, olive-gray (5Y 4/2) clay; a few, medium, prominent, olive-brown (2.5Y 4/4) mottles; moderate, very fine, subangular blocky structure; firm when moist, very plastic and sticky when wet; calcareous; clear, smooth boundary.

C3g—41 to 48 inches, dark grayish-brown (2.5Y 4/2) to grayish-brown (2.5Y 5/2) clay; a few, fine, faint, olive-brown 2.5Y 4/4) mottles; massive (structureless); firm when moist; a few nests of gypsum crystals; calcareous.

The Ap horizon has a texture ranging from heavy silty clay to clay and a thickness ranging from 6 to 10 inches. It is always calcareous. A very dark gray subsurface layer that ranges from 4 to 12 inches in thickness occurs in many places.

Hegne soils contain more clay than Vallers soils. They contain more lime than Dovray soils, which are noncalcareous in the upper part.

Hegne clay (0 to 1 percent slopes) (Ho).—This is the only Hegne soil mapped in the county. Some areas are on flats that contain many small depressions. Others are on rims around potholes consisting of wet Dovray soils. Runoff is slow, and water is likely to be ponded on the areas for a few days after heavy rain.

Included with this soil in mapping are small areas of nearly level and sloping Hattie and Nutley soils. Also included are small, shallow depressions of Dovray and Tonka soils. In some small areas the black surface soil is thicker than that of this soil. Other included areas consist of somewhat poorly drained soils.

If this soil is drained, it is well suited to all crops commonly grown in the county. Many areas have been drained and are now cultivated. Plowing generally is done in fall because it is difficult to prepare a seedbed in this sticky soil early in spring. The chief concerns of management are improving fertility and providing and maintaining drainage outlets. Keeping all crop residues on the surface in winter and early in spring helps to control soil blowing. Capability unit IIw-2; windbreak group 2.

Hidewood Series

Hidewood soils are nearly level and are somewhat poorly drained. They formed in silty material underlain by loam and clay loam till. These soils are in swales or shallow depressions.

In a typical profile the surface layer is black and very dark grayish-brown, neutral silty clay loam about 23 inches thick. The subsoil is olive-gray, neutral to mildly alkaline silt loam in the upper part and mottled olive, slightly calcareous loam in the lower part. It is about 15 inches thick and is friable throughout. The till is mottled olive-gray to light olive-gray, calcareous loam.

The content of organic matter in the surface layer of these soils is high. Reaction ranges from neutral to mildly alkaline. Fertility is naturally high. Permeability is moderate to moderately slow, and available water capacity is high. During the growing season the water table is high for a long enough period that root penetration is restricted. Because these soils are wet, they warm up later in spring than surrounding silty soils. The upper part of the profile generally is free of stones, but in places the lower part contains stones and boulders.

Many areas of Hidewood soils are drained and are used for cultivated crops. Undrained areas are used primarily for pasture.

Typical profile of Hidewood silty clay loam (SE¼NE¼NE¼ sec. 13, T. 124 N., R. 41 W.):

Ap—0 to 6 inches, black (N 2/0 to 10YR 2/1) silty clay loam; cloddy, but breaks to weak and moderate, fine, granular structure; friable when moist; neutral; abrupt, smooth boundary.

A11—6 to 12 inches, black (10YR 2/1) and very dark grayish-brown (2.5Y 3/2) silty clay loam; moderate, fine, subangular blocky structure; friable when moist; neutral; gradual, smooth boundary.

A12—12 to 23 inches, black (10YR 2/1) and very dark grayish-brown (2.5Y 3/2) silty clay loam; moderate, fine, subangular blocky structure; friable when moist; neutral; clear, smooth boundary.

B21g—23 to 30 inches, olive-gray (5Y 4/2) heavy silt loam that is olive (5Y 4/3) as depth increases; a few, fine, faint and distinct, gray and yellowish-brown mottles; weak and moderate, very fine and fine, subangular blocky structure; friable when moist; neutral to mildly alkaline; clear, smooth boundary.

IIB22—30 to 38 inches, olive (5Y 5/4) loam; a few, fine, prominent, yellowish-brown mottles; weak, medium, fine, subangular blocky structure; friable when moist; slightly calcareous; gradual, smooth boundary.

IIC—38 to 50 inches, olive-gray (5Y 5/2) to light olive-gray (5Y 6/2) loam; a few, fine, prominent, yellowish-brown mottles; massive; friable when moist; slightly calcareous.

The A horizon ranges from 14 to 24 inches in thickness. Thickness of the silty material ranges from 24 to 60 inches. The B horizon commonly contains the same amount of clay, or less, than the A horizon. The C horizon commonly is strongly calcareous and contains more free calcium carbonates than indicated in the typical profile. Depth to free carbonates ranges from 30 to more than 42 inches.

Hidewood soils have more silt in the surface layer and subsoil than Flom soils. They are noncalcareous to a greater depth than Winger soils.

Hidewood silty clay loam (0 to 1 percent slopes) (Hw).—This is the only Hidewood soil mapped in the county. It occupies circular or oblong flats and concave areas. The concave areas are likely to hold water for about 2 weeks after spring runoff and after heavy rains in summer. Areas of this soil generally are surrounded by nearly level, moderately well drained McIntosh soils and by poorly drained, calcareous Winger soils.

The thickness of the silty material overlying the glacial till varies greatly in this soil. In some places the silty material is 2 to 3 feet thick, and in others, it is 4 to 5 feet thick. In places a thin gravelly or sandy layer occurs between the silt loam and loam layers.

Included with this soil in mapping are many areas, in the lowest part of shallow depressions, that have a thicker surface layer than this soil; a subsoil that is more clayey than the surface layer; and continuous clay films on the surface of prisms. Other included small areas consist of wet, calcareous Winger soils on narrow rims near the outer edge of depressions.

Hidewood silty clay loam is well suited to cultivated crops when drained. Either open ditches or tile drains that have open inlets can be used to provide drainage. Undrained areas are used chiefly for pasture. Capability unit IIw-1; windbreak group 2.

Lamoure Series

In the Lamoure series are deep, nearly level, poorly drained soils. These soils are calcareous. They formed in loamy alluvium along the rivers and creeks in the county.

The surface layer in a typical profile is black, strongly calcareous silty clay loam about 17 inches thick. Below is very dark gray to dark-gray, strongly calcareous silt loam. The soil material is friable throughout.

Because the water table is high in these soils for much of the growing season, depth to which roots can penetrate is restricted. The content of organic matter is high. Available water capacity also is high. Permeability is moderately slow. Supplies of most plant nutrients generally are high, but the supply of available phosphorus is low in many places.

Lamoure soils are used chiefly for pasture.

Typical profile of Lamoure silty clay loam (NE¼NE¼SW¼ sec. 20, T. 123 N., R. 42 W.):

Ap—0 to 6 inches, black (N 2/0) light silty clay loam; moderate, very fine to fine, granular structure to moderate, fine, subangular blocky; friable when moist, slightly sticky when wet; a few fragments of snail shells; a few white specks; strongly calcareous; gradual, smooth boundary.

A11—6 to 17 inches, black (N 2/0) light silty clay loam; moderate, very fine to fine, granular structure; friable when moist, slightly sticky when wet; many fragments of snail shells; strongly calcareous; gradual, smooth boundary.

A12g—17 to 29 inches, very dark gray (N 3/0 to 10YR 3/1) silty clay loam; moderate, very fine to fine, granular structure; friable when moist, slightly sticky when wet; many fragments of snail shells; strongly calcareous; diffuse, smooth boundary.

A13g—29 to 39 inches, very dark gray (N 3/0 to 10YR 3/1) to dark-gray (N 4/1 to 5Y 4/1) silty clay loam; moderate, very fine to fine, granular structure; friable when moist, slightly sticky when wet; many fragments of snail shells; strongly calcareous; diffuse, smooth boundary.

A14g—39 to 51 inches, dark-gray (N 4/0 to 5Y 4/1) silty clay loam; moderate to strong, very fine, granular structure; friable when moist, slightly sticky when wet; many fragments of snail shells; calcareous.

The Ap and A11 horizons range from heavy silt loam to light silty clay loam in texture. Thin strata of sandier material are common in these horizons. Snail shells ordinarily occur throughout the profile. Gypsum crystals range from common to many in the underlying material.

Lamoure soils are better drained than Rauville soils.

Lamoure silty clay loam (0 to 1 percent slopes) (Lm).—This soil has the profile described for the series. Most areas are on narrow flood plains along the Chippewa and Pomme de Terre Rivers. The areas are long and narrow and are adjacent to lower lying Rauville soils and to Alluvial land, frequently flooded. Adjacent slightly higher terraces are occupied by slightly droughty and droughty Fordville, Renshaw, and Sioux soils. In some places the surface layer of this soil is 3 to 4 feet thick. A few areas, mainly in Swan Lake Township, are underlain by sand and gravel at a depth between 2 and 3 feet.

Included with this soil in mapping are a few small areas of wet Rauville soils. Also included are some areas where gypsum crystals are at a depth between 6 and 24 inches and make up from 20 to 30 percent of the soil mass.

A few small areas of Lamoure silty clay loam are used for the cultivated crops commonly grown in the county because runoff is slightly better than on most areas. Also the water table is slightly lower. Many areas cannot be adequately drained because suitable outlets are lacking.

These are used chiefly for pasture or hay. Bluegrass is the most common pasture plant.

This soil contains so much lime as to cause a moderate imbalance of plant nutrients. Adding phosphorus, and possibly iron or zinc, helps to correct the imbalance. This soil warms slowly in spring. From time to time some areas are flooded during thaws early in spring. The flooding occurs before the growing season, however, and little damage is done. Capability unit IIw-2; windbreak group 2.

Lamoure silty clay loam, frequently flooded (0 to 1 percent slopes) (Ln).—Most areas of this soil are on the flood plains of Mud Creek. The areas are flooded each year during spring thaws and in summer after heavy rains. Except for flooding, this soil is similar to Lamoure silty clay loam.

Included with this soil in mapping are small areas on higher elevations than this soil that have better runoff and normally are not flooded. Also included are small areas of the wet Rauville soils.

Flooding makes this Lamoure soil better suited to pasture, wildlife, and woodland than to other uses. Capability unit VIw-1; windbreak group 7.

La Prairie Series

In the La Prairie series are deep, nearly level, moderately well drained soils. These soils formed in alluvium underlain by stratified sand and gravel. They are in the valley of the Pomme de Terre River.

The surface layer in a typical profile is black loam about 24 inches thick. Just below is about 4 inches of black to very dark brown loam. The surface and subsurface layers are neutral in reaction. The subsoil is very dark grayish-brown to dark grayish-brown, friable loam in the upper part and dark-brown to olive-brown loam in the lower part. It is neutral to mildly alkaline and is about 22 inches thick. Calcareous, loose, stratified sand and gravel is at a depth of about 50 inches.

These soils have high nutrient supplying capacity. The content of organic matter in the surface soil and the available water capacity also are high. Runoff is medium to slow, and internal drainage is medium. Water moves through these stone-free soils at a moderate rate.

La Prairie soils are used chiefly for cultivated crops.

Typical profile of La Prairie loam (NE¼NE¼SW¼ sec. 32, T. 123 N., R. 42 W.):

Ap—0 to 6 inches, black (10YR 2/1) loam; cloddy, but breaks to weak, very fine, granular structure; friable when moist; neutral; abrupt, smooth boundary.

A11—6 to 12 inches, black (10YR 2/1) loam; weak, very fine, granular structure; friable when moist; neutral; gradual, smooth boundary.

A12—12 to 20 inches, black (10YR 2/1) to very dark brown (10YR 2/2) loam, very dark grayish brown (10YR 3/2) when crushed; weak, fine, granular structure; friable when moist; neutral; gradual, smooth boundary.

A13—20 to 24 inches, black (10YR 2/1) loam, black (10YR 2/1) to very dark brown (10YR 2/2) when crushed; weak, fine, subangular blocky structure; friable when moist; neutral; gradual, smooth boundary.

A3—24 to 28 inches, black (10YR 2/1) to very dark brown (10YR 2/2) loam, very dark brown (10YR 2/2) when crushed; weak, very fine, subangular blocky structure; friable when moist; neutral; gradual, smooth boundary.

B21—28 to 35 inches, very dark grayish-brown (10YR 3/2) to dark grayish-brown (10YR 4/2) loam, dark grayish brown (2.5Y 4/2) when crushed; weak and moderate, fine, subangular blocky structure; friable when moist; neutral; gradual, smooth boundary.

B22—35 to 47 inches, dark-brown (10YR 4/3) to olive-brown (2.5Y 4/4) loam; weak, medium and fine, subangular blocky structure; friable when moist; mildly alkaline; abrupt, wavy boundary.

IIB3ca—47 to 50 inches, light olive-brown (2.5Y 5/4) loamy sand; single grain (structureless); loose when moist; slightly calcareous; abrupt, smooth boundary.

IICca—50 to 54 inches, yellowish-brown (10YR 5/4) and light yellowish-brown (10YR 6/4), stratified sand and gravel; calcareous.

The A horizon ranges from 16 to 28 inches in thickness and from loam to silt loam in texture. Depth to the IICca horizon ranges from 3½ to 7 feet. In Stevens County, La Prairie soils are predominantly loamy, rather than silty, throughout the profile.

La Prairie loam (0 to 1 percent slopes) (Lp).—This is the only La Prairie soil mapped in the county. It occupies large flats and drainageways adjacent to well-drained Fordville soils and droughty Renshaw and Sioux soils. In some places this soil has a clay loam subsoil that is well structured and has continuous clay films. A buried soil profile is common in places.

Included with this soil in mapping are small areas that are shallower than 42 inches to gravel. A few small areas of well-drained Fordville soils also are included. Other small areas are somewhat poorly drained.

La Prairie loam is well suited to all of the common crops grown in the county and is used chiefly for cultivated crops. It generally is in good tilth. Only minimum tillage is needed for preparing a seedbed. Limitations in use are few. Capability unit I-1; windbreak group 1.

Maddock Series

The Maddock series consists of nearly level to gently sloping, well-drained soils. These soils occur mainly along the rivers, terraces, and outwash areas of the county. Some areas, however, are in the uplands in the southeast corner of the county.

In a typical profile the surface layer is black sandy loam and loamy sand about 12 inches thick. The subsoil is dark yellowish-brown, loose sand about 16 inches thick. Below is yellowish-brown to light yellowish-brown and pale-brown, calcareous, loose sand.

The surface layer and subsoil are neutral to mildly alkaline. The content of organic matter and supply of available phosphorus in the surface layer are medium; the supply of available potassium is low. Permeability is rapid, and the infiltration rate is fairly high. The available water capacity is very low, and the soils are droughty. Roots can penetrate deep into these sandy soils. Tillage is easier than in any other soils in the county. Maddock soils warm up early in spring.

Nearly all areas of these soils are used for cultivated crops. Some areas, however, are planted to grass and are used for pasture.

Typical profile of Maddock sandy loam (NW¼NW¼ NW¼ sec. 6, T. 125 N., R. 41 W.):

Ap—0 to 6 inches, black (10YR 2/1) sandy loam to loamy sand; cloddy, but breaks to weak, fine and medium, granular structure; very friable when moist; neutral; abrupt, smooth boundary.

A1—6 to 12 inches, black (10YR 2/1) to very dark brown (10YR 2/2) loamy sand; weak, fine and medium, granular structure; very friable when moist; neutral; gradual, smooth boundary.

B2—12 to 28 inches, dark yellowish-brown (10YR 4/4) sand; single grain (structureless); loose when moist; neutral; clear, smooth boundary.

C1ca—28 to 32 inches, yellowish-brown (10YR 5/4) sand; single grain (structureless); loose when moist; band of pebbles at 32 inches; calcareous; abrupt, smooth boundary.

C2ca—32 to 52 inches, pale-brown (10YR 6/3) to light yellowish-brown (10YR 6/4) sand; single grain (structureless); loose when moist; calcareous; abrupt, smooth boundary.

C3—52 to 56 inches, uncoated calcareous sand.

The A horizon ranges from 6 to 12 inches in thickness. Depth to the underlying calcareous material usually ranges from 22 to 48 inches but in places may be 5 or 6 feet. Other places may be calcareous at or near the surface. The B2 horizon ranges from loamy sand to sand. In many places the lower part of the profile is stratified with sand that ranges in size from fine to coarse and contains a few pebbles.

Maddock soils have more sand and less clay and silt in the upper part of the profile than Sverdrup soils.

Maddock sandy loam, 0 to 4 percent slopes (MaB).—This is the only Maddock soil mapped in the county. Many areas are adjacent to excessively drained and somewhat excessively drained Renshaw, Sioux, and Sverdrup soils on river terraces. Others are adjacent to well-drained Barnes soils in the uplands. Slopes generally are less than 100 feet long.

In some places this soil is noncalcareous to a depth of 5 or 6 feet. In other places the soil is calcareous at or near the surface. These areas are grayish colored in freshly plowed fields.

Permeability is rapid, and little water runs off this soil. The supply of moisture and the capacity to supply plant nutrients are very low.

Most of the crops commonly grown in the county can be grown on this soil, though plant growth generally is poor. Corn or soybeans are poorly suited; small grains that mature by midsummer are better suited. If this soil is plowed in fall and all crop residues are turned under, soil blowing is a hazard when strong winds blow. Capability unit IVs-1; windbreak group 4.

Malachy Series

The Malachy series consists of nearly level, moderately well drained, slightly calcareous soils. These soils formed in loamy material underlain by coarse sand at a depth between 1½ and 3 feet. They are in the southeast corner of the county.

In a typical profile the surface layer is black, mildly alkaline sandy loam about 14 inches thick. Just below is about 4 inches of very dark gray sandy loam. The subsoil is friable sandy loam and loam about 12 inches thick. It is dark grayish brown and very dark grayish brown in the upper 4 inches and grayish brown below. Light olive-brown coarse sand is at a depth of about 30 inches.

These soils are mildly alkaline to moderately alkaline. Available water capacity is low. The water table is at a depth of 3 to 4 feet, however, and plants can obtain substantial amounts of water from it and are not entirely dependent upon rainfall. Malachy soils are low in available phosphorus and low to medium in available potassium. The content of organic matter in the surface and subsurface layers is high.

Nearly all areas of Malachy soils are used for cultivated crops.

Typical profile of Malachy sandy loam, 0 to 2 percent slopes (SE¼SW¼NE¼ sec. 24, T. 123 N., R. 41 W.):

Ap—0 to 8 inches, black (10YR 2/1) heavy sandy loam; cloddy; friable when moist; slightly calcareous; mildly alkaline; abrupt, smooth boundary.

A1—8 to 14 inches, black (10YR 2/1) heavy sandy loam; a few narrow tongues of very dark gray (10YR 3/1) material; weak, fine and medium, subangular blocky structure; friable when moist; calcareous; mildly alkaline; abrupt, smooth boundary.

A3—14 to 18 inches, very dark gray (10YR 3/1) heavy sandy loam; a few narrow tongues of very dark grayish-brown (2.5Y 3/2) material; weak, fine and medium, subangular blocky structure; friable when moist; slightly calcareous; moderately alkaline; abrupt, smooth boundary.

B2—18 to 22 inches, dark grayish-brown (2.5Y 4/2) and very dark grayish-brown (2.5Y 3/2) heavy sandy loam; a few grayish-brown (2.5Y 5/2) worm channels; weak, medium, prismatic structure that breaks to weak, fine and medium, subangular blocky; friable when moist; slightly calcareous; moderately alkaline; abrupt, smooth boundary.

B3ca—22 to 30 inches, grayish-brown (2.5Y 5/2) light loam; common, fine, faint, light olive-brown (2.5Y 5/4) mottles; weak, medium, prismatic structure that breaks to weak, fine and medium, subangular blocky; friable when moist; calcareous; moderately alkaline; abrupt, smooth boundary.

IIC—30 to 42 inches, light olive-brown (2.5Y 5/4) coarse sand; single grain (structureless); loose when moist; calcareous; moderately alkaline.

The Ap and A1 horizons range from 8 to 16 inches in thickness. They range from sandy loam to light loam in texture and are about 14 to 16 percent clay. More silt and clay commonly occur in the layer just above the underlying coarse sand. This layer also contains more lime. Thickness of the loamy A and B horizons ranges from 18 to 36 inches.

Malachy soils are better drained than Marysland soils. Also, they are less calcareous in the surface and subsurface layers.

Malachy sandy loam, 0 to 2 percent slopes (MfA).—This is the only Malachy soil mapped in the county. It is on slight swells on the smooth outwash plain in the southeast corner of the county. The areas adjoin lower lying, wet Marysland soils and higher lying, droughty Sverdrup soils.

This soil varies. In some places depth to underlying sand is shallower than in the profile described for the series. Also, the subsurface layer and subsoil generally are sandier. Other areas are noncalcareous to a depth between 12 and 15 inches.

Included with this soil in mapping are small areas of Marysland and Sverdrup soils. Also included are some areas that are somewhat poorly drained.

Nearly all areas of Malachy sandy loam, 0 to 2 percent slopes, are used for the cultivated crops commonly grown in the county. Plant growth is not so good as on some other soils in the county. The available water capacity is low, and the soil is likely to be slightly droughty in July and August. If the soil is left unprotected, soil blowing is a hazard in winter and early in spring. Capability unit IIIs-3; woodland group 6.

Malachy series, Loamy Subsoil Variant

This variant from the normal Malachy soils is nearly level and moderately well drained. It formed in fine sandy loam and fine sand underlain by moderately fine textured and fine-textured material at a depth of about 2 feet. It is in the northwestern part of the county.

In a typical profile the surface layer is black fine sandy loam about 9 inches thick. Just below is about 4 inches of black to very dark gray, very friable fine sandy loam. The subsoil is very dark grayish-brown, very friable fine sandy loam in the upper part and dark grayish-brown to grayish-brown, loose loamy fine sand in the lower part. It is moderately alkaline. Mottled olive-gray, firm, strongly calcareous silty clay loam is at a depth of about 25 inches.

This variant has high available water capacity. Permeability of the fine sandy loam and loamy fine sand is moderate to moderately rapid; permeability of the loamy substratum is moderately slow. In places a perched water table stands above the underlying material during wet periods and restricts penetration of roots. The content of organic matter generally is high. Fertility generally is medium.

The loamy subsoil variant of the Malachy series is used chiefly for cultivated crops.

Typical profile of Malachy fine sandy loam, loamy subsoil variant (SE¼SW¼SE¼ sec. 6, T. 126 N., R. 44 W.):

Ap—0 to 9 inches, black (10YR 2/1) fine sandy loam; weak, very fine, granular structure to weak, subangular blocky; very friable when moist; slightly calcareous; moderately alkaline; abrupt, smooth boundary.

A1—9 to 13 inches, black (10YR 2/1) to very dark gray (10YR 3/1) fine sandy loam; weak, very fine, subangular blocky structure; very friable when moist; slightly calcareous; moderately alkaline; gradual, smooth boundary.

B21—13 to 22 inches, very dark grayish-brown (10YR 3/2) fine sandy loam; weak, very fine, subangular blocky structure; very friable when moist; slightly calcareous; moderately alkaline; gradual, smooth boundary.

B22—22 to 25 inches, dark grayish-brown (2.5Y 4/2) to grayish-brown (2.5Y 5/2) loamy fine sand mixed with light brownish gray (2.5Y 6/2) to light yellowish brown (2.5Y 6/4); single grain (structureless); loose when moist; a few iron and manganese concretions; slightly calcareous; moderately alkaline; abrupt, smooth boundary.

IICcag—25 to 35 inches, olive-gray (5Y 5/2) silty clay loam; a few, fine, prominent, yellowish-brown mottles and light-gray lime concretions; massive (structureless); firm when moist; strongly calcareous.

The A horizon ranges from 6 to 12 inches in thickness. The B22 horizon ranges from loamy fine sand to fine sand in texture. Depth to underlying material, which ranges from silty clay loam to silty clay in texture, is 20 to 30 inches.

This variant from the normal Malachy soils has a less calcareous surface soil and subsoil than Grimstad soils. It has less clay in the surface soil and subsoil than Malachy soils, and it lacks the sandy substratum typical of those soils.

Malachy fine sandy loam, loamy subsoil variant (0 to 1 percent slopes) (Mc).—This is the only variant from the normal Malachy soils mapped in the county. It occupies small areas, chiefly in the basin of old glacial Lake Agassiz. The areas are adjacent to Grimstad and Rockwell soils.

Included with this soil in mapping are some areas as deep as 40 inches and other areas that are shallower than this soil. Also included are some areas that have a noncalcareous surface soil and subsoil. Some small concave areas have poor drainage, and some included small areas are somewhat poorly drained.

Malachy fine sandy loam, loamy subsoil variant, is well suited to all crops commonly grown in the county, and all areas are cultivated. Most crops on this soil respond if fertilizer that contains nitrogen, phosphorus, and potassium is applied. Soil blowing is a severe hazard if the soil is left bare in winter and early in spring. Even though the available water capacity is high, growth of crops is limited in some years because a perched water table hinders root development. Capability unit IIs-2; windbreak group 6.

Marsh

Marsh (Mh) consists of poorly drained areas that normally have 1 to 3 feet of water on them. A dense growth of cattails, reeds, sedges, and other plants that tolerate wetness covers most areas, but some areas consist chiefly of open water. Drainage is not feasible at the present time.

Areas of Marsh provide excellent food and cover for many kinds of wildlife. Capability unit VIIIw-1; windbreak group 7.

Marysland Series

Marysland soils are deep, nearly level, poorly drained, and calcareous. These soils formed in loamy material underlain by coarse-textured outwash sand at a moderate depth. They are in the southeast corner of the county.

In a typical profile the surface layer is black, calcareous sandy loam about 10 inches thick. Just below is about 5 inches of black to very dark gray, strongly calcareous sandy loam. The underlying material is friable, strongly calcareous sandy loam to loam. It is dark gray in the upper part and gray to olive gray in the lower part. Depth to multicolored, loose, slightly calcareous coarse sand is about 32 inches.

The water table is within a few inches of the surface of these soils during the early part of the growing season and after heavy rains. It limits depth to which roots can penetrate. Drainage is needed if the soils are to be cropped continuously. Permeability of the sandy loam and loam is moderately rapid, and that of the sandy material is rapid. Supplies of available phosphorus and potassium generally are low. The content of organic matter in the surface layer generally is high. These soils contain no stones that would hinder tillage.

Many areas of Marysland soils are drained and are used for cultivated crops. Areas undrained are used chiefly for pasture.

Typical profile of Marysland sandy loam (NE¼NW¼NE¼ sec. 36, T. 123, N., R. 41 W.):

Ap—0 to 6 inches, black (N 2/0 to 10YR 2/1) heavy sandy loam; cloddy, but breaks to weak, fine, granular structure; friable when moist; calcareous; abrupt, smooth boundary.

A11—6 to 10 inches, black (N 2/0 to 10YR 2/1) heavy sandy loam; weak, fine, granular structure; friable when moist; moderately calcareous to strongly calcareous; clear, smooth boundary.

A12ca—10 to 15 inches, black (10YR 2/1) to very dark gray (10YR 3/1) sandy loam; weak, fine, granular structure;

friable when moist; strongly calcareous; abrupt, wavy boundary.

C1ca—15 to 25 inches, dark-gray (10YR 4/1) heavy sandy loam to loam that has spots of gray (10YR 6/1); weak, fine, subangular blocky structure; friable when moist; strongly calcareous; abrupt, wavy boundary.

C2g—25 to 32 inches, gray (5Y 5/1) to olive-gray (5Y 5/2) heavy sandy loam to loam; weak, fine, subangular blocky structure; friable when moist; strongly calcareous; abrupt, smooth boundary.

IIC3g—32 to 42 inches, multicolored, loose, coarse sand; slightly calcareous.

The A horizon has a thickness ranging from 7 to 16 inches. Normally, the A1, C1, and C2 horizons are more than 14 percent clay and range from sandy loam to loam or light sandy clay loam in texture. In Stevens County, Marysland soils contain slightly less silt and clay than in other places. Thickness of the loamy material ranges from 24 to 36 inches.

Marysland soils are more calcareous than Malachy soils and have poorer drainage.

Marysland sandy loam (0 to 1 percent slopes) (Mr).—This is the only Marysland soil mapped in the county. It is in low-lying swales in smooth, nearly level outwash areas. It adjoins moderately well drained Malachy soils on slightly higher areas. Very poorly drained Biscay soils occupy the deeper depressions.

Included with this soil in mapping are small areas of soil that are shallower than this soil to underlying sandy material and some areas that are more than 42 inches deep to the underlying material. Also included are small areas of Biscay and Malachy soils and of a somewhat poorly drained soil.

Marysland sandy loam is suited to all crops commonly grown in the county, and many areas are cultivated. Growth of plants is moderate to good. Undrained areas are suitable for pasture. Surface drains can be used for draining this soil. Tile drains are not suitable, because the underlying sandy material is likely to flow when wet and plug the tile. Capability unit IIw-3; windbreak group 5.

McIntosh Series

The McIntosh series consists of nearly level to gently sloping, moderately well drained, calcareous soils. These soils formed in silty sediment underlain by loam and clay loam glacial till. They are in the northwestern and southeastern parts of the county.

In a typical profile the surface layer is black silt loam, and the subsurface layer is very dark gray silt loam. Both layers are calcareous and each is about 7 inches thick. They are underlain by grayish-brown, friable silt loam that is strongly calcareous. Below is mottled light olive-brown to light yellowish-brown loam that is strongly calcareous and calcareous.

These soils contain so much lime as to have an imbalance of plant nutrients. They are particularly low in available phosphorus, but in many places they are high to very high in available potassium. The content of organic matter in the surface soil is high. Available water capacity also is high. Workability of these friable soils is good. Depth to which roots can penetrate generally is not restricted. Cobblestones and other stones generally do not occur in the upper part of these soils.

Nearly all areas of McIntosh soils are used for cultivated crops.

Typical profile of McIntosh silt loam, 0 to 3 percent slopes (NW¼NW¼SW¼ sec. 27, T. 124 N., R. 41 W.):

Ap—0 to 7 inches, black (10YR 2/1) silt loam; cloddy, but breaks to weak, very fine, granular structure; friable when moist, slightly sticky when wet; many roots; calcareous; abrupt, smooth boundary.

A1ca—7 to 14 inches, very dark gray (2.5Y 3/1 to 10YR 3/1) silt loam; weak, very fine, granular structure; friable when moist, slightly sticky when wet; many roots and gypsum crystals; calcareous; clear, irregular boundary.

C1ca—14 to 21 inches, grayish-brown (2.5Y 5/2 to 5/3) silt loam; weak, fine, granular structure; friable when moist, slightly sticky when wet; a few gypsum crystals; strongly calcareous; clear, smooth boundary.

IIC2ca—21 to 36 inches, light olive-brown (2.5Y 5/4) to light yellowish-brown (2.5Y 6/4) loam; common, fine, prominent, strong-brown (7.5YR 5/8) mottles and a few, fine, prominent, gray (10YR 6/1) mottles; weak, very fine, granular structure; friable when moist, slightly sticky when wet; strongly calcareous; clear, smooth boundary.

IIC3—36 to 54 inches, light olive-brown (2.5Y 5/4 loam: many, medium, prominent, gray (10YR 6/1) mottles and a few, fine, prominent, strong-brown (7.5YR 5/8) mottles; weak, very fine, granular and subangular blocky structure; friable when moist, slightly sticky when wet; a few iron and manganese concretions; calcareous.

The Ap horizon has a thickness ranging from 6 to 9 inches, and the A1ca horizon, a thickness of 3 to 10 inches. The mantle of silt varies in thickness within a short distance. It typically ranges from 24 to 30 inches in thickness. In some places, however, the silt mantle is only about 18 inches thick, and in other places, it is as much as 36 inches thick.

McIntosh soils have better drainage than Winger soils and a browner subsurface. They have more silt in the surface and subsurface layers than Hamerly soils.

McIntosh silt loam, 0 to 3 percent slopes (MsA).—This is the only McIntosh soil mapped in the county. It occupies irregular shaped areas adjacent to lower lying flats and depressions of poorly drained and somewhat poorly drained Hidewood and Winger soils. Very poorly drained Parnell soils are in the deep potholes. In many places in the northwestern part of the county, this soil adjoins areas of somewhat poorly drained Bearden soils and of low-lying, poorly drained Colvin soils.

Included with this soil in mapping are small areas of Bearden, Colvin, Hidewood, Parnell, and Winger soils. Also included, in areas that have a very thin mantle of silt or that lack such a mantle, are some areas of Hamerly soils. Many small grayish spots are also included with this soil. On these lighter colored areas, soybeans and flax are likely to be affected by the imbalance of plant nutrients.

McIntosh silt loam, 0 to 3 percent slopes, is suited to all crops commonly grown in the county, and most areas are cultivated. If this soil is plowed in fall and crop residues turned under, soil blowing is likely to be a slight hazard in winter and early in spring. Capability unit IIs-2; windbreak group 3.

Muck and Peat

Three organic soils occur in the county. Muck and peat, calcareous, is mainly in the uplands; Muck and peat, calcareous, flooded, is along rivers; and Muck, shallow, is in the uplands and on river terraces.

Muck and peat, calcareous (0 to 1 percent slopes) (Mv).—These soils occur mainly in wet upland sloughs throughout the county. They formed in calcareous, organic material more than 3½ feet thick. Areas in the uplands are underlain by loamy and clayey material, and areas along rivers, by gravelly material. Sedges, cattails, reeds, and rushes form a dense vegetative cover on the areas.

The water table generally is within a few inches of the surface of these soils, and the areas usually are flooded during part of the growing season. These soils are more than 30 percent organic matter. Permeability is moderately slow, and available water capacity is high. Reaction is moderately alkaline.

Most areas of these soils are undrained and provide excellent cover for wildlife. Some undrained areas are pastured along with surrounding land but provide only limited grazing. Drained areas are well suited to corn and soybeans. Small grains are likely to lodge. Frost comes earlier to the low-lying areas occupied by these soils than to other areas in the county. Capability unit IIIw-2; windbreak group 7.

Muck and peat, calcareous, flooded (0 to 1 percent slopes) (Mw).—These soils are in low-lying areas along the Pomme de Terre River. They have a dense cover of reeds and cattails.

Areas of these soils are flooded frequently during spring runoff and after heavy rains in summer. Because of their location next to the river, drainage is not feasible. These soils are not suited to any of the crops commonly grown in the country, but they are suitable for use as wildlife habitats. Capability unit VIw-1; windbreak group 7.

Muck, shallow (0 to 1 percent slopes) (Mu).—This organic soil occupies wet sloughs on uplands and on river terraces. A dense cover of marsh grasses and cattails is on the areas. Muck, shallow, is noncalcareous and is thinner than Muck and peat, calcareous. Thickness of the mildly alkaline, organic material that makes up this soil generally ranges from 18 to 36 inches. The underlying material generally is loamy and clayey, though a few areas, chiefly on river terraces, are underlain by sand and gravel.

Included with this soil in mapping are a few areas that contain snail shells and are calcareous throughout.

Many areas of Muck, shallow, are undrained and provide excellent cover for wildlife. Areas that are partly drained generally are planted to reed canarygrass and provide excellent pasture. Some upland areas have been drained and are used for cultivated crops, which are moderately suited to well suited. Corn and soybeans are the most common crops grown. Small grains are likely to lodge. Capability unit IIIw-2; windbreak group 7.

Nutley Series

Nutley soils are deep, nearly level and gently sloping, and well drained. They formed in the uplands on clayey material.

In a typical profile the surface layer is black clay that is plastic when wet and is about 7 inches thick. Just below is about 10 inches of neutral to moderately alkaline, very dark gray clay that is plastic when wet and has darker streaks in the lower part. The underlying material consists of dark grayish-brown to olive-gray clay that is moderately calcareous and has a few mottles.

The content of organic matter in the surface layer of these soils is high. Permeability of the soils is slow, and available water capacity is high. The soils are neutral to mildly alkaline. These plastic, clayey soils are difficult to plow. As they dry, many cracks form in them. A few stones are in these soils.

In this county most areas of Nutley soils are mapped in a complex with Hattie soils. A description of Hattie soils is given under the Hattie series.

Nutley soils are used mainly for cultivated crops.

Typical profile of a Nutley clay (NW¼NW¼NE¼ sec. 1, T. 126 N., R. 42 W.):

Ap—0 to 7 inches, black (10YR 2/1 to N 2/0) clay; strong, very fine, granular structure; friable when moist, plastic when wet; neutral; abrupt, smooth boundary.

A11—7 to 11 inches, very dark gray (10YR 3/1) and black (10YR 2/1 to N 2/0) clay; moderate, medium, prismatic structure that breaks to moderate, strong, very fine and fine, subangular blocky; firm when moist, plastic when wet; neutral; gradual, smooth boundary.

A12—11 to 17 inches, very dark gray (10YR 3/1) clay; streaks of black (N 2/0), dark grayish brown (2.5Y 4/2), and very dark gray (10YR 3/1) are in the lower part; strong, medium and coarse to fine, prismatic structure that breaks to moderate, fine and very fine, subangular blocky; firm when moist, plastic when wet; moderately alkaline; clear, irregular boundary.

C1—17 to 32 inches, dark grayish-brown (2.5Y 4/2) to grayish-brown (2.5Y 5/2) clay, dark grayish brown (2.5Y 4/2) to light olive brown (2.5Y 5/4) when crushed; moderate, medium, prismatic structure that breaks to moderate, medium and fine, subangular blocky; firm when moist, plastic when wet; calcareous; clear, irregular boundary.

C2—32 to 43 inches, dark grayish-brown (2.5Y 4/2) to olive-brown (2.5Y 4/4) clay; a few, fine, prominent, reddish-brown mottles, dark grayish brown (2.5Y 5/2) when clay is crushed; moderate, medium, fine and very fine, subangular blocky structure; firm when moist, plastic when wet; strongly calcareous; gradual, smooth boundary.

C3—43 to 54 inches, olive-gray (5Y 5/2) clay, dark grayish brown (2.5Y 4/2) to olive brown (2.5Y 4/4) when crushed; a few, fine, faint, dark-gray to gray mottles and a few, fine, distinct, olive mottles; moderate, medium to fine and very fine, subangular blocky structure; firm when moist, plastic when wet; strongly calcareous.

The A horizon ranges from 16 to 20 inches in thickness. The content of clay is about 50 to 65 percent. Depth to free carbonates ranges from 16 to 24 inches. Many black vertical tongues of material extend from the lower part of the subsurface to a depth of 30 inches.

Nutley soils lack the calcareous surface layer typical of Hattie soils and have a thicker surface layer and subsurface. They contain more clay than Aastad soils.

Nutley-Hattie clays, 0 to 2 percent slopes (NhA).—This complex consists of clayey Nutley and Hattie soils. The soil layers change within a horizontal distance of a few feet, and the proportion of each soil varies from one place to another. Each soil, however, normally occupies about 50 percent of each mapped area. The areas adjoin lower lying, wet Dovray and Hegne soils. Runoff is medium to slow, and the soils are somewhat wetter than gently sloping and steeper soils.

Included with this complex in mapping are small areas of Dovray and Hegne soils. Also included are some areas that have only a thin cap of clayey glacial till over clay loam glacial till. In these areas the soil is coarser textured in the lower part than typical Nutley and Hattie soils. Also included are a few areas in Rendsville Township that are 40 to 50 feet across and consist of 6 to 12 inches of loamy material over clayey material.

The soils in this complex are well suited to all crops commonly grown in the county. Workability of these clayey soils is poor, and timely tillage is needed. The soils remain wet for a longer time after rains than loamy soils that have similar runoff. Soil blowing is a serious hazard when strong winds blow in winter and early in spring, particularly if plowing is done in fall and all crop residues are turned under. Capability unit IIs-3; windbreak group 1.

Nutley clay, silty substratum, 0 to 2 percent slopes (NcA).—This soil occurs mainly in the south-central part of Synnes Township in the basin of a glacial lake. A smaller area is in the southwestern part of Eldorado Township in the basin of glacial Lake Agassiz.

This soil is underlain by silty sediment at a depth between 2½ and 4 feet, but its profile otherwise is similar to that of the Nutley clay described as typical for the series. In Eldorado Township thickness of the clayey material commonly is about 48 inches, but it is thinner in some places and thicker in others.

Included with this soil in mapping are soils that consist of a clayey layer; a thin silty layer; and then loam glacial till at a depth of about 3½ feet. Areas of these soils are on slight rises and rims around small islands of loam till occupied by Barnes soils, which presumably were above the water level of the glacial lake. A few included areas have a calcareous surface layer and subsurface.

This Nutley soil is used for feed grains, grasses, and legumes. Soil blowing is a hazard in winter and early in spring if the areas are left bare. Timely tillage is needed for maintaining good tilth in these clayey soils. Also needed are practices that maintain or improve fertility. Capability unit IIs-3; windbreak group 1.

Oldham Series

Oldham soils are nearly level, poorly drained, and calcareous. They occupy low-lying areas scattered throughout much of the county. The native vegetation consists of reeds, sedges, cattails, and similar plants.

In a typical profile the surface layer is black silty clay loam, about 20 inches thick, that contains many fragments of snail shells. Below is black and very dark gray, friable silty clay loam that also contains many fragments of snail shells. The soil is calcareous throughout.

Permeability is moderately slow in these soils. Internal drainage is very slow, and available water capacity is high. The content of organic matter is high.

Some areas of Oldham soils have been drained and are used for cultivated crops. Areas undrained provide excellent cover for wildlife.

Typical profile of Oldham silty clay loam (NE¼-NE¼NW¼ sec. 5, T. 124 N., R. 43 W.):

Ap—0 to 7 inches, black (N 2/0 to 5Y 2/1) silty clay loam; weak, fine, granular and subangular blocky structure; friable when moist; many fragments of snail shells; calcareous; abrupt, smooth boundary.

A11g—7 to 20 inches, black (N 2/0) silty clay loam; weak, very fine and fine, subangular blocky structure; friable when moist; many fragments of snail shells; a few gypsum crystals; calcareous; gradual, smooth boundary.

A12g—20 to 27 inches, black (5Y 2/1) silty clay loam; a few, fine, faint, olive mottles; weak, very fine, subangular blocky structure; friable when moist; many fragments of snail shells; a few gypsum crystals; calcareous; gradual, smooth boundary.

A13g—27 to 35 inches, very dark gray (5Y 3/1) silty clay loam to silt loam; a few, fine, faint, olive mottles; weak, very fine, subangular blocky structure; friable when moist; many fragments of snail shells; strongly calcareous; gradual, smooth boundary.

A14gb—35 to 45 inches, black (5Y 2/1) silty clay loam; a few, medium, faint, olive mottles; weak, very fine, subangular blocky structure; friable when moist; many fragments of snail shells; calcareous.

A15g—45 to 55 inches, very dark gray (5Y 3/1) silty clay loam; common, medium, faint, olive (5Y 4/3) mottles; massive (structureless); friable when moist; a few fragments of snail shells; slightly calcareous; gradual, smooth boundary.

A16g—55 to 80 inches, black (5Y 2/1) silty clay loam that as depth increases is very dark gray (5Y 3/1 to 4/1); common, medium, faint, olive-gray (5Y 4/2) mottles; massive (structureless); a few fragments of snail shells; calcareous.

The black and very dark gray silty clay loam material varies in thickness, but it typically is thicker than 3½ feet. These soils are calcareous throughout. Gypsum crystals are lacking in places.

Oldham soils contain less organic matter than Blue Earth soils. They are more alkaline than Parnell soils.

Oldham silty clay loam (0 to 1 percent slopes) (Om).—This is the only Oldham soil mapped in the county. It occupies sloughs that are circular and oblong in shape. The areas range from about 10 to 20 acres in size. Much water from surrounding areas drains onto areas of this low-lying soil. As much as a foot of runoff water is likely to stand on the areas for part of the normal growing season. By midsummer, the areas may be dry.

On the outwash plain in Moore Township are a few areas underlain by sand at a depth of more than 3½ feet. In some places the underlying material is peat, which is at a depth between 7 and 10 feet. In other places the soil is underlain by glacial till at a depth between 4 and 5 feet.

Undrained areas of Oldham silty clay loam are not suitable for cultivated crops. Drained areas are suited to all cultivated crops commonly grown in the county. This soil contains so much lime that availability of phosphorus and some other plant nutrients is low. The chief concerns of management are correcting the deficiency of plant nutrients and providing drainage for removal of excess surface water. Capability unit IIIw-3; windbreak group 2.

Parnell Series

The Parnell series consists of nearly level, poorly drained soils. These soils are in deep potholes or sloughs. The vegetation consists of marsh grasses, cattails, and similar kinds of plants.

In a typical profile the surface layer is black, neutral to mildly alkaline silty clay loam about 30 inches thick. Below is black to very dark gray, firm, neutral silty clay loam to silty clay about 8 inches thick; about 8 inches of gray to olive-gray, friable silty clay loam that is slightly calcareous to moderately calcareous; and then the olive-gray, slightly calcareous clay loam glacial till.

Runoff ponds on these soils, and internal drainage is slow. Permeability is moderately slow, and the available water capacity is high. Because of the high water table, the root zone is shallow. The supply of plant nutrients is adequate, and the soils generally are fertile. The content of organic matter is high.

Parnell soils are suited to cultivated crops when drained. Areas undrained provide excellent cover for wildlife.

Typical profile of Parnell silty clay loam (SE¼SE¼-NE¼ sec. 7, T. 124 N., R. 42 W.):

Ap—0 to 8 inches, black (N 2/0) silty clay loam; cloddy, but breaks to moderate, fine and medium, granular structure; friable when moist, sticky when wet; neutral to mildly alkaline; abrupt, smooth boundary.

A11—8 to 15 inches, black (N 2/0) silty clay loam; moderate, fine and medium, granular structure; friable to firm when moist, sticky when wet; neutral to mildly alkaline; gradual, smooth boundary.

A12g—15 to 30 inches, black (10YR 2/1) silty clay loam that has a few spots of very dark gray (10YR 3/1); moderate, fine, granular and very fine, subangular blocky structure; firm when moist, sticky when wet; neutral; diffuse, smooth boundary.

B2g—30 to 38 inches, black (10YR 2/1) to very dark gray (10YR 3/1) heavy silty clay loam to silty clay; moderate, very fine to fine, subangular blocky structure; firm when moist, sticky when wet; neutral; clear, smooth boundary.

C1g—38 to 46 inches, gray (5Y 5/1) to olive-gray (5Y 5/2) light silty clay loam mixed with very dark gray (5Y 3/1); common, medium, prominent, brown and olive-brown mottles; massive (structureless); friable when moist; snail shells in upper part; strongly calcareous in upper part, slightly to moderately calcareous in lower part; clear, smooth boundary.

IIC2g—46 to 54 inches, olive-gray (5Y 5/2) clay loam; many, medium, prominent, reddish-brown mottles; massive (structureless); friable when moist; slightly calcareous.

The A and B horizons combined have a thickness ranging from 28 to 48 inches. Texture of the A horizon ranges from silt loam to silty clay loam. In places, however, the A horizon is mucky silty clay loam to a depth of less than 12 inches. Content of clay in the B horizon ranges from 35 to 45 percent. Depth to calcareous underlying material ranges from 36 to more than 54 inches. Depth to underlying glacial till ranges from 3½ to more than 6 feet.

Parnell soils contain more silt and less clay than Dovray soils. They are noncalcareous to a greater depth than Oldham soils.

Parnell silty clay loam (0 to 1 percent slopes) (Pa).—This soil has the profile described for the series. It occupies deep swales or potholes that receive runoff from surrounding areas. The areas are likely to be under water for part of the normal growing season, but many of them are dry by midsummer. Most of the areas are circular or oblong. Many are surrounded by strongly calcareous, poorly drained Vallers soils on narrow rims.

This soil varies from one place to another. East of the Pomme de Terre River, many areas are underlain by strata of olive-gray silt loam as much as several feet thick over loam glacial till. In areas surrounded by gently sloping to hilly soils, this soil is calcareous or noncalcareous to a considerable depth and is underlain by peat at a depth of 8 feet or more. In some places the texture is uniform throughout the surface layer and subsoil.

Included with this soil in mapping are small areas of Vallers soils.

Even when adequately drained, Parnell silty clay loam dries out and warms up more slowly than surrounding better drained soils. Many areas have been drained and are now in crops. All cultivated crops commonly grown in the county are suited, but small grains are likely to lodge. Frost comes to the low-lying areas occupied by this soil late in summer and is likely to damage corn and soybeans. Areas undrained provide excellent marshy habitat for wildlife. Capability unit IIIw-1; windbreak group 2.

Parnell and Flom soils (0 to 1 percent slopes) (Pf).—This mapping unit consists of soils in shallow, concave swales that receive runoff from surrounding areas. The areas are circular or oblong and are 4 to 10 acres in size. The Parnell soil generally occupies the lowest part of the depressions, and the Flom soil, the flats on the edges of the depressions. Some of the areas are predominantly Flom soil, and still others consist of about equal parts of both soils.

The Parnell soil in this mapping unit is poorly drained and is shallower than the soil described as typical for the series. Also, horizon boundaries are more distinct; the subsoil has strong, prismatic structure; and the soil is calcareous at a shallower depth.

Included with this soil in mapping are small, narrow areas of Vallers soil on the outer edges of areas of this unit.

Parnell and Flom soils are suitable for crops only if they are drained. Water generally stays on the areas for 2 weeks after spring runoff and after heavy rains in midsummer. If these soils are adequately drained, row crops can be grown continuously. All cultivated crops commonly grown in the county are well suited. Tile drains or open ditches can be used to provide drainage. The subsoil of the Parnell soil is slowly permeable, however, and open inlets must be provided if tile is used. Capability unit IIw-1; windbreak group 2.

Rauville Series

Rauville soils are deep, nearly level, very poorly drained, and calcareous. They are along the rivers and creeks in the county. The native vegetation was chiefly sedges, rushes, and grasses, but willows grow in some places.

In a typical profile the surface layer is black mucky silty clay loam, about 14 inches thick, that contains a few snail shells. Below is about 39 inches of black to very dark gray and dark greenish-gray, friable, slightly calcareous silty clay loam to sandy clay loam that contains a few to many snail shells. Stratified sand and gravel is at a depth of about 53 inches.

The content of organic matter in these soils is high to very high. Available water capacity is high. Internal drainage is moderately slow. The root zone is shallow because the water table generally is at a depth of 36 inches or less.

Most areas of Rauville soils are pastured. Some areas are idle and provide good cover for wildlife.

Typical profile of Rauville silty clay loam (SW¼-NW¼SE¼ sec. 29, T. 123 N., R. 42 W.):

A11—0 to 14 inches, black (N 2/0) mucky silty clay loam; weak and moderate, very fine and fine, subangular and angular blocky structure; some horizontal cleavage in lower part in undisturbed areas; friable when moist, slightly sticky when wet; a few snail shells; slightly calcareous; abrupt, smooth boundary.

A12g—14 to 24 inches, black (N 2/0) to very dark gray (N 3/0) silty clay loam; strong, very fine and fine, subangular blocky structure; moderate, medium, platy structure that breaks to moderate, very fine, subangular blocky in the lower 6 inches; firm to friable when moist, sticky when wet; a few snail shells; slightly calcareous; clear, smooth boundary.

A13g—24 to 50 inches, black (5Y 2/1) to very dark gray (5Y 3/1) mucky silty clay loam; massive (structureless), but shows some horizontal cleavage; friable when moist, nonsticky when wet; many snail shells; a few pebbles; calcareous; abrupt, smooth boundary.

A14g—50 to 53 inches, dark greenish-gray (5G 4/1) sandy clay loam; massive (structureless); slightly sticky when wet; slightly calcareous; abrupt, smooth boundary.

IICg—53 to 58 inches, multicolored, slightly calcareous, stratified sand and gravel.

These soils commonly are stratified with thin lenses of sandy material. In places bluish-gray or greenish-gray mottles are at a depth of about 36 inches. The A horizon is predominantly silty clay loam, but it is silt loam in places.

Rauville soils are wetter than Lamoure soils.

Rauville silty clay loam (0 to 1 percent slopes) (Ra).—This is the only Rauville soil mapped in the county. It occupies low-lying areas and abandoned river channels along the Pomme de Terre and Chippewa Rivers. This soil adjoins poorly drained Lamoure soils and Alluvial land, frequently flooded, on bottom lands.

This soil is likely to be flooded early in spring and after heavy rains in summer. The water table generally is at a depth of less than 36 inches throughout most of the growing season. Drainage generally is not practical, because adequate outlets are lacking.

Flooding, poor drainage, and lack of suitable outlets make this soil better suited to pasture, wildlife, and woodland than to other uses. Capability unit VIw-1; windbreak group 7.

Renshaw Series

The Renshaw series consists of well-drained to somewhat excessively drained soils. These soils are underlain by stratified sand and gravel at a depth between 1 and 2 feet. Most areas are in river valleys and on outwash.

In a typical profile (fig. 10) the surface layer is black loam about 7 inches thick. The subsoil is very dark brown to dark yellowish-brown, friable loam that is neutral to mildly alkaline and about 13 inches thick. Below is strongly calcareous, stratified sand and gravel.

The available water capacity of these soils is low. In dry periods not enough water is available for most cultivated crops. The supply of available phosphorus is low in some places, but the supply of exchangeable potassium generally is high. These soils warm up earlier in spring than many other soils in the county. They are easy to cultivate. A good seedbed easily can be prepared.

Most areas of Renshaw soils are used for cultivated crops.

Typical profile of a Renshaw loam (NW¼NW¼NE¼ sec. 34, T. 123 N., R. 41 W.):

Ap—0 to 7 inches, black (10YR 2/1) loam; cloddy, but breaks to weak, very fine and fine, granular structure; friable when moist; neutral; abrupt, smooth boundary.

B1—7 to 12 inches, very dark brown (10YR 2/2) to very dark grayish-brown (10YR 3/2) loam; weak, medium, prismatic structure that breaks to weak, fine, subangular blocky; friable when moist; neutral; clear, wavy boundary.

Figure 10.—**Typical profile of a Renshaw loam.**

B2—12 to 20 inches, dark-brown (10YR 3/3) to dark yellowish-brown (10YR 3/4) loam; weak, medium, prismatic structure that breaks to weak, fine, subangular blocky; friable when moist; neutral to mildly alkaline; abrupt, wavy boundary.

IICca—20 to 48 inches, dark grayish-brown (10YR 4/2) stratified sand and gravel; strongly calcareous.

The Ap horizon has a thickness ranging from 6 to 10 inches, and the B horizon, a thickness of 6 to 14 inches. A thin layer of sandy loam commonly is just above the underlying sand and gravel.

Renshaw soils are deeper to sand and gravel than Sioux soils. They are shallower to sand and gravel than Fordville soils.

Renshaw loam, 0 to 2 percent slopes (ReA).—Most areas of this soil are in river valleys and on outwash, but some areas are in the uplands near Barnes soils. The areas in river valleys and on uplands are irregular in shape. They adjoin the Sioux soils that are shallow to sand and gravel and the Fordville soils that are moderately deep to deep to sand and gravel.

This soil is variable. Some areas along the Pomme de Terre River in Horton Township have a light clay loam subsoil. In outwash areas in Moore Township, the subsoil is silt loam and depth to sand and gravel uniformly ranges from 18 to 20 inches. In other areas depth to sand and gravel is more variable.

Included with this soil in mapping are many small areas of excessively drained Sioux soils. Also included are small areas of Fordville soils, which are deeper than this soil. Other small areas, next to Lamoure soils and Alluvial land, frequently flooded, are calcareous and moderately well drained. Some included small areas on knobs have a thinner surface layer than this soil.

Most areas of this Renshaw soil are cultivated. Corn, soybeans, grasses, legumes, and small grains are the crops most commonly grown. Because of the low available water capacity, such crops as small grains, which mature in midsummer, are better suited than row crops. Growth of corn and soybeans is unpredictable. These crops often fail if no rain falls for a week or two and hot winds blow. Soil blowing is a slight hazard in winter and early in spring if the areas are plowed in fall. If feasible, plowing should be done just before planting early in spring. Capability unit IIIs-1; windbreak group 4.

Renshaw loam, 2 to 6 percent slopes (ReB).—This soil occurs mainly in river valleys and on outwash, but a few areas are in the uplands on stratified glacial drift. In the river valleys the areas adjoin well-drained Fordville soils, excessively drained Sioux soils, and nearly level Renshaw soils. Slopes generally are short and irregular. In places near the brow of the slopes, depth to sand and gravel is less than that described as typical for the series.

Included with this soil in mapping are many small areas of Sioux soils. Near the bottom of slopes, where the sand and gravel is deeper than typical, are included small areas of Fordville soils. Other small areas are sandy loam throughout the surface layer and subsoil. Also included are small areas of moderately eroded soils.

This Renshaw soil is used for pasture and cultivated crops. The available water capacity is low, and failure of crops is common. Small grains and other crops that mature by midsummer are better suited than row crops. Grain sorghum is fairly well suited.

Runoff is medium on this soil, and if row crops are grown, erosion is a slight hazard. Areas on rounded knolls are subject to soil blowing in winter and early in spring if this soil is plowed in fall and all crop residues are turned under. Plowing should be delayed until early in spring just before planting is done. Capability unit IIIs-1; windbreak group 4.

Rockwell Series

Rockwell soils are level or nearly level, poorly drained, and calcareous. They formed in layers of loamy and sandy material underlain by clayey material. These soils are in the northwestern part of the county.

In a typical profile the surface layer is black, calcareous fine sandy loam about 8 inches thick. Just below is about 5 inches of very dark gray fine sandy loam that is strongly calcareous and contains gypsum crystals. Next is about 9 inches of dark grayish-brown, loose, strongly calcareous loamy fine sand, and then about 7 inches of olive, loose, calcareous fine sand. Below is mottled olive-gray, calcareous silty clay to clay underlain by mottled, gray, calcareous silty clay loam to silty clay.

The available water capacity of these soils is high. Fertility is low. Available phosphorus is fairly low, and available potassium generally is low. The content of organic matter in the surface layer is high. Permeability is moderately rapid in the loamy and sandy material and slow in the clayey material. As a result, the water table is perched above the clayey material for fairly long periods during the growing season and limits depth to which roots can penetrate. Stones generally are not present in the loamy and sandy material.

In this county Rockwell soils are mapped only in a complex with Grimstad soils. A description of Grimstad soils is provided under the Grimstad series.

368-621—71——4

Typical profile of Rockwell fine sandy loam (NW¼-SW¼SW¼ sec. 7, T. 126 N., R. 44 W.):

Ap—0 to 8 inches, black (10YR 2/1 to N 2/0) fine sandy loam; cloddy, but breaks to weak, fine, granular structure; very friable when moist; calcareous; abrupt, smooth boundary.

A1ca—8 to 13 inches, very dark gray (10YR 3/1) fine sandy loam; single grain (structureless); very friable when moist; nests of gypsum crystals present; strongly calcareous; clear, wavy boundary.

C1ca—13 to 22 inches, dark grayish-brown (2.5Y 4/2) loamy fine sand; single grain (structureless); loose when moist; nests of gypsum crystals present; strongly calcareous; gradual, wavy boundary.

C2—22 to 29 inches, olive (5Y 5/3) fine sand; a few, fine, distinct, light-olive brown mottles; single grain (structureless); loose when moist; iron and manganese concretions present; calcareous; abrupt, smooth boundary.

IIC3g—29 to 50 inches, olive-gray (5Y 5/2) silty clay to clay; a few, fine, distinct and prominent, olive-brown (2.5Y 4/4) and dark-brown to brown (7.5YR 4/4) mottles; strong, fine, subangular blocky structure; sticky when wet; shale, granite, and limestone pebbles and gypsum crystals present; calcareous; gradual, smooth boundary.

IIC4g—50 to 60 inches, gray (5Y 5/1) heavy silty clay loam to silty clay; many, medium, distinct and prominent, olive-brown (2.5Y 4/4) and dark-brown to brown (7.5Y 4/4) mottles; strong, fine, subangular blocky structure; strongly calcareous.

The Ap horizon generally ranges from black to very dark gray in color, but it is gray in places. The A horizon has a thickness ranging from 8 to 15 inches. In places the A1ca horizon changes abruptly to sand, and in other places it grades gradually to sand. The loamy and sandy layers generally range from 20 to 30 inches in thickness. Depth to gleyed material is greater in Rockwell soils in Stevens County than in other places.

Rockwell soils are wetter than Grimstad soils and have a grayer subsurface.

Rothsay Series

The Rothsay series consists of deep, nearly level to gently sloping, well-drained soils. These soils formed in silty sediment. They are in the uplands, mainly around Wintermute Lake.

In a typical profile the surface layer is black silt loam about 6 inches thick. The subsurface is very dark brown silt loam, about 4 inches thick, and the subsoil consists of about 5 inches of dark-brown silt loam. All of these are neutral to mildly alkaline. The underlying material is brown to light olive-brown, strongly calcareous silt loam.

These soils are friable throughout. Fertility generally is medium to high. The soils are free of stones, and root penetration is deep. Permeability is moderate, and available water capacity is high.

Most areas of these soils are cultivated. They are used for the crops commonly grown in the county.

Typical profile of a Rothsay silt loam (SW¼SE¼-NW¼ sec. 2, T. 125 N., R. 42 W.):

Ap—0 to 6 inches, black (10YR 2/1) silt loam; cloddy and weak, very fine, granular structure; friable when moist; mildly alkaline; abrupt, smooth boundary.

A3—6 to 10 inches, very dark brown (10YR 2/2) silt loam; weak, coarse, prismatic structure that breaks to weak, fine, subangular blocky; friable when moist; mildly alkaline; clear, smooth boundary.

B2—10 to 15 inches, dark-brown (10YR 3/3) silt loam; weak, coarse, prismatic structure that breaks to weak, fine subangular blocky; friable when moist; mildly alkaline; clear, wavy boundary.

C1ca—15 to 28 inches, brown (10YR 5/3) silt loam; massive (structureless); friable when moist; strongly calcareous; gradual, smooth boundary.

C2—28 to 54 inches, light olive-brown (2.5Y 5/5) silt loam; common, medium, prominent, gray (10YR 5/1) and yellowish-red (5YR 4/8) mottles; friable when moist; massive (structureless); strongly calcareous.

The A horizon has a thickness ranging from 6 to 12 inches, and the B2 horizon, a thickness of 5 to 12 inches. The B2 horizon has weak structure and lacks clay films on the faces of prisms. Depth to the strongly calcareous layer ranges from 12 to 24 inches. In places the C2 horizon is stratified with thin lenses of more sandy and clayey material. Mottling in the C2 horizon is lacking in some places. The silty material has a thickness ranging from 5 to 10 feet; it is underlain by loamy or clayey material.

Rothsay soils contain more silt and less sand than Barnes soils.

Rothsay silt loam, 0 to 2 percent slopes (RoA).—This soil has the profile described for the series. It is north of Morris around Wintermute Lake. It occupies a small acreage, chiefly between large areas of clayey Nutley soils and sandy Sverdrup soils. Other adjoining areas consist of gently sloping Rothsay and Zell soils.

Included with this soil in mapping are small, moderately eroded areas of Rothsay soil that appear brownish after plowing. Also included are grayish Zell soils that make up about 20 percent of the mapped areas. Other small areas have stronger slopes than this soil.

The content of organic matter in this Rothsay soil is medium. Runoff is slight, and row crops can be grown without excessive water erosion.

Except for a few odd-shaped areas, most areas of this soil are cultivated. The soil is well suited to feed grains, grasses, and legumes. Most crops on this soil respond if fertilizer that contains nitrogen and phosphorus is applied. This soil is friable and has good workability. Only minimum tillage is needed for preparing a seedbed. Capability unit I-1; windbreak group 1.

Rothsay-Zell silt loams, 2 to 6 percent slopes (RzB).—The soils in this complex are well drained to excessively drained. The brownish areas are Rothsay soil, which generally makes up about 55 percent of each mapped area. The rest is Zell soil. The grayish areas on the most convex part of the slopes are Zell soil, surrounded by Rothsay soil. Slopes generally are 150 to 250 feet long and generally extend in one direction. The areas generally adjoin nearly level Rothsay and Zell soils.

Included with this complex in mapping are small areas of soils that are steeper than this soil.

The content of organic matter is high in both soils. The Zell soil is low in available phosphorus.

These soils are well suited to the cultivated crops commonly grown in the county. Crops grow better, however, on the Rothsay soil than on the Zell soil. Runoff is medium, and if row crops are grown, the hazard of erosion is moderate. Capability unit IIe-1; windbeak group 1.

Sandy Lake Beaches

Sandy lake beaches (Sa) occupy narrow rims that border some present lakes and beds of former lakes. The soil material was deposited by wave action and commonly has a sparse cover of coarse grasses, reeds, sedges, and other aquatic plants. The areas are wet. The water table is at about the same level as the water in the lakes. Many boulders commonly are at the foot of the steep slopes that surround many of the lakes.

If the lakes are dry or have been drained, Sandy lake beaches are farmed the same as surrounding areas. Because the available water capacity of this sandy material is low, sufficient moisture for crops is lacking in many places. Also, fertility generally is low. Capability unit IVw-1; windbreak group 5.

Sioux Series

Sioux soils are nearly level to rolling and are excessively drained. These soils formed in less than a foot of loamy material over stratified sand and gravel. These soils generally are in valleys of the Pomme de Terre and Chippewa Rivers or are in the uplands, but some areas are on the outwash plain in the southeast corner of the county.

In a typical profile the surface layer is black, mildly alkaline gravelly sandy loam. Below is stratified sand and gravel that is slightly calcareous.

These soils have very low available water capacity and are extremely droughty. Permeability of the surface layer is moderately rapid, and that of the gravelly substratum is very rapid. The root zone is very shallow.

Sioux soils are a good source of gravel. Many pits have been opened to provide gravel for roads.

Typical profile of Sioux gravelly sandy loam, 2 to 12 percent slopes NE¼SW¼SW¼ sec. 18, T. 125 N., R. 41 W.):

Ap—0 to 6 inches, black (10YR 2/1) gravelly sandy loam; weak, fine and very fine, granular and subangular blocky structure; friable when moist; mildly alkaline; abrupt smooth boundary.

IICca—6 to 36 inches, dark grayish-brown (10YR 4/2) stratified sand and gravel; slightly calcareous; calcium carbonates occur chiefly on the bottom side of the gravel.

The Ap horizon ranges from 4 to 10 inches in thickness. It generally is gravelly sandy loam, but in some places it is sandy loam.

Sioux soils are shallower to sand and gravel than Renshaw soils.

Sioux gravelly sandy loam, 2 to 12 percent slopes (SgC).—This soil has the profile described for the series. Most areas are on terraces in valleys of the Pomme de Terre and Chippewa Rivers and on the outwash plain in the southeast corner of the county. A few small areas are in the uplands. The areas are irregular in shape. In the river valleys and on the outwash plain, this soil occupies areas among areas of Fordville soils, which are moderately deep to sand and gravel, and droughty Renshaw soils, which are shallow to sand and gravel. In the uplands this soil occupies small areas that are adjacent to Barnes soils.

The surface layer ranges from gravelly loam to gravelly loamy sand, but it is predominantly gravelly sandy loam. It is calcareous in places. Slopes generally are short and irregular. A few areas have nearly level slopes, and a few have steep slopes.

Included with this soil in mapping are small areas of Barnes, Fordville, and Renshaw soils. Also included are a few small areas of Sioux sandy loam.

This Sioux soil is too droughty for cultivated crops. Some areas are cultivated, but these generally are small and are within areas of other more productive soils. This soil is better suited to grasses and legumes than to cultivated crops. Growth is sufficient to provide some good grazing early in spring and late in fall. Capability unit VIs-1; windbreak group 7.

Sioux sandy loam, 0 to 2 percent slopes (SsA).—Most areas of this soil are irregular in shape and are on river terraces, but some areas are in the uplands. On the terraces the areas are adjacent to Renshaw loams and to Sioux gravelly sandy loam, 2 to 12 percent slopes. Many areas in the uplands adjoin areas of deep Barnes and Forman soils.

The surface layer is predominantly sandy loam, but it ranges from loam to loamy sand. In places a very thin, brown subsoil occurs, but it is discontinuous within a short distance.

This soil has very low available water capacity. It is better suited to grasses and small grains than to corn or soybeans. Capability unit IVs-1; windbreak group 4.

Sioux sandy loam, 2 to 6 percent slopes (SsB).—Areas of this soil are on river terraces or are in the uplands. The areas on terraces are irregular in shape and have short slopes. They are adjacent to Renshaw loams and to Sioux gravelly sandy loam, 2 to 12 percent slopes. Many areas in the uplands adjoin areas of deep Barnes and Forman soils.

The surface layer is predominantly sandy loam, but it ranges from loam to loamy sand. In places a thin, discontinuous, brown subsoil is present.

This soil has very low available water capacity. It is better suited to grasses and small grains than to corn or soybeans. Capability unit IVs-1; windbreak group 4.

Svea Series

The Svea series consists of nearly level, moderately well drained soils. These soils are on glacial moraines east of the Pomme de Terre River.

In a typical profile the surface layer is black loam about 10 inches thick. Below is about 3 inches of very dark brown loam; about 4 inches of very dark grayish-brown loam; and then about 5 inches of mottled dark grayish-brown loam. Olive-brown, calcareous loam, about 3 inches thick, is at a depth of about 22 inches. It is underlain by mottled light brownish-gray and olive-brown loam that is strongly calcareous and calcareous.

Svea soils are friable throughout. The surface layer and subsoil are neutral in reaction. They generally are low in available phosphorus and high in exchangeable potassium. The content of organic matter in the surface layer is high. Movement of water through the soil profile is moderate. Fertility is high. A few stones and boulders generally are in these soils.

Nearly all areas of Svea soils are used for cultivated crops.

Typical profile of Svea loam (SW¼NW¼NW¼ sec. 9, T. 126 N., R. 41 W.):

Ap—0 to 6 inches, black (10YR 2/1) loam; cloddy, but breaks to weak, very fine, granular structure; friable when moist; neutral; clear, smooth boundary.

A12—6 to 10 inches, black (10YR 2/1) loam; weak, coarse, prismatic structure that breaks to weak and moderate, subangular blocky; friable when moist; neutral; clear, wavy boundary.

A3—10 to 13 inches, very dark brown (10YR 2/2) loam that is very dark grayish brown (10YR 3/2) in some areas; moderate, coarse, prismatic structure that breaks to weak and moderate, medium, subangular blocky; friable when moist; neutral; clear, wavy boundary.

B21—13 to 17 inches, very dark grayish-brown (10YR 3/2 to 2.5Y 3/2) loam; weak and moderate, medium and coarse, prismatic structure that breaks to weak, medium, subangular blocky; friable when moist; a few patchy clay films on vertical peds; neutral; clear, wavy boundary.

B22—17 to 22 inches, dark grayish-brown (2.5Y 4/2) to light olive-brown (2.5Y 4/4) loam; a few, fine, faint, olive-brown mottles; weak, medium, prismatic structure that breaks to weak, medium, subangular blocky; friable when moist; a few patchy clay films on vertical peds; neutral; clear, wavy boundary.

B3ca—22 to 25 inches, olive-brown (2.5Y 4/4) loam; a few, fine, distinct, olive mottles; weak, medium, prismatic structure that breaks to weak, fine, subangular blocky; friable when moist; calcareous; clear, smooth boundary.

C1ca—25 to 36 inches, light brownish-gray (2.5Y 6/2) and light yellowish-brown (2.5Y 6/4) loam; common, medium, distinct, olive-brown (2.5Y 4/4) mottles; massive (structureless) to weak, fine and medium, subangular blocky structure; friable when moist; some soft lime concretions and threads; strongly calcareous; gradual, wavy boundary.

C2—36 to 45 inches, olive-brown (2.5Y 4/4) to light olive-brown (2.5Y 5/4) loam; many, medium, distinct, dark-gray (5Y 4/1) and olive (5Y 5/4) mottles; massive (structureless); friable when moist; calcareous.

The Ap and A1 horizons have a combined thickness ranging from 8 to 16 inches, and the B horizon, a thickness of 6 to 12 inches. The content of clay in the A and B horizons ranges from about 18 to 26 percent. Depth to free lime ranges from 16 to 26 inches.

Svea soils have less clay in the surface soil and subsoil than Aastad soils. They are slightly wetter and thicker than Barnes soils.

Svea loam, 0 to 2 percent slopes (SvA).—This is the only Svea soil mapped in the county. It is in the uplands. Slopes are smooth. The areas are irregular in shape and are within areas of well-drained Barnes soils on swells. Other nearby soils are the moderately well drained Hamerly, the poorly drained Flom, and the very poorly drained Parnell in swales or depressions. Runoff is medium to slow on this soil.

Included with this soil in mapping are some areas that are silt loam in the surface layer and upper part of the subsoil. A few small areas consist of Tara soils. Other included areas have gentle slopes, or are somewhat poorly drained.

Svea loam, 0 to 2 percent slopes, is well suited to corn, soybeans, small grains, grasses, and legumes. Workability is good. Capability unit I-1; windbreak group 1.

Sverdrup Series

Sverdrup soils are nearly level to gently sloping and are somewhat excessively drained. They are shallow and moderately deep over sand. These soils are in the uplands, on river terraces, and on outwash areas.

In a typical profile the surface layer is black sandy loam about 6 inches thick. Just below is very dark brown sandy loam about 5 inches thick. The subsoil is dark-brown, friable sandy loam in the first 6 inches and brown loamy sand to sand in the next 9 inches. The underlying material is yellowish-brown and pale-brown, loose sand. It is mildly alkaline in the upper 16 inches, but it is calcareous at a depth of about 42 inches.

The surface layer and subsoil are neutral to mildly alkaline. Permeability is moderately rapid, and the infiltration rate is fairly high. The content of organic matter generally is medium. Available potassium generally is low, and available phosphorus in the surface layer and subsoil is medium. Root penetration is deep, but the low available water capacity makes the soils droughty.

Sverdrup soils are used for cultivated crops and for permanent pasture.

Typical profile of Sverdrup sandy loam (SE¼SE¼NW¼ sec. 32, T. 126 N. R. 41 W.):

Ap—0 to 6 inches, black (10YR 2/1) sandy loam; cloddy, but breaks to weak, fine, granular structure; friable when moist; neutral; abrupt, smooth boundary.

A3—6 to 11 inches, very dark brown (10YR 2/2) sandy loam; weak, fine, granular structure; friable when moist; neutral; gradual, smooth boundary.

B21—11 to 17 inches, dark-brown (10YR 3/3) sandy loam; weak, medium, prismatic structure that breaks to weak, fine, subangular blocky; friable when moist; neutral; clear, wavy boundary.

B22—17 to 26 inches, brown (10YR 4/3) to dark yellowish-brown (10YR 3/4) loamy sand to sand; single grain; chance of vertical cleavage; very friable when moist; neutral; clear, wavy boundary.

C or B3—26 to 42 inches, yellowish-brown (10YR 5/4) to pale-brown (10YR 6/3) sand; single grain (structureless); loose when moist; mildly alkaline; clear, wavy boundary.

Cca—42 to 50 inches, pale-brown (10YR 6/3) sand; single grain (structureless); loose when moist; segregated lime; strongly calcareous.

The A horizon ranges from light loam to sandy loam in texture, and from 6 to 12 inches in thickness. Thickness of the loamy material ranges from 16 to 25 inches. In places the lower part of the profile contains strata of coarse sand, fine sand, and thin lenses of gravelly material. Depth to free lime is variable within a short distance; it ranges from 22 to 48 inches.

Sverdrup soils have more clay and less sand in the surface layer and subsoil than nearby Maddock soils.

Sverdrup sandy loam, 0 to 2 percent slopes (SwA).—Some areas of this soil are in the uplands; others are on river terraces; and some are on outwash in the southeast corner of the county. This soil adjoins areas of well-drained Barnes and Forman soils, in the uplands, and excessively drained Sioux and somewhat excessively drained Renshaw soils, on river terraces. Adjoining soils in outwash areas are moderately well drained Malachy soils and poorly drained Marysland soils.

Included with this soil in mapping are small areas of Maddock soils. Also included are some areas of a very shallow soil that has lime near the surface and appears as gray spots in freshly plowed fields. In other small areas, lime is at a depth of more than 4 feet.

Sverdrup sandy loam, 0 to 2 percent slopes, absorbs moisture readily, and runoff is slight. Water percolates deep into this droughty soil. As a result, little moisture is held available for crops. This soil also blows readily. Leaving all crop residues on the surface and plowing in spring are ways of controlling soil blowing. This coarse-textured, friable soil is easy to cultivate. It can be worked within a wide range of moisture content.

This soil is better suited to crops that mature by midsummer than to other crops. Capability unit IIIs-1; windbreak group 4.

Sverdrup sandy loam, 2 to 6 percent slopes (SwB).—Some areas of this soil are in the uplands, and others are on river terraces. Slopes generally range from about 100 to 150 feet in length. In the uplands the areas are adjacent to well-drained Barnes and Forman soils. On the river terraces, the soil generally is adjacent to droughty Renshaw and Sioux soils. Many areas, however, adjoin areas of well-drained Maddock soils.

Included with this soil in mapping are small areas of sandy loam that have free lime at or below the surface. This gently sloping soil is on the most convex part of the slopes and is gray in freshly plowed fields. Also included are small areas of a moderately eroded soil.

Runoff is medium on this soil. The water-holding capacity is low. The soil therefore is better suited to small grains and grasses than to row crops. If plowing is done in fall and all crop residues are turned under, the soil blows readily in winter and early in spring. Capability unit IIIs-1; windbreak group 4.

Tara Series

The Tara series consists of nearly level, moderately well drained soils. These soils formed in a moderately thick mantle of silt underlain by glacial till. Most areas are in the eastern one-third of the county.

In a typical profile the surface layer is black silt loam about 12 inches thick. Just below is about 7 inches of black to very dark brown silt loam. The subsoil is 13 inches thick and is neutral to mildly alkaline. It is very dark grayish-brown to dark grayish-brown silt loam in the upper part and olive-brown silt loam in the lower part. The underlying material is mottled light olive-brown loam that is moderately calcareous to strongly calcareous.

The surface and subsurface layers of these soils are neutral to mildly alkaline. Fertility and content of organic matter are high. These soils are friable and are easy to cultivate within a wide range of moisture content. Available water capacity is high, and water percolates through the profile at a moderate rate. Root development is not significantly restricted. The soils generally have no stones in the upper part of the profile, but the underlying material contains a few stones and boulders.

Nearly all areas of Tara soils are used for cultivated crops.

Typical profile of Tara silt loam (SW¼SW¼SW¼ sec 26, T. 123 N., R. 42 W.):

Ap—0 to 8 inches, black (10YR 2/1) silt loam; moderate, fine and very fine, subangular blocky structure; friable when moist, neutral; abrupt, smooth boundary.

A1—8 to 12 inches, black (10YR 2/1) to very dark brown (10YR 2/2) silt loam; weak, very fine, subangular blocky structure; friable when moist; a few tongues of black (10YR 2/1) material extend into this horizon from the horizon just above; neutral; clear, smooth boundary.

A3—12 to 19 inches, black (10YR 2/1) to very dark brown (10YR 2/2) silt loam; weak, coarse, prismatic structure that breaks to weak, very fine, subangular blocky; friable when moist; neutral; gradual, wavy boundary.

B21—19 to 26 inches, very dark grayish-brown (10YR 3/2 to 2.5Y 3/2) to dark grayish-brown (10YR 4/2 to 2.5Y 4/2) silt loam; weak, medium, prismatic structure that breaks to weak, very fine, subangular blocky; friable when moist; neutral to mildly alkaline; gradual, smooth boundary.

B22—26 to 32 inches, olive-brown (2.5Y 4/4) silt loam; weak, medium, prismatic structure that breaks to weak, very fine, subangular blocky; friable when moist; neutral to mildly alkaline; abrupt, wavy boundary.

IIC1ca—32 to 42 inches, light olive-brown (2.5Y 5/4) loam; many, coarse, faint, olive-brown (2.5Y 4/4) mottles; massive (structureless); friable when moist; moderately calcareous to strongly calcareous; gradual, smooth boundary.

IIC2—42 to 48 inches, light olive-brown (2.5Y 5/4) and gray (10YR 5/1 to 6/1) loam; massive (structureless); friable when moist; calcareous.

The Ap and A1 horizons have a combined thickness ranging from 8 to 16 inches, and the B2 horizon, a thickness of 8 to 16 inches. Thickness of the mantle of silt loam generally ranges from 24 to 34 inches, but in places it ranges from 18 to 42 inches. Lime typically is leached to a depth between 18 and 30 inches, but in places it is slightly deeper.

Tara soils are not so well drained as Doland soils. They are noncalcareous to a greater depth than McIntosh soils.

Tara silt loam, 0 to 2 percent slopes (TaA).—This is the only Tara soil mapped in the county. The areas are irregular in shape and many occur in the same fields as Hidewood, McIntosh, and Winger soils. This soil occupies less concave areas than somewhat poorly drained Hidewood soils.

Included with this soil in mapping are some areas that have a capping of silt that is thicker than 42 inches. A few included small areas west of the Pomme de Terre River, in the southern part of the county, are underlain by clayey till. Also included are a few slightly concave areas of soil, the subsoil of which contains clay films and has stronger structure than that in this soil. Other small areas have a slightly calcareous subsoil, or are gently sloping.

Tara silt loam, 0 to 2 percent slopes, is well suited to all crops commonly grown in the county. Runoff is medium to slow, and erosion is not a hazard. A seedbed can easily be prepared. Capability unit I-1; windbreak group 1.

Tonka Series

Nearly level, somewhat poorly drained soils that have a claypan are in the Tonka series. These soils occur throughout most of the county.

In a typical profile the surface layer is black, mildly alkaline loam to silt loam, about 9 inches thick. It is underlain by about 9 inches of very dark gray loam to silt loam. Below is about 12 inches of black to very dark gray, neutral silty clay; about 9 inches of very dark gray clay loam; and then mottled olive to olive-gray, friable, calcareous clay loam.

Because the clayey subsoil is very slowly permeable, water is likely to stand on the surface of these soils for several days after heavy rains. The underlying material, however, may remain fairly dry. The claypan also limits depth to which roots can penetrate. Drainage is needed for good crop growth and to make tillage easier. If tile drains are used, open inlets are needed because of the very slow permeability of the claypan.

Many areas of Tonka soils are used for cultivated crops.

Typical profile of Tonka loam (NE¼NE¼SE¼ sec. 8, T. 125 N., R. 43 W.):

Ap—0 to 9 inches, black (N 2/0 to 10YR 2/1) loam to silt loam; weak clods that break to weak, very fine, granular structure; friable when moist; mildly alkaline; abrupt, smooth boundary.

A2—9 to 18 inches, very dark gray (10YR 3/1) loam to silt loam, gray (10YR 5/1) when dry; weak, thin, platy structure that breaks to moderate, very fine, angular blocky when displaced; friable when moist; neutral; clear, smooth boundary.

B21t—18 to 30 inches, black (5Y 2/1) silty clay that grades to very dark gray (5Y 3/1) to black (5Y 2/1) in lower part; strong, medium, prismatic structure that breaks to strong, very fine, angular blocky; thick, continuous clay films; firm when moist, very sticky when wet; neutral; gradual, wavy boundary.

B22—30 to 39 inches, very dark gray (5Y 3/1) heavy clay loam on ped surfaces and olive gray (5Y 4/2) in ped interiors; moderate, medium, prismatic structure that breaks to moderate, very fine and fine, angular blocky; thick, continuous clay films; firm when moist, sticky when wet; neutral to mildly alkaline; clear, smooth boundary.

C1g—39 to 51 inches, olive (5Y 4/3) to olive-gray (5Y 4/2) clay loam; many, fine, prominent, strong-brown (7.5YR 5/6) mottles; massive (structureless); firm to friable when moist; some dark-colored, vertical clay films; a few lime concretions; calcareous; gradual, smooth boundary.

C2g—51 to 57 inches, mixed gray (5Y 5/1) and yellowish-brown (10YR 5/8) clay loam; massive (structureless); friable when moist; segregated lime occurs, chiefly along cleavage planes; calcareous.

The A horizon ranges from 6 to 12 inches in thickness. Depth to the claypan ranges from 11 to 24 inches. The B horizon ranges from heavy clay loam to clay. Depth to free lime typically is between 36 and 48 inches. No appreciable amounts of sodium occur in these soils.

Tonka soils have a grayer subsurface than Parnell soils. They also have stronger structure and contain more clay.

Tonka loam (0 to 1 percent slopes) (To).—This is the only Tonka soil mapped in the county. It occupies small, shallow depressions that are circular or oblong in shape. The areas are scattered throughout the county and generally range in size from 2 to 5 acres.

This soil commonly is surrounded by well drained and moderately well drained soils, such as the Aastad, Barnes, Forman, and Hamerly. Some areas are on clayey glacial till, however, and are surrounded by Hattie and Nutley soils. Still other areas formed in silty material and generally are surrounded by Doland and Tara soils. Areas of less than 1 acre are indicated by a spot symbol on the detailed soil map.

Because the areas are small, Tonka loam generally is farmed the same as the areas that surround it. These areas hold water for about 2 weeks after spring runoff and are likely to refill after heavy rains in summer. If many of these small, wet areas occur in a field, use of the surrounding soils is limited. Drainage is needed, and drained areas are suited to all crops commonly grown in the county. Capability unit IIIw-1; windbreak group 2.

Vallers Series

Vallers soils are nearly level, somewhat poorly drained to poorly drained, and calcareous. These soils are in the uplands. They occupy low-lying flats that contain many small depressions or are along the rims of potholes.

In a typical profile the surface layer consists of black, calcareous silty clay loam that is sticky when wet and is about 8 inches thick. Just below is about 4 inches of very dark gray to dark-gray, friable, strongly calcareous clay loam. The underlying material is gray, strongly calcareous clay loam in the first 9 inches and light olive-gray to light-gray, strongly calcareous and calcareous light clay loam below.

Runoff is slow to very slow on these soils. Internal drainage is slow. Permeability is moderate to moderately slow, and available water capacity is high. The content of organic matter in the surface layer generally is high. These soils contain so much lime as to cause an imbalance of plant nutrients. Depth to which plant roots can penetrate is restricted by the fluctuating high water table.

Vallers soils are used chiefly for cultivated crops.

Typical profile of Vallers silty clay loam (SE¼SE¼SW¼ sec. 19, T. 125 N., R. 43 W.):

Ap—0 to 8 inches, black (10YR 2/1) silty clay loam; cloddy, but breaks to weak, fine, granular and subangular blocky structure; sticky when wet; calcareous; abrupt, smooth boundary.

A1ca—8 to 12 inches, very dark gray (10YR 3/1) to dark-gray (10YR 4/1) clay loam; weak, fine, subangular blocky structure; friable when moist; strongly calcareous; clear, smooth boundary.

C1cag—12 to 21 inches, gray (5Y 5/1) clay loam; a few, fine, distinct, light olive-brown mottles; weak, fine, subangular blocky structure; friable when moist, sticky when wet; strongly calcareous; gradual, irregular boundary.

C2g—21 to 29 inches, light olive-gray (5Y 6/2) to light-gray (5Y 7/2) light clay loam; weak, fine, subangular blocky structure; friable when moist, sticky when wet; strongly calcareous; clear, smooth boundary.

C3g—29 to 36 inches, olive-gray (5Y 5/2) light clay loam; a few, fine, distinct, olive-brown mottles; massive (structureless) to weak, fine, subangular blocky structure; friable when moist, sticky when wet; calcareous; clear, smooth boundary.

C3g—36 to 45 inches, gray (5Y 5/1) to light-gray (5Y 6/2) light clay loam; many, medium, distinct and prominent, olive-brown (2.5Y 4/4) and brown (7.5YR 4/4) mottles; massive (structureless); friable when moist, sticky when wet; calcareous.

The Ap horizon has a thickness ranging from 6 to 10 inches, and the A1ca horizon, a thickness of 4 to 15 inches. In places the silty clay loam is 20 inches or more thick over the glacial till. East of the Pomme de Terre River, the underlying material is predominantly loam. In places many gypsum crystals occur throughout the profile.

Vallers soils are calcareous nearer the surface than Flom soils. Their surface and subsurface layers have more sand and less silt than Winger soils.

Vallers silty clay loam (0 to 1 percent slopes) (Va).—This is the only Vallers soil mapped in the county. Some areas are on rims of potholes occupied by very poorly drained Parnell soils. Others are on flats that contain many small depressions occupied by poorly drained Flom and Tonka soils and very poorly drained Parnell soils. Many of the areas adjoin areas of moderately well drained Aastad and Hamerly soils.

The surface layer is loam in places, and in the eastern part of the county, it is thin and silty. Within the lake basin in the northwestern part of the county, the surface layer and subsurface are loam. The color of the surface layer is gray in many small areas.

If this soil is drained, it is suited to all of the crops commonly grown in the county. Tile or open ditches can be used, but if feasible, tile is best to use because tile drains remove subsurface water and also some excess lime. The imbalance of plant nutrients can be corrected by adding fertilizer that contains phosphorus, and possibly iron or zinc. Capability unit IIw-2; windbreak group 2.

Winger Series

The Winger series consists of nearly level, somewhat poorly drained to poorly drained, calcareous soils. These soils formed in moderately shallow deposits of silty sediment underlain by glacial till. They are in the uplands.

In a typical profile the surface layer is black, calcareous silty clay loam about 7 inches thick. Below is black to very dark gray, strongly calcareous silt loam about 15 inches thick; about 9 inches of gray and olive-gray, friable, strongly calcareous and calcareous silt loam; and then the mottled olive-gray, calcareous loam glacial till.

The content of organic matter in the surface layer of these soils generally is high. Water percolates through the profile at a moderate rate. Runoff is slow to very slow, and internal drainage is slow. Available water capacity is high. The content of lime is so high as to cause an imbalance of plant nutrients. Depth to which plant roots can penetrate is restricted by a fluctuating high water table.

When drained, Winger soils are used chiefly for cultivated crops.

Typical profile of Winger silty clay loam (SW¼SW¼SW¼ sec. 29, T. 123 N., R. 41 W.):

Ap—0 to 7 inches, black (10YR 2/1) light silty clay loam that contains a few peds of very dark gray (10YR 3/1) to dark gray (10YR 4/1); cloddy; friable when moist, sticky when wet; many roots; calcareous; abrupt, smooth boundary.

A1ca—7 to 14 inches, black (10YR 2/1) to very dark gray (10YR 3/1) heavy silt loam that contains a few spots of very dark gray (10YR 3/1) to dark gray (10YR 4/1); weak, very fine, subangular blocky structure; friable when moist; moderately calcareous to strongly calcareous; gradual, wavy boundary.

ACcag—14 to 22 inches, dark-gray (10YR 4/1) silt loam to very dark gray (10YR 3/1) when moist, gray (10YR 5/1 to 6/1) when dry; weak, fine, subangular blocky structure; friable when moist, slightly sticky when wet; a few roots; strongly calcareous; gradual, wavy boundary.

C1cag—22 to 27 inches, gray (5Y 6/1) to light olive-gray (5Y 6/2) silt loam; massive (structureless); friable when moist, slightly sticky when wet; strongly calcareous; clear, wavy boundary.

C2g—27 to 31 inches, olive-gray (5Y 5/2) silt loam; a few, fine, distinct, olive-brown mottles; massive (structureless); friable when moist, slightly sticky when wet; a few iron and manganese concretions; calcareous; clear, wavy boundary.

IIC3g—31 to 50 inches, olive-gray (5Y 5/2) loam; common, medium, prominent, yellowish-brown (10YR 5/8) mottles; massive (structureless); friable when moist, slightly sticky when wet; calcareous; many pebbles of shale and granite; a few stones.

The Ap horizon has a thickness ranging from 6 to 10 inches, and the A1ca horizon, a thickness of 4 to 15 inches. Texture of the Ap horizon ranges from silt loam to silty clay loam. In places a thin, discontinuous layer of pebbles or of thin sand lenses is at the surface of the underlying till. The silt cap typically is 24 to 30 inches in thickness, but it ranges from 18 to 40 inches.

Winger soils have more silt in the surface and subsurface layers than Vallers soils. They have poorer drainage than McIntosh soils and a grayer subsurface.

Winger silty clay loam (0 to 1 percent slopes) (Wn).—Some areas of this soil are on low-lying flats, and others are on rims around potholes occupied by somewhat poorly drained Hidewood soils. Many of the areas adjoin moderately well drained McIntosh soils. In many places the strongly calcareous subsurface is nearer the surface than in the typical soil.

Included with this soil in mapping are small areas of Colvin and Vallers soils.

If Winger silty clay loam is drained, it is suited to all crops commonly grown in the county. Either tile or open ditches can be used to provide drainage. The imbalance of plant nutrients can be corrected by adding phosphorus, potassium, and possibly iron or zinc. Areas undrained are used chiefly for pasture. Capability unit IIw-2; windbreak group 2.

Zell Series

The Zell series consists of deep, gently sloping, somewhat excessively drained and excessively drained soils. These soils formed in silty sediment.

In a typical profile the surface layer is very dark grayish-brown silt loam about 10 inches thick. Below is friable, light yellowish-brown to yellowish-brown silt loam that is strongly calcareous and calcareous.

These soils are moderately permeable throughout, and available water capacity is high. They are free of stones, and root penetration is deep. Fertility generally is low to medium. The content of nitrogen and phosphorus is low.

Zell soils are used chiefly for cultivated crops. In this county Zell soils are mapped only in a complex with Rothsay soils. A description of Rothsay soils is given under the Rothsay series.

Typical profile of Zell silt loam (NW¼SE¼NE¼ sec. 2, T. 125 N., R. 42 W.):

Ap—0 to 10 inches, very dark grayish-brown (10YR 3/2) silt loam; weak, very fine, granular structure; friable when moist; calcareous; abrupt, smooth boundary.

C1ca—10 to 17 inches, light yellowish-brown (10YR 6/4) to yellowish-brown (10YR 5/4) silt loam; massive (structureless) to weak, very fine, subangular blocky structure; friable when moist; strongly calcareous; gradual, smooth boundary.

C2—17 to 30 inches, yellowish-brown (10YR 5/4) very fine sandy loam; friable when moist; massive (structureless); calcareous; abrupt, smooth boundary.

C3—30 to 40 inches, yellowish-brown (10YR 5/4) silt loam; common, medium, light-gray (10YR 7/1) mottles; massive (structureless); friable when moist; calcareous; clear, smooth boundary.

C4—40 to 58 inches, light yellowish-brown (2.5Y 6/4) heavy silt loam; common, medium, light-gray (10YR 7/1) and brown (7.5Y 5/4) mottles; massive (structureless); friable to firm when moist; calcareous; abrupt, smooth boundary.

C5—58 to 62 inches, light-gray to gray (10YR 6/1) silt loam to very fine sandy loam; massive (structureless); friable when moist; calcareous.

The Ap horizon generally is calcareous and ranges from 3 to 10 inches in thickness. Thin strata of finer textured and coarser textured material are common in the lower layers of these soils.

Zell soils are calcareous nearer the surface than nearby Rothsay soils. They contain more silt and less sand than Buse soils.

Use and Management of the Soils

This section explains the system of capability classification used by the Soil Conservation Service and describes the management of the soils by capability units. Then predicted average acre yields of the principal crops are given and management of the soils for windbreaks, for wildlife, and for engineering is discussed.

Capability Groups of Soils

Capability classification is the grouping of soils to show, in a general way, their suitability for most kinds of farming. It is a practical classification based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment. The classification does not apply to most horticultural crops, or to rice and other crops having special requirements. The soils are classified according to degree and kinds of permanent limitation, but without consideration of major and generally expensive landforming that would change the slope, depth, or other characteristics of the soils; and without consideration of possible major reclamation.

In the capability system all soils are grouped at three levels, the capability class, subclass, and unit. These are discussed in the following paragraphs.

Capability Classes, the broadest grouping, 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 some limitations that reduce the choice of plants or 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 restrict 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, range, woodland, or wildlife food and cover. (None in Stevens County.)

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife food and cover.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to grazing, woodland, or wildlife. (None in Stevens County.)

Class VIII soils and landforms have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, or water supply, or to 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 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 of the United States, but not in Stevens County, 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 subclasses indicated by *w*, *s*, and *c*, because the soils in it are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife, 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 IIIw-4. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation, and the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph. The Arabic numeral specifically identifies the capability unit within each subclass.

Management by Capability Units

In the pages that follow, the capability units in Stevens County are described and suggestions for the use and management for all the soils of each unit are given. The names of soil series represented are mentioned in the description of each capability unit, but this does not mean that all soils of a given series appear in the unit. The names of all soils in any given capability unit can be found by referring to the "Guide to Mapping Units" at the back of this survey. The capability units are not numbered consecutively, because not all the units used in Minnesota are in this county.

The cropping systems suggested are those that are based on a slope of average percent that has an average length of 200 feet. It is assumed that plowing is done in fall and that all crop residues are returned to the soil. Other cropping systems also can be used if they are suited to the farming system and if they protect the soils from erosion and improve and maintain soil fertility.

The sloping soils, such as those of the Barnes, Doland, and Forman series, are subject to water erosion if they are cultivated and not protected. Using cropping systems that permit the regular return of organic matter to the soil and growing cover crops, as needed, help to control erosion. All crop residues should be returned to the soils, either directly or through use as bedding or grazing. If manure is available, it should be applied to the eroded areas first.

The sandy and clayey soils are more susceptible to soil blowing than the other soils. Examples are soils of the Hattie, Malachy, Nutley, and Sioux series. Soil blowing can be reduced by keeping vegetation on the soil or by leaving the plowed surface rough until time to prepare a seedbed. Leaving crop residues on the surface also helps to control soil blowing.

Drainage is needed for intensive farming of wet, level or depressional soils, such as those of the Dovray and Parnell series. Tile or open ditches can be used to drain most of the wet soils.

Crops on most soils in the county respond if fertilizer is applied. The need for fertilizer depends on the kind of soil, the crop that is grown, and the past and present management. The kinds and amounts of fertilizer to use can be determined by soil tests.

Capability unit I-1

In this unit are deep, well drained and moderately well drained, loamy soils of the Aastad, Barnes, Darnen, Doland, Forman, La Prairie, Rothsay, Svea, and Tara series. The Darnen soils are on lower slopes of uplands, the La Prairie soils are on bottom lands, and the other soils are on uplands. Most of the soils in this unit are nearly level, but the Darnen soil is nearly level to gently sloping. Supplies of moisture and plant nutrients are high in all of the soils. Permeability is moderate. The hazards of drought and erosion are slight. Runoff also is slight.

These soils are well suited to corn, soybeans, wheat, oats, flax, and barley. They also are well suited to the grasses and legumes commonly grown in the county. Row crops can be grown almost continuously. If corn is grown year after year, more fertilizer is required than if grasses and legumes are included in the cropping system. Nitrogen, in particular, is needed if corn is grown continuously. Phosphorus also may be needed. If the same crop is grown on a field for several years, weeds, insects, and plant diseases are likely to be difficult to control.

The soils in this unit generally are in good tilth, and only minimum tillage is needed to prepare a good seedbed. Tillage can be done in spring or in fall but must be done at the proper moisture content.

Capability unit IIe-1

This unit consists of deep, gently sloping to undulating, moderately well drained to well drained, loamy and clayey soils. These soils are in the Barnes, Buse, Doland, Forman, Hattie, Nutley, Rothsay, and Zell series. They are moderately permeable to slowly permeable. The available water capacity is high. Content of organic matter is low to medium. Runoff is medium, and some of the soils are eroded.

These soils are well suited to corn, soybeans, wheat, oats, and barley. They also are suited to grasses and legumes. Crops grow well on these soils, but runoff during intensive rains is likely to cause further erosion and to reduce the amount of moisture available for plants.

Using a suitable cropping system, keeping tillage to a minimum, growing the optimum number of plants, and applying adequate amounts of fertilizer are ways of controlling erosion, conserving moisture, and improving fertility and tilth. Also needed are terracing, contour farming, contour stripcropping, and wheel-track planting.

Areas that have uniform slopes can be terraced or farmed on the contour. The terraces generally need to be graded. Outlets should be constructed and seeded to grass a year before the terraces are built. In this way excess water is safely removed, and gullies are kept from forming. Terraces are not suitable where slopes are irregular or undulating. In such areas tillage should be kept to a minimum and all crop residues should be left on the surface. These practices help to keep the surface layer permeable, permit optimum infiltration, and thus help to control erosion.

A cropping system commonly followed if practices such as contour farming or terracing are not used is 3 years of row crops, 1 year of a small grain, and 2 years of meadow. Less meadow can be used in the cropping system and more row crops can be grown if conservation practices are used.

Plowing most meadow land late in summer or early in fall is an effective way of conserving moisture. The Hattie and Nutley clays generally are too wet and sticky for 1 or 2 weeks after a rain for spring plowing. The loamy soils are well suited to spring plowing and to wheel-track planting.

Nitrogen and phosphorus are required for good growth of most crops. The calcareous Buse and Hattie soils, however, are low in phosphorus. On these soils, such crops as corn respond if small amounts of zinc are added.

Capability unit IIw-1

In this unit are deep, nearly level, poorly drained, clayey soils of the Dovray, Flom, Hidewood, and Parnell series. These soils occupy shallow depressions in the uplands. Supplies of moisture and plant nutrients are high. Permeability is moderate to slow. A fluctuating high water table keeps the soils wet for fairly long periods during the growing season.

These soils require drainage before cultivated crops can be grown successfully. If adequately drained, these soils are well suited to corn, soybeans, wheat, oats, barley, and the grasses and legumes adapted to the county. Some undrained areas are used for pasture, which is productive if grazing is carefully controlled. Most areas are small and are used and managed the same as surrounding areas.

Drainage can be provided by tile or open ditches. If tile is used, open inlets are needed for removing surface water. Even when these soils are drained, they warm up and dry out more slowly than naturally well-drained soils. All crop residues should be returned to the soils either directly or through use as bedding or grazing.

Capability unit IIw-2

This unit consists of deep, nearly level, moderately well drained to poorly drained soils of the Borup, Colvin, Grimstad, Hegne, Lamoure, Rockwell, Vallers, and Winger series. The Borup, Colvin, Hegne, Vallers, and Winger soils occupy flats, shallow depressions, or the rims of potholes in the uplands; the Grimstad and Rockwell soils are on a lake plain; and the Lamoure soil is on flood plains.

Permeability of these soils is moderate to slow. The available water capacity is high. A fluctuating high water table keeps these soils wet for fairly long periods during the growing season. The content of lime near the surface is so high as to cause an imbalance of plant nutrients. Supplies of available phosphorus and of such minor elements as iron and zinc are low.

The chief concerns of management are improving or maintaining fertility and providing drainage. If these soils are adequately drained, they are well suited to corn, soybeans, wheat, oats, barley, and the grasses and legumes adapted to the county. Areas undrained are used chiefly for pasture, which is productive if grazing is carefully controlled. Most areas are small and are used and managed the same as surrounding areas.

Young soybean and flax plants are susceptible to chlorosis, or yellowing of leaves, because of the excess lime in these soils. They are severely affected by chlorosis in some small areas.

Open ditches are needed for draining the Grimstad and Rockwell soils, but either tile or open ditches can be used to provide drainage for the other soils in this unit. If tile is used, open inlets are needed for removing surface water. Even when these soils are drained, they warm up and dry out more slowly than naturally well drained soils. Plowing therefore generally is done in fall.

Capability unit IIw-3

In this unit are nearly level, poorly drained soils of the Borup, Biscay, and Marysland series. The soils are in low-lying areas. They are underlain by sand or gravel at a depth of less than 3½ feet. Runoff is slow to very slow, and available water capacity is low to medium. The water table is at a depth between 2 and 3 feet for fairly long periods during the growing season.

If these soils are drained, they are suited to the crops commonly grown in the county. Drainage should be controlled, for if the water table is lowered permanently to an excessive depth, these soils become somewhat droughty. Open ditches are used to drain most areas. Tile drains are not suitable, because of the coarse-textured substratum of these soils. Most areas are small and are used and managed the same as surrounding better drained soils.

The Borup and Marysland soils are calcareous near the surface and generally are less fertile than the Biscay soil. They also have less available phosphorus, and in many places they have less available potassium.

Capability unit IIs-1

This unit consists of nearly level, well-drained, loamy soils of the Estelline and Fordville series. These soils are 24 to 42 inches deep over sand and gravel. Most areas are in river valleys and on outwash, but a few areas are in the uplands. The available water capacity is medium, and the supply of plant nutrients is high. These soils are moderately droughty.

The soils in this unit are well suited to corn, soybeans, wheat, oats, barley, and the grasses and legumes adapted to the county. The chief concerns of management are maintaining and improving fertility, conserving moisture, and controlling soil blowing in winter and early in spring. In some years crops are likely to be damaged by drought. Drought occurs most often in August and early September, and corn and soybeans are more likely to be affected than small grains.

Many kinds of cropping systems are suitable for these soils. Cultivated crops can be grown continuously. A cropping system that includes more years of corn than of grasses and legumes, however, requires more fertilizer, and especially nitrogen. Weeds, insects, and diseases also are more difficult to control if the same crop is grown on the same field year after year.

The soils in this unit are free of cobblestones. A good seedbed can easily be prepared by plowing just before planting is done. Additional amounts of nitrogen and phosphorus are needed in places.

Capability unit IIs-2

Deep, nearly level, moderately well drained and somewhat poorly drained, loamy soils of the Bearden, Glyndon, Hamerly, and McIntosh series are in this unit. Also in this unit is a variant from the Malachy series. All of these soils are in the uplands. Water moves through these soils at a moderate rate, and medium to large amounts of it are available for plant growth. Excess lime near the surface causes an imbalance of plant nutrients. Supplies of available phosphorus and of such minor elements as iron and zinc are low.

These soils are suited to corn, soybeans, wheat, oats, and barley. They also are suited to the grasses and legumes adapted to the county. The main concerns of management are improving fertility and preventing soil blowing in winter and early in spring.

Many kinds of cropping systems are suitable for these soils. Row crops can be grown continuously. A cropping system that includes more years of corn, however, than of grasses and legumes requires more fertilizer, and especially nitrogen. Weeds, insects, and diseases also are more difficult to control if the same crop is grown on the same field year after year.

Young soybean and flax plants are susceptible to chlorosis, or yellowing of leaves, because of excess lime in these soils. They are severely affected in some small areas.

A good seedbed can easily be prepared in all except the Hamerly soil, which consists of clay loam. Preparing a seedbed in this soil is slightly more difficult.

Capability unit IIs-3

This unit consists of deep, nearly level, well drained and moderately well drained clays of the Hattie and Nutley series. These soils are in the uplands. Fertility generally is high. Permeability is slow, and available water capacity is high.

The soils in this unit are well suited to corn, soybeans, wheat, oats, barley, flax, and grasses and legumes. The chief concern of management is plowing at the proper moisture content.

Many kinds of cropping systems are suitable for these soils. Row crops or small grains can be grown almost continuously. A cropping system that includes more years of corn, however, than of grasses and legumes requires more fertilizer, and especially nitrogen. Weeds, insects, and diseases also are more difficult to control if the same crop is grown on the same field year after year. In some places additional nitrogen and phosphorus are needed.

If this soil is plowed just before planting in spring, it is difficult to prepare a good seedbed. These soils stay wet for a longer time after rains than most other soils. If they are too wet when plowed, the furrow slice is likely to form a ribbon that is very hard when dry and requires several tillage operations to break. Plowing in fall permits wetting and drying along with freezing and thawing. As a result, any clods that form generally break into fine granules. Only minimum tillage just before planting then is needed for preparing a good seedbed. The fine granules are susceptible to soil blowing, however, when strong winds blow in winter and early in spring.

Capability unit IIIe-1

In this unit are deep, rolling, moderately well drained to somewhat excessively drained, loamy and clayey soils of the Barnes, Buse, Forman, and Hattie series. These soils are in the uplands. Fertility is low to medium. Permeability is slow to moderate, and available water capacity is high. The content of organic matter generally is low. Runoff is rapid, and the soils are moderately eroded.

The soils in this unit are suited to corn, soybeans, wheat, oats, and barley. They also are suited to grasses and legumes adapted to the county. Most areas are cultivated. A few areas remain in permanent pasture because of their odd shape or because of nearness to areas too steep to farm.

Rolling slopes and hazard of further erosion limit the use of these soils. Using a suitable cropping system, keeping tillage to a minimum, growing the optimum number of plants, and applying adequate amounts of fertilizer are ways of controlling further erosion. Also needed are terracing, contour farming, contour stripcropping, and wheel-track planting.

Areas that have uniform slopes can be terraced, farmed on the contour, or contour stripcropped. Terraces and contour farming are not suitable where slopes are irregular or undulating.

A cropping system commonly used if such practices as contour farming or terracing are not used, is 1 year each of a row crop and a small grain and 3 years of meadow. Less meadow can be used in the cropping system and more row crops can be grown if conservation practices are used.

The loamy soils are well suited to spring plowing and wheel-track planting. The Hattie clay, however, generally is too wet and sticky in spring for plowing. It is easier to prepare a seedbed in the Hattie soil if plowing is done in fall.

The most common pasture mixture consists of alfalfa and bromegrass. Timothy and meadow fescue also make a suitable mixture. Pastures require clipping to reduce competition from undesirable plants and to encourage uniform growth of desirable plants. Rotating grazing on well-managed, fertilized pasture increases production. Fertilizer that contains nitrogen and phosphorus generally is needed.

Capability unit IIIw-1

In this unit are deep, nearly level, poorly drained and very poorly drained soils of the Dovray, Parnell, and Tonka series. These soils ocupy potholes or depressions on river terraces and uplands. They receive runoff from surrounding areas. The water table remains at or near the surface for long periods during the growing season. Internal drainage is very slow. Available water capacity and supplies of plant nutrients are high.

The chief concerns of management are maintaining or improving fertility and providing drainage. If these soils are adequately drained, they are well suited to corn, soybeans, wheat, oats, and barley. They also are suited to grasses and legumes adapted to the county. Partly drained areas and undrained areas generally are used for pasture or for wildlife, though they may be cropped in dry years. Many areas are small and are used and managed the same as surrounding areas.

Row crops can be grown continuously on these soils. A cropping system that includes more years of corn than of grasses and legumes, however, requires more fertilizer, and especially nitrogen. Weeds, insects, and diseases also are more difficult to control if the same crop is grown on the same field year after year. Fertilizer is needed on areas that have been cultivated for a number of years, though the soils generally are high in plant nutrients.

Tile or open ditches can be used to provide drainage. If tile is used, open inlets are needed for removing surface water. Even when these soils are drained, they warm up and dry out more slowly than naturally well-drained soils.

Undrained areas of these soils provide habitat for wildlife. Some areas can be improved for this purpose by diverting more water onto these low-lying soils. Other areas can be improved for wildlife by constructing resting places for waterfowl.

Capability unit IIIw-2

In this unit are deep, very poorly drained soils that consist of muck and peat. These highly organic soils occupy deep depressions that are frequently flooded by runoff from surrounding areas. Internal drainage is very slow. Available water capacity is high. Fertility is medium to high.

These soils require drainage before cultivated crops can be grown. If adequate drainage is provided, all of the crops commonly grown in the county can be grown. The soils are well suited to row crops. In some years crops are damaged by frost which comes early to these low-lying soils. Small areas generally are managed the same as surrounding soils, except for those that are surrounded by strongly sloping soils. Undrained areas provide excellent habitat for wildlife.

Open ditches or tile can be used to provide drainage. If tile is used, open inlets are needed for removing surface water. Even when these soils are drained, they warm up and dry out more slowly than naturally well-drained soils.

Many kinds of cropping systems are suitable for these soils. Row crops can be grown almost continuously. Weeds, insects, and diseases are more difficult to control, however, if the same crop is grown on the same field year after year.

Capability unit IIIw-3

This unit consists of deep, nearly level, very poorly drained and poorly drained, loamy soils of the Blue Earth, Colvin, and Oldham series. These soils occupy deep depressions. Fertility generally is medium. The soils are calcareous throughout. In many places supplies of available phosphorus and other plant nutrients are low.

Water is ponded on undrained areas of these soils for part of the growing season. On such areas the vegetation consists mainly of reeds, sedges, and cattails that provide excellent habitat for wildlife.

If these soils are drained, they are suited to all crops generally grown in the county. Small grains, however, are likely to lodge for the first few years after the soils are drained. Drained areas generally are planted to reed canarygrass and used as pasture.

Tile drains or open ditches can be used to provide drainage. If tile is used, open inlets are needed.

Some areas of these soils are farmed the same as surrounding soils. Other areas are large enough to farm separately. Row crops can be grown continuously if tillage is done at the proper time, the soils are adequately fertilized, and weeds, insects, and diseases are controlled.

Capability unit IIIw-4

This unit consists of deep, nearly level soils in the Arveson and Biscay series. These soils have a loam surface layer and a sandy substratum. Runoff is very slow to none. Available water capacity is low to medium. The Arveson soil is low to very low in available phosphorus and medium to low in available potassium. It is not so fertile as the Biscay soil. Fertility is medium to high. The Arveson soil blows readily.

If the soils in this unit are drained, they are suited to all crops commonly grown in the county. Drainage should be controlled, for if the water table is lowered permanently, these soils become droughty. Open ditches generally are used to drain these soils because the sand in the substratum would plug tile lines.

Most areas of these soils are small and are farmed the same as surrounding soils. Reed canarygrass generally is planted on drained areas. Undrained areas are pastured, are left idle, or are used as wildlife habitat.

Capability unit IIIs-1

In this unit are nearly level and gently sloping, well-drained and somewhat excessively drained, loamy soils of the Eckman, Renshaw, and Sverdrup series. These soils are in river valleys and in the uplands. Permeability is moderately rapid to moderate. The soils are droughty and blow readily.

These soils are suited to corn, soybeans, wheat, oats, barley, and flax. They also are suited to grasses and legumes. Drought occurs most often in July, August, and September, which is the critical growth period for corn and soybeans. These crops therefore generally are not so well suited to these soils as small grains, which mature by midsummer.

Many areas of these soils are undulating and have slopes that range from about 100 to 150 feet in length. Management for these areas is similar to that for the nearly level soils. Slopes are slightly longer in a few areas, however, and here contour farming or contour stripcropping is needed for control of erosion.

Because these soils are droughty, no more than about 10,000 plants per acre should be planted in most places. Planting rates for other crops also should be reduced. A suitable cropping system includes small grain interseeded with a catch crop. The catch crop can be left on the soil until early in spring.

Stripcropping and stubble mulch tillage are needed on these soils for control of soil blowing. These soils warm up early in spring and have few wet spots that would delay tillage. They are in good tilth and can be plowed easily just before planting. The soils are well suited to minimum tillage and wheel-track planting.

Capability unit IIIs-3

This unit consists of nearly level, moderately well drained, calcareous soils in the Glyndon and Malachy series. These soils have a loamy surface layer and a sandy substratum. Runoff is medium to slow, and available water capacity is low. The water table is fairly high during the early part of the growing season. It drops to low in midsummer in many places and makes the soils droughty. The supply of available phosphorus is very low, and that of available potassium is medium to low.

These soils are suited to all crops grown in the county. Many kinds of cropping systems are suitable, but generally crops that mature by midsummer are better suited than those that mature in fall.

The soils in this unit blow readily. Stubble mulching, field stripcropping, and shelterbelts are needed for control of erosion. The fairly coarse texture and favorable drainage make these soils well suited to plowing just before planting in spring.

Capability unit IVe-1

In this unit are hilly, moderately well drained to well drained and somewhat excessively drained, loamy to clayey soils of the Barnes, Buse, Forman, and Hattie series. These soils are in the uplands. The available water capacity is high. Because of the strong slopes and very rapid runoff, however, less moisture is available for plant growth than on gently sloping soils. Also, the hazard of further erosion is severe. Fertility is low to high. In the Buse and Hattie soils, the content of organic matter is low and that of lime is high. Fertility of these soils therefore is particularly low.

Soils of this unit are only fairly well suited to corn, soybeans, flax, oats, wheat, and barley. Some areas are in permanent pasture that consists chiefly of bluegrass or of bromegrass and alfalfa.

The choice of cropping systems is limited because of the hazard of further erosion. In areas that are farmed up and down the slope, a cropping system that consists of 1 year of a small grain and 3 years of meadow controls erosion fairly well. Areas where slopes are uniform and are mostly 12 to 13 percent can be terraced, and less meadow can be used in the cropping system. Permanent pasture is a suitable use for areas that have slopes steeper than 13 percent.

Large amounts of fertilizer and manure are needed in eroded areas for increasing fertility. Nitrogen and phosphorus generally are the plant nutrients most needed.

Grazing should be controlled, and if feasible, the pastures should be renovated every few years and reseeded to grasses. Alfalfa and bromegrass is the mixture most commonly used. Clipping the pastures reduces competition from undesirable plants. Rotating grazing in well-managed pastures that are properly fertilized increases production.

Capability unit IVw-1

Sandy lake beaches make up this unit. This land type consists of sandy material underlain by finer textured material. Many stones and boulders are on the surface.

This land type generally is too sandy and droughty for good growth of crops. If the adjoining soils are drained, areas of Sandy lake beaches generally are farmed the same as the drained soils. Areas of Sandy lake beaches are too narrow to be farmed separately. In some places the sandy surface soil is thin. It can be improved by the use of deep plowing to mix the underlying finer textured material with the sandy material.

Many areas of this land type are used for pasture. Areas around the lakes and undrained ponds in the county provide beaches for recreational use. They also provide good habitat for wildlife. Some of the beaches could be developed further for these uses.

Capability unit IVs-1

This unit consists of nearly level to gently sloping, well-drained and excessively drained sandy loams of the Maddock and Sioux series. These soils have a sandy and gravelly subsurface. Some of them are in the uplands, and others are in river valleys. Internal drainage is very rapid, and available water capacity is very low. The content of organic matter generally is medium. Fertility is low. These soils blow readily. Droughtiness is very severe.

The soils in this unit are poorly suited to corn, soybeans, wheat, oats, flax, and barley. They are probably better suited to grasses and legumes than to other crops. Also, small grains, which mature by midsummer, are better suited than corn and soybeans. Sweetclover and alfalfa are the legumes most commonly planted.

Most undulating or gently sloping areas of these soils have slopes that range from about 100 to 150 feet in length. Management for these areas generally is similar to that for nearly level soils. In a few areas slopes are slightly longer. Here, contour farming and contour stripcropping are needed for control of erosion.

Field stripcropping and stubble mulch tillage can be used on these soils for control of soil blowing. The soils warm up early in spring and have few wet spots that would delay tillage. Plowing can easily be done just before planting. The soils are well suited to minimum tillage and to wheel-track planting.

Capability unit VIe-1

Buse loam, 18 to 35 percent slopes, is the only soil in this unit. This somewhat excessively drained soil is in the uplands and along the walls of river valleys. Runoff is very rapid, and the hazard of erosion is very severe.

Steep slopes make this soil better suited to pasture than to cultivated crops. Renovating the pastures, applying fertilizer, and controlling grazing are ways of improving the pastures. Control of weeds and brush also is needed. Cattle do not readily graze the steep slopes, and such areas could be improved for wildlife by planting trees and shrubs.

Capability unit VIw-1

In this unit are poorly drained and very poorly drained clay loams of the Lamoure and Rauville series and areas of wet alluvial land and of poorly drained, calcareous muck and peat. The areas are on flood plains of rivers and creeks. They are flooded frequently during spring thaws and after heavy rains.

Use of these soils is limited unless the areas are adequately drained and protected from flooding. On many of the soils, engineering structures are needed for control of flooding and to provide outlets for drainage.

A cover of permanent vegetation should be kept on these soils. All of the acreage is in pasture or wild hay or is used as wildlife. The forage in many of the pastures is of low quality. Forage of excellent quality is obtained, however, from pastures that are mowed and sprayed for control of weeds, undesirable grasses, and brush. Bluegrass is dominant in the pastures, though some areas have been planted to bromegrass. On the very wet areas, the plant cover consists chiefly of cattails, rushes, and sedges.

Capability unit VIs-1

Sioux gravelly sandy loam, 2 to 12 percent slopes, is the only soil in this unit. This soil is very shallow to sand and gravel and is excessively drained. It occupies gently sloping to rolling areas, mainly in river valleys. A few small areas are in the uplands. This gravelly soil is underlain by sand and gravel at a depth of 12 inches or less. Available water capacity therefore is very low. Runoff is medium on the gentle slopes, and rapid on the rolling ones.

A permanent cover of vegetation should be kept on this soil. Stands of grasses and legumes are easy to establish and provide some grazing early in summer and in fall. They also provide cover for upland game. Small odd-shaped areas and gravel pits can be improved for wildlife by planting shrubs on them that resist drought.

Applying manure and fertilizer helps in establishing stands of grass. Bluegrass and smooth bromegrass are the grasses most commonly grown. Other native and introduced grasses also are well suited. Among them are prairie sandreed, sand bluestem, switchgrass, western crested wheatgrass, and big and little bluestems.

Capability unit VIIIw-1

Marsh makes up this unit. It is in sloughs and shallow lakes that normally are wet all year but that may go dry during extended droughts.

Areas of Marsh provide good habitat for waterfowl, muskrats, and upland game, which find food, cover, and nesting places in marshy areas. The areas can be improved for wildlife by level ditches or by building structures to control the water level. In some areas trapping of such animals as muskrats and mink and the sale of hunting rights are done commercially.

Predicted Yields

Table 2 gives predicted average acre yields for the principal crops grown in Stevens County under two levels of management. These predictions are based on records and observations of technicians of the Soil Conservation Service, the Extension Service, the University of Minnesota, and the U.S. Census of Agriculture. They also are based on interviews with farmers.

The yield figures represent the average for a period of 10 years. They do not take into account abnormal crop seasons or past management. Considered in making the predictions were the prevailing climate, characteristics of the soils, and the influence of different kinds of management on the soils. Fluctuations in moisture from year to year and other cropping factors could reduce or increase the predicted yields by as much as 20 percent.

In columns A are yields to be expected under the management commonly used by most farmers in the county. Yields in columns B are those to be expected under the improved management used by about one-third of the farmers. For both levels of management, it is assumed that tile or surface drainage systems have been installed where needed; that recommended varieties of seed are used; that weeds are controlled by use of normal tillage, and herbicides, if needed; that diseases and insects are controlled; and that all farm operations are timely within practical limits. Under common management one or more of these practices generally receives less attention than under improved management. Thus yields are reduced because of less effective management.

Under the management used to obtain the yields in columns A, few practices are used for control of erosion and little fertilizer is used on any plants in the rotation. When corn is grown, the seedbed is prepared by plowing and use of two or three other tillage operations; the number of corn plants per acre is about 12,000 on well-drained soils. If soybeans are grown, the seed is insufficiently inoculated and planting is done in 40-inch rows. Recommended varieties of small grains are planted. In meadows, the legumes are carelessly inoculated and weeds and brush are only partly controlled.

The management used to obtain the yields in columns B is better than that used to obtain yields in columns A. Under improved management erosion is controlled by using approved practices, such as those suggested in the section "Management by Capability Units."

For corn, the management needed for obtaining the yields in columns B consists of applying enough fertilizer that contains nitrogen, phosphorus, and potassium to maintain a balanced supply of plant nutrients; growing 16,000 or more plants of corn on the well-drained soils, and 10,000 or more plants of corn on the droughty soils; and using minimum tillage.

For soybeans, the management needed for obtaining the yields given in columns B consists of properly inoculating the seed; planting in rows of less than 40 inches; planting after corn, which has received sufficient amounts of phosphate and potash that these need not be directly supplied to the soybeans; and on soils high in lime, adding enough minor plant nutrients to correct any deficiency.

For small grains, management needed to obtain the yields in columns B consists of planting recommended varieties of seed at approved rates; adding adequate amounts of nitrogen, phosphorus, and potassium; and interseeding with a legume.

For meadow, all hay yields are based on first year stands and two cuttings are made each year. The meadow is assumed to be alfalfa and bromegrass on all soils where alfalfa is adapted. Soils that are not suited to alfalfa are

TABLE 2.—*Predicted average acre yields of principal crops under two levels of management*

[Yields in columns A are those expected under common management; those in columns B are under improved management. Absence of a figure indicates the crop ordinarily is not grown or the soil is not suited to that crop]

Soil	Corn		Soybeans		Oats		Barley		Flax		Wheat		Alfalfa-bromegrass hay	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*
Aastad clay loam, 0 to 2 percent slopes	55	70	20	30	55	70	45	60	13	17	30	40	2.5	3.7
Alluvial land, frequently flooded													2.0	3.0
Arveson fine sandy loam	40	50	18	23	45	55	25	40	19	12	22	32	1.0	2.5
Barnes loam, 0 to 2 percent slopes	50	65	18	25	55	65	40	50	12	15	26	36	2.6	3.5
Barnes loam, 2 to 6 percent slopes	50	65	18	25	50	65	36	45	11	14	23	35	2.2	3.2
Barnes-Buse loams, 2 to 6 percent slopes, eroded	45	55	14	21	40	55	25	35	11	14	18	28	2.0	3.0
Barnes-Buse loams, 6 to 12 percent slopes, eroded	35	50	13	18	35	50	25	35	9	12	16	26	1.5	2.5
Bearden silt loam, 0 to 2 percent slopes	50	65	19	25	55	70	35	50	10	13	23	36	2.3	3.7
Biscay silty clay loam	55	65	23	28	55	70	45	55	10	13	25	35	2.3	3.3
Biscay silty clay loam, depressional	50	60	18	23	45	60	25	50	11	14	24	34	1.5	3.0
Blue Earth silt loam	45	65	19	25	45	65	25	50	11	14	20	34	2.0	3.5
Borup silt loam	50	60	20	25	50	65	35	50	11	14	23	35	2.0	3.0
Buse loam, 18 to 35 percent slopes													0.5	1.0
Buse-Barnes loams, 12 to 18 percent slopes, eroded	30	45	10	15	35	45	20	30	8	11	12	22	1.5	2.5
Buse-Forman complex, 12 to 18 percent slopes	35	45	10	15	40	50	20	30	8	11	15	25	1.5	2.5
Colvin silty clay loam	45	65	19	25	50	65	35	50	11	14	23	36	2.2	3.7
Colvin silty clay loam, depressional	45	65	18	23	50	60	40	50	11	14	24	34	2.0	3.5
Colvin-Borup complex	50	65	15	23	55	65	40	50	11	14	26	36	2.5	3.5
Darnen loam, 0 to 4 percent slopes	55	75	22	32	55	75	40	55	16	18	28	43	2.5	3.7
Doland silt loam, 0 to 2 percent slopes	50	65	18	23	55	70	40	50	12	17	26	36	2.2	3.3
Doland silt loam, 2 to 6 percent slopes	50	60	18	23	50	65	35	45	11	15	23	33	2.0	3.0
Dovray clay, poorly drained	50	65	23	28	50	70	40	50	13	16	24	36	2.5	3.8
Dovray clay, very poorly drained	45	65	20	28	45	65	30	50	12	15	20	35	2.5	3.8
Eckman very fine sandy loam, 1 to 4 percent slopes	35	45	15	20	45	55	30	40	10	13	20	30	2.0	3.0
Estelline silt loam, 0 to 2 percent slopes	40	55	18	24	45	60	35	45	12	15	22	34	1.5	2.5
Fordville loam, 0 to 2 percent slopes	40	55	16	21	45	60	35	45	12	15	25	35	1.5	2.5
Forman clay loam, 0 to 2 percent slopes	50	60	18	23	55	65	40	50	12	15	26	36	2.2	3.3
Forman clay loam, 2 to 6 percent slopes	50	60	18	23	50	60	35	45	11	14	23	33	2.0	3.0
Forman clay loam, 2 to 6 percent slopes, eroded	45	60	17	21	45	60	35	45	11	14	23	33	2.0	3.0
Forman-Buse complex, 2 to 6 percent slopes, eroded	40	55	14	20	40	55	25	35	10	13	18	28	2.0	3.0
Forman-Buse complex, 6 to 12 percent slopes, eroded	35	50	13	18	35	50	25	35	9	12	16	26	1.5	2.5
Glyndon silt loam, 0 to 2 percent slopes	50	60	18	23	50	60	35	45	11	14	26	36	2.0	3.0
Glyndon very fine sandy loam, 0 to 2 percent slopes	40	55	18	23	45	55	30	40	10	13	25	35	1.7	2.8
Glyndon-McIntosh complex, 0 to 2 percent slopes	50	60	18	23	55	65	40	50	12	15	26	36	2.0	3.5
Grimstad-Rockwell fine sandy loams	50	60	18	23	50	60	40	50	11	14	24	34	2.0	3.0
Hamerly clay loam, 0 to 3 percent slopes	50	65	16	25	50	65	35	50	11	14	23	36	2.2	3.5
Hattie clay, 6 to 12 percent slopes, eroded	35	50	13	18	35	50	25	35	9	12	16	26	1.6	2.5
Hattie clay, 12 to 18 percent slopes, eroded	30	45	10	15	35	45	25	35	8	11	13	23	1.5	2.5
Hattie-Nutley clays, 2 to 6 percent slopes	50	60	18	23	50	65	35	45	15	18	25	35	2.5	3.5
Hegne clay	50	65	18	23	55	65	40	50	11	14	26	36	2.0	3.5

TABLE 2.—*Predicted average acre yields of principal crops under two levels of management*—Continued

Soil	Corn		Soybeans		Oats		Barley		Flax		Wheat		Alfalfa-bromegrass hay	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*
Hidewood silty clay loam	50	70	23	32	50	75	35	50	15	18	30	45	2.5	3.5
Lamoure silty clay loam	45	65	22	27	50	65	40	50	11	14	26	36	2.5	3.5
Lamoure silty clay loam, frequently flooded	------	------	------	------	------	------	------	------	------	------	------	------	2.0	3.0
La Prairie loam	55	70	20	30	60	75	45	60	15	18	30	45	2.5	3.5
Maddock sandy loam, 0 to 4 percent slopes	20	30	10	15	25	35	20	25	6	8	12	20	1.0	1.5
Malachy sandy loam, 0 to 2 percent slopes	40	50	15	20	50	60	35	45	10	13	20	30	2.0	3.0
Malachy fine sandy loam, loamy subsoil variant	50	60	18	23	50	60	40	50	12	15	24	34	2.0	3.0
Marsh	------	------	------	------	------	------	------	------	------	------	------	------	------	------
Marysland sandy loam	50	60	15	20	50	60	35	45	10	13	20	30	2.0	3.0
McIntosh silt loam, 0 to 3 percent slopes	50	75	16	26	55	70	35	50	12	15	23	36	2.3	3.8
Muck and peat, calcareous	45	65	18	23	45	65	30	50	10	13	20	30	1.5	3.5
Muck and peat, calcareous, flooded	------	------	------	------	------	------	------	------	------	------	------	------	------	------
Muck, shallow	45	65	18	23	45	65	30	50	10	13	20	30	1.5	3.5
Nutley-Hattie clays, 0 to 2 percent slopes	50	60	18	23	50	65	35	45	15	18	25	35	2.5	3.5
Nutley clay, silty substratum, 0 to 2 percent slopes	50	65	20	25	50	65	45	55	15	18	25	35	2.5	3.5
Oldham silty clay loam	45	65	15	23	45	60	25	50	11	14	24	34	2.5	3.5
Parnell silty clay loam	45	70	20	28	45	65	30	50	12	15	20	35	2.0	3.8
Parnell and Flom soils	55	75	23	28	50	70	35	50	15	16	25	38	2.5	3.5
Rauville silty clay loam	------	------	------	------	------	------	------	------	------	------	------	------	2.0	3.0
Renshaw loam, 0 to 2 percent slopes	30	40	8	10	30	35	25	30	6	8	10	15	1.0	1.3
Renshaw loam, 2 to 6 percent slopes	25	30	8	10	30	35	25	30	6	8	10	15	1.0	1.3
Rothsay silt loam, 0 to 2 percent slopes	45	55	16	21	50	60	40	50	11	14	24	34	2.2	3.3
Rothsay-Zell silt loams, 2 to 6 percent slopes	40	50	15	20	40	55	30	40	11	14	19	28	2.0	3.0
Sandy lake beaches	------	------	------	------	------	------	------	------	------	------	------	------	0.5	1.5
Sioux gravelly sandy loam, 2 to 12 percent slopes	------	------	------	------	------	------	------	------	------	------	------	------	0.5	0.7
Sioux sandy loam, 0 to 2 percent slopes	------	------	------	------	15	20	10	15	5	7	6	9	0.75	0.75
Sioux sandy loam, 2 to 6 percent slopes	------	------	------	------	15	20	10	15	5	7	6	9	0.75	0.75
Svea loam, 0 to 2 percent slopes	55	70	22	30	55	70	40	50	13	17	30	40	2.5	3.7
Sverdrup sandy loam, 0 to 2 percent slopes	30	40	10	15	35	45	25	30	6	8	15	25	1.2	2.0
Sverdrup sandy loam, 2 to 6 percent slopes	25	35	7	12	30	40	25	30	6	8	15	25	1.2	2.0
Tara silt loam, 0 to 2 percent slopes	55	70	20	30	60	75	40	55	15	18	30	40	2.5	3.7
Tonka loam	45	65	20	25	45	65	30	50	12	15	20	34	1.8	3.3
Vallers silty clay loam	50	65	18	23	55	65	40	50	11	14	26	36	2.0	3.5
Winger silty clay loam	50	70	16	26	50	70	35	50	11	14	23	36	2.3	3.8

planted to red clover and timothy. The improved level of management includes inoculating the legumes; applying fertilizer according to the results of soil tests; controlling grazing; and controlling weeds and brush.

The estimates for yields of corn are given in bushels. They can be converted to tons of corn silage by multiplying the bushels of corn per acre by 0.20. Also, estimates for yields of hay, given in tons, can be converted to animal-unit days by multiplying the tons of hay per acre by 50.0. An animal-unit day is the number of days during a normal growing season that 1 acre will provide grazing for an animal unit (one cow, horse, or steer; five hogs; or seven sheep) without injury to the pasture.

Woodland and Windbreaks [2]

Less than 1 percent of the land area of Stevens County is wooded. The wooded areas are interspersed among the

[2] By THOR BERGH, woodland conservationist, Soil Conservation Service.

farmland, are on bottom lands, or are on valley slopes along the streams. In these wooded areas the trees consist chiefly of American elm, green ash, box elder, basswood, bur oak, red oak, and cottonwood. The trees have little commercial value.

Most trees planted in the county are planted for the purpose of establishing windbreaks. Windbreaks are much needed for protecting farmsteads. The expense and labor of planting are more than offset by the many benefits to the farmer. Windbreaks help to control soil blowing, especially of the sandy soils. They also help to obtain more uniform distribution of snow and to reduce loss of soil moisture from hot, dry winds. In addition, they protect the homestead from cold north and west winds and reduce damage from cyclonic winds. Among other benefits are reduced cost of heating homes; beautifying and protecting buildings, lots, gardens, and orchards; and control of drifting snow. Windbreaks also provide livestock shelter in outdoor feedlots that help to reduce feed costs, and they improve habitats for songbirds and other wildlife (fig. 11).

Windbreak suitability groups

The soils of Stevens County have been placed in seven windbreak groups to help the farmer in establishing windbreak plantings. Each group is made up of soils that are suited to the same kinds of trees and need similar management. Suitability of the soils for various kinds of trees is based on soil characteristics that affect growth, survival, and general vigor of the trees. Among the soil features considered were soil texture, depth, and reaction; drainage; stones in and on the soils; steepness of slopes; and aspect, or the direction the slope faces.

Each windbreak group is discussed in the pages that follow. The names of soil series represented are mentioned in the description of each windbreak group, but this does not mean that all soils of a given series appear in the unit. The names of all soils in any given windbreak group can be found by referring to the "Guide to Mapping Units" at the back of this survey. Additional information about windbreaks can be obtained from local technicians of the Soil Conservation Service and of the Extension Service.

***Figure 11.*—Typical windbreak on Aastad clay loam, 0 to 2 percent slopes. The main part of the windbreak consists of cottonwoods that are 14 years old; a snow catch of honeysuckle and caragana is on the windward side.**

WINDBREAK GROUP 1

This group consists of soils of the Aastad, Barnes, Buse, Darnen, Doland, Estelline, Fordville, Forman, Hattie, La Prairie, Nutley, Rothsay, Svea, Tara, and Zell series. Most of the soils are moderately well drained or well drained, but the Buse and Zell soils are somewhat excessively drained or excessively drained. Slopes range from 0 to 6 percent in most areas, but in some they range up to 35 percent. Some of the soils are eroded.

Root penetration is deep in these fertile soils. Available water capacity ranges from medium to high. Most of the soils are neutral and have a balanced supply of plant nutrients. The Buse, Hattie, and Zell soils are calcareous and are not so well suited to trees and shrubs as the noncalcareous soils. Their surface layer is light gray, and many areas are intermingled with areas of other soils.

Soils in this group are better suited to trees than to other uses. Evergreen trees preferred for windbreak plantings are eastern redcedar, northern white-cedar, jack pine, western yellow pine, Black Hills spruce, and Colorado spruce. Red pine, Scotch pine, and white spruce also can be planted and grow satisfactorily, but white pine is not suited to these soils and should not be planted.

Deciduous trees preferred for planting in windbreaks are green ash, American elm, Siberian elm, soft maple, Norway poplar, Siouxland poplar, robusta poplar, and white willow. Hackberry also can be planted and grows fairly well.

Small trees and shrubs preferred for planting in windbreaks are buffaloberry, caragana, Siberian crabapple, honeysuckle, common lilac, villosa lilac, ginnala maple, Russian-olive, American plum, laurel willow, and purple-osier willow.

WINDBREAK GROUP 2

Soils of the Biscay, Blue Earth, Colvin, Dovray, Hegne, Hidewood, Lamoure, Oldham, Parnell, Tonka, Vallers, and Winger series are in this group. These soils are deep and are loamy and clayey. They are on flats that contain some potholes or depressions. Most of them are poorly drained or very poorly drained. The Hidewood soils, however, are somewhat poorly drained and the Flom, Vallers, and Winger soils are somewhat poorly drained or poorly drained.

The content of organic matter is high in these soils. Because the water table is near the surface, depth to which roots can penetrate is restricted. These soils are neutral to mildly alkaline. Some of them are strongly calcareous near the surface. Wetness somewhat limits suitability for trees and shrubs, but suitability can be improved by providing adequate drainage.

In drained areas the evergreens preferred for planting in windbreaks are northern white-cedar and western yellow pine. Eastern redcedar, jack pine, red pine, white pine, Scotch pine, Black Hills spruce, Colorado spruce, and white spruce can be planted in windbreaks in drained areas and will grow satisfactorily. The only evergreen that can be planted in windbreaks in undrained areas that will grow satisfactorily is northern white-cedar. Other evergreens are poorly suited to undrained areas of these soils and should not be planted.

Deciduous trees preferred for planting in windbreaks in drained areas are green ash, Siberian elm, soft maple, Norway poplar, Siouxland poplar, robusta poplar, and white willow. American elm, hackberry, and honeylocust can be planted in windbreaks in drained areas and will grow satisfactorily. Norway, Siouxland, and robusta poplars and white willow are the deciduous trees preferred for planting in undrained areas of these soils. Green ash, American elm, Siberian elm, and soft maple can be planted and grow satisfactorily, but hackberry and honeylocust are poorly suited to undrained areas of these soils and should not be planted.

Small trees and shrubs preferred for planting in windbreaks in drained areas are buffaloberry, caragana, honeysuckle, common lilac, villosa lilac, ginnala maple, Russian-olive, American plum, laurel willow, and purple-osier willow. Siberian crabapple can be planted and grows satisfactorily. In areas undrained laurel willow and purple-osier willow are preferred for planting. Buffaloberry, caragana, honeysuckle, common lilac, ginnala maple, Russian-olive, and American plum can be planted and grow satisfactorily. Villosa lilac is poorly suited to undrained areas of these soils and should not be planted.

WINDBREAK GROUP 3

This group consists of soils of the Bearden, Hamerly, and McIntosh series. These soils are deep, moderately well drained or somewhat poorly drained, and calcareous. They have a clay loam or silt loam texture. Slopes are 0 to 3 percent.

Available water capacity of these soils is high. The content of organic matter also is high. Reaction is moderately alkaline. These soils are not so well suited to trees and shrubs as noncalcareous soils.

The evergreen trees preferred for planting in windbreaks on these soils are eastern redcedar and western yellow pine. Jack pine, red pine, Scotch pine, Black Hills spruce, Colorado spruce, and white spruce can be planted and grow satisfactorily. Northern white-cedar and white pine are not suited to these soils and should not be planted.

Deciduous trees preferred for planting in windbreaks on these soils are green ash; American elm; Siberian elm; honeylocust; Norway, Siouxland, and robusta poplars; and white willow. Hackberry and soft maple can be planted, and they grow satisfactorily.

Small trees and shrubs preferred for planting in windbreaks on the soils of this group are buffaloberry, Siberian crabapple, honeysuckle, common lilac, villosa lilac, ginnala maple, Russian-olive, American plum, laurel willow, and purple-osier willow. Caragana can be planted and grows satisfactorily.

WINDBREAK GROUP 4

Soils of the Eckman, Maddock, Renshaw, Sioux, and Sverdrup series are in this group. These loamy soils are well drained to excessively drained. They are underlain by sand and gravel at a depth of less than 2 feet and are droughty. Slopes are 0 to 6 percent. Reaction ranges from neutral to mildly alkaline.

Evergreens preferred for planting in windbreaks on these soils are eastern redcedar, jack pine, red pine, western yellow pine, and white spruce. Northern white-cedar, Scotch pine, Black Hills spruce, and Colorado spruce can be planted, and growth is satisfactory. White pine is poorly suited to these soils and should not be planted in windbreaks.

The only deciduous tree preferred for planting in windbreaks on the soils of this group is Siberian elm. Green ash, American elm, and honeylocust can be planted and grow satisfactorily. Hackberry; soft maple; Norway, Siouxland, and robusta poplars; and white willow are poorly suited to these soils and should not be planted in windbreaks.

Buffaloberry and Siberian crabapple are the preferred small trees and shrubs for windbreak plantings on these soils. Caragana, honeysuckle, common lilac, villosa lilac, Russian-olive, and American plum can be planted and grow satisfactorily. Ginnala maple, laurel willow, and purple-osier willow are poorly suited to these soils and should not be planted in windbreaks.

WINDBREAK GROUP 5

This group consists of soils of the Arveson, Borup, Colvin, and Marysland series and of the land type Sandy lake beaches. These soils are wet and calcareous. They are sandy or are underlain by sand at a depth of less than 3 feet. Available water capacity is very low to medium. Reaction is moderately alkaline. Providing adequate drainage makes these soils more suitable for trees and shrubs than they naturally would be.

The evergreens preferred for planting in drained areas are eastern redcedar, northern white-cedar, western yellow pine, Colorado spruce, and white spruce. Jack pine, red pine, white pine, Scotch pine, and Black Hills spruce can be planted and will grow satisfactorily. The only evergreens that can be planted in windbreaks in undrained areas that will grow satisfactorily are northern white-cedar and white spruce. Other evergreens are poorly suited to these soils and should not be planted in windbreaks.

Deciduous trees preferred for planting in windbreaks in drained areas are green ash, American elm, Siberian elm, hackberry, soft maple, Norway maple, and Siouxland poplar. American elm, hackberry, and soft maple can be planted and grow satisfactorily. The deciduous trees preferred for planting in undrained areas are green ash; Siberian elm; Norway, Siouxland, and robusta poplars; and white willow. American elm, hackberry, and soft maple can be planted and grow satisfactorily, but honeylocust is not suited to undrained areas of these soils and should not be planted.

Small trees and shrubs preferred for planting in windbreaks in drained areas of these soils are caragana, Siberian crabapple, honeysuckle, common lilac, villosa lilac, Russian-olive, and American plum. Buffaloberry, ginnala maple, laurel leaf willow, and purple-osier willow can be planted and grow satisfactorily. The small trees and shrubs preferred for planting in undrained areas are Russian-olive, laurel leaf willow, and purple-osier willow. Buffaloberry, caragana, Siberian crabapple, honeysuckle, ginnala maple, and American plum can be planted in windbreaks and grow satisfactorily, but common lilac and villosa lilac are poorly suited to undrained areas of these soils and should not be planted.

WINDBREAK GROUP 6

In this group are soils of the Glyndon, Grimstad, Malachy, McIntosh, and Rockwell series and the variant from the Malachy series. These soils are nearly level, loamy, and calcareous. They are underlain by sand, and some have loamy material underlying the sand. Most of the soils are moderately well drained, but the Rockwell soils are poorly drained.

The content of organic matter normally is high in these soils. Available water capacity is high to medium. The content of lime near the surface is so high that availability of such plant nutrients as phosphorus, potassium, and possibly iron or zinc, are low. Reaction is moderately alkaline.

Soils of this group are fairly well suited to trees and shrubs. Evergreen trees preferred for windbreak plantings are eastern redcedar, red pine, western yellow pine, and white spruce. Northern white-cedar, jack pine, white pine, Scotch pine, Black Hills spruce, and Colorado spruce also can be planted and grow satisfactorily.

Deciduous trees preferred for planting in windbreaks are Siberian elm and honey locust. Green ash, American elm, soft maple, Norway poplar, Siouxland poplar, robusta poplar, and white willow can be planted and grow fairly well. Hackberry is poorly suited to these soils and should not be planted.

Small trees and shrubs preferred for planting in windbreaks are caragana, Siberian crabapple, honeysuckle, common lilac, villosa lilac, Russian-olive, and American plum. Buffaloberry, ginnala maple, laurel willow, and purple-osier willow can be planted and grow satisfactorily.

WINDBREAK GROUP 7

This group consists of soils of the Lamoure, Rauville, and Sioux series and of alluvial and marshy areas and of areas of muck and peat. The areas are wet or are gravelly near the surface and are droughty.

These soils and land types generally are not suitable for trees. Some wet areas can be planted to willows, poplars, northern white-cedar, and other trees or shrubs that tolerate wetness, and growth is satisfactory. Each site, however, must be carefully inspected before planting trees and shrubs.

Wildlife [3]

Wildlife resources in Stevens County have important economic, recreational, and esthetic value. The occurrence and abundance of some wildlife are related to the kinds of soils. Many of these relationships are indirect and are influenced chiefly by the way the land is used, the kind of plants, and the topography. Ring-necked pheasant, various kinds of waterfowl, and white-tailed deer are the principal game in the county. There are also many small mammals and many kinds of songbirds. In addition, fish are abundant in the streams and lakes.

This county is good to excellent range for ring-necked pheasant. The number varies from year to year, depending on the severity of the weather, which fluctuates greatly. Pheasant are most numerous in years when the winter is mild. Lack of cover in winter and at nesting time and severe weather at the time of nesting greatly reduce the number of pheasant. In some years, the density of pheasant per square mile has been as much as 59 to 115 cocks.

Most of the county is good for pheasant, but the best pheasant range is in soil associations 4 and 7 (shown on the general soil map and described in the section "General Soil Map"). These associations are in the western and north-central parts of the county, respectively. They contain many wet or marshy areas that provide needed winter cover, as well as nesting areas along the edges of fields.

Pheasant are somewhat less abundant in soil association 3, in the northwestern part of the county. The soils in these areas are nearly level and are moderately well drained. Much of the acreage is farmed intensively. Consequently, little food and cover are available for pheasant in winter or for nesting. Pheasant probably are least numerous in the southern part of the county, east of the Pomme de Terre River, in associations 2 and 5. The land here is flat, and the soils are farmed intensively; thus, little cover is available for pheasant.

In the past the habitat for waterfowl was excellent in this county. Intensive farming, use of water for crops, and drought have reduced the habitat available for ducks and other waterfowl. Many migratory ducks, geese, and swans, however, rest and feed in the county in spring and fall.

White-tailed deer like the wooded parts of Swan Lake and Framnas Townships and are most numerous there. Many deer also are attracted to areas near the bottoms of the rivers and creeks and to large marshes in other parts of the county.

White-tailed jack rabbit, cottontail rabbit, red fox, mink, beaver, muskrat, and Hungarian gray partridge find food and cover in various parts of the county. Among the songbirds common in the county are robins, English sparrows, meadowlarks, blackbirds, and mourning doves.

Fish are abundant in the Pomme de Terre Lake and River system. Among the most numerous are northern pike, walleye, yellow perch, bullhead, and crappie. Carp also are abundant and cause much damage to spawning areas and to young fish. In some of the other lakes in the county, the fish are subject to winterkill.

Engineering Uses of the Soils

Some soil properties are of special interest to engineers because they affect the construction and maintenance of roads, airports, and pipelines, the foundations of buildings, facilities for storing water, structures for controlling erosion, drainage systems, and systems for disposing of sewage. The properties most important to the engineer are permeability to water, shear strength, compaction characteristics, soil drainage, shrink-swell characteristics, grain size, plasticity, and reaction. Also important are depth to water table, flooding hazard, depth to bedrock or to sand and gravel, and relief. Such information is made available in this section. Engineers can use it to—

[3] By HANS UHLIG, biologist, Soil Conservation Service.

1. Make studies that will aid in selecting and developing sites for industries, businesses, residences, and recreational areas.
2. Make estimates of the engineering properties of soils for use in the planning of agricultural drainage systems, waterways, farm ponds, irrigation systems, terraces and diversions, and other structures for conserving soil and water.
3. Make preliminary evaluations of soil and ground conditions that will aid in selecting locations for highways, airports, pipelines, cables, and sewage disposal fields and in planning more detailed surveys of the soils at the selected locations.
4. Locate probable sources of sand, gravel, and other materials for use in construction.
5. Correlate performance of engineering structures with the soil mapping units and thus develop information for overall planning that will be useful in designing and maintaining the structures.
6. Determine the suitability of the soils for cross-country movement of vehicles and of construction equipment.
7. Supplement information obtained from other published maps, reports, and aerial photographs for the purpose of making maps and reports that can be used readily by engineers.
8. Develop other preliminary estimates for construction purposes pertinent to the particular area.

It should be emphasized that the interpretations made in this soil survey are not a substitute for the sampling and testing needed at a site chosen for a specific engineering work that involves heavy loads or at a site where excavations are to be deeper than the depths of the layers here reported. Also, engineers should not apply specific values to the estimates for bearing capacity given in this survey. Nevertheless, by using this survey, an engineer can select and concentrate on those soil units most important for his proposed kind of construction, and in this manner reduce the number of soil samples taken for laboratory testing and complete an adequate soil investigation at minimum cost.

The soil mapping units shown on the maps in this survey may include small areas of a different soil material. These included soils may be as much as 2 acres in size. They are too small to be mapped separately and generally are not significant to the farming in the area but may be important in engineering planning.

Information of value in planning engineering work is given throughout the text, particularly in the sections "Descriptions of the Soils" and "Formation, Morphology, and Classification of Soils."

Some of the terms used by the scientist may be unfamiliar to the engineer, and some words—for example, soil, clay, silt, and sand—may have special meaning in soil science. These and other special terms used in the soil survey are defined in the Glossary at the back of this survey. Most of the information about engineering is given in tables 3, 4, and 5.

Engineering classification systems

Agricultural scientists of the United States Department of Agriculture classify soils according to texture. In some ways this system of naming textural classes is comparable to the systems most commonly used by engineers for classifying soils; that is, the system of the American Association of State Highway Officials (AASHO) and the Unified system.

Most highway engineers classify soil material in accordance with the system approved by the American Association of State Highway Officials (*1*). In this system soil materials are classified in seven principal groups. The groups range from A-1 (gravelly soils having high bearing capacity, the best soils for subgrade), to A-7 (clayey soils having low strength when wet, the poorest soils for subgrade). Within each group the relative engineering value of the soil material is indicated by a group index number. Group index numbers range from 0 for the best material to 20 for the poorest. The group index number is shown in parentheses following the soil group symbol in table 3.

Some engineers prefer to use the Unified soil classification system (*14*). In this system soil materials are identified as coarse grained, eight classes; fine grained, six classes; and highly organic. The last column in table 3 gives the classification of the tested soils according to the Unified system.

Engineering test data

Soil samples from four important series in Stevens County were tested by standard procedures to help evaluate the soils for engineering purposes. The tests were performed by the Minnesota Department of Highways in cooperation with the U.S. Department of Commerce, Bureau of Public Roads. The samples were taken from 12 locations, and only selected layers of each soil were sampled. Tests made were for moisture-density relationships, grain-size distribution, liquid limit, and plasticity index. The results of the tests and the classification of each sample, according to both the AASHO and Unified systems, are given in table 3.

The engineering classifications in table 3 are based on data obtained by mechanical analysis and by tests to determine liquid limits and plastic limits. The mechanical analysis was made by combined sieve and hydrometer methods.

In the *moisture density*, or compaction test, a sample of the soil material is compacted several times with a constant compactive effort, each time at a successively higher moisture content. The moisture content increases until the optimum moisture content is reached. After that the density decreases with increase in moisture content. The highest density obtained in the compaction test is termed "maximum density." Moisture-density data are important in construction, for as a rule, optimum stability is obtained if the soil is compacted to about the maximum dry density when it is at approximately the optimum moisture content.

The results of the mechanical analysis may be used to determine the relative proportions of the different size particles that make up the soil sample. The percentage of fine-grained material, obtained by the hydrometer method, which generally is used by engineers, should not be used in determining textural classes of soils.

TABLE 3.—*Engineering*

[Tests performed by the Minnesota Department of Highways in cooperation with the U.S. Department of Commerce, Bureau of

Soil name and location	Parent material	Minnesota report No. SS63	Depth	Moisture-density [1]	
				Maximum dry density	Optimum moisture
			Inches	*Lb. per cu. ft.*	*Percent*
Barnes loam:					
NE¼SW¼SW¼ sec. 23, T. 125 N., R. 41 W. (Modal profile.)	Loam glacial till.	55	0–8	97	22
		56	8–16	108	16
		57	16–31	115	14
		58	31–60	116	14
NE¼SE¼SE¼ sec. 15, T. 126 N., R. 41 W. (Finer textured than the modal profile.)	Loam glacial till.	59	0–7	100	19
		60	7–15	104	19
		61	20–38	112	16
		62	38–42	111	15
SE¼SE¼NE¼ sec. 20, T. 126 N., R. 41 W. (Coarser textured than the modal profile.)	Loam glacial till.	51	0–5	78	33
		52	9–16	105	18
		53	16–33	110	16
		54	33–55	113	15
Forman clay loam:					
NE¼NE¼NW¼ sec. 4, T. 123 N., R. 42 W. (Modal profile.)	Clay loam glacial till.	71	0–8	94	25
		72	8–16	97	22
		73	22–37	101	21
		74	37–48	104	20
SE¼SE¼NE¼ sec. 24, T. 126 N., R. 42 W. (Finer textured than the modal profile.)	Clay loam glacial till.	67	0–7	93	25
		68	7–19	99	22
		69	19–38	104	19
		70	38–60	104	19
NW¼NW¼SW¼ sec. 18, T. 124 N., R. 42 W. (Coarser textured than the modal profile.)	Clay loam glacial till.	63	0–8	89	27
		64	8–18	102	20
		65	21–30	105	18
		66	30–48	104	20
McIntosh silt loam:					
NE¼NE¼SE¼ sec. 26, T. 124 N., R. 42 W. (Modal profile.)	Silt over glacial till.	83	0–7	90	25
		84	7–16	96	23
		85	16–27	107	17
		86	44–65	111	15
NW¼NW¼SW¼ sec. 27, T. 124 N., R. 41 W. (Coarser textured than the modal profile.)	Silt over glacial till.	79	0–7	84	30
		80	7–14	94	23
		81	21–36	115	15
		82	37–54	110	18
SW¼NW¼NW¼ sec. 22, T. 125 N., R. 44 W. (Finer textured than the modal profile.)	Silt over glacial till.	75	0–7	80	28
		76	7–16	87	29
		77	20–29	108	17
		78	29–60	101	22
Nutley clay:					
SW¼NE¼NE¼NE¼ sec. 26, T. 123 N., R. 44 W. (Modal profile.)	Clayey glacial till.	87	0–7	81	34
		88	7–14	82	33
		89	14–38	95	25
		90	38–72	98	23
SE¼NE¼SE¼ sec. 19, T. 123 N., R. 44 W. (Thicker solum than the modal profile.)	Clayey glacial till.	91	0–8	84	31
		92	8–24	91	26
		93	24–39	99	23
		94	53–72	96	25
NE¼NE¼SE¼ sec. 19, T. 123 N., R. 43 W. (Finer textured than the modal profile.)	Clayey glacial till.	95	0–10	82	31
		96	10–20	85	30
		97	30–42	92	27
		98	42–51	90	26
		99	51–89	97	26

[1] Based on AASHO Designation: T 99–57, Method C (*1*).

[2] Mechanical analyses according to the AASHO Designation: T 88–57 (*1*). Results by this procedure frequently may 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 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analysis data used n this table are not suitable for naming textural classes for soils.

test data

Public Roads (BPR), in accordance with standard procedures of the American Association of State Highway Officials (AASHO) (*1*)]

Mechanical analysis [2]									Liquid limit	Plasticity index	Classification	
Percentage passing sieve—					Percentage smaller than—							
⅜-in.	No. 4 (4.7 mm.)	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.			AASHO	Unified [3]
100	98	97	88	61	55	35	13	7	42	13	A-7-6(6)	OL
100	99	97	89	56	48	36	16	11	35	13	A-6(5)	ML-CL
100	98	95	85	53	46	35	22	15	29	10	A-4(3)	CL
100	97	94	84	55	46	36	21	17	29	11	A-6(4)	CL
---	100	99	93	66	55	41	19	12	36	11	A-6(6)	OL
---	100	98	93	66	58	46	28	22	39	15	A-6(8)	ML-CL
---	100	96	87	60	52	41	26	20	33	13	A-6(6)	CL
---	100	93	85	57	49	37	23	18	31	11	A-6(4)	CL
100	96	94	84	50	46	23	5	5	(4)	(4)	A-4(3)	SM
100	99	97	87	45	40	28	14	10	36	13	A-6(3)	SM-SC
100	98	96	90	55	47	35	21	15	30	10	A-4(4)	CL
100	97	94	85	56	49	36	23	13	30	10	A-4(4)	CL
---	100	99	96	82	73	59	35	26	51	18	A-7-5(13)	OH
100	99	98	94	78	73	64	44	34	56	29	A-7-6(19)	CH
100	98	96	91	76	70	60	43	31	45	22	A-7-6(14)	CL
100	98	95	90	75	71	60	41	32	48	25	A-7-6(16)	CL
100	99	99	93	76	69	54	29	20	52	19	A-7-5(14)	OH
100	99	98	96	84	77	63	42	33	46	21	A-7-6(13)	ML-CL
100	97	95	90	76	71	59	41	29	45	22	A-7-6(14)	CL
100	97	96	91	75	68	56	37	29	41	20	A-7-6(12)	CL
100	99	99	96	83	80	57	27	18	53	20	A-7-5(15)	OH
100	99	99	95	78	75	58	39	28	45	20	A-7-6(13)	ML-CL
100	98	96	91	73	68	56	40	29	44	19	A-7-6(12)	ML-CL
100	98	95	89	71	65	55	37	26	43	21	A-7-6(12)	CL
100	98	98	95	84	69	43	21	15	46	15	A-7-5(11)	OL
---	---	100	98	91	81	49	25	19	45	19	A-7-6(13)	ML-CL
---	---	100	99	94	78	45	23	18	34	10	A-4(8)	ML-CL
100	97	94	85	59	51	39	23	17	30	11	A-6(5)	CL
---	---	100	97	86	75	51	26	22	53	18	A-7-5(14)	OH
---	---	100	96	82	73	36	16	8	44	14	A-7-5(10)	ML
[5] 97	93	88	78	60	52	36	20	15	30	8	A-4(5)	ML-CL
100	96	93	84	64	57	44	28	18	34	13	A-6(7)	CL
---	100	99	93	78	68	48	24	16	57	18	A-7-5(14)	OH
---	100	99	96	88	70	42	20	14	51	21	A-7-5(14)	MH-CH
---	100	98	95	82	71	44	24	16	34	13	A-6(9)	CL
100	99	98	90	73	69	59	37	14	39	16	A-6(10)	CL
---	---	100	98	95	90	79	60	44	66	27	A-7-5(19)	OH
---	---	100	97	95	94	88	70	55	81	41	A-7-5(20)	MH
100	98	92	90	83	80	75	61	48	65	36	A-7-6(20)	CH
100	98	96	93	85	81	74	59	46	60	34	A-7-6(20)	CH
---	100	99	96	86	84	69	49	37	63	27	A-7-5(19)	OH
100	96	94	91	82	80	73	57	48	66	32	A-7-5(20)	MH-CH
100	99	98	94	84	79	72	58	50	69	42	A-7-6(20)	CH
100	97	95	92	84	82	75	62	48	71	43	A-7-6(20)	CH
---	---	100	97	88	82	65	44	33	62	24	A-7-5(18)	OH
---	---	100	98	90	88	79	61	51	67	30	A-7-5(20)	MH
---	100	99	97	90	89	86	74	61	66	37	A-7-6(20)	CH
100	99	96	94	90	88	84	73	61	78	46	A-7-5(20)	CH
100	99	92	89	81	76	69	58	48	69	41	A-7-6(20)	CH

[3] SCS and BPR have agreed to consider that all soils having plasticity indexes within 2 points from A-line are to be given a borderline classification. Examples of borderline classifications obtained by this use are ML-CL and MH-CH.

[4] Nonplastic.

[5] The amount of material passing the ¾-inch sieve was 100 percent.

TABLE 4.—*Engineering*

[Not included in this table, because their characteristics are too variable to be classified, are the land types Alluvial land, frequently flooded would not be applicable.

Soil series and map symbols	Depth to seasonally high water table	Depth from surface	Classification
			USDA texture
	Feet	*Inches*	
Aastad: AaA	3–4	0–10	Clay loam
		10–50	Clay loam
Arveson: Ar	2–3	0–12	Fine sandy loam
		12–24	Fine sandy loam
		24–48	Fine sand
Barnes: BaA, BaB, BbB2, BbC2 (For properties of Buse soil in mapping units BbB2 and BbC2, refer to Buse series in this table.)	>5	0–8	Loam
		8–60	Loam
Bearden: BdA	3–4	0–14	Silt loam
		14–50	Silt loam
Biscay:			
Be	2–3	0–20	Silty clay loam
		20–38	Silty clay loam
		38–46	Sand and gravel
Bf	0–2	0–32	Silty clay loam
		32–46	Sand
Blue Earth: Bh	0–2	0–17	Mucky silt loam
		17–54	Silty clay loam
Borup: Bm	2–3	0–12	Silt loam
		12–31	Silt loam
		31–55	Very fine sand
Buse: BnE, BoD2, BuD (For properties of Barnes soil in mapping unit BoD2 and of Forman soil in mapping unit BuD, refer to Barnes and Forman series, respectively, in this table.)	>5	0–54	Loam
Colvin:			
Co, Cu (For properties of Borup soil in mapping unit Cu, refer to Borup series in this table.)	2–3	0–10	Silty clay loam
		10–29	Silty clay loam
		29–54	Silt loam
Cp	1–2	0–9	Silty clay loam
		9–62	Silty clay loam
Darnen: DaB	3–4	0–24	Loam
		24–42	Loam
		42–80	Loam to silt loam
Doland: D1A, D1B	>5	0–10	Silt loam
		10–21	Silt loam
		21–54	Loam
Dovray:			
Do	2–3	0–8	Clay
		8–36	Clay
		36–54	Clay
Dv	0–2	0–34	Clay
		34–66	Clay
Eckman: EcB	5	0–11	Very fine sandy loam
		11–31	Very fine sandy loam
		31–52	Loamy very fine sand
Estelline: EsA	>5	0–10	Silt loam
		10–32	Silt loam
		32–42	Sand and gravel
Flom (Mapped only in a complex with soils of the Parnell series.)	2–3	0–17	Silty clay loam
		17–25	Clay loam
		25–54	Clay loam or loam

properties

(Af), Marsh (Mh), and Sandy lake beaches (Sa). Absence of an entry in a column indicates a determination was not made or that it >=greater than and <=less than]

Classification—Continued		Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4	No. 10	No. 200				
					Inches per hour	*Inches per inch of soil*	*pH value*	
OH	A–7	98–100	95–98	70–80	0. 6– 2. 0	0. 16–0. 18	6. 6–7. 3	Moderate.
CL	A–7	98–100	95–98	70–80	0. 2– 0. 6	0. 16–0. 18	6. 6–7. 3	Moderate to high.
SM	A–2	100	100	25–35	2. 0– 6. 0	0. 12–0. 16	7. 9–8. 4	Low.
SM	A–2	100	100	25–35	2. 0– 6. 0	0. 12–0. 16	7. 9–8. 4	Low.
SP	A–3	100	100	0–5	6. 0–10. 0	0. 02–0. 04	7. 9–8. 4	Low.
OL	A–6	98–100	95–98	50–60	0. 6– 2. 0	0. 14–0. 18	6. 6–7. 3	Moderate.
CL	A–6	98–100	95–98	50–60	0. 6– 2. 0	0. 14–0. 18	6. 6–7. 8	Moderate.
OL	A–6 or A–4	100	100	80–90	0. 6– 2. 0	0. 18–0. 23	7. 9–8. 4	Moderate.
ML	A–4 or A–6	100	100	80–90	0. 6– 2. 0	0. 18–0. 23	7. 9–8. 4	Moderate.
OH	A–7	100	100	75–85	0. 2– 0. 6	0. 19–0. 21	6. 6–7. 3	Moderate.
CL	A–7	100	100	75–85	0. 2– 0. 6	0. 19–0. 21	6. 6–7. 3	Moderate.
SW	A–1	60–80	35–50	2–5	>10	0. 02	7. 9–8. 4	Low.
OH or MH	A–7	100	100	70–80	0. 2– 0. 6	0. 19–0. 21	7. 4–7. 8	Moderate.
SP	A–3	100	100	0–5	6. 0–10. 0	0. 02–0. 04	7. 9–8. 4	Low.
OL	A–4	100	100	80–90	0. 6– 2. 0	0. 18–0. 23	7. 9–8. 4	Low.
OH or MH	A–7	100	100	80–90	0. 2– 0. 6	0. 19–0. 21	7. 9–8. 4	Moderate.
OL	A–4 or A–6	100	100	80–90	0. 6– 2. 0	0. 18–0. 23	7. 9–8. 4	Low.
ML or CL	A–4 or A–6	100	100	80–90	0. 6– 2. 0	0. 18–0. 23	7. 9–8. 4	Low.
SM	A–2	100	98–100	10–20	2. 0– 6. 0	0. 06–0. 08	7. 9–8. 4	Low.
CL	A–6	98–100	95–98	55–75	0. 6– 2. 0	0. 14–0. 18	7. 4–7. 8	Moderate.
OH or OL	A–7 or A–6	100	100	80–90	0. 2– 0. 6	0. 19–0. 21	7. 9–8. 4	Moderate.
MH or CH	A–7	100	100	80–90	0. 2– 0. 6	0. 19–0. 21	7. 9–8. 4	Moderate to high.
ML	A–7	100	100	80–90	0. 6– 2. 0	0. 18–0. 23	7. 9–8. 4	Low.
OH	A–7	100	100	80–90	0. 2– 0. 6	0. 19–0. 21	7. 9–8. 4	Moderate.
CL	A–7	100	100	80–90	0. 2– 0. 6	0. 19–0. 21	7. 9–8. 4	Moderate.
OL	A–6	100	95–100	55–65	0. 6– 2. 0	0. 14–0. 18	6. 6–7. 3	Moderate.
ML or CL	A–6	100	95–100	55–65	0. 6– 2. 0	0. 14–0. 18	6. 6–7. 3	Moderate.
ML or CL	A–6	100	95–100	55–75	0. 6– 2. 0	0. 14–0. 18	7. 9–8. 4	Moderate.
OL	A–4 or A–6	100	100	80–90	0. 6–2. 0	0. 18–0. 23	6. 6–7. 3	Low.
ML	A–4 or A–6	100	100	80–90	0. 6–2. 0	0. 18–0. 23	6. 6–7. 3	Low.
CL	A–6	98–100	95–98	55–65	0. 6–2. 0	0. 14–0. 18	7. 9–8. 4	Moderate.
OH	A–7	100	95–100	85–95	<0. 05	0. 15–0. 18	6. 6–7. 3	High.
CH	A–7	100	95–100	85–95	<0. 05	0. 15–0. 18	6. 6–7. 3	High.
CH	A–7	100	95–100	85–95	<0. 05	0. 15–0. 18	7. 9–8. 4	High.
OH	A–7	100	100	85–85	<0. 05	0. 15–0. 18	6. 6–7. 3	High.
CH	A–7	100	95–100	85–95	<0. 05	0. 15–0. 18	7. 4–7. 8	High.
ML–CL	A–4	100	100	50–60	0. 6–2. 0	0. 12–0. 16	6. 6–7. 3	Low.
ML–CL	A–4	100	100	50–60	0. 6–2. 0	0. 12–0. 16	7. 4–7. 8	Low.
SM	A–4	100	100	35–50	2. 0–6. 0	0. 06–0. 08	7. 9–8. 4	Low.
OL	A–4 or A–6	100	100	80–90	0. 6–2. 0	0. 18–0. 23	6. 6–7. 3	Low.
ML	A–4 or A–6	100	100	80–90	0. 6–2. 0	0. 18–0. 23	6. 6–7. 3	Low.
SW	A–1	60–80	35–50	2–5	>10. 0	0. 02	7. 9–8. 4	Low.
OL	A–6 or A–7	100	100	80–90	0. 2–0. 6	0. 19–0. 21	6. 4–7. 8	Moderate.
CL	A–7	98–100	95–98	70–75	0. 2–0. 6	0. 14–0. 18	7. 4–7. 8	Moderate to high.
CL	A–6 or A–7	98–100	95–98	55–80	0. 2–0. 6	0. 14–0. 18	7. 9–8. 4	Moderate.

TABLE 4.—*Engineering*

Soil series and map symbols	Depth to seasonally high water table	Depth from surface	Classification: USDA texture
	Feet	*Inches*	
Fordville: FdA	>5	0–15	Loam
		15–36	Loam
		36–40	Sand and gravel
Forman: FmA, FmB, FmB2, FuB2, FuC2 (For properties of Buse soil in mapping units FuB2 and FuC2, refer to Buse series in this table.)	>5	0–8	Clay loam
		8–16	Clay loam
		16–48	Clay loam
Glyndon:			
GdA, GmA (For properties of McIntosh soil in mapping unit GmA, refer to McIntosh series in this table.)	3–4	0–9	Silt loam
		9–30	Silt loam
		30–60	Very fine sand
G1A	2–3	0–8	Very fine sandy loam
		8–22	Very fine sandy loam
		22–45	Very fine sand
Grimstad: Gr (For properties of Rockwell soil in this mapping unit, refer to Rockwell series in this table.)	3–4	0–13	Fine sandy loam
		13–24	Fine sand
		24–45	Silty clay
Hamerly: HaA	3–4	0–7	Clay loam
		7–50	Clay loam
Hattie: HcC2, HcD2, HnB (For properties of Nutley soil in mapping unit HnB, refer to Nutley series in this table.)	>5	0–6	Clay
		6–46	Clay
Hegne: Ho	2–3	0–7	Clay
		7–48	Clay
Hidewood: Hw	2–3	0–23	Silty clay loam
		23–30	Silt loam
		30–50	Loam
Lamoure: Lm, Ln	2–3	0–17	Silty clay loam
		17–51	Silty clay loam
La Prairie: Lp	3–4	0–24	Loam
		24–50	Loam
		50–54	Sand and gravel
Maddock: MaB	>5	0–12	Sandy loam
		12–28	Medium sand
		28–56	Medium sand
Malachy: MfA	3–4	0–14	Heavy sandy loam
		14–30	Heavy sandy loam
		30–42	Coarse sand
Malachy, loamy subsoil variant: Mc	2–5	0–13	Fine sandy loam
		13–25	Fine sandy loam to loamy fine sand
		25–35	Silty clay loam
Marysland: Mr	2–3	0–10	Heavy sandy loam
		10–32	Heavy sandy loam
		32–42	Coarse sand
McIntosh: MsA	3–4	0–7	Silt loam
		7–21	Silt loam
		21–54	Loam
Muck, shallow: Mu	0–2	0–24	Muck
		24–54	Silty clay loam
Muck and peat: Mv, Mw	0–2	0–42	Muck and peat

properties—Continued

Classification—Continued		Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4	No. 10	No. 200				
					Inches per hour	*Inches per inch of soil*	*pH value*	
OL	A–4 or A–6	100	100	55–65	0. 6–2. 0	0. 14–0. 18	6. 6–7. 3	Moderate.
ML or CL	A–4 or A–6	100	100	55–65	0. 6–2. 0	0. 14–0. 18	6. 6–7. 3	Moderate.
SW	A–1	60–80	35–50	2–5	>10. 0	0. 02	7. 9–8. 4	Low.
OH	A–7	98–100	95–98	70–80	0. 2–0. 6	0. 16–0. 18	6. 6–7. 3	Moderate.
CL	A–7	98–100	95–98	70–80	0. 2–0. 6	0. 16–0. 18	6. 6–7. 3	Moderate to high.
CL	A–7	98–100	95–98	70–80	0. 2–0. 6	0. 16–0. 18	7. 9–8. 4	Moderate to high.
OL	A–4 or A–6	100	100	80–90	0. 6–2. 0	0. 18–0. 23	7. 9–8. 4	Low.
ML	A–4 or A–6	100	100	80–90	0. 6–2. 0	0. 18–0. 23	7. 9–8. 4	Low.
SM	A–2 or A–3	100	100	10–20	6. 0–10. 0	0. 06–0. 08	7. 9–8. 4	Low.
OL	A–4	100	100	50–65	0. 6–2. 0	0. 12–0. 16	7. 9–8. 4	Low.
ML	A–4	100	100	50–65	0. 6–2. 0	0. 12–0. 16	7. 9–8. 4	Low.
SP–SM	A–2 or A–3	100	100	5–12	6. 0–10. 0	0. 06–0. 08	7. 9–8. 4	Low.
SM	A–2	100	100	25–35	2. 0–6. 0	0. 12–0. 16	7. 9–8. 4	Low.
SP–SM ----	A–2 or A–3	100	100	5–12	6. 0–10. 0	0. 02–0. 04	7. 9–8. 4	Low.
CH	A–7	100	95–100	85–95	0. 06–0. 2	0. 15–0. 18	7. 9–8. 4	High.
CL or CH	A–6 or A–7	98–100	95–98	50–80	0. 2–0. 6	0. 16–0. 18	7. 9–8. 4	Moderate.
CL	A–6 or A–7	98–100	95–98	50–80	0. 2–0. 6	0. 16–0. 18	7. 9–8. 4	Moderate.
OH	A–7	100	95–100	85–85	<0. 05	0. 15–0. 18	7. 9–8. 4	High.
CH	A–7	100	95–100	85–95	<0. 05	0. 15–0. 18	7. 9–8. 4	High.
OH	A–7	100	95–100	85–95	<0. 05	0. 15–0. 18	7. 9–8. 4	High.
CH	A–7	100	95–100	85–95	<0. 05	0. 15–0. 18	7. 9–8. 4	High.
OH or OL	A–7 or A–6	100	100	80–90	0. 2– 0. 6	0. 19–0. 21	6. 6–7. 3	Moderate.
ML or CL	A–4	100	100	75–85	0. 6– 2. 0	0. 18–0. 23	6. 6–7. 3	Low.
CL	A–6	98–100	95–98	55–66	0. 6– 2. 0	0. 14–0. 18	7. 9–8. 4	Moderate.
OH or OL	A–6 or A–7	100	100	89–90	0. 2– 0. 6	0. 19–0. 21	7. 9–8. 4	Moderate.
CL	A–6 or A–7	100	100	80–90	0. 2– 0. 6	0. 19–0. 21	7. 9–8. 4	Moderate.
OL	A–4 or A–6	100	98–100	55–65	0. 6– 2. 0	0. 14–0. 18	6. 6–7. 3	Moderate.
ML or CL	A–4 or A–6	100	98–100	55–65	0. 6– 2. 0	0. 14–0. 18	6. 6–7. 3	Moderate.
SW	A–1	60–80	35–50	2–5	>10	0. 02	7. 9–8. 4	Low.
SM	A–2	100	100	25–35	2. 0– 6. 0	0. 10–0. 14	6. 6–7. 3	Low.
SP–SM	A–2 or A–3	100	98–100	5–15	6. 0–10. 0	0. 02–0. 04	6. 6–7. 3	Low.
SP–SM	A–2 or A–3	100	98–100	5–15	6. 0–10. 0	0. 02–0. 04	7. 9–8. 4	Low.
SM–SC	A–2	100	100	25–35	2. 0– 6. 0	0. 10–0. 14	7. 4–7. 8	Low.
SM–SC	A–2	100	100	25–35	2. 0– 6. 0	0. 10–0. 14	7. 9–8. 4	Low.
SP–SM	A–2	100	100	5–15	6. 0–10. 0	0. 02–0. 04	7. 9–8. 4	Low.
SM–SC	A–2	100	100	25–35	2. 0– 6. 0	0. 12–0. 16	7. 4–7. 8	Low.
SM	A–2	100	100	10–20	2. 0– 6. 0	0. 8–0. 14	7. 4–7. 8	Low.
CH	A–7	98–100	95–98	85–95	0. 2– 0. 6	0. 19–0. 21	7. 9–8. 4	Moderate to high.
SM–SC	A–2	100	100	25–35	2. 0– 6. 0	0. 10–0. 14	7. 9–8. 4	Low.
SM	A–2	100	100	25–35	2. 0– 6. 0	0. 10–0. 14	7. 9–8. 4	Low.
SP–SM	A–2	100	100	5–15	6. 0–10. 0	0. 02–0. 04	7. 9–8. 4	Low.
OL	A–4 or A–6	100	100	80–90	0. 6– 2. 0	0. 18–0. 23	7. 9–8. 4	Low.
ML	A–4 or A–6	100	100	80–90	0. 6– 2. 0	0. 18–0. 23	7. 9–8. 4	Low.
CL	A–6 or A–7	98–100	95–98	55–80	0. 6– 2. 0	0. 14–0. 18	7. 9–8. 4	Moderate.
Pt	----------	----------	----------	----------	0. 2– 0. 6	0. 3–0. 5	7. 4–7. 3	Moderate.
OH	A–7	100	----------	89–90	0. 2– 0. 6	0. 19–0. 21	7. 9–8. 4	Moderate.
Pt	----------	----------	----------	----------	0. 2– 0. 6	0. 3–0. 5	7. 9–8. 4	Moderate.

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TABLE 4.—*Engineering*

Soil series and map symbols	Depth to seasonally high water table	Depth from surface	Classification
			USDA texture
	Feet	*Inches*	
Nutley:			
NcA	3–4	0–11	Clay
		11–36	Clay
		36–54	Silt loam
NhA (For properties of Hattie soil in this mapping unit, refer to Hattie series in this table.)	3–4	0–11	Clay
		11–54	Clay
Oldham: Om	0–2	0–80	Silty clay loam
Parnell: Pa, Pf (For properties of Flom soil in mapping unit Pf, refer to Flom series in this table.)	0–2	0–38	Silty clay loam
		38–46	Silty clay loam to silty clay
		46–54	Clay loam
Rauville: Ra	1–2	0–14	Silty clay loam
		14–53	Silty clay loam
		53–58	Sand and gravel
Renshaw: ReA, ReB	>5	0–7	Loam
		7–20	Loam
		20–48	Sand and gravel
Rockwell (Mapped only in a complex with Grimstad soils.)	2–3	0–13	Fine sandy loam
		13–29	Fine sand
		29–60	Silty clay
Rothsay: RoA, RzB (For properties of Zell soil in mapping unit RzB, refer to Zell series in this table.)	>5	0–10	Silt loam
		10–54	Silt loam
Sioux:			
SgC	>5	0–6	Gravelly sandy loam
		6–36	Sand and gravel
SsA, SsB	>5	0–10	Sandy loam
		10–14	Sand and gravel
Svea: SvA	3–4	0–10	Loam
		10–22	Loam
		22–45	Loam
Sverdrup: SwA, SwB	>5	0–11	Sandy loam
		11–17	Sandy loam
		17–50	Medium sand
Tara: TaA	3–4	0–12	Silt loam
		12–32	Silt loam
		32–48	Loam, silt loam
Tonka: To	2–3	0–18	Loam
		18–39	Silty clay
		39–57	Clay loam
Vallers: Va	2–3	0–8	Silty clay loam
		8–45	Clay loam
Winger: Wn	2–3	0–14	Silty clay loam and silt loam
		14–31	Silt loam
		31–50	Loam
Zell (Mapped only in a complex with Rothsay soils).	>5	0–62	Silt loam

properties—Continued

Classification—Continued		Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4	No. 10	No. 200				
					Inches per hour	*Inches per inch of soil*	*pH value*	
OH	A-7	100	95-100	85-95	<0. 05	0. 15-0. 18	6. 6-7. 3	High.
CH	A-7	100	95-100	85-95	<0. 05	0. 15-0. 18	7. 4-7. 8	High.
ML	A-4 or A-6	100	100	85-95	0. 6- 2. 0	0. 18-0. 23	7. 9-8. 4	Low.
OH	A-7	100	95-100	85-95	<0. 05	0. 15-0. 18	6. 6-7. 3	High.
CH	A-7	100	95-100	85-95	<0. 05	0. 15-0. 18	7. 4-7. 8	High.
OH or MH	A-7	100	100	80-90	0. 2- 0. 6	0. 19-0. 21	7. 9-8. 4	Moderate.
OH	A-7	100	100	80-90	0. 2- 0. 6	0. 19-0. 21	6. 6-7. 3	Moderate.
CL	A-7	100	100	80-90	0. 2- 0. 6	0. 19-0. 21	7. 4-7. 8	Moderate to high.
CL	A-6 or A-7	98-100	95-98	50-80	0. 2- 0. 6	0. 16-0. 18	7. 9-8. 4	Moderate to high.
OH	A-7	100	98-100	80-90	0. 2- 0. 6	0. 19-0. 21	7. 9-8. 4	Moderate.
ML or CL	A-7	100	98-100	80-90	0. 2- 0. 6	0. 19-0. 21	7. 9-8. 4	Moderate.
SW	A-1	60-80	35-50	2-5	>10. 0	0. 02	7. 9-8. 4	Low.
OL	A-4 or A-6	100	100	55-65	0. 6-2. 0	0. 14-0. 18	6. 6-7. 3	Moderate.
ML or CL	A-4 or A-6	100	100	55-65	0. 6-2. 0	0. 14-0. 18	6. 6-7. 3	Moderate.
SW	A-1	60-80	35-50	2-5	>10	0. 02	7. 9-8. 4	Low.
SM	A-2	100	100	25-35	2. 0-6. 0	0. 12-0. 16	7. 9-8. 4	Low.
SP-SM	A-2 or A-3	100	100	5-15	6. 0-10. 0	0. 02-0. 04	7. 9-8. 4	Low.
CH	A-7	100	95-100	85-95	<0. 05	0. 15-0. 18	7. 9-8. 4	High.
OL	A-4 or A-6	100	100	80-90	0. 6-2. 0	0. 18-0. 23	6. 6-7. 3	Low.
ML	A-4 or A-6	100	100	80-90	0. 6-2. 0	0. 18-0. 23	7. 9-8. 4	Low.
SM	A-2	80-85	50-70	25-35	2. 0-6. 0	0. 6-0. 08	7. 4-7. 8	Low.
SW	A-1	60-80	35-50	2-5	>10. 0	0. 02	7. 9-8. 4	Low.
SM	A-2	100	98-100	20-35	2. 0-6. 0	0. 10-0. 14	7. 4-7. 8	Low.
SW	A-1	60-80	35-50	2-5	>10. 0	0. 02	7. 9-8. 4	Low.
OL	A-6	98-100	95-98	55-65	0. 6-2. 0	0. 14-0. 18	6. 6-7. 3	Moderate.
ML or CL	A-6	98-100	95-98	55-65	0. 6-2. 0	0. 14-0. 18	6. 6-7. 3	Moderate.
CL	A-4 or A-6	98-100	95-98	55-65	0. 6-2. 0	0. 14-0. 18	7. 9-8. 4	Moderate.
SM	A-2	100	100	25-35	2. 0-6. 0	0. 10-0. 14	6. 6-7. 3	Low.
SM	A-2	100	100	25-35	2. 0-6. 0	0. 10-0. 14	6. 6-7. 3	Low.
SP-SM	A-2 or A-3	100	98-100	5-15	6. 0-10. 0	0. 02-0. 04	7. 4-7. 8	Low.
OL	A-4 or A-6	100	100	80-90	0. 6-2. 0	0. 18-0. 23	6. 6-7. 3	Low.
ML	A-4 or A-6	100	100	80-90	0. 6-2. 0	0. 18-0. 23	7. 4-7. 8	Low.
CL	A-6	98-100	95-98	55-65	0. 6-2. 0	0. 14-0. 18	7. 9-8. 4	Moderate.
OL	A-4 or A-6	100	100	60-70	0. 6-2. 0	0. 14-0. 18	6. 6-7. 3	Moderate.
CH	A-7	100	100	80-90	<0. 05	0. 19-0. 21	6. 6-7. 3	High.
CL	A-7	98-100	95-98	70-80	0. 2-0. 6	0. 16-0. 18	7. 9-8. 4	Moderate to high.
OH	A-7	100	98-100	80-90	0. 2-0. 6	0. 19-0. 21	7. 9-8. 4	Moderate.
CL	A-6 or A-7	98-100	95-98	55-80	0. 2-0. 6	0. 16-0. 18	7. 9-8. 4	Moderate.
OL	A-4 or A-6	100	100	80-90	0. 6-2. 0	0. 18-0. 23	7. 9-8. 4	Low.
ML	A-4 or A-6	100	100	80-90	0. 6-2. 0	0. 18-0. 23	7. 9-8. 4	Low.
CL	A-6 or A-7	98-100	95-100	55-80	0. 6-2. 0	0. 14-0. 18	7. 9-8. 4	Moderate.
ML	A-4 or A-6	100	100	80-90	0. 6-2. 0	0. 18-0. 23	7. 9-8. 4	Low.

TABLE 5.—*Engineering*

[The land type Marsh (Mh) is not included in this table

Soil series, land types, and map symbols	Suitability as a source of—			Highway location
	Topsoil [1]	Sand or gravel	Highway subgrade [2]	
Aastad: AsA	Good	Not suitable	Fair: fair shear strength; medium compressibility; good to fair workability; moderate to high volume change.	Slight to moderate susceptibility to frost action.
Alluvial land, frequently flooded: Af.	Good	Not suitable	Mixed characteristics, check each site.	High water table; frequent flooding; moderate to very high susceptibility to frost action.
Arveson: Ar	Good	Fair: about 30 inches of overburden; material below is fine sand.	Good: good to fair shear strength; low compressibility; fair workability; low volume change; good to fair bearing capacity.	High water table; high to very high susceptibility to frost action.
Barnes: BaA, BaB, BbB2, BbC2 (For interpretations of Buse soil in mapping units BbB2 and BbC2, refer to Buse series in this table.	Good	Not suitable	Fair: fair shear strength; medium compressibility; good to fair workability; moderate volume change.	Slight to moderate susceptibility to frost action.
Bearden: BdA	Good	Not suitable	Poor: fair shear strength and workability; medium compressibility; moderate volume change; very poor bearing capacity.	Severe susceptibility to frost action.
Biscay:				
Be	Good	Poor: about 38 inches of overburden; material below is sand and gravel.	Fair in upper 2½ to 3½ feet: fair shear strength; moderate volume change. Good below depth of 3½ feet: excellent shear strength; low volume change.	High water table; moderate to high susceptibility to frost action.
Bf	Fair	Poor: about 32 inches of overburden; material below is medium and coarse sand.	Upper layers not suitable, substratum good: good shear strength, low compressibility, fair workability; low volume change; fair bearing capacity.	High water table; moderate to high susceptibility to frost action.
Blue Earth: Bh	Good	Not suitable	Not suitable: poor shear strength, workability, and bearing capacity; high and medium compressibility; moderate volume change.	High water table; moderate to high susceptibility to frost action.
Borup: Bm	Good	Poor: about 30 inches of overburden; material below is very fine sand.	Poor in upper 2½ feet, good below that depth: good to fair shear strength; low compressibility; fair workability; good to fair bearing capacity.	High water table; high to very high susceptibility to frost action.
Buse: BnE, BoD2, BuD (For interpretations of Barnes and Forman soils in mapping units BoD2 and BuD, refer to Barnes and Forman series, respectively, in this table.)	Good: thin surface layer.	Not suitable	Fair: fair shear strength; medium compressibility; good to fair workability; moderate volume change.	Slight susceptibility to frost action.

See footnotes at end of table.

interpretations

because its characteristics are too variable to be classified]

Farm ponds		Agricultural drainage	Terraces and diversions	Waterways
Reservoir area	Embankment			
Moderately pervious; bottom should be compacted.	Good stability, compaction characteristics, and resistance to piping; moderately slow permeability; medium compressibility.	Generally not needed; moderately well drained.	No important limitations; slopes are short in many places; a few boulders.	No important limitations; a few boulders.
High water table; mixed characteristics; check each site.	Check each site	Needed; suitable outlets generally are not available.	Not needed; nearly level	Not needed; slopes are nearly level.
Seasonal high water table; pervious substratum.	Fair stability and compaction characteristics; moderate permeability; slight compressibility; poor resistance to piping.	Needed; soil material may flow when wet and plug tile.	Not needed; nearly level	Not needed; slopes are nearly level.
Moderately pervious; bottom should be compacted.	Good stability; good compaction characteristics; moderate permeability; medium compressibility; good resistance to piping.	Not needed; soils are well drained.	Terraces are not suited on slopes of more than 12 percent; low fertility; slopes irregular in many places; a few boulders.	No important limitations; a few boulders.
Silty material; moderately pervious, bottom should be compacted.	Poor stability and resistance to piping; fair compaction characteristics; moderate permeability; medium compressibility.	Generally not needed	No important limitations; slopes are short in many places.	No important limitations; low fertility.
Seasonal high water table; pervious substratum.	Upper 3 feet has good stability and moderately slow permeability; substratum has good stability and rapid permeability.	Needed; moderately slow permeability; seasonal high water table.	Not needed; nearly level.	Not needed; nearly level.
High water table; pervious substratum.	Upper 32 inches not suited; substratum has fair stability and compaction characteristics, rapid permeability, and poor resistance to piping.	Needed; soil material may flow when wet and plug tile.	Not needed; nearly level.	Not needed; nearly level.
High water table; normally suitable for dug ponds.	Poor shear strength, compaction characteristics, and workability; high compressibility; moderate volume change; very poor bearing capacity.	Needed; moderately slow permeability; needs surface drainage.	Not needed; nearly level	Not needed; nearly level.
Seasonal high water table; pervious substratum.	Upper 2 to 3 feet has fair stability and moderate permeability; substratum has fair stability, moderately rapid permeability, and poor resistance to piping.	Needed; material becomes quick and flows when wet and may plug tile.	Not needed; nearly level	Not needed; nearly level.
Moderately pervious, bottom should be compacted.	Good stability, compaction characteristics, and resistance to piping; moderate permeability; medium compressibility.	Not needed; soils are somewhat excessively drained.	Terraces are not suited on slopes of more than 12 percent; slopes irregular in many places; a few boulders.	No important limitations; low fertility; steep slopes in some places; a few boulders.

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TABLE 5.—*Engineering*

Soil series, land types, and map symbols	Suitability as a source of—			Highway location
	Topsoil [1]	Sand or gravel	Highway subgrade [2]	
Colvin:				
Co, Cu (For interpretations of Borup soil in mapping unit Cu, refer to Borup series in this table.)	Good	Not suitable	Poor: fair shear strength; medium compressibility; fair to poor workability; moderate to high volume change; poor bearing capacity.	High water table; moderate to high susceptibility to frost action.
Cp	Good	Not suitable	Fair to poor: fair shear strength; medium compressibility; good to fair workability; moderate to high volume change.	Highly plastic clayey material over silt, highly susceptible to frost action.
Darnen: DaB	Good	Not suitable	Fair to poor: fair shear strength and workability; medium compressibility; moderate volume change.	Slight to moderate susceptibility to frost action.
Doland: D1A, D1B	Good	Not suitable	Poor in upper 2 to 3 feet: very poor bearing capacity. Good below depth of 3 feet: fair shear strength; moderate volume change.	Slight to moderate susceptibility to frost action.
Dovray:				
Do	Poor	Not suitable	Poor: poor shear strength; high compressibility and volume change; fair workability; fair to poor bearing capacity.	High water table; highly plastic, clayey material.
Dv	Poor	Not suitable	Poor: poor shear strength; high compressibility; poor workability; high volume change; fair to poor bearing capacity.	High water table; highly plastic, clayey material.
Eckman: EcB	Good	Good: about 30 inches of overburden; underlying material is fine sand.	Fair to good: good to fair shear strength; low compressibility, good to fair workability; low volume change.	Slight susceptibility to frost action.
Estelline: EsA	Good	Good: 24 to 42 inches of overburden; underlying material is sand and gravel.	Poor in upper 2 to 3½ feet: very poor bearing capacity. Fair below depth of 3½ feet: excellent shear strength; low volume change; good bearing capacity.	Slight susceptibility to frost action.
Flom (Mapped only in a complex with Parnell soils.)	Good	Not suitable	Fair to poor: fair shear strength; medium compressibility; good to fair workability; moderate volume change.	High water table; moderate to high susceptibility to frost action.
Fordville: FdA	Good	Good: 24 to 48 inches of overburden; underlying material is sand and gravel.	Fair to poor in upper 2 to 3½ feet. Good below depth of 3½ feet: excellent shear strength; very low compressibility; excellent workability; good bearing capacity.	Very slight susceptibility to frost action.

See footnotes at end of table.

interpretations—Continued

Farm ponds		Agricultural drainage	Terraces and diversions	Waterways
Reservoir area	Embankment			
Seasonal high water table; moderately pervious.	Fair stability and compaction characteristics; moderately slow permeability; medium compressibility; fair resistance to piping.	Moderately slow permeability, seasonal high water table; needs surface drainage.	Not needed; nearly level	Not needed nearly level.
High water table; normally suitable for dug ponds.	Good stability and compaction characteristics; moderately slow permeability; medium compressibility; good resistance to piping.	Moderately slowly permeable; needs surface drainage.	Not needed; nearly level	Not needed; nearly level.
Moderately pervious; bottom should be compacted.	Fair stability; fair compaction characteristics; moderate permeability; medium compressibility; fair resistance to piping.	Generally not needed	No important limitations.	No important limitations.
Moderately pervious; bottom should be compacted.	Upper 2 to 3 feet: fair stability; moderate permeability. Below a depth of 3 feet: moderate permeability; good stability and resistance to piping.	Not needed; well drained.	No important limitations; slopes irregular in many places; a few boulders in deep cuts; low fertility.	No important limitations; a few boulders in deep cuts.
Seasonal high water table; highly plastic, clayey material.	Fair stability; medium compaction; very slow permeability; high compressibility; excellent resistance to piping.	Very slow permeability; seasonal high water table; needs surface drainage.	Not needed; nearly level	Not needed; nearly level.
High water table; highly plastic, clayey material.	Upper 34 inches: not suited. Substratum: fair stability; medium compaction characteristics; very slow permeability; high compressibility; excellent resistance to piping.	Very slow permeability; needs surface drainage.	Not needed; nearly level	Not needed; nearly level.
Material too porous to hold water.	Fair stability; good compaction; moderately rapid permeability; poor resistance to piping.	Not needed; well drained.	Sandy substratum; highly erodible; difficult to vegetate.	Sandy substratum; highly erodible; difficult to vegetate.
Material too porous to hold water.	Upper 2 to 3 feet: poor stability; moderate permeability. Below depth of 3 feet: very good stability; rapid permeability; fair resistance to piping.	Not needed; well drained.	Moderately deep to sand and gravel.	Maximum cut should be no more than 2 to 3 feet: low available water capacity; difficult to vegetate.
Seasonal high water table; moderately pervious.	Fair stability and compaction characteristics; moderately slow permeability; medium compressibility; good resistance to piping.	Needed; moderately slow permeability; seasonal high water table; needs surface drainage.	Not needed; nearly level	No important limitations; wet for short periods in places.
Material too porous to hold water.	Upper 2 to 3½ feet: fair compaction characteristics; moderately permeable. Substratum: very good stability; good compaction characteristics; rapid permeability.	Not needed; well drained.	Maximum cuts should be no more than 2 to 3 feet deep; moderately deep to sand and gravel.	Difficult to vegetate.

TABLE 5.—*Engineering*

Soil series, land types, and map symbols	Suitability as a source of—			Highway location
	Topsoil [1]	Sand or gravel	Highway subgrade [2]	
Forman: FmA, FmB, FmB2, FuB2, FuC2. (For interpretations of Buse soil in mapping units FuB2 and FuC2, refer to Buse series in this table.)	Fair	Not suitable	Fair: fair shear strength; medium compressibility; good to fair workability; moderate to high volume change.	Slight to moderate susceptibility to frost action.
Glyndon: GdA, G1A, GmA (For interpretations of McIntosh soil in mapping unit GmA, refer to McIntosh series in this table.)	Good	Fair: 18 to 36 inches of overburden; underlying material is fine sand.	Poor in upper 1½ to 3 feet. Good below depth of 3 feet: good to fair shear strength; low compressibility; fair workability; low volume change.	High to very high susceptibility to frost action.
Grimstad: Gr (For interpretations of Rockwell soil in this mapping unit, refer to Rockwell series in this table.)	Good	Not suitable	Fair in upper 2 to 3 feet: fair shear strength; low volume change. Poor below depth of 3 feet: high volume change; fair compaction characteristics.	High susceptibility to frost action.
Hamerly: HaA	Fair	Not suitable	Fair: fair shear strength; medium compressibility; good to fair workability; moderate volume change.	Slight to moderate susceptibility to frost action.
Hattie: HcC2, HcD2, HnB (For interpretations of Nutley soil in mapping unit HnB, refer to Nutley series in this table.)	Poor	Not suitable	Poor: poor shear strength and workability; high compressibility and volume change; fair to poor bearing capacity.	Highly plastic, clayey material.
Hegne: Ho	Poor	Not suitable	Poor: poor shear strength and workability; high compressibility and volume change; fair to poor bearing capacity.	High water table; highly plastic, clayey material.
Hidewood: Hw	Good	Not suitable	Fair to poor: fair shear strength and workability; medium compressibility; moderate volume change.	High water table; moderate to high susceptibility to frost action.
Lamoure: Lm, Ln	Good	Not suitable	Fair to poor: fair shear strength; medium compressibility; fair to good workability; moderate volume change; good to poor compaction characteristics.	High water table; moderate to very high susceptibility to frost action.
La Prairie: Lp	Good	Poor: more than 42 inches of overburden; underlying material is sand and gravel.	Fair to poor in upper 3½ feet. Good below depth of 3½ feet: excellent shear strength and workability; very low compressibility; good bearing capacity.	Slight susceptibility to frost action.
Maddock: MaB	Good to fair	Good: less than 12 inches of overburden; underlying material is medium sand.	Good: good to fair shear strength; low compressibility; fair workability and bearing capacity; low volume change.	Very slight to slight susceptibility to frost action.

See footnotes at end of table.

interpretations—Continued

Farm ponds		Agricultural drainage	Terraces and diversions	Waterways
Reservoir area	Embankment			
Moderately pervious; bottom should be compacted.	Good stability, compaction characteristics, and resistance to piping; moderately slow permeability; medium compressibility.	Not needed; soils are well drained.	Terraces not suitable on slopes of more than 12 percent; low fertility; irregular slopes in many places; a few boulders.	No important limitations; a few boulders.
Pervious substratum; requires a seal blanket that has been compacted.	Upper 2 to 3 feet: fair stability; moderate permeability. Below depth of 3 feet: fair stability; slight compressibility; poor resistance to piping.	Generally not needed; moderately well drained.	Moderately deep to sandy material; short slopes in many places.	Maximum cut should be no more than 2 to 3 feet; low fertility and available water capacity.
Slowly pervious below depth of 2 to 3 feet; bottom needs compacting in places.	Upper 2 to 3 feet: fair stability; medium compaction characteristics; poor resistance to piping. Below depth of 3 feet: fair stability and compaction characteristics; excellent resistance to piping.	Generally not needed; moderately well drained.	Not needed; nearly level.	Not needed; nearly level.
Moderately pervious; bottom should be compacted.	Good stability, compaction characteristics, and resistance to piping; moderately slow permeability; medium compressibility.	Generally not needed; moderately well drained.	No important limitations; slopes are short in many places; a few boulders; low fertility.	No important limitations; a few boulders; low fertility.
Slowly pervious; clayey material.	Fair stability; medium compaction characteristics; very slow permeability; high compressibility; excellent resistance to piping.	Generally not needed.	Clayey soils; difficult to vegetate and to construct terraces and diversions.	Clayey soils; difficult to vegetate and construct waterways.
Seasonal high water table; highly plastic, clayey material.	Fair stability; medium compaction characteristics; very slow permeability; high compressibility; excellent resistance to piping.	Very slow permeability; seasonal high water table; needs surface drainage.	Not needed; nearly level.	Not needed; nearly level.
Seasonal high water table; moderate to high susceptibility to frost action.	Fair stability; fair compaction characteristics; moderate permeability; medium compressibility; fair resistance to piping.	Moderate permeability; seasonal high water table; needs surface drainage.	Not needed; nearly level.	No important limitations.
High water table; normally suitable for dug ponds.	Fair stability, compaction characteristics, and resistance to piping; moderately slow permeability; medium compressibility.	Needed; suitable outlets in a few places; in places overflow is a hazard.	Not needed; nearly level.	Not needed; nearly level.
Pervious substratum; requires a seal blanket that has been compacted.	Upper 4 feet: fair stability, compaction characteristics, and resistance to piping; medium compressibility. Substratum: rapid permeability.	Generally not needed; moderately well drained.	Not needed; nearly level.	Not needed; nearly level.
Material too porous to hold water.	Fair stability and compaction characteristics; rapid permeability; slight compressibility; poor resistance to piping.	Not needed; well drained.	Shallow to sand; highly erodible; difficult to vegetate.	Sandy; low available water capacity; difficult to vegetate.

TABLE 5.—*Engineering*

Soil series, land types, and map symbols	Suitability as a source of—			Highway location
	Topsoil [1]	Sand or gravel	Highway subgrade [2]	
Malachy: MfA	Good	Good: about 28 inches of overburden; underlying material is medium to coarse sand.	Fair to good: good to fair shear strength; low compressibility and volume change; fair workability.	Moderate to high susceptibility to frost action.
Malachy, loamy subsoil variant: Mc.	Good	Not suitable	Fair in upper 2 to 3 feet: fair shear strength; low volume change. Poor below depth of 3 feet: high volume change; fair compaction characteristics.	High susceptibility to frost action.
Marysland: Mr	Good	Not suitable	Poor: poor shear strength and workability; slight compressibility; low volume change.	High water table; high to very high susceptibility to frost action.
McIntosh: MsA	Good	Not suitable	Poor in upper 2 to 3 feet: very low bearing capacity. Fair below depth of 3 feet: fair shear strength; good to fair workability; moderate volume change.	Moderate to high susceptibility to frost action.
Muck, shallow: Mu	Fair to good if mixed with mineral soil.	Not suitable	Not suitable	Organic material
Muck and peat: Mv, Mw	Fair to good if mixed with mineral soil.	Not suitable	Not suitable	Organic material
Nutley: NcA	Poor	Not suitable	Poor in upper 2 to 3 feet: poor shear strength; high volume change. Poor below depth of 3 feet: fair shear strength; low volume change.	Highly plastic, clayey material underlain by silt; highly susceptible to frost action.
NhA (For interpretations of Hattie soil in this mapping unit, refer to Hattie series in this table.)	Poor	Not suitable	Poor: poor shear strength; high compressibility and poor workability; high volume change; fair to poor bearing capacity.	Highly plastic, clayey material.
Oldham: Om	Fair	Not suitable	Not suitable; poor shear strength, workability, and bearing capacity; high compressibility; moderate volume change.	High water table; moderate to high susceptibility to frost action.
Parnell: Pa, Pf (For interpretations of Flom soil in mapping unit Pf, refer to Flom series in this table.)	Fair	Not suitable	Not suitable; poor shear strength, workability, and bearing capacity; medium compressibility; moderate to high volume change.	High water table; moderate to high susceptibility to frost action.

See footnotes at end of table.

interpretations—Continued

Farm ponds		Agricultural drainage	Terraces and diversions	Waterways
Reservoir area	Embankment			
Material too porous to hold water.	Fair stability; good compaction characteristics; rapid permeability; slight compressibility; poor resistance to piping.	Generally not needed; moderately well drained.	Not needed; nearly level.	Not needed; nearly level.
Slowly pervious below depth of 2 to 3 feet; bottom needs compacting in places.	Upper 2 to 3 feet: fair stability; moderately rapid permeability. Substratum: fair stability; excellent resistance to piping.	Generally not needed; moderately well drained.	Not needed; nearly level.	Not needed; nearly level.
Seasonal high water table; pervious substratum.	Fair stability and compaction characteristics; moderately rapid permeability; slight compressibility; poor resistance to piping.	Needed; soil material may flow when wet and plug tile; water control structures needed to prevent overdraining.	Not needed; nearly level.	Not needed; nearly level.
Moderately pervious; bottom should be compacted.	Upper 2 to 3 feet: poor stability; moderate permeability. Below depth of 3 feet: slow permeability; good stability and resistance to piping.	Generally not needed; moderately well drained.	No important limitations; low fertility.	No important limitation; low fertility.
Organic material	Unstable; poor bearing capacity.	Needed; moderately slow permeability; needs surface drainage.	Not needed; nearly level.	Not needed; nearly level.
Organic material	Unstable; poor bearing capacity.	Needed; moderately slow permeability; seasonal high water table; needs surface drainage.	Not needed; nearly level.	Not needed; nearly level.
Slowly pervious to moderately pervious clay underlain by silty material.	Upper 2½ to 3 feet: fair stability; very slow permeability. Below depth of 3 feet: poor stability; moderate permeability.	Generally not needed	Clayey subsoil; difficult to vegetate and construct terraces and diversions; short slopes in most places.	Clayey subsoil; difficult to vegetate and construct waterways.
Slowly pervious; clayey material.	Fair stability; medium compaction; very slow permeability; high compressibility; excellent resistance to piping.	Generally not needed	Not needed; nearly level.	Not needed; nearly level.
High water table; normally suitable for dug ponds.	Poor shear strength, workability, and compaction characteristics; high compressibility; moderate volume change; very poor bearing capacity.	Needed; moderately slow permeability; needs surface drainage.	Not needed; nearly level.	Not needed; nearly level.
High water table; normally suitable for dug ponds.	Upper 38 inches: not suited. Substratum: fair to good stability and compaction characteristics; moderately slow permeability; medium compressibility; good resistance to piping.	Moderately slow permeability; needs surface drainage.	Not needed; nearly level.	Not needed; nearly level.

TABLE 5.—*Engineering*

Soil series, land types, and map symbols	Suitability as a source of—			Highway location
	Topsoil [1]	Sand or gravel	Highway subgrade [2]	
Rauville: Ra	Good	Not suitable	Fair to poor: fair shear strength and workability; medium compressibility; poor bearing capacity.	High susceptibility to frost action.
Renshaw: ReA, ReB	Good	Good; 12 to 24 inches of overburden; material below is sand and gravel.	Good below depth of 2 feet: excellent shear strength and workability; very low compressibility; good bearing capacity.	Very slight susceptibility to frost action.
Rockwell (Mapped only in a complex with Grimstad soils.)	Good	Not suitable	Fair in upper 2 to 3 feet: fair shear strength; low volume change. Poor below depth of 3 feet: high volume change; fair compaction characteristics.	High water table; high to very high susceptibility to frost action.
Rothsay:				
RoA	Good	Not suitable	Poor: fair shear strength and workability; medium compressibility; low volume change; very poor bearing capacity.	Slight to high susceptibility to frost action.
RzB (For interpretations of Zell soil in this mapping unit, refer to Zell series in this table.)	Good; thin surface layer.	Not suitable	Poor: fair shear strength and workability; medium compressibility; moderate to high volume change; very poor bearing capacity.	Slight to high susceptibility to frost action.
Sandy lake beaches: Sa	Poor	Fair: medium to coarse sand.	Mixed characteristics; check each site.	May have high water table; slight to moderate susceptibility to frost action.
Sioux: SgC, SsA, SsB	Good	Good: less than 12 inches of overburden; underlying material is sand and gravel.	Good: excellent shear strength and workability; very low compressibility; good bearing capacity.	Very slight susceptibility to frost action.
Svea: SvA	Good	Not suitable	Fair: fair shear strength; medium compressibility; good to fair workability; moderate volume change.	Slight to moderate susceptibility to frost action.
Sverdrup: SwA, SwB	Good	Good: about 20 inches of overburden; underlying material is medium sand.	Good: good to fair shear strength; low compressibility; fair workability and bearing capacity; low volume change.	Very slight to slight susceptibility to frost action.
Tara: TaA	Good	Not suitable	Poor in upper 2 to 3 feet: very poor bearing capacity. Fair below depth of 3 feet: fair shear strength; moderate volume change.	Moderate susceptibility to frost action.

See footnotes at end of table.

interpretations—Continued

Farm ponds		Agricultural drainage	Terraces and diversions	Waterways
Reservoir area	Embankment			
High water table; normally suitable for dug ponds.	Upper 4 feet: fair to poor stability; fair compaction characteristics; moderately slow permeability; medium compressibility; fair resistance to piping.	Needed; suitable outlets in a few places; moderately slow permeability in upper 4 feet; high water table.	Not needed; nearly level.	Not needed; nearly level.
Material too porous to hold water.	Below depth of 1 to 2 feet: good stability and compaction characteristics; rapid permeability; very slight compressibility; fair resistance to piping.	Not needed; well drained to somewhat excessively drained.	Shallow to sand and gravel; slopes irregular in many places.	Maximum cuts should be no more than 1 to 2 feet deep; difficult to vegetate.
Seasonal high water table; slowly pervious.	Upper 2 to 3 feet: fair stability; poor resistance to piping. Below depth of 3 feet: fair stability; very slow permeability; excellent resistance to piping.	Needed; soil material may flow when wet and plug tile.	Not needed; nearly level.	Not needed; nearly level.
Silty material; moderately pervious; bottom should be compacted.	Poor stability, compaction characteristics, and resistance to piping; moderate permeability; medium compressibility.	Not needed; well drained.	No important limitations; low fertility.	Highly erodible; low fertility.
Silty material; moderately pervious; bottom should be compacted.	Poor stability, compaction characteristics, and resistance to piping; moderate permeability; medium compressibility.	Not needed; well drained.	No important limitations; low fertility.	Highly erodible; low fertility.
Material too porous to hold water.	Investigate each site.	Suitable outlets generally not available.	Not needed; nearly level.	Not needed; nearly level.
Material too porous to hold water.	Good stability and compaction characteristics; rapid permeability; very slight compressibility; fair resistance to piping.	Not needed; excessively drained.	Very shallow to sand and gravel; slopes irregular in many places.	Very shallow to sand and gravel; low available water capacity; difficult to vegetate.
Moderately pervious; bottom should be compacted.	Good stability and compaction characteristics; slow permeability; medium compressibility; good resistance to piping.	Generally not needed; moderately well drained.	No important limitations; slopes are short in many places; a few boulders.	No important limitations; a few boulders.
Material too porous to hold water.	Below depth of 1½ to 2 feet: fair stability; fair compaction characteristics; rapid permeability; slight compressibility; poor resistance to piping.	Generally not needed; somewhat excessively drained.	Shallow to sand; highly erodible; difficult to vegetate.	Low available water capacity; difficult to vegetate.
Moderately pervious; bottom should be compacted.	Upper 2 to 3 feet: poor stability; moderate permeability. Below depth of 3 feet: good stability and resistance to piping; moderate permeability.	Generally not needed; moderately well drained.	No important limitations.	No important limitations.

See footnotes at end of table.

TABLE 5.—*Engineering*

Soil series, land types, and map symbols	Suitability as a source of—			Highway location
	Topsoil [1]	Sand or gravel	Highway subgrade [2]	
Tonka: To	Good	Not suitable	Poor in upper 3 to 4 feet: poor workability; high volume change. Fair below depth of 4 feet: good to fair workability; moderate to high volume change.	High water table; moderate to high susceptibility to frost action.
Vallers: Va	Good	Not suitable	Fair: fair shear strength; medium compressibility; good to fair workability; moderate volume change.	High water table; moderate to high susceptibility.
Winger: Wn	Good	Not suitable	Poor in upper 2 to 3 feet: very low bearing capacity. Fair below depth of 3 feet: fair shear strength; good to fair workability; moderate volume change.	Moderate to high susceptibility to frost action.
Zell (Mapped only in a complex with Rothsay soils.)	Good: very thin surface layer.	Not suitable	Poor: fair shear strength; medium compressibility; fair workability; low volume change; very poor bearing capacity.	Slight to high susceptibility to frost action.

[1] Refers to surface soil only.
[2] Refers to substratum or underlying material unless otherwise specified.

The tests to determine liquid limit and plastic limit measure the effect of water on consistence of the soil material. As the moisture content of a clayey soil increases from a very dry state, the material changes from a semisolid to a plastic state. As 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 a semisolid to a plastic state. The *liquid limit* is the moisture content at which the soil material passes from a plastic to a liquid state. The *plasticity index* is the numerical difference between the liquid limit and the plastic limit. It indicates the range in moisture content within which a soil material is in a plastic condition.

Engineering properties

In table 4 the soil series of the county and the symbols for mapping units are listed, and certain characteristics that are significant to engineering are described. The estimated classification according to the AASHO and Unified classification systems is given for each important layer. These estimates are based on soil test data in table 3, on information in the rest of the survey, and on experience with similar soils in this and other counties. Because bedrock is at a great depth in this county and is not significant to engineering, it is not mentioned in table 4.

Permeability of the soil as it occurs in place was estimated. The estimates are based on the structure and porosity of the soil as it occurs in place and on permeability tests on undisturbed cores of similar material.

Available water capacity, given in inches per inch of soil depth, refers to approximate amount of capillary water in the soil when the soil is wet to field capacity. When the soil is air dry, this same amount of water will wet the soil material to a depth of 1 inch without deeper percolation. Data are needed on representative soils from undisturbed soil samples or from field measurements if reliable estimates are to be made.

Reaction as shown in the table is the estimated range in pH values for each major horizon as determined in the field. It indicates the acidity or alkalinity of the soils. A pH of 7, for example, indicates a neutral soil, a lower pH value indicates acidity, and a higher value indicates alkalinity.

The shrink-swell potential refers to the change in volume of the soil that results from a change in moisture content. It is estimated on the basis of the amount and type of clay in the soil layers. In general soils classified as A-7 and CH have high shrink-swell potential. Clean sands and gravels and those having a small amount of nonplastic to slightly plastic fines have low shrink-swell potential, as does most other nonplastic to slightly plastic soil material.

interpretations—Continued

Farm ponds		Agricultural drainage	Terraces and diversions	Waterways
Reservoir area	Embankment			
Seasonal high water table; slowly pervious.	Fair stability and compaction characteristics; very slow permeability; medium compressibility; good resistance to piping.	Very slow permeability; needs surface drainage.	Not needed; nearly level..	Not needed; nearly level.
Seasonal high water table; moderately pervious.	Good stability, compaction characteristics, and resistance to piping; moderately slow permeability; medium compressibility.	Moderately slow permeability; seasonal high water table; needs surface drainage.	Not needed; nearly level..	Not needed; nearly level.
Seasonal high water table; moderately pervious.	Upper 2 to 3 feet: poor stability; moderate permeability. Below depth of 3 feet: good stability; moderate permeability; good resistance to piping.	Moderate permeability; seasonal high water table; needs surface drainage.	Not needed; nearly level..	Not needed; nearly level.
Silty material; moderately pervious; bottom should be compacted.	Poor stability, compaction characteristics, and resistance to piping; moderate permeability; medium compressibility.	Not needed; somewhat excessively drained to excessively drained.	No important limitations; low fertility.	Highly erodible; low fertility.

Engineering interpretations

Table 5 rates the soils according to their suitability as a source of topsoil, sand or gravel, and highway subgrade material. It also gives facts that would affect use of the soils as sites for highways and for agricultural engineering. The information is based partly on estimates. It is also based on data obtained by testing soils from this county and on data for similar soils from other counties.

One main feature considered in rating the suitability of the soils for various purposes was susceptibility to frost heaving. Susceptibility of the soils to frost action is a serious limitation in Stevens County. It affects the amount of earthwork that can be done in winter. Earthwork can normally be done in winter, however, in gravelly and sandy material that contains only a small amount of silt or clay if the soil material is not frozen and can readily be compacted.

Soils that consist of a mixture of clay, silt, and coarse-textured material are less susceptible to frost heaving and subsequent frost boils than soils that contain a large amount of silt or very fine sand. A soil is susceptible to damaging frost action if about 10 percent or more of the soil material passes a No. 200 sieve.

Each particular deposit of sand and gravel needs to be examined to determine if it is suitable for the intended use. Suitable sources of sand or gravel are available in the Eckman, Estelline, Fordville, Sioux, and Sverdrup soils. The sand underlying the Eckman and Sverdrup soils is medium- to fine-grained.

Use of soil material that is uniform is important in highway construction. Damage from frost heaving results where there are differences in expansion between one material and another. Moisture content also is important. If a highway subgrade is laid over soil material that is high in clay and that has high shrink-swell potential, the pavement may crack or warp, depending on the moisture content. Examples are soils of the Dovray, Hegne, Hattie, and Nutley series. Also soils, such as the Bearden and Colvin, that are high in silt are most susceptible to frost action if located where drainage is poor.

The bearing capacity of the soils generally is favorable for highway location. Some of the soils, however, are in potholes and other depressions or consist of alluvium and are not suitable as sites for highways. The Blue Earth, Oldham, Parnell, and Rauville soils are some of these.

Good sites for farm ponds are available in the county. Deep drainageways that have steep side slopes, such as those in Buse soils, make good reservoir areas. The seepage rate in the Buse soils is slow, and the glacial till that underlies these soils generally is suitable for use in embankments. Also, stability and compaction characteristics are fair, and permeability is slow. Before selecting a site for a pond, borings should be made in the reservoir area to determine if lenses of sand or pockets of gravel are present. Such material would cause differential frost heave.

All wet soils in the county require artificial drainage for best growth of crops. Ordinary cement tile cannot be used to provide drainage in the Colvin and Vallers soils. The soils contain excessive amounts of calcium and magnesium sulfates, and these salts could disintegrate cement tile.

Terraces are the most practical way to provide water management and erosion control on slopes of less than 12 percent if row crops are grown intensively. Parallel terraces generally are used. Where slopes are irregular, such as those of Barnes soils, cutting and filling generally are needed for good alinement of the terraces. Compaction is likely to be a problem in the terrace channel if the terraces are constructed in spring. If the terraces are built in fall, compaction is less severe because freezing and thawing before the next growing season improve soil structure. Diversion terraces are used mainly on slopes that are steeper than 12 percent.

Waterways that are grassed provide drainageways that safely remove excess water and reduce loss of soil. Establishing sod vegetation in waterways on highly erodible sandy and gravelly soils is difficult. The topsoil in waterways built in Fordville, Renshaw, and Sverdrup soils, for example, generally needs to be replaced after shaping, before vegetation can be established. Tile may be needed for draining wet soils, such as the Flom, Hidewood, Parnell, and Vallers, before a good grass sod can be established.

Soil limitations for septic tank filter fields.—Most soils in this county are in areas beyond existing sewerage lines, and the use of septic tanks is necessary. Areas selected for homes and other community developments must therefore be suitable for septic tanks. Each site must be examined carefully to determine the ability of the soil to absorb and filter the effluent that flows from the septic tank (*13*).

Among the features that affect the suitability of a specific site for filter fields are slopes, drainage, depth to the water table, and frequency of flooding. In general, soils that have slopes of more than 12 percent are severely limited for use as filter fields. Also severely limited for such use are soils that have a high water table and are poorly drained. Examples are the clayey Hattie and Nutley soils. Other soils that have severe limitations for filter fields are those that have slow permeability. Soils that are well drained or excessively drained, on the other hand, generally have slight limitations for use as filter fields.

The soil map in the back of this soil survey is reliable for predicting the general suitability of an area of several acres, but it may not contain sufficient detail to predict the suitability for a specific site. Soil variations may occur within a short distance, and most maps are not detailed enough to supply the precise information as to where on a building site a filter field should be located. Therefore, onsite evaluation by a soil scientist or measurements of the rate of water movement may be needed. The rate of water movement is measured by a percolation test. A percolation test not only indicates whether the soil is suitable but also provides the information needed to calculate the size of the filter field.

Formation, Morphology, and Classification of Soils

In this section the factors that have affected the formation and morphology of the soils in Stevens County are discussed. Then the current system of soil classification is explained and the soil series are placed in higher categories. The soil series in the county, including a profile representative of each series, are described in the section, "Descriptions of the Soils."

Factors of Soil Formation

Soil is formed by weathering and other processes that act upon parent material. The characteristics of the soil at any given point depend upon parent material, climate, plants and animals, relief, and time.

Climate and plants and animals are the active forces of soil formation. They act on the parent material accumulated through the weathering of rocks and slowly change it into soil. All five factors come into play in the formation of every soil. The relative importance of each differs from place to place; sometimes one is more important and sometimes another. In extreme cases one factor may dominate in the formation of a soil and fix most of its properties. In general, however, it is the combined action of the five factors that determines the present character of each soil.

Parent material

Glacial till, outwash sediment, and glacial lake sediment make up much of the parent material of the soils in Stevens County. Some of the soils, however, formed in loess, or wind-laid silt. The differences in these parent materials account for many of the differences among the soils in the county. For example, some of the soils are sandy because their parent material was sandy, and others are silty because their parent material was loess. In the paragraphs that follow the different kinds of parent material are discussed.

Glacial till.—Glacial ice deposited unsorted, nonstratified till in Stevens County (*8*). The till is of three different kinds—loam, clay loam, and clay. The properties of the different kinds of till are reflected in the different soils that formed from them.

Loam till was deposited mainly east of the Pomme de Terre River. It is about 43 percent sand, 35 percent silt, and 22 percent clay on a gravel-free basis. Boulders of granite, limestone, gneiss, greenstone, and mica-schist are common in loam till, as are fragments of shale. Loam till is light olive brown to olive brown in well-drained areas. At a depth between 3 and 4 feet, mottles generally are present and bulk density is about 1.6. In most places the till is a little more than 20 percent calcium and magnesium carbonates. Soils of the Barnes and Svea series are examples of soils formed on loam till.

Clay loam till occurs west of the Pomme de Terre River. It is about 27 percent sand, 42 percent silt, and

31 percent clay on a gravel-free basis. Boulders and fragments of shale are the same as in the loam till. Permeability, depth of leaching, and color and amount of carbonates also are similar.

Differences between soils formed on loam till and those formed on clay loam till are associated chiefly with the amount of clay in the till. Volume changes on wetting and drying are greater in the clay loam till than in the loam till. Thus, structure in the Aastad and Forman soils, formed on clay loam till, is stronger than in soils formed on loam till.

Clayey till is about 9 percent sand, 33 percent silt, and 58 percent clay on a gravel-free basis. Boulders generally are less common than in the loamy till. Shale fragments are more abundant than fragments of other sedimentary rocks or of igneous rocks. In well-drained areas, clayey till is very dark grayish brown to grayish brown. Conspicuous cleavage or structure generally occurs well below the solum. Slickensides are common.

In a few places the clayey till occurs as a smear over the clay loam till, and in other places the clay loam till occurs as a smear over the clayey till. These factors indicate that both materials were deposited at about the same time. Possibly, the clayey till was laid down in lakes and then was redeposited by glacial ice.

Nutley soils are examples of soils formed on clayey till. These clayey soils shrink when they dry, and cracks ½ to 1½ inches wide form. As the soil becomes moist, it swells and the cracks close. Dark-colored material from the surface soil falls into the vertical cracks that in places are as much as 40 inches deep. As the result of wetting and drying, the surface soil slakes into very fine, strong granules, which is uncommon in soils formed on loamy till.

Outwash sediment.—The Pomme de Terre and Chippewa River Valleys and the southeastern part of the county are the major areas on glacial outwash sediment. Here the soils formed chiefly in loamy material underlain by sediment consisting of sand and gravel. The loamy material ranges from 5 to more than 100 inches in thickness.

The Pomme de Terre River Valley, which probably existed long before the advance of the last ice sheet (*7*), was covered by ice during the last glacial advance. The Pomme de Terre Lakes are good examples of basins blocked by ice (*16*). Except for two small remaining islands, all of the unsorted glacial till in the river valleys in Stevens County was washed away by melt water from the glacier. Distinct high river terraces of sand and gravel were formed by the melt water.

In the river valleys and in some areas in the southeastern part of the county, the outwash sediment consists of stratified layers of sand and gravel. In the extreme southeast corner of the county and in small areas just south of the Pomme de Terre Lakes, north of Morris, the outwash sediment consists of well-sorted medium and coarse sand. Renshaw and Fordville soils are examples of soils that formed in loamy material underlain by stratified sand and gravel. Examples of soils that formed in well-sorted outwash sediment are those of the Maddock, Malachy, Marysland, and Sverdrup series.

Glacial lake sediment.—Water-sorted sediment laid down in glacial lakes is the parent material of soils in the northwestern part of the county. This material ranges in texture from sand to clay.

The northwest corner of the county was once a basin of postglacial Lake Agassiz I. Within the basin of this lake, the soils formed in water-sorted loam and sand underlain by silty clay till that was partly water-sorted. The Grimstad and Rockwell soils are examples of soils formed in this material.

Adjacent to Lake Agassiz I is Herman Beach Ridge, which follows a southwest to northeast direction in Stevens County. This ridge consists of gravelly and sandy material and is the parent material of the Sioux soils. To the west, near the county line, the ridge merges with the flat landscape. South and southeast of where Herman Beach ends is a small area made up of water-sorted clayey material underlain by silty material. On this material the silty substratum soil of the Nutley series formed. About 11,740 years ago the water level of Lake Aggassiz I was lower than during the postglacial time of the lake (*15*).

Southeast of Herman Beach, and extending in a semicircle for a distance of about 12 miles, is a nearly level area where differences in elevation are 3 feet or less. This area was once a shallow lake formed by melt water as the glacier receded. It antedates Lake Agassiz I (*7*). No beaches of any consequence were formed. It is therefore assumed that the period of inundation was fairly short compared to the time of inundation required to form Herman Beach.

The relief of the glacial ground moraine before the shallow lake was formed consisted of swells and swales in a fine pattern. In places silt and sand deposited by water form a continuous mantle over both the swells and swales. In other places the silt and sand is too thin to cover the swells. Small islands of glacial till are interspersed with the water-sorted sand and silt. In many places the pattern of deposition is very fine and several different textural soil profiles occur within a distance of 100 feet. Soils of the Colvin-Borup complex and the Glyndon-McIntosh complex occupy these areas.

Another glacial lake basin is in the southern part of Synnes Township near Griffin Lake. This glacial lake probably lasted only a short time. It was drained by Drywood Creek, which cut back from the Pomme de Terre River. The gravelly area of Sioux and Renshaw soils in section 29 of Synnes Township may have been a delta formed by glacial melt water from the north as it flowed into the lake basin. The silty substratum soil of the Nutley series is in this lake basin.

Loess.—Deposits of wind-sorted material cap areas east of the Pomme de Terre River in Stevens County. Most of this windblown silt probably came from the flood plains of the Pomme de Terre and Chippewa Rivers. As soon as the ice sheet receded, prevailing westerly winds blew the silt onto areas east of the river before the areas had a cover of grass. Little loess occurs on the west side of the Pomme de Terre River.

The ground moraine on which the loess was deposited consisted of swells and swales. Consequently, the thickness of the loess varies within a short distance. The loess generally is less than 42 inches thick. In places, however, the swells lack a loess cap but the swales have a capping of loess more than 42 inches thick. In the nearly level areas, the capping of loess gives the landscape a smooth appearance. In the undulating to hilly areas, loess flanks the hillside slopes but generally is lacking on the stronger convex slopes, where erosion is active. A discontinuous line of pebbles occurs at the boundary between the loess and the underlying till. In many places thin lenses of sand also are present.

The loess is about 22 percent sand, 58 percent silt, and 20 percent clay in a calcareous matrix. Soils that formed in loess normally are leached to a greater depth than soils formed on loamy till because the loess is more permeable. Texture is the only other significant difference between the two kinds of soils. Examples of soils formed in loess are the Doland and Tara.

Climate

Climate is a major factor in determining the kinds of soils that form from different kinds of parent material. It determines the vegetation and influences the rate and intensity of the physical, chemical, and biological relationships in the soil profile, chiefly through the effects of precipitation and temperature. In turn, the effects of climate and vegetation vary according to the topography and the length of time the parent material has been in place.

Stevens County has a subhumid, continental type of climate that varies widely from summer to winter. The climate is essentially uniform throughout the county. It is described in detail in the section "General Nature of the County." The soils generally are frozen to a depth of 4 to 6 feet from the last of November to the middle of April. Depth of frost penetration is greatest in March (*4*).

Studies made in other parts of Minnesota show the climate has changed significantly since the last glacier receded (*6*). Carbon-14 dates and pollen counts indicate a drier climate than the present existed from 5,000 to 7,200 years ago. Thus, some of the differences in the soils resulted partly from differences in the climate.

Plants and animals

Plants, animals, bacteria, and other organisms are active in soil-forming processes. The changes they bring about depend chiefly on the life processes peculiar to each. The kinds of plants and animals that live on and in the soil are affected, in turn, by the climate, the parent material, relief, and age of the soil.

At the time of settlement, much of Stevens County had a cover of tall grasses and legumes. A few scattered deciduous trees grew along the rivers and around the many lakes in the county.

On the well drained to moderately well drained soils, the most important native grasses were big bluestem, little bluestem, broomsedge, indiangrass, switchgrass, Canada wildrye, junegrass, porcupinegrass, side-oats grama, hairy grama, prairie dropseed, and sand dropseed. The wet soils had a cover made up mostly of bluejoint, prairie cordgrass, American sloughgrass, mannagrass, reed canarygrass, and common reedgrass.

Soils formed under grasses, such as those in Stevens County, generally are higher in organic content than soils formed under trees, such as those in northern Minnesota. Grasses have many roots and tops that decay on and in the surface layer of soils. Thus, soils formed under grasses have a thick, dark-colored surface layer. Soils formed under trees have a thinner, lighter colored surface layer because the organic matter, derived mostly from leaves, is deposited only on the surface.

Small animals, earthworms, insects, and micro-organisms also influence the formation of soils by mixing organic matter into the soil and helping to break down the remains of plants. Such small animals as gophers burrow into the soil and thus mix the layers. Earthworms and other small invertebrates feed on the organic matter in the upper few inches of the soil. In this way they slowly mix the soil material and may alter it chemically. Bacteria, actinomycetes, fungi, algae, and other micro-organisms hasten the weathering of rocks and the decomposition of organic matter.

Relief

Relief, through its effect upon drainage, aeration, and erosion, is an important factor in the formation of soils. In more than 75 percent of the county, the soils are nearly level and differences in elevation are less than 5 feet. In slightly more than 5 percent of the county, the soils are gently sloping to steep. Here differences in elevation are as much as 30 to 50 feet. In the remaining 20 percent of the county, the soils are nearly level to gently sloping and differences in elevation range from 3 to about 30 feet.

Runoff from steep soils and from soils on knolls, such as the Buse, is more rapid than on more nearly level soils. Much of the soil material is likely to be washed away before a soil profile can develop. Less water percolates through steep soils and the profile is likely to be less well developed than that of more level soils, where runoff is less and more water percolates through the soil. In swales and other low areas, the soils receive more water than can percolate through them. They therefore are wet during much of the growing season. Many of these wet soils are leached of salts to a depth of 36 inches or more. Examples of such soils are those of the Parnell series, which have a thick, black surface layer.

Time

The soils in Stevens County vary in maturity, depending on the length of time the soil-forming forces have been active. Many of the soils in the county started developing after the last glacier receded more than 12,000 years ago. The till left by the glacier was calcareous. In time soil began to form, and plants that could tolerate the cold climate grew in the fresh parent material and contributed to development of the soils. The equilibrium of soil, climate, and vegetation was broken by man more than 100 years ago when he started to plow the virgin grass sod.

Many soils in the county are young because they are forming along streams where sediment is still being deposited. Some of the soils, such as Muck and peat, are young because they are forming in a thin layer of organic material. Still other soils, such as the Buse, are said to be young because they are forming in steep areas where the soil material is washed away almost as fast as it forms.

Morphology of Soils

Soil morphology in Stevens County is expressed by prominent horizons within the solum. The differentiation of horizons in soils of the county is the result of the accumulation of organic matter, the leaching of carbonates and salts, the accumulation of clay minerals, the reduction and transfer of iron and manganese, or of one or more of these processes.

In most of the soils, some organic matter has accumulated to form an A1 horizon. Much of the organic matter has accumulated in the upper 6 to 12 inches to form a dark-colored surface layer. The Barnes soils, for example, have a thick surface layer that is high in organic matter.

Leaching of such soluble salts as calcium carbonates, magnesium carbonates, and calcium sulfates has occurred in most soils of the county. The salts are dissolved by water and moved downward by percolating water. Most of the well-drained soils, such as the Forman, are leached to a depth between 12 and 24 inches. Wet soils, such as the very poorly drained Parnell, are leached of soluble salts to a depth of 40 or 60 inches or more. These soils receive runoff from surrounding areas in addition to natural precipitation. Leaching is slow in such soils as the Vallers that have a high water table. In such soils, the water moves upward from the saturated zone, and because of evaporation, the salts are transferred to the surface and accumulate there. In this county the chief salts are calcium and magnesium carbonates, though calcium sulfates are abundant in places.

Reduction and transfer of iron has occurred in the poorly drained and very poorly drained soils of the county. In these wet soils, this process, called gleying, is important in differentiation of horizons. Some of such soils have horizons that contain reddish-brown mottles and concretions caused by segregated iron.

Translocation of clay minerals has contributed to the development of horizons in some of the soils. In the Tonka soils, for example, an accumulation of clay is expressed in B horizons that have clay films in pores and on the surfaces of peds.

Classification of Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationship to one another and to the whole environment, and to develop principles that help us to understand their behavior and their response to manipulation. First through classification, and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

Thus in classification, soils are placed in narrow categories that are used in detailed soil surveys so that knowledge about the soils can be organized and used in managing farms, fields, and woodland; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad classes to facilitate study and comparison in large areas, such as countries and continents.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 (*3*) and later revised (*10*). The system currently used was adopted for general use by the National Cooperative Soil Survey in 1965. It is under continual study (*9*, *12*). Therefore, readers interested in developments of the current system should search the latest literature available. The soil series of Stevens County are placed in some categories of the current system in table 6.

The current system of classification has six categories. Beginning with the broadest, these categories are order, suborder, great group, subgroup, family, and series. In this system the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that the soils of similar origin are grouped together. The classes of the current system are briefly defined in the paragraphs that follow.

ORDERS. Ten soil 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. Two exceptions, the Entisols and Histosols, occur in many different kinds of climate.

In Stevens County nearly all of the series are classified in the Mollisol order. *Mollisols* have formed mostly under grass. They have a thick, friable, dark-colored surface layer. Base saturation is more than 50 percent.

Also in the county are some organic soils of the Histosol order. These mapping units consist of muck and peat.

SUBORDERS. Each order is subdivided into groups (suborders) that are based mostly on soil characteristics that seem to produce classes having the greatest similarity from the standpoint of their genesis. Suborders narrow the broad climatic range of soils that are in the orders.

Soil characteristics used to separate suborders mainly reflect either the presence or absence of waterlogging or soil differences produced through the effects of climate or vegetation. The names of suborders have two syllables. The last syllable indicates the order. An example is Borolls (Bor, meaning cold, and oll, from Mollisol).

GREAT GROUPS. Soil suborders are separated into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and other features. The horizons used as a basis for distinguishing between great groups are those in which (1) clay, iron, or humus have accumulated; (2) a pan has formed that interferes with growth of roots, movement of water, or both; or (3) a thick, dark-colored, surface horizon has formed. The other features used commonly are the self-mulching properties of clay, temperature of the soil, major differences in chemical composition (mainly the bases calcium, magnesium, sodium, and potassium), or the dark-red or dark-brown colors associated with soils formed in material weathered from basic rocks. Names of great groups have three or four syllables. They are made by adding a prefix to the name of the suborder. An example is Argiboroll (Argi, meaning clayey; bor, for cold; and oll,

TABLE 6.—*Classification of soil series of Stevens County, Minnesota* [1]

[All of the series in this county are classified in the Mollisol order. The order, which generally is placed after the subgroup in a table of this kind, is therefore not shown in this table]

Series	Family	Subgroup	1938 Classification
Aastad	Fine-loamy, mixed	Pachic Udic Haploborolls	Chernozems.
Arveson	Coarse-loamy, mixed, frigid	Typic Calciaquolls	Solonchak soils.
Barnes	Fine-loamy, mixed	Udic Haploborolls	Chernozems.
Bearden	Fine-silty, mixed, frigid	Aeric Calciaquolls	Solonchak soils.
Biscay	Fine-loamy over sandy or sandy-skeletal, mixed, noncalcareous, mesic.	Typic Haplaquolls	Humic Gley soils.
Blue Earth	Fine-silty, mixed, calcareous, mesic	Cumulic Haplaquolls	Humic Gley soils.
Borup	Coarse-silty, mixed, frigid	Typic Calciaquolls	Solonchak soils.
Buse	Fine-loamy, mixed	Udorthentic Haploborolls	Regosols.
Colvin	Fine-silty, mixed, frigid	Typic Calciaquolls	Solonchak soils.
Darnen	Fine-loamy, mixed	Pachic Udic Haploborolls	Chernozems.
Doland	Fine-loamy, mixed	Udic Haploborolls	Chernozems.
Dovray	Fine, montmorillonitic, noncalcareous, frigid	Vertic Haplaquolls	Humic Gley soils.
Eckman	Coarse-silty, mixed	Udic Haploborolls	Chernozems.
Estelline	Fine-silty over sandy or sandy skeletal, mixed	Pachic Udic Haploborolls	Chernozems.
Flom	Fine-loamy, mixed, noncalcareous, frigid	Typic Haplaquolls	Humic Gley soils.
Fordville	Fine-loamy over sandy or sandy skeletal, mixed, frigid.	Pachic Udic Haploborolls	Chernozems.
Forman	Fine-loamy, mixed	Udic Argiborolls	Chernozems.
Glyndon	Coarse-silty, mixed, frigid	Aeric Calciaquolls	Solonchak soils.
Grimstad	Coarse-loamy over clayey, mixed, frigid	Aeric Calciaquolls	Solonchak soils.
Hamerly	Fine-loamy, mixed, frigid	Aeric Calciaquolls	Solonchak soils.
Hattie	Fine, montmorillonitic	Udertic Haploborolls	Grumusols.
Hegne	Fine, montmorillonitic, frigid	Typic Calciaquolls	Solonchak soils.
Hidewood	Fine-silty, mixed, noncalcareous, frigid	Typic Haplaquolls	Humic Gley soils.
Lamoure	Fine-silty, mixed, calcareous, frigid	Cumulic Haplaquolls	Alluvial soils intergrading to Humic Gley soils.
La Prairie	Fine-loamy, mixed	Cumulic Udic Haploborolls	Chernozems.
Maddock	Sandy, mixed	Udorthentic Haploborolls	Chernozems.
Malachy	Coarse-loamy, mixed	Pachic Udic Haploborolls	Chernozems intergrading to Solonchak soils.
Malachy, loamy subsoil variant.	Coarse-loamy, mixed	Pachic Udic Haploborolls	Chernozems intergrading to Solonchak soils.
Marysland	Fine-loamy, over sandy or sandy skeletal, mixed, frigid.	Typic Calciaquolls	Solonchak soils.
McIntosh	Fine-silty, mixed, frigid	Aeric Calciaquolls	Solonchak soils.
Nutley	Very fine, montmorillonitic	Udertic Haploborolls	Grumusols.
Oldham	Fine-silty, mixed, calcareous, frigid	Cumulic Haplaquolls	Humic Gley soils.
Parnell	Fine, mixed, noncalcareous, frigid	Typic Argiaquolls	Humic Gley soils.
Rauville	Fine-silty, mixed, calcareous, frigid	Cumulic Haplaquolls	Alluvial soils intergrading to Humic Gley soils.
Renshaw	Fine-loamy over sandy skeletal, mixed	Udic Haploborolls	Chernozems.
Rockwell	Coarse-loamy over clayey, mixed, frigid	Typic Calciaquolls	Solonchak soils.
Rothsay	Coarse-silty, mixed	Udic Haploborolls	Chernozems.
Sioux	Sandy-skeletal, mixed	Udorthentic Haploborolls	Regosols.
Svea	Fine-loamy, mixed	Pachic Udic Haploborolls	Chernozems.
Sverdrup	Coarse-loamy, mixed	Udic Haploborolls	Chernozems.
Tara	Fine-silty, mixed	Pachic Udic Haploborolls	Chernozems.
Tonka	Fine, montmorillonitic, frigid	Argiaquic Argialbolls	Planosols.
Vallers	Fine-loamy, mixed, frigid	Typic Calciaquolls	Solonchak soils.
Winger	Fine-silty, mixed, frigid	Typic Calciaquolls	Solonchak soils.
Zell	Coarse-silty, mixed	Udorthentic Haploborolls	Regosols.

[1] Placement of some soil series in the current system of classification, particularly in families, may change as more information becomes available.

from Mollisol). The great group is not shown separately in table 6, because it is the last word in the name of the subgroup.

SUBGROUPS. Great soil groups are subdivided into subgroups. One of these represents the control, or typic, segment of the group. Other subgroups have properties of the group but also have one or more properties of another group, suborder, or order, and these are called intergrades. Subgroups may also be established for soils having properties that intergrade outside the range of any other great group, suborder, or order. The names of subgroups are formed by placing one or more adjectives before the name of the great group. An example is Udic Argiborolls.

FAMILIES. Families are separated within a subgroup primarily on the basis of properties that are important to the growth of plants or to the behavior of soils used for engineering. The main properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence. The names of families consist of a series of adjectives that precede the name of a subgroup. The adjectives used are the class names for texture, mineralogy, and so on (see table 6). An example is the fine-loamy, mixed family of Udic Argiborolls.

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 in arrangement in the profile. Among these characteristics are color, structure, reaction, consistence, and mineralogical and chemical composition.

General Nature of the County

This section is provided mainly for those who are not familiar with the county. It gives general facts about settlement and development of the county, discusses the climate, and then gives information about the farming. Statistics used in the discussion of farming are mainly from reports of the U.S. Census of Agriculture.

Settlement and Development

Stevens County was ceded to the U.S. Government from Indian Territory by Treaty of Traverse de Sioux in 1851. The county was first established early in 1862, but an outbreak of the Sioux in summer slowed growth and development. The first permanent settlement was made in 1866 in Framnas Township. Present boundaries were established in 1868.

Early explorers and geologists in the area noted that the rich, black, loamy soils of the county had potential for agriculture. The first settlers grew mainly such crops as cabbage, rutabaga, and potatoes for use on the farm. Soon more land was put into cultivation and large areas were planted to wheat, flax, barley, and oats. These crops were sold in the market or were traded for other goods and services.

The county was officially organized in 1871, and Morris was chosen at the county seat. By 1900 the population was 8,721. The population has remained fairly stable for the past 20 years, and 11,262 people lived in the county in 1960. Most of the people are engaged in farming, the most important enterprise. Some, however, find employment in small manufacturing plants.

At the time of settlement, most travel in the county was by way of the Wadsworth Trail, which crossed the county from east to west. In 1871 the first railroad reached Morris, and today two railways serve the county. State and Federal highways crisscross the county, and rural roads provide ready access from the farms to the markets in the towns and villages. Most of these are gravel surfaced, though some have a bituminous surface. All of the grain produced in the county is taken to grain elevators in the towns and villages. Most of the livestock is shipped by truck to markets in St. Paul and in Fargo, N. Dak., and in Sioux City, Iowa. Dairy and poultry products generally are marketed through local cooperatives.

Several public and private elementary schools and high schools are in the county. In addition a branch college of the University of Minnesota recently was established at Morris. Medical services are available through a hospital at Morris, as well as through facilities in other areas.

Recreational facilities are available throughout the county. Areas suitable for hunting and fishing (see the section "Wildlife") and for other kinds of recreation abound. Pheasant hunting generally is good, and in many parts of the county, it is very good. Leasing of hunting rights is fairly common. At the opening of the hunting season, hunting space and lodging for the hunters are scarce. Most fishing is in the Pomme de Terre Lake and River system. Fishing is less good in lakes where winterkill of fish is common.

Facilities for swimming, boating, skiing, and other water sports are available at Lake Hattie, Page Lake, Lower Pomme de Terre Lake, and at Pomme de Terre State Park. Most recreational facilities have been provided by civic groups and are maintained by them. Other recreational facilities could be developed and would provide additional income to landowners. Some of the deep, natural drainageways that extend back from the walls of river valleys provide excellent sites for dams that could be developed into areas for fishing and other recreation.

Climate [4]

Stevens County has a continental climate, typical of that near the center of the great land mass that makes up the North American continent. Summers are warm and moist. Winters are cold and dry. No large areas of water or marked differences in topography occur in the county, and the climate throughout the county therefore is fairly uniform. Temperature and precipitation data for the county are given in table 7.

The average annual temperature for December, January, and February is 13.9° F. In the winter of 1935–36, however, an average temperature of 1.6° was recorded for these 3 months. The temperature in most winters drops to 20° below zero, or lower, for 1 or 2 days. In January it can be expected that 2 years in 10 will have at least 4 days when the temperature is 23° or lower. The average annual temperature for June through August is 69.3°. Temperatures as high as 100° or more have been recorded on 50 days in the 30-year period from 1930 through 1959. In July it can be expected that 2 years in 10 will have at least 4 days when the temperature is 97° or higher.

More than 75 percent, or about 17 inches, of the annual precipitation falls during the growing season, from April through September. Measurable precipitation of at least 0.01 inch can be expected on about 85 days a year, and on 4 of these days, 1 inch or more can be expected. Rainfall at the intensity of about 1 inch an hour can be expected once in 2 years. Annual rainfall has ranged from a low of 15.31 inches in 1933, to a high of 33.03 inches in 1906. The most rain that fell in any month was 12.53 inches in June 1914. On the other hand, the annual average rainfall for the period 1931 to 1934 was only 17.50 inches.

Measurable snowfall of 1 inch or more generally comes late in October 1 year out of 3. The last measurable snow in spring generally falls in April. The smallest annual snowfall recorded was 8.1 inches in 1895, and the largest, was 89.2 inches in 1951.

Much of the rain during the growing season comes in thunderstorms, and about 40 of these occur in the county each year. Some of the thunderstorms are accompanied

[4] By DONALD A. HAINES, State climatologist for Minnesota, Weather Bureau, ESSA, U.S. Department of Commerce.

TABLE 7.—*Temperature and precipitation*

[Morris, Stevens County, Minn.]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Two years in 10 will have at least 4 days with—		Average 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
			Maximum temperature equal to or higher than—	Minimum temperature equal to or lower than—		Less than—	More than—		
	°F.	*°F.*	*°F.*	*°F.*	*Inches*	*Inches*	*Inches*	*Number*	*Inches*
January	20	0	42	−23	0.6	0.1	1.0	24	4
February	25	4	44	−17	.7	.1	1.2	24	4
March	37	18	56	−6	1.1	.3	2.0	18	4
April	55	32	75	19	2.1	.6	3.9	4	2
May	69	45	85	31	3.0	1.2	5.5	0	----------
June	78	55	91	43	3.9	1.9	6.5	0	----------
July	84	60	97	50	3.2	1.2	5.9	0	----------
August	82	58	95	47	3.0	1.4	5.5	0	----------
September	72	47	90	33	1.9	.7	3.7	0	----------
October	61	36	81	21	1.5	.1	2.8	(1)	----------
November	40	21	62	−1	1.0	.1	2.1	9	2
December	26	8	42	−15	.6	.1	1.1	19	4
Year	54	32	(2) 109	(3) −41	22.6	17.4	26.1	98	3

[1] Less than one-half day. [2] Highest maximum recorded, July 18, 1940. [3] Lowest minimum recorded, February 16, 1936.

by hail and damaging winds. Tornadoes are rare. Only 5 were recorded during the period from 1916 to 1965.

The growing season is long enough for the crops commonly grown in the county to mature without much damage from frost. The probabilities of certain temperatures occurring in spring and in fall are shown in table 8 (*2*). This table shows, for example, that 5 years out of 10, or 50 percent of the time, a temperature of 32° or lower can be expected to occur later than May 12 in spring and earlier than September 25 in fall.

In farming it is helpful to know the best time for preparing a seedbed, for planting and for doing certain other tasks to take advantage of wet or dry periods. Table 9 lists percentages of probability that specified amounts of precipitation will fall during periods of 1 week. Similar information for periods of 3 weeks is given in table 10. The data are based on information published by Iowa State University (*5*). In table 9, for example, the probability that Morris will receive 0.20 inch or more of rain during the week of June 7 through June 13 is 79 percent. The probability of receiving 1.00 inch or more during that week is 34 percent. That is, during this period, in 79 years out of 100 the rainfall is expected to be 0.20 inch or more; and in 34 years out of 100, it is expected to total 1.00 inch or more.

Long-term records of humidity, of cloudy days, and of wind velocity are not available for Stevens County, but data from weather stations at St. Cloud, Minn., and

TABLE 8.—*Probabilities of freezing temperatures in spring and in fall*

[Morris, Stevens County, Minn.]

Probability	Dates for given probability and temperature			
	24° F. or lower	28° F. or lower	32° F. or lower	36° F. or lower
Spring:				
1 year in 10 later than	May 6	May 20	May 27	June 7
2 years in 10 later than	May 1	May 14	May 22	June 2
5 years in 10 later than	April 21	May 4	May 12	May 24
Fall:				
1 year in 10 earlier than	September 30	September 19	September 11	August 3
2 years in 10 earlier than	October 6	September 24	September 16	September 5
5 years in 10 earlier than	October 17	October 4	September 25	September 16

TABLE 9.—*Probability of receiving a trace or less of precipitation or at least the amounts shown in a 1-week period*

[Morris, Stevens County, Minn.]

Week	Precipitation							
	Trace or less	0.20 inch	0.40 inch	0.60 inch	0.80 inch	1.00 inch	1.40 inch	2.00 inch
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
April 26 through May 2	17	67	54	44	36	29	19	10
May 3 through May 9	24	61	48	37	28	22	13	6
May 10 through May 16	11	68	54	43	34	27	17	9
May 17 through May 23	11	73	56	42	32	23	13	5
May 24 through May 30	19	65	51	40	31	25	15	7
May 31 through June 6	6	78	65	54	44	37	26	14
June 7 through June 13	9	79	65	53	43	34	22	11
June 14 through June 20	6	77	62	50	40	32	22	11
June 21 through June 27	6	78	65	55	46	39	29	17
June 28 through July 4	9	78	66	56	47	40	29	17
July 5 through July 11	13	71	59	49	41	35	26	15
July 12 through July 18	15	68	55	44	35	28	19	9
July 19 through July 25	11	67	49	36	27	19	11	4
July 26 through August 1	22	57	46	37	30	25	17	10
August 2 through August 8	9	65	48	36	27	20	12	5
August 9 through August 15	15	67	48	33	22	15	7	2
August 16 through August 22	11	65	51	41	33	26	18	10
August 23 through August 29	28	52	38	28	21	16	9	4
August 30 through September 5	24	59	42	30	21	14	7	2
September 13 through September 19	20	55	41	31	23	18	11	5
September 20 through September 26	20	55	39	28	21	15	8	3
September 27 through October 3	35	48	34	23	16	10	5	1

from Huron, S. Dak., are representative of conditions in Stevens County. These records show that the average windspeed is nearly 12 miles per hour. The prevailing direction of the wind is from the northwest in winter and from the south in summer. Relative humidity at noon ranges from 55 percent in summer to as much as 72 percent in winter. In a typical year there are 98 days that are clear, 116 days that are partly cloudy, and 151 days that are cloudy.

Farming

Farming has always been important in Stevens County. Livestock and livestock products and dairy products account for much of the farm income. About 95 percent of the farmland is used for cultivated crops and for rotational pasture. Farmsteads, permanent pasture, and pastured woodland occupy the remaining acreage. Much of the acreage in permanent and wooded pasture is too steep or wet for cultivation. The North Central Soil and Water Conservation Research Field Station and the University of Minnesota Experimental Station are at Morris. They can provide information to help the farmer in planning the kind of farming suited to the soils.

In 1964, according to the U.S. Census of Agriculture, the total land in farms was 350,352 acres. The farms numbered 1,020, and their average size was 342.5 acres. Of these, about 30 percent were cash-grain farms; about 38 percent were livestock farms; about 12 percent were dairy farms; about 11 percent were general farms; and the remaining farms were miscellaneous and unclassified. Most of the cash-grain farms are on the nearly level soils in the western two-thirds of the county.

The average size of the farms has increased in recent years, mainly because of the increased use of labor-saving machinery. About 45 percent of the farms in the county in 1964 were between 260 and 499 acres, and about 17 percent were larger than 500 acres. Most of the farms, or 429, were operated by owners, 347 were operated by part owners; 239 by tenants; and only 5 by managers. Most of the cultivated land is rented for a share of the crop, but pasture or hayland generally is rented for cash. Cash rent for farm buildings is becoming common, especially if the buildings are modern.

Grain crops and hay occupy the largest acreage in crops. These crops are fed on the farms to the livestock or are sold for cash. The acreage of the crops grown in 1964 follows:

	Acres
Corn	98,537
Oats	56,486
Wheat	16,518
Flax	14,133
Barley	9,214
Alfalfa	15,838

More than three-fourths of the corn crop is harvested for grain. Most of the rest is cut for silage. Nearly 70 percent of the acreage in corn received some fertilizer.

The acreage in soybeans has increased in recent years. Soybeans generally are sold for cash. Little of the acreage in soybeans is fertilized.

Wheat and flax are grown mainly as cash crops. In addition, some flax straw is baled and sold at local markets. Oats and barley are used both as cash crops and to provide feed for livestock. Also, oat straw is baled and used as bedding for livestock. Commercial fertilizer is used chiefly on wheat, oats, and barley.

TABLE 10.—*Probability of receiving a trace or less of precipitation or at least the amounts shown in 3-week periods*

[Morris, Stevens County, Minn.]

Weeks	Precipitation							
	Trace or less	0.20 inch	0.40 inch	0.60 inch	0.80 inch	1.00 inch	1.40 inches	2.00 inches
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
March 1 through March 21	13	80	63	46	32	21	9	2
March 22 through April 11	9	86	77	67	57	48	32	17
April 12 through May 2	2	94	87	80	72	64	50	33
May 3 through May 23	0	99	95	90	83	76	62	42
May 24 through June 12	0	98	94	90	84	79	67	52
June 14 through July 4	0	100	98	96	93	90	81	66
July 5 through July 25	0	99	96	91	85	79	67	49
July 26 through August 15	2	96	91	84	77	69	54	35
August 16 through September 5	0	95	86	78	69	61	47	31
September 6 through September 26	0	97	91	84	76	69	55	37
September 27 through October 17	4	83	70	58	48	40	27	15
October 18 through November 7	9	79	65	52	41	32	19	8
November 8 through November 28	7	70	53	41	31	24	14	6
November 29 through December 19	13	65	43	28	17	10	4	1
December 20 through January 9	11	59	39	25	17	11	5	1
January 10 through January 30	7	73	49	31	19	11	4	1
January 31 through February 27	7	68	49	35	25	17	9	3

Alfalfa is grown chiefly for hay. It also is grown in rotational pastures in mixtures of brome and other grasses. Sweetclover and red clover are the chief other legumes grown.

Most of the farms have vegetable gardens. Tomatoes, cucumbers, green beans, peas, cabbage, and potatoes are the chief vegetables grown. On a few farms apple, pear, plum, and cherry trees provide fruit for home use.

The chief livestock in the county are beef cattle and hogs and pigs. Milk cows have decreased in number, though total milk production has increased. The number of beef cattle and hogs fed in the county has increased through use of modern equipment. Most of the animals are fattened with grain produced on the farms. The number of sheep and lambs has decreased. Chickens have decreased in number in recent years. The number of eggs produced has increased, however, because of improved breeding and better care. The numbers of livestock on farms in the county in 1964 follow:

Cattle and calves	43,088
Milk cows	4,980
Hogs and pigs	41,310
Sheep and lambs	8,567
Chickens	170,416

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Glossary

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Available moisture capacity (also termed available water capacity). The capacity of a soil to hold water in a form available to plants. Amount of moisture held in soil between field capacity, or about one-third atmosphere of tension, and the wilting coefficient, or about 15 atmospheres of tension.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of clay on the surface of a soil aggregate. Synonyms: clay coat, clay skin.

Claypan. A compact, slowly permeable soil horizon that contains more clay than the horizon above and below it. A claypan is commonly hard when dry and plastic or stiff when wet.

Colluvium. Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

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.

Cemented.—Hard and brittle; little affected by moistening.

Drainage, soil. 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.

Drift (geology). Material of any sort deposited by geologic processes in one place after having been removed from another. Glacial drift consists of earth, sand, gravel, and boulders deposited by glaciers and by the streams and lakes associated with them. It includes *glacial till*, which is unassorted and nonstratified, and *glacial outwash*, which is stratified.

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.

Ground moraine (geology). Glacial till accumulated beneath advancing ice and deposited from it during its dissolution, rather than aggregated in a thickened belt at the ice edge. The deposit is relatively thin and characteristically forms an undulating plain with gently sloping swells, sags, and closed depressions.

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 1, 2, and 3. 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.

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Leaching. The removal of soluble materials from soils or other material by percolating water.

Lime. Chemically, lime is calcium oxide (CaO), but its meaning has been extended to include all limestone derived materials applied to neutralize acid soils. Agricultural lime can be obtained as ground limestone, hydrated lime, or burned lime, with or without magnesium minerals. Basic slag, oystershells, and marl also contain calcium.

Loess. A fine-grained, wind-laid deposit that consists dominantly of silt-sized particles.

Morphology, soil. The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical mineralogical, and biological properties of the various horizons, and their thickness and arrangement in the soil profile.

Mottled. 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 dimensions; 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.

Outwash, glacial (geology). See Drift, glacial.

Parent material (soil). The horizon of weathered rock or partly weathered soil material from which soil has formed; horizon C in the soil profile.

Peat. Unconsolidated soil material, largely undecomposed organic matter, that has accumulated where there has been excessive moisture.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Permeability. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid*, and *very rapid.*

Relief. The elevations or inequalities of a land surface, considered collectively.

Sand. Individual rock or mineral fragments in soils having diameters ranging from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Solum. The upper part of a soil profile, above the 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.

Stratified. Composed of, or arranged in, strata, or layers, such as "stratified alluvium." The term is confined to geological material. Layers in soils that result from the processes of soil formation are called horizons; those inherited from the parent material are called strata.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. Technically the part of the soil below the solum.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Till, glacial. See Drift, glacial.

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.

Variant, soil. A soil that has properties sufficiently different from those of other known soils to justify a new series name, but of such limited geographic area that establishing a new series cannot 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.

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